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Avian Species Inventory at Manzanar National Historic Site, California—Final Report to the National Park Service

By Jan Hart and Charles Drost

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Cover: Sharp-shinned hawk (*Accipiter striatus*) (U.S. Geological Survey photograph by Chris O'Brien).

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Avian Species Inventory at Manzanar National Historic Site, California—Final Report to the National Park Service

By Jan Hart[1] and Charles Drost[2]

Abstract

We conducted a baseline inventory for avian species at Manzanar National Historic Site, Inyo County, Calif., from 2002 to 2005. Under the guidelines of the Mojave Network Biological Inventory Program, the primary objectives for this study were to (1) inventory and document the occurrence of avian species at Manzanar, with the goal of documenting at least 90% of the species present; (2) provide a geographic information system (GIS)-referenced list of sensitive species occurring at Manzanar that are rare, on Federal or State lists, or otherwise worthy of special consideration; and (3) enter all species data into the National Park Service NPSpecies database. Survey methods included general area searches, variable circular plot point-count censusing, nocturnal surveys, and nest searching. During 13 year-round survey sessions, we documented the occurrence of 132 bird species at Manzanar and confirmed breeding by 19 of these. Based on our findings, as well as review of the literature and searches for records of species occurrence, we estimate inventory completeness for regularly-occurring bird species at Manzanar to be near 90%. No sensitive species on Federal or State lists were found. The distribution and relative abundance of common bird species at this site is now well enough known to begin development of a monitoring protocol for this group.

Introduction

Manzanar National Historic Site was established in 1992 to preserve historical and cultural resources associated with the relocation of Japanese-Americans to the site during World War II. The National Park Service's mission at Manzanar has focused primarily on the recent establishment of the park to protect these resources; natural resource management has not been a park priority until recently. There has been a general lack of verified information on the biological resources present at Manzanar, including those pertaining to avifauna. With the implementation of the National Park Service's Inventory and Monitoring Program within Mojave Network parks in 2002, needed baseline information on biological resources at Manzanar is being secured. Inventories of vertebrate fauna, including reptiles, amphibians, and mammals, have been completed. Here we present the results of avian inventories conducted at Manzanar from 2002 to 2005.

At other park units within the Mojave Network, the National Park Service facilitated formal assessments of documented and potential species prior to inventory. Due to a lack of biological

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resources documentation, this assessment was not done at Manzanar. Consequently, our initial efforts in 2002 at this site focused on identifying the most feasible methods to detect the greatest number of bird species. We also tried to locate accounts of avian species proximate to Manzanar through examination of museum records, scientific literature, and especially of Audubon Society species observations at similar locations nearby and within the Owens Valley.

The primary goal of this inventory has been to provide baseline information on avian species using Manzanar, including their relative abundance, residency status, and habitat associations. Through the process of obtaining this baseline information, we developed standardized monitoring protocols to facilitate ongoing assessment of the avifauna for the effective management of this resource.

Study Area

Located in the Owens Valley of eastern California, Manzanar is the smallest park in the Mojave Network, encompassing 330 ha at 1,187 m elevation (fig. 1). The Owens Valley is sheltered from ocean air masses by the Sierra Nevada Mountains, which tower more than 3 km above the valley to the west. The "rain shadow" effect of this mountain range creates a high desert climate throughout the Owens Valley.

Summer high temperatures at Manzanar often exceed 38°C, followed by mild evening temperatures. The mean maximum and minimum temperatures in July at the Inyo County seat of Independence (ca. 8 km northwest, fig. 2) are 37°C and 18°C, respectively. Winter temperatures are moderate during the day, although on average they drop below freezing at night. January mean maximum and minimum temperatures at Independence are 12°C and –2°C, respectively.

Precipitation in the southern Owens Valley is predictably scarce, occurring primarily from November to March. Average annual precipitation is near 13 cm. The average total snowfall recorded annually at Independence is just over 8 cm. Summer months are typically very dry. Since 1927, the mean precipitation recorded at Independence (yellow arrow, fig. 2) from June to August is just 1 cm.

Physiographically, Manzanar is located near the valley floor along the edges of extensive alluvial fans extending out from the Sierra Nevada. The substrate is predominantly granitic, with coarse-textured, well-drained soils. Land-use practices have led to some extensive gully erosion on the upper (western) portion of the site, and considerable tracts of the lower (eastern) site that were cleared during construction of the camp in the 1940s are still nearly devoid of vegetative cover.

Although technically within the Great Basin geographic province, the southern Owens Valley flora is dominated by Mojave Desert vegetation species, several of which are key natural components at Manzanar. Most of Manzanar is populated by low shrubs, including saltbush (*Atriplex*), rabbitbrush (*Ericameria*), and sagebrush (*Artemisia*), as well as a variety of forbs, cacti, and grasses. Another substantial portion of the park is covered by a large woodland grove, dominated by mature cottonwoods (*Populus*), which exists in a unique hydrologic area where groundwater remains relatively near the surface. Several other native and nonnative tree species are common within this grove, including locusts (*Robinia*), willows (*Salix*), and salt cedar (*Tamarix*), as well as several orchard tree species and other exotics. Lastly, a small riparian zone is present along Bairs Creek near the southern boundary of the site. This zone is highly variable in width and is either lushly or sparsely vegetated.

Figure 1. Location of Manzanar National Historic Site in Inyo County, which is in eastern California. Manzanar is adjacent to U.S. Highway 395, approximately 256 km north of Los Angeles and 8 km south of Independence, the Inyo County seat. The site is in high desert, below and east of the Sierra Nevada mountain range and 32 km west of Death Valley National Park.

Bairs Creek is an intermittent stream that often carries substantial flows during periods of spring and early summer runoff but tapers off to little or no flow during fall and winter months. Many of the tree species present in the woodland grove are also found here, along with some shrubs including wild rose (*Rosa*) and desert olive (*Forestiera*). Although natural vegetation patterns are slowly reasserting themselves over much of the camp, 20th-century agricultural and residential uses have created significant and long-lasting effects on the vegetation throughout the site.

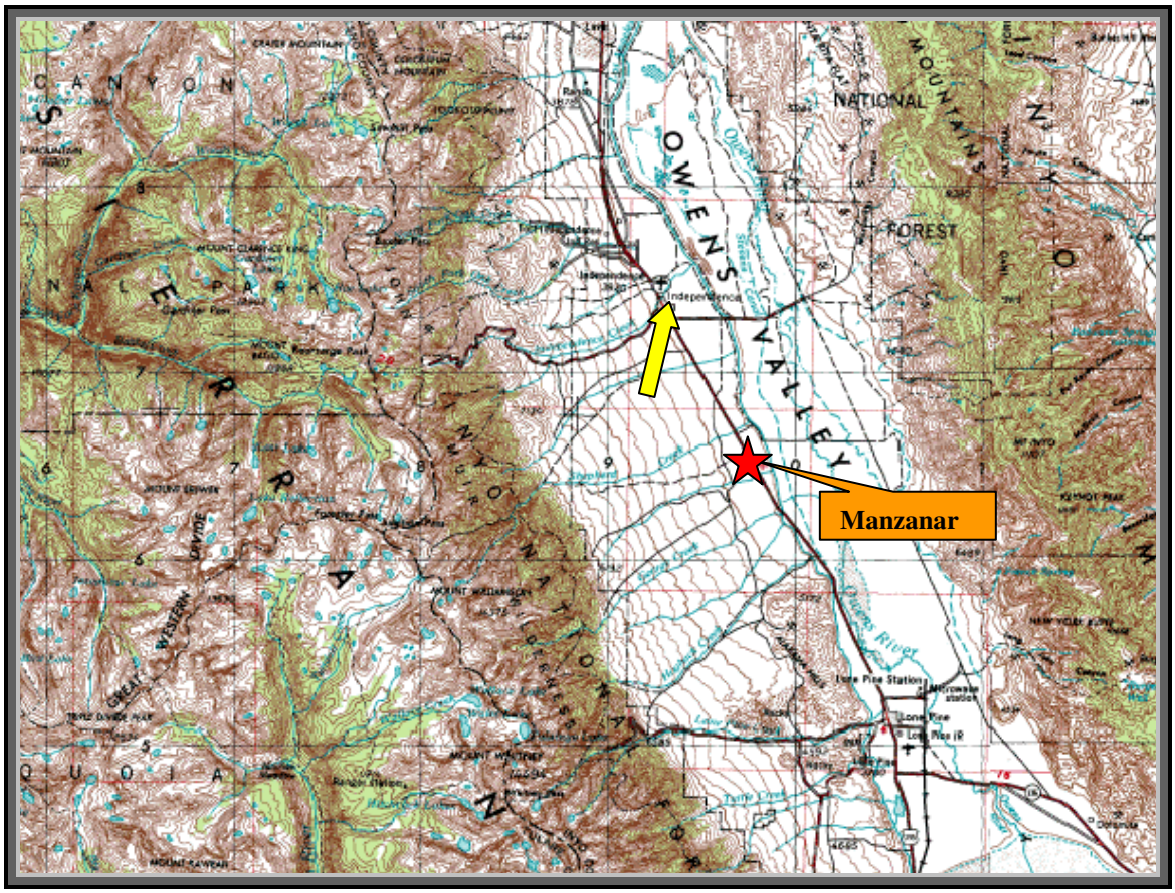

Figure 2. Location of Manzanar National Historic Site within the Owens Valley, Inyo County, Calif.

Methods

Existing Records

We relied upon literature searches for avian species accounts in the Owens Valley area, especially those in proximity to Manzanar. The most notable faunal investigations in Inyo County that included the Owens Valley were conducted during the past 115 years under the auspices of the University of California, Berkeley. Therefore, we searched for historical records and avian species accounts within the holdings of UC Berkeley's Museum of Vertebrate Zoology, Audubon Society Christmas Bird Count data, and online data from the Eastern Sierra Audubon Society Chapter. This information provided background for comparison with the avifauna that we inventoried over the next 3 years at Manzanar.

Habitat Stratification

We organized the park into five census regions according to habitat type. This was accomplished primarily on the ground because no vegetation maps or geographic information system vegetation data themes were available in spring 2002 when the project began. We categorized the largest proportion of habitat at Manzanar as desert scrub, which we divided into eastern and western regions. Saltbush, rabbitbrush, and sagebrush dominate this community. There

are two major vegetation differences between the two desert scrub regions: in the eastern portion, isolated patches of salt cedar trees, which can exceed 6 m in height, are more numerous. Salt cedar provides an additional substrate for birds in habitat otherwise dominated by shrubs. In contrast, in the western desert scrub community, very few vegetative features are taller than 1.5 m, and sagebrush is more dominant. Physiographically, the western section is more rugged, consisting of alluvium cut by numerous small washes. The eastern section was extensively modified to create a relatively flat landscape; the majority of the Manzanar camp buildings were located here.

The third census region consists of a large woodland grove occupying a north-south belt that extends nearly the length of Manzanar, essentially bisecting the desert scrub community. The existing driving tour route essentially circumnavigates this woodland belt. There are numerous mature trees throughout this woodland grove, including cottonwoods, locusts, and willows, as well as significant numbers of several orchard tree species and other exotics. We estimated that this woodland covers 25% of Manzanar.

