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Appendix 1: Methods

Selection of Priority Species

General Selection Criteria

Priority bird species for this plan were selected based on a set of systematic qualifying criteria. By default, a species was given priority status if it: 1) regularly occurs in Nevada (*Appendix 2*), and 2) meets one or more of the following criteria as determined by agencies, bird conservation initiatives, legal mandate, or Nevada stewardship responsibility:

- a) *Audubon Watchlist*: Red or Yellow List rankings
- b) *Partners in Flight North American Landbird Conservation Plan* (Rich et al. 2004): Watch List ranking
- c) *Intermountain West Waterbird Conservation Plan* (Ivey and Herziger 2006): High or Moderate Concern rankings
- d) *Intermountain West Regional Shorebird Plan* (Oring et al. 2000): Critically Important or Very Important rankings
- e) Pacific Flyway portions of the *North American Waterfowl Management Plan* (USFWS 1986, 1998): High-ranking species with significant presence in Nevada
- f) *Nevada Department of Wildlife Upland Game Species Management Plan* (NDOW 2008): High Concern ranking
- g) Listed by USFWS under the Endangered Species Act (ESA), including candidate species
- h) Protected under the Bald and Golden Eagle Protection Act
- i) Significant species stewardship responsibility: $\geq 20\%$ of the estimated global population occurs in Nevada.

Priority species were divided into three different categories, following the usage of Chase and Geupel (2005). All Priority species, regardless of category, are treated in an individual species account. Each category is described below.

Conservation Priority Species

Conservation Priority species require active conservation efforts, such as habitat protection, habitat restoration, special or enhanced monitoring efforts, further research, or additional public education. Generally, there are tangible reasons for concern about a Conservation Priority species, which may include:

- a) Known or probable population declines
- b) Dependence on restricted habitats
- c) Small population size
- d) Habitat threats

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Although the habitat-based conservation strategies presented in this plan were designed to benefit entire bird communities, they were initially motivated by the needs of Conservation Priority species.

Stewardship Species

There were four species that qualified for Priority status based only upon the fact that Nevada is estimated to support $\geq 20\%$ of global population. These were designated as Stewardship species. We believe these Stewardship species deserve priority consideration in Nevada because significant threats in the state can have significant impacts on the entire species. In some cases, Conservation Priority species also had high Nevada stewardship percentages; this is noted in the “Conservation Profile” tables within the species accounts.

Special Status Species

The Special Status designation was used for three species that did not qualify as Conservation Priority or Stewardship Species, but that still merited attention in this plan. Two of these species, Bald Eagle and Peregrine Falcon, have recently been de-listed under the ESA and require ongoing population monitoring. The third species, Burrowing Owl, was included in this category because its conservation status is currently difficult to assess. On the one hand, there are conservation concerns about Burrowing Owls in many western states, but on the other, we could find no evidence of population declines or serious threats in Nevada. We anticipate being able to determine whether or not Burrowing Owl should be assigned Conservation Priority status in some future revision of this plan.

Exceptions

Northern Goshawk and Ferruginous Hawk were included as Conservation Priority species despite not formally qualifying under the guidelines listed above. Both are considered priority species by management agencies in Nevada (USFS, BLM, NDOW), and the Nevada PIF working group felt that their omission from the regional planning documents listed above was an oversight that should be corrected in this plan.

Sources of Information

In preparing this plan, we reviewed and synthesized many sources of information about the status, ecology, and management of Priority species and their habitats in Nevada. We relied most heavily on the following set of sources that were particularly well-suited to the needs of the plan:

Published Sources

Birds of North America (BNA) Species Accounts (Poole and Gill 1992-2002; cited individually in the *Literature Cited* section): This catalog of species accounts generally features an exhaustive literature review and synthesis of knowledge about every North American bird. As such, it is often the best source of information about a given species’ ecology, distribution, habitat use,

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breeding and foraging habits, migration patterns and phenology, population trends, threats, and conservation needs. In practice, not all species accounts cover these topics with equal thoroughness, and Nevada-specific information was available for some species but not for others.

Partners in Flight North American Landbird Conservation Plan (Rich et al. 2004): The continental Partners in Flight (PIF) plan provided global population estimates for landbirds, which were needed for estimating percent of global population size present in Nevada. Global population estimates were based on an analysis of Breeding Bird Survey (BBS) data for the North American portion of a species' distribution. These global estimates were stepped down to the state level by Peter Blancher and colleagues, which provided us with one source of statewide landbird population estimates for Nevada, which we referred to as the "PIF estimate." [These estimates can be found online at the Partners in Flight Landbird Population Estimates Database: http://rmbo.org/pif_db/laped/] Because Nevada has only a few historically-active BBS routes from which to extrapolate, the stepped-down statewide population estimates may be unreliable for some species.

Intermountain West Regional Shorebird Plan (Oring et al. 2000): This regional plan was created under the umbrella of the U.S. Fish and Wildlife Service's *U.S. Shorebird Conservation Plan* (Brown et al. 2001). It provides an excellent source of information about the status, trends, population sizes, hotspots, and conservation issues regarding Nevada's shorebirds.

Intermountain West Waterbird Conservation Plan (Ivey and Herziger 2006): This regional plan was created under the umbrella of the "Waterbird Conservation for the Americas Initiative," which produced the *North American Waterbird Conservation Plan* (Kushlan et al. 2002). It provides an excellent source of information about the status, trends, population sizes, distributions, and conservation issues of Nevada's nongame waterbirds.

Nevada Upland Game Species Management Plan (NDOW 2008): This plan was consulted as the best single source of information about the status, trends, population sizes, distributions, and management concerns of Nevada's upland game birds.

