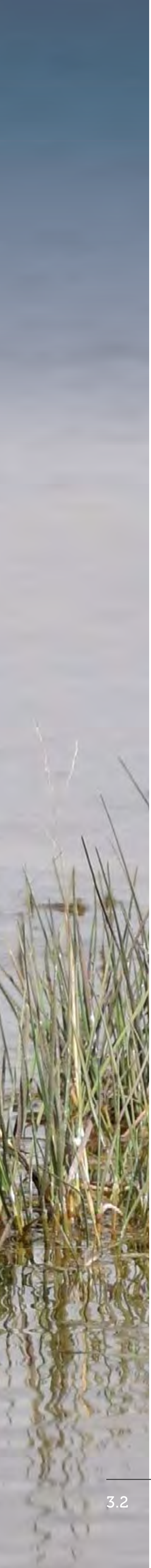
# SHOREBIRD PLAN

## SECTION 3

2017 Principal Authors:
Kevin W. Barnes
Sean P. Fields

2005 Principal Authors:
Diane A. Granfors
Neal D. Niemuth

2017 Prairie Pothole Joint Venture Implementation Plan | March 2017



# CONTENTS

**Photo: Kevin Barnes**

# BACKGROUND AND CONTEXT

## Importance of the Prairie Pothole Region to Continental Shorebird Populations

The North American Prairie Pothole Region (PPR) provides habitat for 13 of 20 shorebird species that breed in the contiguous U.S. and offers important stopover habitat for an additional 23 shorebird species that only migrate through the region (Figure 1; Appendices A and B). The following shorebirds breed in the Prairie Pothole Joint Venture (PPJV) portion of the PPR: Upland Sandpiper, Mountain Plover, Long-billed Curlew, Marbled Godwit, Willet, Piping Plover, Spotted Sandpiper, American Avocet, Black-necked Stilt, Wilson's Phalarope, Killdeer, Wilson's Snipe, and American Woodcock (Figures 1 and 2; BirdLife International and Naturserve 2015, Sauer et al. 2014*a*).

American Woodcock and Black-necked Stilt are distributed primarily outside of the PPR; only a very small proportion (<1%) of their populations breed within the PPJV administrative area. Of note is that their breeding populations are expanding in the PPR, specifically in western (Black-necked Stilt) and eastern Canada (American Woodcock). The Long-billed Curlew, American Avocet, and Mountain Plover are mostly restricted to the western portion of the PPR, with approximately 26%, 9%, and 9% of their populations breeding in the PPJV administrative area, respectively. Although the Spotted Sandpiper has a breeding distribution that spans the PPR, only a small proportion of the population (5%) breeds in the PPJV administrative area. Killdeer, Willet, and Wilson's Snipe also have distributions that span the PPR; however, the proportions of their populations that breed in the PPJV administrative area are greater (12%-18%). Wilson's Phalarope, Marbled Godwit, and Upland Sandpiper, have breeding ranges that occur mostly throughout the PPR, and Piping Plover has a breeding range that is predominantly in the PPR, yet not widespread, and all have large proportions of their populations breeding in the PPJV administrative area (28%-34%).

The study of shorebird migration ecology in the PPR is limited due to the dynamic nature of prairie climate and variety of wetland types that result in a landscape with constantly changing spatial patterns of suitable conditions. Shorebirds disperse widely in the PPR to find appropriate stopover habitats, making population and trend estimates difficult. Skagen et al. (2008) estimated the number and timing of shorebirds that pass through the PPJV administrative area by sampling townships in North Dakota, South Dakota and Minnesota portions of the PPJV area and extrapolating results to the region. They found peak spring migration occurred in May, and was more drawn out in the fall due to temporal variation in species fall migration. They estimated that 7,301,108 (± 1,511,728) shorebirds passed through this region during spring migration and roughly half that amount in the fall. The method used to sample species was not effective for all shorebirds that used the area during migration, such as species that are rare and/or highly aggregated like Red Knot or Sanderling. They estimated that the entire population of some species passed through the region during migration. This was especially pronounced for small calidridines, dowitchers, yellowlegs, Stilt Sandpiper, and Hudsonian Godwit. Niemuth et al. (2006) found that extrapolating observed shorebird use to all seasonal and temporary wetlands in the Drift Prairie of North Dakota indicated use by 3.59 million shorebirds (95% CI 2.01–5.17 million), which is fairly high given the smaller geographic area, but is similar to the Skagen et al. (2008) estimate.

> The North American Prairie Pothole Region (PPR) provides habitat for 13 of 20 shorebird species that breed in the contiguous U.S. and offers important stopover habitat for an additional 23 shorebird species that only migrate through the region

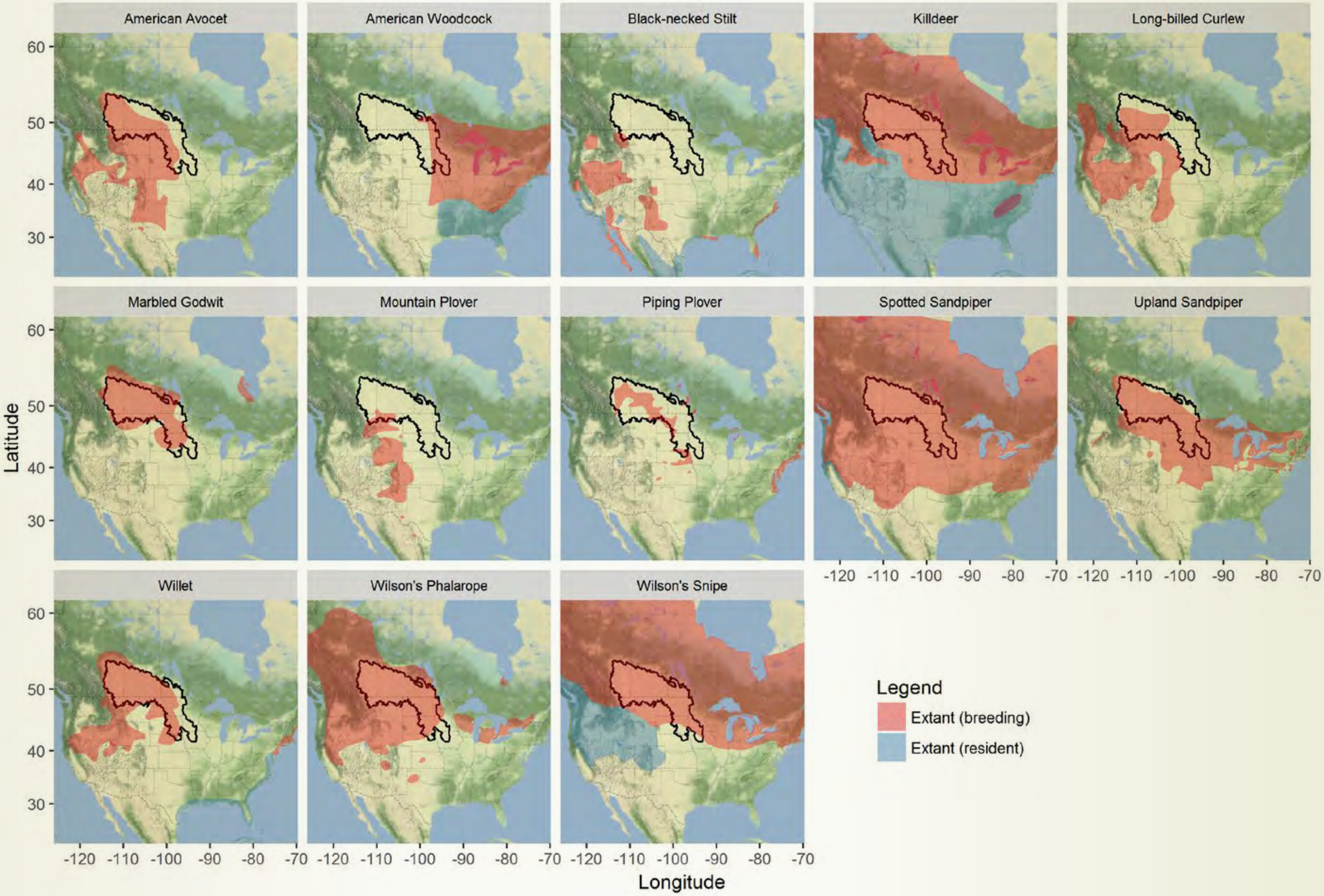


**Figure 1.** Breeding ranges for shorebirds nesting in the PPJV area (BirdLife International and NatureServe 2015). The PPR is outlined in black.

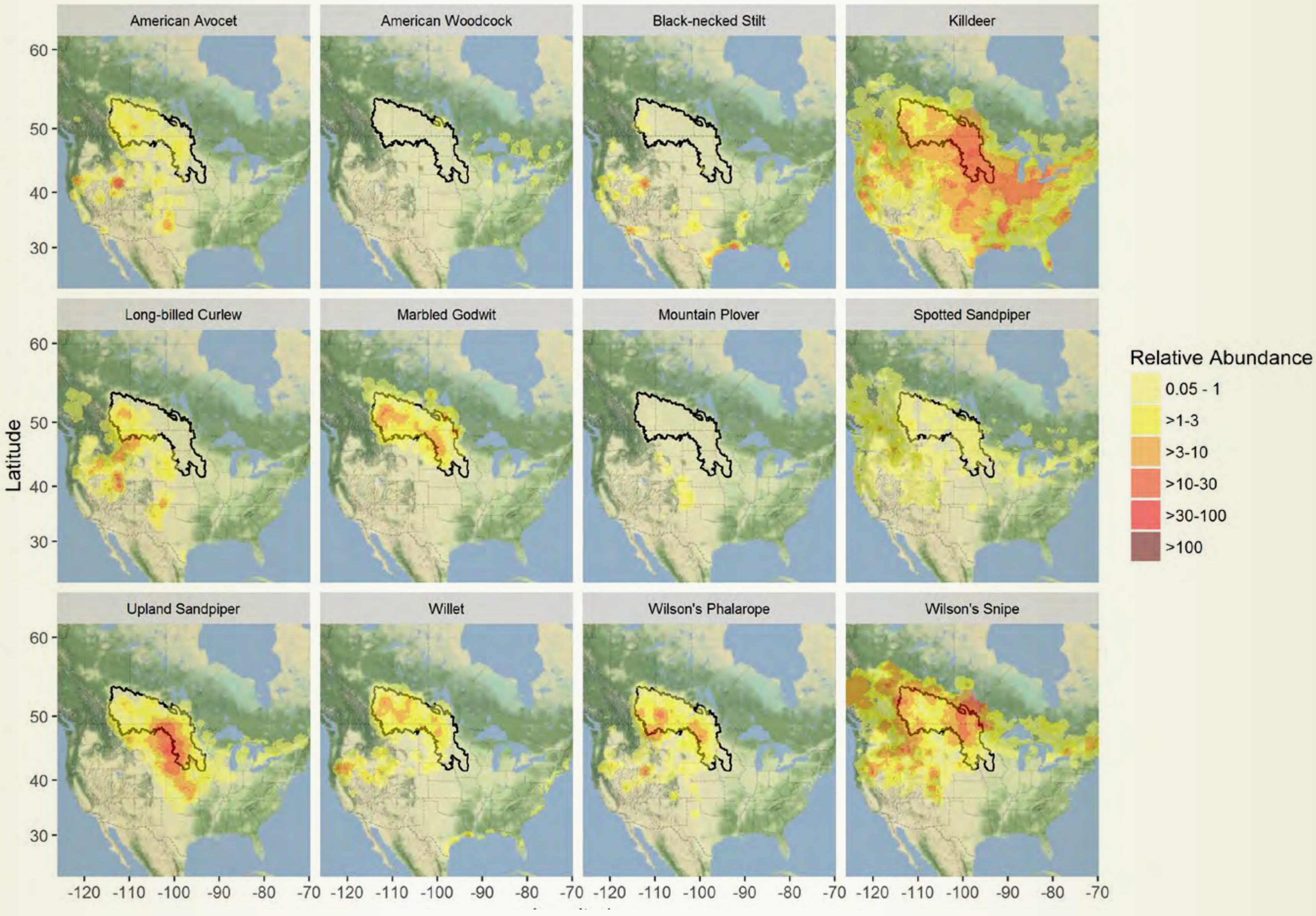


**Figure 2.** Relative abundance of shorebirds breeding in the PPJV administrative area derived from BBS survey data (Sauer et al. 2014*a*). The PPR is outlined in black.

## Breeding and Migration Habitats

The PPR is important to shorebirds due to the abundance and diversity of wetlands and grasslands that provide food (i.e., invertebrates) and appropriate nesting and brood rearing conditions. Breeding shorebirds fill niches provided by wetland and grassland diversity for nesting and foraging. Some are grassland obligates that prefer distinct and contrasting grass structures, others prefer a combination of wetlands and grasslands, while others rely heavily upon wetlands and may even utilize distinct wetland types or zones for foraging (Figure 3, Appendix A). For example, wetland and grassland diversity provide foraging conditions for different species; wetland depths < 5 cm provide foraging conditions for smaller shorebirds and depths 5-10 cm provide foraging conditions for larger shorebirds. Similarly, grass heights < 4 cm are preferable for certain plovers, while grass heights < 10 cm are preferable for some larger shorebirds. Furthermore, wetland diversity ensures appropriate conditions exist despite climatic stochasticity; ephemeral, temporary, and seasonal wetlands offer abundant breeding or stopover habitat during wet conditions in the spring, while semi-permanent and permanent wetlands provide breeding or stopover habitat during the fall or during drought years.

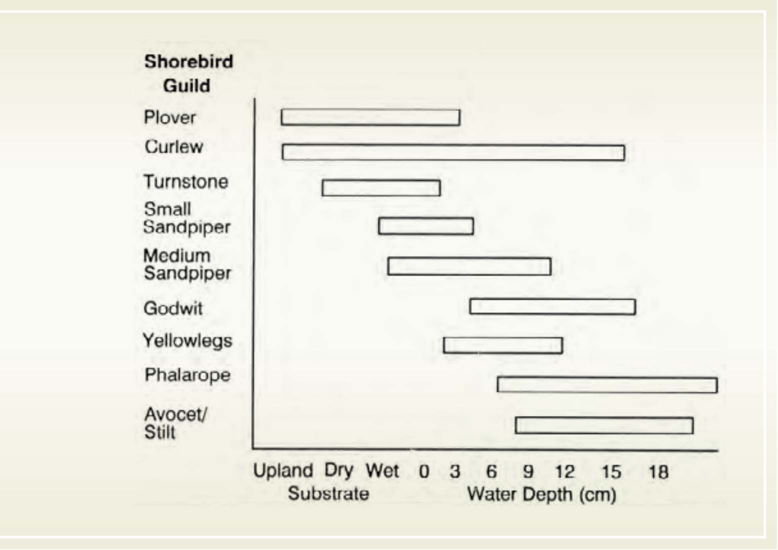


**Figure 3. Water depth (cm) and substrate preferences of different shorebird guilds for foraging (Helmers 1992).**

General habitat requirements for these species represent the diversity of wetland and grassland conditions in the PPR (Appendix A). Upland Sandpiper and Mountain Plover are grassland obligates; however, Mountain Plovers prefer disturbed short stature grass, whereas Upland Sandpipers prefer a mosaic of native grassland conditions from short and sparse to tall and dense vegetation. Long-billed Curlews also make extensive use of upland habitats, using native grasslands, rangeland/pasture, and, to a lesser extent, cropland. Marbled Godwits and Willets rely on a mixture of wetlands (ephemeral, temporary, and seasonal) and grasslands of moderate height; both will occur occasionally in cropland. Spotted Sandpipers, Killdeer, and Piping Plover all rely on shoreline or sparsely vegetated/bare habitat. However, Spotted Sandpipers will nest and raise broods in vegetative cover, Killdeer are less tied to wetlands and often occur in human disturbed areas, and Piping Plovers largely rely on sand/gravel areas on rivers or near large alkali lakes. The American Avocet and Black-necked Stilt have similar habitat requirements; both occur on larger wetlands with sparsely vegetated islands for nesting. However, American Avocets occur more often in alkali lakes. Wilson's Phalaropes will use a variety of wetlands, including deeper wetlands, located in grasslands of moderate height. Last, Wilson's Snipe and American Woodcock rely on marshy areas with moist soil and clumped dense vegetation; however, woodcocks are more dependent on early successional deciduous forest.

Most shorebirds in the PPR seek invertebrates from shallow water and alkaline or fresh water mudflats. The majority of species (>70%) use water depths < 10 cm and many need water depths of <5 cm (Dinsmore et al. 1999). Heavy feeding on invertebrates provides fuel for their long journey, reserves for breeding in spring, and nutrients for molting in fall. Eldridge (1992) estimated that at least 100 invertebrates/m$^2$ are required for migrating shorebird stopover habitat.

