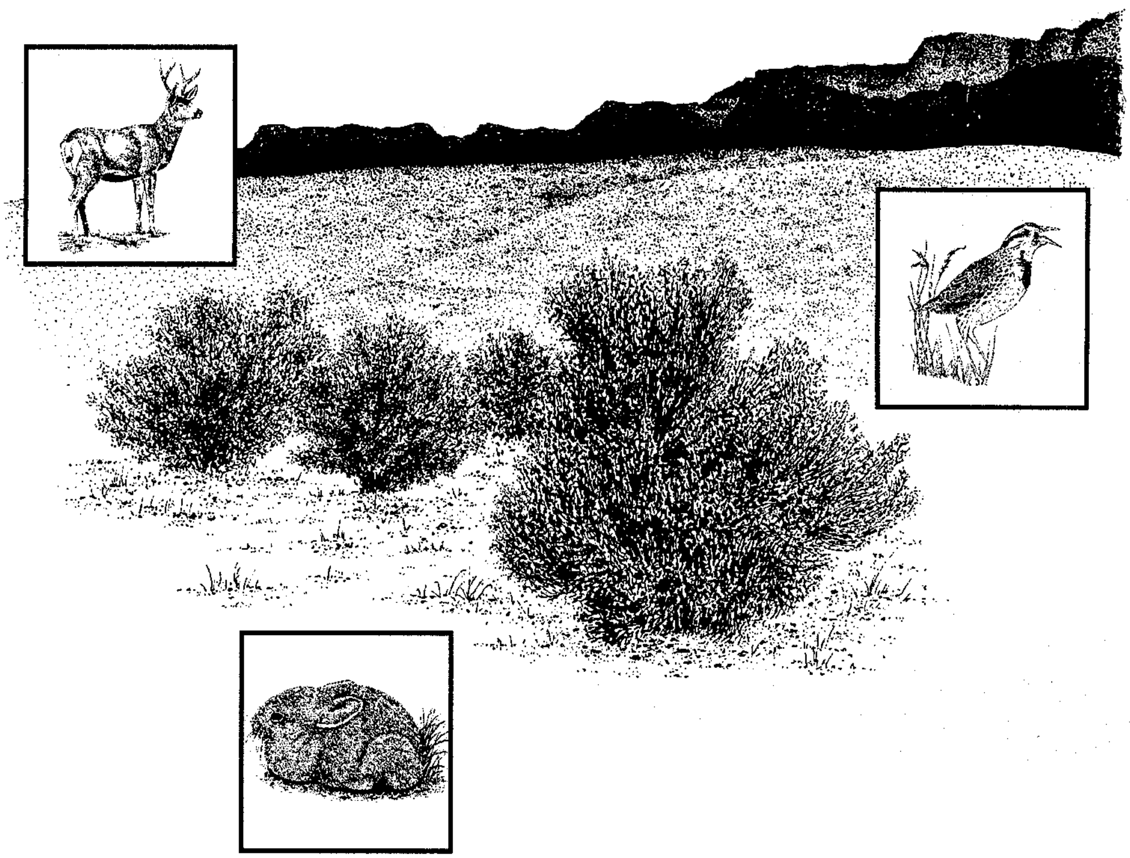
SHRUB-STEPPE RESEARCH PROJECT: *Phase one completion report*

Status of Washington's Shrub-Steppe Ecosystem:

Extent, ownership, and wildlife/vegetation relationships



By Frederick C. Dobler, Jim Eby, Chuck Perry,
Scott Richardson, and Matthew Vander Haegen

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Washington Department of
FISH AND WILDLIFE
Wildlife Management Program

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EXECUTIVE SUMMARY

Changes in land use over the past century have resulted in the loss of over half of Washington's shrub-steppe habitat. Dramatic increases in dry-land agriculture and use of irrigation to expand farming and orchards has reduced the once expansive native grasslands and shrub-steppe to a fragmented landscape with very few large areas of native vegetation. The few remaining large areas of shrub-steppe are primarily on federal holdings (Yakima Training Center, Hanford Nuclear Site, and the Yakama Indian Nation) and may represent the only sites suitable for species requiring extensive areas of continuous shrub-steppe. Combined, the Washington Department of Fish and Wildlife (WDFW) and Washington Department of Natural Resources manage 12% of Washington's remaining shrub-steppe. The majority of extant shrub-steppe in Washington, however, exists on land owned by private individuals or corporations.

Washington's shrub-steppe communities support a wide diversity of wildlife. Ninety-four species of birds were recorded on 55 transects surveyed over 3 years. The diversity of species encountered resulted both from the placement of transects across of range of shrub-steppe range sites, and the interspersion of other land-use types (e.g., agricultural fields, Conservation Reserve Program lands) among the remaining areas of shrub-steppe. The two most common species on the survey, western meadowlark and horned lark, are grassland birds that have adapted well to agriculture and also use shrub-steppe. Studies in more extensive areas of shrub-steppe have found sage sparrows or Brewer's sparrows (both shrub-steppe obligates) to be the most numerous species, perhaps reflecting a lower influence of agriculture in these other regions. Brewer's sparrows and sage sparrows ranked third and eighth in abundance in the Washington surveys.

Although the survey technique used in this study was probably better suited to counting birds than to counting most mammals, 13 species of mammal were recorded ranging from elk to sagebrush voles. Surveys designed specifically for mammals would likely identify additional species.

The occurrence of specific birds on study transects was more closely related to the extent of sagebrush cover and cover of introduced annual grasses than to any other measured vegetation parameter. Sage thrashers, sage sparrows, and Brewer's sparrows were found only where shrubs were the dominant structural feature in the landscape. This was expected, because nesting by these shrub-steppe obligates is dependent upon presence of sagebrush. Both species that occurred more frequently on sites with lower cover of big sagebrush were grassland species (savannah sparrow, long-billed curlew). All species that were negatively associated with percent cover of annual grasses also were positively associated with cover of big sagebrush.

The suitability of Washington's shrub-steppe habitat for wildlife differs from that which occurred a century ago. Conversion of sites with deep, loamy soil to agriculture; invasion by non-native grasses and forbs; and fragmentation of the remaining shrub-steppe habitats have likely lowered the suitability of Washington's shrub-steppe habitat for many native species. WDFW supports a continuing research program on shrub-steppe wildlife to help address these issues.

BACKGROUND

Pioneers in Sagebrush Country

When the first settlers arrived in eastern Washington in the mid-19th century, they found a scene which was far from encouraging. The arid sagebrush-bunchgrass landscape of the uplands was considered, "worthless for agriculture, fit only for roving bands of cattle, horses and sheep" (Anon. 1904). These pioneers limited their settlement to the bottomlands along flowing creeks, where there was water to drink, to grow crops, and to water livestock. When Lt. Thomas Symons surveyed eastern Washington in 1879, he tersely summarized his impression: "It is a desert, pure and simple and can be dismissed in a few words. An almost waterless, lifeless desolation...".

The uplands were used as free rangeland for cattle and horses and for transhumant sheep bands, but lack of water limited their dispersal. In a few years however, adventuresome farmers had discovered that the uplands were more desirable for agriculture than the bottomlands. As soon as the wheat-growing potential of the deep-soil uplands was recognized, shrub-steppe began to fall to the plough. Irrigation of areas too dry to farm without supplementary water began, with 48,000 ac of irrigated lands by 1890. While the grasslands of Whitman County were the first to go, nearly all dryland wheat areas were under cultivation by 1900, including much of the shrub-steppe. Reports at the turn of the century boasted greatly about the yields of wheat, claiming Lincoln County as the most important wheat-growing area in the country (Anon. 1904). As early as 1893, the Worlds Fair Commission of the State of Washington (Evans and Meany 1893) wrote:

> EASTERN WASHINGTON is the great wheat granary of the Pacific coast, its peculiar volcanic soil being adapted to a most marvelous extent to the production of all cereals. Every succeeding year adds to the already extensive wheat area of Eastern Washington, and the time is not far distant when the great sage-brush plains will be as one vast field of waving grain.

By the turn of the century, a land rush had been fueled by the glowing reports of the fruitfulness of eastern Washington, by the Homestead Act of 1862 (and its successors) which allowed anyone without land to make a "claim" to develop and improve, and perhaps most importantly by the land grants which accompanied the completion of the Northern Pacific railroad. The arrival of rail not only made the open lands accessible and desirable, but railway agents promoted land (some of which was marginal for agriculture) to generate the revenues needed to finance the railroad. Promoters published tantalizing reports in the newspapers of eastern cities: "There is no place in the world like the fertile Big Bend country"; "An abundance of homestead land free for the taking, with every opportunity imaginable" (Anon. 1904).

The tactic created a flood of immigrants from every part of the country, eager to prove a claim. Shacks soon dotted the "barren landscape" and wire fences partitioned formerly-limitless expanses of desert. A historical account written in 1904 stated that the best lands in Lincoln County were already "quite well settled and under cultivation," and in *The Last Grand Roundup*, A. A. McIntyre (1906) penned a lament:

> Time has been, and not so many years ago either, when southern Douglas county was the undisputed home of range horses and cattle, with an occasional coyote and jack rabbit. Now all this is changed and farmers are plowing and sowing and reaping crops of grain from land which was then considered a desert. With coming of these farmers the range horses had to go.

Homesteading left its legacy on the eastern Washington landscape. Land which could be cropped was cultivated, that which could not produce crops was grazed. Only small fragments of remaining sagebrush-bunchgrass might be called pristine, but even these cannot be termed untouched. The traditional attitude of the settlement period, which has persisted to the present day, was that the western range covered enormous area and was virtually limitless. Livestock grazing was generally regarded as a transitional phase of land use that would lead to more intensive development, resulting in minimal care of the natural resource (Clapp 1936).

Pioneers survived in a harsh landscape, which was poorly understood and thus often abused, while rapid settlement encouraged by government and economic forces set the stage for exploitation. These historical events are the factors that shaped present-day eastern Washington, and mustn't be regarded with malice.

RESEARCH PROJECT

While an extensive library exists on range management, it generally relates to livestock production or game species habitat management. Most non-game animals that use shrub-steppe are poorly understood, but generally have not been thought to be in critical need of intervention by wildlife managers. However, more than 100 bird species forage and nest in sagebrush communities, and at least four of them--sage grouse, sage thrasher, sage sparrow, and Brewer's sparrow--are obligates, or almost entirely dependent upon sagebrush (Braun et al. 1976 and citations therein) (scientific names for wildlife species are listed in Appendix C).

None of Washington's shrub-steppe birds are listed by the state as endangered and only the ferruginous hawk (*Buteo regalis*) is listed as threatened. However, the sharp-tailed grouse, sage grouse, sage sparrow, sage thrasher, and loggerhead shrike are all candidates for listing. One shrub-steppe mammal, the pygmy rabbit (*Brachylagus idahoensis*), is on the state list of endangered species.

With the continuing loss of shrub-steppe to agricultural development, the habitat's importance to non-game wildlife species began to attract attention (e.g., Gooding 1970, Rich 1980, Reynolds 1981, Petersen and Best 1987), and researchers initiated investigations into the effects of various rangeland land-use practices and management techniques on non-game birds (Best 1972, Schroeder and Sturges 1975, Petersen and Best 1987, McAdoo et al. 1989).

The Washington Department of Fish and Wildlife (WDFW) (then the Washington Department of Wildlife) wished to identify important relationships between shrub-steppe animals and their habitat. The WDFW Shrub-steppe Research Project took shape in 1987, with Phase One field work commencing in 1988 and continuing through 1990. Objectives of this investigation were 1) to map extant shrub-steppe habitat in eastern Washington and determine the pattern of ownership, and 2) to examine relationships among range condition, vegetative composition and diversity, and wildlife occurrence and diversity within Washington's shrub-steppe.

