Riparian Songbird Abundance a Decade After Cattle Removal on Hart Mountain and Sheldon National Wildlife Refuges[1]

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Abstract

Cattle were removed from the high desert riparian habitats of Hart Mountain and Sheldon National Wildlife Refuges in 1990. This study compares songbird abundance in 2000-2001 to that in 1991-1993 on 69 permanent plots. Of the 51 species for which detections were sufficient to calculate changes in abundance, 71% (36/51) exhibited a positive trend and 76% (16/21) of species exhibiting a significant change (either positive or negative) increased. The average increase among the 51 species was equivalent to 3.0 detections/km^2. Increasing species included species of concern in the Columbia Plateau: Yellow Warbler (*Dendroica petechia*), White-crowned Sparrow (*Zonotrichia leucophrys*), Song Sparrow (*Melospiza melodia*), Dusky Flycatcher (*Empidonax oberholseri*), Warbling Vireo (*Vireo gilvus*), Mourning Dove (*Zenaida macroura*), MacGillivray's Warbler (*Oporornis tolmiei*), and Orange-crowned Warbler (*Vermivora celata*). Aspen and willow associates, but not meadow associates, exhibited a significant increase in detections/km^2. Detections of ground/low cup and high cup nesting species, but not cavity nesting species, increased significantly. Ground/understory foraging species, aerial, and overstory foraging species increased significantly in detections/km^2, but bark gleaning species did not. For the 16 significantly increasing species in this study, patterns of change on Breeding Bird Survey routes during 1980-1999 suggest that the changes documented here are not merely a reflection of regional patterns.

Key Words: aspen, cattle, grazing, Great Basin, riparian songbirds.

Introduction

During the last 15 years, much scientific and conservation attention has focused on the health of breeding songbird populations throughout the U.S. (e.g., Robbins et al. 1989; Martin and Finch 1995). In the semi-arid west, riparian habitats are of particular concern because they comprise only 1% of the landscape but support a higher diversity of breeding songbirds than any other habitat (Knopf et al. 1988a), and they have been severely affected by agriculture, recreation, timber harvest, water diversion, and particularly livestock grazing (Thomas et al. 1979; Chaney et al. 1990). Cattle deplete and sometimes eliminate riparian vegetation by grazing on the herbaceous layer and browsing on shrubs and young trees (Sedgwick and Knopf 1991), and they also cause soil compaction, channel widening, and lowering of the water table (Platts 1991).

Effects of cattle grazing on avian abundance has been demonstrated in several studies (see reviews in Saab et al. 1995; Tewksbury et al. 2002). In Saab et al.'s (1995) review of nine studies comparing species abundance in grazed and ungrazed systems, species most affected by grazing were primarily ground or near-ground nesting species and shrub nesting species, as expected from the greater effect that cattle have on the lower vegetation strata. Habitat generalists, canopy nesters, and cavity nesters tended to be less affected by grazing. However, effects throughout the avian community have been documented in cases where grazing has had a severe impact on vegetation (Krueper et al., 2003; Tewksbury et al., 2002).

The high desert riparian habitats of Hart Mountain and Sheldon National Wildlife Refuges (hereafter Hart and Sheldon), in southcentral Oregon and northwestern Nevada, respectively, are among those western landscapes affected by livestock grazing. On Hart, cattle were removed in the autumn of 1990, and a 15-year policy of no grazing was officially adopted in 1994 (USFWS 1994). Soon after cattle were removed, most riparian areas were classified as being in poor (50%) or moderate condition (25%) (USFWS 1994). Similarly, on Sheldon, season-long cattle grazing was recognized as one of the forces responsible for the poor health of riparian areas (USFWS 1981). Most cattle were removed in the autumn of 1990, although a few remained in one area until 1994, and an increasing feral horse

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population continued to impact some riparian areas throughout this study.

In 1991, the year following cattle removal on the refuges, a 3-year study of riparian songbird abundance and riparian vegetation condition was initiated. Dobkin (1994) found that cover of herbaceous vegetation had increased by the third year after cattle removal, consistent with both livestock removal and increased rainfall in the third year. The change in herbaceous vegetation was accompanied by a small increase in avian abundance, especially of ground and understory specialists (Dobkin 1994). There was little change in aspen or willow recruitment during the 3 years, consistent with the slow recovery of woody riparian vegetation. Dobkin et al. (1998) also compared riparian meadow plots inside a long-term livestock exclosure on Hart to adjacent plots recently grazed by cattle (1-3 years previously). They found that exclosure plots had higher avian species richness and abundance and were dominated by wetland and riparian birds rather than the upland species of recently grazed plots.

