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Bird Associations with Shrubsteppe Plant Communities at the Proposed Reference Repository Location in Southeastern Washington

C. A. Schuler
W. H. Rickard
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March 1988

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
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BIRD ASSOCIATIONS WITH SHRUBSTEPPE PLANT COMMUNITIES AT THE PROPOSED REFERENCE REPOSITORY LOCATION IN SOUTHEASTERN WASHINGTON

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Pacific Northwest Laboratory
Richland, Washington 99352

PREFACE

In 1986, the U.S. Department of Energy (DOE) selected the Hanford Site, Washington, for further study as a permanent repository for commercial spent nuclear fuel and high-level radioactive waste. The DOE then initiated a site characterization program to obtain the information necessary for evaluating the suitability of locating a repository at the Hanford Site. These characterization activities were part of the Basalt Waste Isolation Project (BWIP). Pacific Northwest Laboratory (PNL) was contracted by the DOE to do the environmental studies. The DOE was required by Section 113(A) of the Nuclear Waste Policy Act (NWPA) to "conduct site characterization activities in a manner that minimizes any significant adverse environmental impacts identified . . ."

This document is part of the Environmental Topical Report series. Each report presents the results of the environmental monitoring studies at the BWIP site, up until BWIP was closed in response to the enactment of the Nuclear Waste Amendments Act of 1987. Some of the reports are preliminary because not all task objectives were completed at project close-out. However, they can serve as a reference source for other BWIP environmental reports related to site closure and reclamation. These Environmental Topical Reports are listed below:

1. *Cold-Blooded Vertebrates at the Proposed Reference Repository Location in Southeastern Washington*, by R. E. Fitzner, January 1988, PNL-6440.

2. *Natural Vegetation at the Proposed Reference Repository Location in Southeastern Washington*, by W. H. Rickard, February 1988, PNL-6402.

3. *Bird Associations With Shrubsteppe Plant Communities at the Proposed Reference Repository Location in Southeastern Washington*, by C. A. Schuler, W. H. Rickard, and G. A. Sargeant, March 1988, PNL-6493.

4. *Descriptions of Plant Communities at the Proposed Reference Repository Location and Implications for Reclamation of Disturbed Ground*, by W. H. Rickard and C. A. Schuler, March 1988, PNL-6494.

5. *Habitat Associations of Vertebrate Prey Within the Controlled Area Study Zone*, by N. V. Marr, C. A. Brandt, R. E. Fitzner, and L. D. Poole, March 1988, PNL-6495.

6. *Productivity, Mortality, and Response to Disturbance of Nesting Swainson's Hawks on the Hanford Site*, by L. D. Poole, N. V. Marr, R. E. Fitzner, and S. M. McCorquodale, March 1988, PNL-6496.

7. *Water Quality: Historic Values and Impact of Drilling Activities During FY1988 at the Reference Repository Location in Southeastern Washington*, by P. A. Eddy, S. S. Teel, J. R. Raymond, and W. H. Biershank, March 1988,. PNL-6497.

SUMMARY

The proposed reference repository location (RRL) is located in the west central portion of the U.S. Department of Energy's (DOE) Hanford Site in southeastern Washington State and is part of the Basalt Waste Isolation Project (BWIP). This report provides information on the seasonal use of shrubsteppe vegetation by bird species at the RRL. Bird abundance and distribution were studied at the RRL to ensure that the DOE monitored migratory bird species pursuant to the Migratory Bird Treaty Act and to assess potential impacts of site characterization activities on bird populations. Birds were counted on two transects that together sampled an area of 1.39 km^2. The relative abundance of birds, species richness, seasonal distribution, and the association of breeding shrubsteppe birds with major vegetation types were determined from January through December 1987. Only 38 species were counted during 82 surveys. Total bird density during the nesting season (March-June) was 42.96 birds/km^2 and the density for the entire year was 26.74 birds/km^2. The characteristic nesting birds in shrubsteppe habitats were western meadowlark, sage sparrow, burrowing owl, mourning dove, horned lark, long-billed curlew, lark sparrow, and loggerhead shrike. Western meadowlark and sage sparrows were the most abundant breeding birds with an average density of 11.25 and 7.76 birds/km^2, respectively. Seasonal distribution of birds varied with species, but most species were present from March to September.

Distribution and abundance of nesting birds were correlated with habitat type. About 63% of the habitat surveyed was sagebrush, 26% was cheatgrass, and 11% was spiny hopsage. Sagebrush habitat supported a greater total bird density than cheatgrass or hopsage habitats. Sage sparrows were closely associated with sagebrush habitats, while western meadowlarks showed no strong habitat affinities.

Bird densities at the RRL were generally lower than those found in other shrubsteppe study sites. Explanations for these differences include location of study sites, time of year studied, and ajustments made to the census data. Revegetation of areas disturbed by BWIP site characterization activities is needed to provide a vegetative structure that is acceptable for nesting birds, especially sage sparrows.

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INTRODUCTION

The semiarid, intermountain region of the northwestern corner of the United States is characterized by a rigorous physical environment. Precipitation is low, and the daily and annual temperature range is frequently extreme. The regional climate imposes severe seasonal thermal and water stresses on plant growth, and the vegetation is best described as shrubsteppe (Daubenmire 1970). Floristically, the natural vegetation is relatively simple and shoot production is at the lower end of the scale of primary production (Rickard et al. 1976). Plant communities are dominated by desert shrubs, annual exotic grasses, and native bunch grasses. At the Basalt Waste Isolation Project's (BWIP) proposed reference repository location (RRL) on the U.S. Department of Energy's (DOE) Hanford Site (Figure 1) in Benton County, Washington, desert shrubs, especially big sagebrush (*Artemisia tridentata*) and spiny hopsage (*Grayia spinosa*) are the overstory dominants with a sparse understory of herbs, primarily cheatgrass (*Bromus tectorum*) and Sandberg's bluegrass (*Poa sandbergii*) (Rickard 1988).

The extremes of shrubsteppe climate require physiological and behavioral mechanisms for daily survival and reproduction that limit the complexity of bird communities (Rotenberry and Wiens 1978). Shrubsteppe vegetation sustains relatively few species of breeding birds (Rotenberry and Wiens 1978). Birds that characteristically nest in shrubsteppe plant communities are the sage sparrow (*Amphispiza belli*), Brewer's sparrow (*Spizella breweri*), sage thrasher (*Oreoscoptes montanus*), western meadowlark (*Sturnella neglecta*), horned lark (*Eremophila alpestris*), loggerhead shrike (*Lanius ludovicianus*), common nighthawk (*Chordeiles minor*), and long-billed curlew (*Numenius americanus*). Only a few game birds nest in shrubsteppe stands. On the Hanford Site, terrestrial game birds include mourning dove (*Zenaida macroura*), western sage grouse (*Centrocercus urophasians*), gray partridge (*Perdix perdix*), and chukar partridge (*Alectoris chukar*).

Today, there are only a few places in the entire shrubsteppe region that have not had a long, continuous history of livestock grazing, have not been disturbed for industrial purposes, or else have not been converted permanently to dryland or irrigated farming. The largest contiguous expanse of ungrazed shrubsteppe in eastern Washington is located on the Hanford Site. However, large tracts of shrub-dominated communities have been destroyed by off-road vehicle traffic and for construction of buildings, drill pads, equipment laydown areas, roads, and parking lots. Some shrubs have also been destroyed by wildfires with extensive burning occurring at the RRL as recently as 1984 (Rickard 1988). These disturbances and disturbances from BWIP site characterization activities or other DOE-related activities create changes in bird habitat, resulting in

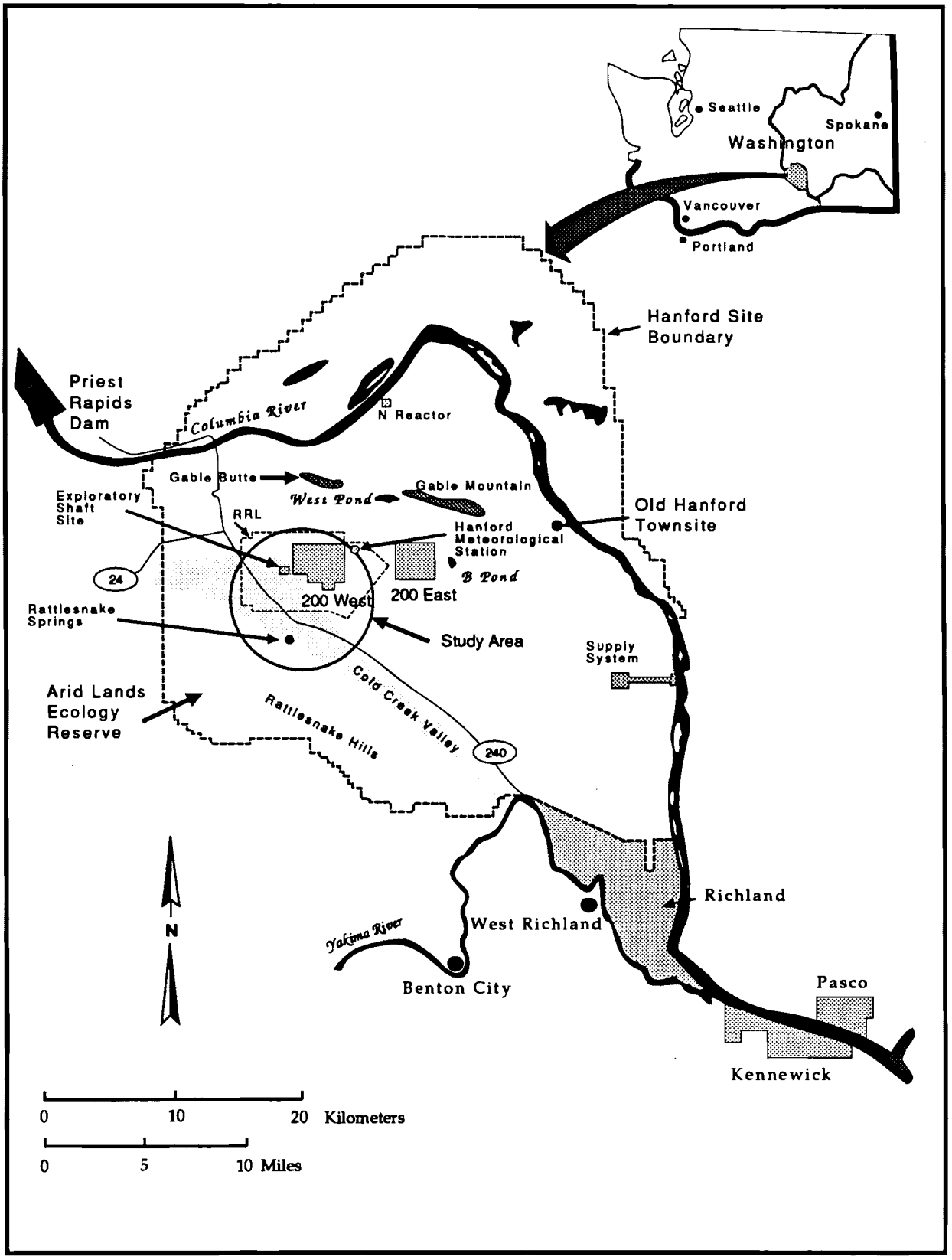

FIGURE 1. Map of the U. S. Department of Energy's Hanford Site showing the Locations of Cold Creek Valley, General Study Area, and Hanford Meterorological Station

changes in species composition and population densities of nesting populations of shrubsteppe birds. Knowledge of the seasonal and daily activity patterns of shrubsteppe birds near sites of potential impact and their relationship to habitat is essential to assess the impact of habitat modifications on bird populations and to reconstitute habitat suitable for breeding birds.

