

An inventory of the avifauna in the Long Pines of southeastern Montana
by Kristi Lynn DuBois

A thesis submitted in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE in Fish and Wildlife Management
Montana State University
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Abstract:
Songbird populations within the Long Pines of southeastern Montana were censused during 1977 and 1978 to provide baseline data prior to possible uranium mining. Breeding pair densities, species composition and relative abundance of birds were determined in grassland, ponderosa pine savannah, ponderosa pine forest, and deciduous draw forest formations. Censuses were taken at 22 stations on a road route, on three 16 ha plots, and on two 31 ha strip-plots. Breeding pair density and number of breeding species were lowest in grasslands (59 pairs/ 100 ha, 2 species), higher in savannah (109 pairs/100 ha, 8 species) and ponderosa pine forest (312 pairs/100 ha, 11 species), and highest in deciduous draw forests (413 pairs/100 ha, 19 species). Species diversity and breeding bird density were related to the structural diversity of the vegetation and interspersion of different plant communities. Habitats which would probably be most heavily impacted from uranium mining are the deciduous draw and ponderosa pine forest which support the highest bird densities and diversity.

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Date April 30, 1979

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by

KRISTI LYNN DUBOIS

A thesis submitted in partial fulfillment
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in

Fish and Wildlife Management

Approved:

Robert L. Eng
Chairperson, Graduate Committee

James M. Pickett
Head, Major Department

Harry L Parsons
Graduate Dean

MONTANA STATE UNIVERSITY
Bozeman, Montana

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ABSTRACT

Songbird populations within the Long Pines of southeastern Montana were censused during 1977 and 1978 to provide baseline data prior to possible uranium mining. Breeding pair densities, species composition and relative abundance of birds were determined in grassland, ponderosa pine savannah, ponderosa pine forest, and deciduous draw forest formations. Censuses were taken at 22 stations on a road route, on three 16 ha plots, and on two 31 ha strip-plots. Breeding pair density and number of breeding species were lowest in grasslands (59 pairs/100 ha, 2 species), higher in savannah (109 pairs/100 ha, 8 species) and ponderosa pine forest (312 pairs/100 ha, 11 species), and highest in deciduous draw forests (413 pairs/100 ha, 19 species). Species diversity and breeding bird density were related to the structural diversity of the vegetation and interspersion of different plant communities. Habitats which would probably be most heavily impacted from uranium mining are the deciduous draw and ponderosa pine forest which support the highest bird densities and diversity.

INTRODUCTION

Increasing demand for energy and oil shortages have stimulated development of atomic energy. As energy costs rise, exploitation of lower-grade uranium ore becomes more economical. One method of exploiting low-grade ore is known as in-situ, or solution mining. This entails leaching the uranium compounds by pumping a sulphuric acid solution directly into the bedrock. Several companies are engaged in exploratory drilling for uranium in the Long Pines of southeastern Montana, to determine the feasibility of in-situ mining.

Songbirds are often used as indicators of environmental change due to their wide distribution and abundance, and sensitivity to habitat changes (Graber and Graber 1976). This study was undertaken to provide baseline data on songbirds in the Long Pines for future reference in monitoring the effects of uranium mining or other land disturbance. Specific objectives were to determine breeding bird densities, relative abundance and species composition of songbirds in the various habitats found within the Long Pines. Field work was conducted from mid-June to mid-August 1977, and from early April to early September 1978.

DESCRIPTION OF STUDY AREA

The Long Pines is a small range of hills located approximately 39 km (24 mi) southeast of Ekalaka in Carter County, Montana. The range is L-shaped, about 24 km (15 mi) long, 11 to 19 km (7 to 12 mi) wide, and rising 366 m (1200 ft) above the surrounding plains to a maximum elevation of 1280 m (4200 ft). The Long Pines, together with several other isolated pine hills, is included in the Sioux Division of the Custer National Forest. The range consists of flat-topped hills with some exposed rimrock, steep ridges and V-shaped valleys. Vegetation consists primarily of grasslands and forests of ponderosa pine (*Pinus ponderosa*). The study area (Figure 1) included 263 sq km (65,000 ac) of National Forest land and some surrounding private land, for a total of 544 sq km (210 sq mi).

Soils in the Long Pines are generally shallow and rocky, often with a high clay content. The surface bedrock is mostly sandstones and clay "gumbo" of the Arikaree Formation (Miocene) and the Fort Union Formation (Paleocene). Underlying beds of the Fox Hills Formation (Upper Cretaceous) contain the uranium deposits (AAPG 1972).

The major drainages in the area are Boxelder Creek, which cuts across the northwest corner of the study area, and the Little Missouri River, several km southeast of the study area. Many of the drainageways in the Long Pines contain intermittent streams. Numerous springs

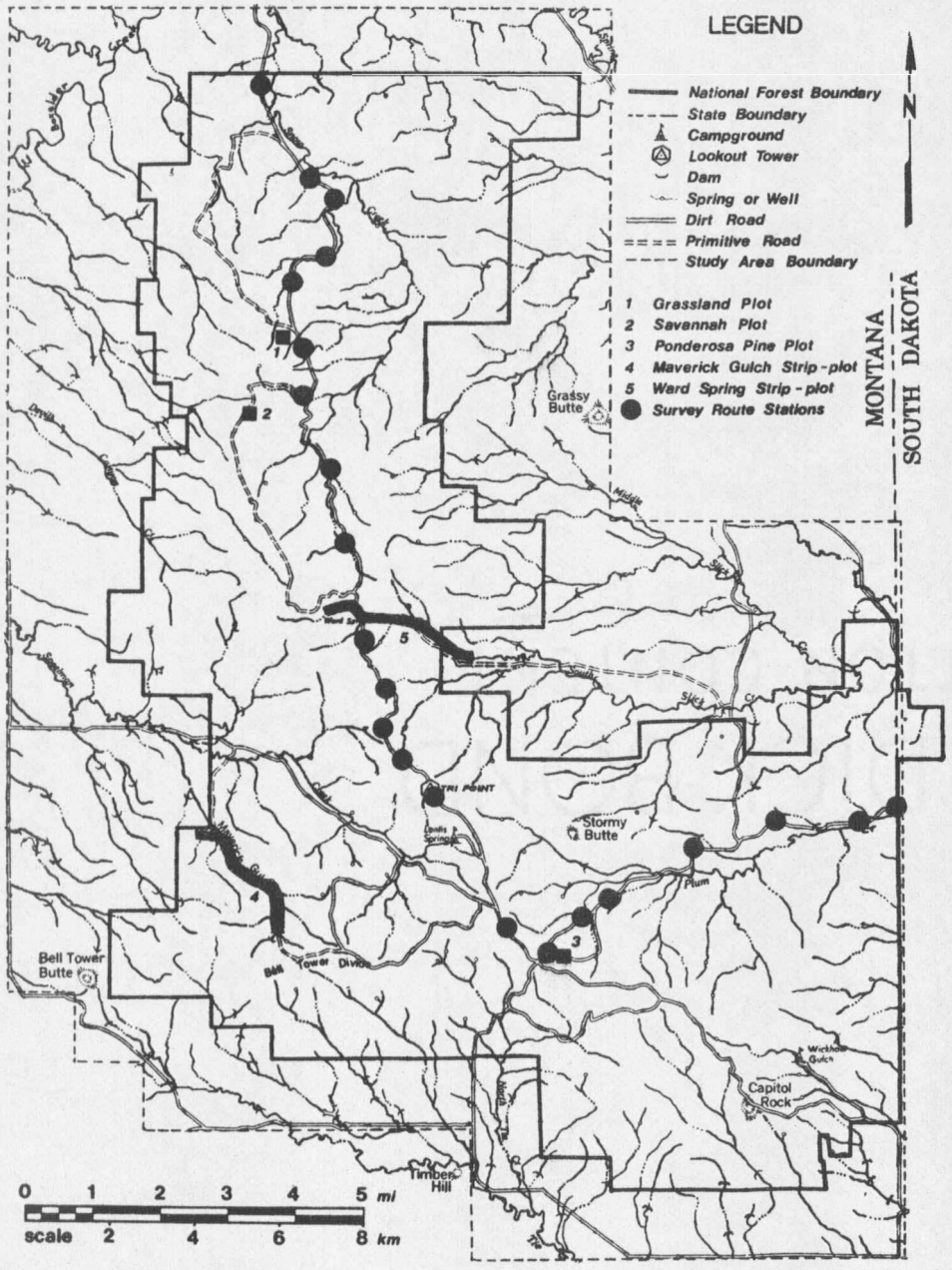


Figure 1. Map of study area including survey route stations and breeding bird plots.

and seeps are found in the draws, providing sufficient water to support many small beaver ponds. Standing water has been increased by the addition of man-made stockdams and tanks. High turbidity is common due to erosion.

The climate is continental with hot, dry summers and cold, dry winters. The mean annual temperature for Ekalaka, Montana is 6.6°C (43.8°F), with means for January and July being -8.1°C (17.5°F) and 21.4°C (70.5°F) respectively. The mean annual precipitation is approximately 38 cm (15 in), with just over half occurring in May, June, and July (U.S.D.C., 1977, 1978).

The summer of 1977 was very hot and dry, with precipitation 7.6 cm (3 in) below normal and mean temperatures averaging 2.8°C (5°F) above normal for April through July (Appendix Table 13). The spring and summer of 1978 were cool and wet, with mean temperatures slightly below normal and precipitation 5.1 cm (2 in) above normal for April through August. The precipitation for May 1978 was extremely high at 15.04 cm (5.92 in), almost ten cm above normal.

The major land uses within the Long Pines are cattle grazing, logging, and recreation. All of the National Forest land is grazed, with individual pastures being grazed for two to three months between May and October. Most of the recreational use is by hunters and campers. Vehicle trails are abundant throughout the Long Pines, attracting off-road vehicle recreationists. Such trails are a potential source of

silt in the ponds and creeks. The private land in the study area is used primarily for sheep and cattle ranching and production of small grains.

The fauna and flora of the Long Pines have been little-studied due to the area's isolation and low human density. Cameron (1907), Saunders (1916), and Visher (1911, 1912, 1913) mentioned the Long Pines in their annotated bird lists for the region. Skaar (1975) and supplements listed 151 species of birds as occurring in the latilong containing Carter County. The mammals of Carter County were described by Lampe et al. (1974).

The vegetation of the Long Pines was described by Jonas (1966). Well-developed ponderosa pine forest covers the higher elevations, grading into a savannah with interspersed patches of ponderosa pine forest and grassland at lower elevations. The forested areas are characterized by even-aged stands of ponderosa pine with many scattered grassland parks. The understory is predominately snowberry (*Symphoricarpos sp.*), kentucky bluegrass (*Poa pratensis*), and oregon grape (*Berberis repens*) on the more mesic slopes; and skunkbush sumac (*Rhus trilobata*) and bluebunch wheatgrass (*Agropyron spicatum*) predominate on the dryer slopes. The shrub layer is poorly developed, giving most stands an open park-like appearance. Similar ponderosa pine forests in North Dakota were described by Potter and Green (1964).

The grasslands are a mixed-grass prairie with a variety of both

bunchgrasses and sod-forming grasses. The dominant type is a western wheatgrass (*Agropyron smithii*) - needle-and-thread (*Stipa comata*) community. A large number of forb species are present, mostly of the composite and legume families. Silver sage (*Artemisia cana*) and big sage (*Artemisia tridentata*) dominate small areas of sagebrush-grassland.

Mesic draws running through the Long Pines support several different deciduous plant communities. Draws running through ponderosa pine forest at higher elevations contain stands of trembling aspen (*Populus tremuloides*), and several north-facing draws contain relict stands of paper birch (*Betula papyrifera*). Draws at lower elevations in more open areas with abundant moisture support boxelder (*Acer negundo*), green ash (*Fraxinus pennsylvanicus*), and fleshy hawthorne (*Crataegus succulenta*). Dry draws running through prairie contain homogeneous stands of snowberry (*Symphoricarpos sp.*).

METHODS

Vegetation

Vegetational analyses were conducted at stations along a breeding bird survey route and on the five breeding bird density plots. Vegetational formations (grassland, savannah, ponderosa pine forest, deciduous draw forest) were delineated at each station along the breeding bird survey route within a circle of 400 m (0.25 mi) radius from aerial photos. A dot grid was used to determine the percentages of each formation.

Three 16 ha (approximately 40 acres) breeding bird plots were established, one each in mixed grass prairie, ponderosa pine savannah, and ponderosa pine forest. Each plot was 400 m on a side, gridded and staked at 50 m intervals. Two strip plots were established, one each along two draws containing deciduous overstory. Each strip-plot was approximately 31 ha in size, 100 m wide and approximately 2950 m long, with stakes at 50 m intervals down the center along the draw. The plant communities were mapped from large-scale color infrared photos. The percentage of each community was determined with a dot grid.

Ground vegetation (including shrubs under 0.5 m) was sampled quantitatively at each survey route station and on the five plots using a modification of the method described by Daubenmire (1959). Twenty points were sampled at 2 m intervals along a 40 m line in vegetation which was characteristic of the community type. Percent cover of the

different plants was determined at each point within a 20 x 50 cm frame. Data from similar plant communities were combined for analysis.

Dominance, densities, and frequencies of trees were determined on the ponderosa pine forest plot, savannah plot, and both deciduous draw strip-plots using the point-quarter method (Cottam and Curtis 1956). Twenty points were sampled in each stand, chosen randomly using the transect method described by Weins (1969). Basal area for trees with multiple trunks was obtained by adding the basal areas of the individual trunks from the same root stock. Tree canopy cover was determined with a dot grid. Percent cover of sampling trees and shrubs under 2 m was estimated within a radius of 2.8 m (area of 25 m^2) at each of the twenty points in each stand.

Heights of the various vegetational strata were measured for comparison between types. The heights of grasses, forbs, shrubs, trees, and lowest tree branches with living foliage were estimated or measured while doing other vegetation work. Heights above 2 m were measured with a clinometer; heights below 2 m were estimated, spot-checking with a ruler.

A plant species list was compiled for the breeding bird survey route stations and five breeding bird density plots (Appendix Table 14). Nomenclature follows Hitchcock and Cronquist (1976) and Gleason and Cronquist (1963).

Birds

Breeding Bird Survey Route

A road route was established through the middle of the Long Pines to determine an index of relative bird abundance using a method similar to that described by Robbins and Van Velzen (1967). Twenty stops were placed along the route at approximately 1.6 km (one mile) intervals, but adjusted so five stations would lie in each of the four major vegetational formations (grassland, savannah, ponderosa pine forest, deciduous draw). Two extra stations were included, one to sample a field being invaded by ponderosa pine, and the other to sample a small cliff, a common micro-habitat found throughout the study area. The route was started one-half hour before sunrise and took about three hours to complete. All birds seen and heard were recorded for three minutes at each stop. The number of individuals of all species, except red crossbills (*Loxia curvirostra*), was recorded. Red Crossbills were wandering in large non-breeding flocks and no accurate count could be made due to poor visibility in the pine forests they favored.

Breeding Bird Density Plots

A breeding pair census was conducted on the three 16 ha plots using a method similar to that described by Robbins (1970). Each plot was covered by walking every other 50 m line and mapping birds seen and heard within 50 m of either side. Species, sex (if possible), and territorial behavior (such as singing) were recorded for each bird observed.

Birds were mapped along the strip-plots in a similar way, by walking along the middle of the strip-plot and mapping birds in and adjacent to the deciduous draw. Each plot or strip-plot took approximately two hours to cover. Two plots were censused per morning from early May through late June. The plots and survey route were run in sequence to form a four-day sampling period. The actual sampling period was usually longer due to poor weather. Census work was started one-half hour before sunrise and completed by 10:00 a.m. Starting in late June only one plot was censused per morning to complete work by 10:00 a.m. before rising temperatures suppressed bird activity. Census work was not conducted when poor weather conditions (rain, fog, high winds) suppressed bird activity or limited the observer's ability to detect birds.

Nest locations and bird sightings during mid-day and unfavorable weather were used to supplement the census data. The Weins chasing method (Weins 1969) was used to supplement census data on the grassland plot. All census data were gathered during the 1978 season; the 1977 season was started too late in the breeding season to obtain meaningful data.

A list of all bird species observed in the entire study area was compiled for both seasons, and is presented in Appendix Table 15. Nomenclature follows the A.O.U. Checklist (1957) and Supplements (1973, 1976).

RESULTS

Vegetation

Breeding Bird Survey Route

Stations with 80% or more grassland were classified as grassland; those with 70% or more ponderosa pine were classified as ponderosa pine forest. Stations with 30% to 80% grassland were classified as savannah. Most of the deciduous draw stations were within savannah areas.

Grassland on the stations mainly consisted of a western wheatgrass - needle-and-thread community with scattered patches of little bluestem (*Andropogon scoparius*). Similar grassland communities were described by Ross and Hunter (1976) for eastern sedimentary plains.

Ponderosa pine communities consisted mainly of ponderosa pine - skunkbush sumac on the savannah stations and ponderosa pine - snowberry on the ponderosa pine forest stations. These communities are similar to communities of the same name described by Pfister et al. (1974). Pfister also described a ponderosa pine - chokecherry (*Prunus virginiana*) community which may also be widespread in the Long Pines. Chokecherry is present in most of the ponderosa pine - snowberry stands, but has probably been suppressed by extensive cattle and deer browsing.

Deciduous draw stations were placed in two aspen draws and three boxelder - ash draws. Two of the boxelder - ash draws contained small ponds. Several other stations also contained small amounts of deciduous forest due to the tendency of the road to follow draws.

The aspen stands in the Long Pines fit the description given by Pfister et al. (1974) of Aspen - Conifer communities which are usually perpetuated by fire. Fire suppression and ungulate grazing may be limiting aspen reproduction in the Long Pines. Many stands contain a few mature and many dead trees, with no saplings present to replace them. The paper birch stand also contained many large dead aspen trees.

Dusek (1977) classified the boxelder - ash draw as a separate habitat type. This community is similar to the Hardwood Climax Forest described by Ross and Hunter (1976) except for the absence of cottonwoods (*Populus sp.*) which require more moisture than the draws provide. The vegetation in the draws can best be described by a continuum with aspen stands occupying the higher, dryer sites, grading into cottonwood forests along the larger, permanent creeks. Draws in grasslands contain a similar continuum, with snowberry on the driest sites, grading into hawthorne thickets on intermediate sites, grading into boxelder or cottonwood forests on the larger creek bottoms.

The station which sampled the field being invaded by ponderosa pine saplings was primarily covered by ponderosa pine forest, with the field occupying 13% of the site. The majority of the young pines within the field were approximately 2 m tall. This invasion of grassy parks by pines is widespread throughout the Long Pines, and may be due to fire suppression.

The last station sampled a cliff on one side of a pine-covered

hill surrounded by grassland. The cliff contained many grasses and forbs found in the surrounding ponderosa pine - skunkbush community. A small pocket of water at the base of the cliff supported several ash trees and a sedge (*Carex sp.*) - wild rye (*Elymus sp.*) - alkali cordgrass (*Spartina gracilis*) community.

Breeding Bird Density Plots

Figure 2 shows the major plant communities found on the grassland plot. The western wheatgrass - needle-and-thread community dominated (Appendix Table 16), although homogeneous patches of snowberry were present in the draws, and several nearly homogeneous patches of creeping juniper (*Juniperus horizontalis*) were located on the uplands (Figure 3). The nearest available water was a small natural pothole about 6 m in diameter and 0.5 m deep, approximately 200 m from the north edge of the plot. This pothole was completely dry by August in 1977 and contained only a few cm of water in August 1978. A stock tank and windmill were located approximately 400 m south of the plot. The topography consisted of gently rolling hills. The area was grazed from about 1 August to 15 October in 1977 and from 21 May to 1 August in 1978.

