Rainwater Basin Joint Venture Shorebird Plan

A regional contribution to the

United States Shorebird Conservation Plan

and the

Rainwater Basin Joint Venture Implementation Plan

By the Rainwater Basin Joint Venture

RAINWATER BASIN

JOINT VENTURE

ESTABLISHED 1992

Contents

List of Tables

Executive Summary

The Rainwater Basin Joint Venture partnership (RWBJV) was formed in 1992 with a primary focus of protecting, restoring, and enhancing wetland habitat in the Rainwater Basin Wetland Complex (RWB). The RWB contains a high density of playa wetlands, which provide critical stopover habitat for various species of migratory waterfowl, waterbirds, and shorebirds. Due to its diversity of wetland types and mid-latitude landscape juxtaposition, the RWB is the focal point of spring migration for millions of waterfowl. Although it was not within the partnership's initial purview, the RWBJV Management Board embraced the 1999 North American Bird Conservation Initiative, expanding the geographic focus and acknowledging the conservation objectives outlined in all four of the national bird conservation plans (North American Waterfowl Management Plan, Partners in Flight North American Landbird Conservation Plan, North American Waterbird Conservation Plan, and the United States Shorebird Conservation Plan). The expanded RWBJV Administrative Area includes the portions of Bird Conservation Regions 11 (BCR 11; Prairie Pothole Region) and 19 (BCR 19; Central Mixed-grass Prairies) that lie within Nebraska.

The RWBJV Shorebird Plan addresses the habitat needs of all shorebirds that use the RWBJV Administrative Area. Recent estimates suggest the RWBJV Administrative Area supports 1.7 million shorebirds during the non-breeding phase of their annual life cycle and over 411,000 breeding shorebirds. The "non-breeding phase" described in the RWBJV Shorebird Plan refers to migration, as no shorebirds winter in this region. At population goal levels described in the United States Shorebird Conservation Plan (USSCP), it is estimated that habitats within the RWBJV Administrative Area will need to support 3.4 million shorebirds. To guide conservation planning, the RWBJV developed a bioenergetics model. This model describes the foraging resources necessary to support the shorebirds expected to use the RWBJV Administrative Area at USSCP goal levels.

To make the RWBJV Shorebird Plan relevant to managers, shorebirds were aggregated into four primary foraging guilds, with habitat objectives described for each guild. The four foraging guilds are: agri-probers and upland associates, small-bodied probers/gleaners, large-bodied probers, and swimmers. The bioenergetics model suggests that wetland habitats within the RWBJV Administrative Area will need be able to provide 2.1 billion kilocalories (kcals) of foraging resources for shorebirds at USSCP goal levels. It is estimated that approximately 202,815 total wetland acres will be required to meet these foraging requirements. Habitat inventories completed for the RWBJV Administrative Area suggest there is adequate wetland and upland habitat to support shorebirds using this large geographic landscape; however sufficient habitat may not be available in geographic regions with high shorebird use, including the RWB.

To evaluate shorebird carrying capacity at finer scales, conservation planning was completed not only for the RWBJV Administrative Area, but also for the RWB. The diversity of wetlands found in the RWB attracts a variety of shorebird species, and a significant proportion of some species. At USSCP goal levels, it is estimated that the RWB will need to provide 207 million kcals or 20,260 acres of suitable foraging habitat. Recent habitat inventories suggest there are adequate "total" wetland acres; however sufficient acres of ponded, or available, habitat are not

present for shorebirds during the non-breeding phase of their annual life cycle. The bioenergetics model outputs and habitat inventories indicate a habitat deficiency for species in the small-bodied probers/gleaners and large-bodied probers foraging guilds. In the RWB, conservation delivery strategies for shorebirds mirror the strategies described in the RWBJV Waterfowl Plan. These strategies focus on: 1) wetland/watershed conservation to increase wetland acres; 2) improved hydrologic function (number of acres that pond water) to increase available habitat during shorebird migration; and 3) appropriate management to promote desired habitat conditions. Conservation delivery will be completed along the major riverine systems found in the RWBJV Administrative Area to provide suitable nesting habitat for Piping Plovers. In the Sandhills, conservation actions will need to be developed that provide opportunities to increase habitat for breeding shorebirds and complement existing cattle production operations.

Research and monitoring will focus on refining shorebird use estimates in both the RWBJV Administrative Area and the RWB. Directed research will focus on the foraging resources available in different wetland habitats found in the RWBJV Administrative Area, as well as forage efficiency by shorebirds using the RWBJV Administrative Area and RWB. Monitoring efforts will be developed to evaluate wetland restoration and habitat management techniques to develop more effective conservation practices that will increase the probability of desired habitat conditions for shorebirds.

Introduction

The purpose of the Rainwater Basin Joint Venture Shorebird Plan is to complement the national, regional, and state plans that address shorebird conservation. The second update to the United States Shorebird Conservation Plan (USSCP) was completed in 2001 (Brown et al. 2001). This plan was authored by a variety of stakeholders, including state and federal agencies, non-governmental conservation organizations, and individual researchers from across the country. The USSCP outlined three overarching conservation strategies at different scales. At the broadest spatial scale, the hemispheric level, the strategy is to restore and maintain the populations of all shorebird species in the Western Hemisphere. At a national scale, the goal is to stabilize populations of all shorebird species known or suspected to be in decline due to limiting factors occurring within the United States, while ensuring that common species are also protected from future threats. At a regional scale, the goal of the USSCP is to ensure that an adequate quantity and quality of habitat is identified and maintained to support the different shorebirds that use these regions during the breeding and non-breeding phases of their annual life cycle (Brown et al. 2001).

The USSCP complements existing landscape-scale conservation efforts, the North American Waterfowl Management Plan, North American Landbird Plan, and North American Waterbird Conservation Plan. The USSCP recognized that Joint Ventures, which are self-directed partnerships among government agencies, non-profit organizations, tribes, corporations, and individuals for the purpose of conserving habitat for priority bird species, are the primary conservation delivery mechanism. Given the regionalized frameworks of Joint Ventures, the multi-scaled strategies outlined in the USSCP needed to be scaled down to meaningful conservation delivery objectives for each Joint Venture.

In 1992, the Rainwater Basin Joint Venture partnership (RWBJV) was formed. The initial focus of the RWBJV was directed toward waterfowl habitat within the Rainwater Basin Wetland Complex (RWB). Beginning in 2001, in response to a national call for Joint Ventures to extend conservation work to all species of birds, the RWBJV partnership expanded its administrative area to include the portions of Bird Conservation Regions (BCRs) 11 (Prairie Pothole Region) and 19 (Central Mixed-grass Prairies Region) that lie within Nebraska. The RWBJV Shorebird Plan represents the RWBJV's initial effort to effectively guide shorebird conservation in the RWBJV Administrative Area.

Although the administrative boundary has expanded, the name of the RWBJV remains the same. The need to retain the name outweighs the confusion it may pose to those unfamiliar with the organization or the geography of Nebraska. Within this document, "RWBJV" will be used to reference the partnership, "RWBJV Administrative Area" will describe the geographic area administered by the partnership, and "RWB" will be used to describe the wetland complex that was the impetus for the creation of the RWBJV. Every attempt will be made to make it clear to the reader which form is being addressed.

The purpose of the RWBJV Shorebird Plan is to estimate shorebird use in the RWBJV Administrative Area, assess shorebird foraging needs, and determine habitat that will be necessary to support the estimated number of shorebirds that will use this region at population goal levels outlined in the USSCP. The RWBJV Shorebird Plan provides an estimate of habitat necessary to support shorebirds during the non-breeding and breeding phases of the annual life

cycle. Conservation strategies are presented to guide on-the-ground delivery. These strategies are based on current conservation programs and tools available to land managers, both public and private. If implemented, these strategies are expected to complement current habitat conditions and result in a landscape capable of supporting shorebirds at desired population levels. This document also presents priority research and monitoring needed to evaluate conservation success, address key assumptions outlined in this plan, and inform future versions of the RWBJV Shorebird Plan.

The RWBJV Administrative Area

Approximately 90% of the RWBJV Administrative Area is in Bird Conservation Region 19 (BCR19), the Central Mixed-grass Prairies Region, while 10% is in BCR 11, the Prairie Pothole Region, (North American Bird Conservation Initiative 1999). The area of BCR 11 that is administered by the RWBJV is at the southern edge of the Prairie Pothole Region. This area has no true prairie pothole wetlands, and the landscape is dominated by land uses and habitats characteristic of BCR 19. In Nebraska, BCR 11 is dominated by row-crop agriculture, while the wetlands and grasslands generally are confined to the drainages of the Missouri and Niobrara rivers (Bishop et al. 2009; Bishop et al. 2011). To define the RWBJV Administrative Area, all of BCRs 11 and 19 in Nebraska were therefore combined into a single unit.

The RWBJV Administrative Area is part of the Great Plains, a region known for its wide variations in temperature and precipitation. West of the 100th meridian, evaporation and transpiration exceed precipitation, commonly drying up wetlands even in wetter years. Precipitation occurs sporadically, which results in variable amounts of water in wetland systems. In some years, precipitation and snow melt may come early and be abundant enough to fill most palustrine wetlands and sustain flows in riverine wetlands. In other years, the greatest precipitation occurs as a result of summer thunderstorms. This temporal variation of precipitation alters the phenology, species composition, and structure of the wetland vegetation communities.

A wide variety of human alterations that impact the palustrine and riverine wetlands are found in the RWBJV Administrative Area. Modifications include water concentration pits, land leveling, culturally accelerated sedimentation, road ditches, drainage ditches, invasive species, stream channelization and degradation, dams, diversions, water withdrawals, and other watershed modifications. These modifications directly impact wetland numbers, size, and function (LaGrange 2005; LaGrange et al. 2011).

Grasslands dominated by mixed-grass, tallgrass, and sandhill prairie communities once occupied a majority of the RWBJV Administrative Area. Outside of the Sandhills, many of these grasslands have been converted to row-crop agriculture. The grasslands that remain are generally associated with the region's riverine systems, or lands not suitable for row-crop agriculture due to the potential for wind and/or water erosion. The remaining grasslands are often integrated into agricultural operations for grazing or haying, which, depending on timing and intensity, can significantly impact the habitat values these lands provide to wildlife.

Woodlands are generally confined to the drainages of the major river systems found in the RWBJV Administrative Area. Along the Loup, Missouri, Platte, and Republican rivers the woodlands are generally composed of deciduous species. Russian olive and eastern red cedar are the primary invasive species impacting these woodlands. Along the Niobrara River there is a greater diversity of species, including both deciduous and coniferous woodlands. Invasion by eastern red cedar is a major threat to these communities as well.

Geographic Focus Areas in the RWBJV Administrative Area

For planning purposes the RWBJV Administrative Area is divided, based on landscape characteristics, into eight Geographic Focus Areas (Figure 1): 1) Central Loess Hills, 2) Central and North Platte River, 3) Missouri River, 4) Northeast Prairies/Elkhorn River, 5) Rainwater Basin 6) Republican River/Blue River Drainages and Loess Canyons, 7) Sandhills, and 8) Verdigris – Bazile Creek Drainages (Figure 1).

In order for states to receive federal funds through the Wildlife Conservation and Restoration Program and the State Wildlife Grants Program, Congress charged each state to develop a State Wildlife Action Plan. Nebraska's plan is the *Nebraska Natural Legacy Project* (Schneider et al. 2011), which was developed as a state-wide plan to direct and focus the actions of conservation partners in Nebraska. To provide geographic focus, biologically unique landscapes (BULs) were

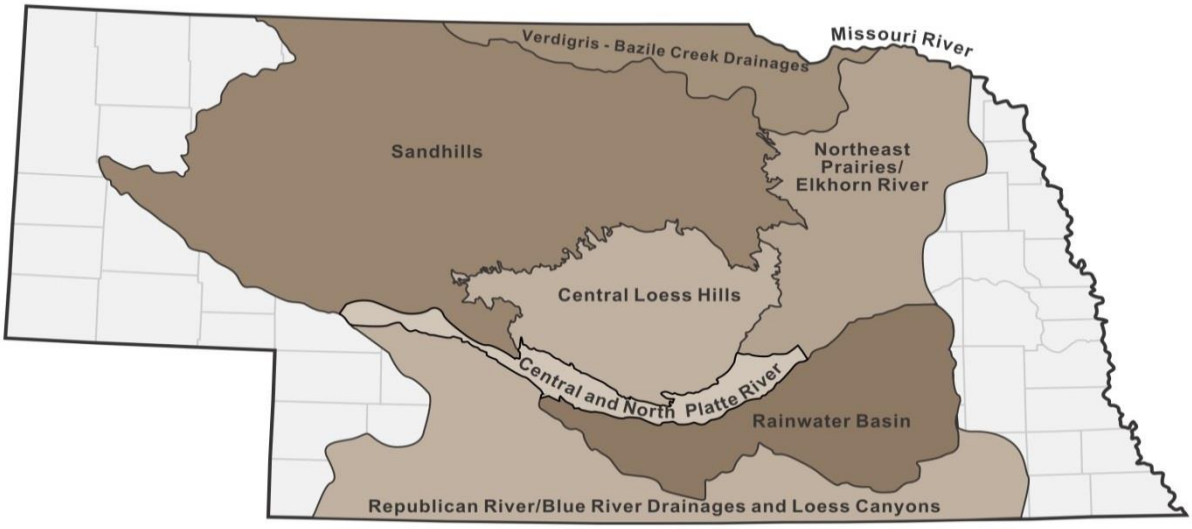

Figure 1. Geographic Focus Areas in the RWBJV Administrative Area.

identified, including 23 located within the RWBJV Administrative Area. These geographic areas were determined to have the highest probability of meeting the criteria of representing the various habitats within the state, and keeping common species common, while not overlooking pockets of habitat which support at-risk species. The 23 BULs in the RWBJV Administrative Area are:

Calamus River	Elkhorn Confluence	Middle Niobrara	Sandstone Prairies
Central Loess Hills	Keya Paha	North Loup River	Snake River
Central Platte River	Loess Canyons	Panhandle Prairies	Southeast Prairies
Cherry County Wetlands	Lower Loup River	Platte Confluence	Verdigris-Bazile
Dismal River Headwaters	Lower Niobrara River	Rainwater Basin	
Elkhorn River Headwaters	Middle Loup River	Sandhills Alkaline Lakes	

The RWBJV Administrative Area encompasses approximately 35 million acres and contains over 2.3 million acres of wetland habitats and over 20 million acres of grasslands (Table 1). Wetlands comprise nearly 7% of the RWBJV Administrative Area, while grasslands cover approximately 60% of the landscape (Table 1). Each Geographic Focus Area contains a variety of wetland, grassland, and woodland habitats. Over half of the wetlands found within the

RWBJV Administrative Area are located in the Sandhills, with a majority of these acres being classified as sub-irrigated wet meadows (palustrine wetlands). The RWB Geographic Focus Area contains the highest density of playa wetlands (palustrine wetlands), followed by the Central Loess Hills (Central Table Playa Complex), Northeast Prairies/Elkhorn River (Todd Valley Wetland Complex), and Republican River/Blue River Drainages and Loess Canyons (Southwest Playa Wetland Complex). The Republican River/Blue River Drainages and Loess Canyons GFA contains the most human-made wetland features (reservoirs, stock dams, and irrigation reuse pits; Table 1). Outside of the Sandhills, grasslands are generally confined to the floodplains of the major river systems or on environmentally sensitive lands. The primary Geographic Focus Areas with significant grasslands are the Central Loess Hills, Northeast Prairies/Elkhorn River, Republican River/Blue River Drainages and Loess Canyons, Sandhills, and Verdigris - Bazile Creek Drainages (Table 1).

Table 1. Wetland and grassland acres and their distribution by geographic focus area (Bishop et al. 2011).

Central Loess Hills

The Central Loess Hills Geographic Focus Area, located in the center of the RWBJV Administrative Area, contains rolling to steep loess hills dissected by the valleys of the Loup rivers. Ridge tops (tables) are nearly level to gently sloping and covered with loess soils.

Geographic Focus Area	Geographic Focus Area (Acres)	Total Wetland (Acres)	Lakes & Reservoirs (Acres)	Palustrine Wetlands (Acres)	Riverine Wetlands (Acres)	Lacustrine Wetlands (Acres)	Grassland (Acres)
Central Loess Hills	3,598,453	169,185	20,504	12,473	136,209	0	2,166,456
Central and North Platte River	1,035,879	107,514	6,597	1,590	99,327	0	160,448
Missouri River	77,852	40,858	12,309	7,714	20,835	0	6,279
Northeast Prairies/ Elkhorn River	4,792,660	339,339	19,676	16,774	302,889	0	1,320,359
Rainwater Basin	3,830,130	120,852	25,703	44,198	50,950	0	677,965
Republican River/Blue River Drainages and Loess Canyons	5,826,800	226,427	60,937	5,437	160,054	0	3,140,230
Sandhills	13,587,519	1,253,724	25,719	1,120,700	22,331	84,974	11,535,386
Verdigris – Bazile Creek Drainages	2,004,581	91,833	7,766	4,770	79,297	0	1,383,183
Total	**34,753,873**	**2,349,733**	**179,212**	**1,213,656**	**871,891**	**84,974**	**20,390,306**

Scattered across these table lands are numerous playa wetlands referred to as the Central Table Playas (LaGrange 2005). Based on hydric soil mapping units (polygons) and depressional wetland points defined in the Soil Survey Geographic Database (SSURGO), as well as the palustrine wetlands delineated in the National Wetlands Inventory (NWI; Cowardin et al. 1979), it is estimated that there were once over 6,300 playas covering more than 18,000 acres. Based on an assessment of aerial photography completed in 2010, just over half of the playas (3,470 individual wetland footprints) continue to demonstrate some level of function, such as ponding water or growing hydric vegetation (Bishop et al. 2011). These playa wetlands are generally smaller than the playas found in the RWB and are characterized by seasonal and temporary water regimes.

The steep, erodible side slopes of the Central Loess Hills drop off into the broad floodplains of the Loup rivers. The Central Loess Hills GFA contains the lower reaches of the Middle Loup, North Loup, and South Loup rivers, all of which are spring-fed and originate in the Sandhills. These broad and shallow sand-bed rivers maintain relatively constant year-round stream flow. Sandbars and shallow side channels are typical features within and adjacent to the active river channels.

Based on a 2011 habitat assessment, the Central Loess Hills GFA contains approximately 12,500 acres of palustrine wetlands, 136,000 acres of wet meadows and other riverine wetlands, and approximately 2.2 million acres of grasslands (Table 1). The playa wetlands found in this GFA provide important migration stopover habitat for the endangered Whooping Crane (Austin and Richert 2001), as well as numerous other species of migratory waterbirds (e.g., waterfowl, shorebirds, and wading birds). The riverine wetlands associated with the Loup rivers provide breeding habitat for the threatened Northern Great Plains population of Piping Plovers and endangered Interior population of Least Terns. The wet meadows and associated grasslands found in the Central Loess Hills currently support an estimated 875,000 grassland nesting birds (RWBJV 2013*a*).

Row-crop agriculture and ranching are dominant land uses in the Central Loess Hills. Row-crop agriculture is generally confined to the river valleys and areas of limited topographic relief. Crops generally include alfalfa, corn, milo, soybeans, and wheat. Most of the steep, more erodible slopes remain as native grasslands dominated by mixed-grass prairie communities. Higher commodity prices and the guaranteed income provided by the Federal Crop Insurance Program have contributed to the conversion of environmentally sensitive grasslands and wetlands to row-crop agriculture. This conversion has reduced the quantity and distribution of grassland, wetland, and wet-meadow habitats found throughout the Central Loess Hills. The encroachment of undesirable plant species (i.e., eastern red cedar, Russian olive, smooth brome, etc.) has occurred on thousands of acres of native habitats. Fire suppression is believed to be a major factor that has contributed to the expansion of invasive species throughout this Geographic Focus Area.

