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FOUR VEGETATIONAL TYPES
IN CENTRAL OREGON**

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Bird Populations in Four Vegetational Types in Central Oregon

by

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Abstract

A long-term study of birds to obtain baseline population data in relatively undisturbed major plant types was started in Deschutes County, Oregon, in 1971. Four study areas were established. The big sagebrush (*Artemisia tridentata*) and western juniper (*Juniperus occidentalis*) areas are located about 34 and 31 km southeast of Bend, Oregon, on open range and on the Horse Ridge Research Natural Area, which are administered by the Bureau of Land Management. The ponderosa (*Pinus ponderosa*) and lodgepole pine (*Pinus contorta*) areas are in the Pringle Falls Research Natural Area about 56 km southwest of Bend on land administered by the U.S. Forest Service. Plant surveys of each area revealed the following percentages of tree canopy, tree reproduction, shrub, and herb coverage, respectively: sagebrush—0.0, 0.0, 22.4, 29.0; juniper—17.1, 0.2, 5.6, 18.6; ponderosa—37.3, 2.6, 25.1, 2.8; and lodgepole—45.7, 4.1, 35.4, and 12.6.

The estimated numbers of breeding bird territories per 40.5 ha by the spot mapping method for 1971-73 were: sagebrush—86, 94, 93; juniper—165, 214, 229; ponderosa—125, 214, 201; and lodgepole—110, 132, and 132. These data show yearly variations in the bird population estimates and diversity but rankings in a given year by type are reasonably uniform. Changes within types are normal and should be considered carefully when evaluating environmental influences.

Winter bird numbers obtained by the Emlen transect count method were more variable. The 1971-73 estimated numbers of birds per 40.5 ha were: sagebrush—48, 22, 1; juniper—91, 239, 39; ponderosa—137, 24, 7; and lodgepole—43, 63, 11. Many of the wintering birds are arboreal and their abundance seemed related to known variations in the tree seed crop and to weather conditions.

Increasing human populations are causing rapid changes in our environment. Such changes must be monitored so that decision makers can evaluate their importance and detect subtle changes that may warn of an impending environmental problem. Some birds and mammals are thought to be well suited as indicators of some aspects of the environment's ecological well-being. Because of their mobility, birds may be exceptionally sensitive indicators of short-term environmental change (Johnson 1974). The first problem in attempting to monitor wild birds subjected to human disturbance is to establish baseline data on populations with which future changes can be compared. Because bird species diversities and population numbers are normally variable (Kendeigh 1944; Hagar 1960; Balda 1975), several years' data are needed for adequate baseline information. With these

considerations in mind, a long-range investigation was started in 1971 to gather baseline data on bird population numbers and species compositions in carefully described and relatively undisturbed forest and range habitat types. This preliminary report includes data from the first 3 years of the investigation.

The scientific names of plants and birds mentioned in this report appear in the tables.

Study Areas

Study areas were sought which would be within large blocks of relatively undisturbed habitat of uniform type. Undisturbed sites are scarce; almost all areas have been, or are being, disturbed by some form

of human activity. Study areas were desired in four plant types as follows: (1) big sagebrush, (2) western juniper, (3) ponderosa pine, and (4) lodgepole pine. These are the most widespread, accessible, and heavily disturbed plant types in central and eastern Oregon and were thought deserving of first attention. The mixed conifers and the alpine vegetation types should also be investigated.

Big Sagebrush

The study area for this type is located in Millican Basin, about 34 km southeast of Bend, Oregon (Fig. 1), and is administered by the Bureau of Land Management. It is an *Artemesia tridentata*/*Festuca idahoensis* community similar to the one described by Daubenmire (1970). The relatively flat basin is roughly saucer-shaped with a diameter of about 10-11 km. The bird census grid is located in S 11, T 20 S, R 14 E at an elevation of about 1,311 m, within an elevated area partially surrounded by low basalt

outcroppings, and slopes slightly toward the northeast. Soil is tentatively classed as a fine wind-distributed, pumice-type sandy loam; it is fragile and blows readily when disturbed. There are, however, some areas with rock-pavement and some with gravel. Scattered over the grid are 23 basalt outcroppings of various sizes (the number varies according to interpretation).

The weather station nearest to the study area of comparable altitude and plant cover is at Brothers, about 32 km to the east. Average weather for this station was calculated from data collected by the U.S. Environmental Data Service (1964-73). Annual average temperature is 6.2 C, ranging from -2.8 C in December to 17.0 C in July. Annual average precipitation is 27.4 cm, ranging from 7.1 mm in September to 4.7 cm (mostly snow) in November. Spring and summer are generally warm to hot and dry, but showers are reasonably common in spring. Prevailing light to moderate southwesterly winds are customary in this area. Before 1900, a few

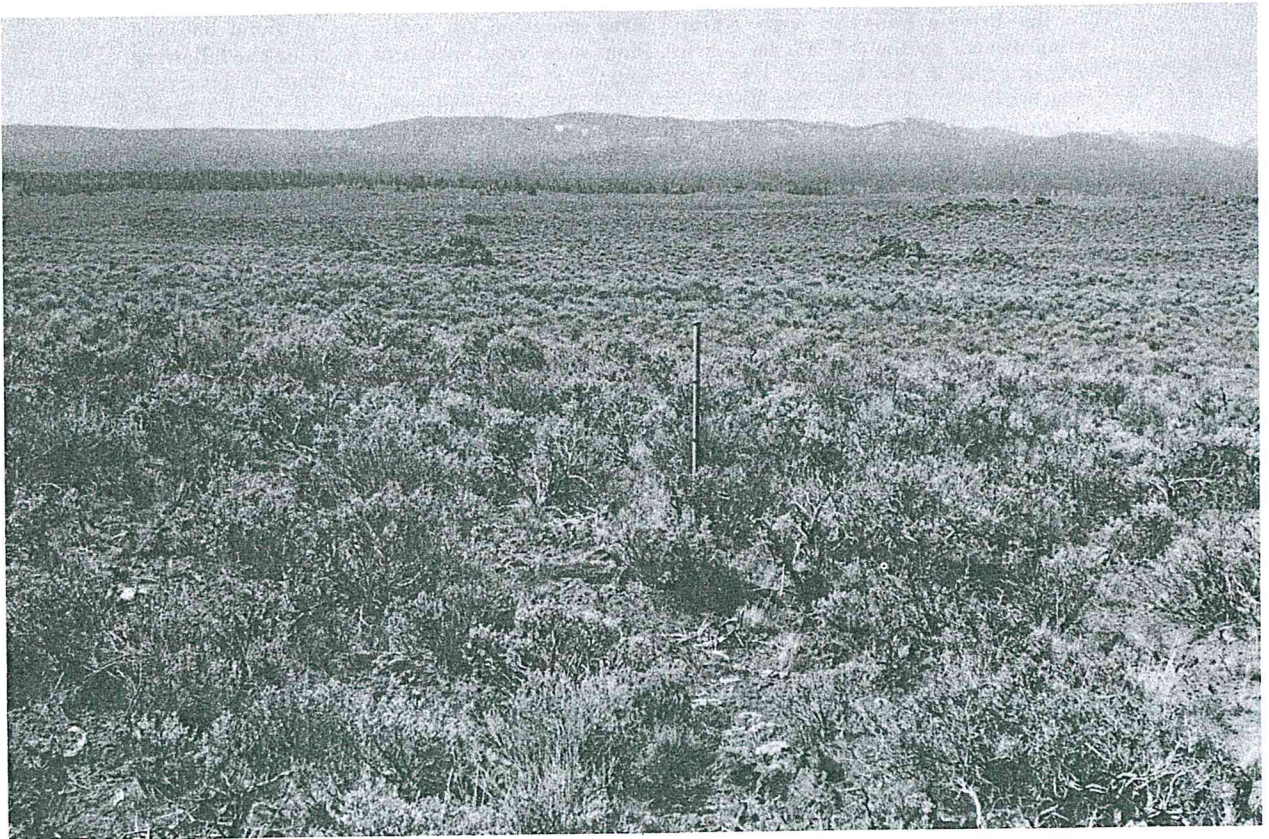


Fig. 1. Big sagebrush is the dominant plant over vast areas in the arid West. Basalt outcroppings frequently dot this range in central Oregon. Despite its aridity and low plant diversity it is an important habitat for birds and many other wildlife species. (Photo by Jay S. Gashwiler)

homesteads had been filed in the Millican Valley or Basin (Brogan 1965) and the bird census grid and its surroundings appear to have been homesteaded and abandoned. Because of the outcroppings on the area, it is doubtful if the study area was cultivated.

