US Army Corps of Engineers
Walla Walla District

Lower Snake River Wildlife Studies: Analysis of Lower Snake River Habitats and Their Ecological Value to Birds and Small Mammals

Ann M. Rockledge
and
John T. Ratti
University of Idaho

1998

Table of Contents

Appendices

List of Tables

List of Figures

List of Plates

Acknowledgements

The U.S. Army Corps of Engineers provided funding for this project. Lonnie Mettler, Clark Derdeyn, and Scott Ackerman from the Corps provided technical and logistical assistance. Bridgett Read (Anteon Corporation) and Scott Ackerman produced the maps in this document. 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.

1. Executive Summary

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 lower Snake dams. As a result, the Corps acquired and/or designated 4,254 acres for wildlife habitat (Corps, 1991). Approximately 1,100 of these acres have been developed as ten intensively managed and irrigated Habitat Management Units (HMUs). Management activities at irrigated HMUs included planting of trees, shrubs, and wildlife crops (*e.g.*, corn and sunflower), haying, and noxious-weed control. The objective of this study was to estimate and compare abundances of birds and small mammals among irrigated HMUs, non-irrigated sites, and drainages along the lower Snake River.

Twenty-seven study sites were selected for bird censuses in 1997 and 1998 on the lower Snake River, from Ice Harbor Dam upriver to Clarkston, Washington. The study area included four reservoirs: Ice Harbor, Lower Monumental, Little Goose, and Lower Granite. Study sites were divided into three habitat types: seven irrigated HMUs, eight non-irrigated sites, and twelve drainages. Irrigated HMUs and non-irrigated sites were bars or benches along the Snake River that supported woody riparian vegetation, although non-irrigated sites were not intensively managed. 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. Forty-four bird census stations were located on irrigated HMUs, 43 on non-irrigated sites, and 46 in drainages. Small mammals were trapped at nine of these study sites: one irrigated HMU, one non-irrigated site, and one drainage in each of Ice Harbor, Lower Monumental, and Little Goose reservoirs. Six sites were also selected for bird censuses in the lower section of Hell's Canyon.

Variable Circular Plot (VCP) methodology was used to census bird populations in three seasons along the lower Snake River. Breeding-bird censuses took place from mid-May through mid-July 1997. Fall birds were censused during September and October of 1997. The Spring bird population was censused from mid-March through April 1998. Each VCP census station was visited four times during the breeding season and three times in fall and spring. Since fall birds were often less vocal and more cryptic than breeding or spring birds, observers also conducted an area search at each site during fall. The area-search method was also used to census birds in Hell's Canyon in summer and fall.

Density estimates were calculated for common bird species in each season. Birds that flew over the sampling area were deleted from density-estimate calculations. A randomized-block Analysis of Variance (ANOVA) was used to test for differences in species' densities among irrigated HMUs, non-irrigated sites, and drainages. A Bonferroni adjustment for pairwise comparisons was used on significant tests. Data from area searches were not subjected to statistical tests.

Ninety-two species were detected **during the breeding season** on the lower Snake River. Observers detected 9,787 individual birds in four visits to each census station, for an average of 2,447 birds per visit. At irrigated HMUs, 3,777 individuals were detected, 3,074 at non-irrigated sites, and 2,936 in drainages. Including flyovers, the five most frequently detected species were, in descending order, bank swallow, cliff swallow, red-winged blackbird, western meadowlark, and northern oriole. Absolute densities were calculated for 30 species and relative abundance was calculated for three swallow species. Northern oriole and red-winged blackbird had the highest densities. Nine species had higher densities at irrigated HMUs than at either drainages or non-irrigated sites. These were American robin, bank swallow, black-billed magpie, California quail, Canada goose, lazuli bunting, mourning dove, ring-necked pheasant, and western meadowlark. Three species, house wren, northern flicker, and northern oriole had higher densities in drainages. Killdeer and spotted sandpiper had higher densities at non-irrigated sites.

Observers detected 605 individual birds and 45 species during two visits to Hell's Canyon in the breeding season. Lazuli bunting was the most-abundant species. The next-most-abundant species were cliff swallow, American goldfinch, wild turkey, and California quail. Wild turkey was not detected on the lower Snake River study area.

During the fall, 114 species were detected using both the VCP and area-search methods. Observers detected 9,071 individual birds in three visits to each station with the VCP method, for an average of 3,024 birds per visit. At irrigated HMUs, 4,316 individuals were detected, 2,878 at non-irrigated sites, and 1,947 in drainages. Including flyovers, red-winged blackbird was the most frequently detected species, followed by white-crowned sparrow, American goldfinch, Canada goose, and European starling. Densities were calculated for 17 species. White-crowned and song sparrows had the highest densities. There was an average of 156 white-crowned sparrows per 10 hectares at irrigated HMUs. American robin and white-crowned sparrow had higher densities at irrigated HMUs. Savannah sparrow had higher densities at non-irrigated sites, and rock wren had higher densities in drainages.

Observers detected 25 species during the fall visit to Hell's Canyon. California quail was the most abundant species. The next-most-abundant species were American goldfinch, song sparrow, cedar waxwing, and yellow-rumped warbler. Again the wild turkey was the only species detected in Hell's Canyon that was not observed along the lower Snake River.

During the spring, observers detected 91 species and 7,921 individual birds in three visits to each station, for an average of 2,640 birds per visit. At irrigated HMUs 3,488 individuals were detected, 2,390 were detected at non-irrigated sites, and 2,043 in drainages. Including flyovers, the five most frequently detected species were, in descending order, white-crowned sparrow, American goldfinch, red-winged blackbird, western meadowlark, and Canada goose. Densities were calculated for 21 species.

White-crowned sparrow and American robin had the highest densities. American goldfinch, American robin, Canada goose, killdeer, mourning dove, ring-necked pheasant and white-crowned sparrow had higher densities at irrigated HMUs. Northern flicker and red-tailed hawk had higher densities in drainages.

The average number of each species at each site was used to calculate species richness and diversity in each season. Differences in species richness and diversity among irrigated HMUs, non-irrigated sites, and drainages and among the four reservoirs were tested with ANOVA. Species richness was consistently higher at irrigated HMUs and non-irrigated sites than in drainages for all three seasons. Species diversity did not differ among habitat types in any season. Species richness was different among the four reservoirs only during the breeding season. Species diversity differed among reservoirs in the breeding season and during spring.

Small mammals were trapped in late-July and August 1997 using two methods. Four drift-fence/pit-fall traps and 112 baited live-traps were open for five nights at each of the nine sites. A total of 374 small mammals were captured. Of these, 122 were recaptures, for a total of 251 individuals. Six small-mammal species were captured. Deer mouse was the most-abundant species, with 186 individuals captured, followed by 22 montane voles and 18 western harvest mice. A slightly higher number of animals were captured at irrigated HMUs when both trap types were combined. At irrigated HMUs 0.054 individuals per trap night were captured. At non-irrigated sites 0.042 individuals and in drainages 0.047 individuals per trap night were captured.

Observers visually estimated percent cover of vegetation in six categories within a 30-meter circle surrounding each VCP station during September 1997. The categories were grasses, forbs, shrubs from 0.0 to 0.5 meters tall, shrubs from 0.5 to 1.0 meters, shrubs from 1.0 to 3.0 meters, and trees greater than 3.0 meters tall. Differences in vegetative cover among irrigated HMUs, non-irrigated sites, and drainages were tested with a randomized-block ANOVA. Irrigated HMUs had a higher percent cover of grass, 0.5 to 1.0 meter shrubs, and 1.0 to 3.0 meter shrubs than non-irrigated sites, but not compared to drainages. Overall, irrigated HMUs and drainages had similar coverages of grass and woody vegetation, and had consistently higher coverages of grass and woody vegetation than non-irrigated sites. In contrast, non-irrigated sites had higher forb cover.

Even though irrigated HMUs and drainages were more similar in vegetative structure than non-irrigated sites, bird-species densities did not always respond accordingly. Birds may have responded to specific habitat features that varied between irrigated HMUs and drainages, regardless of their overall structural similarities. In addition, irrigated HMUs and non-irrigated sites were more alike physiographically than drainages. Therefore, some species may have responded to available habitat on the landscape level, rather than to microhabitat features, such as floristic structure.

Irrigated HMUs provided quality-avian habitat along the lower Snake River. However, all lower Snake River riparian habitats, including irrigated HMUs, non-irrigated sites, and larger drainages, may have a higher ecological value as migratory habitat than breeding habitat. Furthermore, more bird species were using lower Snake River riparian habitats in 1997-1998 than in 1974. Birds appeared to have responded positively to the increase in habitats offered at irrigated HMUs and to the evolution of palustrine emergent and palustrine shrub-scrub habitat. Future changes in reservoir levels will undoubtedly affect bird communities along the lower Snake River in all seasons. If the lower Snake River is allowed to return to pre-impoundment levels, these effects will be influenced by a complicated interaction among natural and management responses.

Additional years of data would strengthen current results significantly. An increase in sample size would increase the number of species for which density could be calculated and would raise statistical power. New species-use patterns may be revealed and would, thus, provide more confidence for the ecological assessment of the value of irrigated HMUs. A more-detailed-habitat study could provide specific data on species use of irrigated HMUs, non-irrigated sites, and drainages. Further information is needed on bird use of riparian habitats during the winter. It is recommended that bird populations be monitored in all seasons if significant changes in water levels are anticipated along the lower Snake River. More information is also needed on small mammal and raptor use of riparian habitats along the lower Snake River.

2. Introduction

Four dams have been constructed on the lower Snake River for hydropower, navigation, irrigation, recreation, and fish and wildlife values (P. Poolman, personal communication). Ice Harbor dam was completed in 1962, Lower Monumental in 1969, Little Goose in 1970, and Lower Granite in 1975. 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 lower Snake dams. As a result, the Corps acquired and/or designated 4,254 acres of land for wildlife habitat (Corps, 1991). Approximately 1,100 of these acres have been developed as ten intensively managed and irrigated Habitat Management Units (HMUs). Management activities at irrigated HMUs included planting of trees, shrubs, and wildlife crops (*e.g.*, corn and sunflower), haying, and noxious-weed control.

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; Corps, 1991; Downs *et al.*, 1996); however, none have specifically addressed the wildlife value of irrigated HMUs. The objective of this study was to estimate and compare abundances of birds and small mammals among irrigated HMUs, non-irrigated sites, and drainages along the lower Snake River.

3. 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 (Appendix F, Plates 1-4). The study area included four reservoirs: Ice Harbor (Appendix F, Plate 1), Lower Monumental (Appendix F, Plate 2), Little Goose (Appendix F, Plate 3), and Lower Granite (Appendix F, Plate 4). The lower Snake River canyon has hot, dry summers and mild winters. Canyon walls gradually increase in height and slope upriver. The upper end of the study area receives on average almost twice as much rainfall as the lower end. Average precipitation at Clarkston, Washington over an 88-year period was 34.9 cm; whereas, precipitation at Kennewick, Washington averaged 18.1 cm over a 77-year period (Asherin and Claar, 1976). Therefore, shrubs and trees were more abundant on the upper end of the study area, while grasses and forbs dominated the lower end. Most rainfall occurs during late fall, winter, and early spring. Summer temperatures average 23° C. Minimum winter temperatures are typically near 0°C.

Twenty-seven study sites were selected for bird censuses in 1997 and 1998 on the lower Snake River (Table 1). Study sites were divided into three habitat types: seven irrigated HMUs (Appendix F, Plates 6, 7, 10, 11, 16, 20, 23), eight non-irrigated sites (Appendix F, Plates 5, 9, 12, 14, 18, 19, 22, 24), and 12 drainages (Appendix F, Plates 8, 9, 13, 14, 15, 17, 19, 20, 21). For this study, irrigated HMUs were defined as those that were irrigated and intensively managed. The Corps manages other HMUs that were not irrigated, and these occasionally were used as non-irrigated study sites or drainages. Both irrigated HMUs and non-irrigated sites were located on bars or benches along the river. Irrigated HMUs were characterized by patches of trees and shrubs interspersed with upland habitats, hay fields maintained as goose pastures, and crops such as corn, sunflower, and millet. Trees common 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*). Upland habitat on both irrigated and non-irrigated sites were largely composed of forbs and grasses, particularly 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 at both irrigated and non-irrigated sites 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 typically had thin strips of palustrine shrub-scrub and palustrine emergent habitats along the shore, bordered immediately by upland vegetation. Non-irrigated sites adjacent to Lower Monumental and Ice Harbor reservoirs had less woody vegetation than the two upper reservoirs.

Table 1
Irrigated Habitat Management Units (HMU),
Non-Irrigated Sites, and Drainages Used in Bird Studies
Lower Snake River, 1997 and 1998

Habitat Type	Name or Description	River Mile	Number of Census Stations
Ice Harbor			
HMU	Hollebeke HMU	25	6
HMU	Big Flat HMU	16	7
Non-Irrigated	Couch Landing	32	4
Non-Irrigated	Near Charbonneau Park	12	4
Non-Irrigated	Walker	30	3
Drainage	Walker Canyon	30	5
Drainage	Upper Walker Embayment	31	2
Drainage	Snake River Junction	26	5
Lower Monumental			
HMU	Fifty-Five Mile HMU	55	5
HMU	Skookum HMU	48	7
Non-Irrigated	Riparia	67	6
Non-Irrigated	Joso	58	6
Drainage	1st Canyon below Little Goose Dam	69	2
Drainage	Alkali Flat Creek	67	2
Drainage	Tucannon River	62	5

Little Goose			
HMU	Swift Bar HMU	96	7
HMU	New York Bar HMU	81	5
Non-Irrigated	Rice Bar	93	6
Non-Irrigated	Willow Bar	87	7
Drainage	At Upriver End of Rice Bar	93	4
Drainage	Wolf Canyon	96	3
Drainage	Dry Gulch	76	4
Drainage	Deadman Creek	83	4
Lower Granite			
HMU	Chief Timothy HMU	133	7
Non-Irrigated	Wilma	135	3
Non-Irrigated	Moses	130	4
Drainage	Nisqually John Canyon	123	6
Drainage	1st Canyon above Nisqually John	124	4
		Total Stations	**133**

Study 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 steepness of canyon walls. Riparian vegetation was immediately bordered by upland habitat. Most drainages had white alder, but in various sizes and densities. Himalayan blackberry was also common. Palustrine willow and emergent vegetation often occurred in drainages, particularly at the confluence with the Snake River. All drainages entering Ice Harbor Reservoir were ephemeral, with big sagebrush as dominant woody vegetation in some areas.

On sites adjacent to Ice Harbor, Lower Monumental, and Little Goose reservoirs, a sufficient number of study sites were selected to support 10 to 15 bird-census stations per habitat type; therefore, the number of sites in each habitat type varied among reservoirs. In Lower Granite Reservoir a sufficient number of sites were selected to support seven to ten bird-census stations per habitat type.

The number of bird-census stations at each study site depended on site size. Stations were placed 400 meters apart along a walking transect. On irrigated HMUs and non-irrigated sites stations were located approximately equidistant between shoreline and the inland edge of the bench. Stations in drainages were placed on the edge of riparian vegetation. A total of 44 stations were located on irrigated HMUs, 43 on non-irrigated sites, and 46 in drainages.

Observers also censused birds at six sites along the lower section of Hell's Canyon, from the confluence with the Grande Ronde River in Washington upriver to two miles above the Oregon border (Appendix F, Plates 25, 26, 27, and 28). This free-flowing reach of the Snake River was selected to allow general comparisons of avian communities with the four lower Snake River reservoirs. The six sites were bars or benches along the river that supported woody riparian vegetation. Vegetation typically consisted of Douglas hackberry (*Celtis douglasii*) and willows adjacent to the water, while grasslands occurred inland. Sites 4 and 6 supported small stands of plains cottonwood (*Populus deltoides*) (Appendix F, Plates 26 and 27).

Small mammals were trapped at nine of the lower Snake River study sites: one irrigated HMU, one non-irrigated site, and one drainage in each of Ice Harbor (Appendix F, Plates 6 and 9), Lower Monumental (Appendix F, Plates 11, 12, 14), and Little Goose reservoirs (Appendix F, Plates, 15, 16, 18) (Table 2). Trapping did not take place in Lower Granite Reservoir due to concerns over heavy recreational use at Chief Timothy HMU.

Table 2
Irrigated Habitat Management Units (HMU),Non-Irrigated Sites, and Drainages Used in Small Mammal Study, Lower Snake River, 1997

Habitat Type	Name or Description	River Mile
Ice Harbor		
HMU	Big Flat HMU	16
Non-Irrigated	Couch Landing	32
Drainage	Walker Canyon	30
Lower Monumental		
HMU	Fifty-Five Mile HMU	55
Non-Irrigated	Joso	58
Drainage	Alkali Flat Creek	67
Little Goose		
HMU	New York Bar HMU	81
Non-Irrigated	Willow Bar	87
Drainage	Dry Gulch	76

4. Methods

4.1. Birds

4.1.1 Variable Circular Plot Censuses

The Variable Circular Plot (VCP) (Reynolds *et al.*, 1980) was the primary method used to census birds along the lower Snake River. Birds were censused in three seasons; summer (*i.e.*, the breeding season), fall, and spring. Breeding-bird censuses took place from mid-May through mid-July 1997. Fall birds were censused during September and October of 1997. The Spring bird population was censused from mid-March through April 1998. Each VCP census station was visited four times during the breeding season and three times in fall and spring. Observers rotated among stations to distribute potential observer differences. To distribute differences due to time of day, they also rotated the order stations were visited. Censuses began at or near official sunrise and continued until 10:00 a.m. Censuses did not take place during rain or when wind interfered with observer hearing ability.

Each VCP census 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 VCP station were counted as if they were detected during the VCP census. 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 census began were recorded as flyovers.

Density estimates for each site in each season were calculated with the ordered-distance method after Roeder *et al.* (1987). This nonparametric method was chosen for its lower variance estimate and robust nature under a variety of situations (Roeder *et al.*, 1987). The method calculates an effective census area for each species. At least 30 detections of a species were needed to calculate a reliable effective area (Burnham *et al.*, 1981). If greater than 20% of species detections were of flocks, then density of flocks and average number of birds in flocks was calculated. Flyovers were not included in density-estimate calculations. All detection distances were truncated to 200 meters at each station to eliminate those outside the study area. Effective areas were calculated separately for each season since species' detectability may vary among seasons. Since observer-hearing ability can change in different habitats, 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 census with the VCP method. Their swift and 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 number of individual swallows observed at the beginning of the VCP census. The relative abundance of swallows (average number observed) was calculated for each site in each season.

Variables were checked for normality prior to analyses with probability and quantile plots. Many species had non-normal plots due to zero entries at some sites; therefore, densities were ranked prior to submitting them to Analysis of Variance (ANOVA) tests. An alpha level of 0.10 was chosen to increase the power of tests with low sample sizes. A Bonferroni adjustment for pairwise comparisons was used on significant tests. An alpha of 0.15 was accepted for pairwise comparisons.

A randomized-block ANOVA was used to test for differences in species' densities and relative abundance of swallows among irrigated HMUs, non-irrigated sites, and drainages. Since precipitation, water levels, and management may vary among reservoirs, this model blocked effects of reservoirs. All tests were examined for a significant interaction between habitat types and reservoirs. For those with an interaction, profile plots were viewed to check the validity of interpreting main effect of habitat type.

A proportional design was needed for ANOVA of a randomized-block design (Zar, 1984). To obtain this, two sites in two reservoirs had to be combined. In Ice Harbor, results were combined for two non-irrigated sites, Walker and Couch Landing. These two sites were across the river from one another and had comparable vegetation types and coverages. In Little Goose, two drainages near Rice Bar were combined. These two drainages were separated by one-half to one river mile and contained similar vegetation.

4.1.2. Area-Search Censuses

The area-search method was used to census birds in Hell's Canyon and to census fall birds along the lower Snake River. The area-search method is similar to "bird watching" in that the observer wanders through an area and simply 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, fruiting plants, and crops. They were allowed to take as much time as needed to identify birds. The search period occurred between sunrise and 12:00 p.m.

The area-search method was used in Hell's Canyon to simplify and expedite visits. Each of the six sites in Hell's Canyon were visited twice during the breeding season and once in the fall. Fall birds were often less vocal and more cryptic than summer or spring birds; thus, this method was used to supplement the fall species list for the lower Snake River. This method is, however, difficult to standardize and was not subjected to statistical tests. Data from area searches were used for comparative purposes only.

4.1.3. Species Richness and Diversity

The average number of each species detected at each site was used to calculate species richness and diversity for each site in each season. Detections greater than 200 meters were deleted, as were all flyovers. Two diversity indices were calculated (Krebs, 1979:357,361). Diversity indices measure number of species and evenness of species representation in a community. Simpson's Index (1-D) ranges from zero to one, and is sensitive to changes in abundant species of a community:

Simpson's index of diversity: $1 - \hat{D} = 1 - \sum_{i=1}^{s}\left[\frac{n_i(n_i - 1)}{N(N-1)}\right]$ for a finite population.

The Shannon-Wiener Function (H') is sensitive to changes in rare species. 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, 1979):

Shannon-Wiener function: $H' = \sum_{i=1}^{s}(p_i)(\log_2 p_i)$.

ANOVA was used to test for differences in breeding bird richness and diversity among habitat types and reservoirs. A Bonferroni adjustment for pairwise comparisons was used on significant tests.

4.1.4. Nesting Guilds

Breeding-bird species were divided into five nesting guilds, based on their typical nest placement (Ehrlich *et al.*, 1988). The tree- and tall-shrub-nesting guild included American goldfinch, American robin, black-billed magpie, black-headed grosbeak, eastern kingbird, northern oriole, red-tailed hawk, western kingbird, and yellow warbler (refer to Appendix A for scientific names of all species detected during lower Snake River wildlife studies). The shrub-nesting guild included lazuli bunting, red-winged blackbird, song sparrow, willow flycatcher, and yellow-breasted chat. The ground-nesting guild included California quail, grasshopper sparrow, killdeer, ring-necked pheasant, spotted sandpiper, spotted towhee, and western meadowlark. The cavity-nesting guild included Bewick's wren, European starling, house wren, and northern flicker. The rock-nesting guild included rock wren and Say's phoebe.

The average density of each guild was calculated for each site. A randomized-block ANOVA was used to test for differences in nesting guilds among irrigated HMUs, non-irrigated sites, and drainages. A Bonferroni adjustment for pairwise comparisons was used on significant tests.

4.2. Small Mammals

Two 560-meter transects were placed at each small-mammal site. For irrigated HMUs and non-irrigated sites, one transect was located near the river shore. For drainages this transect was placed near the drainage center, as close to water as possible. The second transect was located 100 meters inland on irrigated HMUs and non-irrigated sites. Since most drainages were located in steep canyons where vegetation changed dramatically away from the riparian zone, this second transect was placed 50 meters upland in drainages.

Small mammals were trapped using two methods, live-baited traps and drift-fence/pit-fall traps, in order to minimize sampling bias associated with trap types (Williams and Braun, 1983; Szaro *et al.*, 1988). Two Sherman live-traps were placed every 20 meters along each transect, for a total of 112 traps per site. At each 20-meter-interval station two traps were placed approximately 10 meters apart on each side of the line. Traps were placed under vegetation for shading and were baited with a mixture of peanut butter and rolled oats.

Drift-fence/pit-fall traps were placed at the beginning and end of each 560-meter transect at each site, for a total of four per site. One drift-fence/pit-fall trap on each transect was placed perpendicular to the shoreline or drainage, and the other was parallel. Drift fences were 5 meters long and made of 20-centimeter-tall-landscape edging. Pit-fall traps were made of two large coffee cans, taped end-to-end, with the bottom of the top can removed. Drainage holes were punched in the bottom of each can combination. Holes were dug at the end of each drift fence and one pit-fall trap was placed in each hole.

Small-mammal trapping occurred from early July to mid-August 1997. Traps were open for five nights at each site, and were checked daily. Captured animals were identified to species and marked with fingernail polish to distinguish recaptured animals. One trap night was defined as one trap open for one night. For the drift-fence/pit-fall traps, each pit-fall was considered one trap.

4.3. Incidental Animals

All other animals observed at study sites during field work were recorded.

4.4. Vegetative Cover

Observers visually estimated percent cover of vegetation in six categories within a 30-meter circle surrounding each VCP station during September 1997. The categories were grasses, forbs, shrubs from 0.0 to 0.5 meters tall, shrubs from 0.5 to 1.0 meters, shrubs from 1.0 to 3.0 meters, and trees greater than 3.0 meters tall. Vegetative cover estimates were transformed with the arc-sin-square-root transformation. Differences in vegetative cover among irrigated HMUs, non-irrigated sites, and drainages were tested with a randomized-block ANOVA. A Bonferroni adjustment for pairwise comparisons was used on significant tests.

5. Results

5.1. Breeding Birds

5.1.1. Abundance

Ninety-two species were detected during the breeding season on the lower Snake River in 1997 (Table 3). Observers detected 9,787 individual birds in four visits to each census station, for an average of 2,447 birds per visit. More birds were present at irrigated HMUs than non-irrigated sites and drainages. At irrigated HMUs, 3,777 individuals were detected, 3,074 were detected at non-irrigated sites, and 2,936 in drainages. Including flyovers, the five most frequently detected species were, in descending order, bank swallow, cliff swallow, red-winged blackbird, western meadowlark, and northern oriole. These species comprised 43% of all detections during the breeding season. Seven percent of all detections were flyovers; these were generally species easily detected in flight, such as California and ring-billed gulls, double-crested cormorants, and various raptor and waterfowl species. Flyovers were deleted from further analyses. Thirty-two species were detected at less than five of the 27 study sites. Some of these were detected only early in the season, and were considered to be spring migrants. These were chipping sparrow, dusky flycatcher, Nashville warbler, orange-crowned warbler, sharp-shinned hawk, Townsend's warbler, western tanager, white-crowned sparrow, Wilson's warbler, and yellow-rumped warbler. A few species, such as barn owl, common yellowthroat, downy woodpecker, gray catbird, lark sparrow, and red-eyed vireo were within their breeding ranges and habitats, but were nonetheless rarely detected.