What is Shrub-Steppe?

Vegetative communities consisting of one or more layers of perennial grass with a conspicuous but discontinuous over-story layer of shrubs have been termed "shrub-steppe" (Daubenmire 1988). In Washington, these communities usually contain big sagebrush (*Artemisia tridentata*) in association with bunchgrasses, although other associations are found. Shrub-steppe communities once covered most dryland areas of eastern Washington, extending from below the forests of the Cascade slope to the prairies of the Palouse.

The average cover of big sagebrush was about 10% prior to introduction of livestock into Washington (Daubenmire 1988). Because livestock do not eat it, sagebrush often increases in density in grazed areas, replacing most other plants in badly degraded ranges. On the other hand, sagebrush densities are often reduced by range managers to keep the plant from competing with desirable livestock forage plants. Wildfire also can reduce or eliminate sagebrush from a range.

Annual grasses have recently become a prominent feature in the ranges of the west. These grasses are usually one of several introduced bromes that are effective competitors for moisture in low precipitation zones. They readily invade disturbed sites after fire or overgrazing, but can be present on even the best sites.

These findings would guide investigations undertaken in Phase Two (1991-1993) of the Shrub-steppe Research Project, which focused on shrub-steppe obligate species. The outcome of Phase Two research will be reported elsewhere.

STUDY AREA AND METHODS

Mapping with Landsat Data

Mapping. Landsat Thematic Mapper (TM) data were used for most shrub-steppe mapping. A TM scene from path 44, row 27 (9 June 1986) covered most of the central Columbia Basin, including Douglas, Grant, Lincoln, and Adams counties. TM scenes from path 45, rows 27 and

28 (18 July 1986) were used to map parts of Chelan, Kittitas, Yakima, and Benton counties. Some shrub-steppe areas in Okanogan and Klickitat counties were not covered.

Cluster analysis was used to identify spectral variation in the Landsat data. Unique spectral classes were then compared to vegetation measurement data and aerial photographs. Sites for collection of field data were selected by comparing the distribution of the spectral classes to maps and aerial photos and by consulting with biologists familiar with the distribution and location of shrub-steppe areas. Field sites with a wide range of shrub-steppe conditions were visited, detailed vegetation information collected, and the locations mapped on USGS topographic maps.

Landsat Imagery

Landsat Thematic Mapper data are acquired by a scanning sensor on board a polar orbiting satellite at an altitude of about 700 km. The scanner sweeps from side to side as the satellite moves along the orbital track from north to south. As it sweeps, the scanner collects observations of the intensity of light reflected from the surface of the earth. A single unit of ground observation (pixel) is 30 x 30 m in size. The scanner measures the light reflected from each pixel in seven discrete portions of the electromagnetic spectrum (spectral bands). The data are transmitted from the satellite to ground stations, and organized into units called scenes, 200 x 170 km. The scenes are rectified to a map projection and sold to customers in digital form on magnetic tape.

Based on analysis of the collected data, more than 100 spectral classes were grouped into 10 to 20 vegetation or surface cover categories, including several each of shrub-steppe and agricultural, as well as bare ground, rock, water, and cloud. Generally, only 20 to 30 spectral classes were correlated with the occurrence of shrub-steppe vegetation.

Difficulties. The problems encountered in mapping shrub-steppe included typical satellite data mapping problems and some problems unique to shrub-steppe mapping. Two different ground features may exhibit the same pattern of spectral reflectance, or the spatial and spectral resolution of the TM data may not be good enough to separate the differences. In the shrub-steppe region, some differing vegetation communities had overlapping spectral signatures, and in some cases non-shrub-steppe features such as fallow agricultural lands had signatures that were similar to shrub-steppe areas. Another difficulty stemmed from key vegetation elements in some shrub-steppe communities occurring at very low percentages, thus making a negligible contribution to the spectral signature in comparison to the background soil and rock. Significant deposits of Mount St. Helens volcanic ash remained on sites in the Columbia Basin in 1986 and 1987, greatly modifying spectral signatures in these areas.

The seasonal growth pattern of shrub-steppe vegetation influenced the mapping. Most shrub-steppe vegetation matures in the spring, then rapidly loses its moisture and active chlorophyll, changing spectral signatures dramatically. The seasonal status varied greatly from north to south across one TM scene, making the correlation of spectral signatures to plant communities very difficult. Unfortunately, due to cloud cover and data availability it was difficult to purchase TM data obtained during late spring when shrub-steppe vegetation was at its peak. Moreover, a wide range of disturbances occurred in shrub-steppe areas, altering vegetation cover and species composition. A given shrub-steppe parcel could exhibit several degrees and types of disturbance. The degree of disturbance often contributed as much to the spectral signature as did the plant species composition.

Distribution. To assess the overall status of shrub-steppe in the Columbia Basin, a data set covering most of Douglas, Lincoln, Grant, Adams, Franklin, Benton, and Walla Walla counties was created (Current Status map layer). The eastern, non-forested portions of Chelan, Kittitas, and Yakima counties also were included. A mosaic was made of the three TM scenes involved. To fill in some gaps, mainly in Walla Walla and Franklin counties, some older Landsat Multi-spectral Scanner data were used. To keep the data set manageable, pixels were resampled to 85 × 85 m. The mapping categories in this data set were very general and included only one shrub-steppe category. Grasslands used mainly for agricultural purposes were not included as shrub-steppe.

The Current Status map layer was used to estimate the amount of shrub-steppe lost since the arrival of settlers during the 19th century. The assumption was made that all lands currently in agriculture, modified grassland, and bare ground categories were once dominated by shrub-steppe. Bare rock, talus slopes, open water, and riparian forest lands were not included in the calculation of converted lands.

Ownership. Ownership of shrub-steppe was derived by using the WDFW Geographic Information System and the Current Status map layer. A systematic grid of points was plotted on 1:100,000 scale map mylars, which were overlaid on the Washington Department of Natural Resources 1:100,000 scale maps depicting major ownerships. A random sample of 2,426 points was selected from 2,291,633 possible points representing shrub-steppe within the study area. The ownership category at each selected point was then compiled into a data base.

Location of Transects

Wildlife and vegetation were sampled along 500-m long transects placed in the Columbia Basin of central Washington, encompassing all or part of Adams, Benton, Douglas, Franklin, Grant, Lincoln, and Yakima counties (Figure 1). Average temperatures in the region range from -3°C in January to about 22°C in July. Annual precipitation is generally 250-500 mm, with June through August being very dry.

Sites for the transects were selected using a stratified random scheme with modifications. In 1988, USGS 7.5' quadrangle maps covering any portion of the known Washington distribution of sage grouse or sharp-tailed grouse north of Interstate 90 were numbered sequentially. Four maps covering southern Lincoln County were added to represent a disjunct area. Thirty-one maps were selected randomly and all shrub-steppe habitat in those areas was identified from Landsat data.

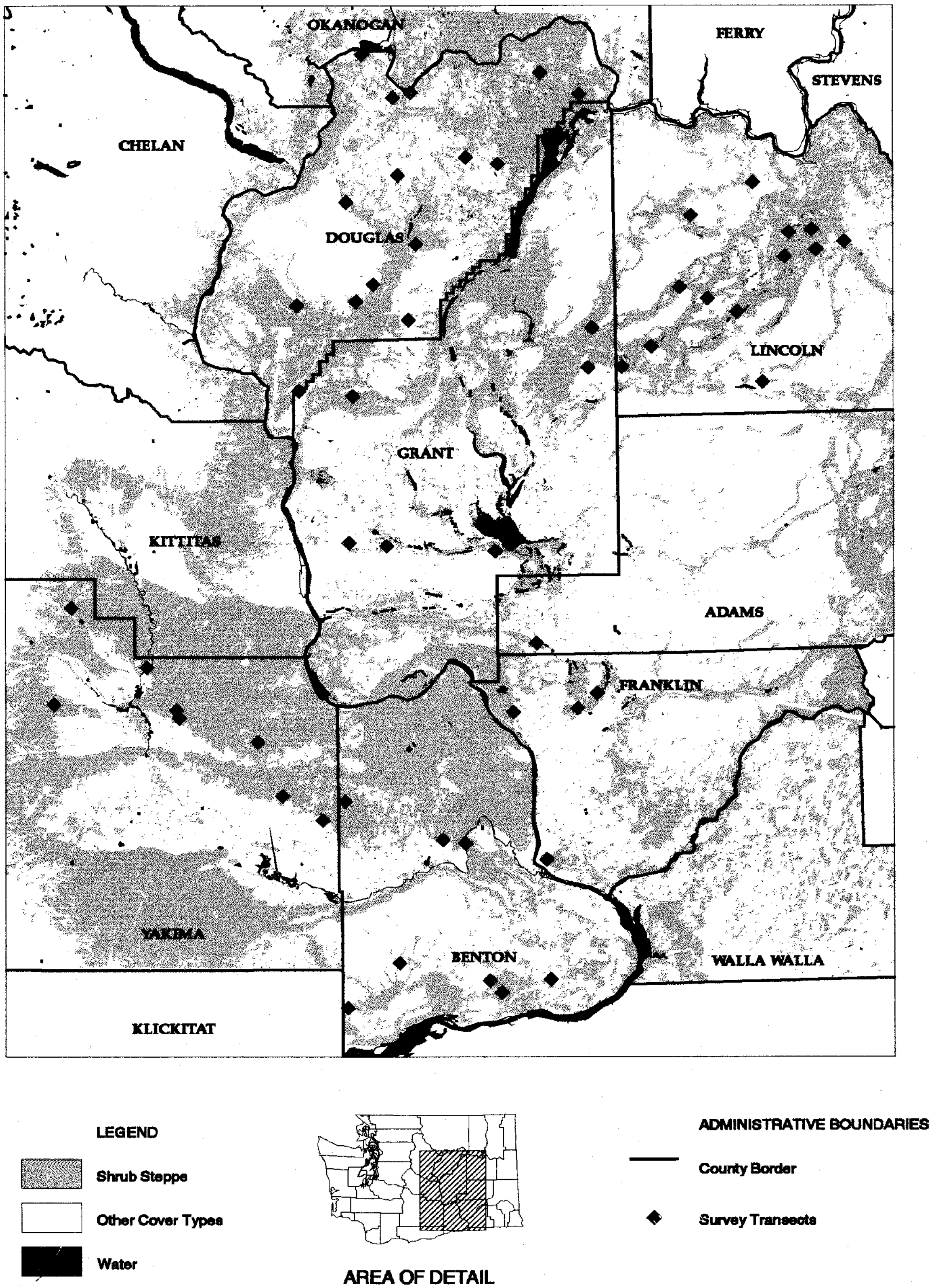

Figure 1. Central Washington study area showing distribution of remaining shrub-steppe and locations of survey transects.

To locate transects, each map width was measured (mm) along its southern edge, an x-coordinate was selected randomly, and an intercept was drawn north of this point. A second random number was used as a y-coordinate to determine a starting point. If this point fell within a polygon of shrub-steppe, a line equivalent to 500 m (representing the length of a transect) was measured north. If this segment remained at least 50 m from any edge of the habitat polygon, the transect was accepted.

If a starting point fell outside a shrub-steppe polygon, or if any point on the segment was within 50 m of a habitat edge, the intercept was followed north until a new polygon was encountered, and a replacement starting point was placed 50 m inside its boundary (this method may have biased transect location toward edges). If the top of the map was encountered before a suitable polygon was found, the search was resumed from the starting point south. If no suitable polygon was located along the intercept, a new set of random numbers was chosen for intercept and starting points. This process was repeated until a suitable site for transect placement was found.