Figure 4 shows the major plant communities found on the savannah plot. The plot was covered by roughly equal amounts of grassland and ponderosa pine stands (Appendix Table 16). Ponderosa pine - skunkbush was the dominant forest community, with some ponderosa pine - snowberry

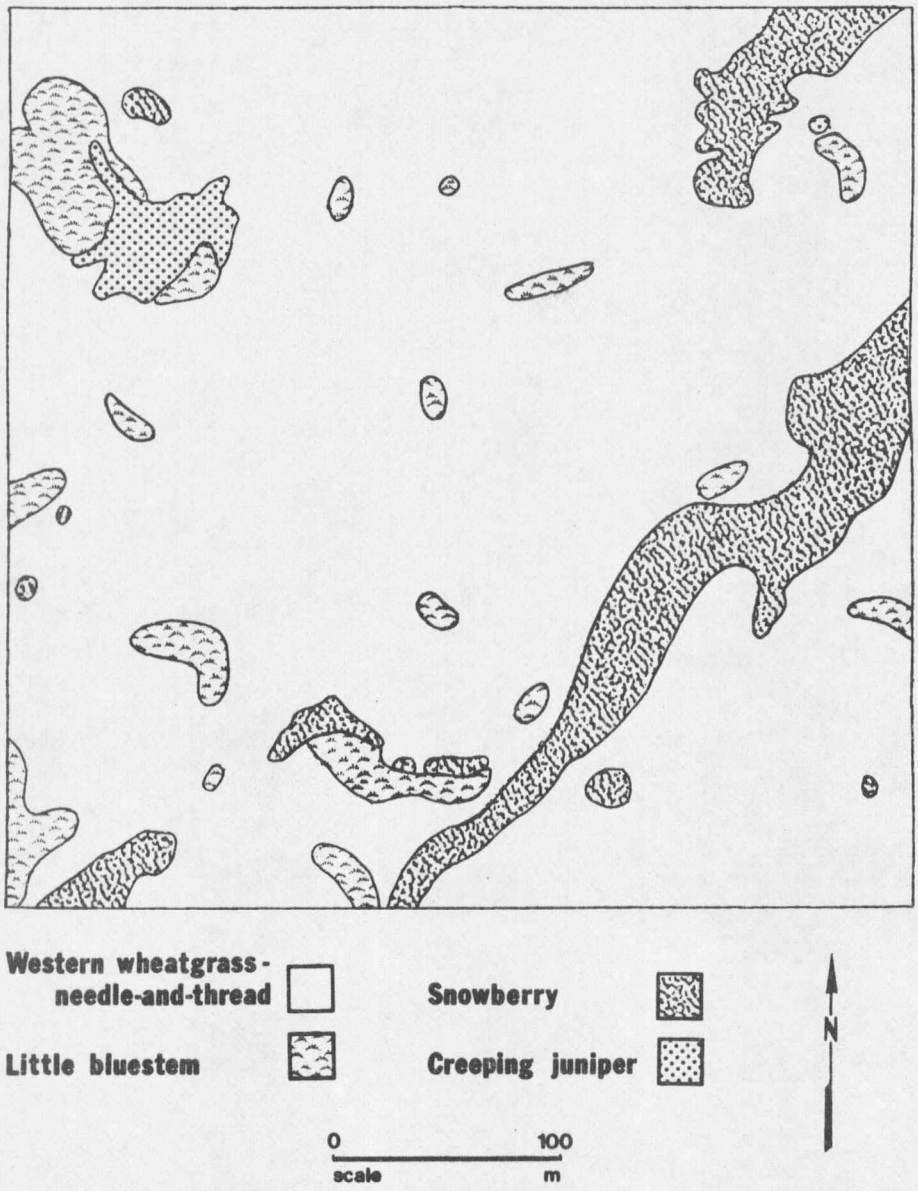


Figure 2. Plant communities found on the grassland plot.



Figure 3. Western wheatgrass - needle-and-thread community (mixed grassland) on the grassland plot.

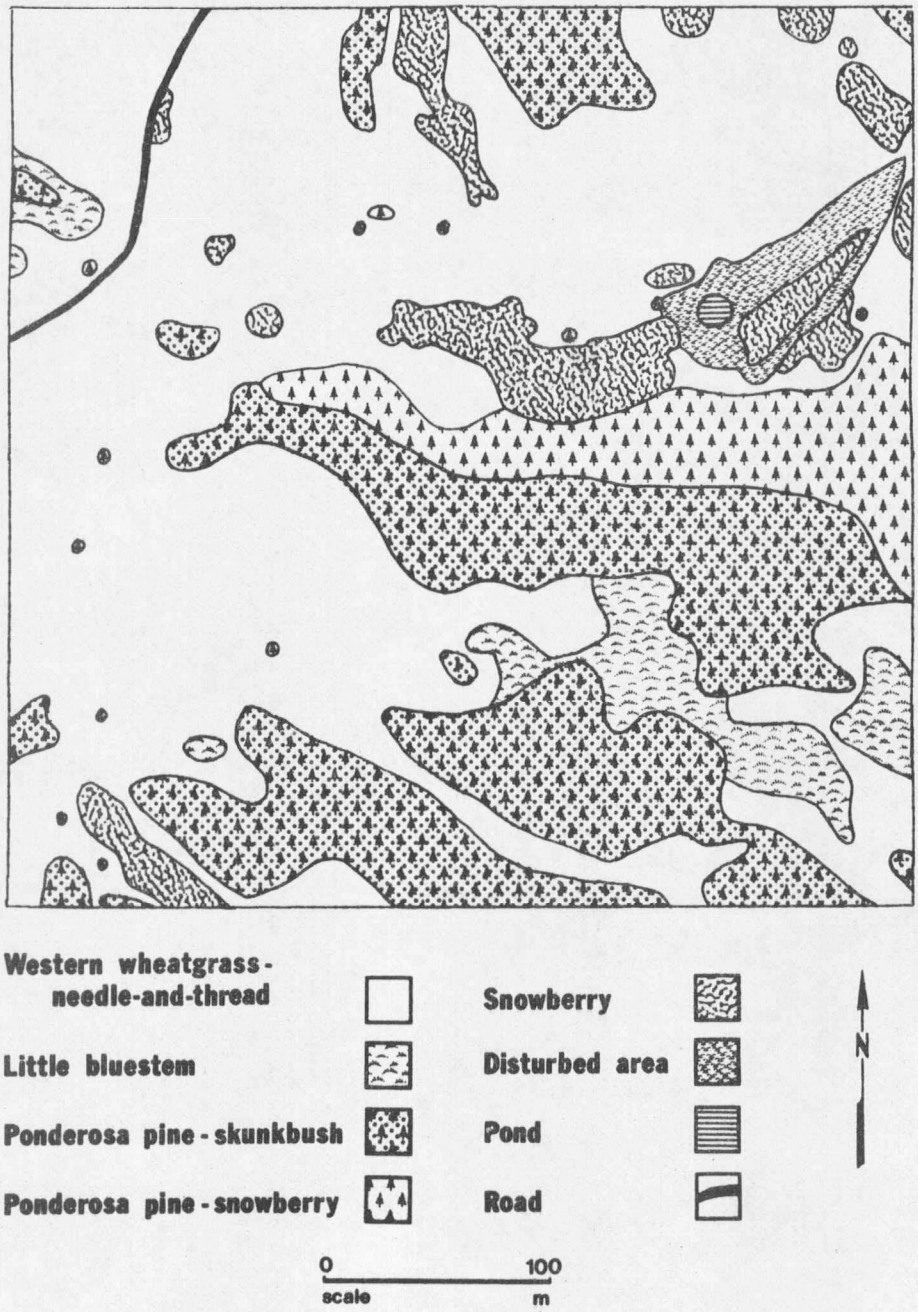


Figure 4. Plant communities found on the savannah plot.

on the north-facing slopes (Figure 5). Grasslands consisted of western wheatgrass - needle-and-thread and little bluestem communities, and patches of snowberry covered the draws. An aspen draw ran just outside the south edge of the plot. A large dike had been built across one of the draws in an attempt to create a stockpond, but it only collected about 15 cm of water due to an insufficient watershed. The dike created a large disturbed area dominated by foxtail barley (*Hordeum jubatum*) near the water, and wild licorice (*Glycyrrhiza lepidota*) and lupine (*Lupinus argenteus*) on the dryer sites. The plot was located on top of a mesa about 100 m from the rimrock. The largest ponderosa pine stand in the middle of the plot, containing both ponderosa pine - skunkbush and ponderosa pine - snowberry communities, was sampled with the point-quarter method (Appendix Table 17). The trees were 100% ponderosa pine with a density of 387.5 trees/ha and a mean basal area of 407 cm^2. Tree canopy cover was 36% within the ponderosa pine - skunkbush stands and 56% within the ponderosa pine - snowberry stand. The plot was grazed from 21 May to 1 August in 1977 and from 1 August to 15 October in 1978.

Figure 6 shows the major plant communities found on the ponderosa pine forest plot. The majority of this plot was covered by a ponderosa pine - snowberry community with large, mature pine trees (Figure 7). One of the aspen draws running through the plot contained a small seep which provided a trickle of running water throughout the summer. The plot was located in fairly steep, hilly terrain. Appendix Tables 17



Figure 5. Ponderosa pine - skunkbush stand on the savannah plot.

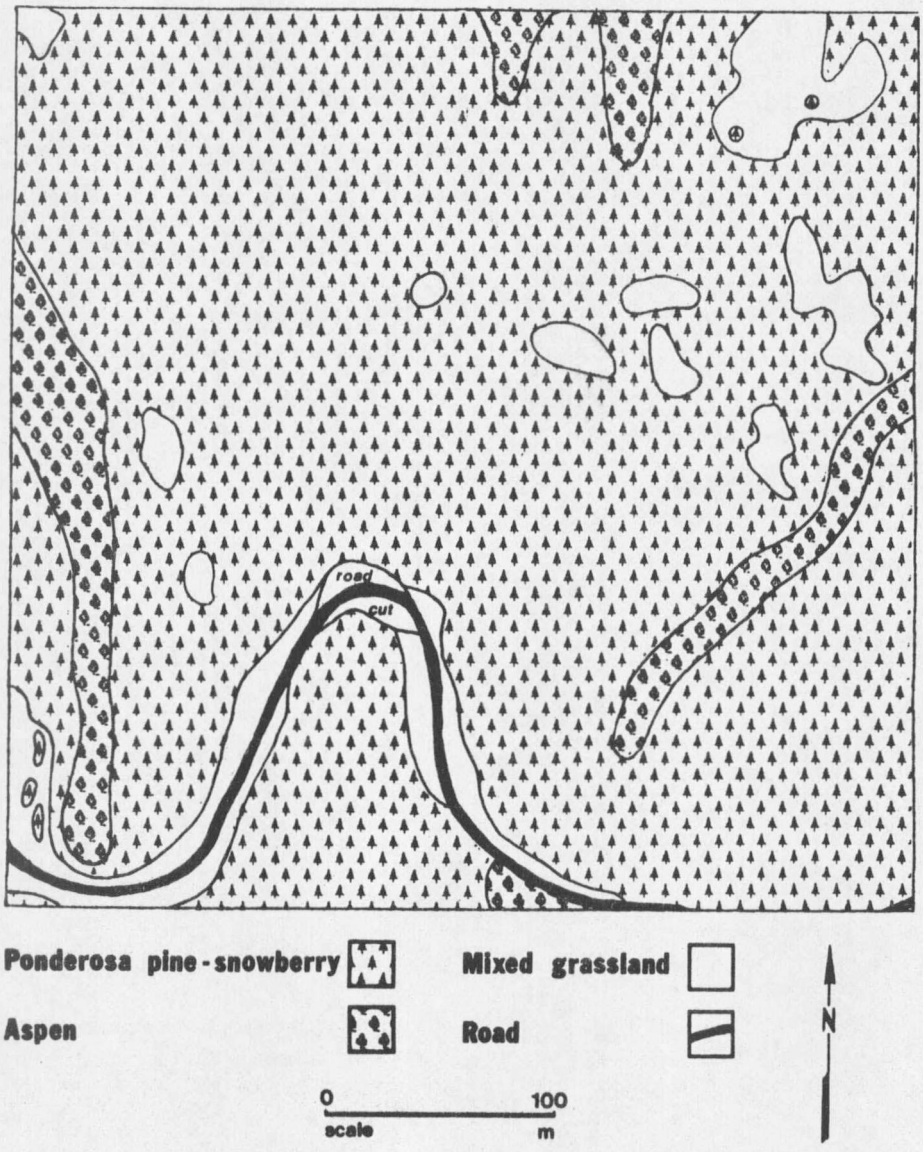


Figure 6. Plant communities found on the ponderosa pine forest plot.



Figure 7. Ponderosa pine - snowberry community on the ponderosa pine forest plot.

and 18 list the results of the point-quarter and shrub analyses respectively, from east and west-facing slopes. Tree canopy covers were 75% and 65% for east and west slopes respectively. The plot was grazed from 16 May to 1 August during 1977, with the draws being very heavily used by cattle. The area was not grazed during 1978.

Figure 8 shows the major plant communities found on the Maverick Gulch strip-plot. The upper portion of the draw contained a relict birch stand (Figure 9) which graded into an aspen community at lower elevations. The lower portion of the draw contained a boxelder - ash community with interspersed ponderosa pine trees. The strip-plot covered 31.2 ha, of which 17% was deciduous draw. The boxelder - ash community covered the majority of the draw (Appendix Table 16). Tree canopy cover within the draw was 57%. Appendix Tables 17 and 18 list the results of the point-quarter and shrub analyses respectively.

The Maverick Gulch draw contained several seeps and small pockets of standing water and a large stock pond at the lower end of the strip-plot. A vehicle trail followed the draw from the top to the bottom. The area was heavily used by cattle, and was grazed from about 16 May to 31 July both years of the study. The bottom of the draw was severely eroded in many places due to the attractiveness of the moist areas to cattle. Water quality was very poor, with high turbidity due to both the road and cattle, and pollution from cattle waste material.

Figure 10 shows the major plant communities on the strip-plot

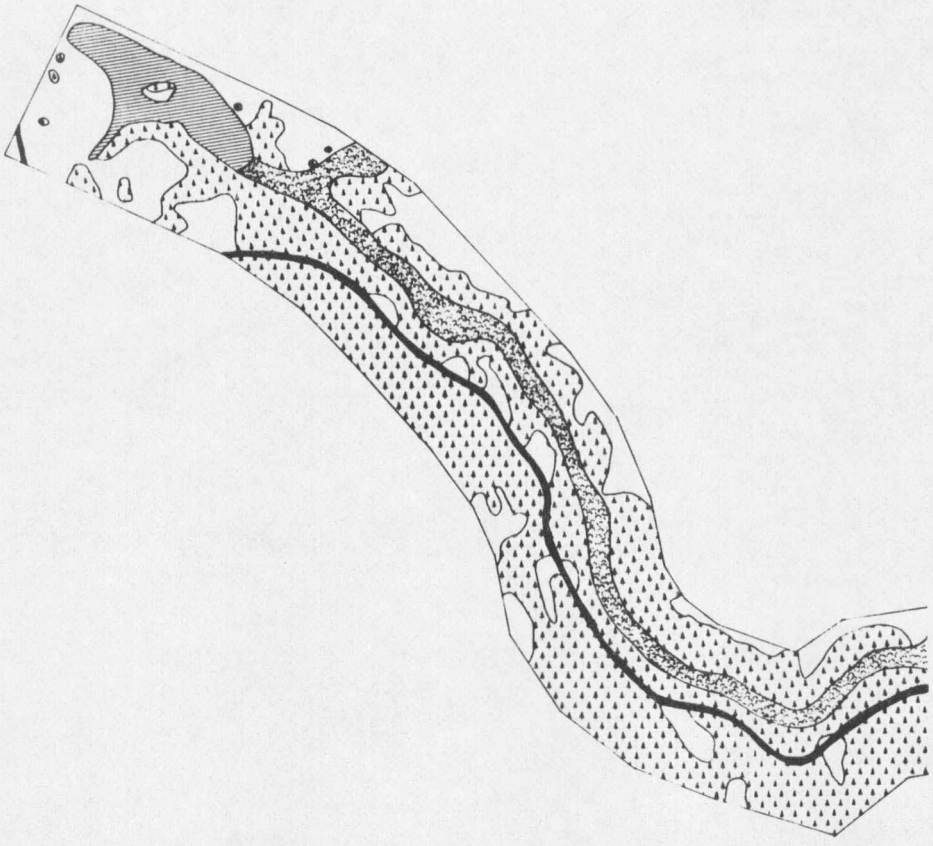


Figure 8. Plant communities found on the Maverick Gulch deciduous draw strip-plot. (Legend on next page)

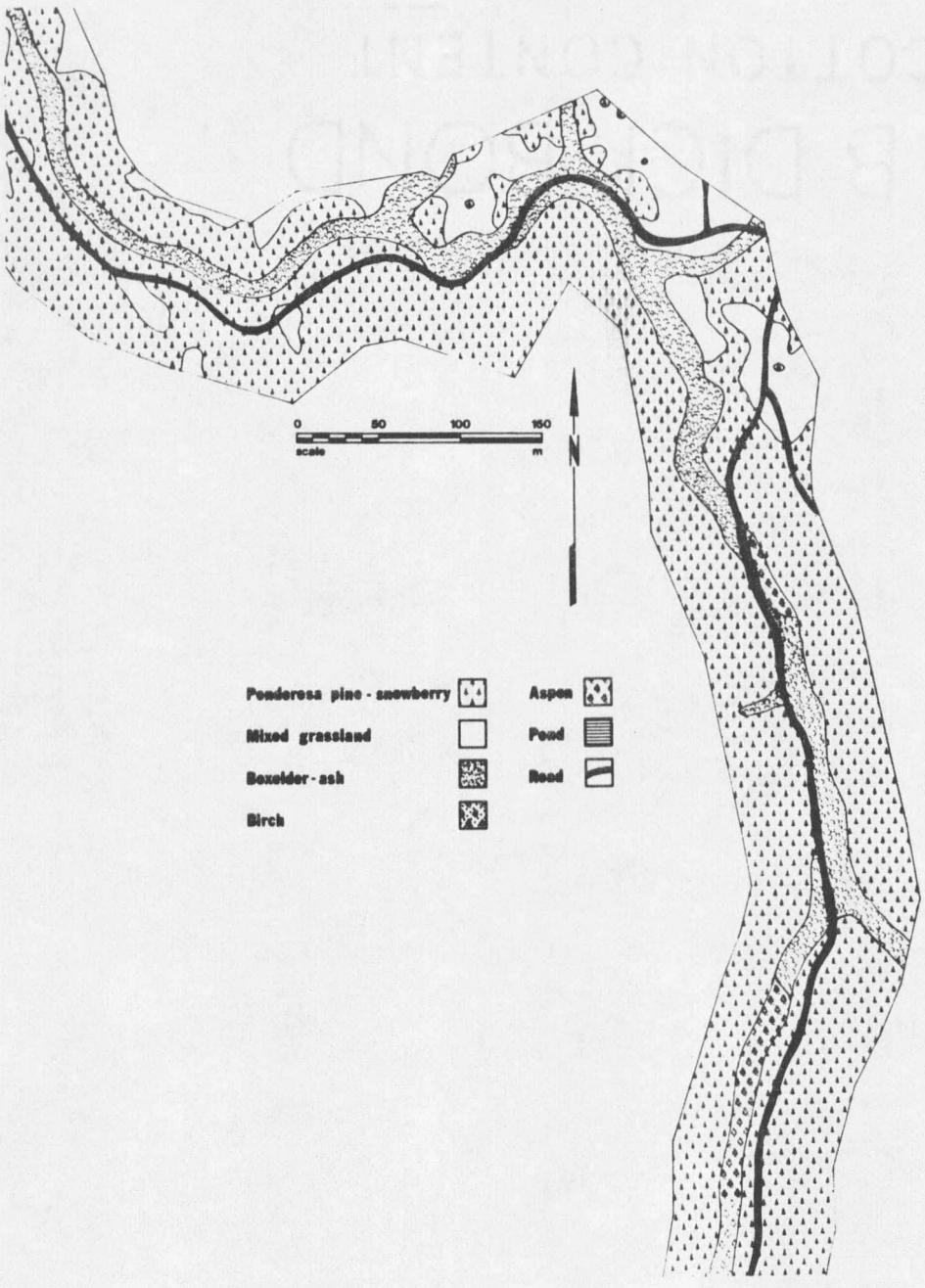


Figure 8. (Continued)

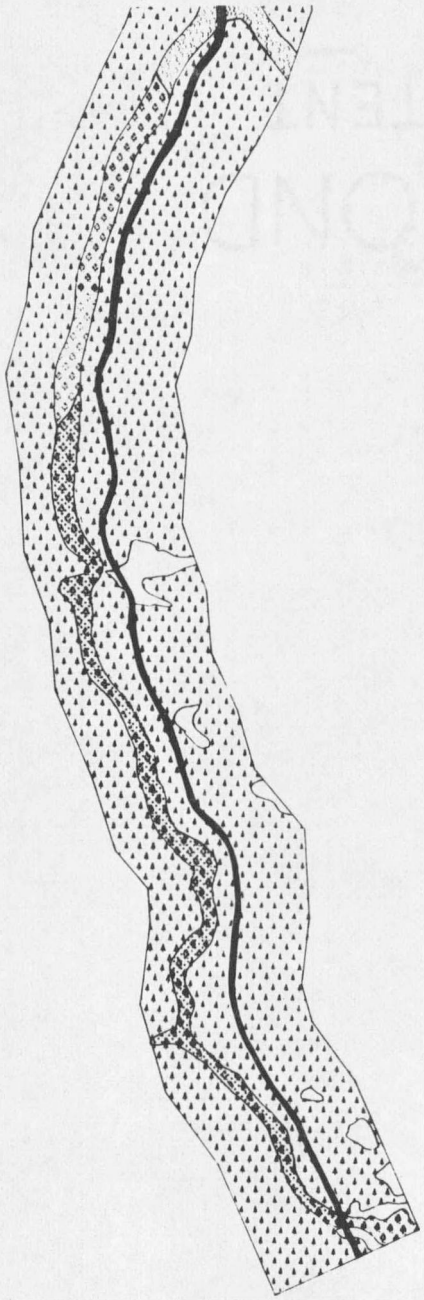


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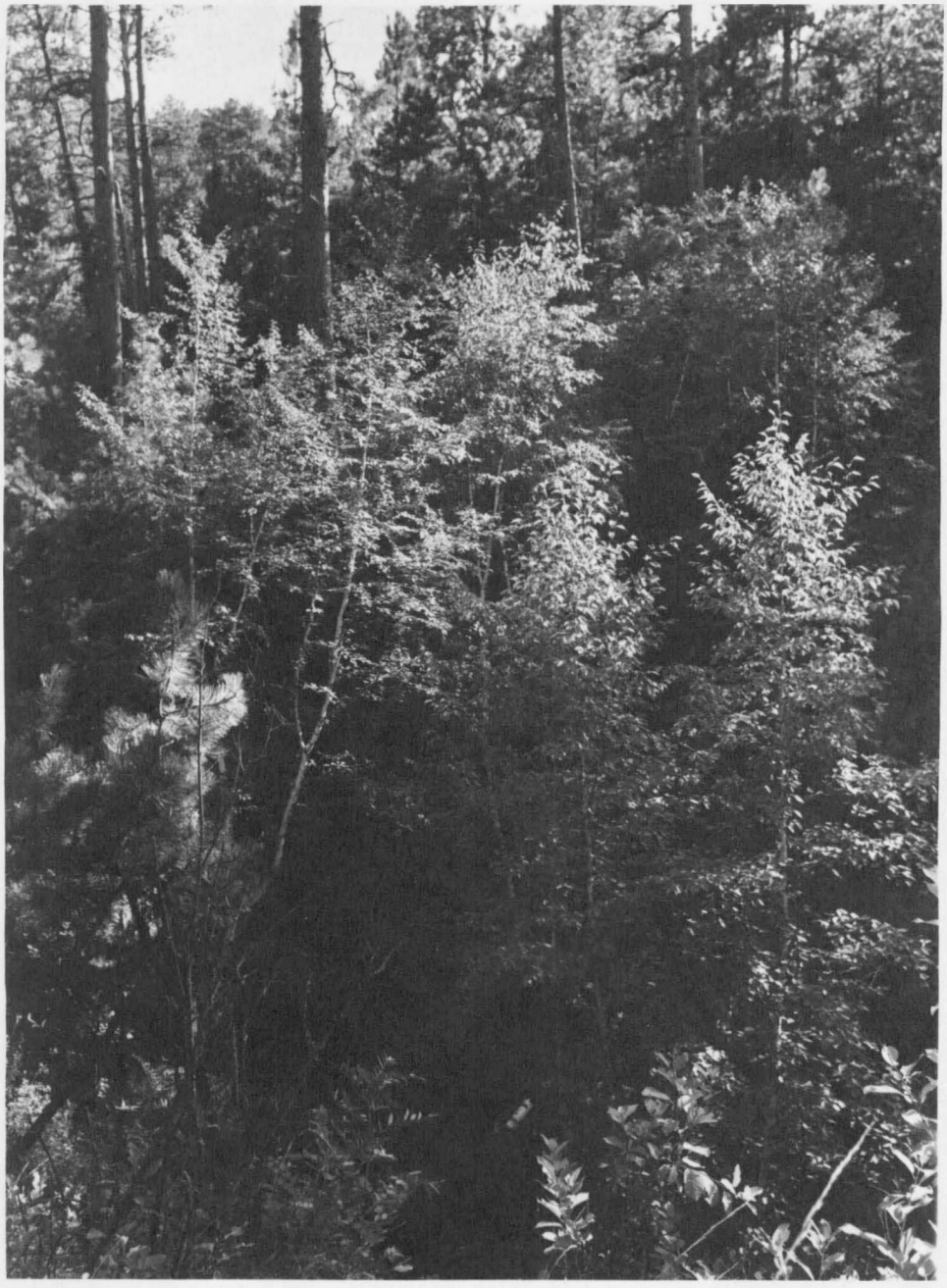


Figure 9. Relict birch stand in Maverick Gulch.

