

# The Importance of Floristics to Sagebrush Breeding Birds of the South Okanagan and Similkameen Valleys, British Columbia<sup>1</sup>

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## Abstract

Habitat associations were determined for five species of songbirds breeding in sagebrush habitat of the South Okanagan and Similkameen valleys, British Columbia. We examined the relative importance of plant species versus “total forbs” and “total grasses” at a local level (<100 m) with point counts and vegetation survey data collected at 245 points. Logistic regression models showed that individual plant species were often more important than variables that grouped species. Habitat associations varied for each species. Brewer's Sparrow (*Spizella breweri*) was associated with parsnip-flowered buckwheat (*Eriogonum heracleoides*) and lupine (*Lupinus sericeus* or *sulphureus*). Lark Sparrow (*Chondestes grammacus*) was positively associated with sand dropseed grass (*Sporobolus cryptandrus*), Grasshopper Sparrow (*Ammodrammus savannarum*) was positively associated with pasture sage (*Artemisia frigida*) and cheatgrass (*Bromus tectorum*), Vesper Sparrow (*Poocetes gramineus*) was positively associated with lupine, and Western Meadowlark (*Sturnella neglecta*) was positively associated with needle-and-thread grass (*Stipa comata*). These herb-layer species have strong associations with rangeland management practices; therefore this information can be used to direct management efforts in this highly threatened area.

*Key words:* Brewer's Sparrow, floristics, Grasshopper Sparrow, habitat associations, Lark Sparrow, Okanagan, sagebrush, Vesper Sparrow, Western Meadowlark.

## Introduction

Grasslands and shrubsteppe of British Columbia contain a disproportionately high number of endangered

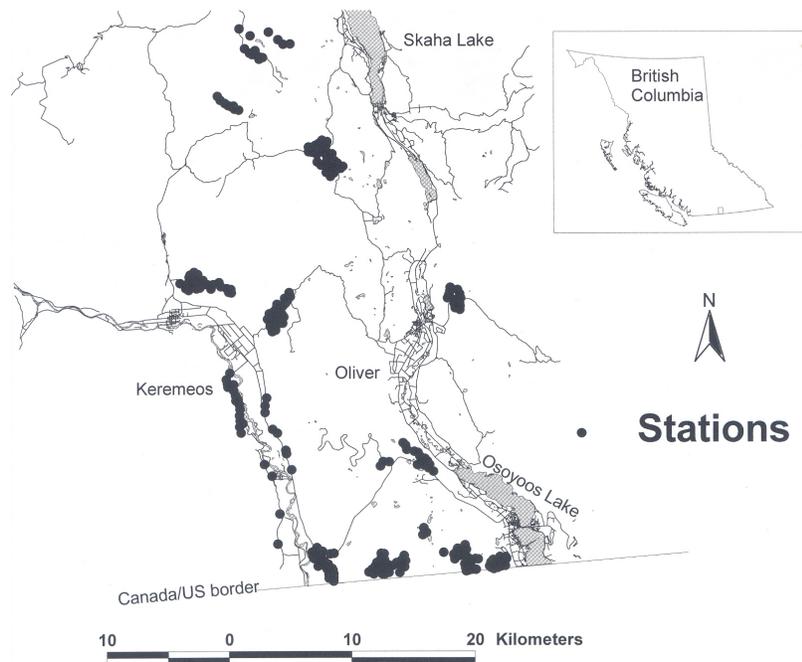
species in Canada relative to the 3 percent of area that these habitat types occupy (Hooper and Pitt 1995). At the northern extent of the Great Basin, the shrubsteppe habitat of the southern Okanagan and Similkameen Valleys (*fig. 1*) supports many species that are at the limit of their range and are unique in Canada. This area contains a high concentration of bird species at risk, including provincially red-listed shrubsteppe birds such as Brewer's Sparrow (*Spizella breweri breweri*), Grasshopper Sparrow (*Ammodrammus savannarum*) and Lark Sparrow (*Chondestes grammacus*). In addition, North American Breeding Bird Survey data compiled for the period 1966 to 1996 showed significant continental decreases in populations of Brewer's Sparrow, Lark Sparrow, Grasshopper Sparrows and Western Meadowlarks (*Sturnella neglecta*; Peterjohn and Sauer 1999), all of which breed in the study area. While the distributions of songbird species are well known within the South Okanagan (Cannings et al. 1987), the specific habitat associations of bird communities within sagebrush habitat of this region are not. Despite recent establishment of parks in the southern Okanagan, between 60-70 percent of potential habitat for the red-listed birds in this study is owned privately or by First Nation reserves (MELP 1998). This habitat is under great threat to irreversible development as the human population of the Okanagan expands. Much of the remaining shrubsteppe habitat is subject to cattle grazing. A good understanding of bird-habitat associations is necessary to guide songbird conservation on public land and to increase the effectiveness of management guidelines for interested private landowners.