Central and North Platte River

The Central Platte River is a 90-mile segment of the Platte River, extending from Lexington, Nebraska to Chapman, Nebraska. Historically, the Platte River was a wide, shallow river with multiple channels that meandered across an expansive floodplain. Large, scouring floods regularly set back vegetation succession and maintained a diversity of habitats across the floodplain. Following European settlement, the Platte River was extensively regulated, and the

flood pulses and river flows that once shaped the ecosystem were greatly reduced. As a result, the areas of active floodplain and associated wet meadows were reduced, the river channels narrowed and deepened, and extensive riparian forests became established on islands and along river banks. For example, a comparison of average annual discharge levels at the city of North Platte, Nebraska, before 1930 and after 1930, shows a 70% reduction in river flows (U.S. Fish and Wildlife Service 1981). At the same monitoring location, the channel width narrowed from nearly 2,950 ft. to less than 330 ft. between 1870 and 1970. Similarly, the average channel width near Overton, Nebraska, declined from 4,800 ft. in 1865 to 740 ft. in 1998 (Murphy et al. 2004). Sidle et al. (1989) reported that 60% to 80 of the open riverine/sandbar habitat and 55% of wet meadow habitat had been lost in this reach of the Platte River due to agricultural conversion, development, and hydrologic changes.

Despite the highly altered nature of this system, the combination of broad, braided river channels, adjacent wet meadows, and abundant food supplies continues to attract millions of wetland-dependent migratory birds each year. The 60,000 acres of palustrine and riverine wetlands and over 140,000 acres of grassland that occur along the Central Platte River continue to provide necessary roosting, loafing, and foraging habitat for millions of migratory birds. These habitats are used by the endangered Whooping Crane (USFWS 1978) and approximately 90% of the world's Sandhill Crane population, and provide migration and wintering habitat for millions of waterfowl, migration habitat for a myriad of waterbirds, and non-breeding habitat for numerous shorebirds. In addition, the Central Platte River provides breeding habitat for the threatened Northern Great Plains population of Piping Plovers and the endangered Interior Least Tern, and for an estimated 160,000 priority grassland-nesting birds (Rainwater Basin Joint Venture 2013*a*).

Today, the Central Platte River Valley is intensely cultivated. Based on the 2009 United States Department of Agriculture (USDA) Cropland Data Layer, over 60% of the historic floodplain is planted to corn, soybeans, or alfalfa (USDA 2009). In 2004, due to the diversion of water for irrigation, much of the Platte River was declared over-appropriated by the Nebraska Department of Natural Resources (DNR). This designation required new groundwater and surface water depletions to be offset, with the intent of managing the system in a sustainable manner. Although cropland conversion has slowed, gravel mining and residential and commercial development continue to result in the loss of riverine and wet-meadow habitats. Invasive plant species also continue to degrade in-channel habitats and adjacent wet meadows. Primary threats include: eastern red cedar, Kentucky bluegrass, *Phragmites*, purple loosestrife, reed canary grass, and smooth brome.

The North Platte River is one of the two tributaries that form the Platte River. The North Platte River originates in Colorado and flows through Wyoming before entering Nebraska. The stretch of the North Platte River within the Central and North Platte River GFA is located approximately 60 miles upstream from the river stretch designated as the Central Platte River. This stretch of river has a high density of palustrine and riverine wetland habitats, including approximately 36,000 acres of wet meadows and 16,000 acres of grasslands dominated by mixed-grass prairie species (Bishop et al. 2011).

The wetland and grassland habitats in this 80-mile stretch of river from Lewellen, Nebraska to North Platte, Nebraska have also been negatively impacted by the extensive regulation of North Platte River flows since European settlement. It is estimated that 25% of the historic wet meadows have been converted to row-crop agriculture (LaGrange 2005). The altered flow

regimes have resulted in an increase of scrub-shrub and forested wetlands at the expense of riverine and emergent wetlands (LaGrange 2005).

Despite the negative impacts of land-use conversion and altered flow regimes, this stretch of river contains a diverse mix of riverine and marsh-like wetlands within the historic floodplain and river channel. Approximately 80% of the wetlands are either temporary or seasonal in nature (LaGrange 2005). This area is extremely important to the portion of the mid-continent population of Sandhill Cranes (approximately 56,000 individuals) that do not stage in the Central Platte valley (Krapu et al. 2011).

Although the conversion of grasslands and wet meadows to row-crop agriculture has slowed as a result of the moratorium on new irrigated acres, these habitats continue to be converted for gravel mining operations and urban/suburban/commercial development. Wet meadows and grasslands in the North Platte River valley are also being invaded by eastern red cedar, Kentucky bluegrass, *Phragmites*, purple loosestrife, reed canary grass, Russian olive, and smooth brome.

Missouri River

The Missouri River GFA area forms the northeast boundary of the RWBJV Administrative Area. This 125-mile stretch of river, between Ponca, Nebraska and Spencer, Nebraska, is the southernmost unchannelized portion of the Missouri River. Because this portion of the river remains unchannelized, the active channel and associated floodplain contain a myriad of riverine and palustrine wetlands.

Prior to the 1930s, the Missouri was an unmanaged, natural river that supported a tremendous number and diversity of fish and wildlife. The river occupied a sandy channel and flowed between erodible banks, from 1,500 feet to over one mile apart, with braided, sinuous channels twisting among sheltered backwaters, sloughs, chutes, oxbows, gravel bars, sandbars, mudflats, snags, alluvial islands, deep pools, marshland, and shallow-water areas (U.S. Fish and Wildlife Service 1980). The character of the Missouri was drastically altered between 1930 and 1970, as channelization and main-stem dams narrowed and deepened the river channel, and associated floodplain wetlands disappeared. The six main-stem dams in the Dakotas, Montana, and Nebraska have changed water quality, quantity, and timing throughout the Missouri River system (LaGrange 2005). The controlled release of water from the upstream dams has reduced the flood pulse that was a key factor in maintaining the in-channel habitat and adjacent floodplain wetlands. Although the stretch of the Missouri River within the GFA is not channelized, it is still negatively impacted by the upstream dams. Reduced sediment loads negatively influence channel morphology, while controlled releases from upstream dams reduce scouring and in-channel habitat maintenance (LaGrange 2005). Many of the off-channel wetlands historically associated with this system have been altered to increase row-crop agriculture. Today 18,000 acres, or 25% of the landscape, are under row-crop agriculture production (USDA 2009).

Based on a 2011 habitat assessment, the Missouri River GFA area contains approximately 28,500 acres of palustrine and riverine wetlands and just over 6,000 acres of grassland (Table 1). Despite the numerous alterations to the system, these wetlands still provide vital stopover habitat for numerous migratory waterfowl and shorebirds, as well as breeding habitat for the threatened Northern Great Plains population of Piping Plovers and the endangered Interior Least Tern.

The greatest threat to the unchannelized portion of the Missouri River is riverbed degradation (LaGrange 2005). Other key threats include residential/agricultural/commercial development,

transportation, water pollution, water development projects, stream bank stabilization, drainage, and filling (LaGrange 2005). Projects associated with each of these threats have both direct and indirect impacts that cumulatively impair river functions by isolating the floodplain from the river and reducing the natural dynamics. Invasive species also impact habitat for migrating waterfowl, shorebirds, and other wetland-dependent species. Purple loosestrife and *Phragmites* have become established throughout this stretch of the Missouri River, including the confluence of the Niobrara River. Expansion of these species into the backwaters of Lewis and Clark Lake and the Niobrara and Missouri rivers is a threat to native plants and habitat.

Northeast Prairies/Elkhorn River

The Northeast Prairies/Elkhorn River GFA is located in the northeastern portion of the RWBJV Administrative Area. The Geographic Focus Area is intensely farmed and has a higher human population density than other Geographic Focus Areas in the RWBJV Administrative Area, creating a fragmented landscape. At one time, the uplands were dominated by grasslands with a diverse assemblage of tallgrass and mixed-grass prairie species (Schneider et al. 2011). Some localized regions in this GFA contained a high density of playa wetlands. The playa wetland complex associated with this GFA is described as the Todd Valley Playa Wetland Complex (LaGrange 2005).

Today the mesic floodplains and steeper drainages associated with the Elkhorn River contain savannahs, woodlands, and densely forested habitats. Remnant tallgrass prairies are scattered across the region. The remaining playa wetlands contain a diverse mix of early successional wetland vegetation communities.

Despite the intensive row-crop and agricultural/urban/suburban development, this Geographic Focus Area contains significant grassland and wetland acres. Approximately 320,000 acres of palustrine and riverine wetlands and over 1.3 million acres of grassland occur throughout the Northeast Prairies/Elkhorn River GFA (Table 1). This landscape provides breeding habitat for numerous grassland nesting birds, while the Elkhorn River provides breeding habitat for the threatened Northern Great Plains population of Piping Plovers and the endangered Interior Least Tern. The Elkhorn River and Todd Valley wetlands provide secondary habitat for migrating wetland-dependent species (shorebirds, waterbirds, and waterfowl).

As with most of eastern Nebraska, this region is intensely cultivated. Nearly all of the grasslands have been converted, and many of the embedded playa wetlands drained to promote row-crop agriculture. Based on the 2009 USDA Cropland Data Layer, 55% of this landscape is cultivated to corn, soybeans, or alfalfa (USDA 2009; Bishop et al. 2011). Nearly 10% of the grassland cover has been re-established through the Conservation Reserve Program (CRP). Although many of these acres were not planted exclusively to native species, the acres complement the native tallgrass remnants scattered throughout the region. A majority of the CRP contracts are expiring, and current high commodity prices, plus the safety net provided by the Federal Crop Insurance Program, are accelerating conversion of these acres back to row-crop agriculture.

Invasive plant species, such as eastern red cedar, Kentucky bluegrass, *Phragmites*, purple loosestrife, reed canary grass, and smooth brome, continue to degrade wet meadows and adjacent mesic floodplains in this region. The loss of grasslands in the region has resulted in higher stocking rates and a shift to year-long grazing regimes. The transitions in grazing practices, as

well as fire suppression, are believed to be a major factor contributing to the encroachment of undesirable plant species (i.e., Kentucky bluegrass, eastern red cedar, and smooth brome, etc.).

Rainwater Basin

The RWB encompasses 6,150 square miles, including parts of 21 counties in the south-central portion of the RWBJV Administrative Area. Condra (1939) identified this landscape as the Loess Plains Region of Nebraska. This region has expansive rolling loess plains formed by deep deposits of wind-blown silt, with a high density of clay-pan playa wetlands. Overland runoff from intense summer storms and melting winter snowfall fill these playa wetlands.

Analysis of the historic soil surveys (1910 – 1917), NWI (1980 – 1982), and SSURGO data (1961 – 2004) indicates that playa wetlands were once a prominent feature of this landscape. Combined, these datasets identified approximately 11,000 individual playa wetlands (204,000 acres) that were historically part of the landscape. It has been estimated that there were over 1,000 semi-permanent and seasonal wetlands, which covered over 70,000 acres, and more than 10,000 temporary wetlands that accounted for an additional 134,000 acres.

A Nebraska Game and Parks Commission (NGPC) breeding waterfowl habitat survey (McMurtrey et al. 1972) used the historic soil surveys as a reference to evaluate the distribution of remaining wetlands. McMurtrey et al. (1972) reported that 82% of the major wetlands had been converted to agriculture, removing approximately 63% of the total wetland acres from the landscape. The fast-paced degradation continued, and by 1985 only 10% of the surveyed wetlands remained. The remaining wetlands represented only 22% of the original surveyed acres, and virtually all were hydrologically impaired (Schildman and Hurt 1984). Due to the extensive wetland loss and continued degradation, RWB wetlands were given a Priority 1 ranking, the most imperiled status, in the Nebraska Wetlands Priority Plan (Gersib 1991).

Land use in the RWB is dominated by row-crop agriculture (70% of the acres), predominantly in a corn and soybean rotation. Grassland habitats make up approximately 20% of the region, while 3% of the area is covered by savannahs, woodlands, and forest communities that are confined to the steeper drainages associated with the Republican and Blue river systems. Riverine wetlands associated with these systems comprise about 2% of the landscape. Of the historic 204,000 RWB wetland acres, roughly 40,000 acres remain, or about 17% of the historic distribution. Today, playa wetlands in the RWB make up less than 1% of the total landscape (Bishop and Vrtiska 2008; Bishop et al. 2011).

Approximately 44,000 acres of palustrine wetlands, 51,000 acres of riverine wetlands, and 678,000 acres of grassland presently occur throughout the RWB Geographic Focus Area (Table 1). Despite the extensive wetland loss, this region still hosts one of the greatest wildlife migration spectacles on earth. During spring migration, the RWB provides roosting, loafing, and foraging habitat for millions of migratory waterfowl and other wetland-dependent species. The RWB provides essential staging habitat for an estimated 8.6 million waterfowl (RWBJV 2013*c*) and nearly 600,000 shorebirds (Appendix C), as well as vital stopover habitat for the endangered Whooping Crane.

Over the years, a variety of wetland rules and laws have helped to significantly reduce active wetland drainage; however, wetland function across the landscape continues to decline as a result of intentional human activity, such as active drainage, and through ecological processes, including natural and culturally accelerated sedimentation (LaGrange et al. 2011). In addition,

wetland modifications, including water concentration/irrigation reuse pits, land leveling, culturally accelerated sediment, and drainage ditches, directly impact the wetlands or limit the amount of runoff reaching the wetlands. Furthermore, the combination of sedimentation and altered watershed hydrology leads to conditions that promote invasive species. Depending on the water regime and duration of saturated conditions, primary threats include reed canary grass, hybrid cattail (Grace and Harrison 1986), and river bulrush (Kaul et al. 2006, Rolfsmeier and Steinauer 2010).

Republican River/Blue River Drainages and Loess Canyons

The Republican River/Blue River Drainages and Loess Canyons GFA lies along the southern boundary of the RWBJV Administrative Area. A limited surface and groundwater supply differentiates the region from other Geographic Focus Areas within the RWBJV Administrative Area. As a result, a significant proportion of the cropland is cultivated with dry-land farming practices. Despite the limited ground- and surface-water resources, significant irrigation development occurred in the Republican River drainage through 2004. The unsustainable irrigation development ultimately led the Nebraska DNR to designate the Republican River drainage as an over-appropriated river basin. This designation led to a combination of restrictions on new acres developed for irrigation and on irrigation water allocations. The Blue River basins are defined by the drainage area of the Big and Little Blue rivers. At this time, the Blue river basins have no limitations on groundwater development, but triggers are in place should further groundwater depletions occur.

In the western portion of this region, there are numerous playa wetlands that are part of the Southwest Playa complex (LaGrange 2005). These freshwater wetlands receive water from runoff and are small (mostly less than 5 acres), temporarily and seasonally flooded wetlands. Most have no natural outlet for water. In most years, these wetlands dry up early enough in the growing season to be farmed. Southwest Playa wetlands are similar to RWB wetlands farther east, except that the RWB complex receives greater rainfall, and the wetlands there tend to be larger (LaGrange 2005).

The topography and soils of this Geographic Focus Area vary from steep hills and canyons with highly erodible soils in the west, to relatively flat and highly productive plains, rolling hills, and breaks in the east. Stream flows vary and are dependent on precipitation. Grasslands are dominated by mixed-grass prairie communities, with tallgrass prairies occurring along the eastern boundary. Fire suppression and year-long grazing regimes are believed to be major factors contributing to the establishment of invasive species in many of the grasslands in this Geographic Focus Area.

Approximately 5,000 acres of palustrine wetlands, 160,000 acres of riverine wetlands, 61,000 acres of lakes and reservoirs, and 3.1 million acres of grassland occur throughout the Republican River/Blue River Drainages and Loess Canyons GFA (Table 1). With the exception of Harlan County Reservoir, a 16,000 acre flood-control reservoir, water bodies are typically associated with small watershed impoundments created for flood control, grade stabilization, and livestock water. These man-made wetland features (reservoirs and stock ponds) provide migration, and at times wintering, habitat for waterfowl, as well as stopover habitat for numerous species of shorebirds. The grasslands in this Geographic Focus Area provide breeding habitat for an estimated 1.5 million grassland nesting birds (Rainwater Basin Joint Venture 2013*a*).

Habitat loss from grassland conversion and wetland drainage for row-crop agriculture has occurred to varying degrees throughout this GFA. Row-crop agriculture development has been slower in the Republican River Basin, primarily due to a limited groundwater aquifer and moratoriums on irrigation development. Invasive species continue to threaten habitat quality of both wetlands and uplands in this GFA. *Phragmites*, purple loosestrife, and reed canary grass have played a role in reducing habitat, constricting river channel widths, and depleting surface water flows.

Sandhills

The Sandhills is a 19,300 square-mile sand dune formation located in north-central Nebraska. Although located in a semi-arid climate, it contains an abundance of lakes, wetlands, wet meadows, and spring-fed streams scattered across the largest contiguous grass-stabilized dune system in North America (Schneider et al. 2011).

Between the dune formations are long, gently sloping valleys containing spring-fed meandering streams, lakes, wetlands, and wet meadows. Groundwater recharge is the prominent characteristic of the sands, creating a vast aquifer that stores 700-800 million acre-feet of groundwater (Keech and Bentall 1971). This volume represents twice the volume of Lake Erie. Most of the area's lakes, wetlands, and streams are sustained by groundwater discharge from adjoining dunes. About 90 percent of the stream flow (2.4 million acre-feet) comes from groundwater discharge (Bentall 1990). The Niobrara River flows along the Sandhills' northern border, and the North Platte River flows along part of the southern boundary. The Calamus, Cedar, Dismal, Elkhorn, and Loup rivers originate within the Sandhills.

Approximately 1.1 million acres of palustrine and riverine wetlands, 85,000 acres of lacustrine wetlands, and over 11.5 million acres of grassland occur throughout the Sandhills GFA (Table 1). The mosaic of wetlands and grasslands was identified by Bellrose (1980) as the most significant waterfowl nesting habitat outside of the Prairie Pothole Region. Vrtiska and Powell (2011) estimated that 275,000 waterfowl annually nest in the Sandhills. The larger Sandhills lakes provide nesting habitat for a majority of the High Plains flock of Trumpeter Swans (Grosse et al. 2012). The wet meadows and grasslands provide vital nesting habitat for an estimated 4 million grassland birds (RWBJV 2013*a*). A significant proportion of the estimated 400,000 breeding shorebirds found in the RWBJV Administrative Area occur in the Sandhills (Appendix A). Nearly all of the nesting waterbirds in the RWBJV Administrative Area occur in the Sandhills (RWBJV 2013*b*).

Wetland loss in the Sandhills has occurred primarily through draining by surface ditches, beginning as early as 1900 (U.S. Fish and Wildlife Service 1960; McMurtrey et al. 1972; LaGrange 2005). With the introduction of center-pivot irrigation systems to the Sandhills in the early 1970s, land leveling/shaping and local water-table declines resulted in extensive wetland losses in some areas. While quantifiable data are not available for the Sandhills, estimates of wetland acres drained range from 15% (McMurtrey et al. 1972) to 46% (U.S. Fish and Wildlife Service 1986). Sandhills wetlands were given a Priority 1 ranking, the most imperiled status, in the Nebraska Wetlands Priority Plan, due to very extensive past losses (Gersib 1991). Sandhills wetlands continue to be threatened by drainage ditches, generally created to increase hay acreage. This drainage directly impacts the lake or wetland where the project occurs and also can lead to cumulative wetland loss, both downstream and upstream, as the channel becomes entrenched, lowering the water table and causing lateral drainages that impact adjacent wetlands.

