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HABITAT ASSOCIATIONS, RELATIVE ABUNDANCE, AND SPECIES RICHNESS OF AUTUMN LANDBIRD MIGRANTS IN SOUTHWESTERN IDAHO

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Abstract. We used count surveys and mist-net captures to compare habitat associations, relative abundance, species richness, and community similarity of migrant landbirds among four major habitats in the Boise Foothills of southwestern Idaho. Count surveys were conducted from August through October 1997–2000 in conifer forest, mountain shrubland, shrubsteppe, and riparian shrubland. We compared bird detections among habitats for all birds pooled, individual species, and three migration strategies: Neotropical, temperate, and resident (including irruptive migrants). Mountain shrubland supported the highest numbers of temperate migrants; both mountain shrubland and riparian shrubland had the highest numbers of Neotropical migrants; and conifer forest had the highest numbers of residents. Species richness was highest in riparian shrubland and lowest in shrubsteppe, whereas diversity and evenness were highest in conifer forest and mountain shrubland. Mist netting was conducted from mid-July to mid-October in two habitats: mountain shrubland (1997–2002) and riparian shrubland (1998–1999). Captures (adjusted for effort) were compared among habitats in 1998–1999 and were similar for temperate migrants, whereas mountain shrubland had higher abundance of Neotropical migrants and riparian shrubland had higher abundance of irruptive migrants. Richness, diversity, and evenness were similar and there was high community similarity between mountain shrub and riparian shrubland habitats. These results emphasize the importance of montane habitats, especially deciduous shrub communities, to migrants in the Intermountain West.

Key words: habitat associations, Idaho, Intermountain West, landbird migration, relative abundance, species richness.

Asociaciones de Hábitat, Abundancia Relativa y Riqueza de Especies de Aves Migratorias Terrestres de Otoño en el Sudoeste de Idaho

Resumen. Empleamos muestreos por conteos y capturas con redes de niebla para comparar asociaciones de hábitat, abundancia relativa, riqueza de especies, y similitud entre comunidades de aves migratorias terrestres, presentes en los cuatro hábitats principales de piedemonte de Boise en el sudoeste de Idaho. Los conteos fueron realizados entre agosto hasta octubre de los años 1997–2000 en bosque de coníferas, hábitat de matorral de montaña, matorral de estepa, y en matorral ripario. Comparamos la detección de aves entre hábitats para todas las especies juntas, para cada especie por separado y para tres categorías de estrategia de migración: especies migratorias neotropicales, especies migratorias de la zona templada y especies residentes (incluyendo migrantes irruptivas). El hábitat de matorral de montaña tuvo los números más altos de especies migratorias templadas. Los hábitats de matorral de montaña y matorral ripario tuvieron los números más altos de especies migratorias neotropicales y el bosque de coníferas tuvo los números más altos de especies residentes. La riqueza de especies fue mayor en el matorral ripario y menor en el matorral de estepa, mientras que la diversidad y la equidad fueron mayores en bosque de coníferas y matorral de montaña. El muestreo con redes de niebla se llevó a cabo desde mediados de julio hasta mediados de octubre en dos hábitats: matorral de montaña (1997–2002) y matorral ripario (1998–1999). Las capturas (ajustadas por esfuerzo de muestreo) fueron comparadas entre hábitats en 1998–1999. La abundancia de las especies migratorias de la zona templada fue similar entre hábitats, mientras que el hábitat de matorral de montaña tuvo la

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mayor abundancia de especies migratorias neotropicales y el matorral ripario tuvo la mayor abundancia de especies migratorias irruptivas. La riqueza, la diversidad y la equidad fueron similares entre hábitats y las comunidades de los hábitats de matorral de montaña y matorral ripario presentaron alta similitud. Estos resultados enfatizan la importancia de los hábitats de montaña, especialmente la de los hábitats de comunidades arbustivas deciduas, para las especies migratorias en el oeste intermontano.

INTRODUCTION

Populations of some migratory birds, including both Neotropical migrants and shorter-distance, temperate migrants, have declined during the last few decades (e.g., Robbins et al. 1989, DeSante and George 1994, Wang and Finch 1997). Most research addressing causes for these population declines has focused on habitat characteristics and population status on the breeding and wintering grounds (Hutto 1988, Sherry and Holmes 1995). Recently, researchers have become increasingly aware of the importance of stopover habitat in the life history of migrant birds (Moore et al. 1995, Petit 2000, Sillett and Holmes 2002). In particular, calculations by Sillett and Holmes (2002) suggest that most mortality in migrant populations may occur during migration. Because migrating landbirds need stopover sites for rest and refueling, large-scale reductions in abundance or distribution of suitable stopover habitat may lead to increased mortality and population declines (Moore et al. 1995). Thus, protection of suitable stopover habitat is an important link in the conservation of migratory birds (Moore et al. 1995, Hutto 1998, Petit 2000). Moore et al. (1995) stressed the need for more information on the ecology and habitat use of birds during migration, especially in the western United States, where less work has been done (but see Austin 1970, Hutto 1985, Skagen et al. 1998, and Wang et al. 1998).

Birds migrating west of the Great Plains likely have evolved under different environmental conditions than their Eastern counterparts. Environments in the western United States are more heterogeneous, with occasional extreme local differences in elevation, temperature, and moisture levels. As opposed to the relatively continuous historical distribution of Eastern forests, Western habitats are more patchy and less extensive (George and Dobkin 2002). In the Intermountain West and Great Basin, habitats for woodland migrants are generally limited to lowland riparian areas and highland forests or shrublands (Austin 1970). Western birds may have developed specific migration strategies to fit the different habitat types and distribution they face during migration. During fall migration, strategies may include avoidance of temperature extremes and preference for areas with higher moisture and thus higher food availability (Austin 1970, Blake 1984).

Considering the different conditions faced by Eastern and Western migrants, applying what is known of habitat use and stopover biology in the eastern United States to Western habitats may not be appropriate (Petit 2000). Conservation efforts directed toward migratory birds depend on our understanding of which habitats, or suites of habitats, are important to migrants on local and regional scales (Petit 2000). Previous studies investigating habitat preferences of migrating landbirds in the West have focused largely on riparian forest habitats, which provide critical habitat for breeding and migrating landbirds (Wang and Finch 1997, Skagen et al. 1998, Wang et al. 1998, Belsky et al. 1999). However, migratory landbirds' use of other Western habitats such as mountain shrubland, conifer forest, and shrubsteppe is less studied (Austin 1970, Blake 1984, Hutto 1985), and thus documenting the relative use of these habitats is an important step to implementing effective conservation strategies.

The four major habitat types in the Boise Foothills (conifer forest, mountain shrubland, shrubsteppe, and willow-dominated riparian shrubland) provide an opportunity to study the habitat associations of autumn landbird migrants that occur in Idaho and throughout the Intermountain West. In this study, we used count surveys and mist netting to quantify occurrence patterns and compare species richness, diversity, relative abundance, and community similarity of migrants among habitats.

METHODS

STUDY SITE

We conducted this study 12 km east of Boise, Idaho (43°36′N, 116°05′W) on Lucky Peak (1845 m), the southernmost peak of the Boise Foothills. The Boise Foothills, composed of

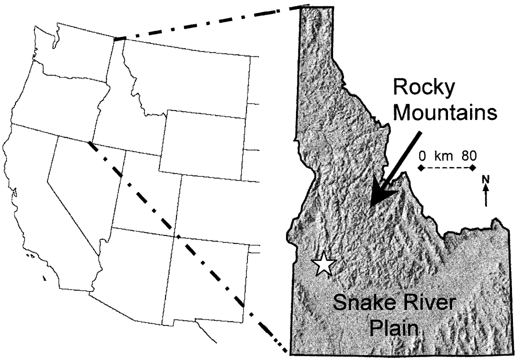

FIGURE 1. Map of western United States and Idaho showing location of the study area (star) in relation to Rocky Mountains and the Snake River Plain.

north-south trending peaks and hills in the Boise Mountains, form the northern boundary of the Snake River Plain and the southernmost extension of the central Idaho mountains (Fig. 1). The study site is located at the boundary between two major habitat zones: the mostly forested mountains to the north and the sagebrush steppe (shrubsteppe) dominated Great Basin to the south (Fig. 1). Four distinct habitat types occur in a mosaic at Lucky Peak and throughout the Boise Mountains: conifer forest, mountain shrubland, shrubsteppe, and willow-dominated riparian shrubland (willow riparian). Shrubsteppe and willow riparian habitats occur from the lowest foothills (about 1000 m in elevation) to near the ridgelines, whereas conifer forest and mountain shrubland habitats occur mostly in the few hundred meters closest to the ridgelines. Studies were conducted at elevations ranging from about 1650–1845 m, where all four habitats co-occur.