Shorebird migration through the PPR can be categorized based on migration distance and spatial pattern of travel (Table 1 and Figure 4; Skagen et al. 1999). Many long distance (>14,000 km) migrants have a narrow band pattern of distribution during travel; > 90% of the population passes between 90-100°W. There are only a few short-distance (<5,000 km) migrants and most have a widespread pattern of distribution during migration. The majority of shorebirds that migrate through the PPR travel intermediate distances and have an array of spatial

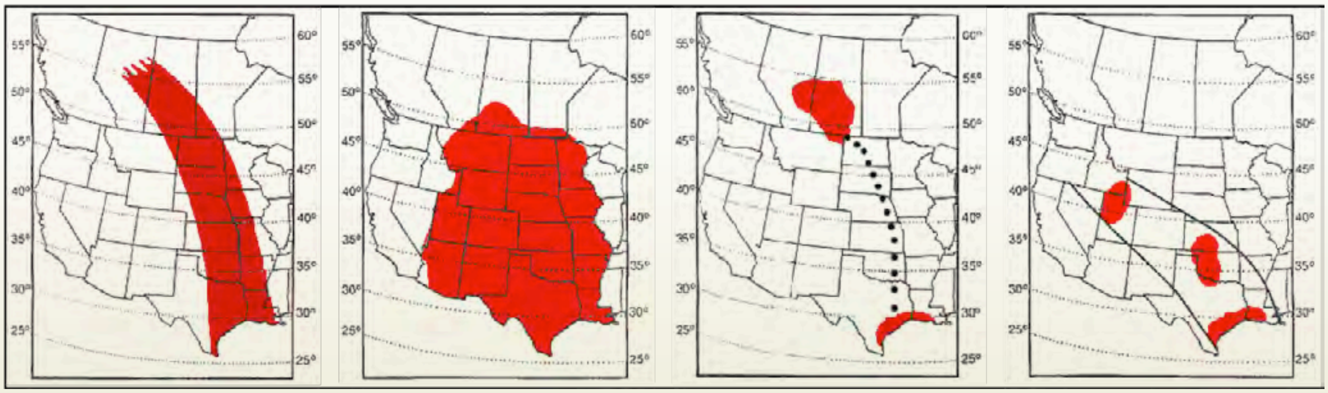


**Figure 4.** Shorebird migration patterns through the U.S. Central Great Plains (Skagen et al. 1999).

patterns including narrow band, widespread, jump, and crossband. Species that utilize a jump pattern are seen infrequently in the PPR. Western Sandpiper is the only crossband migrant in the PPR; however, its migration is generally contained to the south and reporting of observations is infrequent. Short-distance migrants and larger shorebirds are more likely to migrate in the Intermountain Region (Nevada, Utah, Idaho, and western Montana), whereas intermediate- and long-distance migrants, and small to medium-sized shorebirds, migrate mostly through the Great Plains region (Skagen and Knopf 1993). Spring migrants generally utilize areas with an abundance of wetlands. In portions of the PPR, such as the Drift Prairie, ephemeral and temporary wetlands are highly important stopover habitat (Skagen and Knopf 1993, Neimuth et al. 2006).

**Table 1.** Migrant shorebird use of the Prairie Pothole Region as classified by migration pattern and migration distance (modified from Skagen et al. 1999).

| Migration Pattern | *Migration Distance* | | |
|---|---|---|---|
| | Short | Intermediate | Long |
| Narrow band | Piping Plover | Upland Sandpiper<br>Semipalmated Sandpiper<br>Semipalmated Plover<br>Greater Yellowlegs<br>Lesser Yellowlegs<br>Least Sandpiper[1]<br>Short-billed Dowitcher[1] | American Golden-Plover<br>Hudsonian Godwit<br>White-rumped Sandpiper<br>Baird's Sandpiper<br>Pectoral Sandpiper<br>Buff-breasted Sandpiper<br>Stilt Sandpiper |
| Widespread | Killdeer<br>Willet<br>Marbled Godwit | Black-bellied Plover<br>Solitary Sandpiper<br>Spotted Sandpiper<br>Whimbrel<br>Long-billed Dowitcher<br>Wilson's Phalarope<br>Red-necked Phalarope | |
| Jump | | Ruddy Turnstone<br>Red Knot<br>Sanderling<br>Dunlin | |
| Crossband | | Western Sandpiper | |


Kevin Barnes

## Limiting Factors

The lack of long-term and species-specific studies precludes definitive statements about what limits shorebird populations in the PPR. However, decrease of grassland and wetland abundance and diversity can be assumed to be the cause of drastic reduction (e.g., Upland Sandpiper, Marbled Godwit) or elimination (e.g., American Avocet, Willet) of breeding species from the eastern pothole region. It is not known if reduced reproductive success led to eventual elimination of species, or if settlement simply does not occur in areas without some critical amount of grassland and wetlands. Demographic metrics are lacking for many breeding shorebirds in the PPJV administrative area, and it is unknown if populations of some species are self-sustaining or what may be their limiting factors. Most species of migrant shorebirds are believed to be in decline; however, it is not known if declines are due to problems on breeding, wintering, or stopover areas.

While it is difficult to identify limiting factors for shorebirds in the PPR, studies to provide demographic estimates for shorebirds that breed in the PPJV have been conducted (Appendix C). In general shorebird nest success and productivity have considerable temporal and spatial variability, but often nest success is low to moderate, productivity is low, and adult survival and longevity are moderate to high. Little is known regarding annual survival of young. Demographics are better known for Piping Plover and Mountain Plover than other species. Major limiting factors were predation of eggs and young for Piping Plover, and juvenile survival for Mountain Plover. Threats that affected almost all species during breeding include predation of eggs and young. More general threats on breeding grounds included conversion of habitat to cropland, pesticide use reducing prey abundance or causing acute toxicity or chronic sub-lethal effects, and drought or flood conditions. These threats also exist in stopover areas and on wintering grounds. Energy constraints may be an issue for species with longer migratory routes through a changing landscape. In addition, those species that rely on specific stopover areas (i.e., Marbled Godwits and Long-billed Curlews), or have small wintering distributions are especially vulnerable (i.e., Piping Plover).

# POPULATION AND HABITAT TRENDS

## Habitat Changes and Trends

Dynamic wetland and grassland conditions have shaped shorebird evolution in the PPR; many species depend upon wetland variety to buffer against the influences of climatic variability, and benefit from grassland disturbance such as fire and grazing that create grassland diversity. Wetlands of different hydrologic regimes provide needed shallow habitat through the continuum of water cycles from flood to drought. Grazing and fire cleared or greatly reduced vegetation to create preferred nesting and foraging habitat for breeders and migrants. These same disturbances invigorated prairie vegetation enabling higher productivity than areas with stable conditions.

The pre-European settlement landscape of the PPR was usually described as a seemingly endless landscape of grassland and abundant wetlands. Less often is there reference to the variety of grassland and wetland habitats within those landscapes. Areas of the U.S. PPR that are now almost entirely cropland probably once provided the best shorebird habitat in the region for both breeders and migrants. In particular, the Drift Prairie, Glacial Lake Agassiz, Des Moines Lobe, and the James River lowlands historically had the highest density of shallow wetlands in the U.S. PPR, and would have provided an abundance of the sedge forage preferred by bison. Bison wallows likely provided mudflats for feeding migrant shorebirds.

Unfortunately, shallow wetlands were easily drained and converted to cropland along with the surrounding grasslands. Today, shorebirds migrating through these areas in spring make use of the shallow wetland remnants in crop fields following snowmelt and spring rains. Although tillage may make these fields attractive to migrant shorebirds by reducing vegetation, these areas are also likely to contain pesticides that accumulate in snowmelt and are known to reduce prey abundance, and potentially cause acute toxicity or chronic sub-lethal effects ( Main et al. 2014, Morrissey et al. 2015). Euliss and Mushet (1999) found that constant tilling reduced invertebrate numbers and diversity.

In general, the lack of grassland and more permanent water in greatly converted landscapes precludes use by breeding shorebirds. The result of this wholescale conversion has been severe range contraction for breeding shorebirds, especially those species whose primary breeding ground is within the PPR. Restoration potential is generally considered minimal because: 1) much of the land is highly profitable in terms of commodity production, 2) restoration of function of temporary wetlands is more problematic than restoration of seasonal or semipermanent wetlands (due to the difficulty in establishing compatible vegetation), 3) encroachment by reed canary grass and cattail hinders functional restoration, 4) sedimentation from cropping in and around drained shallow wetlands often obliterates the basin, and 5) the complete lack of grass or wetland habitat precludes expending any effort in such areas using current prioritization schemes. When shallow wetlands are restored, intensive management is required to prevent establishment of invasive plants.

**Wetlands of different hydrologic regimes provide needed shallow habitat through the continuum of water cycles from flood to drought.**

Following loss of habitats, any wetlands that remain are often severely degraded. Native prairies, wet meadows, and wetland edges are subject to encroachment by woody species unless actively managed through grazing or fire. Because shorebirds prefer wetlands with minimal vegetation density and height, wetlands invaded by cattail or reed canary grass are avoided by both breeders and migrants.

Most of the breeding shorebirds have been eliminated from Minnesota, Iowa, and low-lying areas of the Dakotas. Breeding shorebirds in Minnesota are generally confined to narrow remnant grassland and wetland landscapes on the beach ridges of Glacial Lake Agassiz, along the Minnesota River, and on the Prairie Coteau. In areas where remnant grasslands and wetlands remain, landowners seeking a means to earn income on native prairie are enrolling in U.S.

Department of Agriculture (USDA) programs that promote tree planting, thus creating areas that are generally avoided by most shorebirds. Other landowners are mining rocks from native prairie to be sold for rip-rap. Once rocks are removed, the land can easily be put into commodity production.

Without adequate stopover sites, suitable habitats may become overused or birds will be forced to use suboptimal areas. The result would be that birds arrive at their breeding grounds in poor condition for breeding and either fail to nest successfully or suffer reduced reproductive success. Given that most shorebird populations are believed to be in decline, this scenario may already be happening.

## Population Estimates and Trends

The most recent shorebird population estimates and trends were calculated by Andres et al. (2012). They reviewed published papers, solicited unpublished data, and sought the opinions of experts (Andres et al. 2012). Their work greatly refined population estimates for many species; as a result, conservation status for many species changed. Population trends were estimated from many sources and both short- and long-term trends and confidence estimates were summarized.

Categories for shorebird species population trends were developed for the U.S. Shorebird Conservation Plan (USSCP; Brown et al. 2001). They are: 1) significant increase, 2) apparent increase, 3) apparently stable or trend unknown (U), 4) apparent decline, and 5) significant decline. Of the 36 species that breed or migrate through the PPR, long-term trends indicate 21 are significantly or apparently declining, 9 are stable, 3 are unknown, and 3 are significantly increasing. Short-term trends indicate 11 are significantly or apparently declining, 16 are stable, 7 are unknown, and 2 are apparently or significantly increasing (Appendix B).

The most current BBS trend estimates (Figures 5 and 6, Table 2; Sauer et al. 2014*a*, Sauer et al. 2014*b*) for breeding shorebirds that were detected in the PPR were also used to inform this plan and determine the species of greatest conservation concern for PPJV partners. Mountain Plover, Piping Plover, and American Woodcock were not detected on BBS routes in the PPJV administrative area, and Black-necked Stilt and Spotted Sandpiper had high to moderate data deficiencies, respectively (i.e., low abundance, low number of routes where detections occurred, and imprecise estimates). Only Wilson's Snipe had significantly increasing long- and short-term trends where zero was not contained within 95% credible intervals. The remaining 7 species had estimates that contained zero within their credible intervals for long and short-term trends, perhaps indicating stable populations. However, in the short-term, Killdeer and Wilson's Phalarope have apparently increasing trends.


Chuck Loesch

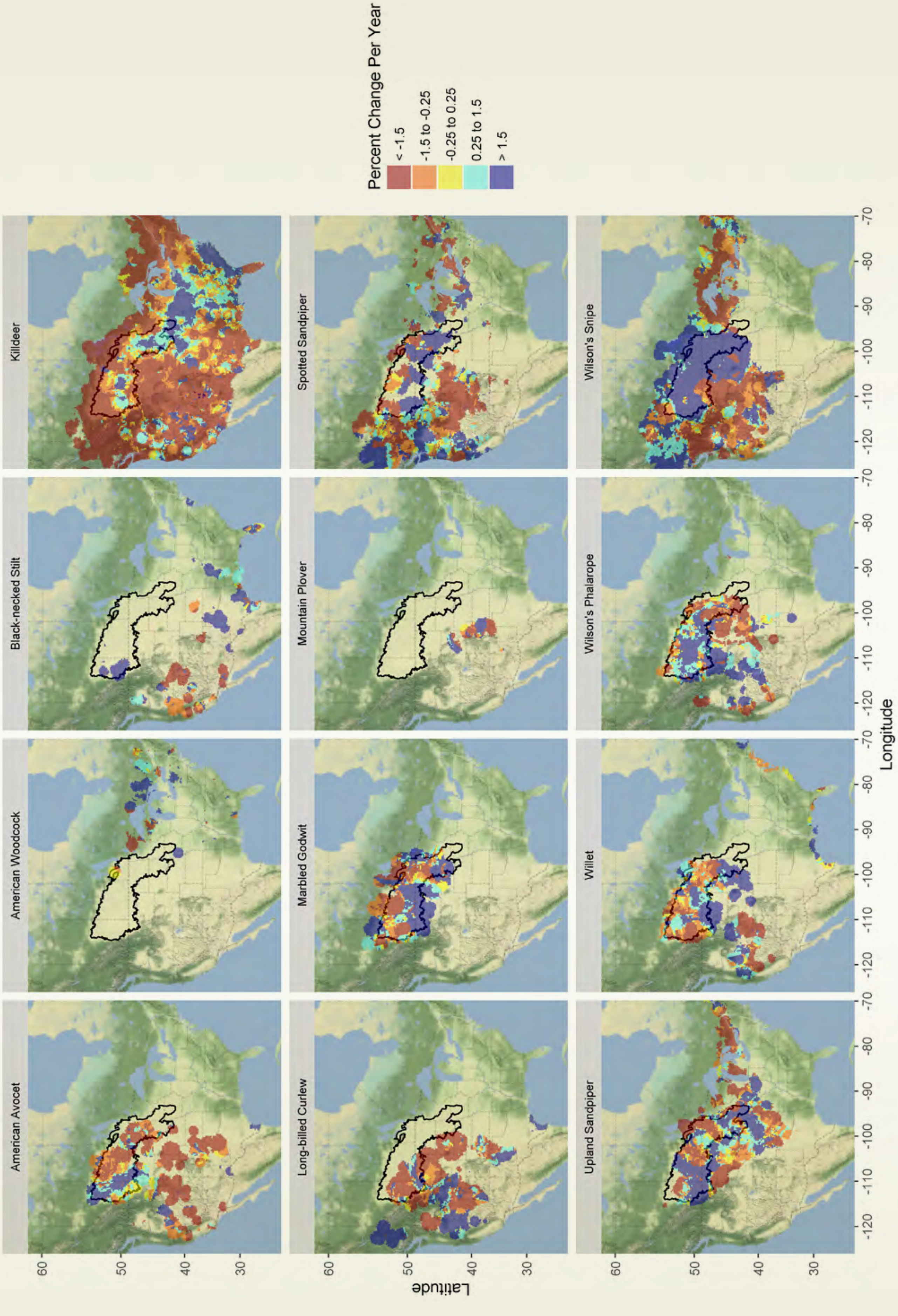


**Figure 5.** Spatial relative abundance trends from BBS survey data for shorebirds breeding in the PPJV administrative area (Sauer et al. 2014b).

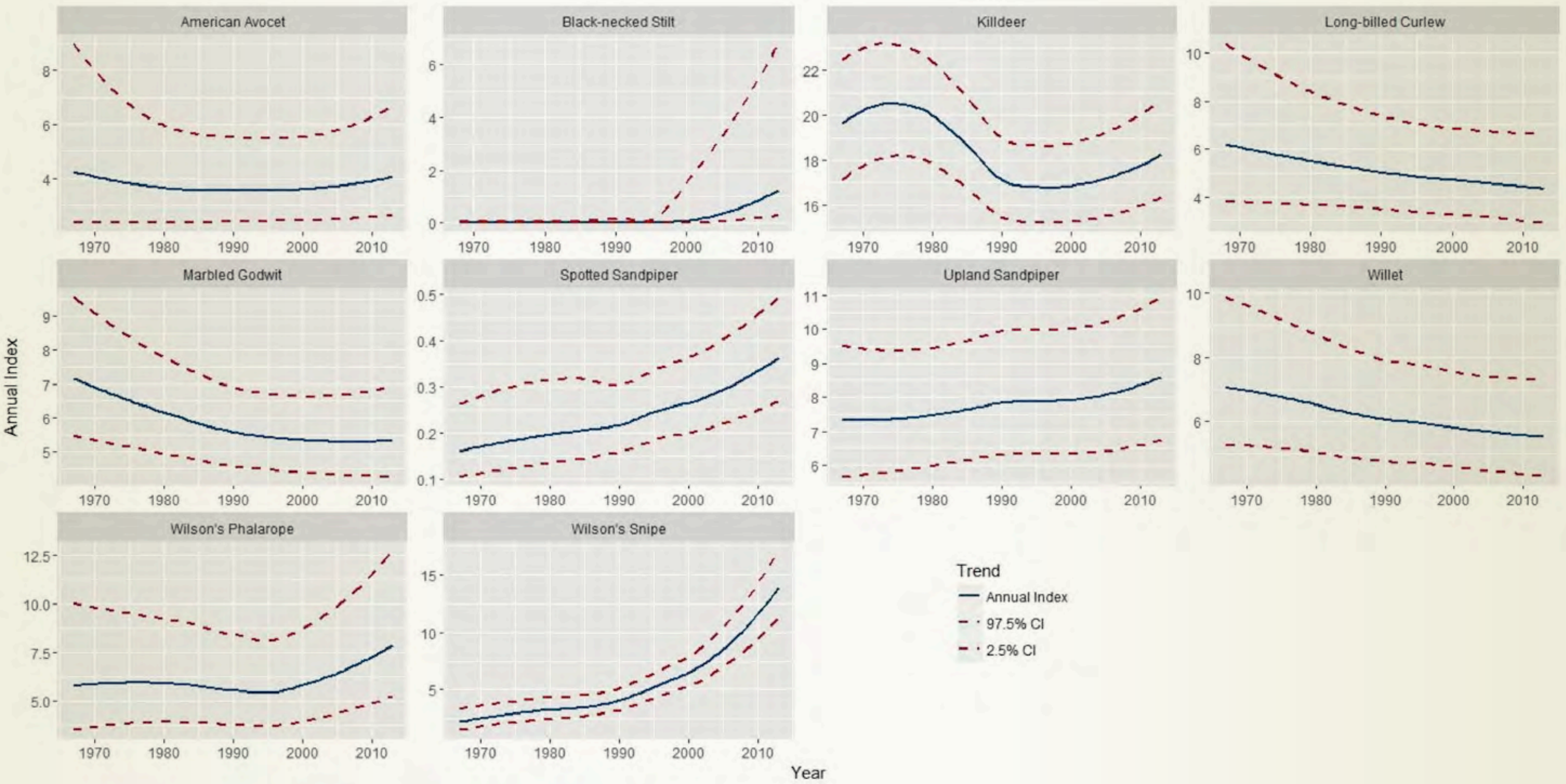


**Figure 6.** Annual relative abundance in the PPR for shorebirds that breed in the PPJV administrative area (Sauer et al. 2014*b*)

**Table 2.** PPR long- and short-term trend estimates and relative abundance from BBS surveys.

| Common Name | Code[1] | N[2] | Long-term Trend[3] | Short-term Trend[3] | Relative Abundance[4] |
|---|---|---|---|---|---|
| Black-necked Stilt | RED | 22 | 25.86 (7.41-58.41) | 8.50 (6.32-10.90) | 0.00 |
| American Avocet | BLUE | 172 | -0.05 (-1.80-1.50) | 1.00 (-2.05-5.11) | 3.40 |
| Killdeer | BLUE | 307 | -0.20 (-.58-0.17) | 0.63 (-0.37-1.66) | 19.05 |
| Long-billed Curlew | BLUE | 102 | -0.79 (-2.06-0.41) | -0.78 (-3.19-1.17) | 5.18 |
| Marbled Godwit | BLUE | 254 | -0.63 (-1.28-0.10) | 0.12 (-1.34-2.02) | 5.64 |
| Spotted Sandpiper | YELLOW | 197 | 1.81 (0.34-3.04) | 3.29 (-0.09-6.83) | 0.22 |
| Upland Sandpiper | BLUE | 250 | 0.30 (-0.35-0.93) | 0.32 (-1.33-1.71) | 7.92 |
| Willet | BLUE | 232 | -0.47 (-1.19-0.22) | 0.19 (-1.34-2.27) | 6.15 |
| Wilson's Phalarope | BLUE | 235 | 0.71 (-0.75-2.08) | 3.70 (0.00-8.76) | 5.40 |
| Wilson's Snipe | BLUE | 270 | 4.29 (3.17-5.32) | 8.55 (6.30-10.90) | 4.07 |

[1] Code indicates if data are deficient according to the abundance of a species detected, the number of routes where the species was detected, and the precision of the estimate. Red indicated major deficiencies, Yellow indicates some deficiencies, and Blue indicates no deficiencies.