In the field, transects were placed with compass and hip chain, with meter-long wooden stakes driven into the ground every 100 m and at each end. Flagging tape was tied to shrubs at irregular intervals along the transect to provide direction to wildlife surveyors. Because transect locations were selected without regard to ownership, some could not be established on the ground due to restricted access to certain lands. As a result, transects were located on privately-owned sites more often than expected by ownership distribution alone, and some ownerships went wholly unrepresented (e.g., Bureau of Indian Affairs, Department of Defense).

In 1989 and 1990, the study area was expanded south of Interstate 90 by adding 24 randomly selected maps and placing a new transect in each of them. Twenty-one of the 1988 maps were selected randomly for a total of 45 sites in 1989 and 1990 and 55 sites overall.

Range Classification

Range site is a term used to describe a particular type of rangeland and is indicative of the climax vegetation that would be expected to occur on a given site. Range site was determined for all transects using a system developed by the USDA Soil Conservation Service (SCS), which describes range sites based on soils information and rainfall. In the present study, range sites were derived from a combination of soil texture class and mean annual rainfall.

Vegetation Measurement

Vegetation surveys were completed between late May and mid July. Sampling was done on a line 5 m west and parallel to the wildlife transect to avoid paths trampled during wildlife surveys. Transects were divided into l0 segments of 50 m each, and alternate segments were sampled. Shrub cover was determined by line intercept sampling (Phillips 1959). Only living parts of the shrub canopy were counted; intra-shrub openings larger than those in healthy growing parts were excluded, though this was done qualitatively rather than quantitatively.

Shrub cover also was measured along with other ground cover classes using the methods described by Daubenmire (1959) as presented in Perry (1982). Micro-plot sampling frames (20 × 50 cm) were placed at 5-m intervals along each of five selected 50-m segments (i.e., 50 micro-plots/transect), with long-side perpendicular to the transect. Annual grasses, annual forbs, and cryptogams (non-seedbearing plants) each were grouped during cover measurements. Shrubs and perennial grasses were identified to species. Perennial forbs were keyed to genus unless specific identity was unambiguous due to known distribution (e.g., *Achillea millifolia*). Nomenclature of plants followed Hitchcock and Cronquist (1973). Litter, cow and horse droppings, bare ground, and rock were the remaining ground cover types.

A comparison of line intercept and microplot methods for measuring big sagebrush showed a high degree of correlation ($r = 0.917$, $P < 0.01$). In determining correlations between wildlife and vegetation, line intercept data were used for shrubs (Mueller-Dombois and Ellenburg 1974) and microplot data for other cover classes.

For long-term comparison of landscape features, 797 photographs (35-mm color transparencies) were taken on 53 transects (Appendix D). The most complete sets of images contain photos taken by aiming north from the start and middle of each selected segment. Twelve transects had fewer than five photos, while 21 transects had at least 20. Several transects had photos taken in more than 1 year. Images are on file at the WDFW office in Olympia.

Wildlife Field Methods

Wildlife surveys took place from 1 April to 6 June, between first light and 3 hr after sunrise, and were suspended in rain or when wind exceeded a value of 3 on the Beaufort wind scale. Each field worker usually completed two transects per day. Four replicates of 29 transects were completed in 1988 (one was done three times and one was done six times). Three replicates of 44 transects were completed in 1989 (another was done only twice). Four replicates of 45 transects were done in 1990. Replicates were distributed to reduce seasonal bias during 1989 and 1990, but in 1988 three sets of repetitions failed to achieve this goal.

Survey methods were based on Mikol (1980). Observers approached a transect in line with its axis and recorded weather data and start time on field data forms. When birds, mammals, or their sign were encountered, information was recorded on data forms. Items included the identity, number, and activity of species observed, and the position of individuals when first sighted. Position usually was described as the perpendicular distance from the transect at first sighting, but the angle and/or distance from the observer were sometimes noted. Optical rangefinders assisted observers in estimating distances and hand-held compasses were used for measuring angles. Coveys or flocks were considered single observations with the location being the flock center. Activity codes included one for birds heard but not seen.

Mammal detections were primarily indirect (i.e., sign) and observers differed in their ability to interpret mammal sign. Only detections of Great Basin pocket gophers were considered reliable for density calculations, because their characteristic mounds persisted after snow tunnels melted and were easily recognized by surveyors.

Statistical Treatment of Wildlife Data

Density (observations/ha) was computed using the program TRANSECT (Burnham et al. 1980) for the 18 bird species and 1 mammal species represented by at least 30 observations, with zeros excluded from calculations. Song-only records (birds heard, but not seen) were not included when estimating bird density unless their exclusion reduced the sample size to less than 30 records. Observations from some transects were grouped by range site when sufficient observations ($\geq$30) were available. These groupings were dictated by the distribution of the observations and were different for each species and year.   All observations (including song-only) were used when calculating densities with grouped data. When the number of records exceeded the program's capacity, the data set was arbitrarily halved, a mean density estimate was calculated, and a new 95% confidence interval was computed using the mean variance. Precision estimates (expressed as 95% confidence intervals) were calculated by TRANSECT assuming asymptotic normality and using the *z*-value of 1.96. Variance of each density estimate was derived from the complete data set (i.e., transects were not counted as replicates in calculating variance).

Two models in program TRANSECT were used to estimate density from survey data. In most cases, the Fourier series estimator (Crain et al. 1978) provided a good representation of the data. However, distribution of the data for sage thrashers indicated that individuals of this species often moved prior to being detected by observers, a violation of one of the assumptions used by the algorithm. Therefore, the exponential polynomial series (Burnham et al. 1980) was used to give less-biased results.

The Shannon index (Pielou 1975) was used to characterize diversity of wildlife and perennial plants. Nonlinear regression was used to describe the relationship between number of birds seen and percent cover of big sagebrush. Data are presented separately for each year because analysis of variance indicated that years were significantly different. Statistics were performed using SAS (SAS Institute 1985)

RESULTS

Distribution of Remaining Shrub-Steppe

Habitat classifications from analysis of Landsat data and predictions (Daubenmire 1988) based upon current land uses, revealed that 10.4 million acres of shrub-steppe existed in Washington prior to the arrival of settlers during the 19th century. Only about 40% of the original shrub-steppe remains. Historically, Grant County contained the greatest acreage of shrub-steppe, but only 35% now remains (Table 1). Today, Yakima County supports the largest amount of shrub-steppe, retaining 58% of its original acreage. The Yakima Training Center and the Yakama Indian Reservation hold two of the largest blocks of shrub-steppe in Washington, contributing significantly to the Yakima County total. Another large block of shrub-steppe is found within the Hanford Site in Benton County. The remainder of this habitat type is distributed along major watercourses in the central Columbia Basin and the channeled scabland, where shallow soils and rock outcrops make farming difficult, and as fragments of varying size within a matrix of agricultural lands.

Table 1. Shrub-steppe acreage in Washington counties, based on Landsat data analyzed at the WDFW Remote Sensing Laboratory using plant community predictions of Daubenmire (1988).

County	Historical	Remaining	% loss
Okanogan*	432,494	266,297	38
Yakima	1,488,672	857,731	42
Kittitas	581,164	323,946	44
Benton	1,032,188	502,523	52
Douglas	1,095,016	502,709	54
Lincoln	1,260,032	473,674	62
Chelan	201,925	76,903	62
Grant	1,614,555	571,830	65
Franklin	753,716	230,778	69
Adams	1,187,399	279,758	76
Walla Walla	770,017	178,037	77
Total	10,417,176	4,264,186	59

*Analysis completed on only 20% of county area.

Ownership of Remaining Shrub-Steppe

Private land constitutes nearly 60% of all ownership classes, with Bureau of Indian Affairs land being the only other class to exceed 10% (Table 2). Public-accessible lands comprise a remarkably small portion of Washington's remaining shrub-steppe habitat.

Table 2. Ownership of shrub-steppe habitat in the study area (based on 2426 random points) and at ends of Research Project Phase One survey transects.

Landowner	% of Study Area	% of Transects North End	% of Transects South End
Private	59	74	74
U.S. Bureau of Indian Affairs	11	0	0
Washington Department of Natural Resources	7	15	15
U.S. Department of Defense	6	0	0
Washington Department of Fish and Wildlife	5	2	4
U.S. Department of Energy	5	0	0
U.S. Bureau of Land Management	3	4	2
U.S. Fish and Wildlife Service	1	0	0
U.S. Bureau of Reclamation	<1	6	6
U.S. Forest Service	<1	0	0
Other Public Lands	<1	0	0
Total	100	101	101

Range Site

Transects fell into 14 range sites, or range site combinations when a transect crossed more than one soil type (Table 3). Loamy 9-12" and loamy 6-9" were the most frequently encountered range sites, but shallow sites, either alone or in combination with loamy soil, occurred on 49% of the transects. Sandy or sandy loam soils occurred on 13% of the 55 transects.

Table 3. Distribution of 55 transects by Range Site, based on Soil Conservation Service definitions. Range site names are a combination of soil texture class and average annual rainfall.

Range Site	Number	Range Site	Number
Loamy 9-12"	13	Shallow 9-12"	3
Loamy 6-9"	10	Shallow 6-9"	2
Loamy 12-15" / Very Shallow 9-18"	5	Very Shallow 9-15"	2
Loamy 9-12" / Very Shallow 9-18"	4	Shallow 6-9" / Loamy 6-9" / Sandy Loam 6-9"	2
Very Shallow 9-15" / Loamy 9-12"	4	Very Shallow 9-18"	1
Sandy 6-9"	4	Loamy 9-12" / Very Shallow 9-12"	1
Very Shallow 9-15" / Shallow Loam 9-12"	3	Sandy Loam 6-9"	1

Vegetation

Ninety-six perennial plant species or genera were measured (Appendices A and B). They included 2 trees, 16 shrubs, 20 perennial grasses, and 58 perennial forbs. Six species each of shrub and perennial grass, and five perennial forbs, occurred on at least one-fifth of the transects (Table 4).

Table 4. Vegetative cover classes occurring on more than 20% of 55 transects in the shrub-steppe study area. Shrub data are based on line-intercept sampling, whereas other cover classes are microplot values. All values represent percentages and do not include transects where a species was absent.

Cover	Occurrence on transects	Occurrence on microplots	Mean cover on all transects	Highest cover among transects
Shrubs				
Artemisia tridentata	76.4	--	6.7	19.2
Chrysothamnus nauseosus	58.2	--	1.0	3.7
C. viscidiflorus	40.0	--	0.9	2.8
A. rigida	32.7	--	2.6	7.2
A. tripartita	30.9	--	1.4	3.6
Tetradymia canascens	20.0	--	0.6	1.6
Perennial grasses				
Poa sandbergii	98.2	67.9	16.8	33.9
Agropyron spicatum	74.5	27.4	12.0	41.9
Stipa comata	32.7	5.3	4.2	22.5
Festuca idahoensis	27.3	5.2	4.7	14.6
S. occidentalis	23.6	4.5	4.9	20.3
Elymus cinereus	23.6	1.2	1.9	9.4
Perennial forbs				
Phlox sp.	65.5	7.6	1.2	5.6
Lomatium sp.	60.0	8.6	1.3	5.0
Achillea millifolium	56.4	7.9	2.2	11.3
Lupinus sp.	52.7	6.4	2.2	7.2
Erigeron sp.	50.9	4.4	1.3	4.5
Eriogonum sp.	50.9	6.5	1.9	6.7
Astragalus sp.	38.2	1.8	0.5	1.6
Carex filifolia	27.3	5.4	7.0	21.2
Orthocarpus	20.0	1.7	0.7	1.6
Annual grasses	100.0	76.0	20.1	75.8
Annual forbs	100.0	73.9	12.3	49.7

Big sagebrush and gray rabbit-brush (*Chrysothamnus nauseosus*) were the most common shrubs and were found on 42 and 32 transects, respectively. Sandberg bluegrass (*Poa sandbergii*) was the most common perennial grass, occurring on all but one transect and in two-thirds of the plots.