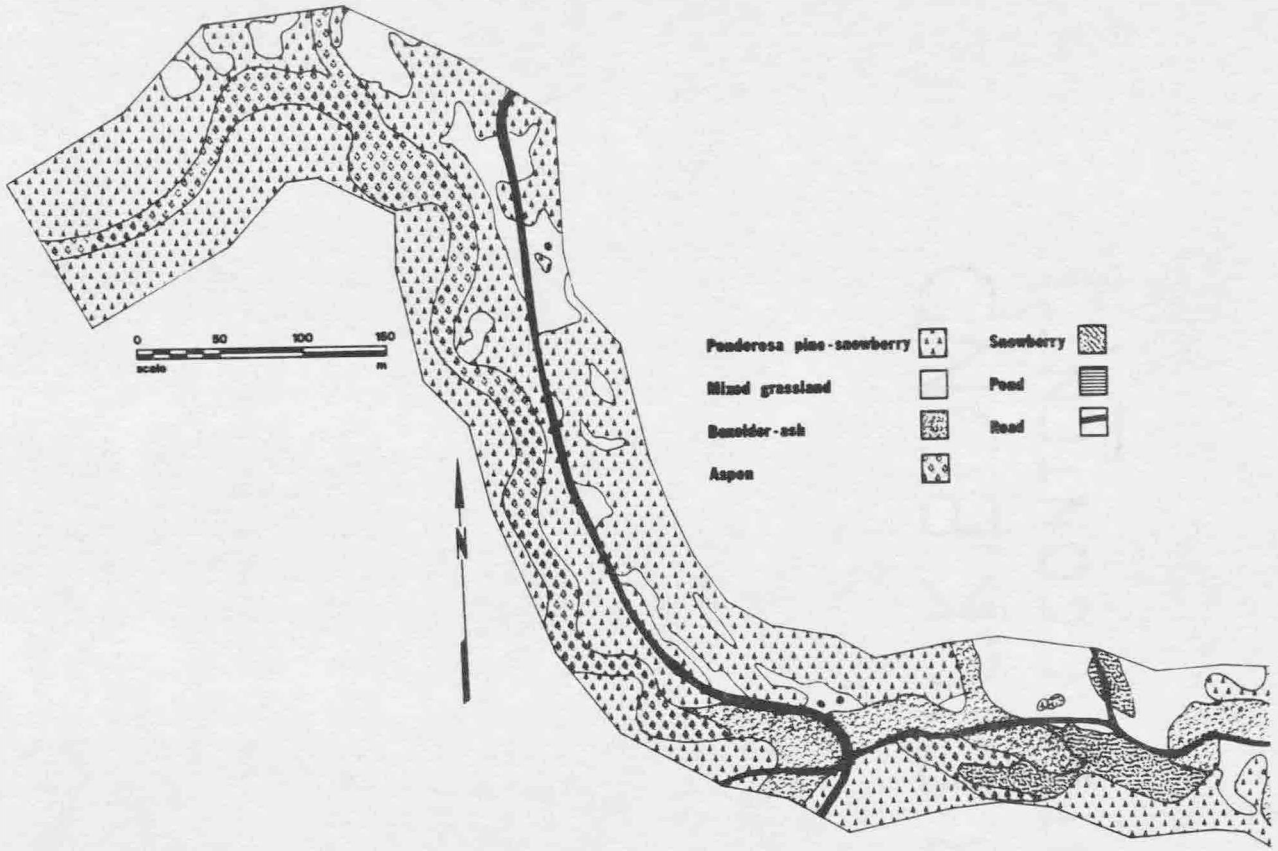


Figure 10. Plant communities found on the Ward Spring deciduous draw strip-plot.

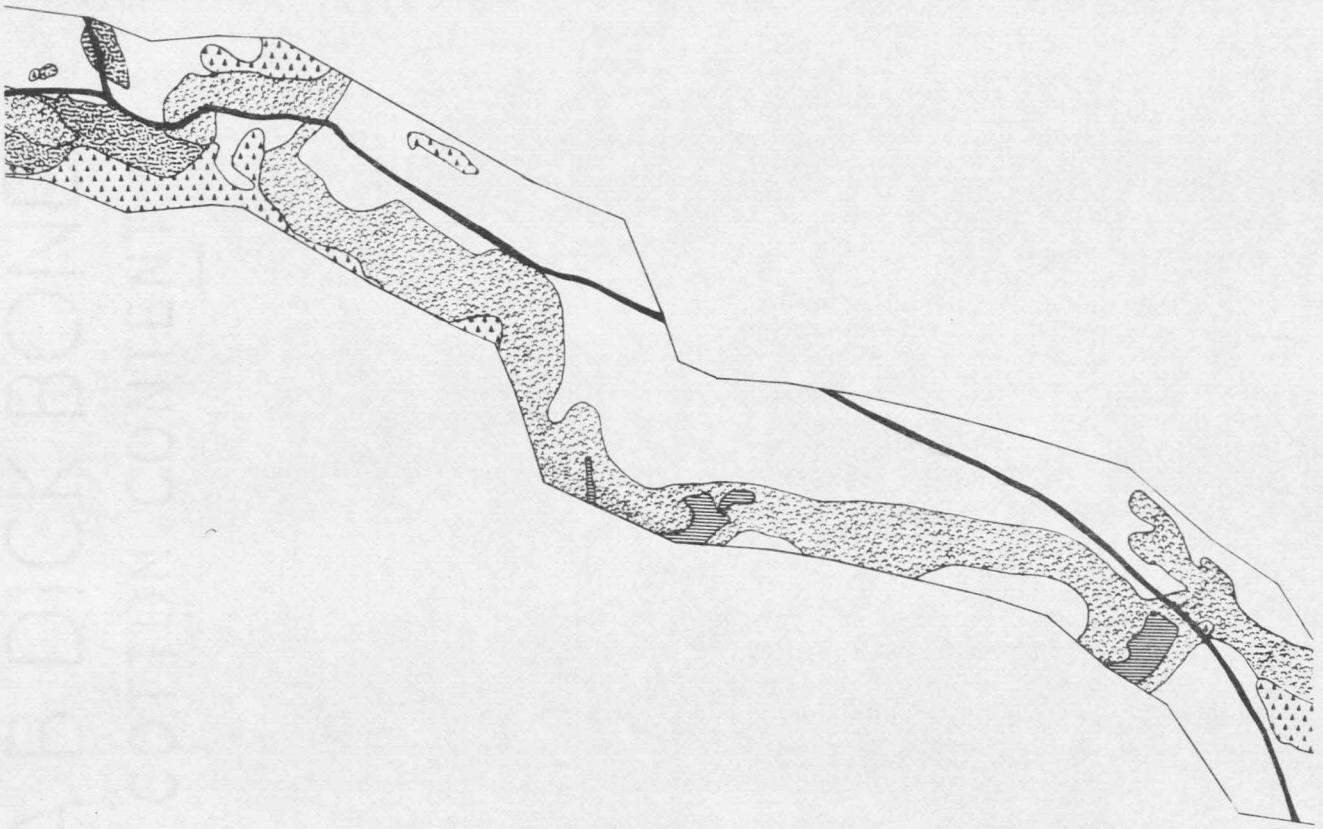


Figure 10. (Continued)

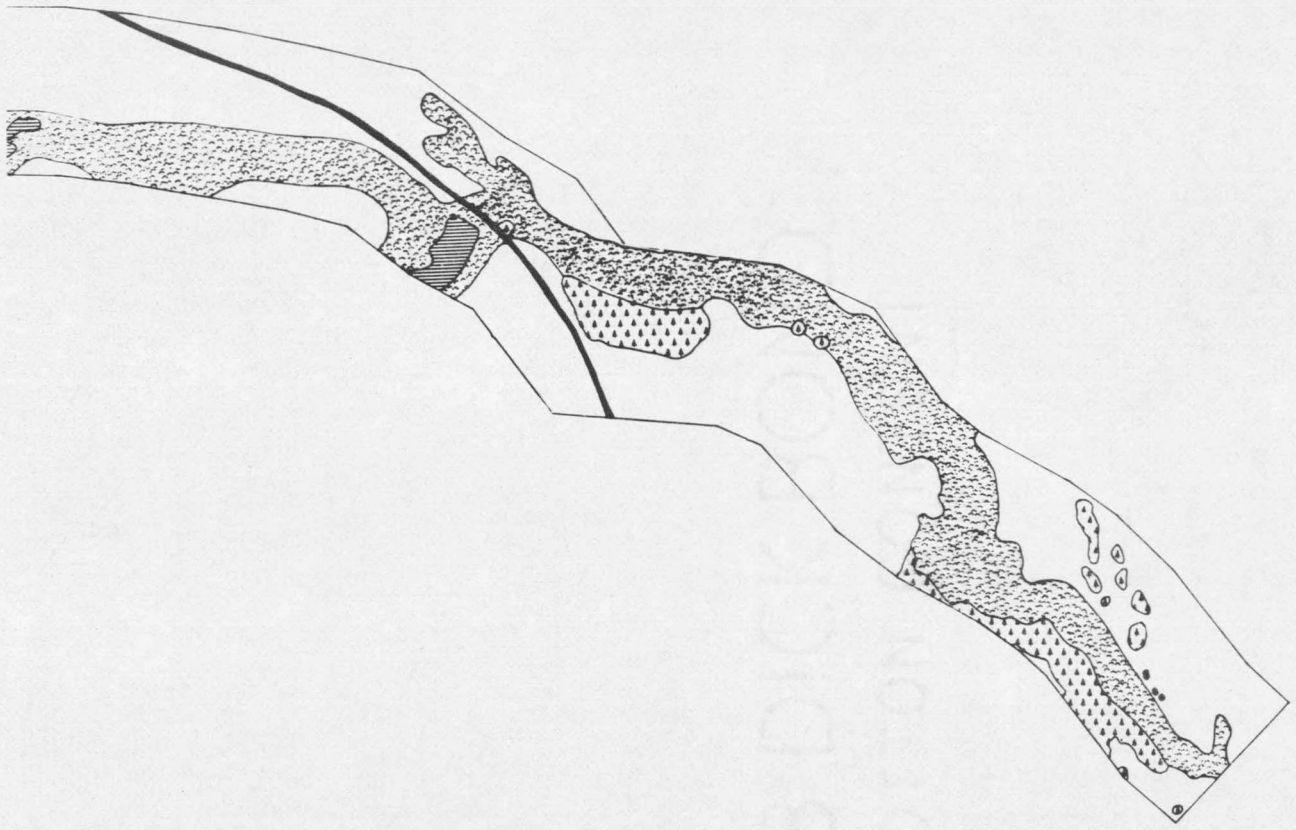


Figure 10. (Continued)

along the draw by Ward Spring. This draw contained a better-developed deciduous forest than the Maverick Gulch draw. The lower half of the strip-plot continued on to private land which was lightly grazed by horses and cattle. This draw contained vegetation more typical of the deciduous draws in the Long Pines (Figure 11).

The upper portion of the draw contained an aspen community which graded into a boxelder - ash community in the lower portion. The strip-plot covered 31.7 ha, of which 38% was deciduous draw. Boxelder - ash forest was the dominant community type in the draw as with the Maverick Gulch draw (Appendix Table 16), however the Ward Spring draw was wider and contained very few interspersed ponderosa pines. The upper portion of the draw contained several seeps surrounded by willow (*Salix sp.*). The lower portion contained a small stock pond and several small beaver ponds. The lowest one-fourth of the strip-plot, running through lightly-grazed private land, contained a small permanent creek, about 1 m wide and 0.75 m deep, with stable, well-vegetated banks. The water quality was excellent in the creek and good in the ponds, with very little siltation.

The upper portion of the draw on National Forest land was in a rest-rotation grazing system. The area was rested in 1977 and grazed from 16 May to 1 August in 1978. The draw showed heavier cattle use than the surrounding ponderosa pine forest, but was not severely eroded like the Maverick Gulch draw. Appendix Tables 17 and 18 show the



Figure 11. Boxelder - ash community (foreground) on the Ward Spring strip-plot.

results of the point-quarter and shrub analyses for the aspen and box-elder - ash stands in the draw. The average tree canopy cover in the draw was 62%.

Appendix Tables 19 through 24 list the results of the Daubenmire analysis of ground vegetation for the six major plant communities found on the plots and survey route. Many of the species with high percent cover in the Daubenmire samples are listed by Ross and Hunter (1976) as increasing with high grazing pressure. Several of these include thread-leaf sedge (*Carex filifolia*), needle-and-thread (*Stipa comata*), Sandberg bluegrass (*Poa secunda*), prairie junegrass (*Koleria cristata*), and yarrow (*Achillea millifolium*).

Appendix Table 25 lists the average heights of ground cover plants (grasses, forbs, shrubs under 0.5 m tall) in the six major plant communities. Snowberry draws had the tallest and aspen draws the shortest ground cover.

Appendix Table 26 lists the average height of tall shrubs (0.5 m to 2.0 m), the tree canopy bottom, and the tree canopy top in the major plant communities found on the breeding bird density plots. Forest communities in the deciduous draw and savannah plots were more diverse structurally than ponderosa pine plots, containing taller shrubs and a tree canopy which started closer to the ground.

Birds

Breeding Bird Survey Route

The breeding bird survey route was censused nine times between May and July. Fifty species were recorded, which was 44% of the species found in the entire study area (Table 1). Red crossbills were not counted, but were recorded as present or absent at each station. Crossbill flocks ranged in size from several birds to over 50.

The percent frequency was determined for each species by dividing the number of stations where the species was present (total for nine census runs) by the total number of stations (9 census runs x 22 stations = 198) times 100. The percent composition was calculated for each species by dividing the number of individuals of a species recorded by the total number of birds observed times 100.

Western meadowlarks, yellow-rumped warblers, chipping sparrows, ovenbirds, red-breasted nuthatches, and vesper sparrows accounted for 61% of the total number of birds. These species plus red crossbills had the highest frequency of observation. The distribution of frequency versus the number of species roughly follows Raunkaier's Law of Frequence (Linsdale 1924), with a few abundant species and many rare species (Figure 12).

Table 2 lists the individual survey route stations and percentages of grassland, ponderosa pine forest, and deciduous forest and the number of bird species, number of birds, bird diversity, and equitability

TABLE 1. PERCENT COMPOSITION AND FREQUENCY OF OCCURRENCE OF BIRDS ALONG THE BREEDING BIRD SURVEY ROUTE

Species	Percent Composition	Frequency of Occurrence
Yellow-rumped Warbler	13.5	61.6
Chipping Sparrow	11.9	51.5
Ovenbird	9.7	41.4
Red-breasted Nuthatch	6.4	37.9
Western Meadowlark	13.6	33.8
Red Crossbill	---	32.3
Rufous-sided Towhee	4.6	28.3
Vesper Sparrow	5.8	27.8
American Robin	4.6	27.3
Western Tanager	4.4	27.3
Black-capped Chickadee	3.6	23.2
House Wren	2.5	13.6
Mourning Dove	2.2	13.1
Mountain Bluebird	2.0	13.1
Dark-eyed Junco	1.4	10.1
Common Crow	1.3	9.6
Red-eyed Vireo	1.1	6.1
Turkey	1.8	5.6
Common Flicker	0.9	5.1
American Goldfinch	0.9	4.6
Brewer's Blackbird	0.7	4.6
Hairy Woodpecker	0.6	4.6
Townsend's Solitaire	0.6	4.6
Common Yellowthroat	0.7	4.0
Rock Wren	0.6	4.0
Lark Sparrow	0.5	4.0
Grasshopper Sparrow	0.5	3.0
Black-billed Magpie	0.4	2.5
Say's Phoebe	0.3	2.5
Red-tailed Hawk	0.3	2.0
Mallard	0.3	2.0
Killdeer	0.3	1.5
White-breasted Nuthatch	0.3	1.5
Red-winged Blackbird	0.2	1.5
Clark's Nutcracker	0.2	1.5
Blue Jay	0.2	1.0
Spotted Sandpiper	0.2	1.0
Horned Lark	0.2	1.0
American Kestrel	0.1	1.0
Great-horned Owl	0.1	1.0
Upland Sandpiper	0.1	1.0
Eastern Kingbird	0.1	0.5
Brown Creeper	0.1	0.5
Black-headed Grosbeak	0.1	0.5
Yellow Warbler	0.1	0.5
American Redstart	0.1	0.5
Common Nighthawk	0.1	0.5
Gray Catbird	0.1	0.5
Brown-headed Cowbird	0.1	0.5
Western Wood Pewee	0.1	0.5

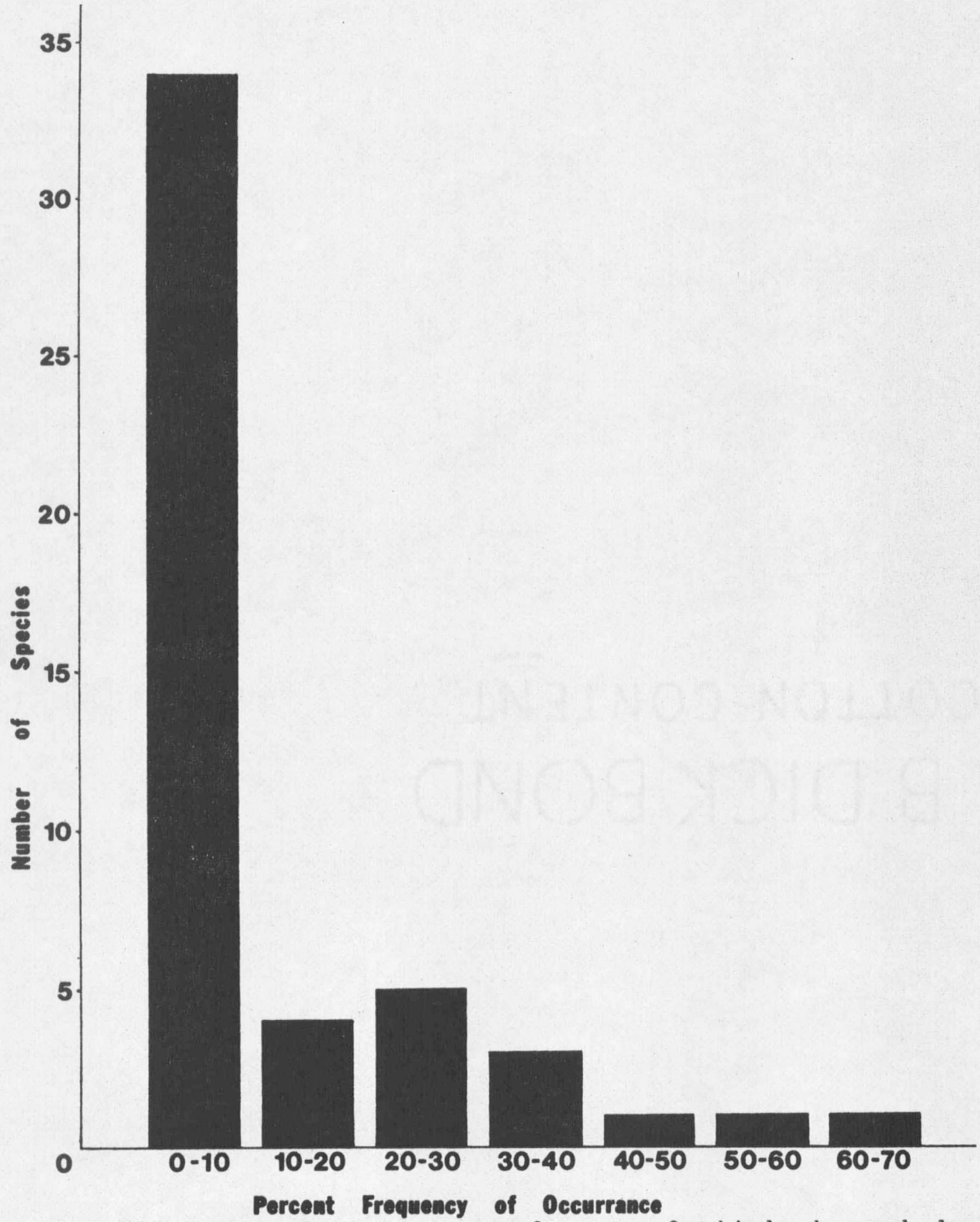


Figure 12. Number of species versus frequency for birds observed along the breeding bird survey route.