Other published sources

We expended considerable effort to glean as much information as possible from scientific journals and agency reports. We gave the greatest weight to quantitative, species-specific conservation or habitat related data from Nevada or immediately adjacent regions. Next in priority were sources relevant to wider regions (such as the Intermountain West) that had some applicability to Nevada. These are cited throughout the plan with full references collected in the *Literature Cited* section.

Data Sources

Nevada Bird Count

The Nevada Bird Count (NBC) was the most heavily used source of data for this plan. Due to its length, a full description of this program is presented at the end of this section (p. App-1-5).

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Breeding Bird Survey (BBS) Trends and Analyses

The latest trends analyses of BBS data (Sauer et al. 2008; <http://www.mbr-pwrc.usgs.gov/bbs/>) were consulted to determine regional and continental population trends for the period 1966 – 2007. For most species, reliable Nevada-specific trends were not available, but trend estimates were often available for wider geographic regions that included Nevada.

Nevada Breeding Bird Atlas Project

The Nevada Breeding Bird Atlas project, conducted by the Great Basin Bird Observatory (GBBO), involved systematic statewide data collection to document all confirmed and probable breeding bird species during the period 1997 – 2000 (see Floyd et al. 2007 for details). The database that was generated by the atlas contains over 30,000 bird observation records, and it provides one of the major sources of data on bird distribution, breeding status, and breeding phenology in Nevada. The atlas database is available upon request to GBBO. Atlas methods were well-suited for surveying most diurnal landbirds and some secretive species, such as owls, but they were less effective for birds that tend to congregate in large numbers in widely scattered sites (e.g., many shorebirds, waterbirds, and waterfowl), for upland game birds with sporadic, disconnected distributions, and for a handful of other bird taxa that are difficult to survey with a standard multi-species protocol (e.g., nightjars, hummingbirds). Many of the species that were under-surveyed by atlas methods were better covered by data sets residing at the federal and state wildlife agencies, which were also consulted for this plan.

Nevada Department of Wildlife Diversity Database

The Nevada Department of Wildlife maintains a database of wildlife occurrence records that are collected during the course of the agency's work across the state. This database, combined with databases from the Nevada Bird Count and the Nevada Breeding Bird Atlas project, was used for determining distribution patterns and creating range maps (see "Range Maps" section, below).

Site-Specific Waterbird and Shorebird Surveys

Site-specific monitoring of waterbirds and shorebirds is routinely performed on National Wildlife Refuges by USFWS refuge staff and on Nevada's State Wildlife Management Areas by NDOW staff. Additionally, NDOW conducts annual aerial surveys of colonial waterbirds and waterfowl, and seasonal migration surveys of shorebirds in the Lahontan Valley area (Larry Neel, *pers. comm.*). Collectively, these data sources allow us to estimate waterbird and shorebird numbers, abundance peaks, distributions, and, in some cases, trends. These data sources were compiled by Larry Neel (NDOW) for use in this plan.

Aquatic Bird Count

The Aquatic Bird Count is a GBBO program for aquatic bird monitoring throughout Nevada. Although this program's survey activities vary in scope from year to year, it has generated a database that is useful in helping to determine the distributions and seasonal presence of

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waterfowl, waterbirds, and shorebirds in many areas of the state. The Aquatic Bird Count database is available upon request to GBBO.

eBird

eBird (www.ebird.org), an offering of the Cornell Laboratory of Ornithology and partners, is a web-based repository of observations and sightings uploaded by birders and ornithologists from across the globe. Its visualization tools are especially useful for determining seasonal presence, phenology, and distribution of birds across any area of interest.

Other

Other data sources consulted for particular species included:

- a) Raptor nest surveys conducted by NDOW, USFS, BLM, and their partners (including the “Great Basin Raptor Nest Survey” program coordinated by HawkWatch International; see www.hawkwatch.org/conservation-science/raptor-nest-survey)
- b) Winter raptor surveys conducted by NDOW and partners (Southern Nevada Water Authority, GBBO)
- c) Special surveys conducted for species of interest (including Yellow-billed Cuckoo, Southwestern Willow Flycatcher, Peregrine Falcon, Yuma Clapper Rail, Snowy Plover, Bendire’s Thrasher, and Flammulated Owl) by a variety of agencies, organizations, consultants, or academic scientists

Nevada Bird Count (detailed program description)

Overview: The Nevada Bird Count (NBC) is a standardized statewide landbird monitoring program that was initiated by the Great Basin Bird Observatory in 2002. Like the atlas project, it is focused on the breeding season, but NBC uses a more quantitative approach to sampling in order to more effectively detect long-term population trends (e.g. Bart 2005a). NBC monitoring has been conducted every year since program inception, and its dataset at the time this plan was prepared included eight years (2002-2009) of monitoring results from 546 transects. As such, it provides the most useful single source of information about the distributions, habitat relationships, population sizes, and densities for Nevada’s landbirds.

The NBC uses a standard point-count protocol combined with area search/spot-mapping surveys in a double-sampling effort, in order to obtain detectability estimates for as many species as possible. It is an “all-bird” protocol, meaning that all species detected during a survey are recorded, but detection rates are best for small diurnal landbirds, such as songbirds, woodpeckers and their allies, and similar species that are readily visible or detectable by sound.