Descriptions of bird-habitat associations at a local level have often been made with measures of vegetation such as “total grasses” and “total forbs” and indices of vegetation variables, such as richness and diversity, based on tradition and convenience (Rotenberry 1985). However, breeding songbirds in temperate regions are likely to be insectivorous migrants that are adapted to certain insect prey, and often have better success in the type of vegetation with which abundance of these insects is correlated (Cody 1981). Host specialization is widespread among herbivorous insects (Minckley et al. 2000) and therefore individual plant species could indirectly affect habitat selection of insectivorous songbirds. For example, grasshopper species composition is directly related to plant species composition in some

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**Figure 1**— Location of point count stations in the southern Okanagan and Similkameen Valleys for songbird surveys conducted in 1998.

grasslands (Quinn and Walgenbach 1990). In other cases, plant species may reflect environmental variables such as moisture that are directly linked to insect productivity (Dunning and Brown 1982).

The measurement of individual plant species, or “floristics,” is of particular value in grazed habitats as grazing impacts both composition and structure of vegetation. While species richness of grassland birds declines in areas of extreme grazing pressure (Bradford et al. 1998), bird species have variable responses to grazing intensities in the middle of this spectrum (Saab et al. 1995). Grazing affects birds indirectly by altering their habitat. For example, litter and cryptogamic crust cover decrease while bare soil increases with grazing (Laycock 1967). Certain plant species are less palatable and/or more robust to livestock grazing and will increase under grazing pressure, while preferred forage or sensitive plant species will decline (Ryder 1980). Insectivorous songbirds can be further affected by grazing, because changes in plant community structure impacts herbivorous insects. Grazing has been positively correlated with increased grasshopper abundance (Smith 1940, Nerney 1958), but has a negative impact on the abundance of small and relatively sedentary insects and arachnids (Dennis et al. 1998). It is difficult to adequately assess grazing effects because of the need for temporal and spatial replication, but the effect of grazing on wildlife can be inferred indirectly from correlations between vegetation and wildlife variables

(Hooper and Pitt 1995). Research of this type can produce reliable grazing management prescriptions.

We examined the relative importance of floristics (plant species) versus total grasses or forbs for five shrubsteppe breeding songbird species: Brewer’s Sparrow, Lark Sparrow, Grasshopper Sparrow, Western Meadowlark, and Vesper Sparrow. We hypothesized that floristics would have a significant effect on bird distribution, as compared to percent horizontal cover of “total grasses” or “total forbs.” Methods, results, and conclusions presented in this paper are summarized from Paczek (2002).

## Methods

### Study Site Selection

Study sites were located in the lower South Okanagan and Similkameen valleys, British Columbia, between approximately 49° 00’ 00” N and 49° 25’ 00” N, and 119° 49’ 00” W and 119° 27’ 00” W (fig. 1). Elevations ranged between 345 m and 1200 m, within the Ponderosa Pine (*Pinus ponderosa*) – Bunchgrass and Interior Douglas-fir (*Pseudotsuga menziesii*) biogeoclimatic zones (Medinger and Pojar 1991). All of the survey areas were dominated by big sagebrush, *Artemisia tridentata*. Variation in the herb understory was used to guide point count station selection. Understory types included areas dominated by sand dropseed grass,

needle-and-thread grass and areas with abundant forbs. Understory types were initially categorized by visual observation. Detailed vegetation sampling was then conducted to quantify differences among point count stations. The sites occurred in 15 geographically distinct areas, several of which contained more than one habitat type. Herb understory types were replicated at three or more of these areas. Study sites had a range of sagebrush densities, varied in surrounding landscape characteristics, and included a range of aspects. Point count stations were at least 300 m apart. Within an area, stations were placed so that each plot was in the center of an area of similar sagebrush density and homogeneous understory. The 15 areas had between three and 34 point count stations, depending on the size of the area, for a total of 245 survey stations (fig. 1).