The draft *Environmental Regulatory Compliance Plan for the Hanford Site for BWIP Site Characterization* (ERCP) references the Migratory Bird Treaty Act, which "... affords protection to many species of migratory birds by prohibiting pursuit, hunting, taking, capture, possession, or killing of such species or their nests or eggs" (U.S. DOE 1987). Many species of migratory birds frequent the Hanford Site, including those areas associated with BWIP site characterization activities. In addition, several of these species are proposed for a State listing by the Washington Department of Game as threatened, sensitive, or monitor species. This listing identifies several species (bald eagles [*Haliaeetus leucocephalus*], Swainson's hawks [*Buteo swainsoni*], golden eagles [*Aquila chrysaetos*], sage grouse, burrowing owls, sage thrashers, loggerhead shrikes, sage sparrows, and long-billed curlews) that should be monitored to ensure that they are not severely impacted from BWIP site characterization activities. It was in light of these environmental regulatory concerns that this study was initiated to provide information on bird abundance and distribution prior to, during, and after completion of site characterization activities. The purpose of this work was to document bird species inhabiting shrubsteppe plant communities at the RRL; determine seasonal use of the RRL by birds; estimate abundance of breeding birds; relate the spatial distribution of breeding birds to vegetation structure; and evaluate potential impacts of present and future RRL site characterization activities on shrubsteppe birds.

METHODS

STUDY AREA

The RRL is situated near the center of the 1,470 km^2 (560 mi^2) Hanford Site in the south central portion of the state of Washington (Figure 1). Elevation of the study area ranges from a low of approximately 190 m (610 ft) above mean sea level in the Cold Creek Valley basin to 260 m (800 ft) on the lower slopes of Yakima Ridge to the west and similar elevations on the broad flat ridge located to the east. The land within fenced exclusion zones around the chemical separation facilities and radioactive waste storage tanks in the 200 Areas is not included in the study zone (Figure 1).

The existing vegetation is a mosaic of shrub- and grass-dominated stands created by wildfires. Natural vegetation is a mixture of annual and perennial grasses, especially cheatgrass and Sandberg's bluegrass, with an overstory of short-statured, widely spaced desert shrubs, especially big sagebrush (Rickard 1988). Other shrubs common to this area are spiny hopsage, gray rabbitbrush (*Chrysothamnus nauseosus*), and green rabbitbrush (*Chrysothamnus viscidiflorus*).

Annual precipitation at the Hanford Meteorological Station (Figure 1) averages only 17 cm (6.40 inches) with most falling in fall and winter. Summers are characteristically hot and dry. The climate at the station closely mimics that of the RRL.

BIRD SURVEYS

Two intersecting transect lines, one running in a west to east (west-east transect) direction and the other in a south to north (south-north transect) direction were established adjacent to the exploratory shaft, during the summer of 1986 (Figure 2). Transects were marked at 161 m (500 ft) intervals (segments) and identified with 2.6 m (8 ft) tall wooden stakes. The west-east transect consisted of 21 segments, and totaled 3.38 km (10,500 ft, 2.0 mi) in length. The south-north transect consisted of 33 segments, totaling 5.32 km (16,500 ft, 3.1 mi) in length.

Birds were counted along each transect by walking along the line at a rate of approximately 2.4 km/hr (1.5 mi/hr). Binoculars were used to assist in bird identification. Birds were recorded when seen within an 80 m (250 ft) zone on either side of the transect (one-half the distance

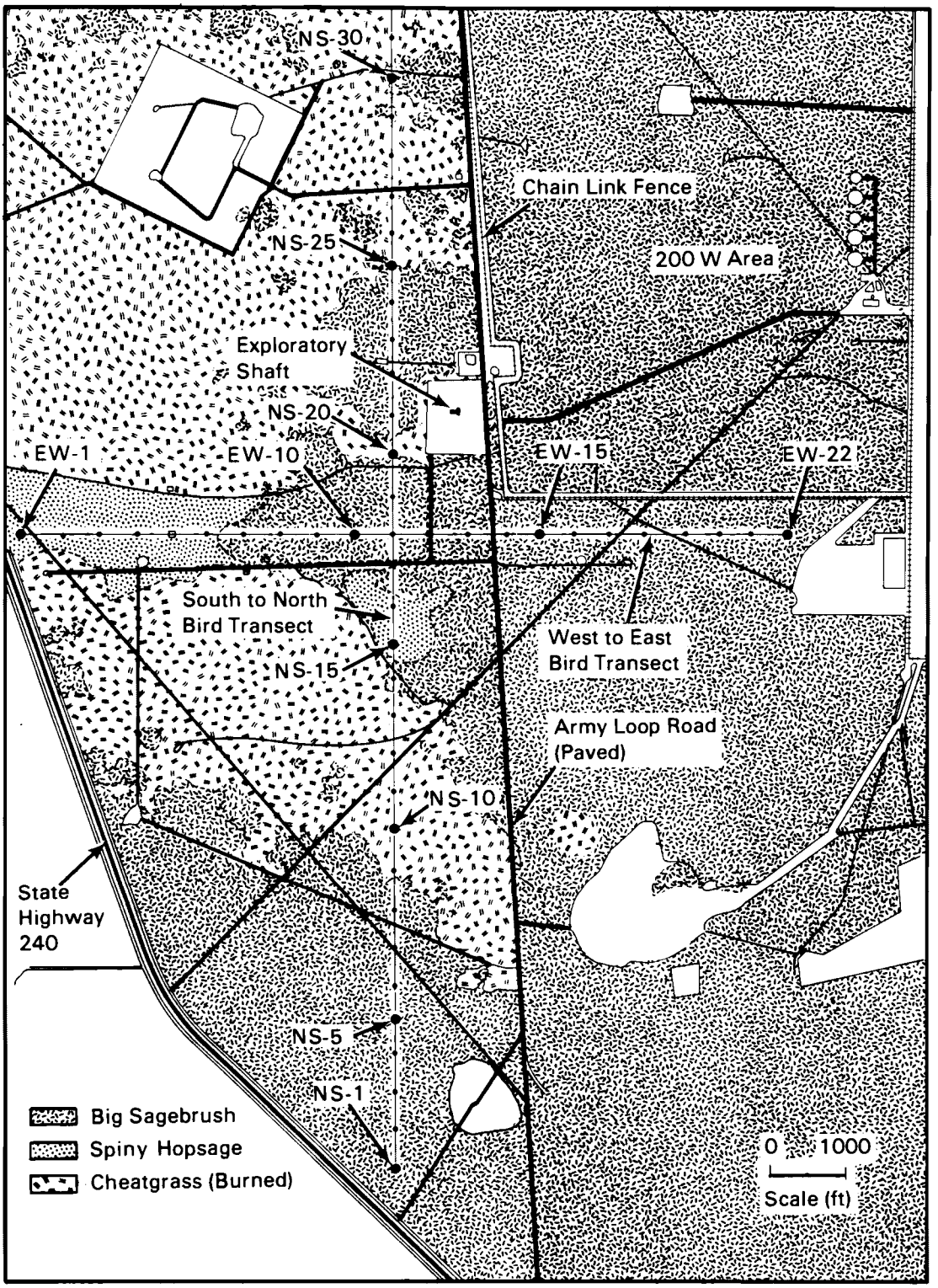

FIGURE 2. Locations of South to North (South-North) and West to East (West-East) Bird Transects at the Reference Repository Location, Numbered Segments, and Their Associated Habitat Types

between stakes). Distance to each sighted bird was visually estimated as the perpendicular distance from the transect to the bird. Behaviors of birds were also recorded at the time of sighting. Flying birds were recorded as "flyby" if they were seen crossing the transect in front of the observer. Singing individuals were recorded as perched and singing. Other behaviors recorded were perched and flushed. Observations of any nesting activities were noted. In most instances, birds sighted were identified to species using visual and acoustic cues. Observations were made within 3 hours of sunrise. Common and latinized bird names follow the recommendations of the American Ornithologists' Union Checklist of North American Birds (1983).

The study was initiated in January 1987 on the west-east transect and in March on the south-north transect, and surveys ceased in December 1987 on both transects. Transects were walked once a week during January and February, on two consecutive days each week during March through September, and again once a week during October through December. Eighty-two surveys were conducted on the west-east transect and 75 on the south-north transect. The breeding season was considered to be from March 10 to June 12, and 28 surveys were conducted during this period. Collectively, surveys on the two bird transects included an area of 1.39 km^2: 0.85 km^2 (85 ha) on the south-north transect and 0.54 km^2 (54 ha) on the west-east transect. A single transect segment covered an area of 0.026 km^2 (2.6 ha). Most observations were made by the same two observers, with each observer walking half of each transect concurrently. Direction of travel on the transects was frequently varied.

VEGETATION STRUCTURE

Features of the shrub component of the vegetation were measured along both bird transects for each 161 m segment. Measurements of shrub height, shrub diameter, shrub canopy cover, and distance between shrubs were taken along 100 m lines that were oriented perpendicular to the direction of the bird transect, with 50 m of the line located on each side of the bird transect. Shrub canopy cover and distance between shrubs were determined for each species by the line interception method (Canfield 1941). Height and diameter of the shrubs intercepting the line were measured to the nearest cm.