[2] N is the number of routes where species were detected over the long-term interval.

[3] Trend estimates were calculated as the ratio of annual indexes from 1966-2013 or 2001-2010 and are presented as a % change/year. Credibility intervals are in parentheses and represent the 2.5% and 97.5% percentiles of the posterior distribution of trend estimates. If the credible interval does not contain 0, the result could be judged significant. Results that are judged unreliable (red credibility index) are not considered significant even if the CIs do not contain 0.

[4] Relative abundance is the annual index for the region from year 1988.

The U.S. Shorebird Conservation Plan Partnership (USSCPP) reevaluated species of conservation concern in light of updated information regarding shorebird population estimates, breeding and winter ranges, and threats to species based on a system developed by Partners in Flight (Panjabi et al. 2012) and categorized species of concern to be congruent with the 2014 Watch List (Rosenberg et al. 2014) and U.S. Fish and Wildlife Service Birds of Conservation Concern (BCC) 2016. They placed species into the following conservation categories based on certain score thresholds: listed according to the Endangered Species Act, Watch List (and BCC), moderate concern, and least concern. Those species contained in the Watch List are prioritized as greatest concern (red listed) and high concern (yellow listed); high concern is further defined as those species that have declining populations and elevated threats, and those that have small populations and ranges. Those listed as moderate concern are further defined as those that are vulnerable to climate change, and those that are common species in decline.

The 13 shorebirds that breed in the PPJV administrative area were given the following designations: Piping Plover is ESA listed as threatened; the Mountain Plover is of greatest concern; the American Woodcock, Long-billed Curlew, Willet, and Marbled Godwit are of high concern due to declining populations and threats; the American Avocet is of moderate concern and vulnerable to climate change; the Killdeer is of moderate concern and a common species in decline; and Black-necked Stilt, Spotted Sandpiper, Upland Sandpiper, Wilson's Phalarope, and Wilson's Snipe are of least concern. Of the 23 species that only migrate through (i.e., do not breed in) the PPJV administrative area, one is federally listed as threatened, 10 are on the Watch List, 4 are of moderate concern, and 8 are of least concern (see Appendix B for more detail regarding subspecies/population designations).

Priority species include Piping Plover, Mountain Plover, Marbled Godwit, Long-billed Curlew, Willet, American Avocet, Killdeer, Wilson's Phalarope, and Upland Sandpiper.

Neal & MJ Mishler

Regional conservation rankings (Skagen and Thompson 2001) were based on national rankings (Brown et al. 2001) and an area importance score that reflected the region's importance to species' population stability. The USSCP population estimates and target population goals, and the Regional conservation rankings have not been updated in lieu of updated population estimates (Andres et al. 2012) and conservation concern designations (USSCPP 2016). In addition, the 2015 prioritization system used a different method to categorize species and results are no longer comparable to previous rankings. Therefore we used population estimates from Andres et al. (2012), species designations from USSCPP 2016, and population percentages that pass through or breed in the PPJV administrative area as guidelines for designating PPJV priority species and populations estimates.

The 13 shorebirds that breed in the PPJV administrative area were given the following designations:

**Piping Plover** is ESA listed as threatened;

the **Mountain Plover** is of greatest concern;

the **American Woodcock**, **Long-billed Curlew**, **Willet**, and **Marbled Godwit** are of high concern due to declining populations and threats;

the **American Avocet** is of moderate concern and vulnerable to climate change;

the **Killdeer** is of moderate concern and a common species in decline;

and **Black-necked Stilt**, **Spotted Sandpiper**, **Upland Sandpiper**, **Wilson's Phalarope**, and **Wilson's Snipe** are of least concern.

Population proportions in the PPJV administrative area were estimated using BBS relative abundance spatial data (Sauer et al. 2014*a*), the 2006 Piping Plover Census (Elliott-Smith 2009), Mountain Plover abundance estimates in Phillips and Valley counties Montana (Childers and Dinsmore 2008), Long-billed Curlew abundance estimates from survey data (B. Andres, USFWS, personal communication), and migration estimates from Skagen et al. (2008; Appendix B). BBS grid data were downloaded from the BBS website for breeding species detected in the PPJV administrative area (Figure 2); relative abundance estimates for each species were associated with each grid cell and we calculated the proportion of sum relative abundance in the PPJV to the total sum relative abundance in North America. The caveats for BBS data listed on the website (e.g., unequal effort across strata, roadside bias, observer variability, etc.) apply to using this method. Especially relevant for shorebirds is the lack of survey routes in the northern parts of the breeding range, thus, some wetland species may not be well represented on BBS surveys. Despite these caveats, the results are useful in indicating the relative importance of the PPR to breeding populations. For Piping Plover, Mountain Plover, and Long-billed Curlew we used estimates from surveys to calculate the proportion of the total population estimate.

For some migratory species, we used estimates of abundance during migration in 2002 and 2003 in the PPJV administrative area from Skagen et al. (2008). Next, we calculated the proportion that passed through the area out of the total population estimate. Estimates were based on stratified random sampling of townships in the PPR of Minnesota, North Dakota, and South Dakota. Estimates depended on assumptions, such as length of stay, adjustments in chronology for peak of migration, and, and extrapolations to townships and landscape strata (based on the abundance of wetlands and cropland). Some of the regional population estimates by Skagen et. al (2008) derived from the migration surveys were greater than the global population estimates, and these estimates were adopted as new population estimates by Andres et al. (2012). Wetland conditions are thought to have a large impact on stopover site selection and length of stay, but it is impossible to quantify this effect until a long term dataset is established.

# BIOLOGICAL FOUNDATION

As with waterfowl and waterbirds, healthy wetland/grassland complexes are the biological foundation of shorebird conservation in the PPJV administrative area. Strategic planning for shorebirds is gaining momentum with the development and implementation of the U.S. Shorebird Conservation Plan and associated state and regional plans. The population estimates and appraisals previously described are the most comprehensive conducted for this group of birds. Data that have been collected for decades are being analyzed in new ways. Such analyses help to clarify information gaps so that research can be focused where it is most needed. In addition, the proliferation of GIS tools and expertise are being used in developing monitoring plans and for analyzing new and existing data. Data from these efforts have supported the selection of priority shorebird species, the development of biological models for conservation planning, and a measure of performance to evaluate conservation actions. Future efforts will focus on understanding fine-scale factors driving shorebird trends, how conservation actions can be most effectively directed to alleviate threats and limiting factors, and how to better evaluate the effect of conservation actions on shorebird populations.

**...healthy wetland/grassland complexes are the biological foundation of shorebird conservation in the PPJV administrative area.**

## Measures of Performance

Currently, the best metric for reflecting the success of PPJV programs are shorebird abundance or relative abundance estimates from surveys previously described. Estimates are currently imprecise or at coarse spatial scales; however, specific surveys designed to sample shorebirds within the PPJV administrative area have been underway, and the first step to improving performance metrics is creating spatially explicit shorebird abundance models using landscape characteristics. Future tasks that will require dedicated studies or long-term surveys within the PPJV administrative area to more effectively measure performance include: 1) surveys related to demographics (i.e., nest success, productivity, survival, etc.), 2) studies examining demographic limiting factors, and 3) studies related to bioenergetics and land use or landscape conditions. To date, information in these areas is rudimentary and research has not been conducted over long time periods or across wide areas.

## Assumptions and Key Uncertainties

It is necessary to assume that metrics of population abundance will be adequate to monitor population trends and will reflect population status. Only rudimentary information is available for life histories and habitat selection of many shorebirds species. A few species have been selected to represent the needs of other shorebirds. It is assumed that these species are adequate to represent the needs of other shorebirds. Because limiting factors are not known, it is uncertain if these species will be responsive to management and if those responses can be detected.

## Research Needs

The Northern Plains/Prairie Potholes Regional Shorebird Conservation Plan (Skagen and Thompson 2001) outlined priority tasks for the goal of identifying and filling information gaps for shorebirds in the region. The priorities included:

1. Developing spatially explicit monitoring programs to determine population status (increasing, decreasing, or stable) and provide data for (2.);
2. Characterizing landscapes that are conducive to high breeding productivity;
3. Estimating vital rates and identify limiting factors of breeding populations;
4. Choosing umbrella species, based on responses to threats and limiting factors, that represent the needs of multiple species;
5. Identifying factors that may limit the quality of stopover habitat.

Kevin Barnes

# PRIORITY SPECIES

## Breeding Species

This plan focuses on on species of moderate concern or higher if >5% of the population occurs in PPJV administrative area. Also included are species of least concern that have >25% of their population in the PPJV administrative area (Appendix B). Priority species include Piping Plover, Mountain Plover, Marbled Godwit, Long-billed Curlew, Willet, American Avocet, Killdeer, Wilson's Phalarope, and Upland Sandpiper. The diversity of habitat required by these species will require a holistic management approach. The 2001 Northern Plains/Prairie Potholes Regional Shorebird Conservation Plan designated many of the same regional priority species as is done in this document; however, their designations occurred prior to USSCPP updated list of species of conservation concern. The priority species in this Plan differ only in that Long-billed Curlew and Killdeer are included, and American Woodcock is excluded.

## Migrating Species

Although emphasis will be focused on priority breeding species, nearly all shorebirds that migrate through the PPJV administrative area warrant attention. There are 14 species/subspecies of moderate concern or higher that rely largely on PPJV stopover habitat, and 6 species of least concern that have >63% of their population migrating through the PPJV area. We recognize there is not a "one-size-fits-all" wetland/grassland condition we can prescribe to ensure these shorebirds have adequate resources to complete their migration; however, there would also be limited feasibility and success in focusing on so many individual species. There are also many species of concern that have migration strategies or low abundance that would limit the success of adaptive management conservation strategies. Therefore we chose to select species of high occurrence and high conservation concern that would represent the diversity of shorebird size (i.e., small, medium, and large), migration patterns (i.e., widespread, jump, crossband, or narrow band), and migration distances (i.e., intermediate or long-distance). These species include: Hudsonian Godwit, Short- and Long-billed Dowitchers, Lesser and Greater Yellowlegs, Stilt Sandpiper, Pectoral Sandpiper, Dunlin, and all small calidridines (Semipalmated, Least, White-rumped, and Baird's Sandpipers).


Kevin Barnes

# POPULATION AND HABITAT GOALS

## Goals

The USSCP represents an effort to create seamless, consistent goals and identify deficits for each North American shorebird species. At this time, on both national and regional scales, population estimates are tentative, goals are general, and tools do not exist that specifically relate population numbers or productivity to habitat characteristics. Common regional goals identified in the USSCP are to ensure availability of adequate habitat, integrate management with other bird initiatives, and better understand how local factors affect regional and hemispheric shorebird use.


Chuck Loesch

Goals from the Northern Plains/Prairie Potholes Regional Shorebird Plan (Skagen and Thompson 2001) are:

1. To attain self-sustaining populations of shorebirds breeding in the NP/PPR;
2. To ensure that stopover habitat is not limiting for migrant species;
3. To identify and fill in information gaps (see Research Needs above);
4. To coordinate with other conservation efforts at multiple spatial scales.

From the viewpoint that much information on shorebirds is tentative, we must proceed with what is known in general terms about habitat needs and work on filling the information gaps. In particular, there is a need to understand how the PPR contributes to the stability of hemispheric populations, and to remove impediments to that stability. It is important to bear in mind that though surveys and studies are currently being initiated or planned, the dynamic nature of prairie ecosystems requires a long term commitment to determine factors influencing shorebird population throughout changing weather conditions and successional cycles.

## Protection, Restoration, and Enhancement Objectives

Six key shorebird habitats for the PPR were identified in the regional shorebird plan: grasslands; grassland-wetland complexes; freshwater wetlands, including lake margins and impoundments; alkaline wetlands; riverine beaches; and, agricultural lands. Strategies for habitat protection, restoration, and enhancement are similar to those for other bird groups in making wise use of available USDA and USFWS programs. However, shorebirds may be unique in some respects because their affinity for shorter grass habitats may allow a greater flexibility in using active farm and rangeland. Cropland should not be considered a substitute for stopover habitat in uncultivated areas; most of the preliminary analyses presented in this plan indicate a strong preference for landscapes with a large grassland component. However, it would be imprudent to ignore the potential value of cropland and we should seek ways to enhance its use by shorebirds.

We need to promote restoration and protection of shallow wetlands and shortgrass habitats with the myriad agricultural programs available to private landowners, and to dovetail the implementation of these programs with the needs of landowners, shorebirds, and other migratory species. Many of the shorebird species that breed in the PPR are associated with uplands more than with wetlands, such as the Upland Sandpiper and Long-billed Curlew, and management practices should be more aligned with promoting healthy grasslands. The most important principle for management of shorebirds that use wetlands in the PPR is to maintain a wide variety of wetland and grassland types in various successional stages to ensure a consistent habitat base for breeders and migrants during all phases of the extreme climatic conditions that occur in prairie regions.

## Prioritization of Objectives

Piping Plover and Mountain Plover are the shorebird species in greatest conservation need in the PPJV administrative area. Efforts should be made to support protection of Piping Plover designated critical habitats (Federal Register 2002), and to enhance the potential for the return of Piping Plovers by protecting wetlands and alkali lakes with extensive beaches. Protection applies not only to securing each site, but to maintaining hydrology by protecting surrounding areas. McCauley et al. (2015) found that wetlands with more consolidation drainage in their catchment and wetlands that were fuller had a lower probability of Piping Plover presence. Practices that allow encroachment of vegetation should be discouraged. Shallow wetlands with sparse vegetation are also beneficial to many other breeding and migrating shorebirds. Protection is also a key component of strategies for Mountain Plover because their range is severely contracted. Supporting cattle grazing, burning, and prairie dog conservation will be key to this species’ persistence in the PPJV administrative area.

Protection of existing grassland and wetland complexes is necessary for the continuance of both breeding and migrating shorebirds in the PPJV administrative area, but probably not sufficient given the downward trends of most species. Enhancement of existing habitat quality and restoration of at least a portion of what has been lost must also be a priority. Existing habitat can be improved by promoting practices such as burning and grazing that reduce vegetation density around wetlands. Where burning is conducted on a rotational basis, habitat quality can be enhanced for other species that need greater densities of vegetation by increasing plant vigor, and would help to reduce the woody encroachment that is a problem for most prairie species. In areas where reed canary grass and cattail encroachment reduce habitat value for shorebirds (and waterfowl and wading birds), rigorous control methods need to be developed not only to improve the quality of the wetland, but to reduce plant populations before the problem spreads to currently unaffected areas. Late season drawdowns in both spring and fall can provide feeding habitat for spring and fall migrants and for local birds during molt and post-fledging periods.

Many USDA and USFWS private lands programs are designed to restore and improve wildlife habitat. Therefore, a related objective would be to ensure programs such as the USDA Agricultural Conservation Easement Program (ACEP), Environmental Quality Incentives Program (EQIP), and Conservation Stewardship Program (CSP) are well targeted and implemented within the PPJV administrative boundaries.

# ACTIONS AND TREATMENTS

There is limited funding for shorebird conservation, therefore a parsimonious approach is to leverage funding with integrated bird conservation. This is accomplished using shorebird habitat models that predict occurrence and/or abundance, which can then be integrated with other bird models, particularly waterfowl, to identify common areas of high biological value, or areas that can be enhanced or restored to create areas of high biological value. In short, identify priority areas using individual species models and use various funding sources and programs to protect, restore, or enhance wetlands and grasslands in those areas. For shorebirds, this would be most beneficial if actions produced large wetland and grassland complexes with a diversity of wetland regimes and heterogeneous vegetation structure. Vegetative heterogeneity can be accomplished with active management practices such as grazing, fire, and mowing, and programs that allow such management should be favored over those that create idle grasslands.

