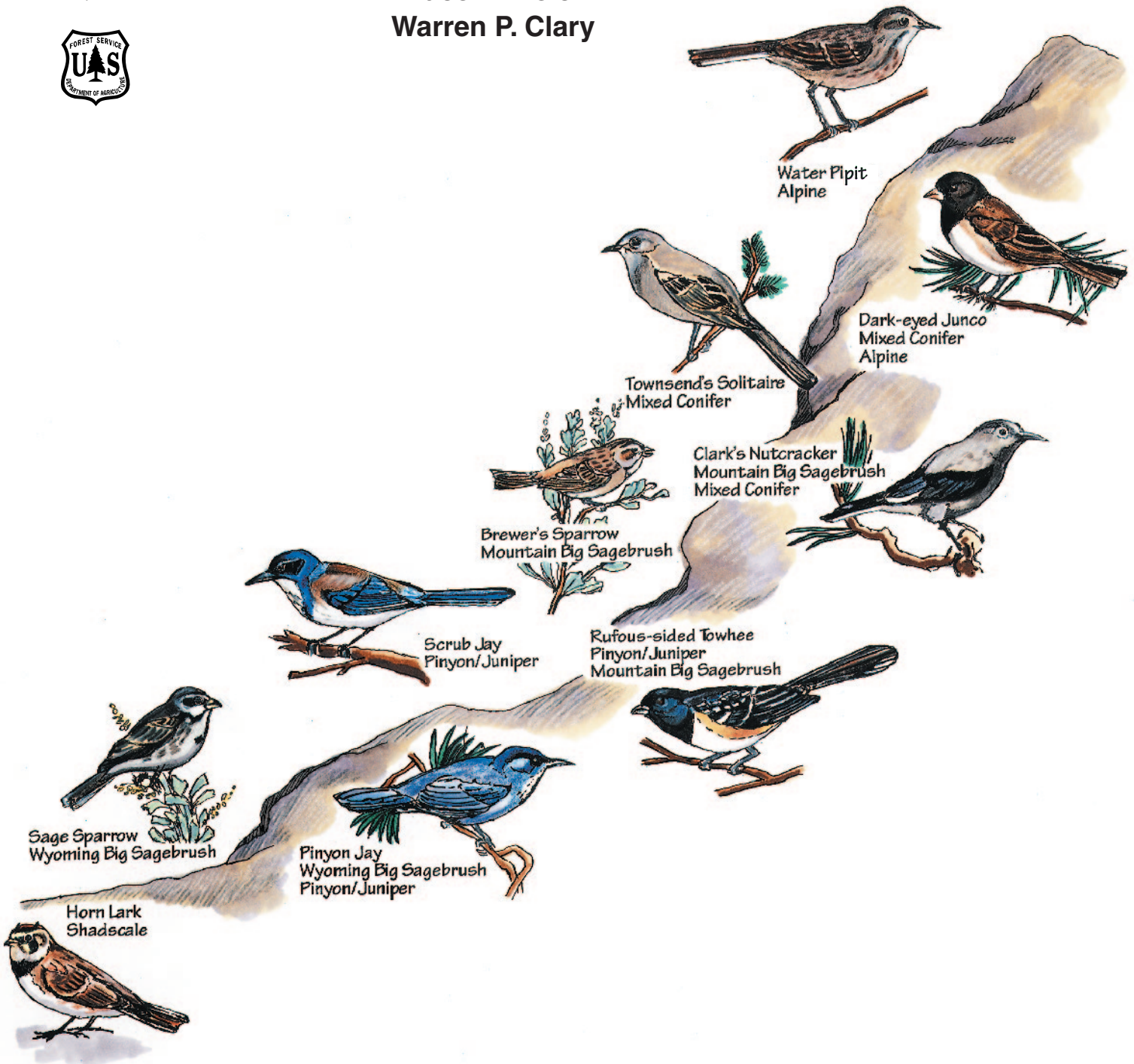




Bird Habitat Relationships Along a Great Basin Elevational Gradient

Dean E. Medin
Bruce L. Welch
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Abstract

Medin, Dean E.; Welch, Bruce L.; Clary, Warren P. 2000. **Bird habitat relationships along a Great Basin elevational gradient.** Research Paper RMRS-RP-23. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 22 p.

Bird censuses were taken on 11 study plots along an elevational gradient ranging from 5,250 to 11,400 feet. Each plot represented a different vegetative type or zone: shadscale, shadscale-Wyoming big sagebrush, Wyoming big sagebrush, Wyoming big sagebrush-pinyon/juniper, pinyon/juniper, pinyon/juniper-mountain big sagebrush, mountain big sagebrush, mountain big sagebrush-mixed conifer, mixed conifer, mixed conifer-alpine, and alpine. Eighty-nine bird species were observed. The total number of birds and bird species followed a skewed bell-shaped distribution. Some birds were quite narrow in their choice of vegetative zones while others showed very little selectivity. Both total number of individual birds and bird species appeared to reach highest values in study plots with a substantial component of mountain big sagebrush.

Keywords: Great Basin National Park, Wheeler Peak, neotropical birds, vegetive zone, ecotones

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Acknowledgments

Those who helped or provided support to Dean were: Russell Groves, Michael Carter, John Shochat, John Kinney, Kathy Woodtle, and Kari Yanskey. Thanks are extended to Dr. Vicki Saab of the Rocky Mountain Research Station, Mr. Kurt Pfaff and Ms. Melissa Renfro of the National Park Service, and Dr. Jordan C. Pederson of the Utah Division of Wildlife Resources for providing reviews of this manuscript.

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Introduction

The distribution of bird species with respect to each other and habitat features can provide insights into which species will be favorably or adversely affected by certain types of habitat alteration. Distribution data can also be used to determine what sort of environmental alteration might increase the amount of habitat utilized by a bird species or bird community.

During the years of 1981, 1982, and 1983, Dean E. Medin conducted bird census data along an elevational gradient (5,250 to 11,400 ft.) near and on Wheeler Peak of east-central Nevada to study the relations of bird distributions to plant communities. Data were collected on bird distribution and abundance and vegetative characteristics from six vegetative zones. In 1982 only, five ecotones were added for a total of 11 zones: shadscale, shadscale-Wyoming big sagebrush, Wyoming big sagebrush, Wyoming big sagebrush-pinyon/juniper, pinyon/juniper, pinyon/juniper-mountain big sagebrush, mountain big sagebrush, mountain big sagebrush-mixed conifer, mixed conifer, mixed conifer-alpine, alpine (figures 1–11). Data on four of 11 zones have been previously published (Medin 1987, Medin 1990a, Medin 1990b, Medin 1992). Further publication of his data was deemed worthy, particularly the 1982 bird census data that set a baseline for future census work in the 11 vegetative zones.

Study Area

Medin's study area was confined to the Snake Valley and Snake Mountain Range, located in White Pine County, east-central Nevada; eight of 11 study plots were within the boundaries of the future Great Basin National Park and either near or on Wheeler Peak. This study area is typical of the basin-and-range topography that characterizes much of the Great Basin. A large range of environmental conditions occur within small distances giving rise to a multiplicity of plant communities. For convenience, Billings (1951) lumped them into vegetation zones that can be typified by common plant communities "whose boundaries are caused primarily by the effects of climate and soil on the distribution of the dominant plant species

of the zone." Such zones of vegetation are particularly well defined on steep mountain slopes where they exist as elevational belts. Medin selected study plots from 11 different plant communities ranging from valley floor to alpine. Precipitation on the study area ranged from 8 in (20 cm) at the valley floor to 30 in (76 cm) at the alpine zone. Climatically, the study area ranged from cold desert with cold winters and hot, dry summers to wet and cold alpine.

Methods

In Medin's original study, sightings of bird species were recorded in selected study plots along an elevational gradient. In addition, 53 environmental variables were recorded for each study plot, and based on sighting, individual bird species' territories were delineated within a study plot. The primary approach in this research consisted of: 1) developing baselines for relative compositions and densities of avian communities along an elevational gradient; 2) determining which study plot (elevational zone) a bird species attained its highest densities; 3) determining if bird species' territories within the study plot of highest densities were different vegetatively from the study plot and other bird species' territories within the plot; and 4) illustrating some of the vegetative characteristics preferred by various bird species. Each study plot contained at least one territorial, non-colonial passerine bird species that achieved highest density within the plot—except the shadscale-Wyoming big sagebrush study plot. An exhaustive analysis of all data was not attempted, nor was all vegetative data included in the analysis.

Study plots, 11 in all, were selected from the following vegetative zones: shadscale (*Atriplex confertifolia*) at 5,250 ft (1600 m), shadscale-Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*), Wyoming big sagebrush at 5,700 ft (1740 m), Wyoming big sagebrush-pinyon/juniper (*Pinus monophylla*, *Juniperus osteosperma*), pinyon/juniper at 6,800 ft (2050 m), pinyon/juniper-mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*), mountain big sagebrush at 8,400 ft (2550 m), mountain big sagebrush-mixed conifer, mixed conifer at 9,600 ft (2900 m), mixed conifer-alpine, and alpine at 11,400 ft (3500 m) (figures 1–11). Each vegetative zone was represented by a 49.42 acre (20 ha) study plot.

