Colorado Birds Monitored by 2001:
Results of Point Transects in Three Colorado Habitats
With an Appendix of Results of
Special-species Monitoring

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ABSTRACT

In 1998, Colorado Bird Observatory, with many partners, initiated the pilot year of count-based monitoring as outlined in the plan *Colorado Birds Monitored by 2001* (*CBM 2001*)(Carter and Leukering 1998 and updates). The *CBM 2001* plan set the goal of being able to detect a ≥3.0% population change with statistical significance of 0.1 and power of 0.8 for species dependent (target species) on 13 Colorado habitats. For a test of methodology, we randomly established 30 point transects within 30 randomly-selected stands in three habitats (Aspen, Ponderosa Pine, and Spruce-Fir) within the state. We used roads as access points to transects but each transect headed in a random direction from its road access point. Each transect consisted of 15 five-minute counts with the sum of detections for each species for each transect treated as a replicate. We analyzed these data using distance-sampling theory via the program DISTANCE (Laake et al. 1994) and a "standard analysis" using unlimited detection radii. Results using both methods were then used to model monitoring efficiency using the program MONITOR (PWRC 1998). Data analyzed via the program DISTANCE exhibited significantly lower variance (vs. the standard analysis) thus resulting in fewer number of years to meet our monitoring goals ($\bar{x}$=6.86 yrs., range=6-9 yrs.). Assuming the density-based variance we obtained will be approximately stable through time, we will be able to effectively monitor 26 of the 29 target species in the three habitats in time periods that are reasonable, i.e. we will start seeing results for most species before a decade has passed. The unmonitored species (Purple Martin in Aspen and Sharp-shinned Hawk and Boreal Owl in Spruce-Fir) may never be monitorable using count-based methods during the breeding season and have been addressed under the special-species techniques within *CBM 2001.* The species that are monitorable under this plan using count-based methods are (habitats are A=Aspen, P=Ponderosa Pine, and S=Spruce-Fir): Broad-tailed Hummingbird (A), Red-naped Sapsucker (A), Hairy Woodpecker (P), Three-toed Woodpecker (S), Olive-sided Flycatcher (S), Western Wood-Pewee (A), Hammond's Flycatcher (S), Warbling Vireo (A), Gray Jay (S), Clark's Nutcracker (S), Tree Swallow (A), Violet-green Swallow (A), Mountain Chickadee (S), Red-breasted Nuthatch (S), Pygmy Nuthatch (P), Golden-crowned Kinglet (S), Ruby-crowned Kinglet (S), Mountain Bluebird (A), Western Bluebird (P), Hermit Thrush (S), Grace's Warbler (P), Chipping Sparrow (P), Pine Grosbeak (S), Cassin's Finch (S), Red Crossbill (S), and Pine Siskin (S). We expect that the annual costs of monitoring birds in these habitats through this plan will not exceed $10,000 per habitat per year (1998 dollars) for the first decade.

INTRODUCTION

Conservation and management of Colorado's birds depend on adequate monitoring information. The Breeding Bird Survey (BBS) has accumulated a 33-year data set, but the routes in Colorado effectively monitor <20% of the state's breeding bird species (BBS web site 1998). In addition, data that corroborates the BBS data set are entirely lacking across the range of that project. Monitoring information is required by legislative

and land/wildlife management agency mandates, as well as a host of long-range plans, Forest plans, ecoregional plans, preserve management plans, etc. From a global biodiversity perspective, Colorado hosts some species at high abundances, thus Colorado has high responsibility for those species (Partners in Flight 1998).

In cooperation with the agencies/organizations charged with protecting and managing Colorado's birds, Colorado Bird Observatory (CBO) has developed and proposed a program of bird monitoring for the state, *Colorado Birds Monitored by 2001* (*CBM 2001*)(Carter and Leukering 1998), in which every interested agency/organization contributes and benefits. The first phase of this plan calls for establishing a statewide, statistically-robust program of randomly-selected point-count transects in each of 13 habitats. With funding from the Great Outdoors Colorado Trust Fund through the Colorado Division of Wildlife and the U.S.D.A. Forest Service, CBO established the transects in three habitats in 1998.

In developing *CBM 2001*, we defined suites of species that are restricted to or that are found at their highest abundances in each of the 16 defined habitats; the species in each group were termed "target species" and were considered indicators of that habitat. We here slightly redefine "target species" as those species that achieve their highest abundance in the state in that habitat and which are common enough for us to be able to monitor their populations, detecting trends of $\geq$3.0%/yr (positive or negative) with statistical significance of 0.1 and power of 80%. The plan also developed a variation on sampling methodology by combining aspects of point-count and transect methodologies for the point transect protocol used herein.

METHODS

We established transects of 15 point counts in each of 30 randomly-selected stands in each of three habitats: Aspen, Ponderosa Pine, and Spruce-Fir. Using USDA Forest Service GIS data, we numbered all publicly-owned stands of the habitats in Colorado (n=478 in Aspen (2,248,526 acres), 521 in Ponderosa Pine (1,672,074 acres), and 490 (4,185,844 acres) in Spruce-Fir) and then randomly selected 53 to 59 from each habitat. We then randomly selected 30 of those in which we established point transects. In a few instances, selected stands were not the indicated habitat or access across private land was denied, so we discarded them and randomly selected a replacement from the original set of randomly-selected stands.

Each transect was conducted by one observer using protocol established by Leukering (1998). The observer located the selected stand on the ground and ran the transect along a randomly-selected bearing. It was usually impossible to run the entire transect along the random bearing, as stand boundaries, property boundaries, and physical obstructions forced turns in the transect direction. When this happened, the observer randomly turned right or left perpendicular to the random bearing, subsequently alternating perpendicular directions if additional turns were necessary. In some stands,

the narrowness of the stands predicated the location and bearing of the transects.

Transects consisted of 15 5-minute point counts spaced at 250-m intervals along a line. We considered the intervals between points as legs of a true transect. At the individual points, we recorded the distance to each bird detected. Along the transect legs, we recorded only individuals of a short list of the habitat's target species whose population densities are relatively low (thus, poorly-recorded on point counts) and estimated distance to each. However, the protocol allowed recording individual birds on both a point and a transect leg, thus eliminating the possibility of analyzing pooled point and transect data. In future years we will record individuals of low-density target species on either a point or a transect leg, not both, with points having priority over transect legs.

Observers recorded weather data (sky condition--cloud cover and precipitation, wind--Beaufort scale, and temperature) and the time at the start and end of each transect. At each point, the observer recorded whether the point was within 100m of a road. Also at each point, he/she recorded the specific habitat and seral stage (1-5 scale; Buttery and Gillam 1983) of each of the two predominant habitats around the point (often there was only one habitat present). Upon arriving at a point, the observer recorded habitat data, then conducted the point count.

Though we anticipated using the data from the transect legs, for virtually all target species, the point data was robust enough to stand alone. We analyzed the point data grouped by transect, with transects as replicates, and developed species means and various descriptive statistics.

DISTANCE Program

We used program DISTANCE (Laake et al. 1994) to analyze distance-estimate data; in this report, all references to density estimates are values provided by DISTANCE from our data. The notation, concepts, and analysis methods of the program were developed in Buckland et al. (1993). The program can analyze several forms of distance sampling data, fitting a detection curve to the data set to be analyzed. The program avoids some serious biases inherent in traditional analysis of point-count data (e.g. detectability among habitats or years), but comes with three assumptions: all birds at distance 0 are detected; distances of birds close to the point are measured accurately, and birds do not move in response to the observer's presence.

We considered well-sampled those species for which DISTANCE provided a model that met three criteria: coefficient of variation (CV) of <50%, <3 parameters included in the detection curve function, and total variance reasonably balanced between the variance caused by sample size and that caused by the detection probability (ratio from $\approx$2:1 to $\approx$1:2; D. Anderson pers. comm.). For those species for which unlimited distance did not meet all three criteria, we truncated the data sets for individual species at various distances (using cut points developed by DISTANCE) and reran DISTANCE.

We used two programs, TRENDS (Gerrodette 1993) and MONITOR (Patuxent Wildlife Research Center 1998), to model monitoring efficacy. The output provided is the number of years required to detect a given trend with certain assumptions (trend of $\geq$3.0% (both positive and negative) with statistical significance of 0.1 and power of 80%, assuming 30 transects run annually). To develop the indices, these programs require input of CVs, for which we used the CVs developed both by "standard analysis" of unlimited-distance radii and density-estimate CVs provided by DISTANCE. The two programs (TRENDS and MONITOR) differed by a factor of 2 or more in these indices. Since we are unsure of the reason(s) for the difference, we report the results from both.

RESULTS

We recorded a total of 11,408 birds of 104 species on 89 transects (one Spruce-Fir transect's data were lost)(Table 1; all scientific names are presented in Appendix A). Of these, 10,431 non-flyover individuals of 95 species were recorded on the 1335 point counts, with only 21 points having no birds (8 in Aspen, 1 in Ponderosa Pine, and 12 in Spruce-Fir). Species totals on the 89 transects ranged from 1 for many species to 1059 Warbling Vireos (almost 10% of all birds recorded; Table 1). Using unlimited-radius detections, we obtained CVs of under 150% for 12 species and under 100% for seven species, with the lowest CV being 46% for Yellow-rumped Warbler.