Bluebunch wheatgrass (*Agropyron spicatum*) occurred on three-quarters of the transects and in one-quarter of the plots. Annual grasses were found on every transect and in 76% of the microplots. Cheatgrass (*Bromus tectorum*) was overwhelmingly the most common annual grass, although all species were grouped during measurements. Three perennial forbs--*Achillea*, *Erigeron*, and *Eriogonum*--were present on more than half the transects.

Bird Occurrences

In 3 years of surveys, 8,727 observations of 94 bird species were recorded (Appendix C). There were 83 species seen in 1988, 67 in 1989, and 76 in 1990. Twelve species (Table 5) represented 84% of all observations, four of which--western meadowlark, horned lark, Brewer's sparrow, and vesper sparrow--accounted for over two-thirds. Only the western meadowlark was seen at all sites; it was detected during almost every survey. Horned larks occurred on 80, 88, and 91% of the transects in 1988, 1989, and 1990, respectively.

Forty-seven species were seen on three or fewer transects and 38 of these were seen on three or fewer surveys. Together, they represented 1.3% (*n*=111) of all observations. The sage grouse was among nine species seen on only three transects and the sharp-tailed grouse was among 13 species recorded on only two transects. The hermit thrush was found on one transect during two surveys. Twenty-four species were recorded on a single occasion.

Table 5. Bird and mammal species with at least 100 observations (animals or sign) during three years of surveys on shrub-steppe transects.

Birds	*n*	Mammals	*n*
Western Meadowlark	2154	Great Basin Pocket Gopher	254
Horned Lark	1418	Coyote	237
Brewer's Sparrow	1299	Badger	145
Vesper Sparrow	1061	Mule Deer	108
Grasshopper Sparrow	312		
White-crowned Sparrow	313		
Sage Thrasher	292		
Sage Sparrow	145		
Brewer's Blackbird	138		
Brown-headed Cowbird	138		
Ring-necked Pheasant	133		
Savannah Sparrow	132		
Mourning Dove	116		

Mammal Occurrences

In 3 survey years, 865 observations representing 16 mammal species were made. There were 11 species recorded in 1988, 9 in 1989, and 12 in 1990.

Coyote sign (e.g., scat, digging) was detected on more than half of the transects during 2 years. Other common species included Great Basin pocket gopher, badger, and mule deer (Table 5). Six species were recorded only once.

The density of Great Basin pocket gopher mounds was 4.2/ha in 1988 and about 11/ha in 1989 and 1990. Observations of other species were insufficient to provide density estimates.

Bird Densities

Mean densities (individuals/ha) each year for all transects combined were generally highest for horned lark, white-crowned sparrow, and Brewer's sparrow (Table 6). Grasshopper sparrow and sage thrasher were found in lower densities. Most species showed variation in density among years, and there were no clear trends among bird densities on transects in different range site/range site combinations (Table 6)

Table 6. Bird density estimates (individuals/ha) on various range sites based on perpendicular distance measurements and calculated using program TRANSECT.

Species	1988		1989		1990	
Range Site(s)[a]	Mean	95% C.I.	Mean	95% C.I.	Mean	95% C.I.
Horned Lark						
All Sites	**0.545**	**0.376 - 0.714**	**0.648**	**0.513 - 0.783**	**1.121**	**0.921 - 1.320**
L9-12	0.785	0.536 - 1.032	0.759	0.528 - 0.989	0.496	0.247 - 0.746
L12-15/VSh9-18			0.547	0.300 - 0.794	0.528	0.329 - 0.727
VSh9-15					2.792	2.019 - 3.566
Vsh9-15/L9-12	0.846	0.581 - 1.111	0.803	9.508 - 1.100		
L6-9			0.771	0.608 - 0.934	1.962	1.519 - 2.405
Brewer's Sparrow						
All Sites	**0.510**	**0.364 - 0.623**	**0.527**	**0.423 - 0.632**	**0.849**	**0.647 - 1.052**
L9-12	0.348	0.204 - 0.492	0.609	0.458 - 0.760	1.117	0.878 - 1.355
L9-12/VSh9-18	0.624	0.358 - 0.889	0.973	0.709 - 1.237	1.918	1.740 - 2.276
L12-15/VSh9-18	0.343	0.227 - 0.458	0.297	0.000 - 0.601	1.203	0.668 - 1.739
VSh9-15/L9-12	0.900	0.672 - 1.129	0.896	0.645 - 1.146	1.038	0.768 - 1.307
L6-9			0.377	0.226 - 0.528[b]	0.412	0.204 - 0.620[b]
White-crowned Sparrow						
All Sites	**0.873**	**0.691 - 1.055**	**0.486**	**0.325 - 0.646**	**0.492**	**0.364 - 0.619**
L9-12	0.735	0.486 - 0.983				
Western Meadowlark						
All Sites[c]	**0.420**	**0.298 - 0.541**	**0.256**	**0.189 - 0.323**	**0.407**	**0.317 - 0.496**
L12-15/VSh9-18	0.345	0.264 - 0.426	0.265	0.146 - 0.384	0.178	0.068 - 0.290
L9-12/VSh9-18	0.317	0.114 - 0.520	0.393	0.200 - 0.586	0.259	0.155 - 0.363
Sh9-12	0.356	0.151 - 0.561				
L9-12	0.488	0.411 - 0.564	0.236	0.140 - 0.332		
VSh9-15/L9-12	0.496	0.359 - 0.634				
L6-9			0.249	0.147 - 0.350	0.650	0.466 - 0.836
S6-9					0.246	0.135 - 0.358
Sh6-9/L6-9/SL6-9					1.310	0.575 - 2.045
Sage Thrasher						
All Sites	**0.204**	**0.127 - 0.283**	**0.212**	**0.118 - 0.306**	**0.090**	**0.017 - 0.161**
L9-12	0.182	0.067 - 0.295	0.367	0.168 - 0.565	0.247	0.065 - 0.429[b]
Grasshopper Sparrow						
All Sites			**0.196**	**0.150 - 0.242**	**0.264**	**0.138 - 0.390**
L6-9			0.177	0.007 - 0.347	0.547	0.209 - 0.885
S6-9					0.321	0.000 - 0.690
Vesper Sparrow						
All Sites	**0.646**	**0.511 - 0.781**	**0.301**	**0.211 - 0.392**	**0.682**	**0.486 - 0.879**
L9-12	0.759	0.631 - 0.889	0.330	0.245 - 0.416	0.498	0.327 - 0.671
L9-12/VSh9-18	0.939	0.547 - 1.330	0.579	0.407 - 0.750	0.807	0.439 - 1.175
L12-15/VSh9-18	0.470	0.236 - 0.705	0.250	0.036 - 0.465	0.956	0.737 - 1.177
L6-9			0.184	0.102 - 0.266	0.236	0.097 - 0.376

[a] Range sites are derived from soil type (L = Loamy; S = Sandy; Sh = Shallow; VSh = Very Shallow) followed by precipitation zone (inches/year).
[b] Calculations were based upon fewer than 30 observations.
[c] Observations divided into smaller groups to accommodate limitations of TRANSECT (see text).

Bird Diversity

Diversity of terrestrial birds was positively correlated with plant diversity in 1989 (*r* = 0.600, *P* < 0.01), 1990 (*r* = 0.382, *P* < 0.05), and all years combined (*r* = 0.492, *P* < 0.01) (Fig. 2). Data from 1988 were too limited to show a significant correlation, but slope and intercept coincided with those for 1990.

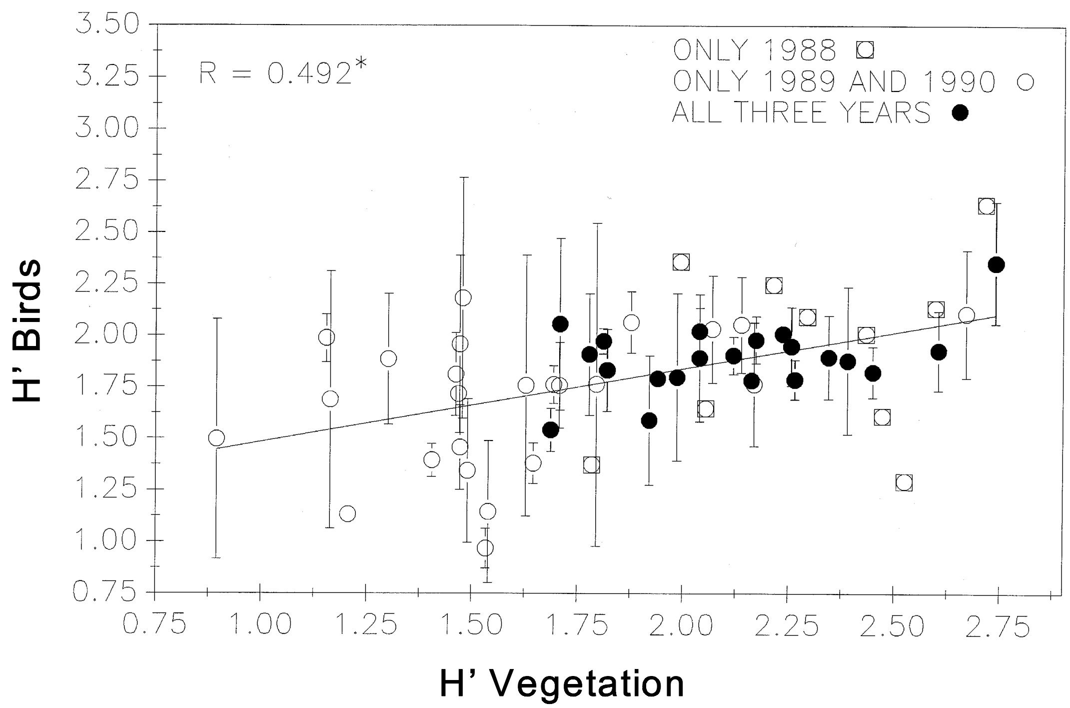

Figure 2. Bird species diversity vs. plant species diversity for 55 transects sampled in 1988-90. Ten transects were surveyed for wildlife only in 1988, 24 transects were sampled both in 1989 and 1990, and 21 transects were sampled in all 3 years. Regression line is fitted to all 55 data points (*r* = 0.492, *P* < 0.01). Error bars show 95% confidence intervals.

Influence of Vegetation Type on Wildlife

Shrubs. Of the 19 bird and mammal species with adequate sample sizes for testing, 9 showed a positive relationship with density of big sagebrush, 2 showed a negative relationship, and 8 had no detectable relationship (Table 7). Greater cover of big sagebrush occurred on transects used by mourning dove, sage thrasher, loggerhead shrike, brown-headed cowbird, sage sparrow, Brewer's sparrow, white-crowned sparrow, pocket gopher, and mule deer. Long-billed curlew and savannah sparrow showed a negative relationship with density of big sagebrush (Figure 3).

