Appendix D. 1991 Wildlife Habitat Inventory and Analysis

INTRODUCTION

In 1991, SWRCB consultants, Jones & Stokes Associates, conducted surveys to characterize the wildlife species inhabiting streamside, lakeshore, upland, and island habitats in Mono Basin, and floodplain habitats on the Upper Owens River. Surveys were conducted from May until October and were designed to identify wildlife responses associated with habitat changes that have occurred since diversions of Mono Lake's tributary streams began in 1941. Data derived in these studies also will be used to analyze future wildlife responses that could potentially occur with implementation of any of the proposed project alternatives.

OBJECTIVES

The objectives of conducting wildlife surveys were to:

- determine the prediversion and current status and habitat associations of birds, mammals, reptiles, and amphibians inhabiting wetland-dependent habitats of Mono Basin and the Upper Owens River;
- determine the occurrence of special-status species, including state and federally listed species and other species of special concern to DFG and USFWS in Mono Basin and the Upper Owens River; and
- estimate the changes that have occurred between prediversion and point-of-reference wildlife populations in Mono Basin and Upper Owens River.

STUDY AREAS

Studies were conducted in riparian, wetland, meadow, and upland habitats within Mono Basin and in riparian and meadow habitats along with the Upper Owens River. Wildlife surveys were conducted in the following study areas:

- Study Area 1: Lee Vining, Rush, Walker, and Parker Creeks (Figure D-1);

Study Area 2: relicted shoreline habitats and open water areas adjacent to the Mono Lake shoreline at Simon Springs, Navy Beach, Lee Vining Tufa Grove, Black Point, DeChambeau Marsh, and mouths of Wilson, Lee Vining, and Rush Creeks (Figure D-2);

Study Area 3: Paoha Island (Figure D-2); and

Study Area 4: the portion of the Upper Owens River occurring on the Arcularius Ranch (Figure 3G-4, "Land Use").

STUDY TEAM

The study design was developed by Jones & Stokes Associates wildlife biologists. Bird surveys were conducted on Mono Lake tributary streams, lakeshore areas, and on the Upper Owens River by Jones & Stokes Associates wildlife biologists Dr. Edward Beedy, Marcus Rawlings, Emilie Strauss, and Daniel Taylor. Under the direction of Jones & Stokes Associates, Dr. Michael Morrison of UC Berkeley conducted bird, mammal, reptile, and amphibian surveys on Paoha Island and upland sites near Black Point. Also under direction of Jones & Stokes Associates, Dr. John Harris of Mills College and five of his undergraduate students conducted mammal, reptile, and amphibian surveys on Mono Lake tributary streams and lakeshore areas and on the Upper Owens River; Steven Clifton of Jones & Stokes Associates also assisted Dr. Harris with the mammal surveys.

METHODS

Standardized fixed-plot and plotless techniques were used to survey wildlife. Fixed-plot surveys were used to determine the occurrence of bird, mammal, reptile, and amphibian species on specific survey plots. Standardized plot surveys permitted direct comparisons of species richness, relative abundance, diversity, and habitat associations of species on different plots.

All survey plots were 1,000 square meters in area and most measured 20 meters by 50 meters. The only exceptions were in some riparian survey sites where riparian corridor widths of less than 20 meters limited plot width and increased plot length.

A habitat classification system was developed by project botanists; specific vegetation types are described in Chapter 3C, "Vegetation". Several habitat designations used in this section combined two or more of the habitat types identified in Chapter 3C, "Vegetation", (Table D-1) in cases where habitats were distinct vegetatively, but functionally provided similar values to wildlife. Eighty-eight survey plots were established in 19 habitat types in Mono Basin and Upper Owens River (Table D-2).

In addition to conducting systematic censuses on the study plots, the study team also recorded daily field notes of wildlife and habitat associations observed during plotless surveys. These surveys were made without space or time restrictions and recorded all wildlife species observed in each major habitat type occurring in Mono Basin and Upper Owens River. Plotless surveys involved systematic searches of specific habitat types and were used to document overall wildlife occurrence and habitat associations rather than the relative abundance of individual species.

Six habitat types, including riparian conifer forests, mature cottonwood-willow woodlands, stream channels, alkali flats, lakeshore areas, and open waters of Mono Lake were surveyed by plotless techniques elusively (Table D-2). Mature cottonwood-willow vegetation along Lee Vining, Rush, Parker, or Walker Creeks is currently restricted to a few small areas (Chapter 3C, "Vegetation"). For this reason, we made plotless surveys of mature cottonwood-willow vegetation along DeChambeau, Post Office, and Wilson Creeks, near the Mono County Park, and near DeChambeau Ranch to develop a species list for this habitat type.

Selection of Survey Plots

Before collecting field data, SWRCB consultants (including both botanists and wildlife biologists) conducted reconnaissance-level surveys to map polygons representing all riparian habitats on Rush, Lee Vining, Parker, and Walker Creeks, and the Mono Lake shoreline. Results of habitat mapping indicated that habitats were distributed unequally among the study areas and only a few polygons for some habitat types were present in specific drainages. Similarly, many polygons classified as the same habitat type had variable structural characteristics, such as percent canopy coverage and stand composition.

Because of this variability, SWRCB consultants selected all polygons of rare habitats (e.g., mature cottonwood-willow woodland) rather than using a stratified random approach. For common habitats (e.g., riparian willow scrub, recovering riparian, alkali dry meadow) several plots were systematically selected in each study area to ensure that all the major habitats and drainages were represented.

Plots were selected using the following guidelines:

- plots sampled the range of habitats occurring within each study area;
- plots sampled the range of structural variability (e.g., percent cover of various canopy layers) that occurred within each habitat type;
- lakeshore plots were located only in areas supporting large acreages of wetlands or meadows, and high-use public recreation areas (e.g., Danburg Beach, South Tufa, and parking areas along U.S. 395) were avoided.

Great Basin scrub plots were located along the tributary streams, north and northeast of Black Point, and on Paoha Island. Survey plots were placed at Black Point because Great Basin scrub habitats in this area closely resemble those present on Paoha Island (Morrison 1991) and lands near Black Point form the mainland side of a land bridge to Negit Island at lake elevations below about 6,376 feet.

Vegetation Surveys

In addition to the detailed vegetation mapping and classification conducted by project botanists (Chapter 3C, "Vegetation"), wildlife biologists characterized the vegetation at individual survey plots. At tree and shrub plots, the botanists visually characterized the dominant plant species, approximate percent cover, average height of vegetation layers, soil moisture (e.g., dry, moist, or saturated), the level of disturbance (e.g., grazing frequency, proximity to developed lands, or public recreational areas), and the state of vegetative vigor (e.g., increasing, stable, or declining). At meadow plots, the relative soil moisture and the total percent vegetative cover of dominant plants were estimated. In marsh habitats, the extent of soil saturation was noted and percent cover was estimated for vegetation less than and above 5 feet.

Wildlife Surveys

Specific field survey methods for birds, mammals, reptiles, and amphibians are discussed separately in the following sections.

Bird Surveys

A total of 415 surveys were conducted on 86 survey plots from May 16 through August 1, 1991 (Table D-2). Seventy-three of the plots were each surveyed five times over the survey period; the Great Basin scrub plots near Black Point and plots on Paoha Island were each surveyed 3 times each (Table D-2). Birds were detected and identified using visual and auditory cues. Guidelines for conducting bird surveys included the following:

- individual plots were surveyed for 7 minutes during the period from 0.5 hour before sunrise until 1000 hours;

- individual plots were surveyed at different times (e.g., early [0530-0700], mid-morning [0700-0830], and late morning [0830-1000]) to compensate for bias associated with bird activity periods;

surveys were conducted only during fair weather; periods of rain, high winds, or extreme cold were avoided to eliminate sampling bias caused by reduced bird activity and detectability;

birds observed flying over survey plots were recorded only if they made use of resources on the plot (e.g., swallows foraging for aerial insects above a plot were counted, but flocks of passing gulls were not).

Plotless surveys were conducted on the Upper Owens River because the narrow willow corridor was discontinuous along the meandering stream (Table D-2). Because the owners of Arcularius Ranch would not permit us to cross the channel, we surveyed all willow thickets and wet meadows on the south side of the river for approximately one-quarter mile as a single census area (about 1.5 acres). Wet meadow plots on Arcularius Ranch were surveyed using the same methods employed for plotless surveys in the other study areas.

From May 16 until October 21, 1991, and from November 9 to 11, 1992, approximately 30 daylong surveys were conducted with a spotting scope to search the Mono Lake shoreline and nearshore waters for shorebirds, wading birds, waterfowl, and other water birds.

Mammal Surveys

Mammal surveys were conducted from May 7 through July 20, 1991 on 66 survey plots (Table D-2). All lakeshore wetland plots were examined by Dr. John Harris to determine their likelihood of use by mammals. Dr. Harris concluded that plots with permanently saturated soils or standing water would receive little or no use by mammals; therefore, only seven of 27 lakeshore plots were surveyed. Due to difficulty of access, one mixed riparian scrub plot also was not surveyed for mammals.