In this paper, we compare the abundance of riparian birds on a set of 69 plots surveyed 1-3 years and 11-12 years after livestock removal on Hart Mountain and Sheldon National Wildlife Refuges. Future analyses will include the final year of data collection (2002), and detailed vegetation measurements from each plot.

Study Area and Plots

Hart encompasses approximately 112,550 ha and includes Hart Mountain, a fault block that rises to 2,438 m elevation. Upland vegetation is primarily low sagebrush (*Artemisia arbuscula*), big sagebrush (*A. tridentata*) and silver sagebrush (*A. cana*) with some rabbitbrush (*Chrysothamnus* sp.). Riparian habitat provides the only trees except for scattered stands of mountain mahogany (*Cercocarpus ledifolius*), western juniper (*Juniper occidentalis*), a single stand of Ponderosa Pine (*Pinus ponderosa*), and white fir (*Abies concolor*) at higher elevations (USFWS 1994). Riparian habitats extend from 1,433 to 2,317 m in elevation, most are along narrow streams (<8 m width) varying from high to low gradient, and most zones of riparian vegetation are less than 50 m in width. Riparian habitat is classified into 6 cover types for the purpose of this study. Of the 134 linear km of riparian habitat on Hart, 29% is quaking aspen (*Populus tremuloides*) along perennial streams, 10% is quaking aspen in snow pockets (small, relatively high elevation depressions where snow collects), 11% willow (*Salix* sp.), 29% meadow (various species of grasses, sedges, and rushes), and 12% mixed deciduous shrub (including aspen, willow, black cottonwood, *Populus balsamifera*, mountain alder, *Alnus incana*, red-osier dogwood, *Cornus sericea*, waterbirch, *Betula occidentalis*, and chokecherry, *Prunus virginiana*). An additional 9% of stream-side zones are dominated by non-riparian shrubs either because the valley and riparian zone were naturally narrow or because upland shrubs, primarily big sagebrush, have encroached to the streamside.

Sheldon encompasses 232,800 ha of high desert, and although only 32 km south of Hart, the climate is hotter and drier. Average precipitation is 15 cm at lower elevations (1,280 m) and 33 cm at higher elevations (2,225 m) at Sheldon (USFWS 1981), compared to 25.0 - 37.5 cm at Hart. The expansive uplands are broken by narrow canyons, rolling valleys, and broad rimrock tables. Upland vegetation is dominated by big sagebrush, low sagebrush, rabbitbrush, bitterbrush (*Purshia tridentata*), and greasewood (*Sarcobatus vermiculatus*). A few mountain mahogany, western juniper, and quaking aspen stands occur at higher elevations. Of the 83 linear km of riparian habitat on Sheldon, which occur primarily along Hell, Virgin, Thousand, Fish, and Badger Creeks, 52% is dominated by meadow, 12% by willow, and 7% by mixed deciduous shrubs. As much as 29% of riparian areas, however, are classified as non-riparian shrub (*Table 1*). The amount of aspen and snow pocket aspen is negligible.

Table 1— *Distribution of avian plots relative to cover type availability (in km) on Hart Mountain and Sheldon National Wildlife Refuges. Riparian aspen includes some aspen in valleys but not along perennial stream segments. Proportion of length (km) is the proportion of the total perennial stream lengths on a refuge made up by each cover type.*

	Hart Mountain			Sheldon			
Cover type	**Length (km)**	**Prop. length**	**No. Plots**	**Length (km)**	**Prop. length**	**No. Plots**	**Total Plots**
Meadow	39.0	0.29	7	42.7	0.52	9	16
Riparian Aspen	39.0	0.29	18	--	--	0	18
Snow Pocket Aspen	13.8	0.10	9	--	--	0	9
Willow	14.3	0.11	5	10.3	0.12	10	15
Nonriparian Shrub	12.2	0.09	8	24.3	0.29	1	9
Mixed Deciduous	16.1	0.12	0	5.7	0.07	2	2
Total	**133.9**		**47**	**82.9**		**22**	**69**