WEATHER DATA

Air temperatures, monthly precipitation totals, and ancillary information were obtained from the Hanford Meterological Station, located between the 200 West and 200 East areas at an

elevation of 240 m (750 ft) above mean sea level (Figure 1). Pertinent data are reported monthly from January through December 1987 (Table 1).

STATISTICAL ANALYSES

Arithmetic means were calculated for each species censused over the entire year and during the breeding season and for structural parameters of the dominant shrub species. Density was also calculated on the basis of number of individuals/km^2 of area for the entire year and for the breeding season (March-June) only. The breeding season was assumed to coincide with the peak abundance of the common species.

Segments of the bird transects that crossed similar plant communities (e.g., sagebrush, hopsage, or cheatgrass) were grouped together for statistical purposes. On the south-north transect, segments 1 through 8 (sagebrush-no burn), 9-14 (cheatgrass-clear burn), 15-25 (sagebrush-slight burn), and 26-33 (sagebrush-patchy burn) were grouped together. On the west-east transect, segments 1-6 (spiny hopsage-no burn), 7-13 (sagebrush-no burn), and 14-21 (sagebrush-no burn) were grouped together. Mean shrub canopy cover, shrub height, shrub diameter, and distance between shrubs, and number of bird species were also calculated for grouped transect segments.

Relationships of shrub cover to bird abundance were obtained for selected bird species. A simple linear regression was performed comparing habitat parameters with bird abundance. All zeros were excluded from the regression analyses. Bird numbers used in the analyses were based on the number of birds counted on a single survey at each segment. The bird counts were then transformed to square roots. Habitat parameters used included percent canopy cover by shrub species and also as total shrub cover. A mean cover value was calculated for each segment by adding the cover values of two consecutive segments (e.g., 2 + 3, 3 + 4, 4 + 5). Shrub cover values were transformed to $\arcsin(\sqrt{x})$ to normalize the distribution of percents. Mean shrub cover per segment was then related to the total number of birds per segment per survey. Beta values from the regression equation are reported and significance of the regression equation is reported at the $P<0.05$, $P<0.01$, and $P<0.001$ levels.

TABLE 1. Monthly Weather Data Obtained From the Hanford Meteorological Station, January to December 1987

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Solar Radiation Average Daily (Langleys)	85	174	284	425	529	598	554	543	421	268	128	78
Temperature (°F) Monthly Average	30.7	40.1	48.3	58.0	66.2	73.4	74.3	76.6	69.9	55.5	43.6	31.5
Maximum	55	60	70	93	102	106	107	105	106	87	66	59
Minimum	9	27	24	30	33	43	49	51	41	31	17	9
Precipitation (in.)	0.80	0.19	1.05	0.14	0.17	0.11	0.50	0.07	0.01	TR	0.40	1.63
Snow (in.)	3.3	–	–	–	–	–	–	–	–	–	1.1	4.7
Number Days <32°F	25	17	9	2	–	–	–	–	–	3	11	25
Number Days >90°F	–	–	–	2	6	15	14	19	12	–	–	–

RESULTS

BIRD SPECIES

A total of 38 species of birds was recorded on 82 surveys made during 1987 (Table 2). Of these only 8 species nested in shrubsteppe habitats. These were western meadowlarks, sage sparrows, horned larks, lark sparrows (*Chondestes grammacus*), long-billed curlews, burrowing owls, common nighthawks, and mourning doves. Birds that nested in the deciduous trees at nearby abandoned army camp sites were occasionally seen on the transects. These included black-billed magpies (*Pica pica*), Swainson's hawks, loggerhead shrikes, northern orioles (*Icterus galbula*), and western kingbirds (*Tyrannus verticalis*) (Table 2). A pair of common ravens (*Corvus corax*) nested on the drill rig at the exploratory shaft as well as a few European starlings (*Sturnus vulgaris*) and rock doves (*Columba livia*) (Table 2). The breeding status of sage thrashers in this area is unknown, but recently fledged young have been observed. Although a few golden eagles use the RRL as a foraging area in winter, only a single golden eagle was seen on the transects, and no bald eagles were seen during the survey period (Table 2). The only game birds recorded along the transects were mourning doves. Most of the other birds were visiting migrants.

Frequency of occurrence for all species for the entire year was relatively low, with only European starlings, meadowlarks, and sage sparrows occurring in at least 50% of the surveys (Table 2). During the breeding season (March-June), several additional species occurred in more than 50% of the surveys, including long-billed curlews, burrowing owls, horned larks, and common ravens (Table 2). Sage sparrows and meadowlarks were the only species to be seen on each of the 28 surveys during the breeding season (Table 2). In decreasing order of occurrence, the other nesting shrubsteppe birds were burrowing owl>horned lark>long-billed curlew>mourning dove>loggerhead shrike>and lark sparrow (Figure 3).

BIRD ABUNDANCE

Bird abundance was expressed as individual birds per km^2 during the entire year and also during the nesting season (Table 3). The greatest percentage of birds for most species was observed during the breeding season (Table 3). Total bird density during the nesting season was 42.96 birds/km^2 and the density for the entire year was 26.74 birds/km^2 (Table 3).

TABLE 2. Bird Species Observed and Their Frequency of Occurrence (%) Along Transects Surveyed at the Reference Repository Location, January through December 1987

Common Name	Scientific Name	Freq. (%)[a] (Jan-Dec) (N=82)	Freq. (%)[b] (Mar-Jun) (N=28)
Anseriformes			
Canada goose	*Branta canadensis* (Linneaus)	1	0
Charadriiformes			
Long-billed curlew[c]	*Numenius americanus* (Bechstein)	29	57
Falconiformes			
Golden eagle	*Aquila chrysaetos* (Linnaeus)	1	0
Northern harrier	*Circus cyaneus* (Linnaeus)	1	4
Red-tailed hawk	*Buteo jamaicensis* (Gmelin)	1	4
Swainson's hawk	*Buteo swainsoni* (Bonaparte)	6	4
Rough-legged hawk	*Buteo lagopus* (Pontoppidan)	1	4
American kestrel	*Falco sparverius* (Linnaeus)	9	0
Columbiformes			
Rock dove	*Columba livia* (Gmelin)	5	0
Mourning dove[c]	*Zenaida macroura* (Linnaeus)	30	32
Strigiformes			
Burrowing owl[c]	*Athene cunicularia* (Molina)	54	68
Caprimulgiformes			
Common nighthawk[c]	*Chordeiles minor* (Forster)	12	11
Piciformes			
Northern flicker	*Colaptes auratus* (Linnaeus)	2	7
Passeriformes			
Western kingbird	*Tyrannus verticalis* (Say)	16	7
Say's Phoebe	*Sayornis saya* (Bonaparte)	1	4
Horned lark[c]	*Eremophila alpestris* (Linnaeus)	46	64
Barn swallow	*Hirundo rustica* (Linnaeus)	20	11
Black-billed magpie[c]	*Pica pica* (Linnaeus)	43	18
Common raven[c]	*Corvus corax* (Linnaeus)	23	50
Townsend's solitaire	*Myadestes townsendii* (Audubon)	1	0
American robin	*Turdus migratorius* (Linnaeus)	11	32
Loggerhead shrike[c]	*Lanius ludovicianus* (Linnaeus)	29	21
Sage thrasher	*Oreoscoptes montanus* (Townsend)	4	7
European starling[c]	*Sturnus vulgaris* (Linnaeus)	50	93
Vesper sparrow	*Pooecetes gramineus* (Gmelin)	1	4
Savannah sparrow	*Passerculus sandwichensis* (Gmelin)	4	11
Lark sparrow[c]	*Chondestes grammacus* (Say)	9	14
Sage sparrow[c]	*Amphispiza belli* (Cassin)	68	100
Chipping sparrow	*Spizella passerina* (Bechstein)	1	4
Brewer's sparrow	*Spizella breweri* (Cassin)	1	0
White-crowned sparrow	*Zonotrichia leucophrys* (Forster)	7	18
Western meadowlark[c]	*Sturnella neglecta* (Audubon)	79	100
Red-winged blackbird	*Agelaius phoeniceus* (Linnaeus)	2	4
Brewer's blackbird	*Euphagus cyanocephalus* (Wagler)	1	4
Brown-headed cowbird	*Molothrus ater* (Boddaert)	10	14
Northern oriole	*Icterus galbula* (Linneaus)	1	4
House finch	*Carpodacus mexicanus* (Müller)	1	4
American goldfinch	*Carduelis tristis* (Linnaeus)	1	0

(a) Percent of surveys on which species were observed during January to December, 1987.
(b) Percent of surveys on which species were observed during the breeding season (March 10 to June 12, 1987).
(c) Species known or believed to nest in shrubsteppe plant communities at the RRL.

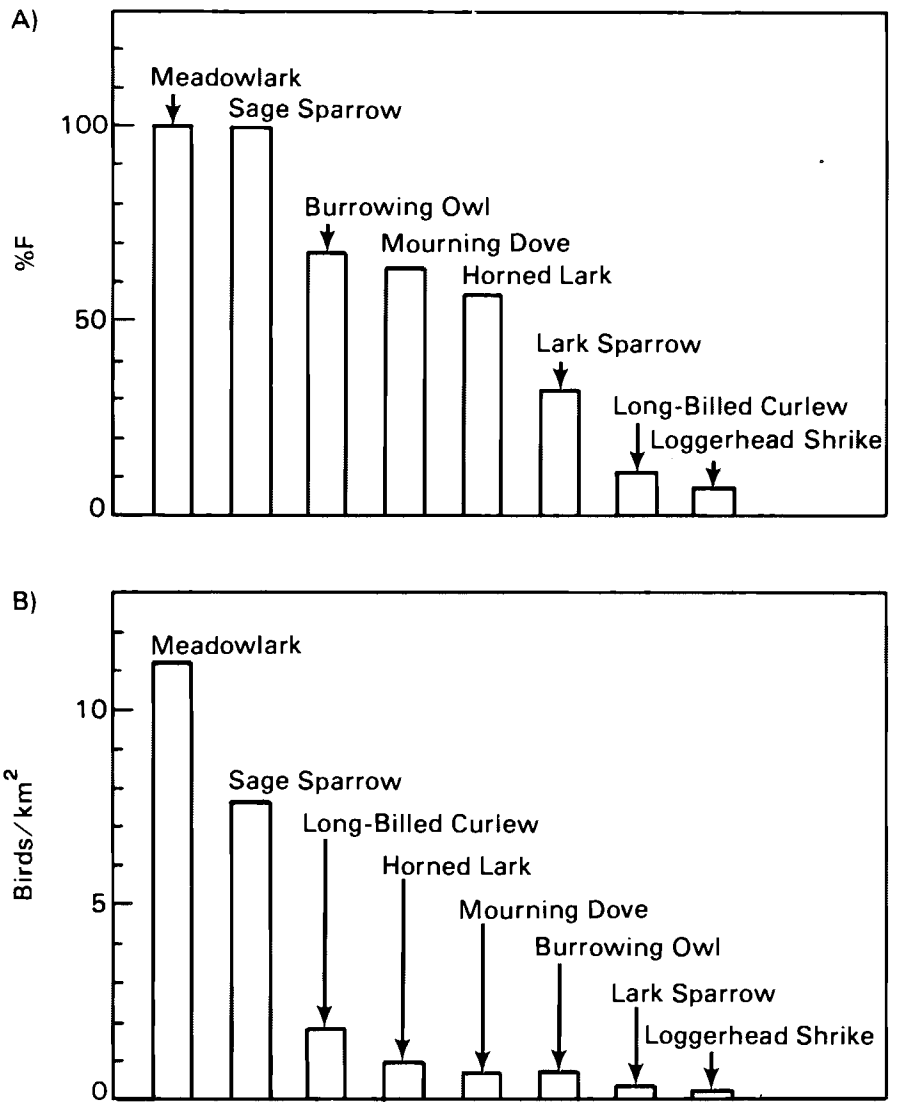

FIGURE 3. Frequency of Occurrence (%F)[A] and Density (Birds/km^2)[B] of Breeding Shrubsteppe Birds During the 1987 Nesting Season at the Reference Repository Location