The fourth census region consists of the riparian zone extending the length of Bairs Creek within Manzanar. This zone is highly variable in width and is either lushly or sparsely vegetated. Dominant trees include cottonwood, willow, locust, and salt cedar; important shrubs are wild rose and desert olive. The desert scrub community borders the entire riparian belt on either side.

The final census region is contained within the Shepherd Ranch site, which combines grassy and shrubby understory with mature cottonwoods and locust windrows. This area is effectively an extension of the woodland grove, but the tree spacing is greater, providing a more open canopy. The northern section of this area near the Manzanar boundary is dominated by salt cedar clumps, and desert scrub bounds the region to the east and west. After the first year we reclassified the Shepherd Ranch site as part of the woodland grove region, although area and nest searches, as well as nocturnal surveys, continued there.

Survey Methods

After testing the efficacy of proposed area searches and randomized plots, we chose instead point counting along transects as the primary census method for use throughout Manzanar. We determined that point counting presented the best opportunity for standardizing bird species detection in the different vegetation communities, while providing Manzanar with an effective tool for long-term monitoring of relative abundance. Additional information about the choice of survey methods is in the discussion section of this report.

Transect Establishment

We established four point-count transects to provide sampling of the stratified habitats. The transects were not intended to sample habitats on the basis of overall abundance. Instead, our allocation of transects by habitat was intended to reflect the relative importance of the habitats to landbirds. Counting points were spaced at ≥200-m intervals along each transect to prevent overlap of 100-m-radius detection plots. In the desert scrub we established two transects, one in each desert scrub region on either side of the woodland grove. The eastern and western scrub transects include 7 and 6 counting points, respectively. The woodland grove contains a horseshoe-shaped transect that includes 12 counting points. The fourth transect, following the riparian belt along Bairs Creek, includes 8 counting points. Overall, there are 33 counting points among the 4 transects, each with a minimum plot radius of 100 m (fig. 3). This provides a nonoverlapping sampling area exceeding 100 ha, which is nearly one-third of the park. To facilitate repeatability, transect counting-point

locations were georeferenced using a global positioning system (GPS) unit with a horizontal position accuracy of ≤5 m (appendix 1).

Point-Count Protocol

Each transect was surveyed 13 times from April 2002 to April 2005, with 3 surveys each during the breeding season, fall migration, and winter, and 4 surveys during spring migration (table 1). Transects were surveyed during the morning, beginning as early as one-half hour before sunrise and ending not later than 9 a.m. local time. We observed a 1-minute quiet interval upon arrival to each counting point, followed by a 5-minute counting period during which we recorded all birds seen or heard (Reynolds and others, 1980). The distance to each bird seen or heard during counting was estimated (Buckland and others, 2001) and categorized using the parameters of a standard variable circular plot form (Ralph and others, 1993). During counts and while walking between points, we noted any behaviors associated with breeding (e.g., courtship, carrying nesting material or food, feeding of young), as well as any nests. Birds flying over transects while apparently in transit were recorded as flyovers, to distinguish them from birds actually using the habitat being inventoried. To maximize detection efficiency, we used a microcassette recorder to narrate observations, thereby freeing us from having to look back and forth to record data by hand. Transcription of the recordings to data forms usually occurred the same day as data collection.

Because of the potential negative influence of wind on bird detectability, we did not conduct surveys if average wind speeds exceeded 11 km/hour, or gusts exceeded 16 km/hour. We measured wind speed using a pocket digital anemometer during the 1-minute period before counting. Precipitation was not a factor during surveys.

Table 1. Survey dates and seasons for avian inventories at Manzanar National Historic Site, Inyo County, Calif.

Survey number	Year	Dates	Season number
1	2002	April 23–25	Spring migration 1
2	2002	June 4–5	Breeding 1
3	2002	August 21–24	Fall migration 1
4	2002	November 21–23	Winter 1
5	2003	February 26–28	Winter 2
6	2003	April 23–25	Spring migration 2
7	2003	June 4–6	Breeding 2
8	2003	July 23–25	Breeding 3
9	2003	September 22–24	Fall migration 2
10	2004	April 26–28	Spring migration 3
11	2004	September 8–10	Fall migration 3
12	2005	February 25–27	Winter 3
13	2005	April 29–May 1	Spring migration 4

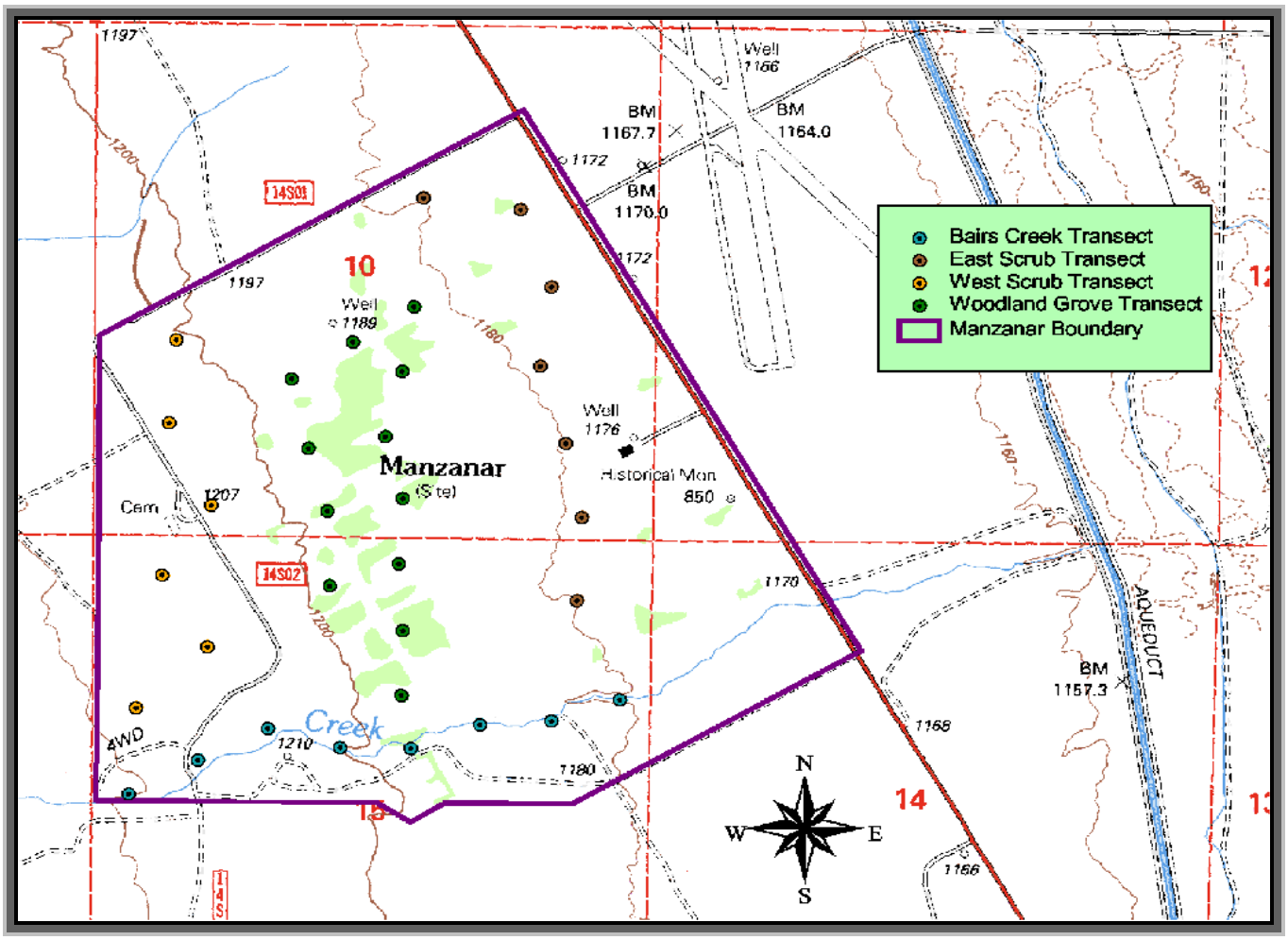

Figure 3. Map of the locations of 33 point-count stations for the four avian census transects at Manzanar National Historic Site, Inyo County, Calif.

We also conducted two mist-netting sessions in spring and fall 2003 at the Bairs Creek riparian habitat region to detect cryptic species in migration that might otherwise escape detection during point counts. Over the course of the two netting sessions, we operated four 12-m nets for a total of 36 net hours. Mist nets were set the night before and furled, to facilitate deployment early the next morning. Nets were operated from one-half hour before sunrise until approximately 9 a.m. local time. The capture effort was exclusive to Bairs Creek, where the densest habitat was located, because this was the most likely place where cryptic nonvocal species might go undetected during point counts.

Nocturnal Surveys

Eight of the survey sessions included nocturnal surveys, two in each season over 3 years (2002 to 2004). These were conducted as walk-through censuses along the auto tour route. They generally took about 1.5 hours to complete, beginning one-half hour after sunset. We used a

combination of passive detection while walking, punctuated by frequent stops for tape playback of calls by potential species.

Area Searches and Nest Searching

Following each day's point counts we spent another hour or more conducting area searches within the habitat that had just been formally censused. The objective was to detect any additional species that might have been missed during point counts. We typically also conducted area searches prior to nocturnal surveys. During the breeding season (late April to early August) the focus of the area searches shifted to nest searching. Wherever evidence of breeding was noted, considerable attention was focused upon those locations. This typically involved much quiet observation in the hopes of seeing the suspected breeders reveal their nest site. Once we located active nests we did not attempt to determine success. Instead, we chose to minimize further disturbance to avoid inadvertently contributing to any nesting failures.

Results

Existing Records

We were unable to locate any verifiable documentation of avian species accounts, collected specimens, or journal notes that could be linked to the present-day location of Manzanar National Historic Site. Similarly, a literature search attempting to link key words in avian contexts with the site was also unsuccessful. Considerable information does exist that pertains to avian topics in the vicinity of Manzanar, however, and the majority of this is available online from the Eastern Sierra Chapter of the Audubon Society Web site (http://esaudubon.org/). These available data consist of sighting accounts by individual birders, as well as group count data from Migratory Bird Day tallies and Christmas Bird Counts. This chapter is quite active and its members are spread throughout the Owens Valley, so reported observations from locations within 16 km or less of Manzanar are not uncommon. These reports, as well as those from other areas of the valley with similar habitats, were valuable for preparing a list of potential species, which forms the basis for comparison between what we expected to find and what we actually detected at Manzanar.

