Platte River

Recovery Implementation Program:

IMPLEMENTATION OF THE WHOOPING CRANE MONITORING PROTOCOL

FALL 2023 REPORT

Prepared for:
PRRIP Technical Advisory and Governance Committees
Date: 14 May 2024

Prepared by:
Jason Bruggeman[1] and Mallory Jaymes
Platte River Recovery Implementation Program
Executive Director's Office
4111 4th Avenue, Suite 6
Kearney, NE 68845
[1] bruggemanj@headwaterscorp.com

Platte River Recovery Implementation Program: Implementation of the Whooping Crane Monitoring Protocol—Fall 2023 Report

Prepared by:
Jason Bruggeman (bruggemanj@headwaterscorp.com) and Mallory Jaymes
Platte River Recovery Implementation Program
Executive Director's Office
4111 4th Avenue
Suite 6
Kearney, Nebraska 68845

Suggested citation:
Platte River Recovery Implementation Program (PRRIP). 2024. Platte River Recovery Implementation Program: Implementation of the Whooping Crane Monitoring Protocol–Fall 2023 Report.

Table of Contents

Table of Abbreviations

Abbreviation	Definition
AHR	Associated Habitat Reach
AMP	Adaptive Management Plan
AWB	Aransas-Wood Buffalo
cfs	Cubic feet per second
CI	Confidence interval
CSRT	Chapman secondary return transect
EBQ	Extension Big Question
EDO	Executive Director's Office
ESRT	Elm Creek secondary return transect
FA	Fall
Fig.	Figure
ft	Feet or foot
GC	Governance Committee
GPS	Global positioning system
ID	Identification number or code
ISAC	Independent Scientific Advisory Committee
km	Kilometer
m	Meters
mph	Miles per hour
MUCW	Maximum width unobstructed by dense vegetation
MUOCW	Maximum unobstructed channel width
NE	Nebraska
NF	Nearest forest
Opp	Opportunistic
PRRIP or Program	Platte River Recovery Implementation Program
PWRTE	Primary wetland return transect east
PWRTW	Primary wetland return transect west
QA/QC	Quality assurance/quality control
SE	Standard error
SP	Spring
Sys	Systematic
TAC	Technical Advisory Committee
TUCW	Total unvegetated channel width
UFCW	Unforested corridor width
UOCW	Unobstructed channel width
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UTM	Universal Traverse Mercator
WC	Whooping crane, *Grus americana*
WSRT	Wood River secondary return transect
0SE	East river transect
0SW	West river transect

Executive Summary

The Executive Director's Office (EDO) of the Platte River Recovery Implementation Program ("Program" or "PRRIP") enumerated and monitored whooping cranes (*Grus americana*) during the fall 2023 migration using daily systematic aerial surveys along PRRIP's Associated Habitat Reach (AHR) on the central Platte River from Lexington to Chapman, Nebraska. During the scheduled 38-day monitoring period that lasted from October 9 to November 15, 2023, PRRIP's EDO completed 58 of 76 (76%) scheduled flight routes with each day's route surveying the length of the river channel and off-channel habitat within the AHR. The monitoring period was extended through January 20, 2024 due to continued presence of one whooping crane group on the AHR. The EDO completed 50 of 78 (64%) additionally scheduled flights between November 16, 2023 and January 20, 2024 with flights after November 28 covering only the east transect to systematically survey the location of the remaining group. Surveyors enumerated 43 individual whooping cranes consisting of 37 adults and six juveniles in 13 unique groups during systematic aerial surveys. Overall, the EDO observed 173 group locations that consisted of repeated observations of 11 of the 13 unique groups. Of these 173 locations, 11 were observations of the same group at a different location on the same day. Surveyors observed the first whooping crane group on October 29 and the final group, consisting of two individuals, remained on the AHR until January 10, 2024.

The 43 individual whooping cranes represented 0.080 (95% confidence interval [CI] = 0.067, 0.097) of the Aransas-Wood Buffalo (AWB) migratory population based on the U.S. Fish and Wildlife Service's 2022–2023 estimate of 536 whooping cranes (95% CI = 444, 644) on wintering grounds along the Texas coast of the Gulf of Mexico. With 38 of the 43 whooping cranes having multiple day stopovers on the AHR, PRRIP's EDO estimated 584 total crane use days for fall 2023. Stopover length of the 13 unique whooping crane groups during fall 2023 ranged between one and 73 days (mean = 14.4; median = 11; standard error [SE] = 5.1). When not including the one group that stayed 73 days, the maximum stopover length was 19 days with a mean of 9.5 days among the 12 groups. When considering whooping cranes observed only between October 18 and November 15, which represented the 5th and 95th percentiles of initial dates of fall whooping crane group observations in Nebraska from the U.S. Fish and Wildlife Service public sightings database during 2014–2023, PRRIP's EDO enumerated 43 whooping cranes and 412 adjusted crane use days. Stopover length of the 13 groups between October 18 and November 15 ranged from one to 17 days (mean = 8.9; median = 10; SE = 1.5).

Flow in the Platte River as measured at four gaging stations along the AHR between Overton and Grand Island, Nebraska ranged from 89 cubic feet per second (cfs) to 2,190 cfs during the standard October 9 to November 15 monitoring period. During the extended monitoring period from November 16 through January 20, 2024, discharge in the AHR ranged from 45 cfs to 2,250 cfs. Instantaneous discharge at the gaging station closest to each of 116 whooping crane groups observed in the river channel ranged from 220 cfs to 2,220 cfs (mean = 993; SE = 61). Whooping crane groups that had longer stay lengths were generally associated with a range of low to high discharge at the nearest gage. Most (82.5%) of the 116 whooping crane groups observed in the river channel were closest to the Grand Island, Nebraska gage. Unobstructed channel widths at the 116 whooping crane riverine use sites ranged from 310 ft to 1,580 ft (mean = 992; median =

963; SE = 25). Distance to the nearest forest at the 116 riverine use sites ranged from 136 ft to 1,371 ft (mean = 489; median = 432; SE = 22).

We calculated 5th and 95th percentiles of dates of fall whooping crane group observations in Nebraska in 10-year periods between 1998 and 2023 and retrospectively calculated the adjusted proportion of the AWB population stopping on the AHR and adjusted number of crane use days from PRRIP fall surveys dating back to 2007. Use of the 5th and 95th percentiles of dates to calculate whooping crane stopover metrics resulted in adjustments being made to metrics in fall of 2009, 2012, 2015, 2017, 2019, 2021, and 2023. Adjustments were minor in four of these years; however, we made large adjustments to the number of crane use days in fall 2015 (decreased by 20 days), fall 2017 (decreased by 46 days), and fall 2023 (decreased by 172 days) due to cranes staying on the AHR beyond the 95th percentile date. We found PRRIP surveys during fall 2007 through 2023 did include the 5th percentile date for the corresponding 10-year period evaluated. Six years of fall PRRIP surveys (2007; 2013; 2014; 2018; 2019; 2020) did not include the 95th percentile date for the corresponding period. However, in five of the years the surveys ended one or two days before the 95th percentile date.

Fall whooping crane stopover metrics on the AHR of the central Platte River as determined through PRRIP's surveys have demonstrated considerable annual variability. During three of the past five years, we have observed the highest proportions of the population stopping on the AHR during fall since 2007. During fall of 2021 and 2023, we documented the highest number of crane use days since 2007. In between these years of high use, we observed historical fall lows in both stopover metrics. In part because of these recent years of high use, we found a significant, positive temporal trend in the adjusted number of fall crane use days during 2007–2023 when using a regression modeling approach. When using a nonparametric Spearman's rank correlation, we found a non-statistically significant relationship (*p*-value of 0.060) between the adjusted number of crane use days and year. We found no relationship between the adjusted proportion of population stopping on the AHR during fall and year during 2007–2023 using either a regression modeling approach or Spearman's rank correlation. The information collected from PRRIP's long-term systematic monitoring of whooping cranes along the central Platte River is being used to assess the Program's management objective of contributing to the survival of whooping cranes during migration and evaluate the biological response of whooping cranes to the Program's water and land management.

Introduction

The Platte River Recovery Implementation Program ("Program" or "PRRIP") is responsible for implementing certain aspects of the recovery plan for endangered whooping cranes (*Grus americana*). In 2007, the Program began its 13-year First Increment and implementation of an Adaptive Management Plan (AMP) to learn more about the physical processes of the central Platte River in Nebraska and the response of whooping cranes from the migratory Aransas-Wood Buffalo (AWB) population to Program management of land and water along the river. In 2020, the Program began a 13-year Extension of the First Increment to continue the work and gather additional information to inform decisions for management of whooping crane habitat along the Program's 90-mile Associated Habitat Reach (AHR) from Lexington to Chapman, Nebraska. The Program's original AMP was updated in 2022 as an Extension Science Plan (PRRIP 2022) to provide guidance for Program science priorities during the Extension.

The Program's management objective for whooping cranes is to contribute to their survival during migration (PRRIP 2021a). Quantifiable metrics to help evaluate the success of this objective include the: (1) availability and area of suitable roosting and foraging habitat; (2) number of days whooping cranes were observed along the AHR (i.e., crane use days); and (3) proportion of the AWB population that stops along the AHR during spring and fall migration. Additionally, several critical scientific and technical uncertainties about physical processes and the response of whooping cranes to management actions are the focus of applying rigorous adaptive management in the First Increment Extension through implementation of the Program's Extension Science Plan. These uncertainties are stated as broad hypotheses in the Extension Science Plan (PRRIP 2022) and, as a means of better linking science learning to Program decision-making, those uncertainties comprise a set of "Extension Big Questions" (EBQs) to link specific hypotheses and metrics to management objectives and overall Program goals (see PRRIP 2017a, PRRIP 2020). Three EBQs directly relate to measuring whooping crane response to Program management (Appendix A):

- *EBQ #4* – What factors influence whooping crane decisions to stop or fly over the AHR?
- *EBQ #5* – What factors influence whooping crane stopover length within the AHR?
- *EBQ #6* – Why is spring use of the AHR greater than fall use by whooping cranes?

To gather information to reduce remaining uncertainties about whooping cranes during the Extension, several finer-scale priority management hypotheses were developed by Program participants to focus on the influence of river discharge for whooping crane decision-making (Appendix A). Underlying physical process hypotheses were developed in support of the management hypotheses to explain how discharge interacts with channel morphology to provide suitable whooping crane roosting habitat (Appendix A). Broader scope alternatives were also posed for investigation as potential factors affecting whooping crane behavior (Appendix A). Implementation of the whooping crane monitoring protocol is intended to provide the systematically-collected whooping crane use and habitat (i.e., landscape level attributes at roost sites and diurnal use sites) data necessary to test these whooping crane hypotheses, evaluate learning related to the whooping crane EBQs, and ultimately assess progress toward meeting the whooping crane management objective (PRRIP 2017a, PRRIP 2020).

The Program's whooping crane monitoring protocol includes two major components (PRRIP 2017b):

1) Detect and confirm whooping crane stopovers through systematic aerial surveys of river channel and palustrine wetland habitat within the 90-mile AHR. Stopover data is used to comparatively evaluate changes in the frequency and distribution of stopovers within the study area over time.
2) Collect landscape-level habitat data at use locations. Habitat data is used for resource selection analyses and other analyses intended to inform Program habitat creation and maintenance activities.

In an effort to align survey dates with the period when most (90%) whooping cranes were sighted in Nebraska, the Program established spring and fall monitoring periods to encompass the 5th through 95th percentiles of initial sighting dates for all recorded sightings of whooping crane groups in Nebraska from the U.S. Fish and Wildlife Service's (USFWS) public sighting database for 1975–1999 (PRRIP 2021c). Since then, the 5th and 95th percentile window of observations has served as a guideline to adjust monitoring dates to accommodate for temporal shifts in whooping crane arrival in Nebraska. In recent years, the Program has conducted fall monitoring between October 9 and November 15.

In this report, we summarize PRRIP's fall 2023 whooping crane monitoring efforts and results and place them in the context of PRRIP's long-term monitoring. Specifically, we report on the number of individual whooping cranes enumerated, proportion of the AWB population observed stopping on AHR, number of crane use days, and use locations and associated habitat and flow metrics. We provide maps of whooping crane locations and photographs of observations. We summarize systematic and opportunistic survey efforts and resulting observations. We report on the detectability of whooping crane decoys during aerial surveys. Finally, we provide an assessment of how the 5th and 95th percentiles of dates of whooping crane group observations in Nebraska from the USFWS public sighting database have changed over time and how these changes may affect interpretation of whooping crane stopover metrics.

Methods

Study area

The study area encompassed the Program's AHR along the central Platte River (Figs. 1, 2) that extends from the Highway 283 Platte River bridge near Lexington, Nebraska (40°44'08.15" N; 99°44'37.31" W) to the Platte River bridge near Chapman, Nebraska (40°59'07.06" N; 98°08'40.40" W). The monitoring area spanned a total of approximately 90 linear miles of river and included Platte River channels and adjacent palustrine wetlands and ponds within 3.5 miles of the river channel(s).

Systematic aerial surveys

The PRRIP EDO conducted fall whooping crane monitoring in accordance with the *Platte River Recovery Implementation Program – Whooping Crane Monitoring Protocol Migrational Habitat Use in the Central Platte River Valley rev. June 2017* (PRRIP 2017b) during October 9, 2023 through January 20, 2024. We used two Cessna 172 aircraft, each crewed by a pilot and two observers, to make aerial observations along predetermined systematic flight transects (Figs. 1, 2). The pilot utilized a GPS unit to follow defined transects and track miles flown. We flew systematic

aerial transects daily, weather and visibility permitting, at an air speed of approximately 100 mph and an altitude of approximately 750 ft unless conditions demanded higher altitudes. Two flights were initiated each morning with one departing from Grand Island, Nebraska (east route; shown in red on Figs. 1, 2) and one from Kearney, Nebraska (west route; shown in green on Figs. 1, 2). Planes were required to be at transect starting points one-half hour before sunrise. Flights were typically completed in less than two hours. In the event of adverse weather, crews were able to wait up to two hours after sunrise for conditions to improve before cancelling the flight. Pilots were also able to cancel flights the night before or morning of a flight if they judged weather to be unsuitable for flying. Due to continued presence of one whooping crane group on the eastern half of the AHR, we used a modified protocol from November 29, 2023 through January 20, 2024, in which only one plane was used to systematically fly the east route.