### Bird Surveys

Point count data were collected by three experienced observers between 12 May and 3 July 1998, within 3 hours of sunrise. Most stations were surveyed four times, with different observers to reduce bias. All birds seen or heard within 5 minutes and within 100 m were recorded to species. Bird counts were averaged across survey dates.

### Vegetation Surveys

Habitat measurements were collected at all point count stations between 18 May and 8 August 1988. Two 50-m tapes were laid out to intersect at each station: one tape in a random direction, and the second tape at 90 degrees to the first tape. The line intercept method was used (Brower et al. 1989) to measure percent linear cover of sagebrush and other shrubs.

Twenty Daubenmire (1959) plots (0.5 m x 0.2 m) were placed at 5-m intervals along the tapes to measure ground cover. Percent cover of grasses and forbs were recorded at the species level. Percent cover of bare soil, rocky soil, cryptogamic crust, litter, rock, dead wood, *Selaginella*, rocky soil, and cattle droppings were also recorded. Percent cover for each variable was recorded to 1 percent increments, and was averaged for the 20 plots per station.

We derived elevation, aspect and slope for each station from BC Terrain Resource Inventory Mapping (TRIM) data. An index of moisture was derived from Landsat Thematic Mapper satellite data, taken 6 July 1996.

### Statistical Analyses

All statistical analyses were performed in SPSS (version 9). For all species, bird presence versus bird absence was used as the dependent variable for logistic regression models (table 1). Logistic regression was used for analysis because most of the habitat and bird variables were not normally distributed, and this could not be remedied with transformations. Logistic regression is robust with non-normal data (Menard 1995), but because of its requirement of a binary response variable it is difficult to assess the relative quality of habitat. For the three most abundant species, Vesper Sparrow, Western Meadowlark, and Brewer's Sparrow, additional binary models were created to explore the value of different habitats (Begg and Gray 1984, Bender and Grouven 1998). In these models, presence data were further divided into low versus high abundance (table 1). As there was no biologically meaningful reason to choose a particular cut off between low and high abundance, cut-offs were calculated within the presence sites for all species that would give an equal number of stations in the low and high classes. Because Vesper Sparrow was highly abundant, few point count stations were surveyed where they were absent. This species was categorized as having low abundance (<1.33 birds), moderate abundance (>1.33 birds <2.66) and high abundance (>2.66 birds).

Vegetation data were analyzed at species level, but some of the less abundant forb species were grouped to genus or family (e.g. pussytoes, *Antennaria*). Data were sorted by frequency and abundance. Plant species or groups of species occurring at fewer than 50 stations were excluded. Floristic independent variables that were used are listed with taxonomic names (table 2). Plant species that were highly correlated with more abundant species were not included (i.e.: *Aristida longiseta* was consistently found with the more abundant *Sporobolus cryptandrus*). To examine the relative

**Table 1**— Dependent variables used in logistic regression models of songbird habitat association. *N* is number of survey stations (total 245).

Species	Dependent variables to measure occurrence	Dependent variables to measure habitat quality
Brewer's Sparrow	presence (N = 105) vs. absence (N = 140)	low (N = 70) vs. high abundance (N = 70)
Lark Sparrow	presence (N = 69) vs. absence (N = 176)	
Grasshopper Sparrow	presence (N = 52) vs. absence (N = 98)	
Western Meadowlark	presence (N = 49) vs. absence (N = 196)	low (N = 102) vs. high abundance (N = 94)
Vesper Sparrow	low (N = 79) vs. moderate and high abundance (N = 166)	moderate (N = 77) vs. high abundance (N = 89)

**Table 2**— Floristic independent variables initially used in individual logistic regression models for songbird habitat association analyses