Higher elevations and north- and east-facing slopes are dominated by conifer forests consisting mostly of Douglas-fir (*Pseudotsuga menziesii*) with an understory dominated by mountain ninebark (*Physocarpus malvaceus*) in sunlit areas. Canopies are fairly closed and range in height from 20–28 m. Mountain shrubland communities occur in forest openings, below treeline, and on south- and west-facing slopes, and are dominated by bittercherry (*Prunus emarginata*) and chokecherry (*P. virginiana*), with lower densities of buckbrush (*Ceanothus velutinus*), serviceberry (*Amelanchier alnifolia*), wild currant (*Ribes* sp.), willow (*Salix* sp.), rose (*Rosa woodsii*), elderberry (*Sambucus* sp.), Rocky Mountain maple (*Acer glabrum*), and quaking aspen (*Populus tremuloides*). The heights of most shrubs range from 1–6 m. Mountain shrubland grades into mid-elevation shrubsteppe, which is characterized by mountain big sagebrush (*Artemisia tridentata vaseyana*), bitterbrush (*Purshia tridentata*), rabbitbrush (*Chrysothamnus* sp.) and an understory of native and introduced bunchgrasses, primarily bluebunch wheatgrass (*Pseudoregnaria spicata*), threeawn (*Aristida longiseta*), Sandberg's bluegrass (*Poa secunda*), intermediate wheatgrass (*Agropyron intermedium*), and pubescent wheatgrass (*A. trichophorum*). Shrub heights are 0.5–1.5 m with some taller sagebrush and bitterbrush occurring at lower elevations. Habitat degradation by overgrazing and frequent fire have allowed encroachment and, in some cases, dominance of exotic annual grasses, primarily cheatgrass (*Bromus tectorum*) and medusahead (*Taeniatherum caputmedusae*) within the shrubsteppe community. Riparian shrubland communities occupy spring or stream-fed draws and are bounded by shrubsteppe vegetation. Riparian draws are dominated by willow but also contain black cottonwood (*Populus trichocarpa*), bittercherry, chokecherry, rose, and elderberry. Most shrubs in the riparian draws range in height from 1–6 m and the vegetation is similar in structure to the mountain shrubland community (Rocklage and Kaltenecker, unpubl. data).

COUNT SURVEYS

We examined habitat associations of fall migrants using variable-width line transects, fixed-area searches, and point counts (Table 1; Bibby and Hill 1992). Because habitats in the Boise Foothills occur in a complex mosaic, sites were not selected randomly; rather, we selected representative sites that contained fairly continuous habitat blocks in order to sample birds only in that habitat. During 1997 and 1998, birds were surveyed along 200-m, variable-width line transects in each habitat and we recorded an estimated distance to each bird (Bibby and Hill 1992, Ralph et al. 1993). One transect was established in each habitat and each transect was surveyed on a near-daily basis during the sampling period (13 August–15 October 1997 and 18 August–15 October 1998) such that over 100 surveys were conducted in each habitat during the two autumn seasons combined (106 for shrubsteppe, 107 for willow riparian, 108 for co-

TABLE 1. Methods used in generating relative abundance estimates in four habitats of the Boise Foothills, Idaho: conifer forest, mountain shrubland, shrubsteppe, and willow riparian shrubland. Data from both count and capture methods were also used for species richness, diversity, evenness, and community similarity measures.

Method	Years	Habitats
Count surveys		
Variable-width line transects	1997–1998	All
Fixed-area searches	1999	All
Point counts	2000	All
Mist-net captures	1997–2002	Mountain shrubland
	1998–1999	Willow riparian

nifer forest, and 111 for mountain shrubland). Count duration was approximately 10 min for each 200-m transect.

We used different survey methods in 1999 and 2000 to determine if alternate survey methods yielded similar results (Bibby and Hill 1992). During 1999, we used 10-min fixed-area searches, only counting birds within the designated count areas (Hutto et al. 1986, Ralph et al. 1993). In 1999, we did not record distance of the birds from the count center. Four count areas were established in representative patches of each of the four habitat types for a total of sixteen count areas. Count area size and shape varied among habitats because of variability in habitat distribution (Bibby and Hill 1992). We established 50-m-radius circles in conifer forest and shrubsteppe habitats, 25-m-radius circles in mountain shrubland, and 100 × 20-m line transects in willow riparian habitats. During 2000, we conducted variable-radius circular point counts (Ralph et al. 1993) using the same count locations as in 1999 and we estimated distance to all birds. In 1999 and 2000, we conducted surveys within a habitat type sequentially such that each count area was sampled approximately weekly from mid-August to mid-October.

Because the goal of these surveys was to determine the distribution of migrants among habitats, observers disregarded birds flying over or birds that remained outside of the count habitat. Centers of count areas were separated by at least 200 m (usually $>$400 m) to minimize repeat sampling of individual birds. Counts were conducted between 0.5 and 4.0 hr after sunrise and we rotated the order in which each habitat was sampled on a given day to reduce possible temporal biases. At least three observers conducted count surveys in each year and all observers were trained in distance estimation and migrant identification. To minimize observer bias, observers were rotated among habitats and count sites regularly.

Abundances of migrants were calculated in two ways. For 1997, 1998, and 2000 survey data (for which we had recorded distance to birds), we used the program DISTANCE to calculate approximate densities (birds km^{-2}) based on best-fit models chosen by the lowest Akaike's Information Criterion (AIC) values (Buckland et al. 2001, Thomas et al. 2003). The DISTANCE program accounts for detectability of birds in calculating density estimates in each habitat and this should help overcome the potential for varying detectabilities of birds in different habitats (Rosenstock et al. 2002). Even though the DISTANCE program calculates densities, we feel it most appropriate to consider these as relative abundances because of the difficulty of detecting actual densities at a time of year when birds are so mobile. During 1999, when we did not record distances to birds, we calculated relative abundance as birds km^{-2} based on all detections within the fixed count areas outlined above. While this may not be as precise as using DISTANCE, we feel these 1999 data are good approximations for two reasons: (1) DISTANCE calculates ''effective strip widths'' for detecting birds in a given habitat-year combination (Thomas et al. 2003) and, during 1997, 1998, and 2000, these effective strip widths were very close to the fixed area boundaries we used in 1999 for each habitat; and (2) abundance values from 1999 were generally within the range found during the other years of the study.

At our site, recapture rates were generally less than 10% ($<$5% for most species), the longest stopover lengths were generally less than 5 days for most species, and few individuals stayed for multiple days (JDC, unpubl. data). This matches the rapid turnover of migrants found at other stopover sites (Moore et al. 1995, Wang and

Finch 2002). Nonetheless, it is possible that a small percentage of migrants were present and detected on repeat surveys of the same count area and, if stopover propensity differed among habitats, this could affect our interpretation of the data, especially when comparing avian relative abundance among habitats. Thus, for 1997 and 1998 (years in which we surveyed the same count areas on a near-daily basis), we tested a subset of the data against the full dataset to make sure that a lack of independence did not bias our results. For our data subset, we used counts separated by at least 3 days (4-day intervals; an interval that should remove the vast majority of stopover individuals) and discarded the counts in between these days. Relative abundance results from this subset were very similar to the full dataset for each year, both within and among habitats. Therefore, we feel confident that our bird surveys conducted throughout autumn migration accurately reflect differential habitat associations of migrants.