The distance-estimate data provided CVs of under 100%, in at least one habitat, for all species with sample size of >5 in at least one habitat (except for Common Nighthawk; total n=59 species; Table 2). Of those 58 species with CVs <100%, 53 had CVs under 50% in at least one habitat. For 21 species with CVs of under 50% in at least one habitat, we obtained robust results (well-balanced variance sources and<3 parameters in the detection-curve model that incorporated the complete data sets) (Table 2). By truncating outliers at various distances for individual species, we attempted to optimize CVs, decrease the number of parameters included in the models, and to balance the two sources of variance: sample size and probability of detection. We truncated data for 36 species in the three habitats. These were primarily target species, but included some species that were recorded in their highest numbers in habitats for which they were not targets. For a few species, low sample sizes precluded truncation (e.g. Red Crossbill). We truncated the data at various distances and report those results by habitat (Tables 3-5). Finally, using 1998 data as a baseline, we provide estimates of the number of years required to monitor various target species (Table 6).

DISCUSSION

The high number of species with low CVs (Table 2) indicates that point transects will be adequate for detecting population trends in the studied habitats and, by extension, all habitats in Colorado. This is particularly so with the use of detection-curve models developed by DISTANCE (Laake et al. 1994). The use of DISTANCE is particularly important, as the results provided by density estimates are much more powerful than

those obtained by considering unlimited-radius detections alone (see Table 7 for the comparison in Spruce-Fir). In fact, the power of DISTANCE enabled us to tighten up the thresholds for effective monitoring. We also increased the size of the population change (from 2.5% to 3.0%) that we wished to detect to align with currently-accepted thresholds (e.g. Patuxent Wildlife Research Center 1998).

There were only three target species in the three habitats that we either did not record or did not record in numbers high enough to analyze: Purple Martin in Aspen (one individual counted) and Sharp-shinned Hawk and Boreal Owl in Spruce-Fir (none of either counted). We achieved sample size with all Ponderosa Pine target species, including the limited-range Grace's Warbler. We will need to establish species-specific inventory methods for Purple Martin and Sharp-shinned Hawk and nocturnal transects may result in useful data for Boreal Owl.

A few target species with low sample sizes had surprisingly robust CVs and/or fairly balanced sources of variance when distance estimates were analyzed (Table 2). All other species for which we obtained low sample sizes are species that are either much more common in other habitats or widespread habitat generalists for which we will need to analyze data from all habitats to monitor. Of the 59 species recorded in sample sizes large enough to analyze (>5), we discuss below those species that were target species in one of the three habitats in which we worked, though we do discuss some non-target species. Trend detection using unlimited-radius detections will, for most species, not be possible in the term of 30 years that was set in *CBM 2001*. Additionally, program TRENDS does not permit input of CVs >99%. Therefore, unless otherwise noted in species accounts below, trend-detection timetables are generated from density-based analysis from DISTANCE. Please refer to Table 6 for trend-detection estimates using unlimited distances.

When perusing the results presented in the various tables and the species accounts below, it is important to keep in mind that most individual transects traversed multiple habitats due to the inter-digitation of high-elevation habitats in mountainous Colorado. While we attempted to run transects in target habitats, GIS systems are often unable to distinguish various coniferous habitats from each other (Lodgepole Pine vs. Spruce-Fir or Mixed Conifer vs. both Ponderosa Pine and Spruce-Fir). In addition, Aspen is regularly mixed in with all coniferous habitats in the state, particularly from the Ponderosa Pine elevations upward. Therefore, many individual points of transects fell in habitats that were not targeted by those transects, thus increasing variance in the data for all habitats. It is also important to know that we are unsure which is better when faced with a decision between an unbalanced model with <3 parameters and a balanced model with three parameters; we chose the former. In the accounts below, the reference Andrews and Righter (1992) is abbreviated to A&R. In addition, "Aspen" (capitalized) refers to the habitat and "aspen" (not capitalized) refers to individual trees.

Band-tailed Pigeon–We recorded only nine individuals of this inhabitant of Ponderosa Pine and Gambel Oak, despite being fairly common to common in southwestern and

south-central forests (A&R). It is a relatively quiet species and despite its size, can be difficult to detect (Leukering pers. obs.). All individuals recorded were found on southwestern Colorado transects as the randomization process selected few Ponderosa Pine transects in south-central Colorado.

Common Nighthawk–We were surprised to record 11 of this species which we designated as requiring species-focused effort *(CBM 2001)*. The most interesting aspect of this species' data was the result from DISTANCE. Common Nighthawk is a species that, though fairly common (A&R), is usually only detected during morning hours by walking very close to, thus flushing, individuals roosting on the ground. This fact was detected by DISTANCE as the variance due to detectability accounted for 99% of the total variance with only 1% due to encounter rate.

Broad-tailed Hummingbird–We detected this Aspen target species more often on Ponderosa Pine transects than on Aspen transects (95 *vs*. 68; Table 2). Variance was balanced In both habitats, but in Aspen the detection curve required four parameters. Truncating the Aspen data set at 52 m provided a better model.

Williamson's Sapsucker–Despite the good sample size for this species in Ponderosa Pine (n=46), the sources of variance were highly skewed and truncation of data failed to reconcile this problem. We are unsure of the reasons for our inability to find a good model for this species and await further years' data for definition of the problem. Our experience with this species in north-central Colorado suggests that, though it prefers Ponderosa Pine forest, it usually nests in aspens as that tree species provides more cavity-excavation sites than does any other tree species (Leukering pers. obs.) Thus, though we were surprised that data from Aspen provided a better model for trend detection in this species, we were not surprised at the number encountered there.

Red-naped Sapsucker–The robust data for this species in Aspen required no truncation to produce a solid model. In Ponderosa Pine, despite a reasonable sample size, DISTANCE was unable to fit a good detection curve.

Hairy Woodpecker–We designated this species a target in Mixed Conifer *(CBM 2001)*, but we obtained reasonable sample sizes for the species in all three habitats this year, with highest numbers in Aspen (n=33). Though Hairy Woodpecker is more of a forest generalist than is Williamson's Sapsucker, like the latter species, it often nests in aspens, though, in the mountains, preferring coniferous forests (Leukering pers. obs.). This partly explains the seeming preference for Aspen in our data. In Aspen, truncating the data set at 118 m produced the best of three well-balanced models.

Three-toed Woodpecker–We only recorded six individuals on point counts of this very quiet species whose population is naturally of very low density in unburned forest. Interestingly, despite the tiny sample size, the CV of the density estimate was very low (16.7%), though, all of the variance was due to the low sample size (Table 3). In addition, we counted seven Three-toeds on transect legs (though, with some

duplication with the point counts). Thus, we believe that we will develop useful data on this species in future years with a slight change in survey protocol. Also of importance is that we recorded ten unidentified woodpeckers on point counts, all of which were drumming birds thought by the observers to be either Hairy or Three-toed woodpeckers. Since drums of the two species are very similar, unseen drumming woodpeckers are best left unidentified, though Stark et al. (1998) suggest that syntopic woodpecker species have distinctive drums. The CV from DISTANCE would result in trend detection in 6 to 15 years (Table 4).

Northern Flicker–We recorded this species, a forest generalist which we designated as a target species in Lowland Riparian *(CBM 2001)*, in good numbers in both Aspen and Ponderosa Pine (n=91 and 45, respectively). As in other woodpecker species, the high number of individuals in Aspen is partly due to aspens being such a good provider of cavity-excavation sites. Detection-curve models were unbalanced in both Aspen and Ponderosa Pine, but truncation at 164 m in Ponderosa Pine produced a good model.

Olive-sided Flycatcher–This is a relatively low-density species with specific structural habitat requirements that are consistent across habitats (Hutto 1995, Leukering pers. obs.). Olive-sideds usually occur in sites with particular combinations of snags, forest, open areas, and water. These situations occur at most montane elevations in Colorado, so the species is distributed across elevations. In 1998, we recorded the species in all three habitats, with the largest numbers occurring in Aspen, despite its designation as a target in Spruce-Fir (in which we recorded the fewest individuals). Though the complete Aspen data set for this species provided a good model, we will analyze the data for this species across all habitats in future years.

Western Wood-Pewee–We found this Aspen target species in highest numbers in Aspen (n=164), but also had significant numbers in Ponderosa Pine (n=102). However, the presence of Aspen interdigitated with most coniferous habitats in Colorado probably accounts for a large proportion of pewees recorded on Ponderosa Pine transects. The model produced by the complete Aspen data set was balanced but

required three parameters. By truncating the data at 105 m, we were able to obtain a model with only one parameter, but one which was unbalanced.

Hammond's Flycatcher–A&R state that Hammond's Flycatcher is primarily an inhabitant of "mature, closed-canopy spruce-fir forests...", but also say that in "some areas it may occur in greater numbers in ponderosa pine forests than in other habitats (J. Sedgwick, pers. comm.)" and that many other forest types are selected by this species. We found Hammond's Flycatchers in decreasing numbers across habitats from Aspen to Ponderosa Pine to Spruce-Fir (n=25, 20, and 14, respectively), despite being designated a target species of the latter. This agrees with our experience with this species in north-central Colorado (Leukering pers. obs.). We did not obtain a good model for Hammond's in Aspen (Table 3), but did so in both Ponderosa Pine and Spruce-Fir. One confounding factor is the difficulty that many observers have in distinguishing this species from the very similar Dusky Flycatcher, although we believe that the distribution in our results of the two species within the three habitats suggest that there were few, if any, mis-identifications in our data set.

