Ann M. Rocklage and **John T. Ratti**[1], Department of Fish and Wildlife Resources, University of Idaho, Moscow, Idaho, 83844-1136

Avian Use of Recently Evolved Riparian Habitat on the Lower Snake River, Washington

Abstract

Since 1975 the U. S. Army Corps of Engineers has managed and irrigated 440 ha along the lower Snake River in Washington as mitigation for four dams constructed 1962-1975. We investigated avian use of irrigated Habitat Management Units (HMUs), compared to non-irrigated sites and streams that entered the river. We conducted bird surveys at 25 sites in summer and fall 1997 and in spring 1998. We compared avian abundance, species richness, and species diversity among habitats and seasons. We detected an average of 169 birds and 33 species at HMUs, 120 birds and 28 species at non-irrigated sites, and 63 birds and 23 species along streams in all three seasons. We detected an average of 29 species/site in summer, 31 in fall, and 22 in spring. Species diversity, as measured by the Shannon-Wiener function, was higher in summer, indicating that large flocks of a few species were common in fall and spring. These data demonstrated that the lower Snake River is an important stopover site for migrating birds. We detected an average of 30 more bird species than a study conducted on the same area in 1974. The increase in species richness is attributed to the development of HMUs and to natural succession of palustrine vegetation since dam construction. Future potential changes in reservoir levels, such as breaching of dams, will undoubtedly affect bird communities along the lower Snake River in all seasons. However, our data demonstrated that habitat perturbations can be partially mitigated by habitat enhancement and management.

Introduction

The importance of riparian zones for birds in the arid and semi-arid West has been well documented (Szaro 1980, Knopf and Samson 1988, Johnson 1989, Schulz and Leininger 1991, Douglas et al. 1992, Clary and Medin 1993). Western riparian zones generally have a higher structural and vegetative diversity than uplands. This leads to a higher number of niches and higher species density, richness, and diversity (Johnson 1989, Clary and Medin 1993). However, many western streams and rivers have been altered for hydropower production, resulting in the loss of riparian habitat (Lewke and Buss 1977).

Four dams were built on the lower Snake River between 1962-1975. These impoundments resulted in the loss of approximately 1,200 ha of riverine habitat (Corps 1991). In 1975, the U. S. Army Corps of Engineers (Corps) initiated the Lower Snake River Fish and Wildlife Compensation Plan to analyze and mitigate impacts to fish and wildlife resulting from these dams. The Corps acquired and/or designated 1,702 ha of land for wildlife habitat (Corps 1991). Approximately 440 ha have been developed as 10 intensively managed and irrigated Habitat Management Units (HMUs).

[1]Author to whom correspondence should be addressed; email: jratti@uidaho.edu

Several studies have been conducted to evaluate wildlife communities and habitats along the lower Snake River (e.g., Asherin and Claar 1976, Lewke and Buss 1977, Monda and Reichel 1989, Corps 1991, Downs et al. 1996); however, none have specifically addressed the wildlife value of irrigated HMUs. Our objectives were to estimate and compare avian abundance, species richness, and species diversity among irrigated HMUs, non-irrigated riparian sites, and streams that entered the river. These data were part of a report submitted to the U. S. Army Corps of Engineers (Rocklage and Ratti 1998).

Study Area

The lower Snake River study area extended 209 km from Ice Harbor Dam near Kennewick, Washington, upriver to the confluence of the Snake and Clearwater rivers at Clarkston, Washington. The study area included four reservoirs: Ice Harbor, Lower Monumental, Little Goose, and Lower Granite. See Asherin and Claar (1976) and Lewke and Buss (1977) for a detailed description of the study area.