MIST-NET CAPTURES

We captured birds using standard mist nets (12 × 2.6 m, 32-mm mesh) in two habitats (Table 1). One netting site was located in mountain shrubland near the summit of Lucky Peak. The second site was in a spring-fed, willow-dominated riparian draw on the western slope of Lucky Peak. The sites were separated by approximately 600 m. At the mountain shrubland site, we used eight nets in 1997 and 10 nets from 1998 to 2002. We used six nets at the willow riparian site, which was sampled during 1998–1999. Due to the constricted nature of the riparian habitat, nets were more spread out at the mountain shrubland site and the area covered by the netting scheme was approximately twice the size of the willow riparian site. Nets were located nonrandomly and opportunistically throughout the habitats in areas that concentrated bird movement for efficient captures (Ralph et al. 1993) and net placement was constant during the study. We operated nets daily for 5 hr beginning at sunrise, except in the case of extreme temperatures (>32°C or <0°C), high winds, or continuous precipitation. We checked and cleared nets at 20–40 min intervals. The mountain shrubland site was operated from 12 August–21 October 1997, 5 August–15 October 1998, 31 July–15 October 1999, 18 July–16 October 2000, and 16 July–15 October 2001 and 2002. The willow riparian site was operated from 21 August–14 October 1998 and 2 August–29 September 1999. We identified captured birds to species with reference to Pyle (1997) and fitted each with individually numbered, U.S. Geological Survey aluminum leg bands. Capture effort, measured in mist-net hours (mnh), with one net open for 1 hr equaling 1 mnh, was recorded for each station. We calculated capture rates for each species and all birds combined based on the numbers of new captures per 1000 mnh. Direct comparisons of capture totals between habitats were made for banding days in common between netting sites (21 August–14 October 1998 and 2 August–29 September 1999) using projected capture totals adjusted to equal netting effort.

STATISTICAL ANALYSES

We assigned species to one of three discrete categories for comparisons: Neotropical migrants (long-distance migrants), temperate migrants (short-distance migrants), or residents (including irruptive migrants). We classified Neotropical migrants according to DeGraaf and Rappole (1995), but applied more stringent criteria such that at least half of the population must winter south of the United States. Temperate migrants were classified as species whose wintering areas lie primarily within the temperate zone; some of these do migrate long distances (i.e., from the arctic or boreal zones) but most individuals winter north of the Neotropics. Several species (notably Ruby-crowned Kinglet, Hermit Thrush, and Yellow-rumped Warbler; see Table 3 for scientific names) have been labeled as Neotropical migrants by other authors but we classified them as temperate migrants because significant portions of their populations winter in the southern and south-central United States (DeGraaf and Rappole 1995).

Relative abundance. We adjusted capture and count totals for similar effort by applying a correction factor based on the number of counts (or net hours) in a habitat relative to the highest number of counts (or net hours) that occurred in any habitat in that year (Swanson et al. 2003). Thus, we compared capture numbers based on an equal number of net hours and total numbers of detections from count surveys based on an equal number of surveys. We then used goodness-of-fit tests (χ^2) to compare among habitats for all species pooled, each migrant category, and individual species with at least 20 total captures or 25 total count detections combined among habitats, such that expected cell frequencies were >5 at all times (Rappole et al. 1979, Brower et al. 1990, Swanson et al. 2003). When making multiple comparisons using the same data set (i.e., by species or migrant strategy), we used the sequential Bonferroni method to control the overall α error rate at $P = 0.05$ (Rice 1989, Zar 1996). When the overall χ^2 was significant for count data comparisons (which had three degrees of freedom), we ran pairwise single-degree-of-freedom tests to determine which habitat(s) had the highest bird numbers and again used the sequential Bonferroni method to control the overall α error rate (Rice 1989, Zar 1996). In some cases, a species or migrant category was most common in two habitats (i.e., the highest numbers of detections were not significantly different between two habitats but were significantly higher than the other habitats). Abundance data for each year were analyzed separately in order to avoid grouping relative abundance data across years with different survey methods.

Community measures. We used count survey, capture, and pooled (capture and count) data for each habitat to compare species richness (number of species), diversity (Shannon Index, H), evenness (J), and Morisita's index of community similarity (I_M; Brower et al. 1990, Rappole et al. 1998). Both J and I_M values range from zero to one, with values close to one being most even or similar, respectively. To correct for unequal sample sizes and netting effort among sites in our assessment of species richness, we used rarefaction to compare expected numbers of species ($\hat{S}_n$) at a given sample size (James and Rathbun 1981). The other community comparison procedures we used are robust to differing sample population sizes since they are based on relative proportions (Brower et al. 1990); therefore those metrics are uncorrected with respect to effort. Pooled capture and count data was derived from 1998 and 1999 only (years in which netting occurred in both mountain shrubland and willow riparian habitats) and using only common banding days. Because methods for surveying birds were similar among habitats in each year, we included all 4 years of data for richness, diversity, and community similarity measures to increase sample size.

Comparing count survey and capture data. We used correlation to compare the abundance of birds in mountain shrubland and willow riparian habitats as detected by mist netting and count surveys (Zar 1996, Wang and Finch 2002). For this analysis, bird totals from each survey method were log transformed and adjusted by a standard score: (species total)-(mean of species total of all species/standard deviation of species total) (Wang and Finch 2002).

RESULTS

HABITAT ASSOCIATIONS AND RELATIVE ABUNDANCE

Count surveys. We calculated relative abundance for 66 species during 1997–2000 in all habitats combined (Fig. 2, Table 2). Although relative abundance estimates varied among years, all years displayed a similar pattern in which the two deciduous habitats (mountain shrubland and willow riparian) had the highest abundances of migrants (Fig. 2). The total number of birds counted in each habitat (adjusted for differing effort) was significantly different among habitats ($P < 0.001$ in all years) with mountain shrubland generally supporting the most birds and shrubsteppe supporting the fewest birds (Fig. 2, Table 2). The number of birds in each migrant category also differed significantly among habitats in all years (Fig. 2, Table 2). Neotropical migrants were generally most common in both mountain shrubland and willow riparian ($P < 0.001$), temperate migrants generally most common in mountain shrubland ($P < 0.001$), and residents most common in conifer forest ($P < 0.001$; Table 2). Most Neotropical and temperate migrant species with significant differences were more abundant in mountain shrubland and willow riparian, whereas residents were most common in conifer forest (Table 2).

Captures. We captured 26 865 birds of 83 species in 22 555 mnh in the mountain shrubland during 1997–2002 (Table 3). In the willow riparian habitat in 1998–1999, we captured 2948 birds of 58 species in 2685 mnh (Table 3). Overall capture rates (birds per 1000 mnh) were 1192 for mountain shrubland and 1098 for willow riparian (Fig. 3). Interestingly, capture rates in willow riparian changed drastically between the 2 years in which netting occurred at that site, whereas capture rates at the mountain shrubland were more stable over time (Fig. 3). For common banding days in 1998–1999, we captured

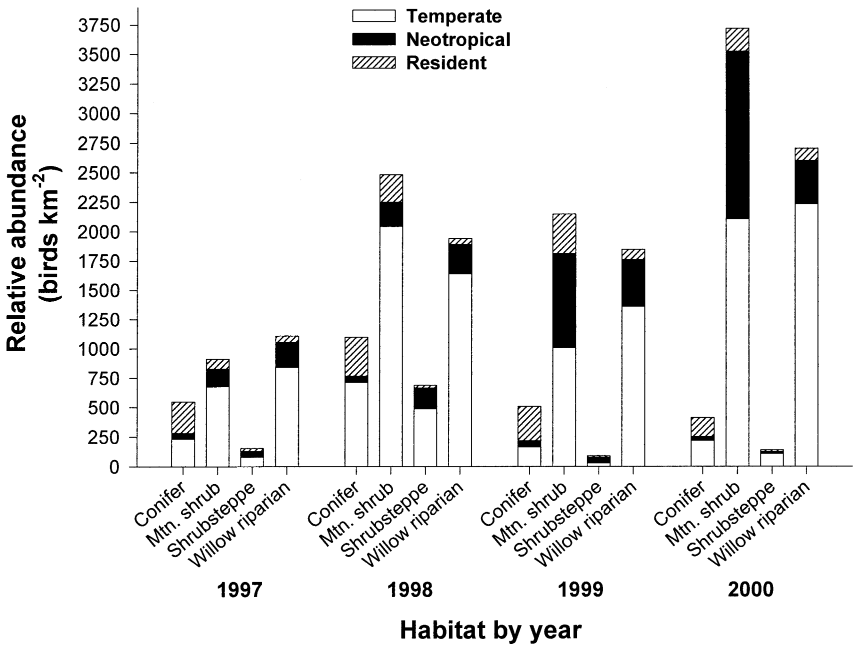

FIGURE 2. Relative abundance of Neotropical migrants, temperate migrants, and residents (including irruptive migrants) from count surveys during 1997–2000 for conifer forest, mountain shrubland, shrubsteppe, and willow riparian habitats in the Boise Foothills, Idaho.