Meadowlarks and sage sparrows were the most abundant shrubsteppe nesting birds counted along the transects (Table 3). The mean density of sage sparrows and meadowlarks during the breeding season was 7.76 and 11.25 birds/km^2, respectively (Table 3). Other nesting birds, arranged in decreasing order of abundance, were long-billed curlews, horned larks, mourning doves, burrowing owls, lark sparrows, and loggerhead shrikes (Figure 3). The other relatively abundant birds that do not nest in shrubsteppe habitats included ravens, European starlings, and white-crowned sparrows (Table 3).

TABLE 3. Mean Bird Abundance and Mean Density Estimated Along Bird Transects at the Reference Repository Location, January Through December 1987

Species	Yearly[a] (Jan-Dec) (N=82)	Breeding Season[b] (% of Total)[c] (Mar-Jun) (N=28)	Yearly Density[d] (Individ/km^2) (N=82)	Breeding Season Density[e] (Individ/km^2) (N=28)
Canada goose	0.01	0	0.01	0
Long-billed curlew	1.16	2.61 (77)	0.83	1.88
Golden eagle	0.01	0	0.01	0
Northern harrier	0.01	0.04 (100)	0.01	0.03
Red-tailed hawk	0.01	0.04 (100)	0.01	0.03
Swainson's hawk	0.06	0.04 (20)	0.04	0.03
Rough-legged hawk	0.01	0.04 (100)	0.01	0.03
American kestrel	0.09	0	0.06	0
Rock dove	0.39	0	0.28	0
Mourning dove	0.76	1.04 (47)	0.54	0.75
Burrowing owl	1.32	1.04 (27)	0.95	0.75
Common nighthawk	0.18	0.14 (27)	0.13	0.10
Northern flicker	0.02	0.07 (100)	0.02	0.05
Western kingbird	0.34	0.07 (7)	0.25	0.05
Say's Phoebe	0.01	0.04 (100)	0.01	0.03
Horned lark	1.23	1.29 (36)	0.89	0.93
Barn swallow	0.46	0.18 (11)	0.33	0.13
Black-billed magpie	1.00	0.25 (9)	0.72	0.18
Common raven	0.35	0.68 (66)	0.25	0.49
Townsend's solitaire	0.04	0	0.03	0
American robin	0.51	1.50 (100)	0.37	1.08
Loggerhead shrike	0.76	0.29 (13)	0.54	0.21
Sage thrasher	0.04	0.07 (67)	0.03	0.05
European starling	4.68	7.82 (57)	3.37	5.63
Vesper sparrow	0.01	0.04 (100)	0.01	0.03
Savannah sparrow	0.12	0.36 (100)	0.09	0.26
Lark sparrow	0.22	0.50 (78)	0.16	0.36
Sage sparrow	5.44	10.79 (68)	3.91	7.76
Chipping sparrow	0.01	0.04 (100)	0.01	0.03
Brewer's sparrow	0.01	0	0.01	0
White-crowned sparrow	5.01	14.64 (99)	3.61	10.53
Western meadowlark	12.02	15.64 (44)	8.65	11.25
Red-winged blackbird	0.02	0.04 (50)	0.02	0.03
Brewer's blackbird	0.02	0.07 (100)	0.02	0.05
Brown-headed cowbird	0.20	0.21 (37)	0.14	0.15
Northern oriole	0.01	0.04 (100)	0.01	0.03
House finch	0.02	0.07 (100)	0.02	0.05
American goldfinch	1.05	0	0.75	0
TOTAL BIRDS	37.17	59.69	26.74	42.96

(a) Mean number of birds counted on the south-north and west-east transects during the entire year, January through December, 1987.
(b) Mean number of birds counted on the south-north and west-east transects during the breeding season, March 10 to June 12, 1987.
(c) Percentage of total birds for each species that were counted during the breeding season.
(d) Mean density (individuals/km^2) of birds counted during the entire year.
(e) Mean density (individuals/km^2) of birds counted during the breeding season.

SEASONAL USE

Temporal variation in bird density for the eight common shrubsteppe nesting species is summarized in Figure 4. Arrival and departure times varied for each species, but most were present in March and showed a sharp decline in abundance in July or August. The earliest arrivals were sage sparrows and meadowlarks, which were recorded for the first time in mid-February. However, most species showed a seasonal peak in abundance that generally occurred sometime during March through July. This peak generally corresponded to the breeding season. Meadowlarks attained a peak of abundance in April, maintained this high level through September, with a sharp decline in October (Figure 4). Sage sparrow density peaked in March and April and then steadily decreased until July (Figure 4). A secondary peak in August may be attributed to the detection of young birds recruited into the sage sparrow population. The last sage sparrow was observed in late September.

Burrowing owls first appeared in April and peak abundance occurred in July when the young birds emerged from their burrows (Figure 4). Burrowing owls left the study area by October. Only one owl nest was found near the transects (located east of post WE-10) (Figure 2). Owls that perched or flushed near this burrow were often included in the counts from both transects because the burrow was near the point of intersection. Long-billed curlews appeared in March and their density peaked in June as the adult birds became aggressive and "mobbed" the observers as they walked the transects (Figure 4). No curlews were observed after July. Loggerhead shrike abundance peaked in July and a few shrikes were still present in November and December. Mourning doves were first counted in April, peak abundance occurred in May and August, and they were last observed on the RRL in September. For the other nesting species, lark sparrow abundance peaked in May and horned larks peaked in February.

The winter months of November, December, January, and February were marked by the absence of most of the characteristic nesting shrubsteppe species (Figure 4). The characteristic winter birds in shrubsteppe habitat were black-billed magpies, common ravens, and European starlings.

VEGETATION HABITAT

The extent of the three major vegetation types along the bird transects is shown in Figure 2. Two of the vegetation types were dominated by desert shrubs, sagebrush and spiny hopsage. The third was dominated by herbaceous species, especially cheatgrass (Rickard and Schuler

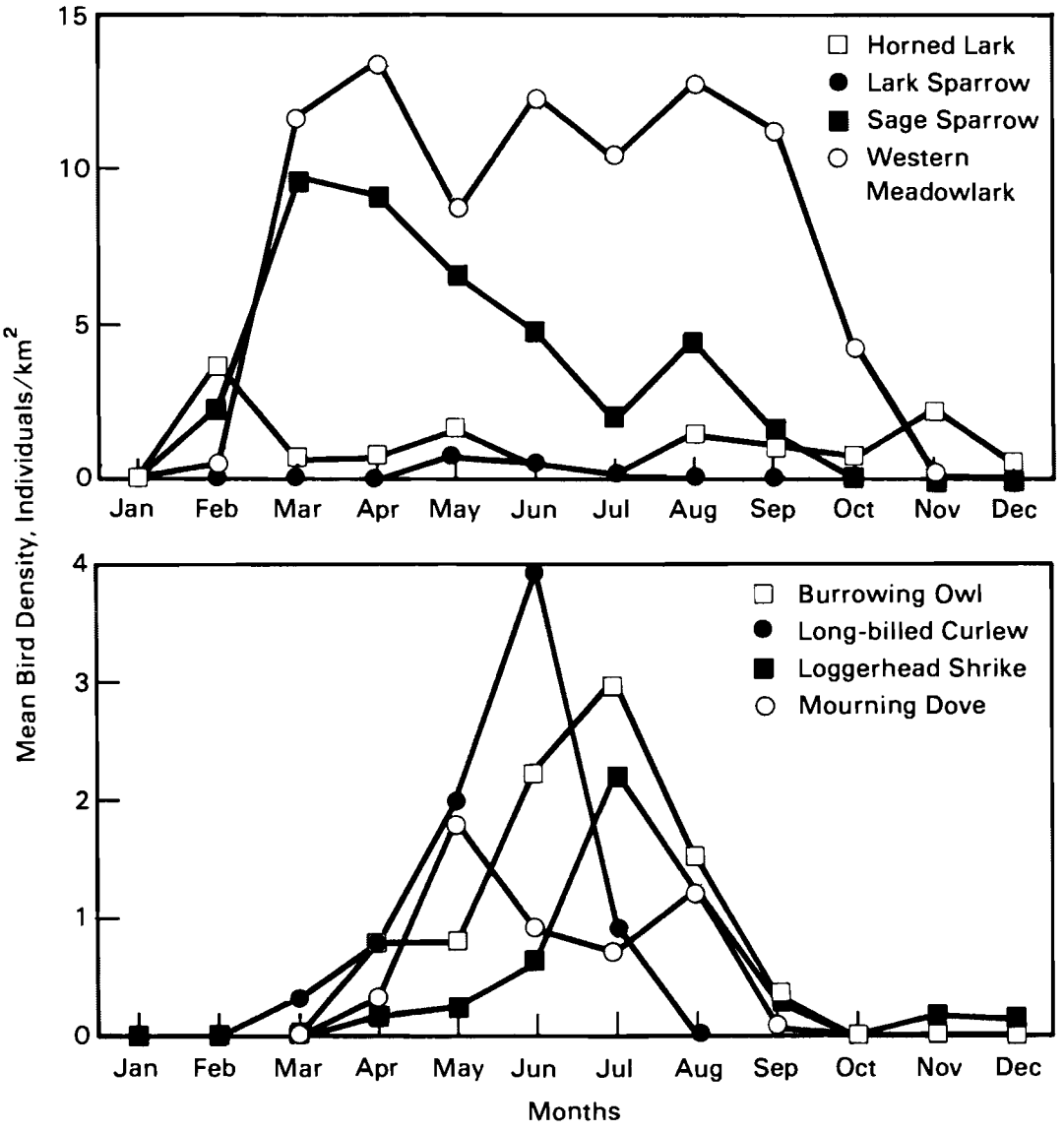

FIGURE 4. Monthly Mean Bird Density of Several Common Shrubsteppe Birds Estimated on Bird Transects at the Reference Repository Location in 1987

1988). The herb-dominated areas were the result of recent wildfires that destroyed the shrubs in irregular shaped patterns according to the extent and intensity of the burning.