Twenty-five study sites were selected for bird surveys in 1997 and 1998. Study sites were divided among three habitat types: 7 irrigated HMUs, 7 non-irrigated sites, and 11 streams. Irrigated

HMUs were located on bars or benches along the Snake River and were intensively managed and irrigated. They were characterized by patches of trees and shrubs interspersed with upland habitats and crops planted for wildlife such as hay, corn, sunflower, and millet. Trees commonly planted on irrigated HMUs were Russian olive (*Elaeagnus angustifolia*), poplars (*Populus* species), dogwood (*Cornus* species) and black locust (*Robinia pseudo-acacia*). Shrubs included Siberian pea (*Caragana arborescens*), buffaloberry (*Shepherdia* species), rose (*Rosa* species), and Himalayan blackberry (*Rubus discolor*). Unmanaged upland habitat was largely composed of forbs and grasses, especially of cheatgrass (*Bromus tectorum*), bluebunch wheatgrass (*Agropyron spicatum*), and Sandberg bluegrass (*Poa sandbergii*). Rubber rabbitbrush (*Chrysothamnus nauseosus*) and big sagebrush (*Artemisia tridentata*) were also common in upland habitats. Shoreline habitat included white alder (*Alnus rhombifolia*), scrub-willow communities (*Salix* species), and palustrine-emergent vegetation, such as cattail (*Typha* species), bullrush (*Scirpus* species), and reed-canary grass (*Phalaris arundinacea*).

Non-irrigated sites were also located along the river. They typically had narrow strips of palustrine shrub-scrub and palustrine-emergent vegetation along the shore, which developed naturally since dam construction and subsequent formation of reservoirs (Downs et al. 1996). Palustrine vegetation was immediately bordered by upland vegetation.

Study streams or drainages entered the Snake River, and ranged in size from the relatively large Tucannon River to small, narrow canyons with ephemeral streams. All drainages had woody vegetation, although type and quantity of vegetation often varied dramatically depending on seasonal water supply, annual precipitation, and slope of canyon walls. Riparian vegetation was immediately bordered by upland vegetation. Most streams had white alder, but in various sizes and densities. Himalayan blackberry was also common. Palustrine willow and emergent vegetation often occurred along streams, particularly at the confluence with the Snake River.

Methods

We placed bird-survey stations 400 m apart along a transect at each site. On irrigated HMUs and non-irrigated sites, stations were located approximately equidistant between shoreline and inland edge of the bench. Stations along streams were placed on the edge of riparian vegetation. There were 44 stations on irrigated HMUs, 43 on non-irrigated sites, and 46 along streams.

The variable-circular plot (VCP) method (Reynolds et al. 1980) was used to survey birds. We surveyed birds in three seasons; summer (i.e., the breeding season), fall, and spring. Breeding-bird surveys took place from mid-May through mid-July 1997. Fall surveys occurred during September and October of 1997, and spring surveys from mid-March through April 1998. Each survey station was visited four times in summer and three times in fall and spring. Observers rotated among stations to distribute potential differences in observer ability. To distribute differences due to time of day, we also rotated the order stations were visited (Robbins 1981). Surveys began at or near official sunrise and continued until 1000. Surveys did not take place during rain or when wind interfered with observer's hearing ability.

Each VCP survey was 10 minutes. Observers recorded species of all individual birds detected and distance in meters to each bird. Birds that flushed as the observer approached the station were counted as if they were detected during the survey. All flocks and family groups were recorded as such. Birds or flocks flying over the sampling area were recorded separately because it could not be determined whether these birds were using the sampling area; however, birds that flew within sampling-area vegetation were recorded as detections within the VCP. Birds that flew from another area and landed in the sampling area after the survey began were recorded as flyovers.

Density estimates (birds/10 ha) for each site in each season were calculated with the ordered-distance method after Roeder et al. (1987). We chose this nonparametric method for its lower variance estimate and robust nature under a variety of situations (Roeder et al. 1987). The method calculated an effective survey area for each species. At least 30 detections of a species were needed to calculate a reliable effective area (Burnham et al. 1981). Given that one assumption of the method is that each detection is independent (Roeder et al. 1987), we calculated density of flocks if greater than 20% of a species detections were of flocks. Flyovers were not included in density-estimate calculations. All detection distances were truncated to 200 m at each station to eliminate those outside the target habitats. Effective areas were calculated separately for each season since species' detectability may vary among seasons (Gutzwiller 1991). Because observer-hearing ability can change in different habitats (Schieck 1997), an effective area was calculated for each habitat type for those species with more than 30 detections in each type.

Swallows are difficult to accurately survey with the VCP method. Their swift, darting flight make it difficult to count and measure distances to all individuals. Furthermore, it is uncertain whether they classify as flyovers. Therefore, observers counted the number of individual swallows observed at the beginning of the survey. We calculated relative abundance of swallows (average number observed) for each site in each season.