Species Detection

The 13 samplings of 33 counting points during the course of this study yielded 429 variable plot censuses. A total of 2,167 individuals of 99 species were detected during these point counts. Including flyovers, the total number counted was 2,237 individuals of 112 species. Area searches and nocturnal surveys detected an additional 20 species, bringing the overall avian counts we observed at Manzanar to 2,596 individuals of 132 species (appendix 2). We also captured 43 individuals of 7 species during mist netting, but all 7 species had been previously detected. The numbers of individuals of species detected during surveys were fairly evenly distributed, with no species observed in substantially greater numbers than others. For example, the three most common species, white-crowned sparrow, European starling, and California quail, accounted for 4.2%, 4.1%, and 4.0%, respectively, of the total individuals detected.

Species Accumulation

Regardless of the season, new species were detected during each survey session except one (session 8). After the first three survey sessions, the average number of new species accumulated per session was 3.8 (surveys 4–13). Even though the total number of species detected during the last (13th) survey session was the lowest among the four spring surveys, three previously undetected species were tallied (fig. 4).

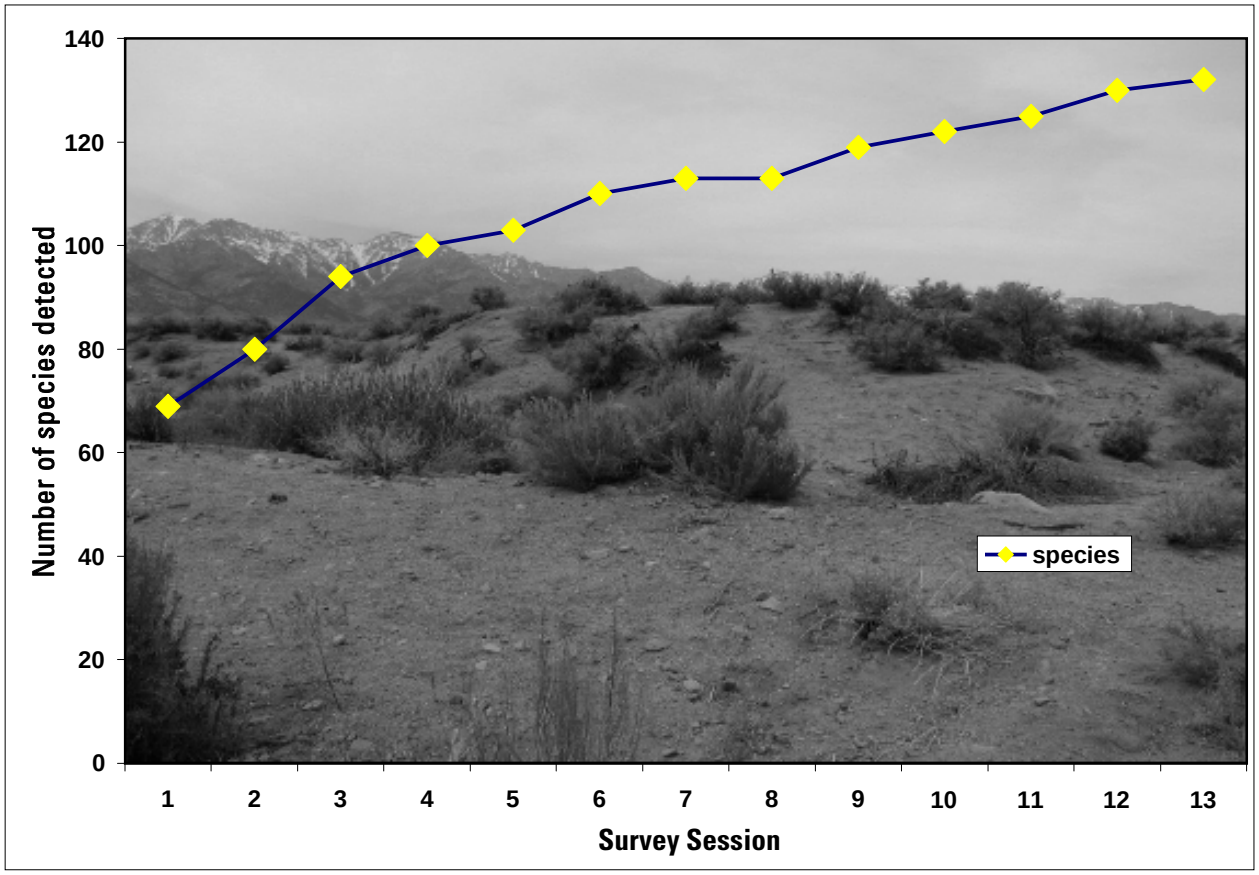

Figure 4. Species accumulation curve for avian surveys at Manzanar National Historic Site, Inyo County, Calif., from 2002 to 2005. After the first three surveys, new species were detected at an average rate of 3.8 per survey. Surveys 1, 6, 10, and 13 occurred during spring migration; surveys 2, 7, and 8 occurred during breeding; surveys 3, 9, and 11 occurred during fall migration; and surveys 4, 5, and 12 occurred during winter.

Seasonal Detection Differences

Observed species richness was generally greatest in spring. The greatest number of species was detected during the first, second, and third spring surveys, conducted in 2002, 2003, and 2004, respectively. The three winter surveys produced consistent results in terms of species richness, which was approximately half of that observed during spring. Species richness during the breeding season and fall was between these extremes.

Habitat Associations

Of 119 species observed using a habitat (flyovers omitted), a majority (61%) were found in more than one habitat type (fig. 5). Eighteen of these species were generalists that were seen throughout Manzanar in all habitat types (table 2).

The remaining 101 species were more specialized, with approximately 60% of these species using woodland habitat primarily. Despite the similarities of the two woodland types in terms of dominant trees, Bairs Creek was used exclusively by 16 species and the Woodland Grove was used exclusively by 17 species (table 3). The desert scrub provided habitat for an additional 23 species, and was used exclusively by 12 of these (table 4).

Table 2. Avian species seen in all habitats at Manzanar National Historic Site, Inyo County, Calif., during seasonal surveys from 2002 to 2005. SM, spring migration; S, breeding; FM, fall migration; W, winter; Y, year-round. See appendix 3 for scientific names.

Common name	Season of observation
American kestrel	Y
California quail	Y
Mourning dove	Y
White-throated swift	FM
Black-chinned hummingbird	S
Broad-tailed hummingbird	SM
Rufous hummingbird	SM
Loggerhead shrike	Y
American crow	Y
Common raven	Y
Violet-green swallow	SM, S, FM
Cliff swallow	S
Barn swallow	SM, S, FM
Northern mockingbird	Y
Chipping sparrow	SM, FM
White-crowned sparrow	W
Dark-eyed junco	Y
House sparrow	Y

Table 3. Avian species seen exclusively in woodland habitats at Manzanar National Historic Site, Inyo County, Calif., during surveys from 2002 to 2005.

[Habitats: RW, riparian woodland (Bairs Creek); WG, woodland grove (and orchard). Seasons: SM, spring migration; S, breeding; FM, fall migration; W, winter; Y, year-round. See appendix 3 for scientific names.]

Common name	Habitat	Season of observation
Merlin	RW	W
Western screech owl	RW	SM
Downy woodpecker	RW	FM
Hairy woodpecker	RW	S, FM
Olive-sided flycatcher	RW	SM
Black phoebe	RW	SM, S, FM
House wren	RW	SM, S
Yellow warbler	RW	SM, S, FM
Townsend's warbler	RW	SM
Hermit warbler	RW	SM
American redstart	RW	S, FM
Song sparrow	RW	SM
Blue grosbeak	RW	SM, S
Lazuli bunting	RW	SM, S
Red-winged blackbird	RW	Y
Yellow-headed blackbird	RW	SM
Cooper's hawk	WG	S, FM, W
Killdeer	WG	FM, W
Barn owl	WG	FM
Acorn woodpecker	WG	S, FM
Red-breasted sapsucker	WG	FM
Ladder-backed woodpecker	WG	W
Nuttall's woodpecker	WG	W
Gray flycatcher	WG	FM
Say's phoebe	WG	Y
Western scrub-jay	WG	Y
Black-billed magpie	WG	S, FM
Mountain chickadee	WG	W
White-breasted nuthatch	WG	FM, W
Pygmy nuthatch	WG	W
American pipit	WG	FM
Great-tailed grackle	WG	FM
Evening grosbeak	WG	SM

Table 4. Avian species seen exclusively in desert scrub habitat at Manzanar National Historic Site, Inyo County, Calif., during surveys from 2002 to 2005.

[Seasons: SM, spring migration; S, breeding; FM, fall migration; W, winter; Y, year-round. See appendix 3 for scientific names.]

Common name	Season of observation
Greater roadrunner	S (Y)
Common poorwill	FM
Costa's hummingbird	SM, S, W
Horned lark	W, SM
Rock wren	SM, S
Sage thrasher	S
Le Conte's thrasher	SM
Brewer's sparrow	FM
Black-throated sparrow	FM
Sage sparrow	Y
Savannah sparrow	SM, S, FM
Western meadowlark	SM, FM, W

Nocturnal Surveys

We detected only three owl species at Manzanar from 2002 to 2005. In 2002, a great horned owl nested in a cottonwood tree at the woodland grove and produced three nestlings, but we were unable to verify fledging. We often saw another owl (assumed to be the male of the pair) roosting in locusts at the other end of the grove. Over the next 3 years we encountered a single owl somewhere in the wooded habitats on almost every survey session (usually flushed during diurnal surveys). On nocturnal surveys we played calls of great horned, long-eared, short-eared, Western screech, and barn owls. These efforts elicited only six call responses, always from a great horned owl, and four of the responses were to the call of a Western screech owl. Following three of those responses, the owl flew in very close to us, prompting us to cease calling other species. No other owl species were detected from 2002 to 2003, but common poorwills were seen. Finally, in 2004, a Western screech owl was spontaneously calling within the Bairs Creek riparian habitat in spring, and that fall a barn owl was roosting on the roof of the visitor center.