Each of the 161 m long segments of both bird transects were assigned a vegetation type based on the dominant shrub or grass species and then segments were grouped together

according to their common vegetation type (Table 4). About 63% of the area was occupied by sagebrush, 26% by cheatgrass (burned areas), and 11% by spiny hopsage.

The west-east bird transect was located entirely within shrub-dominated habitats, and none of the area crossed by the transect had been recently burned (Figure 5). The western segments of the line [1 through 6 (1-6)] were dominated by hopsage with some sagebrush and an understory of Sandberg's bluegrass, but the rest of the transect (7-21) passed through sagebrush-dominated habitat with an understory of cheatgrass. Average sagebrush cover on grouped segments of the west-east transect ranged from 3% on segments 1-6 (but 18% hopsage) to 19% on segments 14-21 (Table 5).

The south-north transect passed through stands of sagebrush-cheatgrass, cheatgrass, and through areas with scattered patches of sagebrush (Figure 5). The southern segments (1-8) of the transect were dominated by sagebrush and cheatgrass. Average sagebrush cover (18%) in this area was similar to the cover found on segments 14-21 on the west-east transect (Table 5). Segments 9-14 were burned in 1984 and were dominated by cheatgrass. This area shows little or no reinvasion by shrubs. The middle section (15-25) of the south-north bird transect has been

TABLE 4. The Percent of Shrub Cover Grouped by Habitat Segments[a] for Each Transect and for Both Transects at the Reference Repostiory Location in 1987

Transect Segments	Habitat Type	% of Total (Each Transect)	% of Total (Both Transects)
West-East Transect			
1-6 (966 m)	Hopsage	28.6	11.1
7-13 (1127 m)	Sagebrush	33.3	13.0
14-21 (1288 m)	Sagebrush	38.1	14.8
TOTAL (3381 m)	—	100	
South-North Transect			
1-8 (1288 m)	Sagebrush	24.2	14.8
9-14 (966 m)	Cheatgrass (Clear Burn)	18.2	11.1
15-25 (1771 m)	Sagebrush	33.3	20.4
26-33 (1288 m)	Cheatgrass (Patchy Burn)	24.2	14.8
TOTAL (5313 m)	—	99.9	
Both Transects Total (8694 m)	—		100

(a) Habitat segments are sections of the bird transects that are grouped according to similar kinds of plant communities.

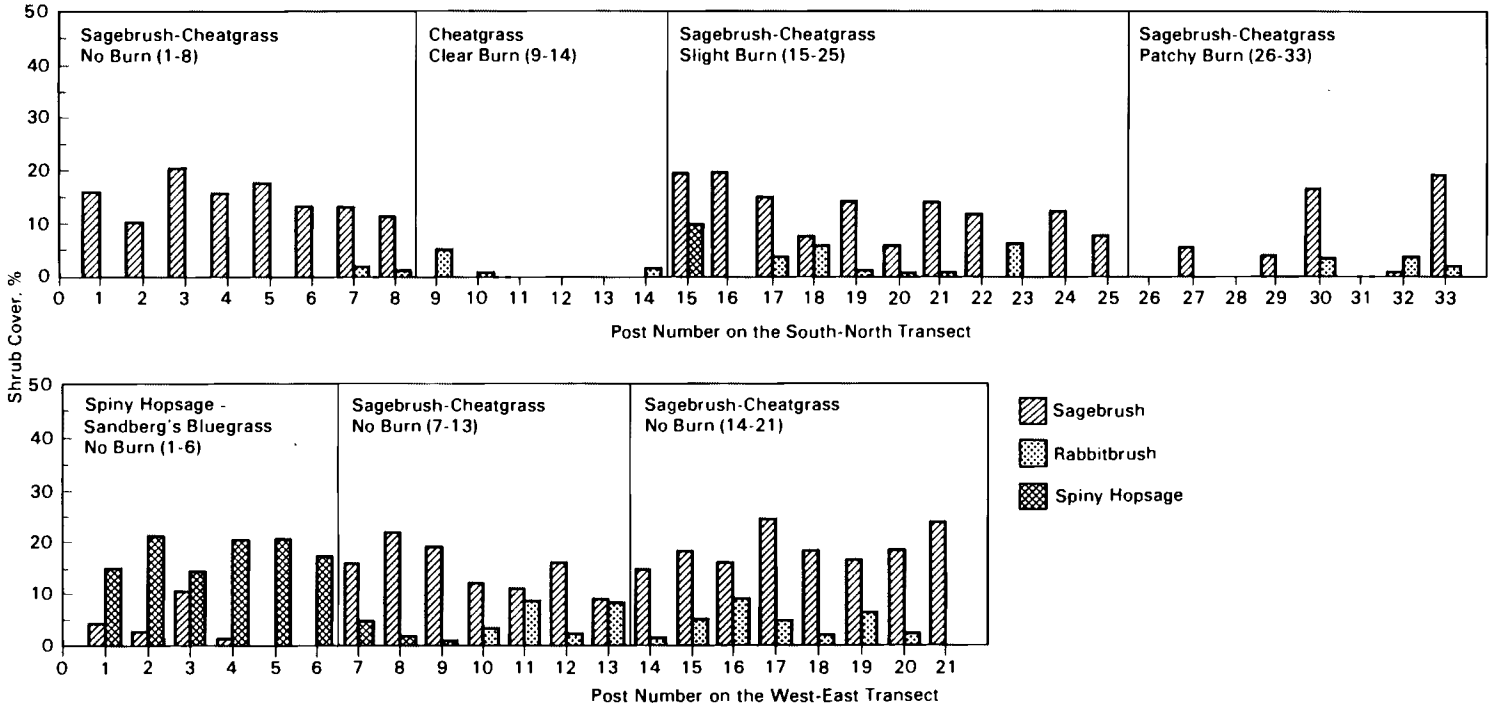

FIGURE 5. Shrub Canopy Cover (%) for each Segment on the South-North and West-East Bird Transects at the Reference Repository Location in 1987

TABLE 5. Average Shrub Cover, Height, and Diameter and Distance Between Shrubs Measured in Grouped Habitat Segments[a] at the References Repository Location in 1987

Measurement	West-East Transect (1-6)[b]	(7-13)[c]	(14-21)[c]	South-North Transect (1-8)[c]	(9-14)[d]	(15-25)[c]	(26-33)[e]
Shrub Canopy Cover (%)							
Big Sagebrush	3	15	19	18	–	14	4
Spiny Hopsage	18	0.9	–	–	–	1	–
Gray Rabbitbrush	–	3	3	0.3	1	1	0.3
Green Rabbitbrush	–	0.5	0.5	0.2	–	0.1	0.5
Total Shrub Cover	22	19	22	19	1	16	5
Shrub Height (cm)							
Big Sagebrush	85	98	127	113	–	101	92
Spiny Hopsage	69	69	–	–	–	72	–
Gray Rabbitbrush	–	49	56	58	56	49	47
Green Rabbitbrush	–	45	63	38	–	33	49
Average Height	72	84	108	109	56	92	82
Shrub Diameter (cm)							
Big Sagebrush	107	126	172	143	–	130	129
Spiny Hopsage	119	113	–	–	–	108	–
Gray Rabbitbrush	–	72	87	93	83	71	74
Green Rabbitbrush	–	54	76	40	–	43	66
Average Diameter	117	111	149	138	83	121	115
Distance (cm) Between Shrubs	316	308	339	331	752	349	457

(a) Habitat segments are sections of the bird transects that are grouped according to similar kinds of plant communities.
(b) Segment is dominated by spiny hopsage.
(c) Segment is dominated by big sagebrush.
(d) Segment recently burned and dominated by cheatgrass.
(e) Segment mostly burned with some patches of unburned sagebrush.

slightly burned and was dominated by sagebrush and cheatgrass intermixed with rabbitbrush, with the exception of segment 15, which was also dominated by hopsage and Sandberg's bluegrass. Sagebrush cover (14%) in these segments was similar but slightly lower than the cover measured in segments 1-8. Segments 26-33 at the northern end of the transect crossed a patchy burn that created irregularly sized areas of unburned sagebrush and severly burned areas devoid of living sagebrush. Overall sagebrush cover in this area was low (4%).

Generally, sagebrush shrubs were taller and had a greater diameter than hopsage shrubs (Table 5, Figure 6). The tallest and widest shrubs (127 and 172 cm, respectively) were found on the eastern end of the west-east transect (Table 5, Figure 6). Distance between shrubs was similar for all segments ranging from 308 to 349 cm, with the exception of burned areas on the south-north transect (Table 5).

BIRD ASSOCIATIONS WITH HABITAT TYPE

Sagebrush habitat on the west-east (7-22) and the south-north (1-8, 15-25) transects had a greater bird species richness than hopsage (1-6, west-east) and cheatgrass (burned) habitats (9-14, south-north) (Figure 7). The hopsage habitat supported more species than cheatgrass habitats, and the cheatgrass habitat with a patchy sagebrush distribution (26-33, south-north) also supported more bird species than the pure cheatgrass habitat. For both transects and all habitat types, the entire year had a greater species richness than the breeding season (Figure 7). This would be expected since a complete year census also includes transient migratory birds.