Dusky Flycatcher–We recorded a large number of Duskies in Ponderosa Pine (n=120), though we designated this a target species in Mountain Shrubland *(CBM 2001)*. This is readily explained in that this species is a shrub inhabitant and that many Ponderosa Pine forests in Colorado have a robust oak understory in which this species achieves amazingly high densities (Hutchings et al. 1998, Leukering pers. obs.). In Ponderosa Pine, the complete data set and all truncations produced unbalanced models (Table 4), though truncation at 84 m produced a model with only one parameter that was nearly balanced. It will be interesting to see Dusky Flycatcher data from the Mountain Shrubland transects when those are initiated in 1999.

Plumbeous Vireo–Though we designated this species a target in Piñon-Juniper *(CBM 2001)*, it is somewhat of a low- to mid-elevation forest generalist, breeding also in Lowland Riparian in western Colorado (A&R, Leukering pers. obs.) and in Aspen. In Piñon-Juniper, it is most common in denser high-elevation forest (A&R, S. Hutchings pers. comm.) and the distribution of transects in that habitat will have an affect on the detection rate. Should lower-elevation transects predominate among the Piñon-Juniper transects, then the Ponderosa Pine transects may produce higher detection rates for this species. With that in mind, the complete data set in Ponderosa Pine in 1998 (n=43) produced a balanced model, but one with three parameters. By truncating the data set at 86 m, we obtained a good model (Table 4).

Warbling Vireo–As we expected, this was the most abundant bird on transects in any one habitat and in all habitats combined (Table 2), being recorded at rates of 1.84 birds per point in Aspen and 0.81 birds per point overall. Despite this abundance, we did not obtain a good model in Aspen; models for all truncation distances were unbalanced (Table 3). However, the Spruce-Fir data set produced a good model.

Gray Jay–This species' data was the most difficult to analyze as it is a species with low-

density populations (Leukering pers. obs.) for which we obtained data indicating high density (density of 26.60/ha in Aspen). However, Gray Jays are exceedingly curious and tame and regularly inspect humans and other disturbances in their vicinity. Thus, we often recorded the species at very close range as individuals or groups came toward the observers before being detected, which violates one of the assumptions of DISTANCE. Because of the species' often quiet nature, we believe that our data are skewed to short distances. We will have to solve the observer-attraction problem before we are comfortable with any results.

Steller's Jay–This is a coniferous-forest generalist that we designated a target in Mixed Conifer *(CBM 2001)*. We obtained good models in all three habitats with the complete data sets. This bodes extremely well for monitoring this species and anticipate initiating transects in Mixed Conifer in 1999.

Clark's Nutcracker–Nutcrackers are difficult to obtain robust data on due to their low-density populations and predilection for habitats at or near timberline. Thus, we were surprised with the data that we obtained in Ponderosa Pine (n=60) and in Spruce-Fir (n=61); it is a target species in the latter. However, the Spruce-Fir model required three parameters, thus we opted to reanalyze the data set. By truncating the data set at 292 m, we obtained a balanced model with only one parameter. The Ponderosa Pine model was suitable using the complete data set.

Tree Swallow–This is a species that nests primarily in Aspen forest, but one which readily adapts to other habitats given the presence of suitable cavity sites (A&R). We were surprised at the low sample size we obtained in Aspen (n=30), particularly since the complete data set model required five parameters. By truncating the Aspen data set at 98 m, we obtained a robust model.

Violet-green Swallow–CBM 2001 designated this a target of Aspen, though it is also a very common nester in Cliff/Rock. This affinity for the latter habitat means that it can be found breeding in many other habitat types, as Cliff/Rock is present within many forest habitats. In addition, the presence of Aspen intermingled with Ponderosa Pine helps to explain the small difference in sample size that Aspen (n=91) obtained over Ponderosa Pine (n=81). The complete data sets for both habitats produced balanced models, but that for Ponderosa Pine required three parameters while that for Aspen required four. Truncating the Aspen data at 171 m produced an unbalanced model with only one parameter. A truncation at 73 m produced a model with two parameters that was just shy of balancing the variance sources (32.8% vs. the minimum of 33.3%).

Mountain Chickadee–This species is a widespread inhabitant of coniferous forests throughout the state and densities undoubtedly vary by habitat. *CBM 2001* designated this a Spruce-Fir bird and we recorded the highest number of individuals in that habitat (n=250). We recorded large sample sizes in all habitats, but only in Spruce-Fir did we obtain a robust model from the complete data set.

Red-breasted Nuthatch–This species is a conifer generalist, however, one with a predilection in Colorado for Spruce-Fir and Lodgepole Pine (A&R). We counted more of this species in Aspen than we did in Spruce-Fir (19 vs. 18), but, as with many woodpeckers (above), this species readily nests in aspens (Leukering pers. obs.) among coniferous forest. In both Aspen and Spruce-Fir, we obtained good models with the complete data sets. However, we recorded more Red-breasted Nuthatches in Ponderosa Pine (n=44) than we did in the other two habitats combined. We did not obtain a balanced model from the Ponderosa Pine data set, with or without truncation, all being skewed to encounter rate (Table 4). This species is dependent upon varying conifer seed crops (A&R) and, thus, like other nomadic species (e.g. many cardueline finches, which, see below), it varies in abundance temporally, spatially, and in regard to what conifer species it exploits. This will make it difficult to monitor this species' population in a short time period and/or in only one habitat. Further years' data may determine whether we continue to consider this species a target of Spruce-Fir or not.

White-breasted Nuthatch–*CBM 2001* designated this a target of Mixed Conifer. We obtained a good sample size in Ponderosa Pine and recorded it in all three habitats that we studied in 1998. The complete Ponderosa Pine data set produced a balanced model, but one with three parameters. Truncating this data set at 107 m produced a robust model. It will be interesting to see the results of the Mixed Conifer transects when we initiate them in 1999, because in 1998, all three nuthatch species were recorded in highest numbers in Ponderosa Pine, despite CBM 2001 designating the three species as target species in three different habitats (see Pygmy Nuthatch, below).

Pygmy Nuthatch–This species is strongly associated with Ponderosa Pine in Colorado, so much so, that its range in the state closely parallels the range of Ponderosa in the state (A&R). In fact, we did not record Pygmy Nuthatches in any other habitat in 1998. The complete data set (n=87) produced a balanced model, but one with three parameters. By truncating distances at 82 m, we obtained a barely-balanced model.

Brown Creeper–Though in *CBM 2001* this is a Mixed Conifer target species, our experience with it in Spruce-Fir, particularly its selection of the oldest seral stages in that habitat (Carter and Gillihan in press), suggested that we analyze Brown Creeper data in that habitat. The Spruce-Fir data set (n=29) provided a slightly-unbalanced model; truncating the data at 47 m produced a robust model (Table 5).

Golden-crowned Kinglet–This species, though difficult to detect beyond 35 meters, was recorded at fairly long distances a few times, thus requiring a model with three parameters to fit the detection curve. Truncating the data at 81 m produced a much more parsimonious model.

Ruby-crowned Kinglet–This species is one of the ubiquitous species of Spruce-Fir forest in Colorado and our sample size reflected that (the 314 detections was the second-highest total of detections for any Spruce-Fir target species). We tried two truncation distances one of which came close to balancing variance sources, but added

a second parameter to the detection-curve model. The other truncation (248 m) made a slight improvement in the model over the non-truncated data set and kept the number of parameters at one, so we selected that one as the best model (Table 5).

Western Bluebird–We only recorded this species in Ponderosa Pine, the habitat in which it is a target. This species seems to occur in denser forests than does Mountain Bluebird (below). Whether this is an actual preference or the result of competition with the habitat-generalist Mountain has yet to be worked out. The complete data set for this species provided a robust model.

Mountain Bluebird–Though *CBM 2001* designated this an Aspen target species, we counted more Mountain Bluebirds in Ponderosa Pine. This species is actually a habitat generalist, breeding in many habitats that provide cavities and fairly open conditions (A&R, Leukering pers. obs.). The complete Aspen data set (n=30) provided a robust model, but the Ponderosa Pine data set (n=43) required truncation to produce such a model. Three different truncation distances only slightly improved the balance, but the truncation at 177 m just managed to get the model balanced (Table 4).

Townsend's Solitaire–This, a Cliff/Rock species according to *CBM 2001*, is a conifer generalist with a limiting structure requirement of rocky slopes or embankments for nesting (A&R). As we will not be conducting Cliff/Rock transects, we will need to track this species' trends in all habitats in which it is relatively numerous. However, the bulk of our detections of Solitaires (103 of 137) was in Ponderosa Pine in which the complete data set provided a balanced model, but one requiring three parameters. We truncated the data at two long distances, one of which produced a one-parameter model that was not balanced, this despite a large sample size.

