CHAPTER 2

AFFECTED ENVIRONMENT

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CHAPTER 2
AFFECTED ENVIRONMENT

2.1 INTRODUCTION

This chapter provides an introduction to the Stillwater NWR Complex and EIS study area, but does not provide a comprehensive overview of information. Details on baseline conditions for each resource are provided in Chapter 4 in conjunction with discussions of conditions anticipated to occur under the No Action Alternative, or status quo alternative. This format avoids repetition of baseline information and places the details of baseline conditions in the same place as details on the potential changes to these conditions.

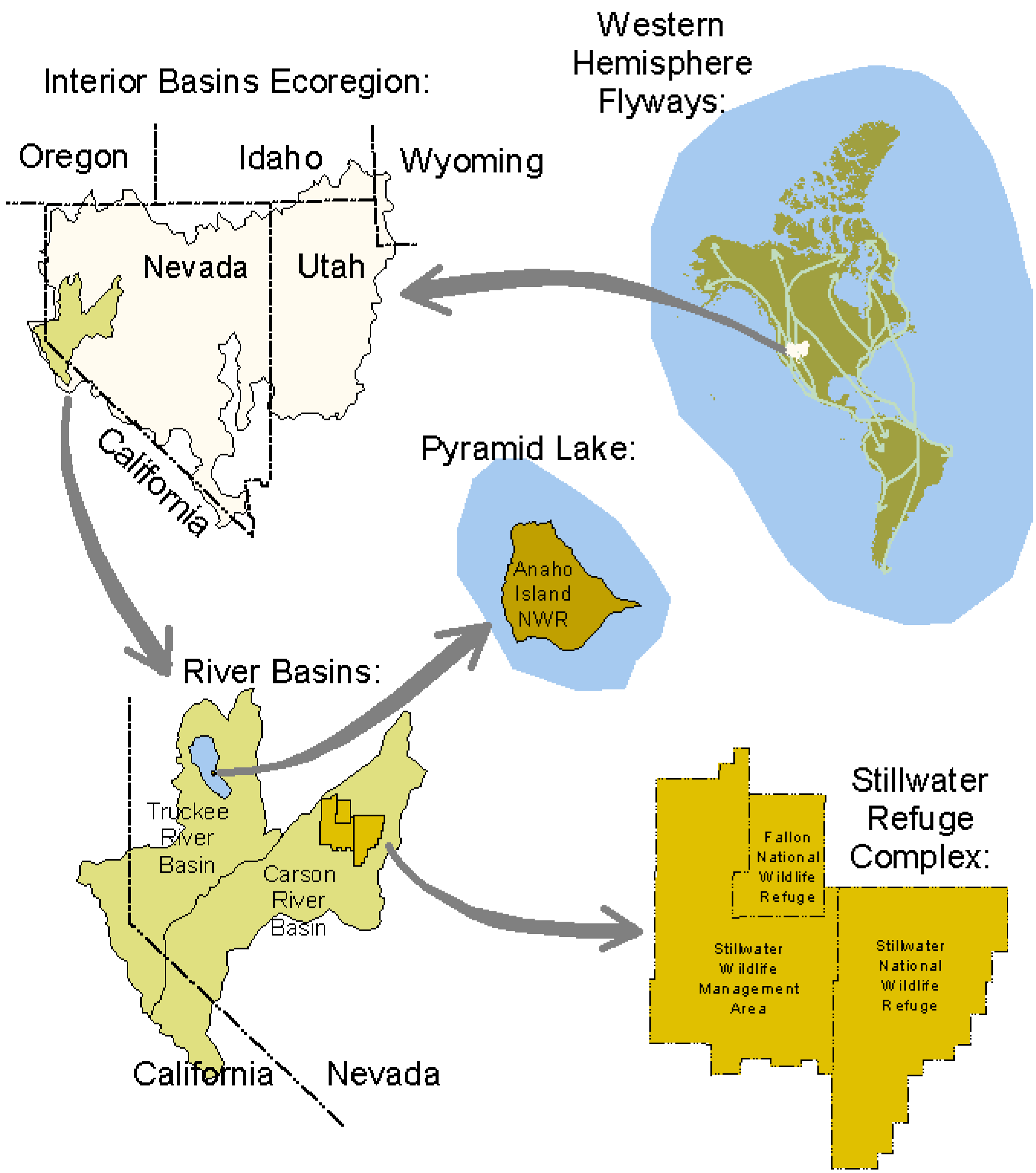
The focus of this Final EIS is the Stillwater NWR Complex (Stillwater NWR, Stillwater WMA, Fallon NWR, and Anaho Island NWR). However, because the alternatives being considered could potentially result in environmental impacts outside the Stillwater NWR Complex, the EIS study area is larger. It includes all areas where measurable environmental impacts could potentially occur: the Carson River basin below Fort Churchill, the lower Truckee River basin from below the Derby Diversion Dam to Pyramid Lake, and the Truckee Canal, which connects the two basins (Map 1.2).

The environmental characteristics of both basins have been thoroughly described in three recent environmental documents that are incorporated by reference: *Final Environmental Impact Statement Water Rights Acquisition for Lahontan Valley Wetlands* (USFWS 1996a); *Draft Environmental Impact Statement Truckee River Operating Agreement* (USDI and State of California 1998); and *Environmental Assessment Adjusted 1988 Newlands Project Operating Criteria and Procedures*. These documents are available to the public at several area public libraries and at the Stillwater NWRC office in Fallon.

Another function of this chapter is to describe the natural ecological conditions of the Lahontan Valley, of which Stillwater NWR is a part. Natural biological diversity, biotic integrity, and environmental health is central to Stillwater NWR purposes, provisions of the Refuge System Administration Act, and international treaties. It is recognized that ecological habitat conditions cannot be fully restored, nor in some cases would this be desirable. However, an understanding of the natural functioning of the Lahontan Valley wetlands and the composition and structure of Lahontan Valley habitats is needed before objectives and strategies targeting natural biological diversity can be developed.

This Chapter is divided into four main sections. The first section (2.2) introduces the "biogeographical" context within which Stillwater NWR Complex is situated (Map 2.1). It highlights the international, regional, and landscape levels. The second section (2.3) delves into the landscape context in more detail, as a basis for summarizing the EIS study area. Section 2.4

Map 2.1 Stillwater National Wildlife Refuge Relationship to Flyways, Ecoregions, and River Basins



focuses directly on the lands and waters within the Stillwater NWR Complex, and the final section (2.5) describes in more detail the natural ecological conditions of the Lahontan Valley. Section 2.5 is more detailed than the section on the existing condition of refuge resources (Section 2.4) because Section 2.4 only presents a summary of existing conditions, with the details presented in Chapter 4.

2.2 INTERNATIONAL, NATIONAL, REGIONAL, AND LANDSCAPE CONTEXT

2.2.1 INTERNATIONAL AND NATIONAL

The Stillwater NWR Complex is nationally and internationally important in several ways. Most notably, the Stillwater NWR Complex provides important migration, breeding, and wintering habitat for migratory birds, including waterfowl, shorebirds, and neotropical migratory birds. As an illustration of their international importance to migratory birds, the Lahontan Valley wetlands, of which Stillwater NWR is a major component, is one of only 15 Sites of International Importance under the Western Hemispheric Shorebird Reserve Network. The Lahontan Valley wetlands are also a focus area of the Intermountain West Joint Venture, a public/private partnership formed to meet objectives of the North American Waterfowl Management Plan within the boundaries of the joint venture. The North American Waterfowl Management Plan established a cooperative effort between Canada, the United States, and Mexico to reverse declines in waterfowl populations and their habitat. The Service is also a partner in the international Partners in Flight program, a voluntary collaboration of governmental and private organizations in North, Central, and South America (Section 3.2.1.2.4.1 for more detail).

At an international level, the United States is also obligated to conserve wetlands, biological diversity, and natural areas through the establishment of refuges and other protected areas, and through establishment and enforcement of regulations. Stillwater NWR and Fallon NWR contribute to these obligations by protecting and enhancing wetland habitat, conserving natural biological diversity, and protecting natural features of the landscape. Several requests to list the Lahontan Valley Wetlands as a Wetland of International Importance have been filed and Senator Harry Reid asked the refuge to re pursue nomination during summer 2001.

The Stillwater NWR Complex is also important nationally, and possibly internationally, for its public use benefits both on and off the refuge complex. The waterfowl produced and fed on Stillwater NWR are seen by birdwatchers and harvested by waterfowl hunters throughout the Pacific Flyway. American white pelicans produced on Anaho Island NWR are enjoyed by birdwatchers and casual wildlife observers up and down the west coast. Long-billed dowitchers, other shorebirds, and waterbirds that rely on Stillwater NWR's wetland habitat during migration also contribute to these off refuge experiences. The annual Spring Wings Bird Festival, in its fifth consecutive year, is advertised in an international directory of birding and nature festivals published by the National Fish and Wildlife Foundation (2001), thus contributing to the growing demand for national and international birdwatching destinations. Also contributing to its role as a national and international destination is the Lahontan Valley wetland's designation as one of only 15 internationally recognized shorebird reserves (Western Hemispheric Shorebird Reserve Network) and designation as one of the first 100 Globally Important Bird Areas by the American Bird Conservancy in 2001. More recently (September 2001) the Audubon Society has requested the refuge to file an application for the Lahontan Valley wetlands as a Globally Important Bird Area under their charter as well. Further, Stillwater NWR and the Lahontan Valley wetlands as a whole are periodically the subject of articles in nationally circulated magazines, such as Audubon, Sunset, and Nevada Magazine, touting it's value as a travel destination for all the reasons listed above.

2.2.2 REGIONAL

The Stillwater NWR Complex is situated at the west central end of the Interior Basin's ecoregion in Region 1 of the Service (Map 2.1). This ecoregion roughly corresponds with the Great Basin and Mojave Desert. The Intermountain West Joint Venture Implementation Plan (Intermountain West Joint Venture 1995), a component of the North American Waterfowl Management Plan, encompasses much of the Interior Basins ecoregion. As a focus area of the Intermountain West Joint Venture , Stillwater NWR Complex contributes toward achieving the primary goal of the joint venture, which is to "provide for the long-term conservation of wetland habitats and their associated wildlife" in the Intermountain West (Intermountain West Joint Venture 1995). Another major goal of the joint venture is to restore and maintain migratory bird populations at 1970 levels. Specific population targets and habitat objectives are listed in the Intermountain West Joint Venture Implementation Plan.

The Stillwater NWR Complex is regionally important to other bird species. For example, Anaho Island NWR contains one of the nation's largest nesting colonies of American white pelicans at 7,000 to 10,000 pairs, annually. White-faced ibis populations are influenced by wetland habitat conditions throughout the Great Basin. The availability and quality of suitable nesting habitat on Stillwater NWR is important to this population of birds.

Long known in western Nevada for high quality waterfowl hunting opportunities, Stillwater NWR and Stillwater WMA are becoming increasingly popular with out-of-state hunters seeking less crowded hunting conditions. The Stillwater NWR Complex is also enjoying a growing regional recognition for the birdwatching opportunities that can be found there. Of primary interest are the numerous waterfowl, shorebirds, and other waterbirds that breed in the refuge's wetlands or rely on its wetlands during migration. Stillwater NWR has recently been included in a number of state and regional birdwatching and wildlife observation guides, which are sure to add to this reputation. The refuge complex contributes to off refuge birdwatching experiences as well. One of the high points of birdwatching in western Nevada is the sight of a white pelican in a desert landscape. These birds are produced on Anaho Island NWR and feed on Stillwater Marsh and other Lahontan Valley wetlands. Other birds produced on the refuge complex contribute to off refuge experiences as well. The Stillwater NWR Complex's environmental map 2.1 education program, which grew considerably starting in the early 1990s has been contributing to environmental education in schools throughout western Nevada since that time. The program continues to grow.

In addition to the more visible activities associated with wetlands that contribute to a local and regional economy, such as birdwatching, hunting, and general recreation, there are other benefits that may accrue. Among these benefits, as they relate to the Lahontan Valley wetlands complex, are (1), the role of the wetlands in the Pacific Flyway in terms of its contribution to the quality of waterfowl hunting throughout the flyway and (2), the impact of the wetlands on non-game species of birds. Furthermore, there is a value associated with the wetlands complex, as a remnant of ancient Lake Lahontan and the knowledge that these important wetlands still exist after 10,000 years.