Because fall birds are less vocal and more cryptic, we also used an area-search method in fall. This method is similar to "bird watching" in that the observer wanders through an area and records numbers of each species seen or heard during a specified time period (Ralph et al. 1993). Observers were instructed to pay particular attention to dense-riparian vegetation and fruiting plants at all sites and crops at irrigated HMUs. They were allowed to take as much time as needed to identify birds. The search period occurred between sunrise and noon. The area-search method was only used to obtain a more complete species list for each site.

Survey data were used to calculate species richness and diversity. Species richness was total number of species detected at each site in each season. Both VCP and area-search data were used for calculation of species richness in fall. We used average number of each species detected at each site to calculate diversity in each season. Diversity indices measure the number of species and evenness of species representation in a community. We chose the Shannon-Wiener Function (H') because it is sensitive to changes in rare species in the community.

Shannon-Wiener function:

$$H' = \sum_{i=1}^{s} (p_i)(\log_2 p_i)$$

where p = proportion of each species in the total sample.

Its theoretical maximum is $\log_2(S)$, where S is maximum number of species in the community. However, in biological communities H' rarely exceeds 5.0 (Krebs 1989).

Variables were checked for univariate normality prior to analyses with probability and quantile plots. Many species had non-normal plots due to zero entries at some sites. Because the research question is multivariate, species densities could not be used in the analyses. Therefore, data were collapsed into overall avian abundance; i.e., the average number of birds detected at each site. Avian abundance, species richness, and species diversity met the normality assumption and were used as dependent variables in a multivariate analysis of variance (MANOVA). The main effects were habitat types (irrigated HMUs, non-irrigated sites, and streams), seasons (summer, fall, spring), and their interaction. We used univariate F-tests and canonical correlations to examine which dependent variables contributed to significant main effects. Fisher's LSD was then used for multiple comparisons within treatments.

Results

We detected 92 species during the breeding season on the lower Snake River. Including flyovers, the five most frequently detected species were bank swallow (*Riparia riparia*; n = 1,185), cliff swallow (*Hirundo pyrrhonota*; n = 1,078), red-winged blackbird (*Agelaius phoeniceus*; n = 881), western meadowlark (*Sturnella neglecta*; n = 573), and Bullock's oriole (*Icterus bullockii*; n = 489). Absolute densities were calculated for 30 species. Red-winged blackbird (13.81 birds/10 ha), Bullock's oriole (10.63 birds/10 ha), American goldfinch (*Carduelis tristis*; 7.72 birds/10 ha), brown-headed cowbird (*Molothrus ater*; 7.81 birds/10 ha), and American robin (*Turdus migratorius*; 5.63 birds/10 ha) had the highest densities. See Rocklage and Ratti (1998) for additional results.

During fall 114 species were detected using both VCP and area-search methods. Including flyovers, the most frequently detected species were red-winged blackbird (n = 1,906), white-crowned sparrow (*Zonotrichia leucophrys*; n = 1,635), American goldfinch (n = 832), Canada goose (*Branta canadensis*; n = 742), and European starling (*Sturnus vulgaris*; n = 737). Starlings, however, were only abundant at one irrigated HMU.

Seventeen species had a sufficient number of detections to calculate density, and we calculated density of flocks for 11 of these species. White-crowned sparrow (17.69 flocks/10 ha, mean flock size = 5.10), song sparrow (*Melospiza melodia*; 14.50 flocks/10 ha, mean flock size = 1.32), savannah sparrow (*Passerculus sandwichensis*; 6.29 flocks/10 ha, mean flock size = 2.31), yellow-rumped warbler (*Dendroica coronata*; 2.30 flocks/10 ha, mean flock size = 3.20), and American goldfinch (3.22 flocks/10 ha, mean flock size = 2.56) had the highest densities.