Many smaller wetlands are also threatened by conversion from ranching to irrigated row-crop agriculture. Concentrated, large-scale irrigation development can result in long-term effects on wetland communities by lowering the groundwater table. Many of the lands originally developed for row-crop production have been planted back to grasslands. This was incentivized by the CRP program. However, CRP acres could be rapidly converted to row-crop agriculture. As CRP contracts expire, there are multiple factors that could influence conversion of these lands back to row-crop agriculture. For example, current commodity prices, land values, and cash rent remain at all-time highs, and the Federal Crop Insurance Program provides a source of guaranteed income for cultivation of these environmentally sensitive lands.

Verdigris – Bazile Creek Drainages

This landscape, located in the northern portion of the RWBJV Administrative Area, is defined by the watersheds of Verdigris and Bazile Creeks, which originate in and flow through Cedar, Knox, Holt, and Antelope counties, emptying into the Niobrara and Missouri rivers in northeast Nebraska.

Topography is variable, resulting in a mosaic of cropland, grasslands, and woodlands. This Geographic Focus Area is located at the transition zone between the tallgrass and mixed-grass prairie ecoregions. As a result, the grasslands contain a diverse assemblage of tallgrass and mixed-grass prairie communities. Tallgrass prairie communities dominate the native grasslands along the eastern boundary, while species associated with mixed-grass prairie prevail in grasslands along the western boundary. Woodlands are generally confined to the drainages and bluffs associated with the major riverine systems (Verdigris Creek, Bazile Creek, Missouri River bluffs and breaks) (Schneider et al. 2011). These woodlands are dominated by deciduous species. The dominant cultivated crops in this region include corn, soybeans, and alfalfa (Bishop et al. 2009).

Approximately 4,800 acres of palustrine wetlands, 79,000 acres of riverine wetlands, 7,800 acres of lakes and reservoirs, and 1.4 million acres of grassland occur throughout the Verdigris-Bazile Creek Drainages GFA (Table 1). The CRP program has been utilized to re-establish grasslands on former row-crop acres with steeper topography and water erosion problems. Although many of these acres were not planted exclusively to native species, the re-established grassland acres complement the native tallgrass and mixed-grass remnants scattered throughout the region. It is estimated that this landscape provides nesting habitat for 600,000 grassland breeding birds (Rainwater Basin Joint Venture 2013*a*). The Niobrara River provides breeding habitat for the threatened Piping Plover and endangered Interior Least Tern.

A majority of the CRP contracts are expiring, and current high commodity prices, plus the safety net provided by the Federal Crop Insurance Program, are accelerating conversion of these acres back to row-crop agriculture. Grassland conversion is also occurring as a result of current farm economics and farm policy. Fire suppression and year-long grazing regimes are suspected of creating conditions that allow eastern red cedars, Kentucky bluegrass, and smooth brome to invade grasslands. Eastern red cedars have also invaded the woodlands and forests associated with the Verdigris – Bazile Creek Drainages.

Priority Shorebird Species Selection and Foraging Guild Aggregation

This plan provides a framework to step down the national, regional, and state shorebird objectives for both the RWBJV Administrative Area and RWB. At the national scale, the USSCP (Brown et al. 2001) provides a continental assessment of shorebird priorities and conservation needs. At the regional scale, the Central Plains and Playa Lakes Shorebird Conservation Plan (CP/PL; Fellows et al. 2001) describes the conservation needs and priorities for this landscape. At the state scale, Nebraska's State Wildlife Action Plan, the *Nebraska Natural Legacy Project* (NNLP; Schneider et al. 2011), identifies shorebirds that are experiencing significant declines and are most at risk of extinction or extirpation from Nebraska.

Each plan provides a shorebird conservation perspective at its respective geographic scale. The initial step in the RWBJV plan was to compile the priority species identified in the other plans. The RWBJV recognized that shorebird distribution is variable within the RWBJV Administrative Area, and that some species identified as priorities in plans with broader geographic focus would not be priorities for the RWBJV Shorebird Plan.

United States Shorebird Conservation Plan Priority Species

In development of this plan, the RWBJV used the USSCP shorebird species prioritization during each phase of the annual life cycle, according to the risk to species' overall populations. Five prioritization categories were developed: highly imperiled, species of high concern, species of moderate concern, species of low concern, and species not at risk. The prioritization of each species is based on its population trend, relative abundance, threats during breeding season, threats during non-breeding season, breeding distribution, and non-breeding distribution. Seventeen species that use the RWBJV Administrative Area fall into the more threatened categories ("highly imperiled" or "high concern"). Long-billed Curlew, Buff-breasted Sandpiper, Piping Plover and Snowy Plover are classified as highly imperiled. American Golden-Plover, American Woodcock, Hudsonian Godwit, Marbled Godwit, Red Knot, Ruddy Turnstone, Sanderling, Short-billed Dowitcher, Solitary Sandpiper, Upland Sandpiper, Western Sandpiper, Whimbrel, and Wilson's Phalarope are considered species of high concern (Brown et al. 2001, U.S. Shorebird Plan Report 2004; Table 2).

Central Plains / Playa Lakes Regional Shorebird Conservation Plan Priority Species

To guide regional implementation, the USSCP identified 12 Shorebird Planning Regions (SPRs). A majority of the RWBJV Administrative Area is within the Central Plains/Playa Lakes SPR (CP/PL SPR). The CP/PL Shorebird Plan developed a regional priority shorebird list. Species were considered a priority if they were: (1) federally or state endangered or threatened and were found in fairly significant numbers within the region; (2) species dependent upon unique habitats within the region for breeding and/or migrating purposes; (3) species with a specialized migratory route which causes them to be dependent upon the southern interior regions during some portion of their migration; (4) long-distance migrants which are particularly dependent upon the region's staging areas to replenish lipid reserves; or (5) species of which a large percentage of the population relies upon the region.

Eleven priority species documented to use the RWBJV Administrative Area were identified as priorities by the CP/PL Shorebird Conservation Plan. American Golden-Plover, American

Avocet, Buff-breasted Sandpiper, Hudsonian Godwit, Least Sandpiper, Long-billed Curlew, Long-billed Dowitcher, Piping Plover, Semipalmated Sandpiper, Stilt Sandpiper, and Upland Sandpiper were classified as priority species (Table 2).

Nebraska State Wildlife Action Plan Priority Species

The NGPC coordinated the development of Nebraska's State Wildlife Action Plan, the NNLP (Schneider et al. 2011). This plan used species occurrence data, input from numerous partners, and feedback from stakeholders to identify Tier I and Tier II at-risk species, as well as the conservation actions needed to support these species. Tier I species are those that are globally or nationally at greatest risk of extinction, while Tier II species are those species that are at risk within Nebraska while apparently doing well in other parts of their range. Priority species identified in this plan were Buff-breasted Sandpiper, Long-billed Curlew, and Piping Plover as Tier I species, while Snowy Plover, American Woodcock, and Wilson's Snipe were identified as Tier II species (Table 2).

Shorebird Foraging Guilds

As a taxonomic group, shorebirds forage in different habitats. Different species select for different forging habitats and exhibit niche segregation of wetland habitats, based on water depth. To effectively describe habitat needed to support shorebirds, species were aggregated into four foraging guilds (Table 2). The foraging guilds are:

1. Agri-probers and Upland Associates, which primarily forage in the uplands, but also rely on wetlands for foraging and water resources.
2. Small-bodied Probers/Gleaners, which are species that forage in mud and shallow water $\leq$ 5 cm in depth.
3. Large-bodied Probers, or species that forage in shallow water $\leq$ 16 cm.
4. Swimmers, or species that use a full range of water depths from shallow to deep.

Table 2. Shorebirds that occur in the RWBJV Administrative Area and their conservation status.

Species	Species Prioritization		
	U.S. Shorebird Conservation Plan 2004	Central Plains/ Playa Lakes Shorebird Plan 2001	Nebraska Natural Legacy Project 2011
Agri-probers and Upland Associates			
American Golden-Plover	High concern	Priority	
Killdeer	Moderate concern		
Upland Sandpiper	High concern	Priority	
Whimbrel	High concern		
Long-billed Curlew	Highly imperiled	Priority	Tier I
Buff-breasted Sandpiper	Highly imperiled	Priority	Tier I
Small-bodied Probers/Gleaners			
Semipalmated Plover	Low concern		
Black-bellied Plover	Moderate concern		
Snowy Plover	Highly imperiled		Tier II
Piping Plover	Highly imperiled	Priority	Tier I
Spotted Sandpiper	Low concern		
Semipalmated Sandpiper	Moderate concern	Priority	
Least Sandpiper	Moderate concern	Priority	
White-rumped Sandpiper	Low concern		
Baird's Sandpiper	Low concern		
Pectoral Sandpiper	Low concern		
Large-bodied Probers			
Black-necked Stilt	Low concern		
American Avocet	Moderate concern	Priority	
Greater Yellowlegs	Moderate concern		
Lesser Yellowlegs	Moderate concern		
Solitary Sandpiper	High concern		
Willet	Moderate concern		
Hudsonian Godwit	High concern	Priority	
Marbled Godwit	High concern		
Ruddy Turnstone	High concern		
Sanderling	High concern		
Red Knot	High concern		
Western Sandpiper	High concern		
Dunlin	Moderate concern		
Stilt Sandpiper	Moderate concern	Priority	
Short-billed Dowitcher	High concern		
Long-billed Dowitcher	Low concern	Priority	
American Woodcock	High concern		Tier II
Wilson's Snipe	Moderate concern		Tier II
Swimmers			
Wilson's Phalarope	High concern		
Red Phalarope	Moderate concern		
Red-necked Phalarope	Moderate concern		

Population Objectives

Planning Species for the RWBJV

The assessment (Table 2) of the three plans identified 37 shorebird species that occur in the RWBJV Administrative Area. To evaluate the importance of the RWBJV Administrative Area to these species, information from recent shorebird research and monitoring projects was compiled. Assessment of this information allowed the RWBJV to identify planning species for the RWBJV Shorebird Plan. Shorebird data evaluated as part of this exercise included United States Geological Survey (USGS) shorebird surveys, NGPC shorebird surveys, directed research projects, and recent monitoring reports.

In 2008, the USGS developed a regional monitoring project to estimate shorebird use in BCRs 18 and 19 (S. K. Skagen, USGS, personal comm.). Previous research projects suggest that the distribution of these habitat features influences habitat selection by waterbirds (Naugle et al. 2000) and shorebirds (Webb et al. 2010). A stratified random sample of townships was selected from each of the four landscape strata to capture the range of landscape conditions. Between 15 April and 30 May 2008, 2-3 surveys were completed along 18 one-mile road segments distributed throughout the selected townships in the RWBJV Administrative Area.

Shorebird counts were adjusted for sampling intensity and detection probability and extrapolated to the landscape stratum from which they were drawn. Additional sampling was completed across the region at sites with documented high shorebird use. This design allowed the data to be analyzed to describe species-specific use of the RWBJV Administrative Area and at finer-scale regions with high shorebird density, such as the RWB (S. K. Skagen, USGS, personal comm.).

In total, 24 species of shorebirds were identified during these surveys. For a few species, the survey estimates were not consistent with recently published literature. The large geographic scale of the survey limited total survey effort across the entire landscape. As a result, the full complement of shorebirds that use the RWBJV Administrative Area was not adequately detected. In these cases, published literature was used to describe species use in the RWBJV Administrative Area. Literature referenced as part of this planning process included: Jorgensen 2004, Jorgensen 2008, Jorgensen et al. 2008, Elliott-Smith et al. 2009, Jorgensen et al. 2009, Sauer et al. 2011, and Gregory et al. 2012.

After comparing the monitoring data and published estimates, thirteen species that occur in the RWBJV Administrative Area were omitted from the planning process because they occurred at low densities (<100 individuals estimated to use the RWBJV Administrative Area). Species excluded from the analysis were the Whimbrel, Snowy Plover, Black-necked Stilt, Marbled Godwit, Ruddy Turnstone, Sanderling, Red Knot, Western Sandpiper, American Woodcock, Dunlin, Short-billed Dowitcher, Red Phalarope, and Red-necked Phalarope.

Population Objectives for RWBJV Planning Species

An underlying assumption for the RWBJV Shorebird Plan is that shorebirds using the RWBJV Administrative Area forage in similar habitats and select for the same resources (invertebrates). The RWBJV landscape provides both non-breeding and breeding shorebird habitat. During different periods of the annual life cycle, species have different nutritional and caloric (energy)

requirements. To address this issue, both non-breeding and breeding objectives were established for the planning species (Appendix A: RWBJV Administrative Area and Appendix B: RWB).

To establish population objectives for the RWBJV Administrative Area and RWB, contemporary use estimates (Jorgensen 2004, Jorgensen 2008, Jorgensen et al. 2008, Elliott-Smith et al. 2009, Jorgensen et al. 2009, Sauer et al. 2011, and Gregory et al. 2012, S.K. Skagen, USGS, personal comm.), national shorebird population estimates (Morrison et al. 2006), and population objectives outlined in the USSCP (Brown et al. 2001) were incorporated into a population objectives framework (Appendices A & B). The initial step in this framework was to evaluate national shorebird population objectives (Brown et al. 2001) against current national shorebird population estimates (Morrison et al. 2006). Dividing the current population estimate (Morrison et al. 2006) by the USSCP population objectives (Brown et al. 2001) provided a planning ratio, or the increase necessary over current populations to achieve the USSCP objectives (Appendices A & B). The planning ratio described, at the national scale, the rate of growth (+/-) necessary to achieve USSCP population objectives. This analysis (Appendices A and B) highlighted that many of the RWBJV shorebird planning species were not at USSCP goal levels; however, for species that were at or above USSCP goal, the RWBJV set the planning ratio to "one", or maintenance of current populations. The species-specific planning ratios were then multiplied by the contemporary use estimates for the RWBJV Administrative Area or RWB to establish species-specific population objectives (Appendices A and B).

To provide species-specific planning objectives during the non-breeding and breeding phases of the annual life cycles, an "en-route ratio*"* was developed. This ratio was developed by dividing the estimated number of individuals that use the RWBJV Administrative Area during the non-breeding phase of the annual life cycle by the number of individuals that remain in the region during the breeding phase. The en-route ratio was based on species' life history accounts, species distribution maps, migration chronology, and professional experience (J. Jorgensen, NGPC, personal comm., S. K. Skagen, USGS, personal comm., Skagen et al. 1999). Multiplying the en-route ratio by the population objectives allowed the RWBJV to establish non-breeding population objectives, while multiplying the population objectives by one minus the en-route ratio allowed the RWBJV to establish breeding population objectives. Because only minor amounts of suitable breeding habitat exist in the RWB, breeding shorebird objectives were only established for the RWBJV Administrative Area (Appendix A).

Non-Breeding Shorebird Population Objectives

At USSCP population objectives (Brown et al. 2001), the RWBJV Administrative Area will need to support 3.0 million shorebirds during the non-breeding phase of the annual life cycle. Wilson's Phalaropes made up the largest percentage of shorebirds in the RWBJV Administrative Area (Appendix A). Semipalmated Sandpipers and Baird's Sandpipers are the primary Small-bodied Probers/Gleaners. Lesser Yellowlegs and Wilson's Snipe represent the greatest proportion of the Large-bodied Probers that forage in ponded wetlands with water depth <16 cm (Appendix A).

Shorebird estimates for the RWB (Appendix B) highlight that it is an important landscape for non-breeding shorebirds in the RWBJV Administrative Area. Shorebird use estimates suggest that the RWB will need to provide foraging resources to support approximately 73% of the Small-bodied Probers/Gleaners and 51% of the Large-bodied Probers that use the RWBJV Administrative Area. Based on foraging needs (kcals), the primary Small-bodied

Probers/Gleaners that rely on the RWB are Baird's Sandpiper (40% of the foraging needs), Semipalmatated Sandpipers (28%), and White-rumped Sandpipers (14%). Of the Large-bodied Probers, Lesser Yellowlegs (69%) and Long-billed Dowitchers (25%) require the most foraging resources from wetlands in the RWB (Appendix B).

Breeding Shorebird Population Objectives

Based on the RWBJV population objectives framework (Appendices A and B), eight breeding shorebird species were incorporated into the RWBJV Shorebird Plan. Population objectives were established for Piping Plovers, Killdeer, Upland Sandpipers, Long-billed Curlews, Spotted Sandpipers, American Avocets, Willets, and Wilson's Phalaropes. It is estimated that the RWBJV Administrative Area will only support approximately 412,000 breeding shorebirds. Approximately 60% will be Wilson's Phalaropes, while 30% will be Killdeer (Appendix A).

In 1986, the Northern Great Plains population of Piping Plovers was designated as a threatened species by the U.S. Fish and Wildlife Service (USFWS). To aid in the species recovery, the USFWS developed a recovery plan for the Great Lakes and Northern Great Plains populations of Piping Plovers (Piping Plover Recovery Plan; USFWS 1988). This plan provided explicit objectives or benchmarks necessary to achieve conservation success. The Piping Plover Recovery Plan identifies a regional population of 1,300 individuals (USFWS 1988). Population objectives were established for the four primary river systems in the RWBJV Administrative Area: 1) Niobrara River –50 breeding pairs, 2) Loup River – 25 breeding pairs, 3) Platte River system –140 breeding pairs, and 4) Missouri River –350 pairs. The Missouri River objectives are included with South Dakota's objectives. For recovery of Piping Plovers, the Nebraska contribution within the RWBJV Administrative Area would be 215 pairs (430 individuals) or 17% of the Northern Great Plains population. However, the federal Piping Plover Recovery Plan is currently being revised, and these numbers and the metrics used to evaluate Piping Plover recovery may change in the near future.

Primary Shorebird Habitat in the RWBJV Administrative Area

Each of the Geographic Focus Areas in the RWBJV Administrative Area contains a unique abundance, distribution, and diversity of wetland types. This landscape composition influences the species and number of shorebirds each landscape can support. Playa wetlands (a type of palustrine wetland), such as those found in the RWB, Central Loess Hills (Central Table Playas Wetland Complex), Northeast Prairies/Elkhorn River (Todd Valley Wetland Complex), and Republican River/Blue River Drainages and Loess Canyons GFAs, and along the North Platte River (Southwest Playa Wetland Complex) provide optimal foraging habitat for Small-bodied Probers/Gleaners, and Large-bodied Probers during the non-breeding phase of their annual life cycle (Appendices A and C). Sandhills lakes (a type of lacustrine wetland) provide critical foraging and nesting habitat for Swimmers during the non-breeding and breeding phases of their annual life cycle. The expansive wet meadows (a type of palustrine wetland) in the Sandhills provide essential nesting habitat for a majority of the upland-associated shorebirds that rely on this region during the breeding phase of their annual life cycle. Riverine wetlands associated with the Elkhorn (Northeast Prairies/Elkhorn River GFA), Loup (Central Loess Hills GFA), Missouri, and Platte (Central Platte River) rivers are identified as critical breeding habitat to support the recovery of Piping Plovers. It is hypothesized that these riverine systems also

provide a reliable stopover for shorebirds, especially during periods of drought (Fellows et al. 2001). Agriculture fields (row-crop and hay fields) provide habitat, of unknown quality, for Killdeer and Upland Sandpiper.

Non-breeding Shorebird Habitat in the RWBJV Administrative Area

At the RWBJV Administrative Area scale, the current bioenergetics model and habitat inventories (Bishop et al. 2009, Appendix C) suggest there is sufficient foraging habitat to support the non-breeding migrant shorebirds using this region. For Small-bodied Probers/Gleaners and Large-bodied Probers, approximately 485,000 of the 2.3 million wetland acres in the RWBJV Administrative Area were identified as potentially suitable habitat (Appendix C). Playa wetlands, like those found in the RWB, Central Loess Hills (Central Table Playas Wetland Complex), Northeast Prairies/Elkhorn River (Todd Valley Wetland Complex) and Republican River/Blue River Drainages and Loess Canyons GFAs, and along the North Platte River (Southwest Playa Wetland Complex) are estimated to provide the most significant portion of the foraging resources for non-breeding shorebirds. Although playa wetlands only make up 14% of the wetland acres, these habitats are estimated to provide 27.1% of the foraging resources for Small-bodied Probers/Gleaners and 27.4% of the foraging habitat for Large-bodied Probers (Appendix C). Sandhills lakes and emergent marsh are the other primary foraging habitats for these two guilds. Sandhills lakes are estimated to provide 26% of the suitable foraging habitat, while emergent marsh habitats associated with riverine systems in the RWBJV Administrative Area are expected to provide 25% of the foraging habitat for these two guilds (Appendix C).