Two types of transects were flown on each route to ensure coverage of both on-channel riverine and off-channel wetland habitat. On-channel river transects (shown in blue on Figs. 1, 2) were flown east to west with the plane located south of the southern-most river channel to reduce the effect of sun glare. Starting points along riverine transects were alternated daily between two flight routes to allow different sections of the study area to be observed as early as possible in the flight times. Off-channel transects (shown in red and green on Figs. 1, 2) were designed to survey existing off-channel habitat within 3.5 mi of the river and serve as functional routes for planes to return to starting airports. Both types of transects were flown on the east route during November 29 through January 20, 2024.

Route 1. The first pilot flew the transect covering the west half of the AHR from the Minden, Nebraska bridge west to the Lexington, Nebraska bridge (0SW; Fig. 1). The first pilot then flew the primary wetland return transect (PWRTW) from west to east (Fig. 1). The second pilot simultaneously flew the transect covering the east half of the AHR from the Chapman, Nebraska bridge west to the Minden bridge (0SE), followed by the primary wetland return transect (PWRTE) from west to east (Fig. 1). The second pilot flew a secondary transect (CSRT) to return to the airport (Fig. 1).

Route 2. The first pilot flew the transect covering the west half of the AHR beginning at the midpoint of the 0SW river channel transect at the Odessa, Nebraska bridge west to the Lexington bridge (Fig. 2). The first pilot then flew the primary wetland return transect (PWRTW) east to the Minden bridge, followed by the 0SW river channel transect back to the Odessa bridge (Fig. 2). The first pilot flew a secondary return transect (ESRT) from Hwy 183 at Elm Creek, Nebraska east to return to the Kearney airport (Fig. 2). The second pilot simultaneously flew the transect covering the east half of the AHR from the midpoint of the 0SE river channel transect at the Wood River, Nebraska bridge west to the Minden bridge (Fig. 2). The second pilot then flew the primary wetland return transect (PWRTE) east to the Chapman bridge, followed by the remainder of the east half of the 0SE transect back to the Wood River bridge (Fig. 2). The second pilot flew a secondary return transect east (WSRT) to return to the Grand Island airport (Fig. 2).

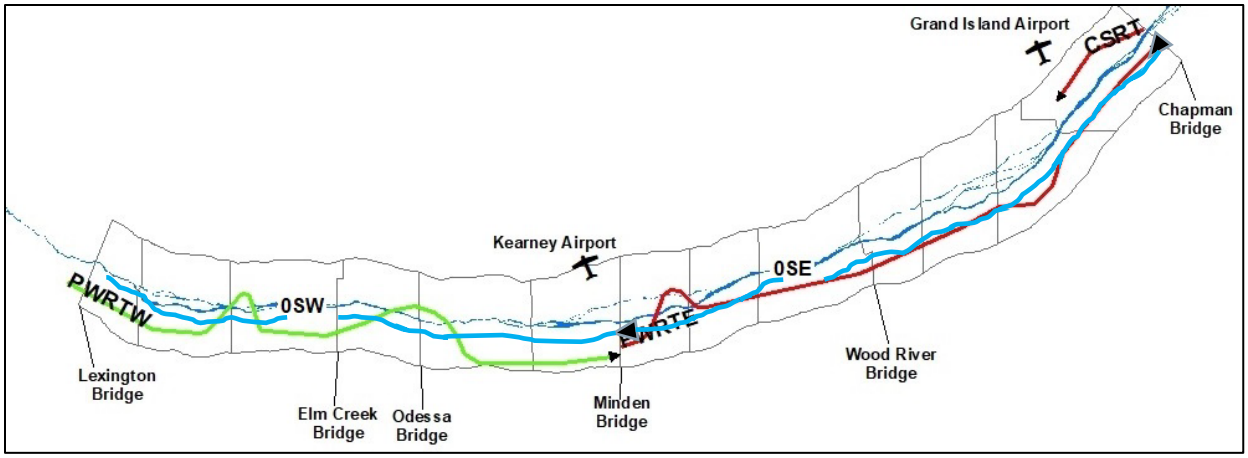


Figure 1. East and west flight transects for Route 1 of whooping crane aerial surveys between Lexington, and Chapman, Nebraska. Black and grey triangles indicate starting points of flights. River channel transects (0SW; 0SE) are shown in blue. The west primary wetland return transect (PWRTW) is shown as a green line. The east primary wetland return (PWRTE) and secondary return transects (CRST) are shown in red.

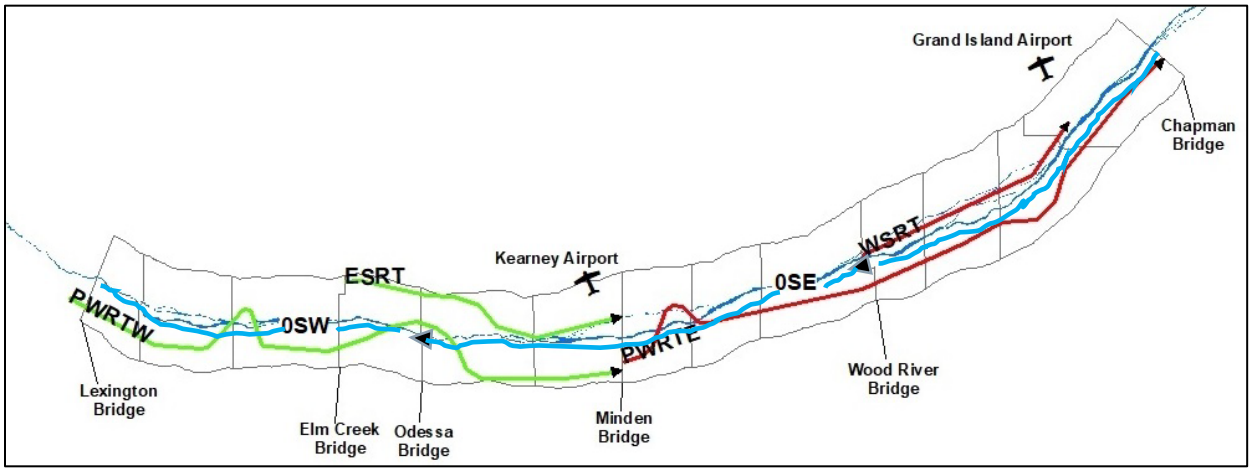


Figure 2. East and west flight transects for Route 2 of whooping crane aerial surveys between Lexington, Nebraska and Chapman, Nebraska. Black and grey triangles indicate starting points of flights. River channel transects (0SW; 0SE) are shown in blue. The west primary wetland return transect (PWRTW) and secondary return transect (ESRT) are shown as green lines. The east primary wetland return (PWRTE) and secondary return transects (WRST) are shown as red lines.

Observations and data collection

In addition to survey crews in airplanes, the EDO simultaneously deployed two ground crews on west and east survey routes to verify locations and identities of possible whooping cranes observed by aerial surveyors. Aerial survey crews relayed their position to ground survey crews via mobile phone at the beginning of each transect and at turn around points. Aerial surveyors used binoculars for sighting and a Canon Rebel T6s 760D camera for photo documentation of possible whooping cranes. If an aerial surveyor spotted potential whooping crane(s), then he or she took aerial photographs of the birds and the surrounding area to later confirm the identity and location. If additional observations for species identification were needed, then aerial surveyors contacted the nearest ground observer who positioned herself or himself to make a positive identification of the

whooping crane(s) without disturbance. Aerial and ground survey crews also confirmed and recorded opportunistic whooping crane sightings that occurred in addition to those observed during aerial systematic surveys. On days when flights were cancelled or after receiving a report of a potential whooping crane group requiring confirmation, ground personnel surveyed the area until the whooping crane(s) were located and confirmed, or sufficient search time had been allotted to confirm the whooping cranes had left or were not present in the area. Ground searches concluded when the whooping crane group was located, a bird species other than whooping cranes were located and identified at the general location where potential whooping cranes were reported, or a reasonable amount of search effort had been put forth with no whooping crane observed or other species identified. We notified USFWS biologists of survey results and opportunistic sightings daily following the completion of both morning flights and any ground search efforts. We coordinated with USFWS to determine whether whooping crane groups had been observed on previous mornings or whether they were new to the AHR.

Throughout the fall monitoring period, EDO staff placed a total of 20 whooping crane decoy sets consisting of 40 decoys (one to three decoys per set) in 20 unique locations along the aerial transects to evaluate the ability of aerial surveyors to detect whooping cranes. We placed 10 decoy sets at randomly selected locations within the river channel and 10 decoy sets at randomly selected locations along off-channel conservation lands within 500 ft of the channel.

Aerial and ground surveyors documented their observations of whooping crane groups with photographs and recorded the number of whooping cranes observed, age category of individuals as adults or juveniles, location, land cover type, time, and date of observation. Surveyors defined a whooping crane group as one or more whooping cranes observed at one location. Surveyors gave each whooping crane group a unique identification (ID) code (e.g., 2023FA01) combining the year, season (FA for fall), and PRRIP group number at sighting. If the same confirmed group was observed at more than a single location within the same day, the initial sighting received an A location identifier (e.g., 2023FA01A) with all subsequent locations receiving a B, C, etc... If the same confirmed group was observed the following day, then surveyors gave the group a new group ID (e.g., 2023FA02). We used aerial flight logs and ground search data sheets to document time and mileage devoted to searching for and identifying whooping cranes. During ground search surveys, mileage was calculated based on the driving distance from the location of the last reported sighting or known location to the conclusion of the search effort.

We recorded locations of each whooping crane group in Universal Transverse Mercator (UTM) coordinates within UTM Zone 14N using satellite imagery in ArcGIS Pro 3.1.1 (ESRI 2023) in conjunction with observation photographs and location descriptions provided by surveyors. We assigned use sites a number based on the date and time of sighting if the whooping crane group was observed in riverine, lacustrine, or palustrine land cover types. Whooping crane groups sighted outside of these land cover types were not assigned a use site number, but surveyors recorded the location's land cover classification. If the group was sighted while in flight, then surveyors recorded the location's land cover as "AIR." After entering data into the PRRIP species database, we conducted Quality Assurance/Quality Control (QA/QC) checks to ensure accuracy.

We used whooping crane group locations to evaluate river flow and habitat metrics at or near the use location. Four U.S. Geological Survey (USGS) flow gages were located on the Platte River

throughout the AHR from west to east during fall 2023 monitoring: Overton (USGS 2023a); Cottonwood Ranch (USGS 2023b); Kearney (USGS 2023c); and Grand Island (USGS 2023d). We used data from the gage closest to the whooping crane group location to the nearest 15 min of the group observation to assign a discharge in cubic feet per second (cfs) to each location. The width of the Platte River channel unobstructed by dense vegetation (i.e., unobstructed channel width) and the distance to the nearest riparian forest (i.e., distance to nearest forest) have both been found to be important predictors of whooping crane use of the Platte River (Baasch et al. 2019). We used fall 2023 aerial imagery of the Platte River channel and surrounding habitat and ArcGIS (ESRI 2023) to estimate the unobstructed channel width and distance to nearest forest for each of the whooping crane group locations located in the Platte River channel.

Calculation of whooping crane stopover metrics and 5th and 95th percentiles of dates of observations

Proportion of population stopping on the AHR. We determined the total number of unique individual whooping cranes observed by PRRIP's EDO during both systematic and opportunistic monitoring efforts throughout the AHR between October 9, 2023 and January 20, 2024. Due to continued presence of whooping cranes on the AHR past the typical November 15 monitoring period end date, we continued surveys into January 2024 in accordance with the *Platte River Recovery Implementation Program Whooping Crane Monitoring Protocol Migrational Habitat Use in the Central Platte River Valley rev. June 2017* (PRRIP 2017b). We concluded surveying on January 20, 2024 after whooping cranes were not observed for two consecutive flights.

Unique individuals and groups were typically identifiable by their arrival date, location, and group composition (but see PRRIP 2021b for unique considerations during fall 2021). We divided the total number of unique individual whooping cranes observed through combined systematic and opportunistic monitoring efforts by the estimated size of the AWB population from winter 2022–2023 surveys (USFWS 2023) to estimate the proportion of the AWB population that stopped on the AHR during the fall 2023 migration.

Number of crane use days. We calculated the number of crane use days for each whooping crane group observed by multiplying the number of individual cranes in each group by the number of days the group was present, and adding one day per whooping crane observed if the initial observation was made before noon. We added one day per whooping crane observed because we assumed birds observed before noon were present and roosting on or near the river the evening prior to the morning of the observation. Similarly, an additional day per crane was added to USFWS public sightings only for observations made before noon. PRRIP crane use days includes observations made within the designated systematic survey period and any extensions of that survey period due to continued observed crane presence on the AHR per the Program's monitoring protocol. PRRIP crane use days includes days when crane groups are not observed by PRRIP if dates of no observations are between consecutive PRRIP observations of that group. This assumes the group did not leave and return and that it is the same group. Unique groups are typically individually identifiable by their arrival date, location, and group composition. USFWS data are not used to calculate PRRIP crane use days, such that groups not observed by PRRIP and dates that groups were observed by USFWS prior to or after PRRIP observations are not included in the

calculation of PRRIP crane use days. We calculated the total number of crane use days for fall 2023 by summing the number of crane use days across all whooping crane groups observed.

5th and 95th percentiles and adjusted whooping crane metrics. We used the USFWS whooping crane public sighting database for Nebraska (USFWS *unpublished data*) to determine the initial date of fall whooping crane group observations during 1998–2023. We divided the data into 17 10-year rolling periods with the first and last periods spanning 1998–2007 and 2014–2023, respectively. We used R version 4.2.2 (R Core Team 2022) to calculate the 5th and 95th percentiles of initial dates of group observations for each 10-year period.