Table 3
Total Numbers of Breeding-Bird Species Detected With the Variable Circular Plot Method in Irrigated Habitat Management Units (HMU), Non-Irrigated Sites (NI), and Drainages (D), Including Flyovers and Flocks
Lower Snake River, 1997

Species	Ice Harbor			Lower Monumental			Little Goose			Lower Granite			Totals			
	HMU	NI	D	HMU	NI	D	HMU	NI	D	HMU	NI	D	HMU	NI	D	Total
American coot*	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0	2
American crow	21	3	0	1	1	6	4	0	2	0	0	1	26	4	9	39
American goldfinch	17	2	1	5	14	42	35	27	89	63	32	57	120	75	189	384
American kestrel	3	2	4	5	6	3	7	1	10	1	0	2	16	9	19	44
American robin	43	9	3	16	9	15	52	50	88	67	17	20	178	85	126	389
Bald eagle	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Bank swallow	396	302	123	67	5	16	115	140	12	9	0	0	587	447	151	1,185
Barn owl	1	0	0	1	2	0	4	1	7	0	0	0	6	3	7	16
Barn swallow	0	5	9	12	1	5	8	3	1	0	2	0	20	11	15	46
Belted kingfisher	1	0	0	0	1	0	0	0	0	0	0	0	1	1	0	2
Bewick's wren	2	0	0	0	1	27	4	2	4	3	0	3	9	3	34	46
Black-billed magpie	49	37	60	28	13	13	51	15	13	0	10	15	128	75	101	304
Black-capped chickadee	0	0	0	0	0	5	0	0	0	0	0	4	0	0	9	9
Black-headed grosbeak	12	1	1	3	2	8	0	0	9	0	8	19	15	11	37	63
Brown-headed cowbird	70	6	13	19	14	31	41	57	61	39	35	9	169	112	114	395
California gull	9	32	2	28	12	0	8	23	0	3	44	0	48	111	2	161
California quail	38	0	0	5	0	8	6	15	9	30	6	4	79	21	21	121
Canada goose	22	7	0	27	0	0	46	37	1	138	24	0	233	68	1	302
Canyon wren	1	4	2	4	9	1	9	1	0	1	3	14	15	17	17	49
Caspian tern	3	1	0	1	0	0	0	0	0	0	0	0	4	1	0	5
Cedar waxwing	0	0	0	4	0	1	1	0	0	7	1	1	12	1	2	15
Chipping sparrow	1	2	0	5	0	0	0	0	2	0	0	0	6	2	2	10
Chukar	0	0	0	0	0	0	15	2	0	0	4	0	15	6	0	21
Cinnamon teal	0	0	0	0	0	0	1	0	0	0	1	0	1	1	0	2
Cliff swallow	0	7	16	28	107	464	245	112	11	6	29	53	279	255	544	1,078
Common merganser	0	0	0	10		0	0	0	0	0	3	0	10	3	0	13
Common nighthawk	0	1	0	5	3	1	3	0	1	0	1	0	8	5	2	15
Common raven	3	5	4	16	11	3	12	3	2	6	5	1	37	24	10	71
Common snipe	0	0	0	2	0	0	0	1	0	0	0	0	2	1	0	3
Common yellowthroat	2	0	0	1	1	0	0	1	0	0	0	0	3	2	0	5
Double-crested cormorant	10	8	1	1	0	0	1	0	0	0	0	0	12	8	1	21
Downy woodpecker	1	0	0	0	0	0	0	0	3	0	0	0	1	0	3	4
Dusky flycatcher	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	2
Eastern kingbird	5	6	1	27	7	5	14	3	20	0	2	2	46	18	28	92
European starling	0	32	1	47	18	61	16	0	117	30	6	3	93	56	182	331
Forster's tern	10	11	2	18	2	0	0	0	0	0	4	0	28	17	2	47
Franklin's gull	0	0	0	0	9	0	0	0	0	0	0	0	0	9	0	9
Grasshopper sparrow	0	1	8	3	30	1	0	2	1	0	0	1	3	33	11	47
Gray catbird	1	0	0	0	0	0	0	0	0	1	0	0	2	0	0	2
Great blue heron	2	4	0	0	1	0	1	0	1	1	33	0	4	38	1	43
Great horned owl	1	0	1	0	1	1	2	0	6	0	0	1	3	1	9	13
Horned lark	0	0	4	2	22	0	0	9	0	1	0	0	3	31	4	38
House finch	0	1	0	2	3	6	3	0	3	1	2	5	6	6	14	26
House sparrow	0	0	0	0	0	0	0	7	0	0	0	0	0	7	0	7
House wren	4	0	0	0	0	3	0	1	32	0	0	7	4	1	42	47
Killdeer	1	1	1	4	11	7	9	14	2	5	32	0	19	58	10	87
Lark sparrow	0	0	0	0	0	0	0	0	1	0	1	0	0	1	1	2
Lazuli bunting	24	0	2	1	2	7	20	3	27	7	2	55	52	7	91	150
Long-eared owl	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	1
MacGillivray's warbler	0	0	0	1	0	0	0	0	3	0	0	0	1	0	3	4
Mallard	1	1	3	0	12	2	0	1	2	10	3	0	11	17	7	35
Marsh wren	0	0	0	0	0	0	2	1	1	0	0	0	2	1	1	4
Mourning dove	58	16	41	48	21	22	23	22	16	37	18	4	166	77	83	326
Nashville warbler	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1
Northern flicker	1	1	2	0	4	7	1	0	16	2	2	10	4	7	35	46
Northern harrier	2	2	1	7	2	4	5	4	1	0	0	0	14	8	6	28
Northern oriole	70	32	41	43	19	32	49	25	77	54	27	20	216	103	170	489
Northern rough-winged swallow	0	0	4	7	0	0	1	0	0	5	1	0	13	1	4	18
Orange-crowned warbler	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1
Osprey	1	0	0	1	1	1	2	0	0	1	1	0	5	2	1	8
Pine siskin	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1

Prairie falcon	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1
Red-eyed vireo	0	0	0	0	0	0	0	0	0	0	0	5	0	0	5	5
Red-tailed hawk	8	8	7	3	9	4	8	15	26	1	0	5	20	32	42	94
Red-winged blackbird	105	86	80	49	88	40	61	207	41	76	48	0	291	429	161	881
Ring-billed gull	3	12	2	0	8	0	15	8	0	1	6	0	19	34	2	55
Ring-necked pheasant	35	9	5	14	12	5	60	44	12	9	10	0	118	75	22	215
Rock dove	10	0	10	0	0	0	0	1	6	2	8	18	12	9	34	55
Rock wren	0	20	51	12	23	12	21	3	11	8	9	16	41	55	90	186
Say's phoebe	1	2	3	9	6	6	13	3	8	0	2	1	23	13	18	54
Sharp-shinned hawk	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
Short-eared owl	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1
Song sparrow	15	8	3	4	4	24	33	65	36	28	11	12	80	88	75	243
Spotted sandpiper	0	1	0	0	3	3	3	7	20	19	21	0	22	32	23	77
Spotted towhee	0	0	0	0	0	0	2	11	0	0	0	30	2	11	30	43
Swainson's hawk	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0	2
Townsend's solitaire	0		0	1	0	0	0	0	0	0	0	0	1	0	0	1
Townsend's warbler	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	2
Tree swallow	0	0	0	13	2	0	0	0	2	0	0		13	2	2	17
Violet-green swallow	0	9	4	11	2	6	1	4	0	26	10		38	25	25	88
Warbling vireo	0	0	0	1	0	0	0	0	3	0	0		1	0	4	5
Western grebe	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
Western kingbird	7	16	13	18	4	9	8	4	32	11	13	1	44	37	55	136
Western meadowlark	61	66	75	102	88	9	36	56	29	10	35	6	209	245	119	573
Western tanager	0	0	0	0	0	4	0	0	2	0	0	0	0	0	6	6
Western wood-pewee	0	8	0	0	1	9	0	2	2	0	0	0	0	11	11	22
White-crowned sparrow	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1
Willow flycatcher	0	15	0	1	0	4	0	3	3	4	0	0	5	18	7	30
Wilson's warbler	0	0	1	2	0	1	3	0	1	0	0	0	5	0	3	8
Yellow-breasted chat	13	2	0	5	5	9	7	7	6	0	0	25	25	14	40	79
Yellow-rumped warbler	0	0	1	0	0	0	14	27	7	0	19	0	14	46	8	68
Yellow warbler	9	23	0	3	0	15	0	0	0	40	9	11	52	32	26	110
Total	**1,156**	**828**	**606**	**756**	**634**	**970**	**1,102**	**1,052**	**902**	**763**	**560**	**458**	**3,777**	**3,074**	**2,936**	**9,787**

*Refer to Appendix A for scientific names of all species detected during Lower Snake River wildlife studies.

Absolute densities were calculated for 30 species, and relative abundance was calculated for three swallow species (Table 4). Northern oriole and red-winged blackbird had the highest densities. Nine species had higher densities at irrigated HMUs than at either non-irrigated sites or drainages. American robin (*P* = 0.008), black-billed magpie (*P* = 0.092), California quail (*P* = 0.079), lazuli bunting (*P* = 0.022), and mourning dove (*P* = 0.007) had higher densities at irrigated HMUs than at non-irrigated sites. These species did not show differences in density between irrigated HMUs and drainages. Bank swallow (*P* = 0.001) had a higher relative abundance and Canada goose (*P* = 0.006) had a higher density at irrigated HMUs than in drainages. Both also had high numbers at non-irrigated sites. Ring-necked pheasant (*P* = 0.0001) and western meadowlark (*P* = 0.004) had higher densities at both irrigated HMUs and non-irrigated sites than in drainages.

Table 4
Density Estimates for Breeding Birds (Birds/10 Ha) and Relative Abundance for Swallows (Average Number Detected/Site), 90% Confidence Intervals (CI), and *P*-Values for Analysis of Variance Tests for Differences Among Irrigated Habitat Management Units (HMU), Non-Irrigated Sites, and Drainages, Lower Snake River, 1997

Species	HMU		Non-Irrigated		Drainages		*P*
	Density[1]	90% CI	Density	90% CI	Density	90% CI	
American goldfinch	6.83	1.46-12.20	10.06	2.30-17.83	6.28	2.82-17.83	0.645
American robin	9.42a	4.11-17.73	2.09b	0.89-3.29	5.38ab	2.00-8.77	0.008
Bank swallow	20.96a	5.13-36.80	13.39ab	0.00-28.97	3.13b	0.00-8.01	0.001
Bewick's wren	0.27	0.01-0.53	0.09	0.00-0.21	1.07	0.00-2.19	0.544
Black-billed magpie	1.90a	0.79-3.01	0.33b	0.02-0.63	2.12ab	0.88-3.35	0.092
Black-headed grosbeak	1.26	0.00-2.77	0.92	0.00-2.07	2.30	0.71-3.88	0.700
Brown-headed cowbird	7.83	4.67-10.99	6.13	2.49-9.77	9.47	4.38-14.57	0.749
California quail	1.48a	0.13-2.83	0.27b	0.00-0.68	0.47ab	0.11-0.83	0.079
Canada goose[2]	0.12a	0.02-0.23	0.12ab	0.00-0.24	0.00b	0.00-0.00	0.006
Cliff swallow	9.96	0.00-26.29	9.11	3.06-15.15	12.36	0.00-30.39	0.195

Eastern kingbird	1.89	0.37-3.40	0.74	0.08-1.41	0.96	0.19-1.74	0.600
European starling[3]	2.25	0.16-4.35	1.01	0.10-1.92	1.70	0.00-3.44	0.838
Grasshopper sparrow	0.14	0.00-0.40	1.75	0.00-4.74	0.50	0.00-1.00	0.380
House wren	0.27ab	0.00-0.81	0.00a	0.00-0.00	2.24b	0.52-3.96	0.021
Killdeer	0.45ab	0.15-0.74	1.28a	0.29-2.28	0.19b	0.03-0.36	0.008
Lazuli bunting	2.07a	0.99-3.15	0.25b	0.00-0.51	2.92a	0.95-4.88	0.022
Mourning dove	5.47a	3.87-7.08	2.11b	1.15-3.08	2.39b	1.34-3.45	0.007
Northern flicker	0.06a	0.00-0.14	0.17ab	0.00-0.36	0.87b	0.38-1.37	0.069
Northern oriole	13.29ab	9.18-17.41	3.94a	2.33-5.54	14.66b	10.01-19.31	0.024
Red-tailed hawk	0.07	0.03-0.11	0.07	0.01-0.12	0.11	0.02-0.19	0.948
Red-winged blackbird	7.42	3.87-10.96	22.70	11.30-34.11	11.31	2.17-20.46	0.129
Ring-necked pheasant	0.74a	0.23-1.26	0.37a	0.13-0.62	0.09b	0.01-0.17	0.0001
Rock wren	0.43	0.09-0.77	0.47	0.03-0.91	1.04	0.53-1.54	0.164
Say's phoebe	0.50	0.00-1.06	0.19	0.09-0.30	0.37	0.04-0.70	0.971
Song sparrow	4.32	1.09-7.56	4.64	0.53-8.75	3.03	1.11-4.94	0.670
Spotted sandpiper	0.09ab	0.00-2.51	1.33a	0.00-2.79	0.12b	0.00-0.33	0.089
Spotted towhee	0.32	0.00-0.65	0.72	0.00-1.55	2.10	0.25-3.94	0.909
Violet-green swallow	1.36	0.00-3.18	0.89	0.13-1.66	0.57	0.02-1.12	0.505
Western kingbird	1.15	0.53-1.77	1.67	0.46-2.88	2.85	1.37-4.32	0.467
Western meadowlark	2.73a	1.79-3.66	3.62a	2.15-5.08	1.22b	0.52-1.91	0.004
Willow flycatcher	0.20	0.00-0.50	0.13	0.00-0.39	0.84	0.00-1.98	0.561

Yellow-breasted chat	0.70	0.22-1.19	0.58	0.20-0.96	1.08	0.29-1.88	0.965
Yellow warbler	3.74	0.00-7.73	2.91	0.16-5.65	3.97	0.47-7.46	0.418

[1]Densities followed by the same letter in rows are not different (Bonferroni pairwise comparisons).
[2]Density of flocks, average flock size = 6.23.
[3]Density of flocks, average flock size - 4.57.

Three species had higher densities in drainages; house wren (*P* = 0.021), northern flicker (*P* = 0.069), and northern oriole (*P* = 0.024). Orioles also had high densities at irrigated HMUs. House wrens were not detected at non-irrigated sites.

Two shorebirds, killdeer (*P* = 0.008) and spotted sandpiper (*P* = 0.089) had higher densities at non-irrigated sites than in drainages. Both species also had high densities at irrigated HMUs.

5.1.2. Species Richness and Diversity

There was a difference in species richness among irrigated HMUs, non-irrigated sites, and drainages (*P* = 0.026) (Table 5). Irrigated HMUs had higher species richness than drainages, but was not different from non-irrigated sites (Figure 1). There was no difference in avian-species diversity among irrigated HMUs, non-irrigated sites, or drainages (Table 5).

Table 5
Species Richness and Diversity Estimates for Breeding Birds,
90% Confidence Intervals (CI), and *P*-Values for
Analysis of Variance Tests for Differences Among Irrigated Habitat Management Units (HMU),
Non-Irrigated Sites, and Drainages
Lower Snake River, 1997

	HMU		Non-Irrigated		Drainages		*P*
	Mean[1]	90% CI	Mean	90% CI	Mean	90% CI	
Richness[2]	34.57a	32.03-37.11	29.71ab	24.09-35.34	25.73b	21.42-30.03	0.002
Simpson's[3]	0.88	0.81-0.94	0.85	0.75-0.94	0.86	0.77-0.95	0.588
Shannon-Wiener[4]	3.85	3.41-4.29	3.55	2.92-4.18	3.59	3.11-4.07	0.762

[1]Means followed by the same letter in rows are not different (Bonnferroni pairwise comparisons).
[2]Species richness is the total number of species detected.

[3]Simpson's index of diversity: $$1 - \hat{D} = 1 - \sum_{i=1}^{s}\left[\frac{n_i(n_i-1)}{N(N-1)}\right]$$ for a finite population.

[4]Shannon-Wiener function: $$H' = \sum_{i=1}^{s}(p_i)(\log_2 p_i)$$

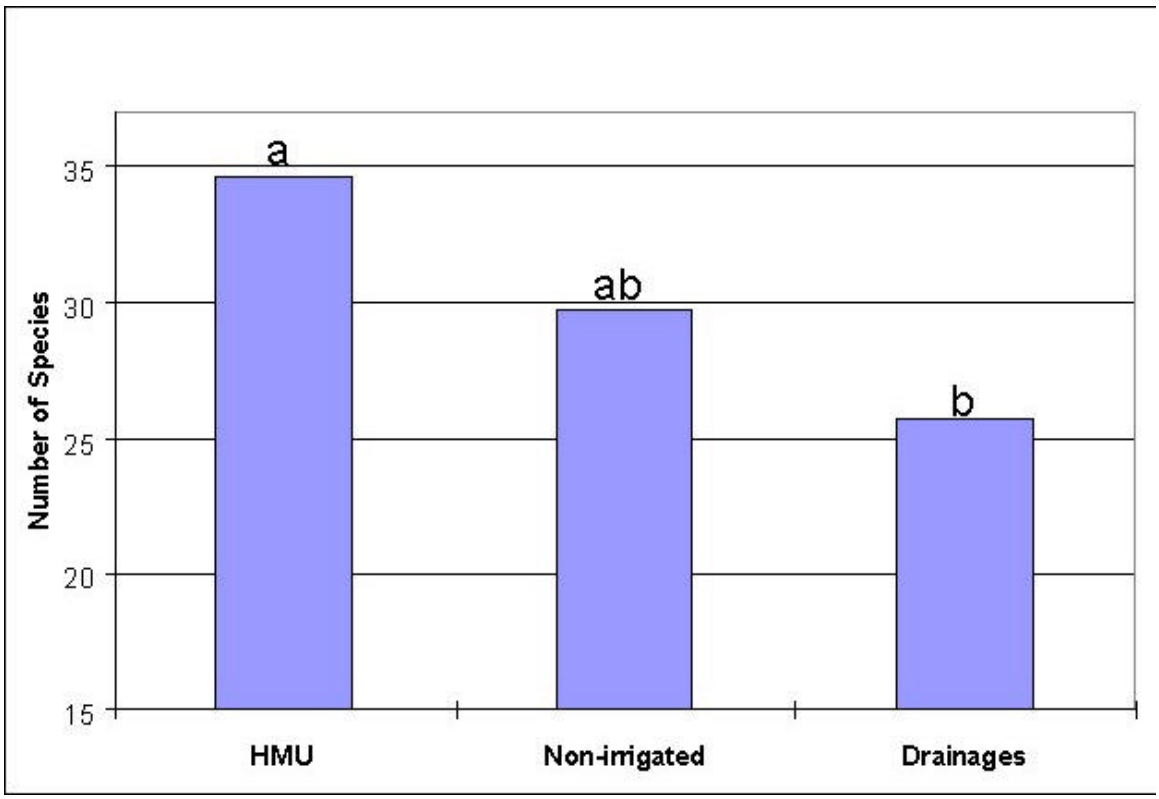

Figure 1. Species Richness Estimates for Breeding Birds for Irrigated Habitat Management Units (HMU), Non-Irrigated Sites, and Drainages, Lower Snake River, 1997. *P*-value = 0.026 for Analysis of Variance Test for Differences in Species Richness Among Habitat Types. Columns with the same letters are not different (Bonferroni Pairwise Comparisons).

There was a difference in species richness ($P = 0.056$) and in Simpson's diversity index ($P = 0.046$) among the four reservoirs (Table 6). Little Goose Reservoir had greater species richness than Ice Harbor (Figure 2). Lower Granite had a higher Simpson's diversity index than Ice Harbor (Figure 3). Diversity increased linearly from Ice Harbor to Lower Granite. Simpson's index is sensitive to common species in a community; thus, there were more common species that were equally abundant in Lower Granite than in Ice Harbor.

Table 6
Species Richness and Diversity Estimates for Breeding Birds, 90% Confidence Intervals (CI), and *P*-Values for Analysis of Variance Tests for Differences Among Reservoirs Lower Snake River, 1997

	Ice Harbor		Lower Monumental		Little Goose		Lower Granite		*P*
	Mean[1]	90% CI	Mean	90% CI	Mean	90% CI	Mean	90% CI	
Richness[2]	24.43a	19.22-29.64	29.43ab	22.44-36.42	33.43b	30.35-36.51	30.50ab	22.55-38.45	0.314
Simpson's[3]	0.79a	0.69-0.89	0.86ab	0.72-1.00	0.89ab	0.83-0.94	0.94b	0.92-0.96	0.040
Shannon-Wiener[4]	3.11	2.56-3.67	3.65	2.94-4.37	3.87	3.47-4.28	4.20	3.85-4.56	0.104

[1]Means followed by the same letter in rows are not different (Bonnferroni pairwise comparisons).
[2]Species richness is the total number of species detected.
[3]Simpson's index of diversity: $1 - \hat{D} = 1 - \sum_{i=1}^{s}\left[\frac{n_i(n_i-1)}{N(N-1)}\right]$ for a finite population.
[4]Shannon-Wiener function: $H' = \sum_{i=1}^{s}(p_i)(\log_2 p_i)$

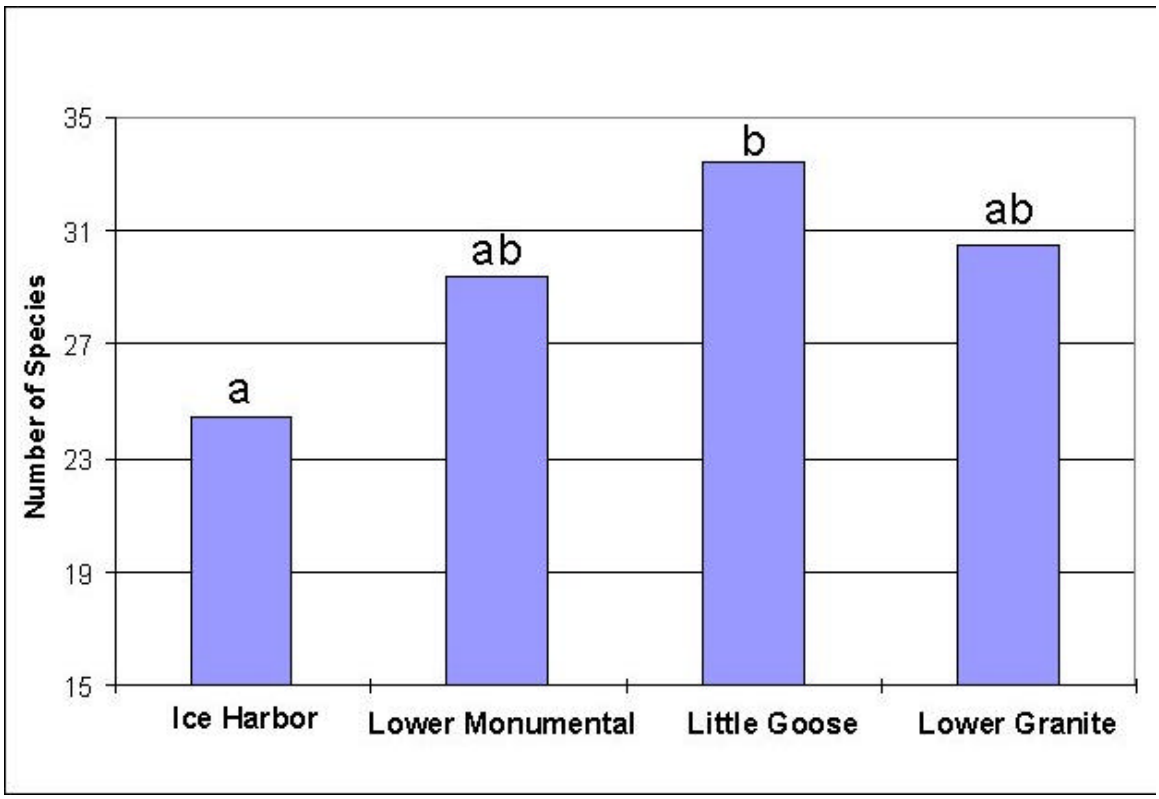

Figure 2. Species Richness Estimates for Breeding Birds for Reservoirs, Lower Snake River, 1997. *P*-value = 0.056 for Analysis of Variance Test for Differences in Species Richness Among Reservoirs. Columns with the same letters are not different (Bonferroni Pairwise Comparisons).

Figure 3. Simpson's Diversity Estimates for Breeding Birds for Reservoirs, Lower Snake River, 1997. *P*-value = 0.040 for Analysis of Variance Test for Differences in Species Diversity Among Reservoirs. Columns with the same letters are not different (Bonferroni Pairwise Comparisons).

5.1.3. Nesting Guilds

Only the ground-nesting guild had a difference in density among the three habitat types (*P* = 0.016) (Table 7). Pairwise comparisons showed that ground-nesters had a higher density at non-irrigated sites than in drainages. No differences were detected for comparisons with irrigated HMUs. Other nesting guilds may not have shown differences among habitat types due to the broad inclusion of species within these guilds.

Table 7
Density Estimates for Nesting Guilds (Birds/10 Ha),
90% Confidence Intervals (CI), and *P*-Values for
Analysis of Variance Tests for Differences Among Irrigated Habitat Management Units (HMU),
Non-Irrigated Sites, and Drainages
Lower Snake River, 1997

Nesting Guild	HMU		Non-Irrigated		Drainages		*P*
	Density[1]	90% CI	Density	90% CI	Density	90% CI	
Tree, Tall Shrub[2]	4.39	2.80-5.99	2.52	1.48-3.56	4.29	3.16-5.42	0.155
Low Shrub[3]	2.94	1.62-4.26	5.66	2.91-8.41	3.84	2.03-5.64	0.241
Ground[4]	0.96ab	0.64-1.29	1.33a	0.73-1.94	0.67b	0.41-0.93	0.016
Cavity[5]	0.71	0.22-1.21	0.32	0.04-0.60	1.47	0.54-2.40	0.124
Rocks[6]	0.46	0.04-0.89	0.33	0.08-0.59	0.70	0.39-1.02	0.353

[1]Densities followed by the same letter in rows are not different (Bonnferroni pairwise comparisons).
[2]Tree and tall shrub-nesting guild = American goldfinch, American robin, black-billed magpie, black-headed grosbeak, eastern kingbird, northern oriole, red-tailed hawk, western kingbird, yellow warbler
[3]Low shrub-nesting guild = lazuli bunting, red-winged blackbird, song sparrow, willow flycatcher, yellow-breasted chat.
[4]Ground-nesting guild = California quail, grasshopper sparrow, killdeer, ring-necked pheasant, spotted sandpiper, spotted towhee, western meadowlark.
[5]Cavity-nesting guild = Bewick's wren, European starling, house wren, northern flicker.
[6]Rock-nesting guild = rock wren, Say's phoebe.

5.1.4. Hell's Canyon

Observers detected 605 individual birds and 45 species during two visits to Hell's Canyon (Table 8). Lazuli bunting was the most-abundant species. The next-most-abundant species were cliff swallow, American goldfinch, wild turkey, and California quail. Wild turkey was not detected on the lower Snake River study area.