The NBC dataset was heavily used in the preparation of this plan, especially for generating:

- a) Nevada population size estimates
- b) Density estimates by habitat type
- c) Statistical analyses of habitat associations

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d) Range maps, in combination with atlas data and NDOW data, as described above

NBC Study Design: The NBC sampling plan is habitat-stratified (see “Habitat Types” section below for a complete description of the habitat designations used). To the extent possible, transects were randomly selected within each habitat type with the help of GIS land cover maps, although adjustments were sometimes required due to access issues or poorly mapped habitat types. All transects were located off-road, except in sites where roads could not be avoided (e.g., riparian areas in canyons), or where roads are part of the habitat type being surveyed (e.g., agricultural areas). Allocation of survey effort among habitat types was determined by conservation priorities, agency needs, and a statistical power analysis conducted during the first two years of the NBC program.

Several partner organizations and agencies were willing to integrate their ongoing monitoring efforts by adhering to NBC protocols and contributing their data to the NBC database. These partners included the Clark County Desert Conservation Program, Great Basin National Park, the USFS Humboldt-Toiyabe National Forest, NDOW, BLM, Lake Mead National Recreation Area, Southern Nevada Water Authority, the USFWS National Wildlife Refuge system, and the U.S. Bureau of Reclamation. This coordination has greatly improved the scope and statistical power of the NBC database.

NBC Survey Protocol: Full descriptions of NBC survey protocols can be obtained at <http://www.gbbo.org/data.html>. Briefly, NBC surveys are conducted between April 25 and June 30 in the Mojave Desert region, and between May 25 and July 10 in the Great Basin region. Each transect (location) is covered using an array of ten point-count stations. A 10-minute survey is conducted at each point, in fair weather conditions, and with all ten points of one transect completed within four hours after daybreak. All birds detected by sight and sound are recorded in three time intervals (0-3 min, 3-5 min, 5-10 min) and at three distance intervals (0-50 m, 50-100 m, > 100 m).

Detectability: Point-count data are affected by species-specific detectability, and thus the NBC protocol includes a double-sampling effort that combines areas searches with point-counts to estimate species-specific detectability (Bart and Earnst 2002). Results to date show that for moderately vocal or visible species, the 10-minute survey protocol for point counts results in a detection ratio of close to 1.0 within a 100 m distance (all birds present are detected). Therefore, all NBC-based analyses (in particular, densities and population size estimates) presented in this plan assume a detection ratio of 1.0. All cryptic species, or species groups known to be poorly sampled by NBC, are assumed to have a detection ratio of significantly < 1.0, and these species are excluded from NBC-based analyses in this plan.

Vegetation Assessments: Vegetation and habitat assessments are part of the NBC protocol, as more fully described at <http://www.gbbo.org/data.html>. We used NBC-derived habitat measurements for statistical analyses of habitat relationships for a small number of relatively common Priority species in this plan.

Transect Habitat Assignments: Many NBC transects were located entirely within a single relatively uniform habitat type. In order to survey habitat types that occur in small or narrow

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patches, however, many transects had to cross habitat type boundaries. Rules were therefore established to ensure that a minimum amount of the target habitat type was present, and to generate an acceptable level of consistency in habitat-based analyses.

Habitat Types

Habitat types are defined, for the purpose of this plan, as distinct land cover categories that support relatively distinct bird communities. While the term “habitat” technically describes only the environmental needs of one particular species, here we embrace the less formal use of the word, where “habitat” means a major land cover type or local setting providing environmental requirements or suitable environments for a unique bird assemblage. This definition allows us to group bird species under the umbrella of shared habitat conservation strategies.

The process of selecting habitat types for this plan paralleled the processes used in the original *Nevada PIF Bird Conservation Plan* (Neel 1999) and the Nevada Bird Count (NBC) habitat stratification. For both the 1999 plan and NBC, habitat types were created by lumping together land cover types identified in the GAP vegetation map (Homer et al. 1998). For instance, several land cover types that were dominated by coniferous trees were combined into a “Coniferous Forest” habitat type (we capitalize formal habitat type designations to distinguish them from more casual references to dominant vegetation). Other coniferous land cover types were combined to form “Pinyon-Juniper” habitat. In the more recent *Nevada Wildlife Action Plan* (Nevada Wildlife Action Plan Team 2006), the same general approach was used, but it was based primarily on land cover types identified by the Southwest Regional Gap Analysis Project (SW ReGAP) mapping effort (Prior-Magee et al. 2007). We also used the same approach in this plan, but chose to consider land cover types as defined in several different mapping efforts. A more detailed description of this process is given below in the “Spatial Habitat Data” section.

The habit types designated in the four efforts described above were very similar, but there were some variations resulting from the use of different fundamental land cover types, different approaches to grouping land cover types, and different terminology. The relationships between habitat types designated in these four efforts are summarized in Table App-1-1, below.

Table App-1-1: Cross-walk of habitat types defined by four different programs / plans. 1999 Plan = original PIF bird plan (Neel 1999); NWAP = Nevada Wildlife Action Plan

This Plan	1999 Plan¹	NBC	NWAP²	Short Description for This Plan
Agriculture	Ag Lands	Agriculture	Agricultural Lands	All irrigated agricultural fields and associated infrastructure
Alpine	(not included)	(not included)	Alpine and tundra	Above treeline (tundra)
Aspen	Aspen	Aspen	Aspen woodland	All aspen-dominated woodlands