The present plant cover appears to be normal for this type of habitat under its primary use—grazing by cattle. Cattle are generally turned onto the area in the fall, after the grasses have seeded. Although the date is usually after 1 September, it varies considerably. The cattle are usually taken off the range in late fall or early winter. While on the area they are watered about 2.0 km northwest of the grid which helps control the usage.

Millican Basin is also used for cross-country motorcycle rides and races; such usage has increased greatly within the last 2-3 years. Bureau of Land Management personnel have located the trails to avoid the basalt outcrops, the bird population grid, and areas immediately adjacent to the grid. Nearest approach by the trails to the grid is about 0.6 km and that is only near one corner. Most of the grid has a relatively wide buffer zone, and it is believed that the study area is not presently affected, at least not greatly, by motorcycle activity. Antelope (*Antilocapra americana*) have been seen on the area throughout the year, and mule deer (*Odocoileus hemionus*) use it primarily for wintering.

Western Juniper

The juniper study area is in a virgin stand of western juniper within the Horse Ridge Research Natural Area administered by the Bureau of Land Management (Fig. 2). Hall (Franklin et al. 1972) described the vegetation of this area as being a *Juniperus occidentalis*/*Artemisia tridentata*/*Carex filifolia* community. It is about 31 km southeast of Bend in S 15 and 22, T 19 S, R 14 E in Deschutes County, Oregon (Franklin et al. 1972). The bird census grid is at an elevation of about 1,372 m on top of the low ridge running across the Natural Area in a northwesterly-southeasterly direction. The terrain is gently sloping, mostly in a northeasterly to northerly direction, although some slopes have an easterly aspect. The soil is a fragile windborne, pumice-type sandy loam. Basalt outcroppings form a low broken face exposed toward the north and northeast, but they also surface on the southwestern part of the grid. Some rock-pavement and gravel areas are present.

The nearest weather station with roughly comparable vegetation and elevation is at Bend. Long-term average weather at this station reveals an annual temperature of 7.9 C with a range of -1.0 C in January to 17.7 C in July. Total average annual precipitation was 30.6 cm, ranging from 1.1 cm in

September to 4.6 cm in January. Since Bend is near the more humid western edge of the juniper type (Driscoll 1964), the study area may be somewhat drier; conversely, it is about 274 m higher than Bend and thus may receive more precipitation. Moisture occurs mostly in winter as snow, but spring showers are reasonably common and provide water for little rock basins in the outcroppings. These intermittent water sources are used intensively for drinking and bathing by the songbirds. Winds are light to moderately strong, blowing from a southwesterly or westerly direction, similar to those in the nearby sagebrush area.

Livestock have grazed the Natural Area for many years; cattle are turned on the area in the early fall and removed in late fall or early winter. Because the bird census grid is about 2.5 km from the nearest watering place, livestock usage in the grid is not great. The abundance of threadleaved sedge on the area is considered an indication of light livestock disturbance (Franklin et al. 1972). Mule deer are present on the area year-round; however, it is primarily a wintering range. Although antelope have not been noted on the Natural Area, they probably range there occasionally from nearby Millican Basin.

Ponderosa Pine

The ponderosa study area is located in Unit 2 (eastern) of the Pringle Falls Research Natural Area (Fig. 3). It is in a *Pinus ponderosa*/*Purshia tridentata* plant community (Franklin et al. 1972). The Natural Area is within the Pringle Falls Experimental Forest where research work is directed by the Pacific Northwest Forest and Range Experiment Station and is administered by the Deschutes National Forest staff. It is about 56 km southwest of Bend in S 34 and 35, T 21 S, R 9 E (Franklin et al. 1972). The bird census grid is at an elevation of about 1,372 m with terrain sloping gently toward the west. Soil is composed of aerially distributed pumice which forms a sandy-loam type that is easily disturbed. A few widely scattered basalt rocks are present on the ground surface.

The nearest weather station with comparable vegetation and altitude is at Wickiup Dam about 3 km south of the area. Average temperature and precipitation were calculated from the annual summaries (U.S. Environmental Data Service 1964-73). The average temperature is 6.8 C ranging from -2.5 C in January to 16.6 C in July, and precipitation averages 52 cm per year ranging from 1.2 cm in July to 11.0 cm (mostly snow) in January. Summers generally are clear and dry, but winters often are overcast and wet. The occasional wind generally

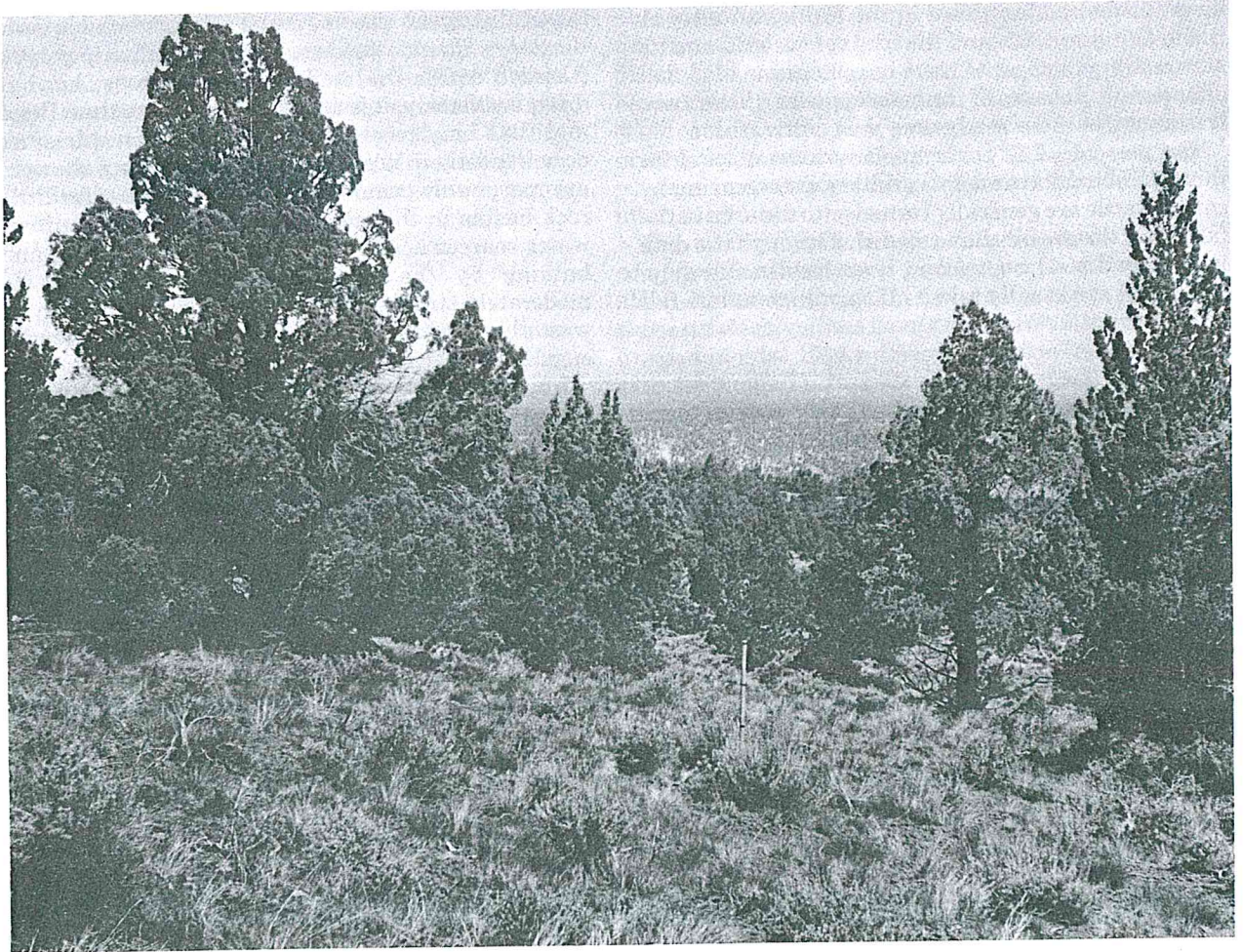


Fig. 2. Western juniper forests have widely spaced trees with limbs, often down to ground level. Between the trees big sagebrush, rabbitbrush, bluebunch wheatgrass, and other species grow. Many birds breed in this forest and the juniper berries are an important source of food for large populations of wintering birds. Western juniper is valuable wildlife habitat in central Oregon. (Photo by Jay S. Gashwiler)

blows from a westerly or southwesterly direction and is frequently gusty.