For Swimmers during the non-breeding phase, the RWBJV Administrative Area will need to provide 838 million kcals of foraging resources. The bioenergetics model suggests this will require approximately 81,850 acres of suitable wetland habitat. Based on the habitat assessment process, there is sufficient habitat (197,000 acres) to support this guild. It is estimated that 40% of this habitat will be provided by Sandhills wetlands, while most of the other habitat will be provided by human-made wetland features, including stock dams and reservoirs (Appendix C).

The RWBJV shorebird bioenergetics model assumes a uniform density and use of habitat by non-breeding shorebirds throughout the RWBJV Administrative Area. To evaluate this assumption, RWBJV Administrative Area shorebird population objectives were compared to population objectives developed for the RWB. This analysis showed Small-bodied Probers/Gleaners and Large-bodied Probers occurred in greater abundance in the RWB compared to other Geographic Focus Areas, with 73% of the Small-bodied Probers/Gleaners and 51% of the Large-bodied Probers documented in the RWBJV Administrative Area actually found in the RWB (Appendices A and B).

Within the RWB there are sufficient acres of potential habitat; however, wetland and watershed modifications negatively impact these wetlands, and as a result, many of the wetlands do not reliably pond water during shorebird migration. Conservation work by the RWBJV in the RWB has focused, and will continue to focus, on providing reliable habitat for waterfowl, shorebirds, and waterbirds during the non-breeding phase of the annual life cycle. Shorebird conservation strategies within the RWB are consistent with those outlined in the RWBJV Waterfowl Plan. These strategies include on-site wetland restoration to increase wetland function, watershed restorations to increase runoff to the wetland, and management to promote desired habitat conditions.

The close proximity of the playa wetland complexes (RWB, Central Table Playas, Todd Valley, and Southwest Playas) to adjacent riverine wetland systems (Elkhorn, Loup, Missouri, and Platte rivers) creates multiple macro wetland complexes. The diversity of wetland types provides a complementary set of habitat conditions for migrating shorebirds. Within this region, localized weather events and long-term weather patterns (el-Niño, la-Niña, and drought) impact the number of wetlands ponding water. During periods of drought with above-average winter temperatures and below-average precipitation, few, if any, playa wetlands provide habitat (Robichaux 2010, Uden 2012), and instead the riverine systems provide habitat (National Research Council of the National Academies 2005).

Breeding Shorebird Habitat in the RWBJV Administrative Area

Breeding shorebirds found in the RWBJV Administrative Area require a diverse assemblage of nesting habitat. Willets, Long-billed Curlews, and Upland Sandpipers nest in grasslands, but require wetland habitats for brood rearing. Piping Plovers require bare or sparsely vegetated sand in the active floodplain of the major rivers found in the RWBJV Administrative Area. Killdeer use a variety of disturbed habitats. Wilson's Phalaropes require a mosaic of wetland habitats, including wet meadows.

In the Sandhills, the extensive amount of intact grasslands, higher wetland density, and the interspersion and greater number of semi-permanent wetlands provide nesting and foraging habitat for shorebirds. Although the grassland landscape has remained relatively intact, wetland drainage continues, but at a slower pace compared to years before the "Swampbuster" provision of the 1985 Farm Bill. Recent spikes in commodity prices may have increased grassland conversion to cropland. The increased commodity prices also may have made it profitable for some producers to opt out of the USDA farm program. As a result, wetlands within such operations are not protected by the "Swampbuster" provision and are subject to drainage and filling. The Clean Water Act may protect some of the wetlands from drainage, but many of the Sandhills wetlands are considered to be geographically isolated and may no longer be protected under the Clean Water Act.

The large expanse of wetlands and open grassland (95% of 12.8 million acres within the Sandhills; Schneider et al. 2011) is conducive to wind development. Development of large-scale wind farms will fragment the landscape and could lead to increased nest predation and aversion to the area. The spread of invasive species is also a concern. As wind farms are constructed, there will be significant disturbance of the vegetative communities and soils on-site. These disturbed conditions will provide optimal germination conditions for invasive species, while service vehicles will provide a vector to transport seeds throughout the landscape. Establishment of these species will degrade nesting and wetland habitats. Smooth brome grass, Canada thistle, leafy spurge, eastern red cedar, hybrid cattail, *Phragmites*, and reed canary grass pose the greatest current threat.

Energetic Needs of Shorebirds Using the RWBJV Administrative Area

At the most conceptual level, shorebird conservation in the RWBJV Administrative Area means a sufficient distribution of wetlands to meet the foraging needs of shorebirds. To determine if the RWBJV Administrative Area could support shorebird population objectives, the RWBJV

developed a bioenergetics model, which estimates foraging needs of shorebirds at population–objective levels. The model incorporates species-specific population objectives, bird-use days, and energetic needs. It also provides estimates of the energetic needs of both breeding and non-breeding shorebirds. The model allowed the RWBJV to estimate energetic needs, by guild, for shorebirds that use the RWBJV Administrative Area (Appendix A) and RWB (Appendix B).

The bioenergetics model showed that the RWBJV Administrative Area will need to provide 2.1 billion kcals (Appendix A) for breeding and non-breeding shorebirds (Table 3), while the RWB will need to provide 207 million kcals (Appendix B) for non-breeding shorebirds (Table 4).

GIS technology was used to evaluate the distribution and abundance of shorebird foraging habitat. The energetic or foraging resources available from these habitats, for each shorebird foraging guild, were based on estimates reported in scientific literature or agency reports (Appendix C). An estimated 202,815 acres of available shorebird habitat would be needed to support shorebirds at goal levels throughout the RWBJV Administrative Area during the breeding and non-breeding phases of the annual life cycle (Table 3). In the RWB, an estimated 20,260 acres of available habitat would be needed to support shorebirds using this region during the non-breeding phase of the annual life cycle at population objectives (Table 4; Appendix C).

Table 3. Total wetland acres required to meet the energetic needs of breeding and non-breeding population targets of shorebirds using the RWBJV Administrative Area.

Species Guilds	Total Energetic Need (kcals/acre)	Acres to Provide Energetic Resources
Agri-probers/Upland Associates	669,696,068	65,413
Small-bodied Probers/Gleaners	54,150,393	5,289
Large-bodied Probers	153,036,832	14,948
Swimmers	1,199,537,678	117,165
Total	**2,076,420,971**	**202,815**

Appendix C describes the process used to estimate the acres of suitable foraging habitat for each guild in both the RWBJV Administrative Area and RWB. Regional shorebird experts (S.K. Skagen, USGS, personal comm. and J.G. Jorgensen, NGPC, personal comm.) evaluated each wetland habitat described in the RWBJV Administrative Area GIS landcover dataset (Bishop et al. 2009) to determine a shorebird suitability index by habitat. The suitability index represents the proportion of wetland habitat usable by the different shorebird guilds. The index was created by multiplying the percentage of habitat acres that would be usable if covered by ponding water, by the percent of time the acres would pond water at the appropriate depth suitable for the species guild.

Table 4. Total wetland acres required to meet the energetic needs of non-breeding populations of shorebirds using the RWB.

Species Guilds	Total Energetic Need (kcals/acre)	Acres to Provide Energetic Resources
Agri-probers /Upland Associates	71,869,671	7,020
Small-bodied Probers/Gleaners	39,703,172	3,878
Large-bodied Probers	65,272,054	6,375
Swimmers	30,574,035	2,986
Total	**207,418,932**	**20,260**

Based on the habitat suitability indices, and given the specified assumptions, the RWBJV Administrative Area is estimated to have sufficient habitat available to support shorebird populations at current goal levels. However, when the RWB survey information was evaluated (Appendix B and C), the analysis indicated that the RWB would not have sufficient habitat to support the Small-bodied Probers/Gleaners or Large-bodied Probers that use this region.

Non-breeding Shorebird Habitat Strategies

The habitat requirements for shorebirds are diverse. Many of the migrating species select shallow wetlands with mudflats. These habitats provide invertebrates that are the primary food for shorebirds (Davis and Smith 1998).

The RWB is the most important non-breeding habitat for the Small-bodied Probers/Gleaners and Large-bodied Probers within the RWBJV Administrative Area (Appendix B). The RWBJV bioenergetic and habitat inventories suggest that 3,878 acres of available foraging habitat is needed to support Small-bodied Probers/Gleaners, while 6,375 acres of suitable habitat is necessary to support Large-bodied Probers that use the RWB. Habitat inventories indicate that under average climatic conditions, the RWB can reliably provide 2,740 acres for Small-bodied Probers/Gleaners and 5,640 acres for Large-bodied Probers. Based on these habitat inventories, there is a 1,138-acre deficit for Small-bodied Probers/Gleaners and a 735-acre deficit for Large-bodied Probers (Appendix C). Inventories indicate that there are sufficient wetland acres in the RWB; however, the hydrology must be improved to ensure ponded acres on a more reliable basis for shorebirds using the RWB during migration (Appendices B and C).

Precipitation events and weather patterns are highly variable throughout the Great Plains. The RWBJV recognizes the importance of having non-breeding shorebird habitat distributed across the landscape to maximize the probability that wetlands will provide ponded habitat. Therefore the RWBJV has also set habitat conservation strategies for playa wetlands located in the Central Table Playas, within the Central Loess Hills GFA. Increasing functional playa wetlands in this wetland complex will provide a reserve habitat base for shorebirds during the non-breeding phase of their annual life cycle, and will provide high-quality migration stopover habitat for Whooping Cranes.

RWB Conservation Targets and Strategies

Target 1. By 2030, ensure that publicly owned wetlands are capable of providing wetland habitat to support non-breeding shorebirds that rely on this region.

Strategy A: Through active management, maintain 80% of public wetland acres in early–succession plant communities. Management will be targeted at reducing the distribution of invasive species, to provide open water and mudflats for foraging shorebirds.

Strategy B: Increase ponding frequency under average moisture conditions from 17.7% to 45% on public lands.

- Restore the natural hydrologic characteristics of each wetland to the greatest feasible degree.
- Increase the function of associated watersheds by reclaiming irrigation reuse pits and implementing other conservation practices to increase water conveyance to the wetlands.
- Provide additional supplemental water delivery by increasing the use of high-volume wells.
- Develop a long-term funding mechanism to operate high-volume wells.

Target 2. By 2030, long-term conservation wetlands will provide 25% of the total natural forage needed by shorebirds in the RWB.

Strategy A: Through management, maintain 75% of these wetland acres in early-succession plant communities.

Strategy B: Increase ponding frequency under average weather conditions to 45%.

- Restore the natural hydrologic characteristics of each wetland to the greatest feasible degree.
- Increase the function of associated watersheds by reclaiming irrigation reuse pits and implementing other conservation practices.
- Provide additional supplemental water delivery by increasing the use of high-volume wells.
- Develop a long-term funding mechanism to operate high-volume wells.

Central Platte River Conservation Targets and Strategies

Target 1. Develop landscape inventories that RWBJV partners can use to guide river management to increase the frequency of in-stream target flows that maintain in-channel habitat conditions through scouring and other ecological processes, and provide nesting habitat for Piping Plovers, as well as reliable foraging and nesting habitat for shorebirds.

Strategy A: Provide technical resources for geospatial analysis to quantify and map the habitat conditions under different flow regimes.

Strategy B: Provide technical resources necessary to quantify the impacts of different flow regimes on available in-channel habitat for Piping Plovers and other shorebirds.

Target 2. When necessary, implement active management (disking, herbicide treatments, tree removal, roto-tilling) to promote desired habitat conditions within the active channel, plus a matrix of wetland habitats to benefit non-breeding shorebirds.

Target 3. Work with partners to assess the capacity of the Central Platte River to provide suitable nesting habitat for the different shorebird guilds and provide guidance for strategic habitat conservation.

Strategy A: Provide technical resources for geospatial analysis to quantify and map current nesting habitat for shorebirds.

Strategy B: Provide technical resources necessary to develop decision support tools to assist conservation partners and land managers in prioritizing restoration and management projects to provide the greatest biological return for priority nesting shorebird species (e.g., Piping Plovers).

Central Loess Hills Conservation Targets and Strategies

Target 1. By 2030, enroll 4,000 acres of playa wetlands in existing or newly developed conservation programs that fully restore wetland and watershed function. At goal, these wetlands should, under average climate conditions, provide 2,000 acres of reliable wetland habitat during spring and fall migration to support the shorebirds that use this region.

Strategy A: Strategically market wetland conservation programs, such as the Natural Resources Conservation Service's (NRCS) Wetlands Reserve Program (WRP), and Farm Service Agency's (FSA) Conservation Reserve Program, which provide financial and technical assistance to restore wetland functions.

- Annually enroll 200 acres of playa wetlands into the Wetlands Reserve Program or similar programs in the Central Table Playas.
- Develop a CRP Conservation Practice, like CP 23A, that provides a ten-year contract to restore playa wetlands and adjacent upland buffer enrolled in the program. The RWBJV will pursue opportunities to compensate enrolled acres at county irrigated rental rates, since a majority of the Central Table Playa wetlands are embedded in center pivot-irrigated crop fields. The program should be structured to require full hydrologic restoration to the extent possible and also require mid-contract management.
- Enroll 75 acres annually (50 acres of wetland and 25 acres of adjacent upland buffer) in conservation programs.
- Integrate geospatial habitat prioritization tools to promote conservation programs to high-priority landowners and producers.

Strategy B: Develop a watershed restoration program to fill irrigation reuse pits that are negatively impacting Central Table Playa wetlands.

- Analyze existing geospatial datasets to determine the number of watershed modifications (irrigation reuse pits) and the potential impacts (storage volume) of these features on wetland function.
- Analyze existing irrigation practices to identify those irrigation reuse pits that have been abandoned and are no longer actively used due to a transition to pivot irrigation systems.
- Develop a prioritization tool to identify those abandoned irrigation pits that have the greatest impact on existing playa wetlands in the Central Table Playas.
- Develop and implement conservation initiatives to remove 75% of these modifications by 2030.

Strategy C: Develop infrastructure to integrate Central Table Playa wetlands into producers' operations for either forage or cattle production. Such activities (grazing, fire, and haying) emulate the ecosystem processes under which these wetlands evolved, and will promote desired vegetation communities and habitat conditions for priority species.

- Develop and implement programs that will provide cost-share for agriculture producers to install cross fence, perimeter fence, and livestock water systems to integrate these wetlands into agriculture operations.

Breeding Shorebird Habitat Strategies

The Sandhills region is the primary nesting habitat for shorebirds in the RWBJV Administrative Area (Fellows et al. 2001). Many of the breeding species nest in grasslands and wet meadows in close association to larger wetlands. There are nearly 1.3 million acres of wetlands in the Sandhills, including approximately 85,000 acres of Sandhills lakes. The juxtaposition of palustrine and lacustrine wetlands embedded in this grass-dominated landscape provides high-quality breeding habitat for shorebirds. Additional monitoring and survey data will be required to identify local landscapes and habitat features within the Sandhills that are important to the different priority breeding species. Therefore, the RWBJV habitat goal for the Sandhills is no net loss of current wetland distribution and abundance. To successfully implement this conservation measure, the RWBJV will need to expand the current partnership and more effectively coordinate with the local grass-roots partnerships, like the Sandhills Task Force. The Sandhills Task Force is composed of ranchers, Nebraska Cattlemen members, conservation organizations, and government agencies. The goal of the Sandhills Task Force is to enhance the Sandhills wetland-grassland ecosystem in a way that sustains profitable private ranching, wildlife and vegetative diversity, and associated water supplies.

Loss of sufficient high-quality shorebird nesting habitat (wetlands and grasslands) continues to be a major threat throughout the RWBJV Administrative Area, along with reduction in stream flows and the degradation of major rivers and streams. A dramatic increase in irrigation in recent decades has caused groundwater levels to drop, affecting stream flows, and the rivers' ability to maintain bare sandbars and flooded wet meadows. Piping Plovers, a priority species, depend on unvegetated sandbars to nest and rear their young. Stream flows of significant magnitude and duration are necessary to maintain sandbars and braided stream channels. Flows in the Platte River and Republican River are over-appropriated due to extensive irrigation. Major rivers providing shorebird habitat within the Sandhills are currently not over-appropriated,

but the threat remains, along with the threat from channelization and the head cutting and degradation of important streams and associated habitats.

For Piping Plovers the RWBJV will work closely with the USFWS, NGPC, and Platte River Recovery and Implementation Program to better understand nesting habitat availability under different flow regimes. In addition, the RWBJV will provide GIS and technical support to help identify the highest-priority lands for conservation within the river systems that support Piping Plovers.

Sandhills Conservation Targets and Strategies

Target 1. Work with partners to identify conservation opportunities that can be developed to promote nesting shorebird habitat on private lands managed for beef production.

Strategy A: Provide technical resources necessary to complete landscape-level surveys that can be used to define species-habitat relationships and identify priority landscapes for shorebird conservation.

Strategy B: Develop conservation programs and strategies that will promote shorebird nesting habitat and complement cattle operations in the Sandhills.

Central Loess Hills Conservation Targets and Strategies

Target 1. Work with partners to maintain stream flows necessary for maintenance of in-channel habitat conditions, through scouring and other ecological processes, to provide nesting habitat for Piping Plovers and establish reliable habitat for shorebirds during the non-breeding phase of their annual life cycle.

Strategy A: Provide technical resources for geospatial analysis to quantify and map the habitat conditions found on the Loup River systems.

Strategy B: Provide technical resources necessary to describe available in-channel nesting habitat for Piping Plovers to better target conservation activities.

Central Platte, Loup, Missouri, and Niobrara River Conservation Targets and Strategies

Target 1. Work with partners to increase the frequency of flows that support ecological processes (scouring and maintaining in-channel habitat conditions) and provide nesting habitat for Piping Plovers, as well as reliable foraging and nesting habitat for shorebirds during their annual life cycle.

Strategy A: Provide technical resources for geospatial analysis to quantify and map the habitat conditions under different flow regimes.

Strategy B: Provide technical resources necessary to quantify the impacts of different flow regimes on available in-channel habitat for nesting Piping Plovers and other shorebirds (e.g., Spotted Sandpipers).

Target 2. Work with partners to assess the capability of the central Platte River to provide suitable nesting habitat for the different shorebird guilds, and provide guidance for strategic habitat conservation.

Strategy A: Provide technical resources for geospatial analysis to quantify and map existing nesting habitat for shorebirds.

Strategy B: Provide technical resources necessary to develop decision support tools to assist conservation partners and land managers in prioritizing restoration and management projects to provide the greatest biological return for priority nesting shorebird species (e.g., Piping Plovers).

Conservation Delivery

Similar conservation approaches will be taken for breeding and non-breeding shorebirds, relying on partners' expertise, staff, existing conservation programs, and new conservation programs, when needed, to achieve targets. Conservation programs are grouped into two basic categories: short-term or long-term.

Short-term programs are typically carried out under ten-year agreements. The agreements are designed to complement existing environmental and socio-economic conditions and can be tailored to the specific wishes of the landowner. They often provide financial as well as technical assistance for practices such as wetland restoration, riverine management, watershed restoration, and vegetation management. Some of these agreements augment USDA projects.