5243 birds of 59 species in 4776 mnh in mountain shrubland and 2948 birds of 58 species in 2685 mnh in willow riparian. In considering migrants only, we captured 5105 migrants of 48 species in mountain shrubland and 2612 migrants of 50 species in willow riparian. Capture rates for all birds (birds per 1000 mnh from common banding days) were 1098 for both sites. Capture totals were similar between habitats for temperate migrants but we found significant differences between sites for Neotropical migrants and residents. Neotropical migrants were most frequently captured in mountain shrubland ($P < 0.001$) and residents were most common in willow riparian ($P < 0.001$; Table 3). Of the 66 species captured in 1998–1999, 36 species had ≥20 total captures in both sites combined. Of these, 27 showed significant differences in projected capture totals between sites: 15 species were more commonly captured in mountain shrubland and 12 species in willow riparian (Table 3).

RICHNESS, DIVERSITY, AND COMMUNITY SIMILARITY

Count survey data (1997–2000). Overall species richness was 53 for willow riparian, 50 for mountain shrubland, 46 for conifer forest, and 31 for shrubsteppe. Because of unequal numbers of individuals counted among habitats, we used rarefaction curves to compare expected numbers of species ($\hat{S}_n$) at similar sample sizes. At n = 400 (rarefaction limit for shrubsteppe), expected species richness was 36 in mountain shrubland, 35 in willow riparian, 32 in conifer forest, and 28 in shrubsteppe (Fig. 4a). After n exceeded 500, at which point both mountain shrubland and willow riparian reached an $\hat{S}_n$ of 38, the willow riparian curve accumulated species more quickly than mountain shrubland or conifer forest (Fig. 4a). Shannon diversity values (H) were 2.79 for conifer forest, 2.75 for mountain shrubland, 2.17 for shrubsteppe, and 2.40 for willow riparian. Evenness (J) values were 0.73 for conifer forest, 0.72 for mountain shrubland, 0.57 for shrubsteppe, and 0.63 for willow riparian. Morisita's index of community similarity (I_M) values for all birds were: conifer forest vs. mountain shrubland = 0.52, conifer forest vs. shrubsteppe = 0.13, conifer forest vs. willow riparian = 0.23, mountain shrubland vs. shrubsteppe = 0.48, mountain shrubland vs. willow riparian = 0.73, and shrubsteppe vs. willow ri-

TABLE 2. Habitat associations based on count surveys in four habitats of the Boise Foothills, Idaho: conifer forest, mountain shrubland, shrubsteppe, and willow riparian shrubland. Chi-squared comparisons were performed on detection totals in each habitat (adjusted to correct for unequal numbers of counts) for species and categories with >25 total detections. Only those species with significant overall comparisons in any year are shown. Pairwise *post-hoc* χ^2 tests using a sequential Bonferroni procedure were used to determine which habitats were significantly different from each other. Habitats shown are those that had significantly higher detections than other habitats in that year. Scientific names appear in Table 3.

Species	1997	1998	1999	2000
Neotropical migrants				
Dusky Flycatcher	Mtn. Shrub			
MacGillivray's Warbler	Mtn. Shrub	Mtn. Shrub		
Brewer's Sparrow	Shrubsteppe	Shrubsteppe		
Chipping Sparrow	Riparian, Mtn. Shrub	Riparian	Mtn. Shrub	
Lazuli Bunting		Riparian		
All Neotropical migrants	Mtn. Shrub, Riparian	Riparian, Mtn. Shrub, Shrubsteppe	Mtn. Shrub	Mtn. Shrub
Temperate migrants				
Northern Flicker		Conifer, Shrubsteppe		
Golden-crowned Kinglet	Conifer	Conifer		
Ruby-crowned Kinglet	Mtn. Shrub	Mtn. Shrub	Mtn. Shrub, Riparian	
Townsend's Solitaire	Conifer, Mtn. Shrub	Mtn. Shrub		
American Robin	Mtn. Shrub	Mtn. Shrub		Mtn. Shrub
Yellow-rumped Warbler	Conifer, Mtn. Shrub	Conifer	Conifer	
Spotted Towhee	Mtn. Shrub, Riparian	Mtn. Shrub	Riparian	Riparian, Mtn. Shrub
White-crowned Sparrow	Riparian	Riparian	Mtn. Shrub, Riparian	
Dark-eyed Junco	Riparian, Mtn. Shrub	Mtn. Shrub, Riparian	Mtn. Shrub	
All temperate migrants	Mtn. Shrub	Mtn. Shrub	Mtn. Shrub, Riparian	Mtn. Shrub, Conifer
Residents[a]				
Mountain Chickadee	Conifer	Conifer	Conifer, Mtn. Shrub	
Red-breasted Nuthatch	Conifer	Conifer	Conifer	
Brown Creeper	Conifer	Conifer		
Pine Siskin	Conifer	Mtn. Shrub, Conifer, Riparian		
All residents	Conifer	Conifer	Conifer	Conifer, Shrubsteppe

[a] Including irruptive migrants.

parian = 0.78. Thus, I_M values for all birds combined showed that shrubsteppe and willow riparian shared the highest community overlap while conifer forest and shrubsteppe were least similar. This pattern also was observed for temperate migrants (Table 4). Neotropical migrants showed the highest overlap between mountain shrubland and willow riparian, shrubsteppe and willow riparian, and conifer forest and mountain shrubland (Table 4).

Capture data. Species richness derived from common banding days in 1998–1999 was 59 species for mountain shrubland and 58 species for willow riparian. Total species richness for the mountain shrubland site over 6 years of capture data (1997–2002) was 83 species. For compari-

TABLE 3. Capture totals and rate (birds per 1000 mist-net hr) from mountain shrubland and willow riparian shrubland habitats in the Boise Foothills, Idaho. Data include 1997–2002 totals for mountain shrubland, 1998–1999 totals for willow riparian, and, for comparison with willow riparian, totals for mountain shrubland from the same banding days as willow riparian in 1998–1999. Chi-squared comparisons were performed on adjusted capture totals (to correct for unequal effort between sites) for species and migrant categories with >25 total detections during 1998–1999; χ^2 values are reported for significant comparison. ** $P < 0.01$; *** $P < 0.001$.

	Mountain shrubland						
	1997–2002		1998–1999		Willow riparian 1998–1999		
Species	Captures	Rate	Captures	Rate	Captures	Rate	χ^2_1
Neotropical migrants							
Black-chinned Hummingbird (*Archilochus alexandri*)	14	0.6	4	0.8	3	1.1	
Calliope Hummingbird (*Stellula calliope*)	137	6.1	13	2.7	5	1.9	
Broad-tailed Hummingbird (*Selasphorus platycerus*)					3	1.1	
Rufous Hummingbird (*Selasphorus rufus*)	59	2.6	3	0.6	4	1.5	
Yellow-bellied Sapsucker (*Sphyrapicus varius*)	1	<0.1					
Red-naped Sapsucker (*Sphyrapicus nuchalis*)	14	0.6	6	1.3	3	1.1	
Olive-sided Flycatcher (*Contopus borealis*)	4	0.2					
Western Wood-Pewee (*Contopus sordidulus*)	59	2.6	9	1.9	15	5.6	9.0**
Willow Flycatcher (*Empidonax trailli*)	9	0.4	5	1.1	4	1.5	
Hammond's Flycatcher (*Empidonax hammondi*)	498	22.1	102	21.4	26	9.7	21.2***
Gray Flycatcher (*Empidonax wrightii*)	12	0.5	2	0.4	1	0.4	
Dusky Flycatcher (*Empidonax oberholseri*)	1449	64.2	366	76.6	94	35.0	74.3***
''Western'' Flycatcher[a]	59	2.6	13	2.7	5	1.9	
Cassin's Vireo (*Vireo cassinii*)	439	19.5	166	34.8	43	16.0	32.6***
Blue-headed Vireo (*Vireo solitarius*)	2	0.1					
Warbling Vireo (*Vireo gilvus*)	803	35.6	265	55.5	109	40.6	11.0***
Red-eyed Vireo (*Vireo olivaceus*)	3	0.1	1	0.2			
House Wren (*Troglodytes aedon*)	62	2.8	14	2.9	20	7.5	9.7**
Blue-gray Gnatcatcher (*Polioptila caerulea*)	1	<0.1					
Swainson's Thrush (*Catharus ustulatus*)	68	3.0	22	4.6	2	0.8	12.5**
Tennessee Warbler (*Vermivora peregrina*)	3	0.1					
Orange-crowned Warbler (*Vermivora celata*)	1128	50.0	196	41.0	63	23.5	22.9***
Nashville Warbler (*Vermivora ruficapilla*)	975	43.2	192	40.2	45	16.8	46.1***
Yellow Warbler (*Dendroica petechia*)	628	27.8	76	15.9	64	23.8	7.6**
Chestnut-sided Warbler (*Dendroica pensylvanica*)	1	<0.1					
Magnolia Warbler (*Dendroica magnolia*)	1	<0.1					

TABLE 3. Continued.