Distribution and abundance of several nesting birds were related to habitat type (Table 6). Sagebrush habitat supported a greater total bird density than cheatgrass (burned) or hopsage habitats (Table 6). Most species occurred either at densities too low to draw any useful conclusions about specific associations to habitat type, or else appeared to be randomly distributed. Furthermore, simple linear regressions of bird counts against shrub cover suggested that most species were not significantly influenced by shrub cover (Table 7). However, affinities for habitat types were evident for burrowing owls, horned larks, long-billed curlews, meadowlarks, and sage sparrows (Figure 8). Only one pair of burrowing owls nested along the transects, and all sightings of owls were made very close to the burrow in sagebrush habitat (Table 6). This was expected since burrowing owls are crepuscular or nocturnal foragers and our surveys were made in daylight hours when the owls were perched near or on the edge of the burrow opening. Horned larks were most abundant in the hopsage-Sandberg's bluegrass community on the western end of the west-east transect (segments 1-6), which appeared to be their preferred nesting habitat (Figure 8). Long-billed curlews were more abundant in sagebrush habitat on both transects (Figure 8). Curlews usually nest in sparse, grass-dominated habitats and move their young into sagebrush cover after they hatch (Allen 1980). Curlews were seldom seen along the transects during the egg incubation phase of nesting. However, they become vocal and aggressive (mobbing behavior) during brood-rearing when young were in sagebrush habitats.

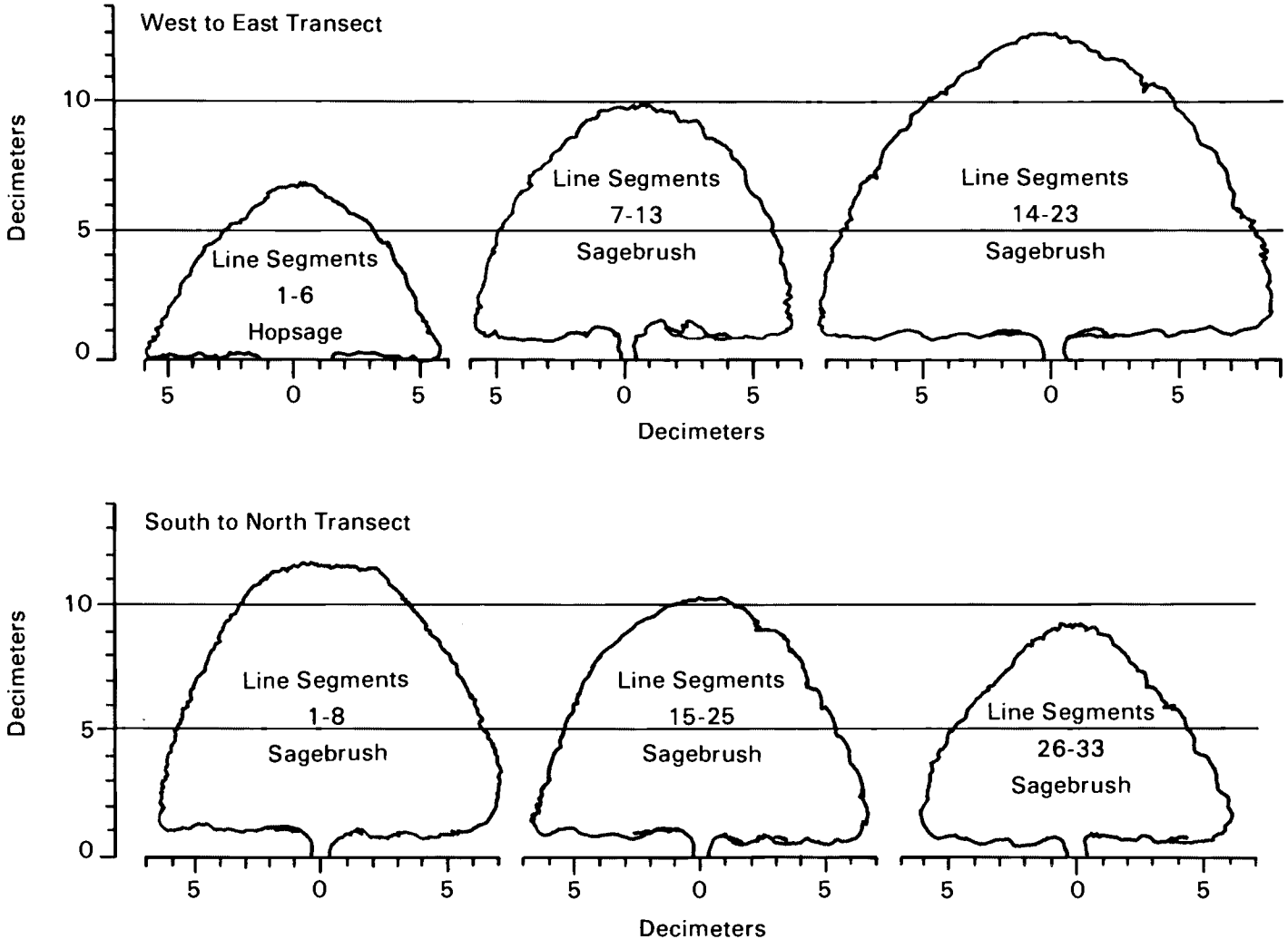

FIGURE 6. Average Heights and Diameters of Dominant Shrubs Along 161 m Segments of the South-North and West-East and Transects at the Reference Repository Location in 1987

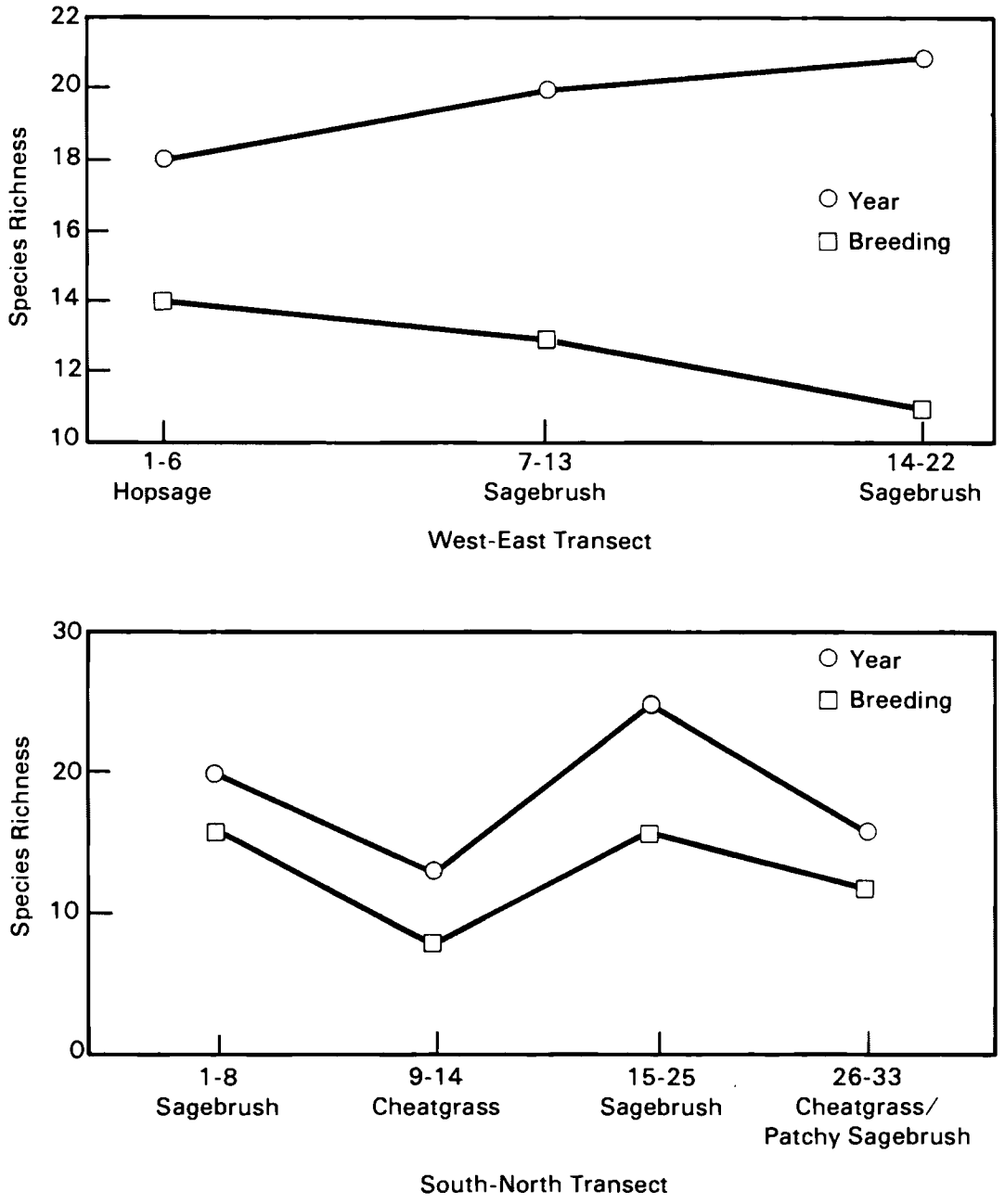

FIGURE 7. Species Richness of Birds Observed on Transects for the Entire Year (January-December 1987) and for the Breeding Season (March-June 1987)

Sage sparrows were more abundant in the sagebrush habitats along the west-east transect (7-22) than meadowlarks, but meadowlarks had greater densities in the hopsage habitat (1-6) on the west-east transect and in all habitat types, including sagebrush, on the south-northtransect

TABLE 6. Mean Density (individuals/km^2) of Birds Estimated on Bird Transects During the Breeding Season (March 10 Through June 12, 1987) at the Reference Repository Location

	Segments[a]						
	South-North Transect				West-East Transect		
Species	(1-8)[b]	(9-14)[c]	(15-25)[b]	(26-33)[d]	(1-6)[e]	(7-13)[b]	(14-21)[b]
Long-billed curlew	0.35	0.92	3.28	0.87	0.46	6.75	(f)
Northern harrier	0.17						
Red-tailed hawk			0.13				
Swainson's hawk					0.23		
Rough-legged hawk				0.17			
Mourning dove	0.87		0.38	0.52	0.92	1.98	0.69
Burrowing owl			0.50			4.96	
Common nighthawk	0.52				0.23		
Northern flicker			0.13		0.23		
Western kingbird					0.23	0.20	
Say's phoebe			0.13				
Horned lark		0.92		1.56	5.30		
Barn swallow	0.17		0.25			0.35	
Black-billed magpie	1.21						
Common raven	0.17	0.69	1.14	0.17	0.23	0.40	0.35
American robin	2.95		2.52			0.40	0.52
Loggerhead shrike	0.52			0.35	0.23		0.35
Sage thrasher		0.23		0.17			
European starling	6.41		21.45	0.35		0.60	1.21
Vesper sparrow			0.13				
Savannah sparrow		0.46		0.35	0.92		0.35
Lark sparrow	0.17	0.46			0.69	0.79	0.69
Sage sparrow	10.92	0.23	6.31	1.73	4.84	21.03	8.84
Chipping sparrow		0.23					
White-crowned sparrow	15.95		6.06	10.06	14.05	4.37	22.36
Western meadowlark	15.43	17.74	9.72	7.80	15.21	9.72	6.07
Red-winged blackbird							0.17
Brewer's blackbird			0.25				
Brown-headed cowbird	0.52		0.38				
Northern oriole	0.17						
House finch						0.40	
TOTAL BIRDS	56.50	21.88	52.76	25.83	43.77	51.95	41.60

(a) Habitat segments are sections of the bird transects that are grouped according to similar kinds of plant communities.
(b) Segment is dominated by big sagebrush.
(c) Segment recently burned and dominated by cheatgrass.
(d) Segment mostly burned with some patches of unburned sagebrush.
(e) Segment is dominated by spiny hopsage.
(f) Spaces with numbers are zeros.