Plots were established in five cover types on five drainages on Hart (n = 47) and four cover types in six drainages on Sheldon (n = 22) (*Table 1*). Of the 18 riparian aspen plots, all of which were on Hart, 14 were within multi-aged, mature stands; two were within decadent stands that had little or no regeneration and a large proportion of dead trees; and two were within a dense, even-aged stand that had burned in a 1972 wildfire. Stands of snow pocket aspen consist of trees that are shorter and more scrub-like than those in mature riparian aspen stands, but most also have some mature trees interspersed (Dobkin et al. 1995). Willow stands on riparian plots were typically narrow (<50 m) and varied substantially in sparseness and structural diversity. The two mixed deciduous plots, both along Idaho Creek on Sheldon, were in narrow, dense stands of mountain alder, red-osier dogwood, willow, and snowberry (*Symphoricarpos oreophilus*). Meadow plots varied from dry to moist to marshy, and from narrow strips surrounded by non-riparian shrub, to meadows extending the width of the plot. Seven meadow plots (4 in 1985 and 3 since 1993) and two willow plots (1990 and 1999) have undergone prescribed burning, and an additional 1-3 meadow plots were affected by a 1972 wildfire.

Methods

Each plot was 150 m long by 100 m wide, and most plots were at least 250 m apart. The width of the riparian vegetation on a plot ranged from <5 m to 100 m, but was typically less than the width of the plot. The center-line of the plot, which was marked at 50-m increments with permanent steel fence posts, ran near and parallel to the stream. Each plot was surveyed 3 times during 8 May – 24 June in 2000 and 17 May – 25 June in 2001. In 2001, 4 observers conducted surveys in a balanced design such that, except for a few exceptions, no person surveyed the same plot twice. Two observers conducted all surveys in 2000. In 1991-1993, each plot was surveyed six times, once on each of two consecutive days during each of 3 survey rounds during 7 May – 11 July (Dobkin and Rich 1998). In both 1991-1993 and 2000-2001, the order in which plots were surveyed within a day (and within a drainage) alternated between consecutive visits. During a survey, an observer walked slowly along the center-line recording the first occurrence of each individual seen or heard within the plot. Surveys were conducted between 0.25 and 3.5 hours after sunrise, and time allowed for a survey depended on cover type – 25 min in aspen, 20 in willow, and 15 in meadow or non-riparian shrub. Results provided an index to avian species abundance.

For each of the 69 plots, mean detections per visit were averaged among visits within a year, then among years within a phase (i.e., 1991-1993 and 2000-2001 are phases). The difference between phases was then calculated. The mean difference across all plots was calculated for each species and a paired t-test was used to determine whether the difference for each species was significantly different from 0. As a means of restricting the analysis to those species having a large enough sample to provide a reasonable power to detect a difference, only the 51 species with an average of ≥ 0.02 detections per plot-visit (equivalent to ≥ 1.3 detections /km^2) in either phase were used.

The comparison is restricted to passerines, doves, woodpeckers, and shorebirds that either nest or forage primarily in riparian habitat within the Hart-Sheldon landscape; shrubsteppe specialists are excluded because it is not clear how they would be expected to change as the riparian vegetation replaces shrubsteppe vegetation within plots but the shrubsteppe vegetation also improves. In three cases, "species" are combinations of species that were created to keep data recording and species identification consistent between phases. *Empidonax* includes Hammond's, Cordilleran, Pacific-slope, and Willow Flycatchers, unidentified flycatchers, and the Olive-sided Flycatcher (genus *Contopus*); Dusky and Gray Flycatchers were analyzed separately. Hummingbird species include Broad-tailed, Calliope, and Rufous Hummingbirds, and unidentified hummingbirds. Sapsuckers include Red-naped and Red-breasted Sapsuckers, hybrids, and those recorded as unidentified. Scientific names for species mentioned in the text are given in *Table 2*.

Species were assigned to primary habitats (aspen, willow, or meadow) based on the cover type in which its mean detections per plot-visit was highest in this study. Species were assigned to nesting guilds (ground/low cup, high cup, and cavity) and foraging guilds (ground /understory, overstory, aerial, and bark) based on Dobkin (1994) and Ehrlich et al. (1988). Within each guild, the proportion of species exhibiting a change was compared to 0.50, the proportion expected by chance, using a binomial test. Change in detections/km^2 (i.e., phase II – phase I) was calculated for each guild by pooling detections for all species within each guild and treating the plot as the primary sampling unit. Paired t-tests were used to determine whether the change in detections/km^2 was significantly different from 0 for each guild, and one-way ANOVAs were used to test for differences among guilds in change in detections/km^2. Standard errors are reported with means throughout the text and tables.