We detected 91 species during spring. The most frequently detected species were white-crowned sparrow (n = 1,344), American goldfinch (n = 862), red-winged blackbird (n = 809), western meadowlark (n = 802), and Canada goose (n = 407). Of the 21 species for which density was calculated, white-crowned sparrow (4.28 flocks/10 ha, mean flock size = 5.86), song sparrow (6.90 birds/10 ha), western meadowlark (6.62 birds/10 ha), red-winged blackbird (5.30 birds/10 ha), and American robin (4.62 birds/10 ha) had the highest estimates.

There was no significant interaction between habitats and seasons in the MANOVA model (F = 0.772; df = 12,169; P=0.679); thus, the interaction term was removed. Main effects of habitat types (F = 5.744; df = 6,136; $P \le 0.001$) and seasons (F = 8.574; df = 6,136; $P \le 0.001$) were significant. Univariate F tests and canonical correlations showed that avian abundance (F = 24.685; df = 2,70; $P \le 0.001$) and species richness (F = 14.206; df = 2,70; $P \le 0.001$) were different among habitat types in all three seasons. Mean avian abundance was higher at irrigated HMUs (168.84 ± 22.91 birds) than both non-irrigated sites (120.47 ± 10.30 birds) and streams (62.55 ± 5.54 birds) (Table 1). Species richness showed the same trend, with more species found at irrigated HMUs (33.14 ± 1.52 species), followed by non-irrigated sites (27.91 ± 1.64 species) and streams (23.18 ± 1.48 species) (Table 1).

For the effect of seasons, species richness (F = 13.817; df = 2,70; $P \le 0.001$) and diversity (F = 2.808; df = 2,70; P = 0.067) contributed to the significant MANOVA, and were different among seasons. Species richness was higher in fall (30.96 ± 1.84 species), followed by summer (29.32 ± 1.52 species), and spring (21.60 ± 1.31 species) (Table 2). Species diversity, however, was highest in summer (summer, Shannon-Wiener Function = 3.651 ± 0.157, spring = 3.291 ± 0.110, fall = 3.227 ± 0.133) (Table 2). Although the average number of birds detected was higher in fall, numbers were not statistically different. We detected

TABLE 1. Mean number of birds, number of species, and species diversity (Shannon-Wiener function) at irrigated Habitat Management Units (HMU), non-irrigated sites, and streams, lower Snake River, Washington, 1997-1998. Means combine summer, fall, and spring estimates. Different letters following means indicate significant differences (Fisher's LSD; $P \le 0.100$).

	F	df	P	Irrigated HMU Mean	Irrigated HMU SE	Non-irrigated Mean	Non-irrigated SE	Stream Mean	Stream SE
Number of Birds	24.685	2,70	≤ 0.001	168.837a	22.905	120.468b	10.302	62.545c	5.542
Number of Species	14.206	2,70	≤ 0.001	33.143a	1.517	27.905b	1.636	23.182c	1.483
Species Diversity	0.206	2,70	0.814	3.456a	0.163	3.406a	0.141	3.336a	0.122

TABLE 2. Mean number of birds, number of species, and species diversity (Shannon-Wiener function) in summer, fall, and spring, lower Snake River, Washington, 1997-1998. Means combine estimates from irrigated Habitat Management Units (HMU), non-irrigated sites, and streams. Different letters following means indicate significant differences (Fisher's LSD; $P \le 0.100$).

	F	df	P	Summer Mean	Summer SE	Fall Mean	Fall SE	Spring Mean	Spring SE
Number of Birds	0.394	2,70	0.676	97.870a	9.075	121.880a	21.004	105.827a	14.429
Number of Species	13.817	2,70	≤ 0.001	29.320a	1.516	30.960a	1.843	21.600b	1.311
Species Diversity	2.808	2,70	0.067	3.651a	0.157	3.227b	0.133	3.291b	0.110

121.88 ± 21.00 birds in fall, 105.83 ± 14.43 birds in spring, and 97.87 ± 9.08 birds in summer (Table 2).

Discussion

Quality stopover sites that offer safe and plentiful food sources are critical for migrating birds (Moore et al. 1995). Such sites are probably most available in riparian areas in the arid and semi-arid West (Moore et al. 1995). Our numbers indicated that all lower Snake River riparian habitats were important stopover areas during fall migration. Asherin and Claar (1976) observed more species on the lower Snake River in spring. Riparian habitats on the Umatilla National Wildlife Refuge along the Columbia River near Hermiston, Oregon, also appeared to have higher numbers of birds during fall migration than summer (S. Hudson, University of Idaho, Dept. of BioSci., Moscow, ID, pers. comm.). Because this was only a one-year study, we do not have data on annual variation in numbers or weather patterns. Unfortunately, we did not study avian communities along the lower Snake River during winter, and we feel this is an important area for future research.