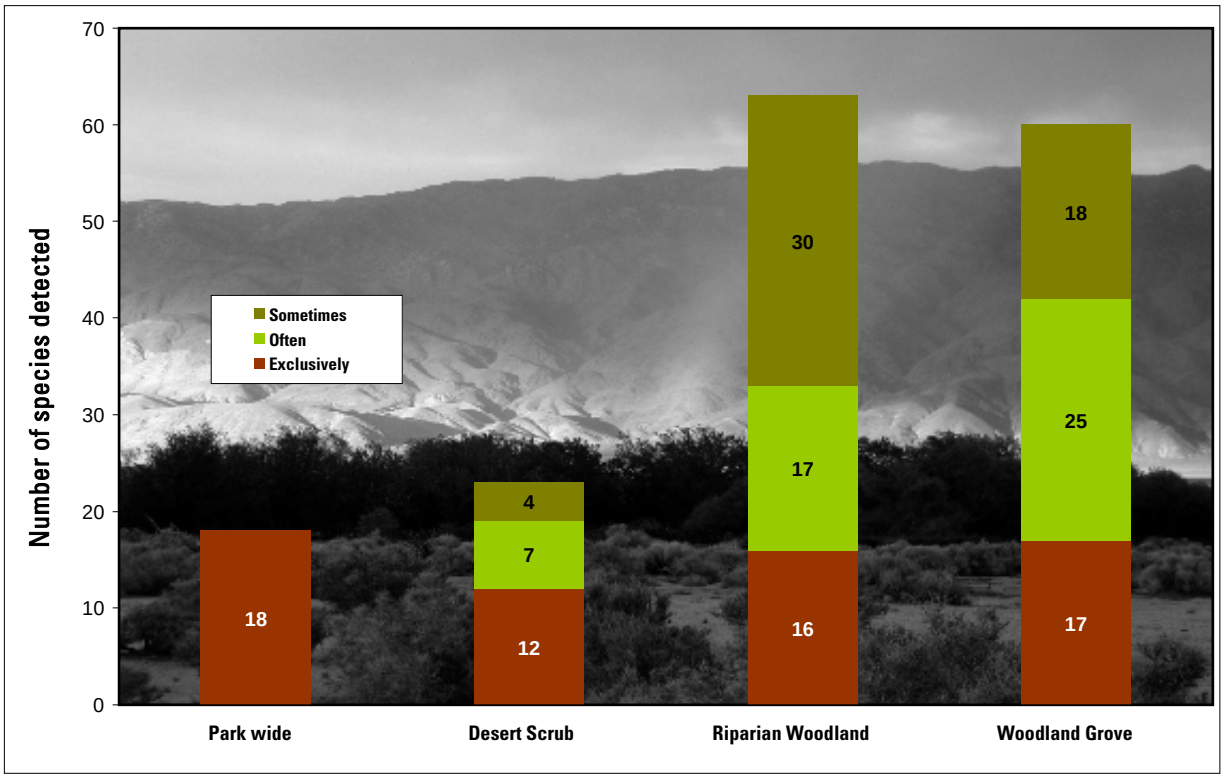

Figure 5. Number of bird species detected per habitat association at Manzanar National Historic Site, Inyo County, Calif. Bottom segments of each bar show the number of detected species found exclusively in that habitat type. Middle and upper segments show species either often or sometimes found in that habitat, respectively. Eighteen species were found parkwide; these species could be found in any habitat at Manzanar. Species richness was highest in the riparian woodland (Bairs Creek).

Area Searches and Nest Searching

Seventeen species not detected during point-count censuses were found during area searches (table 5). Three of these species were detected just once during a flyover. Only three species, the rock dove, sharp-shinned hawk, and Cooper's hawk, were seen on multiple surveys. The others were detected on just one occasion and in fairly low numbers (≤6). Typically, each of these species was detected visually during migration or winter when it was not vocalizing. We located the active nests of 11 species either incidentally or while nest searching. We confirmed breeding for 19 species at Manzanar, and acquired circumstantial evidence for 8 more (table 6). Breeding success for 9 species was confirmed by the presence of young.

Table 5. Avian species detected during area searches at Manzanar National Historic Site, Inyo County, Calif., from 2002 to 2005.

[Habitats: RW, riparian woodland; WG, woodland grove; DS, desert scrub; FO, flyover. Seasons: SM, spring migration; S, breeding; FM, fall migration, W, winter; Y, year-round. See appendix 3 for scientific names.]

Common name	Habitat(s)	Season of observation
Sharp-shinned hawk	WG, RW	Y
Cooper's hawk	WG	S, FM, W
Ferruginous hawk	FO	W
Rough-legged hawk	FO	W
Merlin	RW	W
Killdeer	WG	FM, W
Caspian tern	FO	FM
Rock dove	FO	SM, FM
Acorn woodpecker	WG	S, FM
Red-breasted sapsucker	WG	FM
Ladder-backed woodpecker	WG	W
Olive-sided flycatcher	RW	SM
Hammond's flycatcher	RW, WG	SM
Gray flycatcher	WG	FM
Green-tailed towhee	WG, RW	W
Yellow-headed blackbird	RW	SM
American goldfinch	WG, DS	W

Table 6. Avian species that bred or are suspected of breeding at Manzanar National Historic Site, Inyo County, Calif., from 2002 to 2005, and the evidence for those determinations. Status: B, confirmed; {B}, probable. See appendix 3 for scientific names.

Common name	Status	Evidence
Red-tailed hawk	B	Nest
American kestrel	B	Nest
California quail	B	Young and adults
Mourning dove	B	Nest
Great horned owl	B	Young in nest
Black-chinned hummingbird	B	Nest
Hairy woodpecker	B	Feeding young
Northern flicker	B	Feeding young
Say's phoebe	B	Nest
Ash-throated flycatcher	B	Nest
Western kingbird	B	Feeding young
Common raven	B	Nest
Bewick's wren	B	Feeding young
House wren	B	Nest
American robin	B	Nest
Northern mockingbird	B	Nest
Vesper sparrow	B	Feeding young
Sage sparrow	B	Feeding young
European starling	B	Feeding young
Lesser nighthawk	{B}	Courtship
Costa's hummingbird	{B}	Unoccupied nest
Black phoebe	{B}	Unoccupied nest
Loggerhead shrike	{B}	Nest material
Phainopepla	{B}	Nest material
Spotted towhee	{B}	Unoccupied nest
Brown-headed cowbird	{B}	Female nest watch
House finch	{B}	Nest material

Relative Abundance

White-crowned sparrows were the most abundant species detected; the number of individual white-crowned sparrows was compared with numbers of other species to calculate indices of relative abundance (IRAs). IRAs are furnished for all species detected from 2002 to 2005 at Manzanar (appendix 3). Among birds present during the breeding season, the European starling was the most abundant, followed closely by the California quail. Both of these species are year-round residents at Manzanar, as were 71% of the species detected during surveys in the breeding season. The most abundant summer residents were brown-headed cowbirds, which outnumbered most of their prospective host species (table 7).

Table 7. Relative abundance of avian species at Manzanar National Historic Site, Inyo County, Calif., during breeding surveys from 2002 to 2005.

[Number of individuals, total number detected; IRA, index of relative abundance with respect to the most common species. Habitats: RW, riparian woodland; WG, woodland grove; DS, desert scrub; ALL, any habitat. Residency: S, summer resident or visitor; Y, found in any season. See appendix 3 for scientific names.]

Common name	Number of individuals	IRA	Habitat(s)	Residency
European starling (nonnative)	88	1.00	RW, WG	Y
California quail	87	0.99	ALL	Y
Sage sparrow	76	0.86	DS	Y
American robin	71	0.81	WG, RW	Y
Brewer's blackbird	62	0.70	DS, RW	Y
Common raven	56	0.64	ALL	Y
Bushtit	55	0.63	WG, RW	Y
Dark-eyed junco	53	0.60	ALL	Y
Mourning dove	51	0.58	ALL	Y
Vesper sparrow	49	0.56	DS, RW	Y
House sparrow (nonnative)	38	0.43	ALL	Y
Western bluebird	35	0.40	WG, DS	Y
Red-winged blackbird	34	0.39	RW	Y
Brown-headed cowbird	34	0.39	RW, WG	S
Bewick's wren	33	0.38	RW, WG	Y
House finch	32	0.36	WG, RW	Y
Northern flicker	29	0.33	WG, RW	Y
American crow	27	0.31	ALL	Y
Blue-gray gnatcatcher	25	0.28	WG, RW	S
Red-tailed hawk	23	0.26	WG, RW	Y

Table 7. Relative abundance of avian species at Manzanar National Historic Site, Inyo County, Calif., during breeding surveys from 2002 to 2005. —Continued

Common name	Number of individuals	IRA	Habitat(s)	Residency
Say's phoebe	23	0.26	WG	S
Orange-crowned warbler	23	0.26	RW, WG	S
Black-chinned hummingbird	22	0.25	ALL	S
Ash-throated flycatcher	22	0.25	WG, RW	S
Common nighthawk	21	0.24	DS, RW	Y
Spotted towhee	21	0.24	WG, RW	S
Western kingbird	19	0.22	WG, RW	Y
Lesser goldfinch	19	0.22	WG, RW	S
Great horned owl	18	0.20	RW,WG	Y
Northern mockingbird	18	0.20	ALL	Y
Turkey vulture	17	0.19	A, WG	Y
American kestrel	17	0.19	ALL	S
Phainopepla	17	0.19	DS, RW	S
Bullock's oriole	16	0.18	RW, WG	S
Loggerhead shrike	15	0.17	ALL	Y
Hairy woodpecker	14	0.16	RW	Y
Black-billed magpie	14	0.16	WG	Y
Lesser nighthawk	13	0.15	DS, RW	S
Black-headed grosbeak	13	0.15	RW,WG	S
Black phoebe	12	0.14	RW	Y
Rock wren	12	0.14	DS	Y
Western scrub jay	11	0.13	WG	Y
Costa's hummingbird	9	0.10	DS	S
Cooper's hawk	5	0.06	WG	Y
House wren	5	0.06	RW	Y
Sharp-shinned hawk	4	0.05	WG, RW	Y
Swainson's hawk	2	0.02	A	Y
Acorn woodpecker	2	0.02	WG	Y
Greater roadrunner	1	0.01	DS	Y
Lesser goldfinch	19	0.22	WG, RW	S

Abundance During Migration

Although we detected the greatest number of species during spring and fall migration, numbers of individuals were low for most migrants; we detected no "flush" of migrants during surveys in either season. A higher proportion of migrant species were detected in spring (42%) rather than fall (22%), while the remaining 36% were detected during both migration periods. The violet-green swallow and chipping sparrow were the most numerous migrants detected, and both of these were visitors to Manzanar during spring and fall (table 8).

Abundance During Winter

Similar to what was observed during the breeding season, year-round resident species composed the largest number of birds (71%) present during the winter (November–February), although considerably fewer species were present. Abundance within individual species detected in winter was generally greater than during migration. Abundance of species detected in winter in desert scrub habitat was generally greater than during breeding. White-crowned sparrows were the most abundant, followed closely by such year-round species as the European starling, California quail, and sage sparrow (table 9).

Potential Species

Based primarily on the review of online sighting reports from the Eastern Sierra Audubon Web site from 2002 to 2005, we assembled a preliminary list of 34 landbird species that could be present to augment those we had detected at Manzanar. We then subjectively estimated the likelihood of each species occurring at Manzanar and the likely habitats they would occupy (table 10)

Table 8. Relative abundance of avian migrant species during migration (spring/fall) from 2002 to 2005 at Manzanar National Historic Site, Inyo County, Calif.

[Number of individuals, total number detected; IAR, index of relative abundance with respect to most common species. Habitats: RW, riparian woodland; WG, woodland grove; DS, desert scrub; ALL, any habitat. Seasons: SM, spring only; FM, fall only; BO, both seasons. See appendix 3 for scientific names.]