Table 8
Total Numbers and Proportions of Breeding-Bird Species Detected
Lower Hell's Canyon, 1997

Species	Total	Proportions
American crow	13	0.022
American goldfinch	41	0.068
American kestrel	1	0.002
American robin	6	0.010
Bank swallow	1	0.002
Belted kingfisher	2	0.003
Black-billed magpie	4	0.007
Black-capped chickadee	18	0.030
Brown-headed cowbird	1	0.002
California quail	33	0.055
Canyon wren	25	0.041
Cedar waxwing	13	0.022
Chipping sparrow	7	0.017
Chukar	13	0.022
Cliff swallow	49	0.081
Common merganser	5	0.008
Common raven	3	0.005
Eastern kingbird	6	0.010
Grasshopper sparrow	1	0.002
Gray catbird	2	0.003
Horned lark	1	0.002
Killdeer	2	0.003
Lazuli bunting	118	0.195
Mallard	9	0.015
Mourning dove	17	0.028
Northern flicker	4	0.007
Northern oriole	24	0.040
Northern rough-winged swallow	1	0.002
Red-winged blackbird	5	0.008
Ring-billed gull	1	0.002
Rock dove	1	0.002
Rock wren	9	0.015
Say's phoebe	2	0.003
Song sparrow	23	0.038
Spotted sandpiper	21	0.034
Spotted towhee	21	0.035
Tree swallow	1	0.002
Violet-green swallow	12	0.020
Western kingbird	9	0.015
Western meadowlark	12	0.020
Western tanager	7	0.012
Western wood-pewee	3	0.005
Wild turkey	37	0.061
Yellow-breasted chat	8	0.013
Yellow warbler	13	0.022
Total	**605**	**1.000**

5.2. Fall Birds

5.2.1. Abundance

During the fall, 114 species were detected using both the VCP and area-search methods. Observers detected 9,071 individual birds and 94 species over three visits to each station with the VCP method (Table 9). An average of 3,024 birds were detected per visit. Observers detected 4,316 individuals at irrigated HMUs, 2,878 at non-irrigated sites, and 1,947 in drainages. Eighteen percent of all VCP detections were flyovers, and 31% were flocks. Including flyovers, red-winged blackbird was the most frequently detected species, followed by white-crowned sparrow, American goldfinch, Canada goose, and European starling. Starlings, however, were abundant only at Swift Bar HMU. These five species comprised 64% of all fall detections. Forty-five species were detected at less than five of the 27 study sites. Most of these species, such as Cooper's hawk, goshawk, MacGillivray's warbler, Nashville warbler, solitary vireo, and Townsend's warbler were rare migrants using Snake River riparian habitats as stop-over sites. Some rarely-detected species, such as pine siskin, red crossbill, and winter wren may use these areas throughout winter.

Table 9
Total Numbers of Fall Bird Species Detected With The Variable Circular Plot Method
In Each Reservoir In Irrigated Habitat Management Units (HMU), Non-Irrigated Sites (NI), and Drainages (D)
Including Flyovers and Flocks
Lower Snake River, 1997

Species	Ice Harbor			Lower Monumental			Little Goose			Lower Granite			Totals			
	HMU	NI	D	HMU	NI	D	HMU	NI	D	HMU	NI	D	HMU	NI	D	Total
American coot	3	0	0	0	0	0	0	65	0	0	4	0	3	69	0	72
American crow	5	2	0	13	5	21	0	1	2	0	0	0	18	8	23	49
American goldfinch	94	30	48	55	60	130	56	113	93	87	60	6	292	263	277	832
American kestrel	4	0	0	0	2	1	2	0	1	0	1	1	6	3	3	12
American robin	135	85	0	14	22	58	43	2	16	48	0	5	240	109	79	428
American wigeon	0	25	0	0	0	0	0	1	0	0	0	0	0	26	0	26
Bank swallow	0	0	0	0	0	0	0	5	0	0	0	0	0	5	0	5
Barn owl	0	0	0	0	1	0	0	2	0	0	0	0	0	3	0	3
Barn swallow	2	12	0	1	3	1	9	37	8	4	9	0	16	61	9	86
Belted kingfisher	0	3	1	2	3	3	0	1	0	2	4	0	4	11	4	19
Bewick's wren	0	0	0	0	0	3	1	2	0	0	0	1	1	2	4	7
Black-billed magpie	55	10	11	24	15	20	18	16	15	1	12	19	98	53	65	216
Black-capped chickadee	0	0	0	0	0	6	0	0	6	1	0	9	1	0	21	22
Brewer's blackbird	8	0	0	0	0	0	0	0	0	0	0	0	8	0	0	8
Bufflehead	0	0	0	0	10	0	0	0	0	0	0	0	0	10	0	10
California gull	0	3	0	1	1	1	1	1	0	1	3	0	3	8	1	12
California quail	5	0	0	3	4	0	0	3	13	49	32	4	57	39	17	113
Canada goose	90	371	89	6	0	14	26	33	33	80	0	0	202	404	136	742
Canyon wren	0	4	1	1	0	0	1	1	6	2	1	23	4	6	30	40
Cedar waxwing	1	0	0	1	0	0	0	0	0	2	0	0	4	0	0	4
Chipping sparrow	5	2	11	2	2	0	0	2	5	0	0	0	7	6	16	29
Chukar	0	0	36	0	1	0	0	0	0	1	7	24	1	8	60	69
Cliff swallow	0	0	0	0	0	0	0	6	0	0	0	0	0	6	0	6
Common merganser	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1
Common raven	0	0	0	7	0	0	1	0	0	0	1	0	8	1	0	9
Cooper's hawk	1	1	2	0	0	0	0	0	0	0	0	0	1	1	2	4
Dark-eyed junco	6	6	14	2	0	5	0	0	8	5	4	4	13	10	31	54
Double-crested cormorant	1	7	0	1	1	0	0	5	0	0	0	0	2	13	0	15
Downy woodpecker	0	0	0	0	0	0	0	0	2	2	0	0	2	0	2	4
Eastern kingbird	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1
European starling	6	1	0	9	46	0	570	0	97	2	6	0	587	53	97	737
Franklin's gull	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1
Golden-crowned kinglet	0	0	0	0	0	0	0	0	2	0	0	4	0	0	6	6
Grasshopper sparrow	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1
Gray catbird	0	0	0	0	0	1	0	0	0	1	0	0	1	0	1	2
Great blue heron	1	0	0	0	3	1	0	1	0	0	1	0	1	5	1	7
Great horned owl	0	0	0	0	0	0	1	0	4	0	0	0	1	0	4	5
Green-winged teal	0	0	0	0	0	0	7	7	0	0	0	0	7	7	0	14
Horned grebe	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1
Horned lark	0	0	2	0	32	3	0	0	0	0	0	0	0	32	5	37
House finch	8	7	0	0	7	2	3	4	3	5	8	0	16	26	5	47
House wren	0	0	0	0	0	2	0	0	2	0	0	0	0	0	4	4
Killdeer	0	1	1	0	0	2	0	4	3	1	2	0	1	7	6	14
Lark sparrow	0	0	0	0	0	0	0	1	1	0	0	0	0	1	1	2
Lazuli bunting	0	0	0	0	0	0	3	0	0	0	0	0	3	0	0	3
Lesser yellowlegs	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1
Lincoln's sparrow	2	0	2	0	0	7	1	2	0	0	0	2	3	2	11	16
MacGillvray's warbler	3	0	0	0	0	1	4	2	0	0	0	0	7	2	1	10
Mallard	2	12	0	0	0	1	0	6	0	21	0	0	23	18	1	42
Marsh wren	1	1	1	0	1	3	0	1	1	0	0	0	1	3	5	9
Mourning dove	5	3	6	5	4	1	6	1	3	9	1	0	25	9	10	44
Nashville warbler	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	2
Northern flicker	20	13	5	19	7	13	12	6	28	6	3	4	57	29	50	136
Northern goshawk	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Northern harrier	4	2	1	3	2	1	4	9	2	0	1	0	11	14	4	29
Northern oriole	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	2
Northern rough-winged swallow	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1
Northern shoveler	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1
Orange-crowned warbler	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	1
Osprey	0	0	1	0	1	0	1	2	0	3	1	0	4	4	1	9
Pied-billed grebe	0	0	0	1	0	0	0	1	0	0	0	0	1	1	0	2
Pine siskin	0	0	0	0	0	0	0	0	1	0	1	0	0	1	1	2
Red-eyed vireo	1	0	0	0	0	0	3	0	0	2	0	0	6	0	0	6

Red-tailed hawk	0	2	0	3	4	0	11	5	8	2	0	8	16	11	16	43
Red-winged blackbird	68	6	12	84	84	25	971	460	71	107	18	0	1,230	568	108	1,906
Red crossbill	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1
Redhead	0	0	0	0	0	3	0	0	0	0	0	0	0	0	3	3
Ring-billed gull	3	7	0	2	1	0	5	15	0	8	12	0	18	35	0	53
Ring-necked pheasant	5	7	1	11	0	6	51	34	32	0	2	0	67	43	39	149
Rock dove	0	28	26	0	0	2	1	0	24	0	6	0	1	34	52	87
Rock wren	0	8	6	1	0	5	0	0	3	1	4	6	2	12	20	34
Ruby-crowned kinglet	1	1	2	7	0	7	3	3	18	1	6	16	12	10	43	65
Savannah sparrow	6	6	6	4	5	1	7	44	1	0	1	0	17	56	8	81
Say's phoebe	0	0	0	0	0	1	0	0	0	0	1	3	0	1	4	5
Sharp-shinned hawk	3	3	1	3	0	0	1	0	2	1	0	1	8	3	4	15
Solitary vireo	0	0	1	0	0	0	0	0	0	1	0	0	1	0	1	2
Song sparrow	44	27	17	18	21	32	41	88	67	33	25	27	136	161	143	440
Spotted towhee	5	1	1	1	0	2	3	2	5	4	1	21	13	4	29	46
Swainson's hawk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Townsend's solitaire	0	0	1	0	0	0	0	0	3	0	0	0	0	0	4	4
Varied thrush	0	0	0	0	0	0	0	0	5	0	0	0	0	0	5	5
Vaux's swift	0	0	0	0	0	0	0	4	0	0	0	0	0	4	0	4
Vesper sparrow	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1
Warbling vireo	0	0	0	0	0	1	1	0	0	0	0	0	1	0	1	2
Western grebe	6	0	0	0	0	0	0	0	0	0	0	0	6	0	0	6
Western meadowlark	13	55	37	29	57	6	10	10	16	4	7	0	56	129	59	244
Western wood-pewee	1	0	0	0	0	0	1	0	0	0	0	0	2	0	0	2
White-crowned sparrow	312	40	105	375	19	114	112	295	151	65	36	11	864	390	381	1,635
Wilson's warbler	2	0	0	0	0	3	5	2	3	0	0	0	7	2	6	15
Winter wren	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1
Yellow-breasted chat	1	0	0	1	0	0	1	0	1	0	0	0	3	0	1	4
Yellow-headed blackbird	0	0	0	0	0	0	0	2	0	1	0	0	1	2	0	3
Yellow-rumped warbler	23	55	0	31	8	2	48	4	18	0	0	1	102	67	21	190
Yellow warbler	0	0	0	0	1	1	0	0	0	0	0	0	0	1	1	2
Total	**962**	**847**	**450**	**743**	**435**	**512**	**2,045**	**1,314**	**785**	**566**	**282**	**200**	**4,316**	**2,878**	**1,947**	**9,141**

Seventeen species had a sufficient number of detections to calculate density (Table 10). The density of flocks was calculated for 11 of these species. White-crowned and song sparrows had the highest densities of flocks. White-crowned sparrows dominated the fall bird community. There was an average of 156 white-crowned sparrows per 10 hectares at irrigated HMUs. Song sparrows had the next-highest densities, with an average of only 20 birds per hectare at irrigated HMUs.

Table 10
Density Estimates for Fall Birds (Birds/10 Ha),
90% Confidence Intervals (CI), and *P*-Values for
Analysis of Variance Tests for Differences Among Irrigated Habitat Management Units (HMU),
Non-Irrigated Sites, and Drainages
Lower Snake River, 1997

Species	Flock Size	HMU		Non-Irrigated		Drainages		*P*
		Density[1]	90% CI	Density	90% CI	Density	90% CI	
American goldfinch	2.56	3.88	2.83-4.93	3.11	2.47-3.75	2.68	1.58-3.78	0.340
American robin	2.22	4.50a	2.96-6.03	1.88b	0.00-4.04	1.24b	0.52-1.97	0.016
Black-billed magpie	1.00	0.60	0.33-0.87	0.49	0.35-0.62	0.41	0.19-0.64	0.585
California quail	3.65	0.46	0.00-1.00	0.21	0.00-0.44	0.23	0.03-0.43	0.854
Canyon wren	1.00	0.07	0.00-0.17	0.13	0.00-0.30	0.53	0.05-1.02	0.765
Dark-eyed junco	1.69	1.22	0.17-2.26	1.33	0.00-3.19	1.38	0.56-2.20	0.749
Northern flicker	1.00	1.63	0.96-2.29	0.96	0.50-1.43	1.42	0.69-2.15	0.496
Red-winged blackbird	6.03	1.33	0.57-2.10	0.95	0.05-1.85	0.75	0.24-1.27	0.295
Ring-necked pheasant	1.80	0.93	0.19-1.68	0.67	0.05-1.29	0.51	0.14-0.88	0.235
Rock wren	1.00	0.02a	0.00-0.05	0.12ab	0.00-0.29	0.23b	0.11-0.35	0.057
Ruby-crowned kinglet	1.50	2.05	0.84-3.26	1.23	0.28-2.19	3.79	1.43-6.15	0.237
Savannah sparrow	2.31	1.46ab	0.43-2.49	3.87a	1.66-6.09	0.96b	0.17-1.76	0.035
Song sparrow	1.32	14.94	9.09-20.78	11.48	6.34-16.63	17.09	10.36-23.82	0.835
Spotted towhee	1.00	0.91	0.47-1.35	0.32	0.00-0.64	1.01	0.14-1.89	0.235
Western meadowlark	1.00	1.65	0.69-2.60	2.77	0.89-4.65	1.08	0.53-1.63	0.174
White-crowned sparrow	5.10	31.10a	16.90-45.29	12.36ab	5.33-19.39	9.26b	5.27-13.24	0.031
Yellow-rumped warbler	3.20	3.14	1.01-5.27	2.69	0.00-6.29	1.06	0.18-1.94	0.248

[1]Densities followed by the same letter in rows are not different (Bonferroni pairwise comparisons).

Four species had differences in density among habitat types (Table 10). American robin had higher densities at irrigated HMUs than at non-irrigated sites and drainages (P = 0.016). White-crowned sparrow had higher densities at irrigated HMUs than drainages (P =0.031), and had intermediate densities at non-irrigated sites. Rock wren had higher densities in drainages than irrigated HMUs (P = 0.057). Savannah sparrow had higher densities at non-irrigated sites than drainages (P = 0.035), but also had high densities at irrigated HMUs.

Observers detected an additional 12 species with the area-search method that were not detected during VCP censuses (Table 11). These 12 species were detected in low numbers, and were often quiet, secretive birds, such as American tree sparrow, fox sparrow, and hermit thrush.

Table 11
Fall Bird Species Detected With The Area-Search Method That Were Not Detected During Variable Circular Plot Census In Each Reservoir In Irrigated Habitat Management Units (HMU), Non-Irrigated Sites (NI), and Drainages (D), Including Flyovers and Flocks, Lower Snake River, 1997

Species	Ice Harbor			Lower Monumental			Little Goose			Lower Granite		
	HMU	NI	D	HMU	NI	D	HMU	NI	D	HMU	NI	D
American dipper	0	0	0	0	0	0	0	0	1	0	0	0
American pipit	5	0	6	0	0	0	0	0	0	0	0	0
American tree sparrow	1	0	0	0	0	0	0	0	0	0	0	0
Black-headed grosbeak	0	0	0	0	0	0	0	0	0	2	0	0
Blue-winged teal	0	0	0	0	0	0	0	2	0	0	0	0
Bohemian waxwing	0	0	0	0	0	5	0	0	0	0	0	0
Common nighthawk	0	0	0	0	0	0	0	0	1	0	0	0
Fox sparrow	0	0	0	1	0	0	0	1	0	0	0	0
Golden eagle	0	0	0	0	0	0	2	1	0	0	1	0
Greater scaup	0	0	0	0	0	0	0	2	0	0	0	0
Greater yellowlegs	0	0	0	0	0	0	0	1	0	0	0	0
Hermit thrush	2	0	0	0	0	0	0	0	0	0	0	1
House sparrow	0	0	0	0	0	0	0	21	0	0	0	0
Long-eared owl	0	0	0	1	0	0	0	0	0	0	0	0
Merlin	0	0	0	0	0	0	0	1	0	0	0	0
Northern shrike	1	0	0	0	0	0	0	0	0	0	0	0
Ring-necked duck	0	0	0	0	0	0	0	1	0	0	0	0
Rufous hummingbird	0	0	0	0	0	0	0	1	0	0	0	0
Rough-legged hawk	0	1	0	0	0	0	2	0	0	0	0	0
Townsend's warbler	0	0	0	0	0	0	1	0	0	0	0	0
Western kingbird	0	0	0	1	0	1	0	1	2	0	0	0

5.2.2. Species Richness and Diversity

There was a higher species richness in both irrigated HMUs and non-irrigated sites than in drainages (P = 0.006) (Table 12) (Figure 4). There was no difference in species diversity, using the Simpson's or Shannon-Wiener index, among the three habitat types or four reservoirs (Tables 12 and 13).

Table 12
Species Richness and Diversity Estimates for Fall Birds,
90% Confidence Intervals (CI), and *P*-Values for
Analysis of Variance Tests for Differences Among Irrigated Habitat Management Units (HMU),
Non-Irrigated Sites, and Drainages
Lower Snake River, 1997

	HMU		Non-Irrigated		Drainages		*P*
	Mean[1]	90% CI	Mean	90% CI	Mean	90% CI	
Richness[2]	26.71a	23.72-29.70	25.14a	21.96-28.33	18.00b	14.47-21.53	0.006
Simpson's[3]	0.75	0.62-0.87	0.86	0.80-0.92	0.86	0.80-0.92	0.230
Shannon-Wiener[4]	2.96	2.47-3.47	3.44	3.11-3.77	3.12	2.89-3.36	0.256

[1]Means followed by the same letter in rows are not different (Bonnferroni pairwise comparisons).
[2]Species richness is the total number of species detected.

[3]Simpson's index of diversity: $$1 - \hat{D} = 1 - \sum_{i=1}^{s}\left[\frac{n_i(n_i - 1)}{N(N-1)}\right]$$ for a finite population.

[4]Shannon-Wiener function: $$H' = \sum_{i=1}^{s}\left(p_i\right)\left(\log_2 p_i\right)$$

Table 13
Species Richness and Diversity Estimates for Fall Birds, 90% Confidence Intervals (CI), and *P*-Values for Analysis of Variance Tests for Differences Among Reservoirs Lower Snake River, 1997

	Ice Harbor		Lower Monumental		Little Goose		Lower Granite		*P*
	Mean[1]	90% CI	Mean	90% CI	Mean	90% CI	Mean	90% CI	
Richness[2]	20.86	15.81-25.90	20.71	15.03-26.40	25.43	22.43-28.42	23.00	13.84-32.17	0.425
Simpson's[3]	0.82	0.75-0.89	0.83	0.68-0.97	0.80	0.72-0.87	0.91	0.89-0.92	0.245
Shannon-Wiener[4]	3.09	2.76-3.42	3.06	2.55-3.58	3.14	2.75-3.52	3.55	3.32-3.77	0.333

[1]Means followed by the same letter in rows are not different (Bonnferroni pairwise comparisons).
[2]Species richness is the total number of species detected.

[3]Simpson's index of diversity: $$1 - \hat{D} = 1 - \sum_{i=1}^{s}\left[\frac{n_i(n_i - 1)}{N(N-1)}\right]$$ for a finite population.

[4]Shannon-Wiener function: $$H' = \sum_{i=1}^{s}\left(p_i\right)\left(\log_2 p_i\right)$$

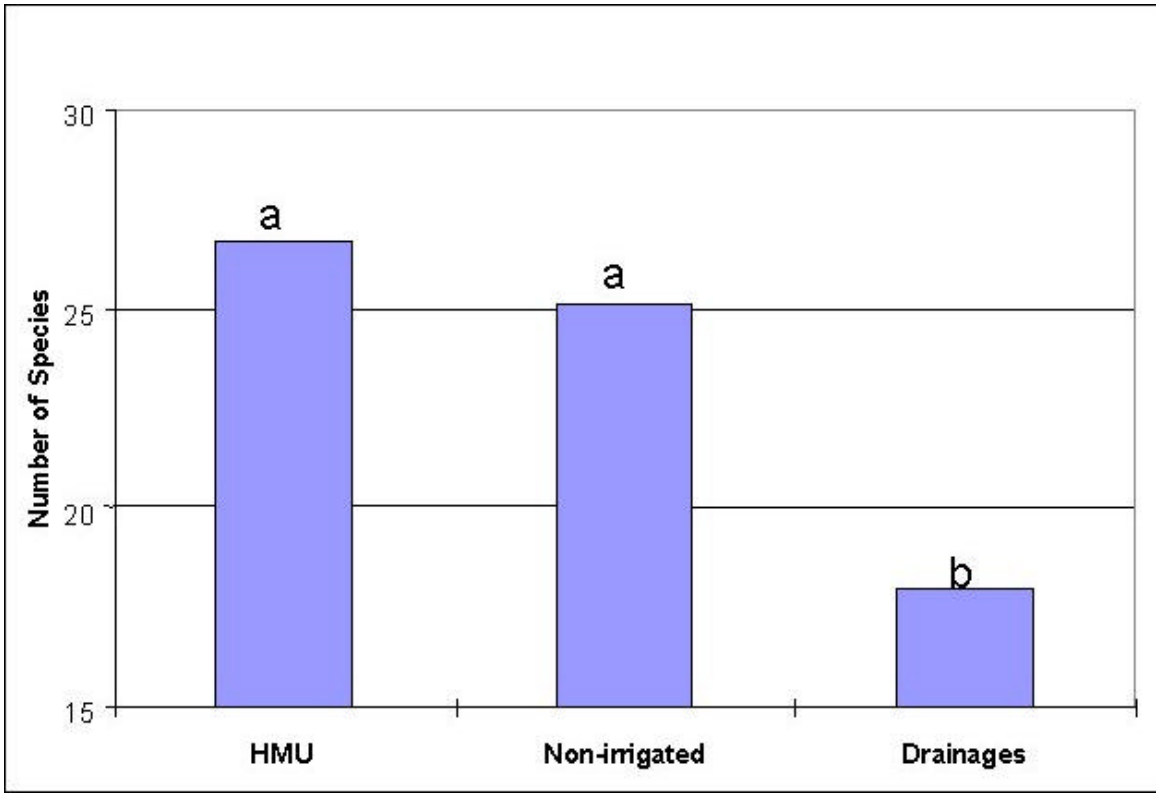

Figure 4. Species Richness Estimates for Fall Birds for Irrigated Habitat Management Units (HMU), Non-Irrigated Sites, and Drainages, Lower Snake River, 1997. *P*-value = 0.006 for Analysis of Variance Test for Differences in Species Richness Among Habitat Types. Columns with the same letters are not different (Bonferroni Pairwise Comparisons).

5.2.3. Hell's Canyon

Observers detected 25 species during the fall visit to Hell's Canyon (Table 14). California quail was the most-abundant species. The next-most-abundant species were American goldfinch, song sparrow, cedar waxwing, and yellow-rumped warbler. As with the breeding-bird censuses, wild turkey was the only species detected in Hell's Canyon that was not observed along the lower Snake River.

Table 14
Total Numbers and Proportions of Fall Bird Species Detected
Lower Hells Canyon, 1997

Species	Total	Proportion
American crow	2	0.010
American goldfinch	39	0.186
American kestrel	1	0.005
American robin	2	0.010
Belted kingfisher	1	0.005
Black-billed magpie	3	0.014
California quail	41	0.195
Canyon wren	2	0.010
Cedar waxwing	15	0.071
Chukar	1	0.005
Dark-eyed junco	1	0.005
Great-blue heron	1	0.005
Killdeer	1	0.005
Merlin	1	0.005
Mourning dove	11	0.052
Northern flicker	11	0.052
Red-winged blackbird	5	0.024
Rock dove	2	0.010
Rock wren	3	0.014
Ruby-crowned kinglet	1	0.005
Song sparrow	35	0.167
Spotted towhee	2	0.010
White-crowned sparrow	10	0.048
Wild turkey	5	0.024
Yellow-rumped warbler	14	0.067
Total	**210**	**1.000**

5.3. Spring Birds

5.3.1. Abundance

Observers detected 91 species and 7,921 individual birds in three visits to each station during spring, for an average of 2,640 birds per visit (Table 15). At irrigated HMUs 3,488 individuals were detected, 2,390 were detected at non-irrigated sites, and 2,043 in drainages. Eleven percent of all detections were flyovers, and 20% were flocks. Including flyovers, the five most frequently detected species were, in descending order, white-crowned sparrow, American goldfinch, red-winged blackbird, western meadowlark, and Canada goose. These species made up 53% of bird detections during spring. Fifty species were detected at less than five of the 27 study sites. Species with few detections included golden-crowned kinglet, golden-crowned sparrow, hermit thrush, loggerhead and northern shrikes, merlin, purple finch, Ross' goose, and varied thrush.