For each year of PRRIP systematic surveys dating back to 2007, we calculated adjusted metrics as the total number of individual whooping cranes observed and total number of crane use days within the dates corresponding to the 5th and 95th percentiles of initial dates of group observations for each 10-year period. For example, for PRRIP surveys conducted during 2007, we used percentiles calculated from USFWS data from 1998–2007. For PRRIP surveys conducted during 2023, we used percentiles calculated from USFWS data from 2014–2023. We used a non-parametric Spearman's rank correlation (Neter et al. 1996) to calculate the Spearman's correlation coefficient (ρ) and assess whether significant relationships at $\alpha = 0.05$ existed between the adjusted proportion of population and year, and adjusted number of crane use days and year during 2007–2023. We also used package *nlme* in R (Pinheiro and Bates 2000, R Core Team 2022, Pinheiro et al. 2023) to fit mixed-effects models to examine whether a trend existed between the adjusted proportion of the population and year, and adjusted number of crane use days and year. In each model, we included year as a random effect with an autoregressive correlation structure of order one to account for repeated measurements across years.

Results

Whooping crane observations and monitoring effort

Aerial and ground surveyors enumerated 43 individual whooping cranes consisting of 37 adults and six juveniles in 13 unique groups during fall 2023 monitoring (Figs. 3, 4; Appendix B, Appendix C). Two of the groups had multiple birds leave the group and AHR during the monitoring period, but some individuals of the group remained (USFWS ID 23B-32; USFWS ID 23B-34; Appendix B). The locations and distribution of historical fall observations of whooping crane groups by PRRIP during 2001–2023 are provided in an online interactive GIS database at: https://hwcorp.maps.arcgis.com/apps/mapviewer/index.html?webmap=ab525e32ac22460faa6fa87148fc16d6.

Overall, PRRIP surveyors recorded 173 whooping crane group locations based on repeated observations of the same groups during the 104-day monitoring period (Appendix B, Appendix C). Of these 173 locations, 11 were observations of the same group at a different location on the same day (i.e., "B" locations in Appendix B). Seventeen of the 173 locations were comprised of groups that were first observed as separate groups when they arrived on the AHR, but later merged with other unique groups and we retained the unique PRRIP group identification number to record

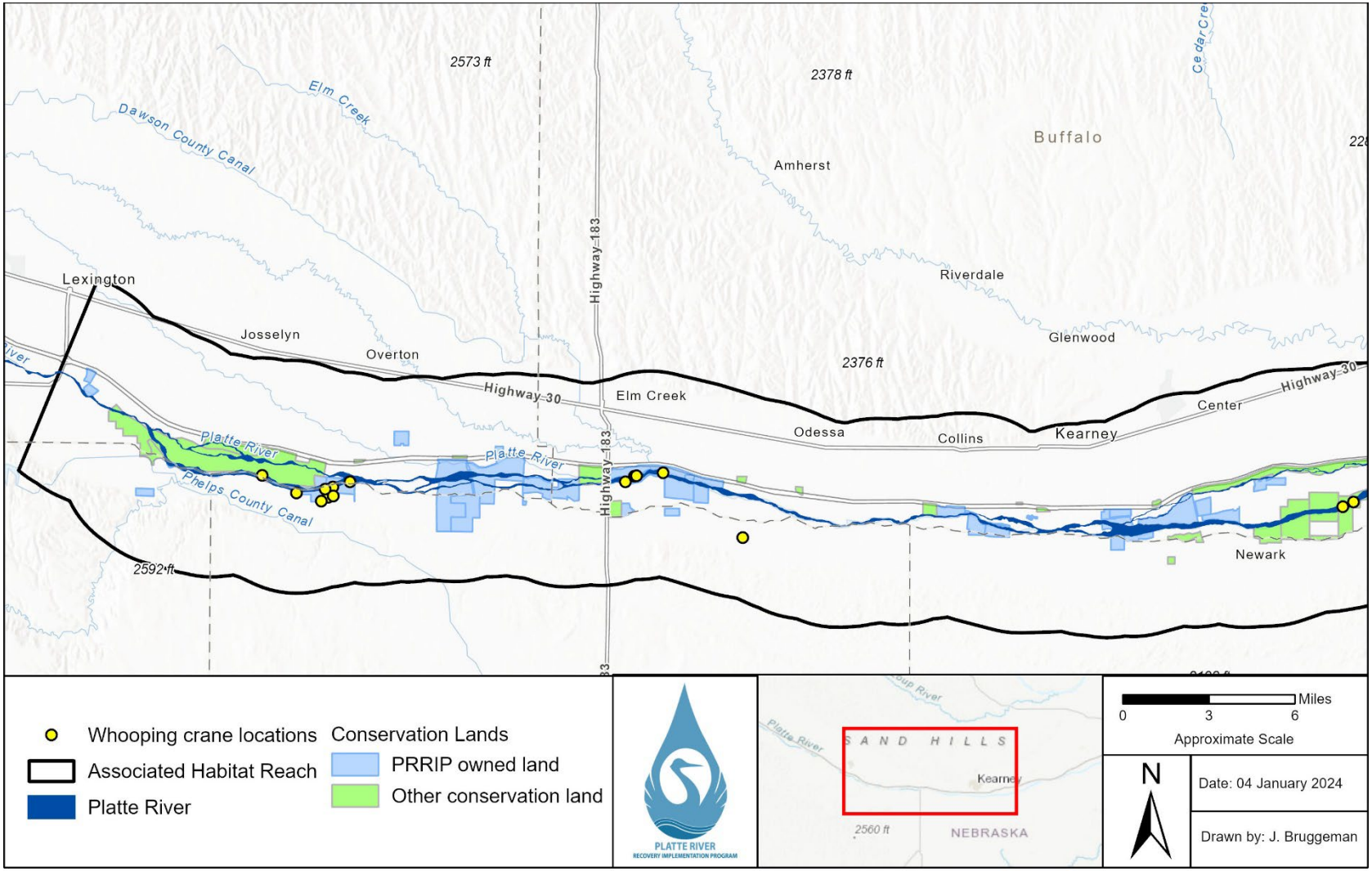


Figure 3. Locations of whooping crane groups observed during fall 2023 PRRIP systematic aerial surveys and ground surveys along the Associated Habitat Reach of the central Platte River between Lexington and Kearney, Nebraska. Enlarged and detailed location maps with group identification numbers are provided in Appendix C. Locations of historical fall observations of whooping crane groups by PRRIP during 2001–2023 are provided online at https://hwcorp.maps.arcgis.com/apps/mapviewer/index.html?webmap=ab525e32ac22460faa6fa87148fc16d6.

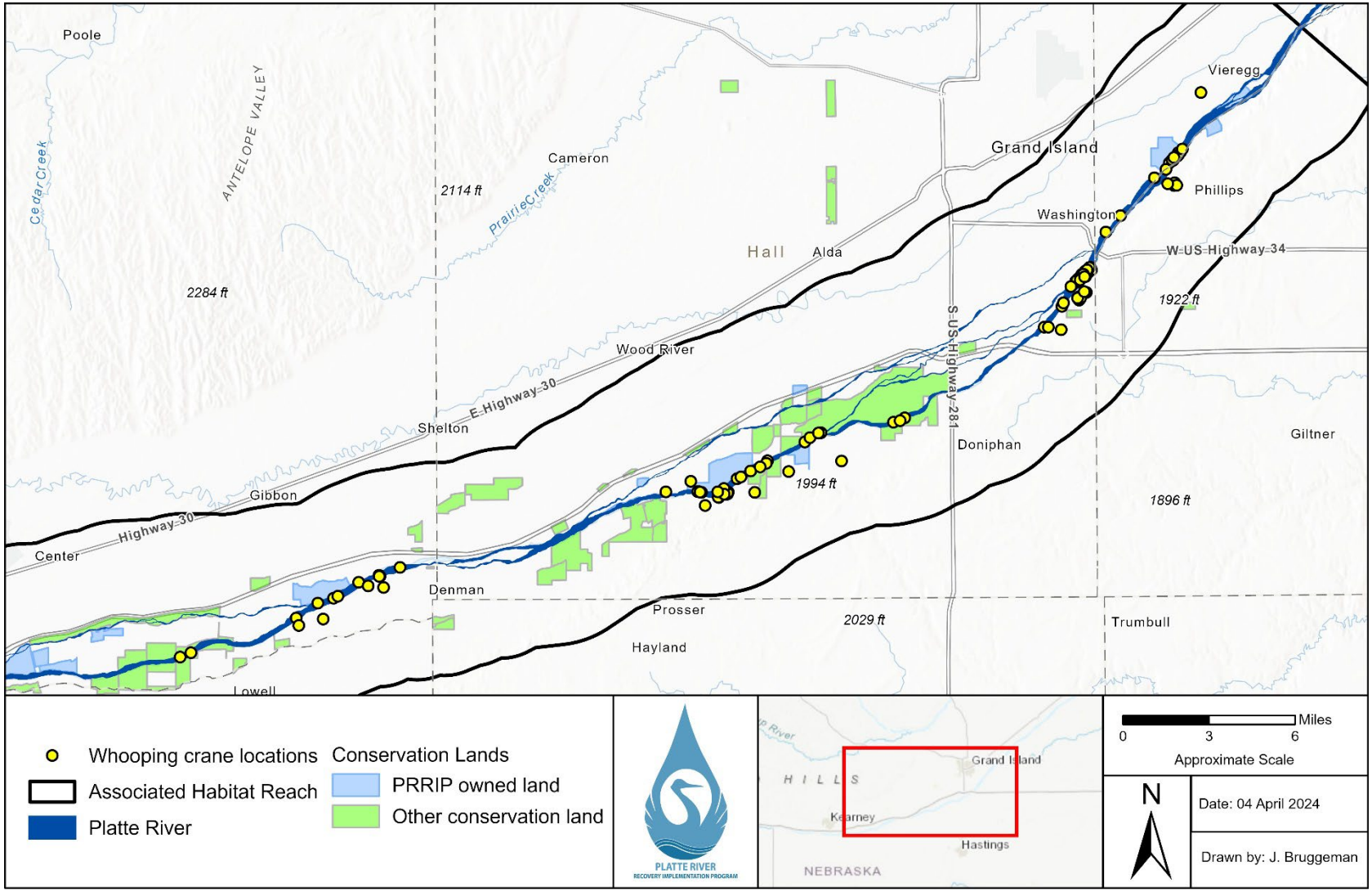


Figure 4. Locations of whooping crane groups observed during fall 2023 PRRIP systematic aerial surveys and ground surveys along the Associated Habitat Reach of the central Platte River between Kearney and Chapman, Nebraska. Enlarged and detailed location maps with group identification numbers are provided in Appendix C. Locations of historical fall observations of whooping crane groups by PRRIP during 2001–2023 are provided online at https://hwcorp.maps.arcgis.com/apps/mapviewer/index.html?webmap=ab525e32ac22460faa6fa87148fc16d6.

Table 1. Number of whooping crane groups observed during systematic aerial surveys and opportunistic aerial and ground surveys during fall 2023 along the Associated Habitat Reach (AHR) of the central Platte River between Lexington and Chapman, Nebraska. Included for each type of survey effort are the: number of whooping crane groups observed; number of transects completed, incomplete, cancelled, and scheduled; duration of survey effort; and number of miles flown or driven during surveys. Additional systematic aerial surveys were conducted during November 16, 2023–January 20, 2024 due to the continued presence of one group on the eastern AHR.

Survey type		Flight transects	No. whooping crane groups observed[a]	No. transects completed	No. transects incomplete	No. transects cancelled	Total no. transects scheduled	Duration of survey effort[b]	Miles flown or driven
Systematic aerial surveys (October 9–November 15)	On channel	0SE, 0SW[c]	73	60	2	14	76	32:34	6,730
	Off channel	PWRTE, PWRTW[d]	26	58	2	16	76	28:24	
	Off channel	WSRT, CSRT, ESRT[e]	2	44	0	13	57	7:44	
Additional systematic aerial surveys (November 16–January 20, 2024)	On channel	0SE, 0SW[c]	33	50	2	26	78	24:21	5,510
	Off channel	PWRTE, PWRTW[d]	14	50	2	26	78	22:52	
	Off channel	WSRT, CSRT, ESRT[e]	0	43	0	26	69	6:10	
Opportunistic surveys	Flight[f]	na	0	na	na	na	na	na	na
	Ground[g]	na	25	na	na	na	na	11:35	158
	Total		173	305	8	121	434	133:42	12,398

[a] see Appendix B for whooping crane group observation details.
[b] duration of survey effort is denoted in hours:minutes
[c] primary transect (riverine): East – 0SE; West – 0SW (Figs. 1, 2)
[d] primary return transect: East – PWRTE; West – PWRTW (Figs. 1, 2)
[e] secondary return transect: East – WSRT; CSRT; West – ESRT (Figs. 1, 2)
[f] opportunistic flight: includes aerial observations made while in route to systematic transects or deviations from the systematic transects.
[g] opportunistic ground: includes efforts made by ground crew in motorized vehicle to search for known groups when flights were cancelled or to confirm or deny unconfirmed crane groups located outside of systematic flight transects. Does not include efforts to confirm possible crane groups at locations first observed by aerial observers during systematic flights.

stay length. Therefore, we observed 145 original group locations (Appendix B, Appendix C). Surveyors observed the first whooping crane group on October 29, 2023, and the final group remained until January 10, 2024. The mean and median initial dates of whooping crane group observations were November 3 and November 2, respectively (standard error [SE] = 1.3 days, n = 13). The mean and median dates of all 145 group observations were November 17 and November 11, respectively (SE = 1.4 days).