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This Plan	1999 Plan¹	NBC	NWAP²	Short Description for This Plan
Cliff	Cliffs and Talus	(not included)	Cliffs and Canyon	Prominent cliffs and talus
Coniferous Forest	Coniferous Forest	Coniferous Forest	Intermountain (and Sierra) conifer forests and woodlands	All mixed and pure coniferous woodlands except pinyon-juniper
Springs	(included under Wetlands/Lakes)	(not included)	Springs and springbrooks	All spring systems that are too small to form major riparian or wetland patches
Ephemeral Wetland and Playa	(included under Wetlands/Lakes)	(not included)	Desert playas and ephemeral pools	All wetlands without perennial, or mostly perennial, water
Great Basin Lowland Riparian	Lowland Riparian	Lowland Riparian	Intermountain Rivers and streams	Streamside vegetation and river-fed wetlands that are mostly restricted to valley floors in the Great Basin (generally < 5,500 ft or 1,800 m)
Joshua Tree	(included under Mojave Shrub)	Joshua Tree	Mojave mid-elevation mixed Desert Scrub	Mid-elevation Mojave uplands that have a significant component of Joshua tree or other <i>Yucca</i> spp.
Marsh	(included under Wetlands/Lakes)	(included under Wetland)	Marshes	Permanent wetlands dominated by emergent vegetation, interspersed with open water
Mesquite-Acacia	Mesquite-Catclaw	Mesquite-Catclaw	Mesquite bosques and Desert washes	Mesquite and/or <i>Acacia</i> -dominated washes and bosques in the Mojave Desert

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This Plan	1999 Plan¹	NBC	NWAP²	Short Description for This Plan
Mojave Lowland Riparian	Lowland Riparian	Lowland Riparian	Mojave rivers and streams	Streamside vegetation and river-fed wetlands that are mostly restricted to valley floors in the Mojave Desert and White River Valley (generally < 4,000 ft or 1,300 m)
Mojave Scrub	Mojave Shrub	Mojave Scrub	Mojave/Sonoran Warm Desert Scrub	Low-mid elevation scrub communities of the Mojave Desert, usually dominated by creosote
Montane Riparian	Montane Riparian	Montane Riparian	Intermountain rivers and streams	Streamside vegetation that is mostly restricted to montane areas (generally > 5,000 ft or 1,600 m)
Montane Shrubland	Montane Shrub and Sagebrush	Montane Shrub and Montane Sagebrush	(shared among several habitat types)	Deciduous and non-deciduous shrubs generally at or above the pinyon-juniper zone, but not including the alpine zone, including Montane Sagebrush
Open Water	Wetlands/Lakes	(not included)	Lakes and Reservoirs	Water bodies that are usually large and have only a minor component of emergent vegetation, such as lakes and reservoirs
Pinyon-Juniper	Pinyon-Juniper and Mountain Mahogany	Pinyon-Juniper and Mountain Mahogany	Lower Montane woodlands	Pinyon-juniper dominated landscapes, including mountain

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This Plan	1999 Plan ¹	NBC	NWAP ²	Short Description for This Plan
				mahogany components and open woodlands with shrub understory
Sagebrush	Sagebrush (including Montane Sagebrush)	Sagebrush (excluding Montane Sagebrush)	Sagebrush (including Montane Sagebrush)	Sagebrush-dominated shrublands below the pinyon-juniper zone (not including Montane Sagebrush – see Montane Shrubland)
Salt Desert Scrub	Salt Desert	Salt Desert Scrub	Intermountain cold desert scrub	Desert scrub below the sagebrush or Mojave Scrub zone, often dominated by saltbush, greasewood, and other salt-tolerant species
Wet Meadow	Wetlands/Lakes and Montane Parkland	Wetland	Wet Meadows	Mesic graminoid-dominated meadows (sedges, rushes, grasses) that have ample access to water, but little emergent vegetation

¹ Neel (1999); ² Nevada Wildlife Action Plan Team (2006)

The 20 habitat types listed above provide the basis for the habitat accounts presented in this plan, where we describe the physical and floristic characteristics of each habitat type, relate these characteristics to bird habitat suitability, list major threats, and recommend conservation strategies. These habitat types account for most of the surface area in Nevada. The remaining portions of the state consist mostly of developed areas (urban, suburban, rural, industrial, roads), barren areas, and exotic vegetation, none of which were considered conservation priority habitats. There are also very limited upland areas of native grassland, but they are difficult to distinguish accurately from irrigated fields or wet meadows in GIS maps, so they were not included in our habitat classification.

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Spatial Habitat Data

Overview

In order to analyze NBC data as a function of habitat, we needed to define habitat types listed above in terms of underlying land cover categories (we refer to this process as a “roll-up” hereafter), and then map the spatial distributions of each habitat type. We felt that all of the individual mapping efforts upon which the roll-ups could be based had inadequacies, and further that these inadequacies could be partly rectified by combining their more reliable features. Therefore, we used land cover categories derived from several different sources as the basis for rolling-up habitat types.

Habitat classification and mapping

We relied primarily on the multi-partner LandFire Existing Vegetation Type (EVT) map (www.landfire.gov) as a source of land cover categories. The LandFire Existing Vegetation Type (EVT) map, in particular, is thought to capture small-scale riparian features more effectively than the Southwest ReGAP map (Peterson 2008), which was a major basis for our decision. Table App-1-2 shows the sources of the land cover categories that were used for habitat type roll-ups in this plan. A detailed accounting and rationale of exactly which land cover categories were used to define each habitat type is available from GBBO upon request. Below, we describe the exceptions to the general pattern of rolling up either LandFire land cover categories.