# BIOLOGICAL MODELS

To accomplish the goals of the Northern Plains/Prairie Potholes Regional Shorebird Conservation Plan (Skagen and Thompson 2001), there is an implicit need to obtain information on shorebird occurrence, abundance, and demographics, and obtain information on the landscapes where they occur. This includes identifying habitat needs and predicting occurrence to spatially prioritize areas for integrated bird conservation.

## Breeding Shorebirds

Although BBS data have been used to develop models of occurrence in PPR landscapes for grassland birds (see Niemuth et al. 2005), the timing of the BBS is not optimal for monitoring some species of breeding shorebirds (Niemuth et al. 2012). In 2016, U.S. Fish and Wildlife Service (USFWS) completed the fifth year of breeding shorebird surveys in the Montana PPJV glaciated plains region, and the 13th year of shorebird surveys in eastern Montana, North Dakota, and South Dakota PPJV regions. Surveys are similar to BBS roadside surveys; however, they were designed to adequately sample the environmental gradient of the landscape, and only focus on recording the abundance of 7 priority breeding shorebirds. Data from these roadside surveys have been used to create preliminary occurrence models that can be used in conjunction with waterfowl, waterbird, and landbird models to inform management decisions. They can also be used to identify habitat needs, and be used for population trend analyses although a longer dataset would be needed to infer trends. Continued collection of data will bolster the models and help refine or confirm priority areas for conservation delivery. Expansion of these surveys into Minnesota and Iowa is needed to gain a holistic understanding of shorebird habitat throughout the PPJV administrative area and how best to deliver conservation. Conceptual models will be used to guide shorebird conservation until the survey is operational and data are available to develop empirical models.

Models developed from shorebird survey data have already provided some preliminary guidance (Figures 7-8). Current validation of shorebird models in PPJV administrative areas in Montana indicated 5 of 7 shorebird models predict occurrence well to moderately well. The 5 models are those for American Avocet, Marbled Godwit, Willet, Wilson's Snipe, and Wilson's Phalarope. General trends indicate a positive association with wetland diversity, certain wetland regimes, and grasslands, and a negative association with CRP land, crop, forest, and shrubs. In general, occurrence was often high for these species in the Glaciated Northern and Dark Brown Prairie ecoregions. Occurrence was also high for Wilson's Snipe, Wilson's Phalarope, and Marbled Godwit in the Rocky Mountain Front Foothill Pothole and Foothill Grassland ecoregions, the Milk River Pothole Uplands ecoregion, and the Sweetgrass Uplands ecoregion, respectively. Long-billed Curlew and Upland Sandpiper preliminary models did not validate well due to generalized habitat requirements and low abundance, respectively.

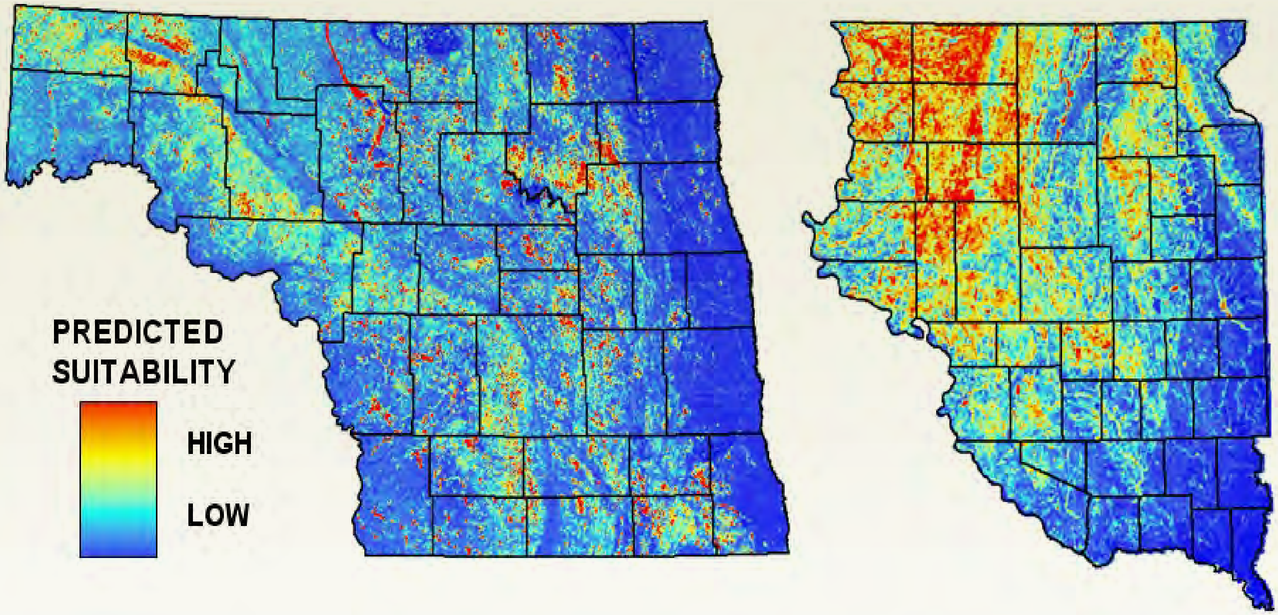
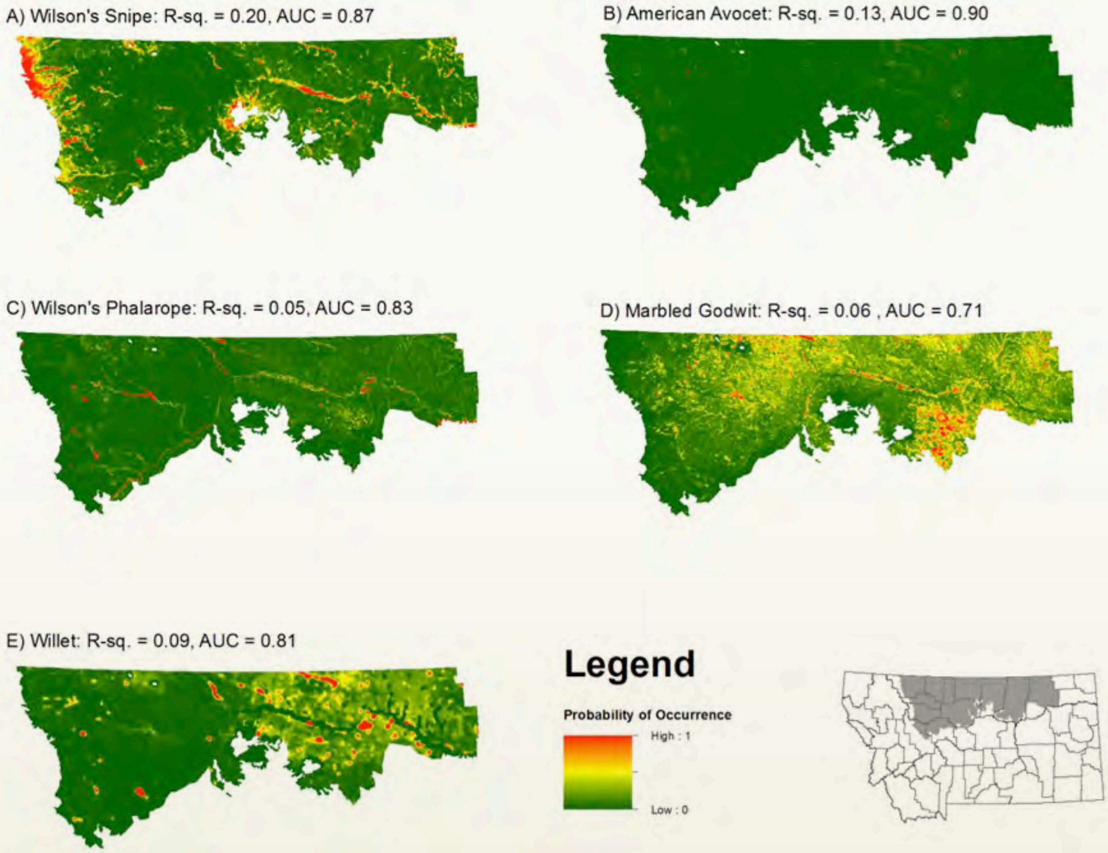


**Figure 7.** Preliminary models predicting suitability of breeding landscapes for Wilson's Phalarope in east-river North Dakota (left) and Willet in east-river South Dakota based on 2004 HAPET Breeding Shorebird Survey data. Models are based on landscape characteristics within 800 m of sample points as well as trend surface (e.g., easting, northing) variables.


A) Wilson's Snipe: R-sq. = 0.20, AUC = 0.87

B) American Avocet: R-sq. = 0.13, AUC = 0.90

C) Wilson's Phalarope: R-sq. = 0.05, AUC = 0.83

D) Marbled Godwit: R-sq. = 0.06 , AUC = 0.71

E) Willet: R-sq. = 0.09, AUC = 0.81

**Figure 8.** Probability of occurrence habitat models for Wilson's Snipe, American Avocet, Wilson's Phalarope, Marbled Godwit, and Willet in the MT PPJV administrative area. Models were created using 2011-2015 survey data, and wetland, land cover, and climactic spatial data. Ten-fold cross validation metrics are included for each species.

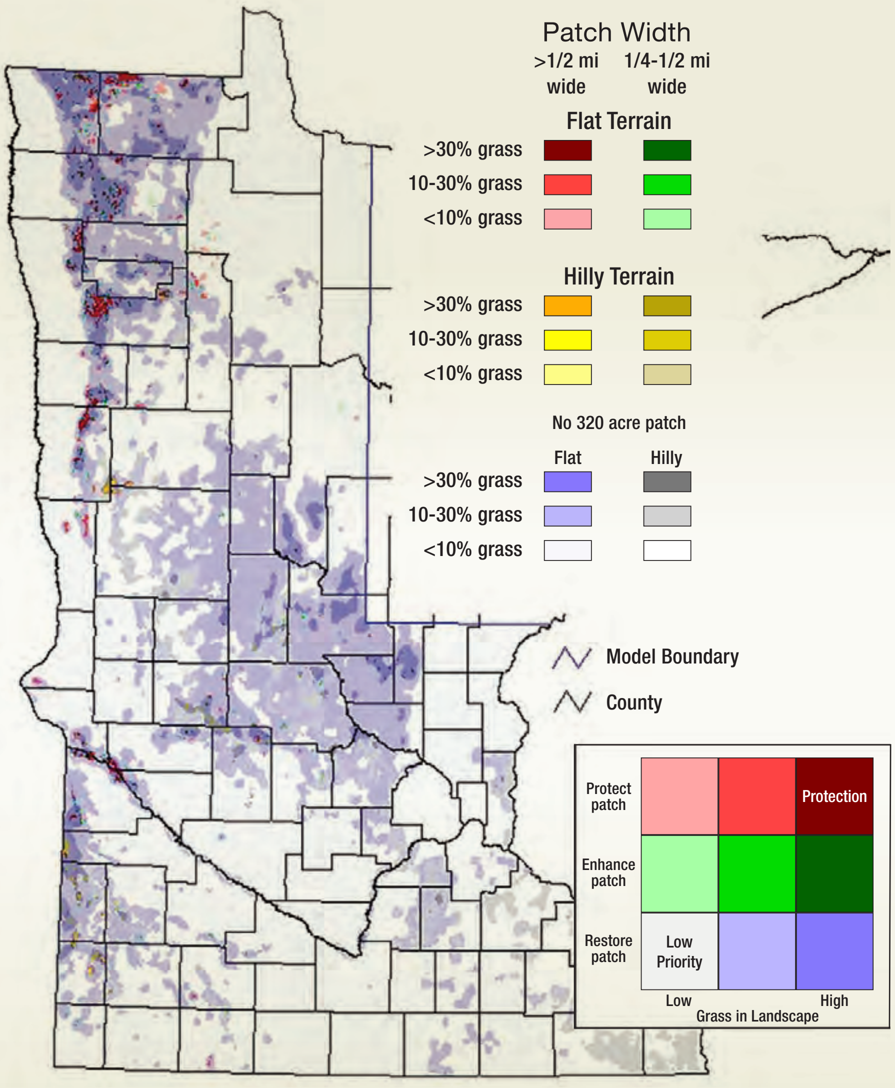


**Figure 9.** Conceptual model for Marbled Godwits based on expert knowledge of patch and landscape needs.

An alternative to models based on empirical data are models based on the expertise of shorebird biologists. To provide guidance for land use planning for Marbled Godwits in Minnesota, the HAPET office queried regional godwit experts on requisite and desirable landscapes and patches for breeding Marbled Godwits. These features were mapped to yield a spatially explicit conceptual model (Figure 9).

## Migrant Shorebirds

Migrant shorebirds have been addressed by the HAPET office, which completed analyses of a spring shorebird migration survey of agricultural landscapes of the Drift Prairie in North Dakota (Niemuth et al. 2006). Migrant shorebirds preferred temporary (versus seasonal) wetlands with extensive shorelines and receding water through early spring, but without evidence of drainage. It was also noted that shorebirds chose wetlands with more semipermanent and permanent wetlands in the surrounding landscape, indicating the need to consider conservation of wetland complexes rather than isolated wetlands.

Three broad spatial patterns emerged from analysis of 2 years of migration survey data for breeding and migrating shorebirds (Figure 10). The first pattern was that Marbled Godwit, American Avocet, and Willet were strongly associated with a high amount of grass in the landscape; highest suitability was on the Missouri and Prairie Coteaus, northern areas of the Drift Prairie, and the southern James River Lowlands (Figure 10A). The second pattern was provided by Wilson's Phalarope and Semipalmated

Sandpiper, which was similar to the first, but with higher suitability only on the eastern edge of the Missouri Coteau, on the Prairie Coteau, and in the Drift Prairie (Figure 10B). These two species were associated primarily with a high percentage of palustrine wetlands, secondarily with the amount of grass.

A third spatial pattern showed up for Upland Sandpiper, Dunlin, Hudsonian Godwit, and White-rumped Sandpiper, which were associated with shallow wetlands and not with a high amount of grass. These 4 species had an even lower suitability on the Coteaus and higher suitability in the Drift Prairie and James River lowlands (Figure 10C). Suitable areas for Dunlin appeared different between 2002 and 2003, in that wetlands were the dominant factor in 2002, whereas in 2003 the most important factor was level topography and the absence of grass. This indicates that inundated crop fields in the Glacial Lake Agassiz and Des Moines Lobe can play an important role in providing stopover habitat during the right climatic conditions.

Along with the three broad spatial patterns, the models for all 9 species indicated that habitat suitability is low in the Glacial Lake Agassiz and, with the exception of Dunlin, in the Des Moines Lobe, too. The high agricultural value of these areas encouraged drainage and cultivation to such a degree that palustrine wetlands and grasslands are nearly absent in these areas. However, they can have abundant sheetwater during wet springs which provides habitat for shorebirds even in (or because of) tilled cropland. Several areas in Minnesota are prominent on all maps, including the newly formed Glacial Ridge NWR as well as areas in Marshall, Kittson and Roseau Counties in northern Minnesota.

To address migrant shorebird needs region-wide, the USGS Fort Collins Science Center and HAPET office developed models to estimate landscape characteristics associated with migrant shorebird use. Survey sites were townships selected using a stratified random sample based on the amount of cropland (>60%, <60%) and wetlands (>8%, < 8%). Shorebirds were counted along 18 or more 1-mile road segments within each selected township. The initial models are based on landscape characteristics within townships. Predictor variables include average topographical slope, percent grass, percent palustrine wetland basins, and the proportion of palustrine wetlands with temporary or seasonal water regimes. Although the models predict probability of occurrence, in this context they are used as an index to landscape suitability. More spatially refined models are being developed based on individual road segments and/or wetlands, allowing more flexibility in defining optimum landscape size and the use of local wetland features as explanatory variables.

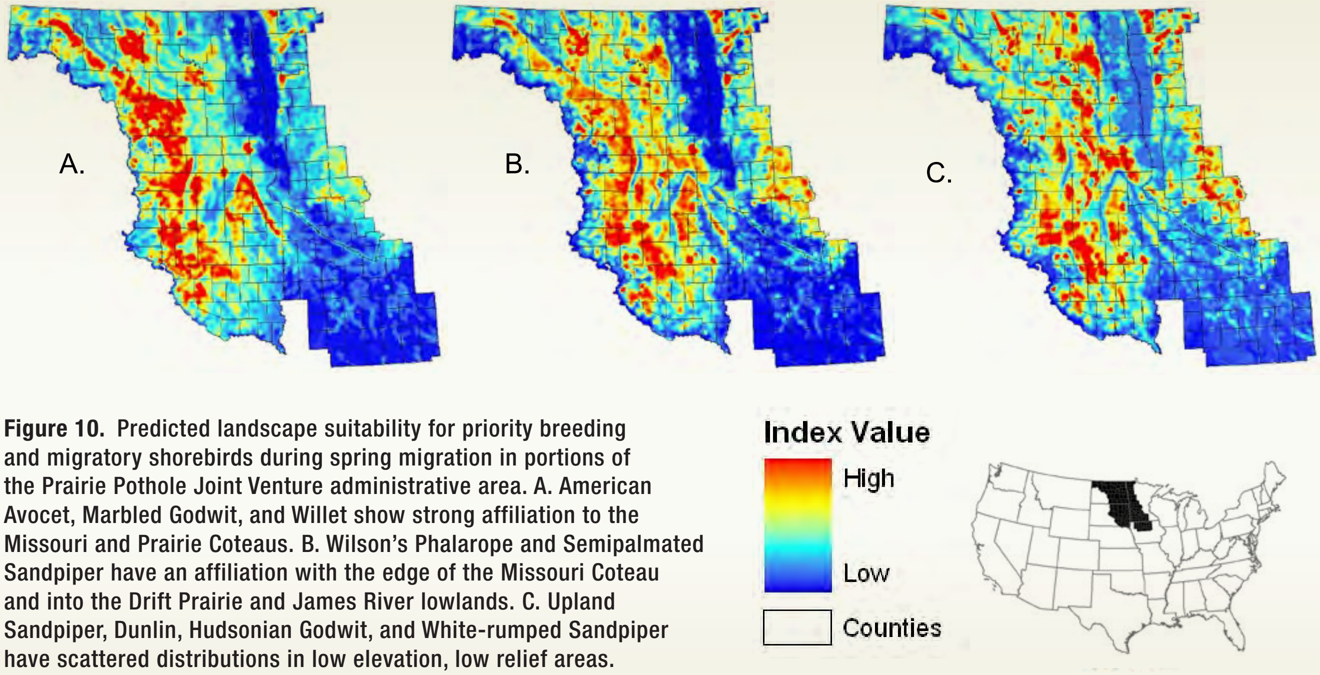


**Figure 10.** Predicted landscape suitability for priority breeding and migratory shorebirds during spring migration in portions of the Prairie Pothole Joint Venture administrative area. A. American Avocet, Marbled Godwit, and Willet show strong affiliation to the Missouri and Prairie Coteaus. B. Wilson's Phalarope and Semipalmated Sandpiper have an affiliation with the edge of the Missouri Coteau and into the Drift Prairie and James River lowlands. C. Upland Sandpiper, Dunlin, Hudsonian Godwit, and White-rumped Sandpiper have scattered distributions in low elevation, low relief areas.