	Mountain shrubland				Willow riparian 1998–1999		
	1997–2002		1998–1999				
Species	Captures	Rate	Captures	Rate	Captures	Rate	χ^2_1
Black-throated Blue Warbler (*Dendroica caerulescens*)	1	<0.1					
Townsend's Warbler (*Dendroica townsendi*)	405	17.1	63	13.2	13	4.8	18.6***
Blackburnian Warbler (*Dendroica fusca*)	1	<0.1					
Palm Warbler (*Dendroica palmarum*)	1	<0.1					
Bay-breasted Warbler (*Dendroica castanea*)	1	<0.1					
Blackpoll Warbler (*Dendroica striata*)	4	0.2	2	0.4	3	1.1	
Black-and-white Warbler (*Mniotilta varia*)	1	<0.1					
American Redstart (*Setophaga ruticilla*)	4	0.2	1	0.2	1	0.4	
Northern Waterthrush (*Seiurus noveboracensis*)	1	<0.1	1	0.2			
MacGillivray's Warbler (*Oporornis tolmiei*)	1496	66.3	305	63.9	122	45.5	14.8***
Wilson's Warbler (*Wilsonia pusilla*)	355	15.7	106	22.2	33	12.3	13.4***
Yellow-breasted Chat (*Icteria virens*)					1	0.4	
Western Tanager (*Piranga ludoviciana*)	614	27.2	128	26.8	80	29.8	
Chipping Sparrow (*Spizella passerina*)	745	33.0	136	28.5	140	52.2	33.2***
Brewer's Sparrow (*Spizella breweri*)	135	6.0	20	4.2	94	35.0	115.6***
Lark Sparrow (*Chondestes grammacus*)					1	0.4	
Lincoln's Sparrow (*Melospiza lincolnii*)	11	0.5	4	0.8	5	1.9	
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)	1	<0.1					
Black-headed Grosbeak (*Pheucticus melanocephalus*)	155	6.9	26	5.4	15	5.6	
Lazuli Bunting (*Passerina amoena*)	247	11.0	104	21.8	86	32.0	9.3**
Bullock's Oriole (*Iceterus bullockii*)	15	0.7	1	0.2	2	0.8	
Neotropical migrant totals	10 622	470.9	2352	492.5	1105	411.6	34.5***
Temperate migrants							
Sharp-shinned Hawk (*Accipiter striatus*)	14	0.6	6	1.3	2	0.8	
Copper's Hawk (*Accipiter cooperii*)	2	0.1	2	0.4			
Northern Saw-whet Owl (*Aegolius acadicus*)					1	0.4	
Northern Flicker (*Colaptes auratus*)	11	0.5			1	0.4	
Blue Jay (*Cyanocitta cristata*)	1	<0.1					
Rock Wren (*Salpinctes obsoletus*)	1	<0.1					

TABLE 3. Continued.

	Mountain shrubland				Willow riparian 1998–1999		
	1997–2002		1998–1999				
Species	Captures	Rate	Cap-tures	Rate	Captures	Rate	χ^2_1
Canyon Wren (*Catherpes mexicanus*)	2	0.1					
Winter Wren (*Troglodytes troglodytes*)	3	0.1	2	0.4	6	2.2	
Golden-crowned Kinglet (*Regulus satrapa*)	415	18.4	64	13.4	47	17.5	
Ruby-crowned Kinglet (*Regulus calendula*)	6788	301.0	918	192.2	198	73.8	252.3***
Townsend's Solitaire (*Myadestes townsendi*)	282	12.5	66	13.8	5	1.9	43.3***
Hermit Thrush (*Catharus guttatus*)	177	7.9	42	8.8	10	3.7	9.6**
American Robin (*Turdus migratorius*)	124	5.5	16	3.4	8	3.0	
Cedar Waxwing (*Bombycilla cedrorum*)	12	0.5	2	0.4			
Yellow-rumped Warbler (*Dendroica coronata*)	1190	52.8	136	28.5	63	23.5	
Spotted Towhee (*Pipilo maculatus*)	1070	47.4	324	67.8	133	49.5	13.5***
American Tree Sparrow (*Spizella arborea*)	1	<0.1					
Vesper Sparrow (*Pooecetes gramineus*)	22	1.0	7	1.5	20	7.5	19.6***
Savannah Sparrow (*Passerculus sandwichensis*)	3	0.1	2	0.4	4	1.5	
Fox Sparrow (*Passerella iliaca*)	59	2.6	20	4.2	9	3.4	
Song Sparrow (*Melospiza melodia*)	4	0.2			4	1.5	
White-crowned Sparrow (*Zonotrichia leucophrys*)	1659	73.6	527	110.4	526	195.9	114.3***
Golden-crowned Sparrow (*Zonotrichia atricapilla*)	11	0.5	4	0.8	6	2.2	
Dark-eyed Junco (*Junco hyemalis*)	3096	137.3	615	128.8	464	172.8	30.9***
Temperate migrant totals	14 947	662.7	2753	576.5	1507	561.4	
Residents[b]							
Ruffed Grouse (*Bonasa umbellus*)	1	<0.1	1	0.2			
California Quail (*Callipepla californica*)	2	0.1			1	0.4	
Northern Pygmy-Owl (*Glaucidium gnoma*)	12	0.5	3	0.6	1	0.4	
Downy Woodpecker (*Picoides pubescens*)	4	0.2	1	0.2			
Hairy Woodpecker (*Picoides villosus*)	3	0.1	1	0.2			
Steller's Jay (*Cyanocitta stelleri*)	8	0.4	2	0.4	1	0.4	
Black-capped Chickadee (*Poecile atricapilla*)	126	5.6	16	3.4	12	4.5	
Mountain Chickadee (*Poecile gambeli*)	309	13.7	41	8.6	5	1.9	20.5***
Chestnut-backed Chickadee (*Poecile rufescens*)	1	<0.1					

TABLE 3. Continued.

	Mountain shrubland				Willow riparian 1998–1999		
	1997–2002		1998–1999				
Species	Captures	Rate	Captures	Rate	Captures	Rate	χ^2_1
Bushtit (*Psaltriparus minimus*)	1	<0.1					
Red-breasted Nuthatch (*Sitta canadensis*)	400	17.7	39	8.2	114	42.5	114.3***
Brown Creeper (*Certhia americana*)	47	2.1	16	3.4	22	8.2	9.6**
Cassin's Finch (*Carpodacus cassinii*)	35	1.6	4	0.8			
Red Crossbill (*Loxia curvirostra*)	2	0.1			7	2.6	
Pine Siskin (*Carduelis pinus*)	338	15.0	14	2.9	173	64.4	268.4***
Evening Grosbeak (*Coccothraustes verspertinus*)	7	0.3					
Resident totals	1296	57.5	138	28.9	336	125.2	285.0***
Overall totals	26 885	1191.1	5243	1097.9	2948	1098.2	

[a] Likely both Pacific-slope (*Empidonax difficilis*) and Cordilleran (*E. occidentalis*) Flycatchers based on Pyle 1997.

[b] Including irruptive migrants.

son, the $\hat{S}_n$ at $n = 2000$ captures was 50 species for mountain shrubland and 55 species for willow riparian (rarefaction curve is very similar to that for pooled data, see Fig. 4b). Thus, as with data from count surveys, willow riparian appeared to accumulate species at a slightly higher rate than mountain shrubland. Shannon diversity and evenness values were similar among sites ($H = 2.98$ for mountain shrubland and 3.01 for willow riparian; $J = 0.74$ for both mountain shrubland and willow riparian). Morisita's index of community similarity was 0.82 for all 1998–1999 captures. The I_M value was 0.87 for Neotropical migrants and 0.84 for temperate migrants; thus, the least overlap among sites occurred for residents.