Acquisition and long-term programs (30 years or more) generally involve the fee-title purchase of lands, or the purchase of conservation easements. Easement acquisitions are accomplished by various partners within the Joint Venture, with individual partners taking the leadership in their own acquisitions. In some GFAs within the RWBJV Administrative Area the RWBJV partners collaborate to identify potential properties, leverage funding, and help facilitate long-term management of lands enrolled in long-term conservation programs. All acquisitions are strictly on a voluntary-seller basis.

In the RWB, publicly owned wetlands will play a critical role, however in other Geographic Focus Areas, acquisition of public lands will be very limited. The focus will be on short-term conservation programs administered by the USFWS, NGPC, and USDA's NRCS and Farm Service Agency. Partners will work with willing landowners to establish conservation programs that ultimately will help integrate palustrine, riverine, and upland habitats into the producer's operation and provide critical shorebird habitat.

Research and Monitoring

The RWBJV Shorebird Plan represents a significant step forward for the RWBJV partnership. For the first time, RWBJV partners can link conservation delivery to the habitat needs of those priority species outlined in the USSCP. Multiple research and monitoring projects will need to be completed to strengthen this plan.

Non-breeding Shorebirds

Shorebird research and monitoring efforts will focus on refining the population estimates, and on assessing invertebrate abundance or available foraging resources in the different wetland habitats found throughout the RWBJV Administrative Area. To better understand the variation in use by non-breeding shorebirds, the RWBJV will need to build upon previous monitoring efforts. These additional efforts will have to be temporally and spatially balanced to better quantify shorebird use throughout the RWBJV Administrative Area during migration. Data collected will help refine the planning estimates and provide insight into how different weather patterns and associated habitat conditions influence shorebird use. The RWBJV will begin a habitat assessment protocol to better refine the shorebird habitat suitability index. Invertebrate abundance and density by habitat type will need to be evaluated. Foraging efficiency, by shorebird species and foraging guild, needs to be refined. These results will help to refine the bioenergetics model and landscape carrying capacity estimates. The spatial juxtaposition of habitat features and the influence these features have on habitat selection by shorebirds are also a key uncertainty. This type of analysis will help the RWBJV understand the impacts of different biotic and abiotic features (e.g., wetland size, wetland density, wetland type, influence of disturbance features) on habitat selection. Such information will help the RWBJV develop tools to guide conservation delivery to those landscapes that have the greatest potential to positively influence priority shorebirds.

Breeding Shorebirds

Breeding shorebird distribution and abundance across the RWBJV Administrative Area, especially in the Sandhills, have been documented; however, our understanding of local landscape features that influence habitat selection by shorebirds needs to be refined. This will require the RWBJV to initiate statistically valid, spatially balanced surveys. In the Sandhills, access to grasslands and wetlands will be challenging, due to the limited number of roads and over 97% private ownership. Multiple-year sampling will be required, to account for temporal variability.

Research and monitoring should determine the trends of breeding shorebirds in the Sandhills. If negative trends are detected, then research should be implemented to determine the proximal cause of the declines. Research may also be needed to guide management actions that increase shorebird recruitment in the Sandhills. Because livestock grazing is the primary land use within the Sandhills, a greater understanding of different grazing systems and their effects on shorebird recruitment and beef production is needed. By understanding how various grazing systems impact the profit margin of beef production, conservation programs can be developed to encourage grazing systems that benefit shorebirds as well as the ranching community.

Summary

The RWBJV Administrative Area has an abundance of wetlands and grasslands that provide habitat for both non-breeding and breeding shorebirds. These habitats support a significant proportion of the continent's shorebirds during a portion of their annual life cycle. For non-breeding shorebirds, on-the-ground conservation by the RWBJV will be focused in the RWB. Conservation delivery to benefit breeding shorebirds will be focused in the Sandhills. The

RWBJV will work with the conservation partners to delineate suitable habitat along the major rivers. In addition, the RWBJV will develop geospatial tools to guide conservation delivery to restore and maintain suitable nesting habitat along high-priority riverine systems (e.g., central Platte River, Loup rivers, Niobrara River) for the federally listed Piping Plover.

Future monitoring and research will be developed to help identify those landscapes that have the greatest potential to positively influence shorebirds. With 97% of Nebraska's lands in private ownership, conservation delivery will need to align with agriculture land uses. In the Sandhills, projects will have to complement cattle production, while in the other regions the RWBJV will have to strike a balance with row-crop production and cattle production. All conservation programs will be developed on a voluntary basis with willing participants. The RWBJV will support research and monitoring activities to address key uncertainties and validate current planning assumptions. Future priority research and monitoring projects include validation of shorebird-use estimates in both the RWB and RWBJV Administrative Area, and determining invertebrate abundance under different types of management and ownership. In the Sandhills, research and monitoring will focus on habitat selection by breeding shorebirds. Along major river systems such as the central Platte River, research and monitoring will focus on habitat availability (i.e., riverine sandbar habitat for the federally threatened Piping Plover), habitat selection, and use by both breeding and non-breeding shorebirds.

Appendix A

Energetic Requirements of Shorebirds Using the RWBJV Administrative Area

Much of the RWBJV Shorebird Plan is based on the "Cross Seasonal Effects" hypothesis (Krapu 1981). The hypothesis suggests that sufficient habitat conditions at mid-latitude staging areas are necessary to allow individual birds to acquire sufficient nutrient reserves to complete migration, initiate nesting, and produce viable offspring. Migration is energetically expensive, and staging areas such as the RWBJV Administrative Area provide key opportunities for birds to refuel before reaching the breeding grounds (Skagen 1997, Skagen et al. 1999). Although the RWBJV Administrative Area is primarily a mid-latitude staging area for many shorebird species, a large number of Killdeer, Piping Plovers, Upland Sandpipers, Long-billed Curlews, Spotted Sandpipers, American Avocets, Willets, and Wilson's Phalaropes also breed in this region.

To determine the invertebrate foraging resources that should be available during non-breeding and breeding phases of the annual life cycle for shorebirds, species-specific energetic needs were determined. The quantity of energetic resources necessary to support populations depends on the number of individuals of each species that use the area during both the non-breeding and breeding phases of the annual life cycle, average number of days the individuals spend in the area during each part of their life cycle, and daily energetic requirements of each species.

Population Objectives for the RWBJV Administrative Area

In 2008, the United States Geological Survey (USGS) developed a regional assessment protocol to estimate shorebird use of BCRs 18 and 19. This project was developed to better understand shorebird use throughout the Great Plains Landscape Conservation Cooperative (S. K. Skagen, USGS, personal comm.). The project was important due to its temporal and geographic scale. The study integrated Geographic Information System (GIS) technology to characterize landscape-scale distribution of wetlands and grasslands at the township scale. Previous research suggested that the distribution of habitat features, at the landscape scale, influences habitat selection by waterbirds (Naugle et al. 2000) and shorebirds (Webb et al. 2010). Four strata were developed to characterize the townships in the RWBJV Administrative Area: 1) high-density grassland with high wetland density, 2) high-density grassland with low wetland density, 3) low-density grassland with high wetland density, and 4) low-density grassland with low wetland density. A stratified random sample of townships was selected from each of the four landscape strata to capture the range of landscape conditions. Between 15 April and 30 May 2008, 2-3 surveys were completed along 18 one-mile road segments distributed throughout the selected townships in the RWBJV Administrative Area.

Additional sampling was completed across the RWBJV Administrative Area at sites where high shorebird use had been documented. Shorebird counts from randomly selected townships were adjusted for sampling intensity and detection probability and extrapolated to the landscape stratum from which they were drawn. This design allowed the data to be analyzed to describe species-specific use in the RWBJV Administrative Area and at finer scale for regions with high shorebird density, such as the RWB (S. K. Skagen, USGS, personal comm.).

In total, 24 species of shorebirds were identified during these surveys (Table A-1). For a few species, the survey estimates were not consistent with recently published literature. In these cases, the published literature was used to modify estimated use in the RWBJV Administrative Area. Literature referenced as part of this planning process included: Jorgensen 2004, Jorgensen 2008, Jorgensen et al. 2008, Elliott-Smith et al. 2009, Jorgensen et al. 2009, Sauer et al. 2011, and Gregory et al. 2012.

Table A-1. National population estimates and population objectives for species with measurable populations within the RWBJV Administrative Area.

Species	Population Estimate (Morrison et al. 2006)	Population Objective (Brown et al. 2001)	Planning Ratio
Agri-probers and Upland Associates			
American Golden-Plover	200,000	300,000	1.50
Killdeer	1,000,000	2,440,000	2.44
Upland Sandpiper	350,000	470,000	1.34
Long-billed Curlew	55,000 - 123,500	28,500	1.00
Buff-breasted Sandpiper	30,000	150,000	5.00
Small-bodied Probers/Gleaners			
Semipalmated Plover	150,000	150,000	1.00
Black-bellied Plover	150,000	272,200	1.81
Piping Plover	2,953	6,000	2.03
Spotted Sandpiper	150,000	150,000	1.00
Semipalmated Sandpiper	2,000,000	8,200,000	4.10
Least Sandpiper	700,000	1,400,000	2.00
White-rumped Sandpiper	1,120,000	400,000	1.00
Baird's Sandpiper	300,000	300,000	1.00
Pectoral Sandpiper	500,000	400,000	1.00
Large-bodied Probers			
American Avocet	450,000	450,000	1.00
Greater Yellowlegs	100,000	100,000	1.00
Lesser Yellowlegs	400,000	2,400,000	6.00
Solitary Sandpiper	100,000	21,000	1.00
Willet	160,000	160,000	1.00
Hudsonian Godwit	70,000	70,000	1.00
Stilt Sandpiper	820,000	200,000	1.00
Long-billed Dowitcher	400,000	500,000	1.25
Wilson's Snipe	2,000,000	4,345,000	2.17
Swimmers			
Wilson's Phalarope	1,500,000	2,800,000	1.87

The Rainwater Basin Joint Venture partners completed species-specific assessments to evaluate current national population estimates (Morrison et al. 2006) against national population objectives (Brown et al. 2001). These assessments provided a "Planning Ratio" or the relative increase required over current population numbers to meet population objectives. For species that are at or above population objectives outlined in the USSCP, the planning ratio was set to "one," with a goal to maintain these species at the current population levels.

Shorebird Planning Ratio = Shorebird Plan species goal (Brown et al. 2001) / Current population estimate (Morrison et al. 2006)

The RWBJV recognizes that many of the planning species are not at goal levels described in the USSCP. The goals outlined in the RWBJV Shorebird Plan describe habitat that will be necessary to support shorebirds at target levels.

Non-Breeding Shorebird Population Objectives

The wetland and upland habitats found in the RWBJV Administrative Area provide both non-breeding migratory and breeding habitats. At different physiological periods of the annual life cycle (non-breeding vs. breeding), species have different nutritional and caloric (energy) requirements. To develop planning objectives for breeding and migrating shorebirds, an "en-route ratio*"* was created. This ratio estimates the proportion of individuals that migrate through the RWBJV Administrative Area compared to the proportion of individuals that remain and nest in the RWBJV Administrative Area. The en-route ratios were established by species experts, based on range maps, migration chronology, and professional experience (J. Jorgensen, NGPC, personal comm., S. K. Skagen, USGS, personal comm., Skagen et al. 1999).

To estimate a non-breeding migratory population target for the RWBJV landscape the "***contemporary species-specific estimates****"* (Table A-2; S.K. Skagen, USGS, personal comm.) were multiplied by the "***planning ratio****"* (population growth needed to meet USSCP objectives) and by the "***en-route ratio***" (proportion of species that are using the region as a migratory stopover site). This approach allowed the Rainwater Basin Joint Venture partners to evaluate current migratory shorebird use, estimate species-specific use at goal levels, and account for the estimated number of individuals that are migrating through the RWBJV Administrative Area landscape. The RWBJV's non-breeding (migratory) objectives were based on the following equation:

Non-breeding Population Goals = Shorebird Estimates * Shorebird Planning Ratio * En-Route Ratio

Breeding Shorebird Population Objectives

To estimate species-specific breeding (nesting) population objectives for the RWBJV Administrative Area the "***contemporary species-specific estimates****"* (Table A-2; S.K. Skagen, USGS, personal comm.) were multiplied by the "***planning ratio****"* (population growth needed to attain USSCP objectives) and finally by **"*one minus the en-route ratio*"** (the proportion of the species that are *not* migrating through this region, but rather are nesting in the RWBJV Administrative Area). This approach allowed the RWBJV to estimate current numbers of breeding shorebirds by species. The RWBJV Shorebird Plan breeding (nesting) objectives were based on the following equation:

Breeding Population Goals = Shorebird Estimates * Shorebird Planning Ratio * (1 – En-Route Ratio)

Results from the directed research projects, en-route assessment, and planning ratio allowed the RWBJV to establish breeding population objectives for Killdeer, Upland Sandpipers, Long-billed Curlews, Spotted Sandpipers, American Avocets, Willets, and Wilson's Phalaropes. The goal of the RWBJV is to develop a landscape capable of providing sufficient wetland and upland habitats to support these priority breeding shorebirds at target population levels. Unfortunately, few research or monitoring projects have been undertaken to investigate species-specific habitat selection, species distribution, density dependence, and intra/interspecific competition factors influencing breeding shorebirds (see literature cited). As it becomes available, the RWBJV will integrate this information to guide future projects in order to implement practices in landscapes that have the greatest potential to achieve the desired conservation objectives.

The Piping Plover Recovery Plan outlined population objectives for the three river systems in the RWBJV Administrative Area: 1) the Niobrara River system, which should support 100 adults (50 breeding pairs), 2) 50 adults (25 breeding pairs) dispersed along the Loup rivers, and 3) a Platte River system that supports 280 adults (140 breeding pairs). A population estimate of 350 pairs (700 individuals) was established for the Missouri River, however the Missouri River population objective is tracked as a South Dakota objective. In all, the RWBJV Administrative Area needs to support 215 pairs (430 individuals), or 17% of the Great Plains population.

Meeting the bioenergetic needs of shorebirds is an important component of shorebird management. Knowing the energetic needs and feeding habitats of different shorebird species would help direct conservation and management actions. Few research or monitoring projects have been completed to understand individual species' habitat selection, distribution, density dependence, and intra/interspecific competition of breeding populations.

Knowing that this information is lacking, the Joint Venture has made the assumption that shorebirds of each foraging guild use similar habitats and select for the same resources (invertebrates).

A bioenergetics model was developed to quantify energetic needs and evaluate the landscape's ability to support the necessary forage. The foundation of the model is the species-specific Basal Metabolic Rate (BMR). The BMR is the energy (kcals) required for normal cellular function and replacement of worn body tissue; thus BMR is directly related to body mass (Baldassarre and Bolen 1994). Kendeigh et al. (1977) computed the BMR equation for non-passerine birds (all seasons) to be:

$$BMR\ (kcals) = 0.5224*(Mass\ (g))^{0.7347}$$

Energetic Estimates of Non-breeding Shorebirds

To determine the energetic requirements of non-breeding migrating shorebirds, two separate calculations were completed:

1. Total Daily Energetic Expenditure (DEE), or total kcals necessary to sustain daily energetic requirements of migrating shorebirds completing their normal physiological processes and behavioral activities (flying, foraging, resting) during residency in the RWBJV Administrative Area.

2. The cost of lipid acquisition, or the energy needed for migrating shorebirds to acquire 20% more lipid reserves while in the RWBJV Administrative Area. This amount represents an estimate of what is needed to continue migration and initiate nesting on the breeding grounds.

Table A-2. RWBJV Administrative Area shorebird estimates and population objectives.

Species	Planning Ratio	En-Route Ratio	Shorebird Estimates RWBJV Admin Area	Non-Breeding Population Objectives	Breeding Population Objectives	RWBJV Admin. Area Population @ Goal
Agri-probers and Upland Associates						
American Golden-Plover	1.50	1	800[f]	1,200	-	1,200 [a]
Killdeer	2.44	0.5	100,000[a,h]	122,000	122,000 [a]	244,000 [a]
Upland Sandpiper	1.34	0.8	58,628[k]	62,983	15,746 [a]	78,729 [a]
Long-billed Curlew	1.00	0	22,474[d]	-	22,474 [a]	22,474 [a]
Buff-breasted Sandpiper	5.00	1	43,300[g]	216,500	-	216,500 [a]
Small-bodied Probers/Gleaners						
Semipalmated Plover	1.00	1	229[k]	229	-	229 [a]
Black-bellied Plover	1.81	1	220[e]	398	-	398 [a]
Piping Plover	2.03	0.5	232[c]	232	430 [a]	662 [a]
Spotted Sandpiper	1.00	0.5	1,031[k]	516	516 [a]	1,031 [a]
Semipalmated Sandpiper	4.10	1	22,219[k]	91,098	-	91,098 [a]
Least Sandpiper	2.00	1	17,513[k]	35,026	-	35,026 [a]
White-rumped Sandpiper	1.00	1	20,071 [k]	20,071	-	20,071 [a]
Baird's Sandpiper	1.00	1	61,512[i,j]	61,512	-	61,512 [a]
Pectoral Sandpiper	1.00	1	15,664[k]	15,664	-	15,664 [a]
Large-bodied Probers						
American Avocet	1.00	0	5,000[b]	-	5,000 [a]	5,000 [a]
Greater Yellowlegs	1.00	1	2,053[k]	2,053	-	2,053 [a]
Lesser Yellowlegs	6.00	1	15,450[k]	92,700	-	92,700 [a]
Solitary Sandpiper	1.00	1	9,036[k]	9,036	-	9,036 [a]
Willet	1.00	0.8	20,000[j]	16,000	4,000 [a]	20,000 [a]
Hudsonian Godwit	1.00	1	172[e]	172	-	172 [a]
Stilt Sandpiper	1.00	1	2,992[k]	2,992	-	2,992 [a]
Long-billed Dowitcher	1.25	1	19,838[k]	24,798	-	24,798 [a]
Wilson's Snipe	2.17	1	15,847[k]	34,428	-	34,428 [a]
Swimmers						
Wilson's Phalarope	1.87	0.9	1,291,397[k]	2,173,421	241,490 [a]	2,414,912 [a]
Totals			**1,746,355**	**2,983,028**	**411,657**	**3,394,685**

[a] Population goal was derived by multiplying the shorebird estimate by the planning ratio and 1 - proportion en route to correct for shorebird estimates established during the breeding season
[b] Derived from BBS summer distribution map 2006-2010. Sauer et al. 2011
[c] Elliott-Smith et al. 2009
[d] Gregory et al. 2012
[e] Jorgensen 2004
[f] Jorgensen 2008
[g] Jorgensen et al. 2008
[h] Jorgensen et al. 2009
[i] McCarty et al. 2010.
[j] Nebraska Game and Parks Commission, Joel Jorgensen pers comm.
[k] S. K. Skagen, USGS, personal comm. 2008

Table A-3. Body mass, basal metabolic rate, and daily energetic expenditure of non-breeding shorebirds using the RWBJV Administrative Area during spring migration.

Species	Average Body Mass (g)	Basal Metabolic Rate (kcals)	Daily Energy Expenditure (kcal/day)
Agri-probers and Upland Associates			
American Golden-Plover	133.0	19.0	57.0
Killdeer	95.0	14.8	44.5
Upland Sandpiper	170.5	22.8	68.4
Long-billed Curlew	643.1	60.4	181.3
Buff-breasted Sandpiper	75.0	12.5	37.4
Small-bodied Probers/Gleaners			
Semipalmated Plover	47.0	8.8	26.5
Black-bellied Plover	219.0	27.4	82.2
Piping Plover	53.0	9.7	29.0
Spotted Sandpiper	37.0	7.4	22.2
Semipalmated Sandpiper	27.0	5.9	17.7
Least Sandpiper	24.0	5.4	16.2
White-rumped Sandpiper	44.6	8.5	25.5
Baird's Sandpiper	38.0	7.6	22.7
Pectoral Sandpiper	75.9	12.6	37.7
Large-bodied Probers			
American Avocet	322.9	36.4	109.3
Greater Yellowlegs	170.0	22.7	68.2
Lesser Yellowlegs	84.0	13.5	40.6
Solitary Sandpiper	48.0	9.0	26.9
Willet	270.4	32.0	95.9
Hudsonian Godwit	235.0	28.8	86.5
Stilt Sandpiper	57.4	10.2	30.7
Long-billed Dowitcher	115.0	17.1	51.2
Wilson's Snipe	102.5	15.7	47.0
Swimmers			
Wilson’s Phalarope	62.1	10.8	32.5

Daily Energetic Expenditure

Daily Energy Expenditure (DEE) for each species was calculated by multiplying the respective species’ BMR by three (Table A-3). This followed the methods used for waterfowl and Sandhill Cranes (Prince 1979, Miller and Eadie 2006, Pearse et al. 2011).