Common name	Number of individuals	IRA	Habitat(s)	Season(s)
Violet-green swallow	38	1	ALL	BO
Chipping sparrow	37	0.97	ALL	BO
Western tanager	26	0.68	WG, RW	BO
Barn swallow	24	0.63	ALL	BO
Northern rough-winged swallow	23	0.61	RW	BO
Brewer's sparrow	23	0.61	DS	FM
Wilson's warbler	19	0.50	RW, WG	FM
Western meadowlark	19	0.50	DS	BO
Black-throated gray warbler	18	0.47	RW, WG	BO
Warbling vireo	16	0.42	WG, RW	BO
Savannah sparrow	16	0.42	DS	BO
White-throated swift	14	0.37	ALL	FM
Yellow warbler	13	0.34	RW	BO
Western wood-pewee	12	0.32	WG, RW	BO
Cassin's vireo	12	0.32	RW, WG	SM
Tree swallow	11	0.29	RW	SM
MacGillivray's warbler	11	0.29	WG, RW	SM
Lazuli bunting	11	0.29	RW	SM
Hermit thrush	8	0.21	WG, RW	SM
Cedar waxwing	8	0.21	WG, RW	FM
Townsend's warbler	8	0.21	RW	SM
Pacific-slope flycatcher	7	0.18	RW, WG	SM
Nashville warbler	7	0.18	RW/WG	BO
Blue grosbeak	7	0.18	RW	SM
Evening grosbeak	7	0.18	WG	SM
Rufous hummingbird	6	0.16	ALL	SM
Lewis' woodpecker	5	0.13	WG, RW	FM
Hermit warbler	5	0.13	RW	SM
Black-throated sparrow	5	0.13	DS	FM
Broad-tailed hummingbird	4	0.11	ALL	SM
Gray flycatcher	3	0.08	WG	SM
Lark sparrow	3	0.08	WG, DS	FM
Cassin's finch	3	0.08	WG/RW	BO
Red-breasted sapsucker	2	0.05	WG	FM
Hammond's flycatcher	2	0.05	RW, WG	SM
Olive-sided flycatcher	1	0.03	RW	SM

Table 9. Relative abundance of avian species during winter surveys from 2002 to 2005 at Manzanar National Historic Site, Inyo County, Calif.

[Number of individuals, total number detected; IRA, index of relative abundance with respect to most common species. Habitats: RW, riparian woodland; WG, woodland grove; DS, desert scrub; ALL, any habitat. Number of surveys, number of surveys for detection (of three winter surveys total). See appendix 3 for scientific names.]

Common name	Number of individuals	IRA	Habitat(s)	Number of surveys
Horned lark	40	1.00	ALL	3
White-crowned sparrow	34	0.85	RW, WG	3
Dark-eyed junco	30	0.75	ALL	3
European starling	27	0.68	DS	3
Sage sparrow	24	0.60	WG, RW	3
Pygmy nuthatch	20	0.50	DS, RW	1
American robin	19	0.48	ALL	3
Mountain chickadee	18	0.45	WG, RW	2
Ruby-crowned kinglet	18	0.45	DS	3
Mountain bluebird	17	0.43	ALL	3
Common raven	15	0.38	RW, WG	3
California quail	14	0.35	ALL	3
Red-winged blackbird	13	0.33	WG, DS	2
Brewer's blackbird	12	0.30	RW	3
Western bluebird	11	0.28	RW, WG	2
Northern flicker	11	0.28	WG, RW	3
Bewick's wren	9	0.23	DS, WG	3
Brown creeper	9	0.23	WG, RW	2
American crow	7	0.18	WG, RW	3
House sparrow	6	0.15	ALL	3
Northern rough-winged swallow	5	0.13	WG, RW	1
Loggerhead shrike	5	0.13	WG, RW	1
Western meadowlark	5	0.13	WG	3
Northern harrier	5	0.13	WG	3
Pacific-slope flycatcher	5	0.13	RW, WG	1
Fox sparrow	5	0.13	ALL	2
Nuttall's woodpecker	5	0.13	ALL	1
Say's phoebe	5	0.13	WG	2
Bushtit	5	0.13	WG	1
Yellow-rumped warbler (Audubon's)	4	0.10	DS, RW	1
Lincoln's sparrow	4	0.10	WG, RW	2
White-breasted nuthatch	4	0.10	WG	1
Red-tailed hawk	4	0.10	WG	3

Table 9. Relative abundance of avian species during winter surveys from 2002 to 2005 at Manzanar National Historic Site, Inyo County, Calif.—Continued

Common name	Number of individuals	IRA	Habitat(s)	Number of surveys
Sage thrasher	3	0.08	RW, WG	1
Black phoebe	3	0.08	RW	1
Great horned owl	3	0.08	RW	1
Cooper's hawk	3	0.08	WG	3
Ladder-backed woodpecker	3	0.08	WG, RW	2
Northern mockingbird	2	0.05	WG, RW	2
Costa's hummingbird	2	0.05	DS	1
Killdeer	2	0.05	DS	1
American goldfinch	2	0.05	RW	1
Green-tailed towhee	2	0.05	WG	1
Ferruginous hawk	1	0.03	DS	1
Rough-legged hawk	1	0.03	DS	1
Golden eagle	1	0.03	DS	1
Merlin	1	0.03	DS	1
Western scrub jay	1	0.03	RW	1
House finch	1	0.03	WG	1

Table 10. Species that have been detected in nearby areas in recent years that could also occur at Manzanar National Historic Site, Inyo County, Calif.

[Expected habitats of nearby detected species: RW, riparian woodland; WG, woodland grove; DS, desert scrub; ALL, any habitat. Potential (for occurrence): H, high; M, moderate; L, low; (T), threatened (federally listed) species. This list is speculative and intended to identify some additional key species to look for; the presence of other species not listed is certainly possible.]

Common name	Scientific name	Potential	Habitat(s)
Common ground-dove	*Columbina passerina*	M	DS, WG
Ruddy ground-dove	*Columbina talpacoti*	L	DS, WG
Long-eared owl	*Asio otus*	M	WG
Short-eared owl	*Asio flammeus*	H	WG, DS
Vaux's swift	*Chaetura vauxi*	H	ALL
Anna's hummingbird	*Calypte anna*	H	ALL
Calliope hummingbird	*Stellula calliope*	M	ALL
Dusky flycatcher	*Empidonax oberholseri*	H	WG
Vermilion flycatcher	*Pyrocephalus rubinus*	H	RW, WG
Bell's vireo	*Vireo bellii*	L (T)	RW, WG
Bank swallow	*Riparia riparia*	L (T)	RW
Red-breasted nuthatch	*Sitta canadensis*	M	WG,RW
Winter wren	*Troglodytes troglodytes*	M	WG,RW
Golden-crowned kinglet	*Regulus satrapa*	H	WG,RW
Townsend's solitaire	*Myadestes townsendi*	M	WG
Swainson's thrush	*Catharus ustulatus*	H	RW
Bohemian waxwing	*Bombycilla garrulus*	M	WG
Virginia's warbler	*Vermivora virginiae*	M	WG,RW
Lucy's warbler	*Vermivora luciae*	M	RW
Northern parula	*Parula americana*	L	RW
Northern waterthrush	*Seiurus noveboracensis*	L	RW
Common yellowthroat	*Geothlypis trichas*	L	RW
Yellow-breasted chat	*Icteria virens*	L	RW
Summer tanager	*Piranga rubra*	H	WG,RW
American tree sparrow	*Spizella arborea*	L	WG
White-throated sparrow	*Zonotrichia albicollis*	L	WG
Harris's sparrow	*Zonotrichia querula*	L	WG
Golden-crowned sparrow	*Zonotrichia atricapilla*	L	RW,WG
Rose-breasted grosbeak	*Pheucticus ludovicianus*	M	RW
Indigo bunting	*Passerina cyanea*	M	WG
Tricolored blackbird	*Agelaius tricolor*	L	RW
Hooded oriole	*Icterus cucullatus*	M	WG,RW
Pine siskin	*Carduelis pinus*	M	WG
Lawrence's goldfinch	*Carduelis lawrencei*	M	WG,RW

Discussion

Existing Records

The lack of verifiable information on avian species at Manzanar is not surprising for several reasons. First, Manzanar has only existed as a National Historic Site for less than 15 years, and there was little incentive prior to that time to locate information. Second, the understandable focus on cultural resource protection and interpretation has limited efforts to collect natural resource information since the site's current status was formalized. Third, and in our view most important, Manzanar is only a little more than 3.2 km^2 in area, and there is little (especially from a distance) to distinguish the site itself from hundreds upon hundreds of square kilometers of similar habitats up and down the Owens Valley. The land-use history of the site, and the availability of so much nearby habitat that is arguably much more interesting from a natural resource perspective, decreases the likelihood that the Manzanar site would be selected for biological or ecological investigations. Examinations of records from the Museum of Vertebrate Zoology at Berkeley reveal that numerous collections of native flora and fauna, dating back over 115 years, have originated in the Owens Valley, along its watercourses and in its adjacent foothills. However, we were unable to reference, either descriptively or geographically, any of the avian records in those collections to the place we now know as Manzanar. Online searches for verifiable records from other sources yielded no better results. From the perspective of building a knowledge base for avian resources at Manzanar, we are clearly starting with a pretty clean slate.

Transect Establishment

As originally conceived the inventory at Manzanar was to rely on randomized plots except where linear habitat features were present. However, we reconsidered this approach after the first site reconnaissance. On our first planning visit to the site we studied aerial photographs and then walked the site on an April morning, doing informal bird counts as we went. We estimated that 60% of Manzanar outside of the currently developed areas was covered by desert scrub, 25% was occupied by the central woodland (woodland grove), 5% was the Shepherd Ranch area, and 5 to 10% was the riparian zone along Bairs Creek, depending on how that zone is defined. Had we allocated sampling effort as random points (plots) in proportion to habitat availability, there should have been 20 random points in the desert scrub, 10 points (combined) in the central woodland plus Shepherd Ranch complex (woodland grove), and 3 points (the prescribed minimum) in the riparian zone. Instead, based upon what we saw during that planning visit, we allocated 40% of the effort to desert scrub, 35% to the woodland grove, and 25% to the Bairs Creek riparian zone. Given the limited extent of woodland habitats at Manzanar, especially riparian woodland, the number of points along these transects constitute over sampling with respect to habitat availability. However, we decided that the importance of woodland habitats for birds justified some additional sampling within them, and that 40% (instead of 60%) of the effort in desert scrub at Manzanar would suffice to ensure adequate sampling in that habitat.

Over sampling woodland habitats created some logistical problems, mostly in terms of how best to locate points. Bairs Creek was linear, so a transect there was logical, but the woodland grove was shaped more like an elongated rectangle. It was, therefore, difficult to randomly locate enough points within the woodland to provide for sufficient spacing without capturing too much edge in the plots. One model that appeared both simple and adequate consisted of running a transect north a sufficient distance inside of the eastern edge, gradually turning west and then returning south inside

of the western edge. Ultimately we adopted this model, removing as much bias as possible by following a fixed bearing from a randomized starting point and establishing points a fixed distance apart. At this point, having broken away from the fully randomized model, we used a similar methodology to establish the two desert scrub transects. Our goal was to facilitate adequate coverage of the different habitats at Manzanar, while focusing some extra attention on habitat features that are known to be important to a variety of avian species.