Locations of the six primary (non-ecotonal) study plots—shadscale, Wyoming big sagebrush, pinyon/juni-

Figures 1-11 (following pages) are photographs of the study plots selected in 11 vegetative zones of this study. (1) shadscale, (2) shadscale-Wyoming big sagebrush, (3) Wyoming big sagebrush, (4) Wyoming big sagebrush-pinyon/juniper, (5) pinyon/juniper, (6) pinyon/juniper-mountain big sagebrush, (7) mountain big sagebrush, (8) mountain big sagebrush-mixed conifer, (9) mixed conifer, (10) mixed conifer-alpine, and (11) alpine.





per, mountain big sagebrush, mixed conifer, and alpine—are shown in figure 12. Ecotonal study plots were not mapped, but photographs are printed here (Figs. 2, 4, 6, 8, and 10) as a means of relocating them. Maps, photographs, and raw data are stored at the Great Basin National Park Headquarters.

The 11 study plots were censused for birds using the Williams spot-map method (International Bird Census Committee 1970). The square study plots were surveyed and gridded by Cartesian Coordinate System using points and numbered stakes at 246.1 ft (75 m) intervals. Ten census visits were made to each plot in 1982. Most spot-mapping was conducted between sunrise and early afternoon when the birds were most active. To ensure complete coverage, the study plots were censused by walking within 164 ft (50 m) of all points on the grid. Different census routes through the plots were used, with different starting and ending points distributed as evenly as practical among visits. Dates for the censuses were chosen to include the breeding season for most of the bird species involved and varied according to elevation. Bird census dates for the various study plots were: shadscale—April 2 to May 31; shadscale-Wyoming big sagebrush—April 3 to June 11; Wyoming big sagebrush—April 4 to June 12; Wyoming big sagebrush-pinyon/juniper—April 5 to June 12; pinyon/juniper—April 6 to June 14; pinyon/juniper-mountain big sagebrush—April 19 to June 25; mountain big sagebrush—May 4 to June 29; mountain big sagebrush-mixed conifer—May 14 to July 9; mixed conifer—May 14 to July 9; mixed conifer-alpine—June 15 to July 21; and alpine—June 24 to July 21.

At the end of the bird census periods, clusters of observations and coded activity patterns on species maps were circled, indicating areas of activity or approximate territories. Fractional parts of boundary territories were determined by estimating the portion of each edge cluster that fell within the study plots. Oelke (1981) and Verner (1985) summarized methodological and other special problems of the mapping method. These bird territories were used to measure various vegetative characteristics and to compare these characteristics to those of the study plot. Also, bird census data were used to determine total number of birds and species occupying the various study plots and to compare these values among study plots.

Vegetative measurements within the study plots were based on 49 1-m² quadrats centered on the grid points of the 246.1 ft (75 m) grid. Cover variables—litter and bare ground—were ocularly estimated on quadrats and recorded as the midpoint of one of eight coverage classes (0–1, 1–5, 5–10, 10–25, 25–50, 50–75, 75–95, 95–100%). Percent-volume of grasses, forbs, shrubs, and downed woody material was ocularly estimated using a three-dimensional 1-m² quadrat that was 0.25 m tall for grasses and forbs, and 1 m tall for shrubs and downed woody material (Zamora 1981). Percent-volume estimates were

recorded as the midpoint of one of eight volume classes (0–1, 1–5, 5–10, 10–25, 25–50, 50–75, 75–95, 95–100%). Each volume estimate included not only those plants rooted within the quadrat boundaries but also overhanging parts of the plants rooted outside the quadrat. In addition, maximum grass, forb, shrub, and tree heights were recorded as well as species of shrubs and trees present for each quadrat. Maximum tree height and species presence was based on 100-m² quadrats centered on 49 1-m² quadrats.

For bird species' territories that attained highest densities within a study plot, environmental measurements were based on 20 1-m² quadrats except for tree data, which was based on 100-m² quadrats centered on the 20 1-m² quadrats. Quadrats were located within the boundaries of a bird species' territory in a stratified random design. The individual territories were partitioned into four approximately equal "blocks" by bisecting the long and short axes of the territories. Quadrats were equally spaced along randomly selected lines perpendicular to the baseline bisecting the long axis of the territories. A minimum of one line was selected in each of the four blocks. Spacing of quadrats did vary according to territory size. Data collected from each of the 20 quadrats were the same as collected from the study plots. Number of territories measured varied from 4 to 5 and all were within the study plot containing the highest count or sighting of a given bird species. Not all 89 bird species were represented; only territorial and non-colonial species of sufficient numbers (>5) were included in this portion of the study.

Because most data sets were not normally distributed, the Kruskal-Wallis Test, a nonparametric analog of the parametric one-way analysis of variance, F-test was used to compare variable or character means (Hintze 1992). Probability level was set at 5 percent. Comparisons made were: 1) 10 environmental characteristics—percentage of litter, bare ground, and so on—among the 11 study plots; 2) total number of birds and mean number of species among study plots; and 3) 10 environmental characteristics among bird species' territories attaining a peak population within a study plot and the study plot itself. Also, shrub and tree species frequency are given for study plots and bird territories.

Plant taxonomy follows Holmgren and Reveal (1966). Bird nomenclature is from the 1983 AOU Check-list (American Ornithologists' Union 1983). Scientific names of plants and birds cited in the text and tables are listed in the appendix.

Results and Discussion

Comparisons of environmental characteristics of the 11 study plots in this study are given in table 1. For visual

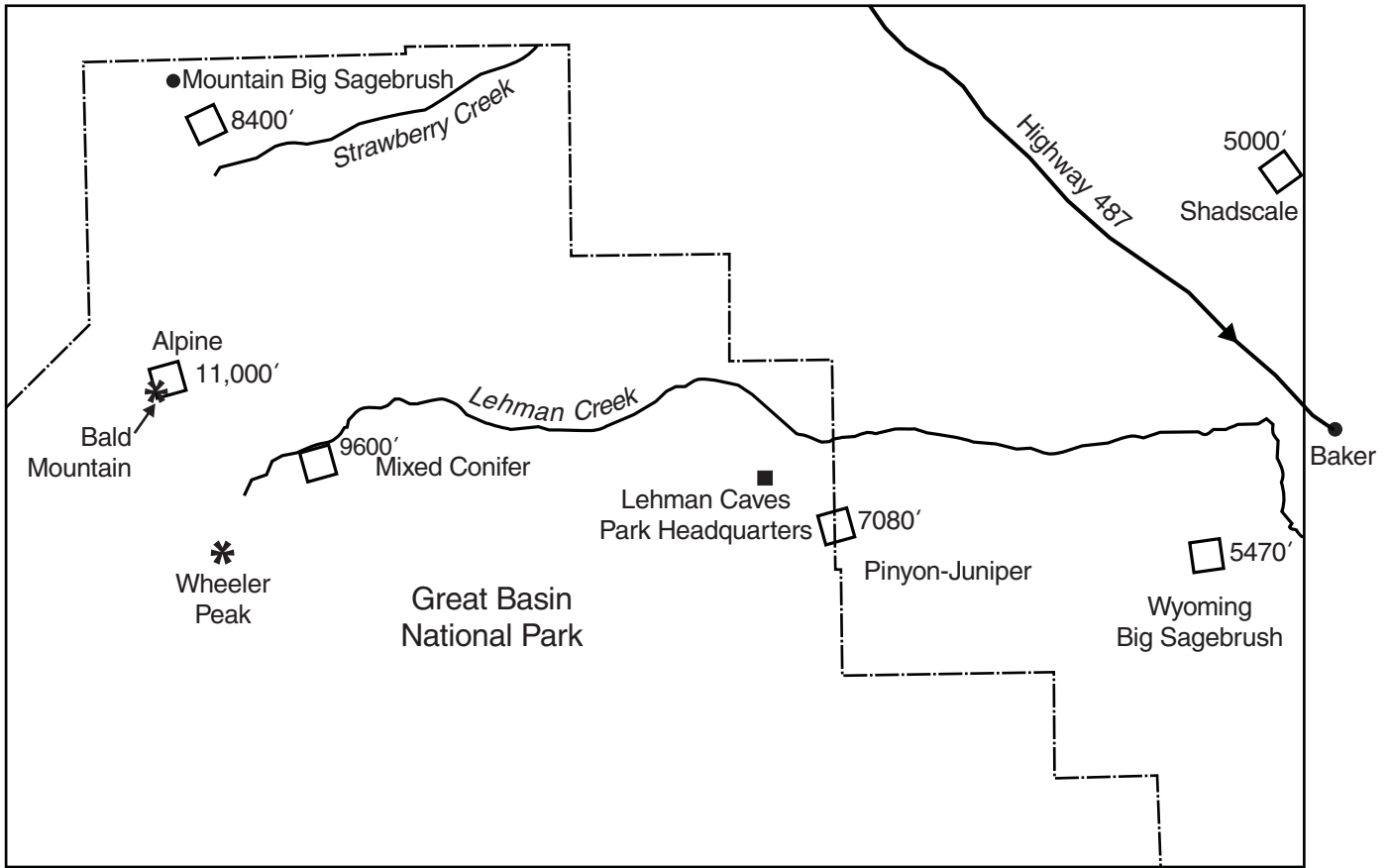


Figure 12 shows the location of six study plots in the shadscale, Wyoming big sagebrush, pinyon/juniper, mountain big sagebrush, mixed conifer, and alpine vegetative zones of this study.

comparisons see figures 1–11. In line with expectations, gross vegetation and ground cover characteristics differed in many ways along the wide altitudinal range of 5,250 to 11,400 ft. Some general trends were apparent, such as: bare soil was most prevalent in the lowest study plots (shadscale and shadscale-Wyoming big sagebrush); litter, tree height, and downed woody materials were greater in the study plots containing mixed conifer; and the greatest volumes of understory vegetation occurred in the middle elevation study plots, typically in those containing mountain big sagebrush.