TABLE 2. SUMMARY OF MEASUREMENTS ON VEGETATION AND AVIFAUNA ON THE BREEDING BIRD SURVEY ROUTE STATIONS

Station Type	% Area of Vegetational Formation			Bird Numbers and Diversity			
	Grass-land	Ponderosa Pine	Decid-uous Draw	No. Species	No. Birds	Diver-sity*	Equit.**
Grassland	100	0	0	4	62	1.0	.51
Grassland	100	0	0	6	61	1.8	.68
Grassland	92	4	4	13	70	2.0	.54
Grassland	82	18	0	13	50	2.8	.78
Grassland	80	20	0	15	69	2.5	.66
Cliff	76	22	2	21	78	3.8	.87
Savannah	62	38	0	17	68	3.4	.84
Savannah	59	41	0	15	72	3.2	.84
Deciduous Draw	57	31	12	19	80	3.7	.89
Savannah	44	53	3	20	90	3.6	.86
Savannah	42	55	3	15	73	3.3	.87
Deciduous Draw	42	48	10	24	112	4.0	.88
Savannah	38	57	5	18	82	3.4	.83
Deciduous Draw	21	73	6	20	87	3.9	.91
Deciduous Draw	21	66	13	22	103	3.9	.88
Field	13	87	0	13	87	3.1	.91
Deciduous Draw	8	86	6	9	43	2.3	.76
Ponderosa Pine Forest	8	92	0	10	60	2.6	.81
Ponderosa Pine Forest	1	99	0	11	65	2.8	.83
Ponderosa Pine Forest	0	97	3	11	60	2.9	.88
Ponderosa Pine Forest	0	100	0	12	46	2.8	.81
Ponderosa Pine Forest	0	100	0	9	57	2.8	.87

*Shannon and Weaver (1949)
**Lloyd and Ghelardi (1964)

at each station. The index of diversity (H') was calculated for each station by using the Shannon-Weaver Index (Shannon and Weaver 1949). Equitability (E) was calculated by using the formula described by Lloyd and Ghelardi (1964). This is a measure of the distribution of the numbers of birds between the various species.

The number of bird species, number of birds, diversity, and equitability are lower in homogeneous grassland and ponderosa pine forest and higher in savannah areas where nearly equal proportions of forest and grassland exist. Leopold (1933) stated that wildlife densities were dependent on the amount of interspersion between vegetational types and the resulting amount of edge. Savannah areas in the Long Pines showed a high degree of interspersion, with many small patches of forest, grassland, and deciduous draws.

The stations were grouped by vegetational formation with five stations each of grassland, savannah, ponderosa pine forest, and deciduous draw forest. Table 3 presents the number of birds, number of species, diversity, and equitability by vegetational formation. The ponderosa pine forest was lowest and the deciduous draw forest highest in both numbers of birds and species. The low counts in the ponderosa pine forest may reflect the poor visibility and audibility in forest habitats compared to the other formations. An attempt was made to record all birds within 400 m of each station, but most species inhabiting ponderosa pine forests probably cannot be detected farther than 200

TABLE 3. NUMBERS OF SPECIES AND BIRDS, AND SPECIES DIVERSITY AND EQUITABILITY IN THE FOUR MAIN VEGETATIONAL FORMATIONS ALONG THE BREEDING BIRD SURVEY ROUTE

Vegetational Formation	Number of Species	Number of Birds	Diversity	Equitability
Grassland	26	312	2.4	0.51
Savannah	30	359	3.8	0.79
Ponderosa pine forest	16	273	3.0	0.76
Deciduous draw	40	409	4.2	0.79

m from the observer.

The grassland formation had the lowest index of diversity and deciduous draws the highest. This may be due to the increase in complexity of foliage structure in the draws, which allows a greater diversity of feeding and nesting guilds within the bird community.

Equitability was substantially lower in the grassland formation than in the other three formations. The savannah, ponderosa pine, and deciduous draw formations had nearly equal equitability values, with the grassland formation considerably lower. This is probably a result of many forest species being recorded in grassland areas, but in very small numbers.

The yellow-rumped warbler, chipping sparrow, ovenbird, red-breasted nuthatch, American robin, western tanager, black-capped chicka-

dee, mountain bluebird, dark-eyed junco, common crow, and red crossbill were common to all four formations, however most were more characteristic of wooded areas and only occasionally used adjacent grassland areas. The breeding bird survey route is probably a better measure of habitat use than breeding habitat for each species.

Figure 13 shows the relationship between the abundance of three common species and the percent grassland. Western meadowlarks are found in both savannah and grassland areas, but are found in increasing numbers as the percent grassland increases. Yellow-rumped warblers increase as the percent grassland decreases. Chipping sparrows reach their highest numbers in savannah areas and decrease in more homogeneous grassland or ponderosa pine forests, demonstrating their need for both trees and open areas.

The birds recorded on the grassland stations are presented in Table 4. The frequencies were ranked according to the scale devised by White (1942) (0-9% = rare, 10-30% = uncommon, 31-64% = moderately common, 65-89% = common, and 90-100% = abundant). Western meadowlarks and vesper sparrows were classified as abundant. Black-billed magpies, American kestrels, grasshopper sparrows, red-winged blackbirds, horned larks, and eastern kingbirds were recorded only on grassland stations. Of these, the American kestrel and black-billed magpie were more characteristic of savannah areas. Red-winged blackbirds were migrants in the study area, but breed in marshy areas nearby.

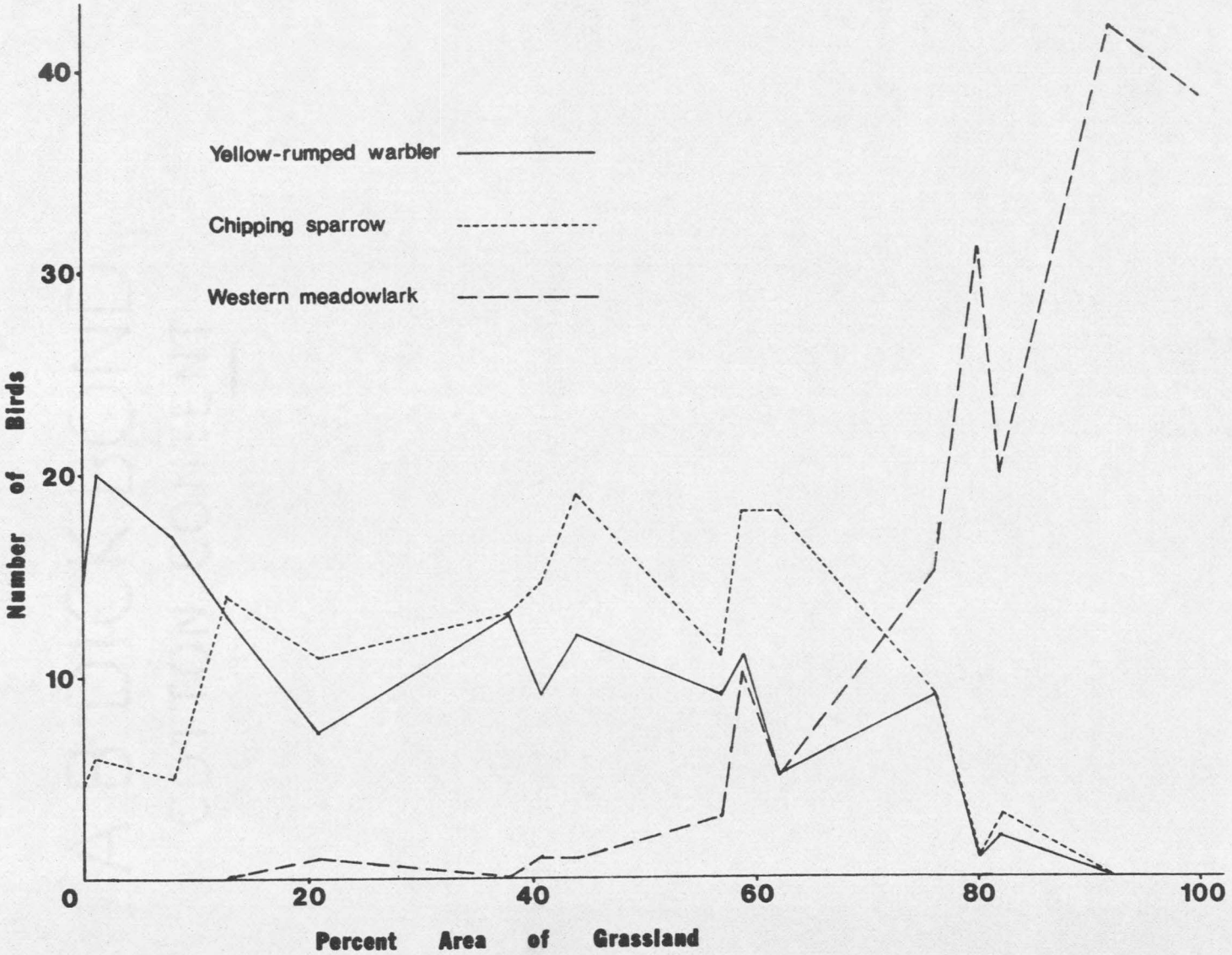


Figure 13. Change in abundance of yellow-rumped warblers, chipping sparrows, and western meadowlarks with increasing percentage of grassland along the breeding bird survey route.

TABLE 4. SPECIES COMPOSITION AND RELATIVE ABUNDANCE OF BIRDS OBSERVED ON FIVE SURVEY ROUTE STATIONS IN GRASSLAND AREAS

Species	Percent Composition	Percent Frequency of Occurrence	Rank*
Western Meadowlark	54.5	95.6	A
Vesper Sparrow	23.4	91.1	A
Mountain Bluebird	2.6	15.5	U
Grasshopper Sparrow	2.2	13.3	U
Mourning Dove	1.9	11.1	U
Black-billed Magpie	1.9	11.1	U
Common Crow	1.6	11.1	U
Chipping Sparrow	1.3	8.9	R
Red Crossbill	---	8.9	R
Yellow-rumped Warbler	1.0	6.7	R
Lark Sparrow	1.0	6.7	R
Ovenbird	1.3	4.4	R
American Robin	1.0	4.4	R
Horned Lark	1.0	4.4	R
Common Flicker	0.6	4.4	R
American Kestrel	0.6	4.4	R
Rufous-sided Towhee	0.6	4.4	R
Western Tanager	0.6	4.4	R
Killdeer	0.6	2.2	R
Red-breasted Nuthatch	0.3	2.2	R
Dark-eyed Junco	0.3	2.2	R
Red-winged Blackbird	0.3	2.2	R
Eastern Kingbird	0.3	2.2	R
Upland Sandpiper	0.3	2.2	R
Black-capped Chickadee	0.3	2.2	R
Turkey	0.3	2.2	R

*R = Rare = 0-9%
U = Uncommon = 10-30%
M = Moderately common = 13-64%
C = Common = 65-89%
A = Abundant = 90-100%

Birds recorded on the savannah stations are listed in Table 5. None of the species were ranked as abundant, but chipping sparrows and yellow-rumped warblers were ranked as common. Rock wrens were recorded only in this type, but were also observed in rocky outcrops in grassland areas. The numbers and frequency of chipping sparrows and turkeys ranked higher in savannah areas than in other formations. Turkey use of savannah areas was well-documented by Jonas (1966).

Birds recorded on the ponderosa pine forest stations are listed in Table 6. The yellow-rumped warbler was classified as abundant. Red-breasted nuthatches, dark-eyed juncos, and Townsend's solitaires occurred with much higher frequency in this formation than in other formations. Brown creepers were recorded only for this formation on the survey route but were observed in deciduous draws on several other occasions. Townsend's solitaires and brown creepers were very secretive, with a much lower singing frequency compared to other species. They may have been more common than the figures indicate.

Birds recorded on the deciduous draw stations are listed in Table 7. None of the species were ranked as abundant, but yellow-rumped warblers and ovenbirds were ranked as common. The red-eyed vireo, blue jay, spotted sandpiper, black-headed grosbeak, yellow warbler, American redstart, common nighthawk, gray catbird, western wood pewee were found only on stations in deciduous draws. Of these, common nighthawks are more characteristic of grassland areas, but forage for insects high in

TABLE 5. SPECIES COMPOSITION AND RELATIVE ABUNDANCE OF BIRDS OBSERVED ON FIVE SURVEY ROUTE STATIONS IN SAVANNAH AREAS

Species	Percent Composition	Percent Frequency of Occurrence	Rank*
Chipping Sparrow	23.4	77.8	C
Yellow-rumped Warbler	13.9	71.1	C
Red Crossbill	-----	55.6	M
Red-breasted Nuthatch	8.6	53.3	M
Rufous-sided Towhee	7.2	53.3	M
Ovenbird	8.1	44.4	M
Black-capped Chickadee	5.0	33.3	M
Western Tanager	4.2	28.9	U
Mourning Dove	4.2	26.7	U
Western Meadowlark	4.5	24.4	U
American Robin	3.6	24.4	U
Mountain Bluebird	2.5	17.8	U
Vesper Sparrow	2.2	17.8	U
Turkey	3.1	13.3	U
Common Flicker	1.4	6.7	R
Hairy Woodpecker	0.8	6.7	R
Common Goldfinch	0.8	6.7	R
Common Crow	0.8	6.7	R
Lark Sparrow	0.8	6.7	R
Rock Wren	0.8	6.7	R
Common Yellowthroat	0.8	6.7	R
Dark-eyed Junco	0.6	4.4	R
Brewer's Blackbird	0.6	2.2	R
House Wren	0.3	2.2	R
Great-horned Owl	0.3	2.2	R
Upland Sandpiper	0.3	2.2	R
Clark's Nutcracker	0.3	2.2	R
Red-tailed Hawk	0.3	2.2	R
Townsend's Solitaire	0.3	2.2	R
Mallard	0.3	2.2	R

* R = Rare = 0-9% M = Moderately common = 31-64%
U = Uncommon = 10-30% C = Common = 65-89%
A = Abundant = 90-100%

TABLE 6. SPECIES COMPOSITION AND RELATIVE ABUNDANCE OF BIRDS OBSERVED ON FIVE SURVEY ROUTE STATIONS IN PONDEROSA PINE FOREST

Species	Percent Composition	Percent Frequency of Occurrence	Rank*
Yellow-rumped Warbler	31.1	91.1	A
Red-breasted Nuthatch	13.6	62.2	M
Ovenbird	18.7	53.3	M
Chipping Sparrow	8.8	42.2	M
American Robin	6.6	33.3	M
Red Crossbill	---	33.3	M
Western Tanager	5.5	28.9	U
Black-capped Chickadee	5.5	26.7	U
Dark-eyed Junco	4.4	24.4	U
Townsend's Solitaire	2.2	13.3	U
White-breasted Nuthatch	1.1	4.4	R
Brewer's Blackbird	0.7	4.4	R
Common Goldfinch	0.7	4.4	R
Brown Creeper	0.4	2.2	R
Common Crow	0.4	2.2	R
Mountain Bluebird	0.4	2.2	R

*R = Rare = 0-9%
U = Uncommon = 10-30%
M = Moderately common = 31-64%
C = Common = 65-89%
A = Abundant = 90-100%

TABLE 7. SPECIES COMPOSITION AND RELATIVE ABUNDANCE OF BIRDS OBSERVED ON FIVE SURVEY ROUTE STATIONS IN DECIDUOUS DRAWS

Species	Percent Composition	Percent Frequency of Occurrence	Rank*
Yellow-rumped Warbler	11.0	68.9	C
Ovenbird	12.0	66.7	C
Chipping Sparrow	11.0	62.2	M
House Wren	9.0	57.8	M
Rufous-sided Towhee	8.3	51.1	M
American Robin	7.8	51.1	M
Western Tanager	7.3	48.9	M
Red-breasted Nuthatch	5.6	40.0	M
Red Crossbill	---	35.6	M
Red-eyed Vireo	3.9	26.7	U
Black-capped Chickadee	3.2	26.7	U
Mourning Dove	2.2	15.6	U
Mountain Bluebird	2.2	15.6	U
Common Goldfinch	2.0	11.1	U
Common Yellowthroat	1.7	11.1	U
Brewer's Blackbird	1.2	11.1	U
Vesper Sparrow	1.2	11.1	U
Western Meadowlark	1.2	8.9	R
Dark-eyed Junco	1.0	8.9	R
Hairy Woodpecker	0.7	6.7	R
Killdeer	0.7	4.4	R
Blue Jay	0.7	4.4	R
Spotted Sandpiper	0.7	4.4	R
Mallard	0.5	4.4	R
Townsend's Solitaire	0.5	4.4	R
Turkey	0.5	4.4	R
Common Flicker	0.5	4.4	R
Common Crow	0.2	2.2	R
Black-headed Grosbeak	0.2	2.2	R
Yellow Warbler	0.2	2.2	R
American Redstart	0.2	2.2	R
Common Nighthawk	0.2	2.2	R
Lark Sparrow	0.2	2.2	R
White-breasted Nuthatch	0.2	2.2	R
Great-horned Owl	0.2	2.2	R
Red-tailed Hawk	0.2	2.2	R
Gray Catbird	0.2	2.2	R
Brown-headed Cowbird	0.2	2.2	R
Clark's Nutcracker	0.2	2.2	R
Western Wood Pewee	0.2	2.2	R

*R = Rare = 0-9%
U = Uncommon = 10-30%
M = Moderately common = 31-64%
C = Common = 65-89%
A = Abundant = 90-100%

the air over forests. They were rarely noted on the survey route due to nocturnal habits. Yellow warblers, American redstarts, and gray catbirds were only noted as migrants in the Long Pines, but breed along creek bottoms around the periphery of the study area.

Blue jays used ponderosa pine forest and savannah areas, but probably depended heavily on deciduous draws for food and nesting requirements. They were at the edge of their breeding range in the Long Pines and were probably existing under marginal conditions. Mast, their major food source (Martin, Zim, Nelson 1951) may be limiting in the Long Pines due to the absence of oaks. Acorns supply much of the blue jay's food in other parts of their range. The only blue jay nest located in the study area was in a wide boxelder - ash draw with running water. They were more quiet and secretive than blue jays observed near the center of their breeding range (Wisconsin and Minnesota). Brooks (1942) described this phenomenon for other bird species near the extremities of their ranges.

The species compositions of the four major vegetational formations were compared using the index of similarity described by Sorenson (1948). The number of species common to two formations is multiplied by 2 and divided by the sum of the number of species found in the two formations. These are summarized in Table 8. The ponderosa pine forest and grassland formations were the least similar, with an index of 0.52. The high level of similarity between deciduous draws and grassland was

TABLE 8. INDICES OF SIMILARITY OF THE BIRD SPECIES FOUND IN THE FOUR MAJOR VEGETATIONAL FORMATIONS ALONG THE BREEDING BIRD SURVEY ROUTE

Index of Similarity (S) = $\frac{2(C)}{A+B}$

where: A = no. species in formation A
B = no. species in formation B
C = no. species common to both

Grassland and Savannah: $S = \frac{2(19)}{26+30} = 0.68$

Savannah and Ponderosa Pine: $S = \frac{2(14)}{30+16} = 0.61$

Ponderosa Pine and Grassland: $S = \frac{2(11)}{16+26} = 0.52$

Ponderosa Pine and Deciduous Draw: $S = \frac{2(15)}{16+40} = 0.54$

Savannah and Deciduous Draw: $S = \frac{2(28)}{30+40} = 0.80$

Grassland and Deciduous Draw: $S = \frac{2(19)}{26+40} = 0.58$

partially the result of the proximity of the two formations. Savannah and deciduous draws were the most similar, with a similarity index of 0.80. Several stations classified as savannah had small amounts of deciduous cover, and both formations were characterized by a high amount of edge habitat, which attracted similar bird species.