Systematic aerial surveys. During systematic aerial monitoring, surveyors observed a total of 148 whooping crane groups, including secondary locations of the same group on the same date, consisting of 43 individual whooping cranes (37 adults; six juveniles) in 13 unique groups (Table 1; Figs. 3, 4; Appendix B, Appendix C). Most (71.6%) whooping crane groups observed during systematic aerial surveys were located along on-channel transects (Table 1). Pilots completed 58 of 76 (76.3%) regularly scheduled flights (Table 2). Eighteen flights were either cancelled or not completed due to low visibility or poor weather (Table 2). In addition, pilots completed 50 of 78 extra flights scheduled after November 15 (Table 2). Among all 434 scheduled systematic transects encompassing river channel and off-channel primary/secondary return transects, 305 (70.2%) were completed (Table 1). There were eight transects initiated but not completed when weather conditions deteriorated mid-survey (Table 1). Transects not initiated prior to ending the survey were recorded as cancelled along with all transects scheduled when the plane did not depart the airport. In total, 121 transects were cancelled (Table 1).

Opportunistic ground and aerial monitoring. We considered all ground monitoring observations that were not made to confirm previously observed whooping crane locations from systematic aerial surveys and all aerial observations made when not surveying defined transects to be opportunistic. Surveyors observed a total of 25 whooping crane groups during ground monitoring Tables 1, 3; Figs. 3, 4; Appendix B, Appendix C). Ground survey crews drove a total of 158 mi to search for potential whooping cranes (Table 3).

Table 2. Number of systematic aerial surveys completed, cancelled or incomplete, and scheduled during fall 2023 whooping crane monitoring for east and west flight routes along the Associated Habitat Reach of the central Platte River between Lexington and Chapman, Nebraska. Also provided are the number of additional systematic aerial surveys completed, cancelled, and scheduled during November 16, 2023 through January 20, 2024, after the scheduled 38-day monitoring period had ended.

Flight route	East route	West route	Total
	Systematic surveys		
No. completed	30	28	58
No. cancelled/incomplete	8	10	18
No. scheduled	38	38	76
Percent systematic completed	*78.9%*	*73.7%*	*76.3%*
	Additional systematic surveys flown[a]		
No. completed	39	11	50
No. cancelled/incomplete	26	2	28
No. scheduled	65	13	78
Percent additional completed	*60.0%*	*84.6%*	*64.1%*
Overall percent completed	**67.0%**	**76.5%**	**70.1%**

[a] After November 28, only the east route for the systematic survey was scheduled to be flown daily.

Table 3. Summary of ground search efforts for whooping cranes during fall 2023 monitoring along the Associated Habitat Reach of the central Platte River between Lexington and Chapman, Nebraska. The date of the search; information source that prompted the search (aerial sighting by plane [plane]; previous known location [known]; no information [none]); miles driven during the search; and type of effort (aerial and ground surveyors working together [both]; ground observation only [ground]) are provided for each ground search effort entry. For confirmed whooping crane observations, the number of adults and juveniles enumerated are provided along with the corresponding USFWS and PRRIP group IDs. Color-coded unique group icons correspond to group symbols on Figures 6–9 and locations on maps in Appendix C.

Unique group icon	USFWS group ID	PRRIP group ID	Date	Source	No. of confirmed whooping cranes (adults:juveniles)	Miles driven	Type of effort
N/A	N/A	N/A	10/9	Plane	None	2	Both
N/A	N/A	N/A	10/14	Plane	None	3	Both
N/A	N/A	N/A	10/15	Plane	None	5	Both
N/A	N/A	N/A	10/16	Plane	None	1	Both
N/A	N/A	N/A	10/24	Plane	None	3	Both
N/A	N/A	N/A	10/28	Plane	None	2	Both
	23B-30	2023FA03	10/30	Known	3:0	1	Ground
	23B-30	2023FA08	10/31	Known	3:0	1	Ground
	23B-48	2023FA25	11/3	Known	3:0	1	Ground
	23B-31	2023FA28	11/4	Known	2:0	1	Ground
	23B-50	2023FA32	11/4	Known	4:1	1	Ground
	23B-31	2023FA40	11/5	Known	2:0	1	Ground
	23B-31	2023FA53	11/7	Known	2:0	3	Ground
	23B-49	2023FA61	11/9	No Info	1:0	1	Ground
	23B-32	2023FA75	11/11	Known	4:0	1	Ground
	23B-67	2023FA81	11/13	Known	2:0	12	Ground
	23B-33	2023FA86	11/13	Known	2:1	1	Ground
	23B-34	2023FA86	11/13	Known	2:1	1	Ground
N/A	N/A	N/A	11/14	Plane	None	15	Both
N/A	N/A	N/A	11/15	Plane	None	2	Both
	23B-33	2023FA94	11/15	Known	2:1	1	Ground
	23B-34	2023FA94	11/15	Known	2:1	1	Ground
N/A	N/A	N/A	11/17	Known	None	10	Ground
	23B-66	2023FA106	11/19	Known	2:1	18	Ground
	23B-66	2023FA107	11/19	Known	3:0	1	Ground
N/A	N/A	N/A	11/19	Known	None	5	Ground
	23B-32	2023FA108	11/19	Known	4:0	1	Ground
	23B-66	2023FA110	11/20	Known	5:1	12	Ground
	23B-32	2023FA109	11/20	Known	4:0	25	Ground
N/A	N/A	N/A	11/22	Known	None	4	Ground
	23B-32	2023FA117	11/27	Known	2:0	1	Ground
N/A	N/A	N/A	12/8	Plane	None	16	Both

Table 3—Continued

Unique group icon	USFWS group ID	PRRIP group ID	Date	Source	No. of confirmed whooping cranes (adults:juveniles)	Miles driven	Type of effort
	23B-32	2023FA133	12/14	Known	2:0	1	Ground
	23B-32	2023FA134	12/15	Known	2:0	1	Ground
	23B-32	2023FA139	12/20	Known	2:0	1	Ground
	23B-32	2023FA140	12/22	Known	2:0	1	Ground
	23B-32	2023FA145	1/1/2024	Known	2:0	1	Ground
	TOTAL				**66:7**	**158**	

Whooping crane stopover metrics

Proportion of population stopping on the AHR. The USFWS estimated the AWB migratory whooping crane population to be 536 birds (95% confidence interval [CI] = 443.5, 644.1) based on winter 2022–2023 survey efforts within the primary survey area along the Texas coast of the Gulf of Mexico, USA wintering range (USFWS 2023; Appendix D). The USFWS did not conduct a winter 2023–2024 survey. Based on the 43 individual whooping cranes enumerated during PRRIP surveys, we estimated that 0.080 (95% CI = 0.067, 0.097) of the AWB whooping crane population was observed on the AHR along the central Platte River during the fall migration (Fig. 5a). The proportion of the AWB population using the AHR along the central Platte River during the fall migration has varied between 0.005 and 0.174 during 2007–2023 (mean = 0.049; median = 0.044; SE = 0.010; Fig. 5a).

Number of crane use days. The 13 unique whooping crane groups remained in the study area between one and 73 days (mean = 14.4; median = 11; SE = 5.1). When not including the one group that stayed 73 days, the maximum stopover length was 19 days with a mean of 9.5 days among the 12 groups. Based on the lengths of stay of the 13 groups and the number of whooping cranes enumerated in each group, we calculated a total of 584 crane use days for the fall 2023 monitoring period between October 9, 2023 and January 20, 2024 (Fig. 5a). Between 2007 and 2023, the number of crane use days during the fall migration has varied between eight and 584 days (mean = 112; median = 42; SE = 42; Fig. 5a).

5th and 95th percentile dates of whooping crane group observations and adjusted whooping crane stopover metrics

Fifth percentile dates of initial whooping crane group observations in Nebraska from the USFWS public sighting database ranged from October 13 to October 18 (mean = October 14; SE = 0.39 days) over the 17 10-year periods (Table 4). Ninety-fifth percentile dates ranged from November 5 to November 16 (mean = November 12; SE = 1.1 days; Table 4). The smallest range of days between the 5th and 95th percentile dates was 23 days between October 13 and November 5 during the 1999–2008 period (Table 4). The largest range of days between the 5th and 95th percentile dates occurred during the 2007–2016 and 2008–2017 periods, which spanned 32 days between October 15 and November 16 (Table 4).

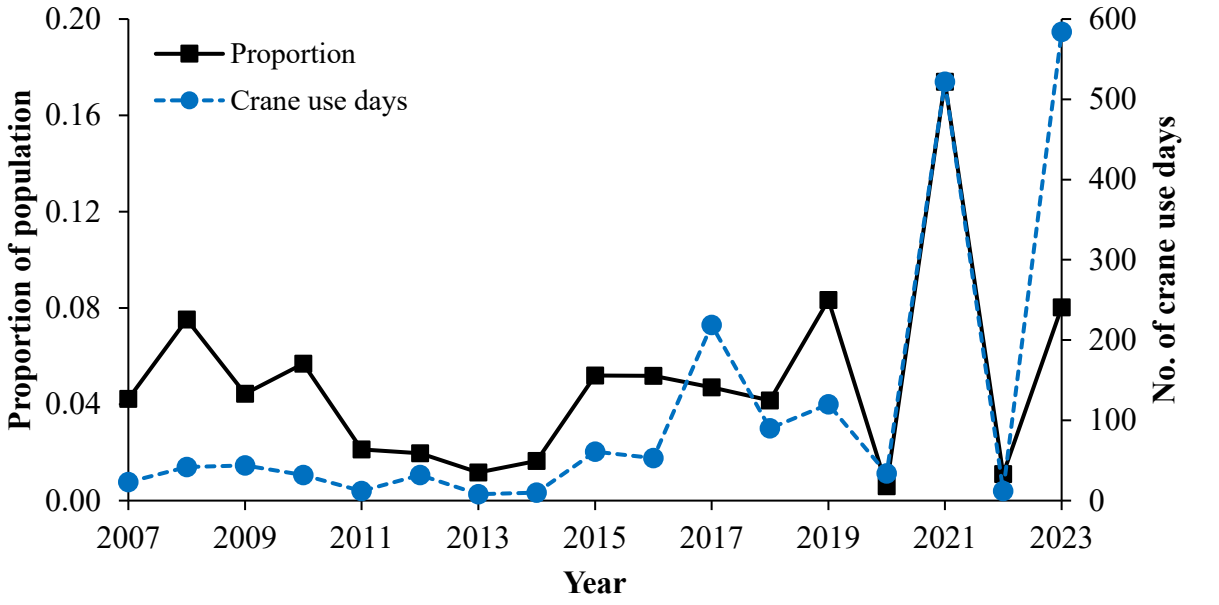
All years of surveys included the 5th percentile date for the corresponding period (Table 4). Surveys during 2007, 2013, 2014, 2018, 2019, and 2020 did not include the 95th percentile date for the corresponding period (Table 4). In 2007, 2018, and 2020, surveys ended one day before the 95th percentile date (Table 4). Surveys ended two days before the 95th percentile date in 2014 and 2019 (Table 4). In 2013, surveys ended three days before the 95th percentile date (Table 4). Therefore, we could not fully assess the extent whooping crane metrics would have been adjusted during those years.

Use of 5th and 95th percentiles of dates to calculate whooping crane metrics resulted in adjustments being made to metrics in 2009, 2012, 2015, 2017, 2019, 2021, and 2023 (Figs. 5, 6). In 2012 and 2019, the number of individual whooping cranes observed decreased by one and two, respectively. This adjustment decreased the proportion of the population in these years to 0.016 in 2012 and 0.079 in 2019 (Figs. 5, 6). The number of crane use days decreased by seven days in 2009, three days in 2012, 20 days in 2015, 46 days in 2017, four days in 2019, three days in 2021, and 172 days in 2023 (Figs. 5, 6). The adjusted number of crane use days was 412 days in fall 2023. Except for 2012 and 2019, all decreases in the number of crane use days resulted from whooping cranes groups arriving before and staying beyond the 95th percentile date.

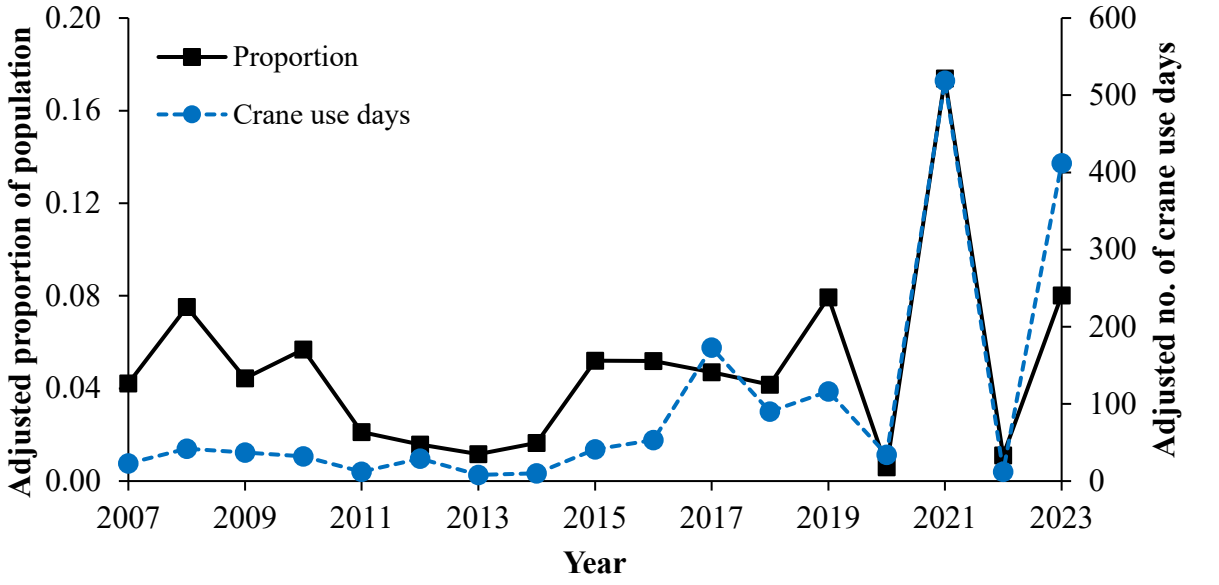
We found no correlation between the adjusted proportion of population stopping on the AHR during fall and year during 2007–2023 using a Spearman's rank correlation ($\rho = 0.081$; $p = 0.758$). Likewise, we found no significant correlation between adjusted proportion of population stopping on the AHR during fall and year when evaluating a trend using mixed-effects models ($\beta_{year} = 0.002$; SE = 0.001; $p = 0.183$). There was a non-statistically significant relationship (at $\alpha = 0.05$) between the adjusted number of crane use days and year during 2007–2023 using a Spearman's rank correlation ($\rho = 0.465$; $p = 0.060$). We did find a statistically significant relationship between the adjusted number of crane use days and year during 2007–2023 using mixed-effects models ($\beta_{year} = 15.5$; SE = 3.38; $p < 0.001$). We found no relationship between the number of whooping cranes enumerated during PRRIP fall surveys and the estimated AWB population size during 2016–2023 ($p > 0.05$, $R^2 = 0.0009$; Fig. D2, Appendix D).