Total DEE for non-breeding shorebirds was calculated by multiplying the non-breeding population objectives (Table A-2) by the DEE (Table A-3) by the average residency time which, for all but one species, is estimated to be seven days (Skagen et al. 1997 and S.K. Skagen, USGS, personal comm.). The results are shown in Table A-4.

Table A-4. Daily and total residency energetic expenditure of non-breeding migratory shorebirds using the RWBJV Administrative Area during spring migration.

Species	Non-breeding Population Objective	Daily Energy Expenditure (kcal/day)	Average Residency Time (days)	Total DEE while in RWBJV Administrative Area (kcals)
Agri-probers and Upland Associates				
American Golden-Plover	1,200	57.0	7 [a]	478,407
Killdeer	122,000	44.5	7 [a]	37,985,323
Upland Sandpiper	62,983	68.4	7 [a]	30,136,669
Buff-breasted Sandpiper	216,500	37.4	2 [b]	16,188,993
Small-bodied Probers/Gleaners				
Semipalmated Plover	229	26.5	7 [a]	42,482
Black-bellied Plover	398	82.2	7 [a]	229,009
Piping Plover	232	29.0	7 [a]	47,047
Spotted Sandpiper	516	22.2	7 [a]	80,358
Semipalmated Sandpiper	91,098	17.7	7 [a]	11,255,215
Least Sandpiper	35,026	16.2	7 [a]	3,968,754
White-rumped Sandpiper	20,071	25.5	7 [a]	3,582,613
Baird's Sandpiper	61,512	22.7	7 [a]	9,768,982
Pectoral Sandpiper	15,664	37.7	7 [a]	4,135,602
Large-bodied Probers				
Greater Yellowlegs	2,053	68.2	7 [a]	980,217
Lesser Yellowlegs	92,700	40.6	7 [a]	26,367,575
Solitary Sandpiper	9,036	26.9	7 [a]	1,703,753
Willet	16,000	95.9	7 [a]	10,741,842
Hudsonian Godwit	172	86.5	7 [a]	104,146
Stilt Sandpiper	2,992	30.7	7 [a]	642,952
Long-billed Dowitcher	24,798	51.2	7 [a]	8,884,338
Wilson's Snipe	34,428	47.0	7 [a]	11,334,650
Swimmers				
Wilson's Phalarope	2,173,421	32.5	7 [a]	495,165,925
Total	**2,983,028**			**673,824,853**

[a] Based on Skagen et al. 1997 and S.K. Skagen USGS personal comm.
[b] McCarty et al. 2010

The RWBJV set a benchmark of providing sufficient forage resources to provide for DEE plus a 20% increase in lipid reserves for migrating shorebirds at the non-breeding target populations (Table A-5).

The body mass of each species was multiplied by 20% to get an estimate of the grams of lipids that an "average" individual would gain while in the RWBJV Administrative Area. Based on

work by Pearse et al. (2011), Walsberg (1983), and Kendeigh et al. (1977), the cost of lipid production was set at 12.7 kcal/g.

Lipid Acquisition Cost = 20% Lipid Acquisition (g) * Lipid Production Cost (12.7 kcal/g)

Table A-5. Energy required to increase lipid reserves by 20% for migratory shorebirds using the RWBJV Administrative Area during spring migration.

Species	Average Body Mass (g)	20% Lipid Acquisition (g)	Lipid Acquisition Cost (kcals)
Agri-probers and Upland Associates			
American Golden-Plover	133.0	26.6	337.8
Killdeer	95.0	19.0	241.3
Upland Sandpiper	170.5	34.1	433.1
Long-billed Curlew	643.1	128.6	1,633.5
Buff-breasted Sandpiper	75.0	15.0	190.5
Small-bodied Probers/Gleaners			
Semipalmated Plover	47.0	9.4	119.3
Black-bellied Plover	219.0	43.8	556.3
Piping Plover	53.0	10.6	134.6
Spotted Sandpiper	37.0	7.4	94.0
Semipalmated Sandpiper	27.0	5.4	68.6
Least Sandpiper	24.0	4.8	61.0
White-rumped Sandpiper	44.6	8.9	113.2
Baird's Sandpiper	38.0	7.6	96.5
Pectoral Sandpiper	75.9	15.2	192.8
Large-bodied Probers			
American Avocet	322.9	64.6	820.0
Greater Yellowlegs	170.0	34.0	431.8
Lesser Yellowlegs	84.0	16.8	213.4
Solitary Sandpiper	48.0	9.6	121.9
Willet	270.4	54.1	686.7
Hudsonian Godwit	235.0	47.0	596.9
Stilt Sandpiper	57.4	11.5	145.7
Long-billed Dowitcher	115.0	23.0	292.1
Wilson's Snipe	102.5	20.5	260.4
Swimmers			
Wilson’s Phalarope	62.1	12.4	157.7

Species-specific estimates of the total energy needed for lipid production (20% of body mass) were obtained by multiplying the population objectives (Table A-2) by the cost of lipid acquisition (Table A-5). These results are presented in Table A-6.

The total energetic needs of non-breeding migratory shorebirds while in the RWBJV Administrative Area, at target populations, were calculated by adding the Total DEE to the Total Energy Cost of Lipid Production (Table A-7).

Table A-6. Total energy needs of non-breeding migratory shorebirds using the RWBJV Administrative Area during spring migration to acquire 20% additional lipid reserves.

Species	Non-breeding Population Objective	Lipid Acquisition Cost (kcals)	Total Energy Cost of Lipid Production (kcals)
Agri-probers and Upland Associates			
American Golden-Plover	1,200	337.8	405,384
Killdeer	122,000	241.3	29,438,600
Upland Sandpiper	62,983	433.1	27,276,144
Buff-breasted Sandpiper	216,500	190.5	41,243,250
Small-bodied Probers/Gleaners			
Semipalmated Plover	229	119.3	27,309
Black-bellied Plover	398	556.3	221,407
Piping Plover	232	134.6	31,232
Spotted Sandpiper	516	94.0	48,494
Semipalmated Sandpiper	91,098	68.6	6,247,494
Least Sandpiper	35,026	61.0	2,135,185
White-rumped Sandpiper	20,071	113.2	2,271,174
Baird's Sandpiper	61,512	96.5	5,937,138
Pectoral Sandpiper	15,664	192.8	3,019,800
Large-bodied Probers			
Greater Yellowlegs	2,053	431.8	886,485
Lesser Yellowlegs	92,700	213.4	19,778,472
Solitary Sandpiper	9,036	121.9	1,101,669
Willet	16,000	686.7	10,987,024
Hudsonian Godwit	172	596.9	102,667
Stilt Sandpiper	2,992	145.7	435,842
Long-billed Dowitcher	24,798	292.1	7,243,350
Wilson's Snipe	34,428	260.4	8,963,228
Swimmers			
Wilson's Phalarope	2,173,421	157.7	342,822,388
Total	**2,983,028**		**510,623,736**

Energetic Estimates of Breeding Shorebirds

Eight species of shorebirds breed within the RWBJV Administrative Area. The population targets range from estimates of 430 Piping Plovers to over 240,000 Wilson's Phalaropes. The RWBJV assumed that species breeding in the RWBJV Administrative Area were not acquiring additional lipid reserves, but were maintaining body condition throughout the breeding season.

Total energetic needs for breeding shorebirds using the RWBJV Administrative Area were calculated by multiplying breeding population objectives by the species-specific DEE (Table A-3) by average residency time (Table A-8).

Total Shorebird Energetic Needs in the RWBJV Administrative Area

Based on this bioenergetics model, non-breeding shorebirds need approximately 1.2 billion kcals, while breeding shorebirds using the RWBJV Administrative Area need nearly 892 million kcals during residency in the RWBJV Administrative Area. Expressed by foraging guild, Agri-probers and Upland Associates need 669.7 million kcals, Small-bodied Probers/Gleaners need 54.1 million kcals, Large-bodied Probers need 153.0 million kcals, and Swimmers need approximately 1.2 billion kcals (Table A-9).

Table A-7. Total energetic needs of non-breeding shorebirds using the RWBJV Administrative Area at population targets.

Species	Total DEE while in RWBJV Administrative Area	Total Energy Cost for Lipid Production (kcals)	Total Energy Requirements of Non-breeding Shorebirds
Agri-probers and Upland Associates			
American Golden-Plover	478,407	405,384	883,791
Killdeer	37,985,323	29,438,600	67,423,923
Upland Sandpiper	30,136,669	27,276,144	57,412,813
Buff-breasted Sandpiper	16,188,993	41,243,250	57,432,243
Small-bodied Probers/Gleaners			
Semipalmated Plover	42,482	27,309	69,791
Black-bellied Plover	229,009	221,407	450,417
Piping Plover	47,047	31,232	78,279
Spotted Sandpiper	80,358	48,494	128,852
Semipalmated Sandpiper	11,255,215	6,247,494	17,502,709
Least Sandpiper	3,968,754	2,135,185	6,103,939
White-rumped Sandpiper	3,582,613	2,271,174	5,853,787
Baird's Sandpiper	9,768,982	5,937,138	15,706,120
Pectoral Sandpiper	4,135,602	3,019,800	7,155,402
Large-bodied Probers			
Greater Yellowlegs	980,217	886,485	1,866,702
Lesser Yellowlegs	26,367,575	19,778,472	46,146,047
Solitary Sandpiper	1,703,753	1,101,669	2,805,422
Willet	10,741,842	10,987,024	21,728,866
Hudsonian Godwit	104,146	102,667	206,813
Stilt Sandpiper	642,952	435,842	1,078,794
Long-billed Dowitcher	8,884,338	7,243,350	16,127,688
Wilson's Snipe	11,334,650	8,963,228	20,297,878
Swimmers			
Wilson’s Phalarope	495,165,925	342,822,388	837,988,313
Total	**673,824,853**	**510,623,763**	**1,184,448,589**

Table A-8. Daily and total energetic requirements for breeding shorebirds in the RWBJV Administrative Area.

Species	Breeding Population Objective	Daily Energy Expenditure (kcal/day)	Average Residency Time (days)	Total Energy Requirements of Breeding Shorebirds(kcals)
Agri-probers and Upland Associates				
Killdeer	122,000	44.5	46	249,617,838
Upland Sandpiper	15,746	68.4	46	49,510,242
Long-billed Curlew	22,474	181.3	46	187,415,218
Small-bodied Probers/Gleaners				
Piping Plover	430	29.0	46	573,028
Spotted Sandpiper	516	22.2	46	528,068
Large-bodied Probers				
American Avocet	5,000	109.3	46	25,131,311
Willet	4,000	95.9	46	17,647,312
Swimmers				
Wilson's Phalarope	241,491	32.5	46	361,549,365
Total	**411,657**			**891,972,382**

Table A-9. Total annual energetic needs (kcals) of breeding and non-breeding shorebirds using the RWBJV Administrative Area.

Species	Total Energy Requirements of Non-breeding Shorebirds (kcals)	Total Energy Requirements of Breeding Shorebirds (kcals)	Total Annual Energetic Requirements (kcals)
Agri-probers and Upland Associates			
American Golden-Plover	883,791	-	883,791
Killdeer	67,423,923	249,617,838	317,041,762
Upland Sandpiper	57,412,813	49,510,242	106,923,055
Long-billed Curlew	-	187,415,218	187,415,218
Buff-breasted Sandpiper	57,432,243	-	57,432,243
Small-bodied Probers/Gleaners			
Semipalmated Plover	69,791	-	69,791
Black-bellied Plover	450,417	-	450,417
Piping Plover	78,279	573,028	651,308
Spotted Sandpiper	128,852	528,068	656,920
Semipalmated Sandpiper	17,502,709	-	17,502,709
Least Sandpiper	6,103,939	-	6,103,939
White-rumped Sandpiper	5,853,787	-	5,853,787
Baird's Sandpiper	15,706,120	-	15,706,120
Pectoral Sandpiper	7,155,402	-	7,155,402
Large-bodied Probers			
American Avocet	-	25,131,311	25,131,311
Greater Yellowlegs	1,866,702	-	1,866,702
Lesser Yellowlegs	46,146,047	-	46,146,047
Solitary Sandpiper	2,805,422	-	2,805,422
Willet	21,728,866	17,647,312	39,376,177
Hudsonain Godwit	206,813	-	206,813
Stilt Sandpiper	1,078,794	-	1,078,794
Long-billed Dowitcher	16,127,688	-	16,127,688
Wilson's Snipe	20,297,878	-	20,297,878
Swimmers			
Wilson’s Phalarope	837,988,313	361,549,365	1,199,537,678
Total	**1,184,448,589**	**891,972,382**	**2,076,420,971**

Appendix B

Energetic Requirements of Shorebirds Using the Rainwater Basin Wetland Complex

Much of the RWBJV Shorebird Plan is based on the "Cross Seasonal Effects" hypothesis (Krapu 1981). The hypothesis suggests that sufficient habitat conditions at mid-latitude staging areas are necessary to allow individual birds to acquire sufficient nutrient reserves to complete migration, initiate nesting, and produce viable offspring. Migration is energetically expensive and staging areas such as the RWB provide key opportunities to refuel before reaching the breeding grounds (Skagen 1997, Skagen et al. 1999). The shallow playa wetlands found in the RWB provide a foraging niche, especially for the Small-bodied Probers/Gleaners that forage in wetlands ≤5 cm deep and Large-bodied Probers that forage in wetlands with a water depth ≤16 cm.

To determine the invertebrate foraging resources necessary to support shorebirds during the non-breeding phase of their annual life cycle, species-specific energetic needs had to be determined. The quantity of energetic resources necessary to support each species depends on the number of individuals of each species that use the area, average number of days individuals spend in the area, lipid acquisition requirements, and daily energetic requirements.

Population Objectives for the Rainwater Basin Wetland Complex

As described, the USGS developed a regional shorebird monitoring protocol in 2008. Based on the survey design, the data could be analyzed to estimate shorebird use across the Great Plains Landscape Conservation Cooperative, across a BCR, or at more local sites, such as the RWB (S. K. Skagen, USGS, personal comm.).

In total, 20 species of shorebirds were identified during these surveys in the RWB (Table B-1). For a few species the survey estimates were not consistent with recently published literature. In these cases the published literature was used to modify estimated use. Literature referenced as part of this planning process included: Jorgensen 2008, Jorgensen et al. 2008, Jorgensen et al. 2009, Sauer et al. 2011, and Gregory et al. 2012.

As with the other elements of the RWBJV Shorebird Plan, species are grouped by foraging guild: 1) Agri-probers and Upland Associates, 2) Small-bodied Probers/Gleaners foraging in ≤5 cm of water, 3) Large-bodied Probers foraging in ≤16 cm of water, and 4) Swimmers foraging in the full range of water depths.

To establish population objectives for the RWB, consistent with the population objectives outlined in the USSCP, the RWBJV completed an assessment of the current national population estimates (Morrison et al. 2006) and national population objectives (Brown et al. 2001). This assessment provided a "Planning Ratio" or the relative increase in the current population necessary to meet population objectives. For species that are at or above population objectives outlined in the USSCP, the planning ratio was set to "one", with a goal to maintain these species at the current population levels.

Shorebird Planning Ratio = Shorebird Plan species goal (Brown et al. 2001) / Current population estimate (Morrison et al. 2006)

Table B-1. National population estimates and population objectives for species with measurable populations within the Rainwater Basin Wetland Complex.

Species	Population Estimate (Morrison et al. 2006)	Population Objective (Brown et al. 2001)	Planning Ratio
Agri-probers and Upland Associates			
American Golden-Plover	200,000	300,000	1.50
Killdeer	1,000,000	2,440,000	2.44
Upland Sandpiper	350,000	470,000	1.34
Buff-breasted Sandpiper	30,000	150,000	5.00
Small-bodied Probers/Gleaners			
Semipalmated Plover	150,000	150,000	1.00
Black-bellied Plover	150,000	272,200	1.81
Spotted Sandpiper	150,000	150,000	1.00
Semipalmated Sandpiper	2,000,000	8,200,000	4.10
White-rumped Sandpiper	1,120,000	400,000	1.00
Baird's Sandpiper	300,000	300,000	1.00
Pectoral Sandpiper	500,000	400,000	1.00
Western Sandpiper	3,500,000	3,500,000	1.00
Large-bodied Probers			
American Avocet	450,000	450,000	1.00
Greater Yellowlegs	100,000	100,000	1.00
Lesser Yellowlegs	400,000	2,400,000	6.00
Hudsonian Godwit	70,000	70,000	1.00
Willet	160,000	160,000	1.00
Stilt Sandpiper	820,000	200,000	1.00
Long-billed Dowitcher	400,000	500,000	1.25
Swimmers			
Wilson's Phalarope	1,500,000	2,800,000	1.87

Non-Breeding Migratory Population Targets

Due to the relatively low numbers of breeding shorebirds and quantity of suitable breeding shorebird habitat found in the RWB, the RWBJV focused on non-breeding population objectives. To estimate a non-breeding shorebird population objective, species-specific estimates derived from the 2008 shorebird survey estimates or research-driven benchmarks were multiplied by the shorebird planning ratio (Table B-2).

Table B-2. Rainwater Basin Wetland Complex shorebird estimates and population objectives.

Species	Planning Ratio	Contemporary RWB Shorebird Estimates	RWB Population Objectives @ Goal
Agri-probers and Upland Associates			
American Golden-Plover	1.50	10,188 [e]	15,282 [a]
Killdeer[a]	2.44	2,330 [f]	5,685 [a]
Upland Sandpiper	1.34	33 [c]	44 [a]
Buff-breasted Sandpiper	5.00	43,300 [d]	216,500 [a]
Small-bodied Probers/Gleaners			
Semipalmated Plover	1.00	229 [f]	229 [a]
Black-bellied Plover	1.81	220 [c]	398 [a]
Spotted Sandpiper	1.00	715 [f]	715 [a]
Semipalmated Sandpiper	4.10	14,325 [f]	58,733 [a]
White-rumped Sandpiper	1.00	18,710 [f]	18,710 [a]
Baird's Sandpiper	1.00	61,512 [e,f]	61,512 [a]
Pectoral Sandpiper	1.00	11,116 [f]	11,116 [a]
Western Sandpiper	1.00	7,361 [f]	7,361 [a]
Large-bodied Probers			
American Avocet	1.00	153 [c]	153 [a]
Greater Yellowlegs	1.00	2,053 [f]	2,053 [a]
Lesser Yellowlegs	6.00	15,092 [f]	90,552 [a]
Willet	1.00	490 [f]	490 [a]
Hudsonian Godwit	1.00	172 [c]	172 [a]
Stilt Sandpiper	1.00	2,992 [f]	2,992 [a]
Long-billed Dowitcher	1.25	19,847 [f]	24,809 [a]
Swimmers			
Wilson's Phalarope	1.9	42,405 [f]	79,297 [a]
Total		**253,243**	**596,803**

[a] Population goal was derived by multiplying the shorebird estimate by the planning ratio
[b] Derived from BBS summer distribution map 2006-2010. Sauer et al. 2011
[c] Jorgensen 2004
[d] Jorgensen 2008
[e] McCarty et al. 2010
[f] S. K. Skagen, USGS, personal comm. 2008

Estimating Energetic Needs of Shorebirds in the RWB Wetland Complex

Meeting the bioenergetic needs of shorebirds during migration is an important component of shorebird management. Knowing the energetic needs of shorebirds will help direct conservation and management actions. Few research or monitoring projects have been undertaken to investigate individual species' habitat selection, distribution, density dependence, and intra/interspecific competition of breeding populations.