Table 2— *Species exhibiting significant increases and decreases in detections between 1991-1993 and 2000-2001. Changes in detections/km^2 are paired differences using the 69 original plots as sampling units; statistical significance based on paired t-tests with (*) p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001. Species categorized by foraging and nesting guilds based on Dobkin (1994) and Ehrlich et al. (1988). Habitat association is the habitat in which the species was most often recorded in this study. Species in bold are riparian species of concern based on BBS trends (1966-1999) and Partners in Flight prioritization (see Methods).*

Species	Scientific name	Change in detections per km^2	Foraging guild	Nesting guild	Habitat association
Increasing species					
Yellow Warbler	***Dendroica petechia***	**28.2 *** **	**Understory**	**Grnd/Low C**	**Willow**
White-crowned Sparrow	***Zonotrichia leucophrys***	**24.3 *** **	**Ground**	**Grnd/Low C**	**Aspen**
Song Sparrow	***Melospiza melodia***	**23.0 *** **	**Ground**	**Grnd/Low C**	**Willow**
Savannah Sparrow	*Passerculus sandwichensis*	17.9 **	Ground	Grnd/Low C	Meadow
Tree Swallow	*Tachycineta bicolor*	16.9 **	Aerial	Cavity	Aspen
Red-winged Blackbird	*Agelaius phoeniceus*	16.4	Ground	Grnd/Low C	Meadow
Dusky Flycatcher	***Empidonax oberholseri***	**12.2 *** **	**Aerial**	**Grnd/Low C**	**Aspen**
Warbling Vireo	***Vireo gilvus***	**9.4 *** **	**Overstory**	**High Cup**	**Aspen**
House Finch	*Carpodacus mexicanus*	8.5 **	Ground	High Cup	Aspen
Cliff Swallow	*Petrochelidon pyrrhonota*	7.7	Aerial	Other	Meadow
Common Snipe	*Gallinago gallinago*	5.9 *	Ground	Grnd/Low C	Meadow
Killdeer	***Charadrius vociferus***	**5.6 (*)**	**Ground**	**Grnd/Low C**	**Meadow**
Mourning Dove	***Zenaida macroura***	**5.5 ***	**Ground**	**Grnd/Low C**	**Willow**
MacGillivray's Warbler	***Oporornis tolmiei***	**3.9 ****	**Understory**	**Grnd/Low C**	**Aspen**
Empidonax[a]	***Empidonax* spp**	**3.7 (*)**	**Aerial**	**Grnd/Low C**	**Aspen**
Dark-eyed Junco	*Junco hyemalis*	3.7 **	Ground	Grnd/Low C	Aspen
Western Tanager	*Piranga ludoviciana*	3.4 *	Overstory	High Cup	Aspen
Brown-headed Cowbird	*Molothrus ater*	3.3	Ground	Other	Willow
Orange-crowned Warbler	***Vermivora celata***	**3.1 ***	**Overstory**	**Grnd/Low C**	**Aspen**
Spotted Towhee	*Pipilo maculatus*	3.1 **	Ground	Grnd/Low C	Aspen
Fox Sparrow	*Passerella iliaca*	2.2 (*)	Ground	Grnd/Low C	Aspen
Yellow-rumped Warbler	*Dendroica coronata*	2.1	Overstory	High Cup	Aspen
Mountain Bluebird	*Sialia currucoides*	1.8	Aerial	Cavity	Aspen
Yellow-breasted Chat	***Icteria virens***	**1.6**	**Ground**	**Grnd/Low C**	**Willow**
Black-headed Grosbeak	*Pheucticus melanocephalus*	1.3	Overstory	High Cup	Aspen
Say's Phoebe	*Sayornis saya*	1.2 *	Aerial	Other	Willow
American Robin	*Turdus migratorius*	1.0	Ground	High Cup	Aspen
Western Wood-Pewee	***Contopus sordidulus***	**0.6**	**Aerial**	**High Cup**	**Aspen**
Common Yellowthroat	*Geothlypis trichas*	0.5	Understory	Grnd/Low C	Willow
Hairy Woodpecker	*Picoides villosus*	0.5	Bark	Cavity	Aspen
Violet-green Swallow	*Tachycineta thalassina*	0.4	Aerial	Cavity	Meadow
Cassin's Finch	***Carpodacus cassinii***	**0.3**	**Ground**	**High Cup**	**Aspen**
Northern Flicker	***Colaptes auratus***	**0.3**	**Bark**	**Cavity**	**Aspen**
White-throated Swift	***Aeronautes saxatalis***	**0.2**	**Aerial**	**Other**	**Willow**
Sora	*Porzana carolina*	0.2	Ground	Grnd/Low C	Meadow
Barn Swallow	***Hirundo rustica***	**0.0**	**Aerial**	**Other**	**Meadow**
Decreasing species					
House Wren	*Troglodytes aedon*	-17.6 **	Understory	Cavity	Aspen
European Starling	*Sturnus vulgaris*	-13.3 **	Ground	Cavity	Aspen
Wilson's Phalarope	***Phalaropus tricolor***	**-11.0 (*)**	**Ground**	**Grnd/Low C**	**Meadow**
Bullock's Oriole	***Icterus bullockii***	**-4.0 *** **	**Overstory**	**High Cup**	**Aspen**
Willet	*Catoptrophorus semipalmatus*	-3.3 (*)	Ground	Grnd/Low C	Meadow