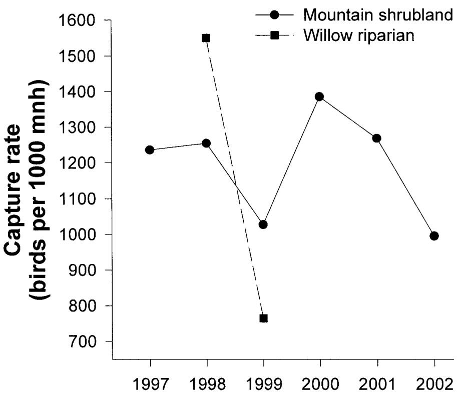

FIGURE 3. Capture rates (birds per 1000 mnh) for all birds in the mountain shrubland site, 1997–2002, and in the willow riparian site, 1998–1999, in the Boise Foothills, Idaho.

Pooled capture and count data (1998–1999). The total number of species detected by pooled survey and capture data was 67 in mountain shrubland and 66 in willow riparian. The $\hat{S}_n$ at $n = 500$ birds was 40 species for mountain shrubland and 42 species for willow riparian, whereas at $n = 3000$ birds, $\hat{S}_n$ was 57 species for mountain shrubland and 63 species for willow riparian (Fig. 4b). Although not tested statistically, rarefaction from pooled data may suggest that willow riparian supports a higher species richness potential than the mountain shrubland site. As with capture data, the following community metrics were derived from common banding days only: Shannon diversity values were 2.93 for mountain shrubland and 2.91 for willow riparian, and evenness values were 0.70 for mountain shrubland and 0.70 for willow riparian. Morisita's index of community similarity for all species was 0.77 for mountain shrubland × willow riparian. This value represents high community overlap among habitats and closely

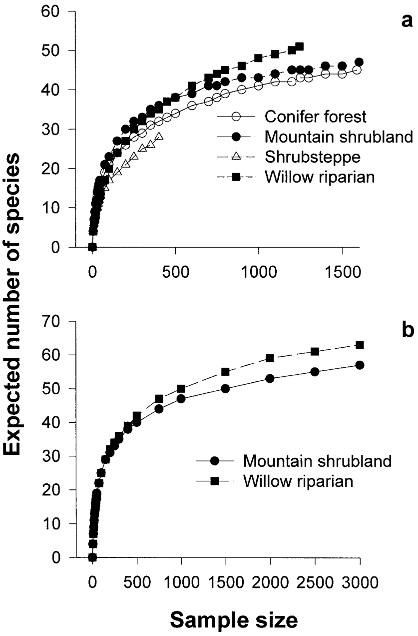

FIGURE 4. Rarefaction curves for (a) count surveys from 1997–2000 for conifer forest, mountain shrubland, shrubsteppe, and willow riparian habitats and (b) pooled count and capture data from 1998–1999 for mountain shrubland and willow riparian habitats in the Boise Foothills, Idaho. Curves compare species richness by providing the expected number of species detected for a given sample size (number of total birds detected) from the different habitats.

matches the I_M between these two sites generated by count survey data (0.73; 1997–2000) and capture data (0.82). The I_M was 0.84 for Neotropical migrants and 0.77 for temperate migrants.

COMPARING COUNT SURVEY AND CAPTURE DATA

We detected 89 species using count surveys and mist netting, including 81 species in mountain shrubland (1997–2000) and 64 species in willow riparian (1998–1999). In mountain shrubland, seven species (9%) were not captured in mist nets and 31 species (38%) were not detected in count surveys. In willow riparian, five species (8%) were not captured whereas 26 species (41%) were not detected in count surveys. The count-only species were larger birds or birds whose behavior tended to keep them above net level (e.g., Galliformes, bluebirds), whereas the capture-only species were mostly passerines that were rarely captured at the site or are rare in Idaho altogether (i.e., secretive sparrows and vagrants). Total numbers of individuals (log transformed and standardized) detected by both methods in willow riparian (34 species) were significantly correlated ($r = 0.62$, $P < 0.001$). Detections of temperate migrants ($n = 14$) were most strongly correlated ($r = 0.88$, $P < 0.001$), whereas detections of Neotropical migrants ($n = 14$) were less strongly correlated ($r = 0.52$, $P = 0.06$). Detections of the 43 species sampled by both methods in mountain shrubland (1997–2000) were significantly correlated ($r = 0.59$, $P < 0.001$). Detections of both temperate migrants ($n = 13$, $r = 0.78$, $P < 0.01$) and Neotropical migrants ($n = 19$, $r = 0.69$, $P < 0.01$) were strongly correlated.

DISCUSSION

HABITAT ASSOCIATIONS AND RELATIVE ABUNDANCE

Our study examined habitat associations of migrant landbirds in four upland habitats in Idaho. Count surveys in the Boise Foothills revealed that deciduous habitats, including mountain shrubland and willow-dominated riparian shrub communities, supported higher abundance and species richness of fall migrants than conifer forest and shrubsteppe habitats. The few exceptions include Brewer's Sparrow, which was most abundant in shrubsteppe, and Golden-crowned Kinglet and Yellow-rumped Warbler, which tended to be most commonly detected in conifer

TABLE 4. Morisita's index of community similarity (I_M) for count survey data 1997–2000. Values in upper right are for Neotropical migrants; values in lower left are for temperate migrants. Higher values (closer to 1) indicate greater similarity.

Habitat	Conifer forest	Mountain shrubland	Shrubsteppe	Willow riparian
Conifer forest		0.53	0.02	0.16
Mountain shrubland	0.62		0.08	0.61
Shrubsteppe	0.25	0.61		0.55
Willow riparian	0.33	0.77	0.90	

forest. Residents and irruptive migrants were most abundant in conifer forest and, secondarily, in mountain shrubland. Of the irruptive migrants, only Red-breasted Nuthatch and Pine Siskin were commonly detected in willow riparian and none were common in shrubsteppe.

Capture results, collected only from mountain shrubland and willow riparian, were broadly similar to count results. We acknowledge that caution should be exercised when comparing relative abundance among habitats using mist-net capture results (e.g., Remsen and Good 1996). However, we feel confident in doing so for the following reasons: (1) habitat structure is very similar in the mountain shrubland and willow riparian habitats (Rocklage and Kaltenecker; unpubl. data), (2) migrants tend to be more mobile than the breeding birds in Remsen and Good's (1996) modeling, and (3) relative abundances from count surveys and mist-net captures were similar between the two habitats for both Neotropical and temperate migrants. While migrant capture rates were high at both the mountain shrubland and willow riparian sites, the higher capture rates of Neotropical migrants in mountain shrubland emphasize the importance of a habitat largely overlooked in the literature. The habitat × year interaction in capture rates observed in 1998 and 1999, especially at the willow riparian site, is noteworthy. Several factors may help explain this pattern. First, capture rates in mountain shrubland also dropped from 1998–1999 (by over 18%); while not as extreme as the decrease in the willow riparian capture rate, this may indicate that fewer migrants overall were present in 1999. While difficult to corroborate with count results because different methods were used between years, Figure 2 also suggests that fewer birds were detected on count surveys in 1999 relative to 1998 in all habitats. Also, we noticed that the willow riparian site seemed drier and therefore less suitable to migrants in 1999 relative to 1998.

In contrast to results from count surveys, we captured more irruptive migrants in willow riparian than in mountain shrubland and this difference was driven by irruptions of Red-breasted Nuthatches in 1998 and Pine Siskins in 1999. However, irruptions of both species, as well as Mountain Chickadee, in 2001 were reflected in the mountain shrubland capture results. This suggests that both habitats may be used by irruptive migrants, at least in some years, possibly depending on environmental conditions.

Comparing avian abundance across studies can be misleading due to differences in habitat structure, methods, and detectability of birds (Remsen and Good 1996, Rosenstock et al. 2002, Thompson 2002). However, such comparisons may at least suggest differences in avian use of different sites. Density estimates, capture rates, and species richness for autumn migrants in this study compare favorably to other studies in the western and central United States (Hutto 1985, Wang and Finch 1997, Skagen et al. 1998). In fact, capture rates from this study were generally greater than those reported in other studies (Mewalt and Kaiser 1988, Winker et al. 1992, Taylor et al. 1994, Wang and Finch 1997, Swanson et al. 2003).