2.2.3 LANDSCAPE

Stepping down from the Interior Basins ecoregion, the Carson and Truckee River Basins (Maps 1.2 and 2.1) provide the water that flows into the Lahontan Valley wetlands and Pyramid Lake, respectively. The Truckee Canal created a link between the two basins hydrologically, but there are other connections between the two basins. Many of the white pelicans nesting on Anaho Island in Pyramid Lake make daily feeding forays to Stillwater Marsh and other Lahontan Valley wetlands, a distance of roughly 60 miles. The majority of people who visit the Stillwater NWR Complex live within the Truckee Carson River Basins, including many people from the Reno area, through which the Truckee River flows.

Wetlands in Stillwater NWR, Stillwater WMA, and Fallon NWR are components of the Lahontan Valley wetland ecosystem. Other components include wetlands in the Carson Lake Wildlife Management Area (managed jointly by NDOW and TCID) and Fallon Paiute-Shoshone Reservation, the Carson River, Carson Sink, and various irrigation reservoirs, canals, and drains. The Lahontan Valley wetland ecosystem forms the terminus of the Carson River, which originates in the Sierra Nevada Mountains south of Lake Tahoe. Wetland habitat in Stillwater NWR and Stillwater WMA contribute toward meeting requirements of P.L. 101-618. One requirement of this law is for the Department of the Interior to acquire, in conjunction with the State of Nevada, enough water to sustain a long-term average of 25,000 acres of primary wetland habitat in four designated areas in the Lahontan Valley. The other two areas are the Carson Lake Wildlife Management Area and the Fallon Paiute-Shoshone Reservation. No other valley wide goals or objectives exist with respect to conserving wildlife, wetlands or other habitat, or for providing opportunities for wildlife-dependent recreation. The alternatives considered in this Final EIS were developed in consideration of the management objectives and strategies being considered for the Carson Lake Wildlife Management Area. Also considered is the current status and management of the Carson River, regulating reservoirs, canals, and drains throughout the Lahontan Valley and the wetland habitat these areas support.

At a landscape level, the visitor services program at Stillwater NWR Complex most notably contributes to the hunting opportunities available to local residents. Other local hot spots for hunting include Carson Lake, Humboldt Sink, and several private hunt clubs, all of which provide different types of experiences. Given the increasingly urban component of Fallon and Churchill County, it is anticipated that the Stillwater NWR Complex will become more important as a destination for local residents interested in viewing wildlife and touring natural areas, in addition to continued use of the area by local residents for hunting. The growing environmental education program will also reach more local residents over time.

2.3 ENVIRONMENTAL IMPACT STATEMENT STUDY AREA

2.3.1 GEOGRAPHIC AND CLIMATIC SETTING

The EIS study area, the area in which potential impacts are identified and analyzed in Chapter 4, encompasses the lower reaches of the Carson and Truckee River Basins. The portion of the Carson River Basin included in the study area begins at the upper end of Lahontan Reservoir, near Fort Churchill, and continues downstream to the terminus of the Carson River in the Lahontan Valley and Carson Sink. Carson River flows, recorded just above Lahontan Reservoir from 1912 to 1992, have averaged about 263,200 acre-feet per year. Flow volumes have varied widely during the period of record, with a high annual flow at Fort Churchill of 804,300 acre-feet (1983 water year) and a low annual flow of 26,300 acre-feet (1977 water year). Lahontan Reservoir is a water storage facility for the Carson Division of the Newlands Irrigation Project which is located in Churchill County, Nevada. Water from Lahontan Reservoir is conveyed to farmland and wetlands through the lower Carson River and an extensive network of canals and drains, which terminate at the Lahontan Valley wetlands and Carson Sink. Carson River water that is delivered and otherwise conveyed to Carson Division farmland and wetlands is supplemented by Truckee River water (an estimated average of 37,700 acre-feet per year) via the Truckee Canal.

The Carson Desert, or Lahontan Valley as it is more popularly known, is the largest intermountain basin in Nevada. This basin is bounded by several mountain ranges, with peaks ranging from 5,338 to 8,790 feet in elevation. The vast majority of the Carson Desert, about 2,000 square miles (1.3 million acres), is comprised mainly of gently rolling desert shrublands and flat alkali playas. Proportionally, farmland, City of Fallon and associated suburbs, and wetlands in the Lahontan Valley comprise a small component of the basin (roughly 7 percent). The Carson Division of the Newlands Project is situated near the southwestern end of the basin and the Lahontan Valley wetlands lie at the eastern, northeastern, and northern periphery of the Carson Division. An estimated 55,075 acres of water righted farmland is irrigated each year on average in the Carson Division. The City of Fallon sits roughly in the center of the Carson Division.

When they have water, the Lahontan Valley wetlands are some of the most productive in the western United States. They are unique in that they provide expansive areas of relatively shallow wetland habitats with waters of varying salinity. The Lahontan Valley wetlands are characterized by shrinking and swelling, both seasonally and annually, as well as over geologic time. This fluctuation creates a diverse Great Basin wetland ecosystem, which encompasses a wide range of wetland habitat types within a localized area. Within the span of one season, these wetlands can transform from shallow lakes with clear, freshwater, to shallow, brackish marshes with high salt concentrations.

The Lahontan Valley wetland system is comprised of the Carson River and its delta, Carson Lake, Stillwater Marsh, and wetlands on the Fallon Paiute-Shoshone Indian Reservation. Upon completion of the ongoing water rights acquisition program, a long-term average of 25,000 acres of wetland habitat will be maintained in Carson Lake, Stillwater Marsh, and the Fallon Paiute-Shoshone Indian Reservation. The Carson Sink is an additional wetland associated with the Carson River, and it is the ultimate terminus of the system. This wetland is not part of the Lahontan Valley wetlands described in P.L. 101-618.

In general, the climate of the Lahontan Valley is arid, summers are hot, and winters are cold. In summer, night temperatures are characteristically cool. The average daytime maximum temperature during July through August, typically the hottest months, is about 91°F and the average daily low is about 52°F. Temperatures in July and August can exceed 100°F. The average daytime low temperature during December through January is about 18°F and the average high is about 46°F. The minimum temperature recorded since 1900 is -25°F and temperatures below 10°F are not uncommon. Annual precipitation ranges from one to nine inches and averages about five inches. An average of about two inches is received during February through May. Annual evaporation of surface water exceeds precipitation by about 12 to 1, due to the desert climate. Lahontan Reservoir, other Newlands Project regulating reservoirs, and the primary wetland areas show evaporative losses of 60 or more inches per year. The long-term average (1940 to 1990) evaporative loss rate for Fallon is 53 inches per year.

The study area also includes the lower Truckee River Basin from where the Truckee Canal leaves the Truckee River (Map 1.2) at the Derby Diversion Dam downstream to Pyramid Lake. Downstream of the Derby Dam, the Truckee River enters the Pyramid Lake Indian Reservation and then flows north before entering Pyramid Lake. Major features along this stretch include Marble Bluff Dam and Pyramid Lake Fishway which are about three miles upstream of Pyramid Lake, and Numana Dam and Fish Ladder which are located upstream of Marble Bluff Dam.

Anaho Island NWR is a rocky island that rises from the waters of the southeastern portion of Pyramid Lake. From its two prominent center peaks, the terrain slopes gently toward the water's edge through a series of old stranded beaches. Anaho Island is the largest island in Pyramid Lake. The size of the island depends on the level of the lake. In 1913 when the refuge was established, the island was 247 acres. Based on a water level elevation in Pyramid Lake of 3,809 feet in July 1997, Anaho Island was an estimated 575 acres.

The Truckee Canal conveys Truckee River water from the Derby Diversion Dam to the Lower Carson River Basin. Along the way, water is diverted to supply the Truckee Division of the Newlands Project. About 4,000 acres of water righted farmland is irrigated each year in the Truckee Division.

2.3.2 SOCIOECONOMIC SETTING

Historically, farming, ranching, livestock production, and a rural lifestyle have characterized the social and economic environment in the study area. In recent years however, rapid population growth, increased commercial and light industrial development, and the enhancement of the Naval Air Station Fallon have changed Fallon and Churchill County. Generally, these changes represent a transition toward a more urban lifestyle. Cities and towns within the study area are Fallon, Stillwater, and Hazen (Churchill County); Fernley (Lyon County), and Wadsworth and Nixon (Washoe County). Because the changes that could occur as a result of the alternatives being considered in this Final EIS would not measurably affect the social and economic resources in the Truckee River Basin, the social and economic study area is limited to the lower Carson River Basin, most of which lies in Churchill County, Nevada.

Communities in the lower Carson River Basin, like much of Nevada, are experiencing population increases at a steady annual rate. Churchill County's population, for example, grew by more than 3 percent annually between 1990 and 1996 and almost 6 percent between 1996 and July 1, 1997 (Nevada Division of Water Planning 1999). In 1997, Churchill County’s population base was approximately 23,860 residents, which included residents of the Fallon Paiute-Shoshone Indian Reservation. Fallon is the largest city in the county, in which approximately 35 percent of the County’s population resides. Growth is projected to continue at a rate of about 2 percent over the next five years.

More than 95 percent of Churchill County's 3.1 million acres is classified as fourth class grazing lands or rangelands. Another 355,000 acres remain classified as agricultural. Most of the irrigated agriculture in Churchill County is in the Newlands Irrigation Project. The balance is classified as residential, industrial, and commercial. Expansion of the industrial, commercial, and residential land use pattern is displacing prior land uses, typically agricultural (irrigated farm lands or grazing lands).

According to a report prepared by the University of Nevada, Reno Department of Applied Economics and Statistics (Englin et al. 1999), the major employers in Churchill County are Federal, State and local governments; the service industry; and wholesale and retail trade. Federal, State and local governments account for nearly one third of the jobs in the County.

According to the Nevada Division of Water Planning (Nevada Division of Water Planning 1999), the service sector provides about 34 percent of the total jobs in the community. This is followed by wholesale and retail trade with 24 percent of the employment. Agriculture and its associated service sector account for an estimated 8 percent of jobs in the county, while construction provides 7 percent. Mining, manufacturing, transportation and public utilities, finance, insurance and real estate make up the remainder of employment in Churchill County.