Perennial Grasses. Brewer's blackbirds occurred more often on sites with greater cover of *Poa sandbergii*. Sage thrashers and mule deer exhibited the opposite relationship to *Poa*, and mule deer occurred more often where *Agropyron spicatum* cover was high. Long-billed curlews were found more often where *A. spicatum* density was lower, whereas mourning doves occurred more often where *Stipa* cover was reduced (Table 7).

Annual Grasses. None of the 18 bird species showed a positive relationship with annual grass (Table 7). Sage thrasher, sage sparrow, and brown-headed cowbird all showed a negative relationship with percent cover of annual grass (Fig. 4), as did white-crowned sparrow. The other 15 species showed no relationship.

Table 7. Wildlife occurrence in relation to plant species cover. A plus (+) indicates the plant species had higher cover where the animal species occurred. A minus (-) indicates the plant species had lower cover. A bar (|) denotes no relationship detected. The number of pluses or minuses shows the level of significance (0.1, 0.05, 0.01, 0.001).

	Agropyron spicatum	*Poa sandbergii*	*Stipa* spp.	*Artemisia tridentata*	Annual grass
Sage Thrasher	|	- -	|	++++	- - - -
Brewer's Sparrow	|	|	|	+++	|
Sage Sparrow	|	|	|	++	- -
Loggerhead Shrike	|	|	|	++++	|
White-crowned Sparrow	|	|	|	++	- - - -
Brown-headed Cowbird	|	|	|	+++	- - -
Mourning Dove	|	|	-	++++	|
Gray Partridge	|	|	|	|	|
Mule Deer	+	-	|	++++	|
Savannah Sparrow	|	|	|	- -	|
Long-billed Curlew	- - -	|	|	- - -	|
Brewer's Blackbird	|	++	|	|	|
Badger	|	|	|	|	|
Black-billed Magpie	|	|	|	|	|
Chukar	|	|	|	|	|
Ring-necked Pheasant	|	|	|	|	|
Pocket Gopher	|	|	|	+++	|
Grasshopper Sparrow	|	|	|	|	|
Vesper Sparrow	|	|	|	|	|

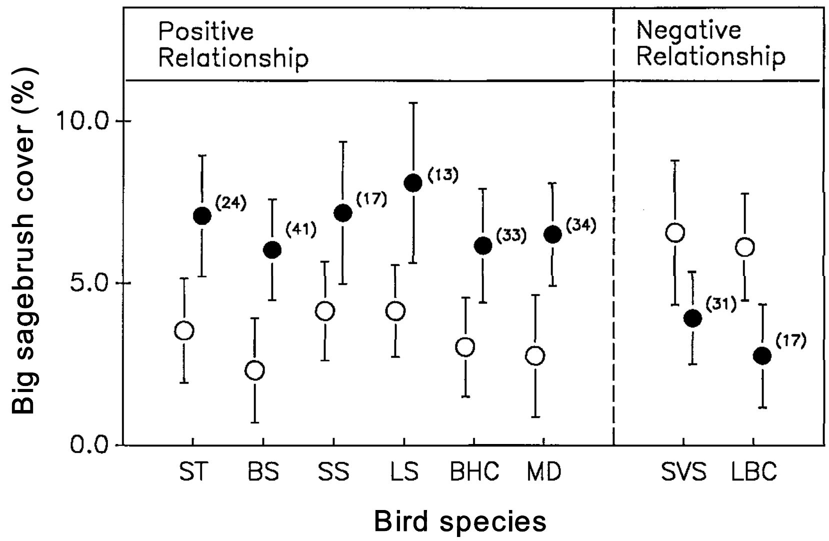

Figure 3. Comparison of big sagebrush cover on transects where eight bird species were present (filled circles) and absent (open circles). In parentheses is the number of transects (of 55) where the species occurred. Species are sage thrasher (ST), Brewer's sparrow (BS), sage sparrow (SS), loggerhead shrike (LS), brown-headed cowbird (BHC), mourning dove (MD), savannah sparrow (SVS), and long-billed curlew (LBC). Error bars indicate 95% confidence intervals.

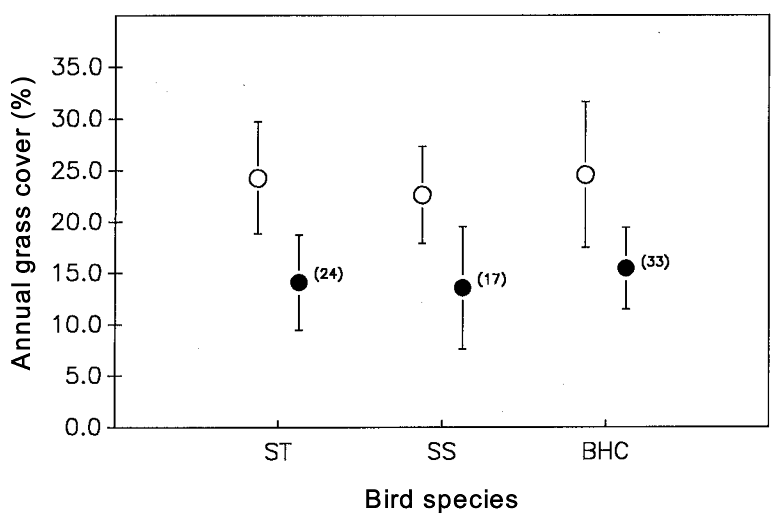

Figure 4. Comparison of annual grass cover on transects where sage thrasher (ST), sage sparrow (SS), and brown-headed cowbird (BHC) were present (filled circles) and absent (open circles). In parentheses is the number of transects (of 55) where the species occurred. Error bars indicate 95% confidence intervals.

Shrub-Steppe Obligate Species

Sage Thrasher. Sage thrasher abundance was related to big sagebrush cover (Figure 5). Thrashers were most abundant where sagebrush cover was 11.3%, which approximates the presumed historical cover in this region (Daubenmire 1988). Sagebrush cover above or below this level coincided with lower thrasher abundance. Caution is advised in the interpretation of this relationship, as the drop in the curve after 13% cover is driven entirely by data derived from only 2 transects.

Sage Sparrow. Transects where sage sparrows occurred had significantly greater big sagebrush cover than those without sage sparrows (Table 7, Figure 3). In addition, cover of annual grass was less on transects where sage sparrow were present (Figure 4). The limited number of sage sparrow observations may have prevented underlying trends from becoming evident.

Brewer's Sparrow. Abundance of Brewer's sparrows increased as sagebrush cover approached the historic 10% level (Figure 6). Unlike the pattern shown by the sage thrasher, this species did not decline in abundance as sagebrush cover increased beyond 10%. Abundance of Brewer's sparrows regressed against total shrub cover exhibited the same trend at a lower level of significance.

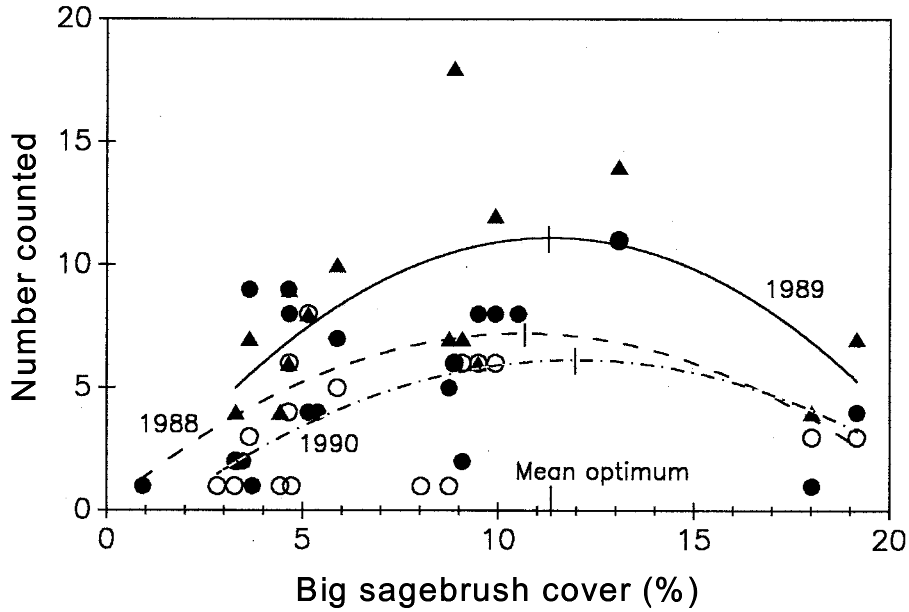

Figure 5. Abundance of sage thrashers in relation to cover of big sagebrush on transects where sage thrashers occurred. Regressions were significant at the $P < 0.05$ level in 1988 (filled circles; $r = 0.539$), 1989 (triangles; $r = 0.567$), and 1990 (open cirles; $r = 0.536$).

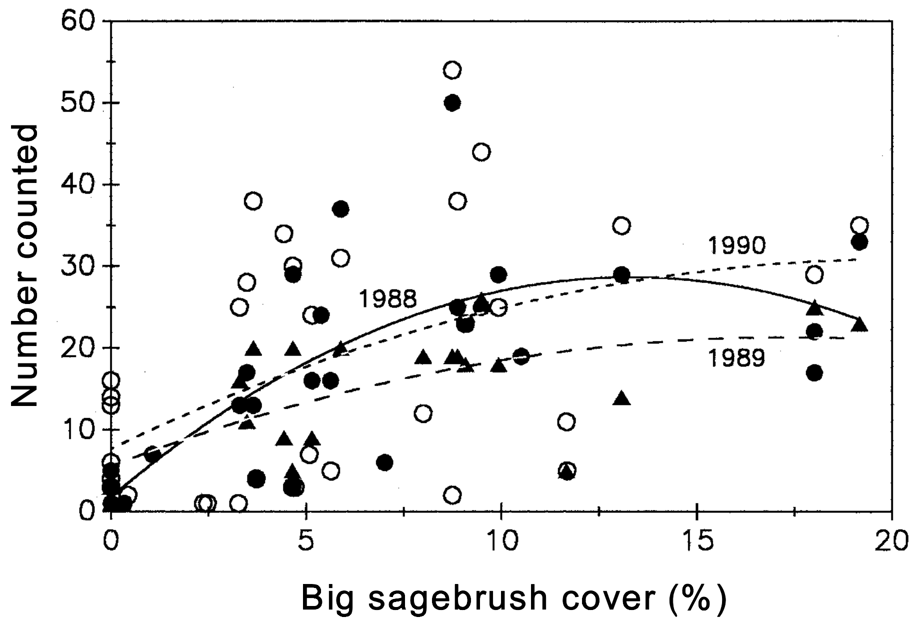

Figure 6. Abundance of Brewer's sparrows in relation to cover of big sagebrush on transects where Brewer's sparrows occurred. Regressions were significant at the $P < 0.01$ level in 1988 (filled circles; $r = 0.705$), 1989 (triangles; $r = 0.623$), and 1990 (open circles; $r = 0.467$).

DISCUSSION

Status of Shrub-Steppe in Washington

Changes in land use over the past century have resulted in the loss of over half of Washington's shrub-steppe habitat. Dramatic increases in dry-land agriculture and use of irrigation to expand farming and orchards has reduced the once expansive native grasslands and shrub-steppe to a fragmented landscape with very few large areas of native vegetation. The few remaining large areas of shrub-steppe are primarily on federal holdings (Yakima Training Center, Hanford Nuclear Site, and the Yakama Indian Nation) and may represent the only sites suitable for species requiring extensive areas of continuous shrub-steppe. Combined, the WDFW and Department of Natural Resources manage 12% of Washington's remaining shrub-steppe. Although this is a relatively small proportion of the total, ample opportunities exist for maintaining and improving shrub-steppe habitats on these lands. The majority of extant shrub-steppe in Washington, however, exists on land owned by private individuals or corporations, and perhaps the greatest opportunity--and the greatest challenge--lies with the retention and improvement of shrub-steppe habitats on these lands.