Species Detection

The average detection rate over all seasons and habitats was just over one bird per minute during 2,145 minutes of point-count censusing. Many of the low counts were in desert scrub habitat in winter (least productive habitat and season). Flushes of activity in the riparian habitat, even during spring (most productive habitat and season), were not common. Also, the higher quality riparian habitat is limited in extent, with only two point count stations. The woodland grove habitat was often more productive than the Bairs Creek area, especially when there was no flowing or standing water in Bairs Creek during summer and fall. The trees in the woodland grove, especially the old-growth cottonwoods, furnish high-quality habitat for a variety of avian species. Unfortunately, there appears to be little or no regeneration of these native trees, which may have a negative impact on Manzanar's avifaunal community.

Our purpose for mist netting was to detect cryptic (nonvocal, secretive) species during migration, so it is difficult to judge success if no cryptic species are found. We captured a total of seven species during the mist netting effort, but none of these were previously undetected. The mist net capture rate averaged 1.2 birds per net hour. This is only a moderate capture rate compared to other studies in riparian habitats (see Skagen and others, 2005), but mist netting was limited to two brief sessions on what appeared to be 2 slow days. Our point count and other sampling in the riparian zone probably detected most species that were present, but more intensive and frequent mist netting during the migration periods would have been useful.

Species Accumulation

After 13 survey sessions there were still new bird species to be found at Manzanar, which was not surprising. As highly mobile vertebrates, birds can easily move into or out of an area, causing frequent changes in species assemblages. The species accumulation curve only shows new arrivals. It does not reflect uncommon species that are detected once, then not seen in subsequent surveys. This probably contributes to the lack of any asymptote. Continued monitoring of breeding, wintering, and especially migrant birds at Manzanar will likely yield new species. Most of these will probably be transients.

Seasonal Detection Differences

The relatively large numbers and variability in species composition during the spring and fall were not surprising, given the inherent volatility associated with migration timing. Conversely, the stability of species richness in winter probably reflects relatively mild and consistent conditions at Manzanar during this period. The breeding survey results appear to show a negative trend over time, but the biggest drop in richness occurred between two surveys in 2003, and was likely an artifact of our sampling. Both of these surveys occurred during the same breeding season, the first in early June, at the same time as the previous year, and the second near the end of July, 7 weeks later. We suspect that several of those species detected in June but not in July, such as the blue

grosbeak, were still moving to their breeding grounds. A few others, such as the blue-gray gnatcatcher, had in fact already bred and left by the last week in July.

The final spring migration survey, which was not originally planned, was intended to detect some later migrants that we suspected we might be missing. We kept track of the Audubon Web site, watching the numbers of migrant sightings to determine whether migration was ready to peak, and traveled from Flagstaff, Ariz., to Manzanar hoping to be there at the right time. The first 2 years we ended up at Manzanar on the same dates in April, but recorded considerably fewer species the second year. As it happened, the wave of migrants we had hoped to catch came a few days later. The third year we waited just a few days longer and it turned out to be an improvement over the second year. We then decided to add a fourth session and go a little later still. Once again we missed the main wave of migrants, which in this year came the previous week, and detected only 77% of the species that we had detected in 2002.

Habitat Associations

The habitat association data reveal some of the complexities of habitat stratification, even in what appears to be a relatively simple system. The degree of overlap between bird species that used the woodland grove and those that used the Bairs Creek riparian zone is unsurprising. There is considerable overlap in dominant tree species, so we expected black-headed grosbeaks, Bullock's orioles, and orange-crowned warblers to use them similarly. The number of species that are exclusive to one or the other habitat is surprising. Four of eight woodpecker species we detected used only the woodland grove, while four of ten warbler species used only Bairs Creek riparian habitat—even when the watercourse was dry. The understanding of this segregation is further complicated by the proximity of the south end of the woodland grove to Bairs Creek (<200 m). We suspect that differences in understory species and structure are influencing the choice of habitat by some species (warblers), while differences in tree maturity are influencing others (woodpeckers).

Nocturnal Surveys

One of the complexities in using active detection methods for bird species, such as call playback, is that you may get a response from another species. This was a problem when we conducted nocturnal surveys at Manzanar. Hearing a great horned owl when surveying for any other species may be sufficient reason to end the survey. This species is a fierce competitor and will fly in upon hearing the call of almost any sympatric species. Once a great horned owl is attracted it will likely be necessary to move a considerable distance (perhaps 3 to 5 km) before beginning surveys again, as the owl will follow the surveyor and find them every time they try another call. As long as great horned owls are nearby, and especially if they are calling, other owls will remain silent. This happened frequently at Manzanar, which resulted in the abbreviation of >50% of nocturnal surveys.

Area Searches and Nest Searching

To maximize species detection at Manzanar, it was desirable to use several methods. Point counting is widely held to be a preferred method of avian censusing due to its repeatability (Ralph and others, 1993), but cryptic species within a census plot or incidental species outside it may remain undetected. By conducting thorough area searches after point counts we were able to increase species detection by 15% over what we achieved through point counting alone. Cryptic, nonvocal species that might have otherwise gone unnoticed included three flycatchers. But there

were other species detected during area searches that are usually easier to notice, including five raptor and three woodpecker species. Supporting our contention that increased sampling in woodland areas is needed, of the 17 species detected exclusively through area searches, all were found in woodland habitats.

Besides the active nests of 11 species, discovered incidentally or during nest searching, unoccupied nests in good condition that appeared to have been recently used were found for three species. Nest material and construction, substrate location, and prior species detection in that habitat were all consistent with the prospective species (Baicich and Harrison, 1997). In the case of spotted towhee, eggshell fragments consistent with normal hatching were also found. Circumstantial breeding evidence for five other species required less interpretation. Three species were seen on multiple occasions carrying nest material, although we were unable to locate any of their nests. Even easier to document were courtship displays by lesser nighthawks. The most circumstantial of breeding evidence, however, was exhibited by brown-headed cowbird females as they conducted their own nest searches by watching females of other species. Among the species we suspected of breeding at Manzanar, but for which we lacked evidence, were blue-gray gnatcatchers and orange-crowned warblers, both of which we observed being watched by female cowbirds. Both species are parasitized by cowbirds, especially the gnatcatcher (Erlich and others, 1988).

Relative Abundance

The prevalence of year-round species during both breeding season and winter is not surprising considering the high desert climate at Manzanar. It is hot during the summer, but most desert-adapted species would not find it excessively so. Similarly, the typically moderate winter conditions would be tolerable for many species. Such conditions help provide for a relatively stable population of resident species, although the individuals representing each species would be different in each season (Sibley, 2000). At Manzanar, the response of birds to these moderate conditions is evidenced by residents accounting for 18 of the 20 most abundant species during the breeding season, and 16 of the 20 most abundant during the winter months. During migration, the relative abundance of resident species declines somewhat due to the influx of transient species.

Potential Species

Not counting flyovers, we detected 119 species at Manzanar, but we expect that this tally will increase substantially as more people turn their attention to the natural resources at the historic site. The criteria for being on the list of potential species are only two: (1) multiple sightings of the species must have occurred within the general area since 2000, and (2) there must be a plausible match between habitat at Manzanar and the habitat(s) where the species is typically found.

To assign occurrence potential as high, moderate, or low, we considered a bit more critically whether each species was a good candidate for arrival at Manzanar. For example, if we expected the appearance of a prospective species, and it had been seen in habitat within a 16-km radius that was analogous to the habitat at Manzanar, we would assign it high potential. Species that could find suitable habitat at Manzanar but had not been sighted within 16 km would be assigned moderate potential. Species that had not been sighted within 16 km and would find only limited suitable habitat in Manzanar would be assigned low potential. Such species, if they do occur at Manzanar, would likely be classified as accidental.

Species of Concern

The possible presence of two species of concern provided some of the impetus for the avian inventory at Manzanar. During this inventory, we detected no threatened species or species of serious concern. In our potential species list we included the federally endangered least bell's vireo (*Vireo bellii pusillus*) as low potential, but these birds are now so rare that this is probably an understatement. Any sightings of this species in the vicinity of Manzanar or anywhere else in the eastern Sierra would certainly be noteworthy. We were also tasked with evaluating possible habitat at Manzanar for the Southwestern willow flycatcher (*Empidonax traillii extimus*), a federally listed subspecies. We did not conduct formal surveys for this bird, but in our opinion the habitat at Manzanar is not suitable for breeding by this species; it remains plausible, however, that the flycatcher might stop there on occasion while migrating.

Management Considerations

Although it is quite small in area, and this fact alone limits its importance to avian species on a landscape scale, Manzanar does provide some diverse habitats that support well over 100 species of landbirds. Two of these habitats possess attributes uncommon in this high-desert landscape that may warrant management consideration. First, the Bairs Creek riparian zone, even with intermittent water flows, is the only riparian habitat at Manzanar, and is also likely to be the most biologically diverse. From what we could see during our avian inventories, a major threat to this habitat (besides persistent drought) is heavy browsing and trampling by tule elk (*Cervus elaphus nannodes*). We expect that it would be very costly to exclude these large, introduced ungulates, but it might be worthwhile to study the problem. Monitoring of the riparian area within Manzanar would help in understanding the magnitude of this potential problem.

The woodland grove is the other area that warrants attention. The hydrological features that raise the water table between Bairs and Shepherd Creeks, while perhaps not unique, do not appear to have many replicates in the Owens Valley. This mature woodland dominated by cottonwoods provides the largest expanse of habitat for the greatest number of bird species at Manzanar. This is also the area that could potentially be most affected by visitor use-related activities, as roads and trails are constructed or improved. The old-growth trees and snags provide nesting habitat for many of the species inventoried, but there appears to be little or no regeneration of major tree species, especially cottonwood. Without intervention to promote regeneration of cottonwood, the character of this woodland can be expected to change dramatically as the old-growth trees die, bringing with it corresponding changes to avian assemblages as foraging and nesting habitat is lost for numerous species.

The presence of exotic fruit tree species within the woodland grove is something extraordinary in this area (fig. 6). While we did not study how the presence of these trees might affect the avifauna at Manzanar, we did notice that both figs and pears are popular with a variety of bird species. We lost count of the times that we saw a raven fly by with a whole pear clamped in its bill. There has been some restoration work occurring in the orchards and it appears that these efforts are expanding in both scope and success. As this rather unique, nonnative resource gains stature, it would be desirable to track its potential influence on bird species. In particular, do certain species appear to derive greater benefit? Are bird species assemblages in the woodland changing in response to the enhancement of nonnative tree species?

In addition to its obvious historical importance, Manzanar also contains important habitat that supports a diverse avifauna. This and other natural resources are now receiving needed

attention, and the baseline information essential to their management is being extracted. The inventory study described here provides a baseline for, and should encourage, further study and observations. Aside from the obvious benefits for enabling resource protection, knowledge of the avian community provides another facet to the visitor experience at Manzanar—a small site with a very big story.

Figure 6. A remnant orchard within the woodland grove at Manzanar National Historic Site, Inyo County, Calif., that still produces fruit and attracts birds.