Table 2– *contd.*

Species	Scientific name	Change in detections per km^2	Foraging guild	Nesting guild	Habitat association
Decreasing species (contd.)					
Brewer's Blackbird	***Euphagus cyanocephalus***	**-3.2**	**Ground**	**Grnd/Low C**	**Meadow**
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	-3.0	Ground	Grnd/Low C	Meadow
Ruby-crowned Kinglet	***Regulus calendula***	**-2.4 ****	**Overstory**	**High Cup**	**Willow**
Lazuli Bunting	***Passerina amoena***	**-2.2**	**Ground**	**Grnd/Low C**	**Willow**
Western Meadowlark	***Sturnella neglecta***	**-2.0**	**Ground**	**Grnd/Low C**	**Meadow**
Wilson's Warbler	***Wilsonia pusilla***	**-1.7 ***	**Understory**	**Grnd/Low C**	**Willow**
Hummingbird species[b]	***Selasphorus/Stellula***	**-0.8**	**Understory**	**Grnd/Low C**	**Aspen**
Swainson's Thrush	***Catharus ustulatus***	**-0.8**	**Understory**	**Grnd/Low C**	**Aspen**
Sapsuckers[c]	***Sphyrapicus nuchalis, S. ruber***	**-0.4**	**Bark**	**Cavity**	**Aspen**
Downy Woodpecker	*Picoides pubescens*	-0.2	Bark	Cavity	Aspen

[a]Includes: Hammond's Flycatcher (*Empidonax hammondii*), Cordilleran Flycatcher (*E. occidentalis*), Pacific-slope Flycatcher (*E. difficilis*), Willow Flycatcher (*E. traillii*), and one *Contopus*, the Olive-sided Flycatcher (*Contopus cooperi*).
[b]Includes: Broad-tailed Hummingbird (*Selasphorus platycercus*), Calliope Hummingbird (*Stellula calliope*), and Rufous Hummingbird (*Selasphorus rufus*).
[c]Includes: Red-naped Sapsucker (*Sphyrapicus nuchalis*) and Red-breasted Sapsucker (*Sphyrapicus ruber*) and those recorded as hybrid or unidentified sapsuckers.

Riparian species of concern, for the purpose of this study, are those riparian associates that had either (1) a significant declining trend on North American Breeding Bird Survey (BBS) routes within U.S. Fish and Wildlife Service Region 1, which includes California, Oregon, Washington, Nevada, and Idaho; (2) a significant declining trend on BBS routes in the Columbia Plateau physiographic area; (3) a Partners in Flight score for the Columbia Basin >20; or (4) an Oregon Management Index score >10. The latter two scores, obtained from Partners in Flight's Columbia Plateau Bird Conservation Plan (Altman and Holmes 2000), are based on relative abundance, population trend, threats on the breeding and wintering grounds, and the extent of the species' breeding and nonbreeding distributions.

Results

Preliminary results one decade after cattle removal, 1991-1993 compared to 2000-2001, indicate that 71% (36/51) of riparian species exhibited positive trends ($P < 0.01$, binomial test) and 76% (16/21) of species exhibiting a significant change (either positive or negative) increased ($P < 0.05$) (*Table 2*). The average increase among the 51 species was 0.045 detections per plot or 3.0 detections/km^2 (a rate significantly greater than zero, paired t-test, $P < 0.01$). The 16 significantly increasing species were Yellow Warbler, White-crowned Sparrow, Song Sparrow, Savannah Sparrow, Tree Swallow, Dusky Flycatcher, Warbling Vireo, House Finch, Common Snipe, Mourning Dove, MacGillivray's Warbler, Dark-eyed Junco, Western Tanager, Orange-crowned Warbler, Spotted Towhee, and Say's Phoebe (*Table 2*). The five significantly declining species were House Wren, European Starling, Bullock's Oriole, Ruby-crowned Kinglet, and Wilson's Warbler (*Table 2*). Here we interpret the pattern of increasing species by primary habitat, nesting guild, and foraging guild.