Hermit Thrush–Though of low density, this species' loud voice permitted us to record it for the largest number of detections for any Spruce-Fir target species (Table 2). We detected 342 in Spruce-Fir, the habitat in which it is a target. Density estimation with the complete data set produced a very low CV and very balanced sources of variance, but required a whopping 6 parameters in the model. We tried various truncation distances and selected a distance of 189 m as the best model as it produced a low CV with only one parameter. However, this was at the expense of balanced variance sources (Table 3). The truncation at 147 m almost produced a balanced model.

American Robin–We recorded this habitat generalist in large sample sizes in all habitats, but with the 330 in Ponderosa Pine just besting the Aspen total of 326 (Table 2). Of the complete data sets, Aspen provided the only robust model, though the Ponderosa Pine model only missed being robust by requiring three parameters. Truncating the Ponderosa Pine data did not produce a better model. American Robin will probably be our most general of habitat generalists and we will need to analyze all habitats in which it breeds to develop a statewide trend for the species.

Yellow-rumped Warbler–This, the second-most numerous species on the transects

(Table 2), is a coniferous forest generalist, though more common in forests with a Fir component (*CBM 2001* allocated it to Mixed Conifer), that we recorded in highest numbers in Spruce-Fir. The complete Spruce-Fir data set produced a robust model, with none of four different truncation distances producing a better model.

Grace's Warbler–This species is limited in Colorado to Ponderosa Pine forests in the southwestern corner of the state (A&R). Since it is so limited in distribution in the state, we were pleasantly surprised at the reasonably-good sample size, which, in its complete form (n=20), provided a robust model.

Western Tanager–CBM 2001 records this species as a target in Mixed Conifer. However, we counted a large number of tanagers (213) in Ponderosa Pine and await initiation of Mixed Conifer transects to compare sample sizes. Unfortunately, the complete Ponderosa data set produced an unbalanced model with four parameters. Truncating the data at 132 m resulted in a good model.

Green-tailed Towhee–This is a Sage Shrubland target species (*CBM 2001*) that we recorded in large numbers in Ponderosa Pine (n=197) due to the strong oak or sage understory of many stands. The complete data set in Ponderosa produced an unbalanced model that we could not correct by truncation. Interestingly, the complete Aspen data set (with a much lower sample size) did produce a robust model.

Chipping Sparrow–We recorded this Ponderosa Pine target species (*CBM 2001*) in all three habitats in at least reasonable numbers, though among complete data sets, only Spruce-Fir produced a robust model. By truncating distances in Ponderosa Pine, we obtained two robust models, with the one we selected producing a lower CV (Table 4).

Lincoln's Sparrow–Though we designated this a target species of High-elevation Riparian (*CBM 2001*), Lincoln's Sparrow also occupies moist, grassy slopes in Aspen forest, thus accounting for the large number detected on the Aspen transects (n=119). The complete data set produced a poor model. Truncation did not produce a balanced model, but did provide a model with only one parameter (Table 3).

White-crowned Sparrow–This is a target species of High-elevation Riparian, though it achieves highest densities in krummholz Spruce-Fir (T. Leukering, M. Carter pers. obs.). However, we felt that we would not get enough transects in that aspect of Spruce-Fir so selected another habitat in which it is common. Since High-elevation Riparian runs through all other high-elevation habitats, we recorded White-crowns in good numbers in both Aspen and Spruce-Fir. However, due to these birds being in riparian areas in those two habitats, variance sources were very unbalanced in both. We did not attempt truncation in either habitat and await initiation of High-elevation Riparian transects to fully analyze data for this species.

Dark-eyed Junco–We have allocated this species to Mixed Conifer *(CBM 2001)*, though it is a forest generalist requiring a particular structure and which we recorded most often

in Aspen (n=330). Numerous truncation attempts in Aspen (Table 3) and in Spruce-Fir (Leukering and Carter 1998) did not produce a model better than that produced by the complete data set in either habitat.

Cardueline finches: special cases in bird-monitoring–The Cardueline finches (subfamily Carduelinae) are, for the most part, nomadic or semi-nomadic due to their dependence (during at least parts of every year) on highly variable food sources, often conifer seeds. The Red-breasted Nuthatch (see above) has a similar lifestyle for the same reason. This nomadism makes monitoring populations very difficult, except in very long time periods. We anticipate that densities and CVs in this group will vary widely across the history of this project. Whether we will be successful in monitoring these species awaits the compilation of many years of data.

Pine Grosbeak–Despite this bird's name, it is most common in Spruce-Fir forest, virtually throughout its holarctic breeding range. It is a tame species that we often recorded at very close range on the transects. We tried four truncation distances in Spruce-Fir to provide a better model than that produced by the complete data set. Two truncation distances (89 m and 118 m) produced robust models, but the model from the shorter truncation required only one parameter (vs. 2 for 118 m; Table 5).

Cassin's Finch–Despite the low sample size for this species in Spruce-Fir (the habitat in which it is a target), the CV of 40.3% is quite good, particularly when combined with a good model.

Red Crossbill–This is a very enigmatic species and is probably the most highly-nomadic species in Colorado. To compound the problem, recent research on Red Crossbill suggests that the various taxonomic units of that species, each of which is tied to a particular conifer species, may all be good species (Groth 1993). Thus, our anticipated highly-variable results across years will be made even more variable when considering individual taxa. In Colorado, two forms are regular breeders, a Ponderosa Pine specialist and a Lodgepole Pine specialist (C. Benkman, pers. comm., Leukering pers. obs.). At least two other forms have occurred in the state and could breed. Since vocalizations are the primary field-detectable differences between forms (Groth 1993) and since most birders and ornithologists have not yet learned how to separate these various forms (T. Leukering, pers. obs.), data on occurrence of the various forms in the state are generally unavailable (A&R predates general knowledge of this information). Analysis of results for this species should more correctly be performed on flocks, not on individuals, as this species was almost always recorded in flocks, thus clumping distance estimates. Because we did not record flock composition in the field, we are unable to perform a by-flock analysis and we advise that the results for this species in Table 3 be viewed accordingly. One last confounding factor in monitoring Red Crossbills is that this species can breed at any time of year (often in mid-winter), thus our transects performed in June will probably not record this species during their breeding season in most years. Complete data sets in Ponderosa Pine and Spruce-Fir produced poor models and sample sizes were too small to attempt any truncation.

Pine Siskin–This is the most common of the carduelines in Colorado and the one most likely to be found in a given place from year to year. However, previous banding work performed by CBO in the Arapaho National Forest (Leukering 1996, CBO unpubl. data) has shown that though this species may be common at one site year after year, very few individuals are site-faithful. The 1998 transect data for this species are difficult to analyze due to the high proportion of individuals recorded as flyovers and different interpretations by various observers as to the "countability" of these flyovers (some observers identified all as flyovers, some identified many of them as "on point"). We believe that this is the primary reason behind the poor performance of the large sample (n=212) at compromising between number of parameters and balanced sources of variance in Spruce-Fir. Despite many truncation attempts, we could not produce a balanced model (Table 5). Perhaps, more rigorous training on identifying whether individuals are on point or not will help with this problem.

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Table 1. Birds detected on point transects in three habitats in Aspen, Ponderosa Pine, and Spruce-Fir in Colorado in summer 1998. Categories are: P=birds detected on point counts, F=birds detected only as flyovers, and T=birds detected on transect legs (see text).

	Aspen				Ponderosa Pine				Spruce-Fir			
Species	P	F	T	Total	P	F	T	Total	P	F	T	Total
Turkey Vulture					0	2	0	2	0	1	0	1
Canada Goose					1	0	0	1				
Mallard					2	2	0	4				
Osprey					0	1	0	1				
Sharp-shinned Hawk					1	0	0	1				
Cooper's Hawk	3	2	1	6	2	0	2	4				
Northern Goshawk	0	1	0	1	2	0	1	3				
unidentified accipiter	1	0	0	1								
Red-tailed Hawk	3	0	5	8	6	3	4	13	1	0	1	2
Golden Eagle	1	0	1	2	1	0	0	1				
American Kestrel					0	1	2	3				
Prairie Falcon					0	1	0	1				
Blue Grouse	2	0	1	3	4	0	1	5	1	0	1	2
Wild Turkey	6	0	0	6	0	0	1	1				
Sora					0	0	1	1				
Spotted Sandpiper	2	0	0	2					2	0	1	3
Common Snipe	1	0	0	1	1	0	0	1				
Wilson's Phalarope					0	0	1	1				
Band-tailed Pigeon					5	0	6	11				
Mourning Dove	2	0	0	2	26	2	0	28				
Great Horned Owl									3	0	0	3
Common Nighthawk					8	1	6	15				
White-throated Swift					3	2	0	5				
Broad-tailed Hummingbird	68	18	1	87	87	21	1	109	13	7	0	20
Belted Kingfisher					1	0	0	1				
Lewis's Woodpecker					0	0	2	2				
Williamson's Sapsucker	11	0	2	13	41	0	14	55	5	0	1	6
Red-naped Sapsucker	36	0	10	46	14	0	8	22	2	0	0	2

Table 1. Continued.