# IMPLEMENTATION FRAMEWORK

HAPET will continue surveys and develop or improve empirical models. Currently, there is a need to finalize versions of occurrence models to define priority areas for integrated bird conservation. HAPET will also work on producing abundance models to gauge conservation success. The PPJV will continue collaboration with other state, federal, tribal, and non-government agencies to develop surveys or studies that lead to a better understanding of habitat needs, species distribution and abundance, demographics, and limiting factors. It will be imperative to utilize funding sources to protect, restore, and enhance wetlands and grasslands. This includes utilizing Farm Bill provisions that promote large blocks of heterogeneous grasslands and wetland complexes. In addition, programs that promote managed grasslands, such as incentives to retain grazing animals and prevent grassland conversion to cropland, or promoting mid-contract management for CRP land, would benefit shorebirds.

# PROGRAM DELIVERY, COORDINATION, AND TIMETABLE

Given the voluntary nature of joint ventures and present lack of dedicated funding for shorebird conservation, it is difficult to identify specific roles and assign duties for more than a few tasks. The HAPET offices in Bismarck, North Dakota and Fergus Falls, Minnesota will be responsible for implementing regional shorebird surveys, developing spatial planning tools, and evaluating conservation actions. A priority is to expand these tools and surveys into the PPJV areas of Minnesota and Iowa. The PPJV must also coordinate with Prairie Habitat Joint Venture partners in Canada to further shorebird conservation across the entire PPR.

# LITERATURE CITED

**Andres,** B. A., P. A. Smith, R. I. Guy Morrison, C. L. Gratto-Trevor, S. C. Brown, and C. A. Friis. 2012. Population estimates of North American shorebirds, 2012. Wader Study Group Bulletin 119:178-194.

**BirdLife International and NatureServe.** 2015. Bird species distribution maps of the world. BirdLife International, Cambridge, England, United Kingdom and NatureServe, Arlington, Virginia, USA.

**Brown,** S., C. Hickey, B. Harrington, and R. Gill, eds. 2001. The United States shorebird conservation plan, 2nd ed. Manomet Center for Conservation Sciences, Manomet, Massachusetts, USA.

**Butcher,** G. S., and D. K. Niven. 2007. Combining data from the Christmas Bird Count and the Breeding Bird Survey to determine the continental status and trends of North America birds. National Audubon Society, New York, USA.

**Carter,** M. F., W. C. Hunter, D. N. Pashley, and K. V. Rosenberg. 2000. Setting conservation priorities for landbirds in the United States: the Partners in Flight approach. Auk 117:541-548.

**Dinsmore,** S. J, S. K. Skagen, and D. L. Helmers. 1999. Shorebirds: overview for the Prairie Pothole Joint Venture. Special Publication, North American Waterfowl Management Plan, Prairie Potholes Joint Venture, Denver, Colorado, USA.

**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.

**Euliss,** N. H., Jr., and D. M. Mushet. 1999. Influence of agriculture on aquatic invertebrate communities of temporary wetlands in the prairie pothole region of North Dakota, USA. Wetlands 19:578-583.

**Federal Register.** 2002. Endangered and threatened wildlife and plants; designation of critical habitat for the Northern Great Plains breeding population of the piping plover. USFWS, DOI, 50 CFR Part 17.

**Ferland,** C. L., and S. M. Haig. 2002. 2001 International piping plover census. U.S. Geological Survey, Forest and Rangeland Ecosystem Science Center, Corvallis, Oregon, USA.

**Helmers,** D. L. 1992. Shorebird management manual. Western Hemisphere Shorebird Research Network, Manomet, Massachusetts, USA.

**Main,** A. R., J. V. Headley, K. M. Peru, N. L. Michel, A. J. Cessna, and C. A. Morrissey. 2014. Widespread use and frequent detection of neonicotinoid insecticides in wetlands of Canada's Prairie Pothole Region. PLoS One 9(3):e92821.

**McCauley,** L. A., M. J. Anteau, and M. P. van der Burg. 2016. Consolidation drainage and climate change may reduce Piping Plover habitat in the Great Plains. Journal of Fish and Wildlife Management 7:4-13.

**Morrissey,** C. A., P. Mineau, J. H. Devries, F. Sanchez-Bayo, M. Liess, M. C. Cavallaro, and K. Liber. 2015. Neonicotinoid contamination of global surface waters and associated risk to aquatic invertebrates: a review. Environment International 74:291-303.

**Morrison,** R. I. G., R. E. Gill, Jr., B. A. Harrington, S. Skagen, G. W. Page, C. L. Gratto-Trevor, and S. M. Haig. 2001. Estimates of shorebird populations in North America. Occasional Paper No. 104, Canadian Wildlife Service, Ontario, Canada.

**Naugle,** D. E. 1997. Habitat area requirements of prairie wetland birds in eastern South Dakota. Dissertation, South Dakota State University, Brookings, USA.

**Niemuth,** N. D., M. E. Estey, and C. R. Loesch. 2005. Developing spatially explicit habitat models for grassland bird conservation planning in the Prairie Pothole Region of North Dakota. Pages 469-477 in Bird Conservation Implementation and Integration in the Americas: Proceedings of the Third International Partners in Flight Conference 2002, C. J. Ralph and T. D. Rich, eds. USDA Forest Service GTR-PSW-191, Albany, California, USA.

**Niemuth,** N. D., M. E. Estey, R. E. Reynolds, C. R. Loesch, and W. A. Meeks. 2006. Use of wetlands by spring migrant shorebirds in agricultural landscapes of the drift prairie of North Dakota. Wetlands 26:30-39.

**Niemuth,** N. D., M. E. Estey, and R. E. Reynolds. 2012. Factors influencing presence and detection of breeding shorebirds in the Prairie Pothole Region of North Dakota, South Dakota, and Montana. Wader Study Group Bulletin 119:37-45.

**Panjabi,** A. O., P. J. Blancher, R. Dettmers, and K. V. Rosenberg. 2012. The Partners in Flight handbook on species assessment, version 2012. Partners in Flight Technical Series No. 3, Rocky Mountain Bird Observatory, Fort Collins, Colorado, USA.

**Rosenberg,** K. V., D. Pashley, B. Andres, P. J. Blancher, G. S. Butcher, W. C. Hunter, D. Mehlman, A. O. Panjabi, M. Parr, G. Wallace, and D. Wiedenfeld. 2014. The State of the Birds 2014 Watch List. North American Bird Conservation Initiative, U.S. Committee, Washington, D.C., 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. U.S. Geological Survey, Patuxent Wildlife Research Center, Laurel, Maryland, USA.

**Sauer,** J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski, Jr., and W. A. Link. 2014a. The North American Breeding Bird Survey, Results and Analysis 1966 - 2012. Version 02.19.2014 USGS Patuxent Wildlife Research Center, Laurel, Maryland, USA.

**Sauer,** J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski, Jr., and W. A. Link. 2014b. The North American Breeding Bird Survey, Results and Analysis 1966 - 2013. Version 01.30.2015 USGS Patuxent Wildlife Research Center, Laurel, Maryland, USA.

**Skagen,** S. K., and F. L. Knopf. 1993. Towards conservation of midcontinental shorebird migrations. Conservation Biology 7:533-541.

**Skagen,** S. K., P. B. Sharpe, R. G. Waltermire, and M. B. Dillon. 1999. Biogeographical profiles of shorebird migration in midcontinental North America. Biological Science Support USGS/BRD/BSR—200-0003. U.S. Government Printing Office, Denver, Colorado, USA.

**Skagen,** S. K., D. A. Granfors, and C. P. Melcher. 2008. On determining the significance of ephemeral continental wetlands to North American migratory shorebirds. Auk 125:20-29.

**Skagen,** S. K., and G. Thompson. 2001. Northern plains/prairie potholes regional shorebird conservation plan, version 1.0 *http://www.shorebirdplan.org/wp-content/uploads/2013/01/NORPLPP2.pdf*

**U.S. Shorebird Conservation Plan Partnership.** 2016. U.S. Shorebirds of Conservation Concern — 2016. *http://www.shorebirdplan.org/science/assessment-conservation-status-shorebirds*

# SHOREBIRD PLAN APPENDIX A:

# SHOREBIRD HABITAT DESCRIPTIONS

General habitat descriptions for shorebirds breeding in the PPJV administrative area. Water depth, wetland size, and vegetation height and density adapted from Helmers (1992).

| Species | Habitat Description | Water depth[1] | Wetland size[2] | Veg height[3] | Veg density[4] | Citations |
|---|---|---|---|---|---|---|
| Upland Sandpiper | Obligate grassland species and indicator species of native prairie. Prefers large blocks of grassland with a mosaic of vegetation structure. Nests in taller grass (~26 cm, moderate density), and forages in shorter grass (often grazed, burned, or mowed the previous season). Will use pasture and hay to a lesser extent. | n | n | s-t | s-m | Dorio and Grewe 1979, Kantrud and Higgins 1992, Dechant et al. 2002, Vickery 2010 |
| Mountain Plover | Typically found in dry shortgrass landscapes with low sparse vegetation that has been disturbed (i.e., burned or heavily grazed). Most often associated with prairie dog colonies. Nests in areas with at least 30% bare ground. | n | n | s | s | Knopf and Miller 1994, Knopf and Wonder 2006, Childers and Dinsmore 2008, Augustine and Derner 2012, 2015 |
| Long-billed Curlew | Makes extensive use of uplands during the breeding season; however, occurrence is positively associated with local wetland conditions. Typically use landscapes with short and sparse vegetation < 10 cm (i.e., pasture/rangeland in shortgrass landscape) and avoid trees and shrubs. Will nest and forage in wheat and hay fields. | n-m | n-l | s | m | Allen 1980, Jenni et al. 1981, Cochrane and Anderson 1987, Pampush and Anthony 1993, Devries et al. 2010, Saalfeld et al. 2010 |
| Marbled Godwit | Grasslands associated with shallow wetlands. Will use grassland, pasture, and to a lesser extent hay fields. Vegetation typically < 15 cm. Prefer grazed native grassland over idle native or introduced grassland and alfalfa/wheatgrass. Prefers ephemeral, temporary, and seasonal wetlands, and to a lesser extent, semipermanent wetlands (especially in dry years). Use wetlands containing short sparse vegetation. | s-m | s-l | m | m | Higgins et al. 1979, Ryan et al. 1984, Renken and Dinsmore 1987, Johnson et al. 1998 |
| Willet | Grasslands associated with shallow wetlands. Will use native grass and to a lesser extent cropland. Vegetation typically < 15 cm. Breeding adults and broods usually found near water. Prefer ephemeral, temporary, and seasonal over semipermanent and permanent wetlands. Use wetlands containing short sparse vegetation. Broods and adults typically found close to wetlands. | s-m | l | m | m | Higgins et al. 1979, Ryan and Renken 1987, Kantrude and Higgins 1992 |
| Killdeer | Usually associated with open areas and bare ground/short sparse vegetation. Will use shoreline, sandbars, mudflats, shortgrass prairie, prairie dog colonies, and human-disturbed landscape (e.g., gravel parking lots, mowed grass, and cropland). | s | s-l | n-s | n-s | Skinner et al. 1984, Kantrude and Higgins 1992, Jackson and Jackson 2000 |
| Spotted Sandpiper | Use a variety of habitats, but all territories typically include shoreline for forage and have surrounding vegetation for nesting and brood rearing. | s-m | s | n-m | n-m | Maxson and Oring 1980, Oring et al. 1983 |

| Species | Habitat Description | Water depth[1] | Wetland size[2] | Veg height[3] | Veg density[4] | Citations |
|---|---|---|---|---|---|---|
| Piping Plover | Generally favor open areas with sparsely vegetated sand or gravel near large alkali lakes.Also occur near reservoirs, rivers, lakes, sand/gravel pits, etc. Wetlands are usually adjacent to shortgrass or midgrass prairie. Nest in areas with < 20% cover, usually on sand/gravel substrate. | s | l | n-s | n-s | Whyte 1985, Haig 1986, Gaines and Ryan 1988 |
| Black-necked Stilt | In the interior, they are typically found in shallow freshwater emergent wetlands, but also flooded lowlands or permanently flooded pastures. Will usually nest near water on islets or dikes, but also on emergent vegetation over water. Will forage at depths < 18 cm. | s-m | l | s | s | Hamilton 1975 |
| American Avocet | Usually occur in alkali wetlands, salt ponds, mudflats or lakes/impoundments/ponds that contain areas to forage with water depths from < 18 cm. Prefer to nest on islands containing sparse vegetation. Can be found on ephemeral ponds and usually occur in areas containing a variety of water regimes. | s-m | l | s | s | Hamilton 1975, Lokemoen and Woodward 1992, Koper and Schmiegelow 2006, Niemuth et al. 2012 |
| Wilson's Phalarope | Open water wetlands with surrounding grass. Will use deeper water. Nests often within 100 m of wetland in areas containing taller, denser and more heterogeneous vegetation than random points in the same area. | s-d9 | l | m | m | Colwell and Oring 1988a, 1988b, Colwell and Oring 1990, Naugle 1997 |
| Wilson's Snipe | Prefers marshy areas with soft organic soil. Avoids marshes with dense vegetation; prefers clumped vegetation and a mean water depth of 3.5 cm. Nests close to wetland on hummocks. Will use woody wetlands. | s | s-l | m | d | Tuck 1972, Mueller 1999 |
| American Woodcock | Not a prairie species. Found in early successional habitat in young deciduous forests. Occur in regions with moist organic soil with low clay content for probing. Rely heavily upon earthworms. In the western part of its range (i.e., eastern portion of PPR) it could be reliant upon moist woody riverine systems, young encroaching forests, and wet meadows. | s | s-l | s-t | s-d | Owen and Galbraith 1989, Sepik and Derleth 1993, Keppie et al. 2013 |

[1] n= none, s=shallow, m=moderate, and d=deep

[2] n=none, s=small, m=medium, and l=large

[3] n=none, s=short, m=medium, and t=tall

[4] n=none, s=sparse, m=moderate, and d=dense

## LITERATURE CITED

**Allen,** J. N. 1980. The ecology and behavior of the Long-billed Curlew in southeastern Washington. Wildlife Monographs 73:1-67.

**Augustine,** D. J., and J. D. Derner. 2012. Disturbance regimes and Mountain Plover habitat in shortgrass steppe: large herbivore grazing does not substitute for prairie dog grazing or fire. Journal of Wildlife Management 76:721-728.

**Augustine,** D. J., and J. D. Derner. 2015. Patch-burn grazing management, vegetation heterogeneity, and avian responses in a semi-arid grassland. Journal of Wildlife Management 79:927-936.

**Childers,** T.M., and S.J. Dinsmore. 2008. Density and abundance of Mountain Plovers in northeastern Montana. Wilson Journal of Ornithology 120:700-707.

**Cochrane,** J. F., and S. H. Anderson. 1987. Comparison of habitat attributes at sites of stable and declining Long-billed Curlew populations. Great Basin Naturalist 47:459-466.

**Colwell,** M. A., and L. W. Oring. 1988*a*. Breeding biology of Wilson's Phalarope in southcentral Saskatchewan. Wilson Bulletin 100:567-582.

**Colwell,** M. A., and L. W. Oring. 1988*b*. Habitat use by breeding and migrating shorebirds in southcentral Saskatchewan. Wilson Bulletin 100:554-566.

**Colwell,** M. A., and L. W. Oring. 1990. Nest site characteristics of prairie shorebirds. Canadian Journal of Zoology 68:297-302.

**Dechant,** J. A., M. F. Dinkins, D. H. Johnson, L. D. Igl, C. M. Goldade, B. D. Parkin, and B. R. Euliss. 2002. Effects of management practices on grassland birds: Upland Sandpiper. U.S. Geological Service Northern Prairie Wildlife Research Center Paper 118.

**Devries,** J. H., S. O. Rimer, and E. M. Walsh. 2010. Cropland nesting by Long-billed Curlews in southern Alberta. Prairie Naturalist 42:123-129.

**Dorio,** J. C., and A. H. Grewe. 1979. Nesting and brood rearing habitat of the Upland Sandpiper. Journal of the Minnesota Academy of Science 45:8-11.

**Gaines,** E. P., and M. R. Ryan. 1988. Piping Plover habitat use and reproductive success in North Dakota. Journal of Wildlife Management 52:266-273.

**Haig,** S. M. 1986. Piping Plover distribution and biology. Endangered Species Information System Workbooks. U.S. Fish and Wildlife Service, Washington, D.C., USA.