When assessing the importance of habitats for migrants, caution is necessary because abundance of migrants does not necessarily correlate with the suitability of that habitat for stopover (Winker 1995). In fact, migrants may lose mass at certain stopover sites that concentrate migrants due to their topography (Hansson and Pettersson 1989). Also, migrant density can affect food availability and the ability of migrants to gain mass (Moore and Wang 1991, Kelly et al. 2002). However, preliminary results (JDC, unpubl. data) suggest that migrants are able to at least maintain, if not gain, mass in our mountain shrubland and willow riparian study sites in Idaho. Thus, these deciduous habitats likely are important to Western migrants.

RICHNESS, DIVERSITY, AND COMMUNITY SIMILARITY

Willow riparian had the highest species richness of all habitats. Interestingly, for count survey data only, Shannon diversity and evenness values were lower for willow riparian than for conifer forest and mountain shrubland. While willow riparian had high species richness, the lower diversity and evenness values are explained by the proportionately larger number of species with five or fewer total observations detected in willow riparian. For capture data, as well as for pooled capture and count data, mountain shrubland and willow riparian had similar diversity and evenness values. Also, diversity and evenness values for willow riparian were higher from capture data than from count survey data. A discrepancy therefore exists between how count surveys and captures of birds portray the diversity and evenness of the migrant community in willow riparian. Thus, comparisons of diversity and evenness among habitats might be best served by combining methods (Rappole et al. 1998).

Mountain shrubland and willow riparian showed a relatively high degree of community similarity and less overlap with conifer forest and shrubsteppe, both of which had somewhat distinct bird communities. We detected more overlap among habitats for temperate migrants than for Neotropical migrants, and this may reflect the widespread habitat use exhibited by several common temperate migrants such as Ruby-crowned Kinglets, Spotted Towhees, Dark-eyed Juncos, and White-crowned Sparrows.

COMPARING COUNT SURVEY AND CAPTURE DATA

Migrant detection rates among survey and capture methods were significantly correlated in both mountain shrubland and willow riparian habitats. Similarly, Wang and Finch (2002) found general agreement between the two methods during spring and fall migration for three habitats in New Mexico. In our study, the most commonly counted species from surveys closely matched those most commonly captured by the netting effort. Consistent with these data, I_M values between mountain shrubland and willow riparian habitats were similar between count surveys and mist-netting. There were several notable exceptions. Birds for which the two methods produced divergent estimates of abundance were either: (1) very vocal and thus were counted more often than captured (e.g., Spotted Towhee); (2) fairly quiet and thus captured more often than detected on surveys (e.g., Nashville and Orange-crowned Warblers); (3) tended to stay in the forest canopy above net level (e.g., Cedar Waxwing); or (4) were too large to be captured efficiently by the mesh size of mist nets used in this study (e.g., Steller's Jay, American Robin, Spotted Towhee). Interestingly, there was a closer match for temperate than for Neotropical migrants in both habitats, and this could be attributed to some of the temperate migrants being more vocal and therefore more detectable on count surveys. Our results differed from those of Wang and Finch (2002), who conducted their work in both spring and fall, in that our count surveys missed more species than were missed by mist netting. Wang and Finch (2002) conducted more count surveys relative to their netting effort, and this may have allowed them to detect more species on counts. Also, our study occurred only during autumn migration, when most passerines are largely silent. As discussed in previous studies (e.g., Rappole et al. 1998, Wang and Finch 2002, Swanson et al. 2003), combining the two methods reduces inherent biases in either method and more accurately portrays the migrant community.

CONSERVATION IMPLICATIONS

The two deciduous habitats in this study, willow-dominated riparian shrubland and mountain shrubland, have limited distributions in Idaho and throughout the western United States. Shrubby riparian habitats make up less than 1% of Idaho's vegetation cover (Scott et al. 2002), and warm mesic shrubland, which includes the mountain shrubland described in this study, occupies about 4% of the state and is especially prevalent in and near the Boise Mountains (Scott et al. 2002). Riparian habitats in the western United States have suffered extensively from anthropogenic changes over the last century and the need for conservation of these important systems is already well documented (Bock et al. 1992, Belsky et al. 1999, Tewksbury et al. 2002). Mountain shrublands occur at edges of conifer forest and in response to fires and timber harvest (Mueggler 1965, Oakley and Franklin 1998) and is an important early successional habitat in mesic forested areas (Mueggler 1965).

The other two habitats in this study, conifer forest and shrubsteppe, are more widespread in the West, although anthropogenic influences have changed the extent and structure of both habitats (Bock et al. 1992, Dobkin 1994, Knick et al. 2003). Conifer forests are broadly but patchily distributed throughout the Intermountain West at middle- to high elevations (Barbour and Billings 1988, Hejl et al. 2002), and Douglas-fir forests make up approximately 7% of the land cover in Idaho (Scott et al. 2002). Shrubsteppe is a widespread but declining habitat in the western United States (Bock et al. 1992, Dobkin 1994, Knick et al. 2003) that occupies over 25% of Idaho (Scott et al. 2002). Population declines are apparent among breeding birds of the shrubsteppe, including Brewer's Sparrow (Dobkin 1994, Rotenberry et al. 1999), the most common migrant detected in shrubsteppe in this study. Conifer forest and shrubsteppe both served as stopover habitat for select migrants in this study (i.e., Golden-crowned Kinglet and Brewer's Sparrow, respectively), in addition to being important to resident birds. Also, some migrant species characteristic of the shrubsteppe were detected in riparian and mountain shrub habitats in this study (i.e., Brewer's and Vesper Sparrows) and it seems likely that as the shrubsteppe dries up in late summer, these migrants also spend time in more productive deciduous habitats (Rocklage and Kaltenecker, unpubl. data).

In summary, results from both count surveys and mist netting showed that many Western migrant landbirds occurred in the Boise Foothills during fall migration and a high proportion of these species passed through in large numbers. Overall, the highest abundance and diversity of migrant species occurred in our two deciduous habitats, while a few species were more common in conifer forest or shrubsteppe. In addition to the importance of the deciduous habitats, the mosaic pattern and intermingling of four habitats likely enables the Boise Foothills to support such a high abundance and richness of migrants. This mosaic pattern occurs throughout the mountains of southern Idaho (Scott et al. 2002) and much of the Intermountain West (George and Dobkin 2002). Also, the hot and dry autumn weather across much of western North America may push many migrants to higher elevations in search of cooler temperatures and higher arthropod and fruit availability (Austin 1970). Results in this study further support the hypothesis that Western montane habitats provide critical stopover habitat, especially during autumn (Austin 1970, Greenberg et al. 1974, Blake 1984, Hutto 1985). Thus, conserving middle to high elevation sites in western North America, especially those with deciduous habitat components, may be a key component in the conservation of migratory landbirds.

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LITERATURE CITED

AUSTIN, G. T. 1970. Migration of warblers in southern Nevada. Southwestern Naturalist 15:231–237.

BARBOUR, M. G., AND W. D. BILLINGS [EDS.]. 1988. North American terrestrial vegetation. Cambridge University Press, Cambridge, UK.

BELSKY, A. J., A. MATZKE, AND S. USELMAN. 1999. Survey of livestock influences on stream and riparian ecosystems in the western United States. Journal of Soil and Water Conservation 54:419–431.

BIBBY, C. J., AND D. A. HILL. 1992. Bird census techniques. Academic Press, London.

BLAKE, J. G. 1984. A seasonal analysis of bird communities in southern Nevada. Southwestern Naturalist 29:463–474.

BOCK, C. E., V. A. SAAB, T. D. RICH, AND D. S. DOBKIN. 1992. Effects of livestock grazing on Neotropical migratory landbirds in western North America, p. 296–309. *In* D. M. Finch and P. W. Stangel [EDS.], Status and management of Neotropical migratory birds. USDA Forest Service General Technical Report RM-GTR-229.

BROWER, J. E., J. H. ZAR, AND C. N. VON ELDE. 1990. Field and laboratory methods for general ecology. 4th ed. McGraw Hill, Boston, MA.

BUCKLAND, S. T., D. R. ANDERSON, K. P. BURNHAM, J. L. LAAKE, D. L. BORCHERS, AND L. THOMAS. 2001. Introduction to distance sampling. Oxford University Press, London.

DEGRAAF, R. M., AND J. H. RAPPOLE. 1995. Neotropical migratory birds: natural history, distribution, and population change. Cornell University Press, Ithaca, NY.