Knowing that this information is lacking, the RWBJV has made the assumption that shorebirds of each foraging guild use similar habitats and select for the same resources (invertebrates).

The framework provided by the bioenergetics model allowed the RWBJV to quantify energetic needs of shorebirds by foraging guild and evaluate the landscape's ability to provide the necessary forage resources. The foundation of the model is the species-specific Basal Metabolic Rate (BMR). The BMR is the energy (kcals) required for normal cellular function and replacement of worn body tissue; thus BMR is directly related to body mass (Baldassarre and Bolen 1994). Kendeigh et al. (1977) computed the BMR equation for non-passerine birds (all seasons) to be:

$$\text{BMR (kcals)} = 0.5224*(\text{Mass (g)})^{0.7347}$$

Energetic Estimates of Non-breeding Shorebirds in the RWB Wetland Complex

To determine the necessary energetic requirements of non-breeding migrating shorebirds in the RWB, two separate calculations were completed:

1. Total Daily Energetic Expenditure (DEE), or total kcals necessary to sustain daily energetic requirements of migrating shorebirds completing their normal physiological processes and behavioral activities (flying, foraging, and/or resting) during residency in the RWB Wetland Complex.
2. The cost of lipid acquisition, or the energy needed for migrating shorebirds to acquire 20% more lipid reserves while in the RWB Wetland Complex. This amount represents an estimate of what is needed to continue migration and initiate nesting on the breeding grounds.

Daily Energetic Expenditure

Daily Energy Expenditure (DEE) for each species was calculated by multiplying the respective species' BMR by three (Table B-3). This followed the methods used for waterfowl and Sandhill Cranes (Prince 1979, Miller and Eadie 2006, Pearse et al. 2011).

Total DEE for shorebirds during residency in the RWB was calculated by multiplying the population objectives (Table B-2) by the DEE (Table B-3) by the average residency time, which, for all but one species, is estimated to be seven days (Table B-4).

Table B-3. Body mass, basal metabolic rate, and daily energetic expenditure of non-breeding shorebirds using the Rainwater Basin Wetland Complex during spring migration.

Species	Average Body Mass (g)	Basal Metabolic Rate (kcals)	Daily Energy Expenditure (kcal/day)
Agri-probers and Upland Associates			
American Golden-Plover	133.0	19.0	57.0
Killdeer	95.0	14.8	44.5
Upland Sandpiper	170.5	22.8	68.4
Buff-breasted Sandpiper	75.0	12.5	37.4
Small-bodied Probers/Gleaners			
Semipalmated Plover	47.0	8.8	26.5
Black-bellied Plover	219.0	27.4	82.2
Spotted Sandpiper	37.0	7.4	22.2
Semipalmated Sandpiper	27.0	5.9	17.7
White-rumped Sandpiper	44.6	8.5	25.5
Baird's Sandpiper	38.0	7.6	22.7
Pectoral Sandpiper	75.9	12.6	37.7
Western Sandpiper	28.5	6.1	18.4
Large-bodied Probers			
American Avocet	322.9	36.4	109.3
Greater Yellowlegs	170.0	22.7	68.2
Lesser Yellowlegs	84.0	13.5	40.6
Willet	270.4	32.0	95.9
Hudsonian Godwit	235.0	28.8	86.5
Stilt Sandpiper	57.4	10.2	30.7
Long-billed Dowitcher	115.0	17.1	51.2
Swimmers			
Wilson's Phalarope	62.1	10.8	32.5

Cost of Lipid Acquisition

The RWBJV set a benchmark of providing sufficient forage resources to provide for DEE plus a 20% increase in lipid reserves for migrating shorebirds at the non-breeding population objectives (Table B-5).

The body mass of each species was multiplied by 20% to get an estimate of the grams of lipids that an "average" individual would gain while in the RWB Wetland Complex. Based on work by Pearse et al. (2011), Walsberg (1983), and Kendeigh et al. (1977), the cost of lipid production was set at12.7 kcal/g (Table B-5).

Estimates of the total energy needed to acquire lipids equal to 20% of body mass were obtained by multiplying the population objectives (Table B-2) by the cost of lipid acquisition (Table B-5). The results are found in Table B-6.

The total energetic needs of non-breeding migratory shorebirds while in the RWB, at target populations, were calculated by adding the Total DEE to the Total Energy Cost for Lipid Production (Table B-7).

Table B-4. Total daily energetic expenditure for non-breeding shorebirds using the Rainwater Basin Wetland Complex during spring migration.

Species	RWB Population Objectives	Daily Energy Expenditure (kcal/day)	Average Residency Time (days)	Total DEE while in the RWB (kcals)
Agri-probers and Upland Associates				
American Golden-Plover	15,282	57.0	7 [a]	6,092,513
Killdeer	5,685	44.5	7 [a]	1,770,116
Upland Sandpiper	44	68.4	7 [a]	21,204
Buff-breasted Sandpiper	216,500	37.4	2 [b]	16,188,993
Small-bodied Probers/Gleaners				
Semipalmated Plover	229	26.5	7 [a]	42,482
Black-bellied Plover	398	82.2	7 [a]	229,007
Spotted Sandpiper	715	22.2	7 [a]	111,349
Semipalmated Sandpiper	58,733	17.7	7 [a]	7,256,445
White-rumped Sandpiper	18,710	25.5	7 [a]	3,339,679
Baird's Sandpiper	61,512	22.7	7 [a]	9,768,982
Pectoral Sandpiper	11,116	37.7	7 [a]	2,934,841
Western Sandpiper	7,361	18.4	7 [a]	946,311
Large-bodied Probers				
American Avocet	153	109.3	7 [a]	117,024
Greater Yellowlegs	2,053	68.2	7 [a]	980,217
Lesser Yellowlegs	90,552	40.6	7 [a]	25,757,598
Willet	490	95.9	7 [a]	328,969
Hudsonian Godwit	172	86.5	7 [a]	104,178
Stilt Sandpiper	2,992	30.7	7 [a]	642,952
Long-billed Dowitcher	24,809	51.2	7 [a]	8,888,368
Swimmers				
Wilson’s Phalarope	79,297	32.5	7 [a]	18,066,147
Total	**596,803**			**103,586,375**

[a] Based on Skagen et al. 1997 and S.K. Skagen, USGS, personal comm.
[b] McCarty et al. 2010

Table B-5. Specific energetic requirement to increase lipid reserves by 20% for an individual shorebird.

Species	Average Body Mass (g)	20% Lipid Acquisition (g)	Lipid Acquisition Cost (kcals)
Agri-probers and Upland Associates			
American Golden-Plover	133.0	26.6	337.8
Killdeer	95.0	19.0	241.3
Upland Sandpiper	170.5	34.1	433.1
Buff-breasted Sandpiper	75.0	15.0	190.5
Small-bodied Probers/Gleaners			
Semipalmated Plover	47.0	9.4	119.3
Black-bellied Plover	219	43.8	556.3
Spotted Sandpiper	37.0	7.4	94.0
Semipalmated Sandpiper	27.0	5.4	68.6
White-rumped Sandpiper	44.6	8.9	113.2
Baird's Sandpiper	38.0	7.6	96.5
Pectoral Sandpiper	75.9	15.2	192.8
Western Sandpiper	28.5	5.7	72.4
Large-bodied Probers			
American Avocet	322.9	64.6	820.0
Greater Yellowlegs	170.0	34.0	431.8
Lesser Yellowlegs	84.0	16.8	213.4
Willet	270.4	54.1	686.7
Hudsonian Godwit	235.0	47.0	596.9
Stilt Sandpiper	57.4	11.5	145.7
Long-billed Dowitcher	115.0	23.0	292.1
Swimmers			
Wilson’s Phalarope	62.1	12.4	157.7

Table B-6. Energy needs of non-breeding migratory shorebirds using the Rainwater Basin Wetland Complex during spring migration to acquire 20% additional lipid reserves.

Species	RWB Population Objectives	Lipid Acquisition Cost (kcals/individual)	Total Energy Cost of Lipid Production (kcals)
Agri-probers and Upland Associates			
American Golden-Plover	15,282	337.8	5,162,565
Killdeer	5,685	241.3	1,371,839
Upland Sandpiper	44	433.1	19,191
Buff-breasted Sandpiper	216,500	190.5	41,243,250
Small-bodied Probers/Gleaners			
Semipalmated Plover	229	119.3	27,309
Black-bellied Plover	398	556.3	221,519
Spotted Sandpiper	715	94.0	67,196
Semipalmated Sandpiper	58,733	68.6	4,027,875
White-rumped Sandpiper	18,710	113.2	2,117,167
Baird's Sandpiper	61,512	96.5	5,937,138
Pectoral Sandpiper	11,116	192.8	2,143,009
Western Sandpiper	7,361	72.4	532,863
Large-bodied Probers			
American Avocet	153	820	125,466
Greater Yellowlegs	2,053	431.8	886,485
Lesser Yellowlegs	90,552	213.4	19,320,175
Willet	490	686.7	336,478
Hudsonian Godwit	172	596.9	102,667
Stilt Sandpiper	2,992	145.7	435,842
Long-billed Dowitcher	24,809	292.1	7,246,636
Swimmers			
Wilson’s Phalarope	79,297	157.7	12,507,888
Total	**596,803**		**103,832,557**

Table B-7. Total energetic needs of non-breeding shorebirds using the Rainwater Basin Wetland Complex.

Species	Total DEE while in RWB (kcals)	Total Energy Cost for Lipid Production (kcals)	Total Energy Requirements of Non-breeding Shorebirds
Agri-probers and Upland Associates			
American Golden-Plover	6,092,153	5,162,565	11,255,078
Killdeer	1,770,116	1,371,839	3,141,955
Upland Sandpiper	21,204	19,191	40,395
Buff-breasted Sandpiper	16,188,993	41,243,250	57,432,243
Small-bodied Probers/Gleaners			
Semipalmated Plover	42,482	27,309	69,791
Black-bellied Plover	229,007	221,519	450,525
Spotted Sandpiper	111,349	67,196	178,545
Semipalmated Sandpiper	7,256,445	4,027,875	11,284,320
White-rumped Sandpiper	3,339,679	2,117,167	5,456,846
Baird's Sandpiper	9,768,982	5,973,138	15,706,120
Pectoral Sandpiper	2,934,841	2,143,009	5,077,851
Western Sandpiper	946,311	532,863	1,479,174
Large-bodied Probers			
American Avocet	117,024	125,466	242,490
Greater Yellowlegs	980,217	886,485	1,866,702
Lesser Yellowlegs	25,756,598	19,320,175	45,076,773
Willet	328,969	336,478	665,447
Hudsonian Godwit	104,178	102,667	206,844
Stilt Sandpiper	642,952	435,842	1,078,794
Long-billed Dowitcher	8,888,368	7,246,636	16,135,004
Swimmers			
Wilson’s Phalarope	18,066,147	12,507,888	30,574,035
Total	**103,586,375**	**103,832,557**	**207,418,932**

Appendix C

Assessing Habitat Availability for Shorebirds

Davis and Smith (1998), Skagen (1997), and others have documented that shorebirds demonstrate an opportunistic foraging strategy, consuming invertebrates based on availability, and demonstrating little preference for forage type. Invertebrates are the major food resource during the breeding and non-breeding portions of the annual life cycle. Principal insect families include midges, water beetles, and water boatmen. Other forage includes worms, leeches, and snails (Davis and Smith 1998).

Available Foraging Resources

Research completed across the High Plains has evaluated invertebrate abundance to better understand temporal availability and the impacts of land use, management actions, and landscape composition (Davis and Smith 1998, Riens 2009). Davis and Bidwell (2008) completed an assessment of the impacts of wetland management on invertebrate availability in the RWB during spring migration. Their research results suggest that on average, RWB wetlands provide 1.22 g/m^2 or approximately 4,934 g/acre of invertebrate biomass.

True Metabolizable Energy

For planning purposes, the gross energy content of invertebrate foraging resources available to shorebirds was based on True Metabolizable Energy (TME). TME is the amount of energy available from one gram (dry weight) of chironomids (midges). Cummins and Wuycheck (1971) established that one gram (dry weight) of chironomids has a gross energy content of 23.8 kJ or 5.68 kcal/g. Castro et al. (1989) found that the assimilation efficiency of birds feeding on invertebrates was 73%. Therefore, the Net Energy Content (NEC) for invertebrates would be 4.15 kcals/g (5.68 kcal/g * 0.73). This value is central to the bioenergetics model, as it allows the conversion of grams of invertebrates to be expressed as forage energy per acre.

NEC = Gross energy content * Assimilation efficiency

or

4.15 kcals/g = 5.68 kcal/g * 0.73

TME/acre = Invertebrate availability * NEC

or

20,476 kcal/acre = 4,934 g/acre * 4.15 kcal/g

Total metabolizable energy produced by RWB wetlands, if 100% of the invertebrates were consumed, would be 20,476 kcals/acre. The RWBJV chose to use a foraging efficiency level of 50% of available invertebrates, or 10,238 kcals/acre. The foraging efficiency estimate is based on professional opinions and needs to be validated through further research.

Habitat Needs by Foraging Guild

Based on total energetic needs, approximately 202,815 acres of suitable habitat is needed throughout the RWBJV Administrative Area (Table C-1), while the RWB Wetland Complex would need to provide 20,260 acres of available foraging habitat for shorebirds during the non-breeding phase of their annual life cycle (Table C-2).

Table C-1. Total wetland acres required to meet the energetic needs of breeding and non-breeding population targets of shorebirds using the RWBJV Administrative Area.

Species Guilds	Total Energetic Need (kcals)	Acres to Support Population Targets of Shorebirds
Agri-probers and Upland Associates	669,696,068	64,413
Small-bodied Probers/Gleaners	54,150,393	5,289
Large-bodied Probers	153,036,832	14,948
Swimmers	1,199,537,678	117,165
Total	**2,076,420,971**	**202,815**

To determine available foraging habitat in the RWBJV Administrative Area, GIS landcover data were analyzed. The RWBJV landcover was developed by integrating multiple data layers into a seamless landcover dataset. When data were not available to describe important foraging habitats, new data were created using a combination of remote sensing and photo interpretation (Bishop et al. 2009).

The RWBJV landcover describes 485,615 acres of wetlands capable of providing suitable foraging habitat for shorebirds. The RWBJV relied on a group of shorebird biologists and habitat managers to estimate the proportion of each wetland habitat type suitable for each of the different foraging guilds. The analysis integrated the results of the RWBJV's Annual Habitat Surveys (2004 – 2012), which document wetland function (ponded water and hydric vegetation) in the RWB, and habitat surveys of the Central Table Playa wetland complex (2009 – 2010). These assessments have provided insight into the distribution and abundance of wetland habitats available to shorebirds and other wetland-dependent species during temporally important periods.

Table C-2. Total wetland acres required to meet the energetic needs of non-breeding populations of shorebirds using the RWB Wetland Complex.

Species Guilds	Total Energetic Need (kcals)	Acres to Support Population Targets of Shorebirds
Agri-probers and Upland Associates	71,869,671	7,020
Small-bodied Probers/Gleaners	39,703,172	3,878
Large-bodied Probers	65,272,054	6,375
Swimmers	30,574,035	2,986
Total	**207,418,932**	**20,260**

Tables C-3 through C-5 list the various habitats and the associated acres considered suitable for shorebird use by foraging guild within the RWBJV Administrative Area, while tables C-6 through C-8 outline available habitat for non-breeding shorebirds in the RWB.

Based on the current landcover data (Bishop et al. 2009), the distribution and function of wetlands in the RWBJV Administrative Area (485,615 acres) should be sufficient to support shorebirds at population targets outlined in this plan. However, recent annual habitat surveys suggest that ponding duration and ponded acres in the RWB may be limited for Small-bodied Probers/Gleaners and for Large-bodied Probers during the non-breeding phase of their annual life cycle. The RWBJV has prioritized on-site wetland restoration and off-site watershed restoration activities to increase hydrologic function of the existing playa wetlands in the RWB, and at goal playa wetlands in the RWB should be capable of providing sufficient habitat to support shorebirds at levels consistent with the population objectives outlined in the USSCP.

The RWBJV will continue to evaluate available habitat conditions and species habitat requirements to refine habitat objectives and thus ensure that this landscape continues to provide sufficient habitat during critical periods to support shorebirds at desired population levels.

Table C-3. Estimated wetland habitat available for Small-bodied Probers/Gleaners within the RWBJV Administrative Area.

Habitat	RWBJV Administrative Area Wetland Acres	% of Wetland Habitats	% Suitable for Shorebird Use	RWBJV Administrative Area Suitable Habitat (Acres)
Playas	1,602.8	0.3	5.0	80.1
Sandhills wetlands	72,183.3	14.9	2.5	1,804.6
Rainwater Basins	679.2	0.1	5.0	34.0
CRP - Wetland	7,528.9	1.6	2.5	188.2
CRP - Playa	28.2	0.0	2.5	0.7
Sandhills lake	85,542.5	17.6	5.0	4,277.1
Pit	25,956.8	5.3	0.5	129.8
Reservoir	73,676.0	15.2	0.8	552.6
Stock pond	75,837.0	15.6	0.8	568.8
Farmed playa	10,708.1	2.2	12.5	1,338.5
Buffered playa	3,794.7	0.8	5.0	189.7
RWB farmed	11,895.9	2.4	12.5	1,487.0
RWB early successional vegetation	20,349.3	4.2	5.0	1,017.5
RWB late successional vegetation	10,990.5	2.3	0.0	0.0
Emergent marsh	80,537.3	16.6	5.0	4,026.9
Saline wetlands	4,303.8	0.9	7.5	322.8
Total	**485,614.5**			**16,018.2**

Table C-4. Estimated wetland habitat available for Large-bodied Probers within the RWBJV Administrative Area.

Habitat	RWBJV Administrative Area Wetland Acres	% of Wetland Habitats	% Suitable for Shorebird Use	RWBJV Administrative Area Suitable Habitat (Acres)
Playas	1,602.8	0.3	10.0	160.3
Sandhills wetlands	72,183.3	14.9	5.0	3,609.2
Rainwater Basins	679.2	0.1	10.0	67.9
CRP - Wetland	7,528.9	1.6	5.0	376.4
CRP - Playa	28.2	0.0	5.0	1.4
Sandhills lake	85,542.5	17.6	10.0	8,554.3
Pit	25,956.8	5.3	1.0	259.6
Reservoir	73,676.0	15.2	1.5	1,105.1
Stock pond	75,837.0	15.6	1.5	1,137.6
Farmed playa	10,708.1	2.2	25.0	2,677.0
Buffered playa	3,794.7	0.8	10.0	379.5
RWB farmed	11,895.9	2.4	25.0	2,974.0
RWB early successional vegetation	20,349.3	4.2	10.0	2,034.9
RWB late successional vegetation	10,990.5	2.3	1.5	164.9
Emergent marsh	80,537.3	16.6	10.0	8,053.7
Saline wetlands	4,303.8	0.9	15.0	645.6
Total	**485,614.5**			**32,201.3**

Table C-5. Estimated wetland habitat available for Swimmers within the RWBJV Administrative Area.