Although the magnitude of agricultural conversion of Washington's shrub-steppe is impressive, its effect on wildlife may be magnified by a pattern of land alteration that has resulted in extreme fragmentation of the remaining habitat. Species tend to evolve in concert with their surroundings, and for shrub-steppe wildlife this would mean species adapted to expansive landscapes of steppe and shrub-steppe communities. When landscapes are fragmented by conversion to land-use types different from what occurred naturally, wildlife that depend on the remnant native habitat may be subjected to adverse population pressures, including: isolation of breeding populations; competition from similar species associated with other, now adjacent, habitats; increased nest predation by generalist predators; and increased nest loss through parasitism by brown-headed cowbirds. It is not known to what extent these population pressures affect birds in fragmented shrub-steppe environments, although a recent study from Idaho (Knick and Rotenberry 1995) suggests that landscape characteristics influence site-selection by some shrub-steppe birds. Most research on fragmentation effects on birds has occurred in the forests and grasslands of eastern and central North America, where conversion to agriculture and suburban/urban development has created a landscape quite different from that which existed previously. The potential for fragmentation to adversely affect shrub-steppe wildlife in Washington warrents further research.

Wildlife Associated with Washington's Shrub-Steppe

Washington's shrub-steppe communities support a wide diversity of wildlife species. Although the survey technique used in this study was probably better suited to counting birds than to counting most mammals, 13 species of mammal were recorded ranging from elk to sagebrush voles. Surveys designed specifically for mammals would likely identify additional species.

A broad array of bird species were recorded on the transects, although not all nest in shrub-steppe. Occurrence of waterfowl and gulls on the transects, for example, was due to nearby wetlands or water wasteways, or to fly-overs by birds en route to other sites. The diversity of species encountered resulted both from the placement of transects across of range of shrub-steppe range sites, and the interspersion of other land-use types (e.g., agricultural fields, Conservation Reserve Program lands) among the remnant parcels of shrub-steppe. The two most common species, western meadowlark and horned lark, are grassland species that have adapted well to agriculture and also use shrub-steppe. Studies in more extensive areas of shrub-steppe have found sage or Brewer's sparrows to be the most numerous species (Wiens and Rotenberry 1981, Petersen and Best 1987, Medin 1990), perhaps reflecting a lower influence of agriculture in these landscapes.

Wildlife/Vegetation Relationships

The tendency for vegetative communities with greater complexity to support a more diverse assemblage of bird species has been documented in shrub-steppe and other habitats (MacArthur and MacArthur 1961, Willson 1974, McAdoo et al. 1989). Shrub-steppe habitat deprived of a shrub component was shown by Reynolds and Trost (1981) to support a lower diversity of bird species. They found reduced diversity of nesting, migrant, and non-nesting birds in an area converted from sagebrush to crested wheatgrass. When sagebrush reinvades such plantings, shrub-nesting bird species join grass-nesters that have become established, thereby increasing the level of diversity (McAdoo et al. 1989).

In the present study, the strongest relationships between vegetation and occurrence of specific birds were for percent cover of big sagebrush and percent cover of annual grasses. Sage thrashers, sage sparrows, and Brewer's sparrows were found only where shrubs were the dominant structural feature in the landscape. This was expected, because nesting by these shrub-steppe obligates is dependent upon presence of sagebrush. Nests of sage sparrows and Brewer's sparrows are usually constructed in the canopy of sagebrush plants, as are many sage thrasher nests (Rich 1980, Reynolds 1981, Petersen and Best 1987). Thrashers that nest on the ground place their nests beneath sagebrush (Rich 1980, Reynolds 1981). Both species that occurred more frequently on sites with lower cover of big sagebrush were grassland species (savannah sparrow, long-billed curlew). All species that were negatively associated with percent cover of annual grasses also were positively associated with cover of big sagebrush. These relationships are suggestive of preferences for specific vegetation characteristics; however, these results should be considered exploratory and preliminary in nature. Based on the findings of this study, a second set of transects (stratified by range site) was established and surveyed for Phase Two of the Shrub-Steppe Research Project, and a more complete assessment of the relationships between vegetation and bird abundance must await analysis of those data.

The association of shrub-steppe obligate birds with the structure and percent cover of sagebrush has been demonstrated in a number of accidental and intended experiments, although the outcomes did not always agree. Sage sparrows were almost unaffected in an area partially burned (45%) by fire (Petersen and Best 1987). Nest site selection in burned areas was somewhat different than in control areas, but the difference apparently did not affect breeding success during the short term. In another study (Rotenberry and Wiens 1980), a more complete burn (88%) was shown to reduce sage sparrow abundance. Sage thrashers had not shown a response within 4 years following a partial burn on an Idaho study plot (Petersen and Best 1987). Castrale (1982) conjectured that sage thrashers may not nest in areas with suitable sagebrush densities if larger shrubs, which may be preferred for nesting (Rich 1980), are not available.

The strong correlation between Brewer's sparrow abundance and big sagebrush cover was well illustrated in a study where sagebrush was killed with the herbicide 2,4-D. In the Idaho study, Schroeder and Sturges (1975) reported that density of Brewer's sparrows declined 67% in 1 year and 99% in 2 years after sagebrush was sprayed. However, Brewer's sparrows may be largely unaffected if a kill of sagebrush is incomplete. In a situation where fire left a mosaic of unburned and incompletely burned areas, Petersen and Best (1987) found that "islands" of big sagebrush continued to support Brewer's sparrows. Although a short-term reduction in nest density was shown, breeding populations had recovered within 4 years after the burn, and no significant alteration of other reproductive parameters was observed. Castrale (1982) indicated that chaining, another means of shrub removal, may not affect sagebrush enough to reduce Brewer's sparrow density 4 years later. A problem with these and other studies is the potential for time lags in response to vegetation changes within a bird's territory to mask longer term effects (Wiens et al. 1986).

CONCLUSIONS

The relationships between birds and vegetation in shrub-steppe habitat revealed in this study support the axiom that wildlife diversity increases with the complexity of a plant community. Habitat management in the shrub-steppe should strive to preserve shrub cover, particularly big sagebrush, and avoid disturbances which would increase distribution and density of annual grasses. Results from this study suggest that management practices that reduce annual grass cover could potentially benefit at least two important shrub-steppe birds (sage thrasher and sage sparrow), while apparently harming none. Wildlife species react uniquely to elements of their habitat, so closer examination of the responses of shrub-steppe obligates--sage thrasher, sage sparrow, and Brewer's sparrow--to vegetation characteristics could isolate key structural components and their value to wildlife.

The suitability of Washington's shrub-steppe habitat for wildlife differs from that which occurred a century ago. Conversion of sites with deep, loamy soil to farming early this century changed the distribution of shrub-steppe across soil types, with a greater proportion now occurring on sites with shallow and rocky soils. Soils play an important part in determining the vegetation at a site, which in turn influences use by wildlife. The introduction of non-native grasses and forbs also has changed the vegetation of many shrub-steppe sites, in some cases drastically altering the plant community. Fragmentation of shrub-steppe is probably another factor influencing wildlife distribution and abundance in remaining tracts of shrub-steppe. Landsat analysis showed that few large tracts of shrub-steppe remain in Washington, with considerable shrub-steppe occurring in comparatively small patches surrounded by agricultural lands. In such fragmented landscapes dispersal corridors for wildlife are frequently unavailable or greatly reduced, and effects of edge are likely increased. Further, the suitability of small patches of shrub-steppe habitat as breeding areas for birds and other wildlife is unknown. Although not addressed in this study, grazing by livestock also can significantly alter the vegetation on shrub-steppe sites and has the potential to influence suitability of these sites for wildlife.

The relationships between certain bird species and vegetation floristics and structure suggested in this study illustrate the importance of assessing the influence of human activities on shrub-steppe habitats and their associated wildlife. Field work for Phase Two of the Shrub-Steppe Project, which concentrated on soil and vegetation associations of shrub-steppe obligate birds, was completed in 1993 and reports are currently in preparation. WDFW supports a continuing research program on shrub-steppe wildlife to help address these issues.

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Appendix A. Occurrence and cover (where present) of shrubs and trees measured by line intercept on 55 transects in eastern Washington's shrub-steppe.

	Occurrence on transects		Percent cover on transects		
Species	*n*	%	Mean	Min	Max
Amelanchier alnifolia	1	1.8	0.8		
Artemisia arbuscula	5	9.1	1.6	0.2	5.9
A. rigida	18	32.7	2.6	0.1	7.2
A. tridentata	42	76.4	6.7	0.3	19.2
A. tripartita	17	30.9	1.4	0.2	3.6
Berberis repens	1	1.8	0.7		
Chrysothamnus nauseosus	32	58.2	1.0	0.0	3.7
C. viscidiflorus	22	40.0	0.9	0.1	2.8
Holodiscus discolor	1	1.8	1.0		
Leptodactylon pungens	1	1.8			
Populus spp.	3	5.5	2.4	0.3	3.8
Prunus spp.	3	5.5	1.7	0.0	4.0
Purshia tridentata	2	3.6	4.0	2.6	5.3
Ribes aureum	5	9.1	0.8	0.1	1.4
Rosa nutkana	5	9.1	0.9	0.2	2.1
Sarcobatus vermiculatus	2	3.6	1.0	0.6	1.4
Symphoricarpus albus	2	3.6	3.3	2.8	3.9
Tetradymia canescens	11	20.0	0.6	0.0	1.6

Appendix B. Occurrence and cover (where present) of grasses, forbs, and other ground covers as measured by microplots on 55 transects in eastern Washington's shrub-steppe.