2.4 STILLWATER NWR COMPLEX

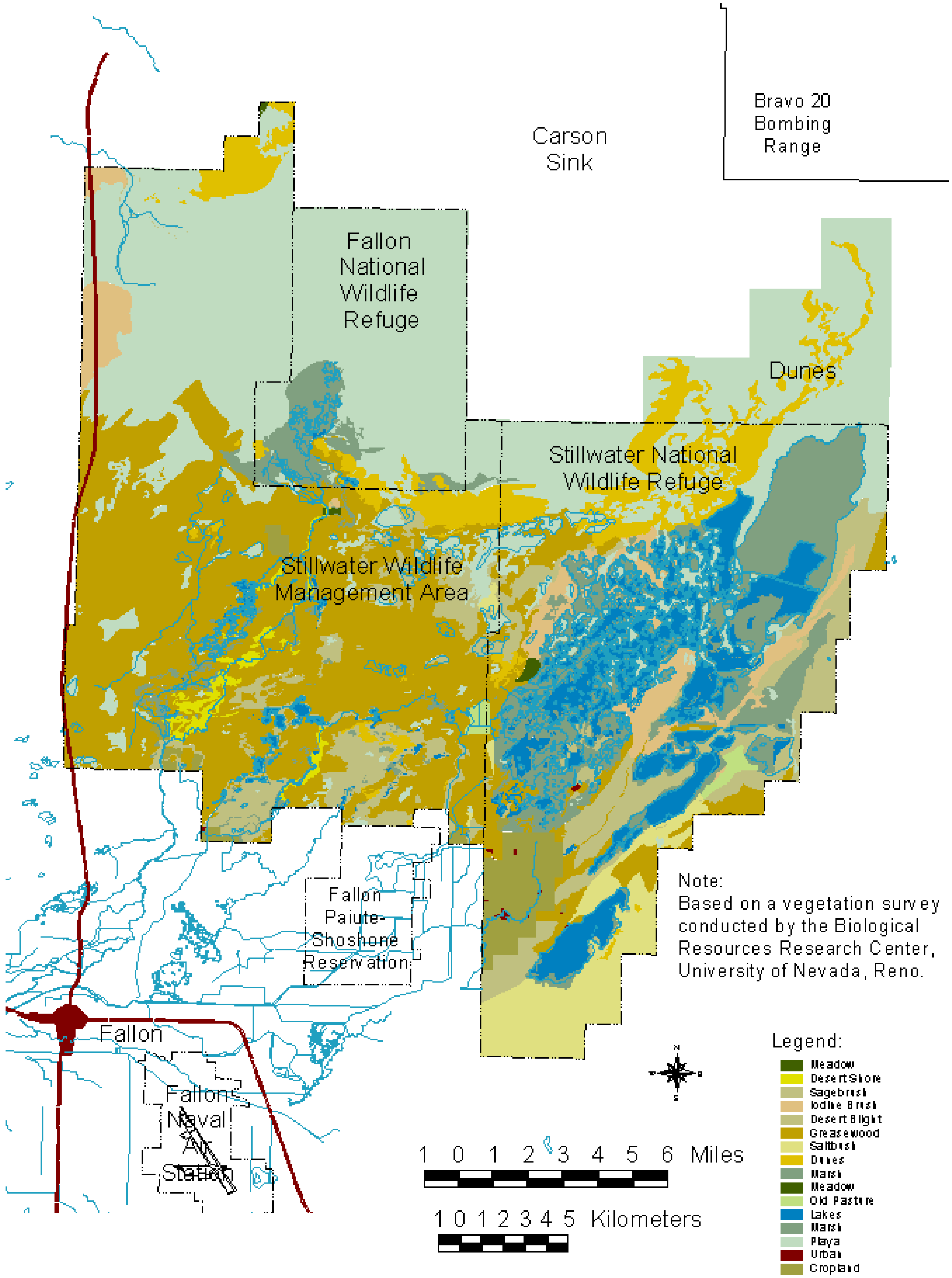
2.4.1 ECOLOGICAL SETTING

Stillwater NWR, Stillwater WMA, and Fallon NWR adjoin Federal wildlife areas located northeast of Fallon in Churchill County. They are situated at the southwestern end of the Carson Sink and entirely within the subbasin of Pleistocene Lake Lahontan. The three Federal wildlife areas lack any significant topographic relief, with elevations ranging between a low of about 3,865 feet in the Carson Sink within the Fallon NWR to a high of 4,270 feet at the base of the Stillwater Range in the extreme southeastern portion of Stillwater NWR. In general, substrates on the three Federal wildlife areas are fine grained, valley bottom sands and silts. Major geographic features within the Federal wildlife areas include numerous playas with highly alkaline sediments, both active and stable dune formations adjacent to the playas, and marshes which receive water from the Carson River and agricultural activities in the Lahontan Valley (Charlet et al 1998).

Being fairly representative of the Lahontan Valley in terms of the habitats encompassed within its borders, the landscape of Stillwater NWR, Stillwater WMA, and Fallon NWR is dominated by gently rolling to flat desert shrublands and flat alkali playas. Desert shrub plant communities on Stillwater NWR, Stillwater WMA, and Fallon NWR typically are made up of plant species that can tolerate moderate to highly alkaline soils and can survive on minimal precipitation (about five inches per year). Three different upland desert shrub community types have been identified on Stillwater NWR, Stillwater WMA, and Fallon NWR: greasewood shrublands, saltbush desert shrublands, and dunes (Map 2.2). The topographic depressions tend to have saline, clay based soils that pond water whereas raised areas tend to have sandy, less saline, more well drained soils. The depressions are the playas that are scattered throughout the upland shrublands.

Although they comprise the smallest amount of area, the basin wetland and riparian areas support the highest diversity of wildlife. The main sources of water enter Stillwater NWR, Stillwater WMA, and Fallon NWR through Newlands Project canals and drains and the Carson River. The lower Carson River within the Stillwater WMA is in degraded condition, suffering from a depleted water supply, heavy livestock grazing, and encroachment by saltcedar and other

Map 2.2 Land Cover



introduced species. Historically, this riparian area was dominated by cottonwoods and a variety of shrub species.

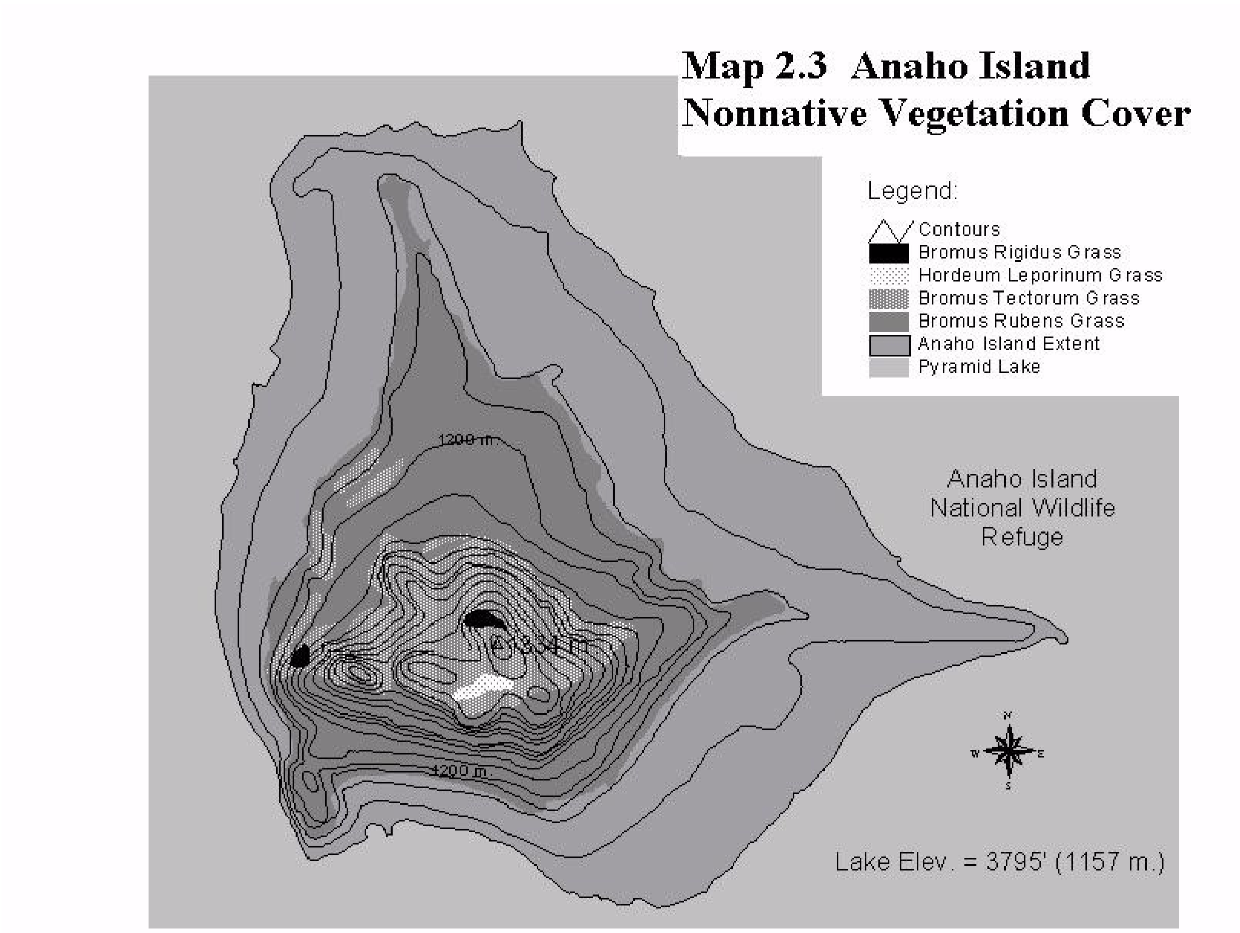
Deep water, more than four feet, is rare in Stillwater Marsh. This wetland is now characterized by shallow and deep emergent vegetation (such as alkali bulrush, cattails, and hardstem bulrush), vast areas of submergent vegetation (such as horned pond weed and wigeon grass), mudflat habitats, and wet meadow communities around the periphery of some wetland units and monotypic saltcedar communities along the edges of others. The wetlands at the delta of the Carson River (on Fallon NWR) has similar wetland habitat when it has water, but it typically only contains water every three to four years. Saltcedar is abundant on Fallon NWR.

Anaho Island NWR is in the Pyramid Lake Indian Reservation and is about 30 miles northeast of Reno, Washoe County, and about 60 miles northwest of Stillwater NWR. The island, which has fluctuated in size from 220 to 745 acres in recent history, has fairly gentle slopes near the shoreline, but the topography becomes steep and rocky toward its peak. The island harbors desert shrub communities, including greasewood and winterfat; nonnative annual grass species such as red brome and cheatgrass; and native bunch grasses and forbs such as desert needlegrass and buckwheat (Map 2.3). Closer to the shoreline, vegetation is scant.

2.4.2 PUBLIC USE

Although public use is prohibited on Anaho Island NWR, a variety of public activities occur on Stillwater NWR and WMA. These uses include but are not limited to the six priority public uses of the Refuge System identified in the Refuge System Administration Act, namely hunting, fishing, wildlife observation and photography, and environmental education and interpretation.

Wildlife observation and photography are popular activities, with attention focused primarily in the 80,000 acre Stillwater NWR and its diverse waterfowl and waterbird populations. Spring and fall migrations of waterfowl and shorebirds reach peaks of over 200,000, and a number of heron rookeries furnish opportunity for viewing some of the more showy species. Other favorite areas for observing avian life are the Indian Lakes portion of the Stillwater WMA, and the Timber Lake area to the north of Indian Lakes (Map 1.3). Timber Lake is currently being surveyed for its rich diversity of passerine (songbird) species, and it offers breeding habitat for herons and night roosting habitat for bald eagles. The upland areas provide opportunity for viewing shrub reliant species such as sage sparrows, loggerhead shrikes, rodents such as kangaroo rats, and a variety of lizards. Mule deer are commonly seen in the agricultural fields located near the southern entrance to Stillwater NWR, and muskrats are common throughout the canals and in the wetland units. An annual birding festival, Spring Wings, provides opportunity for over 400 participants to enjoy organized tours of not only Stillwater NWR, but a number of other Lahontan Valley birding sites. A primary focus of this festival is to elevate national awareness on education and awareness of wetland species and conservation issues. Waterfowl hunting is a favorite recreational pursuit at



Map 2.3 Anaho Island Nonnative Vegetation Cover

Stillwater NWR in years when sufficient water is available to provide fall and winter habitat for waterfowl. Abundant fall waterfowl support an active hunting program with few restrictions. Boating has historically been permitted on all open wetland units any time of the year, but most boating is done to support waterfowl hunting. Opportunities for hunting other species such as quail, deer, and coyote are currently available in the Stillwater WMA. Environmental education and interpretation are important on Stillwater NWR. Refuge staff lead tours, conduct school educational outings, and provide assistance to visitors. The program, lacking in the past, has continued to grow over the last ten years as educational methods and materials are acquired and developed. Interpretive panels as well as staff led talks and tours are currently undergoing extensive design and enhancement. Over 1,000 students and educators from a 150 mile radius have benefitted from Stillwater's current programs.

In years past, fishing rivaled hunting in terms of the number of people partaking in this activity on Stillwater NWR, and a small number of people can still occasionally be found fishing for carp and catfish in some of the canals and wetland units of Stillwater NWR. Likes Lake in the Indian

Lakes area of Stillwater WMA is annually stocked with trout by NDOW, which has enabled these small lakes to sustain a fairly well used seasonal sport fishery.

People also use the area for a variety of uses including camping, swimming, sightseeing, muskrat trapping, and horseback riding. Most of these uses occur in the Indian Lakes area within the Stillwater WMA. Muskrat trapping is done primarily in Stillwater Marsh.

2.4.3 CULTURAL RESOURCES

Stillwater NWR and Stillwater WMA contain some of the richest cultural resources in the Great Basin. Humans have flocked to Stillwater Marsh for millennia. Because the area provides exceptional habitat for wildlife, the Stillwater area has been an excellent place for people to live.

Cultural resources are physical remains, sites, objects, records, oral testimony, and traditional ways that connect us to our nations past. Cultural resources include archaeological and historical artifacts, sites, landscapes, plants, animals, sacred locations, and traditional cultural properties that play an important role in the traditional but continuing life of a community. Most of the recorded cultural resources at Stillwater are archaeological sites.