Table 4. The 5th and 95th percentiles of initial dates of fall whooping crane group observations in Nebraska for 16 10-year periods ranging from 1998–2007 to 2014–2023. Percentiles were calculated using the USFWS whooping crane public sighting database for Nebraska during 1998–2023. For each period, the applicable survey year(s) for which the percentiles were used to adjust whooping crane metrics is provided. The start and end dates for PRRIP monitoring during each survey year are also provided.

Period	Applicable survey year(s)	5th percentile	95th percentile	Survey start date	Survey end date
1998–2007	2007	14-Oct	11-Nov	9-Oct	10-Nov
1999–2008	2008	13-Oct	5-Nov	9-Oct	10-Nov
2000–2009	2009	13-Oct	6-Nov	9-Oct	10-Nov
2001–2010	2010	13-Oct	5-Nov	9-Oct	10-Nov
2002–2011	2011	13-Oct	6-Nov	10-Oct	10-Nov
2003–2012	2012	14-Oct	10-Nov	9-Oct	16-Nov
2004–2013	2013	13-Oct	13-Nov	9-Oct	10-Nov
2005–2014	2014	15-Oct	14-Nov	9-Oct	12-Nov
2006–2015	2015	15-Oct	15-Nov	9-Oct	19-Nov
2007–2016	2016	15-Oct	16-Nov	9-Oct	20-Nov
2008–2017	2017	15-Oct	16-Nov	9-Oct	22-Nov
2009–2018	2018	16-Oct	16-Nov	9-Oct	15-Nov
2010–2019	2019	16-Oct	16-Nov	9-Oct	14-Nov
2011–2020	2020	16-Oct	16-Nov	9-Oct	15-Nov
2012–2021	2021	18-Oct	16-Nov	9-Oct	19-Nov
2013–2022	2022	17-Oct	16-Nov	9-Oct	18-Nov
2014–2023	2023	18-Oct	15-Nov	9-Oct 2023	20-Jan 2024



(a)



(b)

Figure 5. Annual variability in the proportion of the Aransas-Wood Buffalo (AWB) migratory whooping crane population that stopped on the Associated Habitat Reach (AHR) of the central Platte River and the associated number of crane use days between 2007 and 2023 during the fall migration. Panel **(a)** depicts the proportion of the population and number of crane use days for the entire fall survey period, whereas **(b)** illustrates the proportion of the population and number of crane use days calculated only for dates constrained by the 5th and 95th percentiles of dates of fall whooping crane group observations in Nebraska (see text for details). Whooping cranes were enumerated using PRRIP's systematic aerial surveys and opportunistic aerial and ground sightings during fall of each year across the AHR between Lexington and Chapman, Nebraska. For the 2021 and 2023 proportion calculations, the estimated AWB population from winters 2019–2020 and 2022–2023, respectively, were used because no winter survey was completed during 2020–2021 or 2023–2024.

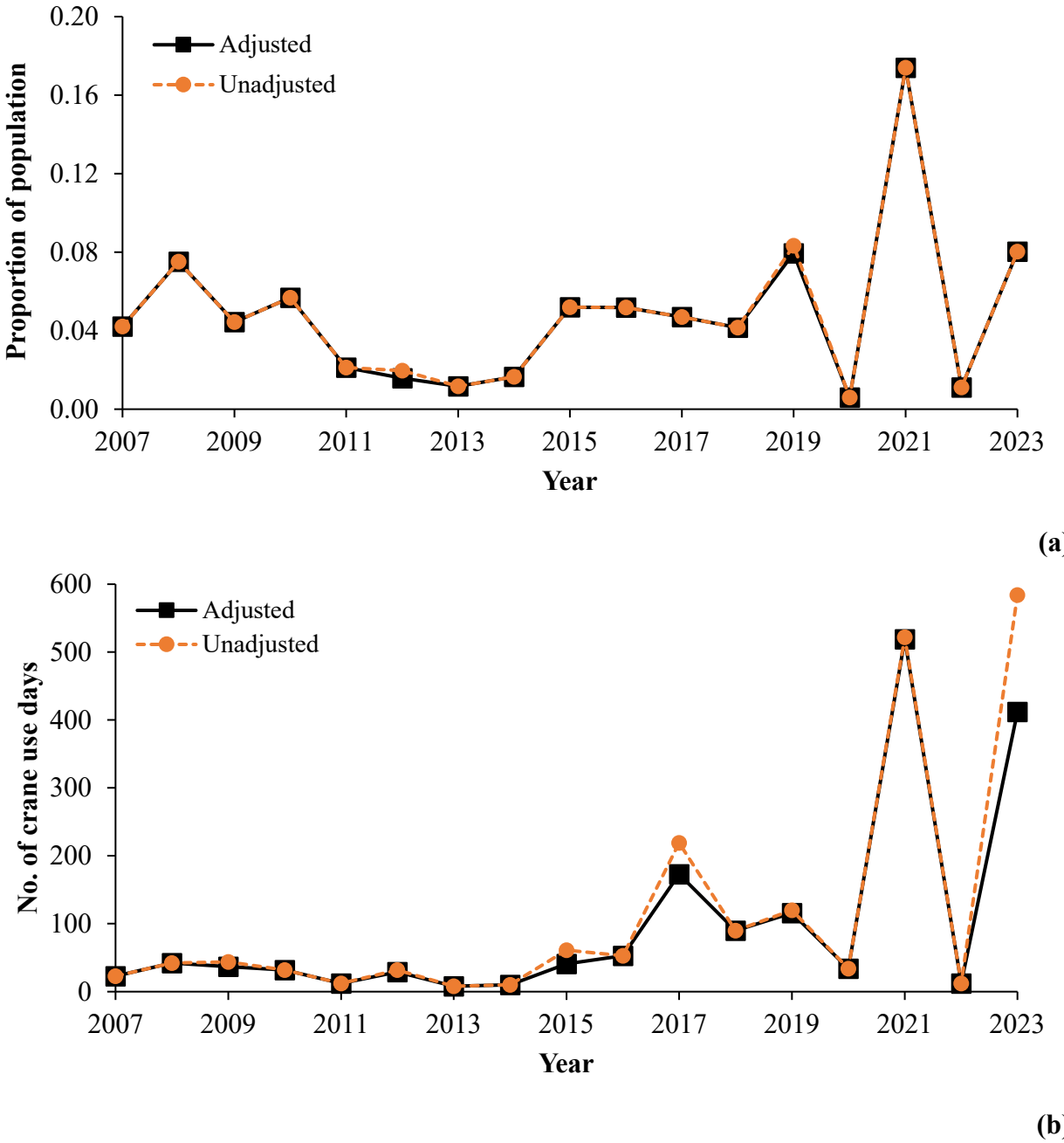


Figure 6. Annual variability between 2007 and 2023 during the fall migration in **(a)** the proportion of the Aransas-Wood Buffalo migratory whooping crane population that stopped on the Associated Habitat Reach (AHR) of the central Platte River, and **(b)** the associated number of crane use days. Each panel illustrates the whooping crane metric for the entire fall survey period (unadjusted; orange circles and dashed line) and only for dates constrained by the 5th and 95th percentiles of dates of fall whooping crane group observations in Nebraska (adjusted; black squares and solid line; see text for details). Whooping cranes were enumerated using PRRIP's systematic aerial surveys and opportunistic aerial and ground sightings during fall of each year across the AHR between Lexington and Chapman, Nebraska. Data from 2007, 2013, 2014, 2018, 2019, and 2020 did not include the 95th percentile date for the corresponding period (Table 4) and values of adjusted metrics may be an underestimate. For the 2021 and 2023 proportion calculations, the estimated AWB population from winters 2019–2020 and 2022–2023, respectively, were used because no winter survey was completed during 2020–2021 or 2023–2024.

Whooping crane observations in relation to Platte River discharge and habitat metrics

During the standard October 9 through November 15 fall 2023 whooping crane migration monitoring period, Platte River discharge in the AHR ranged from a low of 89 cfs at Kearney on October 12 (USGS 2023c) to a high of 2,190 cfs at Kearney on November 1 and 2 (USGS 2023c; Figs. 7–10). Platte River discharge at the Overton gage (USGS 2023a) ranged from 149 cfs to 2,140 cfs (mean = 756; SE = 10.3; n = 3,652) with low and high flows recorded on October 11 and October 29–30, respectively (Fig. 7). Discharge at the Cottonwood Ranch gage (USGS 2023b) ranged from 160 cfs to 1,350 cfs (mean = 586; SE = 6.6; n = 3,631) with low flow recorded on October 11 and high flow recorded on October 29 (Fig. 8). At the Kearney gage (USGS 2023c), discharge reached a low of 89 cfs on October 12 and a high of 2,190 cfs on November 1 and 2 (mean = 798; SE = 11.7; n = 3,541; Fig. 9). The Grand Island gage (USGS 2023d) recorded a low discharge of 176 cfs on October 13 and peak discharge of 2,010 cfs on November 3 (mean = 766; SE = 10.3; n = 3,652; Fig. 10). During November 16, 2023 through January 20, 2024, discharge in the AHR ranged from a low of 45 cfs at Overton on January 9, 2024 (USGS 2023a) to a high of 2,250 cfs at Kearney on December 4 (USGS 2023c; Figs. 7–10). Gage discharge data was provisional as of the writing of this report and will be updated once the USGS approves the data.

Instantaneous discharge at the gaging station closest to the whooping crane group location ranged from 220 cfs to 2,220 cfs for all 116 riverine locations (mean = 993; median = 760; SE = 61; Table 5; Fig. 11), which included repeated observations of the same 12 riverine groups. The thirteenth unique group (USFWS ID 23B-65; PRRIP ID 2023FA65) was only observed on one day in a corn landcover type. These discharge measurements were recorded to the nearest 15 min of the time the whooping crane group was observed. Most (82.5%) of the 116 whooping crane groups observed in the river channel were closest to the Grand Island gage (Table 5; Fig. 10). Instantaneous discharge during the first riverine observation of each of the 12 unique groups ranged from 295 cfs to 2,080 cfs (mean = 1,468; median = 1,785; SE = 195; Table 5; Fig. 12). It is worth noting that these instantaneous discharges are indicative of river flow conditions when the group was first observed in the river channel by aerial or ground surveyors and not a measure of conditions when the group decided to stop.

Unobstructed channel widths at the 116 whooping crane riverine use sites ranged from 310 ft to 1,580 ft (mean = 992; median = 963; SE = 25; Table 6). Distance to the nearest forest at the 116 riverine use sites ranged from 136 ft to 1,371 ft (mean = 489; median = 432; SE = 22; Table 6).

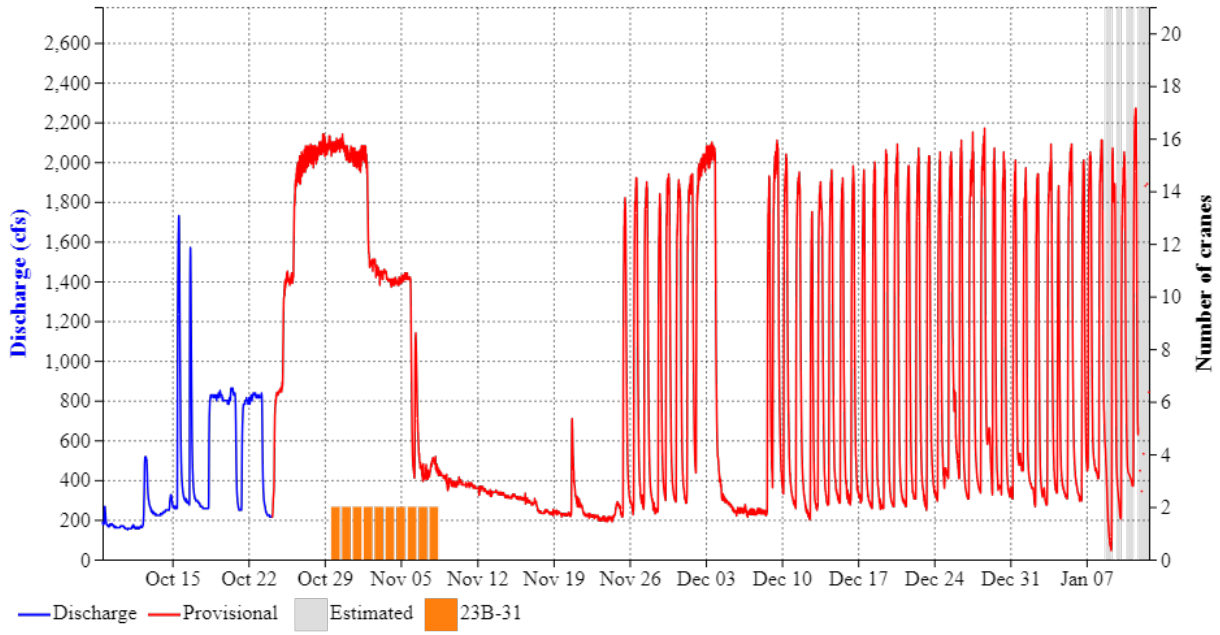


Figure 7. Platte River discharge in cubic feet per second (cfs; blue line [approved data]; red line [provisional data]; dotted line [estimated]) at the Overton, Nebraska gage during October 9 through January 10, 2024 (USGS 2023a) and the corresponding numbers of whooping cranes from each group (USFWS group 23B-31 in color-coded bar) observed on the indicated dates either on- or off-channel at locations for which Overton was the nearest gaging station. Ice affected the gage during periods of estimated discharge.