Class Species/cover type	Occurrence on transects n	 %	Occurrence on microplots (%)	Percent cover on microplots Mean	 Min	 Max
Grasses						
Annual grasses	55	100.0	76.0	20.1	0.1	75.8
Agropyron cristatum	2	3.6	1.1	5.4	3.5	7.4
A. dasystachyum	2	3.6	0.3	0.8	0.4	1.2
A. intermedium	1	1.8	0.2	1.3		
A. spicatum	41	74.5	27.4	12.0	0.1	42.0
Distichlis stricta	4	7.3	1.5	4.2	0.3	11.8
Elymus cinereus	13	23.6	1.2	1.9	0.1	9.4
E. glaucus	2	3.6	0.1	0.4	0.1	0.8
Festuca idahoensis	15	27.3	5.2	4.7	0.8	14.6
Hordeum jubatum	4	7.3	1.6	4.9	0.3	12.4
Koeleria cristata	4	7.3	0.4	1.2	0.1	2.3
Oryzopsis hymenoides	4	7.3	0.8	4.8	0.1	16.8
Poa ampla	7	12.7	0.5	0.4	0.1	1.4
P. bulbosa	4	7.3	0.3	0.1	0.1	0.1
P. cusikii	6	10.9	1.3	2.4	0.1	10.3
P. pratensis	8	14.5	2.6	6.1	1.1	26.4
P. sandbergii	54	98.2	67.9	16.8	3.1	51.5
Sitanion hystrix	54	98.2	78.8	0.1	0.1	1.2
Stipa comata	18	32.7	5.3	4.2	0.3	22.5
S. occidentalis	13	23.6	4.5	4.9	0.3	20.3
S. thurberiana	8	14.5	3.0	5.8	0.3	27.2
Forbs						
Annual forbs	55	100.0	73.9	12.3	1.0	9.7
Achillea millefolium	31	56.4	7.9	2.2	0.1	11.3
Agoseris glauca	4	7.3	0.8	1.5	0.1	5.0
Allium	8	14.5	0.7	0.5	0.1	1.9
Antennaria	9	16.4	0.4	0.4	0.1	1.8
Artemisia douglasiana	1	1.8	0.0	0.8		
Arnica fulgans	1	1.8	0.1	1.8		
Aster	5	9.1	0.6	1.4	0.3	3.0
Astragalus	21	38.2	1.8	0.5	0.1	1.6
Balsamorhiza careyana	1	1.8	0.3	7.0		
B. hookeri	9	16.4	0.3	0.2	0.1	1.4
B. rosea	1	1.8	0.0	0.1		
B. sagittata	7	12.7	1.3	3.1	0.3	6.7
Brassica	2	3.6	0.1	0.2	0.1	0.3
Carex filifolia	15	27.3	5.4	7.0	0.1	21.2
Calochortus macrocarpus	1	1.8	0.4	1.1	0.1	0.4
Castilleja thompsonii	1	1.8	0.0	0.3		
Chaenactis douglasii	5	9.1	0.6	0.6	0.1	1.7

(continues)

Class Species/cover type	Occurrence on transects n	 %	Occurrence on microplots (%)	Percent cover on microplots Mean	 Min	 Max
Forbs (continued)						
Cirsium vulgare	1	1.8	0.0	0.8		
Comandra umbellata	2	3.6	0.4	1.4		
Crepis atrabarba	5	9.1	1.3	1.9	0.1	4.5
Delphinium	8	14.5	1.8	1.3	0.3	5.0
Erigeron	28	50.9	4.4	1.3	0.1	4.5
Eriogonum	28	50.9	6.5	1.9	0.1	6.7
Erodium cicutarium	1	1.8	0.0	0.1		
Frasera	1	1.8	0.1	0.3		
Fritillaria pudica	1	1.8	0.1	0.1		
Gaillardia aristata	4	7.3	0.3	0.5	0.1	1.3
Galium	9	16.4	1.1	0.7	0.1	1.4
Geranium	2	3.6	0.1	0.8		
Gilia	1	1.8	0.1	0.6		
Haplopappus stenophyllus	1	1.8	0.0	0.1		
Hieracium	7	12.7	1.0	1.3	0.3	3.8
Iris	1	1.8	0.1	1.1		
Juncus	1	1.8	0.0	1.3		
Lewisia	1	1.8	0.0	0.1		
Linum perenne	1	1.8	0.3	4.8		
Lithophragma	1	1.8	0.0	0.1		
Lithospermum ruderale	4	7.3	0.2	0.5	0.1	1.5
Lomatium	33	60.0	8.6	1.3	0.1	5.0
Lupinus	29	52.7	6.4	2.2	0.1	7.2
Medicago sativa	1	1.8	0.1	0.9		
Microseris troximoides	2	3.6	0.3	0.5	0.3	0.6
Oenothera	3	5.4	0.6	0.8	0.1	1.9
Orthocarpus	11	20.0	1.7	0.7	0.1	1.6
Oxytropis	1	1.8	0.0	0.1		
Penstemon confertus	1	1.8	0.3	7.0		
Phlox	36	65.5	7.6	1.2	0.1	5.6
Potentilla	4	7.3	0.3	1.5	0.1	3.5
Psoralea	1	1.8	0.1	0.4		
Ranunculus	1	1.8	0.1	0.3		
Rumex venosus	2	3.6	0.3	1.1	0.9	1.2
Sedum	2	3.6	0.1	0.6	0.6	0.6
Sisyrinchium	1	1.8	0.1	0.1		
Sporobolus	1	1.8	0.1	1.1		
Trifolium	4	7.3	5.0	2.1	0.3	5.2
Urtica dioica	1	1.8	0.0	0.1		
Vicia	2	3.6	0.1	0.2	0.1	0.3
Viola trinervata	2	3.6	0.5	0.9	0.1	1.8

(continues)

Appendix B (continued)

Class Species/cover type	Occurrence on transects n	 %	Occurrence on microplots (%)	Percent cover on microplots Mean	 Min	 Max
Other cover types						
Bare Ground	55	100.0	72.0	16.0	2.0	52.5
Cow Manure	27	49.1	5.4	1.2	0.1	3.9
Cryptogams	55	100.0	68.0	22.9	0.8	58.0
Horse Manure	4	7.3	0.1	0.6	0.3	1.3
Litter	55	100.0	97.2	51.5	19.1	82.7
Rock	42	76.4	22.3	7.3	0.1	43.6

Appendix C. Summary of wildlife species detected during surveys in eastern Washington, 1988-90. For each species, the total number of individuals and observations is given for each year, followed by the number of transects and surveys on which the species was encountered. Transect and survey (replicate) totals were 31/125, 45/134, and 45/180, for 1988, 1989, and 1990, respectively. Birds, mammals, and reptiles are each arranged alphabetically.

	Individuals			Observations			Transects			Surveys		
Species	1988	1989	1990	1988	1989	1990	1988	1989	1990	1988	1989	1990
Birds												
American Crow *Corvus brachyrhynchos*	0	1	1	0	1	1	0	1	1	0	1	1
American Goldfinch *Carduelis tristis*	26	5	2	17	2	1	4	2	1	7	2	1
American Kestrel *Falco sparverius*	18	5	6	18	5	6	13	3	5	17	5	6
American Robin *Turdus migratorius*	58	13	15	49	12	12	8	7	6	20	8	7
American Wigeon *Anas americana*	4	0	0	2	0	0	2	0	0	2	0	0
Barn Swallow *Hirundo rustica*	0	2	20	0	2	15	0	2	10	0	2	12
Black-billed Magpie *Pica pica*	14	37	46	12	27	37	6	12	13	9	20	25
Blue-winged Teal *Anas discors*	0	2	0	0	1	0	0	1	0	0	1	0
Brewer's Blackbird *Euphagus cyanocephalus*	142	26	104	70	22	46	14	13	22	25	17	35
Brewer's Sparrow *Spizella breweri*	467	300	607	444	289	566	26	20	34	87	52	100
Brown-headed Cowbird *Molothrus ater*	60	56	74	48	33	57	12	18	23	24	22	43
Bufflehead *Bucephala albeola*	0	2	0	0	2	0	0	1	0	0	1	0
California Gull *Larus californicus*	0	0	13	0	0	7	0	0	4	0	0	4
California (Valley) Quail *Callipepla californica*	16	7	7	15	7	7	5	2	5	12	4	6
Canada Goose *Branta canadensis*	136	7	39	10	4	8	7	2	7	9	3	8
Caspian Tern *Sterna caspia*	0	1	0	0	1	0	0	1	0	0	1	0
Chipping Sparrow *Spizella passerina*	1	0	2	1	0	2	1	0	2	1	0	2
Chukar *Alectoris chukar*	26	23	27	20	20	21	5	9	9	10	14	15
Cinnamon Teal *Anas cyanoptera*	0	9	0	0	4	0	0	3	0	0	4	0

(continues)

Appendix C (continued).

Species	Individuals 1988	1989	1990	Observations 1988	1989	1990	Transects 1988	1989	1990	Surveys 1988	1989	1990
Clark's Nutcracker *Nucifraga columbiana*	5	0	0	4	0	0	2	0	0	4	0	0
Cliff Swallow *Hirundo pyrrhonota*	15	0	0	4	0	0	3	0	0	3	0	0
Common Nighthawk *Chordeiles minor*	0	0	2	0	0	2	0	0	2	0	0	2
Common Poorwill *Phalaenoptilus nuttallii*	1	0	0	1	0	0	1	0	0	1	0	0
Common Raven *Corvus corax*	31	24	31	24	18	23	13	13	15	21	16	23
Common Snipe *Gallinago gallinago*	6	0	6	6	0	6	3	0	3	6	0	5
Dark-eyed Junco *Junco hyemalis*	5	3	0	5	1	0	4	1	0	5	1	0
Eastern Kingbird *Tyrannus tyrannus*	1	2	3	1	1	1	1	1	1	1	1	1
European Starling *Sturnus vulgaris*	50	4	25	33	3	12	11	1	7	21	1	9
Glaucous-winged Gull *Larus glaucescens*	0	0	36	0	0	17	0	0	4	0	0	7
Grasshopper Sparrow *Ammodramus savannarum*	18	98	203	18	95	199	3	23	27	8	40	63
Gray Partridge *Perdix perdix*	25	5	11	15	3	6	8	3	5	14	3	5
Great Blue Heron *Ardea herodias*	0	0	1	0	0	1	0	0	1	0	0	1
Great-horned Owl *Bubo virginianus*	0	3	0	0	3	0	0	3	0	0	3	0
Green-winged Teal *Anas crecca*	6	0	0	2	0	0	1	0	0	1	0	0
Hammond's Flycatcher *Empidonax hammondii*	0	0	1	0	0	1	0	0	1	0	0	1
Hermit Thrush *Catharus guttatus*	2	0	0	1	0	0	1	0	0	2	0	0
Herring Gull *Larus argentatus*	0	0	34	0	0	5	0	0	1	0	0	1
Horned Lark *Eremophila alpestris*	425	461	877	286	424	708	25	40	41	81	99	136
House Finch *Carpodacus mexicanus*	1	14	13	1	8	1	1	4	1	1	4	1

(continues)

Appendix C (continued).

Species	Individuals			Observations			Transects			Surveys		
	1988	1989	1990	1988	1989	1990	1988	1989	1990	1988	1989	1990
House Sparrow *Passer domesticus*	1	1	5	1	1	5	1	1	1	1	1	1
House Wren *Troglodytes aedon*	9	0	1	8	0	1	1	0	1	4	0	1
Killdeer *Charadrius vociferus*	33	14	15	27	13	14	10	8	10	22	12	13
Lark Sparrow *Chondestes grammacus*	7	14	2	6	13	1	4	6	1	4	9	1
Lazuli Bunting *Passerina amoena*	0	1	0	0	1	0	0	1	0	0	1	0
Loggerhead Shrike *Lanius ludovicianus*	8	5	15	8	5	14	4	5	8	7	4	13
Long-billed Curlew *Numenius americanus*	2	36	48	1	31	33	1	14	17	1	23	28
MacGillivray's Warbler *Oporornis tolmiei*	3	0	0	1	0	0	1	0	0	1	0	0
Mallard *Anas platyrhynchos*	12	6	13	7	5	6	7	1	4	7	2	6
Mountain Bluebird *Sialia currucoides*	0	0	1	0	0	1	0	0	1	0	0	1
Mourning Dove *Zenaida macroura*	46	35	67	40	26	50	12	15	22	25	19	35
Northern Flicker *Colaptes auratus*	18	3	1	17	3	1	6	1	1	13	2	1
Northern Goshawk *Accipiter gentilis*	0	0	1	0	0	1	0	0	1	0	0	1
Northern Harrier *Circus cyaneus*	10	11	9	9	9	9	8	9	8	9	9	9
Northern Oriole *Icterus galbula*	2	1	0	2	1	0	1	1	0	1	1	0
Northern Pintail *Anas acuta*	2	0	0	1	0	0	1	0	0	1	0	0
Orange-crowned Warbler *Vermivora celata*	1	0	0	1	0	0	1	0	0	1	0	0
Osprey *Pandion haliaetus*	0	0	1	0	0	1	0	0	1	0	0	1
Pine Siskin *Carduelis pinus*	7	1	0	5	1	0	3	1	0	5	1	0
Prairie Falcon *Falco mexicanus*	0	1	2	0	1	2	0	1	2	0	1	2
Red-breasted Nuthatch *Sitta canadensis*	1	0	0	1	0	0	1	0	0	1	0	0

(continues)

Appendix C (continued).