Habitat	RWBJV Administrative Area Wetland Acres	% of Wetland Habitats	% Suitable for Shorebird Use	RWBJV Administrative Area Suitable Habitat (Acres)
Playas	1,602.8	0.3	50.0	801.4
Sandhills wetlands	72,183.3	14.	50.0	36,091.6
Rainwater Basins	679.2	0.1	50.0	339.6
CRP - Wetland	7,528.9	1.6	50.0	3,764.5
CRP - Playa	28.2	0.0	50.0	14.1
Sandhills lake	85,542.5	17.6	50.0	42,771.3
Pit	25,956.8	5.3	50.0	12,978.4
Reservoir	73,676.0	15.2	50.0	36,838.0
Stock pond	75,837.0	15.6	50.0	37,918.5
Farmed playa	10,708.1	2.2	50.0	5,354.0
Buffered playa	3,794.7	0.8	50.0	1,897.4
RWB farmed	11,895.9	2.4	50.0	5,947.9
RWB early successional vegetation	20,349.3	4.2	10.0	2,034.9
RWB late successional vegetation	10,990.5	2.3	1.5	164.9
Emergent marsh	80,537.3	16.6	10.0	8,053.7
Saline wetlands	4,303.8	0.9	50.0	2,151.9
Total	**485,614.5**			**197,122.2**

Table C-6. Estimated wetland habitat available for Small-bodied Probers/Gleaners within the RWB Wetland Complex.

Habitat	RWB Wetland Complex Wetland (Acres)	% of RWB Wetlands	% Suitable for Shorebird Use	RWB Suitable Habitat (Acres)
CRP - Wetland	259.3	0.40	2.50	6.48
Sandhills lake	4.2	0.00	5.00	0.21
Pit	5,734.4	8.10	0.50	28.67
Reservoir	4,649.4	6.60	0.80	37.20
Stock pond	16,195.0	22.90	0.80	129.56
RWB farmed	11,944.4	16.80	12.50	1,493.05
RWB early successional vegetation	20,977.6	28.80	5.00	1,048.88
RWB late successional vegetation	10,994.3	15.50	0.00	0
Emergent marsh	48.9	0.10	5.00	2.45
Total	**70,807.5**			**2,746.50**

Table C-7. Estimated wetland habitat available for Large-bodied Probers within the RWB Wetland Complex.

Habitat	RWB Wetland Complex Wetland (Acres)	% of RWB Wetlands	% Suitable for Shorebird Use	RWB Suitable Habitat (Acres)
CRP - Wetland	259.3	0.40	5.0	12.97
Sandhills lake	4.2	0.00	10.0	0.42
Pit	5,734.4	8.10	1.0	57.34
Reservoir	4,649.4	6.60	1.5	69.74
Stock pond	16,195.0	22.90	1.5	242.93
RWB farmed	11,944.4	16.80	25.0	2,986.10
RWB early successional vegetation	20,977.6	28.80	10.0	2,097.76
RWB late successional vegetation	10,994.3	15.50	1.5	164.95
Emergent marsh	48.9	0.10	10.0	4.89
Total	**70,807.5**			**5,637.10**

Table C-8. Estimated wetland habitat available for Swimmers within the RWB Wetland Complex.

Habitat	RWB Wetland Complex Wetland (Acres)	% of RWB Wetlands	% Suitable for Shorebird Use	RWB Suitable Habitat (Acres)
CRP - Wetland	259.3	0.40	50.0	129.65
Sandhills lake	4.2	0.00	50.0	2.10
Pit	5,734.4	8.10	50.0	2,867.20
Reservoir	4,649.4	6.60	50.0	2,324.70
Stock pond	16,195.0	22.90	50.0	8,097.50
RWB farmed	11,944.4	16.80	50.0	5,972.20
RWB early successional vegetation	20,977.6	28.80	10.0	2,097.76
RWB late successional vegetation	10,994.3	15.50	1.5	164.915
Emergent marsh	48.9	0.10	10.0	4.89
Total	**70,807.5**			**21,660.90**

Appendix D

Common and Scientific Nomenclature for Species and Distinct Subspecies Described in the RWBJV Shorebird Plan

Birds	
Common Name	**Scientific Name**
American Avocet	*Recurvirostra americana*
American Golden-Plover	*Pluvialis dominica*
American Woodcock	*Scolopax minor*
Baird's Sandpiper	*Calidris bairdii*
Black-bellied Plover	*Pluvialis squatarola*
Black-necked Stilt	*Himantopus mexicanus*
Buff-breasted Sandpiper	*Tryngites subruficollis*
Dunlin	*Calidris alpina*
Greater Yellowlegs	*Tringa melanoleuca*
Hudsonian Godwit	*Limosa haemastica*
Killdeer	*Charadrius vociferus*
Least Sandpiper	*Calidris minutilla*
Interior Least Tern	*Sternula antillarum athalassos*
Lesser Yellowlegs	*Tringa flavipes*
Long-billed Curlew	*Numenius americanus*
Long-billed Dowitcher	*Limnodromus scolopaceus*
Marbled Godwit	*Limosa fedoa*
Pectoral Sandpiper	*Calidris melanotus*
Piping Plover	*Charadrius melodus*
Red Knot	*Calidris canutus*
Red-necked Phalarope	*Phalaropus lobatus*
Red Phalarope	*Phalaropus fulicaria*
Ruddy Turnstone	*Arenaria interpres*
Sandhill Crane	*Grus canadensis*
Sanderling	*Calidris alba*
Semipalmated Plover	*Charadrius semipalmatus*
Semipalmated Sandpiper	*Calidris pusilla*
Short-billed Dowitcher	*Limnodromus griseus*
Snowy Plover	*Charadrius nivosus*
Solitary Sandpiper	*Tringa solitaria*
Spotted Sandpiper	*Actitis macularia*
Stilt Sandpiper	*Calidris himantopus*
Trumpeter Swan	*Cygnus buccinator*

Birds	
Common Name	**Scientific Name**
Upland Sandpiper	*Bartramia longicauda*
Western Sandpiper	*Calidris mauri*
Whimbrel	*Numenius phaeopus*
White-rumped Sandpiper	*Calidris fuscicollis*
Whooping Crane	*Grus americana*
Willet	*Tringa semipalmata*
Wilson's Phalarope	*Phalaropus tricolor*
Wilson's Snipe	*Gallinago delicata*

Invertebrate (Family)	
Common Name	**Scientific Name**
Leeches	*Hirudinea*
Midges	*Chironomidae*
Snails	*Planorbidae*
Water beetles	*Hydrophilidae*
Water boatmen	*Corixidae*
Worms	*Oligochaeta*

Plants	
Common Name	**Scientific Name**
Alfalfa	*Medicago sativa*
Canada thistle	*Cirsium arvense*
Common reed grass/*Phragmites*	*Phragmites australis*
Corn	*Zea mays*
Eastern red cedar	*Juniperus virginiana*
Hybrid cattail	*Typha* x *glauca*
Kentucky bluegrass	*Poa pratensis*
Leafy spurge	*Euphorbia esula*
Milo	*Sorghum bicolor*
Purple loosestrife	*Lythrum salicaria*
Reed canary grass	*Phalaris arundinacea*
River bulrush	*Schoenoplectus fluviatilis*
Russian olive	*Elaeagnus angustifolia*
Smooth brome grass	*Bromus inermis*
Soybeans	*Glycine max*
Wheat	*Triticum aestivum*

Literature Cited

Austin, J. E., and A. L. Richert. 2001. A comprehensive review of the observational and site evaluation data of migrant whooping cranes in the United States, 1943-99. U.S. Geological Survey, Northern Prairie Wildlife Research Center, Jamestown, North Dakota, and State Museum, University of Nebraska, Lincoln, Nebraska, USA.

Baldassarre G. A. and E. G. Bolen. 1994. Waterfowl ecology and management. John Wiley, New York, New York, USA.

Bellrose, F. C. 1980. Ducks, geese, and swans of North America. Stackpole, Harrisburg, Pennsylvania, USA.

Bentall, R. 1990. Streams. Pages 93–114 in A. Bleed and C. Flowerday, eds. Atlas of the Sand Hills. Resource Atlas No. 5a. Conservation and Survey Division, University Nebraska, Lincoln, Nebraska, USA.

Bishop, A. A., and M. Vrtiska. 2008. Effects of the Wetlands Reserve Program on waterfowl carrying capacity in the Rainwater Basin region of south-central Nebraska. U.S. Fish and Wildlife Service, Grand Island, Nebraska, USA.

Bishop, A.A., J. Liske-Clark, and R. Grosse. 2009. Nebraska landcover development. Unpublished report. Great Plains GIS Partnership, Grand Island, Nebraska, USA.

Bishop, A.A., A. Barenberg, N. Volpe, and R. Grosse. 2011. Nebraska land cover development, Rainwater Basin Joint Venture report. Grand Island, Nebraska, USA.

Brown, S., C. Hickey, B. Harrington, and R. Gill, editors. 2001. United States Shorebird Conservation Plan, 2nd ed. Manomet Center for Conservation Sciences, Manomet, Massachusetts, USA.

Castro, G., N. Stoyan, and J. P. Myers. 1989. Assimilation efficiencies in birds: a function of taxon or food type? Comp. Biochem. Physiol. 92:271-278.

Condra, G. E. 1939. An outline of the principal natural resources of Nebraska and their conservation. University of Nebraska Conservation and Survey Division Bulletin No. 20.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service, FWS/OBS/-79/31, Washington, D.C., USA.

Cummins, K. W. and J. C. Wuycheck. 1971. Caloric equivalents for investigations in ecological energetics. Mitteilungen Internationale Vereinigung. Limnological No. 18, Stuttgart, Germany.

Davis, C. A. and J. R. Bidwell. 2008. Response of aquatic invertebrates to vegetation management and agriculture. Wetlands 28: 793 – 805.

Davis, C. A., and L. M. Smith. 1998. Ecology and management of migrant shorebirds in the playa lakes region of Texas. Wildlife Monographs 140.

Elliott-Smith, E., S. M. Haig, and B. M. Powers. 2009. Data from the 2006 international piping plover census: U.S. Geological Survey Data Series 426.

Fellows, S., K. Stone, S. Jones, N. Damude, and S. Brown. 2001. Central Plains/Playa Lakes conservation plan, version 1.0. http://www.shorebirdplan.org/wp-content/uploads/2013/01/CPPLR.pdf accessed August 2003 .

Gersib, R.A. 1991. Nebraska wetlands priority plan. Nebraska Game and Parks Commission. Lincoln, Nebraska, USA.

Grace, J.B. and J.S. Harrison. 1986. The biology of Canadian weeds: *Typha latifolia* L., *T. angustifolia* L. and *T.* x *glauca* Gord. Canadian Journal of Plant Science 66: 361-379.

Gregory, C. J., S. J. Dinsmore, L. A. Powell, and J. G. Jorgensen. 2012. Estimating the abundance of long-billed curlews in Nebraska. Journal of Field Ornithology 83:122-129.

Grosse, R. C., N. D. Niemuth, T. L. Shaffer, and A. A. Bishop. 2012. Landscape-level habitat use by trumpeter swans in the Sandhills of Nebraska and South Dakota. Twenty second Trumpeter Swan Society Conference. Polson, Montana, USA.

Jorgensen, J. G. 2004. An overview of shorebird migration in the eastern Rainwater Basin, Nebraska. Nebraska Ornithologists' Union Occasional Paper Number 8.

Jorgensen, J.G. 2008. 2008 update to an overview of shorebird migration in the eastern Rainwater Basin, Nebraska. Published by author. Lincoln, Nebraska, USA.

Jorgensen, J. G., J. P. McCarty, and L. L. Wolfenbarger. 2008. Buff-breasted sandpiper density and numbers during migratory stopover in the Rainwater Basin, Nebraska. The Condor 110:63-69.

Jorgensen, J. G., J. P. McCarty, and L. L. Wolfenbarger. 2009. Killdeer *Charadrius vociferus* breeding abundance and habitat use in the eastern Rainwater Basin, Nebraska. Wader Study Group Bulletin 116.

Kaul, R. B., D. Sutherland, and S. Rolfsmeier. 2006. The flora of Nebraska. School of Natural Resources, University of Nebraska-Lincoln, Lincoln, Nebraska, USA.

Kendeigh, S. C., V. R. Dol'nik, and V. M. Gavrilov. 1977. Avian energetics. Pages 129–204 in J. Pinowski and S. C. Kendeigh, editors. Granivorous birds in ecosystems. Cambridge University Press, Cambridge, United Kingdom.

Keech, C. and R. Bentall. 1971. Dunes on the plains: the Sandhills region of Nebraska. Resource Report No. 4. Conservation and Survey Division. University of Nebraska, Lincoln, Nebraska, USA.

Krapu, G. L. 1981. The role of nutrient reserves in mallard reproduction. Auk 98:29-38.

Krapu, G. L., D. A. Brandt, K. L. Jones, and D. H. Johnson. 2011. Geographic distribution of the mid-continent population of sandhill cranes and related management applications. Wildlife Monographs, 175:1-38.

LaGrange, T. G. 2005. A guide to Nebraska's wetlands and their conservation needs. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

LaGrange, T.G., R. Stutheit, M. Gilbert, D. Shurtliff, and P.M. Whited. 2011. Sedimentation of Nebraska's playa wetlands: a review of current knowledge and issues. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

McCarty, J.P., L.L. Wolfenbarger, and J.G. Jorgensen. 2010. Stopover ecology of high priority shorebirds in the Rainwater Basin. Final Report. Nebraska Game and Parks Commission, Lincoln NE. http://outdoornebraska.ne.gov/wildlife/programs/nongame/NGBirds/pdf/McCarty_Wolfenbarger_Jorgensen_2010.pdf

McMurtrey, M. D., R. Craig, and G. Schildman. 1972. Nebraska wetland survey. Habitat work plan K-71. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Miller, M. R., and J. M. Eadie. 2006. The allometric relationship between resting metabolic rate and body mass in wild waterfowl (Anatidae) and an application to estimation of winter habitat requirements. The Condor 108:166–177.

Morrison, R. I. G., B. J. McCaffery, R. E. Gill, [Jr.], S. K. Skagen, S. L. Jones, G. W. Page, C. L. Gratto-Trevor, and B. A. Andres. 2006. Population estimates of North America shorebirds, 2006. Wader Study Group Bulletin 111:67–85.

Murphy, P. J., T. J. Randle, L. M. Fotherby, and J. A. Daraio. 2004. The Platte River channel: history and restoration. Bureau of Reclamation Technical Service Center. Denver, Colorado, USA.

National Research Council of the National Academies. 2005. Endangered and threatened species on the Platte River. The National Academies Press, Washington, D.C.

Naugle, D. E., K. F. Higgens, M. E. Estey, R. R. Johnson, and S. M. Nusser. 2000. Local and landscape-level factors influencing black tern habitat suitability. Journal of Wildlife Management 64:253–260.

North American Bird Conservation Initiative. 1999. Bird Conservation Regions. http://www.nabci-us.org/bcrs.htm.

Pearse, A.T., G.L. Krapu, D.A. Brant, and P.J. Kinzel. 2011. Changes in agriculture and abundance of snow geese affect carrying capacity of sandhill cranes in Nebraska. Journal of Wildlife Management 74:479–488.

Prince, H. H. 1979. Bioenergetics of post breeding dabbling ducks. Pages 103–117 *in* T. A. Bookhout, editor. Waterfowl and wetlands: an integrated review. Proceedings of the Thirty-ninth Midwest Fish and Wildlife Conference, Madison, Wisconsin, USA.

Rainwater Basin Joint Venture. 2013*a*. Rainwater Basin Joint Venture Landbird Plan. Grand Island, Nebraska, USA.

Rainwater Basin Joint Venture. 2013*b*. Rainwater Basin Joint Venture Waterbird Plan. Grand Island, Nebraska, USA.

Rainwater Basin Joint Venture. 2013*c*. Rainwater Basin Joint Venture Waterfowl Plan. Grand Island, Nebraska, USA.

Riens, J.R. 2009. Assessment of macroinvertebrates, water quality, and pollution risk modeling in playa wetlands of Rainwater Basin Waterfowl Production Areas. M.S. Thesis, University of Nebraska, Kearney, Nebraska, USA.

Robichaux, R.M. 2010. Correlating climate with late-winter wetland habitat in the Rainwater Basin, South-central Nebraska. M.S. Thesis, Kansas State University, Manhattan, Kansas, USA.

Rolfsmeier, S.B., and G. Steinauer. 2010. Terrestrial ecological systems and natural communities of Nebraska. Nebraska Natural Heritage Program, Nebraska Game and Parks Commission, Lincoln, Nebraska. USA.

Sauer, J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski, Jr. and W. A. Link. 2011. The North American breeding bird survey, results and analysis 1966-2010. Version 12.07.2011 USGS Patuxent Wildlife Research Center, Laurel, Maryland, USA.

Schildman, G. and J. Hurt. 1984. Update of Rainwater Basin wetland survey. Survey of habitat work plan K-83. W-15-R-40. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Schneider, R., M. Humpert, K. Stoner, G. Steinauer, and M. Panella. 2011. The Nebraska Natural Legacy Project: State Wildlife Action Plan, 2nd edition. Nebraska Game and Parks Commission, Lincoln, Nebraska, USA.

Sidle, J. G., E. D. Miller, and P. J. Currier. 1989. *Changing habitats in the Platte River valley of Nebraska*. Prairie Naturalist 21:91–104.

Skagen, S. K. 1997. Stopover ecology of transitory populations: the case of migrant shorebirds. Pages 244–269 in F. L. Knopf and F. B. Samsom, 118 The Journal of Wildlife Management N 74(1) editors. Ecology and conservation of Great Plains vertebrates. Springer-Verlag, New York, New York, USA.

Skagen, S.K., P.B. Sharpe, R.G. Waltermire, and M.B. Dillon. 1999. Biogeographical profiles of shorebird migration in midcontinental North America: U.S. Geological Survey Biological Science Report 2000-0003.

Uden, D. R. 2012. Agricultural landuse change impacts on bioenergy production, avifauna, and water use in Nebraska's Rainwater Basins. M.S. Thesis, University of Nebraska-Lincoln, Lincoln, Nebraska, USA.

United States Department of Agriculture. 2009. The USDA/NASS 2009 Cropland Data Layer: Nebraska State Coverage.

U.S. Fish and Wildlife Service. 1960. Drainage Report Nebraska 1954-1958. Minneapolis, Minnesota, USA.

U.S. Fish and Wildlife Service. 1978. Determination of critical habitat for the Whooping Crane. Federal Register. 43:20938-20942.

U.S. Fish and Wildlife Service. 1980. Missouri River stabilization and navigation project, Sioux City, Iowa to mouth. Fish and Wildlife Coordination Act Report. U.S. Fish and Wildlife Service, North Kansas City, Missouri, USA.

U. S. Fish and Wildlife Service. 1981. The Platte River ecology study. United States Fish and Wildlife Service Special Research Report, Jamestown, North Dakota, USA.

U.S. Fish and Wildlife Service. 1988. Great Lakes and Northern Great Plains piping plover recovery plan. Twin Cities, Minnesota, USA.

U.S. Fish and Wildlife Service. 1986. Sandhills wetlands a special investigation. Unpublished Report.

U. S. Fish and Wildlife Service. 2004. U.S. shorebird conservation plan. 2004. High Priority Shorebirds ─ 2004. Unpublished Report, U. S. Fish and Wildlife Service, 4401 N. Fairfax Dr., MBSP 410, Arlington, Virginia, USA.

Vrtiska, M. P., and L. A. Powell. 2011. Estimates of duck breeding populations in the Nebraska Sandhills using double observer methodology. Waterbirds 34:96–101.

Walsberg, G. E. 1983. Avian ecological energetics. Pages 161–220 in D. S. Farner and J. R. King, editors. Avian biology. Volume 7. Academic Press, New York, New York, USA.

Webb, E.B., L.M. Smith, M. Vrtiska, and T.G. LaGrange. 2010. Effects of local and landscape variables on wetland bird habitat use during migration through the Rainwater Basin. Journal of Wildlife Management 74:109-119.