Common Name	Taxonomic Name
<i>Grasses</i>	
Bluebunch wheatgrass	<i>Agropyron spicatum</i>
Cheatgrass	<i>Bromus tectorum</i>
Junegrass	<i>Koeleria macrantha</i>
Kentucky bluegrass	<i>Poa pratensis</i>
Needle-and-thread grass	<i>Stipa comata</i>
Sand dropseed grass	<i>Sporobolus cryptandrus</i>
Sandberg bluegrass	<i>Poa secunda</i>
Spreading needlegrass	<i>Stipa richardsonii</i>
Six weeks fescue	<i>Vulpia octoflora</i>
<i>Forbs</i>	
Balsamroot	<i>Balsamorhiza sagittata</i>
Cactus	<i>Opuntia fragilis</i>
Dandelion	<i>Taraxacum officinale</i>
Desert-parsley	<i>Lomatium</i> spp.
Fleabane (daisies)	<i>Erigeron</i> spp.
Knapweed	<i>Centaurea diffusa</i>
Knotweed	<i>Polygonum majus</i>
Lemonweed	<i>Lithospermum ruderales</i>
Lupine	<i>Lupinus sericeus</i> or <i>sulphureus</i>
Milk-vetches	<i>Astragalus</i> spp.
Mullein	<i>Verbascum thapsus</i>
Parsnip-flowered buckwheat	<i>Eriogonum heracleoides</i>
Phlox	<i>Phlox longifolia</i>
Pussytoes	<i>Antennaria</i> spp.
Snow buckwheat	<i>Eriogonum niveum</i>
Woolly plantain	<i>Plantago patagonica</i>
Yarrow	<i>Achillea millefolium</i>
Yellow salsify	<i>Tragopogon dubius</i>
<i>Shrubs</i>	
Big sagebrush	<i>Artemisia tridentata</i>
Pasture sage	<i>Artemisia frigida</i>
Rabbit-brush	<i>Chrysothamnus nauseosus</i>
Snowberry	<i>Symphoricarpos albus</i>
Three-tip sagebrush	<i>Artemisia tripartita</i>

importance of floristics, all forbs and all grasses were combined into two additional variables: “total forbs” and “total grasses.” Other independent variables included were percent cover of cow dung, cryptogamic crust, dead wood, litter, moss, rock, rock/*Selaginella*, rocky soil, soil, aspect, elevation, moisture and slope.

To screen data for the selection of variables for stepwise models, individual logistic regressions were performed for each bird species dependent variable (*table 1*) with each of the independent variables (Hosmer and Lemeshow 1989). This step was used to prioritize variables, since sample size was not sufficient for all independent variables to be entered into a single stepwise regression. Variables were retained if the individual model was significant ( $P < 0.05$ ). Data were log transformed where this improved the fit of these regressions

(Menard 1995). Where this was the case, the log-transformed variables were included in the models.

After the screening process determined which independent variables had significant associations and should be retained, all habitat associations were modeled using stepwise logistic regression. This allowed us to determine the relative importance of the different variables including plant species versus “total forbs” or “total grasses.” We used backward elimination to reduce the risk of excluding variables that had a significant relationship to the dependent variable (Menard 1995). The maximum likelihood ratio was used to decide which variables to retain. Alpha levels used in all models were  $P < 0.05$  for entry and  $P > 0.10$  for removal of variables. A higher  $P$  value (such as  $P >$

0.10) is recommended for removal to prevent the elimination of important variables (Menard 1995).

## Results

In initial logistic regression analyses, all dependent variables were significantly associated, either positively or negatively, with six or more independent variables. In most cases, significant associations occurred between bird species and plant species (table 2) rather than “total forbs” or “total grasses.” Significant variables from individual regressions were entered into the stepwise models for each species. The direction of an association was only interpreted if it was supported by regression results from individual models, to ensure that the direction of association did not change when variables were used in a group. All variables listed below were significant, and had the same directional relationship as in the single regressions. Values of  $r$ , the partial correlation coefficient, are provided.

Probability of Brewer’s Sparrow presence was higher at sites having higher elevations, and at sites with more parsnip-flowered buckwheat ( $r = 0.08$ ,  $P = 0.03$ ), junegrass (*Koeleria macrantha*;  $r = 0.06$ ,  $P = 0.04$ ), litter ( $r = 0.10$ ,  $P = 0.02$ ) and cryptogamic crust ( $r = 0.06$ ,  $P = 0.07$ ). Brewer’s Sparrow seldom occurred at sites with a north aspect ( $r = -0.05$ ,  $P = 0.02$ ), cactus (*Opuntia fragilis*;  $r = -0.07$ ,  $P = 0.02$ ) and sand dropseed grass ( $r = -0.04$ ,  $P = 0.09$ ; table 3). Although “total forb” was positively associated with Brewer’s Sparrow at the individual model level, this variable was not significant in either the presence vs. absence or low vs. high stepwise models, while particular plant species were. Within occupied sites, high relative abundance of Brewer’s Sparrow was positively associated with parsnip-flowered buckwheat ( $r = 0.10$ ,  $P = 0.02$ ), lupine ( $r = 0.13$ ,  $P = 0.04$ ), sagebrush ( $r = 0.06$ ,  $P = 0.09$ ) and litter ( $r = 0.09$ ,  $P = 0.06$ ; table 3). Elevation was not significant, meaning that for occupied sites at a given elevation, Brewer’s Sparrow relative abundance was predicted by parsnip-flowered buckwheat, lupine, sagebrush and litter.