Species	Individuals			Observations			Transects			Surveys		
	1988	1989	1990	1988	1989	1990	1988	1989	1990	1988	1989	1990
Red-winged Blackbird *Agelaius phoeniceus*	18	19	19	12	11	11	7	5	5	11	8	8
Red-tailed Hawk *Buteo jamaicensis*	8	3	8	8	3	4	5	3	4	8	3	4
Ring-necked Pheasant *Phasianus colchicus*	25	18	97	24	18	91	7	13	27	20	16	66
Ring-billed Gull *Larus delawarensis*	1	0	1	1	0	1	1	0	1	1	0	1
Rock Wren *Salpinctes obsoletus*	14	26	8	14	26	7	4	6	1	9	13	3
Rock Dove *Columba livia*	10	11	1	1	6	1	1	3	1	1	4	1
(Gray-crowned) Rosy Finch *Leucosticte arctoa*	60	0	0	1	0	0	1	0	0	1	0	0
Rough-legged Hawk *Buteo lagopus*	1	4	0	1	3	0	1	2	0	1	2	0
No.Rough-winged Swallow *Stelgidopteryx serripennis*	0	1	0	0	1	0	0	1	0	0	1	0
Ruby-crowned Kinglet *Regulus calendula*	7	0	0	3	0	0	2	0	0	3	0	0
Rufous Hummingbird *Selasphorus rufus*	1	0	0	1	0	0	1	0	0	1	0	0
Rufous-sided Towhee *Pipilo erythrophthalmus*	19	3	0	18	3	0	4	3	0	10	3	0
Sage Grouse *Centrocercus urophasianus*	6	0	2	3	0	2	1	0	2	2	0	2
Sage Sparrow *Amphispiza belli*	38	41	76	36	40	69	7	9	13	18	15	2
Sage Thrasher *Oreoscoptes montanus*	100	123	75	98	123	71	19	15	19	60	41	48
Sandhill Crane *Grus canadensis*	0	33	1	0	2	1	0	1	1	0	1	1
Savannah Sparrow *Passerculus sandwichensis*	88	41	17	82	34	16	16	12	10	33	14	12
Say's Phoebe *Sayornis saya*	6	1	2	6	1	2	3	1	2	5	1	2
Sharp-tailed Grouse *Typanuchus phasianellus*	1	0	7	1	0	5	1	0	1	1	0	3
Short-eared Owl *Asio flammeus*	0	0	9	0	0	9	0	0	5	0	0	8
Song Sparrow *Melospiza melodia*	15	1	33	15	1	30	4	1	14	10	1	19

(continues)

Appendix C (continued).

Species	Individuals 1988	1989	1990	Observations 1988	1989	1990	Transects 1988	1989	1990	Surveys 1988	1989	1990
Swainson's Hawk *Buteo swainsoni*	0	1	0	0	1	0	0	1	0	0	1	0
Swainson's Thrush *Catharus ustulatus*	0	0	1	0	0	1	0	0	1	0	0	1
Tree Swallow *Tachycineta bicolor*	1	0	0	1	0	0	1	0	0	1	0	0
Vesper Sparrow *Pooecetes gramineus*	446	247	430	408	245	408	30	23	35	108	68	107
Violet-green Swallow *Tachycineta thalassina*	17	0	3	7	0	2	6	0	2	13	0	2
Western Meadowlark *Sturnella neglecta*	717	740	847	641	715	798	31	45	45	121	133	173
Western Wood-pewee *Contopus sordidulus*	0	0	1	0	0	1	0	0	1	0	0	1
Western Kingbird *Tyrannus verticalis*	1	2	0	1	1	0	1	1	0	1	1	0
Western Tanager *Piranga ludoviciana*	0	0	1	0	0	1	0	0	1	0	0	1
White-crowned Sparrow *Zonotrichia leucophrys*	371	156	156	138	71	104	24	28	30	53	37	43
Wilson's Warbler *Wilsonia pusilla*	4	1	0	1	1	0	1	1	0	1	1	0
Yellow-headed Blackbird *Xanthocephalus xanthocephalus*	9	6	4	4	5	4	4	2	4	4	4	4
Yellow-rumped Warbler *Dendroica coronata*	16	0	0	4	0	0	2	0	0	4	0	0
Mammals												
Badger *Taxidea taxus*	131	34	87	62	33	50	15	8	17	37	13	35
Black-tailed Jackrabbit *Lepus californicus*	3	23	6	3	23	5	2	6	2	3	9	3
Bushytail Woodrat *Neotoma cinerea*	2	0	0	2	0	0	1	0	0	2	0	0
Coyote *Canis latrans*	185	32	222	105	30	102	23	19	29	54	23	60
Deer Mouse *Peromyscus maniculatus*	0	0	2	0	0	1	0	0	1	0	0	1
Elk *Cervus elaphus*	0	18	22	0	18	16	0	3	3	0	7	6
Northern Pocket Gopher *Thomomys talpoides*	116	101	164	96	101	57	24	22	20	61	46	36

(continues)

Appendix C (continued).

Species	Individuals 1988	1989	1990	Observations 1988	1989	1990	Transects 1988	1989	1990	Surveys 1988	1989	1990
Least Chipmunk *Eutamias minimus*	1	0	0	1	0	0	1	0	0	1	0	0
Mule Deer *Odocoileus hemionus*	38	47	63	31	32	45	13	10	11	22	15	25
Nuttall's Cottontail *Sylvilagus nuttallii*	6	3	27	7	3	12	5	2	7	5	3	9
Ord's Kangaroo Rat *Dipodomys ordii*	0	1	1	0	1	1	0	1	1	0	1	1
Porcupine *Erethizon dorsatum*	1	0	0	1	0	0	1	0	0	1	0	0
Sagebrush Vole *Lagurus curtatus*	0	0	1	0	0	1	0	0	1	0	0	1
Western Harvest Mouse *Reithrodontomys megalotis*	0	0	1	0	0	1	0	0	1	0	0	1
Yellow-bellied Marmot *Marmota flaviventris*	6	5	15	7	5	8	1	1	1	3	3	4
Yellow-pine Chipmunk *Tamias amoenus*	5	0	0	5	0	0	3	0	0	4	0	0
Reptiles												
Common Garter Snake *Thamnophis sirtalis*	1	0	0	1	0	0	1	0	0	1	0	0
Short-horned Lizard *Phrynosoma douglassi*	0	0	1	0	0	1	0	0	1	0	0	1

Appendix D. Descriptions of transects used in Phase One of the shrub-steppe research project. There were 31 transects established in 1988, 21 of which (*) were carried over to 1989 and 1990. An additional 24 new transects were established for 1989-1990. The number of landscape photos on file is given for each transect.

No.	Name	USGS Quad	T(N)	R(E)	Section	County	Est.	Photos
01	Alstown	Alstown	23	23	06	Douglas	88	0
33	Aqueduct	Beverly NE	17	24	04	Grant	89	13
02	Barnes Butte	Barnes Butte	27	27	09/16	Douglas	88	2
34	Basin City	Mesa West	13	29	13	Franklin	89	11
03	Bechtel	Jameson Lake East	25	26	19	Douglas	88*	27
36	Bert James	Lenzie Ranch	7	25	28/33	Benton	89	20
35	Bing Canyon	Prior Ranch	6	27	11	Benton	89	27
37	Black Canyon	Wenas Lake	16	17	28	Yakima	89	22
04	Black Rock	Wilson Creek SE	22	30	29	Grant	88*	20
05	Brewster	Brewster	30	24	24/25	Douglas	88	4
38	Camp Lake	Scooteney Reservoir	13	30	04	Franklin	89	12
06	Canniwai Creek	Almira SE	24	32	27	Lincoln	88	3
07	Chief Joseph	Chief Joseph Dam	29	25	27	Douglas	88	1
08	Coffeepot Lake	Coffeepot Lake	23	34	18	Lincoln	88*	24
39	Coffin Road	Johnson Butte	6	29	08	Benton	89	21
09	Coleman Hill	Coleman Hill	29	26	19/30	Douglas	88	2
40	Corral Creek	Corral Canyon	10	26	27	Benton	89	20
10	County Line	Marlin SW	22	31	30	Lincoln	88*	17
41	Cowiche Mountain	Tieton	13	16	7	Yakima	89	23
11	Creston	Creston	26	34	04	Lincoln	88*	2
42	Demoss	Benton City	10	27	30	Benton	89	24
12	Division	Jameson Lake SW	24	25	19	Douglas	88*	25
43	Douglas Ranch	Black Rock Springs	12	22	06/07	Yakima	89	2
13	Draper Lake	Draper Lake	23	33	05	Lincoln	88*	18
14	Dutch Henry Draw	Jameson Lake West	25	25	22	Douglas	88*	24
15	Grand Coulee Dam	Electric City	29/23	30/25	29/24	Douglas	88	3
16	Hawk Creek	Davenport	25	36	26	Lincoln	88*	25
44	Homestead	Royal City	17	25	08	Grant	89	13
45	L.T. Murray	Pomona	14	19	08	Yakima	89	21
17	Lake Creek	Rocklyn SW	35	24	05	Lincoln	88*	17
18	Mansfield	Mansfield	27	25	27	Douglas	88*	24
20	Monument Hill (19)	Monument Hill	21	24	16	Grant	88*	8
21	Palisades	Appledale	22	23	07	Douglas	88*	4
22	Pine Canyon	Farmer	24/23	24	34/03	Douglas	88	2
46	Plymouth	Umatilla	6	27	24	Benton	89	21
47	Potholes	O'Sullivan Dam	17	27	13	Grant	89	12
23	Rocklyn	Rocklyn, Rocklyn SE	25	35	36	Lincoln	88*	19
48	Roza Canal	Grandview	10	23	3/10	Yakima	89	15
49	Roza Hill	Elephant Mountain	13	20	19	Yakima	89	2
51	Saddle Mountain	Othello	15	28	25	Adams	89	14

(continues)

No.	Name	USGS Quad	T(N)	R(E)	Section	County	Est.	Photos
24	Sagebrush Flat	Sagebrush Flat	23	25	13/24	Douglas	88*	11
50	Sand Dune	Columbia Point	9	29	07	Franklin	89	22
52	Savage Island	Savage Island	13	28	16	Franklin	89	12
25	Sim's Corner	Sim's Corner	27	28	18/19	Douglas	88*	28
26	Sinking Creek	Wagner Lake	26	32	36	Lincoln	88*	17
27	Strahl Canyon	Alameda Flat	29	29	04	Douglas	88	5
53	Sulphur Creek	Maiden Spring	11	24	19/30	Benton	89	26
28	Sylvan Lake	Sylvan Lake	21	34	3/10	Lincoln	88*	17
29	Tracy Rock	Telford	25	35	16	Lincoln	88*	15
54	Two Bar A Ranch	Granger NE	11	22	22	Yakima	89	4
55	Waggoner	Canoe Ridge	6	24	31	Benton	89	20
30	Webley Lake	Sullivan Lake	22	31	12	Lincoln	88*	14
31	Wilson Creek	Wilson Creek	23	30	28	Grant	88	0
32	Withrow	Withrow	26	24	16	Douglas	88*	24
56	Yakima Ridge	Yakima East	13	20	07/18	Yakima	89	18