Table 15
Total Numbers of Spring Bird Species Detected With The Variable Circular Plot Method In Each Reservoir In Irrigated Habitat Management Units (HMU), Non-Irrigated Sites (NI), and Drainages (D) Including Flyovers and Flocks
Lower Snake River, 1997

Species	Ice Harbor			Lower Monumental			Little Goose			Lower Granite			Totals			
	HMU	NI	D	HMU	NI	D	HMU	NI	D	HMU	NI	D	HMU	NI	D	Total
American coot	6	0	1	11	1	5	0	14	0	26	0	0	43	15	6	23
American crow	22	4	3	5	2	1	1	3	1	3	0	1	31	9	6	64
American goldfinch	45	58	48	66	131	31	67	32	137	125	19	103	303	240	319	46
American green-winged teal	0	0	0	2	18	3	0	0	0	0	0	0	2	18	3	862
American kestrel	2	1	0	0	0	0	4	0	6	1	0	1	7	1	7	15
American robin	73	15	7	30	5	14	50	18	66	64	13	16	217	51	103	371
American wigeon	2	0	0	0	0	0	0	3	0	0	0	0	2	3	0	5
Bald eagle	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1
Bank swallow	23	100	6	0	0	0	0	0	0	0	0	0	23	100	6	129
Barn owl	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	4
Barn swallow	0	0	4	0	0	0	0	0	0	0	0	0	0	0	4	285
Belted kingfisher	0	0	0	0	0	6	0	0	0	0	1	0	0	1	6	28
Bewick's wren	0	1	0	0	3	20	7	10	11	11	0	8	18	14	39	7
Black-billed magpie	65	44	46	45	3	16	14	5	18	1	1	27	125	53	107	71
Black-capped chickadee	1	0	0	0	0	8	0	0	2	0	0	17	1	0	27	2
Blue-winged teal	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	407
California gull	9	8	0	3	3	0	1	1	0	2	17	0	15	29	0	44
California quail	45	5	3	8	0	21	5	29	24	12	3	6	70	37	54	33
Canada goose	27	55	4	39	22	9	56	111	2	58	18	6	180	206	21	161
Canyon wren	0	6	1	0	1	0	4	0	2	2	0	17	6	7	20	128
Cedar waxwing	69	0	0	0	0	0	0	0	1	58	0	0	127	0	1	2
Chipping sparrow	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0	34
Chukar	0	0	3	5	0	0	4	0	0	1	18	3	10	18	6	66
Cliff swallow	0	3	0	0	0	30	20	13	0	0	0	0	20	16	30	1
Common goldeneye	0	0	0	0	11	0	0	0	0	0	0	0	0	11	0	11
Common loon	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1
Common merganser	0	0	0	7	0	0	12	0	0	3	0	0	22	0	0	22
Common nighthawk	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1
Common raven	1	0	0	2	0	2	1	1	1	0	0	1	4	1	4	9
Dark-eyed junco	17	0	12	0	0	3	0	2	12	9	16	7	26	18	34	24
Double-crested cormorant	4	3	9	0	0	0	0	1	0	6	1	0	10	5	9	78
Downy woodpecker	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
European starling	1	54	7	6	56	6	3	0	65	5	3	6	15	113	84	212
Golden eagle	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Golden-crowned kinglet	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	1
Golden-crowned sparrow	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	12
Grasshopper sparrow	0	1	0	1	6	0	0	0	0	0	0	0	1	7	0	1
Great blue heron	2	2	0	0	0	0	1	0	0	1	16	0	4	18	0	8
Great horned owl	0	0	2	0	0	0	0	3	7	0	0	0	0	3	9	22
Hermit thrush	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1
Horned lark	0	2	7	0	63	9	3	0	0	0	0	1	3	65	17	37
House finch	0	0	0	4	1	0	2	1	8	15	4	2	21	6	10	85
House sparrow	0	0	0	0	0	0	0	14	0	0	0	0	0	14	0	14
House wren	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1
Killdeer	2	2	2	5	11	4	3	6	0	7	16	0	17	35	6	58
Lincoln's sparrow	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2	1
Loggerhead shrike	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1
Long-billed curlew	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	2
Long-eared owl	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1
MacGillvray's warbler	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	270
Mallard	162	2	1	4	5	12	7	50	1	20	6	0	193	63	14	2
Marsh wren	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	1
Merlin	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	2
Mourning dove	17	5	0	1	2	0	7	3	3	28	9	0	53	19	3	75
Northern flicker	0	5	3	5	5	8	1	2	17	3	6	23	9	18	51	78
Northern harrier	2	0	1	5	6	6	7	11	3	0	1	0	14	18	10	42
Northern rough-winged swallow	0	0	0	0	27	0	0	0	0	0	0	0	0	27	0	11
Northern shoveler	0	0	0	2	9	0	0	0	0	0	0	0	2	9	0	27
Northern shrike	0	0	0	0	0	0	1	0	0	0	0	1	1	0	1	2
Osprey	0	0	0	0	0	1	0	1	0	2	0	0	2	1	1	4
Purple finch	0	0	0	0	0	0	0	0	0	1	0	2	1	0	2	3
Red-tailed hawk	8	1	5	2	4	7	6	2	38	1	0	4	17	7	54	27
Red-winged blackbird	123	57	76	12	77	113	54	125	52	68	52	0	257	311	241	4

Ring-billed gull	0	4	0	7	3	0	5	6	0	0	2	0	12	15	0	318
Ring-necked pheasant	63	22	12	27	4	15	79	40	39	10	7	0	179	73	66	40
Rock dove	32	5	1	0	0	0	0	0	0	2	0	0	34	5	1	1
Rock wren	0	20	7	3	3	2	2	1	3	4	1	4	9	25	16	50
Ross' goose	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	78
Ruby-crowned kinglet	1	1	0	2	0	0	0	0	0	0	0	0	3	1	0	809
Savannah sparrow	0	1	1	0	0	4	0	0	0	0	0	0	0	1	5	44
Say's phoebe	2	3	4	3	8	7	5	1	9	1	0	1	11	12	21	6
Sharp-shinned hawk	0	1	0	0	0	0	1	0	0	0	1	0	1	2	0	2
Short-eared owl	0	0	0	0	0	0	0	1	0	0	0	1	0	1	1	1
Snow goose	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	274
Song sparrow	31	5	4	9	2	22	46	56	41	31	5	22	117	68	89	84
Spotted towhee	4	2	0	0	0	2	4	11	29	1	0	31	9	13	62	3
Townsend's solitaire	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	2
Tree swallow	0	0	0	0	0	0	0	2	0	0	0	0	0	2	0	2
Tundra swan	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1
Varied thrush	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
Violet-green swallow	5	0	0	1	2	12	2	5	18	8	3	0	16	10	30	56
Warbling vireo	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1
Western grebe	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	1,344
Western kingbird	1	5	6	0	0	0	1	0	0	0	0	0	2	5	6	2
Western meadowlark	96	125	148	88	118	36	46	34	54	19	24	14	249	301	252	13
White-crowned sparrow	632	46	79	57	4	28	210	139	37	38	67	7	937	256	151	802
Willow flycatcher	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1
Wilson's warbler	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Yellow-headed blackbird	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	24
Yellow-rumped warbler	3	0	20	1	0	0	0	0	0	0	0	0	4	0	20	18
Yellow warbler	0	1	0	15	0	0	0	0	0	2	0	0	17	1	0	1
Total	**1,601**	**676**	**537**	**490**	**617**	**464**	**744**	**762**	**708**	**653**	**335**	**334**	**3,488**	**2,390**	**2,043**	**7,921**

Densities were calculated for 21 species; the density of flocks was calculated for four of these species (Table 16). White-crowned sparrow and American robin had the highest densities. Nine species had a significant difference in density among irrigated HMUs, non-irrigated sites, and drainages. Seven species had higher densities at irrigated HMUs than at either non-irrigated sites or drainages. American goldfinch (P = 0.069), killdeer (P = 0.066), and white-crowned sparrow (P = 0.019) had higher densities at irrigated HMUs than in drainages. Killdeer and white-crowned sparrow also had high densities at non-irrigated sites. American robin had higher densities at irrigated HMUs than at non-irrigated sites, but had intermediate densities in drainages (P = 0.001). Canada goose (P = 0.0001) and mourning dove (P = 0.001) both had higher densities at irrigated HMUs and non-irrigated sites than in drainages. Ring-necked pheasant had higher densities at irrigated HMUs than both non-irrigated sites and drainages (P = 0.0001).

Table 16
Density Estimates for Spring Birds (Birds/10 Ha), 90% Confidence Intervals (CI), and *P*-Values for Analysis of Variance Tests for Differences Among Irrigated Habitat Management Units (HMU), Non-Irrigated Sites, and Drainages
Lower Snake River, 1998

Species	Flock Size	HMU		Non-Irrigated		Drainages		*P*
		Density[1]	90% CI	Density	90% CI	Density	90% CI	
American goldfinch	1.00	3.65a	1.66-5.63	1.70ab	1.12-2.28	1.62b	0.85-2.40	0.069
American robin	1.00	8.18a	4.79-11.56	0.91b	0.45-1.37	4.85a	2.44-7.26	0.001
Bewick's wren	1.00	1.73	0.00-3.95	1.42	0.24-2.59	4.45	0.82-8.09	0.617
Black-billed magpie	1.00	2.43	1.05-3.82	0.80	0.11-1.49	1.60	0.69-2.50	0.106
California quail	2.45	0.40	0.11-0.68	0.12	0.00-0.23	0.17	0.07-0.28	0.214
Canada goose	3.44	0.56a	0.15-0.98	0.69a	0.35-1.03	0.02b	0.00-0.05	0.0001
Canyon wren	1.00	0.05	0.00-0.13	0.06	0.00-0.14	0.11	0.00-0.23	0.928
European starling	3.88	0.16	0.00-0.32	0.73	0.00-1.49	0.46	0.14-0.78	0.433
Horned Lark	1.00	0.05	0.00-0.15	2.09	0.00-6.00	0.83	0.00-1.84	0.532
Killdeer	1.00	0.38a	0.20-0.55	0.52ab	0.09-0.95	0.17b	0.00-0.38	0.066
Mourning Dove	1.00	1.46a	0.50-2.42	0.51a	0.18-0.83	0.13b	0.00-0.29	0.001
Northern flicker	1.00	0.06a	0.01-0.11	0.15ab	0.02-0.27	0.39b	0.23-0.56	0.019
Red-tailed hawk	1.00	0.02ab	0.00-0.05	0.01a	0.00-0.02	0.09b	0.01-0.16	0.039
Red-winged blackbird	1.00	2.32	0.93-3.72	7.79	4.12-11.45	5.80	1.66-10.02	0.250
Ring-necked pheasant	1.00	2.56a	1.52-3.60	0.72b	0.26-1.18	0.43b	0.12-0.73	0.0001
Rock wren	1.00	0.04	0.01-0.08	0.11	0.00-0.27	0.07	0.01-0.12	0.966
Say's Phoebe	1.00	0.13	0.04-0.22	0.14	0.00-0.28	0.28	0.07-0.50	0.944
Song sparrow	1.00	6.14	2.67-9.60	5.51	1.06-9.95	9.04	5.14-12.94	0.337
Spotted towhee	1.00	0.58	0.12-1.05	0.78	0.00-1.73	2.74	0.46-5.03	0.687
Western meadowlark	1.00	6.23	4.55-7.91	8.07	4.16-11.97	5.57	3.02-8.13	0.212
White-crowned sparrow	5.86	6.23a	3.34-9.12	4.72ab	1.80-7.63	1.88b	0.49-3.27	0.019

[1]Densities followed by the same letter in rows are not different (Bonferroni pairwise comparisons).

Two species had higher densities in drainages. Northern flicker had higher densities in drainages than at irrigated HMUs (*P* = 0.019). Red-tailed hawk had higher densities in drainages than at non-irrigated sites (*P* = 0.039).

5.3.2. Species Richness and Diversity

Irrigated HMUs and non-irrigated sites had higher species richness than drainages (*P* = 0.001) (Table 17) (Figure 5). There was no difference in diversity among habitat types. In contrast, there was no difference in species richness among the four reservoirs, while there was a difference in both the Simpson's diversity index (*P* = 0.042) and Shannon-Wiener function (*P* = 0.084) (Table 18). Species diversity increased linearly from Ice Harbor to Lower Granite Reservoir (Figure 6).

Table 17
Species Richness and Diversity Estimates for Spring Birds,
90% Confidence Intervals (CI), and *P*-Values for
Analysis of Variance Tests for Differences Among Irrigated Habitat Management Units (HMU),
Non-Irrigated Sites, and Drainages
Lower Snake River, 1998

	HMU		Non-Irrigated		Drainages		*P*
	Mean[1]	90% CI	Mean	90% CI	Mean	90% CI	
Richness[2]	27.00a	23.02-30.98	23.43a	20.26-26.60	17.00b	14.09-19.91	0.001
Simpson's[3]	0.85	0.79-0.91	0.86	0.82-0.89	0.84	0.80-0.89	0.935
Shannon-Wiener[4]	3.46	3.08-3.84	3.33	3.03-3.62	3.16	2.80-3.52	0.597

[1]Means followed by the same letter in rows are not different (Bonnferroni pairwise comparisons).
[2]Species richness is the total number of species detected.

[3]Simpson's index of diversity: $$1 - \hat{D} = 1 - \sum_{i=1}^{s}\left[\frac{n_i(n_i - 1)}{N(N-1)}\right]$$ for a finite population.

[4]Shannon-Wiener function: $$H' = \sum_{i=1}^{s}\left(p_i\right)\left(\log_2 p_i\right)$$

Table 18
Species Richness and Diversity Estimates for Spring Birds, 90% Confidence Intervals (CI), and *P*-Values for Analysis of Variance Tests for Differences Among Reservoirs Lower Snake River, 1998

	Ice Harbor		Lower Monumental		Little Goose		Lower Granite		*P*
	Mean[1]	90% CI	Mean	90% CI	Mean	90% CI	Mean	90% CI	
Richness[2]	20.14	15.75-24.54	20.14	14.42-25.87	22.57	18.38-26.77	25.00	16.04-33.96	0.504
Simpson's[3]	0.79a	0.73-0.84	0.86ab	0.83-0.90	0.87ab	0.82-0.91	0.91b	0.88-0.94	0.042
Shannon-Wiener[4]	2.94a	2.56-3.33	3.22ab	2.77-3.68	3.45ab	3.11-3.79	3.75b	3.47-4.02	0.084

[1]Means followed by the same letter in rows are not different (Bonnferroni pairwise comparisons).
[2]Species richness is the total number of species detected.
[3]Simpson's index of diversity: $1 - \hat{D} = 1 - \sum_{i=1}^{s}\left[\frac{n_i(n_i-1)}{N(N-1)}\right]$ for a finite population.
[4]Shannon-Wiener function: $H' = \sum_{i=1}^{s}(p_i)(\log_2 p_i)$

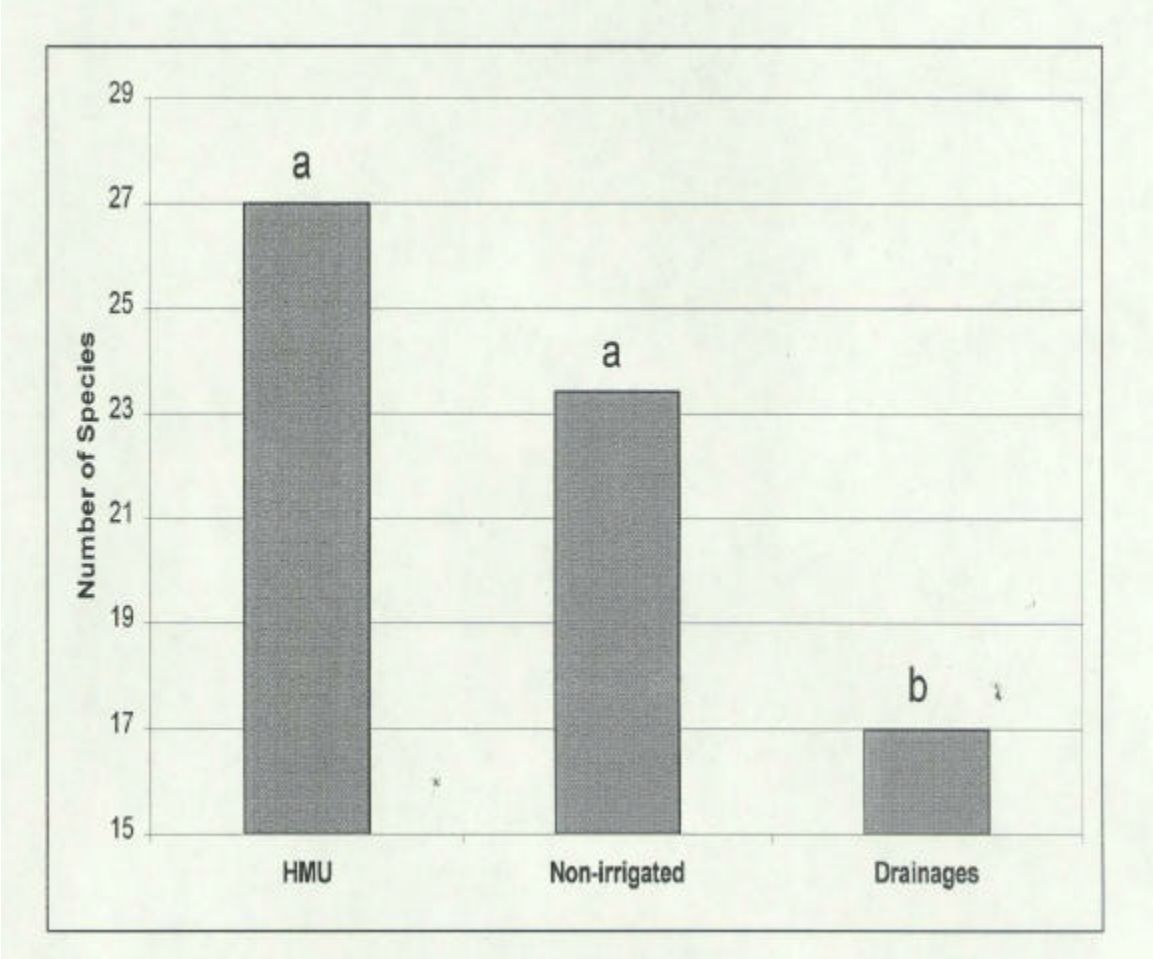

Figure 5. Species Richness Estimates for Spring Birds for Irrigated Habitat Management Units (HMU), Non-Irrigated Sites, and Drainages, Lower Snake River, 1998. *P*-value = 0.001 for Analysis of Variance Test for Differences in Species Richness Among Habitat Types. Columns with the same letters are not different (Bonferroni Pairwise Comparisons).

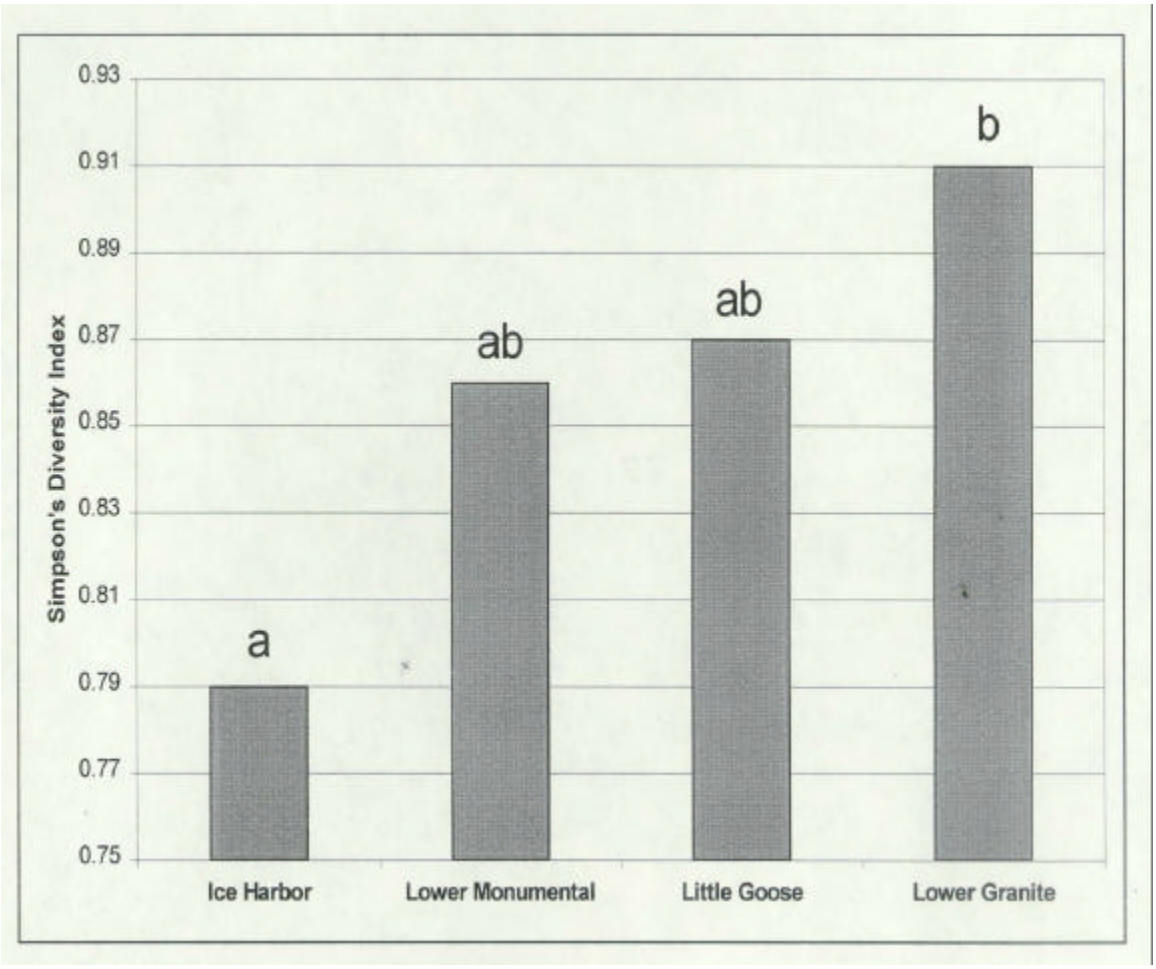

Figure 6. Simpson's Diversity Estimates for Spring Birds for Reservoirs, Lower Snake River, 1998. *P*-value = 0.042 for Analysis of Variance Test for Differences in Species Diversity Among Reservoirs. Columns with the same letters are not different (Bonferroni Pairwise Comparisons).

5.4. Small Mammals

A total of 374 small mammals were captured with baited live-traps and drift-fence/pit-fall traps. Of these, 122 were recaptures, for a total of 251 individuals. Six small-mammal species were captured. Deer mouse was the most-abundant species, with 186 individuals captured, followed by 22 montane voles and 18 western harvest mice. One bushy-tailed wood rat was captured at Alkali Flat Creek.

Trapping effort included 4,919 trap nights for baited live-traps and 120 for drift-fence/pit-fall traps. Baited live-traps and drift-fence/pit-fall traps had comparable capture rates (Tables 19 and 20). Live-traps caught 0.049 individuals per trap night, and drift-fence/pit-falls caught 0.047 individuals per trap night. However, pit-falls appeared to capture species at equal rates, while live-traps captured a disproportionate number of deer mice (Tables 19 and 20). In addition, no animals were recaptured in drift-fence/pit-fall traps.

Table 19
Total Numbers and Numbers Per Trap Night of Small Mammals Captured With Baited Live-Traps at Irrigated Habitat Management Units (HMU), Non-Irrigated Sites, and Drainages, Excluding Recaptures
Lower Snake River, 1997

Species	HMU		Non-Irrigated		Drainages	
	Total	#/Trap Night	Total	#/Trap Night	Total	#/Trap Night
Bushy-tailed wood rat	0	0.0000	0	0.0000	1	0.0006
Deer mouse	92	0.0559	49	0.0297	45	0.0277
Great Basin pocket mouse	2	0.0012	0	0.0000	4	0.0025
Western harvest mouse	12	0.0073	2	0.0012	4	0.0025
Montane vole	15	0.0091	2	0.0012	2	0.0012
Vagrant shrew	3	0.0018	4	0.0024	2	0.0012
Total	**124**	**0.0754**	**57**	**0.0345**	**58**	**0.0357**

Table 20
Total Numbers and Numbers Per Trap Night of Small Mammals Captured With Drift-Fence/Pit-Fall Traps at Irrigated Habitat Management Units (HMU), Non-Irrigated Sites, and Drainages, Excluding Recaptures
Lower Snake River, 1997

Species	HMU		Non-Irrigated		Drainages	
	Total	#/Trap Night	Total	#/Trap Night	Total	#/Trap Night
Deer mouse	3	0.0250	0	0.0000	1	0.0083
Great Basin pocket mouse	1	0.0083	3	0.0250	2	0.0167
Western harvest mouse	0	0.0000	0	0.0000	1	0.0083
Montane vole	0	0.0000	2	0.0167	1	0.0083
Vagrant shrew	0	0.0000	1	0.0083	2	0.0167
Total	**4**	**0.0333**	**6**	**0.0500**	**7**	**0.0583**

Sample sizes were too small for statistical tests for differences in small mammal abundances among irrigated HMUs, non-irrigated sites, and drainages. Baited live-traps caught 0.075 individuals per trap night at irrigated HMUs, 0.035 at non-irrigated sites, and 0.036 in drainages (Table 19). In contrast, 0.033 individuals were captured per trap night at irrigated HMUs in drift-fence/pit-fall traps, 0.050 at non-irrigated sites, and 0.060 in drainages (Table 20). A higher number of animals were captured at irrigated HMUs when both trap types were combined. At irrigated HMUs 126 small mammals (0.054 individuals per trap night) were captured with both trap types. At non-irrigated sites 61 individuals (0.042 per trap night) and in drainages 65 individuals (0.047 per trap night) were captured with both trap types.

Small mammal populations varied significantly among the three reservoirs. Little Goose Reservoir had the highest number of animals captured, with 191 individual captured (0.038 per trap night). In contrast Ice Harbor and Lower Monumental reservoirs captured 29 and 30 animals respectively (0.006 per trap night each).

5.5. Incidental Animals

One amphibian, four reptile, and 15 mammal species were observed during field work in 1997 and 1998 (Table 21). Mule deer was the most common species, with 108 individuals observed. White-tailed deer followed with 65 individuals observed.

Table 21
Incidental Animals Observed at Irrigated Habitat Management Units (HMU), Non-Irrigated Sites, and Drainages
Lower Snake River, 1997 and 1998

Species	Total	HMU	Non-Irrigated	Drainages
Amphibians				
Western toad	1	1		
Reptiles				
Garter snake	2	1		1
Gopher snake	1		1	
Racer	1		1	
Rattlesnake	4			4

Mammals				
Badger	1	1		
Beaver	3	1	2	
Cottontail	30	21	7	2
Coyote	23+*	11+	4+	8
Deer mouse	1	1		
Red fox	1			1
Fox squirrel	2	1		1
Long-tailed weasel	1	1		
Marmot	1			1
Mule deer	108	35	36	37
Muskrat	2	1		1
Porcupine	4	1		3
Raccoon	3	2	1	
Striped skunk	1	1		
White-tailed deer	65	36	16	13

*Coyotes were often detected while howling, and were not directly observed. Therefore, the exact number was unknown.

5.6. Vegetative Cover

Irrigated HMUs had a higher percent cover of grass ($P = 0.044$), 0.5 to 1.0 meter shrubs ($P = 0.090$), and 1.0 to 3.0 meter shrubs ($P = 0.031$) than non-irrigated sites, but not compared to drainages (Table 22). Overall, irrigated HMUs and drainages had similar coverages of grass and woody vegetation, and had consistently higher coverages of grass and woody vegetation than non-irrigated sites. In contrast, non-irrigated sites had higher forb cover.

Table 22
Percent Cover Estimates of Vegetation, 90% Confidence Intervals (CI), and *P*-Values For Analysis of Variance Tests For Differences Among Irrigated Habitat Management Units (HMU), Non-Irrigated Sites, and Drainages Lower Snake River, 1997

	HMU		Non-Irrigated		Drainages		*P*
	Mean[1]	90% CI	Mean	90% CI	Mean	90% CI	
Grasses	26.07a	17.76-34.39	14.50b	11.15-17.85	18.60ab	13.35-23.85	0.044
Forbs	9.76	6.06-13.46	15.24	9.43-21.05	11.14	8.06-14.22	0.373
0-0.5m Shrubs	13.78	5.94-21.62	8.73	4.02-13.43	11.53	6.94-16.11	0.370
0.5-1.0m Shrubs	20.40a	12.73-28.07	12.18b	6.72-17.64	12.74ab	7.75-17.73	0.090
1.0-3.0m Shrubs	21.98a	16.80-27.17	9.35b	4.23-14.67	15.28ab	10.99-19.56	0.031
>3.0m Trees	4.45	2.88-6.02	3.52	0.00-7.49	9.20	2.88-15.52	0.475

[1]Means followed by the same letter in rows are not different (Bonferroni pairwise comparisons).

6. Discussion

6.1. Avian Habitat

A species' habitat is an array of physical environmental variables that can fulfill life requisites (Martin, 1991; Block and Brennan, 1993). Habitat requirements have been formed through natural selection, and are represented as morphological, physical, and behavioral adaptations of the organism (Klopfer and Hailman, 1965; Block and Brennan, 1993). Suitable habitat for birds is typically identified by floristic composition and structure (James, 1971; Anderson, 1979). Vegetation, therefore, influences avian species abundance and community composition (Johnston and Odum, 1956).