Sherman live traps and pitfall traps were used to capture small mammals. Fifty-one plots were surveyed on three consecutive days using 36 live traps per plot (108 trap nights per plot). Paoha Island and Black Point plots (15 plots) were surveyed using 18 live traps per plot on three consecutive days (54 trap nights per plot).

Pitfall traps were used to determine occurrence of shrews, reptiles, and amphibians (see below). One pitfall trap was placed in each of 61 plots and was operated for a minimum of three consecutive days (Table D-2).

Large mammal surveys were conducted on 66 plots. Mammals observed on plots were recorded and plots were searched to locate tracks, scats, or other sign that would indicate use of the plots by larger species of mammals (Table D-2). One track plate or plot baited with cat food was placed at each of 59 plots to attract and record plot use by wide-ranging carnivores (Table D-2).

Reptile and Amphibian Surveys

In addition to the pitfall traps, plots were searched during the period of May 7-July 20, 1991, to locate reptiles and amphibians. Searches were conducted in conjunction with mammals surveys; therefore, surveys were limited to the 66 plots surveyed for mammals (Table D-2).

Analytical Methods

Wildlife Habitat Index Analyses

A wildlife habitat index (WHI) methodology was developed and applied to:

quantify the relative value of each habitat type to wildlife,

identify the probable effects on wildlife of diversions from Mono Lake's primary tributary streams that occurred from 1941 until the present, and

quantify the potential future effects of each project alternative on wildlife.

The WHI is a habitat-specific value and is used to evaluate project impacts on wildlife in a manner similar to the USFWS's habitat evaluation procedures (HEP) methodology (U.S. Fish and Wildlife Service 1980). The method, however, differs significantly from HEP in that WHI is based on the observed wildlife species richness in each habitat type, rather than on modeled habitat values developed for a selected group of evaluation wildlife species.

A WHI value was determined for each habitat type in the study areas based on its combined species richness determined during the fixed-plot and plotless surveys. WHI values were calculated as the sum of the bird, mammal, reptile, and amphibian species observed in each habitat type divided by the total number of species observed in the four study areas. A habitat-specific WHI value was not calculated for ponds and lagoons because these habitats did not exist around the lakeshore during the 1991 field surveys. Similarly, specific bird census data on these habitats from the prediversion period were unavailable. Prediversion observations indicated that lakeshore ponds and lagoons attracted large concentrations of various duck and shorebird species (Banta and McPherson pers. comms.), but no attempt was made to quantify these migrant populations in the present analysis.

The relative species richness associated with each habitat in the four study areas was determined by calculating wildlife habitat units (WHUs). Habitat-specific WHUs were derived by multiplying the number of prediversion and 1991 acres by the WHI value for that habitat type. Prediversion acreage estimates were available for all habitats except for irrigated meadows in Study Area 4 and lakeshore scrub, meadow, and marsh habitats in Study Area 2. Irrigated meadows were not mapped in the prediversion period or during the 1991 field surveys (Chapter 3C, "Vegetation"). Thus, no attempt was made to calculate WHUs for this habitat. Similarly, wetland habitats around the lakeshore in Study Area 2 were not distinguishable on pre-1940 aerial photographs and their combined 356 acres were mapped as a single wetland type (Stine pers. comm.).

Lacking specific data, SWRCB consultants derived prediversion acreages for scrub, meadow, and marsh habitats in Study Area 2 by assuming that the proportions of individual habitats were similar under prediversion and current conditions. For example, the 206 acres of lakeshore willow scrub habitat mapped in 1991 represented about 4.1% of 5,034 vegetated acres around Mono Lake in that year; using this percentage, the prediversion lakeshore acreage for this habitat was estimated at 14.5 acres (i.e., 4.1% x 356 acres).

In addition to lakeshore willow scrub habitats, derived acreages for lakeshore mixed scrub, alkali wet and dry meadows, and short and tall emergent marsh habitats were used to calculate prediversion WHUs in Study Area 2. Throughout all the study areas, WHUs provided a quantitative basis for comparing the relative number of species associated with each surveyed habitat under prediversion and 1991 conditions.

Statistical Analyses

Vegetation, bird, and mammal data derived from the fixed plot surveys were subjected to statistical analyses using Biomedical Computer Programs-P (BMDP) (1992). Reptile and amphibian data were not included in these analyses due to their infrequent occurrence on the survey plots.

The independent variables, plot vegetation characteristics, were coded into discrete, ordered categories. For example, total percent vegetation coverage had four categories: 1 = 0-24%, 2 = 25-49%, 3 = 50-74%, and 4 = 75-100%. Relative cover in overstory, midstory, and understory, and dominant trees, shrubs, and herbaceous species were assigned to the same percentile categories. Vegetation vigor (e.g., establishing, mature, and decadent) and the site hydrology (e.g., standing water, saturated soil, and dry) were assigned to three categories.

The dependent variables were mean wildlife species densities and bird and mammal diversity values. Mean densities were calculated by dividing the total number of individuals of each species observed by the number of surveys over all plots. Species whose mean densities did not exceed 0.01 were omitted from the statistical analyses.

A measure of species diversity, the Shannon-Wiener Index (H'), was calculated on the mean densities of individual species observed on the plots. This index assumes equal sampling intensity on individual plots (Green 1979). For this reason, we did not include the bird data from the Paoha Island and Black Point survey plots in diversity calculations or other statistical analyses because only three, rather than five, surveys were conducted there. If no species were observed on an individual plot during the census period, the Shannon-Wiener index was set to zero.

For all statistical tests we assumed that vegetation and wildlife data gathered at individual plots were independent. This assumption was met by placing all survey plots at least 200 meters apart. For biological samples, non-normality of the error (or observation) distributions is common. In this analysis, we log-transformed H' values and individual bird densities to improve the normality of the data.

We used stepwise multiple regression analysis (BMDP 2R) to identify those vegetation variables that provide the best correlations with H'. This analysis selects the best correlative model by evaluating statistics (univariate F-statistics) for independent variables that are sequentially added or deleted to the model. (Addition and deletion sequences resulted in the same model in this analysis.) Independent variables in this analysis were individual layers, vegetation vigor, total percent cover, site hydrology, and the presence or absence of mature conifers.

We calculated univariate analyses of variance (ANOVAs) (specifically, BMDP 7D) to identify significant relationships between bird diversity and vegetation variables considered individually. We also applied a robust test to the equality of variance in our univariate ANOVAs by computing the absolute values of deviations from the group means (Brown and Forsythe 1974). After applying the Brown and Forsythe computations, significance criteria for the ANOVAs included: $P < 0.05$, moderately significant, $P < 0.01$, fairly significant, and $P < 0.001$ highly significant.

Individual correlations between bird and mammal species and vegetation variables were identified using multivariate regression and correlation analyses (BMDP 6R). Significant correlations between the mean densities of bird and mammal species and vegetation variables were identified by evaluating t-tests (two-tailed) of the regression coefficients.

RESULTS AND DISCUSSION

General Wildlife and Habitat Relationships

General results of the 1991 field surveys, the WHU calculations, and statistical analyses are presented and interpreted in the following sections. The characteristic species and relative importance of specific habitats to wildlife are described in a later section entitled "Specific Wildlife and Habitat Relationships."

Summary of Observations during the 1991 Field Surveys

A total of 193 vertebrate species were observed in the four study areas during the 1991 field surveys, including 161 bird, 29 mammal, two reptile, and one amphibian species (Table D-3). The highest species richness of birds and mammals was observed along tributary streams in Study Area 1 (116 species) and nearly 80 bird species were seen at the shoreline and nearshore waters of Mono Lake (Study Area

2). The Upper Owens River had the lowest species counts for all vertebrate taxa of the four study areas (Table D-3).

Combining data from both the fixed-plot and plotless surveys, conifer-broadleaf forests, cottonwood-willow woodlands, riparian willow scrub habitats, and the shores of Mono Lake supported the most bird species, and unvegetated floodplains and alkali flats supported the fewest (Table D-4).

The highest mammal species richness was encountered in riparian willow scrub habitats, but conifer-broadleaf forests, aspen groves, mixed riparian scrub, montane meadows, and great basin scrub habitats also supported at least 10 mammal species (Table D-4). Mature cottonwood-willow woodlands were not surveyed intensively for mammals due to the limited extent of this habitat in Study Area 1. Riparian conifer forest, stream channel, lakeshore willow scrub, alkali flat, and unvegetated shoreline habitats supported only one mammal species and no mammals were observed in short or tall emergent marshes in any of the study areas (Table D-4).

Two reptile species were observed in eight habitats and one amphibian, the western spadefoot, was noted exclusively in alkali wet meadows (Table D-4).

Habitats where a combined total of more than 40 bird, mammal, reptile, and amphibian species were observed included conifer-broadleaf forests, cottonwood-willow woodlands, aspen groves, riparian willow scrub (Study Area 1), and the shoreline of Mono Lake (Study Area 2) (Table D-4). These results suggest that habitats with dense tree or shrub cover along tributary streams, as well as the waters and shorelines of the lake, typically have the highest species richness within the four study areas.

Wildlife Habitat Values

Conifer-broadleaf forest, cottonwood-willow woodland, and riparian willow scrub habitats had the highest WHI values in the four study areas (i.e., WHI > 0.30), while unvegetated floodplains, alkali flats, lakeshore mixed scrub, and short and tall emergent marshes had the lowest (e.g., WHI < 0.10) values (Table D-5). Relative values of different wildlife habitats are discussed separately below for each study area.