Lark Sparrow presence was positively associated with bare soil ( $r = 0.14$ ,  $P = 0.00$ ) and sand dropseed grass ( $r = 0.07$ ,  $P = 0.06$ ), and negatively associated with total forbs ( $r = -0.10$ ,  $P = 0.03$ ) and elevation ( $r = -0.09$ ,  $P = 0.04$ ; table 3).

Grasshopper Sparrow was positively associated with cheatgrass ( $r = 0.15$ ,  $P = 0.01$ ) and pasture sage (*Artemisia frigida*;  $r = 0.20$ ,  $P = 0.00$ ), and negatively associated with spreading needlegrass (*Stipa richardsonii*;  $r = -0.13$ ,  $P = 0.00$ ), sagebrush ( $r = -0.29$ ,  $P = 0.00$ ) and north aspects ( $r = -0.12$ ,  $P = 0.07$ ; table 3). ‘Total

grass’ was not important to this species in either individual or stepwise regressions.

Western Meadowlark presence was positively associated with pasture sage ( $r = 0.07$ ,  $P = 0.04$ ), total grasses ( $r = 0.20$ ,  $P = 0.00$ ) and knapweed (*Centaurea diffusa*;  $r = 0.09$ ,  $P = 0.03$ ), and negatively associated with moisture ( $r = -0.18$ ,  $P = 0.00$ ), elevation ( $r = -0.09$ ,  $P = 0.04$ ) and balsamroot (*Balsamorhiza sagittata*;  $r = -0.18$ ,  $P = 0.00$ ; table 3). Within occupied sites, higher abundance was more likely at drier sites (moisture  $r = -0.23$ ,  $P = 0.00$ ) with needle-and-thread grass ( $r = 0.05$ ,  $P = 0.04$ ) and negatively associated with three-tip sage (*Artemisia tripartita*;  $r = -0.13$ ,  $P = 0.01$ ; table 3).

Vesper Sparrow presence was positively associated with lupine ( $r = 0.09$ ,  $P = 0.03$ ) and pasture sage ( $r = 0.10$ ,  $P = 0.01$ ), and negatively associated with pussytoes ( $r = -0.07$ ,  $P = 0.06$ ), dead wood ( $r = -0.18$ ,  $P = 0.00$ ) and the combination of rock and *Selaginella* species ( $r = -0.07$ ,  $P = 0.06$ ; table 3). “Total forbs” was not a significant predictor in either individual or stepwise models. Within occupied sites, higher abundance of Vesper Sparrow was positively associated with yarrow (*Achillea millefolium*;  $r = 0.12$ ,  $P = 0.02$ ) and pasture sage ( $r = 0.08$ ,  $P = 0.08$ ), and negatively associated with sand dropseed grass ( $r = -0.20$ ,  $P = 0.00$ ), sagebrush ( $r = -0.18$ ,  $P = 0.01$ ) and moisture ( $r = -0.14$ ,  $P = 0.02$ ; table 3).

## Discussion

By considering broadly distributed occupied and unoccupied survey stations within big sagebrush habitat, we were able to confirm the suggestion that floristics play an important role in habitat associations (Tomoff 1974, Rotenberry 1985). All five focal songbird species had significant associations with particular understory plant species. Our approach of using binary logistic regressions to assess habitat quality undoubtedly resulted in the loss of information as dependent variables were collapsed into “presence versus absence” and “high and low” abundance classes for bird species. Despite the limitations of this method, in many cases individual understory species were more important than “total forbs” and “total grasses,” highlighting the importance of measuring individual understory species. Inclusion of plant species improved the description of habitat associations, as compared to associations identified by Wiens and Rotenberry (1981) whose study included all of our focal bird species except Grasshopper Sparrow. By looking at habitat associations within shrubsteppe at a regional level, they found that many of the correlations to habitat features were weak, with the strongest associations occurring between songbirds and shrub species (Wiens and Rotenberry 1981). The associations

**Table 3**— Results of stepwise logistic regressions for the focal songbird species. Only significant variables are listed, ( $P < 0.10$ ). “L.” before a variable means that it was log-transformed for better model fit. All models are significant ( $P < 0.05$ ).