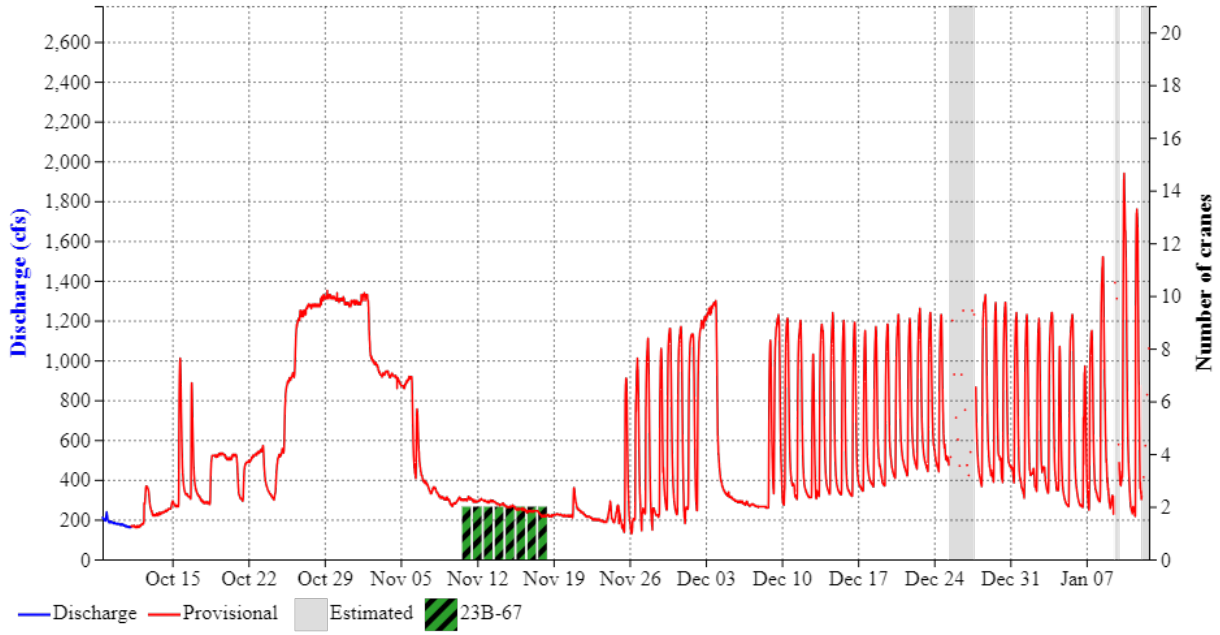


Figure 8. Platte River discharge in cubic feet per second (cfs; blue line [approved data]; red line [provisional data]; dotted line [estimated]) at the Cottonwood Ranch, Nebraska gage during October 9 through January 10, 2024 (USGS 2023b) and the corresponding numbers of whooping cranes from each group (USFWS group 23B-67 in color-coded bar) observed on the indicated dates either on- or off-channel at locations for which Cottonwood Ranch was the nearest gaging station. Ice affected the gage during periods of estimated discharge.

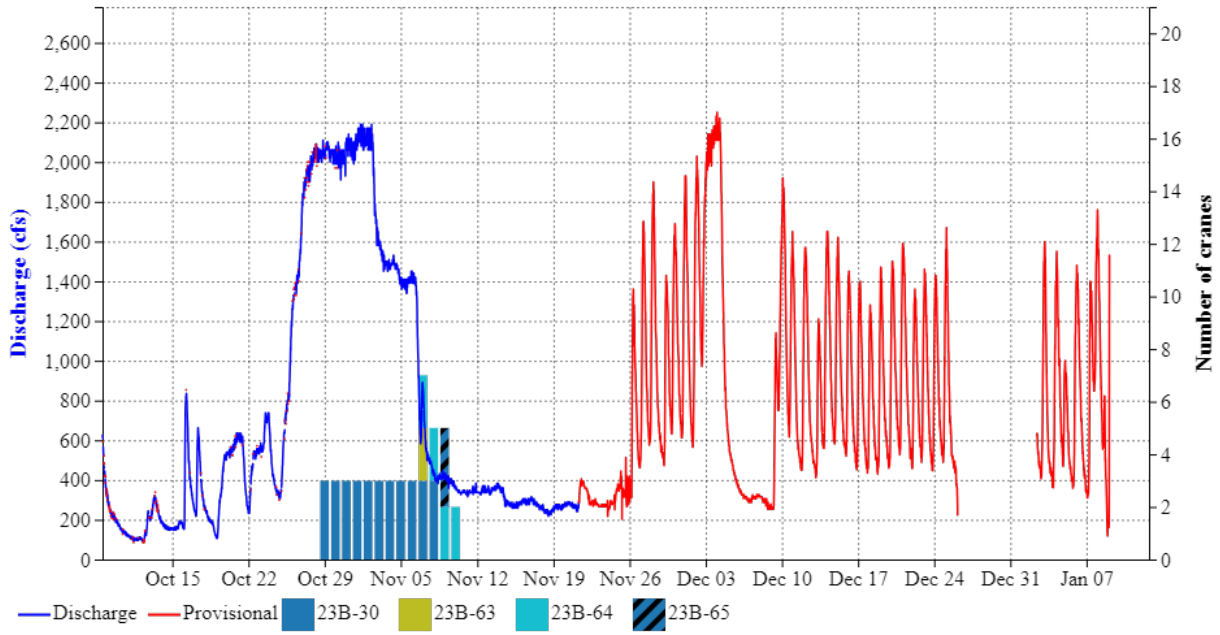


Figure 9. Platte River discharge in cubic feet per second (cfs; blue line [approved data]; red line [provisional data]) at the Kearney, Nebraska gage during October 9 through January 10, 2024 (USGS 2023c) and the corresponding numbers of whooping cranes from each group (USFWS groups 23B-30; 23B-63; 23B-64; 23B-65 in color-coded bars) observed on the indicated dates either on- or off-channel at locations for which Kearney was the nearest gaging station. Ice affected the gage from December 26–January 2, 2024.

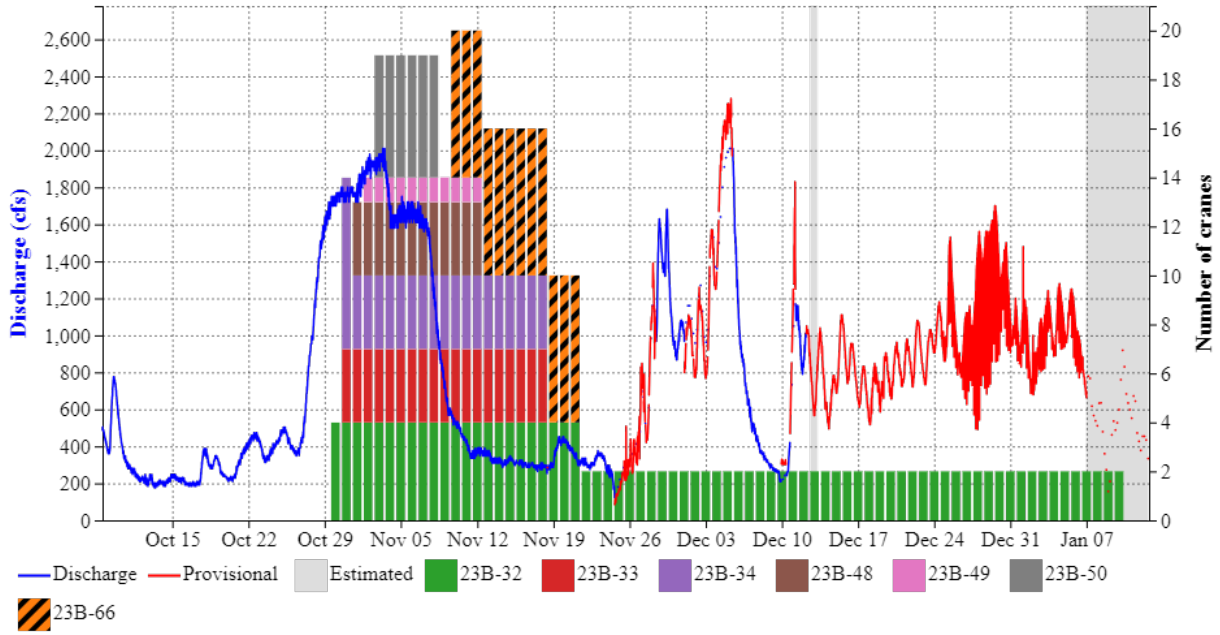


Figure 10. Platte River discharge in cubic feet per second (cfs; blue line [approved data]; red line [provisional data]; dotted line [estimated]) at the Grand Island, Nebraska gage during October 9 through January 10, 2024 (USGS 2023d) and the corresponding numbers of whooping cranes from each group (USFWS groups 23B-32; 23B-33; 23B-34; 23B-48; 23B-49; 23B-50; 23B-66 in color-coded bars) observed on the indicated dates either on- or off-channel at locations for which Grand Island was the nearest gaging station. Ice affected the gage during periods of estimated discharge.

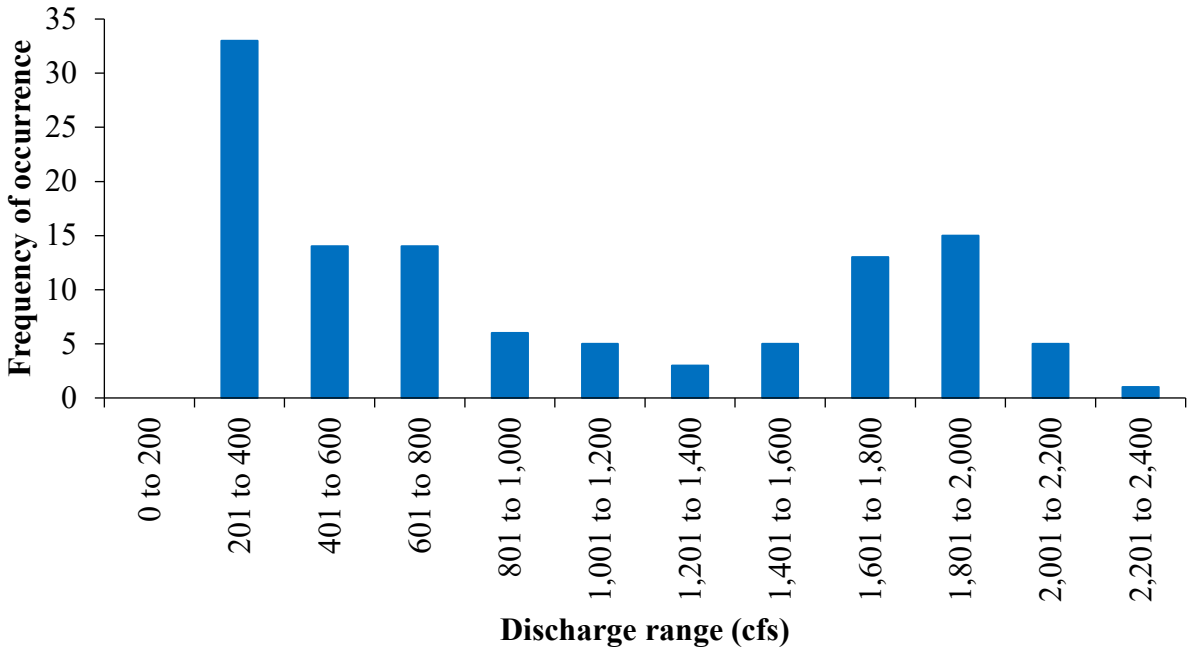


Figure 11. Distribution of Platte River discharge (cubic feet per second [cfs]) at the 114 total whooping crane group locations observed in the river channel during fall 2023 PRRIP monitoring. Discharge was determined from the gaging station nearest to the group location. Discharge data from the gaging station was used based on the time of group observation to the nearest 15 minutes.

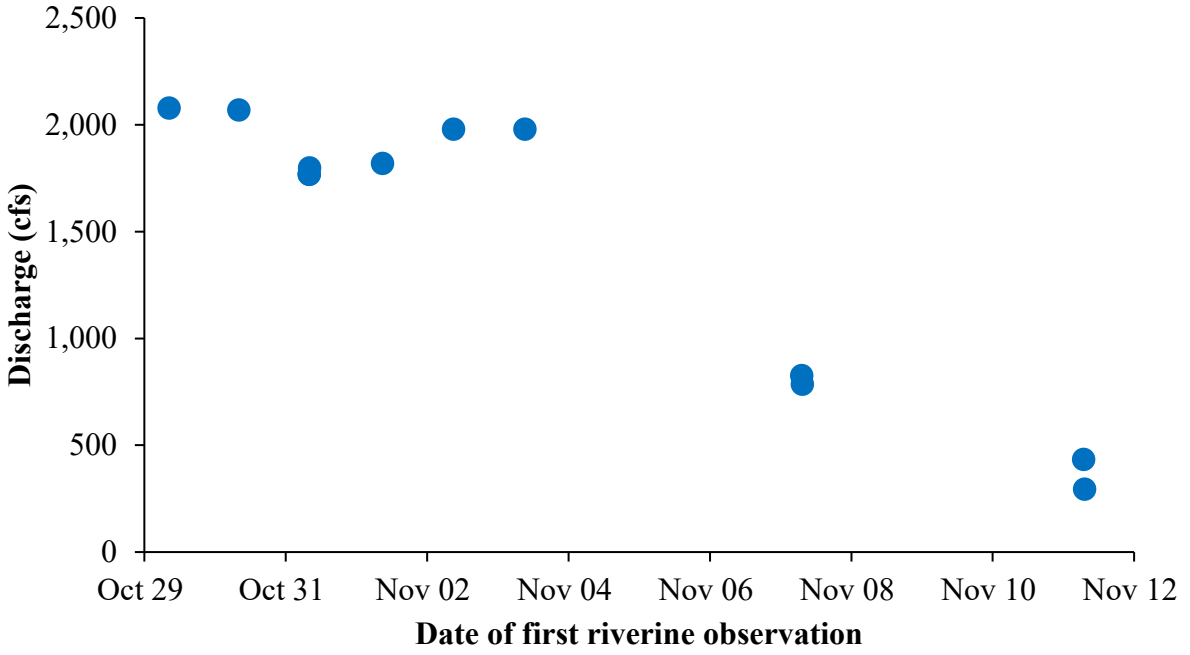


Figure 12. Platte River discharge (cubic feet per second [cfs]) by date during the first riverine observation of 12 unique whooping crane groups observed during fall 2023 PRRIP monitoring. Discharge was determined from the gaging station nearest to the group location. Discharge data from the gaging station was used based on the time of group observation to the nearest 15 minutes. Discharge is indicative of river flow conditions when the group was first observed in the river channel by aerial or ground surveyors and not a measure of conditions when the group decided to stop on the AHR.