Tributary Streams (Study Area 1). Between the prediversion period and 1991, acreages of riparian willow scrub, mixed riparian scrub, Great Basin scrub, and unvegetated floodplains increased in Study Area 1 (Table D-5). Major losses of acreage, however, occurred in cottonwood-willow woodlands and montane meadows, and moderate reductions also were found in conifer-broadleaf forests during this period. Conversion of riparian forests and montane meadows to scrub and unvegetated habitats resulted in an overall loss of more than 28 WHUs, or a 6% loss, in Study Area 1 in this time period (Table D-5).

Since diversion of Mono Lake's tributary streams began in 1941, the receding shoreline extended the channel of Lee Vining Creek by about 1,700 linear feet (0.32 mile) and that of Rush Creek by about 2,300 feet (0.44 mile) resulting in a combined increase of about 110 acres of new wildlife habitat for the two creeks (Chapter 3C, "Vegetation"). Changes in habitat acreages along Lee Vining and Rush Creeks were primarily due to increased channel length and the conversion of mature, riparian forests to scrub and unvegetated habitats resulting from stream dewatering and subsequent events (Table D-5).

In Study Area 1, the largest acreage increases occurred in arid, unvegetated floodplain and Great Basin scrub habitats and increases in WHUs were highest for these habitats (Table D-5). Moderate acreage increases also occurred, however, in certain water-dependent habitats with high WHI values, such as riparian willow scrub, especially along drainage ditches, irrigated pastures (e.g., Cain Ranch), and other artificially maintained wetland areas (Chapter 3C, "Vegetation").

Using the same WHI value to calculate both prediversion and current wildlife WHUs assumes that each habitat type supported a similar array of wildlife species in both time periods. Prediversion aerial photographs and wildlife surveys of Mono Lakes' tributary streams (e.g., those from Dixon 1915, 1916; Grinnell 1915; Taylor 1915) suggested that this assumption was valid for habitats such as mature conifer-broadleaf forests (i.e., above the diversion dam on Lee Vining Creek), aspen groves, riparian willow scrub, and montane meadows that were similar in structure and extent in both time periods. Cottonwood-willow woodlands were reduced by a greater acreage than any other habitat in Study Area 1 (Table D-5), and prediversion stands in Mono Basin probably supported more species than current early successional cottonwood habitats (Gaines 1988).

In prediversion years, cottonwood-willow woodlands formed broad riparian corridors of mature forest comprising about 50 and 160 acres along Lee Vining and Rush Creeks, respectively (Table D-6). Currently, only about 4 acres of narrow, regenerating cottonwood-willow woodlands are present along selected reaches of each creek. The extent of mature cottonwood-willow forests has been reduced by almost 93% on Lee Vining Creek and by more than 97% on Rush Creek (Table D-6).

Current cottonwood-willow woodlands along Lee Vining and Rush Creeks lack mature, multistoried vegetation (e.g., ground cover, shrub layer, saplings, and mature trees) that characterized prediversion riparian corridors (Chapter 3C, "Vegetation"). Narrow, discontinuous stands of small trees and shrubs offer fewer nesting, foraging, and resting opportunities habitat for wildlife than mature riparian corridors (Verner and Boss 1980). Bird distributional summaries of Mono Basin and the eastern Sierra Nevada (Gaines 1988, Hart and Gaines 1983) suggest that prediversion cottonwood-willow woodlands probably supported more species than any other terrestrial habitat. Thus, a simple multiplication of 1991 WHI values with prediversion acreages probably underestimates the overall wildlife values of this habitat lost during the diversion period. Moreover, the almost complete loss of mature riparian habitat along creeks in these areas resulted in virtual elimination of the riparian wildlife corridor that once connected the montane forests with the shores of Mono Lake.

Mono Lake Shoreline (Study Area 2). Wetland habitats occupied about 553 acres of Mono Lake's shoreline in the prediversion period, and 260 acres of shoreline (about 47%) consisted of pond and lagoon habitats (Table D-5). Derived prediversion estimates suggest that the remaining 293 vegetated acres probably consisted of a mixture of wet meadows, marshlands, and scrublands.

During the diversion period, the total acreage of Mono Lake's shoreline area increased by about 10,600 acres and lakeshore scrublands, alkali dry and wet meadows, short and tall emergent marshes, and alkali flats grew to their greatest probable extent (Table D-5). Exposure of vast areas of former lakebed sediments and subsequent colonization by marsh and upland vegetation created thousands of acres of new wildlife habitat and resulted in an overall increase of about 615 WHUs (Table D-5).

Wildlife habitats colonizing the shoreline during the diversion period were dominated by arid, sparsely vegetated uplands, dense marshlands, or unvegetated alkali flats. Alkali flats represent almost 50% of Mono Lake's current lakeshore acreage and had the lowest WHI value within the four study areas (Table D-5). Similarly, lakeshore scrub habitats, alkali wet and dry meadows, and short and tall emergent marshes had relatively low WHI values (i.e., < 0.15), indicating that they are used by relatively few species compared to many terrestrial habitats in Mono Basin (Tables D-4 and D-5).

Lakeshore willow and mixed scrub habitats are usually found in relatively small (a few acres or less), isolated patches around the lake. Their small size and isolation, together with a lack of fresh water and the presence of typically saline, saturated soils, limit the number of resident bird and mammal species that can occur there. WHI values are relatively low. Lakeshore scrub habitats are probably used by a variety of migratory birds passing over Mono Lake, however, offering important habitat for these species.

Due to their lack of fresh water and low wildlife cover, alkali and dry meadows have moderately low habitat values (i.e., WHI < 0.15) (Table D-5). These arid habitats are often dominated by sparse stands of saltgrass and are used by a few specialized species. Because of its large acreage, however, these habitats contribute about 70% of the new WHUs that have been created around the lakeshore during the diversion period. Wet meadows have grown by about 45 acres during the diversion period and added some new wildlife habitat within Study Area 2 (Table D-5). Wet meadows around Mono Lake currently do not support high numbers of birds or other wildlife; their use by ducks, shorebirds, and wading birds would probably increase, however, if sources of open water were available nearby.

Almost all of the prediversion ponds and lagoons were lost during the diversion period as the lake's elevation receded (Chapter 3C, "Vegetation"). In the absence of bird census data from ponds and lagoons in the prediversion period, it is impossible to calculate how loss of this habitat contributed to changes in wildlife use of Mono Basin. Clearly, the major concentrations of ducks and shorebirds that used to visit Mono Lake are no longer present (Banta, DeChambeau, and McPherson pers. comms.).

In addition to attracting a high number of bird species (i.e., high species richness), ponds and lagoons around Mono Lake served as concentration areas for a few of the most abundant duck, wading, and shorebird species; during fall migration the bird densities there were far higher than at any other habitat in Mono Basin (Banta and McPherson pers. comms.). Thus, an index based on resident species richness alone does not reflect the overall importance of ponds and lagoons to regional migratory water bird populations in the prediversion period.

Paoha Island (Study Area 3). The only source of fresh water on Paoha Island is the spring and surrounding marshland near the southeast shore of the island (Chapter 3C, "Vegetation"). Studies conducted on the island in 1991 suggested that short and tall emergent marsh vegetation associated with this spring have somewhat higher WHI values than similar mainland habitats (Morrison 1991). This difference may reflect the water needs of many bird and mammal species on the island that depend on this single source of water and may visit it frequently. In contrast, marsh-dependent species on the mainland have extensive acreages of similar habitats to choose from, and few areas offer sources of fresh water. The marsh at Paoha Island has increased by about 1.2 acres during the diversion period, representing a slight increase in its wildlife habitat value.

Upper Owens River (Study Area 4). The acreage of willow scrub habitat decreased by 12.4 acres along the Upper Owens River during the diversion period, which represents a loss of about 2 WHUs (Table D-5). Assuming that irrigated meadow habitat replaced the willow scrub habitat, a loss of only 0.7 WHUs occurred, which is a minor decrease in wildlife value along the Upper Owens River.

Wildlife and Habitat Diversity Relationships

The wildlife value of a specific habitat depends on its size, condition, structural characteristics, plant species composition, and continuity with adjacent habitats. Previous studies have identified correlations between the richness and diversity of bird communities and various vegetation measurements such as foliage height diversity (MacArthur and MacArthur 1961, Karr 1968, Karr and Roth 1971, Cody 1981), foliage volume (Balda 1969, Franzreb and Ohmart 1978, Szaro and Balda 1979, Larson 1981), or percent canopy closure (Whitmore 1975, Beedy 1981). Other workers, however, have found few correlations between bird communities and various measures of vegetative diversity, especially between habitats with similar structure (Tomoff 1974, Willson 1974, Rotenberry and Wiens 1980, Wiens and Rotenberry 1981, Beedy 1982). In general, taxonomic diversity of forests has not been predictive of avian community patterns (MacArthur and MacArthur 1961, Cody 1974, Beedy 1982).