Bird abundance was relatively low in low elevation study plots, increased to a maximum in upper mid-elevations study plots, and declined in the highest elevation study plot (table 2). A similar trend was followed by the number of bird species. Both total number of individual birds and number of bird species reached the highest value in those study plots with a substantial component of mountain big sagebrush (pinyon/juniper-mountain big sagebrush, mountain big sagebrush, and mountain big sagebrush-mixed conifer). The climatically harsh alpine study plot had the lowest number of individual birds and

was second only to the shadscale study plot in fewest bird species (table 2).

Eighty-nine bird species were sighted on the 11 study plots in 1982. The distribution of these birds among the study plots are presented as mean number of sightings out of 10 bird censuses in table 3. Some species were narrow in their use of vegetative zones; e.g., the water pipit was found only in the alpine study plot. Other species that were narrowly distributed included evening grosbeak—96% mountain big sagebrush; green-tailed towhee—81% mountain big sagebrush; sage sparrow—84% Wyoming big sagebrush; rufus-sided towhee—69% pinyon/juniper-mountain big sagebrush; and horned lark—69% shadscale. Some species showed very little selectivity; e.g., the common raven was sighted in all 11 study plots while the American kestrel, mountain bluebird, violet-green swallow and broad-tailed hummingbird were sighted in 10 study plots.

The following sections (tables 4–13) are comparisons of study plot environmental characteristics with bird species' territory characteristics. The only bird territories analyzed were for those species that obtained their highest

densities within a given study plot. The shadscale-Wyoming big sagebrush study plot was the only study plot lacking a peak bird species density.

Shadscale zone

Only one bird species had its highest density in the shadscale study plot—the horned lark (table 3). This bird showed some selectivity within the study plot (table 4). Horned lark territories appeared to be more rocky—this is an inference from the significant difference between percent of bare soil of the study plot and the bird territories, and the lack of a significant difference between percent cover of litter—and contained more downed woody material, less grass, and more forbs (table 4). Individual frequencies of shrub species appear to be very similar.

Wyoming big sagebrush zone

For the Wyoming big sagebrush study plot, three bird species attained highest densities: black-throated sparrow, sage sparrow, and sage thrasher (table 3). Also, the raven numbers peaked in this zone (tied with two other zones, table 3). Two species, the sage sparrow and sage thrasher, are considered to be obligate species of big sagebrush (Braun and others 1976; Reynolds 1981; Welch 1993).

All three species selected territories having less grass and fewer forbs than the study plot (table 5). Shrub volume was less in the territories of sage sparrow than for the other two species but shrub maximum height was shortest for sage thrasher. Percent volume of downed woody material was greater in the territories of the black-throated sparrow than for the other two bird species and for the study plot. Shrub frequency for Wyoming big sagebrush, low rabbitbrush, and spiny hopsage appeared to be similar for the three bird species and study plot. Sage thrashers appear to prefer territories with great amounts of black sagebrush, shadscale, and bud sagebrush. These are in general shorter shrubs and probably account for a smaller maximum height of shrubs in the sage thrasher's territories as compared to the other two bird species.

Wyoming big sagebrush-pinyon/juniper zone

Four bird species attained peak populations in the Wyoming big sagebrush-pinyon/juniper study plot: bushtit, raven (tied with two other zones), mourning dove, and pinyon jay (table 3). Unfortunately, territorial data were collected only for the bushtit. Vegetative characteristics of bushtit territories differed significantly from the study plot's characteristics in all aspects except tree maximum

height and frequency of Utah juniper (table 6). This bird seems to prefer less shrub volume but perhaps more shrub height than what was available on the study site, yet the frequency of Wyoming big sagebrush was more than three times that of the study plot. In fact, the frequency of Wyoming big sagebrush in the bird territories was second only to the more abundant Utah juniper of the study plot. Bushtits also used areas with greater frequency of trees: Utah juniper and singleleaf pinyon pine but not necessary taller trees.

Pinyon/juniper zone

Three bird species occupied the pinyon/juniper study plot in peak numbers (table 3). These three species were: plain titmouse, scrub jay, and black-throated gray warbler. Territorial data were not collected on the black-throated gray warbler. In general, plain titmouse and scrub jay territories contained more litter, less grass, less forbs, more shrubs, and perhaps fewer trees of singleleaf pinyon pine than the study plot (table 7). Compared with the plain titmouse, scrub jay's territories appear to have a greater volume of forbs and shrubs, taller grass, and perhaps greater frequency of black sagebrush, singleleaf pinyon pine, and Utah juniper.

Pinyon/juniper-mountain big sagebrush zone

Ten bird species were sighted more often in the pinyon/juniper-mountain big sagebrush study plot than in the remaining 10 study plots. These species were: broad-tailed hummingbird, black-headed grosbeak, chipping sparrow, lazuli bunting, MacGillivray's warbler, American robin, rufous-sided towhee (currently called spotted towhee), Virginia's warbler, scrub jay, and Steller's jay. Of the nine, territories were not delineated for four species—broad-tailed hummingbird, Virginia's warbler, scrub jay, and Steller's jay. The remaining six species' territories contained shorter trees, less forbs, more mountain big sagebrush (except MacGillivray's warbler, American robin, and rufous-sided towhee), more buckwheat, and more broom snakeweed than the study plot (table 8). Other comparisons among the bird territories and study plot are highly variable and too numerous for individual enumeration.

Mountain big sagebrush zone

The mountain big sagebrush study plot contained seven bird species with the highest population counts compared to the other 10 study plots. These species

were: Brewer's sparrow, evening grosbeak, green-tailed towhee, house wren, northern harrier, white-crowned sparrow, and yellow-bellied sapsucker (currently called red-naped sapsucker). Territories were not delineated for evening grosbeak, northern harrier, and white-crown sparrow. Litter cover values were higher in the territories for all four birds than the study plot (table 9). Grass volume was less in the territories of Brewer's sparrow and green-tailed towhee as compared to the house wren, yellow-bellied sapsucker, and the study plot. Forb volume and height was less for all four bird species than the study plot. Shrub volume was greater in the territories of Brewer's sparrow, green-tailed towhee, and study plot than for the territories of the house wren and yellow-bellied sapsucker. The frequency of mountain big sagebrush appears to be greater for Brewer's sparrow and green-tailed towhee territories than for the other two bird species and perhaps the study plot. These two species have been described as big sagebrush obligates (Braun and others 1976; Reynolds 1981; Welch 1993). The frequency of buckwheat was highest in the territories of Brewer's sparrow and green-tailed towhee. Tree frequency appears to be greater in the house wren and yellow-bellied sapsucker territories than for other bird species found in this study plot (table 9).

Mountain big sagebrush-mixed conifer zone

Twelve bird species, the most for any of the 11 study plots, occurred more often in the mountain big sagebrush-mixed conifer study plot. These species were: blue grouse, Clark's nutcracker, dusty flycatcher, hairy woodpecker, hermit thrush, northern flicker, red-breasted nuthatch, ruby-crowned kinglet, vesper sparrow, western tanager, warbling vireo, and yellow-rumped warbler. Because of the many species having highest densities in this study plot, comparison combinations are numerous. Yet, environmental characteristics differ among bird species' territories and study plot (table 10). Vesper sparrow's territories were significantly different from the hermit thrush in 8 of the 10 characteristics measured—percent litter; percent volume of down woody material, grasses, forbs, and shrubs; and maximum height of grasses, shrubs, and trees. There appears to be differences in the frequency of certain species of shrubs between these two bird species (snowberry, white fir, quaking aspen, mountain big sagebrush, and perhaps others). This was also true for tree frequency (white fir and quaking aspen). Other species like Clark's nutcracker and northern flicker were occupying territories having similar characteristics. But some differences did occur in percent volume of grasses, forbs, and shrubs and frequency of limber pine beyond shrub height.

Mixed conifer zone

Four bird species attained their highest densities in the mixed conifer zone: brown creeper, mountain chickadee, Townsend's solitaire, and white-breasted nuthatch (table 3). Mountain chickadee's territories were found to have a significantly higher percentage of litter and taller trees than the other bird species and the study plot (table 11). Brown creeper territories were more grassy and shrubby and appeared to contain less Douglas-fir than the other territories and study plot. Maximum tree height was significantly less in the brown creeper territories than for the other territories and study plot.

Mixed conifer-alpine zone

Five bird species attained their highest densities in the mixed conifer-alpine study plot. These were Cassin's finch, dark-eyed junco, mountain bluebird, pine siskin, and rosy finch. Territories were not delineated for rosy finch. All bird species' territories contained significantly more litter than the study plot (table 12). Mountain bluebird territories had greater percent volume of grasses, and forbs than pine siskin territories.

Alpine zone

The water pipit was unique to the alpine study plot (table 3). Its territories differed from the study plot in four ways: percent of bare ground; percent volume of grasses and forbs; and perhaps in the frequency of gooseberry (table 13).

Epilogue

We assume that Medin's baseline data will become even more valuable as future bird censuses are conducted. The composition of the avian communities relative to elevation, vegetation, and other environmental factors may change as new stresses are experienced. Species of special interest that may be observed in the future are brown-headed cowbird—a brood parasite—and the rare ash-throated flycatcher.