**Hamilton,** R. B. 1975. Comparative behavior of the American Avocet and the Black-necked Stilt (*Recurvirostridae*). Ornithological Monographs 17:1-98.

**Higgins,** K. F., L. M. Kirsch, M. R. Ryan, and R. B. Renken. 1979. Some ecological aspects of Marbled Godwits and Willets in North Dakota. Prairie Naturalist 11:115-118.

**Jackson,** B. J., and J. A. Jackson. 2000. Killdeer (*Charadrius vociferus*). *In* The Birds of North America Online, A. Poole, editor. Cornell Lab of Ornithology, Ithaca, New York, USA.

**Jenni,** D. A., R. L. Redmond, and T. K. Bicak. 1981. Behavioral ecology and habitat relationships of Long-billed Curlew in western Idaho. Bureau of Land Management, Boise District, Idaho, USA.

**Johnson,** D. H., L. D. Igl, J. A. Dechant, M. L. Sondreal, and C. M. Goldade. 1998. Effects of management practices on grassland birds: Marbled Godwit. Northern Prairie Wildlife Research Center, Jamestown, North Dakota, USA.

**Kantrud,** H. A., and K. F. Higgins. 1992. Nest and nest site characteristics of some ground-nesting, non-passerine birds of northern grasslands. Prairie Naturalist 24:67-84.

**Knopf,** F. L., and B. J. Miller. 1994. *Charadrius montanus* - montane, grassland, or bare-ground plover? Auk 111:504-506.

**Knopf,** F. L., and M. B. Wunder. 2006. Mountain Plover (*Charadrius montanus*). *In* The Birds of North America Online, A. Poole, editor. Cornell Lab of Ornithology, Ithaca, New York. USA.

**Koper,** N., and F. K. A. Schmiegelow. 2006. Effects of habitat management for ducks on target and nontarget species. Journal of Wildlife Management 70:823-834.

**Lokemoen,** J. T., and R. O. Woodward. 1992. Nesting waterfowl and water birds on natural islands in the Dakotas and Montana. Wildlife Society Bulletin 20:163-171.

**Maxson,** S. J., and L. W. Oring. 1980. Breeding season time and energy budgets of the polyandrous Spotted Sandpiper. Behaviour 74:200-263.

**McAuley,** D., D. M. Keppie, and R. M. Whiting, Jr. 2013. American Woodcock (*Scolopax minor*). *In* The Birds of North America Online, A. Poole, editor. Cornell Lab of Ornithology, Ithaca, New York, USA.

**Mueller,** Helmut. 1999. Wilson's Snipe (*Gallinago delicata). In* The Birds of North America Online, A. Poole, editor. Cornell Lab of Ornithology, Ithaca, New York, USA.


Casey Stemler

**Naugle,** D. E. 1997. Habitat area requirements of prairie wetland birds in eastern South Dakota. Dissertation, South Dakota State University, Brookings, USA.

**Niemuth,** N. D., M. E. Estey, and R. E. Reynolds. 2012. Factors influencing presence and detection of breeding shorebirds in the Prairie Pothole Region of North Dakota, South Dakota, and Montana, USA. Wader Study Group Bulletin 119:37-45.

**Oring,** L. W., D. B. Lank, and S. J. Maxson. 1983. Population studies of the polyandrous Spotted Sandpiper. Auk 100:272-285.

**Owen,** Jr., R. B., and W. J. Galbraith. 1989. Earthworm biomass in relation to forest types, soil and land use: implications for woodcock management. Wildlife Society Bulletin 17:130-136.

**Pampush,** G. J., and R. G. Anthony. 1993. Nest success, habitat utilization and nest-site selection of Long-billed Curlews in the Columbia Basin, Oregon. Condor 95:957-967.

**Renken,** R. B., and J. J. Dinsmore. 1987. Nongame bird communities on managed grasslands in North Dakota. Canadian Field-Naturalist 101:551-557.

**Ryan,** M. R., R. B. Renken, and J. J. Dinsmore. 1984. Marbled Godwit habitat selection in the northern prairie region. Journal of Wildlife Management 48:1206-1218.

**Ryan,** M. R. and R. B. Renken. 1987. Habitat use by breeding Willets in the northern Great Plains. Wilson Bulletin 99:175-189.

**Saalfeld,** S. T., W. C. Conway, D. A. Haukos, M. Rice, S. L. Jones, and S. D. Fellows. 2010. Multiscale habitat selection by Long-billed Curlews (*Numenius americanus*) breeding in the United States. Waterbirds 33:148-161.

**Sepik,** G. F., and E. L. Derleth. 1993. Habitat use, home range size, and patterns of moves of the American Woodcock in Maine. Proceedings of the Woodcock Symposium 8:41-49.

**Skinner,** R. M., T. S. Baskett, and M. D. Blenden. 1984. Bird habitat on Missouri prairies. Terrestrial Series no. 14. Missouri Department of Conservation, Jefferson City, USA.

**Tuck,** L. M. 1972. The snipes: a study of the genus *Capella*. Canadian Wildlife Service Monographs Series, No. 5.

**Vickery,** P. D., D. E. Blanco, and B. López-Lanús. 2010. Conservation plan for the Upland Sandpiper (*Bartramia longicauda*). Version 1.1. Manomet Center for Conservation Sciences, Manomet, Massachusetts, USA.

**Whyte,** A. J. 1985. Breeding ecology of the Piping Plover (*Charadrius melodus*) in central Saskatchewan. Thesis, University of Saskatchewan, Saskatoon, Canada.

# SHOREBIRD PLAN APPENDIX B:

## SHOREBIRD DEMOGRAPHICS

Shorebirds with name in bold are priority species.

| Common name / Subsp. (Population) | Status[1] | Concern[2] | Long-term Trend[3] | Short-term Trend[3] | 2012 Population Estimate[4] | Confidence[4] | % Population in PPJV[5] | 2001 Population estimate[6] | 2001 Target Population[6] | Population estimate in PPJV | Population target in PPJV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **American Avocet** | B | Moderate 1 | STA | STA | 450,000 | low | 0.09 | 450,000 | 450,000 | 41,618 | 41,618 |
| American Woodcock | b | High 1 | DEC | STA | 3,500,000 | high | 0.00 | no estimate | not listed | 0 | |
| **Black-necked Stilt** / *mexicanus* | b | Least | INC | INC | 175,000 | low | 0.00 | 150,000 | 150,000 | 32 | |
| **Killdeer** / *vociferus* | B | Moderate 2 | DEC | dec | 2,000,000 | low | 0.18 | 2,000,000 | 2,440,000 | 350,981 | 428,196 |
| **Long-billed Curlew** | B | High 1 | dec | STA | 140,000 | Moderate | 0.26 | 20,000 | 28,500 | 36,500 | |
| **Marbled Godwit** / *fedoa* (Plains) | B | High 1 | dec | STA | 170,000 | Moderate | 0.34 | 168,000 | 258,500 | 57,919 | |
| **Mountain Plover** | B | Greatest | dec | dec | 20,000 | Moderate | 0.05 | 9,000 | 20,000 | 1,700 | |
| **Piping Plover** / *circumcinctus* (Great Plains) | B | ESA Listed | STA | STA | 4,700 | Moderate | 0.28 | 3,300 | 6,000 | 1,316 | |
| Spotted Sandpiper | B | Least | STA | STA | 660,000 | Low | 0.05 | 150,000 | 150,000 | 36,008 | |
| **Upland Sandpiper** | B | Least | INC | inc | 750,000 | Moderate | 0.31 | 350,000 | 470,000 | 231,253 | |
| **Willet** / *inornata* | B | High 1 | dec | STA | 160,000 | Low | 0.18 | 160,000 | 160,000 | 29,035 | 29,035 |
| **Wilson's Phalarope** | B | Least | dec | UNK | 1,500,000 | Low | 0.30 | 1,500,000 | 2,800,000 | 449,437 | 838,949 |
| Wilson's Snipe | B | Least | STA | STA | 2,000,000 | Low | 0.12 | 2,000,000 | 4,345,000 | 237,269 | 515,468 |
| American Golden-Plover | m? | High 1 | dec | UNK | 500,000 | Moderate | UNK | 150,000 | ? | | |
| **Baird's Sandpiper** | M | Least | UNK | UNK | 300,000 | Low | 0.63 | 300,000 | 300,000 | 189,000 | 189,000 |
| **Black-bellied Plover** / *cynosurae* | M? | Moderate 1 | DEC | STA | 100,000 | Moderate | 0.19 | 50,000 | 90,900 | 18,897 | |
| **Buff-breasted Sandpiper** | M? | High 1 | DEC | UNK | 56,000 | Moderate | UNK | 15,000 | 150,000 | | |
| **Dunlin** / *hudsonia* | M | High 2 | STA | STA | 450,000 | Low | 0.83 | 225,000 | > 225,000 | 374,787 | |
| **Greater Yellowlegs** | M | Least | STA | STA | 137,000 | Low | 0.77 | 100,000 | 100,000 | 105,971 | |
| **Hudsonian Godwit** | M | High 2 | STA | STA | 77,000 | Moderate | 0.92 | 50,000 | 54,700 | 70,710 | |
| **Least Sandpiper** | M | Least | STA | STA | 700,000 | Moderate | 0.91 | 600,000 | 1,400,000 | 634,582 | |
| **Lesser Yellowlegs** | M | High 1 | DEC | DEC | 660,000 | Low | 0.86 | 500,000 | 2,400,000 | 567,156 | |

| Common name / Subsp. (Population) | Status[1] | Concern[2] | Long-term Trend[3] | Short-term Trend[3] | 2012 Population Estimate[4] | Confidence[4] | % Population in PPJV[5] | 2001 Population estimate[6] | 2001 Target Population[6] | Population estimate in PPJV | Population target in PPJV |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Long-billed Dowitcher** | M | Least | UNK | UNK | 500,000 | Moderate |  | 500,000 | 500,000 |  |  |
| Marbled Godwit / *fedoa* (Hudson Bay) | M* | High 1 | UNK | STA | 2,000 | Moderate | UNK | 2,000 | 2,000 |  |  |
| **Pectoral Sandpiper** | M | High 1 | DEC | DEC | 1,600,000 | Moderate | 0.45 | 400,000 | 400,000 | 713,424 |  |
| Red Knot / *rufa* | m? | ESA Listed | DEC | DEC | 42,000 | High | UNK | 170,000 | 240,000 |  |  |
| Red-necked Phalarope | m | Moderate 2 | dec | UNK | 2,500,000 | Low | 0.03 | 2,500,000 | 5,000,000 | 83,530 | 167,060 |
| Ruddy Turnstone / *morinella* | m? | High 1 | DEC | DEC | 180,000 | Moderate | 0.01 | 180,000 | > 180,000 | 1,000 |  |
| Sanderling | m? | Moderate 1 | dec | dec | 300,000 | Low | UNK | 300,000 | 1,500,000 |  |  |
| Semipalmated Plover | M | Least | INC | STA | 200,000 | Low | 0.31 | 150,000 | 150,000 | 61,999 |  |
| Semipalmated Sandpiper / (Central and Western) | M | High 1 | dec | STA | 1,855,000 | Moderate | 0.40 |  |  |  |  |
| Semipalmated Sandpiper/ (Central Western Eastern) |  | High 1 | dec | STA | 2,260,000 | Moderate | 0.33 | 3,500,000 | 8,200,000 | 906,050 |  |
| **Short-billed Dowitcher** / *griseus & hendersoni* | M | High 1 | STA | STA | 78,000 | Low |  | 210,000 | ? |  |  |
| Short- and Long-billed Dowitchers | M |  |  |  | 578,000 |  | 1 | 860,000 | ? | 578,000 |  |
| Solitary Sandpiper | M | Least | UNK | UNK | 126,000 | Low | 0.13 | 25,000 | > 25000 | 16,426 |  |
| **Stilt Sandpiper** | M | Least | dec | STA | 1,243,700 | Low | 1 | 200,000 | 200,000 | 1,243,700 |  |
| Western Sandpiper | m | Moderate 1 | dec | dec | 3,500,000 | Moderate | UNK | 3,500,000 | 3,500,000 |  |  |
| Whimbrel / *hudsonicus* | M* | High 1 | dec | dec | 45,000 | Low |  | 17,000 | 42,500 |  |  |
| **White-rumped Sandpiper** | M | Least | STA | STA | 1,694,000 | Low | 1 | 400,000 | 400,000 | 1,694,000 |  |

[1] b or m = < 5 % population; B or M = 5 - < 25 % population; **B** or **M** = > 25 % population; ? = evidence lacking; * = inferred from telemetry studies

[2] From USSCP 2015, High1 = Steep declines and elevated threats; High 2 = Small population and range; Moderate 1 = Vulnerable to Climate Change; Moderate 2 = Common shorebird in decline

[3] From Andres et al. 2012, DEC = significant decline; dec = apparent decline; STA or UNK = stable or unknown; inc = apparent increase; INC = significant increase

[4] Population estimates and confidence from Andres et al. 2012; bold confidence estimates indicate they were derived from a study rather than expert opinion.

[5] Proportions for shorebirds that breed in the PPJV administrative area were derived from BBS relative abundance spatial data; however, Piping Plover estimates were from Elliott-Smith et al. (2011), Mountain Plover were from Childers and Dinsmore (2008), and Long-billed Curlew from B. Andres (USFWS, personal communication). Proportions for migratory species were from Skagen et al. (2008) estimates.

[6] Population estimates and target population goals were from USSCP 2001

# SHOREBIRD PLAN APPENDIX C:

## VITAL RATES AND THREATS FOR SHOREBIRDS THAT BREED IN THE PPJV ADMINISTRATIVE AREA

| Species | Vital Rate | Threat/Stressor | Estimate | Location | Notes |
|---|---|---|---|---|---|
| LBCU | Longevity | | 8-10 yrs | ID | Redmond and Jenni 1986 |
| LBCU | Adult Survival | | 85% | ID | Redmond and Jenni 1986 |
| LBCU | Age of First Breeding | | 3 yrs | ID | Redmond and Jenni 1986 |
| LBCU | Nest Success | | 65-69% | OR | Pampush and Anthony 1993. Mayfield method. |
| LBCU | Nest Success | | 40.00% | ID | Redmond and Jenni 1986. Mayfield method. |
| LBCU | Nest Success | | 34.00% | WY | Cochrane and Anderson 1987. Mayfield method. |
| LBCU | Nest Success | | 45% | NV | Hartmand and Oring 2009. Interannual variation high; 31-67% Four-year range. Logistic exposure method. |
| LBCU | Nest Success | | 33% | NE | Gregory et al. 2011. Logistic exposure method. |
| LBCU | Nest Success | | 15-39% | SD | Clarke 2006. Two year study. Mayfield method. |
| LBCU | Productivity (fledged/ breeding adult/year | | 0.25 | ID | Redmond and Jenni 1986. Interyear variation range .07-.45. Earlier nesting individuals did better than late nesting individuals. |
| LBCU | Productivity (female fledged/female/year) | | 0.33 | NV | Hartmand and Oring 2009. Early nest initiation and wet conditions increased chick survival rates. |
| LBCU | Chick Survival | | 35% | ID | Redmond and Jenni 1986. Radio tagged chicks. |
| LBCU | Chick Survival | | 47% | NV | Hartmand and Oring 2009. Radio tagged chicks. |
| LBCU | | Nest Predation | 36% | ID | Redmond and Jenni 1986. % predated of all nests . 29% Canids, 7% avian depredation. |
| LBCU | | Nest Predation | 10-16% | OR | Pampush and Anthony 1986. % predated of all nests. |
| LBCU | | Nest Predation | 60% | NV | Hartmand and Oring 2009. % predated of nest failures. Majority mammalian (34%). |
| LBCU | | Nest Predation | 0-52% | SD | Clarke 2006. % predated of all nests in two year study. |
| LBCU | | Nest Trampling | 20-30% | SD | Clarke 2006. % of nest failures due to livestock trampling in two year study. |
| LBCU | | Energy Constraints | | Range wide | Inferred via variable clutch size (Dugger and Dugger 2002) and low productivity (see above). Pesticides can also reduce food supply (Gibbons et al. 2015). |
| LBCU | | Migration/Wintering | | MT/ALB | Page et al. 2014. Longer migration than those breeding west of Rocky Mountains. High fidelity to winter, stopover, and breeding sites. Longer and more frequent stops during migration. |
| WILL | Longevity | | ~ 10 yrs | Range wide | Klimkiewicz 1997 |