Within the four study areas, our fixed-plot surveys included a broad array of habitats ranging from mature conifer-broadleaf forests to barren alkali flats. Measurable differences in the richness and diversity of wildlife communities and in the occurrence of individual species and wildlife-habitat associations are likely when ecologically and structurally dissimilar habitats are compared (Verner and Boss 1980, Weins and Rotenberry 1981, Zeiner 1990a).

Stepwise multiple regression and univariate ANOVA analyses of the wildlife plot data revealed significant relationships ($P < 0.05$) between bird species diversity (H') and the number of vegetative layers; percent cover of tall trees, shrubs, and low trees; and the degree of soil saturation (Table D-7). Univariate anovas also indicated a moderately significant relationship between mammal diversity and the percent cover of shrubs and low trees but not for the other vegetation variables (Table D-7).

Multivariate regression and correlation analyses were used to analyze relationships between 16 of the most common bird species and vegetation characteristics on the survey plots (Table D-8). Four species, including western wood pewees, house wrens, American robins, and warbling vireos, were significantly correlated with increased percent cover of tall trees. Similarly, seven species were correlated with conifer or aspen overstory or midstory vegetation, and six species were correlated with rose and snowberry midstory vegetation. These correlations probably do not represent a preference for specific plant species by birds; rather conifers, aspens, roses, and snowberries were frequently dominant species in the tree and shrub categories on the study plots. Significant correlations were not found with tall cottonwoods or willows, probably because only one study plot contained individuals of these species that exceeded 12 feet.

Percent cover of shrubs and low trees had a moderately significant correlation with mammal diversity (Table D-7). Nuttall's cottontails, Douglas' squirrels, lodgepole chipmunks, and deer mice had significant correlations with more than one vegetation variable (Table D-9). In general, however, fewer significant relationships between vegetation characteristics and individual mammal species were found than for bird species. This suggests that small mammals may select habitats based on microhabitat conditions that were not measured in this study.

Major Conclusions

Correlation analyses suggested that mature, multistoried habitats offer the greatest array of resources to wildlife, especially birds, along Mono Lake's tributary streams. Bird diversity and the abundance of many species were highest in moist forests with vertical layering and many tall trees. These conditions were typical of prediversion mature cottonwood-willow woodlands. The conversion of more than 200 acres of these woodlands along Lee Vining and Rush Creeks to arid Great Basin scrub and unvegetated floodplain habitats had the effect of replacing a high-value wildlife habitat with low- and moderate-value habitats. Elimination of this prediversion mature riparian corridor substantially diminished carrying capacity, disrupted the natural movement patterns of resident wildlife, and removed an important migratory stopover area for birds migrating through the arid Great Basin.

Creation of more than 10,600 acres of new habitat around the shoreline of Mono Lake has benefited specialized wildlife species, such as snowy plovers, that tolerate arid, saline conditions and a lack of fresh water. Most of the exposed lakeshore is now dominated by habitats with limited wildlife value, such as alkali flats, dry and alkaline meadows, sparsely vegetated uplands, and dense, brackish, or saline marshes. Together with this large habitat increase was the elimination of about 260 acres of pond and lagoon habitat around the lakeshore. These former wetland habitats attracted an abundance of ducks and shorebirds, but their value to other wetland-dependent wildlife is unknown. While the overall increase in wildlife value of existing lakeshore habitats can be estimated, eliminating ponds and lagoons resulted in a major but incalculable reduction in habitat conditions for ducks, shorebirds, and probably other wildlife. Thus, while the increase in habitat acreage benefits terrestrial wildlife, these benefits must be weighed against the detrimental effects of the losses of the aquatic habitats around Mono Lake.

Specific Wildlife and Habitat Relationships

Tributary Streams (Study Area 1)

Riparian Conifer Forest. Riparian conifer forests consist primarily of an association of lodgepole and Jeffery pine trees. These habitats were not mapped or surveyed systematically for wildlife because they occur primarily above the LADWP diversion points and would be unlikely to be affected by any of the alternatives. Incidental observations of wildlife associated with riparian conifer forests, however, were recorded during our field investigations but were not used to calculate WHI and WHU values for this habitat.

Twenty-eight species of birds and one mammal were observed in riparian conifer-forest during plotless surveys (Table D-4). Characteristic wildlife species included great horned owl, red-breasted sapsucker, hairy woodpecker, western wood pewee, brown creeper, Steller's jay, mountain chickadee, pygmy nuthatch, warbling vireo, western tanager, dark-eyed junco, and Douglas' squirrel.

Riparian conifer forest habitats generally support a greater diversity of plants and provide more overstory, midstory, and understory cover compared to adjacent, drier conifer habitats. Similarly, riparian conifer forests provide higher breeding, resting, and escape cover, and foraging values for more wildlife than adjacent uplands.

Conifer cones provide nuts that are fed on by many wildlife species, such as Douglas' squirrels, chipmunks, and Clark's nutcrackers. Bark surfaces provide favored habitats for several invertebrates, such as insects and arachnids, that are favored food sources for insectivorous species. Tree sap and cavities provided by conifers are favored nesting and feeding areas for woodpeckers. Cavities excavated by woodpeckers also provide nesting sites for several bird species that are incapable of excavating their own, such as western bluebirds.

Conifer-Broadleaf Forest. Riparian conifer-broadleaf forests were defined as habitats in which Jeffrey pine and cottonwood or aspen are codominant species. A total of 32.4 acres of riparian conifer-broadleaf forest was mapped on the upper reaches (i.e., upstream from U.S. 395) of Rush, Lee Vining, Parker, Walker Creeks (Table D-5). The density of riparian conifer-broadleaf forest canopy, midstory, and understory cover varied considerably between individual reaches (Chapter 3C, "Vegetation").

Eight plots were established in conifer-broadleaf habitats (Table D-2), and a total of 50 bird, 10 mammal, and one reptile species were observed there during our surveys (Table D-4). Species typically associated with this habitat include red-breasted sapsucker, calliope hummingbird, western wood pewee, mountain chickadee, house wren, Townsend's solitaire, warbling vireo, Nuttall's cottontail, least chipmunk, lodgepole chipmunk, long-tailed vole, mule deer, and sagebrush lizard (Table D-4).

This habitat provides the greatest diversity of plant species and vegetative structure of the habitat types currently existing in Study Area 1. In addition to understory and midstory layers, conifer-broadleaf forests usually provide a multilayered overstory canopy with mature conifers as the tallest species.

This habitat attracts wildlife associated with conifers as well a deciduous trees. Conifers and deciduous trees provide cavities and support a variety of insects for food. Lands adjacent to this habitat are often unforested; therefore, wildlife, such as brown creepers and nuthatches, that normally are not present in lower elevation habitats frequent these sites.

Conifer-broadleaf forest had the third highest WHI value among surveyed habitats, and only mature cottonwood-willow woodlands and riparian willow scrub habitats support more wildlife species (Table D-5). Among surveyed habitats, conifer-broadleaf forests have the most tall trees and vertical layering; both vegetation variables are significantly correlated with bird diversity (Table D-7). Current conifer-broadleaf forests in the Mono Lake Basin are probably structurally similar to prediversion forests, but the loss of almost 20 acres of this habitat has resulted in some reduced wildlife habitat value in Study Area 1 (Table D-5).

Cottonwood-Willow Woodland. Cottonwood-willow woodlands are dominated by black cottonwoods that may be codominant with willows or aspens in some locations. Most of the 39.8 acres of cottonwood-willow woodland in Study Area 1 is on Rush and Lee Vining Creeks (Table D-6). Most currently existing stands are narrow, discontinuous, and lacking in mature trees (Chapter 3C, "Vegetation").

More than 200 acres of mature cottonwood-willow woodland have been lost from Rush and Lee Vining Creeks since diversions began (Table D-6). Before 1941, cottonwood-willow woodland was a dominant cover type occurring as broad, continuous, and multilayered stands (Stine 1991, Chapter 3C, "Vegetation"). After years of dewatering and recent rewatering, this habitat now occurs as small disjunct clumps and most stands are associated with cobbley floodplain deposits. These sparsely vegetated areas are dominated by cottonwood trees standing less than 30 feet tall. Most stands contain decadent trees or saplings that have resprouted in response to recent rewatering of stream channels.

Three plots were established in early successional stages of this habitat type (Table D-2), and 17 bird and four mammal species were observed there (Table D-4). An additional 47 bird and one mammal species, however, were observed in cottonwood-willow woodlands outside Study Area 1 during plotless surveys of riparian stands along DeChambeau, Post Office, and Wilson Creeks and stands of mature cottonwood near the Mono County Park. These additional bird species increased the WHI index value of this habitat from that derived from fixed plots located in sparsely vegetated, early successional stands on Lee Vining and Rush Creeks.

Characteristic species observed in cottonwood-willow habitats of Mono Basin included great horned owl, long-eared owl, downy woodpecker, hairy woodpecker, dusky flycatcher, Steller's jay, violet-green swallow, mountain chickadee, brown creeper, house wren, American robin, cedar waxwing, blue-gray gnatcatcher, warbling vireo, solitary vireo, Wilson's warbler, yellow warbler, MacGillivray's warbler, western tanager, lazuli bunting, rufous-sided towhee, song sparrow, northern oriole, deer mouse, long-tailed vole, and mule deer (Table D-4).