Archaeological evidence shows that human beings have lived in and around Stillwater Marsh for at least 12,000 years. The historic descendants of this legacy are the *Toedokado* or Cattail-eater Northern Paiute of Stillwater Marsh and vicinity. The *Toedokado* occupied an area bounded by the Humboldt Range to the north, Alpine Mountains to the east, Desert Range and south end of the Sand Springs Mountains to the south, and the Truckee and Virginia Ranges and the lower Carson River to the West. The modern descendants of the *Toedokado* are represented by the Fallon Paiute-Shoshone Tribe whose reservation borders are near Stillwater NWR to the east and Stillwater WMA to the north. Cultural resources in the Stillwater area remind us that people have been part of the American wildlife landscape not for a mere 100 years, but for at least 12,000 years.

Toedokado origin myths place Jobs Peak, located in the Stillwater Range, at the center of creation. From there, the first people were dispersed to Stillwater Marsh (among other places) which was filled with water by the tears shed by the Creator because of warring among his children (Fowler 1992). The explorers, settlers, and journalists who came into *Toedokado* territory all remarked on the vibrant Indian population at Stillwater Marsh. The marsh was alive with people as much as it was with wildlife and fish. Archaeological research has shown that the marsh has been a human landscape for thousands of years. Archaeological remains of *Toedokado* culture pervade the soil of every island, peninsula, and dune of the marsh. Even the barren playas have yielded evidence of the people.

The *Toedokado* were year round residents of the marsh. They were not fleeting nomads who somehow eked out a living in a harsh environment. They understood the complexities of the ecosystem and were able to extract all the necessary food and raw materials to maintain a rich and thriving culture. For *Toedokado* descendants and members of the Fallon Tribe, the archaeological sites, sacred places, plants, and animals of Stillwater Marsh are basic elements of individual and group identity. Thus, the management of the Stillwater NWR and its cultural resources is of particular concern to the Fallon Tribe. As the CCP compels us to contemplate our interaction with the Stillwater environment today, we must remember that the *Toedokado* and their ancestors have been doing this for thousands of years.

One of the salient features of Stillwater archaeology is an abundance of human burials (Brooks et al.1988, Larsen and Kelly 1995).   The flood of the mid-1980s revealed more than 4000 human bones representing at least 140 people. Overnight, the number of known archaeological human remains in the Great Basin doubled. It is safe to infer that hundreds more human burials lie just below the surface of greasewood studded islands and peninsulas of the Stillwater wetlands. The archaeological pattern appears to be that any residential archaeological site may contain one or more human burials. The possibility of encountering human remains almost anywhere in and around the marsh is high. The exposure of burials does not require a massive erosion event like the flood of the mid-1980s. Localized wind or sheet wash erosion occasionally bring bones or a burial to the surface.

2.5 NATURAL ECOLOGICAL CONDITIONS OF THE CARSON DESERT WETLANDS

The “maintenance and restoration of natural biological diversity” purpose of Stillwater NWR, in addition to the emphasis on natural habitat conditions in international treaties and Service policy, prompted an investigation of natural ecological conditions in the Lahontan Valley and other parts of the Carson Desert. This section summarizes the results of this investigation.

The level of detail in the following discussion is higher than preceding discussions, primarily because the subject matter of previous sections is dealt with in more detail in Chapter 4 and nowhere else is there a discussion on natural ecological conditions. This information is directly pertinent to objectives and strategies in the action alternatives of this Final EIS.

2.5.1 DEFINITIONS OF KEY CONCEPTS

“Natural biological diversity” and the "range of natural conditions" are key concepts of the natural biological diversity purpose of Stillwater NWR. Natural biological diversity is defined as the variety within and among biological communities that evolved in the Carson Desert under geological, evolutionary, and other ecological processes apart from human influence. Biological diversity, which is commonly defined as the variety of life and its processes, can be measured in terms of the number and types of species and biotic communities, and the abundance, distribution, and structure of each, as well as the genetic diversity, structural complexity of vegetation, and diversity of biotic processes (DeLong 1996).

Because of the highly dynamic nature of Great Basin wetland systems, the natural range of ecological conditions is a very important consideration in developing objectives and strategies for restoring natural biological diversity, as opposed to an estimation of the average conditions. Natural conditions cannot be boiled down to a "snap-shot in time." Assessing the natural range of ecological conditions should help managers avoid what has been termed a "museum" approach to management (Parsons et al. 1986). For this reason, a 95 year period was used to assess natural conditions, enough time to account for conditions that can reasonably be foreseen during the planning horizon of the Stillwater NWR Complex Comprehensive Conservation Plan (15 years) and beyond.

Managing for natural conditions does not necessarily eliminate active management. In fact, excluding active management could hamper efforts to approximate natural conditions. Although human actions and developments tend to reduce the degree of naturalness, the term natural more importantly refers to *a set of conditions* that would exist under the operation of natural processes, rather than referring to the *absence of human intervention*. Because the hydrology is so highly altered and will not return to a naturally functioning state, and because a whole host of other reasons including the introduction of nonnative species and contaminants, active management will be a necessary part of approximating natural conditions. To address questions concerning long-term changes in climate and prediction of conditions that existed long ago, the conceptual model focused on estimating the range of natural conditions that would have occurred from 1912 to 1996 if humans had no influence on the wetland ecosystem.

2.5.2 NATURAL FUNCTIONING AND COMPOSITION OF THE CARSON DESERT WETLANDS

The Lahontan Valley wetlands are part of the Carson Desert wetland ecosystem, which includes Carson Sink in addition to the Lahontan Valley wetlands. The six major hydrologic components of the Carson Desert wetland ecosystem are: Carson River, Carson Lake, Stillwater Marsh, Carson Sink (historically known as North Carson Lake), numerous scattered alkali playas and seep ponds not associated with the Carson River system, and groundwater. All of the components of the Carson Desert wetland ecosystem, except the scattered playas and seep ponds, are integrally linked by water originating from the Carson River. Water from the Humboldt Basin rarely entered the Carson Sink under natural conditions (before the opening in the ridge at the lower end of the Humboldt Basin was enlarged).

2.5.2.1 HYDROLOGY

The main factors that affected wetland ecology in the Carson Desert were the annual volume of inflow, timing of inflow, flow route of the Carson River through the system of wetlands, and evaporation rates. These and other factors are discussed in the following sections.

2.5.2.1.1 Flow Routes of Carson River

Historically, runoff from the Sierra Nevada Mountains (via the Carson River) constituted the primary inflow of water to the Lahontan Valley wetlands. The Carson River was more dynamic prior to construction of the Newlands Irrigation Project; the river channel frequently changed paths during flood flows (Maurer et al. 1994). Russell (1885) reported that prior to 1862, the Carson River flowed only into South Carson Lake (Map 2.4). In the Spring of 1862, high water divided the flow into two separate branches flowing east toward South Carson Lake, and northeast toward the Stillwater Marsh.

Although the actual river channel changed course over time, in recent history (during the mid to late 1800s), the river took three routes on its way to the Carson Sink (formerly called North Carson Lake), the ultimate terminus of the Carson River. At times water flowed first into Carson Lake (formerly called South Carson Lake), which overflowed nearly every year into Stillwater Slough, which flowed into Stillwater Marsh (Map 2.4; Russell 1885). In most years under this flow pattern, Stillwater Marsh overflowed into Carson Sink during the peak runoff period. At other times, the Carson River flowed directly into Stillwater Marsh, bypassing Carson Lake, and then into Carson Sink. Other periods saw the Carson River bypass Carson Lake and Stillwater Marsh, and directly flow into Carson Sink. Undoubtedly peak runoff of the Carson River resulted in several channels carrying water through the Lahontan Valley into two or three of the subbasins. Over the course of geologic time, the Carson River took thousands of paths through these three different routes. Stillwater Marsh appears to have acted as a delta to the former North

Carson Lake, until the chain of sand dunes that formed along the south shore of the lake interrupted the flow. This may have aided in the development of the marsh. As a consequence of the sand dune chain, the Carson River at times likely formed a marsh similar to Stillwater Marsh further to the west. At the western most edge of the dunes, in the area of Battleground Point and Pelican Island, and to the west, the Carson River could flow uninterrupted into North Carson Lake. A dune blockade would not have formed the same type of marsh as was formed to the east, and the delta wetlands may have been similar to that formed at the delta entering South Carson Lake.

2.5.2.1.2 Wetland Topography and Shape

Wetland geomorphology ranged from Carson Lake, which was a relatively deep circular lake, and Carson Sink, a relatively shallow circular lake, to Stillwater Marsh, a highly complex wetland with shallow to deep areas, areas of highly intermixed habitats, and vast expanses of other habitats. Carson Lake was about ten feet deep when full, at which time 80 percent was over four feet deep. Carson Sink generally was less than four feet deep. During the late 1800s and early 1900s, a relatively deep channel meandered through Stillwater Marsh, creating deep water areas and providing a path for Carson River water to flow into the Carson Sink. Although the channels running through the marsh and most of the upper end of Stillwater Marsh appear to

Map 2.4. Reproduction of an early map showing the Carson Desert wetlands before development (1880's). The "South Carson Lake" is now known as Carson Lake; "North Carson Lake" is now known as Carson Sink, and the vast delta of the Carson River as it enters "North Carson Lake" is now known as Stillwater Marsh. (Illustration was published in 1885 as Plate VII by I.C. Russell in U.S. Geological Survey Monograph 11, A Report on Ancient Lake Lahontan.)

have been deeper than four feet, the majority of the marsh was less than two feet deep when Stillwater Marsh was at full pool.

The complexity of wetland shorelines can have considerable influence on wetland communities (Wetzel 1975). Shoreline complexity is a function of the length of the wetland shoreline relative to the amount of wetted surface of the wetland and can be expressed using an index in which a perfect circle has an index of 1.0. Carson Lake, when at full pool, has a simple shape near that of a circle (an index of 1.6). This is similar to the Carson Sink, which had a shoreline complexity varying between about 1.4 and 2.0. Stillwater Marsh, on the other hand, had a highly complex shoreline, ranging from about 3.6 up to 13.8 or more, depending on location in the marsh. Marshes that formed to the west would have similarly had complex shorelines.

2.5.2.1.3 Annual and Seasonal Volumes of Inflow

In the absence of any diversions or water control structures during the period of record, an estimated average of about 410,000 acre-feet would have flowed past Fort Churchill into the Lahontan Valley as surface runoff (Kerley et al. 1993). The flow volumes under these natural conditions would have ranged from an estimated low of 90,000 acre-feet (1977 water year) to an estimated high of about 940,000 acre-feet (1983 water year). In 80 percent of the years, about 200,000 to 700,000 acre-feet of water would have flowed into the Lahontan Valley, sufficient enough to produce annual peak acreages of wetland habitat of roughly 60,000 to 200,000 acres.

Stemming from the average conditions identified in Kerley et al. (1993), a model was developed as a tool to estimate the natural range in hydrologic conditions in the Carson Desert wetland ecosystem (DeLong 1997). Variability is a key element of Great Basin ecology. Although specific numbers are presented, the results of the model are intended to portray general patterns and trends. The basis of the model is monthly flows that occurred in the Carson River during 1912-1996, using U.S. Geological Survey flow gauge records. For each year during this period, unobstructed flows were determined by accounting for the diversions that have occurred from the river, as done in Kerley et al. (1993). After ordering all of the water years from lowest volume to highest unobstructed volumes, five representative years were identified:

- 1994 (lower 10-percentile) - 190,000 acre-feet
- 1920 (lower quartile) - 270,000 acre-feet
- 1941 (median) - 385,000 acre-feet
- 1993 (upper quartile) - 480,000 acre-feet
- 1982 (upper 10-percentile) - 690,000 acre-feet

Under natural, unobstructed conditions, Carson River water flow would have been less than 385,000 acre-feet in half the years and more in the other half. Centered around the midpoint of 385,000 acre-feet, about half the years would have seen an annual flow volume of 270,000 to 480,000 acre-feet of water. Carson River flow into the Lahontan Valley would have been less than 270,000 acre-feet in 25 percent of the years and would have been above 480,000 acre-feet in another 25 percent of the years. Similarly, 10 percent of the years would have seen less than 190,000 acre-feet and another 10 percent would have seen more than 690,000 acre-feet.