Species	Aspen				Ponderosa Pine				Spruce-Fir			
	P	F	T	Total	P	F	T	Total	P	F	T	Total
unidentified sapsucker					6	0	1	7				
Downy Woodpecker	1	0	4	5	0	0	3	3				
Hairy Woodpecker	31	1	12	44	27	0	20	47	20	0	8	28
Three-toed Woodpecker								0	6	0	7	13
Northern Flicker	44	0	5	49	80	1	14	95	9	1	0	10
unidentified woodpecker	2	2	1	5	9	0	2	11	10	0	2	12
Olive-sided Flycatcher	33	0	5	38	18	0	4	22	11	0	3	14
Western Wood-Pewee	164	0	0	164	98	0	0	98	3	0	0	3
Hammond's Flycatcher	24	0	15	39	15	0	2	17	14	0	3	17
Dusky Flycatcher	62	0	1	63	114	0	0	114	4	0	0	4
Cordilleran Flycatcher	25	0	0	25	20	0	0	20	10	0	1	11
unidentified flycatcher					1	0	0	1				
Ash-throated Flycatcher					1	0	0	1				
Plumbeous Vireo	1	0	0	1	43	0	0	43				
Warbling Vireo	828	0	0	828	202	1	0	203	28	0	0	28
Gray Jay	17	0	0	17				0	77	3	10	90
Steller's Jay	48	0	1	49	133	0	0	133	46	0	0	46
Clark's Nutcracker	19	4	3	26	53	9	12	74	61	2	9	72
Black-billed Magpie					7	2	0	9				
American Crow	1	0	0	1	13	5	0	18	1	0	0	1
Common Raven	11	8	0	19	14	18	0	32	30	9	0	39
Purple Martin	1	0	1	2								
Tree Swallow	30	4	0	34	10	3	0	13				
Violet-green Swallow	91	5	0	96	77	24	0	101	5	5	0	10
N. Rough-winged Swallow					1	0	0	10				
Cliff Swallow					0	1	0	1				
unidentified swallow	6	1	0	7								
Black-capped Chickadee	4	0	0	4								
Mountain Chickadee	177	0	0	177	196	2	0	198	250	1	0	251

Table 1. Continued.

Species	Aspen				Ponderosa Pine				Spruce-Fir			
	P	F	T	Total	P	F	T	Total	P	F	T	Total
Red-breasted Nuthatch	19	0	4	23	31	0	4	35	18	0	1	19
White-breasted Nuthatch	12	0	1	13	69	0	1	70	5	0	0	5
Pygmy Nuthatch	1	0	0	1	82	1	5	88		0		
Brown Creeper	5	0	3	8	13	0	10	23	29	0	13	42
Rock Wren					13	0	1	14				
House Wren	302	0	0	302	96	0	0	96	3	0	03	
American Dipper	1	0	0	1					3	0	2	5
Golden-crowned Kinglet	10	0	6	16	1	0	0	1	91	0	46	137
Ruby-crowned Kinglet	89	0	0	89	92	1	0	93	314	0	0	314
Blue-gray Gnatcatcher					5	0	0	5				
Western Bluebird					24	0	0	24				
Mountain Bluebird	30	1	0	31	42	0	0	42	15	0	0	15
Townsend's Solitaire	8	1	0	9	94	0	0	94	26	0	2	28
Veery					1	0	0	1				
Swainson's Thrush	1	0	0	1					2	0	0	2
Hermit Thrush	97	0	1	98	112	0	0	112	342	0	0	342
American Robin	326	2	0	328	305	4	0	309	185	2	0	187
European Starling					1	0	0	1				
Orange-crowned Warbler	85	1	0	86	38	0	0	38	3	0	0	3
Virginia's Warbler	2	0	0	2	27	0	0	27				
Yellow Warbler	7	0	0	7								
Yellow-rumped Warbler	328	1	0	329	207	1	0	208	414	1	0	415
Grace's Warbler					20	0	0	20				
MacGillivray's Warbler	31	0	1	32	13	0	0	13	5	0	0	5
Wilson's Warbler	8	0	0	8	1	0	0	1	28	0	0	28
Western Tanager	49	0	0	49	204	0	0	204	21	0	0	21
Green-tailed Towhee	44	0	0	44	190	0	0	190	4	0	0	4
Spotted Towhee	3	0	0	3	38	0	0	38				
Chipping Sparrow	22	0	0	22	126	0	0	126	20	0	0	20

Table 1. Continued.

Species	Aspen				Ponderosa Pine				Spruce-Fir			
	P	F	T	Total	P	F	T	Total	P	F	T	Total
Brewer's Sparrow					2	0	0	2				
Vesper Sparrow	4	0	0	4	30	0	0	30				
Lark Sparrow					2	0	0	2				
Fox Sparrow									2	0	0	2
Song Sparrow	1	0	0	1	2	0	0	2				
Lincoln's Sparrow	119	0	0	119	3	0	0	3	48	0	0	48
White-crowned Sparrow	41	0	0	41					47	0	0	47
Dark-eyed Junco	330	1	0	331	261	0	0	261	248	0	0	248
Black-headed Grosbeak	10	0	0	10	28	0	0	28	1	0	0	1
Blue Grosbeak					2	0	0	2				
Lazuli Bunting	1	0	0	1	4	0	0	4				
Red-winged Blackbird					7	0	0	7				
Western Meadowlark	1	0	0	1	3	0	0	3				
Yellow-headed Blackbird					2	0	0	2				
Brewer's Blackbird					2	0	0	2				
Brown-headed Cowbird	18	2	0	20	47	2	0	49	0	1	0	1
Pine Grosbeak	5	1	1	7					59	4	16	79
Cassin's Finch	7	1	0	8	10	0	0	10	19	0	1	20
Red Crossbill	3	14	0	17	11	67	0	78	11	38	0	49
White-winged Crossbill									0	8	0	8
Pine Siskin	121	83	0	204	113	97	0	210	213	100	0	313
American Goldfinch					0	3	0	3				
Evening Grosbeak	2	4	0	6	9	9	0	18	15	4	2	21
unidentified finch					1	0	0	1	2	0	0	2
Totals	3899	158	86	**4143**	3727	287	129	**4143**	2805	187	130	**3122**

Table 2. Species recorded on point transects in three habitats, Aspen (A), Ponderosa Pine (P), and Spruce-Fir (S), in Colorado, Summer 1998. Only species that were recorded >5 times in at least one habitat are included. Asterisks indicate target species in listed habitat. Density (D) is n/ha; CV (D) is the coefficient of variation of the density; % var (n) is the percentage of the variance due to variation in sample size; P=probability of detection; K=number of transects on which the species was recorded; and m=the number of parameters included in the detection-curve function.

Species	Habitat	n	D	CV (D)	% var (n)	P	K	m
Band-tailed Pigeon	P*	9	0.60	42.1	100.0	1.000	4	0
Mourning Dove	P	26	1.14	36.5	37.4	0.165	11	3
Common Nighthawk	P	11	183.35	171.9	1.0	0.221	6	3
Broad-tailed Hummingbird	A*	68	12.40	24.8	41.5	0.086	24	4
	P	95	17.33	25.3	48.6	0.021	24	2
	S	13	2.24	15.4	100.0	1.000	11	0
Williamson's Sapsucker	A	11	3.42	58.0	39.4	0.237	3	2
	P*	46	6.31	82.6	7.1	0.050	18	2
	S	8	1.60	25.0	4.4	0.154	5	2
Red-naped Sapsucker	A*	36	3.16	18.8	39.2	0.191	22	1
	P	20	0.80	33.0	100.0	1.000	8	0
	S	2						
Hairy Woodpecker	A	33	3.52	25.1	55.2	0.119	14	3
	P	30	2.09	46.2	16.5	0.155	18	4
	S	20	2.90	18.7	44.5	0.169	9	2
Three-toed Woodpecker	S*	6	1.89	16.7	100.0	1.000	5	0
Northern Flicker	A	45	1.80	31.0	26.2	0.075	17	2
	P	91	1.53	19.4	23.0	0.068	28	2
	S	9	1.66	73.5	4.1	0.094	6	3
Olive-sided Flycatcher	A	33	0.53	19.3	48.8	0.321	15	2
	P	20	0.68	21.5	21.6	0.379	11	1
	S*	11	0.46	33.5	12.9	0.420	9	1
Western Wood-Pewee	A*	164	3.84	25.6	53.5	0.235	24	3
	P	102	2.44	24.6	87.4	0.133	23	1
	S	7						
Hammond's Flycatcher	A	25	4.50	24.5	100.0	1.000	8	0
	P	20	6.13	27.7	52.3	0.251	6	2
	S*	14	3.97	25.3	51.1	0.349	6	1
Dusky Flycatcher	A	62	4.89	42.3	28.2	0.362	17	4
	P	120	11.62	17.8	75.5	0.070	21	4
	S	4						
Cordilleran Flycatcher	A	25	3.19	65.8	8.4	0.123	13	4
	P	21	3.02	31.6	17.2	0.123	11	3
	S	10	0.54	22.4	100.0	1.000	5	0
Plumbeous Vireo	P	43	6.64	26.7	55.7	0.130	11	3
Warbling Vireo	A*	828	23.70	9.1	88.4	0.101	30	1
	P	237	4.70	23.1	95.0	0.099	23	1
	S	28	0.96	21.0	34.0	0.195	11	1

Table 2. Continued.