Even though our methods detected more birds and species during fall, we feel that abundance estimates for fall were conservative for several reasons. First, bird song is decreased in fall; thus, we probably missed birds with the VCP method. Even though we detected more species with the area search (106 species with area search, 94 with VCP), this method was not standardized and abundances could not accurately be compared with those from the VCP. Second, 31% of all detections in fall were of flocks, compared to 20% in spring and 2% in summer. We believe there was often serious underestimation when counting birds in flocks, particularly when mixed flocks were foraging in dense-shrub patches. Species diversity was lowest in fall, which also indicated that large flocks of a few species, such as white-crowned sparrow and red-winged blackbird, were superabundant. Third, 18% of all detections in fall were of flyovers, compared to 11% in spring, and 7% in summer. Because it could not be accurately determined whether flyovers were using the survey area, flyovers were not included in any statistical tests. Birds that were flying over the area during surveys may have been using the Snake River corridor for migration. In addition, many flyovers were of large flocks that may have been disturbed by the observer. We therefore stress that our numbers may underestimate the value of the lower Snake River as a migration stopover site.

We demonstrated that more species and more birds were present at irrigated HMUs than at non-irrigated sites and streams in all three seasons. To further examine the importance of irrigated HMUs and other lower Snake River habitats, we compared our results with those from a study conducted in 1974 (Asherin and Claar 1976). They divided the lower Snake River into two reaches: Ice Harbor reservoir and from Lower Monumental dam to Clarkston, Washington. We divided our data similarly. In Ice Harbor, we detected 39 more species in summer, 49 more in fall, and 16 more in spring (Figure 1). In the second reach, we detected 24 more species in summer, 40 more in fall, and 14 more in spring (Figure 2). Although survey intensity differed and actual survey locations occasionally differed, we believe methodology alone cannot account for these dramatic differences. The increase in number of bird species detected likely was attributable to an increase in quality habitat since the first lower Snake dam was constructed in 1962 and the development of irrigated HMUs in 1975. In 1974 there was little or no shoreline vegetation, as previous vegetation was flooded and new vegetation had little time to develop. Monda and Reichel (1989) compared avian abundance and species richness along Lower Granite Reservoir pre- and post-impoundment. They found that riparian-associated passerines decreased from 1973 to 1981, and that upland-associated species correspondingly increased. This change was attributed to loss in riparian vegetation. A study conducted in 1996 showed an increase in palustrine emergent and palustrine shrub-scrub vegetation along the lower Snake River since 1987, particularly at slack water areas and at deltas of major tributaries (Downs et al. 1996). Therefore, birds have responded positively to habitats offered at HMUs and to the natural succession of riparian vegetation.

Future potential changes in reservoir levels, such as breaching of dams, will undoubtedly affect bird communities along the lower Snake River in all seasons. If the Snake River is allowed to return to pre-impoundment levels, effects on the avian community will be a complicated interaction among natural and management responses;