Carson River runoff during April through June consistently accounted for about 40 to 70 percent of the total annual flow (Table 2.1, Figure 2.1). This does not take into account the irregular floods that can occur any time between November and June when rainstorms at high elevations melt the snowpack. In many years, runoff prior to April was sufficient to refill Carson Lake and/or Stillwater Marsh and subsequent April through June runoff flowed through these wetlands into Carson Sink. However, April through June flows would have been sufficient in most years to overflow the banks of the lower Carson River and the deltas leading into Carson Lake, Stillwater Marsh, and/or Carson Sink. This created a considerable amount of seasonal wetland habitat that is not produced to any large extent today. An estimate of the seasonal pattern of wetland habitat acreage that would have occurred in Stillwater Marsh under various annual inflow volumes is depicted in Figure 2.2.

Table 2.1.Proportional amount of the annual volume of water that would have flowed into the Lahontan Valley under natural conditions for five representative water years.

		Percent of Flow Volume by Season				
Representative Water year		Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Total
lower 10%	(190,000 AF)	13	69	8	10	100
lower 25%	(270,000 AF)	13	68	11	8	100
median	(385,000 AF)	13	68	13	6	100
upper 25%	(480,000 AF)	16	70	12	2	100
upper 10%	(690,000 AF)	27	57	11	5	

Spring flow volumes flushed the wetland habitats of accumulated salts and other dissolved solids. At times when the Carson River flowed into Carson Lake and/or Stillwater Marsh, water volumes were likely sufficient in most years to maintain most of Stillwater Marsh as a relatively freshwater system. The concentration of total dissolved solids of inflowing water was an estimated average of 170 milligrams per liter (Kerley et al. 1993), and was estimated to have ranged from roughly 50 to 350 milligrams per liter. This compares with current concentrations of 1,170 milligrams per liter in drainwater inflows, which until recently were the primary water source outside of spill years. The amount of water flowing into Stillwater Marsh in most years was much higher than the amount of water needed to offset evaporation and transpiration from plants (evapotranspiration). Using estimates provided in Kerley et al. (1993), the average amount of water flowing into Stillwater Marsh would have been in the neighborhood of 15 to 20 acre-feet/acre/year or more. This assumes an average inflow of 270,000 acre-feet and an average

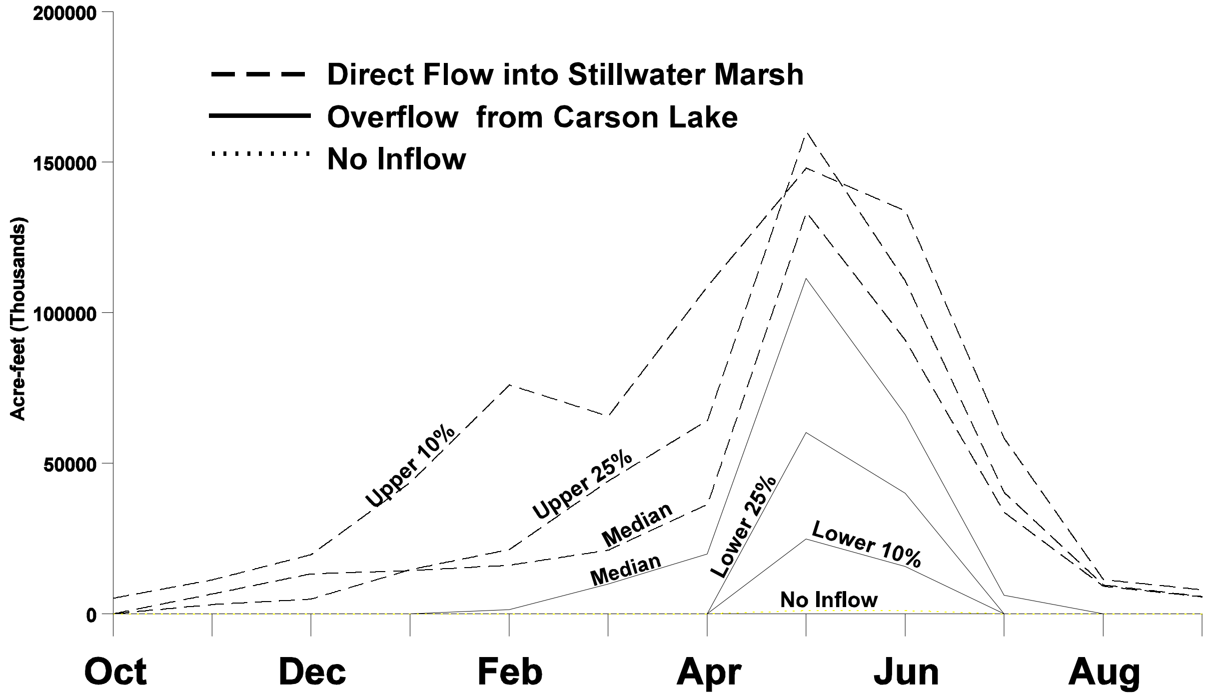


Figure 2.1. Estimated unrestricted flow of the Carson River into Stillwater Marsh, illustrating the range in variability from year to year.

of 15,000 acres of wetland habitat in Stillwater Marsh. Given this inflow volume and an estimated evapotranspiration rate of 5 acre-feet/acre/year, two-thirds to three-quarters of the water entering Stillwater Marsh would have flowed through the marsh and out into the Carson Sink.

Episodic flooding, which once sent voluminous flows into the marshes of Lahontan Valley, had considerable influence on vegetative structure in the wetlands by changing the course of the Carson River, scouring, flushing accumulated salts, and matting or uprooting vegetation. This was an important factor in shaping wildlife habitat in the wetlands. On average, there has been one flood in ten years on the Carson River that has exceeded 15,000 cubic-feet per second at the recorded peak flow was 30,000 cubic feet per second in 1955 (Glancy and Katzer 1975). Peak flow during flood events has exceeded 5,000 cubic feet per second in about one of four years. For comparative purposes, the maximum amount of water that can safely be released and spilled from Lahontan Reservoir is about 1,800 cubic-feet per second. Flood flows of several thousand to 10,000 cubic feet per second or more was an irregularly timed, but fairly common occurrence in Stillwater Marsh. Under present conditions, the maximum inflow rate is 450 cubic feet per second from several points of entry, although this flow rate rarely occurs. Floods can occur anytime between November and early June.

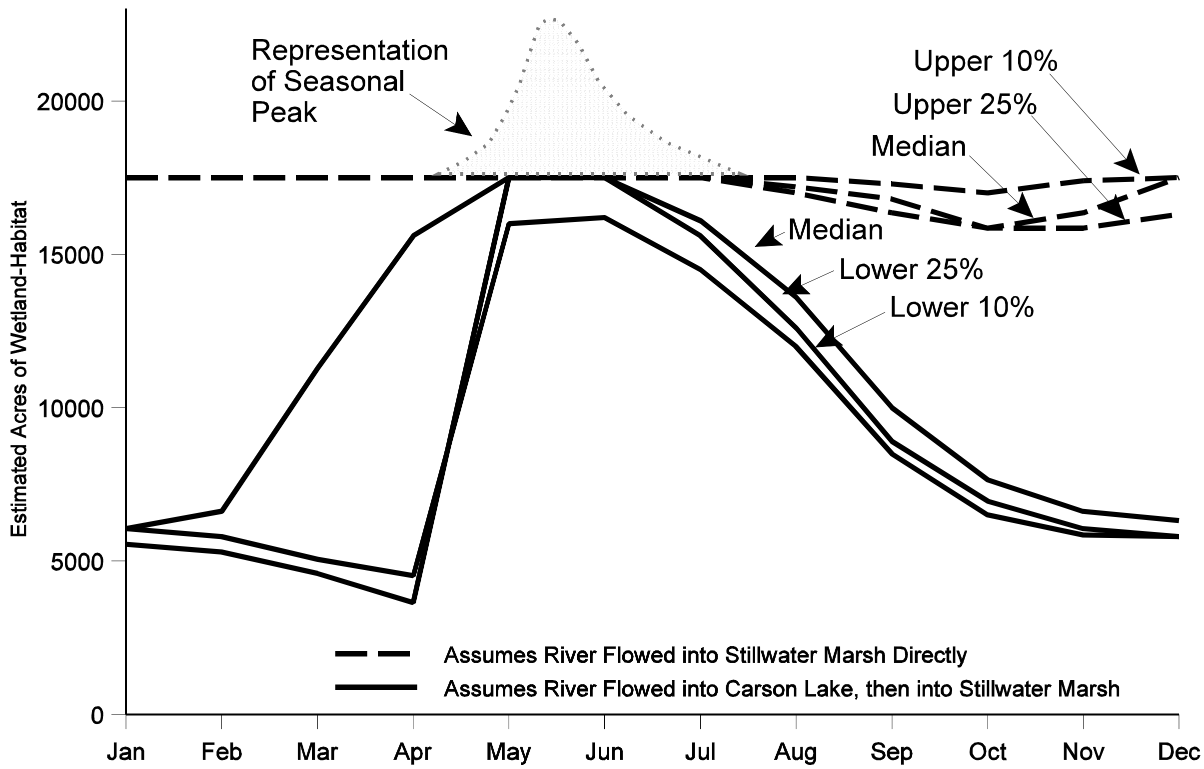


Figure 2.2. Estimated natural seasonal wetland-habitat acreage in Stillwater Marsh under six different scenarios to illustrate the variability that would have occurred among years. Acreages are rough estimates and are primarily included to illustrate seasonal patterns. Included is a representation of the potential seasonal peak acreage, which the conceptual model used to develop this graph was not designed to estimate. Not shown is the situation when the Carson River would have bypassed the Stillwater Marsh for extended periods, at which time the marsh would have remained dry.

At the time when Carson River inflow decreased (July through September), evapotranspiration was at its highest. During July through September, about 10 to 15 percent of the annual flow of the Carson River would have entered the Lahontan Valley wetlands. However, in many years when the Carson River flowed directly into Stillwater Marsh, there was enough water flowing into the marsh in all but the driest years to keep it full, given an estimated 25,000 to 50,000 acre-feet of inflow during this period in most years (Figure 2.1). In other years, especially when Carson River flowed into Carson Lake first, Stillwater Marsh would have shrunk during this period. This would have left shallower, more saline marsh habitats. In areas continuing to receive Carson River inflow, concentrations of total dissolved solids would have remained in the low hundreds of milligrams per liter. However, in backwater areas of Stillwater Marsh and in the Carson Sink, total dissolved solid concentrations would have exceeded 10,000 milligrams per liter, and likely approached 100,000 milligrams per liter. This would have resulted in a wide range of water conditions in the Carson Desert wetland ecosystem.

Even in the driest of years, a considerable amount of wetland habitat would have remained in the Lahontan Valley through fall and winter. Inflow during October through December accounted for about 5 to 10 percent of the annual inflow into the Lahontan Valley, and in January through March, inflow would have consistently been about 10 to 20 percent in most non-flood years.

2.5.2.2 OTHER ECOLOGICAL PROCESSES

No other ecological process had as much effect on the Lahontan Valley wetland ecosystem as the hydrologic functioning of the marsh. Second to hydrology, grazing by muskrats was likely a significant factor influencing wetland vegetation, especially in the marshes. However, little is known about the peak of flow. The maximum muskrat ecology prior to the introduction of nonnative muskrats to the Lahontan Valley wetlands. Some evidence indicates that, prior to muskrats being introduced from Tule Lake NWR, California (USFWS 1950), which had been stocked with muskrats from the north central United States, the local population were burrowers rather than mound builders (Fowler 1992). This may have limited the amount of grazing in the interior of the marsh prior to the introduction of muskrats originating from north-central United States. When populations are high, muskrats can maintain open areas within extensive stands of cattail and hardstem bulrush. Under natural conditions, muskrat populations are very dynamic, meaning that at times their influence on vegetation is small and at other times, very pronounced.

Disease was another factor that had a major influence on marsh ecology. When populations are high, muskrats are susceptible to disease. Whether native populations were susceptible to the same diseases is unknown. In some years, fowl cholera and botulism likely took a toll on waterfowl populations migrating through the Lahontan Valley wetlands during the summer, fall, and winter. However, under natural conditions, water conditions were different from today and there was significantly more wetland habitat, so the extent of mortality caused by these diseases is unclear.

Although browsing by mule deer may have been high at times in riparian areas, grazing by large ungulates (a hoofed, grazing mammal) had minimal influence on wetland plant communities before the introduction of livestock. The only native ungulates that occurred over the past 1,000 years in the Lahontan Valley were mule deer, bighorn sheep, and pronghorn. Mule deer were the only resident ungulate of the basin and they are primarily browsers; when they graze, it is primarily on forbs rather than grasses. Other herbivores that may have had varying influence on vegetation include cottontail rabbits, voles, and a variety of invertebrates. Whether beaver were native to the area is unclear.