| Species | Vital Rate | Threat/Stressor | Estimate | Location | Notes |
|---|---|---|---|---|---|
| WILL | Adult Survival |  | 76-96% | ALB | Lowther et al. 2001 |
| WILL | Age of First Breeding |  | ~3 yrs | ALB | Lowther et al. 2001 |
| WILL | Nest Success |  | 31% | ND/SD/MT/MAN | Kantrud and Higgins 1992. Discrete-Green Estimator. |
| WILL | Nest Success |  | 3-34% | ALB | Lowther et al. 2001. Mayfield method. |
| WILL | Nest Success |  | 50% | SK | Garvey et al. 2013. Logistic exposure method. DNS = .9763. Landscape and nest site characteristics had no effect on nest survival. Grasslands were selected more than available. |
| WILL | Productivity (fledged/female/year) |  | 0.48 | ALB | Lowther et al. 2001 |
| WILL |  | Nest Predation | 43% | ND/SD/MT/MAN | Kantrud and Higgins 1992. % predated of all nests. |
| WILL |  | Nest Predation | 98% | ALB | Lowther et al. 2001. % predated of failed nests. |
| MAGO | Longevity |  | up to 25 yrs |  | Colwell et al. 1995. Based on 4 banded adults seen 25 years later. Oldest recorded is > 29 years old. |
| MAGO | Adult Survival |  | 96% | ALB | Gratto-Trevor 2000 |
| MAGO | Nest Success |  | 40% | ND/SD/MT/MAN | Kantrud and Higgins 1992. Discrete-Green Estimator. |
| MAGO | Nest Success |  | 11-67% | ALB | Gratto-Trevor 2000. Mayfield method. |
| MAGO | Productivity (fledged/female/year) |  | 0.25 | ALB | Gratto-Trevor 2000 |
| MAGO |  | Nest Predation | 33% | ND/SD/MT/MAN | Kantrud and Higgins 1992. % predated of all nests. |
| MAGO |  | Nest Predation | 97% | ALB | Gratto-Trevor 2000. % predated of failed nests |
| MAGO |  | Migration/Wintering |  | Range wide | Olsens et al. 2014. MAGO wintering in GA bred in ND/SD. MAGO that pass through UT (i.e. MT, ND, ALB, SK breeders) wintered in MX. GA MAGO complete a shorter migration, in less time, with few and shorter stops than other MAGO. |
| PIPL | Longevity |  | up to 11 yrs | NY | Wilcox 1959. 13% of females and 28% of males lived 5+ years. 12 of 298 PIPL lived to reach 8-11 years. |
| PIPL | Adult Survival |  | 63% | SK/ND/MN | Gaines and Ryan 1988 |
| PIPL | Adult Survival |  | 66% | ND | Roots et al. 1992 |
| PIPL | Adult Survival |  | 74% | ND | Larson et al. 2000 |
| PIPL | Adult Survival |  | 70% | SD | Catlin et al. 2016 |
| PIPL | Adult Survival |  | 69-81% | SD/SK | Roche et al. 2010 |
| PIPL | Age of First Breeding |  | 1 yrs |  | Elliott-Smith and Haig 2004 |
| PIPL | Productivity (fledged/pair/year) |  | 0.7-1.1 | SK | Whyte 1985 |

| Species | Vital Rate | Threat/Stressor | Estimate | Location | Notes |
|---|---|---|---|---|---|
| PIPL | Productivity (fledged/ pair/year) | | 0.3-1.5 | MAN | Haig and Oring 1988 |
| PIPL | Productivity (fledged/ pair/year) | | 0.7-1.5 | ND | Gaines and Ryan 1988 |
| PIPL | Productivity (fledged/ pair/year) | | 0.3-3 | MN | Wiens 1986, Haig and Oring 1987 |
| PIPL | Productivity (fledged/ pair/year) | | 0.6-1.5 | SD | Catlin et al. 2016 |
| PIPL | Productivity (fledged/ pair/year) | | 0.76 | MT/ND | Murphy et al. 2000 |
| PIPL | Juvenile Survival | | 32% | ND | Larson et al. 2000 |
| PIPL | Juvenile Survival | | 24% | SD/SK | Roche et al. 2010 |
| PIPL | | Predation of Chicks and Eggs | | Great Plains | Whyte 1985; Haig and Oring 1987, 1988; Gaines and Ryan 1988; Ivan and Murphy 2005 |
| PIPL | | Migration/Wintering | | Range wide | Catlin et al. 2016 found that populations that use the same wintering grounds have correlated population trends indicating wintering or migrating habitat may be influencing vital rates. |
| PIPL | | Wet Conditions/ Wetland Drainage | | Great Plains | Catlin et al. 2016, McCauley et al. 2016. PIPL emigrate from typical habitat during wet conditions and due to consolidation drainage, temporary wetlands that would normally be used are not available. Temporal bottleneck for breeding habitat during wet years. |
| PIPL | | Water Quality/Prey Abundance | | | Le Fer et al. 2008 found greater invertebrate density on alkali lakes than below hypolimnetic release dams and chicks gained weight more rapidly on alkali lakes, suggesting water quality can influence prey abundance and chick condition |
| MOPL | Longevity | | 1.9 yrs | Range wide | Dinsmore et al. 2003. Mean longevity. Survival observed up to 10 years. |
| MOPL | Adult Survival | | 68-98% | MT | Dinsmore et al. 2003; Dinsmore et al. 2008. Annual survival highest during drought conditions. |
| MOPL | Adult Survival | | 95% | CA | Knopf and Rupert 1995. Wintering. |
| MOPL | Age of First Breeding | | 1 yr | Range wide | Knopf and Wunder 2006 |
| MOPL | Nest Success | | 33-49% | MT | Dinsmore et al. 2002. Logistic exposure method. Two clutches per year, one tended by female, the other tended by male. Male nest survival is 49% and female nest survival is 33%. Mayfield method. Daily nest survival increased with age and decreased with daily precipitation (most predation events occurred after a precipitation event). |

| Species | Vital Rate | Threat/Stressor | Estimate | Location | Notes |
|---|---|---|---|---|---|
| MOPL | Productivity (fledged/ nest attempt) | | 0.26 | CO | Miller and Knopf 1993, Knopf and Rupert 1996; .17-.74 young migrated south per nesting attempt. |
| MOPL | Juvenile Survival | | 46-49% | MT | Disnmore et al. 2003. From time of capture. |
| MOPL | Juvenile Survival | | 6% | MT | Dinsmore et al. 2008. From time of hatching. Survival increased with age and mass. |
| MOPL | Juvenile Survival | | see notes | CO | Walsh et al. 2015. Mortality hazard rate highest when chick is <5 days old. Mortality rate lower for chicks with higher mass. |
| MOPL | Juvenile Survival | | ≤ 0.98 | CO | Lukacs et al. 2004. Chick survival was lowest during the first 3 days and then became a constant .98. |
| MOPL | | Predation | | MT | Dinsmore et al. 2010. Predation of young a limiting factor. |
| MOPL | | Migration | | MT | Dinsmore et al. 2010. Adult mortality during migration is a limiting factor. |
| MOPL | | Removal of Grazers | | Range wide | Knopf and Miller 1994, Dinsmore et al. 2005, Augustine et al. 2008, Augustine et al. 2012, Augustine et al. 2015; since the removal of bison they rely heavily on prairie dog colonies and populations decline following plague induced colony collapse. Fire does increase settlement. |
| MOPL | | Sunflower and Millet | | W Great Plains | Knopf and Wunder 2006. Sunflower and millet fields remain fallow until May when nesting has commenced and then nests are destroyed by farm equipment. |
| MOPL | | Planting Taller Vegetation | | Range wide | Knopf and Wunder 2006. CRP promotes planting taller tame grass in shortgrass prairie. Plowing sod and planting wheat. |
| UPSP | Longevity | | 1-3.4 yrs | Range wide | Mong and Sandercock 2007. Estimated with radio marked birds, that had lower survival than color banded birds. Houston et al. 1999. Longest survivor based on band recovery ~ 9 years. |
| UPSP | Adult Survival | | 82-95% | KS | Mong and Sandercock 2007. Survival during breeding season (10-week period). Female = 82%, male = 95%. Estimates based on radio marked birds, which had lower survival than color banded individuals. |
| UPSP | Adult Survival | | 20-50% | KS | Mong and Sandercock 2007. Annual return rate. However, harness lowered rates of return. |
| UPSP | Adult Survival | | 33% | WI | Ailes 1976. 3/15 banded adults returned. |
| UPSP | Nest Success | | 51% | MN | Dorio 1977. Apparent nest success. |

| Species | Vital Rate | Threat/Stressor | Estimate | Location | Notes |
|---|---|---|---|---|---|
| UPSP | Nest Success | | 85% | WI | Ailes 1976. Apparent nest success. N = 13. |
| UPSP | Nest Success | | 48% | ND/SD/MT/MAN | Kantrud and Higgins 1992. N = 617. Discrete Green Estimator method. |
| UPSP | Nest Success | | 67% | ND | Kirsch and Higgins 1976. Apparent nest success. N = 172. Nest success higher in natural and + 1 year post-burn, than grazed or tilled land. |
| UPSP | Nest Success | | 66% | WI | Buss and Hawkins 1939. Apparent nest success. N = 47 |
| UPSP | Nest Success | | 63% | MN | Lindmeier 1960. Apparent nest success. N = 29 |
| UPSP | Nest Success | | 100% | ND/SD | Oetting and Cassel 1971. Apparent nest success in ND. N=13. Lokemoen and Duebbert 1974. Apparent nest success in SD. N = 12. |
| UPSP | Nest Success | | 14-82% | ND | Bowen and Kruse 1993. Mayfield nest success. N = 342. Nest success was higher where cattle were absent (post-grazing or control) than where cattle were grazing. |
| UPSP | Nest Success | | 20% | SK | Garvey et al. 2013. Logistic exposure method. DNS = .9462. Landscape and nest site variables had no effect on nest survival. Grasslands were selected more than were available. |
| UPSP | Nest Success | | 52% | IL | Westemeir 1989. Apparent nest success. N = 34 |
| UPSP | Nest Success | | 72% | SK | Jackson 2003. Apparent nest success. N=46. |
| UPSP | Nest Success | | 48% | IL | Buhnerkempe and Westemeier 1988. Mayfield nest success. N=33. Nested in fields mowed or burned the previous season more than than expected. |
| UPSP | Nest Success | | 18% | KS | Sandercock et al. 2015. Logistic exposure method. N= 238. Nest survival was 25% in unburned sites, 20% in ungrazed sites (20%), 21% in ungrazed with annual fires, 6% in sites managed with grazing and annual fire (6%) which was also the most selected nesting area. |
| UPSP | Fledging Success | | 51% | WI | Ribic et al. 2012.. N=9, logistic exposure DNS = .9308, N=9. Nested in remnant prairie with sparse and open vegetation. |
| UPSP | Fledging success | | 40% | OR | Houston et al. 2011. N=35 pairs. 14 fledged ≥ 1. |
| UPSP | Juvenile survival | | 3% | WI | Ailes 1976. 2/60 banded young returned. |
| UPSP | | Nest Predation | 51% | KS | Sandercock et al. 2015. 34% apparent nest success, the rest failed due to weather, trampling, and abandonment. |
| UPSP | | Nest Predation | 28% | ND | Bowen and Kruse 1993. |
| UPSP | | Nest Predation | 32% | ND/SD/MT/MAN | Kantrud and Higgins 1992. Majority lost to mammalian predators. |

| Species | Vital Rate | Threat/Stressor | Estimate | Location | Notes |
|---|---|---|---|---|---|
| UPSP | | Nest Predation | 0% | WI | Ailes 1976. Only 4 of 47 eggs failed to hatch due to infertility or abandonment. |
| UPSP | | Migration/Wintering | | | Blanco and Lopez-Lanus 2008. Long Migration. Habitat modification and agrochemicals on wintering grounds. |
| AMAV | Longevity | | up to 15 yrs | | Ackerman et al. 2013. Chick banded found dead 15 years later. Other older band returns include 14 , 12.5, and 9 years. |
| AMAV | Adult Survival | | 83-86% | CA | Robinson and Oring 1997. Apparent survival for adults captured on nests. |
| AMAV | Nest Success | | 41% | CA | Ackerman et al. 2013. Apparent nest success. N=1,307 |
| AMAV | Nest Success | | 41% | CA | BNA author (Ackerman et al. 2013). Mayfield nest success. N=4,507 |
| AMAV | Nest Success | | 37% | UT | Cavitt 2006, Ackerman et al. 2013. Mayfield nest success. N=6,961 |
| AMAV | Nest Success | | 39% | CA | Marn 2003. Mayfield nest success. N = 3,446 |
| AMAV | Nest Success | | 85% | ND | Dahl et al. 2003. Apparent nest success. N=174. Constructed wetlands. |
| AMAV | Fledging Success | | 6% | CA | Ackerman et al. 2013. Radio marked. N=161 |
| AMAV | Fledging Success | | 62-70% | CA | Marn 2003 .Radio marked. N = 193 radio marked 62% fledged, N= 737 banded that fledged. |
| AMAV | Fledging Success | | 38% | CA | Ackerman et al. 2013. N=1,206 banded. |
| AMAV | Productivity (fledged/brood) | | 0.54 | CA | Ackerman et al. 2013. N=537. |
| AMAV | Productivity (fledged/brood) | | 2.82 | | Sordahl 1996. N = 45. |
| AMAV | Productivity (fledged/brood) | | 305% | | Gibson 1971. N = 110. |
| AMAV | Juvenile Survival | | 48-57% | CA | Ackerman et al. 2013. Based on mark resight from hatch to 2 years. N = 19. |
| AMAV | Juvenile Survival | | 58% | CA | Marn 2003. Survival of radio marked chicks from hatching to fledging. N = 163. Survival lowest in first week after hatching. |
| AMAV | Juvenile Survival | | 9% | CA | Ackerman et al. 2006. Survival of radio marked chicks from hatching to fledging. N=161. Survival lowest in first week after hatching. |
| AMAV | | Nest Predation | 59% | CA | Herring et al. 2011. % of all nests. 71% mammalian and 14% avian depredation. |
| AMAV | | Nest Predation | 57% | UT | Sordahl 1996. % of nest losses. |
| AMAV | | Chick Predation | 55% | CA | Marn 2003. % of chick mortalities caused by predation. |

| Species | Vital Rate | Threat/Stressor | Estimate | Location | Notes |
|---|---|---|---|---|---|
| AMAV | | Chick Predation | 59% | CA | Ackerman et al. 2006. % of chick mortalities caused by predation. |
| AMAV | | Selenium | | | Ackerman et al. 2008. Mortality in eggs and in chicks or chronic sub-lethal effects in chicks and adults. |
| WISN | Longevity | | 1.3-1.5 yrs | Range wide | BNA author (Mueller 1999). Based on band recoveries. Longest life span recorded is 12 years. |
| WISN | Adult Survival | | 50% | Range wide | BNA author (Mueller 1999). Based on band recoveries. |
| WISN | Age of First breeding | | 1 yr | Range wide | Tuck 1972 |
| WISN | Productivity (fledged/ adult/year) | | 0.72 | Range wide | Tuck 1972. Based on ratio of adults to juveniles on wintering grounds. |
| WISN | | Hunting | 900,000/yr | Range wide | Fogarty et al. 1980 |
| WISN | | Hunting | 69,100-94,900/yr | US | US hunting estimates for 2014 and 2015. |
| WIPH | Adult Survival | | ~88% | SK | Colwell and Oring 1988a. 87% males and 88% females observed yr+1, 7% males and 12% females observed yr+2, 6% males and 0% females observed yr+3. |
| WIPH | Age of First breeding | | 1 yr | SK | Colwell et al. 1988 |
| WIPH | Nest Success | | 32.60% | SK | Colwell and Oring 1988b. Apparent nest success. Indiv-idual male success higher due to successful re-nesting. |
| WIPH | Renest | | 27.00% | SK | Colwell and Oring 1988b. Male re-nesting. |
| WIPH | | Nest predation | 12-60% | SK | Colwell and Oring 1988b |
| WIPH | | Migration/Wintering | | | Ballesteros et al. 2014. Long Migration. Habitat modification and agrochemicals on wintering grounds. |
| KILL | Longevity | | up to 11 yrs | | Clapp et al. 1982. Mark recapture. Lenington and Mace 1975. Observed some males and females returned to same territory for 4-3 years. |
| KILL | Age of First Breeding | | 1 yr | | Jackson and Jackson 2000 |
| KILL | Nest Success | | 44% | ND/SD/MT/MAN | Kantrud and Higgins 1992. Discrete Green estimator. N= 135. |
| KILL | Nest Success | | 29-64% | ON | Nol 1980. Mayfield nest success. 29% on island, and 64% on mainland, N=17, N=12, respectively. |
| KILL | Nest Success | | 38% | MS | Schardien 1981. Apparent nest success. N = 101 |
| KILL | Hatching Success | | 36% | MS | Schardien 1981. % of eggs laid that hatched. N = 374. |
| KILL | Fledging Success | | 12% | MS | Schardien 1981. % of hatched eggs that fledged. |

| Species | Vital Rate | Threat/Stressor | Estimate | Location | Notes |
|---|---|---|---|---|---|
| KILL | Productivity (fledged/ nesting attempt/year) | | 0.16 | MS | Schardien 1981 |
| KILL | Productivity (fledged/ pair/year) | | 1.6 | MN | Lenington 1980 |
| KILL | Productivity (fledged/ pair/year) | | 0.5 | MN | Mace 1971 |
| KILL | | Nest Predation | 36-71% | ON | Nol 1980. All mammalian or avian. |
| KILL | | Nest Predation | 35% | ND/SD/MT/MAN | Kantrud and Higgins 1992. N= 135. |
| | | Agrochemicals | | | Mineau et al. 2005. Occurs on croplands and vulnerable to agrochemical use. Common species in decline. |
| SPSA | Longevity | | ~ 3 yrs | MN | Oring et al. 1991 had adults return to territory up to 9 years. Maximum 12 years Clapp et al. 1982. |
| SPSA | Adult Survival | | 63% | MN | Reed and Oring 1993. return rates lower for unsuccessful breeders likely due to dispersal. |
| SPSA | Age of First Breeding | | 1 yr | MN | Oring et al. 1991 |
| SPSA | Hatching success | | 51% | MN | Reed et al. 2013. % hatched for all eggs laid. N=670. |
| SPSA | Fledging success | | 83% | MN | Reed et al. 2013. % fledged per hatched eggs. N=346 |
| SPSA | Fledging success | | 43% | MN | Reed and Oring 1993. Mean % fledged for hatched eggs. |
| SPSA | Lifetime Productivity (fledged/lifetime) | | 3.3-5.2 | MN | Oring et al. 1991. Mean number fledged per lifetime. Males fledge 3.3, females fledge 5.2. Males can fledge up to 20 and females > 20. |
| SPSA | Productivity (fledged/year) | | 1.48-2.32 | MN | Oring et al. 1983. Males = 1.48, females = 2.32. |
| SPSA | Juvenile Survival | | 17% | MN | Oring et al. 1991. Minimum natal return rate. |

## LITERATURE CITED

**Ackerman,** J. T., J. Y. Takekawa, C. Strong, N. Athearn, and A. Rex. 2006*a*. California Gull distribution, abundance, and predation on waterbird eggs and chicks in south San Francisco Bay - Final report. U. S. Geological Survey, Western Ecological Research Center, Davis, California, USA.