This study compared avian abundances in three seasons for three riparian habitats along the lower Snake River. Irrigated HMUs and drainages had similar vegetative structure in comparison to non-irrigated sites (Table 22). Therefore, one may expect that species richness and density would be similar in irrigated HMUs and drainages (Tables 4, 10, and 16; Figures 1, 4, and 5). Although some species did have similar densities in irrigated HMUs and drainages (*e.g.*, American robin, black-billed magpie, lazuli bunting, and northern oriole during the breeding season; American robin in fall), other species did not follow this pattern (*e.g.*, species richness in all three seasons, ground-nesting guild, bank swallow, Canada goose, spotted sandpiper, and western meadowlark during the breeding season; Savannah sparrow and white-crowned sparrow in fall; Canada goose, killdeer, and white-crowned sparrow in spring).

Species densities may differ between irrigated HMUs and drainages because birds may have responded to specific habitat features that varied between irrigated HMUs and drainages, regardless of their overall vegetative structural similarities. Drainages used in this study varied dramatically, from dry, ephemeral canyons dominated by sagebrush, to large tributaries with mature stands of white alder. Irrigated HMUs also varied due to different management histories and characteristics. Irrigated HMUs and non-irrigated sites were, however, more alike physiographically than drainages. Irrigated HMUs and non-irrigated sites were large, flat areas adjacent to the river; whereas, drainages were thin strips of riparian vegetation in dry, steep canyons. Therefore, some species may have responded to available habitat on the landscape level, rather than to microhabitat features such as floristic structure (Morris, 1987; Freemark *et al.*, 1995).

Irrigated HMUs provided quality-avian habitat along the lower Snake River. The high number of individuals and species observed at irrigated HMUs is likely attributable to their quantity and diversity of habitats in comparison to non-irrigated sites and drainages. Avian density and species richness is often correlated with vegetation volume (Mills *et al.*, 1991) and diversity and structure of vegetation (Willson, 1974).

In 1991, the Corps initiated a Habitat Evaluation Program (HEP) along the lower Snake River (Corps, 1991). The purpose was to evaluate wildlife habitat along the river by using several key species as representative of particular habitats or management goals. Ten bird species were included: California quail, Canada goose, chukar, downy woodpecker, mallard, marsh wren, ring-necked pheasant, song sparrow, western meadowlark, and yellow warbler. Of these, four were found in low numbers during the

breeding season in 1997. Mallard and chukar were relatively uncommon, but this study was not designed to effectively census waterbirds or upland birds normally found beyond the study-area boundaries. Only four downy woodpeckers were detected in 1997. One was detected at Hollebecke HMU (Appendix F, Plate 7) and the other three were in Deadman Creek (Appendix F, Plate 17). The HEP committee selected this species as a representative of riparian forest. Corps (1991) recognized riparian forests as lacking along the lower Snake River since dam construction. Drainages not influenced by past water fluctuations were likely the only areas where nesting snags were available. Two other cavity nesters, northern flicker and house wren, were also more common in drainages during the breeding season (Table 4). The HEP committee selected the marsh wren as representative of emergent wetlands. Only four marsh wrens were observed during the breeding season in 1997. Two were detected at Swift Bar HMU (Appendix F, Plate 20), one at Rice Bar (Appendix F, Plate 19), and one in Deadman Creek (Appendix F, Plate 17). Emergent wetlands continue to be rare along the lower Snake River (Corps, 1991).

Direct comparisons in avian communities cannot be made between the lower Snake River study area and the Hell's Canyon reach, since census methods and survey efforts were different. However, one can make general observations. Observers detected fewer species in Hell's Canyon. Although much of the differences may be due to methodology, some can be attributed to physiographic and habitat differences. Habitat diversity may have been lower in Hell's Canyon. Benches along the river in Hell's Canyon were typically shorter in width, canyon walls were steeper, and water velocity faster, all of which limit development of vegetation adjacent to the river. Hell's Canyon sites were dominated by Douglas Hackberry, a small tree that was rarely observed along the lower Snake River. The difference in habitat likely influenced species observed in the two areas.

6.2. Avian Seasonal Trends

More birds used lower Snake River riparian habitats during fall and spring than during the breeding season. Lower Snake River riparian habitats, including irrigated HMUs, non-irrigated sites, and larger drainages, were probably more important as migratory habitat than breeding habitat. 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 (S. Hudson, personal communication). Quality stop-over sites that offer safe and plentiful food sources are critical for migrating birds (Moore *et al.*, 1995). Such sites are probably best available in riparian areas in the arid and semi-arid West. Riparian areas in the West have a higher structural and vegetative diversity in comparison to uplands. This leads to a higher number of niches and food sources, and therefore a higher species density, richness, and diversity (Knopf and Samson, 1988; Johnson, 1989; Clary and Medin, 1993).

Regardless of the fact that more birds and species were detected during fall, birds appeared to be less selective in their use of habitat types during fall. Only four out of 17 fall species had higher densities at either irrigated HMUs, non-irrigated sites, or drainages. Strong and Bock (1990) found that wintering birds were more evenly distributed among riparian habitat types in Arizona. Furthermore, winter bird

abundances in riparian zones were attributed to their proximity to quality grasslands, which would provide food for granivorous birds. All three habitat types along the Lower Snake River may have provided or allowed access to sufficient forage in fall, particularly of seed-producing plants.

The seasonal changes in bird communities were reflected by the five most-abundant species in each season. Only the red-winged blackbird was abundant in all three seasons. Bank and cliff swallows, western meadowlark, and northern oriole were abundant during the breeding season. Swallows and orioles were rare in fall and spring, because these populations had moved South by fall censuses and had not returned by spring censuses. Western meadowlark detections declined in fall, but were high again in spring, because they were early spring arrivals. American goldfinch, white-crowned sparrow, and Canada goose were abundant in flocks during both fall and spring. These three species likely used Snake River riparian habitats throughout the winter (Lewke and Buss, 1977). White-crowned sparrow dominated both the fall and spring bird populations (Tables 10 and 16). Irrigated HMUs and, to a lesser extent, non-irrigated sites were particular important to migrating and possibly to wintering white-crowned sparrows. This species has exhibited a significant population decline since 1966 in the western U. S. (DeGraaf and Rappole, 1995). European starling flocks were also abundant in fall, but it appeared these winter residents were keying in on planted-food sources offered at Swift Bar HMU (Appendix F, Plate 20).

Some common species in all three seasons were consistently more abundant in one habitat type, while others shifted their habitat preferences among seasons. American robin had higher densities at irrigated HMUs in all three seasons. Ring-necked pheasants had higher densities at irrigated HMUs in the breeding season and spring, but showed no preferences in fall. Pheasants were early breeders and appeared to prefer irrigated HMUs for nesting, but expanded their ranges in fall, probably to exploit new food resources or to avoid hunting pressure. Northern flickers are short-distance migrants within the United States and set up breeding territories in early spring (Ehrlich *et al.*, 1988; DeGraaf and Rappole, 1995). Flickers had higher densities in drainages in spring and summer. Drainages offered more nesting snags than either irrigated HMUs or non-irrigated sites, due to the recent development of irrigated HMUs and changes in river levels following dam construction (Corps, 1991). Flickers expanded their food choices during the non-breeding season to seeds and fruits (Ehrlich *et al.*, 1988), which were readily available at irrigated HMUs and non-irrigated sites. Western meadowlarks had higher densities at irrigated HMUs and non-irrigated sites during the breeding season, but did not show similar preferences in fall and spring. Meadowlarks likely preferred flat, grassy areas at irrigated HMUs and non-irrigated sites for nesting, but were not as specific during other seasons.

This study did not examine avian-habitat use along the lower Snake River during the winter, and no recent data were available. Asherin and Claar (1976) and Lewke and Buss (1977) both censused winter bird populations along the lower Snake River. Asherin and Claar (1976) observed high numbers of dark-eyed junco, horned lark, and white-crowned sparrow. Prior to the construction of Lower Granite Dam, Lewke and Buss (1977) observed high numbers of black-capped chickadee, dark-eyed junco,

evening grosbeak, golden-crowned kinglet, and white-crowned sparrow in riparian habitats. They detected several species that the current study did not or rarely observed during fall or spring, including brown creepers, evening grosbeaks, golden-crowned kinglet, mountain chickadee, varied thrush, and winter wren. It is not known whether these species currently winter along the lower Snake River; however, these species typically occured in forested habitats during the winter (DeGraaf and Rappole, 1995), and such habitats were no longer common along the lower Snake River.

6.3. Avian Population Changes Along the Lower Snake River

A team from the Idaho Cooperative Wildlife Research Unit conducted an in-depth census of wildlife along the lower Snake River in 1974 (Asherin and Claar, 1976). They divided the study area into two reaches, one was Ice Harbor Reservoir and the other extended from Lower Monumental Dam to the confluence of the Snake and Clearwater Rivers near Clarkston, Washington. Although their study methods differed from those for this study, it is instructive to compare general results. The current study detected 39 more bird species than Asherin and Claar in Ice Harbor Reservoir in summer, 49 more in fall, and 16 more in spring (Table 23). The current study detected 24 more bird species from Lower Monumental Dam to Clarkston, Washington during summer, 40 more in fall, and 14 more in spring.

Table 23
Comparison Between Asherin and Claar, 1976[1] (A & C)
And Lower Snake River Wildlife Studies, 1997 and 1998 (LSRWS)

Season	Number of Species			
	Ice Harbor		Lower Monumental Dam to Clarkston, Washington	
	A & C	LSRWS	A & C	LSRWS
Summer	25	64	62	86
Fall	22	71	61	101
Spring	38	54	69	83

[1]Asherin, D.A., and J.J. Claar, 1976. *Inventory of Riparian Habitats and Associated Wildlife Along the Columbia and Snake Rivers.* Volume IIIA. US Army Corps of Engineers, North Pacific Division.

The increase in number of bird species detected from 1974 to 1997-1998 is likely was attributable to an increase in quality habitat since the first lower Snake River dam was constructed in 1962 and the development of irrigated HMUs in 1975. Existing riparian vegetation was flooded when dams were constructed, and new riparian vegetation has slowly been evolving. A study conducted in 1995 showed an increase in palustrine emergent and palustrine shrub-scrub habitat along the lower Snake River since 1987, particularly at slack-water areas and at the deltas of major tributaries (Downs *et al.*, 1996).

Excluding waterbirds, raptors, and gamebirds, only two species were observed during the 1970's along the lower Snake River that were not detected during 1997 and 1998. Lewke and Buss (1977) observed five veerys during summer. This study did not detect the veery in any season. However, the lower Snake River is on the western edge of the veery's breeding range. In addition, veery typically nest in moist deciduous forests or swamps (DeGraaf and Rappole, 1995). Veery, therefore, were probably never a major component of the avian community along the lower Snake River. Asherin and Claar (1976) observed nine pine grosbeaks during spring. This species is known for its sporadic distribution during the non-breeding season (Ehrlich *et al.*, 1988); hence, one would not expect to regularly find this species along the lower Snake River.

A few species may have been more abundant in the 1970's. Both Asherin and Claar (1976) and Lewke and Buss (1977) noted high numbers of Brewer's blackbirds. Asherin and Claar observed 83 Brewer's blackbirds during summer. Lewke and Buss (1977) observed approximately 400 Brewer's blackbirds in the Lower Granite area prior to dam construction. Only eight Brewer's blackbirds were detected along the lower Snake River during the fall of 1997, and none were detected in other seasons. Brewer's blackbird typically nest near water in habitats ranging from wooded riparian areas to agricultural lands (DeGraaf and Rappole, 1995), habitats which are currently readily available along the lower Snake River. Brewer's blackbird has, however, exhibited a strong population decline since 1966 (DeGraaf and Rappole, 1995), which likely contributed to its current relative absence along the lower Snake River. Asherin and Claar (1976) also noted several purple finch along the three upper reservoirs; however, this species has a rare and erratic distribution in the inland northwest (Svingen and Dumroese, 1997).

A few woodland species appeared to be more abundant during the breeding season along the Lower Granite area prior to dam construction. Lewke and Buss (1977) observed 12 gray catbirds, 21 red-eyed vireos, and 27 western wood-pewees. The current study observed only one gray catbird at Chief Timothy HMU (Appendix F, Plate 23) and five red-eyed vireos in Nisqually John Canyon (Appendix F, Plate 21). Red-eyed vireos were probably breeding in Nisqually John Canyon in 1997. No western wood-pewees were observed in Lower Granite Reservoir in 1997; however, several were observed in the other reservoirs, including eight at the mouth of Walker Canyon (Appendix F, Plate 9) and nine along the Tucannon River (Appendix F, Plate 13). The Breeding Bird Survey indicated a significant population decline for all three of these species (DeGraaf and Rappole, 1995); thus, these differences may be related to regional population declines.

Bewick's Wren may have extended its nesting range eastward since the early 1970's. Asherin and Claar (1976) observed a nesting pair at the mouth of the Walla Walla River, Washington. At the time they noted that this observation extended the known nesting distribution of this species. Lewke and Buss (1977) observed eight Bewick's wrens wintering in the Lower Granite area, but observed none during other seasons. The current study detected two Bewick's wrens in Ice Harbor during the breeding season, 28 in Lower Monumental, ten in Little Goose, and six in Lower Granite. Twenty-one of these detections were along the Tucannon River (Appendix F, Plate 13). Bewick's wrens were likely breeding along the Tucannon River, at Alkali Flat Creek (Appendix F, Plate 14), and Chief Timothy HMU (Appendix F, Plate 23) in 1997.

6.4. Small Mammal Populations

There appears to be no significant changes in the small mammal community along the lower Snake River since Asherin and Claar's work in 1976. They trapped for two nights at each of their study sites, and used five trap types: baited snap-traps, unbaited snap-traps, rat traps, pit-fall-traps, and baited live-traps. They captured 0.042 small mammals per trap night. The current study captured a slightly higher number at 0.050 animals per trap night. Deer mice dominated the small mammal community in both studies. Asherin and Claar capture 0.029 deer mice per trap night, and the current study trapped 0.037 per trap night. The increase in small mammal abundances may be attributable to the high number of deer mice captured at irrigated HMUs in 1997 (Tables 19 and 20). Asherin and Claar (1976) noted that the highest numbers of individuals and species were captured in cattail and shrub-willow habitats.

There were a few differences in species captured between Asherin and Claar's work and the current study. Asherin and Claar (1976) captured nine house mice (*Mus musculus*) during summer in Little Goose and Lower Monumental reservoirs; however, none were captured during the current study. They also trapped one Norway rat (*Rattus norvegicus*) in Little Goose and Lower Monumental reservoirs, and none were captured in 1997. The current trapping effort, however, captured one new species, the bushy-tailed wood rat. Asherin and Claar (1976) mentioned the potential for Ord's kangaroo rat (*Dipodomys ordi*) habitat in Ice Harbor Reservoir, particularly at Big Flat HMU (Appendix F, Plate 6); however, none were captured in 1997. The small difference in species captured between the two studies may be attributable to the use of different trap types and length of trapping period. Asherin and Claar (1976) also trapped small mammals in Hell's Canyon, where they captured deer mouse, house mouse, and bushy-tailed wood rat. Of the small mammal species captured along the lower Snake River, only vagrant shrew appears to be dependent on riparian vegetation types (Clothier, 1955; Asherin and Claar, 1976; Lewke and Buss, 1977).

In their pre-impoundment study of Lower Granite Reservoir, Lewke and Buss (1977) also trapped small mammals. They used snap-traps in the spring, winter, and fall. They captured one new species, long-tailed vole, at Alpowa Creek. Their capture rate of 0.071 animals per trap night was significantly higher than either that of the current study or Asherin and Claar. This higher number is largely due to the large number of deer mice captured in spring, a season in which trapping did not occur during either of the other two lower Snake River studies.

6.5. Management Implications

Irrigated HMUs provided quality-avian habitat along the lower Snake River. However, all lower Snake River riparian habitats, including irrigated HMUs, non-irrigated sites, and larger drainages, may have a higher ecological value as migratory habitat than breeding habitat. Furthermore, more bird species were using lower Snake River riparian habitats in 1997 and 1998 than in 1974 (Asherin and Claar, 1976). Birds responded positively to the increase in habitats offered at irrigated HMUs and to the evolution of palustrine emergent and palustrine shrub-scrub habitat (Downs *et al.*, 1996). Downs et al. (1996) attributed the increase in riparian vegetation to an expansion in available shoreline due to maintenance of Lower Snake reservoirs at lower levels within the last decade.

Future changes in reservoir levels will undoubtedly affect bird communities along the lower Snake River in all seasons. If the lower Snake River is allowed to return to pre-impoundment levels, these effects will be influenced by a complicated interaction among natural and management responses; thus, predictions of changes in bird communities will be difficult. It is unlikely, however, that riparian habitat and the avian community would revert to exactly that found in Hell's Canyon. Physiographic and river-management histories of the two areas are too different for this to occur. If the water level is lowered, more shoreline will be available for growth of palustrine emergent and palustrine shrub-scrub vegetation. Correspondingly, current riparian vegetation may senesce as the water table drops. Upland vegetation will likely replace senescing riparian vegetation. Current gains in riparian forest may be lost if these trees die due to the drop in water table or loss of irrigation at HMUs. Future vegetative growth will also be influenced by the Corps' management along newly exposed shoreline. Bird species diversity and abundance, therefore, may only be negatively impacted by changes in vegetation over the short-term. After drawdown, riparian habitats and the bird community will likely rebound to patterns similar to those that currently exist. This process may take 25 to 40 years.

Breeding birds that will be immediately impacted by lower water levels would be those that depend on willow shrub-scrub vegetation. Breeding birds, such as northern oriole, song sparrow, willow flycatcher, yellow-breasted chat, and yellow warbler (Knopf and Sedgwick, 1992), may temporarily decrease in numbers. Some 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). Grasshopper sparrow, horned lark, lark sparrow, ring-necked pheasant, Say's phoebe, and western meadowlark may increases on benches along the lower Snake River.

Migrating birds will also be affected by changes in water levels along the lower Snake River. 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 (*e.g.*, Willow Bar and Rice Bar, Appendix F, Plates 18 and 19) and in the larger drainages (*e.g.*, Tucannon River and Deadman Creek, Appendix F, Plates 13 and 17) during the fall and spring. Migrating birds, particularly American goldfinch, Savannah sparrow, song-sparrow, and white-crowned sparrow, concentrated in weedy fields that offered a plentiful seed supply and that were adjacent to protective cover, such as

blackberry and willows (Strong and Bock, 1990; A. Rocklage, personal observation). Weedy fields should persist at lower water levels, and as long as some shrub patches survive, migrating birds may not be severely affected. Large concentrations of birds, such as European starling, red-winged blackbird, and sparrows, were also observed in crop fields during fall (A. Rocklage, personal observation). Thus, fall populations will also be influenced by whether these crops are provided in the future. If migrating birds are no longer able to find a safe and plentiful food supply along the lower Snake River, they may simply move on to other areas. However, little is known about quality stop-over sites and migration patterns in the inland Northwest.

Birds that rely on riparian forests in all seasons may never increase in numbers above current levels along the lower Snake River. Riparian forests, particularly those of sufficient age to support nesting snags, may continue to be available only in drainages. Birds that breed in riparian forests, such as gray catbird, western wood-pewee, and downy woodpecker may never be found in large numbers. Migrating birds that rely on riparian forests will also be negatively effected by the loss or decrease in riparian forest. Northern flicker, ruby-crowned kinglet (Laurenzi *et al.*, 1982), and yellow-rumped warbler may decline in fall and spring. Lewke (1982) examined foraging strategies of winter residents at Alpowa Creek prior to construction of Lower Granite Dam. He found that black-capped chickadee, golden-crowned kinglet, and ruby-crowned kinglet gleaned insects from trees at one-to-nine meters above ground. Therefore, birds that typically occupy the tree-foliage-gleaning guild may decline during migration and in winter with the loss or decrease in riparian forest.

Of the small mammals, only the vagrant shrew, a riparian-dependent species, may be affected over the short-term by lower water levels (Clothier, 1955; Asherin and Claar, 1976; Lewke and Buss, 1977). Deer mice may temporarily increase in numbers as they move into disturbed habitats (Williams, 1955; Gashwiler, 1959; LoBue and Darnell, 1959; Hingtgen and Clark, 1984).

The results of this study should, however, be interpreted with caution. Avian populations are known to fluctuate in time and space (Anderson, 1972; Wiens, 1977; Wiens and Rotenberry, 1985). Populations may fluctuate in size or shift habitat preferences in response to changes in food supply or environmental conditions (Block and Brennan, 1993). Furthermore, competing species and predators also respond to habitat changes, which influences community organization (Wiens, 1977; Martin, 1991; Block and Brennan; 1993). It is unknown how competition, predation, and brood parasitism affect bird populations along the lower Snake River. A one-year study may not be sufficient to capture adequate information on avian populations and habitat use.

Additional years of data would strengthen current results significantly. An increase in sample size would increase the number of species for which density could be calculated and would raise statistical power. New species-use patterns may be revealed and would, thus, provide more confidence for the ecological assessment of the value of irrigated HMUs. A more-detailed-habitat study could provide specific data on species

use of irrigated HMUs, non-irrigated sites, and drainages. Information is urgently needed on bird use of riparian habitats during winter, because these habitats may be very important to wintering birds. It is recommended that bird populations be monitored in all seasons if significant changes in water levels are anticipated along the lower Snake River. More information is also needed on small mammal and raptor use of riparian habitats along the lower Snake River.

7. References

Anderson, S.H., 1972.

Seasonal Variations in Forest Birds of Western Oregon. Northwest Science 46(3):194-206.

Anderson, S.H., 1979.

Habitat Structure, Succession and Bird Communities. Pages 9-21 *in* R. M. DeGrauf and W. Evans, editors. Workshop Proceedings on Management of North Central and Northeastern Forests for Nongame Birds. U.S. Forest Service General Technical Report NC 51.

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.

Bibby, C. J., N. D. Burgess, and D. A. Hill. 1992.

Bird Census Techniques. Academic Press. London, England.

Block, W. M., and L. A. Brennan. 1993.

The Habitat Concept in Ornithology: Theory and Applications. Pages 38-81 in D. M. Power, editor. Current Ornithology. Volume 11. Plenum Press. New York, New York.

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.

Clary, W. P., and D. E. Medin. 1993.

Vegetation, Nesting Bird, and Small Mammal Characteristics: Wet Creek, Idaho. U. S. Forest Service General Technical Report INT-293.

Clothier, R. R. 1955.

Contributions to the Life History of Sorex vagrans in Montana. Journal of Mammalogy 36:214-221.

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, Corps 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.

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.

Ehrlich, P. R., D. S. Dobkin, and D. Wheye. 1988.

The Birder's Handbook: A Field Guide to the Natural History of North American Birds. Simon and Schuster. New York, New York.

Freemark, K. E., J. B. Dunning, S. J. Hejl, and J. R. Probst. 1995.

A Landscape Ecology Perspective for Research, Conservation, and Management. Pages 381-427 in T. E. Martin and D. M. Finch, editors. Ecology and Management of Neotropical Migratory Birds. Oxford University Press. New York, New York.

Gashwiler, J. S. 1959.

Small Mammal Study in West-central Oregon. Journal of Mammalogy 40:128-139.

Hingtgen, T. M., and W. R. Clark. 1984.

Small Mammal Recolonization of Reclaimed Coal Surface-mined land in Wyoming. Journal of Wildlife Management 48:1255-1261.

James, F. C. 1971.

Ordinations of Habitat Relationships Among Breeding Birds. Wilson Bulletin 83(3): 215-236.

Johnson, A. S. 1989.

The Thin Green Line. Pages 35-46 in Preserving Communities and Corridors. Defenders of Wildlife. Washington, D. C.

Johnston, D. W., and E. P. Odum. 1956.

Breeding Bird Populations in Relation to Plant Succession on the Piedmont of Georgia. Ecology 37(1):50-62.

Klopfer, P. H., and J. P. Hailman. 1965.

Habitat Selection in Birds. Pages 279-303 in D. S. Lehrman, R. A. Hinde, and E. Shaw, editors. Advances in the Study of Behavior. Academic Press. New York, New York.

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, Washington.

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, New York.

Laurenzi, A. W., B. W. Anderson, and R. D. Ohmart. 1982.

Wintering Biology of Ruby-crowned Kinglets in the Lower Colorado River Valley. Condor 84:385-398.

Lewke, R. E. 1982.

A Comparison of Foraging Behavior Among Permanent, Summer, and Winter Resident Bird Groups. Condor 84:84-90.

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.

LoBue, J., and R. M. Darnell. 1959.

Effect of Habitat Disturbance on a Small Mammal Population. Journal of Mammalogy 40:425-437.

Martin, T. E. 1991.

Breeding Productivity Considerations: What are the Appropriate Habitat Features for Management? Pages 455-473 in J. M. Haggan III and D. W. Johnston, editors. Ecology and Conservation of Neotropical Migrant Landbirds. Smithsonian Institution Press. Washington, D. C.

Mills, G. S., J. B. Dunning, Jr., and J. M. Bates. 1991.

The Relationship Between Breeding Bird Density and Vegetation Volume. Wilson Bulletin 103(3):468-479.

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, New York.

Morris, D. W. 1987.

Ecological Scale and Habitat Use. Ecology 68(2):362-369.

Ralph, C. J., G. R. Geupel, P. Pyle, T. E. Martin, and D. F. DeSante. 1993.

Handbook of Field Methods for Monitoring Landbirds. U. S. Forest Service General Technical Report PSW-GTR-144.

Reynolds, R. T., J. M. Scott, and R. A. Nussbaum. 1980.

A Variable Circular-Plot Method for Estimating Bird Numbers. Condor 82:309-313.

Roeder, K., B. Dennis, and E. O. Garton. 1987.

Estimating Density from Variable Circular Plot Censuses. Journal of Wildlife Management 51(1):224-230.

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.

Svingen, D., and K. Dumroese. 1997.

A Birder's Guide to Idaho. American Birding Association. Colorado Springs, Colorado.

Szaro, R. C., L. H. Simons, and S. C. Belfit. 1988.

Comparative Effectiveness of Pitfalls and Live-traps in Measuring Small Mammal Community Structure. Pages 282-288 in R. C. Szaro, K. E. Severson, and D. R. Patton, technical coordinators. Management of Amphibians, Reptiles, and Small Mammals in North America. U. S. Forest Service General Technical Report RM-166.

Wiens, J. A. 1977.

On Competition and Variable Environments. American Scientist 65:590-597.

Wiens, J. A., and J. T. Rotenberry. 1985.

Response of Breeding Passerine Birds to Rangeland Alteration in a North American Shrubsteppe Locality. Journal of Applied Ecology 22:655-668.

Williams, D. F., and S. E. Braun. 1983.

Comparisons of Pitfall and Conventional Traps for Sampling Small Mammal Populations. Journal of Wildlife Management 47(3):841-845.

Williams, O. 1955.