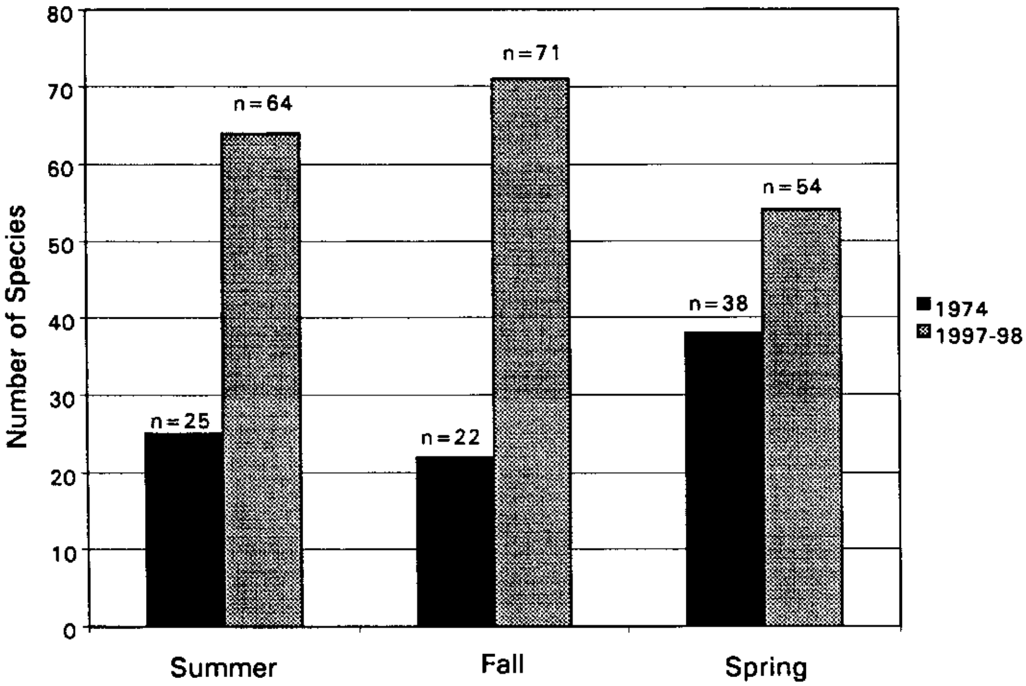

Figure 1. Number of bird species observed in three seasons along Ice Harbor Reservoir, Washington in 1974 (Asherin and Claar 1976) and in 1997-1998.

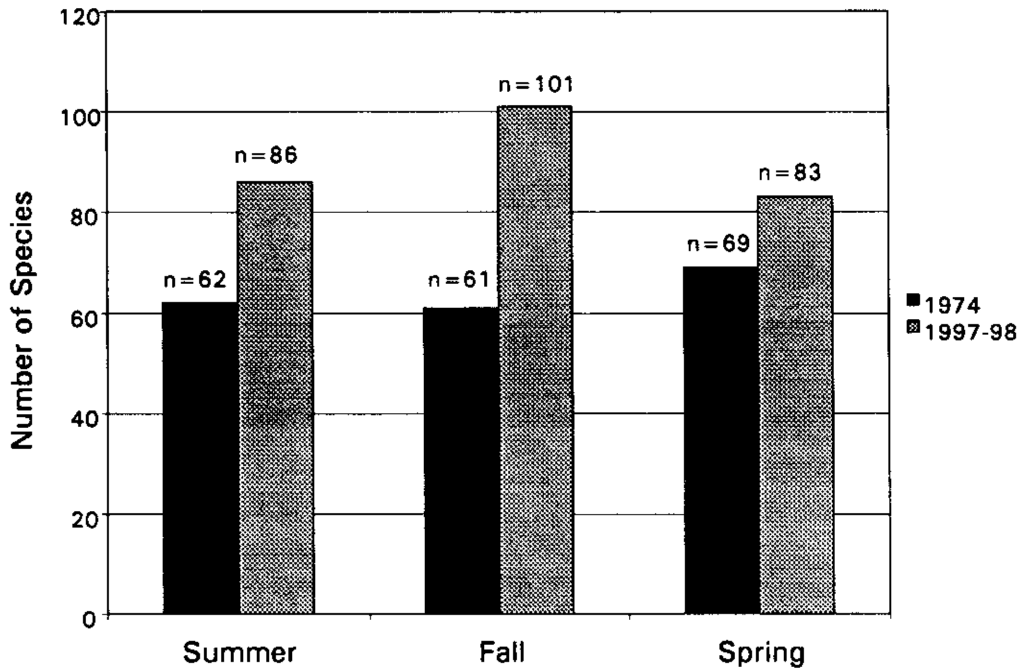

Figure 2. Number of bird species observed in three seasons from Lower Monumental Dam to Clarkston, Washington in 1974 (Asherin and Claar 1976) and in 1997-1998.

thus, predictions of changes in bird communities will be difficult. Current riparian vegetation may senesce as the water table drops. Upland vegetation will likely replace senescing riparian vegetation. Natural revegetation may take decades.