The species lists for the stations sampling the field invaded by ponderosa pine saplings, and the small cliff, are presented in Tables 9 and 10 respectively. Results from these two stations were analyzed separately and compared to those from the main formations. The station in the clearing being invaded by ponderosa pine was most similar to the other ponderosa pine stations (index of similarity = 0.62). It was more diverse than the other ponderosa pine stations, with diversity = 3.1, although it did not contain enough grassland to support grassland bird species.

The station containing the cliff was most similar to savannah (similarity = 0.75). Rock wrens were recorded at this station with highest frequency, and Say's phoebes were recorded only at this station. Say's phoebes seemed to require more extensive rock areas than rock wrens, and were most abundant along the peripheral rimrock in the Long Pines.

Breeding Bird Density Plots

Plot censusing of birds, also known as the international mapping method, is considered to be the most accurate measure of bird densities, but is also the most time-consuming method (Kendeigh 1944). It works

TABLE 9. SPECIES COMPOSITION OF BIRDS OBSERVED ON THE SURVEY ROUTE STATION IN A FIELD WITH PONDEROSA PINE SAPLINGS

Species	Percent Composition	Percent Frequency of Occurrence
Yellow-rumped Warbler	15.5	88.9
Common Crow	9.5	88.9
Chipping Sparrow	16.7	77.8
Ovenbird	16.7	66.7
Black-capped Chickadee	8.3	55.6
Western Tanager	4.8	44.4
Red-breasted Nuthatch	4.8	33.3
Red Crossbill	---	33.3
Turkey	15.5	22.2
Hairy Woodpecker	2.4	22.2
Dark-eyed Junco	2.4	22.2
Common Flicker	2.4	22.2
Clark's Nutcracker	1.2	11.1

TABLE 10. SPECIES COMPOSITION OF BIRDS OBSERVED ON THE SURVEY ROUTE STATION WITH A SMALL CLIFF

Species	Percent Composition	Percent Frequency of Occurrence
Western Meadowlark	19.5	100.0
Chipping Sparrow	11.7	100.0
Yellow-rumped Warbler	11.7	77.8
Rufous-sided Towhee	10.4	77.8
Rock Wren	7.8	55.6
Say's Phoebe	6.5	55.6
American Robin	5.2	33.3
Mountain Bluebird	3.9	33.3
Common Flicker	3.9	22.2
Mourning Dove	3.9	22.2
Red-tailed Hawk	2.6	22.2
Red-winged Blackbird	2.6	22.2
Red-breasted Huthatch	1.3	11.1
Black-capped Chickadee	1.3	11.1
Hairy Woodpecker	1.3	11.1
Brewer's Blackbird	1.3	11.1
Lark Sparrow	1.3	11.1
Vesper Sparrow	1.3	11.1
Common Crow	1.3	11.1
Red Crossbill	---	11.1
Mallard	1.3	11.1

best on breeding birds with the type A territory described by Nice (1941), in which courtship, nesting, feeding, and rearing young all occur within a fairly well-defined area. The method has not been extensively tested, and many sources of error exist. These include errors in interpreting territories (Best 1975), mis-identification of birds due to atypical songs (Short 1966), possible singing by females (Hiatt 1943, Nolan 1958), and presence of territorial, but unmated males (Davis 1965).

Several territorial non-breeding males were present on the areas censused. These were distinguished from breeding birds by their failure to remain during the entire breeding season and lack of female sightings or nesting activity. The other sources of error were minimized by repeating census runs as often as possible during the breeding season and recording concurrent singing by adjacent males of the same species to distinguish between territories.

Strips are considered less accurate than plots, but more efficient in terms of area covered per unit time (Emlen 1971). They were considered the best method for sampling the long, narrow strips of deciduous vegetation in the study area. A number of methods exist for calculating bird densities from strips (Emlen 1971, 1977, Balph et al. 1977, Jarvinen 1976, Tilghman 1977a). Most of these are designed for strips through homogeneous habitats, making corrections for the decrease in detectability as the distance from the bird to observer increases.

In this study, multiple sightings of a territorial male were used

to determine the number of territories along the strip-plot, combining the strip method D described by Emlen (1971) with the international mapping method. The number of territories within the strip-plot was divided by the area of the plot to obtain breeding pair densities. This method worked well for bird species, such as yellowthroats and house wrens, whose territories were entirely within the draw. The method may have overestimated densities for species, such as ovenbirds and black-capped chickadees, which are attracted to the draw, but whose territories extend into habitat outside the draw. A similar effect was described by Kendeigh (1944) for hedgerows.

The 16 ha plots were each censused thirteen times between late May and mid-July. The Ward Spring strip-plot was censused eleven times during the same period. The Maverick Gulch strip-plot was only censused seven times due to poor access in wet weather. A minimum of ten census runs are required for the international mapping method, and five runs are considered adequate for most strip methods (Emlen 1971, Tilghman 1977a).

The number of birds recorded per census run increased until late May and early June, then decreased in June and July on all plots. Several of the plots showed a second peak in bird numbers later in July, as a result of fledglings coming into the population.

The bird species, the number of breeding pairs, and the breeding bird densities recorded for all plots are presented in Table 11.

TABLE 11. BREEDING STATUS OF BIRD SPECIES OBSERVED ON THE FIVE BREEDING BIRD DENSITY PLOTS

Species	Grass-land	Savannah	Ponderosa Pine	Maverick Gulch	Ward Spring
Mallard					B
Turkey Vulture	B	B			
Sharp-shinned Hawk	B	B		B	B
Cooper's Hawk		B			
Red-tailed Hawk		B			B
Golden Eagle	B	B			
Marsh Hawk	B	B			
Prairie Falcon		B		B	
American Kestrel	B	B			
Sharp-tailed Grouse	B	B			
Turkey		B	B		B
Mourning Dove		1	B		B
Poor-will			1		
Belted Kingfisher					B
Common Flicker		B	B	B	
Hairy Woodpecker			1	1	1
Downy Woodpecker		B		B	B
Least Flycatcher					M
Western Wood Pewee		M			
Violet-green Swallow		B			
Blue Jay		B	B		1
Black-billed Magpie	B			B	
Common Crow	B	B			
Pinyon Jay				B	
Clark's Nutcracker		P			P
Black-capped Chickadee		1	3	3	4
White-breasted Nuthatch		B		B	
Red-breasted Nuthatch		1.5	4	7	7
Brown Creeper				1	1
House Wren		B			12
American Robin		B	9	3	12
Mountain Bluebird		2		B	B
Townsend's Solitaire		B	1	1	1
Red-eyed Vireo			B		7
Tennessee Warbler					M

TABLE 11. (Continued)

Species	Grass-land	Savannah	Ponderosa Pine	Maverick Gulch	Ward Spring
Northern Parula					M
Yellow Warbler					M
Yellow-rumped Warbler		3	9	8	14
Blackpoll Warbler					M
Ovenbird		B	7	17	18
Common Yellowthroat					16
American Redstart					M
Western Meadowlark	2.5	B			
Northern Oriole					M
Brewer's Blackbird			B		B
Western Tanager		1	4	3	6
Black-headed Grosbeak					1
Lazuli Bunting					3
American Goldfinch			B		3
Red Crossbill		P	P	P	P
Rufous-sided Towhee		B		B	12
Grasshopper Sparrow	B				
Vesper Sparrow	7	1			B
Lark Sparrow		B			
Dark-eyed Junco			3	3	4
Chipping Sparrow		7	8	6	11
Total No. Species	11	34	19	21	38
Total Breeding Species	2	8	11	11	19
No. Breeding Pairs	9.5	17.5	50.0	53.0	131.0
Pairs per 100 ha	59.4	109.4	312.5	169.9	413.2
Pairs per 100 acres	23.8	43.8	125.0	67.9	165.3
Pairs per km draw				18.3	43.7

Number = No. Breeding Pairs
B = Breeding in Locality of Plot
M = Spring Migrant Only (on plot)
P = Present as Non-breeder throughout Field Season (April-August)

Species not breeding on the plot were categorized as B (breeding in the locality of the plot), M (observed only during spring migration), and P (present throughout the field season as a non-breeder). The index of diversity (Shannon and Weaver 1949) and equitability (Lloyd and Ghelardi 1964) were calculated using only the bird species breeding on the plot.

Appendix Figure 14 shows the distribution of bird sightings on the grassland plot. This plot had the lowest number of breeding species and density, with two breeding species and 59.4 pairs per 100 ha. Eight other species were observed on the plot. Sharp-tailed grouse were observed displaying on the plot on several occasions. These may have been males associated with an established dancing ground located about 1.5 km east of the plot. The grassland plot had the lowest diversity ($H' = 0.8$) and lowest equitability ($E = 0.83$).

Appendix Figure 15 shows the distribution of bird sightings on the savannah plot. Forested areas were more heavily used than grassland areas. The savannah plot was next lowest in breeding species and density, with eight breeding species and 109.4 pairs per 100 hectares. Twenty-six other species were observed on the plot. The diversity and equitability were 2.6 and 0.86 respectively.

Appendix Figure 16 shows the distribution of bird sightings on the ponderosa pine plot. The largest aspen draw was heavily used by birds. The breeding bird density on the ponderosa pine plot was 312.5 pairs per 100 hectares with eleven breeding species. Eight other species were

observed on the plot. The diversity and equitability were 3.1 and 0.90 respectively.

Appendix Figure 17 shows the distribution of bird sightings on the Maverick Gulch strip-plot. The draw did not seem to be more heavily used compared to adjacent areas. The Maverick Gulch strip-plot had 170.1 breeding pairs per 100 hectares and eleven breeding species. Eleven other species were observed on the plot. The diversity and equitability were 3.0 and 0.85 respectively. This plot was lower in both diversity and breeding density than the ponderosa pine plot.

Appendix Figure 18 shows the distribution of bird sightings on the Ward Spring strip-plot. Bird sightings were concentrated in the draw, especially where the draw was adjacent to grassland. The Ward Spring strip-plot had the highest density and number of breeding species with 412.6 pairs per 100 hectares and 19 breeding species. Eighteen other species were observed on the plot. The diversity was also the highest of any plot, with diversity and equitability values of 3.9 and 0.91 respectively. This plot attracted more spring migrants than the other plots, especially of the Family Parulidae.

The plots were compared using the index of similarity (Sorenson 1948) described earlier (Table 12). Only species breeding on the plots were considered for the calculations. The ponderosa pine plot and the Maverick Gulch strip-plot were the most similar, with a similarity index of 0.91. The two strip-plots were next in similarity, with an index of

TABLE 12. INDICES OF SIMILARITY OF THE BIRD SPECIES FOUND BREEDING ON THE FIVE BREEDING BIRD DENSITY PLOTS

Index of Similarity (S) = $\frac{2(C)}{A+B}$ where: A = no. species on plot A
B = no. species on plot B
C = no. species common to both

Grassland and Savannah: $S = \frac{2(1)}{2+8} = .20$

Savannah and Ponderosa Pine: $S = \frac{2(5)}{8+11} = .53$

Ponderosa Pine and Maverick Gulch: $S = \frac{2(10)}{11+11} = .91$

Maverick Gulch and Ward Spring: $S = \frac{2(11)}{11+19} = .73$

Ponderosa Pine and Ward Spring: $S = \frac{2(10)}{11+19} = .67$

Savannah and Maverick Gulch: $S = \frac{2(5)}{8+11} = .53$

Savannah and Ward Spring: $S = \frac{2(5)}{8+19} = .37$

Grassland and Ponderosa Pine: $S = \frac{2(0)}{2+11} = 0$

Grassland and Maverick Gulch: $S = \frac{2(0)}{2+11} = 0$

Grassland and Ward Spring: $S = \frac{2(0)}{2+19} = 0$

0.73. The grassland plot was the most unique, only 0.20 similar to the savannah plot, and no similarity to the other plots.

DISCUSSION

Breeding bird densities and diversity were lowest in grasslands, higher in ponderosa pine forest, and highest in the deciduous forests found in the draws. Savannah areas of the Long Pines were not true savannahs, but represented small, interspersed patches of grassland and pine forest. Although the savannah areas were richer in numbers of bird species than either the grasslands or ponderosa pine forests and contained species of both types, they had lower breeding densities of grassland birds than homogeneous grasslands, and lower breeding densities of forest birds than homogeneous ponderosa pine forest.

Breeding bird populations have been shown to increase as the vegetation structure increases in diversity (MacArthur and MacArthur 1961). The deciduous draws which supported the highest breeding bird densities were also the most diverse; they were in open areas, were fairly wide (20-50 m), were more diverse in tree species (usually 3 species present), supported a well-developed understory of large shrubs, had low ground vegetation cover, and had a fairly constant water source. Open areas around draws were attractive to several edge species, such as yellowthroats and lazuli buntings, which tend to frequent deciduous forest edges. Low ground cover and tall shrubs have been correlated with high densities of ground-dwelling birds, such as ovenbirds and rufous-sided towhees (Tilghman 1977b). Intensive grazing reduces populations of

ground-dwelling species by reducing the shrub layer (Tilghman 1977b). Overgrazing and high densities of snowberry (a very low shrub) may have contributed to the low densities of birds in the Maverick Gulch draw.

The deciduous tree canopy and understory in draws allowed more feeding and nesting guilds of birds to be present, such as understory foliage gleaners (common yellowthroat, house wren) and deciduous tree and shrub nesters (red-eyed vireo, goldfinch, black-headed grosbeak).

The general absence of water outside the draws may limit the distribution of many species of birds in the Long Pines. Most of the passerines in the Long Pines probably require free drinking water. Yellow-rumped warblers, ovenbirds, dark-eyed juncos, black-capped chickadees, red-breasted and white-breasted nuthatches, and red crossbills were commonly observed drinking from seeps and springs. Dew is common in the morning until late June, but becomes rare in July and August. Many species probably travel from their territories to a water source (Nice 1937). Each species probably has a maximum distance which it will travel to water (Merriam 1888). Poor water quality may have contributed to the low bird densities in Maverick Gulch.

The bird species found in the forested areas tended to have smaller territories than species in grassland areas (Dorst 1974a). Territory size is primarily related to body size (Schoener 1968), but may involve other factors, such as food supply. Smaller territories allow for a greater population density of a given species. However, territory

size does not limit population density unless the population is near maximum, with all available habitat filled (Brown 1969).

The Long Pines is essentially an island of pine forest habitat surrounded by grassland. Other pine forest islands in the area include the Ekalaka Hills, Chalk Buttes and Sheep Mountains in Montana, and the Cave Hills, Short Pines, and Slim Buttes in South Dakota. The Black Hills, which lie 160 km (100 mi) southeast of the Long Pines, have nearly the same common breeding birds as the Long Pines (Pettingill and Whitney 1965). The common breeding birds of the two areas were 0.90 alike when compared using the index of similarity described previously.

Johnson (1975) related the number of breeding bird species found on montane islands in the Great Basin to a variety of factors. He found that the number of species was significantly and positively correlated to the total area of the range, elevation of highest peak, and habitat diversity. Numbers of species were negatively correlated with the width of the grassland and desert barrier to the nearest "continental" source (the Rocky Mountains and Sierra Nevadas). The number of species was most strongly correlated with the habitat diversity. In turn, the habitat diversity was negatively correlated with the width of the barrier. This implies that barriers between habitat islands limit the number of bird species both directly, by limiting dispersal of non-migratory breeding birds, and indirectly, by limiting dispersal of plant species between islands. The Long Pines is smaller and less diverse in habitat

and bird species than the Black Hills. Both areas are less diverse than, but contain bird species common to the "continental" habitats of both the Rocky Mountains and the eastern deciduous forest.

The possible effects of uranium mining on the breeding bird density, species composition, and diversity are difficult to predict. Some habitat changes have been shown to cause lower density, with diversity unaffected due to the replacement of some species by others (Tilghman 1977b). Other habitat changes may cause the opposite effect with lowered diversity, but unchanged density (Dorst 1974b).

Two important impacts of uranium mining would be removal of vegetation due to mining activity (road construction, injection and extraction wells, waste disposal sites, etc.) and an increase in human activity. Removal of vegetation would increase erosion rates around the site of disturbance and increase siltation in the watershed. High erosion and siltation is already a serious problem in most of the drainages in the Long Pines. The deciduous draws, which would suffer the most from erosion, harbor the highest diversity and breeding densities of songbirds, but cover the least area. Most of the active claims are in the more heavily-forested south-central part of the Long Pines (Allen 1979). These ponderosa pine forest habitats are second-highest in breeding bird densities. Thus the habitats most likely to be affected by mining activity contain the highest songbird densities.

Most species of songbirds are fairly tolerant of human activity

as long as the quality of their habitat is preserved. Human activity would have the greatest impact on raptors. Allen (1979) suggested leaving buffer zones around known nest sites of the raptors most sensitive to disturbance.

Most mining activity would take place during the summer, unless winter access to the Long Pines is improved. The nesting season for most of the songbirds in the Long Pines is from mid-May through late June. The birds of the deciduous draw communities tend to nest later than the birds of other communities. Most nest from late May through mid-July. They would be more vulnerable to disturbance from mining than the birds of open areas which tend to nest earlier.

Starlings and house sparrows, now limited to the periphery of the study area, may increase as a result of human activity (construction of buildings) in the Long Pines. Both of these species are hole-nesters and would compete with the ten native hole-nesting species. Mountain bluebirds, which are listed as a species of special interest or concern by Flath (1979), would probably suffer heavily from competition for nest-sites with starlings. They are about the same size and depend upon holes excavated by other birds, such as woodpeckers.

Any increase in levels of radioactivity in the environment due to uranium mining would be detrimental to songbird populations. Sensitivity of passerine birds to ionizing radiation (gamma rays) decreases through the egg, nestling, and adult stages (Wagner and Marples 1966,

Buech 1976, Willard 1963). Therefore, exposure to radiation would be most detrimental during the nesting season.

During mining activity, draws should be avoided, road construction and removal of vegetation should be minimized, and activity should be minimized during the nesting season (mid-May through mid-July). Disturbed areas should be re-vegetated as quickly as possible. Mining activities should be accomplished in a way that will not increase levels of radioactivity in the environment.