The prediversion value of this habitat to wildlife is probably not reflected by its current WHI value derived from both fixed-plot and plotless surveys. None of the extant stands of cottonwood-willow woodland in Mono Basin offer the length, width, or habitat structure present on the lower reaches of Lee Vining and Rush Creeks under prediversion conditions (Chapter 3C, "Vegetation"). The diversity of wildlife associated with cottonwood-willow habitats would be expected to increase significantly as recovering stands gradually become more extensive, mature, and continuous.

Mature cottonwood-willow habitats in good condition would support several layers of vegetation and provide important nesting and foraging habitat for many resident and migratory wildlife species. Historically, cottonwood-willow woodlands often occurred as wide bands of vegetation that provided a near continuous corridor of wooded habitat from higher elevation conifer-broadleaf forests to the lakeshore terrace (Chapter 3C, "Vegetation"). Stand continuity allows secretive species that are intolerant of open habitats to move along the length of the corridor, and wider stands provide more protection from disturbance by humans and more movement of predators than narrower stands.

Aspen Groves. This habitat is dominated by aspen trees but may include a few Jeffery pine and/or cottonwood trees. The current total of 11.3 acres of aspen represented a slight decline from the prediversion acreage (Table D-5). Aspen is present on all the diverted creeks, and the largest stands occur above the diversion structures on Lee Vining, Walker, and Parker Creeks.

Aspen stands may be supported hydrologically by springs, seeps from snow saturation, or streamflows (Chapter 3C, "Vegetation"). Only those groves associated with surface streams, however, were considered riparian habitats in this study. Aspen stands usually provide dense overstory cover and may support a mixed midstory of young aspen trees and riparian and Great Basin scrub species. Riparian aspen groves along Parker and Walker Creeks often had evidence of disturbance such as grazing, firewood clearing, and camping areas.

Four wildlife survey plots were established in aspen groves (Table D-2). Eighteen bird, 10 mammal, and one reptile species were observed during the fixed-plot surveys and 16 additional bird species were observed in this habitat during plotless surveys (Table D-4). Species using aspen stands included rufous hummingbirds, red-breasted sapsuckers, western wood pewees, tree swallows, white-breasted nuthatches, house wrens, mountain bluebirds, yellow warblers, western tanagers, northern orioles, Nuttall's cottontails, least chipmunks, Douglas' squirrels, Panamint kangaroo rats, bushy-tailed wood rats, and sagebrush lizards.

Aspen stands provide important wildlife habitat in Mono Basin, especially since mature cottonwood-willow woodland and other broad-leaved habitats are currently scarce. Aspen stands, however, tend to have dense overstory cover and reduced understory vegetation compared to mature cottonwood-willow habitats.

Despite their increased cover of tall trees, aspen groves in Study Area 1 had a lower WHI value than riparian willow scrub habitats (Table D-5). In general, habitats with tall trees and several vertical layers support higher bird diversities (Table D-7). Within Study Area 1, however, riparian scrub habitats occupied far greater acreage and varied more widely in other vegetation characteristics (e.g., percent cover, age class, understory composition, and soil saturation) than aspen habitats.

Riparian Willow Scrub. Willows are the dominant woody vegetation in this habitat; however, a subdominant component of rose, buffaloberry, or other shrubs also may be present. A total of 207.1 acres of willow scrub currently exists in the study area, representing more than 20 acres of new habitat since the prediversion period (Table D-5). Willow scrub is present on all the diverted streams and is uncommon only on Lee Vining Creek (Chapter 3C, "Vegetation").

Riparian willow scrub habitats vary in structural characteristics depending on site location. Decadent, impenetrable thickets are common in areas that have been dewatered during the past 50 years. Very young, sparse stands supporting little or no understory vegetation are establishing adjacent to recently rewatered channels and deltas on Lee Vining and Rush Creeks. Open-canopied, mature stands with meadow understorys are common on more stable, meandering reaches of the creeks, especially above U.S. 395.

Nine survey plots were established on willow scrub habitats on the tributary streams (Table D-2). A total of 19 bird, 15 mammal, and two reptile species were observed during the fixed-plot surveys, and 28 additional bird species were observed during nonsurvey periods (Table D-4). Species present in willow scrub habitat include long-eared owls, Pacific-slope and ash-throated flycatchers, mountain bluebirds, American robins, yellow warblers, McGillvray's warblers, rufous-sided towhees, fox sparrows, song sparrows, Brewer's blackbirds, vagrant shrews, Belding's ground squirrels, Great Basin pocket mice, pinyon mice, long-tailed voles, porcupines, mule deer, and western aquatic garter snakes.

Riparian willow scrub habitats provide high-quality nesting, escape, feeding, and resting cover required by many wildlife species. Because willow scrub in Mono Basin most often occurs within open habitats, such as meadows, irrigated pastures, and unvegetated floodplains, this community provides vertical structure and cover for wildlife that otherwise would not be present.

The WHI value of riparian willow scrub was second highest, and only cottonwood-willow woodlands had a larger value (Table D-5). Willow scrub habitats had four more mammal species than any other habitat type. The diversity of mammals was probably greater because adjacent habitats were typically open (e.g., meadows and unvegetated floodplains), and mammals were attracted to the shade and cover of willow scrub habitats. Bird species richness values recorded in this habitat were probably also increased due to its relatively large acreage (Table D-5); proportionally more time was spent there than in other scrub and forested habitats during the 1991 field surveys.

Mixed Riparian Scrub. Mixed riparian scrub is dominated by rose or buffaloberry shrubs growing in association with willows, young cottonwoods, or other upland shrubs. A total of 82.0 acres of this habitat currently exists on Rush, Lee Vining, Parker, and Walker Creeks and represents more than 60 acres of new habitat since 1941 (Table D-5).

This habitat usually occupies complex hydrologic sites in which soil moisture changes with minor changes in floodplain elevation (Chapter 3C, "Vegetation"). Mixed riparian scrub generally supports a dense canopy that, depending on the dominant species, can range from approximately 3 feet to over 15 feet in height.

Seven plots were established in mixed riparian scrub habitats along Walker and Rush Creeks (Table D-2). A total of 21 bird, 10 mammal, and one reptile species were observed there during the fixed-plot surveys, and six additional bird and one mammal species were observed during plotless surveys (Table D-4). Species observed in mixed riparian scrub habitat included bushtits, yellow warblers, green-tailed towhees, song sparrows, American goldfinches, Brewer's blackbirds, Nuttall's cottontails, Great Basin pocket mice, deer mice, bushy-tailed woodrats, ermine, bobcat, coyotes, and sagebrush lizards.

Mixed riparian scrub provides wildlife cover values similar to those described for riparian willow scrub. Because it often occupies somewhat drier sites, however, mixed riparian scrub habitats appear to have somewhat lower wildlife habitat value than streamside willow thickets.

Unvegetated Floodplain. This habitat category consists primarily of stream deposits dominated by large cobbley substrates supporting less than 10% herbaceous or woody cover. More than 270 acres of this habitat currently exist in the study area, representing an increase of almost 180 acres from the prediversion period (Table D-5).

In Study Area 1, these habitats are primarily located on Lee Vining and Rush Creeks and were created by floodflows that deposited gravel and cobble or exposed stream deposits through channel incision (Chapter 3C, "Vegetation").

One survey plot was established on sparsely vegetated stream cobble (Table D-2) and five bird, two mammal, and one reptile species were observed during the fixed-plot surveys. Additional bird and mammal species were observed in this habitat during the plotless surveys and representative species in this habitat were killdeer, spotted sandpiper, violet-green swallow, cliff swallow, Brewer's blackbird, Panamint kangaroo rat, water shrew, deer mouse, and coyote (Table D-4).

This habitat provides foraging and loafing habitat for a few species of wildlife. Gravels and sands along these creeks support invertebrates and ruderal vegetation that frequently grows there and provides foraging and resting cover for wildlife. Many California gulls, eared grebes, ducks, and a few other species of waterbirds frequent the deltas of Lee Vining, Rush, and Wilson Creeks to drink, loaf, and forage on exposed gravel bars. Open stream deposits adjacent to channels also allow access to water for large mammals such as mule deer. Aside from alkali flats and tall emergent marshes, however, the WHI value of unvegetated floodplain habitat was the lowest recorded in any of the study areas (Table D-5).

Montane Meadow. For the purposes of wildlife analyses, montane meadows included wet meadows, upland meadows, and irrigated pasturelands (Table D-1). These habitats were considered as a single habitat type during the fixed-plot surveys because different types were difficult to distinguish due to past land use practices such as altered water regimes and grazing. Also, wet meadows and irrigated pasturelands are similar structurally and in their functional wildlife habitat values. Montane meadows in Mono Basin are managed primarily to produce livestock forage and are grazed in late spring to fall (Chapter G, "Land Use").

Almost 500 acres of montane meadows exist in Study Area 1, representing a loss of 92 acres from the prediversion period (Table D-5). Under current conditions, unirrigated meadows are usually small areas dominated by forbs, rushes, sedges, or grasses. Most of these meadows support plant species adapted to drier soils, however, inclusions of wet meadow plant communities may occur within drier meadow types near springs, seeps, and creek banks. Irrigated pastures are similar in character to montane meadows, but are more extensive and have a larger component of grass species (Chapter 3C, "Vegetation").