The Natural Area was part of a sheep allotment until 1960. Although the Area was grazed, no readily visible evidence of grazing is apparent and the habitat is considered essentially natural. Fires, however, have been controlled, which has created an unnatural situation. Mule deer are present during all seasons except for a period in winter.

Lodgepole Pine

The lodgepole pine study area is in Unit 1 (western) of the Pringle Falls Research Natural Area (Fig. 4). It

is in a *Pinus contorta/Purshia tridentata* plant community (Franklin et al. 1972). Since this unit is near the ponderosa area, most of the information given for it also applies to the lodgepole area. Unit 1 includes most of S 3, T 21 S, R 9 E (Franklin et al. 1972). It lies at an elevation of about 1,311 m with a flat terrain and is thought to be subirrigated by seepage from Wickiup Reservoir.

The lodgepole bird census grid also was within a sheep allotment, which was grazed until 1960. Grazing apparently caused no changes of consequence, and presently the area is considered essentially undisturbed by man although fires have been controlled. Mule deer and elk (*Cervus canadensis*) frequent this area, except for a period in winter.

Methods

Plant Measurements

Vegetation was sampled on the four bird census grids. The sagebrush and juniper grids had 144 (12×12) stations each spaced 40.2 m apart and covered 19.6 ha. In 1973, the perimeter stations in juniper were deleted and it became a 10×10 grid. Ponderosa and lodgepole grids had 100 (10×10) stations with similar spacing and covered 13.1 ha. Although efforts were made to gather the same types of plant data described by James and Shugart (1970), different methods were used. These methods were devised primarily by Jerry F. Franklin and C. Theodore Dyrness of the Pacific Northwest Forest and Range Experiment Station.

The sampling scheme for describing the plants on the grids involved 0.04-ha circular plots, each with a radius of about 11.3 m. Sixteen of these were randomly chosen per grid in sagebrush and juniper and 13 in ponderosa and lodgepole. On each plot, all

tree stems over 5.1 cm diameter were tallied by species, diameter class, and whether alive or dead. Diameters of all species, except juniper, were measured 1.4 m above ground; junipers were measured at ground level. Since juniper often grows in clumps, each apparently independently rooted branch was considered a stem. Two measuring tapes 22.6 m long and crossed in the center at right angles were placed across the center of each plot, forming a total of 45.2 m of line. Shrub cover and coverage of trees less than 0.9 m in height were measured by the total length of canopy coverage (Daubenmire 1959) of each species intercepted by the 22.6-m plot tapes. A total of 16 mechanically selected herbaceous vegetative microplots was sampled at 3.0-m intervals along the tapes across each of the 0.04-ha plots with a rectangular steel frame 20×50 cm as described by Daubenmire (1959). The frame was placed at right angles along one side of the tape and canopy coverage of each species was estimated by broad classes. A smaller subsample of seedlings and saplings (trees less than 5.1 cm dbh) was taken on one 40.5-m^2



Fig. 3. Old-growth ponderosa pine stands may vary from open park-like conditions to those with dense reproduction or shrub cover. It is especially good habitat for tree-oriented birds. During good seed years large flocks of crossbills and grosbeaks come to these forests to feed and small mammals also respond to this bountiful food supply. (Photo by Jay S. Gashwiler)



Fig. 4. Mature lodgepole pine forests in central Oregon form nearly pure stands and have a large number of live and dead stems per hectare. The ground is often crisscrossed with fallen trees. Bitterbrush forms a dense shrub cover wherever light penetrates to the forest floor. The black-backed three-toed woodpeckers find this an especially good place to search for bark beetles and woodborers. (Photo by Jay S. Gashwiler)

(radius 3.5 m) plot centered in each of the 0.04-ha plots. Canopy coverage of the trees was obtained from a vertical photograph taken from the ground at the center of each 0.04-ha plot except in juniper which was photographed from the ground obliquely over the plot center. The height of the tallest trees on each 0.04-ha plot was measured with a clinometer.

Ground Surface Cover

Ground surface cover was measured by the method of Daubenmire (1959), which was to tally the types of cover (in this study: bare soil, duff, wood debris under 5.1 cm diam, stone over 5.1 cm diam, logs over 5.1 cm diam, and live plants) the legs of the 20 × 50 cm plots contacted when obtaining the herbaceous plant data. These data were compiled on a frequency of occurrence basis to give the percentage of coverage. Since a leg sometimes contacted more

than one type of surface cover, the total percentages do not necessarily equal 100.

Bird Censuses

Birds were censused during their most stable population periods in the breeding season (April, May, and June) and in winter (December, January, and February). In Illinois, Kendeigh (1944) used the same two periods, but also included July in the breeding census. The spot mapping method was used during the breeding season and the Emlen (1971) line transect method was employed in winter.

The spot mapping censuses were made essentially as was recommended by Svensson et al. (1970). Briefly, the grid lines (each spaced 40.2 m apart) were traversed slowly on foot from north to south or vice versa starting about sunrise. Each singing male bird, other evidence of breeding (e.g., nests and food

gathering), or birds seen were plotted by species and type of observation on a map (scaled about 13 mm = 40.2 m) of the grid. Censuses were made at about 1-week intervals during the breeding season in each type, and the route of travel was rotated between the north and south lines in order not to favor a particular part of the grid. After all weekly censuses were completed, records of each species were combined on individual species maps and clumped observations were considered individual territories. A territory consisted of at least two definite observations of a breeding nature plus one observation of a general nature. In a few instances, two observations of a breeding nature were considered a territory. Fractions of territories along the boundaries were included in density calculations of the number of territories per 40.5 ha. The numbers of breeding season censuses for 1971-73 were: sagebrush, 11, 13, 19; juniper 10, 13, 9; ponderosa, 8, 12, 8; and lodgepole, 8, 12, 9.

Bird censuses along line transects, similar to those described by Emlen (1971), were made on the study areas twice each winter. The census lines were traversed slowly on foot with frequent stops to listen and to confirm bird identities. Right angle distances from the line of travel to first sightings or identifiable sounds and locations of birds were estimated and recorded. The distance estimates were checked occasionally by pacing. Both range finder and triangulation methods were tested as measurements of distances but they were not satisfactory. Sightings of low-flying birds or flocks which were moving around within the habitat for feeding or other purposes were classed as residents. High-flying birds which appeared to be making long movements were not counted. The right angle distance of the first sighting of a flying bird or the average for a flock was considered the observed distance. Each bird of a flock was treated as though it were a single bird in the calculations. It is realized that a flock of birds may be sighted at a greater distance than a single bird and could cause sampling error.

The observed distances for the entire census period were grouped for each species by 3.0- or 6.1-m belts, and the distance where the number of observations declined was considered one-half the average width of strip sampled. Strip width multiplied by the length of line gave the area censused for each species. In compiling the data, the average number of individuals per species for both monthly censuses was considered as the population because the conspicuousness of each species was reasonably uniform throughout the winter period. These data permitted the calculation of the number of birds per 40.5 ha. Since the winter census included all the individuals

encountered, whereas only territorial birds were counted during the breeding season, breeding values should be doubled or the winter values halved for direct comparison between seasons.

Scientific names of plants follow those of Hitchcock et al. (1971). Scientific names of birds are in accord with Robbins et al. (1966) and Eisenmann et al. (1973). Scientific names of mammals agree with those of Burt and Grossenheider (1964).

Results and Discussion

Plant Survey

Plant surveys were made on all four study areas in the spring of 1972. Data for juniper, ponderosa, and lodgepole are presented for that year (Table 1), but because the detailed 1972 sagebrush data were destroyed in an office fire, those for the sagebrush grid are from 1974. Since natural vegetation changes in arid places are relatively slow, a 2-year difference was not considered too important, especially for the shrubs and perennial herbs. The moisture regimes in a given year and the timing of the survey can cause great differences, however, especially for the annual herbs. The shrub data from the sagebrush type were comparable in 1972 and 1974, but the herbs were more abundant in 1974. (The 1974 survey included the small spring annuals that had largely dried and disintegrated in the 1972 survey.)