A complex multi-variate analysis of this large data set was not attempted. The assumption was made for the purposes of this document that a species' highest numbers occurred in the most favorable habitat and, therefore, the characteristics of these habitats were the most favorable for a given bird species. These characteristics then provide

clues as to the likely effects of various management practices or environmental changes on avian populations.

This presentation included only 10 out of 53 environmental characteristics in the original data set. Substantial information such as the amounts of coniferous and deciduous canopy volumes were not included in this document. However, the entire data set will be deposited with the Great Basin National Park to serve as a data source.

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Table 1. Vegetative characteristics of 11 study plots (vegetation zones) near and in the Great Basin National Park of east-central Nevada.

	Shadscale	Shadscale- Wyoming big sagebrush	Wyoming big sagebrush	Wyoming big sagebrush Pinyon/juniper	Pinyon/ juniper	Pinyon/juniper Mountain big sagebrush	Mountain big sagebrush	Mountain big sagebrush- Mixed conifer	Mixed conifer	Mixed conifer- Alpine	Alpine
Litter ¹ %	0.9 ^a	2.8 ^b	2.6 ^b	8.0 ^b	5.6 ^b	27.0 ^c	28.9 ^c	64.8 ^c	54.7 ^d	11.4 ^b	13.2 ^b
Bare ² %	90.0 ^b	83.9 ^{bc}	78.0 ^{cd}	69.0 ^{de}	62.6 ^{ef}	31.8 ^h	58.9 ^f	34.4 ^h	4.3 ^a	54.6 ^{fg}	41.8 ^{gh}
DWM ³ %	0.5 ^b	0.8 ^{bc}	0.8 ^{bc}	1.4 ^{cd}	1.3 ^{cd}	1.2 ^{bcd}	1.2 ^{bcd}	2.0 ^d	3.6 ^e	1.2 ^{bcd}	0.04 ^a
Grass ⁴ %	0.6 ^a	2.1 ^b	2.3 ^b	4.3 ^{bc}	6.8 ^d	15.4 ^e	12.4 ^e	7.4 ^d	0.7 ^a	4.4 ^{cd}	2.4 ^b
Forb ⁵ %	1.2 ^a	1.2 ^a	1.5 ^a	0.9 ^a	1.3 ^a	9.1 ^{cd}	10.8 ^d	8.3 ^c	0.4 ^a	4.1 ^b	7.8 ^c
Shrub ⁶ %	3.2 ^{ab}	6.0 ^{cd}	7.8 ^{def}	10.0 ^{fg}	2.5 ^{ab}	9.7 ^{efg}	12.3 ^g	7.1 ^{de}	0.8 ^a	4.0 ^{bc}	0.8 ^a
Grass ⁷ m	0.14 ^a	0.25 ^b	0.32 ^b	0.25 ^b	0.27 ^b	0.47 ^c	0.46 ^c	0.26 ^b	0.06 ^a	0.26 ^b	0.10 ^a
Forb ⁸ m	0.24 ^{def}	0.29 ^f	0.25 ^{def}	0.23 ^{de}	0.19 ^{cd}	0.29 ^f	0.40 ^g	0.28 ^{ef}	0.02 ^a	0.15 ^c	0.09 ^b
Shrub ⁹ m	0.39 ^b	0.70 ^c	0.80 ^c	1.50 ^{de}	2.20 ^f	1.70 ^e	1.20 ^d	1.60 ^e	1.40 ^{de}	1.40 ^{de}	0.10 ^a
Tree ¹⁰ m	0.0 ^a	0.0 ^a	0.0 ^a	1.7 ^c	3.9 ^d	4.1 ^d	0.7 ^b	7.5 ^e	14.4 ^f	2.8 ^c	0.0 ^a

Means within rows sharing the same superscripts are not statistically different, based on Kruskal-Wallis nonparametric tests, probability level 5 percent (Hintze 1992).

¹ Litter cover was ocularly estimated on 49 1-m² quadrats and recorded as the midpoint of one of eight coverage classes (0–1, 1–5, 5–10, 10–25, 25–50, 50–75, 75–95, 95–100%).

² Bare soil cover was determined in the same manner as for litter.

³⁻⁶ Percent-volumes of downed woody material (DWM), grasses, forbs, and shrubs were ocularly estimated using a three-dimensional 1-m² quadrat that was 0.25 m tall for grasses and forbs and 1 m tall for downed woody material and shrubs (Zamora 1981).

⁷⁻¹⁰ Maximum height for grass, forb, shrub, and tree recorded in meters.

Table 2. Total number of birds and mean number of bird species sighted on 20 ha study plots located in 11 vegetation zones near and in the Great Basin National Park of east central Nevada. Total number of birds and mean number of bird species are based on 10 bird censuses per study plot.

	Shadscale	Shadscale- Wyoming big sagebrush	Wyoming big sagebrush	Wyoming big sagebrush Pinyon/juniper	Pinyon/ juniper	Pinyon/juniper Mountain big sagebrush	Mountain big sagebrush	Mountain big sagebrush- Mixed conifer	Mixed conifer	Mixed conifer- Alpine	Alpine
Total birds	50.0 ^b	51.3 ^b	52.1 ^b	58.8 ^{bc}	78.2 ^{cd}	133.1 ^e	151.1 ^e	163.5 ^f	83.4 ^d	110.7 ^e	23.3 ^a
Species	4.7 ^a	8.8 ^b	8.2 ^b	15.9 ^c	18.1 ^c	24.8 ^d	23.9 ^d	23.0 ^d	16.8 ^c	16.1 ^c	6.2 ^{ab}

Means within rows sharing the same superscripts are not statistically different, based on Kruskal-Wallis nonparametric tests, probability level 5 percent (Hintze 1992).

Table 3. The distribution of individual bird species in 11 study plots (vegetation zones) near and in the Great Basin National Park in east-central Nevada. Data based on the mean of 10 censuses visits per study plot. Peak species values are in bold type, except for those species that averaged less than 2 sightings.

	Shadscale-		Wyoming		Wyoming		Pinyon/juniper		Mountain		Mixed	
	Shadscale	Wyoming big sagebrush	Wyoming big sagebrush	Pinyon/juniper	Wyoming big sagebrush	Pinyon/juniper	Mountain big sagebrush	Mountain big sagebrush	Mountain big sagebrush	Mixed conifer	Mixed conifer	Alpine
American crow	0.4	0.2	0.2	0.9	0.3							0.1
American kestrel	0.4	0.4	0.1	0.4	0.3		0.8	2.0	1.0			0.2
American robin				0.3	0.4		12.0	10.0	7.0	2.0		3.0
Ash-throated flycatcher				0.2								
Barn swallow	0.3	0.1		0.2								
Black-billed magpie				0.1								
Black-chinned hummingbird				0.1								
Black-headed grosbeak					0.1			0.2				
Black-throated gray warbler					4.0							
Black-throated sparrow		7.0	11.0	0.4	0.3							
Blue grouse								0.8	1.0			
Brewer's blackbird					0.1			0.2				
Brewer's sparrow	1.0	12.0	19.0	2.0	1.0		0.7	23.0	0.5			
Broad-tailed hummingbird		0.1	0.2	0.8			5.0	2.0	0.3	0.3	1.0	0.2
Brown creeper					0.2		0.2	0.1	0.2	5.0	0.1	
Brown-headed cowbird				0.1	0.5		0.8	0.1				
Bushtit				6.0	5.0		2.0	0.4				
Calliope hummingbird							0.1	0.2			0.2	
Cassin's finch					4.0		5.0	6.0	8.0	6.0	23.0	0.1
Chipping sparrow				6.0	5.0		16.0	10.0	12.0	0.7	6.0	
Clark's nutcracker					0.6		0.6	3.0	12.0	6.0	5.0	1.0
Common nighthawk		0.1	0.1	0.3				0.8				
Common poorwill			0.2									
Common raven	2.0	3.0	3.0	3.0	2.0		0.7	1.0	0.6	0.1	0.4	0.2
Dark-eyed junco				1.0	2.0		1.0	0.8	16.0	5.0	26.0	0.3
Dusty flycatcher				0.8	0.3		4.0	6.0	7.0	0.4	0.3	
Evening grosbeak					0.2		0.2	10.0				
Ferruginous hawk	0.2	0.1		0.1	0.1							
Golden-crowned kinglet									0.4			
Golden eagle	0.2	0.1	0.5	0.2	0.2		0.1					0.1