Breeding birds that may be immediately affected by lower water levels would be those that depend on willow shrub-scrub vegetation. Breeding birds, such as American goldfinch, Bullock's oriole, song sparrow, willow flycatcher (*Empidonax traillii*), yellow-breasted chat (*Icteria virens*), and yellow warbler (*Dendroica petechia*), may temporarily decrease in numbers (Monda and Reichel 1989, Knopf and Sedgwick 1992). Monda and Reichel (1989) noted a large decrease in numbers in American goldfinch and lazuli bunting (*Passerina amoena*) six years after construction of Lower Granite Dam. Although our data demonstrated that American goldfinch numbers have rebounded, lazuli buntings were still rare. Some birds will move into drainages, but drainages may be too small and narrow to support large numbers of nesting birds. Upland birds, however, may benefit from the gradual expansion of upland vegetation (Stauffer and Best 1980, Monda and Reichel 1989). Grasshopper sparrow (*Ammodramus savannarum*), horned lark (*Eremophila alpestris*), lark sparrow (*Chondestes grammacus*), ring-necked pheasant (*Phasianus colchicus*), and western meadowlark may increase on benches along the lower Snake River.

Migrating birds will also be affected by changes in water levels. Migrating birds need an adequate food supply and protective cover (Moore et al. 1995). These resources were readily available at irrigated HMUs, some non-irrigated sites and along larger streams during fall and spring. Migrating sparrows concentrated in weedy fields that offered a plentiful seed supply adjacent to protective cover, such as blackberry and willows (Strong and Bock 1990, A. Rocklage pers. obs.). Large flocks of red-winged blackbirds and sparrows were also observed in crop fields at irrigated HMUs during fall (A. Rocklage pers. obs.). Migrating white-crowned sparrows appeared to have benefited from the gradual expansion of riparian vegetation. Lewke and Buss (1977) detected 320 white-crowned sparrows prior to the construction of Lower Granite Dam, Monda and Reichel (1989) observed 14 six years after its construction, and our study detected 224. Along all four reservoirs, we estimated an average of 156 white-crowned sparrows per 10 ha at irrigated HMUs. This species has exhibited a significant population decline since 1966 in the western U.S. (DeGraaf and Rappole 1995); thus, Snake River habitats may be vital to current populations. Little is known about other quality stopover sites and migration patterns in the inland Northwest (Moore et al. 1995).

The comparison between our data and that from Asherin and Claar (1976) and Monda and Reichel (1989) clearly indicated that bird populations have rebounded from impoundment of the lower Snake River. This rebound was undoubtedly due to the development and management of irrigated HMUs, as well as to the natural succession of shoreline vegetation. However, we emphasize that it is unknown how annual variation, competition, predation, and cowbird parasitism affect bird populations on the lower Snake River. Our data demonstrated that future habitat perturbations can be partially mitigated by habitat enhancement and management.

Acknowledgements

The U. S. Army Corps of Engineers provided funding for this project. Lonnie Metler, Clark Derdeyn, and Scott Ackerman from the Corps provided technical and logistical assistance. We particularly thank our field assistants, Suzanne Tomassi, Gene Orth, and Karen Kriesel. We thank Mark Ulliman and John Giudice for contributions during the early design phase of this project.

Literature Cited

Asherin, D. A., and J. J. Claar. 1976. Inventory of riparian habitats and associated wildlife along the Columbia and Snake rivers. Volume III A. U. S. Army Corps of Engineers, North Pacific Division.

Burnham, K. P., D. R. Anderson, and J. L. Laake. 1981. Line transect estimation of bird population density using a Fourier series. Pages 466-482 *In* C. J. Ralph and J. M. Scott (editors) Estimating the Number of Terrestrial Birds. Studies in Avian Biology 6. Allen Press, Lawrence, Kansas, USA.

Clary, W. P., and D. E. Medin. 1993. Vegetation, nesting bird, and small mammal characteristics: Wet Creek, Idaho. USDA Forest Service General Technical Report INT-293, Intermountain Research Station, Salt Lake City, Utah.