Table 5. Whooping crane groups observed in the Platte River channel within the Associated Habitat Reach between Lexington and Chapman, Nebraska, and the associated river discharge (cubic feet per second [cfs]) at the gaging station nearest to the group location during fall 2023 monitoring. Discharge data from the gaging station was used based on the time of group observation to the nearest 15 minutes. Color-coded unique group icons correspond to group symbols on Figures 6–9 and locations on maps in Appendix C.

Unique group icon	USFWS Group ID	PRRIP Group ID	No. of cranes (adults: juveniles)	Use site no.	Date	Gaging station[a]	Discharge (cfs)
	23B-30	2023FA01	3:0	1	10/29	Kearney	2,080
	23B-30	2023FA03	3:0	3	10/30	Kearney	1,990
	23B-30	2023FA08	3:0	3	10/31	Kearney	2,100
	23B-30	2023FA10	3:0	9	11/1	Kearney	2,140
	23B-30	2023FA19	3:0	17	11/2	Kearney	2,120
	23B-30	2023FA26	3:0	22	11/3	Kearney	1,600
	23B-30	2023FA39	3:0	30	11/5	Kearney	1,370
	23B-30	2023FA52	3:0	36	11/7	Kearney	827
	23B-30	2023FA55	3:0	39	11/8	Kearney	434
	23B-31	2023FA02	2:0	2	10/30	Overton	2,070
	23B-31	2023FA15	2:0	13	11/2	Overton	1,510
	23B-31	2023FA54	2:0	38	11/8	Overton	495
	23B-32	2023FA07	4:0	6	10/31	Grand Island	1,800
	23B-32	2023FA07	4:0	7	10/31	Grand Island	1,770
	23B-32	2023FA13	4:0	12	11/1	Grand Island	1,850
	23B-32	2023FA17	4:0	15	11/2	Grand Island	1,940
	23B-32	2023FA34	4:0	28	11/4	Grand Island	1,580
	23B-32	2023FA36	4:0	29	11/5	Grand Island	1,750
	23B-32	2023FA43	4:0	32	11/6	Grand Island	1,610
	23B-32	2023FA75	4:0	48	11/11	Grand Island	405
	23B-32	2023FA78	4:0	51	11/12	Grand Island	376
	23B-32	2023FA84	4:0	54	11/13	Grand Island	362
	23B-32	2023FA97	4:0	61	11/16	Grand Island	323
	23B-32	2023FA103	4:0	65	11/18	Grand Island	286
	23B-32	2023FA108	4:0	70	11/19	Grand Island	362
	23B-32	2023FA109	4:0	68	11/20	Grand Island	435
	23B-32	2023FA113	2:0	70	11/22	Grand Island	298
	23B-32	2023FA114	2:0	71	11/23	Grand Island	376
	23B-32	2023FA117	2:0	71	11/27	Grand Island	678
	23B-32	2023FA120	2:0	73	11/30	Grand Island	968
	23B-32	2023FA121	2:0	73	12/1	Grand Island	837
	23B-32	2023FA122	2:0	51	12/2	Grand Island	773
	23B-32	2023FA123	2:0	74	12/4	Grand Island	1,410
	23B-32	2023FA124	2:0	75	12/5	Grand Island	2,220

Table 5—continued

Unique group icon	USFWS Group ID	PRRIP Group ID	No. of whooping cranes (adults: juveniles)	Use site no.	Date	Gaging station[a]	Discharge (cfs)
	23B-32	2023FA125	2:0	76	12/6	Grand Island	1,050
	23B-32	2023FA126	2:0	77	12/7	Grand Island	611
	23B-32	2023FA127	2:0	78	12/8	Grand Island	378
	23B-32	2023FA128	2:0	79	12/9	Grand Island	287
	23B-32	2023FA129	2:0	80	12/10	Grand Island	303
	23B-32	2023FA130	2:0	81	12/11	Grand Island	1,280
	23B-32	2023FA132	2:0	82	12/13	Grand Island	623
	23B-32	2023FA133	2:0	83	12/14	Grand Island	637
	23B-32	2023FA134	2:0	83	12/15	Grand Island	724
	23B-32	2023FA135	2:0	83	12/16	Grand Island	759
	23B-32	2023FA136	2:0	85	12/17	Grand Island	629
	23B-32	2023FA137	2:0	84	12/18	Grand Island	534
	23B-32	2023FA138	2:0	86	12/19	Grand Island	641
	23B-32	2023FA139	2:0	86	12/20	Grand Island	673
	23B-32	2023FA140	2:0	86	12/22	Grand Island	760
	23B-32	2023FA141	2:0	51	12/23	Grand Island	733
	23B-32	2023FA142	2:0	52	12/29	Grand Island	1,530
	23B-32	2023FA143	2:0	53	12/30	Grand Island	1,310
	23B-32	2023FA144	2:0	54	12/31	Grand Island	967
	23B-32	2023FA145	2:0	87	1/1/24	Grand Island	1,060
	23B-32	2023FA146	2:0	87	1/2/24	Grand Island	1,000
	23B-32	2023FA147	2:0	88	1/3/24	Grand Island	1,030
	23B-32	2023FA148	2:0	89	1/7/24	Grand Island	N/A
	23B-32	2023FA149	2:0	90	1/10/24	Grand Island	N/A
	23B-33	2023FA05	2:1	4	10/31	Grand Island	1,770
	23B-33	2023FA11	2:1	10	11/1	Grand Island	1,850
	23B-33	2023FA16	2:1	14	11/2	Grand Island	1,940
	23B-33	2023FA22	2:1	19	11/3	Grand Island	1,980
	23B-33	2023FA29	2:1	24	11/4	Grand Island	1,610
	23B-33	2023FA42	2:1	24	11/6	Grand Island	1,610
	23B-33	2023FA58	2:1	40	11/8	Grand Island	1,160
	23B-33	2023FA70	2:1	14	11/10	Grand Island	533
	23B-33	2023FA72	2:1	46	11/11	Grand Island	420
	23B-33	2023FA77	2:1	50	11/12	Grand Island	376
	23B-33	2023FA86	2:1	55	11/13	Grand Island	336
	23B-33	2023FA87	2:1	56	11/14	Grand Island	323
	23B-33	2023FA94	2:1	59	11/15	Grand Island	323

Table 5—continued

Unique group icon	USFWS Group ID	PRRIP Group ID	No. of whooping cranes (adults: juveniles)	Use site no.	Date	Gaging station[a]	Discharge (cfs)
	23B-33	2023FA96	2:1	24	11/16	Grand Island	310
	23B-33	2023FA102	2:1	64	11/18	Grand Island	298
	23B-34	2023FA06	5:2	5	10/31	Grand Island	1,770
	23B-34	2023FA12	2:1	11	11/1	Grand Island	1,850
	23B-34	2023FA16	2:1	14	11/2	Grand Island	1,940
	23B-34	2023FA22	2:1	19	11/3	Grand Island	1,980
	23B-34	2023FA58	2:1	40	11/8	Grand Island	1,160
	23B-34	2023FA64	2:1	41	11/9	Grand Island	714
	23B-34	2023FA70	2:1	14	11/10	Grand Island	533
	23B-34	2023FA72	2:1	46	11/11	Grand Island	420
	23B-34	2023FA77	2:1	50	11/12	Grand Island	376
	23B-34	2023FA86	2:1	55	11/13	Grand Island	336
	23B-34	2023FA87	2:1	56	11/14	Grand Island	323
	23B-34	2023FA94	2:1	59	11/15	Grand Island	323
	23B-34	2023FA102	2:1	64	11/18	Grand Island	298
	23B-48	2023FA09	3:0	8	11/1	Grand Island	1,820
	23B-48	2023FA18	3:0	16	11/2	Grand Island	1,940
	23B-48	2023FA25	3:0	21	11/3	Grand Island	1,960
	23B-48	2023FA31	3:0	26	11/4	Grand Island	1,630
	23B-48	2023FA45	3:0	34	11/6	Grand Island	1,680
	23B-48	2023FA66	3:0	43	11/10	Grand Island	533
	23B-48	2023FA71	3:0	45	11/11	Grand Island	435
	23B-49	2023FA20	1:0	18	11/2	Grand Island	1,980
	23B-49	2023FA24	1:0	20	11/3	Grand Island	1,980
	23B-49	2023FA30	1:0	25	11/4	Grand Island	1,630
	23B-49	2023FA44	1:0	33	11/6	Grand Island	1,680
	23B-49	2023FA67	1:0	44	11/10	Grand Island	533
	23B-49	2023FA73	1:0	47	11/11	Grand Island	420
	23B-49	2023FA79	1:0	52	11/12	Grand Island	390
	23B-50	2023FA27	4:1	23	11/3	Grand Island	1,980
	23B-50	2023FA45	4:1	34	11/6	Grand Island	1,680
	23B-63	2023FA51	2:0	35	11/7	Kearney	827
	23B-64	2023FA59	2:0	37	11/7	Kearney	787
	23B-64	2023FA82	2:0	42	11/10	Kearney	359
	23B-66	2023FA71	5:1	45	11/11	Grand Island	435
	23B-66	2023FA83	5:1	53	11/13	Grand Island	349
	23B-66	2023FA93	5:1	58	11/15	Grand Island	336

Table 5—continued

Unique group icon	USFWS Group ID	PRRIP Group ID	No. of whooping cranes (adults: juveniles)	Use site no.	Date	Gaging station[a]	Discharge (cfs)
	23B-66	2023FA98	5:1	53	11/16	Grand Island	323
	23B-66	2023FA100	5:1	63	11/17	Grand Island	298
	23B-66	2023FA111	5:1	69	11/21	Grand Island	362
	23B-67	2023FA76	2:0	49	11/11	Cottonwood	295
	23B-67	2023FA91	2:0	57	11/15	Cottonwood	261
	23B-67	2023FA95	2:0	57	11/16	Cottonwood	253
	23B-67	2023FA99	2:0	57	11/17	Cottonwood	239
	23B-67	2023FA105	2:0	66	11/18	Cottonwood	220

[a] Gaging Stations: Overton, Nebraska (USGS 2023a); Cottonwood Ranch, Nebraska (USGS 2023b); Kearney, Nebraska (USGS 2023c); Grand Island, Nebraska (USGS 2023d).

Table 6. Whooping crane groups observed during fall 2023 in the Platte River channel (i.e., riverine locations) within the Associated Habitat Reach between Lexington and Chapman, Nebraska, and the associated unobstructed channel width and distance to the nearest forest (nearest forest) at the used location. Provided for each group are the USFWS and PRRIP group identification (ID) number; use site number; x and y UTM 14N coordinates. Color-coded unique group icons correspond to group symbols on Figures 6–9 and locations on maps in Appendix C.

Unique group icon	USFWS group ID	PRRIP group ID	Use site no.	UTM x	UTM y	Unobstructed channel width (ft)	Nearest forest (ft)
	23B-30	2023FA01	1	521452	4507176	1,047	800
	23B-30	2023FA03	3	520282	4506661	845	273
	23B-30	2023FA08	3	520282	4506661	845	273
	23B-30	2023FA10	9	517963	4505561	655	876
	23B-30	2023FA19	17	520326	4506663	825	245
	23B-30	2023FA26	22	519128	4506330	995	506
	23B-30	2023FA39	30	516835	4505173	1,580	1,036
	23B-30	2023FA52	36	515627	4504332	872	429
	23B-30	2023FA55	39	517719	4505448	1,497	696
	23B-31	2023FA02	2	448520	4503877	557	750
	23B-31	2023FA15	13	453442	4503519	637	560
	23B-31	2023FA54	38	452049	4503123	439	493
	23B-32	2023FA07	6	557606	4520656	329	273
	23B-32	2023FA07	7	559099	4522933	694	357
	23B-32	2023FA13	12	559864	4523472	1,059	257
	23B-32	2023FA17	15	558681	4521997	371	462
	23B-32	2023FA34	28	559616	4523298	1,428	395