- 1) Cliff and talus distribution was best mapped by the Southwest ReGAP product (Prior-Magee et al. 2007), which was used as a basis for our Cliff habitat type
- 2) Ephemeral Wetland and Playa habitat was mapped based on the National Wetlands Inventory (NWI) dataset (<http://www.fws.gov/wetlands/>) and the Nevada Natural Heritage Program’s water-playa shapefile (<http://heritage.nv.gov/gis/gis.htm>)
- 3) The boundary between the Great Basin Lowland Riparian and Mojave Lowland Riparian habitat types was based on the accepted eco-regional boundary between these two regions, although this boundary may vary slightly in different products. Our ecoregional shapefile is available upon request to GBBO
- 4) Joshua Tree was poorly classified by LandFire and ReGAP land cover types. Instead, we used a first-generation Joshua Tree habitat map created by USGS (Todd Esque, *pers. comm.*)
- 5) Marshes and wetlands were captured best by the Southwest ReGAP product, which was used as a basis for the Marsh habitat type
- 6) Mesquite-Acacia was poorly classified by LandFire and ReGAP land cover categories. Instead, we used a map of Mesquite-Acacia habitat that was created by the University of Nevada Reno (UNR) as part of the Clark County MSHCP project (Clark County 2000)
- 7) The LandFire land cover categories contributing to the Mojave Lowland Riparian habitat type roll-up severely overestimated the extent of actual riparian vegetation, as determined by systematic overlays of these land covers with aerial photography. We conducted an in-depth effort to reclassify this habitat type based primarily on a stream-order determination using Arc GIS tools. Details are available upon request to GBBO

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- 8) Montane Riparian habitat could often be separated from the two lowland riparian habitat types based on the definition of underlying land cover categories. In other cases, however, a land cover category spanned what we felt to be the reasonable boundary between the montane and lowland riparian zones. In these cases, we defined Montane Riparian habitat to occur above 1,600 m in elevation, and Lowland Riparian (either Great Basin or Mojave, depending on location) below 1,600 m (5,280 feet)
- 9) Springs habitat could not be distinguished from vegetation-based land covers in the ReGAP or LandFire products. Instead, we used a springs shapefile provided by BLM as the basis for our Springs map
- 10) Wet Meadow was best captured by examining both LandFire and ReGAP land cover categories in tandem, as both resulted in misclassifications considered individually

Table App-1-2: Source of land cover categories used in defining habitat types.

Habitat Type	Land Cover Source
Agriculture	LandFire
Alpine	LandFire
Aspen	LandFire
Cliff	ReGAP
Coniferous Forest	LandFire
Ephemeral Wetland and Playa	National Wetlands Inventory, Nevada Natural Heritage program shapefile
Great Basin Lowland Riparian	LandFire, < 1,600 m elevation threshold, and Great Basin / Mojave ecoregional boundary
Joshua Tree	USGS shapefile
Marsh	ReGAP
Mesquite-Acacia	UNR / Clark County MSHCP shapefile
Mojave Lowland Riparian	LandFire, < 1,600 m elevation threshold, Great Basin / Mojave ecoregional boundary, and manual reclassification based on stream order
Mojave Scrub	LandFire
Montane Riparian	LandFire, > 1,600 m elevation threshold
Montane Shrubland	LandFire
Open Water	LandFire
Pinyon-Juniper	LandFire
Sagebrush	LandFire
Salt Desert Scrub	LandFire
Springs	BLM springs shapefile
Wet Meadow	LandFire and ReGAP

In general, we believe that our final habitat type map was as accurate as possible, given the limitations of its underlying spatial datasets. Map accuracy is poorest for habitats that occur in small or narrow patches, including all Riparian habitat types, Wet Meadow, and Aspen. Improved mapping efforts would significantly improve our ability to analyze bird – habitat relationships.

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Analytical and Statistical Methods

Bird – Habitat Analyses

For the priority songbirds in this plan that were sufficiently well sampled by the NBC, we conducted analyses of NBC data using GIS-derived transect attributes as explanatory variables. In general, we referred to this as “landscape-level” analysis, which was distinct from the microhabitat analysis described in the next section.

The first step required was to define the area effectively sampled by an NBC transect. To do this, we applied a 200 m radius buffer around each survey point, and then merged the buffered points within a given transect into a single polygon in GIS. The 200 m radius buffers were selected because they capture nearly all of the effectively surveyed area around each survey point. Significantly smaller buffers would have resulted in discontinuous transect polygons and may have under-represented the habitats that were actually used by the detected birds. Once the transect polygons were defined, they were intersected with the habitat map described in the previous section, as well as a landownership map. Attributes were then created for each transect polygon, as follows:

- 1) Surface area of each transect polygon occupied by each habitat type that was present
- 2) Shortest distance from any portion of the transect polygon to the nearest year-round water source
- 3) Landownership breakdown of the transect polygon

We also investigated the possibility of extracting transect attributes from maps of recent burn activity, but found that too few NBC transects were located in areas of recent burn activity to permit meaningful analysis.

We used logistic regression to analyze the model the relationships between bird presence (detection or non-detection) and habitat type or distance to water. For most of the species analyzed, data were sufficient to support up to three variables in a multivariate model. For a few of the most common species, we were able to conduct additional analyses by using abundance data in a linear regression analysis. We note these in the species accounts only if they changed the resulting conclusion. Data from the Great Basin and Mojave Desert were analyzed separately.

Microhabitat Analyses

For a few priority songbirds, we also conducted statistical analyses of bird abundance and presence as a function of detailed vegetation measurements that were collected “on the ground” as part of the NBC protocol (see www.gbbo.org/data.html). These analyses were originally presented in a GBBO technical report (GBBO 2008b), where details of these analyses are presented.