Most irrigated pasturelands in Mono Basin are located on the Cain Ranch between Rush and Walker Creeks upstream from U.S. 395 and to the north of the lake near Mono County Park and at Conway and DeChambeau Ranches. Montane meadows provide foraging areas and cover for wildlife species associated with herbaceous habitats. Generally, ungrazed meadows and pastures provide greater cover and forage values than those that are grazed (Medin and Clary 1990). Due to its low stature and relative lack of wildlife cover, however, the WHI value of montane meadow habitat is relatively low compared to shrub- or tree-dominated habitats (Table D-5).

Eight plots were located in montane meadow habitats (Table D-2), and a total of nine bird, 11 mammal, and one reptile species were observed there during the fixed-plot surveys. Eight additional bird species were observed in montane meadow habitats during plotless surveys (Table D-4). Characteristic species observed in this habitat included tree swallows, violet-green swallows, mountain bluebirds, Brewer's blackbirds, black-tailed hares, least chipmunks, Belding's ground squirrels, coyotes, mule deer, and sagebrush lizards.

Recovering Riparian Areas. Areas ecovering riparian areas were defined as stream reaches where historical woody vegetation was lost due to dewatering and where young vegetation is growing in response to recent rewatering. These areas would be expected to increase in extent and condition with continuing streamflows (Chapter 3C, "Vegetation").

Five survey plots were defined as recovering riparian areas (Table D-2). Two of these plots were dominated by mixed riparian scrub, two had reverted to montane meadows, and one was an unvegetated floodplain. Twelve bird, nine mammal, and one reptile species were observed on these plots. Eight additional bird and one mammal species were observed during nonsurvey periods (Table D-4). Representative wildlife species in recovering riparian areas included northern rough-winged swallows, cliff swallows, Bewick's wrens, mountain bluebirds, Brewer's blackbirds, water shrews, Nuttall's cottontails, least chipmunks, Great Basin pocket mice, sagebrush voles, and mule deer (Table D-4).

Recovering riparian areas provide foraging and cover values for wildlife species that are associated with the early successional stages of herbaceous, shrub, and woodland riparian habitats. WHI values were not calculated for these habitats, however, because the early stage of succession made it difficult to determine what the mature vegetation on the plot would be. Thus, recovering riparian areas define an early successional condition rather than a habitat type.

Stream Channels. Stream channels include flowing water, channel banks, and point bar deposits. Incidental observations were made of 10 bird and one mammal species using stream channels in Study Area 1 (Table D-4). Species observed using stream channels included great blue herons, black-crowned night herons, mallards, gadwalls, killdeer, spotted sandpipers, belted kingfishers, American dippers, and water shrews. American dippers are unique to stream channel habitats within the study areas.

Stream channels are required habitat elements for some species because they provide water for drinking and bathing, foraging habitat for some species (e.g., ducks and belted kingfishers that feed on aquatic plants or animals), and escape cover for aquatic birds and mammals. Channel banks and point bars provide loafing and foraging areas for some shorebirds and waterbirds. Exposed cut banks also provide nesting substrates for some species, such as northern rough-winged swallows.

Fixed-plot surveys were not conducted in stream channels; therefore, WHI and WHU values were not calculated for this habitat.

Great Basin Scrub. Great Basin scrub habitat occupies arid sites and is dominated by sagebrush, rabbitbrush, bitterbrush, and other upland shrubs (Chapter 3C, "Vegetation"). Great Basin scrub is the dominant nonforested upland habitat in Mono Basin, surrounding the inventoried wetland and riparian habitats. Currently, more than 900 additional acres of this habitat exist along Mono Lake's diverted tributary streams, representing an increase of more than 140 acres since the prediversion period.

Five Great Basin scrub plots were established in the vicinity of Black Point and a total of nine bird, nine mammal, and one reptile species were observed during the fixed-plot surveys; an additional 20 bird and two mammal species were observed during nonsurvey periods (Table D-4). Species observed in Great Basin scrub habitats during surveys included sage grouse, pinion jays, sage thrashers, green-tailed towhees, Brewer's sparrows, black-tailed hares, least chipmunks, Panamint kangaroo rats, chisel-toothed kangaroo rats, montane voles, and sagebrush lizards.

Great Basin scrub provides nesting, escape, and resting cover, and forage for many species of wildlife not associated with water-dependent habitats. Thus, the WHI value of Great Basin scrub in Study Area 1 is higher than montane meadows and unvegetated floodplains but lower than most habitats dominated by shrubs and trees along the tributary streams (Table D-5). The combination of increasing acreage and a relatively high WHI value result in an increased WHU value for this habitat in Study Area 1 over the diversion period. Similar to other widespread habitats in Mono Basin (e.g., riparian willow scrub), SWRCB consultants spent proportionately more time surveying Great Basin scrub habitats than less common scrub types (e.g., mixed riparian scrub and lakeshore willow scrub), which probably increased the species counts for this habitat.

Lakeshore Habitats (Study Area 2)

Lakeshore Willow Scrub. Lakeshore willow scrub habitats are uncommon in Mono Basin and occur as relatively small (i.e., a few acres or less), isolated patches near lakeshore springs and seeps. A total of 210 acres of this habitat occurs in Study Area 2 (Table D-5), and the largest stands currently exist near Danberg Beach and at the mouth of Wilson Creek. This represents an increase of about 180 acres compared to prediversion conditions (Table D-5).

Lakeshore willows occupy moist sites that are not permanently saturated year-round. They are usually monotypic inclusions in surrounding wetland or meadow habitats. Due to its isolation and habitat structure, lakeshore willow scrub habitat offers similar wildlife habitat values to the lakeshore mixed-scrub areas described below.

Five species of birds were observed during fixed-plot surveys of lakeshore willows, and 13 additional species were observed during plotless surveys of this habitat (Table D-4). Mammal species were not censused in this habitat because most plots were wet during the field surveys. Birds observed nesting in lakeshore willow scrub included house wrens, yellow warblers, song sparrows, red-winged blackbirds, and Brewer's blackbirds. This habitat probably also is used by a variety of migrant flycatchers, warblers, vireos, sparrows, and other songbirds. The structural wildlife values provided by lakeshore willows are similar to those described for riparian willow scrub. Lakeshore sites, however, do not provide habitat for wildlife species requiring large, continuous patches of willows, stream banks, deposits, or flowing water. The WHI value of lakeshore willow scrub, similar to other lakeshore habitats is low compared to tree-dominated habitats along tributary streams (Table D-5).

Lakeshore Mixed Scrub. Lakeshore mixed scrub habitat is uncommon and occurs as small isolated patches near lakeshore springs and seeps, such as those near the Lee Vining Tufa Grove. Most of the 26 acres mapped of this habitat type are composed of willow and typical Great Basin shrub species (Table D-5). This habitat was not distinguishable on prediversion aerial photographs, but the extent of lakeshore scrub habitats appeared to be limited in this period (Stine pers. comm.).

Mixed-scrub habitats occupy lakeshore sites that are hydrologically complex. Abrupt spatial changes in soil moisture on these sites results in a mix of water-tolerant shrubs, such as willows, growing in close association with species adapted to drier soil conditions, such as rabbitbrush. Stands of lakeshore mixed scrub generally occur as inclusions in surrounding wetland, meadow, or Great Basin scrub habitats (Chapter 3C, "Vegetation").

The estimated WHI value of this habitat is slightly lower than that of lakeshore willow scrub (Table D-5), possibly because lakeshore mixed-scrub habitats occupy less acreage and received a lower sampling intensity. Wildlife species observed on surveys included house wrens, European starlings, yellow warblers, Brewer's sparrows, savannah sparrows, song sparrows, red-winged blackbirds, brown-headed cowbirds, Nuttall's cottontails, and California ground squirrels (Table D-4).

The structural characteristics and wildlife values of lakeshore mixed scrub are similar to those described for riparian mixed scrub. Lakeshore mixed scrub habitats are, however, generally composed of fewer shrub species than riparian mixed scrub habitats (Chapter 3C, "Vegetation"). Wildlife species that use mixed scrub habitats only in association with streambanks, deposits, or flowing water would not frequent this habitat.

Alkali and Dry Meadows. Alkaline and dry meadows occupy recently exposed lake terrace sites and are dominated by saltgrass, rushes and other salt-tolerant species. A total of about 3,920 acres of these habitats currently exist around the lake, representing an increase of more than 3,786 acres from prediversion conditions (Table D-5). Dry meadows are widely distributed around the lakeshore, and they are usually associated with alkaline soils that depend on rain and snowfall for moisture (Chapter 3C, "Vegetation").

Six alkali and dry meadow plots were established around the lakeshore (Table D-2). Nine bird and five mammal species were observed there during the fixed-plot surveys (Table D-4), and eight additional bird species were observed during plotless surveys (Table D-4). Typical species observed in alkali and dry meadows included horned larks, violet-green swallows, savannah sparrows, red-winged blackbirds, Brewer's blackbirds, black-tailed hares, Panamint kangaroo rats, deer mice, and coyotes.