Species	Model	Variable	Significance <sup>1</sup>
Brewer’s Sparrow	presence vs. absence	L. Litter	(+)**
		Elevation	(+)**
		L. Parsnip buckwheat	(+)**
		Crust	(+)*
		L. Junegrass	(+)**
		L. Sand dropseed	(-)*
		Aspect	(-)*
		L. Cactus	(-)**
Brewer’s Sparrow	low vs. high abundance	L. Lupine	(+)**
		L. Parsnip buckwheat	(+)**
		L. Litter	(+)*
		L. Sagebrush	(+)*
Lark Sparrow	presence vs. absence	Bare soil	(+)**
		L. Sand dropseed	(+)*
		Elevation	(-)**
		L. Total forbs	(-)**
Grasshopper Sparrow	presence vs. absence	L. Pasture sage	(+)**
		L. Cheatgrass	(+)**
		Aspect	(-)*
		L. Spreading needle	(-)**
		L. Big sagebrush	(-)**
Western Meadowlark	presence vs. absence	L. Total Grasses	(+)**
		L. Knapweed	(+)**
		L. Pasture sage	(+)**
		Elevation	(-)**
		Moisture	(-)**
		L. Balsamroot	(-)**
Western Meadowlark	low vs. high abundance	L. Needle-and-thread	(+)**
		L. Three-tip sagebrush	(-)**
		L. Big sagebrush	(-)**
		Moisture	(-)**
Vesper Sparrow	low vs. moderate/high abundance	L. Pasture sage	(+)**
		L. Lupine	(+)**
		L. Pussytoes	(-)*
		Rock/Selaginella spp.	(-)*
		L. Dead wood	(-)**
Vesper Sparrow	moderate vs. high abundance	L. Yarrow	(+)**
		L. Pasture sage	(+)*
		Moisture	(-)**
		L. Big sagebrush	(-)**
		L. Sand dropseed	(-)*

(\*) indicates  $0.05 < P < 0.10$ ; (\*\*) indicates  $P < 0.05$ ; (\*\*\*) indicates  $P < 0.001$ ; (+/-) is direction of association.

Notes: Aspect was the sole categorical variable, north ( $315^\circ - 44^\circ$ ), east ( $45^\circ - 134^\circ$ ), south ( $135^\circ - 224^\circ$ ) or west ( $225^\circ - 314^\circ$ ). The significant response to aspect represented a negative relationship with north aspects relative to east, south, and west.

we have observed among songbirds and grass and forb species within big sagebrush habitat help to explain the patchy distribution of sagebrush breeding songbird species in our study area, and possibly reflect dietary preference of adult birds, habitat for insect prey, or structural requirements for nesting.

Previous studies have shown that Brewer's Sparrow is positively associated with shrub cover (Knick and Rotenberry 1995). Although Brewer's Sparrow usually nests in big sagebrush in our study area, big sagebrush density was not associated with presence of this species, but was only associated with high abundance within occupied sites. In contrast, Brewer's Sparrow presence was predicted by elevation, parsnip-flowered buckwheat abundance and other variables. Both parsnip-flowered buckwheat and lupines were further associated with high Brewer's Sparrow abundance. This association may be related to foraging habitat. The areas that Brewer's Sparrow select had high abundance of herbaceous perennial forbs, and had three times the abundance and twice the species richness of arthropods compared to sites not selected by Brewer's Sparrow sites in our study area (P. Krannitz, unpubl. data). Lepidopteran larvae make up 72 percent of nestling Brewer's Sparrow diet (Petersen and Best 1986), and adult Brewer's Sparrow have been observed feeding their chicks large lepidopteran larvae collected from lupines from areas of our study sites (N. Mahony, pers. comm.). Lepidopterans often have association with specific 'host plants', including plants for larval food (Swengel and Swengel 1999). Herbaceous perennial forbs have also been used as nesting substrate in burned areas (N. Mahony, unpubl. data).