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Bird Density and Occupancy Rates by Habitat Type

For the Priority species with sufficient NBC data, we calculated average density within each habitat type. Habitat-specific densities were calculated separately for the Great Basin and Mojave Desert regions of Nevada. Density estimates were based on the actual number of birds detected within 100 m of each NBC survey point (assuming a detection probability of 1.0 within this radius), divided by the area of a 100 m radius circle. Results were then standardized to birds per 40 ha. Many transects were surveyed in multiple years, and some were surveyed multiple times within a year, and in these cases we avoided bias by using a single average density for a given transect. Averages for each transect were then averaged again to create the overall density estimate, which is presented in the species accounts along with an estimate of error. For a given species, we averaged densities only from the transects where the bird was present (i.e., zero-density transects were not used). This step was necessary to avoid skewing results for birds whose geographical range in Nevada is smaller than the spatial extent of the habitats they use. The best way to interpret our density estimates, therefore, is that they provide an indication of the average habitat-specific density of a given bird within the parts of the state where they occur.

In calculating density estimates, we considered only the single habitat type designator associated with each NBC transect. We did not create subgroups of points within transects that overlaid multiple habitat types. This created situations where a bird has a non-zero density for a habitat type that it rarely, if ever, uses. For instance, a bird that always occurs within Coniferous Forest habitat may have been counted on some Montane Shrubland transects that contained a small amount of Coniferous Forest habitat. This bird will therefore show a non-zero density within the Montane Shrubland habitat type. To allow us to better detect and interpret these anomalies, we also present “occupancy rate” in the species accounts, which are defined as the proportion of all transects of a given habitat type on which the bird was detected during NBC surveys. If a bird’s occupancy rate for a given habitat is very low, then its associated density estimate for that habitat type is not very meaningful.

Population Size Estimates

Increasingly, bird conservation initiatives have desired to have estimates of the total population sizes of bird species of concern; within a project area, within a state, or within the entire range of the species (i.e. “global”). This is an attempt to explicitly quantify current population status in relation to future conservation targets (Rosenberg and Blanche 2005). Inspired by the success of the North American Waterfowl Management Plan (USFWS 1986, 1998) in following this strategy, the major bird conservation initiatives produced in the last decade have all produced global population size estimates for their focal species (Brown et al. 2001, Kushlan et al. 2002, Rich et al. 2004), which we use as source material in this plan. Below, we discuss the sources of Nevada population size estimates used in this plan.

Partners in Flight’s BBS-based Population Size Estimates

Partners in Flight generated global or continental estimates for landbird population sizes based on Breeding Bird Survey (BBS) data, as part of their development of a continental plan (Rich et al. 2004). The next step was to calculate the proportion of this population estimated to occur in

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Nevada. We have taken these estimates from an unpublished spreadsheet produced by Peter Blancher (*pers. comm.*). However, BBS coverage in Nevada has been poor in past decades, and in order to produce these estimates, it was sometimes necessary to extrapolate from adjoining regions outside of the state (especially for the Sierra Nevada ecoregion). Because of this limitation, we decided to use NBC data to produce a new set of Nevada population size estimates for landbirds.

NBC-Based Population Size Estimates

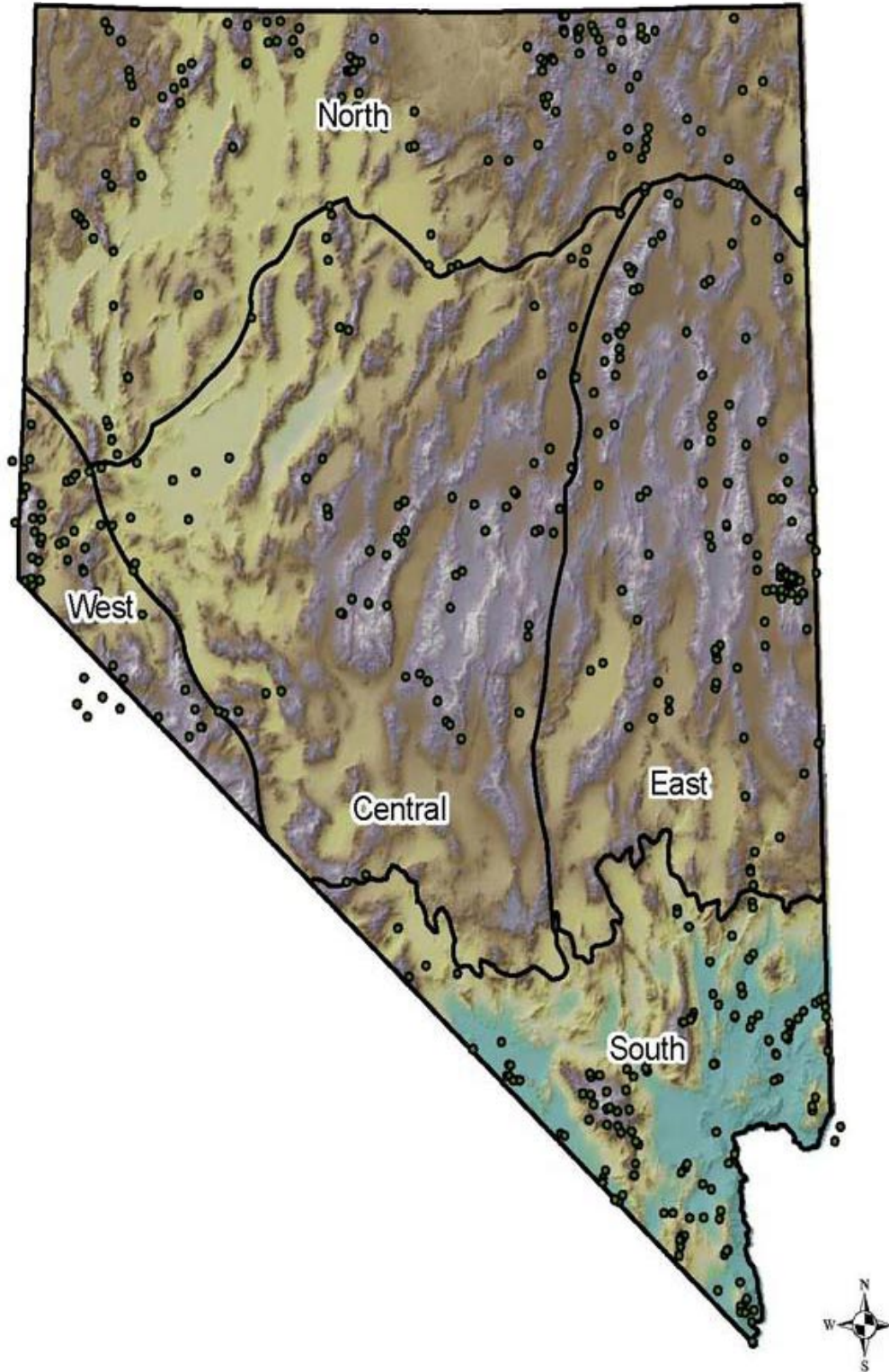
The large Nevada Bird Count database provided us with an opportunity to generate new population size estimates for the state that were improvements on previously available estimates. For species that were well-sampled by the NBC, data-based population estimates were obtained by extrapolating observed bird densities across the entire landscape, while accounting for habitat-based and regional differences in these densities. As with density estimation, we considered only the single habitat type designator associated with each transect; but in contrast, we remained entirely within the framework of the original GAP-based habitat type designators used to stratify the NBC sampling plan throughout this exercise (Table App-1-1). Also in contrast to the density estimation exercise, we used all transects (including those on which a given bird species did not occur). Otherwise, we would have created inflated population size estimates by extrapolating densities that were uncharacteristic of Nevada as a whole.