continued

Table 3. — Continued

	Shadscale-		Wyoming		Wyoming		Wyoming		Pinyon/juniper		Mountain		Mountain		Mixed	
	Shadscale	Wyoming big sagebrush	Wyoming big sagebrush	Pinyon/juniper	Wyoming big sagebrush	Pinyon/juniper	Pinyon/juniper	Wyoming big sagebrush	Mountain big sagebrush	Mountain big sagebrush	Mountain big sagebrush	Mixed conifer	Mixed conifer	Alpine	Alpine	Mixed conifer-
Great horned owl						0.5	0.3	0.1								
Green-tailed towhee			0.1	0.4			6	30.0	0.5							
Hairy woodpecker						0.2	0.8	0.2				1.0	0.5	0.2		
Hermit thrush												10.0	8.0	1.0		
Horned lark	43	19	0.8													
House wren						0.1	1.0	3.0								
Lark sparrow				0.1	0.1											
Lazuli bunting							1.0	0.2								
Loggerhead shrike		0.5	0.2	0.4												
Long-billed curlew	0.6	0.5														
Long-eared owl				0.1												
MacGillivray's warbler							2.0	0.5				0.4				
Mountain bluebird	0.1	0.2		0.7	8.0		5.0	4.0			6.0	0.8	12.0	3.0		
Mountain chickadee				1.0	9.0		12.0	5.0			12.0	13.0	4.0	0.1		
Mourning dove	0.3	0.2	0.5	2.0	0.7		0.2	0.8								
Northern flicker				0.4	0.6		4.0	3.0			8.0	1.0	0.2			
Northern goshawk				0.1	0.3		0.1	0.2			0.7		0.1			
Northern harrier	0.5	0.6	0.8	0.6	0.3		0.2	1.0			0.1			0.1		
Olive-sided flycatcher							0.3	0.2								
Orange-crowned warbler							0.3	0.1								
Pine siskin							2.0	1.0			3.0	11.0	16.0	0.2		
Pinyon jay			0.1	12.0	10.0		0.1	0.3								
Plain titmouse				4.0	6.0											
Prairie falcon			0.1													
Red-breasted nuthatch					0.5		0.7	0.2			12.0	4.0	0.4			
Red-tailed hawk		0.2	0.1	0.3	0.2		0.4	0.3			0.6		0.1			
Rock wren							0.1									0.8
Rough-legged hawk			0.1													
Rough-winged swallow		0.3	0.2	0.1			0.1	0.2								
Rosy finch																
Ruby-crowned kinglet				1.0	4.0		2.0	2.0			0.5		2.0	0.2		
Rufous-sided towhee				4.0	0.2		14.0	2.0			12.0	2.0	0.2			

continued

Table 3. — *Continued*

	Shadscale-		Wyoming		Wyoming		Pinyon/juniper		Mountain		Mixed	
	Shadscale	Wyoming big sagebrush	Wyoming big sagebrush	Pinyon/juniper	Wyoming big sagebrush	Pinyon/juniper	Mountain big sagebrush	Mountain big sagebrush	Mountain big sagebrush	Mixed conifer	Mixed conifer	Alpine
Sage grouse		2.0	0.1									
Sage sparrow		2.0	11.0	0.1								
Sage thrasher	0.1	1.0	3.0	0.2		0.1						
Savannah sparrow	0.1											
Scrub jay		0.1		6.0	7.0	7.0	0.8					
Sharp-shinned hawk								0.9	0.1			
Steller's jay					2.0	2.0	0.2	0.3				
Swainson's hawk	0.1											
Townsend's solitaire					0.7	0.7	0.1	1.0	9.0	3.0	0.7	
Tree swallow					0.7	0.7	0.7	0.7	0.3			
Turkey vulture		0.2				0.1						
Vesper sparrow		0.3	0.1				2.0	3.0				
Violet-green swallow	0.2	0.1	0.2	0.5	0.3	0.6	0.4	0.4	0.2		0.8	
Virginia's warbler						2.0						
Warbling vireo				0.3		5.0	0.8	6.0			15.0	
Water pipit												
Western kingbird				0.2								
Western meadowlark	0.2	0.8	0.1	0.1								
Western tanager		0.1		0.3	0.4	2.0	1.0	4.0	0.1	0.1		
Western wood-pewee				0.3				0.2	0.5	2.0		
White-breasted nuthatch												
White-crowned sparrow			0.1	0.2			2.0				0.1	
White-throated swift		0.1	0.2	0.1	0.3	0.1	0.1	0.1				
Williamson's sapsucker				0.1					0.1	0.1		
Wilson's warbler				0.2								
Yellow-bellied sapsucker					0.1	2.0	4.0	2.0	0.3			
Yellow-rumped warbler		0.1		0.6	1.0	6.0	8.0	12.0	5.0	6.0		

Table 4. Shadscale study plot: comparisons of vegetative characteristics and horned lark territories. Data for the horned lark are based on four or five territories. See footnotes of table 1 for explanation of how characteristics were measured. Shrub and tree percentages are frequency data based on the number of times a given plant species appeared on 49 1-m² quadrat plots for the study plot and on 80 to 100 1-m² quadrat plots for four or five bird territories per species.

Habitat variables	Shadscale	Horned lark	Habitat variables	Shadscale	Horned lark
Litter %	0.9 ^a	1.0 ^a	Shrub %		
Bare %	90.0 ^a	82.0 ^b	Shadscale	100	100
Downed wood material			Bud sagebrush	96	96
% volume/1.0, m ³	0.5 ^a	0.7 ^b	Common winterfat	92	92
Grass % volume/0.25, m ³	0.6 ^a	0.2 ^b	Horsebrush	6	1
Forb % volume/0.25, m ³	1.2 ^a	1.8 ^b	Rubber rabbitbrush	6	1
Shrub % volume/1.0, m ³	3.2 ^a	3.6 ^a	Spiny hopsage	4	
Grass maximum height, m	0.14 ^a	0.13 ^a	Wyoming big sagebrush	2	
Forb maximum height, m	0.24 ^a	0.43 ^b	Pricklypear	2	5
Shrub maximum height, m	0.39 ^a	0.40 ^a			
Tree maximum height, m	0.00	0.00			

Means within rows sharing the same superscripts are not statistically different, based on Kruskal-Wallis nonparametric tests, probability level 5 percent (Hintze 1992).

Table 5. Wyoming big sagebrush study plot: comparisons of vegetative characteristics and bird species' territories having the highest density within the study plot. The data for the bird species are based on four or five territories. See footnotes of table 1 for explanation of how characteristics were measured. Shrub and tree percentages are frequency data based on the number of times a given plant species appeared on 49 1-m² quadrat plots for the study plot and on 80 to 100 1-m² quadrat plots for four or five bird territories per species.

Habitat variables	Wyoming big sagebrush	Black-throated sparrow	Sage sparrow	Sage thrasher
Litter %	2.6 ^a	10.2 ^b	4.0 ^a	5.0 ^a
Bare %	78 ^a	76 ^a	73 ^a	75 ^a
Downed wood material % vol./1.0 m ³	0.8 ^a	4.2 ^c	0.9 ^{ab}	1.4 ^b
Grass % volume/0.25, m ³	2.3 ^a	1.2 ^b	0.6 ^b	0.5 ^b
Forb % volume/0.25, m ³	1.5 ^a	0.6 ^b	0.5 ^b	0.8 ^b
Shrub % volume/1.0, m ³	7.8 ^a	9.3 ^a	3.0 ^b	9.8 ^a
Grass maximum height, m	0.32 ^a	0.21 ^a	0.20 ^a	0.17 ^a
Forb maximum height, m	0.25 ^a	0.13 ^b	0.11 ^b	0.14 ^b
Shrub maximum height, m	0.8 ^{ab}	0.90 ^b	0.84 ^b	0.77 ^a
Tree maximum height, m	0.00 ^a	0.00 ^a	0.00 ^a	0.00 ^a
Shrub %				
Wyoming big sagebrush	100	100	100	100
Low rabbitbrush	92	96	97	95
Spiny hopsage	44	47	37	49
Black sagebrush	22	9	15	48
Shadscale	12	6	3	24
Broom snakeweed	6		1	
Pricklypear	6	16	9	15
Horsebrush	6	2	6	1
Common winterfat	2	1	1	
Nevada ephedra		1	14	2
Bud sagebrush		2		16

Means within rows sharing the same superscripts are not statistically different, based on Kruskal-Wallis nonparametric tests, probability level 5 percent (Hintze 1992).

Table 6. Wyoming big sagebrush-pinyon/juniper study plot: comparisons of vegetative characteristics and bushtit territories. Data for the bushtit are based on four or five territories. See footnotes of table 1 for explanation of how characteristics were measured. Shrub and tree percentages are frequency data based on the number of times a given plant species appeared on 49 1-m² quadrat plots for the study plot and on 80 to 100 1-m² quadrat plots for four or five bird territories per species.

Habitat variables	Wyoming big sagebrush- Pinyon/juniper	Bushtit	Habitat variables	Wyoming big sagebrush- Pinyon/juniper	Bushtit
Litter %	8.0 ^a	13.7 ^b	Utah juniper	72	74
Bare %	69 ^a	62 ^b	Nevada ephedra	46	63
Downed wood material % volume/1.0, m ³	1.4 ^a	0.8 ^b	Low rabbitbrush	40	27
Grass % volume/0.25, m ³	4.3 ^a	0.9 ^b	Wyoming big sagebrush	22	71
Forb % volume/0.25, m ³	0.9 ^a	0.5 ^b	Horsebrush	6	2
Shrub % volume/1.0, m ³	10.0 ^a	2.6 ^b	Pricklypear	6	22
Grass maximum height, m	0.25 ^a	0.19 ^b	Curleaf mountain mahogany	2	
Forb maximum height, m	0.23 ^a	0.11 ^b	Shadscale		8
Shrub maximum height, m	1.5 ^a	1.9 ^b	Rubber rabbitbrush		6
Tree maximum height, m	1.7 ^a	2.4 ^a	Bitterbrush		4
Shrub %			Spiny hopsage		3
Black sagebrush	86	59	Trees %		
Singleleaf pinyon pine	76	65	Utah juniper	12	46
			Singleleaf pinyon pine	11	28

Means within rows sharing the same superscripts are not statistically different, based on Kruskal-Wallis nonparametric tests, probability level 5 % (Hintze 1992).