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Appendix 1. Coordinates for Avian Point-Count Transects

Table 1-1. Coordinates for avian point-count transects at Manzanar National Historic Site, Inyo County, Calif.

[Global positioning system (GPS)-derived Universal Transverse Mercator Coordinates (UTMs) are in Zone 11S, and were collected in datum World Geodetic System 1984 (WGS 84). Estimated position error (EPE) is given in meters for each point. A Garmin 76S GPS unit was used to collect these data and the acceptable accuracy was specified as ≤5 m.]

Transect name	Point	East UTM	North UTM	Estimated position error (m)
		Bairs Creek		
Bairs Creek	1	396027	4064189	4
Bairs Creek	2	396227	4064295	4
Bairs Creek	3	396429	4064391	3
Bairs Creek	4	396635	4064334	3
Bairs Creek	5	396840	4064331	4
Bairs Creek	6	397038	4064405	5
Bairs Creek	7	397244	4064416	4
Bairs Creek	8	397441	4064482	4
		Desert scrub east		
Desert scrub east	1	397318	4064791	5
Desert scrub east	2	397331	4065049	3
Desert scrub east	3	397286	4065279	4
Desert scrub east	4	397213	4065521	4
Desert scrub east	5	397244	4065768	4
Desert scrub east	6	397155	4066007	4
Desert scrub east	7	396877	4066044	4
		Desert scrub west		
Desert scrub west	1	396165	4065603	3
Desert scrub west	2	396144	4065343	4
Desert scrub west	3	396265	4065088	3
Desert scrub west	4	396125	4064870	3
Desert scrub west	5	396254	4064647	4
Desert scrub west	6	396049	4064458	4
		Woodland grove		
Woodland grove	1	396813	4064495	5
Woodland grove	2	396816	4064697	5
Woodland grove	3	396804	4064906	4
Woodland grove	4	396816	4065109	4
Woodland grove	5	396767	4065301	4
Woodland grove	6	396815	4065505	4
Woodland grove	7	396849	4065705	5
Woodland grove	8	396673	4065595	4
Woodland grove	9	396496	4065481	5
Woodland grove	10	396545	4065265	5
Woodland grove	11	396599	4065070	5
Woodland grove	12	396606	4064837	5

Appendix 2. Overall Relative Abundance of Avian Species

Table 2-1. Overall relative abundance of avian species inventoried at Manzanar National Historic Site, Inyo County, Calif., from 2002 to 2005.

[Total counts include birds detected during point counting, area searches, and nocturnal surveys. Abundance is irrespective of season and relative to the most common species detected overall (white-crowned sparrow). See appendix 3 for scientific names.]

Species	Total count	Relative abundance
White-crowned sparrow	92	1.00
European starling	88	0.96
California quail	87	0.95
Sage sparrow	76	0.83
American robin	71	0.77
Brewer's blackbird	62	0.67
Common raven	56	0.61
Bushtit	55	0.60
Horned lark	54	0.59
Dark-eyed junco	53	0.58
Mourning dove	51	0.55
Yellow-rumped warbler (Audubon's)	51	0.55
Vesper sparrow	49	0.53
Violet-green swallow	38	0.41
House sparrow	38	0.41
Chipping sparrow	37	0.40
Western bluebird	35	0.38
Canada goose	34	0.37
Red-winged blackbird	34	0.37
Brown-headed cowbird	34	0.37
Bewick's wren	33	0.36
House finch	32	0.35
Mountain bluebird	30	0.33
Northern flicker	29	0.32
American crow	27	0.29
Ruby-crowned kinglet	27	0.29
Western tanager	26	0.28
Blue-gray gnatcatcher	25	0.27
Barn swallow	24	0.26
Red-tailed hawk	23	0.25
Say's phoebe	23	0.25
Northern rough-winged swallow	23	0.25
Orange-crowned warbler	23	0.25
Brewer's sparrow	23	0.25
Black-chinned hummingbird	22	0.24
Ash-throated flycatcher	22	0.24
Common nighthawk	21	0.23
Spotted towhee	21	0.23
Pygmy nuthatch	20	0.22

Table 2-1. Overall relative abundance of avian species inventoried at Manzanar National Historic Site, Inyo County, Calif., from 2002 to 2005.—Continued

Species	Total count	Relative abundance
Western kingbird	19	0.21
Cliff swallow	19	0.21
Wilson's warbler	19	0.21
Western meadowlark	19	0.21
Lesser goldfinch	19	0.21
Great horned owl	18	0.20
Mountain chickadee	18	0.20
Northern mockingbird	18	0.20
Black-throated gray warbler	18	0.20
Turkey vulture	17	0.18
American kestrel	17	0.18
Phainopepla	17	0.18
Warbling vireo	16	0.17
Savannah sparrow	16	0.17
Bullock's oriole	16	0.17
American white pelican	15	0.16
Loggerhead shrike	15	0.16
Rock dove	14	0.15
White-throated swift	14	0.15
Hairy woodpecker	14	0.15
Black-billed magpie	14	0.15
Lesser nighthawk	13	0.14
Yellow warbler	13	0.14
Black-headed grosbeak	13	0.14
Western wood-pewee	12	0.13
Black phoebe	12	0.13
Cassin's vireo	12	0.13
Rock wren	12	0.13
Nuttall's woodpecker	11	0.12
Western scrub-jay	11	0.12
Tree swallow	11	0.12
MacGillivray's warbler	11	0.12
Lazuli bunting	11	0.12
Northern harrier	10	0.11
Song sparrow	10	0.11
Costa's hummingbird	9	0.10
Brown creeper	9	0.10
Plumbeous vireo	8	0.09
Hermit thrush	8	0.09
Cedar waxwing	8	0.09
Townsend's warbler	8	0.09
Pacific-slope flycatcher	7	0.08
Nashville warbler	7	0.08

Table 2-1. Overall relative abundance of avian species inventoried at Manzanar National Historic Site, Inyo County, Calif., from 2002 to 2005.—Continued

Species	Total count	Relative abundance
Blue grosbeak	7	0.08
Evening grosbeak	7	0.08
Rufous hummingbird	6	0.07
White-breasted nuthatch	6	0.07
Yellow-headed blackbird	6	0.07
Cooper's hawk	5	0.05
California gull	5	0.05
Lewis' woodpecker	5	0.05
House wren	5	0.05
Sage thrasher	5	0.05
Hermit warbler	5	0.05
Black-throated sparrow	5	0.05
Fox sparrow	5	0.05
Great blue heron	4	0.04
Sharp-shinned hawk	4	0.04
Common poorwill	4	0.04
Broad-tailed hummingbird	4	0.04
Lincoln's sparrow	4	0.04
Great-tailed grackle	4	0.04
Cattle egret	3	0.03
Killdeer	3	0.03
Ladder-backed woodpecker	3	0.03
Downy woodpecker	3	0.03
Gray flycatcher	3	0.03
American redstart	3	0.03
Lark sparrow	3	0.03
Cassin's finch	3	0.03
Swainson's hawk	2	0.02
Acorn woodpecker	2	0.02
Red-breasted sapsucker	2	0.02
Hammond's flycatcher	2	0.02
Green-tailed towhee	2	0.02
American goldfinch	2	0.02
Great egret	1	0.01
Osprey	1	0.01
Red-shouldered hawk	1	0.01
Ferruginous hawk	1	0.01
Rough-legged hawk	1	0.01
Golden eagle	1	0.01
Bald eagle	1	0.01
Merlin	1	0.01

Table 2-1. Overall relative abundance of avian species inventoried at Manzanar National Historic Site, Inyo County, Calif., from 2002 to 2005.—Continued

Species	Total count	Relative abundance
Prairie falcon	1	0.01
Caspian tern	1	0.01
Greater roadrunner	1	0.01
Barn owl	1	0.01
Western screech owl	1	0.01
Belted kingfisher	1	0.01
Olive-sided flycatcher	1	0.01
Le Conte’s thrasher	1	0.01
American pipit	1	0.01

Appendix 3. Preliminary Bird List for Manzanar National Historic Site, Calif.

The following list provides an explanation of the abbreviations used in appendix 3.

Abundance

A Abundant: easily seen in correct season and habitat.
C Common: usually encountered in correct season and habitat at Manzanar National Historic Site, Inyo County, Calif.
U Uncommon: not encountered most of the time, but expected to be observed every year.
O Occasional: not encountered most of the time; not observed at Manzanar every year.
R Rare: very low probability of seeing the species; not observed at Manzanar every year.

Residency Status

Y Year-round resident: the species has been recorded in Manzanar throughout the year.
S Summer resident: generally present during the breeding season (March–September).
W Winter resident: generally present during October–February.
M Migrant: transient species present in Manzanar during the spring and fall.
I Irregular: sporadic or accidental occurrences at Manzanar.
UNK Unknown: residency status unknown.
(nn) Nonnative: introduced species.

Habitat Types

DS Desert scrub: Saltbush (*Atriplex*), rabbitbrush (*Ericameria*), and sagebrush (*Artemisia*) dominate this community. The northeastern portion of this habitat also contains scattered groupings of salt cedar (*Tamarix*).
RW Riparian woodland: Restricted to a narrow belt along Bairs Creek, which has intermittent flow. Primary tree species are cottonwood (*Populus*), willow (*Salix*), locust (*Robinia*), and salt cedar (*Tamarix*). Important shrubs are wild rose (*Rosa*), and desert olive (*Forestiera*).
WG Woodland grove: including cottonwood (*Populus*), locust (*Robinia*), and willow (*Salix*), as well as significant numbers of several orchard tree species and other exotics.
AF Aerial foraging: species was foraging in the air above a habitat (noted) without landing.
ALL All habitats: species was seen in all habitats.
FO Flyover: species was detected during a flyover of Manzanar while in transit elsewhere.

Breeding Status

B Confirmed breeding: presence of an active nest, fledglings, food, or nesting material carried by adults.
{B} Probable breeder, with circumstantial evidence (e.g., courtship observed); not confirmed.

{B}? Within expected breeding range and habitat, but no evidence of breeding.

Table 3-1. Preliminary bird list for Manzanar National Historic Site, Calif.