Distribution of Mice and Shrews in a Colorado Montane Forest. Journal of Mammalogy 36:221-231.

Willson, M. F. 1974.

Avian Community Organization and Habitat Structure. Ecology 55:1017-1029.

Zar, J. H. 1984.

Biostatistical Analysis. Prentice Hall. Englewood Cliffs, New Jersey.

Appendix A
Common and Scientific Names of All Species Detected During Snake River Wildlife Studies
Lower Snake River
1997 and 1998

Common Name	Scientific Name
Amphibians	
Western toad	*Bufo boreas*
Birds	
Great Basin gopher snake	*Pituophis melanoleucus*
Western rattlesnake	*Crotalus viridis*
Western terrestrial garter snake	*Thamnophis elegans*
Western yellow-bellied racer	*Coluber constrictor*
Mammals	
American coot	*Fulica americana*
American crow	*Corvus brachyrhynchos*
American dipper	*Cinclus mexicanus*
American goldfinch	*Carduelis tristis*
American green-winged teal	*Anas crecca*
American kestrel	*Falco sparverius*
American pipit	*Anthus rubescens*
American robin	*Turdus migratorius*
American tree sparrow	*Spizella arborea*
American wigeon	*Anas americana*
Bald eagle	*Haliaeetus leucocephalus*
Bank swallow	*Riparia riparia*
Barn owl	*Tyto alba*
Barn swallow	*Hirundo rustica*
Belted kingfisher	*Ceryle alcyon*
Bewick's wren	*Thryomanes bewickii*
Black-billed magpie	*Pica pica*
Black-capped chickadee	*Parus atricapillus*
Black-headed grosbeak	*Pheucticus melanocephalus*
Blue-winged teal	*Anas discors*
Bohemian waxwing	*Bombycilla garrulus*
Brewer's blackbird	*Euphagus cyanocephalus*
Brown-headed cowbird	*Melothrus ater*
Bufflehead	*Bucephala albeola*
California gull	*Larus californicus*
California quail	*Callipepla californica*
Canada goose	*Branta canadensis*
Canyon wren	*Catherpes mexicanus*
Caspian tern	*Sterna caspia*
Cedar waxwing	*Bombycilla cedrorum*
Chipping sparrow	*Spizella passerina*
Chukar	*Alectoris chukar*

Cinnamon teal	*Anas cyanoptera*
Cliff swallow	*Hirundo pyrrhonota*
Common goldeneye	*Bucephala clangula*
Common loon	*Gavia immer*
Common merganser	*Mergus merganser*
Common nighthawk	*Chordeiles minor*
Common raven	*Corvus corax*
Common snipe	*Gallinago gallinago*
Common yellowthroat	*Geothlypis trichas*
Cooper's hawk	*Acipiter cooperii*
Dark-eyed junco	*Junco hyemalis*
Double-crested cormorant	*Phalacrocorax auritus*
Downy woodpecker	*Picoides pubescens*
Dusky flycatcher	*Empidonax oberholseri*
Eastern kingbird	*Tyrannus tyrannus*
European starling	*Sturnus vulgaris*
Forster's tern	*Sterna forsteri*
Fox sparrow	*Passeralla iliaca*
Franklin's gull	*Larus pipixcan*
Golden eagle	*Aquila chrysaetos*
Golden-crowned kinglet	*Regulus satrapa*
Golden-crowned sparrow	*Zonotrichia atricapilla*
Grasshopper sparrow	*Ammodramus savannarum*
Gray catbird	*Dumetalla carolinensis*
Great blue heron	*Ardea herodias*
Great horned owl	*Bubo virginianus*
Greater scaup	*Aythya marila*
Greater yellowlegs	*Tringa melanoleuca*
Hermit thrush	*Catharus guttatus*
Horned grebe	*Podiceps auritus*
Horned lark	*Eremophila alpestris*
House finch	*Carpodacus mexicanus*
House sparrow	*Passer domesticus*
House wren	*Troglodytes aedon*
Killdeer	*Charadrius vociferus*
Lark sparrow	*Chondestes grammacus*
Lazuli bunting	*Passerina amoena*
Lesser yellowlegs	*Tringa flavipes*
Lincoln's sparrow	*Melospiza lincolnii*
Loggerhead shrike	*Lanius ludovicianus*
Long-billed curlew	*Numenius americanus*
Long-eared owl	*Asio otus*
MacGillivray's warbler	*Oporornis tolmiei*
Mallard	*Anas platyrhynchos*
Marsh wren	*Cistothorus palustris*
Merlin	*Falco columbarius*
Mourning dove	*Zenaida macroura*
Nashville warbler	*Vermivora ruficapilla*
Northern flicker	*Colaptes auratus*
Northern goshawk	*Accipiter gentilis*
Northern harrier	*Circus cyaneus*
Northern oriole	*Icterus galbula*
Northern rough-winged swallow	*Stelgidopteryx serripennis*
Northern shoveler	*Anas clypeata*
Northern shrike	*Lanius excubitor*
Orange-crowned warbler	*Vermivora celata*
Osprey	*Pandion haliaetus*
Pied-billed grebe	*Podilymbus podiceps*
Pine siskin	*Carduelis pinus*
Prairie falcon	*Falco mexicanus*
Purple finch	*Carpodacus purpureus*

Red crossbill	*Loxia curvirostra*
Red-eyed vireo	*Vireo olivaceus*
Redhead	*Aythya americana*
Red-tailed hawk	*Buteo jamaicensis*
Red-winged blackbird	*Agelaius phoeniceus*
Ring-billed gull	*Larus delawarensis*
Ring-necked duck	*Aythya collaris*
Ring-necked pheasant	*Phasianus colchicus*
Rock dove	*Columbia livia*
Rock wren	*Salpinctes obsoletus*
Ross' goose	*Chen rossii*
Rough-legged hawk	*Buteo lagopus*
Ruby-crowned kinglet	*Regulus calendula*
Rufous hummingbird	*Salsphorus rufus*
Savannah sparrow	*Passerculus sandwichensis*
Say's phoebe	*Sayornis saya*
Sharp-shinned hawk	*Acipiter striatus*
Short-eared owl	*Asio flammeus*
Snow goose	*Chen caerulescens*
Solitary vireo	*Vireo solitarius*
Song sparrow	*Melospiza melodia*
Spotted sandpiper	*Actitus macularia*
Spotted towhee	*Pipilo maculatus*
Swainson's hawk	*Buteo swainsoni*
Townsend's solitaire	*Myadestes townsendi*
Townsend's warbler	*Dendroica townsendii*
Tree swallow	*Tachycineta bicolor*
Tundra swan	*Cygnus columbianus*
Varied thrush	*Ixoreus naevius*
Vaux's swift	*Chaetura vauxi*
Vesper sparrow	*Pooecetes gramineus*
Violet-green swallow	*Teachycineta thalassina*
Warbling vireo	*Vireo gilvus*
Western grebe	*Aechmophorus occidentalis*
Western kingbird	*Tyrannus verticalus*
Western meadowlark	*Sturnella neglecta*
Western tanager	*Piranga ludoviciana*
Western wood-pewee	*Contopus sordidulus*
White-crowned sparrow	*Zonotrichia leucophrys*
Willow flycatcher	*Empidonax traillii*
Wilson's warbler	*Wilsonia pusilla*
Winter wren	*Troglodytes troglodytes*
Yellow-breasted chat	*Icteria virens*
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*
Yellow-rumped warbler	*Dendroica coronata*
Yellow warbler	*Dendroica petechia*

Mammals

American badger	*Taxidea taxus*
Beaver	*Castor canadensis*
Bushy-tailed wood rat	*Neotoma cinerea*
Common porcupine	*Erethizon dorsatum*
Coyote	*Canis latrans*
Deer mouse	*Peromyscus maniculatus*
Fox squirrel	*Sciurus niger*
Great Basin pocket mouse	*Perognathus parvus*
Long-tailed weasel	*Mustela frenata*
Montane vole	*Microtus montanus*

Mountain cottontail	*Sylvilagus nuttallii*
Mule deer	*Odocoileus hemionus*
Muskrat	*Ondatra zibethicus*
Raccoon	*Procyon lotor*
Red fox	*Vulpes vulpes*
Striped skunk	*Mephitis mephitis*
Vagrant shrew	*Sorex vagrans*
Western harvest mouse	*Reithrodontomys megalotis*
White-tailed deer	*Odocoileus virginianus*
Yellow-bellied marmot	*Marmota flaviventris*

Appendix B

Total Numbers of Breeding-Bird Species Detected at Each Study Site in Each Reservoir, Including Flyovers and Flocks, Lower Snake River, 1997

Species	Ice Harbor Study Sites							
	HO[1]	BF	HOC1	BFC1	BFC2	HOD1	HOD2	BFD1
American coot	0	0	0	0	0	0	0	0
American crow	0	21	0	3	0	0	0	0
American goldfinch	6	11	1	1	0	0	1	0
American kestrel	0	3	1	0	1	2	2	0
American robin	24	19	1	6	2	0	3	0
Bald eagle	1	0	0	0	0	0	0	0
Bank swallow	222	174	78	222	2	0	3	120
Barn owl	1	0	0	0	0	0	0	0
Barn swallow	0	0	2	0	3	7	2	0
Belted kingfisher	1	0	0	0	0	0	0	0
Bewick's wren	2	0	0	0	0	0	0	0
Black-billed magpie	35	14	12	24	1	42	12	6
Black-capped chickadee	0	0	0	0	0	0	0	0
Black-headed grosbeak	9	3	0	1	0	1	0	0
Brown-headed cowbird	23	47	1	2	3	5	6	2
California gull	4	5	12	1	19	0	2	0
California quail	21	17	0	0	0	0	0	0
Canada goose	1	21	6	0	1	0	0	0
Canyon wren	1	0	3	0	1	0	2	0
Caspian tern	2	1	0	1	0	0	0	0
Cedar waxwing	0	0	0	0	0	0	0	0
Chipping sparrow	1	0	0	2	0	0	0	0
Chukar	0	0	0	0	0	0	0	0
Cinnamon teal	0	0	0	0	0	0	0	0
Cliff swallow	0	0	0	0	7	15	0	1
Common merganser	0	0	0	0	0	0	0	0
Common nighthawk	0	0	1	0	0	0	0	0
Common raven	2	1	3	0	2	0	2	2
Common snipe	0	0	0	0	0	0	0	0
Common yellowthroat	1	1	0	0	0	0	0	0
Double-crested cormorant	1	9	2	4	2	1	0	0
Downy woodpecker	1	0	0	0	0	0	0	0
Dusky flycatcher	0	0	0	0	0	0	0	0
Eastern kingbird	4	1	2	0	4	1	0	0
European starling	0	0	26	0	6	1	0	0
Forster's tern	4	6	7	1	3	0	2	0
Franklin's gull	0	0	0	0	0	0	0	0
Grasshopper sparrow	0	0	0	1	0	7	0	1
Gray catbird	1	0	0	0	0	0	0	0
Great blue heron	0	2	0	1	3	0	0	0
Great horned owl	1	0	0	0	0	1	0	0
Horned lark	0	0	0	0	0	1	1	2
House finch	0	0	0	1	0	0	0	0
House sparrow	0	0	0	0	0	0	0	0
House wren	4	0	0	0	0	0	0	0
Killdeer	0	1	1	0	0	0	1	0
Lark sparrow	0	0	0	0	0	0	0	0

Lazuli bunting	10	14	0	0	0	0	0	2
Long-eared owl	0	0	1	0	0	0	0	0
MacGillivray's warbler	0	0	0	0	0	0	0	0
Mallard	0	1	0	1	0	0	3	0
Marsh wren	0	0	0	0	0	0	0	0
Mourning dove	37	21	6	2	8	8	3	30
Nashville warbler	0	0	0	0	0	0	0	0
Northern flicker	1	0	1	0	0	0	2	0
Northern harrier	2	0	0	0	2	1	0	0
Northern oriole	40	30	14	6	12	27	10	4
Northern rough-winged swallow	0	0	0	0	0	2	2	0
Orange-crowned warbler	0	0	0	0	0	0	0	0
Osprey	1	0	0	0	0	0	0	0
Pine siskin	0	0	0	0	0	0	0	0
Prairie falcon	0	0	0	0	0	0	0	0
Red-eyed vireo	0	0	0	0	0	0	0	0
Red-tailed hawk	4	4	6	0	2	3	1	3
Red-winged blackbird	53	52	11	45	30	19	60	1
Ring-billed gull	2	1	0	3	9	0	1	1
Ring-necked pheasant	13	22	5	3	1	4	0	1
Rock dove	4	6	0	0	0	10	0	0
Rock wren	0	0	16	0	4	22	2	27
Say's phoebe	0	1	2	0	0	3	0	0
Sharp-shinned hawk	0	0	0	0	0	0	0	0
Short-eared owl	0	0	0	0	0	0	0	0
Song sparrow	0	15	5	2	1	0	0	3
Spotted sandpiper	0	0	0	1	0	0	0	0
Spotted towhee	0	0	0	0	0	0	0	0
Swainson's hawk	0	0	0	0	0	0	0	0
Townsend's solitaire	0	0	0	0	0	0	0	0
Townsend's warbler	0	0	0	0	0	0	0	0
Tree swallow	0	0	0	0	0	0	0	0
Violet-green swallow	0	0	0	0	9	3	3	0
Warbling vireo	0	0	0	0	0	0	0	0
Western grebe	0	2	0	0	0	0	0	0
Western kingbird	2	5	8	2	6	6	1	6
Western meadowlark	27	34	21	30	15	31	6	38
Western tanager	0	0	0	0	0	0	0	0
Western wood-pewee	0	0	8	0	0	0	0	0
White-crowned sparrow	0	0	0	0	0	0	0	0
Willow flycatcher	0	0	15	0	0	0	0	0
Wilson's warbler	0	0	0	0	0	0	1	0
Yellow-breasted chat	6	7	1	0	1	0	0	0
Yellow-rumped warbler	0	0	0	0	0	0	1	0
Yellow warbler	5	4	21	1	1	0	0	0
Total	**580**	**576**	**300**	**367**	**161**	**221**	**135**	**250**

Species	Lower Monumental Study Sites						
	FM[1]	SK	FMC	SKC	FMD2	FMD3	SKD2
American coot	0	0	2	0	0	0	0
American crow	0	1	0	1	3	0	3
American goldfinch	5	0	14	0	2	15	25
American kestrel	0	5	4	2	2	0	1
American robin	10	6	9	0	0	1	14
Bald eagle	0	0	0	0	0	0	0
Bank swallow	22	45	3	2	2	10	4
Barn owl	0	1	2	0	0	0	0
Barn swallow	3	9	1	0	0	2	3
Belted kingfisher	0	0	0	1	0	0	0
Bewick's wren	0	0	1	0	0	6	21
Black-billed magpie	14	14	5	8	0	0	13
Black-capped chickadee	0	0	0	0	0	0	5
Black-headed grosbeak	0	3	2	0	0	0	8
Brown-headed cowbird	13	6	14	0	0	10	21
California gull	9	19	11	1	0	0	0
California quail	1	4	0	0	0	2	6
Canada goose	10	17	0	0	0	0	0
Canyon wren	0	4	4	5	0	1	0
Caspian tern	1	0	0	0	0	0	0
Cedar waxwing	4	0	0	0	0	0	1
Chipping sparrow	4	1	0	0	0	0	0
Chukar	0	0	0	0	0	0	0
Cinnamon teal	0	0	0	0	0	0	0
Cliff swallow	15	13	66	41	0	445	19
Common merganser	0	10	0	0	0	0	0
Common nighthawk	0	5	0	3	0	0	1
Common raven	4	12	8	3	1	2	0
Common snipe	1	1	0	0	0	0	0
Common yellowthroat	0	1	1	0	0	0	0
Double-crested cormorant	0	1	0	0	0	0	0
Downy woodpecker	0	0	0	0	0	0	0
Dusky flycatcher	0	0	0	0	0	0	0
Eastern kingbird	8	19	7	0	0	2	3
European starling	2	45	15	3	1	58	2
Forster's tern	7	11	0	2	0	0	0
Franklin's gull	0	0	0	9	0	0	0
Grasshopper sparrow	0	3	0	30	0	1	0
Gray catbird	0	0	0	0	0	0	0
Great blue heron	0	0	1	0	0	0	0
Great horned owl	0	0	0	1	0	0	1
Horned lark	2	0	0	22	0	0	0
House finch	2	0	0	3	2	4	0
House sparrow	0	0	0	0	0	0	0
House wren	0	0	0	0	0	0	3
Killdeer	4	0	6	5	0	1	6
Lark sparrow	0	0	0	0	0	0	0
Lazuli bunting	1	0	1	1	0	3	4
Long-eared owl	0	0	1	0	0	0	0
MacGillivray's warbler	0	1	0	0	0	0	0
Mallard	0	0	12	0	0	0	2
Marsh wren	0	0	0	0	0	0	0

Mourning dove	16	32	11	10	0	8	14
Nashville warbler	0	0	0	0	0	0	1
Northern flicker	0	0	4	0	0	3	4
Northern harrier	0	7	1	1	0	0	4
Northern oriole	11	32	15	4	0	8	24
Northern rough-winged swallow	0	7	0	0	0	0	0
Orange-crowned warbler	0	0	0	0	0	0	0
Osprey	0	1	1	0	0	0	1
Pine siskin	0	1	0	0	0	0	0
Prairie falcon	0	0	0	0	0	0	0
Red-eyed vireo	0	0	0	0	0	0	0
Red-tailed hawk	0	3	2	7	1	2	1
Red-winged blackbird	26	23	84	4	0	14	26
Ring-billed gull	0	0	4	4	0	0	0
Ring-necked pheasant	11	3	8	4	1	0	4
Rock dove	0	0	0	0	0	0	0
Rock wren	4	8	3	20	5	6	1
Say's phoebe	0	9	0	6	5	0	1
Sharp-shinned hawk	0	0	0	0	0	0	0
Short-eared owl	0	0	0	0	1	0	0
Song sparrow	1	3	4	0	0	2	22
Spotted sandpiper	0	0	2	1	0	0	3
Spotted towhee	0	0	0	0	0	0	0
Swainson's hawk	0	0	0	0	0	0	0
Townsend's solitaire	0	1	0	0	0	0	0
Townsend's warbler	0	2	0	0	0	0	0
Tree swallow	0	13	2	0	0	0	0
Violet-green swallow	0	11	0	2	6	0	0
Warbling vireo	1	0	0	0	0	0	0
Western grebe	0	0	0	0	0	0	0
Western kingbird	2	16	1	3	4	0	5
Western meadowlark	35	67	24	64	5	0	4
Western tanager	0	0	0	0	0	2	2
Western wood-pewee	0	0	1	0	0	0	9
White-crowned sparrow	0	0	0	0	0	0	0
Willow flycatcher	1	0	0	0	0	1	3
Wilson's warbler	2	0	0	0	0	0	1
Yellow-breasted chat	5	0	4	1	0	5	4
Yellow-rumped warbler	0	0	0	0	0	0	0
Yellow warbler	1	2	0	0	0	0	15
Total	**258**	**498**	**360**	**274**	**41**	**614**	**315**

Species	Little Goose Study Sites							
	SB[1]	NY	SBC	NYC	SBD1	SBD2	NYD1	NYD2
American coot	0	0	0	0	0	0	0	0
American crow	0	4	0	0	0	0	0	2
American goldfinch	19	16	5	22	26	15	16	32
American kestrel	3	4	1	0	0	0	10	0
American robin	37	15	25	25	26	12	13	37
Bald eagle	0	0	0	0	0	0	0	0
Bank swallow	7	108	137	3	0	0	12	0
Barn owl	0	4	0	1	0	0	6	1
Barn swallow	3	5	0	3	0	0	1	0
Belted kingfisher	0	0	0	0	0	0	0	0
Bewick's wren	4	0	0	2	1	3	0	0
Black-billed magpie	44	7	11	4	4	6	3	0
Black-capped chickadee	0	0	0	0	0	0	0	0
Black-headed grosbeak	0	0	0	0	2	5	0	2
Brown-headed cowbird	33	8	32	25	12	12	10	27
California gull	3	5	12	11	0	0	0	0
California quail	6	0	15	0	0	3	6	0
Canada goose	28	18	33	4	1	0	0	0
Canyon wren	4	5	1	0	0	0	0	0
Caspian tern	0	0	0	0	0	0	0	0
Cedar waxwing	0	1	0	0	0	0	0	0
Chipping sparrow	0	0	0	0	2	0	0	0
Chukar	15	0	2	0	0	0	0	0
Cinnamon teal	1	0	0	0	0	0	0	0
Cliff swallow	4	241	92	20	2	0	8	1
Common merganser	0	0	0	0	0	0	0	0
Common nighthawk	2	1	0	0	0	0	0	1
Common raven	6	6	3	0	0	0	0	2
Common snipe	0	0	0	1	0	0	0	0
Common yellowthroat	0	0	0	1	0	0	0	0
Double-crested cormorant	0	1	0	0	0	0	0	0
Downy woodpecker	0	0	0	0	0	0	0	3
Dusky flycatcher	0	0	0	0	0	0	0	2
Eastern kingbird	14	0	2	1	5	6	9	0
European starling	0	16	0	0	0	0	109	8
Forster's tern	0	0	0	0	0	0	0	0
Franklin's gull	0	0	0	0	0	0	0	0
Grasshopper sparrow	0	0	1	1	1	0	0	0
Gray catbird	0	0	0	0	0	0	0	0
Great blue heron	1	0	0	0	0	0	0	1
Great horned owl	1	1	0	0	0	0	5	1
Horned lark	0	0	7	2	0	0	0	0
House finch	2	1	0	0	0	0	0	3
House sparrow	0	0	0	7	0	0	0	0
House wren	0	0	1	0	4	9	14	5
Killdeer	6	3	3	11	0	0	1	1
Lark sparrow	0	0	0	0	0	0	0	1
Lazuli bunting	9	11	3	0	13	7	5	2
Long-eared owl	0	0	0	0	0	0	0	0
MacGillivray's warbler	0	0	0	0	0	1	0	2
Mallard	0	0	0	1	0	0	0	2
Marsh wren	2	0	1	0	0	0	0	1

Mourning dove	14	9	3	19	1	3	2	10
Nashville warbler	0	0	0	0	0	0	0	0
Northern flicker	1	0	0	0	1	7	8	0
Northern harrier	4	1	0	4	1	0	0	0
Northern oriole	39	10	15	10	25	12	26	14
Northern rough-winged swallow	1	0	0	0	0	0	0	0
Orange-crowned warbler	0	0	0	0	1	0	0	0
Osprey	1	1	0	0	0	0	0	0
Pine siskin	0	0	0	0	0	0	0	0
Prairie falcon	0	1	0	0	0	0	0	0
Red-eyed vireo	0	0	0	0	0	0	0	0
Red-tailed hawk	3	5	3	12	3	12	7	4
Red-winged blackbird	61	0	128	79	2	0	12	27
Ring-billed gull	11	4	3	5	0	0	0	0
Ring-necked pheasant	48	12	27	17	7	4	0	1
Rock dove	0	0	1	0	0	0	6	0
Rock wren	9	12	2	1	4	5	1	1
Say's phoebe	3	10	2	1	3	3	2	0
Sharp-shinned hawk	0	0	0	0	0	0	0	0
Short-eared owl	0	0	0	0	0	0	0	0
Song sparrow	28	5	19	46	5	7	4	20
Spotted sandpiper	1	2	6	1	11	7	0	2
Spotted towhee	0	2	0	11	0	0	0	0
Swainson's hawk	0	0	0	2	0	0	0	0
Townsend's solitaire	0	0	0	0	0	0	0	0
Townsend's warbler	0	0	0	0	0	0	0	0
Tree swallow	0	0	0	0	1	0	0	1
Violet-green swallow	0	1	2	2	0	0	0	0
Warbling vireo	0	0	0	0	1	2	0	0
Western grebe	0	0	0	0	0	0	0	0
Western kingbird	4	4	0	4	7	7	14	4
Western meadowlark	36	0	33	23	21	3	3	2
Western tanager	0	0	0	0	1	1	0	0
Western wood-pewee	0	0	0	2	1	1	0	0
White-crowned sparrow	0	0	0	0	0	1	0	0
Willow flycatcher	0	0	3	0	0	1	2	0
Wilson's warbler	2	1	0	0	0	1	0	0
Yellow-breasted chat	7	0	3	4	0	4	2	0
Yellow-rumped warbler	13	1	6	21	0	7	0	0
Yellow warbler	0	0	0	0	0	0	0	0
Total	**540**	**562**	**643**	**409**	**195**	**167**	**317**	**223**

Species	Lower Granite Study Sites				Totals for Reservoirs			
	CT[1]	CTC	CTD1	CTD2	IH[2]	LOMO	LIGO	LOGR
American coot	0	0	0	0	0	2	0	0
American crow	0	0	1	0	24	8	6	1
American goldfinch	63	32	50	7	20	61	151	152
American kestrel	1	0	0	2	9	14	18	3
American robin	67	17	11	9	55	40	190	104
Bald eagle	0	0	0	0	1	0	0	0
Bank swallow	9	0	0	0	821	88	267	9
Barn owl	0	0	0	0	1	3	12	0
Barn swallow	0	2	0	0	14	18	12	2
Belted kingfisher	0	0	0	0	1	1	0	0
Bewick's wren	3	0	2	1	2	28	10	6
Black-billed magpie	0	10	9	6	146	54	79	25
Black-capped chickadee	0	0	0	4	0	5	0	4
Black-headed grosbeak	0	8	13	6	14	13	9	27
Brown-headed cowbird	39	35	2	7	89	64	159	83
California gull	3	44	0	0	43	40	31	47
California quail	30	6	0	4	38	13	30	40
Canada goose	138	24	0	0	29	27	84	162
Canyon wren	1	3	11	3	7	14	10	18
Caspian tern	0	0	0	0	4	1	0	0
Cedar waxwing	7	1	0	1	0	5	1	9
Chipping sparrow	0	0	0	0	3	5	2	0
Chukar	0	4	0	0	0	0	17	4
Cinnamon teal	0	1	0	0	0	0	1	1
Cliff swallow	6	29	48	5	23	599	368	88
Common merganser	0	3	0	0	0	10	0	3
Common nighthawk	0	1	0	0	1	9	4	1
Common raven	6	5	0	1	12	30	17	12
Common snipe	0	0	0	0	0	2	1	0
Common yellowthroat	0	0	0	0	2	2	1	0
Double-crested cormorant	0	0	0	0	19	1	1	0
Downy woodpecker	0	0	0	0	1	0	3	0
Dusky flycatcher	0	0	0	0	0	0	2	0
Eastern kingbird	0	2	0	2	12	39	37	4
European starling	30	6	0	3	33	126	133	39
Forster's tern	0	4	0	0	23	20	0	4
Franklin's gull	0	0	0	0	0	9	0	0
Grasshopper sparrow	0	0	0	1	9	34	3	1
Gray catbird	1	0	0	0	1	0	0	1
Great blue heron	1	33	0	0	6	1	2	34
Great horned owl	0	0	0	1	2	2	8	1
Horned lark	1	0	0	0	4	24	9	1
House finch	1	2	5	0	1	11	6	8
House sparrow	0	0	0	0	0	0	7	0
House wren	0	0	5	2	4	3	33	7
Killdeer	5	32	0	0	3	22	25	37
Lark sparrow	0	1	0	0	0	0	1	1
Lazuli bunting	7	2	33	22	26	10	50	64
Long-eared owl	0	0	0	0	1	0	0	0
MacGillivray's warbler	0	0	0	0	0	1	3	0
Mallard	10	3	0	0	5	14	3	13
Marsh wren	0	0	0	0	0	0	4	0

Mourning dove	37	18	3	1	115	91	61	59
Nashville warbler	0	0	0	0	0	1	0	0
Northern flicker	2	2	4	6	4	11	17	14
Northern harrier	0	0	0	0	5	13	10	0
Northern oriole	54	27	3	17	143	94	151	101
Northern rough-winged swallow	5	1	0	0	4	7	1	6
Orange-crowned warbler	0	0	0	0	0	0	1	0
Osprey	1	1	0	0	1	3	2	2
Pine siskin	0	0	0	0	0	1	0	0
Prairie falcon	0	0	0	0	0	0	1	0
Red-eyed vireo	0	0	5	0	0	0	0	5
Red-tailed hawk	1	0	5	0	23	16	49	6
Red-winged blackbird	76	48	0	0	271	177	309	124
Ring-billed gull	1	6	0	0	17	8	23	7
Ring-necked pheasant	9	10	0	0	49	31	116	19
Rock dove	2	8	18	0	20	0	7	28
Rock wren	8	9	6	10	71	47	35	33
Say's phoebe	0	2	1	0	6	21	24	3
Sharp-shinned hawk	0	0	1	0	0	0	0	1
Short-eared owl	0	0	0	0	0	1	0	0
Song sparrow	28	11	4	8	26	32	134	51
Spotted sandpiper	19	21	0	0	1	6	13	40
Spotted towhee	0	0	21	9	0	0	30	30
Swainson's hawk	0	0	0	0	0	0	2	0
Townsend's solitaire	0	0	0	0	0	1	0	0
Townsend's warbler	0	0	0	0	0	2	0	0
Tree swallow	0	0	0	0	0	15	2	0
Violet-green swallow	26	10	13	2	13	19	5	51
Warbling vireo	0	0	1	0	0	1	3	1
Western grebe	0	0	0	0	2	0	0	0
Western kingbird	11	13	0	1	36	31	44	25
Western meadowlark	10	35	4	2	202	199	121	51
Western tanager	0	0	0	0	0	4	2	0
Western wood-pewee	0	0	0	0	8	10	4	0
White-crowned sparrow	0	0	0	0	0	0	1	0
Willow flycatcher	4	0	0	0	15	5	6	4
Wilson's warbler	0	0	0	0	1	3	4	0
Yellow-breasted chat	0	0	13	12	15	19	20	25
Yellow-rumped warbler	0	19	0	0	1	0	0	19
Yellow warbler	40	9	7	4	32	18	48	60
Total	**763**	**560**	**299**	**159**	**2,590**	**2,360**	**3,056**	**1,781**

[1]See Table 1 and Figure 1 for details of study site descriptions and locations.