Species	Habitat	n	D	CV (D)	% var (n)	P	K	m
Gray Jay	A	17	26.60	64.1	11.5	0.003	7	4
	S*	77	9.88	26.2	31.5	0.015	17	3
Steller's Jay	A	48	1.50	21.4	59.5	0.176	15	1
	P	140	2.85	19.0	38.3	0.071	27	2
	S	46	1.17	48.0	47.8	0.101	18	2
Clark's Nutcracker	A	19	2.63	90.5	17.4	0.076	6	2
	P	60	0.51	21.6	41.2	0.117	20	2
	S*	61	1.02	19.2	52.4	0.045	15	3
Black-billed Magpie	P	10	0.59	59.7	28.0	0.270	5	2
American Crow	P	13	0.51	54.2	55.7	0.160	4	2
	S	1						
Common Raven	A	10	1.20	59.4	28.3	0.059	5	4
	P	13	0.14	91.5	5.8	0.116	6	2
	S	30	1.09	49.5	54.4	0.017	5	2
Tree Swallow	A*	30	2.18	32.2	54.5	0.130	11	5
	P	12	3.06	47.1	20.3	0.276	5	2
Violet-green Swallow	A*	91	5.02	26.9	52.1	0.082	17	4
	P	81	4.34	24.8	63.8	0.053	18	3
	S	5						
Mountain Chickadee	A	177	10.37	27.2	42.1	0.052	24	3
	P	216	7.20	151.7	0.8	0.050	27	4
	S*	250	9.63	15.7	64.3	0.059	28	2
Red-breasted Nuthatch	A	19	1.24	23.7	49.2	0.241	13	2
	P	44	1.20	38.8	80.3	0.241	10	1
	S*	18	2.74	26.8	58.9	0.299	7	2
White-breasted Nuthatch	A	12	3.20	50.3	25.1	0.288	8	2
	P	71	2.74	21.6	46.8	0.107	24	3
	S	5						
Pygmy Nuthatch	P*	87	8.19	37.2	52.7	0.144	16	3
Brown Creeper	A	6	5.53	84.9	100.0	0.088	6	3
	P	18	1.91	17.4	100.0	1.000	12	0
	S	29	7.36	19.1	67.6	0.244	17	2
Rock Wren	P	14	0.58	34.6	69.8	0.370	7	1
House Wren	A	302	20.42	17.7	51.5	0.077	24	4
	P	107	4.62	21.0	63.8	0.094	23	3
	S	3						
Golden-crowned Kinglet	A	12	7.64	80.2	4.9	0.033	8	2
	S*	91	9.72	19.0	53.5	0.047	24	3
Ruby-crowned Kinglet	A	89	0.90	28.6	27.2	0.264	27	3
	P	107	5.20	44.4	30.8	0.074	16	3
	S*	314	5.44	11.8	87.3	0.090	27	1
Western Bluebird	P*	27	6.76	38.3	61.9	0.159	8	2

Table 2. Continued.

Species	Habitat	n	D	CV (D)	% var (n)	P	K	m
Mountain Bluebird	A*	30	3.64	36.1	45.4	0.109	10	2
	P	43	5.11	26.9	69.9	0.029	8	2
	S	15	3.94	20.0	100.0	1.000	4	0
Townsend's Solitaire	A	8	0.86	37.7	44.0	0.260	6	2
	P	103	1.53	25.4	64.3	0.103	23	3
	S	26	0.47	34.3	75.4	0.163	11	2
Hermit Thrush	A	97	0.83	15.2	64.4	0.135	24	1
	P	118	1.61	28.1	77.9	0.056	22	4
	S*	342	3.53	14.6	51.0	0.062	28	6
American Robin	A	326	9.37	13.1	62.7	0.063	28	2
	P	330	8.45	17.4	54.3	0.048	29	3
	S	185	7.54	24.0	35.8	0.048	26	3
Orange-crowned Warbler	A	85	6.56	35.6	77.4	0.160	16	3
	P	38	2.90	30.3	68.5	0.285	10	1
	S	3						
Virginia's Warbler	P	27	3.24	25.4	38.2	0.271	10	1
Yellow Warbler	A	7	1.70	62.8	82.9	0.381	3	1
Yellow-rumped Warbler	A	328	8.97	15.0	79.0	0.146	29	2
	P	225	7.08	36.1	25.7	0.089	26	5
	S	414	12.16	11.7	59.9	0.081	29	2
Grace's Warbler	P*	20	3.36	45.7	62.2	0.494	6	1
MacGillivray's Warbler	A	31	7.25	34.4	61.5	0.495	11	1
	P	13	2.29	27.7	63.3	0.356	6	1
	S	5						
Wilson's Warbler	A	8	0.80	25.0	100.0	1.000	5	0
	S	28	2.45	46.0	73.3	0.228	7	2
Western Tanager	A	49	2.60	26.2	74.6	0.152	16	1
	P	213	5.62	19.0	70.8	0.105	27	4
	S	21	1.51	68.0	14.9	0.131	7	2
Green-tailed Towhee	A	44	1.62	26.3	53.7	0.213	19	2
	P	197	5.43	23.4	81.9	0.056	23	2
	S	4						
Spotted Towhee	P	38	4.73	49.5	83.2	0.163	8	2
Chipping Sparrow	A	22	0.85	22.3	81.5	0.242	10	2
	P*	126	3.58	17.9	73.2	0.122	23	3
	S	20	2.89	63.1	38.6	0.132	6	2
Lincoln's Sparrow	A	119	8.89	28.2	74.8	0.104	16	3
	S	48	4.33	33.5	56.4	0.067	13	3
White-crowned Sparrow	A	41	2.50	23.0	79.9	0.291	7	2
	S	47	13.94	191.7	1.9	0.024	11	4

Table 2. Continued.

Species	Habitat	n	D	CV (D)	% var (n)	P	K	m
Dark-eyed Junco	A	330	23.07	21.6	31.6	0.059	30	3
	P	282	14.11	59.2	5.5	0.024	30	4
	S	248	6.73	9.2	82.8	0.088	28	1
Black-headed Grosbeak	A	10	0.79	56.7	12.5	0.164	8	2
	P	28	1.05	43.9	60.4	0.059	9	4
	S	1						
Brown-headed Cowbird	A	18	3.48	29.2	66.6	0.291	7	2
	P	49	5.91	28.1	47.5	0.045	14	2
Pine Grosbeak	A	6	0.36	19.3	100.0	1.000	4	0
	S*	59	4.73	27.3	32.4	0.101	18	2
Cassin's Finch	P	7	0.37	66.3	4.6	0.174	6	2
	S*	19	0.79	40.3	66.6	0.267	7	1
Red Crossbill	P	14	1.39	73.0	44.1	0.157	5	4
	S*	11	0.81	61.9	12.5	0.164	6	2
Pine Siskin	A	121	6.17	21.6	74.6	0.029	24	2
	P	125	7.63	17.3	84.2	0.069	22	4
	S*	212	6.96	16.8	94.1	0.083	2	1
Evening Grosbeak	P	9	5.79	74.3	26.8	0.293	3	2
	S	15	0.83	55.9	100.0	1.000	4	0

Table 3. Analysis of various truncation distances for selected species in Aspen (target species and non-target species found in highest abundance in Aspen). See Table 2 for column heading explanations. Check-marks indicate those truncations considered the best for optimization of CVs, # of parameters, and variance due to sample size.

Species	Truncation distance (m)	n	D	CV (%)	% var (n)	m	Best model
Broad-tailed Hummingbird	29	52	16.14	41.7	18.5	3	
	52	63	17.60	22.1	54.7	1	✓
	--	68	12.40	24.8	41.5	4	
Hairy Woodpecker	80	30	3.98	29.2	47.3	1	
	97	31	3.88	27.3	51.6	1	
	118	32	3.56	24.8	56.1	1	✓
	--	33	3.52	25.1	55.2	3	
Western Wood-Pewee	105	154	3.60	20.4	96.3	1	✓
	136	161	3.82	19.3	97.8	1	
	--	164	3.84	25.6	53.5	3	
Hammond's Flycatcher	34	14	4.88	23.5	100.0	0	
	--	25	4.50	24.5	100.0	0	✓
Warbling Vireo	61	540	23.38	23.7	22.3	3	
	100	758	22.27	10.1	82.9	1	
	169	826	24.05	9.2	87.4	1	
	--	828	23.70	9.1	88.4	1	✓
Tree Swallow	70	20	3.36	38.3	85.4	1	
	98	24	2.82	33.5	60.5	1	✓
	126	27	2.80	41.7	24.9	2	
	--	30	2.18	32.2	54.5	5	
Violet-green Swallow	73	64	4.83	43.1	32.8	2	
	171	87	4.80	22.4	75.8	1	✓
	--	91	5.02	26.9	52.1	4	
House Wren	58	246	19.02	12.0	91.6	1	✓
	78	277	18.71	21.4	30.9	3	
	--	302	20.42	17.7	51.5	4	
Orange-crowned Warbler	66	60	5.50	45.7	42.4	2	✓
	86	71	5.82	33.4	82.6	1	
	--	85	6.56	35.6	77.4	3	
Lincoln's Sparrow	70	98	11.69	24.2	94.1	1	✓
	--	119	8.89	28.2	74.8	3	
Dark-eyed Junco	58	218	30.35	21.6	58.9	3	
	97	290	26.48	26.2	24.6	3	
	154	329	23.51	21.5	32.0	3	✓
	--	330	23.07	21.6	31.6	3	

Table 4. Analysis of various truncation distances for selected species in Ponderosa Pine (target species and non-target species found in highest abundance in Ponderosa Pine). See Table 2 for column heading explanations. Check-marks indicate those truncations considered the best for optimization of CVs, # of parameters, and variance due to sample size.