Natural fire (lightening strikes) was likely a rare event in the Lahontan Valley wetlands under natural conditions, and therefore had minimal influence on vegetation, although it is likely that the local Paiutes regularly burned the marsh and possibly the riparian corridors as well.

2.5.2.3 WETLAND VEGETATION COMMUNITIES

The seasonal and annual fluctuations in water conditions resulting from differing volumes of inflow, timing of inflow, shifting flow patterns, and high rates of evapotranspiration created a variety of wetland habitats, including braided river channels, closed oxbows, floodplain meadows, ephemeral marshes along the Carson River, and larger perennial and ephemeral marshes and lakes associated with the terminus of the Carson River, such as Carson Lake, Stillwater Marsh, and Carson Sink. Water ranged from freshwater in the river and many of the marshes to very saline in some parts of the marsh and the Carson Sink. This diversity of salinity which produced a great variety of vegetation. This diversity of habitats attracted a wide range of animal species, including vast populations of ducks, pelicans, wading birds, shorebirds, muskrats, fish, and invertebrates, and a large variety of passerine birds and small mammals. The following discussion focuses on historic descriptions of major habitat types (riparian systems, marsh habitats, and terminal basins), changes in these habitats over time, and estimated wildlife use of wetland habitats prior to Newlands Project development.

2.5.2.3.1 Riparian Systems

Branches of the Carson River were characterized by tree and tall shrub species including cottonwood and willows, with a mixed shrub and grass understory (Russell 1885). Changes in channel location left oxbow lakes and associated riparian wetlands in old channels. Following a change in channel location, earlier successional habitats such as mixed meadow grasses and willows would have been the primary vegetation types. After a period of time at a given channel location, late successional cottonwood stands would have developed. Based on estimated dynamics of the river channel, it is unlikely that large, gallery cottonwood stands were abundant. Simpson (1876) and Bailey (1898) describe the river channel as marked by a line of green cottonwoods, of which previous channel locations were delineated by remnant stands of cottonwoods (Russell 1885).

Salinity levels and soil types likely played a role in riparian vegetation development, as J. C. Fremont describes the Stillwater Marsh outlet to the Carson Sink as “having banks eight to ten feet high with willow growth” (Spence and Jackson 1973). As shown on an 1885 map of the Lahontan Valley (Map 2.4), two channels passed through the sand dunes at the northern end of the Stillwater Marsh, likely characterized by higher salinity and sandy soils. Cottonwoods would not become established along this riparian corridor under these conditions. It is uncertain whether the willow vegetative community is representative of an early or late successional habitat; however, sandy soils provide conditions for frequent changing of channel location.

While trees and tall shrubs characterize the previous riparian corridors, Stillwater Slough appears to have been more variable in vegetative coverage. Dequille (1963; as cited in Kerley et al. 1993) recounted a description of Stillwater Slough as “60 feet wide, with vertical banks eight to ten feet high, having grass along the stream, and cutting through the barren sandy plain with only scattered clumps of sage and greasewood." Conversely, the place name for Stillwater Slough used by the *Toedokado* was "tule-flowing" which suggests emergent growth throughout the channel (Fowler 1992). In all likelihood, the slough contained elements of several different vegetation communities ranging from willow to grass to emergent to unvegetated depending on flow amount and duration. Considering this was a popular fishing spot for the *Toedokado* and that the banks were eight to ten feet high, this channel was presumably more static, and thus, less likely to change location. It is uncertain how the flood of 1862 and resulting division of the Carson River into multiple channels affected vegetation in this riparian system, as one of the new channels flowed directly into Stillwater Slough (Bailey 1898).

Active river channels had extensive associated floodplains. These floodplains, which are evidenced by the soils that developed under them (Dollarhide 1975), appear to have included a variety of grass species as well as sedges and rushes. Some grass species that are rare today in the area, such as Great Basin wild rye, likely formed extensive stands in suitable soils (Young 1994).

In summary, riparian vegetation communities were variable with cottonwood and willow stands common along the lower reaches of the Carson River; upland shrub, grasses, and emergent vegetation along the Stillwater Slough; and willows with few other plant species located at the outlet of Stillwater Marsh to the Carson Sink. Other habitats included wooded oxbow lakes with grasses and emergent vegetation; floodplain meadows where the river channel overflowed its banks; and large grass meadow deltas where the channel flowed into the marsh system. Most vegetative species would have been freshwater adapted (and would have left) virtually no information available to predict past species compositions within riparian plant communities. However, there is little question that riparian habitats were much more extensive historically and that a wider diversity of native vegetative species and habitat types were associated with this system.

2.5.2.3.2 Marsh Systems

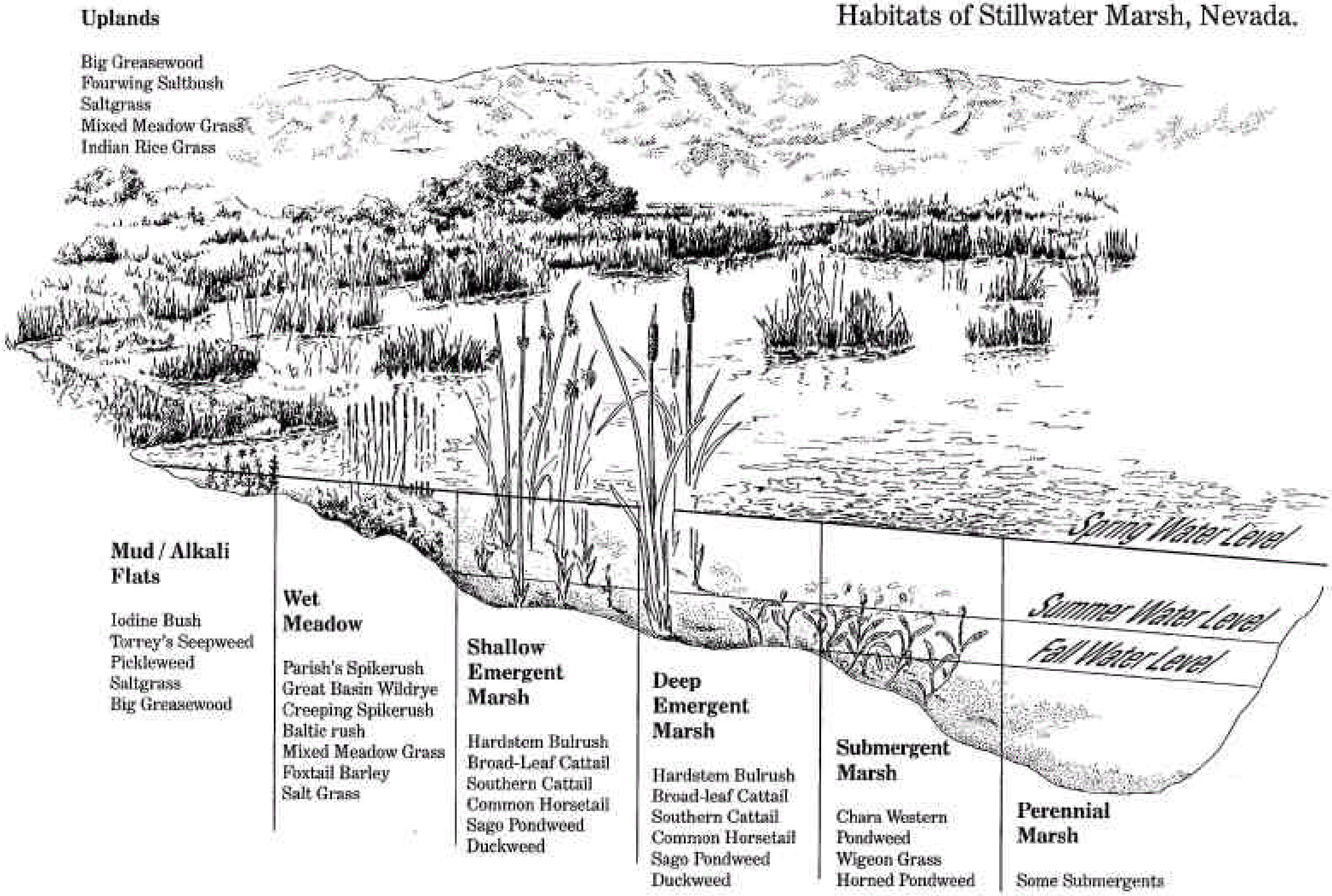
Although the Carson Sink appears to have retained marsh vegetation in most years, two primary marsh complexes have been described in the Lahontan Valley; Carson Lake and the Stillwater Marsh. Prior to 1862, Carson Lake appears to have been a deeper water habitat, with maximum depth approaching ten feet and only a thin ring of marsh vegetation (described as tule margin 30 to 40 yards wide) maintained around the edge during most years (Bailey 1898). The flood of 1862 split the channel resulting in considerably less water entering the lake. By 1883, much of the lake appeared to be a swamp, this suggests that water depths had dropped to a level supporting emergent vegetation throughout much of the lake (Russell 1885). Kerley et al. (1993) proposed that, prior to 1862, based on the size of the cottonwoods described at the mouth of the Carson River, the deep lake system was in place for at least 20 years. It is this long-term variability, in conjunction with annual hydrologic periodicity that maintained the high productivity indicative of Lahontan Valley marsh systems.

Stillwater Marsh appears to have functioned as a single elongated basin that was very complex due to the countless islands and peninsulas. Water flowed from Stillwater Slough, through the maze of watercourses in Stillwater Marsh, to the Carson Sink. Plant communities varied depending on water depth and salinity levels (Figure 2.3). During times when the Carson River or Stillwater Slough flowed into Stillwater Marsh, the large influx of water would have maintained a freshwater system throughout the flow channel to the outlet into the Carson Sink. Salinity levels through the marsh would have increased with increasing distance from these flow channels. Timing and amount of water inflow were variable in this system with marsh permanency determined by flow route, snowpack in the Sierra Nevada Mountains, and timing of inflow. Estimates show that marsh water levels would have remained fairly constant through the year when water entered the Stillwater Marsh directly as excess water would have flowed through the marsh and out to Carson Sink. Conversely, when water flowed through Carson Lake first, high evaporation rates in summer, at a time when inflow was at its lowest, would have reduced much of the wetland surface area in Stillwater Marsh. When the Carson River flowed into the Carson Sink directly, Stillwater Marsh would have been much more seasonal, when at least some water flowed into the marsh during peak flow, or would have dried completely. This variability would have resulted in considerable vegetative variation, both within and among years.

There are few detailed accounts of the historic Stillwater Marsh available. However, two very different marshes were described through the mid- to late-1800s, depicting drought and flood cycles in relation to water flow patterns, which was likely common to the Lahontan Valley historically. During an 1845 expedition, Fremont describes Stillwater marsh as “a large marsh surrounded by sandhills with extremely disagreeable waters” (Spence and Jackson 1973). Fremont may have been describing either a low water year or a period when the river channel bypassed flow to Stillwater Marsh, resulting in high salt concentrations from evaporative drawdown. Bailey (1898) portrayed the Stillwater Marsh as “half shallow lake, half tule swamp which extends for 20 miles along the valley bottom..”

Habitat types would have been similar to those discussed in Section 4.4.1. However, the distribution and species occupying these types would have been somewhat different than suggested in this section and a few additional communities would have been present. Several plant communities known to have occurred historically have either been displaced by nonnative vegetation or can no longer survive under increased salt concentrations present in the marsh today. Even in the late 1950s, two freshwater submergent vegetation species (coontail and water milfoil) were common in early refuge vegetation surveys (Service annual fall surveys, 1959 to present). Recent inventories did not reveal the presence of either plant community (Donohue and Baumgartner 1995, Bundy et al. 1996); however, coontail was located in isolated locations of the Lahontan Valley.

Figure 2.3.
Estimated Natural Plant Distribution in Wetland Habitats of Stillwater Marsh, Nevada.



While still common in the Stillwater Marsh, three emergent vegetation species (hardstem bulrush, cattail, and alkali bulrush) have switched levels of dominance within the deep and shallow emergent habitat types. The historic marsh (around 1900) had an estimated proportional coverage of 33:27:40 (hardstem bulrush, cattail, and alkali bulrush, respectively), while a 1952 survey completed by D. Marshall revealed a ratio of 14:66:20 (Fowler 1992, Giles 1953, USFWS 1952). This is about a 200 percent increase in cattail abundance over a 50-year period with a 1,000 acre increase in emergent vegetation coverage. Similarly, moist soil habitats would have likely been comprised of dock, Torrey's seepweed, and kochia. All of these species are still present, but exotics such as five-hook bassia now dominate this habitat type (Bundy et al. 1996). Additionally, curly dock (an introduced species) has displaced the native dock species which appears to have occurred around the turn of the century (Fowler 1992). Vegetative species thought to have occurred among habitat types around 1900 are included in Table 2.2.