Big Sagebrush

Only three small western juniper trees were present on the sagebrush grid and none of these were within the vegetation plots. Consequently, tree canopy and reproduction were not represented in the sample analysis.

Live shrubs, primarily big sagebrush and green rabbitbrush, covered 22.4% of the surface area. The coverage was similar to that reported for one area (21%) in Montana by Best (1972) but was about 62% of his other area (36%). In the present study, dead, erect shrubs, mostly big sagebrush and green rabbitbrush, covered 15.6% of the surface. The combined coverage of both living and dead shrubs was 38.0%.

Grass and sedge cover, largely Idaho fescue and cheatgrass brome, covered 17.5% of the surface, a much smaller percentage coverage than Best (1972) found for the two Montana areas (39 and 46%). Many of the herbs on the sagebrush grid were small, short-lived, early spring annuals. Hair-stem *gayophytum*, pink *microsteris*, and tansy mustard were the most abundant herbs. They often occurred in spaces between shrub clumps. Hot, dry weather soon dries

Table 1. Percentage of cover and of constancy^a of plants occurring within the four study areas. Estimates rounded to closest 0.1%.

Species	Sagebrush		Juniper		Ponderosa		Lodgepole	
	Cover	Constancy	Cover	Constancy	Cover	Constancy	Cover	Constancy
Tree canopy	—	—	17.1	—	37.3	—	45.7	—
Ponderosa pine (<i>Pinus ponderosa</i>)	—	—	—	—	32.1 ^b	100	0.1	15
Lodgepole pine (<i>Pinus contorta</i>)	—	—	—	—	5.2 ^b	69	45.6	100
Western juniper (<i>Juniperus occidentalis</i>)	—	—	17.1	100	—	—	—	—
Tree reproduction ^c	—	—	0.2	—	2.6	—	4.1	—
Ponderosa pine (<i>Pinus ponderosa</i>)	—	—	—	—	2.3	100	0.3	8
Lodgepole pine (<i>Pinus contorta</i>)	—	—	—	—	0.3	31	3.8	100
White fir (<i>Abies concolor</i>)	—	—	—	—	+	8	—	—
Western juniper (<i>Juniperus occidentalis</i>)	—	—	0.2	19	—	—	—	—
Shrubs	22.4	—	5.6	—	25.1	—	35.4	—
Squaw currant (<i>Ribes cereum</i>)	—	—	—	—	—	—	+	62
Bitterbrush (<i>Purshia tridentata</i>)	0.2	38	+	6	18.4	100	29.9	100
Snowbrush (<i>Ceanothus velutinus</i>)	—	—	—	—	1.9	62	—	—
Bearberry (<i>Arctostaphylos uva-ursi</i>)	—	—	—	—	—	—	5.5	38
Green manzanita (<i>Arctostaphylos patula</i>)	—	—	—	—	4.8	85	—	—
Granite gilia (<i>Leptodactylon pungens</i>)	0.1	13	+	25	—	—	—	—
Gray rabbitbrush (<i>Chrysothamnus nauseosus</i>)	1.1	50	—	—	—	—	—	—
Green rabbitbrush (<i>Chrysothamnus viscidiflorus</i>)	6.4	100	0.4	88	—	—	—	—
Haplopappus (<i>Haplopappus</i> sp.)	—	—	—	—	+	31	—	—
Big sagebrush (<i>Artemisia tridentata</i>)	13.8	100	5.1	94	—	—	—	—
Gray horsebrush (<i>Tetradymia canescens</i>)	0.4	75	+	6	—	—	—	—
Green horsebrush (<i>Tetradymia glabrata</i>)	0.4	56	0.1	44	—	—	—	—
Grasses and sedges ^d	17.5	—	16.6	—	1.8	—	6.9	—
Cheatgrass brome (<i>Bromus tectorum</i>)	1.7	75	+	12	—	—	—	—

Continued

Table 1. Percentage of cover and of constancy^a of plants occurring within the four study areas. Estimates rounded to closest 0.1%.—Continued.

Species	Sagebrush		Juniper		Ponderosa		Lodgepole	
	Cover	Constancy	Cover	Constancy	Cover	Constancy	Cover	Constancy
Idaho fescue (<i>Festuca idahoensis</i>)	13.7	100	5.7	100	—	—	2.0	54
Downy wheatgrass (<i>Agropyron dasystachyum</i>)	0.6	100	—	—	—	—	—	—
Bluebunch wheatgrass (<i>Agropyron spicatum</i>)	0.1	38	2.8	100	—	—	—	—
Ryegrass (<i>Elymus</i> sp.)	—	—	0.1	12	—	—	0.1	+
Bottlebrush squirreletail (<i>Sitanion hystrix</i>)	0.7	94	0.5	88	0.1	100	1.3	100
Prairie junegrass (<i>Koeleria cristata</i>)	+	6	0.8	94	—	—	—	—
Mountain wild oatgrass (<i>Danthonia intermedia</i>)	—	—	—	—	—	—	0.2	15
Thurber's needlegrass (<i>Stipa thurberiana</i>)	0.6	94	0.8	81	—	—	—	—
Western needlegrass (<i>Stipa occidentalis</i>)	—	—	—	—	0.6	100	2.4	92
Threadleaved sedge (<i>Carex filifolia</i>)	—	—	5.9	94	—	—	—	—
Ross' sedge (<i>Carex rossii</i>)	0.1	56	+	38	1.1	100	0.9	92
Herbs ^d	11.5	—	2.0	—	1.0	—	5.7	—
Tansy mustard (<i>Descurainia pinnata</i>)	1.8	100	+	44	—	—	—	—
Broad-petaled strawberry (<i>Fragaria virginiana</i>)	—	—	—	—	0.3	69	1.6	100
Lupine (<i>Lupinus</i> spp.)	—	—	0.5	44	—	—	0.1	100
White-stemmed mentzelia (<i>Mentzelia albicaulus</i>)	0.5	88	—	—	—	—	—	—
Hair-stem gayophytum (<i>Gayophytum ramosissimum</i>)	4.2	100	0.1	44	—	—	—	—
Pink microsteris (<i>Microsteris gracilis</i>)	2.7	88	—	—	—	—	—	—
Cryptantha (<i>Cryptantha</i> spp.)	0.7	93	0.2	75	—	—	—	—
Small-flowered collinsia (<i>Collinsia parviflora</i>)	0.1	19	0.5	69	—	—	—	—
Small-flowered penstemon (<i>Penstemon cinicola</i>)	—	—	—	—	0.3	92	0.9	100
Yarrow (<i>Achillea millefolium</i>)	—	—	+	38	0.1	23	2.4	100

Continued

Table 1. Percentage of cover and of constancy^a of plants occurring within the four study areas. Estimates rounded to closest 0.1%.—Continued.

Species	Sagebrush		Juniper		Ponderosa		Lodgepole	
	Cover	Constancy	Cover	Constancy	Cover	Constancy	Cover	Constancy
Other herbs	1.5	—	0.7	—	0.3	—	0.7	—
Total	51.4	—	41.5	—	67.8	—	97.8	—

^a Constancy = number of large plots in which the species were present ÷ the total number of large plots × 100.

^b Calculated from total tree coverage by using the percentage of each species forming the total dbh.

^c Trees < 5.1 cm dbh.

^d Grasses and sedges ≥ 0.5% of cover in at least one type.

+ = present in small amounts.

these annuals, and they disintegrate so completely that only vestiges of them can be found. The herbs covered 11.5% of the area which is between the values (25 and 8%) for the two Montana areas reported by Best (1972). Although the most abundant herbs on this study area generally have small seeds, they bear considerable fruit and probably represent an important source of food for wildlife in arid sagebrush areas.

Western Juniper

Canopy coverage on the juniper grid was about 17%. Juniper is the only tree species on the area and had a constancy (occurrence in plots) of 100%. Although Driscoll (1964) did not specifically describe this plant community, it appears to be most similar to his *Juniperus/Artemesia/Festuca-Lupinus* association. In this association of the central Oregon juniper zone, he found the canopy coverage was 12.3%. His values for all juniper associations ranged from 12.0 to 76.7%. In southwestern Idaho, seral stands of western juniper had an average crown cover of 22% and ranged from 5 to 46% (Burkhardt and Tisdale 1969). Canopy coverage of juniper in the present study appears to be well within the range of other investigations.