Species	Truncation distance (m)	n	D	CV (%)	% var (n)	m	Best model
Mourning Dove	168	25	2.04	38.1	39.0	3	
	184	25	1.03	28.2	71.4	1	✓
	--	26	1.14	36.5	37.4	3	
Williamson's Sapsucker	115	39	6.74	223.3	0.8	3	
	--	46	6.31	82.6	7.1	2	✓
Northern Flicker	164	80	1.74	15.2	46.1	1	✓
	290	89	1.56	19.8	23.3	2	
	--	91	1.53	19.4	23.0	2	
Dusky Flycatcher	54	98	10.29	19.5	89.0	1	
	84	112	11.67	20.0	71.9	1	✓
	--	120	11.62	17.8	75.5	4	
Plumbeous Vireo	48	29	6.58	34.5	70.9	1	
	86	38	6.42	29.1	61.7	1	✓
	--	43	6.64	26.7	55.7	3	
Red-breasted Nuthatch	123	30	1.25	35.5	76.5	1	✓
	194	43	0.87	36.6	93.5	1	
	--	44	1.20	38.8	80.3	1	
White-breasted Nuthatch	87	57	3.22	20.1	88.7	1	
	107	62	3.05	21.6	63.0	1	✓
	--	71	2.74	21.6	46.8	3	
Pygmy Nuthatch	58	76	8.96	33.2	94.2	1	
	82	85	9.82	34.2	66.5	2	✓
	--	87	8.19	37.2	52.7	3	
Mountain Bluebird	136	42	8.69	28.1	66.9	1	
	177	42	8.62	28.2	66.5	1	✓
	190	42	8.68	28.1	66.8	1	
	--	43	5.11	26.9	69.9	2	
Townsend's Solitaire	204	99	1.56	22.6	81.3	1	✓
	240	101	1.94	23.7	74.3	3	
	--	103	1.53	25.4	64.3	3	
American Robin	120	274	10.98	14.5	71.5	4	
	264	327	9.08	17.8	51.5	3	✓
	--	330	8.45	17.4	54.3	3	

Table 4. Continued.

Species	Truncation distance (m)	n	D	CV (%)	% var (n)	m	Best model
Western Tanager	132	197	4.55	21.1	61.2	2	✓
	148	201	4.65	17.8	83.3	1	
	--	213	5.62	19.0	70.8	4	
Green-tailed Towhee	156	191	7.33	22.8	81.3	3	
	204	196	6.16	24.6	74.7	2	
	288	196	5.14	22.2	92.3	1	✓
	--	197	5.43	23.4	81.9	2	
Spotted Towhee	73	32	5.55	54.6	77.1	2	
	101	36	4.14	46.7	96.3	1	✓
	--	38	4.73	49.5	83.2	2	
Chipping Sparrow	96	99	3.84	19.4	60.6	1	
	128	112	3.63	17.3	65.6	1	✓
	--	126	3.58	17.9	73.2	3	
Black-headed Grosbeak	240	27	1.45	37.8	77.8	1	✓
	352	27	4.01	47.7	48.9	5	
	--	28	1.05	43.9	60.4	4	

Table 5. Analysis of various truncation distances for selected species in Spruce-Fir (target species and non-target species found in highest abundance in Spruce-Fir). See Table 2 for column heading explanations. Check-marks indicate those truncations considered the best for optimization of CVs, # of parameters, and variance due to sample size.

Species	Truncation distance (m)	n	D	CV (%)	% var (n)	m	Best model
Gray Jay	63	60	10.75	23.9	70.5	2	
	190	73	9.47	24.5	40.5	2	✓
	--	77	9.88	26.2	31.5	3	
Clark's Nutcracker	133	48	1.21	18.6	84.0	1	
	292	59	1.34	21.1	50.3	1	✓
	--	61	1.02	19.2	52.4	3	
Red-breasted Nuthatch	70	14	3.33	39.5	22.9	1	
	90	16	3.10	35.4	34.3	1	
	95	16	2.71	25.4	66.5	1	✓
	--	18	2.74	26.8	58.9	2	
Brown Creeper	28	21	10.40	30.3	29.0	1	
	47	28	8.07	17.3	63.2	1	✓
	--	29	7.36	19.1	67.6	2	
Golden-crowned Kinglet	81	83	12.39	17.4	59.4	1	✓
	--	91	9.72	19.0	53.5	3	
Ruby-crowned Kinglet	220	312	5.50	13.5	68.9	2	
	248	312	5.87	12.2	84.1	1	✓
	--	314	5.44	11.8	87.3	1	
Hermit Thrush	147	259	3.24	23.9	30.2	2	
	189	286	3.71	14.0	78.6	1	✓
	357	333	2.96	23.5	20.3	5	
	--	342	3.53	14.6	51.0	6	
Yellow-rumped Warbler	86	344	14.59	10.8	87.8	1	
	140	395	11.41	15.4	32.3	3	
	183	405	11.26	11.2	64.3	2	
	194	405	12.10	20.5	19.3	4	
	--	414	12.16	11.7	59.9	2	✓
Pine Grosbeak	74	51	3.78	21.7	88.9	1	
	89	53	5.56	24.6	60.3	1	✓
	118	57	4.11	25.2	43.4	2	
	141	58	5.24	19.7	67.7	3	
	--	59	4.73	27.3	32.4	2	
Pine Siskin	124	202	7.67	28.0	31.0	3	
	147	205	9.26	17.1	83.8	1	✓
	169	208	7.66	18.1	74.3	2	
	180	208	7.65	18.0	75.0	2	
	--	214	6.84	17.0	94.4	1	

Table 6. Number of years required for target trend detection (>3%/yr. change with statistical significance of 0.1 and power of 80%, assuming 30 transects run annually) for target species in Aspen, Ponderosa Pine, and Spruce-Fir using program MONITOR (PWRC 1998). Asterisks and boldface indicate target species within habitats.

	Aspen		Ponderosa Pine		Spruce-Fir	
Species	CV (D)	# of years	CV (D)	# of years	CV (D)	# of years
Band-tailed Pigeon			**42.1**	**8** *		
Broad-tailed Hummingbird	**24.8**	**7** *	25.3	7	15.4	6
Williamson's Sapsucker	58.0	9	**82.6**	**11** *	25.0	7
Red-naped Sapsucker	**18.8**	**6** *	33.0	8		
Three-toed Woodpecker					**16.7**	**6** *
Olive-sided Flycatcher	19.3	6	21.5	6	**33.5**	**8** *
Western Wood-Pewee	**25.6**	**7** *	24.6	7		
Hammond's Flycatcher	24.5	7	27.7	7	**25.3**	**7** *
Warbling Vireo	**9.1**	**5** *	23.1	6	21.0	6
Gray Jay	64.1	10			**26.2**	**7** *
Clark's Nutcracker	90.5	12	21.6	6	**19.2**	**6** *
Tree Swallow	**32.2**	**7** *	47.1	9		
Violet-green Swallow	**26.9**	**7** *	24.8	7		
Mountain Chickadee	27.2	7	151.7	14	**15.7**	**6** *
Red-breasted Nuthatch	23.7	7	38.8	8	**26.8**	**7** *
Pygmy Nuthatch			**37.2**	**8** *		
Golden-crowned Kinglet	80.2	11			**19.0**	**6** *
Ruby-crowned Kinglet	28.6	7	44.4	9	**11.8**	**5** *
Western Bluebird			**38.3**	**8** *		
Mountain Bluebird	**36.1**	**8** *	26.9	7	20.0	6
Hermit Thrush	15.2	6	28.1	7	**14.6**	**6** *
Grace's Warbler			**45.7**	**9** *		
Chipping Sparrow	22.3	6	**17.9**	**6** *	63.1	10
Pine Grosbeak	19.3	6			**27.3**	**7** *
Cassin's Finch			66.3	10	**40.3**	**8** *
Red Crossbill			73.0	10	**61.9**	**10** *
Pine Siskin	21.6	6	17.3	6	**16.8**	**6** *

Table 7. Comparison, within Spruce-Fir, of coefficients of variation (CV) for results from detections only with those from density estimates, rounded to nearest whole percent. The number of years was calculated from density-derived CVs (Table 2). See Table 4 for more details on truncation results.