Overall, the historic marshes were extremely dynamic systems, with the different areas (Stillwater Marsh, Carson Lake, and the Carson Sink) experiencing long-term drought and flooding based on the flow pattern of the Carson River. Vegetation patterns would have varied accordingly with Carson Lake experiencing periods of high water where the majority of the lake would not support vegetation followed by drought where a large expanse would have been covered by emergent and submergent vegetation. The Stillwater Marsh would have varied from periods where extensive emergent and submergent vegetation stands would have been dominant, to periods where considerable seasonal wetland habitat would have remained only during spring. These long-term cycles were likely the driving force behind plant succession in the Lahontan Valley wetlands.

2.5.2.3.3 Terminal Basins (The Carson Sink)

Vegetation in the Carson Sink was likely the most variable of the wetland basins, due to highly fluctuating water levels and wide ranges in salinity. Bailey (1898) described eight separate habitat zones during a period when water flowed directly to the sink including:

- Slope soils washed of salt and soda with other than alkaline plants.
- Flat valley bottoms loaded with salt and soda, baked mud, where rain settles and devoid of plants.
- Flat bottom of the valley with scattered low shrubs of Sarcobatus (greasewood), Atriplex (shadscale), Suaeda (seepweed), and Tetradymia (dune horsebrush).
- Extensive sand dunes (devoid of vegetation).
- Clay mounds with Sarcobatus near lowest mud flats.
- Extensive shallow lake/tule swamp of the valley bottom.
- Saltgrass/sedges/tules associated with the lake/swamp.
- Narrow and broken line of cottonwoods along the Carson River.

Table 2.2. Representative plant associations thought to have occurred prior to 1900 in transitional upland, wetland, and riparian habitats, by relative coverage and frequency of occurrence.

	Transitional Upland Habitat	**Basin Wetland Habitats**					**Riparian Habitat**
Community Type / **Community Dominant**	**Upland** / **Dry - Moist**	**Mud/Alkali Flat** / **Moist - 6"**	**Wet Meadow** / **Moist - 12"**	**Shallow Emergent** / **6' - 24"**	**Deep Emergent** / **12" - 36"**	**Submergent** / **12" - 48"**	**Riparian** / **0" - 48"**
Tree and tall Shrub Communities							
Fremont Cottonwood	Absent	Absent	Absent	Absent	Absent	Absent	**Common**
Fremont Cottonwood/Great Basin Wildrye	Absent	Absent	Absent	Absent	Absent	Absent	**Common**
Red Willow	Absent	Absent	Absent	Absent	Absent	Absent	**Common**
Sandbar Willow	Absent	Absent	Absent	Absent	Absent	Absent	**Common**
Wetland Shrub Communities							
Big Greasewood	**Common**	Rare	Absent	Absent	Absent	Absent	Present
Big Greasewood - Dotted Dalea	**Common**	Absent	Absent	Absent	Absent	Absent	Rare
Big Greasewood - Torrey's Seepweed	**Common**	Rare	Absent	Absent	Absent	Absent	Rare
Iodine Bush	**Common**	Present	Absent	Absent	Absent	Absent	Absent
Torrey's Seepweed	**Common**	Present	Absent	Absent	Absent	Absent	Absent
Transitional Upland Shrub Communities							
Big Sagebrush	**Common**	Absent	Absent	Absent	Absent	Absent	**Common**
Quailbush	**Common**	Absent	Absent	Absent	Absent	Absent	**Common**
Rubber Rabbitbrush - Dune Horsebrush	**Common**	Absent	Absent	Absent	Absent	Absent	Present
Emergent Communities							
Alkali Bulrush	Absent	Present	Present	**Common**	Present	Absent	Absent
Alkali Bulrush - Narrow-Leaf Cattail	Absent	Rare	Present	**Common**	**Common**	Absent	Absent
Broad-Leaf Cattail	Absent	Absent	Rare	Present	**Common**	Rare	Present
Common Reed	Absent	Rare	Rare	**Common**	Rare	Absent	Present
Common Three-Square	Absent	Present	Present	**Common**	Present	Absent	Absent
Hardstem Bulrush	Absent	Absent	Absent	Present	**Common**	Present	**Common**
Smooth Scouring Rush	Absent	Absent	Rare	Present	**Common**	Rare	**Common**
Narrow-Leaf Cattail	Absent	Rare	Rare	Present	**Common**	Rare	Present
Narrow-Leaf Cattail - Hardstem Bulrush	Absent	Absent	Absent	Present	**Common**	Rare	Present

Community Type Community Dominant	Transitional Upland Habitat Upland Dry - Moist	Basin Wetland Habitats Mud/Alkali Flat Moist - 6"	Wet Meadow Moist - 12"	Shallow Emergent 6' - 24"	Deep Emergent 12" - 36"	Submergent 12" - 48"	Riparian Habitat Riparian 0" - 48"
Wet Meadow Communities							
Baltic Rush	Present	Present	**Common**	Absent	Absent	Absent	**Common**
Baltic rush - Creeping Spikerush	Absent	Present	**Common**	Absent	Absent	Absent	**Common**
Creeping Spikerush	Absent	Present	**Common**	Absent	Absent	Absent	**Common**
Creeping Spikerush - Water Hyssop	Absent	Rare	**Common**	Absent	Absent	Absent	**Common**
Parish's Spikerush	Unknown	Unknown	**Common**	Absent	Absent	Absent	**Common**
Grass Communities							
Alkali Muhly	**Common**	Absent	Rare	Absent	Absent	Absent	Absent
Baltic rush - Inland Saltgrass	Present	Rare	**Common**	Absent	Absent	Absent	Present
Great Basin Wildrye	Present	Rare	Rare	Absent	Absent	Absent	**Common**
Inland Saltgrass	**Common**	Present	Present	Absent	Absent	Absent	Present
Mixed Meadow Grass	Present	Rare	**Common**	Absent	Absent	Absent	**Common**
Submerged Aquatic Communities							
Chara	Absent	Absent	Absent	Rare	Absent	**Common**	Rare
Coontail	Absent	Absent	Rare	Rare	Rare	**Common**	Present
Duckweed	Absent	Absent	Present	Present	**Common**	Present	**Common**
Horned Pondweed	Absent	Absent	Absent	Present	Present	**Common**	Present
Long-leaved pondweed	Absent	Absent	Absent	Present	Present	**Common**	Present
Narrow-leaf Water Plaintain	Absent	Rare	**Common**	Present	Rare	Present	Present
Sago Pondweed	Absent	Absent	Absent	Present	Present	**Common**	Present
Water Hyssop	Absent	Rare	**Common**	Present	Rare	Present	Present
Water Milfoil	Absent	Absent	Absent	Rare	Present	**Common**	Present
Western Pondweed	Absent	Absent	Absent	Present	Present	**Common**	Present
Wigeongrass	Absent	Absent	Absent	Rare	Rare	**Common**	Rare
Herbaceous Communities							
Dock	Present	**Common**	Present	Absent	Absent	Absent	**Common**
Devil's Beggartick	**Common**	Present	Absent	Absent	Absent	Absent	Present
Pickleweed	Absent	**Common**	Rare	Absent	Absent	Absent	Rare

Common - plant community would be indicative of habitat type; found in all years with high coverage Present - Plant community would be found in habitat type but not in all years or in high coverage Rare - Plant community might be present in habitat type but found in few years with low coverage Absent - Plant community would not be found in habitat type (although representative species might under certain conditions)

These eight zones depict the variability in salinity with sedges and tules likely located near the mouth of the Carson River, shrubs located along uplands and areas periodically desicated during low flow years, and areas “devoid of plants” where salts accumulate and settle.

Conversely, Russell (1885) suggests that the Carson Sink was dry during the early part of 1862 as all water in the Carson River was diverted to South Carson Lake. This shrinking and swelling of the sink would have created conditions for a variety of plants adapted to different salinity levels and flooding tolerances. Species such as the sedges described by Bailey (1898) can only survive in freshwater environments and thus, were likely restricted to areas near the Carson River delta where freshwater flow was maintained. Species including tules, saltgrass, cattails, and alkali bulrush have higher salinity tolerance and would probably have extended for a longer distance from the delta. As salinity levels began exceeding 20,000 parts per million, the vast majority of vegetative species would not have survived, leaving vast expanses of open, shallow lake. This level (20,000 parts per million) would have been exceeded in most years when water was primarily diverted to other areas or as a previously hydrated Carson Sink began drying.

Although droughts have been of longer duration over the last century, periodic flooding still creates a wide mosaic of vegetation. Sperry (1929), described the river delta and southwest corner of the sink as having a mix of alkali bulrush, cattail, spikerush, sago pondweed, and horned pondweed. While these species are more tolerant of fresher water (less than10,000 parts per million), the old shoreline was marked by iodinebush and pickleweed which are adapted to highly saline environments. Suitable conditions for iodinebush and pickleweed in the sink are created when salts are left behind as water in the sink evaporates and the wetted area shrinks. It is interesting to note that most of the same species described by the early explorers, still exist throughout the Carson Sink today. The sedges are nolonger present; however, various grasses, tules, cattails and spikerush now abound throughout the Carson River delta and the southwest portion of the Carson Sink after several years of flooding.

2.5.2.4 WETLAND ASSOCIATED WILDLIFE

With a few exceptions, most of the wildlife species that inhabited the historic marsh are present today. The primary difference is the extent to which they occur. Based on archaeological evidence and past explorer’s notes, mink, river otter, and mussels were once prevalent throughout the marsh (Simpson 1876, Russell 1885, Sperry 1929, Fowler 1992, Kerley et al. 1993). All are indicative of a freshwater regime with mink and otter keying in on fish as a food source. This suggests that deeper and fresher water habitats were maintained in the Lahontan Valley wetlands, with abundant fish populations. The historic marsh likely supported large populations of tui chub, Tahoe sucker, and possibly Lahontan cutthroat trout (Fowler 1992, Kerley et al. 1993). This observation is substantiated by early reports of “piles of fish lying about drying” (Simpson 1876) and Indians carrying “several fine strings of fish” (Dequille 1963; as cited in Kerley et al. 1993).

The following discussion focuses on species groups, with the best available historic literature used to estimate the historic abundance of selected native, marsh associated species. While actual numbers are not available, relative population size can be indexed using relative species proportions in archaeological remains combined with firsthand observations and accounts. Species presumed to have changed significantly in abundance are included in Table 2.3.

2.5.2.4.1 Birds

Marsh bird species were abundant and diverse with most of the species present today represented in archaeological data (Livingston 1988, Fowler 1992). Changes in the use of Lahontan Valley by two species, common loon and sandhill crane, may be most representative of long-term habitat changes from historic conditions. Evidence of both species have been found at archaeological sites but have since become rare visitors to the marsh. Loons commonly inhabit deep open water areas while sandhill cranes, as well as white-fronted geese, are associated with wet meadows. The change in composition and coverage by these two habitat types has likely led to the suspected decreases in these species numbers and suggests that the range of water depths and habitat composition in the present marsh is not representative of historic conditions.

Waterfowl assemblages have changed somewhat in composition; however, overall numbers were likely similar to those that now occur during periods of high water. While exact numbers are not available from historic literature, archaeological remains suggest that several dabbling duck, diving duck, goose, and swan species were present. It would appear that deeper water associated species such as canvasback, redheads, ruddy ducks, goldeneye, surf scoter, and lesser scaup were more abundant than at present, likely due to more deep water habitats; however, dabbling ducks (such as mallards, pintail , green-winged teal, gadwall, and shovelers, comprised the majority of the Cattail-eater diet (Livingston 1988). Surf scoter were mentioned in several historic reports (Livingston 1988, Raven and Elston 1988, Fowler 1992) but are an infrequent visitor to the present day marsh, likely for similar reasons as the common loon's more recent absence. White-fronted geese and trumpeter swans were also likely more abundant historically (Fowler 1992); however, trumpeter swan declines at the marsh are probably more related to decreases in continental populations while it is uncertain why white-fronted geese have shifted migration.