Table 7. Pinyon/juniper study plot: comparisons of vegetative characteristics and bird species' territories having the highest density within the study plot. The data for the bird species are based on four or five territories. See footnotes of table 1 for explanation of how characteristics were measured. Shrub and tree percentages are frequency data based on the number of times a given plant species appeared on 49 1-m² quadrat plots for the study plot and on 80 to 100 1-m² quadrat plots for four or five bird territories per species.

Habitat variables	Pinyon/juniper	Plain titmouse	Scrub jay
Litter %	5.6 ^a	20.9 ^b	24.4 ^b
Bare %	63 ^a	60 ^a	59 ^a
Downed wood material % volume/1.0, m ³	1.3 ^a	1.6 ^a	1.7 ^a
Grass % volume/0.25, m ³	6.8 ^a	1.4 ^b	0.9 ^b
Forb % volume/0.25, m ³	1.3 ^a	0.5 ^b	0.6 ^c
Shrub % volume/1.0, m ³	2.5 ^a	7.4 ^b	11.8 ^c
Grass maximum height, m	0.27 ^a	0.19 ^b	0.22 ^c
Forb maximum height, m	0.19 ^a	0.09 ^b	0.15 ^a
Shrub maximum height, m	2.2 ^a	2.4 ^a	2.2 ^a
Tree maximum height, m	3.9 ^a	3.0 ^b	2.7 ^b
Shrub %			
Black sagebrush	100	80	100
Singleleaf pinyon pine	96	79	98
Utah juniper	66	66	80
Green ephedra	54	52	50
Low rabbitbrush	14		23
Curleaf mountain mahogany	8	19	8
Western dogwood	8	15	13
Pricklypear	4		9
Buckwheat	4	1	16
Bitterbrush	4		
Nevada ephedra	2		7
Rubber rabbitbrush		9	
Wyoming big sagebrush			3
Trees %			
Singleleaf pinyon pine	69	38	49
Utah juniper	39	34	29
Western dog wood	2		

Means within rows sharing the same superscripts are not statistically different, based on Kruskal-Wallis nonparametric tests, probability level 5 percent (Hintze 1992)

Table 8. Pinyon/juniper-mountain big sagebrush study plot: comparisons of vegetative characteristics and bird species' territories having the highest density within the study plot. The data for the bird species are based on four or five territories. See footnotes of table 1 for explanation of how characteristics were measured. Shrub and tree percentages are frequency data based on the number of times a given plant species appeared on 49 1-m² quadrat plots for the study plot and on 80 to 100 1-m² quadrat plots for four or five bird territories per species.

Habitat variables	Pinyon/ juniper Mt. big sagebrush	Black- headed grosbeak	Chipping sparrow	Lazuli bunting	MacGillivray's warbler	Robin	Rufous- sided Towhee
Litter %	27.1 ^{ab}	33.5 ^{bc}	35.9 ^{bc}	24.9 ^{ab}	19.4 ^a	43.0 ^c	34.3 ^{bc}
Bare %	32 ^c	29 ^c	25 ^{bc}	11 ^a	11 ^a	20 ^{ab}	23 ^b
Downed wood material % volume/1.0, m ³	1.2 ^a	1.0 ^a	2.6 ^b	0.7 ^a	1.3 ^{ab}	1.1 ^a	1.3 ^{ab}
Grass % volume/0.25, m ³	15.4 ^{cd}	10.6 ^{bc}	4.4 ^a	44.0 ^e	27.9 ^d	8.4 ^{ab}	13.6 ^{bc}
Forb % volume/0.25, m ³	9.1 ^e	2.0 ^a	4.1 ^{bc}	7.3 ^d	5.4 ^c	2.2 ^a	2.3 ^{ab}
Shrub % volume/1.0, m ³	9.7 ^{cde}	2.1 ^a	12.9 ^{de}	13.5 ^e	9.5 ^{cd}	4.7 ^{ab}	7.3 ^{bc}
Grass maximum height, m	0.47 ^a	0.52 ^b	0.65 ^c	0.80 ^d	0.73 ^{cd}	0.52 ^b	0.49 ^{ab}
Forb maximum height, m	0.29 ^{bc}	0.18 ^a	0.33 ^c	0.32 ^c	0.26 ^{ab}	0.21 ^a	0.20 ^a
Shrub maximum height, m	1.72 ^{ab}	1.66 ^a	2.00 ^b	1.76 ^{ab}	1.82 ^{ab}	1.66 ^a	1.91 ^b
Tree maximum height, m	4.1 ^a	2.6 ^b	2.8 ^b	2.6 ^b	2.7 ^b	2.5 ^b	2.5 ^b
Shrub %							
Mountain big sagebrush	86	91	95	98	69	88	82
Curleaf mountain mahogany	60	51	75	3	34	51	67
Singleleaf pinyon pine	44	33	38	3	15	27	32
Oregon grape	38	31	45	63	34	40	24
Low rabbitbrush	24	26	40			26	18
Rose	22	18		78	48	24	18
Chokecherry	20	9	10	73	57	9	13
Elderberry	12						
Current	10	1		23	19	6	7
Black sagebrush	6			8	8		1
Buckwheat	6	57	75	30	36	55	54
Quaking aspen	4	1			5	4	2
White fire	2		3	1		1	
Broom snakeweed	2	53	50	56	49	43	52
Horsebrush		7	23	28	14	24	7
Rubber rabbitbrush		9				3	5
Serviceberry		3			5	2	6
Pricklypear		14	45	8	3	20	16
Snowberry		7	23	38	22	17	17
Trees %							
Curleaf mountain mahogany	41	35	40	2	25	29	44
Singleleaf pinyon pine	37	35	20	13	14	18	35
Quaking aspen	6	1		26	10	7	4
Chokecherry	6	2			11	1	2
White fir		3	3	6		2	
Limber pine			3	1			

Means within rows sharing the same superscripts are not statistically different, based on Kruskal-Wallis nonparametric tests, probability level 5 percent (Hintze 1992).

Table 9. Mountain big sagebrush study plot: comparisons of vegetative characteristics and bird species' territories having the highest density within the study plot. The data for the bird species are based on four or five territories. See footnotes of table 1 for explanation of how characteristics were measured. Shrub and tree percentages are frequency data based on the number of times a given plant species appeared on 49 1-m² quadrat plots for the study plot and on 80 to 100 1-m² quadrat plots for four or five bird territories per species.

Habitat variables	Mountain big sagebrush	Brewer's sparrow	Green-tailed towhee	House wren	Yellow-bellied sapsucker
Litter %	29 ^a	37 ^b	51 ^c	37 ^b	45 ^{bc}
Bare %	59 ^a	54 ^a	42 ^b	43 ^b	37 ^b
Downed wood material % volume/1.0, m ³	1.2 ^a	3.1 ^b	2.8 ^{ab}	1.6 ^a	2.3 ^{ab}
Grass % volume/0.25, m ³	12.4 ^a	8.8 ^b	8.6 ^b	12.8 ^a	15.1 ^a
Forb % volume/0.25, m ³	10.8 ^a	3.3 ^b	2.9 ^b	3.2 ^b	3.3 ^b
Shrub % volume/1.0, m ³	12 ^a	17 ^a	15 ^a	6 ^b	7 ^b
Grass maximum height, m	0.46 ^a	0.49 ^{ab}	0.53 ^b	0.46 ^a	0.42 ^a
Forb maximum height, m	0.40 ^a	0.30 ^b	0.29 ^b	0.25 ^c	0.21 ^c
Shrub maximum height, m	1.2 ^a	1.1 ^a	1.2 ^a	1.6 ^b	1.7 ^b
Tree maximum height, m	0.7 ^a	0.0 ^b	0.0 ^b	4.5 ^c	5.8 ^c
Shrub %					
Mountain big sagebrush	94	100	100	81	75
Snowberry	76	90	76	63	74
Buckwheat	60	75	96	46	31
Bitterbrush	48	13	46	31	26
Rubber rabbitbrush	30	46	55	19	40
Curleaf mountain mahogany	24	1	22	31	14
Oregon grape	22	21	10	17	9
Horsebrush	12	16	24	16	13
Rose	10	11	4	31	39
Black sagebrush	10	10	30	11	
Serviceberry	6	3	6	4	8
Chokecherry	4	2	1	1	6
Pricklypear	4		1		1
Singleleaf pinyon pine	4		8	12	13
Martin ceanothus	2		1		
Current	2			1	1
Quaking aspen	2			19	35
Willow	2			3	3
Trees %					
Curleaf mountain mahogany	8			30	11
Singleleaf pinyon pine	2			20	14
Quaking aspen	2			23	33
White fir	2			18	19
Limber pine				7	1
Engelmann spruce					1
Utah juniper					3

Means within rows sharing the same superscripts are not statistically different, based on Kruskal-Wallis nonparametric tests, probability level 5 percent (Hintze 1992).

Table 10. Mountain big sagebrush-mixed conifer study plot: comparisons of vegetative characteristics and bird species' territories having the highest density within the study plot. The data for the bird species are based on four or five territories. See footnotes of table 1 for explanation of how characteristics were measured. Shrub and tree percentages are frequency data based on the number of times a given plant species appeared on 49 1-m² quadrat plots for the study plot and on 80 to 100 1-m² quadrat plots for four or five bird territories per species.