Alkaline and dry meadows provide foraging areas and cover for a few wildlife species associated with saline, herbaceous habitats. Wildlife habitat values are reduced because vertical structure, vegetative diversity, and sources of fresh water are lacking in this habitat. Thus, despite their large increase in acreage from the prediversion period, alkaline and dry meadow habitats around Mono Lake provide some cover, but offer limited foraging opportunities or water; consequently, their use by wildlife is limited. The WHI value of these habitats were slightly higher than that of lakeshore scrub habitats (Table D-5), possibly because its acreage is so much greater, and because SWRCB consultants spent proportionately more time surveying these areas than other lakeshore habitats.

Wet Meadow. Wet meadows occupy recently exposed lake terraces that are watered by springs, seeps, and groundwater. Wet meadows are dominated by sedges, rushes, or grasses in various combinations (Chapter 3C, "Vegetation"). A total of 51 acres of wet meadow habitats occur around the lakeshore, representing an increase of more than 44 acres from prediversion conditions (Table D-5). Among the lakeshore wetland habitats surveyed, alkali wet meadows supported the greatest diversity of plant species (Chapter 3C, "Vegetation"). Presumably, this is because wet meadows occupy sites with water and soils that vary widely in salinity and alkalinity. For the wildlife analysis, fresh, brackish, and saline marshes were considered as a single habitat type.

Seven wet meadow plots were established (Table D-2). Twelve bird and one mammal species were observed there during the fixed-plot surveys, and eight additional bird, two mammal, and one amphibian species were recorded during plotless surveys (Table D-4). Species observed in alkali wet meadow habitat included killdeer, Wilson's phalaropes, horned larks, violet-green swallows, cliff swallows, savannah sparrows, red-winged blackbirds, western meadowlarks, Brewer's blackbirds, montane voles, and Great Basin spadefoots.

Despite their large acreage (Table D-5), high plant diversity, and variable hydrological conditions, alkali wet meadows, like alkali dry meadows, receive limited wildlife use. Wet meadows typically have higher cover than dry meadows because dominant plants generally grow taller and denser. Wet meadows that hold standing water also provide habitat for some wading birds and shorebirds but few mammals, resulting in a relatively low WHI value for this habitat.

Short Emergent Marsh. Short emergent marsh is dominated by alkali bulrush and sedges that are less than 3.5 feet in height. Stands are dense, and often have 100% cover. Short emergent marshes occupy sites that support seasonally saturated soils (Chapter 3C, "Vegetation"). A total of about 933 acres of short emergent marshes occur around the lakeshore, representing an increase of almost 815 acres from prediversion conditions (Table D-5).

A total of nine plots were located at short emergent marsh habitats on lower lakeshore terraces of extensive wetland areas at Simon Springs, Warm Springs, and at the DeChambeau Marsh. Due to the presence of standing water or saturated soils, these plots were judged to be unsuitable habitat for small mammals (Harris pers. comm.) and were surveyed only for birds (Table D-2). Seventeen bird species were observed during in fixed-plot and plotless surveys of short emergent marshes, including killdeer, American avocets, Wilson's phalaropes, soras, marsh wrens, violet-green swallows, savannah sparrows, red-winged blackbirds, yellow-headed blackbirds, and Brewer's blackbirds (Table D-4).

Short emergent marshes around Mono Lake currently provide limited wildlife habitat value. The dense vegetation typically lacks open water areas that are attractive to ducks and other common marsh inhabitants. Because vegetation is short, it does not provide the nesting structure favored by herons, blackbirds, and other species that frequent tall emergent habitats.

Around the Mono Lake shoreline, this habitat occurs in broad expanses and contains inclusions of alkali meadow and tall marsh habitats. The most concentrated use of this habitat by wildlife probably occurs at the edges of tall and short emergent marshes and meadow habitats where the marsh is available as escape cover and the higher vegetation can be used for perching. Probably due to the lack of open, ponded water nearby, the WHI value of short emergent marshes is low, even compared to other lakeshore wildlife habitats (Table D-5).

Tall Emergent Marsh. Tall emergent marshes were defined as wetland habitats dominated by hardstem bulrush and/or cattail greater than 3.5 feet and that attain heights greater than 6 feet. Tall emergent marsh is associated primarily with permanent springs and seeps on the lower lakeshore terraces, and the largest areas are located at Simon Springs, Warm Springs, the DeChambeau Marsh, and at scattered locations along the western shoreline (Chapter 3C, "Vegetation"). Approximately 55 acres of tall emergent marshes currently exist around Mono Lake, representing an increase of 48 acres from prediversion conditions (Table D-5).

Tall emergent marshes around the lakeshore frequently attain 100% coverage and generally occur as inclusions within short emergent marshes. Unlike prediversion conditions around the lakeshore, tall emergent marshes with areas of ponded, open water are rare. Seven species of birds were observed during fixed-plot surveys, and three additional bird and one amphibian species were observed during plotless surveys of this habitat (Table D-4). Plots were not surveyed for mammals or reptiles due to the presence of standing water or permanently saturated soils. Reconnaissance-level surveys revealed the presence of Great Basin spadefoot larvae in smaller areas of open water near tall emergent marshes at Simon Springs (Simon pers. comm.).

Bird species associated with tall emergent marshes around the lakeshore included Virginia rails, American coots, Wilson's phalaropes, marsh wrens, common yellowthroats, song sparrows, red-winged blackbirds, and yellow-headed blackbirds (Table D-4). Tall emergent marshes are important nesting habitat and hiding cover for Virginia rails, marsh wrens, red-winged blackbirds, and yellow-headed blackbirds. Tall cattails and bulrushes provide structure and cover required by some species. At Mono Lake, however, the diversity of wildlife associated with tall marsh habitats is limited because of the lack of open water, saline conditions, and the high density of stands. The relative lack of fresh or brackish open water near the lakeshore reduces the value of this habitat to ducks, grebes, herons, egrets, and other birds that typically frequent tall marshes in the Great Basin. Thus, similar to short emergent marshes, tall marshes were found to have a low WHI value in Mono Basin (Table D-5).

Alkali Flats. Alkali flats are defined as relicted lake bottomlands that are encrusted with alkali salts that support virtually no vegetation (Chapter 3C, "Vegetation"). The current estimate of 5,959 acres represents an increase of 100% from the prediversion period. We did not conduct fixed-plot surveys in this habitat but did spend many days walking across alkali flat areas along the western, northern, and eastern shorelines of Mono Lake.

Only a few snowy plovers, horned larks, and coyotes were observed in alkali flat areas. California gulls and common ravens, both snowy plover nest predators, also occasionally forage in this habitat type (Page et al. 1983). Because alkali flats are devoid of vegetation, they provide virtually no cover or forage for most wildlife species. Snowy plovers, which construct nests on unvegetated shoreline substrates, often nest on alkali flats (Page et al. 1983). Despite the large increase in alkali flat acreage around the lakeshore, the low WHI value results in an increase of only about 50 WHUs within Study Area 2.

Mono Lake Lakeshore. Lakeshore areas include the shoreline and adjacent nearshore water areas of Mono Lake. In shoreline areas watered by tributary streams, springs, or seeps, adjacent lands often support alkali wet meadows or marsh habitats. Unwatered shoreline areas are typically unvegetated or may support salt grass meadows (Chapter 3C, "Vegetation"). Recently exposed shoreline areas with shallow gradients (located primarily on northern and eastern shorelines) are unvegetated, salt encrusted alkali flats.

Approximately 30 person-days were spent observing birds along the shoreline of Mono Lake. Areas where repeated surveys were made included Danburg Beach; the mouths of Wilson, Lee Vining, and Rush Creeks; from the mouth of Lee Vining Creek to the Lee Vining tufa grove; Navy Beach; Simon Springs; and Warm Springs. Three half days also were spent observing Mono Lake's birds from a boat. Spring and fall shoreline surveys also been conducted by the Point Reyes Bird Observatory (PRBO) since 1989 (Strauss and Shuford pers. comms.).

Forty-eight species of birds were observed during Jones & Stokes Associates and PRBO surveys (Table D-4). The most common species observed in shoreline areas included eared grebes, California gulls, killdeer, American avocets, spotted sandpipers, western sandpipers, and least sandpipers. Thousands of Wilson's phalaropes and red-necked phalaropes also were observed from a boat in the northeast sector of the lake.

The lake shoreline is used as loafing, feeding, and watering sites by a variety of water and shorebirds. Water and shorebirds frequent lakeshore areas because the open terrain allows predators to be more readily detected and the proximity of the lake provides a nearby refuge from terrestrial predators.

Shorelines offer the highest densities of alkali flies and many shorebirds, gulls, and other water birds gather there to forage. Adult alkali flies congregate in large rafts on or immediately adjacent to the shore

(Chapter 3E, "Aquatic Productivity"). This readily available food source can attract large numbers of phalaropes, gulls, grebes, and shorebirds.

Some of the most important lakeshore areas are those adjacent to freshwater inflows to the lake. Freshwater available at these sites allow species that feed on alkali flies or brine shrimp to reduce the salt load ingested when these invertebrates are fed upon. Species not adapted to highly saline conditions, such as ducks, also may use freshwater inflows as bathing areas to remove crusted salt from feathers and feet or to seek relief from irritation caused by the lake's high salt and alkali content. California gulls also make frequent use of freshwater deltas, especially at Lee Vining, Rush, and Wilson Creeks.