Data for population size estimates were obtained from 546 NBC transects that were surveyed at variable frequencies between 2002 and 2009. These transects received an average of 2.5 surveys each during this period, generating 1376 transect-visits. Data from multiple surveys for a given transect were averaged to produce a single density estimate for each species. In order to account for the fact that many species are not distributed equally throughout the entire extent of their habitats, we divided Nevada into five geographical regions (north, west, central, east, and south) based on natural ecoregional boundaries that correspond well with most breeding ranges (Figure M1; see also Floyd et al. 2007). For example, the Gray Vireo is concentrated in Pinyon-Juniper habitat in the south region, is also present in smaller but still significant densities in the east region, and is almost totally absent from Pinyon-Juniper habitat in the remaining regions. The Pinyon Jay, in contrast, uses Pinyon-Juniper habitat statewide, except in the north region where it is mostly absent. Therefore, density estimates were generated for each unique combination of species, habitat type, and region, and those estimates were extrapolated based on the area occupied by that same habitat-region combination to arrive at a population estimate for that habitat-region. Statewide population estimates were then generated by adding all of the unique habitat-region population estimates. Systematic intra-regional variation in density within a habitat type, which no doubt occurs, was not addressed by this method, although it is reasonable to assume that it averaged out in most cases, and did not result in significantly skewed estimates.

Table App-1-3 shows the number of transects that were surveyed, by habitat type, in each of the five regions (see also Figure App-1-1). In many (though not all) cases where there appears to be poor NBC survey coverage for a given habitat-region combination, this was a result of few or no such habitat-region combinations existing. For instance, Mesquite-Catclaw habitat occurs only in southern Nevada, and is simply not present in the other four regions of the state.

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Figure App-1-1: Division of Nevada into regions for population estimates, and locations of NBC transects.



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Table App-1-3: Number of NBC transects surveyed by habitat and region, 2002-2009. Habitat types are those identified in the original GAP-based NBC stratification process.

Habitat Type	Region					Total
	Central	East	North	West	South	
Agricultural	2	0	0	1	5	8
Aspen	2	7	5	4	7	25
Coniferous Forest	0	2	3	14	4	23
Joshua Tree	1	0	0	0	20	21
Lowland Riparian	15	9	26	16	36	102
Mesquite-Catclaw	0	0	0	0	14	14
Mojave Scrub	0	0	0	0	22	22
Montane Riparian	6	35	34	13	9	97
Montane Sagebrush	3	2	4	2	3	14
Montane Shrub	3	4	2	0	5	14
Mountain Mahogany	1	4	4	0	0	9
Pinyon-Juniper	13	35	5	8	12	73
Sagebrush	20	6	4	3	26	59
Salt Desert	5	17	0	1	10	33
Wetland	6	22	1	1	2	32

The following formal sequence of steps was used to derive NBC-generated population estimates:

- a) We determined the total number of hectares for each habitat type within each of the five regions based on the GAP map (Table App-1-4). Using this approach, 93% of the state's total land area could be classified as one of the NBC focal habitat types. The remainder consisted of cover types such as urban, barren, cliffs, alpine, etc. Thus this 7% of the state's total land area was excluded from the analysis
- b) We calculated species-specific average density estimates (birds per 40 ha) for every NBC transect
- c) We averaged the density estimates for all transects within a given habitat-region combination, and repeated this step for all other habitat-region combinations
- d) We multiplied the overall density estimate for each habitat-region combination by the number of hectares of that habitat-region combination to produce a series of population size estimates for each habitat- region combination.
- e) We summed all resulting population size estimates for a given species to produce a statewide population estimate

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Table App-1-4: Total area of land, in hectares, covered by each habitat type in each region of Nevada.