DESANTE, D. F., AND T. L. GEORGE. 1994. Population trends in the landbirds of western North America. Studies in Avian Biology 15:173–190.

DOBKIN, D. S. 1994. Conservation and management of Neotropical migratory landbirds in the northern

Rockies and Great Plains. University of Idaho, Moscow, ID.

George, T. L., and D. S. Dobkin [eds]. 2002. Effects of habitat fragmentation on birds in Western landscapes: contrasts with paradigms from the eastern United States. Studies in Avian Biology 25.

Greenberg, R., T. Keeler-Wolf, and V. Keeler-Wolf. 1974. Wood warbler populations in the Yolla Bolly Mountains of California. Western Birds 5:81–90.

Hansson, M., and J. Pettersson. 1989. Competition and fat deposition in Goldcrests (*Regulus regulus*) at a migration stop-over site. Die Vogelwarte 35: 21–31.

Hejl, S. J., D. E. Mack, J. S. Young, J. C. Bednarz, and R. L. Hutto. 2002. Birds and changing landscape patterns in conifer forests of the north-central Rocky Mountains. Studies in Avian Biology 25:113–129.

Hutto, R. L. 1985. Seasonal changes in the habitat distribution of transient insectivorous birds in southeastern Arizona: competition mediated? Auk 102:120–132.

Hutto, R. L. 1988. Is tropical deforestation responsible for the reported declines in Neotropical migrant populations? American Birds 42:375–379.

Hutto, R. L. 1998. On the importance of stopover sites to migrating birds. Auk 115:823–825.

Hutto, R. L., S. M. Pletschet, and P. Hendricks. 1986. A fixed-radius point count method for nonbreeding and breeding season use. Auk 103:593–602.

James, F. C., and S. Rathbun. 1981. Rarefaction, relative abundance, and diversity of avian communities. Auk 98:785–800.

Kelly, J. F., L. S. DeLay, and D. M. Finch. 2002. Density-dependent mass gain by Wilson's Warblers during stopover. Auk 119:210–213.

Knick, S. T., D. S. Dobkin, J. T. Rotenberry, M. A. Shroeder, W. M. Vander Haegen, and C. van Riper III. 2003. Teetering on the edge or too late? Conservation and research issues for the avifauna of sagebrush habitats. Condor 105:611–634.

Mewalt, L. R., and S. Kaiser. 1988. Passerine migration along the inner Coast Range of central California. Western Birds 19:1–23.

Moore, F. R., and Y. Wang. 1991. Evidence of food-based competition among passerine migrants during stopover. Behavioral Ecology and Sociobiology 28:85–90.

Moore, F. R., S. A. Gauthreaux Jr., P. Kerlinger, and T. R. Simons. 1995. Habitat requirements during migration: important link in conservation, p. 121–144. *In* T. E. Martin and D. M. Finch [eds.], Ecology and management of Neotropical migratory birds. Oxford University Press, New York.

Mueggler, W. F. 1965. Ecology of seral shrub communities in the cedar-hemlock zone of northern Idaho. Ecological Monographs 35:165–185.

Oakley, B. B., and J. F. Franklin. 1998. Bitter cherry (*Prunus emarginata*) distribution, successional dynamics, and implications for the role of the seed bank. Canadian Journal of Botany 76:1725–1732.

Petit, D. R. 2000. Habitat use by landbirds along Nearctic-Neotropical migration routes: implications for conservation of stopover habitats. Studies in Avian Biology 20:15–33.

Pyle, P. 1997. Identification guide to North American birds. Part 1. Slate Creek Press, Bolinas, CA.

Ralph, C. J., G. R. Geupel, P. Pyle, T. E. Martin, and D. F. DeSante. 1993. Handbook of field methods for monitoring landbirds. USDA Forest Service General Technical Report PSW-GTR-144.

Rappole, J. H., M. A. Ramos, R. J. Oehlenschlager, D. W. Warner, and C. P. Barkan. 1979. Timing of migration and route selection in North American songbirds, p. 199–214. *In* D. L. Drawe [ed.], Proceedings of the first Welder Wildlife Foundation symposium. Welder Wildlife Foundation, Sinton, TX.

Rappole, J. H., K. Winker, and G. V. N. Powell. 1998. Migratory bird habitat use in southern Mexico: mist nets versus point counts. Journal of Field Ornithology 69:635–643.

Remsen, J. V., and D. A. Good. 1996. Misuse of data from mist-net captures to assess relative abundance in bird populations. Auk 113:381–398.

Rice, W. R. 1989. Analyzing tables of statistical tests. Evolution 43:223–225.

Robbins, C. S., J. R. Sauer, R. S. Greenberg, and S. Droege. 1989. Population declines in North American birds that migrate to the Neotropics. Proceedings of the National Academy of Sciences 86:7658–7662.

Rotenberry, J. T., M. A. Patten, and K. L. Preston. 1999. Brewer's Sparrow (*Spizella breweri*). *In* A. Poole and F. Gill [eds.], The birds of North America, No. 390. The Birds of North America, Inc., Philadelphia, PA.

Rosenstock, S. S., D. R. Anderson, K. M Geisen, T. Leukering, and M. F. Carter. 2002. Landbird counting techniques: current practices and an alternative. Auk 119:46–53.

Scott, J. M., C. R. Peterson, J. W. Karl, E. Strand, L. K. Svancara, and N. M. Wright. 2002. A Gap analysis of Idaho: final report. Idaho Cooperative Fish and Wildlife Research Unit, Moscow, ID.

Sherry, T. W., and R. T. Holmes. 1995. Summer versus winter limitation of populations: conceptual issues and evidence, p. 85–120. *In* T. E. Martin and D. M. Finch [eds.], Ecology and management of Neotropical migratory birds. Oxford University Press, New York.

Sillett, T. S., and R. T. Holmes. 2002. Variation in survivorship of a migratory songbird throughout its annual cycle. Journal of Animal Ecology 71: 296–308.

Skagen, S. K., C. P. Melcher, W. H. Howe, and F. L. Knopf. 1998. Comparative use of riparian corridors and oases by migrating birds in southeast Arizona. Conservation Biology 12:896–909.

Swanson, D. L., H. A. Carlisle, and E. T. Liknes. 2003. Abundance and richness of Neotropical migrants during stopover at farmstead woodlots and associated habitats in southeastern South Dakota. American Midland Naturalist 149:176–191.

TAYLOR, D. M., D. F. DESANTE, G. R. GEUPEL, AND K. HOUGHTON. 1994. Autumn populations of landbirds along central coastal California 1976–1986. Journal of Field Ornithology 65:169–185.

TEWKSBURY, J. J., A. E. BLACK, N. NUR, V. A. SAAB, B. D. LOGAN, AND D. S. DOBKIN. 2002. Effects of anthropogenic fragmentation and livestock grazing on Western riparian bird communities. Studies in Avian Biology 25:158–202.

THOMAS, L., J. L. LAAKE, S. STRINDBERG, F. F. C. MARQUES, S. T. BUCKLAND, D. L. BORCHERS, D. R. ANDERSON, K. P. BURNHAM, S. L. HEDLEY, J. H. POLLARD, AND J. R. B. BISHOP. 2003. Distance 4.1 Release 1. Research Unit for Wildlife Population Assessment, University of St. Andrews, UK.

THOMPSON, W. L. 2002. Towards reliable bird surveys: accounting for individuals present but not detected. Auk 119:18–25.

WANG, Y., AND D. M. FINCH. 1997. Population trends of migratory landbirds along the middle Rio Grande. Southwestern Naturalist 42:137–147.

WANG, Y., AND D. M. FINCH. 2002. Consistency of mist netting and point counts in assessing landbird species richness and relative abundance during migration. Condor 104:59–72.

WANG, Y., D. M. FINCH, F. R. MOORE, AND J. F. KELLY. 1998. Stopover ecology and habitat use of migratory Wilson's Warblers. Auk 115:829–842.

WINKER, K. 1995. Habitat selection in woodland Nearctic-Neotropical migrants on the Isthmus of Tehuantepec I. Autumn migration. Wilson Bulletin 107:26–39.

WINKER, K., D. W. WARNER, AND A. R. WEISBROD. 1992. Migration of woodland birds at a fragmented inland stopover site. Wilson Bulletin 104:580–598.

ZAR, J. H. 1996. Biostatistical analysis. Prentice Hall, NJ.