TABLE 7. Simple Linear Regression[a] of Total Bird Counts per Transect Post (sample area=0.026 km^2, 54 segments, N=82) Versus Percent Shrub Canopy Cover (N=56) Estimated on Bird Transects (total area sampled=1.39 km^2) During January Through December 1987 at the Reference Repository Location

	Regression Slope (Beta Value)				
Species	Sagebrush	Hopsage	Gray Rabbitbrush	Green Rabbitbrush	Total
Long-billed curlew	3.51	-4.62	8.11	9.73	1.31
Mourning dove	-1.10	1.71	5.72	21.55	-0.04
Horned lark	-4.03	4.60	-24.02	-447.47	0.02
American robin	-37.08[b]	–	-22.85	-15.58	-32.98[c]
Loggerhead shrike	1.44	–	23.81(b)	2.55	1.41
Lark sparrow	-1.32	2.20	0.75	2.10	-0.36
Sage sparrow	8.23[d]	-6.80[b]	18.98	20.59	5.65[b]
Western meadowlark	2.05	-1.03	-2.27	56.64	1.39

(a) Bird counts were transformed to square roots and shrub cover was tranformed to arcsin ($\sqrt{x}$). Zeros were excluded from bird count data
(b) $P<0.05$
(c) $P<0.01$
(d) $P<0.001$

(Figure 8). Meadowlark density was greatest in cheatgrass habitat on the south-north transect, although they showed no clear affinity for any habitat type (Figure 8). In contrast, sage sparrows were generally more abundant in sagebrush habitat on the west-east (7 21) and the south-north (1-8, 15-25) transects (Figure 8). Sage sparrows were the only species to show a highly significant ($P<0.001$) relationship to shrub cover, in particular to sagebrush cover (Table 7). Generally their abundance increased as sagebrush cover increased (Figure 9), while increasing shrub cover had no apparent impact on meadowlark numbers (Table 7).

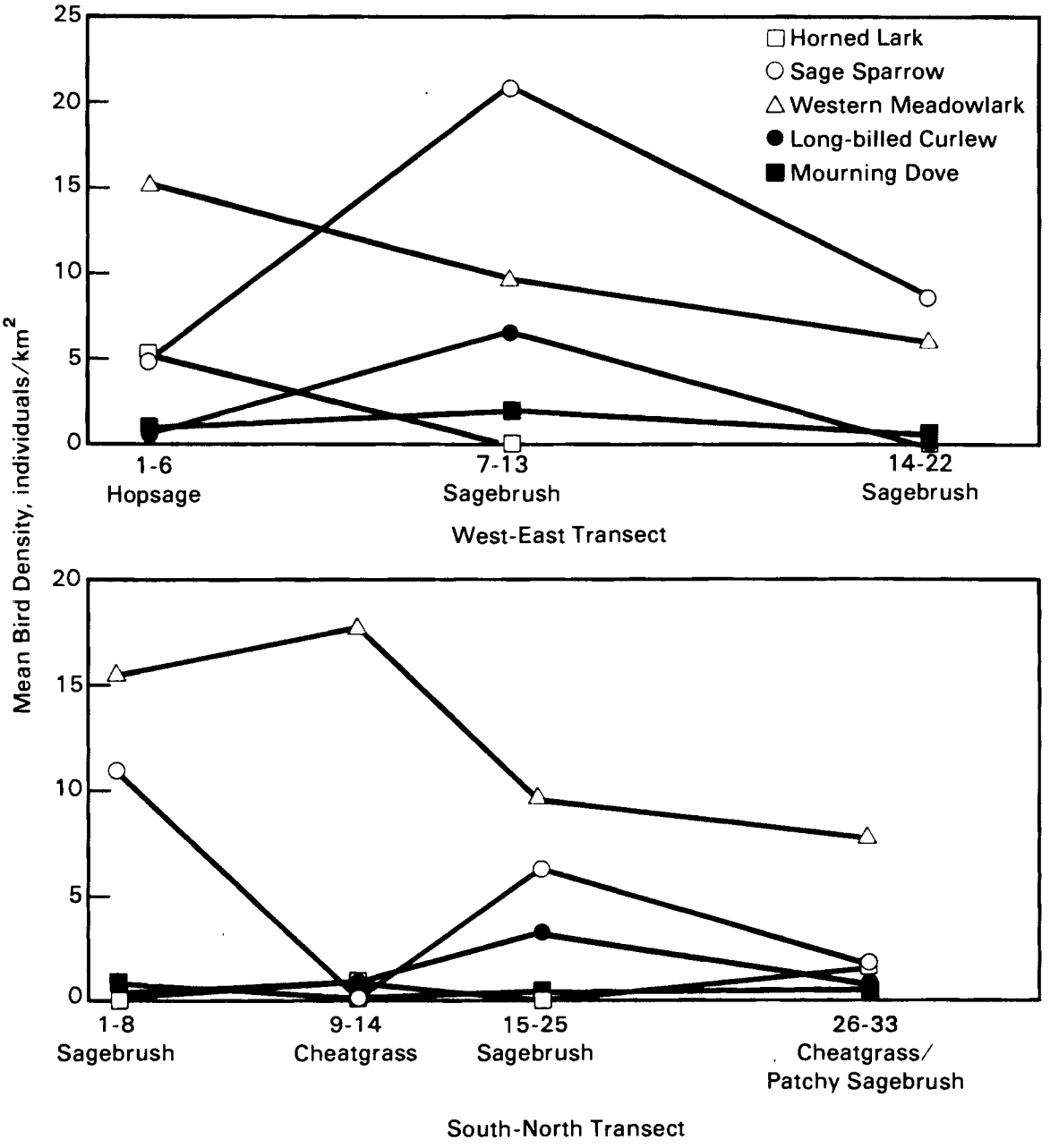

FIGURE 8. Relationship of Mean Bird Densities with Habitat Types on the West-East and South-North Bird Transects at the Reference Repository Location in 1987

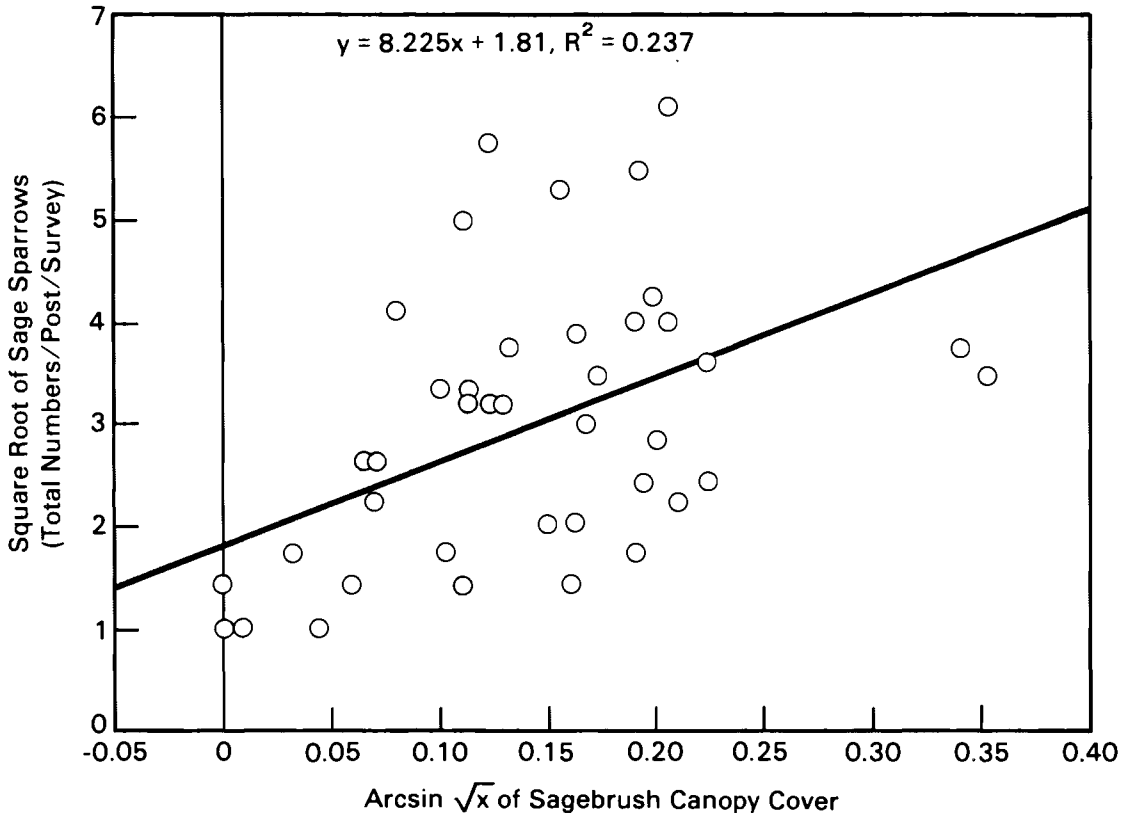

FIGURE 9. Simple Linear Regression of Sage Sparrow Counts on Sagebrush Canopy Cover for Bird Transects at the Reference Repository Location in 1987

DISCUSSION

BIRD ASSOCIATIONS WITH HABITAT

The structural configuration of vegetation stands determines in a large part the species richness and abundance of birds that use them. Structure is especially important for nesting birds. For the most part, shrubsteppe vegetation provides habitat that is acceptable to relatively few species of North American nesting birds (Rotenberry and Wiens 1978, Castrale 1982, Wiens and Rotenberry 1985, Wiens et al. 1986). However, a few birds are so dependent upon shrubsteppe plant communities that their continued existence could be jeopardized if the communities are destroyed and replaced by new man-induced plant communities that do not mimic natural shrubsteppe structural configurations. Our survey showed that sage sparrows had a strong affinity for sagebrush habitats, a moderate affinity for hopsage, and very low association with cheatgrass at the RRL. In contrast, meadowlarks were distributed throughout both the shrub-dominated and grass-dominated portions of the RRL. Similar results have been reported by Rotenberry and Wiens (1978), Wiens and Rotenberry (1981), and Wiens et al. (1986). This suggests that sage sparrows prefer sagebrush habitat while meadowlarks are not as selective.