Juniper reproduction cover was only 0.2%. Plant competition, climatic conditions, and wildlife are probably the major factors in preventing seedling establishment. There is little evidence that fires have burned extensive areas on the juniper grid. Birds that feed on the juniper berries no doubt scatter seeds over a wide area, and many coyote droppings contained juniper berries. These droppings were widely scattered, often in the sagebrush some distance from juniper trees, and must aid greatly in the dispersion of

western juniper. The seeds of western juniper have a hard coat and most appear to pass intact through the alimentary tract of birds and coyotes. Small mammals and insect larvae feed on both the naturally disseminated seeds and those in the droppings and are considered a check on juniper seedling abundance.

The juniper grid had a shrub cover of 5.6% composed mostly of big sagebrush. Big sagebrush formed 5.1% coverage in Driscoll's (1964) comparable association for central Oregon, with a total shrub coverage of 7.5%. In southwestern Idaho, the seral juniper stands averaged 9% big sagebrush coverage and ranged from 3 to 16% (Burkhardt and Tisdale 1969).

Grasses and sedges covered 16.6% of the surface area in the present study. Most of this cover was threadleaved sedge, Idaho fescue, and bluebunch wheatgrass. A very small amount of Sandberg's bluegrass (*Poa secunda*) was also present on the grid, but it had dried beyond recognition at the time of the survey and was probably included with either threadleaved sedge or Idaho fescue in the totals. In his comparable association, Driscoll (1964) found 13.9% coverage for grasses and sedges. Grass and sedge distribution, with respect to the shrubs, was similar to that on the sagebrush grid. On lightly grazed northerly slopes, grass clumps were more abundant between stands of shrubs. On hotter slopes, grasses and forbs appeared to be more abundant in the shade of junipers, except where a heavy layer of duff existed, or where cattle or deer had bedded.

Herb coverage was only 2% on the juniper grid; many of these plants were short-lived annuals of early spring. In his comparable association, Driscoll (1964) found 3.2% herb coverage, the bulk of which was lupines.

Ponderosa Pine

Canopy coverage on this grid was about 37%, more than twice that of juniper. The canopy was mostly ponderosa pine but lodgepole pines were also numerous. The ponderosa pine grid appears to be most comparable to the *Pinus/Purshia/Arc-tostaphylos* community of Dyrness and Youngberg (1966). They reported a canopy coverage of 28% which was mostly ponderosa pine with good representation of lodgepole.

Reproduction cover in the ponderosa type was 2.6%, and was composed of ponderosa pine, lodgepole pine, and white fir. In the comparable community described by Dyrness and Youngberg (1966), reproduction cover was twice as great.

Shrub cover, mostly bitterbrush, green manzanita, and snowbrush was 25.1%, about 84% of the coverage (29.8%) for the comparable community reported by Dyrness and Youngberg (1966). Most of their shrub cover was bitterbrush and pine manzanita (*Arc-tostaphylos parryana*).

Grasses and sedges, mostly western needlegrass and Ross' sedge, formed most of the 1.8% cover in the present study. Dyrness and Youngberg (1966) reported that the 6.7% coverage for this category in their study was composed mostly of western needlegrass, Ross' sedge, and bottlebrush squirreltail.

Herbs were scarce on the ponderosa grid; they made up only 1.0% of the cover. Broad-petaled strawberry and small-flowered penstemon were the most abundant species. The herbs were four times greater in the comparable community of Dyrness and Youngberg (1966).

Lodgepole Pine

The canopy coverage on this grid was 45.7%, surpassing both the juniper and the ponderosa grids. The canopy was nearly pure lodgepole pine, with only a small amount of ponderosa.

Tree reproduction covered 4.1% of the surface area, the largest reproduction coverage found on any of the study areas. Most of the seedlings were lodgepole pine; however, a small amount of ponderosa reproduction was scattered irregularly over the grid.

The lodgepole grid had a shrub coverage of 35.4%, most of which was bitterbrush; there were also some nearly pure patches of bearberry. Lodgepole pine had 1.4 times greater shrub coverage than ponderosa, in which shrubs were next most extensive.

Grasses and sedges made up only 6.9% of the coverage on the lodgepole grid which was only about 39% of the coverage on the sagebrush grid (which had the greatest amount) and 42% of that for the juniper

grid. Thurber's needlegrass, Idaho fescue, and bottlebrush squirreltail comprised the bulk of this cover on the lodgepole grid.

Herb cover, consisting mostly of yarrow and broad-petaled strawberry, constituted 5.7% of the coverage on the lodgepole grid. This coverage was about 50% of that for the sagebrush herb coverage but was greater than that on the juniper and ponderosa grids.

The total plant coverage, including all vegetation categories, was about 51% for sagebrush, 42% for juniper, 68% for ponderosa, and 98% for lodgepole. These total percentages tend to inflate the amount of coverage; because some foliage layers cover the same ground area, actual coverage by vegetation was less complete than the totals of all layers.

The numbers and sizes of tree stems per hectare also can be used to describe a vegetational type. As previously noted, no trees were present in the plots on the sagebrush grid. The juniper grid had 137 live tree stems per 0.4 ha, of which 123 were more than 5.1 cm in diameter at ground level. The basal area (B.A.) was 8.6 m² per 0.4 ha, and the tallest tree in each plot averaged 6.1 m in height. On the ponderosa grid there were 1,728 live tree stems per 0.4 ha. Of these, 212 were over 5.1 cm dbh. The B.A. was 9.9 m² per 0.4 ha and the tallest tree per plot averaged 32.0 m in height. The lodgepole grid had 4,623 live tree stems per 0.4 ha. Of these, 276 were over 5.1 cm dbh and B.A. was 6.4 m² per 0.4 ha. There were also 248 dead stems over 5.1 cm dbh with a B.A. of 3.8 m² per 0.4 ha. The tallest trees in the plots averaged 20.4 m in height.

Ground Surface Cover

The data on ground surface coverage show that about 50% of the ground surface of the sagebrush and juniper grids was bare soil, compared with only about 5% for ponderosa and lodgepole. About 33% of the surface of both sagebrush and juniper types was covered with duff, compared with 75% or more for ponderosa and lodgepole. Wood debris coverage was greatest (about 11%) on the lodgepole and sagebrush grids. The largest amount (8%) of stone was on the juniper grid. Logs formed 3% of the coverage on ponderosa and lodgepole types. Live plants made up 4-6% of the surface coverage on sagebrush, juniper, and lodgepole; the ponderosa grid had only 1%.

Bird Populations

Breeding Season Censuses by Spot Mapping Method

Data on the estimated number of bird territories per 40.5 ha for each habitat type (Table 2) indicate that of the four grid-types, the sagebrush grid had the

Table 2. *Breeding bird territories per 40.5 ha for the four study areas sampled by the spot mapping method.*