**Ackerman,** J. T., J. Y. Takekawa, C. A. Eagles-Smith, and S. A. Iverson. 2006*b*. Mercury contamination and effects on survival of American Avocet and Black-necked Stilt chicks in San Francisco Bay. Ecotoxicology 17:103-116.

**Ackerman,** J. T., C. A. Hartman, M. P. Herzog, J. Y. Takekawa, J. A. Robinson, L. W. Oring, J. P. Skorupa and R. Boettcher. 2013. American Avocet (*Recurvirostra americana*). *In* The Birds of North America Online, A. Poole, editor. Cornell Lab of Ornithology, Ithaca, New York, USA.

**Ailes,** I. W. 1976. Ecology of the Upland Sandpiper in central Wisconsin. Thesis, University of Wisconsin, Stevens Point, USA.

**Augustine,** D. J., S. J. Dinsmore, M. B. Wunder, V. J. Dreitz, and F. L. Knopf. 2008. Response of Mountain Plovers to plague-driven dynamics of black-tailed prairie dog colonies. Landscape Ecology 23:689-697.

**Augustine,** D. J., and J. D. Derner. 2012. Disturbance regimes and Mountain Plover habitat in shortgrass steppe: large herbivore grazing does not substitute for prairie dog grazing or fire. Journal of Wildlife Management 76:721-728.

**Augustine,** D. J., and J. D. Derner. 2015. Patch-burn grazing management, vegetation heterogeneity, and avian responses in a semi-arid grassland. Journal of Wildlife Management 79:927-936.

**Ballesteros,** M. L., K. S. B. Miglioranza, M. Gonzalez, G. Fillmann, D. A. Wunderlin, and M. A. Bistoni. 2014. Multimatrix measurement of persistent organic pollutants in Mar Chiquita, a continental saline shallow lake. Science of the Total Environment 490:73-80.

**Blanco,** D. E., and B. Lopez-Lanus. 2008. Non-breeding distribution and conservation of the Upland Sandpiper (*Bartramia longicauda*) in South America. Ornithologia Neotropical 19:613-621.

**Bowen,** B. S., and A. D. Kruse. 1993. Effects of grazing on nesting by Upland Sandpipers in southcentral North Dakota. Journal of Wildlife Management 57:291-301.

**Buhnerkempe,** J. E., and Westemeier. 1988. Breeding biology and habitat of Upland Sandpipers on prairie-chicken sanctuaries in Illinois. Illinois Academy of Science 81:153-162.

**Buss,** I. O., and A. S. Hawkins. 1939. The upland plover at Faville Grove, Wisconsin. Wilson Bulletin 51:202-220.

**Catlin,** D. H., S. L. Zeigler, M. B. Brown, L. R. Dinan, J. D. Fraser, K. L. Hunt, and J. G. Jorgensen. 2016. Metapopulation viability of an endangered shorebird depends on dispersal and human-created habitats: Piping Plovers (*Charadrius melodus*) and prairie rivers. Movement Ecology 4:6.

**Cavitt,** J. F. 2006. Productivity and foraging ecology of two co-existing shorebirds breeding at Great Salt Lake, Utah: 2005-2006. Avian Ecology Laboratory Technical Report AEL 06-03. Weber State University, Ogden, Utah, USA.

**Clapp,** R. B., M. K. Klimkiewicz, and J. H. Kennard. 1982. Longevity records of North American birds: Gaviidae through Alcidae. Journal of Field Ornithology 53:81-124.

**Clarke,** J. N. 2006. Reproductive ecology of Long-billed Curlews breeding in grazed landscapes of western South Dakota. Thesis, South Dakota State University, Brookings, USA.

**Cochran,** J. F., and S. H. Anderson. 1987. Comparison of habitat attributes at sites of stable and declining Long-billed Curlew populations. Great Basin Naturalist 47:459-466.

**Colwell,** M. A., J. D. Reynolds, C. L. Gratto, D. Schamel, and D. Tracy. 1988. Phalarope philopatry. Proceedings of the XIXth International Ornithological Congress.

**Colwell,** M. A., and L. W. Oring. 1988*a*. Return rates of prairie shorebirds: sex and species differences. Wader Study Group Bulletin 55:21-24.

**Colwell,** M. A., and L. W. Oring. 1988*b*. Breeding biology of Wilson's Phalarope in southcentral Saskatchewan. Wilson Bulletin 100:567-582.

**Colwell,** M. A., R. H. Gerstenberg, O. E. Williams, and M. G. Dodd. 1995. Four Marbled Godwits exceed the North American longevity record for scolopacids. Journal of Field Ornithology 2:181-183.

**Dahl,** T. E., D. H. Johnson, L. D. Igl, K. L. Baer, T. L. Shaffer, M. A. Johnson, and R. E. Reynolds. 2003. American Avocet nesting on constructed islands in North Dakota. Prairie Naturalist 35:95-105.

**Dinsmore,** S. J., G. C. White, and F. L. Knopf. 2002. Advanced techniques for modeling avian nest survival. Ecology 83:3476-3488.

**Dinsmore,** S. J., G. C. White, and F. L. Knopf. 2003. Annual survival and population estimates of Mountain Plovers in southern Phillips County, MT. Ecological Applications 13:1013-1026.

**Dinsmore,** S. J., G. C. White, and F. L. Knopf. 2005. Mountain Plover population responses to black-tailed prairie dogs in Montana. Journal of Wildlife Management. 64:1546-1553.

**Dinsmore,** S. J. 2008. Influence of drought on annual survival of the Mountain Plover in Montana. Condor 110:45-54.

**Dinsmore,** S. J., M. B. Wunder, V. J. Dreitz, and F. L. Knopf. 2010. An assessment of factors affecting population growth of the Mountain Plover. Avian Conservation and Ecology 5:5.

**Dorio,** J. C. 1977. Nesting and brood rearing habitat of the Upland Sandpiper in central Minnesota. Thesis, St. Cloud State University, St. Cloud, Minnesota, USA.

**Dugger,** B. D., and K. M. Dugger. 2002. Long-billed Curlew (*Numenius americanus*). *In* The Birds of North America Online, A. Poole, editor. Cornell Lab of Ornithology, Ithaca, New York, USA.

**Elliott-Smith,** E., and S. M. Haig. 2004. Piping Plover (*Charadrius melodus*). *In* The Birds of North America Online, A. Poole, editor. Cornell Lab of Ornithology, Ithaca, New York, USA.

**Fogarty,** M. J., K. A. Arnold, L. McKibben, L. B. Popischal, and R. J. Tully. 1980. Common Snipe. Management of Migratory Shore and Upland Game Birds in North America, (G. C. Sanderson ed.). International Association of Fish and Wildlife Agencies.

**Gaines,** E. P., and M. R. Ryan. 1988. Piping Plover habitat use and reproductive success in North Dakota. Journal of Wildlife Management 52:266-273.

**Garvey,** M. E., E. Nol, D. W. Howerter, and L. M. Armstrong. 2013. A spatial analysis of factors affecting nest success of shorebirds in the Canadian prairies. Condor 115:58-66.

**Gibson,** F. 1971. The breeding biology of the American Avocet (*Recurvirostra Americana*) in central Oregon. American Midland Naturalist 99:65-82.

**Gibbons,** D., C. Morrissey, and P. Mineau. 2015. A review of the direct and indirect effects of neonicotinoids and fipronil on vertebrate wildlife. Environmental Science Pollution Research 22:103-118.

**Gratto-Trevor,** C. L. 2000. Marbled Godwit (*Limosa fedoa*). *In* The Birds of North America Online, A. Poole, editor. Cornell Lab of Ornithology, Ithaca, New York, USA.

**Gregory,** C. J., S. J. Dinsmore, L. A. Powell, and J. G. Jorgensen. Nest Survival of Long-billed Curlew in Nebraska. Wader Study Group Bulletin 118:109-113.

**Haig,** S. M. 1987. The population biology and life history patterns of the Piping Plover. Ph. D. dissertation, University of North Dakota, Grand Forks, USA.

**Haig,** S. M., and L. W. Oring. 1988. Mate, site, and territory fidelity in Piping Plovers. Auk 105:268-277.

**Hartman,** C. A., and L. W. Oring. 2009. Reproductive success of Long-billed Curlews (*Numenius americanus*) in northeastern Nevada hay fields. Auk 126:420-430.

**Herring,** G. J., T. Akerman, J. Y. Takekawa, C. A. Eagles-Smith, and J. M. Eadie. 2011. Identifying nest predators of American Avocets (*Recurvirostra americana*) and Black-necked Stilts (*Himantopus mexicanus*) in San Francisco Bay, California. Southwestern Naturalist 56:35-43.

**Houston,** C. S., C. R. Jackson, and D. E. Bowen, Jr. 2011. Upland Sandpiper (*Bartramia longicauda*). *In* The Birds of North America Online, A. Poole, editor. Cornell Lab of Ornithology, Ithaca, New York, USA.

**Ivan,** J. S., and R. K. Murphy. 2005. What preys on Piping Plover eggs and chicks? Wildlife Society Bulletin 33:113-119.

**Jackson,** B. J., and J. A. Jackson. 2000. Killdeer (*Charadrius vociferus*). *In* The Birds of North America Online, A. Poole, editor. Cornell Lab of Ornithology, Ithaca, New York, USA.

**Jackson,** C. R. 2003. Breeding ecology of prairie nesting shorebirds: relationships with habitat, land use and predators. Thesis, University of Saskatchewan, Saskatoon, Canada.

**Larson,** M. A., M. R. Ryan, and B. G. Root. 2000. Piping Plover survival in the Great Plains: an updated analysis. Journal of Field Ornithology 71:721-729.

**Kantrud,** H. A., and K. F. Higgins. 1992. Nest and nest site characteristics of some ground-nesting, non-passerine birds of northern grasslands. Prairie Naturalist 24:67-84.

**Kimkiewicz,** M. K. 1997. Longevity records of North American birds – version 97.1. Patuxent Wildlife Research Center, Bird Banding Laboratory, Laurel, Maryland, USA.

**Kirsh,** L. M., and K. F. Higgins. 1976. Upland Sandpiper nesting and management in North Dakota. Wildlife Society Bulletin 4:16-20.

**Knopf,** F. L., and B. J. Miller. 1994. *Charadrius montanus* - montane, grassland, or bare-ground plover? Auk 111:504-506.

**Knopf,** F. L., and J. R. Rupert. 1995. Habits and habitats of Mountain Plovers in California. Condor 97:743-751.

**Knopf,** F. L., and J. R. Rupert. 1996. Productivity and movements of Mountain Plovers breeding in Colorado. Wilson Bulletin 108:28-35.

**Knopf,** F. L., and M. B. Wunder. 2006. Mountain Plover (*Charadrius montanus*). *In* The Birds of North America Online, A. Poole, editor. Cornell Lab of Ornithology, Ithaca, New York, USA.

**Le Fer,** D. J. D. Fraser, and C. D. Kruse. 2008. Piping Plover foraging-site selection on the Missouri River. Waterbirds 31:587-592.

**Lenington,** S., and T. Mace. 1975. Mate fidelity and nesting site tenacity in the Killdeer. Auk 92:149-151.

**Lenington,** S. 1980. Bi-parental care in Killdeer: an adaptive hypothesis. Wilson Bulletin 92:8-20.

**Lindmeir,** J. P. 1960. Plover, rail, and godwit nesting on a study area in Mahmomen County, Minnesota. Flicker 32:5-9.

**Lokemoen,** J. T., and J. A. Beiser. 1997. Bird use and nesting in conventional, minimum tillage, and organic cropland. Journal of Wildlife Management 61:644-655.

**Lowther,** P. E., H. D. Douglas III and C. L. Gratto-Trevor. 2001. Willet (*Tringa semipalmata*). *In* The Birds of North America Online, A. Poole, editor. Cornell Lab of Ornithology, Ithaca, New York, USA.

**Lukacs,** P. M., V. J. Dreitz, F. L. Knopf, and K. P. Burnham. 2004. Estimating survival probabilities of unmarked dependent young when detection is imperfect. Condor 106:926-931.

**Mace,** T. R. 1971. Nest dispersion and productivity of Killdeers, *Charadrius vociferous*. Thesis, University of Minnesota, St. Paul, USA.

**Marn,** C. M. 2003. Post-hatching survival and productivity of American Avocets at drainwater evaporation ponds in the Tulare Basin, California. Thesis, Oregon State University, Corvallis, USA.

**McCauley,** L. A., M. J. Anteau, and M. P. van der Burg. 2016. Consolidation drainage and climate change may reduce Piping Plover habitat in the Great Plains. Journal of Fish and Wildlife Management 7:1-10.

**Mineau,** P., C. M. Downes, D. A. Kirk, E. Bayne, and M. Csizy. 2005. Patterns of bird species abundance in relation to granular insecticide use in the Canadian prairies. Ecoscience 12:267-278.

**Miller,** B. J., and F. L. Knopf. 1993. Growth and survival of Mountain Plovers. Journal of Field Ornithology 64:500-506.

**Mong,** T. W., and B. K. Sandercock. 2007. Optimizing radio retention and minimizing radio impacts in a field study of Upland Sandpipers. Journal of Wildlife Management 71:971-980.

**Mueller,** Helmut. 1999. Wilson's Snipe (*Gallinago delicata*). *In* The Birds of North America Online, A. Poole, editor. Cornell Lab of Ornithology, Ithaca, New York, USA.

**Murphy,** R. K., M. J. Rabenberg, M. L. Sondreal, B. R. Casler, and D. A. Guenther. 2000. Reproductive success of Piping Plovers on alkali lakes in North Dakota and Montana. Prairie Naturalist 32:233-241.

**Nol,** E. 1980. Factors affecting the nesting success of the Killdeer (*Charadrius vociferous*) on Long Point, Ontario. Thesis, University of Guelph, Ontario, Canada.

**Oetting,** R. B., and J. F. Cassel. 1971. Waterfowl nesting on interstate highway right-of-way in North Dakota. Journal of Wildlife Management 35:774-781.

**Olsen,** B. E., K. A. Sullivan, and A. H. Farmer. 2014. Marbled Godwit migration characterized with satellite telemetry. Condor 116:185-194.

**Oring,** L. W., D. B. Lank, and S. J. Maxson. 1983. Population studies of the polyandrous Spotted Sandpiper. Auk 100:272-285.

**Oring,** L. W., M. A. Colwell, and J. M. Reed. 1991. Lifetime reproductive success in the Spotted Sandpiper (*Actitis macularia*): sex differences and variance components. Behavioral Ecology Sociobiology 28:425-432.

**Page,** G. W., N. Warnock, T. L. Tibbitts, D. Jorgensen, C. A. Hartmann, and L. E. Stenzel. 2014. Annual Migratory patterns of Long-billed Curlews in the American West. Condor 116:50-61.

**Pampush,** G. F., and R. G. Anthony. 1993. Nest success, habitat utilization and nest-site selection of Long-billed Curlews in the Columbia Basin, Oregon. Condor 95:957-967.

**Redmond,** R. L., and D. A. Jenni. 1986. Population ecology of the Long-billed Curlew (*Numenius americanus*) in western Idaho. Auk 104:755-767.

**Reed,** J. M. and L. W. Oring. 1993. Philopatry, site fidelity, dispersal, and survival of Spotted Sandpipers. Auk 110:541-551.

**Reed,** J. M., L. W. Oring, and E. M. Gray. 2013. Spotted Sandpiper (*Actitis macularius*). *In* The Birds of North America Online, A. Poole, editor. Cornell Lab of Ornithology, Ithaca, New York, USA.

**Ribic,** C. A., M. J. Guzy, T. J. Anderson, D. W. Sample, and J. L. Nack. 2012. Bird productivity and nest predation in agricultural grasslands. Studies in Avian Biology 43:119-134.

**Robinson,** J. A., and L. W. Oring. 1996. Long-distance movements by American Avocets. Auk 11:416-430.

**Roche,** E. A., J. B. Cohen, D. H. Catlin, D. L. Amirault-Langlais, F. J. Cuthbert, C. L. Gratto-Trevor, J. Felio, and J. D. Fraser. 2010. Range-wide Piping Plover survival: correlated patterns and temporal declines. Journal of Wildlife Management 74:1784-1791.

**Roots,** B. G., M. R. Ryan, and P. M. Mayer. 1992. Piping Plover survival in the Great Plains. Journal of Field Ornithology 63:10-15.

**Sandercock,** B. K., M. Alfaro-Barrios, A. E. Casey, T. N. Johnson, T. W. Mong, K. J. Odom, K. M. Strum, and V. L. Winder. 2015. Effects of grazing and prescribed fire on resource selection and nest survival of Upland Sandpipers in an experimental landscape. Landscape Ecology 30:325-227.

**Shardien,** B. J. 1981. Behavioral ecology of a southern population of Killdeer. Dissertation. Mississippi State University, USA.

**Sordahl,** T. A. 1996. Breeding biology of the American Avocet and Black-necked Stilt in northern Utah. Southwest Naturalist 41:348-354.

**Tuck,** L. M. 1972. The snipes: a study of the genus *Capella*. Canadian Wildlife Service Monograph No. 5.

**Walsh,** D. P., V. J. Dreitz, and D. M. Heisey. 2015. Integrated survival analysis using an event-time approach in a Bayesian framework. Ecology and Evolution 5:769-780.

**Weins,** T. P. 1988. Nest-site tenacity and mate retention of the Piping Plover. Thesis, University of Minnesota, Duluth, USA.

**Westemeir,** R. L. 1989. Upland Sandpipers on Illinois prairie-chicken sanctuaries. Illinois Natural History Survey Representative 284:1-2.

**Whyte,** A. J. 1985. Breeding ecology of the Piping Plover (*Charadrius melodus*) in central Saskatchewan. Thesis, University of Saskatchewan, Saskatoon, Canada.

**Wilcox,** L. 1959. A twenty year banding study of the Piping Plover. Auk 76:129-152.