Sagebrush habitats supported more species, had a greater total bird density, and had a greater individual density for most species than cheatgrass habitats. Similar patterns have been observed by other authors. Wiens and Rotenberry (1985) and Reynolds and Trost (1981) found that sage sparrows, Brewer's sparrows, and sage thrashers had greater abundance in sagebrush habitats, while grassland habitat supported none of these but contained an abundant population of horned larks. Other studies indicated that densities of Brewer's sparrows and sage sparrows decreased (Best 1972, Castrale 1982) and horned larks and meadowlarks increased (Castrale 1982). In our survey, sage sparrow densities were greater in sagebrush habitat; meadowlarks appeared to have no specific habitat affinity but in general had greater densities in cheatgrass habitat; horned larks were most plentiful in cheatgrass habitats; and total bird density and species richness were greater in sagebrush communities. Habitat affinities were consistent with the nesting behaviors of the aforementioned birds. Meadowlarks (Bent 1958) and horned larks (Bent 1942) place their nests on the ground in open grassy areas, and sage sparrows place their nests in shrubs (Reynolds 1981, Castrale 1982).

A major difference between nesting birds populations at the RRL and shrubsteppe localities in southeastern Oregon and northern Nevada (Wiens et al. 1987) was the absence of nesting Brewer's sparrows and sage thrashers. Brewer's sparrows and sage thrashers are

regarded as characteristic shrubsteppe nesting birds (Rotenberry and Wiens 1978, Wiens and Rotenberry 1981, Wiens et al. 1987), but they were seldom sighted and did not nest along the transects at the RRL. Climatic factors along the strong elevation gradient of the shrubsteppe region may be an important factor in segregating local populations of shrubsteppe birds. Climate at the RRL is generally drier and warmer than other parts of the shrubsteppe region, and it may limit the nesting distribution of Brewer's sparrows and sage thrashers.

In addition to the lack of nesting Brewer's sparrows and sage thrashers near the RRL, the area supported lower densities of most bird species relative to those found in other shrubsteppe study sites. Rotenberry and Wiens (1980a, 1980b), in a limited survey conducted over 3 years in southeastern Oregon and northern Nevada of shrubsteppe habitat, found a total breeding bird density of over 200 birds/km^2 and mean densities of 93 sage sparrows/km^2, 22 horned larks/km^2, 1.8 lark sparrows/km^2, and 14 meadowlarks/km^2. In our study of the RRL, the total mean bird density during the breeding season was only 43 birds/km^2, 7.8 sage sparrows/km^2, 0.93 horned larks/km^2, 0.36 lark sparrows/km^2, and 11 meadowlarks/km^2. Meadowlarks were the only species to show any density similarities; all other species and total bird densities were considerably lower at our study site.

Explanations for these differences include locations of study sites, time of year studied, and adjustments made to the census data. Rotenberry and Wiens (1980a, 1980b) placed their study sites in relatively undisturbed habitats, while our study site has been exposed to extensive disturbances over the years, which may have influenced bird abundance. There are isolated patches of relatively undisturbed habitat, but many areas have been disturbed by burning, off-road vehicle traffic, drill pad construction, and other construction activities associated with BWIP site characterization or Hanford Site Operations (Figure 1). The surveys by Rotenberry and Wiens (1980a, 1980b) were also conducted at the peak of nesting season, which in their region was June. They conducted only a few surveys on relatively small plots placed in homogeneous stands of shrubsteppe vegetation. In contrast, our surveys were conducted over relatively large areas throughout the breeding season. Rotenberry and Wiens (1980a, 1980b) adjusted their census numbers for "unseen" birds, which increased their numbers substantially. We did not make these corrections.

HABITAT MITIGATION

Brewer's sparrows, lark sparrows, and sage sparrows have been used as indicator species to monitor the effects of human-induced disturbances in shrubsteppe habitats (Rotenberry and Wiens 1978, Wiens and Rotenberry 1981). Bird abundance and species composition have been

shown to change in response to habitat modifications, and the changes can be monitored by observing indicator species' response to changes in shrub cover (Rotenberry and Wiens 1978). Habitat modifications that alter shrub cover will likely lead to a reduction in abundance or possibly the elimination of the characteristic bird species. Consequently, bird censuses conducted before and after habitat disturbances and during revegetation could be used to monitor damage to an recovery of shrubsteppe habitat and its associated wildlife.

At the RRL, sage sparrows are expected to be the species most sensitive to shrub removal. Sagesparrows characteristically build their nests in sagebrush (Reynolds 1981) and have been shown to be closely associated with sagebrush cover. Unnecessary losses of sagebrush habitat and the subsequent decrease in sage sparrow (and possibly other shrubsteppe "listed" species) abundance would be counter to the intent of the Migratory Bird Treaty Act and could elevate their Washington State status for regulatory and management concern. If populations of nesting sage sparrows are to be sustained on the RRL at or near the same densities as they exist today, it will be necessary to maintain sagebrush habitats of sufficient extent, density and stature to be acceptable to nesting sage sparrows.

The results of this study suggest that the density of sage sparrows could be useful as an indicator of shrubsteppe habitat quality. The availability of such an indicator may become increasingly important as a measure of how well the DOE is managing the Hanford Site, which by virtue of the extensive destruction of similar habitat types in the surrounding region (outside the Hanford Site) is becoming increasingly important as a refugium for a unique element of native shrubsteppe.

Reclamation of ground disturbed by BWIP site characterization activities will be important in maintaining the Hanford Site as a shrubsteppe refugium for native species. Shrubs and native perennial forbs and grasses are expected to provide the greatest challenge for reconstitution of shrubsteppe habitat (Rickard 1988). Restoration of these native plants will be an essential step in providing suitable habitat for shrubsteppe birds. The time required to artificially or naturally reconstitute a sagebrush or hopsage plant community to support nesting shrubsteppe birds is unknown, but is likely to be measured in terms of a few decades rather than a few years.

REFERENCES

Allen, J. N. 1980. "The Ecology and Behavior of the Long-Billed Curlew in South-Eastern Washington." Wildl. Monogr. 73:67.

American Ornithologists' Union. 1983. Check-list of North American Birds. Sixth Edition, Allen, Lawrence, Kansas.

Bent, A. C. 1942. "Life Histories of North American Flycatchers, Larks, Swallows, and Their Allies." U.S. Natl. Mus. Bull. 179:555.

Bent, A. C. 1958. "Life Histories of North American Blackbirds, Orioles, Tanagers, and Allies." U.S. Natl. Mus. Bull. 211:549.

Best, L. J. 1972. " First Year Effects of Sagebrush Control on Two Sparrows." J. Wildl. Manage. 36:534-544.

Canfield, R. H. 1941. "Application of the Line Interception Method in Sampling Range Vegetation." J. Forestry 39:388-394.

Castrale, J. S. 1982. "Effects of Two Sagebrush Control Methods on Nongame Birds." J. Wildl. Manage. 46:945-952.

Daubenmire, R. 1970. "Steppe Vegetation of Washington." Wash. Agric. Expt. Sta. Tech. Bull. 62:131.

Reynolds, T. D. 1981. "Nesting of the Sage Thrasher, Sage Sparrow, and Brewer's Sparrow in Southeastern, Idaho." Condor 83:61-64.

Reynolds, T. D. and C. H. Trost. 1981. "Grazing, Crested Wheatgrass, and Bird Populations in Southeastern Idaho." Northwest Science 55:225-234.

Rickard, W. H. 1988. Natural Vegetation at the Proposed Reference Repository Location in Southeastern Washington. PNL-6402, Pacific Northwest Laboratory, Richland, Washington.

Rickard, W. H., and C. A. Schuler. 1988. Descriptions of Plant Communities at the Proposed Reference Repository Location and Implications for Reclamation of Disturbed Ground. PNL-6494, Pacific Northwest Laboratory, Richland, Washington.

Rickard, W. H., D. W. Uresk, and J. F. Cline. 1976. "Productivity Responses to Precipitation by Native and Alien Plant Communities." In Proceedings of the Symposium on Terrestrial and Aquatic Ecological Studies of the Northwest. Eastern Washington State College, Cheney, Washington.

Rotenberry, J. T., and J. A. Wiens. 1978. "Nongame Bird Communities in Northwestern Rangelands." In Proceedings of a Workshop on Nongame Bird Habitat Management in Conifer Forests of the Western United States. General Technical Report PNW-64, pp. 32-46, USDA Forest Service, Portland, Oregon.

Rotenberry, J. T., and J. A. Wiens. 1980a. "Habitat Structure, Patchiness, and Avian Communities in North American Steppe Vegetation: A Multivariate Analysis." Ecology 61:1228-1250.

Rotenberry, J. T., and J. A. Wiens. 1980b. "Temporal Variation in Habitat Structure and Shrubsteppe Bird Dynamics." Oecologia 47:1-9.

U.S. Department of Energy. 1987. Environmental Regulatory Compliance Plan for the Hanford Site for Site Characterization (Draft). DOE/RW-0173, Prepared by Pacific Northwest Laboratory, for U.S. Department of Energy Richland, Washington.

Washington Department of Game. 1987. Special Animal Species, Olympia, Washington.

Wiens, J. A., and J. T. Rotenberry. 1981. "Habitat Associations and Community Structure of Birds in Shrubsteppe Environments." Ecological Monographs 51:21-41.

Wiens, J. A., and J. T. Rotenberry. 1985. "Response of Breeding Passerine Birds to Rangeland Alteration in a North American Shrubsteppe Locality." J. Applied Ecol. 22:655-668.

Wiens, J. A., J. T. Rotenberry, and B. Van Horne. 1986. "A Lesson in the Limitations of Field Experiments: Birds and Habitat Alteration." Ecology 67:365-376.

Wiens, J. A., J. T. Rotenberry, and B. Van Horne. 1987. "Habitat Occupancy of North American Shrubsteppe Birds: The Effects of Spatial Scale." Oikos 48:132-147.

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