Aspen and willow associates ($t = 2.86$, $P = 0.006$; and $t = 3.83$, $P < 0.001$), but not meadow associates ($t = 1.44$, $P = 0.16$), exhibited a significant increase in detections/km^2 (*Table 3*). The change in detections/km^2 did not vary significantly among the three habitat association groups ($F = 0.76$, $P = 0.47$, *Fig. 1*). Increasing species comprised a significant proportion (0.77) of significant changes among aspen species ($P < 0.05$), but not among willow or meadow associates (*Table 3*).

Detections of ground/low-cup nesting species and high-cup nesting species increased significantly ($t = 6.12$, $P < 0.001$; $t = 2.23$, $P = 0.03$), but cavity nesting species exhibited little change ($t = 0.78$, $P = 0.44$, *Table 3*). The change in detections/km^2 varied significantly among nesting guilds ($F = 22.0$, $P < 0.001$, *Fig. 1*). Ground/low-cup nesting species increased significantly more than either high-cup nesters or cavity nesters, and cavity nesting species increased the least. A similar pattern is evident in the proportion of increasing species. Increasing species comprised a significant proportion (0.92) of significant changes among ground/low-cup nesting species ($P < 0.01$) but not among other nesting guilds (*Table 3*).

Table 3— *Mean change and percent change in detections/km^2, and proportion of species increasing by habitat, nesting, and foraging guilds for riparian species on the 69 original plots on Hart and Sheldon National Wildlife Refuges in 2000-2001 compared to 1991-1993. Paired t-tests with 68 df used to determine significance of change in detections/km^2; binomial test used to determine whether proportion of species increasing differed from 0.50 (* P < 0.05, ** P < 0.01, *** P < 0.001). Guilds were pooled for binomial tests if denominators were < 6 because statistical signficance of P < 0.05 can't be achieved in such cases.*

Guild	Change in detections per km^2 (SE)	Percent change[a] in detections per km^2	Prop. species exhibiting positive trend[b]	Prop. significant changes that are increases[c]
Habitat				
Aspen	64.9 (22.7)**	19	0.74 (20/27)*	0.77 (10/13)*
Willow	57.3 (14.9)***	75	0.73 (8/11)	0.67 (4/6)[d]
Meadow	31.4 (21.9)	13	0.62 (8/13)	1.00 (2/2)[d]
Nesting				
Ground/low cup	132.9 (21.7)***	40	0.67 (18/27)	0.92 (11/12)**
High cup	20.1 (9.0)*	20	0.80 (8/10)	0.60 (3/5)[e]
Cavity	-12.1 (15.4)	-7	0.56 (5/9)	0.33 (1/3)[e]
Foraging				
Ground/Understory	96.1 (25.3)***	20	0.63 (26/41)	0.72 (13/18)
Aerial	44.7 (14.8)**	39	1.00 (10/10)**	1.00 (3/3)[f]
Overstory	12.8 (4.3)**	32	0.71 (5/7)[g]	0.60 (3/5)[f]
Bark	0.1 (3.4)	0	0.50 (2/4)[g]	0.00 (0/1)[f]

[a] Percent change = (change in detections/mean detections in 1991-1993) * 100%
[b] Number species increasing divided by total number species in the guild.
[c] Number of significantly increasing species divided by number of species exhibiting significant changes (either increases or decreases).
[d] Categories pooled for binomial test; 6/8 = 0.75, P = 0.29.
[e] Categories pooled for binomial test; 4/8 = 0.50, P = 1.0.
[f] Categories pooled for binomial test; 6/9 = 0.67, P = 0.51.
[g] Categories pooled for binomial test; 7/11 = 0.64, P = 0.55.