Habitat Type	Region				
	North	South	West	Central	East
Agriculture	191,253	18,060	59,157	149,950	97,400
Aspen	56,131	0	114	5,352	37,345
Coniferous Forest	8,840	29,393	59,990	1,760	126,442
Lowland Riparian	16,030	12,376	6,238	9,077	8,041
Mesquite-Catclaw	0	7,539	0	0	0
Mojave Scrub (combined with Joshua Tree)	0	2,878,464	0	65,941	123,822
Montane Riparian	1,186	0	556	4,242	2,389
Montane Shrubland	62,664	60,496	14,099	48,771	185,060
Mountain Mahogany	2,939	0	1,327	57,504	89,819
Montane Sagebrush	574,378	2	65,434	322,470	161,712
Pinyon-Juniper	59,300	115,978	228,094	984,092	1,484,705
Sagebrush	4,623,741	202,593	579,070	3,661,461	2,792,070
Salt Desert	1,730,663	473,072	107,785	3,211,603	1,244,730
Other (not used)	527,605	168,466	75,891	490,738	133,697
Wetland	1,768	318	2,826	69,884	31,396
TOTAL	7,856,496	3,966,756	1,200,584	9,082,845	6,518,627

Population size estimates were created for all priority passerine birds, hummingbirds, woodpeckers, doves, and easily-detected upland game birds and raptors. Although NBC methods were not designed specifically for raptors, NBC-derived population estimates for this species group corresponded fairly well with previous estimates, with some exceptions. Population size estimates for all species analyzed were rounded to the nearest round number within 5%. This was done to emphasize the imprecise nature of population size estimation, which differs from a total population count in that it includes error from extrapolation and sampling. We decided on a species by species basis whether or not the NBC population estimate was the best available estimate, as presented in the species accounts (see *Appendix 4* for a summary).

Other Population Size Estimates

Population estimates for many of this plan's Priority species could not reasonably be derived from either NBC or BBS data, particularly for waterfowl, waterbirds, shorebirds, and owls. Additionally, NBC-derived population estimates for some upland game birds and raptors were unreliable enough to merit consideration of other population size estimates. For these species groups, we relied on the key sources described previously to obtain population size estimates.

Appendices

Because we chose only one population estimate to report on the front page of the species accounts, readers may wish to examine *Appendix 4*, where the comparison of all available estimates is summarized in tabular form. In the species accounts, we discuss the factors that might weigh in favor of one estimate or the other where appropriate.

Error Estimation for Population Size Estimates

It is generally understood that population estimates derived from any currently available data source are necessarily very approximate. Methods of calculating population size estimates are continuing to be critically reviewed and recommendations being made (Thogmartin et al. 2006). The most important recommendation, of course, would be the collection of more and better monitoring data.

There are many sources of potential error in the process of generating a population size estimate, and integrating them meaningfully into a single error index is a very complex undertaking that deserves careful attention (e.g. Bart 2005b, Thogmartin 2010). Rather than reporting oversimplified (and possibly misleading) estimate errors, we chose to defer this exercise until a future revision of this plan.

Range Maps

For species range maps, we used actual detections of a species as the basis for creating known and presumed distributions within Nevada. This was a conservative, data-driven approach that contrasted, to some extent, with more typical approaches to range map creation. Detection records were obtained primarily from NBC data, the Nevada Breeding Bird Atlas project, the GBBO Aquatic Bird Count, and the NDOW diversity database (see “Sources of Information” section, above). For all of these sources, only records collected since the beginning of the Nevada Breeding bird atlas project (i.e. 1997) were used in order to avoid inadvertently plotting distributions that no longer apply. Other data sources, notably the *Nevada Upland Game Species Management Plan* (NDOW 2008) and personal observations from reliable experts, were occasionally used to supplement these sources, as noted in the species accounts. Once detections were mapped, the range maps were created using the following approaches.

For landbirds, we used the USGS basin and range shapefile to divide the state into a contiguous array of basins and mountain ranges. A bird sighting that occurred within a given basin or mountain range resulted in the extrapolation of “known distribution” to that entire basin or mountain range. For species present at intermediate elevations, detections often occurred in both basins and mountain ranges. Presumed ranges were then superimposed on known range by a subjective, iterative process involving opinion from several experts, outside map review, and biological context.

For waterbirds, waterfowl, shorebirds, and marshbirds, we used a similar approach employing the shapefiles that defined Open Water and Ephemeral Wetland and Playa habitats (see above), rather than basins and mountain ranges. A detection that occurred within or adjacent a water bodies was extrapolated throughout that water feature. Presumed range was then extrapolated to other water bodies, using a process similar to that described above for landbirds.

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Despite our efforts to systematize the distribution mapping process, judgment calls were still required in many cases. It is important to note that the absence of a mapped “known” distribution for a species within a given part of the state is NOT intended to imply that the species is known to be absent from that area. Rather, it has not yet been observed, and definitive determination of presence or absence will require focused local survey efforts. We show both known and presumed range on most species maps to avoid this possible misinterpretation.

Threats Determination and Conservation Strategies

Assessment of conservation concerns and threats is primarily discussed in the *Conservation Concerns* chapter of this plan. Determinations as to whether or not conservation concerns represented threats to a given habitat or bird species were the result of integrating the Conservation Action Planning (CAP) outputs (TNC 2007), literature review, analysis, and substantial discussion among the Nevada PIF planning group. In presenting what we determined to be significant threats, we tended to focus on threats that may lead to significant negative changes in habitats or in the abundance / distribution of Priority species over the next ten years. We did not attempt to formally rank threats to a given bird or habitat; rather we presented only the threats that we regarded to be credible.

Likewise, conservation strategies were formed as the result of literature review, analysis, and feedback from the Nevada PIF planning group. Two PIF meetings were devoted entirely to developing group consensus on conservation strategies.