Habitat variables	Mt. Big sagebrush- conifer	Yellow- rumped warbler	Clark's nutcracker	Hairy woodpecker	Hermit thrush	Northern flicker	Red- breasted nuthatch	Ruby- crowned kinglet	Vesper sparrow	Warbling vireo	Western tanager
Litter %	65 ^{de}	45 ^{bc}	50 ^{bcd}	33 ^b	82 ^f	51 ^{cd}	64 ^{de}	67 ^{def}	7 ^a	68 ^{ef}	70 ^{ef}
Bare %	34 ^{cd}	55 ^c	48 ^{de}	17 ^{ab}	11 ^a	47 ^{de}	32 ^c	25 ^{bc}	17 ^{ab}	23 ^{bc}	26 ^{bc}
Downed wood material % volume/1.0, m ³	2.0 ^{bc}	0.9 ^a	1.5 ^{ab}	1.5 ^{ab}	2.9 ^{cd}	1.3 ^{ab}	4.0 ^d	2.1 ^{bc}	0.8 ^a	1.6 ^{ab}	2.8 ^{cd}
Grass % volume/0.25, m ³	7.4 ^c	6.1 ^c	1.2 ^a	6.2 ^c	0.7 ^a	7.0 ^c	2.5 ^{ab}	5.0 ^{bc}	11.4 ^d	8.1 ^c	1.5 ^{ab}
Forb % volume/0.25, m ³	8.3 ^{de}	4.9 ^{bc}	2.1 ^a	2.7 ^a	3.9 ^{bc}	5.7 ^{cd}	6.6 ^{cde}	3.4 ^{ab}	1.5 ^a	8.8 ^e	3.3 ^{ab}
Shrub % volume/1.0, m ³	7.1 ^c	2.7 ^{ab}	1.3 ^a	3.9 ^{abc}	2.2 ^a	4.7 ^{bc}	2.6 ^{ab}	2.3 ^a	4.7 ^{bc}	5.2 ^{bc}	2.7 ^{ab}
Grass maximum height, m	0.26 ^{cd}	0.39 ^e	0.34 ^{de}	0.29 ^{cd}	0.17 ^a	0.35 ^{de}	0.25 ^{bc}	0.18 ^{ab}	0.36 ^e	0.38 ^e	0.22 ^{abc}
Forb maximum height, m	0.28 ^{bc}	0.22 ^a	0.23 ^a	0.23 ^a	0.24 ^{ab}	0.20 ^a	0.24 ^{ab}	0.20 ^a	0.20 ^a	0.30 ^c	0.22 ^a
Shrub maximum height, m	1.6 ^{bc}	1.6 ^{bc}	1.4 ^b	1.6 ^{bc}	2.0 ^d	1.5 ^{bc}	2.2 ^d	1.8 ^{cd}	0.8 ^a	1.6 ^{bc}	1.9 ^{cd}
Tree maximum height, m	7.5 ^{bc}	7.1 ^b	6.8 ^b	8.1 ^{bc}	15.1 ^e	8.7 ^{bcd}	10.7 ^d	13.9 ^e	1.7 ^a	9.2 ^{cd}	15.6 ^e
Shrub %											
Snowberry	80	65	78	93	92	78	75	80	67	83	75
White fir	46	38	47	63	92	55	72	75	17	53	75
Quaking aspen	40	50	35	43	42	55	62	60	10	47	75
Mt. big sagebrush	36	40	33	35		35	30	25	35	32	25
Black sagebrush	34	35	53	50		45	20	5	87	5	10
Horsebrush	20	5	35	38		28	5	8	50	2	
Low rabbitbrush	18	13	22	25	13	13	7	7	63	12	8
Limber pine	12	3	70	20		5	3	7	5	8	10
Buckwheat	10	8	12	20		5	10	7	35		5
Oregon grape	10	3	17	23	28	25	11	10	3	17	15
Serviceberry	8	3	12	28		5		2	20		
Elderberry	4	3	3	18	13		8	2	2	2	3
Singleleaf pinyon pine	2		3	3		5		5	3		
Rose	2		3	3				3		5	
Douglas-fir	2	5	2		2	45		3		3	
Current					5				2		
Fringed sage						10					
Engelmann spruce						3					8
Pricklypear									3		
Tress %											
White fir	55	50	50	48	95	58	88	88	10	58	93
Quaking aspen	43	40	32	43	63	45	45	53	17	62	58
Douglas-fir	12	3	20		3	5		12		5	10
Limber pine	8	15	10	13	3	5	15	12		8	13
Engelmann spruce					3	5	5	7		2	5

Means within rows sharing the same superscripts are not statistically different, based on Kruskal-Wallis nonparametric tests, probability level 5 percent (Hintze 1992).

Table 11. Mixed-conifer study plot: comparisons of vegetative characteristics and bird species' territories having the highest density within the study plot. The data for the bird species are based on four or five territories. See footnotes of table 1 for explanation of how characteristics were measured. Shrub and tree percentages are frequency data based on the number of times a given plant species appeared on 49 1-m² quadrat plots for the study plot and on 80 to 100 1-m² quadrat plots for four or five bird territories per species.

Habitat variables	Mixed conifer	Brown creeper	Mountain chickadee	Townsend's solitaire	White-breasted nuthatch
Litter %	55 ^a	55 ^a	85 ^b	60 ^a	61 ^a
Bare %	4 ^a	6 ^a	3 ^a	7 ^a	4 ^a
Downed wood material % volume/1.0, m ³	4 ^a	3 ^a	3 ^a	5 ^a	4 ^a
Grass % volume/0.25, m ³	0.6 ^a	1.7 ^b	0.6 ^a	0.6 ^a	0.2 ^a
Forb % volume/0.25, m ³	0.4 ^a	0.4 ^a	0.3 ^a	0.4 ^a	0.1 ^a
Shrub % volume/1.0, m ³	0.8 ^a	4.1 ^a	0.9 ^a	2.7 ^a	1.5 ^a
Grass maximum height, m	0.07 ^{ab}	0.13 ^b	0.11 ^b	0.13 ^b	0.03 ^a
Forb maximum height, m	0.02 ^{ab}	0.07 ^{cd}	0.03 ^{bc}	0.04 ^{cd}	0.01 ^a
Shrub maximum height, m	1.4 ^b	0.9 ^a	1.3 ^b	1.2 ^{ab}	1.4 ^b
Tree maximum height, m	14.4 ^{bc}	12.0 ^a	17.7 ^d	14.1 ^b	16.1 ^{cd}
Shrubs %					
Engelmann spruce	56	57	72	57	57
Common juniper	56	48	32	40	53
Limber pine	24	12	10	27	25
Quaking aspen	20	15	25	23	5
Gooseberry	14		2	10	7
Pine manzanita	14	5		18	3
Douglas-fir	10		18	10	3
Bristlecone pine	4		3		
Oregon grape	4		5	5	
Whitestem golden weed	2		2	3	2
American raspberry	2			2	
Martin ceanothus			2		
Tress %					
Engelmann spruce	90	87	95	77	87
Limber pine	67	78	67	65	82
Douglas-fir	45	8	35	27	37
Quaking aspen	14	20	27	13	3
Bristlecone pine	10	3		3	12

Means within rows sharing the same superscripts are not statistically different, based on Kruskal-Wallis nonparametric tests, probability level 5 percent (Hintze 1992).

Table 12. Mixed conifer-alpine study plot: comparisons of vegetative characteristics and bird species' territories having the highest density within the study plot. The data for the bird species are based on four or five territories. See footnotes of table 1 for explanation of how characteristics were measured. Shrub and tree percentages are frequency data based on the number of times a given plant species appeared on 49 1-m² quadrat plots for the study plot and on 80 to 100 1-m² quadrat plots for four or five bird territories per species.

Habitat variables	Conifer alpine	Cassin's finch	Dark-eyed junco	Mountain bluebird	Pine siskin
Litter %	11 ^a	31 ^{bc}	44 ^c	23 ^b	26 ^b
Bare %	55 ^c	40 ^b	24 ^a	45 ^{bc}	44 ^{bc}
Downed wood material % volume/1.0, m ³	1.2 ^b	1.1 ^{ab}	1.5 ^b	0.6 ^a	0.6 ^a
Grass % volume/0.25, m ³	4.4 ^{ab}	4.7 ^{ab}	3.8 ^a	5.6 ^b	3.8 ^a
Forb % volume/0.25, m ³	4.1 ^{ab}	3.8 ^{ab}	3.7 ^a	5.4 ^b	3.7 ^a
Shrub % volume/1.0, m ³	4.0 ^a	3.4 ^a	3.3 ^a	3.1 ^a	1.8 ^a
Grass maximum height, m	0.26 ^a	0.44 ^c	0.41 ^{bc}	0.46 ^c	0.36 ^b
Forb maximum height, m	0.15 ^a	0.19 ^b	0.24 ^b	0.20 ^b	0.18 ^{ab}
Shrub maximum height, m	1.4 ^b	1.1 ^b	1.5 ^b	0.6 ^a	0.6 ^a
Tree maximum height, m	2.8 ^a	6.4 ^b	5.5 ^b	3.2 ^a	6.7 ^b
Shrubs %					
White stem goldenweed	90	95	90	98	90
Common juniper	46	75	62	38	28
Quaking aspen	32	35	77	10	3
Gooseberry	22	23	12	8	18
Oregon grape	16	3	3		
Snowberry	16	13	7	20	18
Engelmann spruce	12	18	23	5	25
Current	12	3	2	23	10
Limber pine	8	10	12	8	5
Martin ceanothus	4	3	8		
Trees %					
Quaking aspen	20	23	33	10	
Limber pine	15	38	25	15	15
Engelmann spruce	8	18	27	10	30

Means within rows sharing the same superscripts are not statistically different, based on Kruskal-Wallis nonparametric tests, probability level 5 percent (Hintze 1992).