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APPENDIX

TABLE 13. CLIMATOLOGICAL DATA FOR EKALAKA, MONTANA FROM JANUARY 1977 THROUGH AUGUST 1978

Month	Mean Max.	Mean Min.	Mean	Departure from Normal	Precipitation (inches) PPT	Precipitation (inches) Departure from Normal
January	20.8	-3.4	8.7	-8.8	1.11	0.65
February	39.8	20.4	30.1	7.6	0.31	-0.10
March	45.7	23.5	34.6	6.0	1.39	0.76
April	63.6	33.1	48.4	5.6	0.21	-1.09
May	76.0	46.1	61.1	7.5	0.98	-1.27
June	82.1	52.8	67.5	5.6	3.34	-0.33
July	88.1	56.1	72.1	1.6	0.94	-0.95
August	79.0	49.7	64.4	5.1	1.20	-0.30
September	71.1	43.6	57.7	0.2	3.33	1.92
October	60.5	34.3	47.4	0.4	1.85	1.12
November	40.6	17.4	29.0	-2.4	0.83	0.26
December	26.8	7.7	17.3	-5.6	1.35	0.95
January	20.0	-0.3	9.9	-7.6	1.75	1.29
February	21.8	3.0	12.4	-10.1	2.01	1.60
March	43.3	21.1	32.2	3.6	0.06	-0.57
April	55.1	30.5	42.8	0.0	1.19	-0.11
May	65.7	38.9	52.3	-1.3	5.92	3.67
June	77.9	47.6	62.8	0.9	2.26	-1.41
July	83.3	53.9	68.6	-1.9	2.23	0.34
August	86.0	52.0	69.0	-0.5	1.05	-0.45

TABLE 14. PLANT SPECIES OBSERVED ON THE BREEDING BIRD SURVEY ROUTE STATIONS AND BREEDING BIRD DENSITY PLOTS

Aceraceae
Acer negundo
Alismataceae
Alisma plantago-aquatica
Anacardiaceae
Rhus radicans
Rhus trilobata
Apocynaceae
Apocynum androsaemifolium
Asclepiadaceae
Asclepias pumila
Asclepias syriaca
Asclepias verticillata
Asclepias viridiflora
Berberidaceae
Berberis repens
Betulaceae
Betula papyrifera
Boraginaceae
Cryptanthe bradburiana
Lithospermum incisum
Mertensia lanceolata
Cactaceae
Mammillaria vivipara
Opuntia fragilis
Opuntia polycantha
Campanulaceae
Campanula rotundifolia
Capparidaceae
Cleome serrulata
Caprifoliaceae
Symphoricarpos albus
Symphoricarpos occidentalis
Caryophyllaceae
Arenaria lateriflora
Cerastium arvense
Compositae
Achillea millefolium
Antennaria rosea
Artemisia cana
Artemisia dracunculus
Artemisia frigida
Artemisia ludoviciana
Artemisia tridentata
Arctium lappa
Aster falcatus
Aster integrifolius
Chrysothamnus viscidiflorus
Cirsium undulatum
Cirsium vulgare
Echinacea pallida
Erigeron canadensis
Erigeron pumilis
Erigeron strigosus
Eupatorium rugosum
Grindelia squarrosa

TABLE 14. (Continued)

Haplopappus spinulosus	*Juniperus scopulorum*
Helianthus petiolaris	Cyperaceae
Helianthus annuus	*Carex filifolis*
Kuhnia eupatorioides	Elaeagnaceae
Lactuca serriola	*Sherperdia argentea*
Liatris punctata	Ericaceae
Lygodesmia juncea	*Arctostaphylos uva-ursi*
Ratibida columnifera	*Pterospora andromedea*
Senecio plattensis	*Pyrola secunda*
Solidago missouriensis	Geraniaceae
Solidago mollis	*Geranium carolinianum*
Solidago rigida	Gramineae
Taraxicum officinale	*Agropyron cristatum*
Tragopogon dubius	*Agropyron smithii*
Xanthium strumarium	*Agropyron spicatum*
Convolvulaceae	*Agropyron trachycaulum*
Convolvulus arvensis	*Andropogon gerardi*
Cornaceae	*Andropogon scoparius*
Cornus stolonifera	*Aristida longiseta*
Cruciferae	*Bouteloua curtipendula*
Erysimum asperum	*Bouteloua gracilis*
Erysimum inconscpicuum	*Bromus japonicus*
Lepidium sp.	*Bromus tectorum*
Thlaspi arvense	*Buchloe dactyloides*
Cuppressaceae	*Calamovilfa longifolia*
Juniperus communis	*Elymus canadensis*
Juniperus horizontalis	*Festuca octoflora*

TABLE 14. (Continued)

Hordeum jubatum	*Melilotus officinalis*
Koleria cristata	*Oxytropis lambertii*
Muhlenbergia cuspidata	*Petalostemon candidum*
Poa pratensis	*Petalostemon purpureum*
Poa secunda	*Psoralea argophylla*
Schedonnardus paniculatus	*Psoralea esculenta*
Spartina gracilis	*Thermopsis rhombifolia*
Stipa comata	*Vicia americana*
Stipa spartea	Liliaceae
Stipa viridula	*Allium textile*
Grossulariaceae	*Asparagus officinalis*
Ribes americanum	*Calochortus gunnisonnii*
Ribes aureum	*Leucocrinum montanum*
Ribes setosum	*Smilacina racemosa*
Labiatae	*Smilacina stellata*
Dracocephalum parviflorum	*Smilax herbacea*
Hedeoma drummondii	*Yucca glauca*
Mentha arvensis	*Zygadenus venenosus*
Monarda fistulosa	Linaceae
Nepeta cataria	*Linum perenne*
Leguminosae	*Linum rigidum*
Astragalas crassicarpus	Loasaceae
Astragalas scapoides	*Mentzelia decapetala*
Glycyrrhiza lepidota	Malvaceae
Lotus purshianus	*Sphaeralcea coccinea*
Lupinus argenteus	Oleaceae
Medicago lupulina	*Fraxinus pennsylvanica*

TABLE 14. (Continued)

Syringa vulgaris

Onagraceae

Epilobium glandulosum

Gaura coccinea

Oenothera albicaulis

Oenothera caespitosa

Oenothera depressa

Oenothera serrulata

Orchidaceae

Spiranthes romanzoffiana

Oxalidaceae

Oxalis stricta

Pinaceae

Pinus ponderosa

Plantaginaceae

Plantago major

Plantago purshii

Polemoniaceae

Phlox hoodii

Phlox longifolia

Polygalaceae

Polygala alba

Polygala verticillata

Polygonaceae

Eriogonum annuum

Eriogonum multiceps

Rheum rhaponticum

Rumex crispus

Polypodiaceae

one species - not identified

Primulaceae

Steironema ciliatum

Ranunculaceae

Actaea rubra

Anemone cylindrica

Anemone patens

Clematis linguisticifolia

Delphinium bicolor

Ranunculus glaberrimus

Ranunculus sceleratur

Thalictrum venulosum

Rosaceae

Agrimonia striata

Amelancier alnifolia

Crataegus succulenta

Fragaria virginiana

Geum aleppicum

Geum triflorum

Potentilla flabellifolia

Potentilla norvegica

Prunus americana

Prunus virginiana

Rosa arkansana

Rubus idaeus

TABLE 14. (Continued)

Spiraea densifolia	Umbelliferae
Rubiaceae	*Anethum graveolens*
Galium aparine	*Heracleum lanatum*
Galium boreale	*Lomatium foeniculaceum*
Salicaceae	*Osmorhiza longistylis*
Populus deltoides	*Sanicula marilandica*
Populus tremuloides	Urticaceae
Salix scouleriana	*Urtica dioica*
Santalaceae	Violaceae
Comandra umbellata	*Viola canadensis*
Selaginellaceae	*Viola nuttallii*
Selaginella densa	*Viola septentrionalis*
Scrophulariaceae	Vitaceae
Besseya wyomingensis	*Vitis riparia*
Orthocarpus luterus	
Penstemon albidus	
Penstemon eriantherus	
Verbascum thapsus	
Veronica americana	
Typhaveae	
Typha latifolia	

TABLE 15. BIRD SPECIES OBSERVED IN THE STUDY AREA

Mallard	*Anas platy rhynchos*
Gadwall	*Anas strepera*
Pintail	*Anas acuta*
American Green-winged Teal	*Anas crecca*
Blue-winged Teal	*Anas discors*
American Wigeon	*Anas americana*
Northern Shoveler	*Anas clypeata*
Turkey Vulture	*Cathartes aura*
Sharp-shinned Hawk	*Accipiter striatus*
Cooper's Hawk	*Accipiter cooperii*
Red-tailed Hawk	*Buteo jamaicensis*
Swainson's Hawk	*Buteo swainsoni*
Ferruginous Hawk	*Buteo regalis*
Golden Eagle	*Aquila chrysaetos*
Bald Eagle	*Haliaeetus leucocephalus*
Marsh Hawk	*Circus cyaneus*
Prairie Falcon	*Falco mexicanus*
Merlin	*Falco columbarius*
American Kestrel	*Falco sparverius*
Sharp-tailed Grouse	*Pedioecetes phasianellus*
Ring-necked Pheasant	*Phasianus colchicus*
Gray Partridge	*Perdix perdix*
Turkey	*Meleagris gallopavo*
American Coot	*Fulica americana*
Killdeer	*Charadrius vociferus*
Long-billed Curlew	*Numenius americanus*
Upland Sandpiper	*Bartramia longicauda*
Spotted Sandpiper	*Actitis macularia*

TABLE 15. (Continued)

Solitary Sandpiper	*Tringa solitaria*
Greater Yellowlegs	*Tringa melanoleuca*
Willet	*Catoptrophorus semipalmatus*
Wilson's Phalarope	*Steganopus tricolor*
Rock Dave	*Columba livia*
Mourning Dove	*Zenaida macroura*
Black-billed Cuckoo	*Coccyzus erythropthalmus*
Great-horned Owl	*Bubo virginianus*
Burrowing Owl	*Athene cunicularia*
Short-eared Owl	*Asio flammeus*
Poor-will	*Phalaenoptilus nuttallii*
Common Nighthawk	*Chordeiles minor*
White-throated Swift	*Aeronautes saxatalis*
Belted Kingfisher	*Megaceryle alcyon*
Common Flicker	*Colaptes auratus*
Red-headed Woodpecker	*Melanerpes erythrocephalus*
Hairy Woodpecker	*Pecoides villosus*
Downy Woodpecker	*Picoides pubescens*
Eastern Kingbird	*Tyrannus tyrannus*
Western Kingbird	*Tyrannus verticalis*
Say's Phoebe	*Sayornis saya*
Least Flycatcher	*Empidonax minimus*
Western Wood Pewee	*Contopus sordidulus*
Horned Lark	*Eremophila alpestris*
Violet-green Swallow	*Tachycineta thalassina*
Rough-winged Swallow	*Stelgidopteryx ruficollis*
Barn Swallow	*Hirundo rustica*
Cliff Swallow	*Petrochelidon phyrrhonota*

TABLE 15. (Continued)

Blue Jay	*Cyanocitta cristata*
Black-billed Magpie	*Pica pica*
Common Raven	*Corvus corax*
Common Crow	*Corvus brachyrhynchos*
Pinyon Jay	*Gymnorhinus cyanocephalus*
Clark's Nutcracker	*Nucifraga columbiana*
Black-capped Chickadee	*Parus atricapillus*
White-breasted Nuthatch	*Sitta carolinensis*
Red-breasted Nuthatch	*Sitta canadensis*
Brown Creeper	*Certhia familiaris*
House Wren	*Troglodytes aedon*
Canon Wren	*Catherpes mexicanus*
Rock Wren	*Salpinctes obsoletus*
Gray Catbird	*Dumetella carolinensis*
Brown Thrasher	*Toxostoma refum*
American Robin	*Turdus migratorius*
Veery	*Catharus fuscescens*
Mountain Bluebird	*Sialia currucoides*
Townsend's Solitaire	*Myadestes townsendi*
Loggerhead Shrike	*Lanius ludovicianus*
Starling	*Sturnus vulgaris*
Red-eyed Vireo	*Vireo olivaceus*
Tennessee Warbler	*Vermivora peregrina*
Orange-crowned Warbler	*Vermivora celata*
Northern Parula	*Parula americana*
Yellow Warbler	*Dendroica petechia*
Yellow-rumped Warbler	*Dendroica coronata*
Blackpoll Warbler	*Dendroica striata*

TABLE 15. (Continued)

Ovenbird	*Seiurus aurocapillus*
Common Yellowthroat	*Geothlypis trichas*
Yellow-breasted Chat	*Icteria virens*
American Redstart	*Setophaga ruticilla*
House Sparrow	*Passer domesticus*
Western Meadowlark	*Sturnella neglecta*
Red-winged Blackbird	*Agelaius phoeniceus*
Northern Oriole	*Icterus galbula*
Brewer's Blackbird	*Euphagus cyanocephalus*
Common Grackle	*Quiscalus quiscula*
Brown-headed Cowbird	*Molothrus ater*
Western Tanager	*Piranga ludoviciana*
Black-headed Grosbeak	*Pheucticus melanocephalus*
Indigo Bunting	*Passerina cyanea*
Lazuli Bunting	*Passerina amoena*
Pine Siskin	*Carduelis pinus*
American Goldfinch	*Carduelis tristis*
Red Crossbill	*Loxia curvirostra*
Rufous-sided Towhee	*Pipilo erythrophthalmus*
Lark Bunting	*Calamospiza melanocorys*
Savannah Sparrow	*Passerculus sandwichensis*
Grasshopper Sparrow	*Ammodramus savannarum*
Vesper Sparrow	*Pooecetes gramineus*
Lark Sparrow	*Chondestes grammacus*
Dark-eyed Junco	*Junco hyemalis*
Chipping Sparrow	*Spizella passerina*
Field Sparrow	*Spizella pusilla*
Song Sparrow	*Melospiza melodia*

TABLE 16. PERCENT OF TOTAL AREA COVERED BY THE PLANT COMMUNITIES FOUND ON THE BREEDING BIRD DENSITY PLOTS

Plant Community	Breeding Bird Density Plots				
	Grass-land	Savannah	Ponderosa Pine	Maverick Gulch	Ward Spring
W. wheatgrass - needle-and-thread (mixed grassland)	81.3	52.6	9.0	14.5	30.6
Little bluestem	6.3	5.2			
Creeping juniper	1.8	----	---	----	----
Disturbed	---	1.9	---	----	----
Ponderosa pine - skunkbush	---	26.0	---	----	----
Ponderosa pine - snowberry	---	6.7	81.2	64.4	28.3
Aspen draw	---	----	8.0	2.4	9.0
Birch draw	---	----	---	2.7	----
Boxelder - ash draw	---	----	---	11.9	25.5
Snowberry draw	10.6	7.1	---	----	3.0
Pond	---	0.1	---	1.7	1.4
Road	---	0.4	1.8	2.4	2.2
Tree Canopy cover	---	*36 56	**65 75	57 (within draw)	62 (within draw)

*top number - within ponderosa pine-skunkbush
bottom number - within ponderosa pine-snowberry

**top number - west slope
bottom number - east slope

TABLE 17. RESULTS OF POINT-QUARTER ANALYSES ON THE BREEDING BIRD DENSITY PLOTS

Tree Species by Plot	Density Trees/ha	Total Basal Area (cm^2)	Mean Basal Area (cm^2)	Percent Freq. of Occur.	Percent of Total Trees
Savannah	387.5				
Pinus ponderosa		32552	407	100	100
Ponderosa Pine-east slope	558.9				
Pinus ponderosa		37568	470	100	100
Ponderosa Pine-west slope	1312.8				
Pinus ponderosa		23816	298	100	100
Maverick Gulch-birch stand	830.5				
Acer negundo		448	149	15	4
Amelanchier alnifolia		91	30	15	4
Betula papyrifera		6058	242	70	31
Fraxinus pennsylvanica		5501	183	80	38
Pinus ponderosa		17231	957	45	23
Populus tremuloides		293	293	5	1
Maverick Gulch-box.-ash	377.0				
Acer negundo		6479	926	25	9
Crataegus succulenta		29	29	5	1
Fraxinus pennsylvanica		11861	270	100	55
Pinus ponderosa		15036	578	75	33
Populus tremuloides		153	153	5	1
Prunus americana		40	40	5	1
Ward Spring-aspen stand	498.3				
Acer negundo		358	358	5	1
Crataegus succulenta		275	39	25	9
Fraxinus pennsylvanica		1940	129	45	19
Pinus ponderosa		14518	764	60	24
Populus tremuloides		9202	242	80	48
Ward Spring-box.-ash stand	657.5				
Acer negundo		25943	577	90	56
Amelanchier alnifolia		29	29	5	1
Crataegus succulenta		417	60	30	9
Fraxinus pennsylvanica		8222	358	65	29
Pinus ponderosa		263	263	5	1
Populus tremuloides		1736	579	15	4

TABLE 18. PERCENT FREQUENCY AND COVER OF SHRUBS AND SAPLING TREES (0.5 - 2 m TALL) ON THE BREEDING BIRD DENSITY PLOTS (ESTIMATED WITHIN 25 m^2 CIRCLE AT 20 POINTS IN EACH STAND)

Species	Savannah Plot		Ponderosa Pine Plot				Maverick Gulch Plot				Ward Spring Plot			
			East Slope		West Slope		Birch Stand		Box-ash Stand		Aspen Stand		Box-ash Stand	
	Freq.	Cover	Freq.	Cover	Freq.	Cover	Freq.	Cover	Freq.	Cover	Freq.	Cover	Freq.	Cover
Acer negundo	---	---	---	---	---	---	---	---	---	---	---	---	10	1
Amelanchier alnifolia	---	---	35	1	40	3	35	3	30	7	30	4	10	1
Artemisia cana	5	T*	---	---	---	---	---	---	---	---	---	---	---	---
Betula papyrifera	---	---	---	---	---	---	20	2	---	---	---	---	---	---
Cornus stolonifera	---	---	---	---	---	---	30	6	---	---	10	2	25	3
Crataegus succulenta	---	---	---	---	---	---	---	---	---	---	45	11	5	1
Fraxinus pennsylvanica	---	---	---	---	---	---	70	10	70	14	50	8	40	11
Juniperus communis	5	1	---	---	---	---	10	1	15	2	---	---	---	---
Pinus ponderosa	70	12	71	12	95	16	20	1	25	5	15	4	---	---
Populus tremuloides	---	---	---	---	---	---	10	1	5	1	30	6	20	3
Prunus virginiana	15	3	95	22	90	13	90	13	40	5	10	1	45	8
Rhus trilobata	5	T	20	1	50	9	---	---	---	---	---	---	---	---
Ribes sp.	---	---	25	1	30	T	95	13	90	13	45	6	70	7
Rosa arkansana	---	---	5	T	20	T	50	4	80	15	45	6	5	T
Rubus idaeus	---	---	---	---	---	---	---	---	---	---	25	4	---	---
Shepherdia argentea	5	1	---	---	---	---	---	---	---	---	---	---	---	---
Symphoricarpos sp.	70	33	90	26	95	35	50	16	100	61	95	30	30	3

*T = Trace - less than 1% cover.

TABLE 19. PERCENT FREQUENCY AND COVER OF GROUND VEGETATION IN MIXED GRASSLAND (TWELVE STANDS SAMPLED)

Taxa	Percent Frequency of Occurrence	Percent Cover
Grasses and sedges	100	85
Agropyron smithii	83	36
Agropyron trachycaulum	1	T*
Andropogon gerardi	1	T
Andropogon scoparius	14	8
Aristida longiseta	8	2
Bouteloua gracilis	27	6
Bromus sp.	18	4
Calamovilfa longifolia	2	T
Carex filifolia	83	36
Festuca octoflora	21	6
Koleria cristata	64	18
Muhlenbergia cuspidata	3	T
Poa secunda	75	32
Schedonnardus panniculatus	1	T
Stipa comata	38	16
Stipa viridula	6	1
Unknown grass	3	T
Forbs	97	36
Achillea millefolium	25	4
Allium textile	1	T
Anemone patens	1	T
Antennaria sp.	7	1
Artemisia dracunculus	8	1
Artemisia frigida	30	4
Artemisia ludoviciana	21	6

TABLE 19. (Continued)

Taxa	Percent Frequency of Occurrence	Percent Cover
Aster sp.	16	3
Astragalas sp.	5	T
Astragalas crassicarpus	1	T
Cerastium arvense	5	T
Chrysopsis villosa	2	T
Cirsium undulatum	2	T
Commandra umbellata	4	T
Compositae	5	T
Cruciferae	2	T
Echinacea pallida	3	T
Erigeron sp.	1	T
Erigeron canadensis	18	1
Eriogonum multiceps	3	T
Erysimum sp.	2	T
Geum triflorum	1	T
Glycyrrhiza lepidota	4	1
Grindelia squarrosa	3	T
Gutierrezia sarothrae	13	2
Happlopappus spinulosus	1	T
Helianthus sp.	1	T
Leguminosae	15	2
Linum rigidum	3	T
Lupinus argenteus	7	1
Lygodesmia juncea	6	T
Mammillaria vivipara	1	T
Medicago lupulina	2	T

TABLE 19. (Continued)

Taxa	Percent Frequency of Occurrence	Percent Cover
Oenothera sp.	1	T
Oenothera serrulata	1	T
Opuntia sp.	4	T
Orthocarpus luteus	17	2
Penstemon sp.	1	T
Petalostemon purpureum	2	T
Phlox hoodii	7	T
Phlox longifolia	4	T
Plantago purshii	13	T
Polygala alba	3	T
Polygala verticillata	11	T
Psoralea argophylla	13	2
Psoralea esculenta	10	T
Ratibida columnifera	12	1
Senecio sp.	1	T
Solidago sp.	3	T
Sphaeralcea coccinea	38	T
Taraxicum officinale	3	T
Tragopogon dubius	5	T
Unknown forb	17	1
Shrubs	6	1
Artemisia cana	5	T
Rosa arkansana	1	T
Yucca glauca	1	T
Bare ground	43	13
Rock	1	T

TABLE 19. (Continued)

Taxa	Percent Frequency of Occurrence	Percent Cover
Selaginela densa	27	9
Lichen	11	1
Ground litter	98	81
Standing litter	61	32

*T = Trace = less than 1%

TABLE 20. PERCENT FREQUENCY AND COVER OF GROUND VEGETATION IN PONDEROSA PINE - SKUNKBUSH FOREST (SIX STANDS SAMPLED)

Taxa	Percent Frequency of occurrence	Percent Cover
Grasses and sedges	94	61
Agropyron smithii	8	T*
Agropyron spicatum	56	14
Andropogon gerardi	1	T
Andropogon scoparius	15	6
Bouteloua curtipendula	26	10
Bouteloua gracilis	13	2
Bromus sp.	1	T
Calamovilfa longifolia	18	6
Carex filifolia	63	22
Festuca octoflora	11	1
Koleria cristata	10	1
Muhlenbergia cuspidata	17	5
Poa secunda	8	3
Stipa comata	47	15
Stipa viridula	19	5
Unknown grass	7	T
Forbs	89	23
Achillea millefolium	11	1
Allium textile	6	T
Anemone cylindrica	3	T
Anemone patens	3	T
Antennaria sp.	3	T
Artemisia dracunculus	1	T
Artemisia frigida	8	T

TABLE 20. (Continued)

Taxa	Percent Frequency of Occurrence	Percent Cover
Artemisia ludoviciana	18	3
Aster sp.	1	T
Calochortus gunnisonnii	1	T
Campanula rotundifolia	2	T
Cerastium arvense	15	1
Chrysopsis villosa	3	T
Cirsium undulatum	3	T
Commandra umbellata	4	T
Compositae	3	T
Cruciferae	3	T
Echinacea pallida	4	1
Erigeron canadensis	6	T
Gaura coccinea	3	T
Glycyrrhiza lepidota	1	T
Gutierrezia sarothrae	8	T
Hedeoma drummondii	3	T
Helianthus sp.	5	T
Leguminosae	3	T
Lactuca serriola	1	T
Linum perenne	1	T
Lupinus argenteus	4	T
Lygodesmia juncea	7	T
Medicago lupulina	2	T
Oenothera sp.	1	T
Oenothera serrulata	7	1

TABLE 20. (Continued)

Taxa	Percent Frequency of Occurrence	Percent Cover
Petalostemon purpureum	7	T
Phlox hoodii	10	T
Phlox longifolia	7	T
Plantago purshii	6	T
Polygala alba	1	T
Polygala verticillata	8	T
Psoralea argophylla	18	2
Psoralea esculenta	5	T
Ratibida columnifera	2	T
Solidago sp.	2	T
Tragopogon dubius	4	T
Vicia americana	16	2
Unknown forb	39	2
Shrubs	49	18
Artemisia cana	2	T
Juniperus communis	3	2
Pinus ponderosa	6	T
Prunus virginiana	1	T
Rhus trilobata	31	12
Rosa arkansana	3	T
Symphoricarpos sp.	12	4
Yucca glauca	2	T
Bare ground	48	14
Rock	39	16
Ground litter	100	70

TABLE 20. (Continued)

Taxa	Percent Frequency of Occurrence	Percent Cover
Standing litter	31	9
Selaginela densa	4	1
Lichen	4	T

*T = Trace = less than 1%.