Species	Sagebrush			Juniper			Ponderosa			Lodgepole		
	1971	1972	1973	1971	1972	1973	1971	1972	1973	1971	1972	1973
Turkey vulture ^a (<i>Cathartes aura</i>)	—	+	—	—	—	—	+	—	—	—	—	—
Goshawk ^a (<i>Accipiter gentilis</i>)	—	—	—	—	—	—	—	—	—	—	—	+
Sharp-shinned hawk ^a (<i>Accipiter striatus</i>)	+	—	—	—	—	—	—	—	—	—	—	—
Prairie falcon ^a (<i>Falco mexicanus</i>)	—	+	—	+	+	—	—	—	—	—	—	—
American kestrel ^a (<i>Falco sparverius</i>)	—	+	+	+	—	+	—	—	+	—	—	—
Mourning dove (<i>Zenaida macroura</i>)	+	+	—	7	10	+	—	+	—	—	+	—
Great horned owl ^a (<i>Bubo virginianus</i>)	—	—	—	+	—	—	—	—	—	—	—	—
Nighthawk ^a (<i>Chordeiles minor</i>)	2	2	2	2	2	2	—	+	—	+	+	+
Common flicker (<i>Colaptes auratus</i>)	—	+	+	9	9	12	4	3	9	+	+	—
Williamson's sapsucker ^a (<i>Sphyrapicus thyroideus</i>)	—	—	—	—	—	—	2	2	—	—	—	—
Hairy woodpecker ^a (<i>Dendrocopos villosus</i>)	—	—	—	—	—	—	—	3	—	—	—	—
Black-backed three-toed woodpecker ^a (<i>Picoides arcticus</i>)	—	—	—	—	—	—	+	—	—	+	3	2
Empidonax flycatcher (<i>Empidonax</i> spp.)	+	+	+	42	43	58	26	34	35	—	+	—
Western wood pewee (<i>Contopus sordidulus</i>)	—	—	—	—	2	—	—	+	—	—	—	—
Horned lark (<i>Eremophila alpestris</i>)	5	17	20	—	—	—	—	—	—	—	—	—
Tree swallow (<i>Iridoprocne bicolor</i>)	+	+	—	—	—	—	—	—	—	—	—	—
Gray jay (<i>Perisoreus canadensis</i>)	—	—	—	—	—	—	—	+	—	—	3	—
Steller's jay (<i>Cyanocitta stelleri</i>)	—	—	—	—	—	—	+	—	—	—	—	—
Pinyon jay ^b (<i>Gymnorhinus cyanocephalus</i>)	—	—	—	—	2	—	—	—	—	—	—	—
Clark's nutcracker (<i>Nucifraga columbiana</i>)	—	—	—	—	2	—	—	+	—	—	—	—
Common raven ^a (<i>Corvus corax</i>)	—	—	—	—	—	—	—	—	—	—	+	—
Black-capped chickadee (<i>Parus atricapillus</i>)	—	—	—	+	—	—	—	—	—	—	—	—
Mountain chickadee (<i>Parus gambeli</i>)	—	—	—	13	16	22	21	38	39	29	24	28

Continued

Table 2. Breeding bird territories per 40.5 ha for the four study areas sampled by the spot mapping method.—Continued

Species	Sagebrush			Juniper			Ponderosa			Lodgepole		
	1971	1972	1973	1971	1972	1973	1971	1972	1973	1971	1972	1973
White-breasted nuthatch (<i>Sitta carolinensis</i>)	—	—	—	—	—	—	3	8	16	—	—	—
Red-breasted nuthatch (<i>Sitta canadensis</i>)	—	—	—	+	+	—	19	28	27	18	12	12
Brown creeper (<i>Certhia familiaris</i>)	—	—	—	—	—	+	9	16	13	—	+	3
Rock wren (<i>Salpinctes obsoletus</i>)	—	1	—	—	—	—	—	—	—	—	—	—
Sage thrasher (<i>Oreoscoptes montanus</i>)	14	10	9	—	+	+	—	—	—	—	—	—
American robin (<i>Turdus migratorius</i>)	+	—	+	12	20	21	+	+	+	+	+	+
Varied thrush (<i>Ixoreus naevius</i>)	—	—	—	—	—	—	—	4	—	—	+	—
Townsend's solitaire (<i>Myadestes townsendi</i>)	—	—	—	—	5	—	+	+	—	—	+	—
Hermit thrush (<i>Catharus guttata</i>)	—	—	—	+	—	—	4	3	—	+	+	—
Mountain bluebird (<i>Sialia currucoides</i>)	—	+	+	18	21	23	—	—	+	—	+	—
Northern shrike (<i>Lanius excubitor</i>)	—	—	+	—	+	—	—	—	—	—	—	—
Yellow-rumped warbler (<i>Dendroica coronata</i>)	—	—	—	+	—	—	21	29	25	17	19	27
Townsend's warbler (<i>Dendroica townsendi</i>)	—	—	—	+	—	—	—	—	—	—	—	—
Black-throated gray warbler (<i>Dendroica nigrescens</i>)	—	—	—	2	2	—	—	—	—	—	—	—
Wilson's warbler (<i>Wilsonia pusilla</i>)	—	—	—	+	—	—	—	—	—	—	—	—
Western meadowlark (<i>Sturnella neglecta</i>)	—	2	—	—	—	—	—	—	—	—	—	—
Brewer's blackbird ^b (<i>Euphagus cyanocephalus</i>)	+	—	—	1	—	—	+	—	—	+	—	—
Brown-headed cowbird ^c (<i>Molothrus ater</i>)	—	—	—	7	12	12	—	—	+	—	+	—
Northern oriole (<i>Icterus galbula</i>)	+	—	—	—	—	—	—	—	—	—	—	—
Western tanager (<i>Piranga ludoviciana</i>)	—	—	—	—	—	—	—	4	—	—	4	—
Evening grosbeak (<i>Hesperiphona vespertina</i>)	—	—	—	—	—	—	—	+	—	—	—	—
Cassin's finch (<i>Carpodacus cassinii</i>)	—	—	—	+	6	—	—	+	—	—	—	—

Continued

Table 2. Breeding bird territories per 40.5 ha for the four study areas sampled by the spot mapping method.—Continued.

Species	Sagebrush			Juniper			Ponderosa			Lodgepole		
	1971	1972	1973	1971	1972	1973	1971	1972	1973	1971	1972	1973
House finch (<i>Carpodacus mexicanus</i>)	—	—	—	27	21	25	—	—	—	—	—	—
Pine siskin (<i>Spinus pinus</i>)	—	—	—	—	—	—	—	—	—	—	6	—
Red crossbill ^c (<i>Loxia curvirostra</i>)	—	—	—	—	—	+	—	18	+	—	16	9
Green-tailed towhee (<i>Chlorura chlorura</i>)	—	+	—	—	4	—	—	—	—	—	—	—
Savannah sparrow (<i>Passerculus sandwichensis</i>)	—	+	—	—	—	—	—	—	—	—	—	—
Vesper sparrow (<i>Pooecetes gramineus</i>)	—	+	—	—	—	—	—	—	—	—	—	—
Sage sparrow (<i>Amphispiza belli</i>)	28	33	24	—	—	—	—	—	—	—	—	—
Dark-eyed junco (<i>Junco hyemalis</i>)	+	—	—	3	8	17	+	3	3	20	14	14
Chipping sparrow (<i>Spizella passerina</i>)	—	—	—	22	29	18	16	21	21	26	31	28
Brewer's sparrow (<i>Spizella breweri</i>)	36	27	33	+	+	+	—	—	—	—	—	—
White-crowned sparrow ^b (<i>Zonotrichia leucophrys</i>)	1	+	—	+	—	—	—	—	—	—	—	—
Lincoln's sparrow (<i>Melospiza lincolni</i>)	—	—	—	+	—	—	—	—	—	—	—	—
Song sparrow (<i>Melospiza melodia</i>)	+	2	—	—	—	—	—	—	—	—	—	—
Other birds	—	—	5	—	—	19	—	—	13	—	—	9
Total no. territories	86	94	93	165	214	229	125	214	201	110	132	132
Total no. territorial species	6	8	5	13	18	10	10	15	9	5	10	8
Total no. species	15	20	12 ^d	26	23	17 ^d	17	24	15 ^d	11	22	12 ^d

^a Species with large territories.

^b They met the census requirements but may not have nested on the grids.

^c Formed very loose or possibly no territories—estimated population based partially on total number of males observed on grid.

^d Minimum value.

+ = data not adequate for the calculation of a population—the species was present on the study area or its vicinity.

smallest number of territories; yearly totals for 1971–73 were 86, 94, and 93. Brewer's sparrows, sage sparrows, horned larks, and sage thrashers formed the bulk of the species. These birds, with the nighthawks, were territorial birds each year; however, the yearly abundance of most varied. For example, the number of territories of horned larks in

1971 was only 25% of that for 1973. On the other hand, nighthawks apparently had a stable yearly population; this was probably only a coincidence and not the usual pattern. In addition to the regular territorial birds there were a few irregular ones which made up a small part of the yearly population. The total numbers of species with measurable territories on the

sagebrush grid from 1971 to 1973 were 6, 8, and 5. The total numbers of breeding species for 1971-73 were 15, 20, and 12 (the office fire destroyed the records and it is impossible to reduce the "Other Birds" data for 1973 to number of species).