Very little information about historic populations and species composition of shorebirds is available. It is assumed that population parameters were similar to what occurs at present, although there is at least some indication that long-billed curlew were more abundant historically (Fowler 1992). Reasons for this are not clear but it may be related to the reduced wet meadow habitat and the change in plant species composition in adjacent upland habitats.

Similarly, historic data are lacking on most other waterbird species with a few exceptions. American white pelicans were likely more abundant historically as the colony on Pelican Island (within Fallon NWR, near the Carson River delta) was considered a place to collect eggs and

Table 2.3. Estimated change in historic population levels of wetland associated wildlife.

Species[1]	Habitat Frequented	Change from Estimated Historic	Possible Reasons for Population Change
Invertebrates			
Brine flies	Highly saline wetlands	Large increase	Reduction in freshwater flows
Brine shrimp	Highly saline wetlands	Large increase	Reduction in freshwater flows
Mussel (anodonta)	Freshwater lakes and rivers	Large decrease	Loss of freshwater input
Snails	Lakes/permanent water habitat	Decrease	Reduction in permanent water habitats
Fish			
Lahontan Tui Chub	Lakes, rivers, and other permanent water habitats	Decrease	Introduction of exotic species, loss of permanent water
Tahoe sucker	Rivers	Extirpated	Loss of freshwater input
Lahontan cutthroat trout	Rivers	Extirpated	Loss of freshwater input
European carp	All aquatic habitats	Introduced (Abundant)	Introduced, wide tolerance for salinity and introduction
Mosquito fish	All aquatic habitats	Introduced (Abundant)	Introduction for mosquito control
Birds			
White-faced ibis	Emergent and shallow habitats; agricultural lands	Increase	Flood-irrigation of agricultural lands
Long-billed curlew	Upland and shallow water habitats	Decrease	Unknown
American white pelican	Permanent water habitats/open islands	Decrease	Loss of breeding and feeding habitat
Canvasback	Submergent vegetation	Decrease	Less submergent vegetation, factors outside refuge
Common Loon	Deep Open Water	Large Decrease	Loss of deep open water habitat
Sandhill Crane	Wet Meadow	Large Decrease	Reduction in amount and composition of wet meadow habitat
White-fronted goose	Shallow, meadow habitats	Decrease	Loss of wet meadow habitat, factors outside refuge
Common Raven	Marsh edges, uplands	Large Increase	Introduction of dump sites, road kills, agriculture, among others
European Starling	Riparian, agricultural	Introduced (Common)	Introduced, aggressive competitor for nest cavities
House Sparrow	Residential, Agricultural, Riparian	Introduced (Common)	Introduced, aggressive competitor for nest cavities
Mammals			
Mink	Emergent and other permanent water habitat	Large Decrease	Loss of freshwater and fish populations
River Otter	Rivers and associated river delta	Extirpated	Loss of freshwater and fish populations
Beaver	River	possibly introduced, common	
Coyote	Uplands, marsh edges	Increase	Extirpation of wolves and alternate food sources

[1] The species included are those for which historic literature is available and does not represent a complete list of affected species.

young sometime during the middle 1800s (Fowler 1992). A small colony has formed infrequently on Pelican Island and other small islands in the Carson Sink through the past century during high water years only (Refuge files).

Species that have apparently benefitted from changes to the natural system include the common raven and white-faced ibis. Information on historic occurrence of ravens are scant, but from reviewing the literature, it can be estimated as having been low. Grayson (1985), found 11 specimens in a cave which suggests they were in this area; however, this is an upland site located away from the marsh and it is uncertain whether birds were collected at the marsh or in the Stillwater Mountains. Bailey (1898) completed an inventory of bird species observed during a spring trip from Stillwater to Ione (100 miles east of Fallon). His list did not include the common raven. For comparison, a 1996 inventory of Stillwater NWR revealed 112 common ravens in the core wetland area in early June (Stillwater NWR nest survey data).

White-faced ibis have likely become more abundant as a consequence of agricultural development and reduction of wetland habitat throughout the Great Basin (Fowler 1992). A slow increase in ibis abundance was observed from the early 1900s to the 1950s with most observed individuals feeding on newly flooded agricultural fields. This trend is also related to the abundance of nesting sites (e.g., flooded cattail and hardstem bulrush patches) so variations in population size probably varied considerably over the past 50 years.

2.5.2.4.2 Mammals

Most of the animal bones and other parts found in archaeological remains are from a variety of smaller species of mammals including mice, voles, kangaroo rats, muskrats, mink, river otters, badgers, and rabbits (Schmitt 1988, Raven and Elston 1988). Larger species including coyotes, mule deer, and bighorn sheep were less common in these remains, most of which were found at marsh sites near the base of the Stillwater Mountains. It is unlikely that deer and sheep were common throughout the marsh during most of the year, but apparently were abundant in the nearby mountain ranges (Raven and Elston 1988). The described assemblages were likely more abundant and diverse than those at present (Bailey 1898, Schmitt 1988, Raven and Elston 1988, Fowler 1992).

Large predators were also more abundant around the marsh. Bailey (1898) suggests that lynx were common in the area of north Carson Lake (Stillwater Marsh) and Raven and Elston (1988) found wolf and coyote remains at archaeological sites. Wolves have long since been extirpated from the Stillwater Marsh and it is unknown whether lynx (*Lynx lynx*) have ever been present. Historic descriptions of lynx likely refer to bobcat (*Lynx rufous*) as common names have changed through history. Coyotes appear to be more abundant at present, possibly due to the absence of these larger predators. Kit fox and mountain lion have been recently observed in the marsh (although few and infrequently) and it is interesting to note that few historic references to these species exist. Bailey (1898) made inquiries about the abundance of kit fox and found that no one in the valley had ever heard of it.

Wetland specific mammalian species included muskrat, mink, raccoon, and river otter (Schmitt 1988, Raven and Elston 1988, Fowler 1992). All of these species have been found at archaeological sites. River otter no longer exist in the present day marsh and a relatively new addition, beaver, have become established in the system. When consulted about the historic presence of beaver, the response given by Wuzzie George of the Fallon Paiute Shoshone Tribe was "he don't belong here" (Fowler 1992). Additional inquiries suggest that the subspecies of muskrat was also different as Wuzzie George had no idea what the large muskrat mounds in the emergent vegetation zones were (Fowler 1992). It is likely that the original, bank dwelling species was displaced by transplanting muskrat during 1949 following a wide scale muskrat die off.

2.5.2.4.3 Fish

While several fish species have been documented in archaeological remains, only four were likely common in the Stillwater Marsh system (Tui chub, Lahontan red shiner, Lahontan speckled dace, and Tahoe sucker; Greenspan 1988). Even in the historic marsh, Lahontan cutthroat trout and mountain whitefish would likely not survive, although under certain conditions it is possible that the cutthroat made its way to the lower Carson River and associated wetlands. While data on relative population levels are not available, it is assumed that the tui chub and Tahoe sucker were more abundant during the late 1800s. Tui chub are thought to have declined while the Tahoe sucker is no longer present due to decreases in the amount of permanent, open water habitat, reduced water quality, and the introduction of European carp, mosquito fish, and various species of gamefish. Because no recent inventories for Lahontan red shiner or Lahontan speckled dace have been conducted, it is uncertain whether these species are still present.

2.5.2.4.4 Invertebrates

Several accounts of large populations of freshwater mussels and snails have been offered in the historic literature. Bailey (1898) describes the shoreline of Carson Lake as "covered with mussel shells." Simpson (1876) also reports large numbers of mussels along the Carson Lake shoreline while Sperry (1929) states that "clams are common and snails and insect life abundant" in reference to the Stillwater Marsh. Snails, mussels, and insects were considered common food sources for the *Toedokado* (Drews 1988, Fowler 1992). While snails are still quite common within the Lahontan Valley landscape, freshwater mussels have all but disappeared, presumably related to less fresh and/or permanent water.

Some evidence suggests that brine flies and brine shrimp have increased in abundance from historic conditions. Wuzzie George collected brine flies from Soda Lake (the only place that she was aware that they occurred during her childhood) which were *"scooped up from windrows along the shoreline . . . and . . . boiled into a soup"* (Fowler 1992). Brine flies have been recently sampled throughout Stillwater Marsh habitats with brine shrimp commonly found during spring, among the scattered alkali playas (Bundy 1996). Increased salinity throughout the wetland complex has likely led to this result. Historic information on the abundance of other invertebrate species has not been found.

2.5.3 OTHER HABITATS AND ASSOCIATED WILDLIFE

Although the wetlands are a central focus of Stillwater NWR, Stillwater WMA, and Fallon NWR, other habitats on the refuges and wildlife management area, representative of the Carson Desert include greasewood, mixed desert shrub communities, and sand dunes. Most of the historic literature focused on the wetland areas and no historic accounts capable of supporting abundance estimates in upland communities could be found. It is likely that little change has occurred within these habitats over the past few centuries other than geographic location relative to wetland dynamics and changes to the shrub community composition relative to livestock grazing pressure and the introduction of cheatgrass and other nonnative plants, and possibly off-road-vehicle use. strongly dominant across the landscape. The largest estimated change to the system in the recent past was the composition of the understory vegetation such as the various grass species common to the system.

Shrub community composition among upland habitats has likely changed little over the past few centuries. Up to 6,500 years before present, it would appear that sagebrush was a key component of the Lahontan Valley upland system (Thomas 1985). After this period, very little sagebrush pollen appeared in any of the archaeological sites, with greasewood and shadscale becoming Fourteen different greasewood communities were identified in a 1997 vegetation inventory (Charlet et al. 1998), indicating that diversity within the greasewood vegetation type is still quite high under present conditions. Prior to the introduction of livestock, a bunchgrass understory may have been extensive in some communities (Fowler 1992). For example, Indian ricegrass was likely abundant in some areas of the Stillwater NWR Complex, based on historic accounts of Indian ricegrass collection by the *Toedokado* (Fowler 1992). Because of the close relationship between ricegrass and kangaroo rats, several species of kangaroo rats were likely abundant as referenced by the four species of kangaroo rat remains discovered in Hidden Cave (Thomas 1985). Today, bunchgrasses in greasewood communities are rare with cheatgrass forming the most common understory vegetation type. Cheatgrass was introduced to the United States in the late 1800s (Mack 1986).

The sand dune ecosystem is unique and adds to the biological diversity of the area. Several species of beetles and other insects can only be found in the sand dunes, two species of which may be endemic to the Stillwater dunes (Rust 1998). The source of sand appears to be the Carson River, which carried sand down from the Sierra Nevada Mountains, and distributed it throughout an alluvial fan along the Carson River delta. No information is available concerning this historic process and it is possible that other processes, such as wind, contributed to sand dune development.

Wildlife information is equally lacking except for analysis of the archaeological records from selected sites (Thomas 1985, Raven and Elston 1988, Fowler 1992). Results of cave content analyses brought several interesting wildlife trends to view (Thomas 1985). For example, sage grouse remains were unearthed at this site suggesting that the vegetation composition in the surrounding lower slopes of the mountain ranges was different historically. Additionally, remains of prehistoric horses, camels, and even bison were unearthed, raising at least some question to the theory that large ungulates had little contribution to upland vegetation community formation. There is considerable question about the relative age of these remains and it is likely that most of this evidence is dated prior to 5,000 to 10,000 years before present (Thomas 1985, Burkhardt 1996).

Considering the loss of these large grazers, it is more likely that small mammals have had more influence on shaping the natural upland system prior to the introduction of livestock in the mid- to late-1800s. The vast majority of archaeological remains and historic accounts suggest that black-tailed jackrabbits and small mammals, including kangaroo rats, pocket gophers, white-tailed antelope ground squirrels, and desert woodrat, were the most abundant mammals in the historic upland system (Bailey 1898, Thomas 1985, Schmidt 1988, Fowler 1992). This group would appear to have been much more abundant and diverse during pre-settlement times, which makes sense considering the estimated diversity of understories of most upland shrub communities and the reliance of several species of small mammals on grass seed. Some species of kangaroo rats cache seeds from Indian ricegrass, which likely maintained a wider distribution before the introduction of livestock grazing.

Accounts of other wildlife species are almost nonexistent, leaving little information to develop estimates of the historic upland wildlife community. Rather than attempt to do this, it is probably best to assume that similar to wetlands, upland communities were likely more diverse than at present, and that livestock grazing has had the greatest influence on upland vegetation community structure over the past century.