TABLE 21. PERCENT FREQUENCY AND COVER OF GROUND VEGETATION IN PONDEROSA PINE - SNOWBERRY FOREST (NINE STANDS SAMPLED)

Taxa	Percent Frequency of Occurrence	Percent Cover
Grasses and sedges	91	55
Agropyron sp.	15	3
Andropogon scoparius	2	1
Aristida longiseta	3	T*
Bromus sp.	1	T
Carex sp.	49	16
Koleria cristata	5	T
Poa pratensis	52	28
Stipa comata	2	T
Stipa spartea	11	3
Stipa viridula	55	16
Unknown	4	T
Forbs	73	14
Achillea millefolium	18	2
Allium textile	1	T
Anemone cylindrica	2	T
Anemone patens	8	1
Antennaria sp.	7	T
Apocynum androsaemifolium	12	T
Artemisia ludoviciana	13	2
Asclepias sp.	1	T
Campanula rotundifolia	4	T
Cerastium arvense	5	T
Chrysopsis villosa	1	T
Commandra umbellata	1	T

TABLE 21. (Continued)

Taxa	Percent Frequency of Occurrence	Percent Cover
Compositae	6	2
Erigeron sp.	1	T
Galium boreale	26	2
Geum triflorum	1	T
Glycyrrhiza lepidota	1	T
Lactuca serriola	1	T
Leguminosae	6	T
Lupinus argenteus	2	T
Mentha arvensis	1	T
Monarda fistulosa	1	T
Penstemon sp.	1	T
Petalostemon purpureum	1	T
Phlox hoodii	1	T
Phlox longifolia	2	T
Polygala verticillata	2	T
Psoralea esculenta	3	T
Smilacina racemosa	1	T
Smilacina stellata	7	T
Taraxicum officinale	6	T
Thalictrum venulosum	2	T
Thermopsis rhombifolia	8	T
Tragopogon dubius	8	T
Vicia americana	14	2
Viola sp.	2	T
Unknown forb	16	2

TABLE 21. (Continued)

Taxa	Percent Frequency of Occurrence	Percent Cover
Shrubs	96	38
Amelanchier alnifolia	8	1
Berberis repens	45	14
Juniperus communis	1	T
Pinus ponderosa	16	2
Populus tremuloides	1	T
Prunus virginiana	29	6
Ribes sp.	1	T
Rosa arkansana	14	2
Shepherdia argentea	2	T
Spiraea densifolia	9	2
Symphoricarpos albus	64	13
Symphoricarpos occidentalis	14	2
Bare ground	3	T
Rock	1	T
Ground Litter	100	97
Standing litter	26	7

*T = Trace = less than 1%.

TABLE 22. PERCENT FREQUENCY AND COVER OF GROUND VEGETATION IN SNOWBERRY DRAWS (FIVE STANDS SAMPLED)

Taxa	Percent Frequency of Occurrence	Percent Cover
Grasses and sedges	98	67
Agropyron sp.	34	12
Bromus sp.	23	7
Carex sp.	50	25
Elymus sp.	21	12
Poa sp.	68	46
Stipa viridula	31	7
Unknown grass	23	5
Forbs	98	53
Achillea millefolium	24	3
Anemone cylindrica	2	T*
Antennaria sp.	1	T
Artemisia ludoviciana	57	10
Aster sp.	21	3
Compositae	1	T
Convolvulus arvensis	12	3
Galium aparine	8	1
Galium boreale	25	2
Glycyrrhiza lepidota	30	18
Leguminosae	7	T
Monarda fistulosa	77	28
Oxalis stricta	6	1
Smilacina stellata	1	T
Solidago sp.	2	T
Taraxicum officinale	11	T

TABLE 22. (Continued)

Taxa	Percent Frequency of Occurrence	Percent Cover
Tragopogon dubius	2	T
Urtica dioica	1	T
Vicia americana	1	T
Viola sp.	1	T
Unknown forb	3	T
Shrubs	100	75
Prunus virginiana	7	2
Ribes sp.	3	T
Rosa arkansana	20	4
Symphoricarpos sp.	100	73
Ground litter	100	95
Standing litter	75	21

*T = Trace = less than 1%.

TABLE 23. PERCENT FREQUENCY AND COVER OF GROUND VEGETATION IN ASPEN DRAWS (FIVE STANDS SAMPLED, INCLUDES ONE BIRCH STAND

Taxa	Percent Frequency of Occurrence	Percent Cover
Grasses and sedges	92	50
Agropyron sp.	4	T*
Bromus sp.	5	T
Carex sp.	39	16
Elymus sp.	3	T
Poa pratensis	63	34
Stipa viridula	2	T
Unknown grass	22	5
Forbs	97	27
Achillea millefolium	6	T
Antennaria sp.	1	T
Apocynum androsaemifolium	16	1
Campanula rotundifolia	4	T
Cerastium arvense	2	T
Compositae	4	T
Cruciferae	1	T
Erysimum sp.	1	T
Fragaria virginiana	8	T
Galium aparine	23	5
Galium boreale	34	2
Glycyrrhiza lepidota	2	T
Labiatae	7	T
Lupinus argenteus	1	T
Medicago lupulina	5	T
Mentha arvensis	13	2

TABLE 23. (Continued)

Taxa	Percent Frequency of Occurrence	Percent Cover
Monarda fistulosa	7	1
Oxalis stricta	1	T
Polypodiaceae	1	T
Potentilla sp.	3	T
Pyrola secunda	13	2
Sanicula marilandica	16	2
Smilacina racemosa	6	T
Smilacina stellata	38	3
Smilax herbacea	4	T
Steironema ciliatum	8	T
Taraxicum officinale	36	3
Thalictrum venulosum	31	4
Tragopogon dubius	2	T
Urtica dioica	2	T
Vicia americana	1	T
Viola sp.	12	2
Viola nuttallii	2	T
Unknown forb	30	3
Shrubs	95	40
Acer negundo	1	T
Amelanchier alnifolia	3	T
Arctostaphylos uva-ursi	4	T
Berberis repens	64	16
Betula papyrifera	1	T
Crataegus succulenta	9	T

TABLE 23. (Continued)

Taxa	Percent Frequency of Occurrence	Percent Cover
Fraxinus pennsylvanica	4	T
Juniperus communis	6	3
Pinus ponderosa	4	T
Populus tremuloides	6	3
Prunus virginiana	23	3
Rhus radicans	26	4
Ribes sp.	12	2
Rosa arkansana	10	1
Rubus idaeus	19	3
Spiraea densifolia	6	T
Symphoricarpos sp.	58	9
Bare ground	9	3
Ground litter	99	94
Standing litter	8	1
Bryophyta	1	T

*T = T less than 1%.

TABLE 24. PERCENT FREQUENCY AND COVER OF GROUND VEGETATION IN BOX-ELDER-ASH DRAWS (NINE STANDS SAMPLED)

Taxa	Percent Frequency of Occurrence	Percent Cover
Grasses and sedges	94	72
Agropyron sp.	8	2
Bromus sp.	6	T*
Carex sp.	46	27
Elymus sp.	31	13
Poa pratensis	72	49
Stipa viridula	8	2
Unknown grass	12	3
Forbs	94	31
Achillea millefolium	11	1
Actaea rubra	1	T
Anemone cylindrica	1	T
Anethum graveolens	2	T
Arctium lappa	1	T
Artemisia frigida	1	T
Artemisia ludoviciana	1	T
Asclepias sp.	1	T
Campanula rotundifolia	2	T
Cirsium sp.	2	T
Convolvulus arvensis	17	2
Erysimum sp.	2	T
Eupatorium rugosum	1	T
Fragaria virginiana	8	T
Galium aparine	37	7
Galium boreale	16	1

TABLE 24. (Continued)

Taxa	Percent Frequency of Occurrence	Percent Cover
Geranium carolinianum	1	T
Geum gleppicum	1	T
Glycyrrhiza lepidota	2	T
Medicago lupulina	7	T
Mentha arvensis	9	1
Monarda fistulosa	16	3
Osmorhiza longistylis	10	2
Oxalis stricta	6	T
Polypodiaceae	5	T
Potentialla sp.	13	2
Rumex crispus	3	T
Sanicula merilandica	6	T
Smilacina racemosa	1	T
Smilacina stellata	12	1
Smilax herbacea	4	T
Solidago sp.	4	2
Steironema ciliatum	3	T
Taraxicum officinale	32	4
Thalictrum venulosa	32	5
Tragopogon dubius	7	1
Urtica dioica	13	3
Vicia americana	1	T
Viola sp.	3	T
Unknown forb	24	3

TABLE 24. (Continued)

Taxa	Percent Frequency of Occurrence	Percent Cover
Shrubs	88	52
Acer negundo	9	5
Amelanchier alnifolia	2	T
Berberis repens	30	10
Cornus stolonifera	1	T
Crataegus succulenta	1	T
Fraxinus pennsylvanica	11	2
Populus tremuloides	1	T
Prunus americana	3	T
Prunus virginiana	14	3
Rhus radicans	7	T
Ribes sp.	11	2
Rosa arkansana	8	2
Rubus idaeus	22	5
Spiraea densifolia	1	T
Symphoricarpos sp.	61	26
Bare gound	15	9
Ground litter	97	89
Standing litter	28	10

*T = less than 1%.

TABLE 25. AVERAGE HEIGHT (cm) OF GROUND COVER IN THE MAJOR PLANT COMMUNITIES FOUND ON THE BREEDING BIRD SURVEY ROUTE AND DENSITY PLOTS

Plant Community	Grass	Forb	Shrub
Grassland	34	21	20
Ponderosa Pine-Skunkbush Sumac	37	21	33
Ponderosa Pine-Snowberry	29	20	26
Snowberry Draw	41	44	46
Aspen Draw	23	17	25
Boxelder-Ash Draw	37	31	38

TABLE 26. AVERAGE HEIGHT (m) OF TREES AND TALL SHRUBS ON THE BREEDING BIRD DENSITY PLOTS

Plot	Tall Shrubs, Saplings	Tree Canopy Bottom	Tree Canopy Top
Ponderosa Pine-East Slope	0.7	5.8	14.3
Ponderosa Pine-West Slope	0.5	3.6	9.8
Savannah	0.8	0.9	7.4
Maverick Gulch-Birch-Aspen	0.8	2.8	10.2
Maverick Gulch-Boxelder-Ash	1.0	3.3	11.0
Ward Spring-Aspen	0.9	4.1	11.0
Ward Spring-Boxelder-Ash	1.0	1.7	8.3

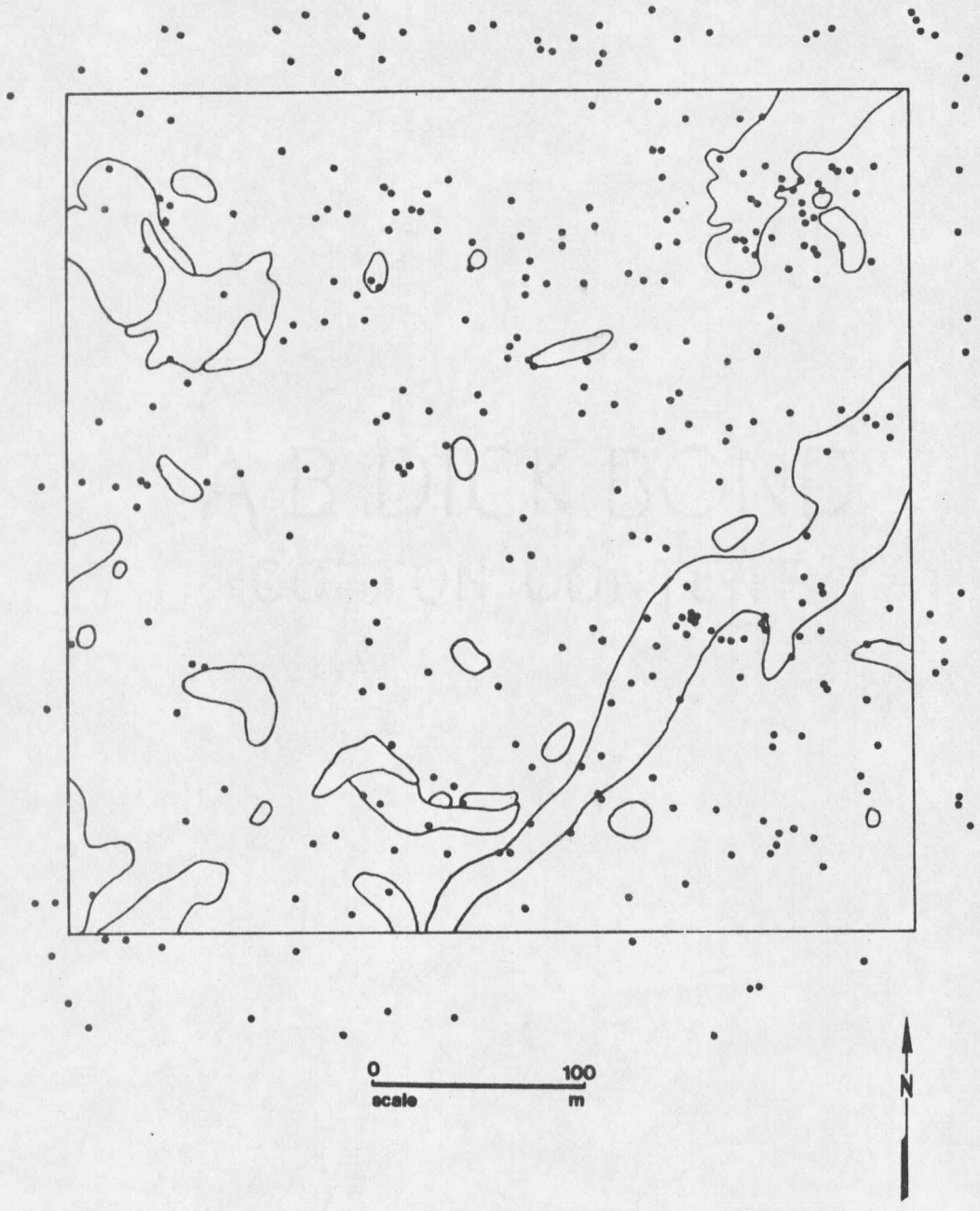


Figure 14. Locations of bird sightings on the grassland plot.

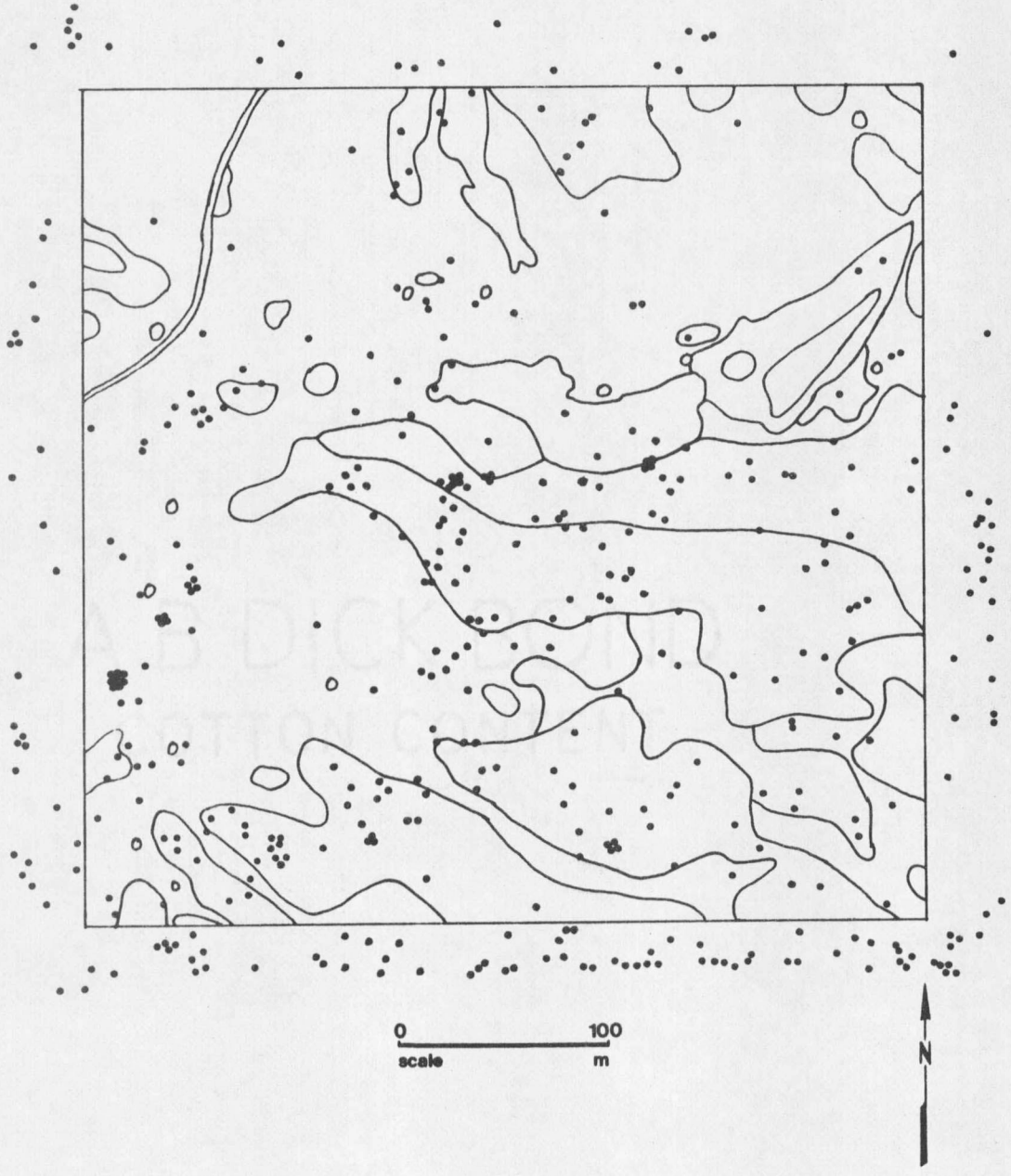


Figure 15. Locations of bird sightings on the savannah plot.

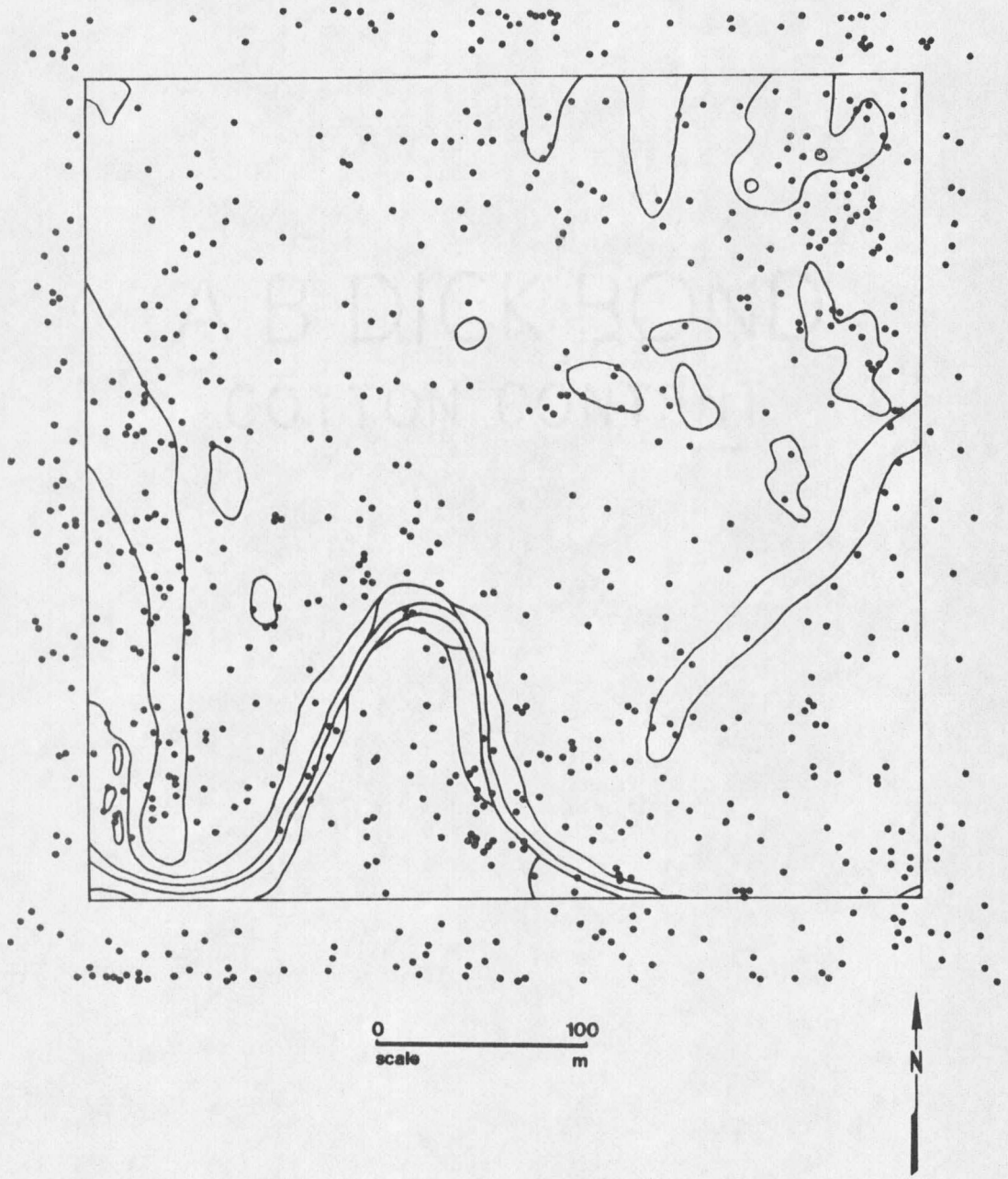


Figure 16. Locations of bird sightings on the ponderosa pine forest plot.