Birds	Abundance	Residency	Habitats	Breeding
Pelicans				
American white pelican (*Pelecanus erythrorhynchos*)	U	I	FO	
Herons, bitterns				
Great egret (*Ardea alba*)	U	I	FO	
Great blue heron (*Ardea herodias*)	U	I	FO	
Cattle egret (*Bubulcus ibis*)	U	I	FO	
Geese, ducks				
Canada goose (*Branta canadensis*)	U	I	FO	
Vultures				
Turkey vulture (*Cathartes aura*)	C	S	WG	
Ospreys				
Osprey (*Pandion haliaetus*)	U	M	A	
Hawks, eagles				
Northern harrier (*Circus cyaneus*)	U	Y	DS, RW	
Sharp-shinned hawk (*Accipiter striatus*)	U	Y	WG, RW	
Cooper's hawk (*Accipiter cooperii*)	U	Y	WG	
Red-shouldered hawk (*Buteo lineatus*)	O	I	FO	
Swainson's hawk (*Buteo swainsoni*)	O	I	FO	
Red-tailed hawk (*Buteo jamaicensis*)	C	Y	WG, RW	B
Ferruginous hawk (*Buteo regalis*)	R	I	FO	
Rough-legged hawk (*Buteo lagopus*)	R	I	FO	
Golden eagle (*Aquila chrysaetos*)	R	I	FO	
Bald eagle (*Haliaeetus leucocephalus*)	O	I	FO	
Falcons				
American kestrel (*Falco sparverius*)	C	Y	ALL	B
Merlin (*Falco columbarius*)	R	I	FO	
Prairie falcon (*Falco mexicanus*)	O	Y	FO	
Quail				
California quail (*Callipepla californica*)	A	Y	ALL	B
Plovers				
Killdeer (*Charadrius vociferus*)	O	I	WG	
Gulls				
California gull (*Larus californicus*)	O	I	FO	
Terns				
Caspian tern (*Hydroprogne caspia*)	R	I	FO	
Pigeons, doves				
Rock dove (*Columba livia*)	O	UNK (nn)	FO	
Mourning dove (*Zenaida macroura*)	A	Y	ALL	B
Cuckoos, roadrunners				
Greater roadrunner (*Geococcyx californianus*)	O	Y	DS	{B}?
Owls				
Barn owl (*Tyto alba*)	U	Y	WG	
Western screech-owl (*Megascops kennicottii*)	U	Y	RW	
Great horned owl (*Bubo virginianus*)	C	Y	RW, WG	B
Nightjars				
Lesser nighthawk (*Chordeiles acutipennis*)	U	S	DS, RW	{B}
Common nighthawk (*Chordeiles minor*)	A	S	DS, RW	
Common poorwill (*Phalaenoptilus nuttallii*)	R	S	DS	
Swifts				
White-throated swift (*Aeronautes saxatalis*)	U	M	AF, ALL	

Table 3-1. Preliminary bird list for Manzanar National Historic Site, Calif.—Continued

Birds	Abundance	Residency	Habitats	Breeding
Hummingbirds				
Black-chinned hummingbird (*Archilochus alexandri*)	C	S	ALL	B
Costa's hummingbird (*Calypte costae*)	U	S	DS	{B}
Broad-tailed hummingbird (*Selasphorus platycercus*)	O	M	ALL	
Rufous hummingbird (*Selasphorus rufus*)	O	M	ALL	
Kingfishers				
Belted kingfisher (*Megaceryle alcyon*)	O	Y	FO	
Woodpeckers				
Lewis' woodpecker (*Melanerpes lewis*)	O	M	WG, RW	
Acorn woodpecker (*Melanerpes formicivorus*)	R	Y	WG	
Red-breasted sapsucker (*Sphyrapicus ruber*)	O	M	WG	
Ladder-backed woodpecker (*Picoides scalaris*)	U	I	WG	
Nuttall's woodpecker (*Picoides nuttallii*)	C	Y	WG	
Downy woodpecker (*Picoides pubescens*)	O	Y	RW	
Hairy woodpecker (*Picoides villosus*)	C	Y	RW	B
Northern flicker (*Colaptes auratus*)	C	Y	WG, RW	B
Flycatchers				
Olive-sided flycatcher (*Contopus cooperi*)	O	M	RW	
Western wood-pewee (*Contopus sordidulus*)	C	M	WG, RW	
Hammond's flycatcher (*Empidonax hammondii*)	O	M	RW, WG	
Gray flycatcher (*Empidonax wrightii*)	O	M	WG	
Pacific-slope flycatcher (*Empidonax difficilis*)	O	M	RW, WG	
Black phoebe (*Sayornis nigricans*)	U	Y	RW	{B}
Say's phoebe (*Sayornis saya*)	C	S	WG	B
Ash-throated flycatcher (*Myiarchus cinerascens*)	C	S	WG, RW	B
Western kingbird (*Tyrannus verticalis*)	C	S	WG, RW	B
Shrikes				
Loggerhead shrike (*Lanius ludovicianus*)	C	Y	ALL	{B}
Vireos				
Plumbeous vireo (*Vireo plumbeus*)	U	M	RW, WG	
Cassin's vireo (*Vireo cassinii*)	R	M	RW, WG	
Warbling vireo (*Vireo gilvus*)	U	M	WG, RW	
Jays, crows				
Western scrub-jay (*Aphelocoma californica*)	U	Y	WG	
Black-billed magpie (*Pica hudsonia*)	U	Y	WG	
American crow (*Corvus brachyrhynchos*)	C	Y	ALL	
Common raven (*Corvus corax*)	C	Y	ALL	B
Larks				
Horned lark (*Eremophila alpestris*)	C	W	DS	
Swallows				
Tree swallow (*Tachycineta bicolor*)	U	M	AF, RW	
Violet-green swallow (*Tachycineta thalassina*)	C	M	AF, ALL	
Northern rough-winged swallow (*Stelgidopteryx serripennis*)	C	M	AF, RW	
Cliff swallow (*Petrochelidon pyrrhonota*)	U	M	AF, ALL	
Barn swallow (*Hirundo rustica*)	C	M	AF, ALL	{B}?
Chickadees, bushtits				
Mountain chickadee (*Poecile gambeli*)	U	W	WG	
Bushtit (*Psaltriparus minimus*)	C	Y	WG, RW	
Nuthatches, creepers				
White-breasted nuthatch (*Sitta carolinensis*)	O	W	WG	
Pygmy nuthatch (*Sitta pygmaea*)	R	W	WG	
Brown creeper (*Certhia americana*)	O	W	WG, RW	

Table 3-1. Preliminary bird list for Manzanar National Historic Site, Calif.—Continued

Birds	Abundance	Residency	Habitats	Breeding
Wrens				
Rock wren (*Salpinctes obsoletus*)	U	Y	DS	
Bewick's wren (*Thryomanes bewickii*)	C	Y	RW, WG	B
House wren (*Troglodytes aedon*)	U	Y	RW	B
Kinglets				
Ruby-crowned kinglet (*Regulus calendula*)	C	W	WG, RW	
Gnatcatchers				
Blue-gray gnatcatcher (*Polioptila caerulea*)	C	S	WG, RW	
Bluebirds, thrushes				
Western bluebird (*Sialia mexicana*)	C	Y	WG, DS	{B}?
Mountain bluebird (*Sialia currucoides*)	C	W	DS, WG	
Hermit thrush (*Catharus guttatus*)	U	M	WG, RW	
American robin (*Turdus migratorius*)	A	Y	WG, RW	B
Mockingbirds, thrashers				
Northern mockingbird (*Mimus polyglottos*)	C	Y	ALL	B
Sage thrasher (*Oreoscoptes montanus*)	O	I	DS	
Le Conte's thrasher (*Toxostoma lecontei*)	O	I	DS	
Starlings				
European starling (*Sturnus vulgaris*)	A	Y (nn)	ALL	B
Pipits				
American pipit (*Anthus rubescens*)	R	I	WG	
Waxwings				
Cedar waxwing (*Bombycilla cedrorum*)	O	M	WG, RW	
Silky flycatchers				
Phainopepla (*Phainopepla nitens*)	C	S	DS, RW	{B}
Wood warblers				
Orange-crowned warbler (*Vermivora celata*)	C	S	RW, WG	{B}?
Nashville warbler (*Vermivora ruficapilla*)	O	M	RW/WG	
Yellow warbler (*Dendroica petechia*)	U	M	RW	
Yellow-rumped warbler (*Dendroica coronata*)	C	W	RW, WG	
Black-throated gray warbler (*Dendroica nigrescens*)	C	M	RW, WG	
Townsend's warbler (*Dendroica townsendi*)	U	M	RW	
Hermit warbler (*Dendroica occidentalis*)	O	M	RW	
American redstart (*Setophaga ruticilla*)	O	I	RW	
MacGillivray's warbler (*Oporornis tolmiei*)	U	M	WG, RW	
Wilson's warbler (*Wilsonia pusilla*)	C	M	RW, WG	
Tanagers				
Western tanager (*Piranga ludoviciana*)	C	M	WG, RW	
Towhees, sparrows				
Green-tailed towhee (*Pipilo chlorurus*)	U	M	WG/RW	
Spotted towhee (*Pipilo maculatus*)	C	Y	WG, RW	{B}
Chipping sparrow (*Spizella passerina*)	C	M	ALL	
Brewer's sparrow (*Spizella breweri*)	C	M	DS	
Vesper sparrow (*Pooecetes gramineus*)	C	Y	DS, RW	B
Lark sparrow (*Chondestes grammacus*)	O	M	WG, DS	
Black-throated sparrow (*Amphispiza bilineata*)	U	M	DS	
Sage sparrow (*Amphispiza belli*)	A	Y	DS,RW	B
Savannah sparrow (*Passerculus sandwichensis*)	O	M	DS	
Fox sparrow (*Passerella iliaca*)	U	W	RW, WG	
Song sparrow (*Melospiza melodia*)	U	Y	RW	
Lincoln's sparrow (*Melospiza lincolnii*)	O	W	RW, WG	
White-crowned sparrow (*Zonotrichia leucophrys*)	A	W	ALL	
Dark-eyed junco (*Junco hyemalis*)	C	Y	ALL	

Table 3-1. Preliminary bird list for Manzanar National Historic Site, Calif.—Continued

Birds	Abundance	Residency	Habitats	Breeding
Cardinals, grosbeaks				
Black-headed grosbeak (*Pheucticus melanocephalus*)	C	S	RW, WG	{B}?
Blue grosbeak (*Passerina caerulea*)	U	M	RW	
Lazuli bunting (*Passerina amoena*)	U	M	RW	
Blackbirds, orioles				
Red-winged blackbird (*Agelaius phoeniceus*)	C	Y	RW	
Western meadowlark (*Sturnella neglecta*)	C	M	DS	
Yellow-headed blackbird (*Xanthocephalus xanthocephalus*)	O	I	RW	
Brewer's blackbird (*Euphagus cyanocephalus*)	C	Y	DS, RW	
Great-tailed grackle (*Quiscalus mexicanus*)	O	Y	WG	
Brown-headed cowbird (*Molothrus ater*)	C	S	RW, WG	{B}
Bullock's oriole (*Icterus bullockii*)	C	S	RW, WG	
Finches				
Cassin's finch (*Carpodacus cassinii*)	O	M	WG/RW	
House finch (*Carpodacus mexicanus*)	C	Y	WG, RW	{B}
Lesser goldfinch (*Carduelis psaltria*)	C	Y	WG, RW	{B}?
American goldfinch (*Carduelis tristis*)	O	M	WG, DS	
Evening grosbeak (*Coccothraustes vespertinus*)	O	M	WG	
Old World sparrows				
House sparrow (*Passer domesticus*)	C	Y (nn)	ALL	{B}?

Common names from Robbins (1999), Birds of North America, 3rd Edition, National Geographic Society. Scientific names from the A.O.U. Check-list of North American Birds (Seventh Edition, 1998, with supplements through 2008), American Ornithologists' Union.