During the 3-year period at least 27 species of birds were observed on the sagebrush area during the breeding season. First impression of the sagebrush habitat was that it had a low number of breeding birds of only a few species. Bird numbers and species diversity were relatively large, however, when one considers that trees, which add greatly to foliage diversity, were almost totally lacking. The present sagebrush bird population data compare favorably with that for the shrub-steppe near Cabin Lake, Oregon (Wiens and Dyer 1975). Geographically, the two areas are reasonably close (roughly 40 km apart) and superficially the vegetation and terrain appear similar. Wiens and Dyer (1975) gave data which indicated 93 bird territories per 40.5 ha. Four species comprised their breeding population which was dominated by Brewer's and sage sparrows. In the shrub-steppe at Chewaucan and Steens Mountain, Oregon, the same authors found 28 and 39 territorial birds, respectively, per 40.5 ha, with 5 and 4 species each. Dominant species were: song sparrows and western meadowlarks at Chewaucan, and vesper sparrows and rock wrens at Steens Mountain. The data show the dominant territorial bird species vary widely in the shrub-steppe habitat. The number of territorial birds also varies greatly which suggests that the shrub-steppe habitat may have a number of niches suitable for different species; however, its quality is variable.

The western juniper grid had the greatest number of territorial birds per 40.5 ha in 1971 (165) and 1973 (229), but, in 1972 the ponderosa pine grid shared the same number with the juniper grid (214, Table 2). The empidonax flycatchers (identified as gray flycatcher) were the most numerous species in the juniper type. They were followed, in order of abundance, by house finches, chipping sparrows, mountain bluebirds, American robins, mountain chickadees, and several less abundant species. All of these birds plus brown-headed cowbirds, common flickers, dark-eyed juncos, and nighthawks were birds with measurable territories on the grid each year of the investigation. The yearly abundance of most species varied; the variation was not a uniform yearly change for all birds but was haphazard. Among the birds with annual territories for the 3-year period, the dark-eyed junco fluctuated the greatest; its lowest number of territories was only 17.6% of its highest. The nighthawk was again the only bird with the same number of territories each year. The juniper grid also

had a group of irregular territorial birds; most were present in 1972. The total numbers of birds with measurable territories from 1971 to 1973 were 13, 18, and 10. The total numbers of species on the area for the same period during the breeding season were 26, 23, 17. At least 36 species of birds were noted on the grid, or its immediate vicinity, during the three breeding seasons. The juniper habitat had the largest number of species found on any of the four areas. Apparently this habitat is composed of a large variety of niches which provide conditions that are necessary for many species. The trees are spaced far enough apart and low enough to serve as excellent watch-perches for insect-catching birds which often hunt both in the air and on the ground. Juniper trees also form excellent protective cover and foliage for nesting sites, and provide berries and insects for food. The older juniper trees have natural cavities suitable for hole-nesting and roosting birds.

Anderson and Anderson (1971) and Anderson and Furniss (1972) reported the breeding birdlife on the same area in the juniper-sage upland near Frenchglen, Harney County, Oregon. Their vegetation species and coverage appeared to be roughly similar to that of the present study. The Frenchglen bird data for 1971 and 1972 were: number of territorial birds per 40.5 ha, 86 and 102; number of species, 22 and 21; dominant species, rock wrens, chipping sparrows, and western meadowlarks; and other species, lark sparrows (*Chondestes grammacus*), and house finches. Territorial birds were about twice as abundant in the present study as they were at Frenchglen. The number of breeding species was about the same on both areas, but, there was considerable difference in the species of birds frequenting each area.

The estimated numbers of breeding bird territories in ponderosa pine per 40.5 ha from 1971 to 1973 were 125, 214, and 201 (Table 2). Mountain chickadees, empidonax flycatchers, yellow-rumped warblers, red-breasted nuthatches, and chipping sparrows were the most abundant species. These birds, with brown creepers, white-breasted nuthatches, and common flickers, were the species found with measurable territories each year. The yearly abundance of the regular territorial species was varied; greatest difference was for white-breasted nuthatches whose low population estimate was 19% of its highest. Chipping sparrows had the most uniform yearly population estimate with a low which was 76% of its high. Several irregular territorial birds were also found in this habitat. The total yearly numbers of species with measurable territories for 1971-73 were 10, 15, and 9. Total numbers of breeding species for the same years were 17, 24, and 15. Altogether at least

32 species of birds were noted on the grid, or its immediate vicinity, during the three breeding seasons. This number was greater than that for the sagebrush grid (27), but below the number for juniper (36).

Trees in the ponderosa type were generally well spaced and offered good watch-perches for flycatchers and other birds. These perches were higher above ground than those on the juniper grid and the feeding birds did not seem to drop to the ground so often for food. Dead and spike-topped trees were relatively scarce, but many contained a few to many holes made by woodpeckers. The ponderosa pine trees bear irregular crops of seed (Dahms and Barrett 1975) which, when available, are very attractive to some of the more erratic species, such as the red crossbills and evening grosbeaks. Shrub cover was spotty, and herbaceous cover was so sparse it was probably of little importance to the birdlife.

In a ponderosa pine community in southeastern Arizona, Balda (1969) found 336 breeding bird territories per 40.5 ha. This is 63, 37, and 41% greater than the three yearly population estimates of this present study. The number of bird species found during the breeding season in the ponderosa pine community of Arizona and in the present study was nearly equal (31 and 32, respectively).

The lodgepole pine grid had more bird territories than sagebrush but far fewer than juniper and ponderosa. Estimated numbers of territories for 1971-73 were 110, 132, and 132, respectively. Chipping sparrows, mountain chickadees, yellow-rumped warblers, dark-eyed juncos, and red-breasted nuthatches had measurable territories each of the 3 years. These birds along with red crossbills, pine siskins, black-backed three-toed woodpeckers, western tanagers, gray jays, and brown creepers made up the bird species with measurable territories in the 3-year study. Among the birds with annual territories the yellow-rumped warbler had the greatest variation; its lowest number of territories was 63% of its highest. The total numbers of species with measurable territories each of the 3 years were 5, 10, and 8. Total numbers of breeding species each year were 11, 22, and 12. At least 25 species of birds were recorded on the lodgepole grid of the current study during the 1971-73 breeding seasons. This was the smallest number of species found in the four vegetation types, but was only two less than sagebrush.

Canopy coverage was more extensive on the lodgepole grid than on the other types. Lodgepole does not seem so favorable for foraging by the watch-perch feeding birds (flycatcher type) as juniper and ponderosa; however, lodgepole favors such crown-feeders as the yellow-rumped warblers. Lodgepole

pine is a more consistent seed producer than ponderosa (Dahms and Barrett 1975) and many birds feed on its seed. Lodgepoles are thin-barked which apparently favors feeding by woodpeckers, especially black-backed three-toed woodpeckers, which flake the bark to expose beetle galleries. Massey and Wygant (1973) considered woodpeckers to be the most important predators on spruce beetles in Colorado. Black-backed three-toed woodpeckers readily excavate nest cavities in live lodgepoles. The numerous dead lodgepoles, in all stages of decay, provide opportunities for nest building by weak excavators such as red-breasted nuthatches, although these birds often utilize abandoned woodpecker nests. Shrub cover, mostly bitterbrush, was heavy in the lodgepole type. Shrubs and herbs provide good habitat for the ground-feeding and/or nesting birds, such as chipping sparrows and dark-eyed juncos.

In Colorado, Snyder (1950) found at least 59 territorial birds per 40.5 ha in his lodgepole plot, roughly half the number of the present study. Most of his birds were pine siskins, hermit thrushes, and mountain chickadees.

In summation, the western juniper area had the largest number of territorial birds followed in order by ponderosa pine, lodgepole pine, and sagebrush. Total breeding season species for the 3-year period were: lodgepole, 25; sagebrush, 27; ponderosa, 32; and juniper, 36. The lodgepole and ponderosa bird communities tended to be similar, while sagebrush and juniper tended to be different from each other and also from those of lodgepole and ponderosa. Chipping sparrows, mountain chickadees, dark-eyed juncos, and possibly other species were present on all wooded habitats. The territorial bird populations in the four vegetation types tended to vary by years and by species but the yearly ranking of the species was roughly similar.

Winter Bird Censuses by the Line Transect Method

Only two winter censuses were made on each area each year from 1971 to 1973. They were made in December and in either January or February. Heavier sampling would have been desirable. Robbins (1972), who used a grid and plotting method, suggested 8-10 trips to get valid winter population estimates. Emlen (1971), however, thought that transect lines of 8.1-16.1 km would probably give a reliable mean of detection. In the present study, length of the transects for the two censuses for the four areas ranged from 9.0-18.4 km, which was larger than the suggested minimum distance.