Species	Unlimited-radius Detections CV (%)	Density estimates (all data) CV (%)	# of years to detect trend using TRENDS[1]	MONITOR[2]
Three-toed Woodpecker	242	17	15	6
Olive-sided Flycatcher	167	34	24	8
Hammond's Flycatcher	200	25	19	7
Gray Jay	121	26	20	7
Clark's Nutcracker	123	19	16	6
Mountain Chickadee	70	16	14	6
Red-breasted Nuthatch	201	27	20	7
Golden-crowned Kinglet	93	19	16	6
Ruby-crowned Kinglet	66	29	21	7
Hermit Thrush	62	15	14	5
Pine Grosbeak	118	27	20	7
Cassin's Finch	250	40	26	8
Red Crossbill	215	62	35	9
Pine Siskin	102	17	15	6
$\bar{x}$			19.64	6.79
StD			5.76	1.05
Variance			33.17	1.10

[1]Gerrodette (1993).
[2]Patuxent Wildlife Research Center (1998).

Appendix A. Species recorded on 89 point transects in Colorado, Summer 1998.

Species	Scientific name
Turkey Vulture	*Cathartes aura*
Canada Goose	*Branta canadensis*
Mallard	*Anas platyrhynchos*
Osprey	*Pandion haliaetus*
Sharp-shinned Hawk	*Accipiter striatus*
Cooper's Hawk	*Accipiter cooperii*
Northern Goshawk	*Accipiter gentilis*
Red-tailed Hawk	*Buteo jamaicensis*
Golden Eagle	*Aquila chrysaetos*
American Kestrel	*Falco sparverius*
Prairie Falcon	*Falco mexicanus*
Blue Grouse	*Dendragapus obscurus*
Wild Turkey	*Meleagris gallopavo*
Sora	*Porzana carolina*
Spotted Sandpiper	*Actitis macularia*
Common Snipe	*Gallinago gallinago*
Wilson's Phalarope	*Phalaropus tricolor*
Band-tailed Pigeon	*Columba fasciata*
Mourning Dove	*Zenaida macroura*
Great Horned Owl	*Bubo virginianus*
Common Nighthawk	*Chordeiles minor*
White-throated Swift	*Aeronautes saxatalis*
Broad-tailed Hummingbird	*Selasphorus platycercus*
Belted Kingfisher	*Ceryle alcyon*
Lewis's Woodpecker	*Melanerpes lewis*
Red-naped Sapsucker	*Sphyrapicus nuchalis*
Williamson's Sapsucker	*Sphyrapicus thyroideus*
Downy Woodpecker	*Picoides pubescens*
Hairy Woodpecker	*Picoides villosus*
Three-toed Woodpecker	*Picoides tridactylus*
Northern Flicker	*Colaptes auratus*
Olive-sided Flycatcher	*Contopus cooperi*
Western Wood-Pewee	*Contopus sordidulus*
Hammond's Flycatcher	*Empidonax hammondii*
Dusky Flycatcher	*Empidonax oberholseri*
Cordilleran Flycatcher	*Empidonax occidentalis*
Ash-throated Flycatcher	*Myiarchus cinerascens*
Plumbeous Vireo	*Vireo plumbeous*
Warbling Vireo	*Vireo gilvus*
Gray Jay	*Perisoreus canadensis*
Steller's Jay	*Cyanocitta stelleri*
Clark's Nutcracker	*Nucifraga columbiana*
Black-billed Magpie	*Pica pica*
American Crow	*Corvus brachyrhynchos*
Common Raven	*Corvus corax*
Purple Martin	*Progne subis*
Tree Swallow	*Tachycineta bicolor*
Violet-green Swallow	*Tachycineta thalassina*
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*
Cliff Swallow	*Petrochelidon pyrrhonota*
Black-capped Chickadee	*Poecile atricapillus*
Mountain Chickadee	*Poecile gambelii*
Red-breasted Nuthatch	*Sitta canadensis*

Appendix A. Continued.

Species	Scientific name
White-breasted Nuthatch	*Sitta carolinensis*
Pygmy Nuthatch	*Sitta pygmaea*
Brown Creeper	*Certhia americana*
Rock Wren	*Salpinctes obsoletus*
House Wren	*Troglodytes aedon*
American Dipper	*Cinclus mexicanus*
Golden-crowned Kinglet	*Regulus satrapa*
Ruby-crowned Kinglet	*Regulus calendula*
Blue-gray Gnatcatcher	*Polioptila caerulea*
Western Bluebird	*Sialia mexicana*
Mountain Bluebird	*Sialia currucoides*
Townsend's Solitaire	*Myadestes townsendi*
Veery	*Catharus fuscescens*
Swainson's Thrush	*Catharus ustulatus*
Hermit Thrush	*Catharus guttatus*
American Robin	*Turdus migratorius*
European Starling	*Sturnus vulgaris*
Orange-crowned Warbler	*Vermivora celata*
Virginia's Warbler	*Vermivora virginiae*
Yellow Warbler	*Dendroica petechia*
Magnolia Warbler	*Dendroica magnolia*
Yellow-rumped Warbler	*Dendroica coronata*
Grace's Warbler	*Dendroica graciae*
MacGillivray's Warbler	*Oporornis tolmiei*
Wilson's Warbler	*Wilsonia pusilla*
Western Tanager	*Piranga ludoviciana*
Green-tailed Towhee	*Pipilo chlorurus*
Spotted Towhee	*Pipilo maculatus*
Chipping Sparrow	*Spizella passerina*
Brewer's Sparrow	*Spizella breweri*
Vesper Sparrow	*Pooecetes gramineus*
Lark Sparrow	*Chondestes grammacus*
Fox Sparrow	*Passerella iliaca*
Song Sparrow	*Melospiza melodia*
Lincoln's Sparrow	*Melospiza lincolnii*
White-crowned Sparrow	*Zonotrichia leucophrys*
Dark-eyed Junco	*Junco hyemalis*
Black-headed Grosbeak	*Pheucticus melanocephalus*
Blue Grosbeak	*Guiraca caerulea*
Lazuli Bunting	*Passerina amoena*
Red-winged Blackbird	*Agelaius phoeniceus*
Western Meadowlark	*Sturnella neglecta*
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*
Brewer's Blackbird	*Euphagus cyanocephalus*
Brown-headed Cowbird	*Molothrus ater*
Pine Grosbeak	*Pinicola enucleator*
Cassin's Finch	*Carpodacus cassinii*
Red Crossbill	*Loxia curvirostra*
White-winged Crossbill	*Loxia leucoptera*
Pine Siskin	*Carduelis pinus*
American Goldfinch	*Carduelis tristis*
Evening Grosbeak	*Coccothraustes vespertinus*

Appendix B. Colorado special species list, with results from 1998 monitoring efforts.

AI	Species	# Adults	# Juveniles	# Nests
4	Common Nighthawk			
4	Common Poorwill			
4	Cordilleran Flycatcher			
4	American Dipper			
3	Western Grebe	843	61	26
3	Clark's Grebe	1678	70	2
3	American White Pelican	507	188	
3	Great Blue Heron			
3	White-faced Ibis			
3	Northern Goshawk			
3	Golden Eagle			
3	Prairie Falcon			
3	Spotted Sandpiper			
3	Black Tern	8		1
3	Flammulated Owl			
3	Western Screech-Owl			
3	Great Horned Owl			
3	Northern Pygmy-Owl			
3	Long-eared Owl			
3	Boreal Owl			
3	Northern Saw-whet Owl			
3	Black Swift	69		37
2	Eared Grebe	2585	78	1186
2	Double-crested Cormorant			
2	Great Egret			11
2	Snowy Egret			
2	Cattle Egret			
2	Green Heron	3 pairs + 2		
2	Black-crowned Night-Heron			
2	Osprey			
2	Mississippi Kite	72		1
2	Black Rail	7 males		

Table 1. Continued.

AI	Species	# Adults	# Juveniles	# Nests
2	Sora			
2	Black-necked Stilt	72		
2	Willet	97 pairs		
2	California Gull			
2	Forster's Tern	93	16	
2	Eurasian Collared-Dove	3 pairs		
2	Black-billed Cuckoo			
2	Barn Owl			
2	Eastern Screech-Owl			
2	Spotted Owl	4 pairs + 1		
2	Black Phoebe	32		2
2	Eastern Phoebe	1		1
2	Scissor-tailed Flycatcher	2		
2	Bell's Vireo	6		
2	Purple Martin			
2	Bank Swallow			
2	American Redstart	3 males+3 pr		
2	Ovenbird	4 males		
2	Bobolink			
2	Scott's Oriole	1 pair		
1	Least Bittern			
1	Little Blue Heron			
1	Yellow-crowned Night-Heron			
1	Harlequin Duck			
1	Broad-winged Hawk			
1	Merlin			
1	Marbled Godwit			
1	Magnificent Hummingbird			
1	Acorn Woodpecker	1 pair		
1	Least Flycatcher			
1	Vermilion Flycatcher			
1	Red-eyed Vireo			

Table 1. Continued.

AI	Species	# Adults	# Juveniles	# Nests
1	Carolina Wren	1		
1	Bendire's Thrasher			
1	Golden-winged Warbler			
1	Lucy's Warbler			
1	Chestnut-sided Warbler	3 males		
1	Bay-breasted Warbler			
1	Northern Waterthrush			
1	Hooded Warbler	1 pair		1
1	Hepatic Tanager			
1	Northern Cardinal	6 males		
1	Eastern Meadowlark			
1	Field Sparrow	14		
1	White-winged Crossbill	28		