Table 13. Alpine study plot: comparisons of vegetative characteristics and water pipit territories. Data for the water pipit are based on four or five territories. See footnotes of table 1 for explanation of how characteristics were measured. Shrub and tree percentages are frequency data based on the number of times a given plant species appeared on 49 1-m² quadrat plots for the study plot and on 80 to 100 1-m² quadrat plots for four or five bird territories per species.

	Alpine	Water pipit		Alpine	Water pipit
Litter %	13	6	Shrub maximum height, m	0.10	0.08
Bare %	42 ^a	14 ^b	Tree maximum height, m	0.00	0.00
Downed wood material % volume/1.0, m ³	0.04	0.04	Shrubs%		
Grass % volume/0.25, m ³	2.4 ^a	2.8 ^b	Gooseberry	38	67
Forb % volume/0.25, m ³	7.8 ^a	2.2 ^b	White stem goldenweed	12	23
Shrub % volume/1.0, m ³	0.8	0.1	Limber pine	2	10
Grass maximum height, m	0.10	0.11	Current	2	
Forb maximum height, m	0.09	0.07	Quaking aspen		2

Means within rows sharing the same superscripts are not statistically different, based on Kruskal-Wallis nonparametric tests, probability level 5 percent (Hintze 1992).

Appendix: Common and Scientific Names of Birds and Plants Cited in the Text and Tables

Birds

American crow	<i>Corvus brachyrhynchos</i>
American kestrel	<i>Falco sparverius</i>
American robin	<i>Turdus migratorius</i>
ash-throated flycatcher	<i>Myiarchus cinerascens</i>
barn swallow	<i>Hirundo rustica</i>
black-billed magpie	<i>Pica pica</i>
black-chinned hummingbird	<i>Archilochus alexandri</i>
black-headed grosbeak	<i>Pheucticus melanocephalus</i>
black-throated gray warbler	<i>Dendroica nigrescens</i>
black-throated sparrow	<i>Amphispiza bilineata</i>
blue grouse	<i>Dendragapus obscurus</i>
Brewer's blackbird	<i>Euphagus cyanocephalus</i>
Brewer's sparrow	<i>Spizella breweri</i>
broad-tailed hummingbird	<i>Selasphorus platycercus</i>
brown creeper	<i>Certhia americana</i>
brown-headed cowbird	<i>Molothrus ater</i>
bushtit	<i>Psaltriparus minimus</i>
calliope hummingbird	<i>Stellula calliope</i>
Cassin's finch	<i>Carpodacus cassinii</i>
chipping sparrow	<i>Spizella passerina</i>
Clark's nutcracker	<i>Nucifraga columbiana</i>
common nighthawk	<i>Chordeiles minor</i>
common poorwill	<i>Phalaenoptilus nuttallii</i>
common raven	<i>Corvus corax</i>
dark-eyed junco	<i>Junco hyemalis</i>
dusky flycatcher	<i>Empidonax oberholseri</i>
evening grosbeak	<i>Coccothraustes vespertinus</i>
ferruginous hawk	<i>Buteo regalis</i>
golden-crowned kinglet	<i>Regulus satrapa</i>
golden eagle	<i>Aquila chrysaetos</i>
great horned owl	<i>Bubo virginianus</i>
green-tailed towhee	<i>Pipilo chlorurus</i>
hairy woodpecker	<i>Picoides villosus</i>
hermit thrush	<i>Catharus guttatus</i>
horned lark	<i>Eremophila alpestris</i>
house wren	<i>Troglodytes aedon</i>
lark sparrow	<i>Chondestes grammacus</i>
lazuli bunting	<i>Passerina amoena</i>
loggerhead shrike	<i>Lanius ludovicianus</i>
long-billed curlew	<i>Numenius americanus</i>
long-eared owl	<i>Asio otus</i>
MacGillivray's warbler	<i>Oporornis tolmiei</i>
mountain bluebird	<i>Sialia currucoides</i>
mountain chickadee	<i>Parus gambeli</i>
mourning dove	<i>Zenaida macroura</i>
northern flicker	<i>Colaptes auratus</i>
northern goshawk	<i>Accipiter gentilis</i>
northern harrier	<i>Circus cyaneus</i>
olive-sided flycatcher	<i>Contopus borealis</i>
orange-crowned warbler	<i>Vermivora celata</i>
pine siskin	<i>Carduelis pinus</i>
pinyon jay	<i>Gymnorhinus cyanocephalus</i>
plain titmouse	<i>Parus inornatus</i>
prairie falcon	<i>Falco mexicanus</i>

red-breasted nuthatch	<i>Sitta canadensis</i>
red-tailed hawk	<i>Buteo jamaicensis</i>
rock wren	<i>Salpinctes obsoletus</i>
rough-legged hawk	<i>Buteo lagopus</i>
rough-winged swallow	<i>Stelgidopteryx serripennis</i>
rosy finch	<i>Leucosticte arctoa</i>
ruby-crowned kinglet	<i>Regulus calendula</i>
rufous-sided towhee	<i>Pipilo erythrophthalmus</i>
sage grouse	<i>Centrocercus urophasianus</i>
sage sparrow	<i>Amphispiza belli</i>
sage thrasher	<i>Oreoscoptes montanus</i>
savannah sparrow	<i>Passerculus sandwichensis</i>
scrub jay	<i>Aphelocoma coerulescens</i>
sharp-shinned hawk	<i>Accipiter striatus</i>
Steller's jay	<i>Cyanocitta stelleri</i>
Swainson's hawk	<i>Buteo swainsoni</i>
Townsend's solitaire	<i>Myadestes townsendi</i>
tree swallow	<i>Tachycineta bicolor</i>
turkey vulture	<i>Cathartes aura</i>
vesper sparrow	<i>Poocetes gramineus</i>
violet-green swallow	<i>Tachycineta thalassina</i>
Virginia's warbler	<i>Vermivora virginia</i>
warbling vireo	<i>Vireo gilvus</i>
water pipit	<i>Anthus spinoletta</i>
western kingbird	<i>Tyrannus verticalis</i>
western meadowlark	<i>Sturnella neglecta</i>
western tanager	<i>Piranga ludoviciana</i>
western wood-pewee	<i>Contopus sordidulus</i>
white-breasted nuthatch	<i>Sitta carolinensis</i>
white-crowned sparrow	<i>Zonotrichia leucophrys</i>
white-throated swift	<i>Aeronautes saxatalis</i>
Williamson's sapsucker	<i>Sphyrapicus thyroideus</i>
Wilson's warbler	<i>Wilsonia pusilla</i>
yellow-bellied sapsucker	<i>Sphyrapicus varius</i>
yellow-rumped warbler	<i>Dendroica coronata</i>

Plants

American red raspberry	<i>Rubus idaeus</i>
black sagebrush	<i>Artemisia nova</i>
antelope bitterbrush	<i>Purshia tridentata</i>
bristlecone pine	<i>Pinus longaeva</i>
broom snakeweed	<i>Gutierrezia sarothrae</i>
buckwheat	<i>Eriogonum</i> spp.
bud sagebrush	<i>Artemisia spinescens</i>
chokecherry	<i>Prunus virginiana</i>
common juniper	<i>Juniperus communis</i>
common winterfat	<i>Eurotia lanata</i>
currant	<i>Ribes</i> spp.
curleaf mountain mahogany	<i>Cercocarpus ledifolius</i>
Douglas-fir	<i>Pseudotsuga menziesii</i>
elderberry	<i>Sambucus caerulea</i>
Engelmann spruce	<i>Picea engelmannii</i>
fringed sagebrush	<i>Artemisia frigida</i>
gooseberry	<i>Ribes</i> spp.

continued

Appendix — Continued

green ephedra	<i>Ephedra viridis</i>	shadscale	<i>Atriplex confertifolia</i>
horsebrush	<i>Tetradymia</i> spp.	singleleaf pinyon pine	<i>Pinus monophylla</i>
limber pine	<i>Pinus flexilis</i>	rose	<i>Rosa</i> spp.
low rabbitbrush	<i>Chrysothamnus viscidiflorus</i>	serviceberry	<i>Amelanchier utahensis</i>
Martin ceanothus	<i>Ceanothus martinii</i>	spiny hopsage	<i>Grayia spinosa</i>
mountain big sagebrush	<i>Artemisia tridentata</i> ssp. <i>vaseyana</i>	snowberry	<i>Symphoricarpos</i> spp.
Nevada ephedra	<i>Ephedra nevadensis</i>	Utah juniper	<i>Juniperus osteosperma</i>
Oregon grape	<i>Mahonia repens</i>	western dogwood	<i>Cornus stolonifera</i>
pine manzanita	<i>Arctostaphylos parryana</i>	white fir	<i>Abies concolor</i>
pricklypear	<i>Opuntia</i> spp.	whitestem goldenweed	<i>Haplopappus macronema</i>
quaking aspen	<i>Populus tremuloides</i>	willow	<i>Salix</i> spp.
rubber rabbitbrush	<i>Chrysothamnus nauseosus</i>	Wyoming big sagebrush	<i>Artemisia tridentata</i> ssp. <i>wyomingensis</i>