- HO = Hollebeke HMU
- BF = Big Flat HMU
- HOC1 = Couch Landing
- BFC1 = Near Charbonneau Park
- BFC2 = Walker
- HOD1 = Walker Canyon
- HOD2 = Upper Walker Embayment
- BFD1 = McCoy Canyon
- FM = Fifty-Five Mile HMU
- SK = Skookum HMU
- FMC = Riparia
- SKC = Joso
- FMD2 = 1st Canyon Below Little Goose Dam
- FMD3 = Alkali Flat Creek
- SKD2 = Tucannon River
- SB = Swift Bar HMU
- NY = New York Bar HMU
- SBC = Rice Bar
- NYC = Willow Bar
- SBD1 = Schaefer Gulch
- SBD2 = Wolf Canyon
- NYD1 = Dry Gulch
- NYD2 = Deadman Gulch
- CT = Chief Timothy HMU
- CTC = Wilma and Moses
- CTD1 = Nisqually John Canyon
- CTD2 = 1st Canyon Above Nisqually John

[2] IH = Ice Harbor
LOMO = Lower Monumental
LIGO = Little Goose
LOGR = Lower Granite

Appendix C
Total Numbers of Fall Bird Species Detected at Each Study Site in Each Reservoir
Including Flyovers and Flocks
Lower Snake River, 1997

Species	Ice Harbor Study Sites							
	HO[1]	BF	HOC1	BFC1	BFC2	HOD1	HOD2	BFD1
American coot	0	3	0	0	0	0	0	0
American crow	1	4	0	2	0	0	0	0
American goldfinch	29	65	13	12	5	7	35	6
American kestrel	3	1	0	0	0	0	0	0
American robin	101	34	2	80	3	0	0	0
American wigeon	0	0	0	25	0	0	0	0
Bank swallow	0	0	0	0	0	0	0	0
Barn owl	0	0	0	0	0	0	0	0
Barn swallow	0	2	0	10	2	0	0	0
Belted kingfisher	0	0	1	1	1	0	1	0
Bewick's wren	0	0	0	0	0	0	0	0
Black-billed magpie	49	6	0	6	4	2	6	3
Black-capped chickadee	0	0	0	0	0	0	0	0
Brewer's blackbird	0	8	0	0	0	0	0	0
Bufflehead	0	0	0	0	0	0	0	0
California gull	0	0	3	0	0	0	0	0
California quail	5	0	0	0	0	0	0	0
Canada goose	0	90	17	254	100	60	10	19
Canyon wren	0	0	3	0	1	0	1	0
Cedar waxwing	1	0	0	0	0	0	0	0
Chipping sparrow	1	4	2	0	0	0	0	11
Chukar	0	0	0	0	0	6	0	30
Cliff swallow	0	0	0	0	0	0	0	0
Common merganser	0	0	0	0	0	0	0	0
Common raven	0	0	0	0	0	0	0	0
Cooper's hawk	1	0	1	0	0	0	1	1
Dark-eyed junco	5	1	0	5	1	1	0	13
Double-crested cormorant	1	0	1	5	1	0	0	0
Downy woodpecker	0	0	0	0	0	0	0	0
Eastern kingbird	0	0	0	0	0	0	0	0
European starling	0	6	0	0	1	0	0	0
Franklin's gull	0	0	0	0	0	0	0	0
Golden-crowned kinglet	0	0	0	0	0	0	0	0
Grasshopper sparrow	0	0	0	0	0	0	0	0
Gray catbird	0	0	0	0	0	0	0	0
Great blue heron	0	1	0	0	0	0	0	0
Great horned owl	0	0	0	0	0	0	0	0
Green-winged teal	0	0	0	0	0	0	0	0
Horned grebe	0	0	0	0	0	0	0	0
Horned lark	0	0	0	0	0	0	0	2
House finch	7	1	6	1	0	0	0	0
House wren	0	0	0	0	0	0	0	0
Killdeer	0	0	0	0	1	0	1	0
Lark sparrow	0	0	0	0	0	0	9	0

Lazuli bunting	0	0	0	0	0	0	0	0
Lesser yellowlegs	0	0	0	0	0	0	0	0
Lincoln's sparrow	1	1	0	0	0	0	0	2
MacGillivray's warbler	3	0	0	0	0	0	0	0
Mallard	0	2	0	12	0	0	0	0
Marsh wren	0	1	0	1	0	1	0	0
Mourning dove	3	2	2	0	1	0	0	6
Nashville warbler	0	0	0	0	0	0	0	0
Northern flicker	13	7	4	7	2	2	0	3
Northern goshawk	1	0	0	0	0	0	0	0
Northern harrier	2	2	2	0	0	0	0	1
Northern oriole	0	0	0	0	0	0	0	0
Northern rough-winged swallow	0	0	0	0	0	0	1	0
Northern shoveler	0	0	0	0	0	0	0	0
Orange-crowned warbler	0	0	0	0	0	0	0	0
Osprey	0	0	0	0	0	0	1	0
Pied-billed grebe	0	0	0	0	0	0	0	0
Pine siskin	0	0	0	0	0	0	0	0
Red-eyed vireo	0	1	0	0	0	0	0	0
Red-tailed hawk	0	0	1	1	0	0	0	0
Red-winged blackbird	16	52	0	1	5	1	11	0
Red crossbill	0	0	0	0	0	0	0	1
Redhead	0	0	0	0	0	0	0	0
Ring-billed gull	2	1	0	5	2	0	0	0
Ring-necked pheasant	4	1	6	1	0	1	0	0
Rock dove	0	0	0	0	28	0	26	0
Rock wren	0	0	8	0	0	6	0	0
Ruby-crowned kinglet	0	1	0	1	0	1	1	0
Savannah sparrow	2	4	3	3	0	5	0	1
Say's phoebe	0	0	0	0	0	0	0	0
Sharp-shinned hawk	1	2	0	2	1	0	0	1
Solitary vireo	0	0	0	0	0	0	0	1
Song sparrow	28	16	10	9	8	5	8	4
Spotted towhee	3	2	0	1	0	0	0	1
Swainson's hawk	0	0	0	0	0	0	0	0
Townsend's solitaire	0	0	0	0	0	0	0	1
Varied thrush	0	0	0	0	0	0	0	0
Vaux's swift	0	0	0	0	0	0	0	0
Vesper sparrow	0	0	0	0	0	0	0	0
Warbling vireo	0	0	0	0	0	0	0	0
Western grebe	0	6	0	0	0	0	0	0
Western meadowlark	8	5	23	27	5	9	7	21
Western wood-pewee	1	0	0	0	0	0	0	0
White-crowned sparrow	95	217	23	10	7	8	4	93
Wilson's warbler	2	0	0	0	0	0	0	0
Winter wren	0	0	0	0	0	0	0	0
Yellow-breasted chat	1	0	0	0	0	0	0	0
Yellow-headed blackbird	0	0	0	0	0	0	0	0
Yellow-rumped warbler	4	19	0	54	1	0	0	0
Yellow warbler	0	0	0	0	0	0	0	0
Total	**394**	**568**	**131**	**536**	**180**	**115**	**114**	**221**

Species	Lower Monumental Study Sites						
	FM[1]	SK	FMC	SKC	FMD2	FMD3	SKD2
American coot	0	0	0	0	0	0	0
American crow	5	8	2	3	0	0	21
American goldfinch	27	28	39	21	3	10	117
American kestrel	0	0	2	0	0	0	1
American robin	11	3	2	20	0	53	5
American wigeon	0	0	0	0	0	0	0
Bank swallow	0	0	0	0	0	0	0
Barn owl	0	0	1	0	0	0	0
Barn swallow	0	1	0	3	0	0	1
Belted kingfisher	1	1	0	3	0	0	3
Bewick's wren	0	0	0	0	0	1	2
Black-billed magpie	10	14	6	9	0	6	14
Black-capped chickadee	0	0	0	0	0	0	6
Brewer's blackbird	0	0	0	0	0	0	0
Bufflehead	0	0	10	0	0	0	0
California gull	0	1	1	0	0	1	0
California quail	3	0	4	0	0	0	0
Canada goose	5	1	0	0	0	0	14
Canyon wren	1	0	0	0	0	0	0
Cedar waxwing	0	1	0	0	0	0	0
Chipping sparrow	0	2	2	0	0	0	0
Chukar	0	0	1	0	0	0	0
Cliff swallow	0	0	0	0	0	0	0
Common merganser	0	0	0	0	0	0	0
Common raven	4	3	0	0	0	0	0
Cooper's hawk	0	0	0	0	0	0	0
Dark-eyed junco	0	2	0	0	0	0	5
Double-crested cormorant	0	1	1	0	0	0	0
Downy woodpecker	0	0	0	0	0	0	0
Eastern kingbird	0	0	0	0	0	0	0
European starling	9	0	37	9	0	0	0
Franklin's gull	1	0	0	0	0	0	0
Golden-crowned kinglet	0	0	0	0	0	0	0
Grasshopper sparrow	0	0	0	1	0	0	0
Gray catbird	0	0	0	0	0	0	1
Great blue heron	0	0	2	1	0	0	1
Great horned owl	0	0	0	0	0	0	0
Green-winged teal	0	0	0	0	0	0	0
Horned grebe	0	0	0	0	0	0	0
Horned lark	0	0	0	32	3	0	0
House finch	0	0	3	4	0	2	0
House wren	0	0	0	0	0	0	2
Killdeer	0	0	0	0	0	0	2
Lark sparrow	0	0	0	0	0	0	0
Lazuli bunting	0	0	0	0	0	0	0
Lesser yellowlegs	0	0	0	0	0	0	0
Lincoln's sparrow	0	0	0	0	0	0	7
MacGillivray's warbler	0	0	0	0	0	0	1
Mallard	0	0	0	0	0	0	1
Marsh wren	0	0	1	0	0	0	3
Mourning dove	3	2	3	1	0	0	1
Nashville warbler	0	2	0	0	0	0	0

Northern flicker	10	9	6	1	0	5	8
Northern goshawk	0	0	0	0	0	0	0
Northern harrier	3	0	2	0	0	0	1
Northern oriole	0	0	0	0	0	0	0
Northern rough-winged swallow	0	0	0	0	0	0	0
Northern shoveler	0	0	0	0	0	0	0
Orange-crowned warbler	0	0	1	0	0	0	0
Osprey	0	0	1	0	0	0	0
Pied-billed grebe	0	1	0	0	0	0	0
Pine siskin	0	0	0	0	0	0	0
Red-eyed vireo	0	0	0	0	0	0	0
Red-tailed hawk	2	1	3	1	0	0	0
Red-winged blackbird	60	24	80	4	0	5	20
Red crossbill	0	0	0	0	0	0	0
Redhead	0	0	0	0	0	0	3
Ring-billed gull	1	1	1	0	0	0	0
Ring-necked pheasant	7	4	0	0	0	1	5
Rock dove	0	0	0	0	0	0	2
Rock wren	0	1	0	0	2	2	1
Ruby-crowned kinglet	4	3	0	0	0	0	7
Savannah sparrow	4	0	3	2	1	0	0
Say's phoebe	0	0	0	0	0	1	0
Sharp-shinned hawk	2	1	0	0	0	0	0
Solitary vireo	0	0	0	0	0	0	0
Song sparrow	9	9	21	0	1	11	20
Spotted towhee	1	0	0	0	0	2	0
Swainson's hawk	0	0	0	0	0	0	0
Townsend's solitaire	0	0	0	0	0	0	0
Varied thrush	0	0	0	0	0	0	0
Vaux's swift	0	0	0	0	0	0	0
Vesper sparrow	0	0	0	0	0	0	0
Warbling vireo	0	0	0	0	0	1	0
Western grebe	0	0	0	0	0	0	0
Western meadowlark	6	23	9	48	2	0	4
Western wood-pewee	0	0	0	0	0	0	0
White-crowned sparrow	342	33	16	3	2	16	96
Wilson's warbler	0	0	0	0	0	2	1
Winter wren	0	0	0	0	0	0	0
Yellow-breasted chat	1	0	0	0	0	0	0
Yellow-headed blackbird	0	0	0	0	0	0	0
Yellow-rumped warbler	19	19	1	7	0	0	2
Yellow warbler	0	0	1	0	0	0	1
Total	**551**	**192**	**262**	**173**	**14**	**119**	**379**

Species	Little Goose Study Sites							
	SB[1]	NY	SBC	NYC	SBD1	SBD2	NYD1	NYD2
American coot	0	0	5	60	0	0	0	0
American crow	0	0	1	0	0	0	0	2
American goldfinch	21	35	52	61	14	11	53	15
American kestrel	2	0	0	0	0	0	0	1
American robin	20	23	0	2	4	0	7	5
American wigeon	0	0	1	0	0	0	0	0
Bank swallow	0	0	0	5	0	0	0	0
Barn owl	0	0	0	2	0	0	0	0
Barn swallow	9	0	1	36	0	0	8	0
Belted kingfisher	0	0	0	1	0	0	0	0
Bewick's wren	1	0	0	2	0	0	0	0
Black-billed magpie	7	11	6	10	3	5	5	2
Black-capped chickadee	0	0	0	0	0	6	0	0
Brewer's blackbird	0	0	0	0	0	0	0	0
Bufflehead	0	0	0	0	0	0	0	0
California gull	1	0	0	1	0	0	0	0
California quail	0	0	3	0	2	4	6	1
Canada goose	0	26	2	31	20	13	0	0
Canyon wren	0	1	1	0	1	5	0	0
Cedar waxwing	0	0	0	0	0	0	0	0
Chipping sparrow	0	0	2	0	0	3	0	2
Chukar	0	0	0	0	0	0	0	0
Cliff swallow	0	0	0	6	0	0	0	0
Common merganser	0	0	1	0	0	0	0	0
Common raven	0	1	0	0	0	0	0	0
Cooper's hawk	0	0	0	0	0	0	0	0
Dark-eyed junco	0	0	0	0	1	6	1	0
Double-crested cormorant	0	0	1	4	0	0	0	0
Downy woodpecker	0	0	0	0	0	0	0	2
Eastern kingbird	0	0	0	0	0	0	0	0
European starling	556	14	0	0	0	4	89	4
Franklin's gull	0	0	0	0	0	0	0	0
Golden-crowned kinglet	0	0	0	0	0	0	1	1
Grasshopper sparrow	0	0	0	0	0	0	0	0
Gray catbird	0	0	0	0	0	0	0	0
Great blue heron	0	0	1	0	0	0	0	0
Great horned owl	0	1	0	0	0	0	4	0
Green-winged teal	0	7	0	7	0	0	0	0
Horned grebe	0	0	0	0	0	0	0	0
Horned lark	0	0	0	0	0	0	0	0
House finch	3	0	0	4	0	0	0	3
House wren	0	0	0	0	0	0	1	1
Killdeer	0	0	0	4	0	0	0	3
Lark sparrow	0	0	1	0	0	0	0	1
Lazuli bunting	3	0	0	0	0	0	0	0
Lesser yellowlegs	0	0	0	1	0	0	0	0
Lincoln's sparrow	1	0	2	0	0	0	0	0
MacGillivray's warbler	4	0	2	0	0	0	0	0
Mallard	0	0	5	1	0	0	0	0
Marsh wren	0	0	0	1	0	0	0	1
Mourning dove	2	4	0	1	0	0	0	3
Nashville warbler	0	0	0	0	0	0	0	0

Northern flicker	4	8	1	5	7	6	10	5
Northern goshawk	0	0	0	0	0	0	0	0
Northern harrier	3	1	3	6	2	0	0	0
Northern oriole	0	0	0	0	0	0	0	0
Northern rough-winged swallow	0	0	0	0	0	0	0	0
Northern shoveler	0	0	0	1	0	0	0	0
Orange-crowned warbler	0	0	0	0	0	0	0	0
Osprey	0	1	0	2	0	0	0	0
Pied-billed grebe	0	0	0	1	0	0	0	0
Pine siskin	0	0	0	0	0	1	0	0
Red-eyed vireo	3	0	0	0	0	0	0	0
Red-tailed hawk	7	4	1	4	1	0	1	5
Red-winged blackbird	650	321	112	348	0	0	26	45
Red crossbill	0	0	0	0	0	0	0	0
Redhead	0	0	0	0	0	1	0	0
Ring-billed gull	5	0	5	10	0	0	0	0
Ring-necked pheasant	44	7	24	10	15	1	3	13
Rock dove	1	0	0	0	0	0	24	0
Rock wren	0	0	0	0	1	1	1	0
Ruby-crowned kinglet	1	2	1	2	2	6	8	2
Savannah sparrow	7	0	34	10	0	0	0	1
Say's phoebe	0	0	0	0	0	0	0	0
Sharp-shinned hawk	1	0	0	0	1	0	1	0
Solitary vireo	0	0	0	0	0	0	0	0
Song sparrow	34	7	35	53	5	10	14	38
Spotted towhee	2	1	2	0	3	2	0	0
Swainson's hawk	0	0	0	0	0	0	0	0
Townsend's solitaire	0	0	0	0	3	0	0	0
Varied thrush	0	0	0	0	0	0	5	0
Vaux's swift	0	0	0	4	0	0	0	0
Vesper sparrow	0	0	0	0	1	0	0	0
Warbling vireo	0	1	0	0	0	0	0	0
Western grebe	0	0	0	0	0	0	0	0
Western meadowlark	3	7	5	5	2	5	4	5
Western wood-pewee	1	0	0	0	0	0	0	0
White-crowned sparrow	107	5	202	93	22	29	7	93
Wilson's warbler	4	1	1	1	0	3	0	0
Winter wren	0	0	0	0	0	0	0	1
Yellow-breasted chat	1	0	0	0	0	1	0	0
Yellow-headed blackbird	0	0	0	2	0	0	0	0
Yellow-rumped warbler	48	0	3	1	14	0	2	2
Yellow warbler	0	0	0	0	0	0	0	0
Total	**1,556**	**489**	**516**	**798**	**124**	**123**	**281**	**257**

Species	Lower Granite Study Sites				Totals for Reservoirs			
	CT[1]	CTC	CTD1	CTD2	IH[2]	LOMO	LIGO	LOGR
American coot	0	4	0	0	3	0	65	4
American crow	0	0	0	0	7	39	3	0
American goldfinch	87	60	5	1	172	245	262	153
American kestrel	0	1	1	0	4	3	3	2
American robin	48	0	1	4	220	94	61	53
American wigeon	0	0	0	0	25	0	1	0
Bank swallow	0	0	0	0	0	0	5	0
Barn owl	0	0	0	0	0	1	2	0
Barn swallow	4	9	0	0	14	5	54	13
Belted kingfisher	2	4	0	0	4	8	1	6
Bewick's wren	0	0	0	1	0	3	3	1
Black-billed magpie	1	12	2	17	76	59	49	32
Black-capped chickadee	1	0	2	7	0	6	6	10
Brewer's blackbird	0	0	0	0	8	0	0	0
Bufflehead	0	0	0	0	0	10	0	0
California gull	1	3	0	0	3	3	2	4
California quail	49	32	0	4	5	7	16	85
Canada goose	80	0	0	0	550	20	92	80
Canyon wren	2	1	15	8	5	1	8	26
Cedar waxwing	2	0	0	0	1	1	0	2
Chipping sparrow	0	0	0	0	18	4	7	0
Chukar	1	7	0	24	36	1	0	32
Cliff swallow	0	0	0	0	0	0	6	0
Common merganser	0	0	0	0	0	0	1	0
Common raven	0	1	0	0	0	7	1	1
Cooper's hawk	0	0	0	0	4	0	0	0
Dark-eyed junco	5	4	1	3	26	7	8	13
Double-crested cormorant	0	0	0	0	8	2	5	0
Downy woodpecker	2	0	0	0	0	0	2	2
Eastern kingbird	0	1	0	0	0	0	0	1
European starling	2	6	0	0	7	55	667	8
Franklin's gull	0	0	0	0	0	1	0	0
Golden-crowned kinglet	0	0	4	0	0	0	2	4
Grasshopper sparrow	0	0	0	0	0	1	0	0
Gray catbird	1	0	0	0	0	1	0	1
Great blue heron	0	1	0	0	1	4	1	1
Great horned owl	0	0	0	0	0	0	5	0
Green-winged teal	0	0	0	0	0	0	14	0
Horned grebe	1	0	0	0	0	0	0	1
Horned lark	0	0	0	0	2	35	0	0
House finch	5	8	0	0	15	9	10	13
House wren	0	0	0	0	0	2	2	0
Killdeer	1	2	0	0	2	2	7	3
Lark sparrow	0	0	0	0	0	0	2	0
Lazuli bunting	0	0	0	0	0	0	3	0
Lesser yellowlegs	0	0	0	0	0	0	1	0
Lincoln's sparrow	0	0	2	0	4	7	3	2
MacGillivray's warbler	0	0	0	0	3	1	6	0
Mallard	21	0	0	0	14	1	6	21
Marsh wren	0	0	0	0	3	4	2	0
Mourning dove	9	1	0	0	14	10	10	10
Nashville warbler	0	0	0	0	0	2	0	0

Northern flicker	6	3	3	1	38	39	46	13
Northern goshawk	0	0	0	0	1	0	0	0
Northern harrier	0	1	0	0	7	6	15	1
Northern oriole	2	0	0	0	0	0	0	2
Northern rough-winged swallow	0	0	0	0	1	0	0	0
Northern shoveler	0	0	0	0	0	0	1	0
Orange-crowned warbler	0	0	0	0	0	1	0	0
Osprey	3	1	0	0	1	1	3	4
Pied-billed grebe	0	0	0	0	0	1	1	0
Pine siskin	0	1	0	0	0	0	1	1
Red-eyed vireo	2	0	0	0	1	0	3	2
Red-tailed hawk	2	0	4	4	2	7	24	10
Red-winged blackbird	107	18	0	0	86	193	1,502	125
Red crossbill	0	0	0	0	1	0	0	0
Redhead	0	0	0	0	0	3	0	0
Ring-billed gull	8	12	0	0	10	3	20	20
Ring-necked pheasant	0	2	0	0	13	17	117	2
Rock dove	0	6	0	0	54	2	25	6
Rock wren	1	4	2	4	14	6	3	11
Ruby-crowned kinglet	1	6	2	14	4	14	24	23
Savannah sparrow	0	1	0	0	18	10	52	1
Say's phoebe	0	1	3	0	0	1	0	4
Sharp-shinned hawk	1	0	0	1	7	3	3	2
Solitary vireo	1	0	0	0	1	0	0	1
Song sparrow	33	25	15	12	88	71	196	85
Spotted towhee	4	1	3	18	7	3	10	26
Swainson's hawk	0	0	0	0	0	0	0	0
Townsend's solitaire	0	0	0	0	1	0	3	0
Varied thrush	0	0	0	0	0	0	5	0
Vaux's swift	0	0	0	0	0	0	4	0
Vesper sparrow	0	0	0	0	0	0	1	0
Warbling vireo	0	0	0	0	0	1	1	0
Western grebe	0	0	0	0	6	0	0	0
Western meadowlark	4	7	0	0	105	92	36	11
Western wood-pewee	0	0	0	0	1	0	1	0
White-crowned sparrow	65	36	9	2	457	508	558	112
Wilson's warbler	0	0	0	0	2	3	10	0
Winter wren	0	0	0	0	0	0	1	0
Yellow-breasted chat	0	0	0	0	1	1	2	0
Yellow-headed blackbird	1	0	0	0	0	0	2	1
Yellow-rumped warbler	0	0	0	1	78	41	70	1
Yellow warbler	0	0	0	0	0	2	0	0
Total	**566**	**282**	**74**	**126**	**2,259**	**1,690**	**4,144**	**1,048**

[1]See Table 1 and Figure 1 for details of study site descriptions and locations.