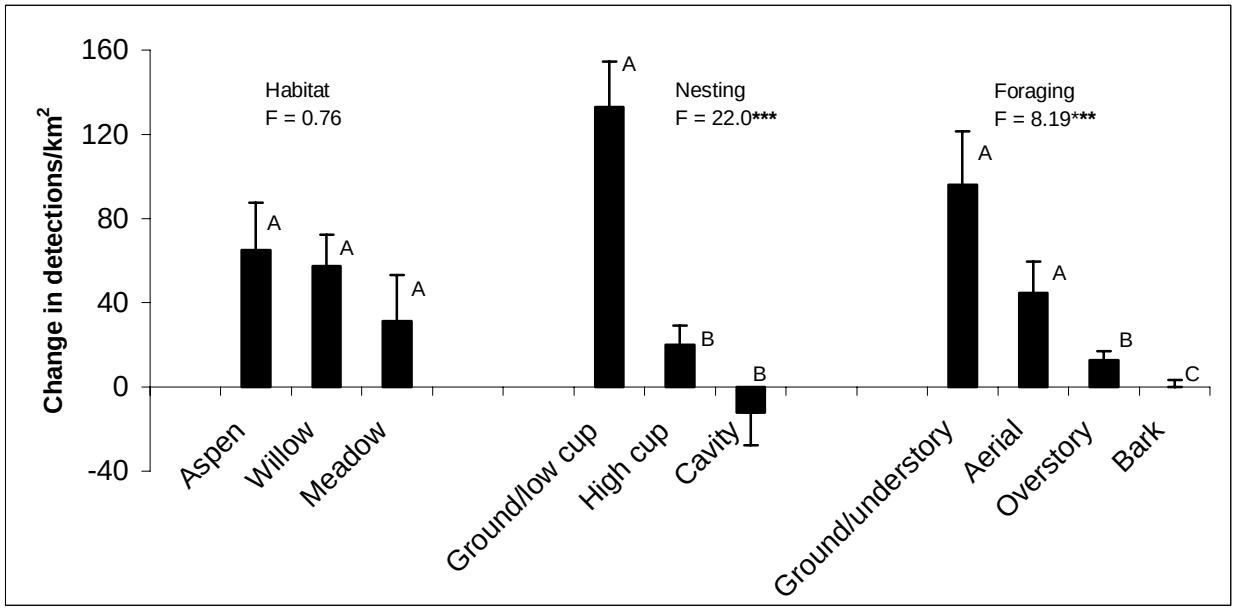

Figure 1— Change in detections/km^2 for riparian species within habitats of primary occurrence, nesting guilds, and foraging guilds. Change in detections is the difference between 2000-2001 and 1991-1993 detections pooled across species on the 69 original plots on Hart and Sheldon National Wildlife Refuges. Statistical tests are one-way ANOVAs (* P < 0.05, ** P < 0.01, *** P < 0.001). Within guild types, guilds with different letters above bars are those that differ significantly in detections/km^2 based on t-tests.

Ground/understory foraging species ($t = 3.79$, $P < 0.001$), aerial ($t = 3.02$, $P = 0.004$), and overstory foraging species ($t = 2.94$, $P = 0.004$) showed significant increases in detections, but bark-gleaning species did not ($t = 0.04$, $P = 0.97$, *Table 3*). The change in detections/km^2 differed significantly among foraging guilds ($F = 8.19$, $P < 0.001$, *Fig. 1*). Ground/understory foraging species increased significantly more than overstory foragers ($P = 0.002$) and bark gleaners ($P < 0.001$) and marginally more than aerial foragers ($P = 0.08$). Aerial foragers increased significantly more than overstory foragers ($P = 0.04$), and the change in detections of bark gleaners was significantly less than that of each of the other foraging guilds (all $P < 0.02$). Among ground/ understory foragers, increasing species comprised a marginally significant proportion (0.72) of significant changes ($P = 0.10$). Among aerial foragers, each of the ten species exhibited a positive trend and the three significant changes were all increases (*Table 3*).

Of the 26 riparian species of concern for which we had sufficient detections (*Table 2*), seven exhibited significant increases on original plots since the removal of cattle (Yellow Warbler, White-crowned Sparrow, Dusky Flycatcher, Warbling Vireo, MacGillivray's Warbler, Orange-crowned Warbler, and Mourning Dove). Three species of concern declined significantly since 1991-1993 (Bullock's Oriole, Ruby-crowned Kinglet, and Wilson's Warbler).