The estimated number of winter birds by species per 40.5 ha (Table 3) shows that the juniper area had

Table 3. Average number of winter birds per 40.5 ha on the four study areas. Each type was sampled with one line transect in December and one in January or February.

Species	Sagebrush ^a			Juniper ^a			Ponderosa ^a			Lodgepole ^a		
	1971	1972	1973	1971	1972	1973	1971	1972	1973	1971	1972	1973
Goshawk (<i>Accipiter gentilis</i>)	—	—	—	—	—	—	1	—	—	—	—	—
Red-tailed hawk (<i>Buteo jamaicensis</i>)	—	—	+	—	—	—	—	—	—	—	—	—
Cooper's hawk (<i>Accipiter cooperii</i>)	—	—	—	—	1	—	—	—	—	—	—	—
Rough-legged hawk (<i>Buteo lagopus</i>)	—	—	+	—	—	—	—	—	—	—	—	—
Golden eagle (<i>Aquila chrysaetos</i>)	+	+	+	—	—	—	—	—	—	—	—	—
Bald eagle (<i>Haliaeetus leucocephalus</i>)	—	—	1	—	—	—	—	—	—	+	—	—
Common flicker (<i>Colaptes auratus</i>)	—	—	—	1	—	—	—	—	—	—	—	—
Woodpecker (<i>Dendrocopos</i> spp.)	—	—	—	—	—	—	—	—	—	—	—	+
Hairy woodpecker (<i>Dendrocopos villosus</i>)	—	—	—	—	—	—	4	+	2	—	2	1
Downy woodpecker (<i>Dendrocopos pubescens</i>)	—	—	—	—	—	—	—	1	—	—	—	—
Black-backed three-toed woodpecker (<i>Picoides arcticus</i>)	—	—	—	—	—	—	—	1	—	1	2	1
Horned lark (<i>Eremophila alpestris</i>)	20	+	—	—	—	—	—	—	—	—	—	—
Steller's jay (<i>Cyanocitta stelleri</i>)	—	—	—	—	—	—	4	—	—	+	—	—
Pinyon jay (<i>Gymnorhinus cyanocephalus</i>)	—	—	—	—	+	—	—	—	—	—	—	—
Gray jay (<i>Perisoreus canadensis</i>)	—	—	—	—	—	—	—	—	—	—	6	—
Clark's nutcracker (<i>Nucifraga columbiana</i>)	—	—	—	1	1	—	—	—	—	—	—	—
Common raven (<i>Corvus corax</i>)	+	+	—	—	+	+	—	—	+	—	+	+
Common crow (<i>Corvus brachyrhynchos</i>)	—	—	+	—	—	+	—	—	—	—	—	—
Mountain chickadee (<i>Parus gambeli</i>)	—	—	—	+	1	—	63	14	—	8	49	6
White-breasted nuthatch (<i>Sitta carolinensis</i>)	—	—	—	—	—	—	1	4	1	—	—	1
Red-breasted nuthatch (<i>Sitta canadensis</i>)	—	—	—	2	—	—	6	3	2	1	3	2
Brown creeper (<i>Certhia familiaris</i>)	—	—	—	—	—	—	4	1	2	2	—	—

Continued

Table 3. Average number of winter birds per 40.5 ha on the four study areas. Each type was sampled with one line transect in December and one in January or February.—Continued.

Species	Sagebrush ^a			Juniper ^a			Ponderosa ^a			Lodgepole ^a		
	1971	1972	1973	1971	1972	1973	1971	1972	1973	1971	1972	1973
American robin (<i>Turdus migratorius</i>)	—	21	—	58	211	12	—	—	—	—	—	—
Townsend's solitaire (<i>Myadestes townsendi</i>)	—	—	—	11	5	7	—	—	—	—	—	—
Mountain bluebird (<i>Sialia currucoides</i>)	28	—	—	8	—	—	—	—	—	—	—	—
Bohemian waxwing (<i>Bombycilla garrulus</i>)	—	—	—	—	1	—	—	—	—	—	—	—
Cedar waxwing (<i>Bombycilla cedrorum</i>)	—	—	—	—	1	—	—	—	—	—	—	—
Northern shrike (<i>Lanius excubitor</i>)	—	1	—	—	—	—	—	—	—	—	—	—
Evening grosbeak (<i>Hesperiphona vespertina</i>)	—	—	—	10	18	20	5	—	—	—	—	—
Purple finch (<i>Carpodacus purpureus</i>)	—	—	—	—	—	—	4	—	—	4	—	—
Cassin's finch (<i>Carpodacus cassinii</i>)	—	—	—	—	—	—	8	—	—	—	—	—
Pine siskin (<i>Spinus pinus</i>)	—	—	—	—	—	—	3	—	—	21	—	—
Red crossbill (<i>Loxia curvirostra</i>)	—	—	—	—	—	—	34	—	+	6	1	—
Total no. birds	48	22	1	91	239	39	137	24	7	43	63	11
Total no. species	4	5	5	8	10	5	12	7	6	9	7	7

^a Census route length was: Sagebrush 9.2 km; juniper 6.4 km; ponderosa 4.8 km, except in December 1973 when it was 4.4 km and in January 1974 when it was 4.6 km; lodgepole 5.0 km.

+ = data not suitable for the calculation of a population—the species was present on the study area or its vicinity.

the greatest number of birds followed by ponderosa, lodgepole, and sagebrush. Winter bird numbers expectedly varied much more than those of the breeding season. Kendeigh (1944) also found that wintering bird populations are less stable than those of the breeding season. In the present study the abundance of such birds as waxwings, evening grosbeaks, red crossbills, and pine siskins seemed to be directly related to the size of the tree seed crop. Populations of many other species were apparently affected both by the food supply and the weather. Weather can control the availability of many food items and often interacts with potential food supply. There was a heavy crop of ponderosa pine seeds in 1971 which attracted relatively large numbers of tree-seed-eating birds. In 1972, the winter weather was relatively mild, and although juniper berries formed

only a lightly scattered crop, robins were present in large numbers throughout the juniper habitat. When the ground was bare in the sagebrush, the robins tended to feed there, especially near the juniper-sagebrush edge. Juniper berries were very scarce during late winter and spring.

An unusually early and heavy snowfall occurred on 3, 4, and 5 November 1973. The snowfall totaled about 1.0 m in the Bend area and was preceded by lower temperatures, about -11.7 C at Bend on 2 and 3 November but warmed to near the month's average during the storm (U.S. Environmental Data Service 1973). The wind was relatively light with little drifting of snow. Although no direct field data were obtained on the influence of the storm on the birds, it seems likely that many of the birds were forced to move to more suitable areas or they would have

perished. Song- and game-bird weather-caused mortality has been documented by Scott (1937), Scott and Baskett (1941), Frenzel and Marshall (1954), Roseberry (1962), Stewart (1972), and others. Regardless of the cause, wintering birds were very scarce in 1973, especially on the sagebrush and ponderosa areas. Hawks, eagles, and crows were the only species noted on or near the sagebrush area. The juniper area also had a low population of wintering birds in 1973, roughly half of the 1971 numbers. Evening grosbeaks, robins, and solitaires were the most abundant species, and all fed heavily on juniper berries which were scarce. These birds also use the heavy juniper foliage for roosting sites. Wintering birds on the ponderosa study area in 1973 totaled only 29% of the 1972 population. Mountain chickadees, hairy woodpeckers, brown creepers, and red- and white-breasted nuthatches were the most abundant species and were largely dependent upon trees and their associated fauna for food and roosting cavities. The wintering birds on the lodgepole area in 1973 totaled only about 25% of the 1971 winter population. Species encountered were very similar to those on the ponderosa area and included mountain chickadees, red- and white-breasted nuthatches, and woodpeckers, all of which depend heavily on trees for their food supply and shelter.

The respective yearly numbers of bird species wintering on the four study areas during 1971-73 were: sagebrush, 4, 5, and 5; juniper, 8, 10, and 5; ponderosa, 12, 7, and 6; and lodgepole, 9, 7, and 7. The total numbers of bird species wintering on study areas for the 3-year period were: sagebrush, 10; juniper, 14; ponderosa, 15; and lodgepole, 13. Since the number of bird species is thought to reflect the habitat niches or diversity of an area, it appears that sagebrush is least varied. In this investigation, the three timbered areas were so close in number of species they are presumably similar in number of winter niches.

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