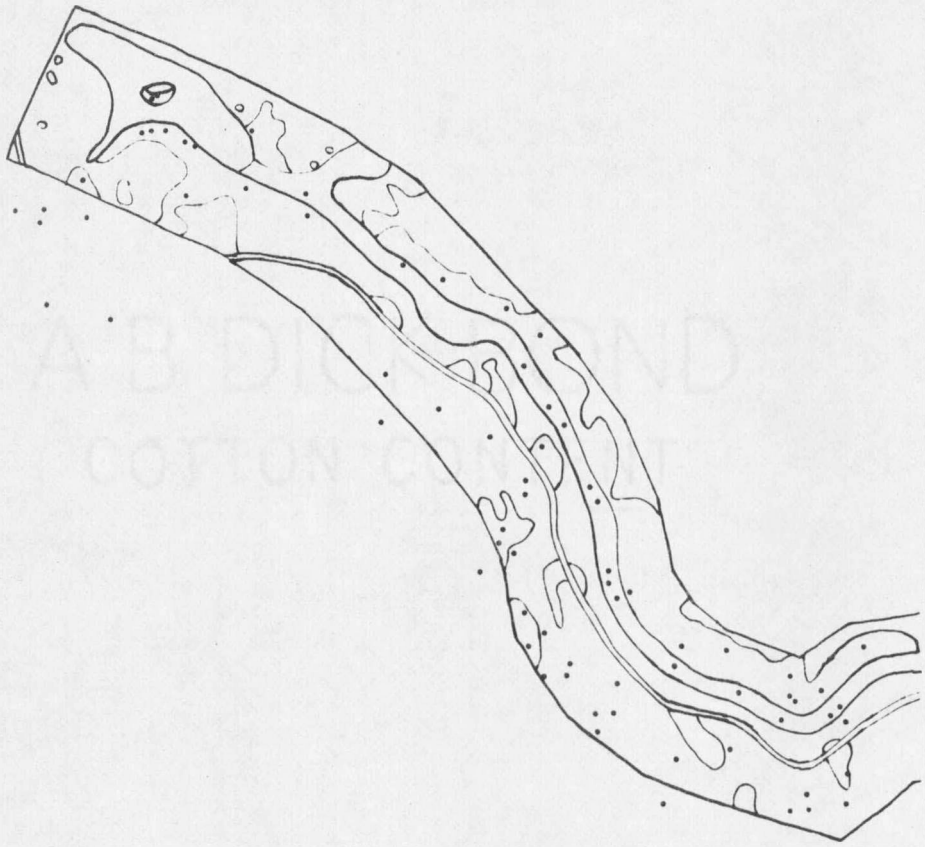


Figure 17. Locations of bird sightings on the Maverick Gulch deciduous draw strip-plot.

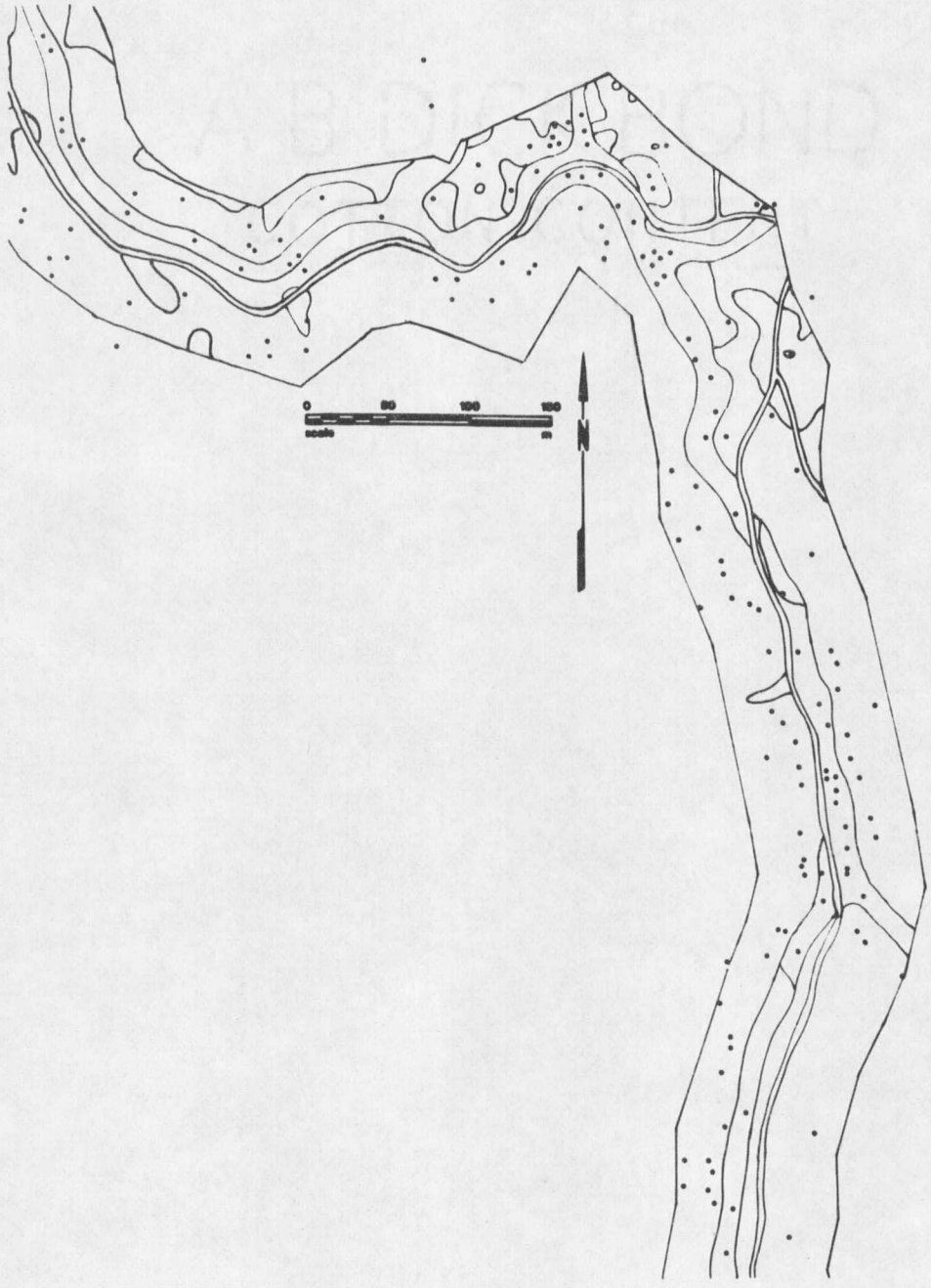


Figure 17. (Continued)

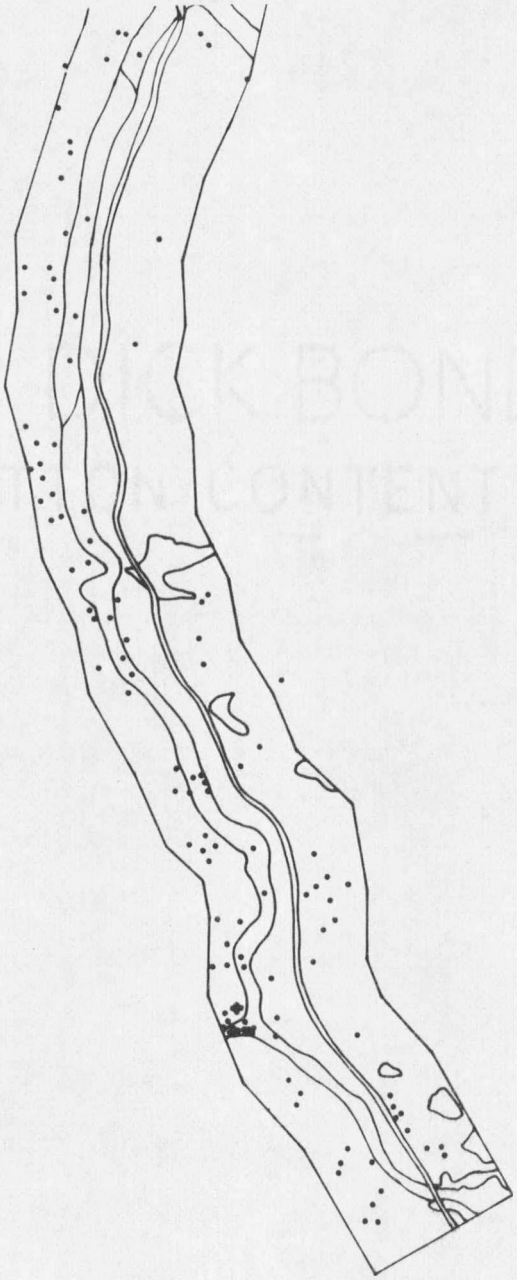


Figure 17. (Continued)

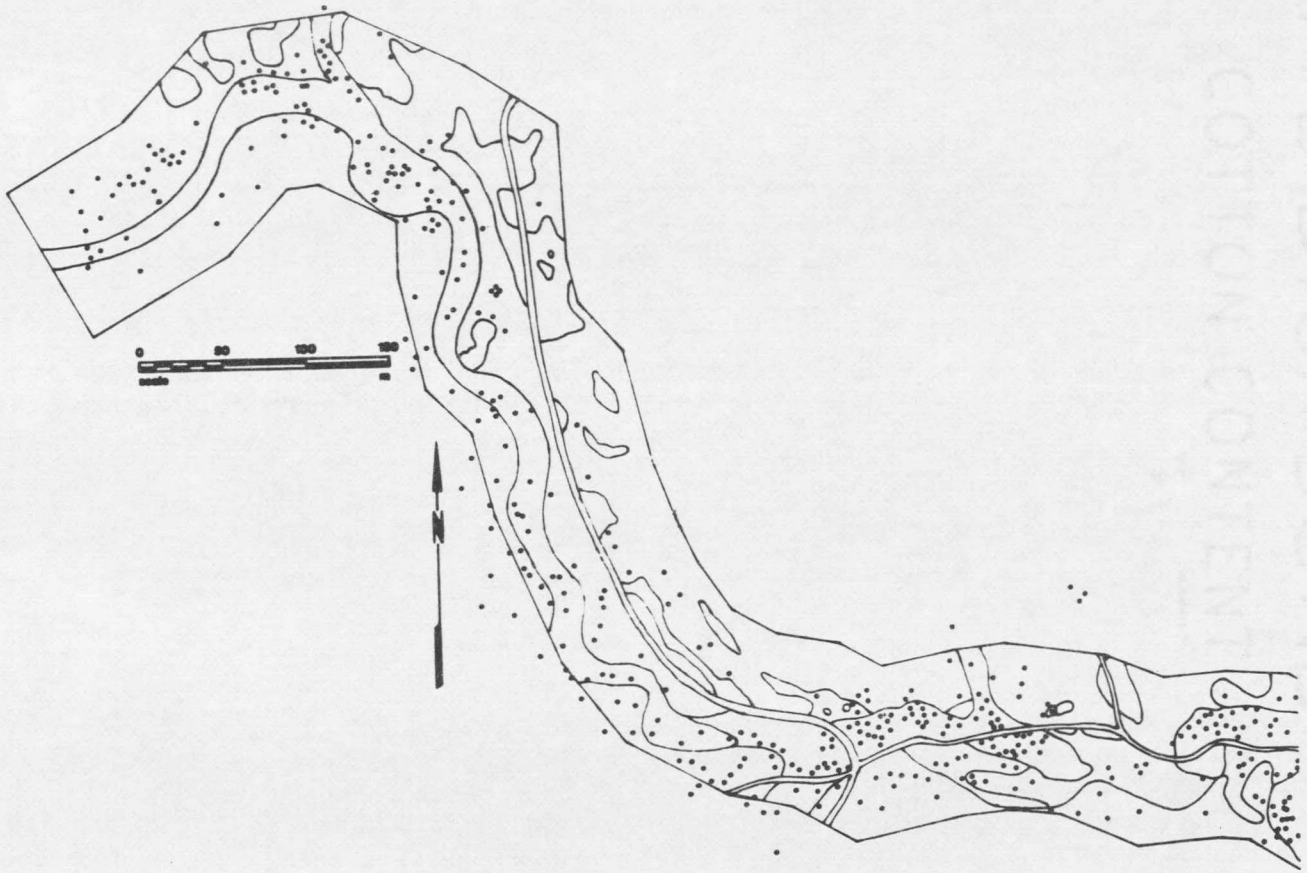


Figure 18. Locations of bird sightings on the Ward Spring deciduous draw strip-plot.

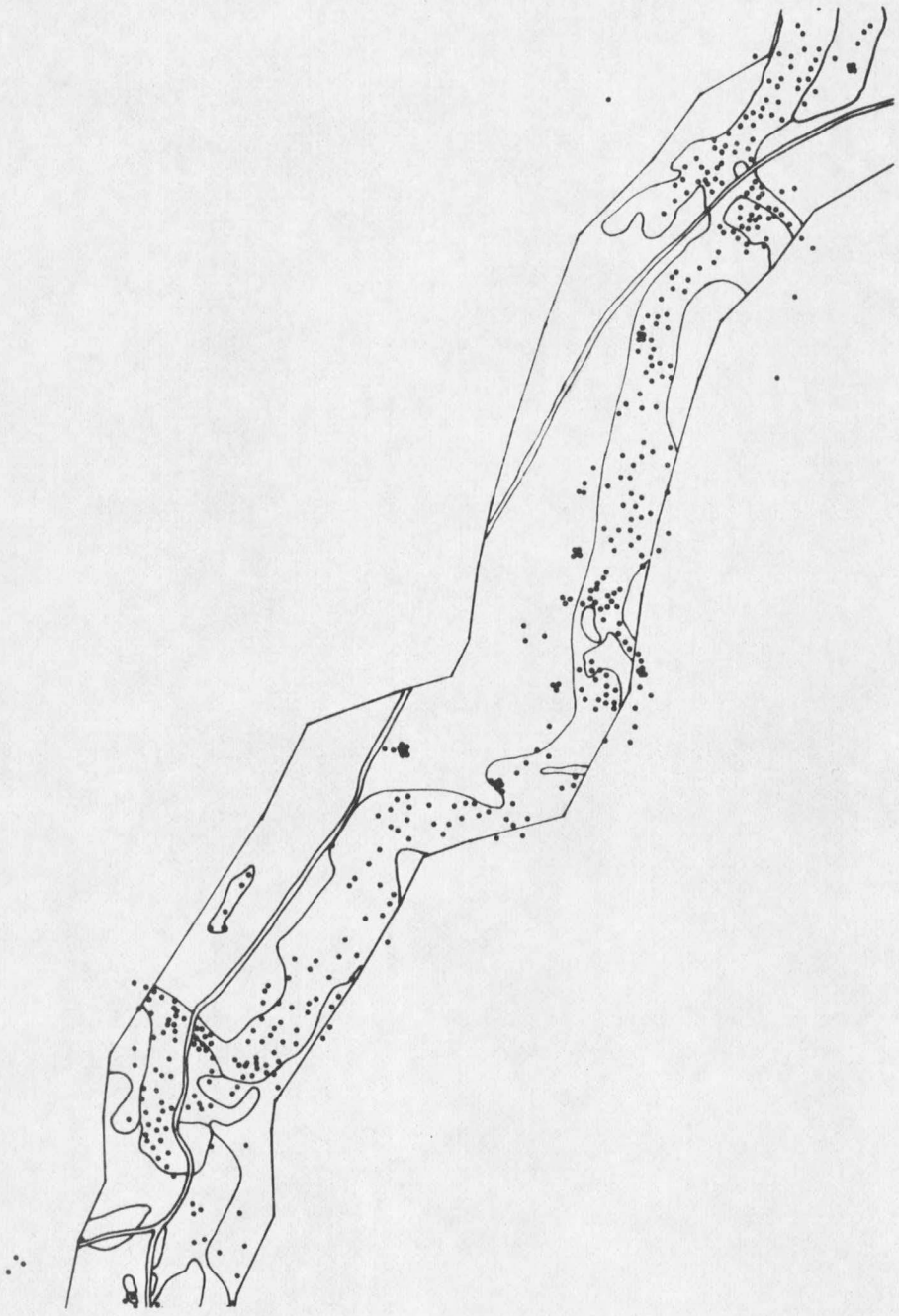


Figure 18. (Continued)

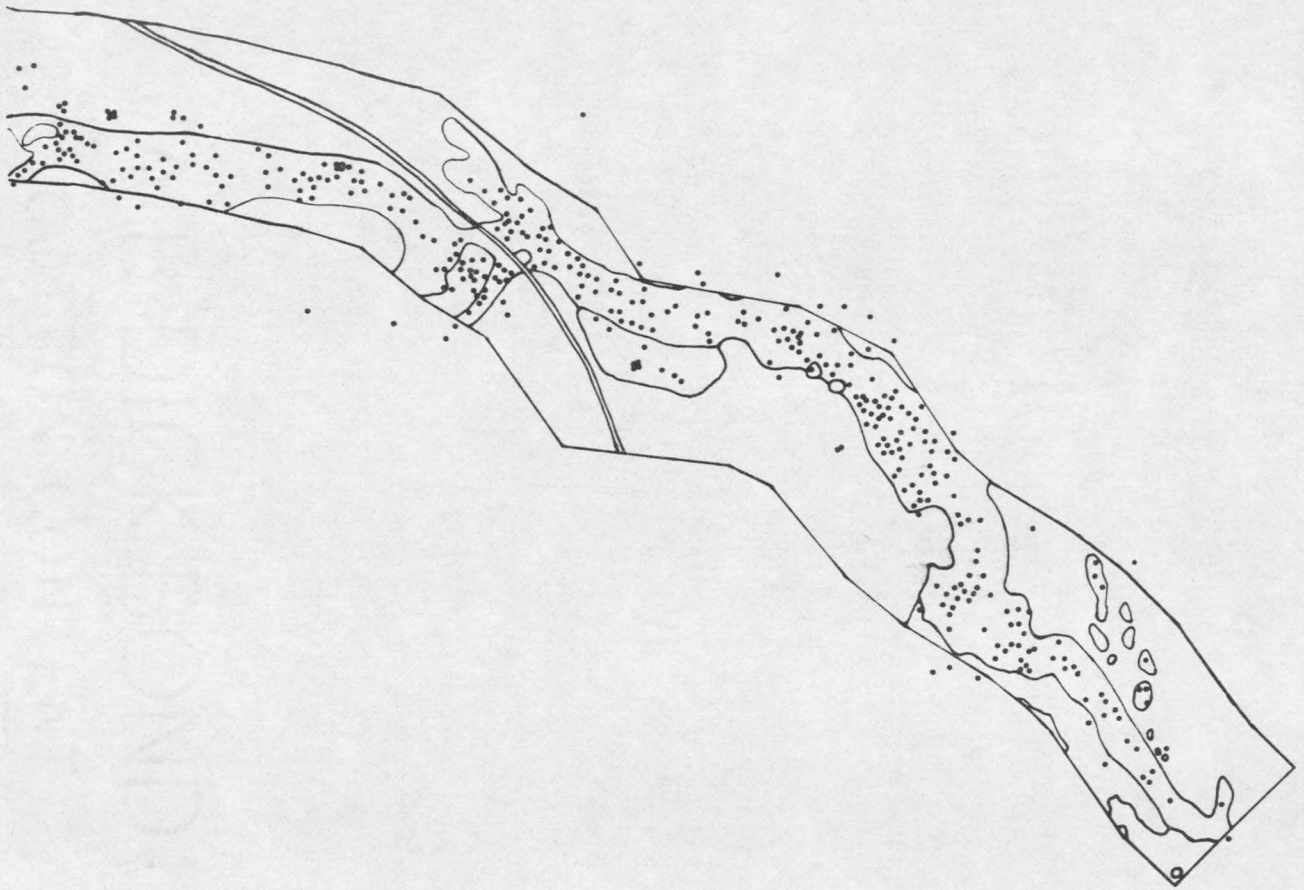


Figure 18. (Continued)

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