- HO = Hollebeke HMU
- BF = Big Flat HMU
- HOC1 = Couch Landing
- BFC1 = Near Charbonneau Park
- BFC2 = Walker
- HOD1 = Walker Canyon
- HOD2 = Upper Walker Embayment
- BFD1 = McCoy Canyon
- FM = Fifty-Five Mile HMU
- SK = Skookum HMU
- FMC = Riparia
- SKC = Joso
- FMD2 = 1st Canyon Below Little Goose Dam
- FMD3 = Alkali Flat Creek
- SKD2 = Tucannon River
- SB = Swift Bar HMU
- NY = New York Bar HMU
- SBC = Rice Bar
- NYC = Willow Bar
- SBD1 = Schaefer Gulch
- SBD2 = Wolf Canyon
- NYD1 = Dry Gulch
- NYD2 = Deadman Gulch
- CT = Chief Timothy HMU
- CTC = Wilma and Moses
- CTD1 = Nisqually John Canyon
- CTD2 = 1st Canyon Above Nisqually John

[2] IH = Ice Harbor
LOMO = Lower Monumental
LIGO = Little Goose
LOGR = Lower Granite

Appendix D
Total Number of Spring Bird Species Detected at Each Study Site in Each Reservoir
Including Flyovers and Flocks
Lower Snake River
1998

Species	Ice Harbor Study Sites							
	HO[1]	BF	HOC1	BFC1	BFC2	HOD1	HOD2	BFD1
American coot	0	6	0	0	0	0	1	0
American crow	4	18	3	1	0	2	1	0
American goldfinch	26	19	7	38	13	46	1	1
American green-winged teal	0	0	0	0	0	0	0	0
American kestrel	2	0	0	1	0	0	0	0
American robin	31	42	4	10	1	3	3	1
American wigeon	0	2	0	0	0	0	0	0
Bald eagle	0	0	0	0	0	0	0	0
Bank swallow	23	0	0	0	0	0	0	6
Barn owl	0	0	0	0	0	0	0	0
Barn swallow	0	0	0	100	0	0	0	4
Belted kingfisher	0	0	0	0	0	0	0	0
Bewick's wren	0	0	0	0	1	0	0	0
Black-billed magpie	41	24	25	16	3	23	15	8
Black-capped chickadee	0	1	0	0	0	0	0	0
Blue-winged teal	0	0	0	0	0	0	2	0
California gull	1	8	3	3	2	0	0	0
California quail	26	19	4	1	0	0	3	0
Canada goose	8	19	23	14	18	4	0	0
Canyon wren	0	0	5	0	1	1	0	0
Cedar waxwing	16	53	0	0	0	0	0	0
Chipping sparrow	0	0	0	0	0	0	0	0
Chukar	0	0	0	0	0	0	0	3
Cliff swallow	0	0	1	0	2	0	0	0
Common goldeneye	0	0	0	0	0	0	0	0
Common loon	0	0	0	0	0	0	0	0
Common merganser	0	0	0	0	0	0	0	0
Common nighthawk	0	0	0	0	0	0	0	0
Common raven	1	0	0	1	1	0	0	0
Dark-eyed junco	3	14	0	0	0	12	0	0
Double-crested cormorant	4	0	0	3	0	0	9	0
Downy woodpecker	0	0	0	0	0	0	0	0
European starling	1	0	50	3	1	0	7	0
Golden eagle	1	0	0	0	0	0	0	0
Golden-crowned kinglet	0	0	0	0	0	0	0	0
Golden-crowned sparrow	1	0	0	0	0	0	0	0
Grasshopper sparrow	0	0	0	1	0	0	0	0
Great blue heron	1	1	0	2	0	0	0	0
Great horned owl	0	0	0	0	0	1	1	0
Hermit thrush	0	0	0	0	0	0	0	0
Horned lark	0	0	5	0	0	2	0	5
House finch	0	0	0	0	0	0	0	0
House sparrow	0	0	0	0	0	0	0	0
House wren	0	0	0	0	0	0	0	0
Killdeer	2	0	0	0	2	0	2	0

Lincoln's sparrow	0	0	0	0	0	0	0	2
Loggerhead shrike	0	0	0	0	0	0	0	0
Long-billed curlew	0	0	0	0	0	0	0	0
Long-eared owl	0	0	0	0	0	0	0	0
MacGillivray's warbler	0	0	0	0	0	0	0	0
Mallard	11	151	0	2	0	0	1	0
Marsh wren	0	0	0	0	0	0	0	0
Merlin	0	0	1	0	0	0	0	0
Mourning dove	8	9	4	0	1	0	0	0
Northern flicker	0	0	2	3	0	2	1	0
Northern harrier	1	1	0	0	0	1	0	0
Northern rough-winged swallow	0	0	0	0	0	0	0	0
Northern shoveler	0	0	0	0	0	0	0	0
Northern shrike	0	0	0	0	0	0	0	0
Osprey	0	0	0	0	0	0	0	0
Purple finch	0	0	0	0	0	0	0	0
Red-tailed hawk	5	3	1	0	0	0	1	4
Red-winged blackbird	36	87	3	40	14	5	71	0
Ring-billed gull	0	0	0	4	0	0	0	0
Ring-necked pheasant	22	41	10	10	2	9	0	3
Rock dove	10	22	0	5	0	0	1	0
Rock wren	0	0	19	0	1	7	0	0
Ross's goose	0	0	0	0	0	0	0	0
Ruby-crowned kinglet	1	0	0	0	1	0	0	0
Savannah sparrow	0	0	1	0	0	0	1	0
Say's phoebe	2	0	1	1	1	4	0	0
Sharp-shinned hawk	0	0	1	0	0	0	0	0
Short-eared owl	0	0	0	0	0	0	0	0
Snow goose	0	0	0	0	0	0	0	0
Song sparrow	11	20	1	3	1	3	1	0
Spotted towhee	3	1	2	0	0	0	0	0
Townsend's solitaire	0	0	0	0	0	0	0	0
Tree swallow	0	0	0	0	0	0	0	0
Tundra swan	0	0	0	0	0	0	0	0
Varied thrush	0	0	0	0	0	0	0	0
Violet-green swallow	0	5	0	0	0	0	0	0
Warbling vireo	0	0	0	0	0	0	0	0
Western grebe	0	0	0	0	0	0	0	0
Western kingbird	1	0	3	0	2	5	0	1
Western meadowlark	40	56	56	54	15	69	12	67
White-crowned sparrow	140	492	14	27	5	4	4	71
Willow flycatcher	0	0	0	0	0	0	0	0
Wilson's warbler	0	1	0	0	0	0	0	0
Yellow warbler	0	0	0	0	1	0	0	0
Yellow-headed blackbird	0	0	0	0	0	0	0	0
Yellow-rumped warbler	2	1	0	0	0	0	20	0
Total	**485**	**1,116**	**249**	**343**	**89**	**203**	**158**	**176**

Species	Lower Monumental Study Sites						
	FM[1]	SK	FMC	SKC	FMD2	FMD3	SKD2
American coot	0	11	1	0	0	0	5
American crow	2	3	1	1	0	0	1
American goldfinch	33	33	87	44	1	15	15
American green-winged teal	0	2	18	0	0	0	3
American kestrel	0	0	0	0	0	0	0
American robin	11	19	1	4	0	7	7
American wigeon	0	0	0	0	0	0	0
Bald eagle	0	0	0	0	0	0	0
Bank swallow	0	0	0	0	0	0	0
Barn owl	0	0	0	0	0	0	0
Barn swallow	0	0	0	0	0	0	0
Belted kingfisher	0	0	0	0	0	0	6
Bewick's wren	0	0	3	0	0	10	10
Black-billed magpie	15	30	2	1	0	0	16
Black-capped chickadee	0	0	0	0	0	0	8
Blue-winged teal	0	0	0	0	0	0	0
California gull	0	3	2	1	0	2	0
California quail	7	1	0	0	0	0	19
Canada goose	16	23	18	4	0	0	9
Canyon wren	0	0	1	0	0	0	0
Cedar waxwing	0	0	0	0	0	0	0
Chipping sparrow	0	0	0	0	0	0	0
Chukar	5	0	0	0	0	0	0
Cliff swallow	0	0	0	0	0	30	0
Common goldeneye	0	0	11	0	0	0	0
Common loon	0	0	0	0	0	0	0
Common merganser	0	7	0	0	0	0	0
Common nighthawk	0	0	0	0	0	0	0
Common raven	0	2	0	0	2	0	0
Dark-eyed junco	0	0	0	0	0	0	3
Double-crested cormorant	0	0	0	0	0	0	0
Downy woodpecker	0	0	0	0	0	0	0
European starling	2	4	51	5	0	3	3
Golden eagle	0	0	0	0	0	0	0
Golden-crowned kinglet	0	0	0	0	0	0	1
Golden-crowned sparrow	0	0	0	0	0	0	0
Grasshopper sparrow	0	1	0	6	0	0	0
Great blue heron	0	0	0	0	0	0	0
Great horned owl	0	0	0	0	0	0	0
Hermit thrush	0	1	0	0	0	0	0
Horned lark	0	0	0	63	9	0	0
House finch	2	2	1	0	0	0	0
House sparrow	0	0	0	0	0	0	0
House wren	0	0	0	0	0	0	0
Killdeer	3	2	1	10	0	0	4
Lincoln's sparrow	0	0	0	0	0	0	0
Loggerhead shrike	0	0	0	0	0	0	0
Long-billed curlew	0	0	0	1	0	0	0
Long-eared owl	1	0	0	0	0	0	0
MacGillivray's warbler	0	2	0	0	0	0	0
Mallard	4	0	5	0	0	0	12
Marsh wren	0	0	0	0	0	0	0

Merlin	0	0	0	0	0	0	0
Mourning dove	1	0	0	2	0	0	0
Northern flicker	1	4	5	0	0	2	6
Northern harrier	5	0	6	0	1	1	4
Northern rough-winged swallow	0	0	27	0	0	0	0
Northern shoveler	0	2	9	0	0	0	0
Northern shrike	0	0	0	0	0	0	0
Osprey	0	0	0	0	0	0	1
Purple finch	0	0	0	0	0	0	0
Red-tailed hawk	2	0	4	0	1	2	4
Red-winged blackbird	4	8	74	3	0	47	66
Ring-billed gull	0	7	2	1	0	0	0
Ring-necked pheasant	11	16	3	1	0	1	14
Rock dove	0	0	0	0	0	0	0
Rock wren	1	2	1	2	0	2	0
Ross's goose	0	0	0	0	0	0	0
Ruby-crowned kinglet	0	2	0	0	0	0	0
Savannah sparrow	0	0	0	0	4	0	0
Say's phoebe	1	2	1	7	5	2	0
Sharp-shinned hawk	0	0	0	0	0	0	0
Short-eared owl	0	0	0	0	0	0	0
Snow goose	0	0	0	0	0	0	0
Song sparrow	3	6	9	3	0	5	14
Spotted towhee	0	0	0	0	0	0	2
Townsend's solitaire	2	0	0	0	0	0	0
Tree swallow	0	0	0	0	0	0	0
Tundra swan	0	0	0	0	0	0	0
Varied thrush	0	0	0	0	0	0	0
Violet-green swallow	1	0	1	1	1	0	11
Warbling vireo	0	1	0	0	0	0	0
Western grebe	0	0	0	0	0	0	0
Western kingbird	0	0	0	0	0	0	0
Western meadowlark	32	56	36	82	12	3	21
White-crowned sparrow	43	14	3	1	0	15	13
Willow flycatcher	0	0	0	0	0	0	0
Wilson's warbler	0	0	0	0	0	0	0
Yellow warbler	0	15	0	0	0	0	0
Yellow-headed blackbird	0	0	0	0	0	0	0
Yellow-rumped warbler	0	1	0	0	0	0	0
Total	**208**	**282**	**384**	**243**	**36**	**147**	**278**

Species	Little Goose Study Sites							
	SB[1]	NY	SBC	NYC	SBD1	SBD2	NYD1	NYD2
American coot	0	0	12	2	0	0	0	0
American crow	0	1	2	1	1	0	0	0
American goldfinch	29	38	7	25	16	0	21	100
American green-winged teal	0	0	0	0	0	0	0	0
American kestrel	1	3	0	0	0	0	6	0
American robin	33	17	11	7	8	7	27	24
American wigeon	0	0	3	0	0	0	0	0
Bald eagle	0	0	0	0	0	0	0	0
Bank swallow	0	0	0	0	0	0	0	0
Barn owl	0	0	0	1	0	0	0	0
Barn swallow	0	0	0	0	0	0	0	0
Belted kingfisher	0	0	0	0	0	0	0	0
Bewick's wren	7	0	4	6	4	3	0	1
Black-billed magpie	9	5	2	3	2	9	7	0
Black-capped chickadee	0	0	0	0	0	2	0	0
Blue-winged teal	0	0	0	0	0	0	0	0
California gull	0	1	0	1	0	0	0	0
California quail	4	1	29	0	1	16	7	0
Canada goose	35	21	91	20	0	2	0	0
Canyon wren	0	4	0	0	0	2	0	0
Cedar waxwing	0	0	0	0	0	0	1	0
Chipping sparrow	0	0	2	0	0	0	0	0
Chukar	1	3	0	0	0	0	0	0
Cliff swallow	0	20	8	5	0	0	0	0
Common goldeneye	0	0	0	0	0	0	0	0
Common loon	0	0	0	0	0	0	0	0
Common merganser	12	0	0	0	0	0	0	0
Common nighthawk	0	1	0	0	0	0	0	0
Common raven	0	1	1	0	1	0	0	0
Dark-eyed junco	0	0	2	0	11	1	0	0
Double-crested cormorant	0	0	1	0	0	0	0	0
Downy woodpecker	0	0	0	0	0	0	0	0
European starling	0	3	0	0	2	11	49	3
Golden eagle	0	0	0	0	0	0	0	0
Golden-crowned kinglet	0	0	0	0	0	0	0	0
Golden-crowned sparrow	0	0	0	0	0	0	0	0
Grasshopper sparrow	0	0	0	0	0	0	0	0
Great blue heron	0	1	0	0	0	0	0	0
Great horned owl	0	0	0	3	0	0	7	0
Hermit thrush	0	0	0	0	0	0	0	0
Horned lark	0	3	0	0	0	0	0	0
House finch	2	0	0	1	0	0	0	8
House sparrow	0	0	14	0	0	0	0	0
House wren	0	0	0	0	0	1	0	0
Killdeer	2	1	1	5	0	0	0	0
Lincoln's sparrow	0	0	0	0	0	0	0	0
Loggerhead shrike	0	0	0	0	0	0	0	0
Long-billed curlew	0	0	0	0	0	0	0	0
Long-eared owl	0	0	0	0	0	0	0	0
MacGillivray's warbler	0	0	0	0	0	0	0	0
Mallard	3	4	8	42	0	0	1	0
Marsh wren	0	0	0	0	0	0	0	0

Merlin	0	0	0	0	0	0	0	0
Mourning dove	4	3	1	2	0	0	2	1
Northern flicker	0	1	2	0	1	3	3	6
Northern harrier	5	2	9	2	2	1	1	0
Northern rough-winged swallow	0	0	0	0	0	0	0	0
Northern shoveler	0	0	0	0	0	0	0	0
Northern shrike	1	0	0	0	0	0	0	0
Osprey	0	0	0	1	0	0	0	0
Purple finch	0	0	0	0	0	0	0	0
Red-tailed hawk	3	3	0	2	1	18	18	10
Red-winged blackbird	43	11	57	68	3	21	21	28
Ring-billed gull	4	1	3	3	0	0	0	0
Ring-necked pheasant	51	28	32	8	23	3	3	6
Rock dove	0	0	0	0	0	6	6	0
Rock wren	0	2	1	0	1	0	0	0
Ross's goose	0	1	0	0	0	0	0	0
Ruby-crowned kinglet	0	0	0	0	0	0	0	0
Savannah sparrow	0	0	0	0	0	0	0	0
Say's phoebe	1	4	1	0	0	7	7	0
Sharp-shinned hawk	1	0	0	0	0	0	0	0
Short-eared owl	0	0	1	0	0	0	0	0
Snow goose	0	0	0	1	0	0	0	0
Song sparrow	38	8	19	37	5	7	7	23
Spotted towhee	1	3	8	3	12	1	1	2
Townsend's solitaire	0	0	0	0	0	0	0	0
Tree swallow	0	0	0	2	0	0	0	0
Tundra swan	0	0	0	0	0	0	0	0
Varied thrush	0	0	0	0	0	0	0	0
Violet-green swallow	0	2	1	4	0	0	0	0
Warbling vireo	0	0	0	0	0	0	0	0
Western grebe	0	0	0	0	0	0	0	0
Western kingbird	0	1	0	0	0	0	0	0
Western meadowlark	20	26	26	8	22	16	7	9
White-crowned sparrow	209	1	131	8	6	0	0	31
Willow flycatcher	0	0	0	0	0	0	0	0
Wilson's warbler	0	0	0	0	0	0	0	0
Yellow warbler	0	0	0	0	0	0	0	0
Yellow-headed blackbird	0	0	0	1	0	0	0	0
Yellow-rumped warbler	0	0	0	0	0	0	0	0
Total	**519**	**225**	**490**	**272**	**122**	**135**	**202**	**252**

Species	Lower Granite Study Sites				Totals for Reservoirs			
	CT[1]	CTC	CTD1	CTD2	IH[2]	LOMO	LIGO	LOGR
American coot	26	0	0	0	7	17	14	26
American crow	3	0	0	1	29	8	5	4
American goldfinch	125	19	96	7	151	228	236	247
American green-winged teal	0	0	0	0	0	23	0	0
American kestrel	1	0	0	1	3	0	10	2
American robin	64	13	10	6	95	49	134	93
American wigeon	0	0	0	0	2	0	3	0
Bald eagle	1	0	0	0	0	0	0	1
Bank swallow	0	0	0	0	29	0	0	0
Barn owl	0	0	0	0	0	0	1	0
Barn swallow	0	0	0	0	104	0	0	0
Belted kingfisher	0	1	0	0	0	1	0	1
Bewick's wren	11	0	6	2	1	19	25	19
Black-billed magpie	1	1	13	14	155	29	37	29
Black-capped chickadee	0	0	12	5	1	17	2	17
Blue-winged teal	0	0	0	0	2	0	0	0
California gull	2	17	0	0	17	19	2	19
California quail	12	3	0	6	53	21	58	21
Canada goose	58	18	0	6	86	82	169	82
Canyon wren	2	1	12	5	7	20	6	20
Cedar waxwing	58	0	0	0	69	58	1	58
Chipping sparrow	0	0	0	0	0	0	2	0
Chukar	1	18	1	2	3	22	4	22
Cliff swallow	0	0	0	0	3	0	33	0
Common goldeneye	0	0	0	0	0	0	0	0
Common loon	1	0	0	0	0	1	0	1
Common merganser	3	0	0	0	0	7	12	3
Common nighthawk	0	0	0	0	0	0	1	0
Common raven	0	0	1	2	3	4	3	1
Dark-eyed junco	9	16	5	0	29	3	14	32
Double-crested cormorant	6	1	0	0	16	0	1	7
Downy woodpecker	0	0	1	0	0	0	0	1
European starling	5	3	6	0	62	68	68	14
Golden eagle	0	0	0	0	1	0	0	0
Golden-crowned kinglet	0	0	0	0	0	1	0	0
Golden-crowned sparrow	0	0	0	0	1	0	0	0
Grasshopper sparrow	0	0	0	0	1	7	0	0
Great blue heron	1	16	0	0	4	0	1	17
Great horned owl	0	0	0	0	2	0	10	0
Hermit thrush	0	0	0	1	0	1	0	0
Horned lark	0	0	0	0	12	72	3	1
House finch	15	4	2	0	0	5	11	21
House sparrow	0	0	0	0	0	0	14	0
House wren	0	0	0	0	0	0	1	0
Killdeer	7	16	0	0	6	20	9	23
Lincoln's sparrow	0	0	0	0	2	0	0	0
Loggerhead shrike	0	1	0	0	0	0	0	1
Long-billed curlew	0	0	0	0	0	1	0	0
Long-eared owl	0	0	0	0	0	1	0	0
MacGillivray's warbler	0	0	0	0	0	2	0	0
Mallard	20	6	0	0	165	21	58	26
Marsh wren	0	2	0	0	0	0	0	2

Merlin	0	0	0	0	1	0	0	0
Mourning dove	28	9	0	0	22	3	13	37
Northern flicker	3	6	15	8	8	18	20	32
Northern harrier	0	1	0	0	3	17	21	1
Northern rough-winged swallow	0	0	0	0	0	27	0	0
Northern shoveler	0	0	0	0	0	11	0	0
Northern shrike	0	0	0	1	0	0	1	1
Osprey	2	0	0	0	0	1	1	2
Purple finch	1	0	2	0	0	0	0	3
Red-tailed hawk	1	0	3	1	14	13	46	5
Red-winged blackbird	68	52	0	0	256	202	231	120
Ring-billed gull	0	2	0	0	4	10	11	2
Ring-necked pheasant	10	7	0	0	97	46	158	17
Rock dove	2	0	0	0	38	0	6	2
Rock wren	4	1	3	1	27	8	6	9
Ross's goose	0	0	0	0	0	0	1	0
Ruby-crowned kinglet	0	0	0	0	2	2	0	0
Savannah sparrow	0	0	0	0	2	4	0	0
Say's phoebe	1	0	0	1	9	18	15	2
Sharp-shinned hawk	0	1	0	0	1	0	1	1
Short-eared owl	0	0	0	1	0	0	1	1
Snow goose	0	0	0	0	0	0	1	0
Song sparrow	31	5	7	15	40	40	143	58
Spotted towhee	1	0	15	16	6	2	44	32
Townsend's solitaire	0	0	0	0	0	2	0	0
Tree swallow	0	0	0	0	0	0	0	0
Tundra swan	1	0	0	0	0	0	0	1
Varied thrush	0	0	1	0	0	0	0	1
Violet-green swallow	8	3	0	0	5	15	25	11
Warbling vireo	0	0	0	0	0	1	0	0
Western grebe	0	2	0	0	0	0	0	2
Western kingbird	0	0	0	0	12	0	1	0
Western meadowlark	19	24	4	10	369	242	134	57
White-crowned sparrow	38	67	4	3	757	89	386	112
Willow flycatcher	1	0	0	0	0	0	0	1
Wilson's warbler	0	0	0	0	1	0	0	0
Yellow warbler	2	0	0	0	1	15	0	2
Yellow-headed blackbird	0	0	0	0	0	0	1	0
Yellow-rumped warbler	0	0	0	0	23	1	0	0
Total	**653**	**336**	**219**	**115**	**2,819**	**1,578**	**2,217**	**1,323**

[1]See Table 1 and Figure 1 for details of study site descriptions and locations.

- HO = Hollebeke HMU
- BF = Big Flat HMU
- HOC1 = Couch Landing
- BFC1 = Near Charbonneau Park
- BFC2 = Walker
- HOD1 = Walker Canyon
- HOD2 = Upper Walker Embayment
- BFD1 = McCoy Canyon
- FM = Fifty-Five Mile HMU
- SK = Skookum HMU
- FMC = Riparia
- SKC = Joso
- FMD2 = 1st Canyon Below Little Goose Dam
- FMD3 = Alkali Flat Creek
- SKD2 = Tucannon River
- SB = Swift Bar HMU
- NY = New York Bar HMU
- SBC = Rice Bar
- NYC = Willow Bar
- SBD1 = Schaefer Gulch
- SBD2 = Wolf Canyon
- NYD1 = Dry Gulch
- NYD2 = Deadman Gulch
- CT = Chief Timothy HMU
- CTC = Wilma and Moses
- CTD1 = Nisqually John Canyon
- CTD2 = 1st Canyon Above Nisqually John

[2] IH = Ice Harbor
LOMO = Lower Monumental
LIGO = Little Goose
LOGR = Lower Granite

Appendix E
Numbers of Small Mammals Captured at Each Study Site in Each Reservoir
With Baited Live-Traps and Drift-Fence/Pit-Fall Traps
Excluding Recaptures
Lower Snake River
1997

Species	Ice Harbor			Lower Monumental			Little Goose			Total
	BF[1]	HOCI	HODI	FM	SKC	FMD3	NY	NYC	NYD1	
Bushy-Tailed Wood Rat	0	0	0	0	0	1	0	0	0	**1**
Deer Mouse	8	0	8	11	2	6	73	47	31	**186**
Great Basin Pocket Mouse	0	1	3	0	2	0	3	0	2	**11**
Western Harvest Mouse	8	0	0	1	1	3	3	1	1	**18**
Montane Vole	0	0	1	1	1	0	14	3	2	**22**
Vagrant Shrew	0	0	0	0	1	0	3	4	4	**12**
Total	**16**	**1**	**12**	**13**	**7**	**10**	**96**	**55**	**40**	**251**

[1]BF = Big Flat HMU
HOCI = Couch Landing
HODI = Walker Canyon
FM = Fifty-Five Mile HMU
SKC = Joso
FMD3 = Alkali Flat Creek
NY = New York Bar HMU
NYC = Willow Bar
NYD1 = Dry Gulch

Appendix F
Plates of Lower Snake River and Hell's Canyon Study Areas

Plates 1-4 depict the Lower Snake River system, separated by reservoirs. In addition to providing an overview of the study area, these maps serve as an index to the more detailed study site maps (Plates 5-24). Variable Circular Plot census stations and small mammal trapping transects are marked on Plates 5-24. Plate 25 is an overview of Hell's Canyon. Plates 26-28 depict the study sites along the Hell's Canyon reach in greater detail. Maps were provided by the U. S. Army Corps of Engineers, Walla Walla District.

Plate 1 Ice Harbor Project, Lower Snake River, Washington and Idaho
Plate 2 Lower Monumental Project, Lower Snake River, Washington and Idaho
Plate 3 Little Goose Project, Lower Snake River, Washington and Idaho
Plate 4 Lower Granite Project, Lower Snake River, Washington and Idaho
Plate 5 Charbonneau HMU, Non-Irrigated Site
Plate 6 Big Flat HMU, Irrigated Site
Plate 7 Hollebeke HMU, Irrigated Site
Plate 8 Snake River Junction, Drainage
Plate 9 Walker HMU and Couch Landing HMU, Two Non-Irrigated Sites and Two Drainages
Plate 10 Skookum HMU, Irrigated Site
Plate 11 Fifty-Five Mile HMU, Irrigated Site
Plate 12 Joso HMU, Non-Irrigated Site
Plate 13 Tucannon River, Drainage
Plate 14 Riparia HMU, Non-Irrigated Site and Two Drainages
Plate 15 Dry Gulch, Drainage
Plate 16 New York Bar HMU, Irrigated Site
Plate 17 Deadman Creek, Drainage
Plate 18 Willow Bar HMU, Non-Irrigated Site
Plate 19 Rice Bar HMU, Non-Irrigated Site and Drainage
Plate 20 Swift Bar HMU, Irrigated Site and Drainage
Plate 21 Nisqually John HMU, Two Drainages
Plate 22 Moses HMU, Non-Irrigated Site
Plate 23 Chief Timothy HMU, Irrigated Site
Plate 24 Wilma HMU, Non-Irrigated Site
Plate 25 Hell's Canyon, Snake River, Washington and Idaho
Plate 26 Hell's Canyon, Sites 3 and 4
Plate 27 Hell's Canyon, Sites 1, 2, and 6
Plate 28 Hell's Canyon, Site 5