The association of Brewer's Sparrow abundance with forb species has management implications, as many of these species are affected by grazing and burning. Lupines, for example, are reported to increase after fires (Grigore and Tramer 1996). Although not all of the burn histories of our point count stations are known, some of the areas of greatest forb productivity had been recently burned. Lupines are toxic to cattle and thought to increase under grazing pressure although in overgrazed areas they may still be used as forage by cows. Cows often eat lupines at our sites (N. Mahony, pers. comm.) and lupines are highly abundant in a grazing exclosure in this area, relative to the surrounding grazed pasture.

A marked spatial separation in the distribution of Lark and Brewer's Sparrow was obvious throughout our study sites. This pattern was reflected by differences in habitat associations for these species with Brewer's Sparrow being negatively associated with sand dropseed grass while Lark Sparrows occurred in areas with high sand dropseed grass abundance and few forbs. Sand dropseed grass is a native species that is com-

monly associated with disturbance and overgrazing (Archer 1953). Local-scale plant variables were similarly important to Lark Sparrow in Colorado, where they preferred shale plant communities (Haire et al. 2000). As in Arizona (Bock and Bock 1992), Lark Sparrow at our sites was positively associated with bare soil. Bare soil is positively associated with grazing (Milchunas et al. 1989), which could further indicate an association between Lark Sparrow and disturbed areas.

Other studies have shown that Grasshopper Sparrow is associated with 'total perennial grasses' (Vander Hagen et al. 2000). We did not observe a relationship between Grasshopper Sparrow occurrence and total grasses at the individual logistic regression model level; therefore this variable was not entered into the stepwise regression. However, the individual logistic regression models showed a strong relationship between this bird species and needle-and-thread grass. Grass cover is important for concealing nests (Vickery 1996), although Grasshopper Sparrow also select areas with bare soil, presumably to aid in foraging on the ground for insects (Whitmore 1981, Vickery 1996). Grasshopper Sparrow was more abundant in areas with abundant Eurasian weeds relative to native plants, in Manitoba, Illinois and Colorado (Wilson and Belcher 1989, Haire et al. 2000, Walk and Warner 2000). The positive association between Grasshopper Sparrow with cheatgrass and pasture sage, both weedy species, may be because these plants are widespread in the dry, open areas of my study sites which this species preferred. However, grasshopper abundance, an important component of Grasshopper Sparrow diet (Vickery 1996), tends to increase on overgrazed rangeland invaded by exotic species (Smith 1940, Nerney 1958). It is possible that Grasshopper Sparrow responds more to plant structure rather than to floristics (Walk and Warner 2000), as supported by the strong negative association we observed between this species and abundance of big sagebrush. A landscape level analysis of habitat associations in these areas suggests that Grasshopper Sparrow presence is mainly dependent on the availability of large areas of shrubsteppe with low density of big sagebrush (Paczek 2002).

A positive association of Western Meadowlark presence with total grass abundance has been found in previous studies (Wiens and Rotenberry 1981, Knick and Rotenberry 1995, Krannitz and Rohner 2000). However, within occupied sites in our study, Western Meadowlark abundance was positively associated with abundance of needle-and-thread grass, rather than total grass cover, implying that presence of this native grass may be important to this species. In other studies, Western Meadowlark was positively correlated with native grass species, and negatively associated with Eurasian weeds (Wilson and Belcher 1989, Haire et al.

2000). The reason for this association is not clear. Seeds are a minor part of Western Meadowlark diet during breeding season (Kaspari and Joern 1993), but grass is important in nest cover (Lanyon 1994), and native grasses could provide habitat for insect prey.

Although Vesper Sparrow was highly abundant throughout our study area, they shared similar associations to Brewer's Sparrow, occurring in highest numbers in areas with abundant lupines, and low abundance of sand dropseed grass. Structure also appeared to be important for this species, as Vesper Sparrow were associated with dry open sites with sparse cover of big sagebrush, as has been previously observed (Kantrud and Kogoloski 1983).

The relationships that we have identified between birds and floristics provides more information on bird distribution than the measurement of total forb and grass cover alone. These associations further provide a means by which wildlife managers can communicate with range managers in order to ensure the protection of songbird habitat, both on public and private land. The associations that we observed are supported by what is known about our focal species in the literature, however further research is required to tease apart the relative importance of floristics from vertical structure and to identify the roles that different plant species may play in songbird foraging.

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