Corps (U. S. Army Corps of Engineers). 1991. Lower Snake River fish and wildlife compensation plan: wildlife habitat compensation evaluation for the lower Snake River project. U. S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

DeGraaf, R. M., and J. H. Rappole. 1995. Neotropical Migratory Landbirds: Natural History, Distribution, and Population Change. Comstock Publishing Associates, Ithaca, New York, USA.

Douglas, D. C., J. T. Ratti, R. A. Black, and J. R. Alldredge. 1992. Avian habitat associations in riparian zones of Idaho's Centennial Mountains. Wilson Bulletin 104(3):485-500.

Downs, J. L., B. L. Tiller, M. Witter, and R. Mazaika. 1996. Monitoring and mapping selected riparian habitat along the lower Snake River. U. S. Army Corps of Engineers, Walla Walla District, Walla Walla, Washington.

Gutzwiller, K. J. 1991. Estimating winter species richness with unlimited-distance point counts. Auk 108:853-862.

Johnson, A. S. 1989. The thin green line. Pages 35-46 *In* Preserving communities and corridors. Defenders of Wildlife, Washington, D. C., USA.

Knopf, F. L., and F. B. Samson. 1988. Ecological patterning of riparian avifaunas. Pages 77-78 *In* K. J. Raedeke (editor) Streamside Management: Riparian Wildlife and Forestry Interactions. Contribution 59, University of Washington Institute of Forestry Resources, Seattle, USA.

Knopf, F. L., and J. A. Sedgwick. 1992. An experimental study of nest-site selection by yellow warblers. Condor 94:734-742.

Krebs, C. J. 1989. Ecological Methodology. Harper Collins, New York, USA.

Lewke, R. E., and I. O. Buss. 1977. Impacts of impoundment to vertebrate animals and their habitats in the Snake River canyon, Washington. Northwest Science 54(4):219-270.

Monda, M. J., and J. D. Reichel. 1989. Avian community changes following Lower Granite Dam construction on the Snake River, Washington. Northwest Science 63(1):13-18.

Received 30 December, 1999
Accepted 3 April, 2000

Moore, F. R., S. A. Gauthreaux, Jr., P. Kerlinger, and T. R. Simons. 1995. Habitat requirements during migration: important links in conservation. Pages 121-144 *In* T. E. Martin and D. M. Finch (editors) Ecology and Management of Neotropical Migratory Landbirds. Oxford University Press, New York, USA.

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, Pacific Southwest Research Station, Albany, California.

Reynolds, R. T., J. M. Scott, and R. A. Nussbaum. 1980. A variable circular-plot method for estimating bird numbers. Condor 82:309-313.

Robbins, C. S. 1981. Effect of time of day on bird activity. Pages 275-286 *In* C. J. Ralph and J. M. Scott (editors) Estimating the Number of Terrestrial Birds. Studies in Avian Biology 6. Allen Press, Lawrence, Kansas, USA.

Rocklage, A. M., and J. T. Ratti. 1998. Analysis of lower Snake River habitats and their ecological value to birds and small mammals. Final report to U. S. Army Corps of Engineers, Lower Snake River Wildlife Studies, Walla Walla District, Walla Walla, Washington.

Roeder, K., B. Dennis, and E. O. Garton. 1987. Estimating density from variable circular plot censuses. Journal of Wildlife Management 51(1):224-230.

Schieck, J. 1997. Biased detection of bird vocalizations affects comparisons of bird abundance among forested habitats. Condor 99:179-190.

Schulz, T. T., and W. C. Leininger. 1991. Nongame wildlife communities in grazed and ungrazed mountain riparian sites. Great Basin Naturalist 51:286-292.

Stauffer, D. F., and L. B. Best. 1980. Habitat selection by birds of riparian communities: evaluating effects of habitat alterations. Journal of Wildlife Management 44(1):1-14.

Strong, T. R., and C. E. Bock. 1990. Bird species distribution patterns in riparian habitats in southeastern Arizona. Condor 92:866-885.

Szaro, R. C. 1980. Factors influencing bird populations in southwestern riparian forests. Pages 403-418 *In* R. M. DeGraff and N. G. Tilgham (editors) Management of Western Forests and Grasslands for Nongame Birds. USDA Forest Service General Technical Report INT-86, Intermountain Research Station, Salt Lake City, Utah.