Standardized plot surveys were not conducted along Mono Lakes shoreline; therefore, WHI and WHU values were not calculated for this habitat.

Ponds and Lagoons. In the prediversion period, about 260 acres of ponds and lagoons around Mono Lake's shoreline included those at DeChambeau Marsh (6 acres), near Bridgeport-Cottonwood Beach (29 acres), at Black Point (4 acres), near dunes along the northern shoreline (175 acres), near the Wilson-Mill Creek deltas (3 acres), and at the Rush Creek delta (38 acres) (Chapter 3C, "Vegetation"). During the early diversion period, large ponded areas formed behind natural berms at Simon Springs and lakeshore ponds were created for duck hunting using water diverted from Rush Creek (Stine pers. comm.). As the lake's elevation receded and the water table dropped, however, freshwater ponds gradually dried up and by about the early 1960s most of them were gone (Banta and Stine pers. comms.).

Aside from a 0.5-acre pond near the mouth of Wilson Creek, lakeshore ponds and lagoons currently are absent from Mono Lake's shoreline (Chapter 3C, "Vegetation"). Because these habitats no longer exist, it was not possible to conduct wildlife surveys there or to calculate their WHI values.

Mono Lake Open Water. At elevation 6,376.8 feet, Mono Lake provides approximately 39,000 acres of open water habitat to migrating birds. Due to extensive previous research on waterbirds of Mono Lake, specific surveys were not conducted to determine wildlife use of open water areas. Sixteen species of birds, however, were recorded incidental to other survey work. In addition to the abundant eared grebes, California gulls, Wilson's phalaropes, and red-necked phalaropes, less common species, such as Caspian terns, Bonaparte's gulls, Canada geese, mallards, northern shovelers, common mergansers, ruddy ducks, redheads, buffleheads, American wigeons, northern pintails, gadwalls, and green-winged teals were observed in open waters of Mono Lake during the 1991 field investigations (Table D-4).

The high salt and alkali content of Mono Lake exceeds the tolerance limits of most invertebrates. However, through the spring and summer months, the lake produces enormous amounts of brine shrimp and alkali flies that provide a food source for large numbers of migratory birds (Chapter 3E, "Aquatic

Productivity"). The lake's large expanse of open water also provides resting areas safe from terrestrial predators for seasonally resident and migratory water birds.

Standardized surveys were not conducted in open water; therefore, WHI and WHU values were not calculated for this habitat.

Paoha Island (Study Area 3)

Ten survey plots were established in Great Basin scrub and short emergent marsh habitats on Paoha Island (Table D-2). A total of 42 bird and four mammal species were observed fixed-plot and plotless surveys on the island during the 1991 surveys (Table D-4).

Great Basin Scrub. Great Basin scrub is the most abundant habitat type on Paoha Island and is dominated by greasewood and spiny hop-sage. Seven Great Basin scrub plots were established and surveyed for bird, mammal, reptile, and amphibians (Table D-2) and a total of 11 bird and three mammal species were observed on fixed-plot surveys. An additional 15 bird and one mammal species were observed during plotless surveys (Table D-4). Species observed in scrub habitats on Paoha Island included horned larks, violet-green swallows, sage thrashers, Brewer's sparrows, Brewer's blackbirds, house finches, black-tailed hares, deer mice, montane voles, and coyotes.

Great Basin scrub provides nesting, escape, and resting cover and forage for many species of wildlife not associated with water-dependent habitats. Probably due to the isolation of Paoha Island, WHI values of Great Basin scrub habitats there are lower than in similar Great Basin scrub habitats located on the mainland (Table D-5). Although more species of birds used Great Basin scrub habitat on Paoha Island than on the mainland, mainland areas supported more species of mammals and reptiles (Table D-4). The acreage of Great Basin scrub habitat within the study area was not determined; therefore, WHUs were not calculated for this habitat.

Short Emergent Marsh. Although small areas of tall emergent marsh exist on Paoha Island, only short emergent marshes were examined during the fixed-plot surveys. Short emergent marsh is limited to the southeast shore of Paoha Island and is composed of soft rush, three-square bulrush, saltgrass, foxtail barley, and fivehook (Morrison 1991). Stands are dense, generally approximating 100% cover, and average 2.5-3.5 feet in height.

Three plots were established and surveyed in short emergent marsh habitats (Table D-2), and 14 bird and three mammal species were observed during fixed-plot surveys (Table D-4). Seven additional species of birds were observed during plotless surveys of short emergent marshes. No reptiles or amphibians were located on Paoha Island. Species associated with short marsh habitat include violet-green swallows, common yellowthroats, Wilson's warblers, song sparrows, red-winged blackbirds, western meadowlarks, and yellow-headed blackbirds, deer mice, montane voles, and coyotes.

Springs supporting emergent marshes near the southeast side of Paoha Island are the only sources of fresh water, and they are an important resource to most species of terrestrial wildlife inhabiting the island. Surprisingly, the WHI value of short emergent marsh habitat on Paoha Island was higher than similar mainland habitats (Table D-4). It is possible that the springs attract especially high numbers of birds compared to mainland areas because other sources of freshwater are lacking on the island.

Upper Owens River (Study Area 4)

Surveys were conducted on the Arcularius Ranch located on the Upper Owens River. Five survey plots were established in irrigated meadow habitat (Table D-2). A plotless survey was conducted along a 1/4-mile stretch of willows and wet meadows along the river (about 1.5 acres).

Riparian Willow Scrub. Willows occur as discontinuous islands of habitat adjacent to the Upper Owens River primarily upstream from the East Portal. Willows are mature and usually open canopied, with an understory of meadow or irrigated pasture. Downstream from the East Portal, willows become sparse and are composed primarily of decadent shrubs.

A total of 3.7 acres of riparian willow scrub habitat currently exist on the Arcularius Ranch, representing a decline of about 12.4 acres since 1944 (Table D-5); these areas are now irrigated meadow and stream channel habitats Seven plotless surveys were made for birds, mammals, reptiles, and amphibians along the Upper Owens River from the East Portal to the Arcularius Ranch headquarters (Table D-2), and one mammal and 33 bird species were observed there (Table D-4). Common species observed included black-crowned night-herons, mourning doves, dusky flycatchers, house wrens, hermit thrushes, warbling vireos, yellow warblers, Wilson's warblers, MaGillvray's warblers, Lincoln's sparrows, and western harvest mice.

Owens River riparian willow scrub provides wildlife values similar to those described for riparian willow scrub in Mono Basin. Perhaps due to its limited acreage and frequent visitation by anglers and cattle, the WHI value for willow scrub habitats of the Upper Owens River was about half the value calculated for similar habitats in Mono Basin.

Irrigated Meadow. Irrigated meadows dominate the floodplain on the Arcularius Ranch and are composed of a mix of sedges and grasses (Chapter 3C, "Vegetation"). The relative abundance of grasses and sedges is determined by soil moisture; wetter sites support a greater proportion of sedges than drier sites (Chapter 3C, "Vegetation"). Acreages of irrigated meadows were not calculated, but qualitative estimates suggest that acreages and land uses were similar under both prediversion and current conditions.

Five plots were surveyed in irrigated meadows on the Upper Owens River (Table D-2). Nine bird and five mammal species were observed there, and seven additional species of birds were observed using these habitats during plotless surveys (Table D-4). Typical species observed in irrigated meadows of the Arcularius Ranch included killdeer, common snipe, spotted sandpipers, cliff swallows, red-wing blackbirds, yellow-headed blackbirds, Brewer's blackbirds, vagrant shrews, Belding ground squirrels, western harvest mice, and deer mice.

Irrigated meadows provide habitat values similar to those described for montane meadows in Study Area 1. Upper Owens River meadows are irrigated more heavily than those in Mono Basin; therefore, meadows there typically have more lush vegetation and standing water than those in Mono Basin (Chapter 3C, "Vegetation").

The WHI value of irrigated meadows along the Upper Owens River were similar to those of montane meadows in Mono Basin (Table D-5). The WHI value is lower on irrigated meadows because fewer mammal species used meadows on the Upper Owens River than used montane in Mono Basin. The number of mammal species using irrigated meadows was probably lower than for montane meadows because most irrigated meadow plots were flooded or supported saturated soils during portions of the study period.

Stream Channels. Stream channels include flowing water, channel banks, and point bar deposits. Within the study area, the Upper Owens River occupies a single, meandering channel. Eleven species of birds and one species of mammal were observed during plotless surveys (Table D-4), and characteristic species included snowy egrets, Canada geese, mallards, northern pintails, American wigeons, American avocets, belted kingfishers, yellow-headed blackbirds, and beavers.

Stream channels provide water for drinking and bathing and foraging habitat for some species of wildlife. Gravel and sand bars harbor invertebrates and ruderal vegetation that frequently grows on these sites provide seeds for forage. Waterfowl and shorebirds that use tributary channels also loaf on exposed gravel bars.

Surveys were not conducted in stream channels; therefore, WHI and WHU values were not calculated for this habitat.

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