Discussion

Several patterns in the effects of grazing on avian communities have emerged. Saab et al. (1995) reviewed nine studies providing quantitative comparisons of species abundance in grazed and ungrazed systems (Page et al. 1978; Crouch 1982; Mosconi and Hutto 1982; Taylor 1986; Sedgwick and Knopf 1987; Medin and Clary 1990, 1991; Schulz and Leininger 1991; Knopf et al. 1988b). Species significantly affected by grazing, either across all studies or in at least one study, were primarily shrub nesting species (Red-winged Blackbirds, Common Yellowthroats, Willow Flycatchers, Yellow Warbler, American Redstart [*Setophaga ruticilla*], Gray Catbird [*Dumetella carolinensis*], and Yellow-breasted Chat) and ground or near-ground nesting species (Veery [*Catharus fuscescens*], Nashville Warbler [*Vermivora ruficapilla*], Fox Sparrow, Dark-eyed Juncos, White-crowned Sparrows, Savannah Sparrows, and Lincoln's Sparrows [*Melospiza lincolnii*]). As expected, habitat generalists, canopy nesters, and cavity nesters tended to be less directly affected by grazing. In a recent study, Krueper et al. (2003) documented dramatic changes in vegetation during the 5 years after cattle removal from the San Pedro River in Arizona and found that open cup nesters increased faster than cavity nesters, insectivores faster than omnivores, and Neotropical migrants faster than residents. In a comparison across seven riparian systems in the western U.S., Tewksbury et al. (2002) found that open cup nesters, species nesting below 2.5 m, and long distance migrants were less abundant in grazed than ungrazed areas, but the difference was greatest for species nesting below 2.5 m.

In this study of riparian bird abundance one decade after cattle removal on Hart Mountain and Sheldon National Wildlife Refuges, we also found patterns of increases consistent with recovery from cattle grazing. Ground/low cup nesting species increased more than either high cup or cavity nesting species, and cavity nesting species increased less than either of the other two guilds. Ground/understory foraging species increased significantly more than overstory or bark foraging species, and bark foraging species increased significantly less than other foraging guilds.

Increases in this study were generally more widespread among species groups than might be expected. Significant increases were seen among aspen and willow associates, ground/low cup nesters, high cup nesters, and among ground/understory, overstory, and aerial foragers. Only meadow associates, cavity nesters, and bark gleaners did not increase significantly. Other studies have also found community-wide effects of cattle removal. Krueper et al. (2003) found significant increases in both open cup and cavity nesting species, both resident and Neotropical migrants, all foraging guilds (insectivores, omnivores, granivores), and all species groups categorized by vertical strata of occurrence (understory, midstory, and upperstory). Similarly, in a comparison of sites grazed for >50 years and sites free of grazing for >25 years along the Missouri River, effects were seen in both open-cup and primary cavity nesters, and low and high nesting species groups were equally affected (Tewksbury et al., 2002).

Widespread effects among foraging and nesting guilds illustrate the importance of understanding the mechanism by which cattle grazing affects avian communities. It is generally accepted that the species composition and structure of herbaceous and understory vegetation are affected by grazing. Presumably this change in vegetation also affects the invertebrate population, and as suggested by Krueper et al. (2003), it is likely that changes in the invertebrate population are not restricted to the lower layers of the vegetation. Studies of how invertebrate populations change with cattle removal, and how this affects avian communities, are largely lacking. However, our detailed vegetation measurements, collected in 1991-1993 and to be collected again in 2001-2002, will likely clarify the relationship between changes in particular aspects of plant species composition or structure and changes in avian abundance.

Regional rainfall may also have changed during the last decade. Cattle were removed from Hart Mountain and Sheldon National Wildlife Refuges at the end of a multi-year drought in the early 1990s, and since then, an increase in regional rainfall could have produced a positive response in riparian vegetation and a corresponding increase in riparian birds. One would expect any improvement due to regional rainfall patterns to be exhibited in other areas in addition to the refuges. To investigate this possibility, we compared our pattern of increasing species to that on Breeding Bird Survey (BBS) routes within the Columbia Plateau physiographic area and within U.S. Fish and Wildlife Service Region 1 during 1980-2001 (Sauer et al. 2002). Of the 16 significantly increasing species documented on the refuges in this study, ten were sufficiently covered by BBS (i.e., observed on > 14 routes) within the Columbia Plateau and all 16 were sufficiently covered within Region 1. Of the ten sufficiently covered species within the Columbia Plateau, none was significantly increasing on BBS routes and one was significantly declining (Mourning Dove). Of the 16 sufficiently covered species within Region 1, only one was significantly increasing (Tree Swallow), but three were significantly decreasing (Common Snipe, Yellow Warbler, and Mourning Dove). Thus, the species increasing in abundance on Hart Mountain and Sheldon National Wildlife Refuges are not a reflection of regional patterns of species' increases. We will investigate this issue in more detail, by evaluating rainfall in relation to detections on the refuges and on BBS routes, after the final year of data collection.

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