Table 6—continued

Unique group icon	USFWS group ID	PRRIP group ID	Use site no.	UTM x	UTM y	Unobstructed channel width (ft)	Nearest forest (ft)
	23B-32	2023FA36	29	559812	4523621	1,017	392
	23B-32	2023FA43	32	559429	4523273	882	284
	23B-32	2023FA75	48	560006	4523860	976	269
	23B-32	2023FA78	51	559989	4523839	954	272
	23B-32	2023FA84	54	559586	4523418	1,340	309
	23B-32	2023FA97	61	559378	4523233	855	261
	23B-32	2023FA103	65	560132	4523990	937	634
	23B-32	2023FA108	70	560034	4523803	966	623
	23B-32	2023FA109	68	559980	4523760	948	643
	23B-32	2023FA113	70	560034	4523803	962	451
	23B-32	2023FA114	71	558593	4521820	310	251
	23B-32	2023FA117	71	559440	4523203	865	481
	23B-32	2023FA120	73	559440	4523203	859	477
	23B-32	2023FA121	73	559440	4523203	861	471
	23B-32	2023FA122	51	559989	4523839	960	266
	23B-32	2023FA123	74	559493	4523313	763	326
	23B-32	2023FA124	75	558683	4522013	374	492
	23B-32	2023FA125	76	559483	4523343	1,490	246
	23B-32	2023FA126	77	560246	4523853	946	139
	23B-32	2023FA127	78	559833	4523507	1,045	415
	23B-32	2023FA128	79	559910	4523795	941	317
	23B-32	2023FA129	80	560101	4523882	1,024	518
	23B-32	2023FA130	81	559707	4523610	1,033	245
	23B-32	2023FA132	82	559782	4523643	1,023	290
	23B-32	2023FA133	83	559758	4523491	1,149	570
	23B-32	2023FA134	83	559758	4523491	1,145	599
	23B-32	2023FA135	83	559758	4523491	1,147	572
	23B-32	2023FA136	85	559923	4523482	1,027	136
	23B-32	2023FA137	84	560070	4523699	962	266
	23B-32	2023FA138	86	559541	4523391	1,410	281
	23B-32	2023FA139	86	559895	4523727	940	431
	23B-32	2023FA140	86	559541	4523391	1,412	307
	23B-32	2023FA141	51	559989	4523839	956	266
	23B-32	2023FA142	52	559840	4523686	964	343
	23B-32	2023FA143	53	559919	4523695	951	536
	23B-32	2023FA144	54	560190	4524005	886	491
	23B-32	2023FA145	87	559895	4523727	941	431
	23B-32	2023FA146	87	559895	4523727	940	412
	23B-32	2023FA147	88	559904	4523745	928	404

Table 6—continued

Unique group icon	USFWS group ID	PRRIP group ID	Use site no.	UTM x	UTM y	Unobstructed channel width (ft)	Nearest forest (ft)
	23B-32	2023FA148	89	559907	4523770	920	356
	23B-32	2023FA149	90	559971	4523826	959	246
	23B-33	2023FA05	4	564881	4530159	1,191	338
	23B-33	2023FA11	10	564781	4530031	1,261	175
	23B-33	2023FA16	14	565359	4530641	1,230	588
	23B-33	2023FA22	19	564432	4529493	1,050	332
	23B-33	2023FA29	24	564843	4530005	1,282	406
	23B-33	2023FA42	24	564843	4530005	1,283	390
	23B-33	2023FA58	40	564859	4530117	1,188	171
	23B-33	2023FA70	14	565359	4530641	1,226	575
	23B-33	2023FA72	46	563787	4529026	806	202
	23B-33	2023FA77	50	565088	4530246	1,288	834
	23B-33	2023FA86	55	565122	4530435	1,206	555
	23B-33	2023FA87	56	565248	4530481	1,173	728
	23B-33	2023FA94	59	565142	4530314	1,293	794
	23B-33	2023FA96	24	564843	4530005	1,266	390
	23B-33	2023FA102	64	564625	4529863	1,334	280
	23B-34	2023FA06	5	561885	4526901	1,385	340
	23B-34	2023FA12	11	561060	4525985	710	322
	23B-34	2023FA16	14	565359	4530641	582	1,230
	23B-34	2023FA22	19	564432	4529493	1,056	328
	23B-34	2023FA58	40	564859	4530117	1,198	170
	23B-34	2023FA64	41	565060	4530259	1,296	815
	23B-34	2023FA70	14	565359	4530641	1,231	605
	23B-34	2023FA72	46	563787	4529026	805	195
	23B-34	2023FA77	50	565088	4530246	1,307	912
	23B-34	2023FA86	55	565122	4530435	1,200	575
	23B-34	2023FA87	56	565248	4530481	1,183	580
	23B-34	2023FA94	59	565142	4530314	1,299	807
	23B-34	2023FA102	64	564625	4529863	1,404	278
	23B-48	2023FA09	8	540579	4512247	1,088	1,092
	23B-48	2023FA18	16	541122	4512574	1,498	1,371
	23B-48	2023FA25	21	541664	4512805	1,438	463
	23B-48	2023FA31	26	542011	4513010	1,032	370
	23B-48	2023FA45	34	539626	4511595	797	620
	23B-48	2023FA66	43	542081	4513154	918	277
	23B-48	2023FA71	45	538163	4511426	587	719
	23B-49	2023FA20	18	549519	4515409	493	283
	23B-49	2023FA24	20	549775	4515563	540	765

Table 6—continued

Unique group icon	USFWS group ID	PRRIP group ID	Use site no.	UTM x	UTM y	Unobstructed channel width (ft)	Nearest forest (ft)
	23B-49	2023FA30	25	549146	4515316	662	558
	23B-49	2023FA44	33	544937	4514711	1,005	1,196
	23B-49	2023FA67	44	544450	4514453	1,131	944
	23B-49	2023FA73	47	545081	4514722	862	894
	23B-49	2023FA79	52	544174	4514212	808	547
	23B-50	2023FA27	23	539274	4511411	1,179	750
	23B-50	2023FA45	34	539626	4511595	788	636
	23B-63	2023FA51	35	520267	4506725	842	432
	23B-64	2023FA59	37	509113	4502137	781	697
	23B-64	2023FA82	42	509713	4502386	776	604
	23B-66	2023FA71	45	538163	4511426	589	638
	23B-66	2023FA83	53	538284	4511391	816	505
	23B-66	2023FA93	58	538380	4511385	900	270
	23B-66	2023FA98	53	538284	4511391	792	498
	23B-66	2023FA100	63	540365	4512141	1,204	680
	23B-66	2023FA111	69	538219	4511423	681	684
	23B-67	2023FA76	49	469381	4503830	1,163	340
	23B-67	2023FA91	57	469516	4503849	1,151	361
	23B-67	2023FA95	57	469516	4503849	1,147	353
	23B-67	2023FA105	66	470987	4504023	902	547
	23B-67	2023FA99	57	469516	4503849	1,157	342

Comparison between PRRIP and USFWS data

We provide a comparison between whooping crane observations collected during PRRIP monitoring with those from the USFWS whooping crane public sighting database (USFWS *unpublished data*) for fall 2023 in Table 7. PRRIP coordinates with the USFWS to determine unique whooping crane groups throughout the monitoring period. Unique groups are typically individually identifiable by their arrival date, location, and group composition. However, discrepancies among datasets occur when: (1) whooping crane groups arrive and are reported to USFWS later in the day after systematic transects have been flown; (2) whooping crane groups leave the river prior to the plane surveying that portion of the transect; (3) observers do not see the group; (4) or flights are cancelled due to poor visibility or weather.

The USFWS public sighting database reported a whooping crane group that was not observed by PRRIP on one occasion during fall 2023 (Table 7). The USFWS reported group 23B-53, consisting of eight adults, on November 5 (Table 7). Overall, the USFWS database consisted of 51 whooping crane (45 adults; six juveniles) observations (Table 7). In comparison, PRRIP surveyors observed 43 whooping cranes (37 adults; six juveniles; Table 7). The total number of crane use days from USFWS data was 16 use days greater than that from PRRIP data due to the group of eight adults that stayed for one night (Table 7).

Table 7. Comparison between whooping crane groups observed during PRRIP surveys with those from the USFWS public sighting database during fall 2023 monitoring along the central Platte River, Nebraska. Included for each unique group are a color-coded icon; group identification (ID) numbers assigned by PRRIP and USFWS; the date(s) the group was observed and number of days present; the number of adults and juveniles in the group; and number of crane use days. Color-coded unique group icons correspond to group symbols on Figures 6–9 and locations on maps in Appendix C.

	PRRIP					USFWS				
Unique group icon	**PRRIP Group ID[a]**	**Dates present**	**Adults: juveniles**	**Days present**	**Crane use days[c]**	**USFWS Group ID[b]**	**Dates present**	**Adults: juveniles**	**Days present**	**Crane use days[d]**
	2023FA01, 03, 08, 10, 19, 26, 33, 39, 47, 52, 55	10/29–11/8	3:0	11	36	23B-30	10/29–11/8	3:0	11	36
	2023FA02, 14, 15, 21, 28, 40, 41, 53, 54	10/30–11/8	2:0	10	22	23B-31	10/30–11/8	2:0	10	22
	2023FA04, 07, 13, 17, 23, 34, 36, 43, 49, 57, 62, 69, 75, 78, 84, 88, 92, 97, 101, 103, 108, 109, 112	10/30–11/21	4:0	23	96	23B-32	10/30–11/21	4:0	23	96
	2023FA113, 114, 115, 116, 117, 118, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 147, 148, 149	11/22–1/10/24	2:0	50	100	23B-32	11/22–1/10/24	2:0	50	100

Table 7—Continued

Unique group icon	PRRIP Group ID[a]	Dates present	Adults: juveniles	Days present	Crane use days[c]	USFWS Group ID[b]	Dates present	Adults: juveniles	Days present	Crane use days[d]
	2023FA05, 11, 16, 22, 29, 35, 42, 48, 58, 63, 70, 72, 77, 86, 87, 94, 96, 102	10/31–11/18	2:1	19	60	23B-33	10/31–11/18	2:1	19	60
	2023FA06	10/31	5:2	1	14	23B-34	10/31	5:2	1	14
	2023FA12, 16, 22, 48, 58, 64, 70, 72, 77, 86, 87, 94, 102, 119	11/1–11/18	2:1	18	54	23B-34	11/1–11/18	2:1	18	54
	2023FA09, 18, 25, 31, 37, 45, 50, 56, 60, 66, 71, 80	11/1–11/12	3:0	12	39	23B-48	11/1–11/12	3:0	12	39
	2023FA20, 24, 30, 44, 61, 67, 73, 79	11/2–11/12	1:0	11	12	23B-49	11/2–11/12	1:0	11	12
	2023FA27, 32, 37, 45, 50, 56	11/3–11/8	4:1	6	35	23B-50	11/3–11/8	4:1	6	35
NA	NA	NA	NA	NA	NA	23B-53	11/5	8:0	1	16
	2023FA51	11/7	2:0	1	4	23B-63	11/7	2:0	1	4
	2023FA59,82	11/7–11/10	2:0	4	10	23B-64	11/7–11/10	2:0	4	10
	2023FA65	11/9	2:1	1	6	23B-65	11/9	2:1	1	6

Table 7—Continued

Unique group icon	PRRIP Group ID[a]	Dates present	Adults: juveniles	Days present	Crane use days[c]	USFWS Group ID[b]	Dates present	Adults: juveniles	Days present	Crane use days[d]
	2023FA68, 71, 80, 83, 89, 93, 98, 100, 104, 106, 107. 110, 111	11/10–11/21	5:1	12	78	23B-66	11/10–11/21	5:1	12	78
	2023FA76, 81, 90, 91, 95, 99, 105	11/11–11/18	2:0	8	18	23B-67	11/11–11/18	2:0	8	18
Total	**173 groups**		**37:6**	**187**	**584**	**Total**	**14 groups**	**45:6**	**188**	**600**

[a] PRRIP assigns a new whooping crane group ID each day a group is observed.
[b] USFWS assigns a whooping crane group ID based on an initial sighting basis of identification and subsequent following of groups.
[c] Crane use days based on PRRIP observations are calculated by multiplying the number of individual cranes in each group by the number of days the group was present, plus one day per crane. This is because each crane observed during early morning PRRIP aerial surveys is assumed to have been present the evening prior to the morning of the first observation.
[d] Crane use days based on USFWS public sighting observations are calculated by multiplying the number of individual cranes in each group by the number of days the group was present, plus one day per crane only for observations made prior to 11:59 a.m.

Detectability of whooping crane decoys

EDO staff placed whooping crane decoy sets at 20 unique locations between October 13 and November 29, 2023 (Table 8). Due to continued presence of whooping cranes near a previous decoy location, placement of decoys was extended to late November after the whooping cranes left the area and decoys could be retrieved. Five decoy sets consisted of one whooping crane decoy; 10 sets contained two decoys; and five sets consisted of three decoys (Table 8). EDO staff placed two of the five decoy sets comprised of one decoy, six of 10 sets consisting of two decoys, and two of five sets containing three decoys in the river channel (Table 8). The remaining decoys were placed in off-channel, lowland grassland habitat (Table 8). Aerial surveyors spotted seven of 10 decoy sets placed in the river channel (70%) and three of 10 decoy sets placed at off-channel locations (30%; Table 8). Aerial surveyors detected two of the five sets consisting of one decoy; six of 10 sets consisting of two decoys; and two of five sets consisting of three decoys (Table 8).

Table 8. Whooping crane decoy sets placed in river channel and off-channel habitats throughout the Associated Habitat Reach of the central Platte River between Lexington and Chapman, Nebraska during PRRIP's fall 2023 systematic aerial surveys. Provided for each decoy set are the date the set was placed, date of the first flight after decoy placement, UTM x and y coordinates, number of decoys in the set, habitat type at the location of placement, and whether aerial surveyors detected the set.

Date placed	Date of flight	UTM x	UTM y	No. of decoys	Habitat type	Detected
10/13	10/14	496663	4500548	1	Grassland - Lowland	Yes
10/13	10/15	518085	4505680	2	Wetted Channel	No
10/16	10/17	453644	4503315	3	Grassland - Lowland	No
10/17	10/19	495941	4501311	3	Wetted Channel	Yes
10/18	10/19	540334	4512474	3	Grassland - Lowland	No
10/19	10/20	488709	4501180	1	Grassland - Lowland	No
10/19	10/20	510904	4503088	3	Wetted Channel	Yes
10/20	10/22	506858	4502039	1	Grassland - Lowland	No
10/23	10/24	506355	4501830	2	Wetted Channel	Yes
10/23	10/24	547747	4515399	2	Grassland - Lowland	Yes
10/25	10/28	567882	4533093	1	Wetted Channel	No
10/30	10/31	458414	4503782	3	Grassland - Lowland	No
10/30	10/31	564981	4530183	2	Wetted Channel	Yes
11/1	11/2	463294	4503325	2	Wetted Channel	Yes
11/3	11/5	458406	4503700	2	Wetted Channel	Yes
11/9	11/10	507706	4501665	2	Grassland - Lowland	No
11/10	11/11	447569	4504743	2	Grassland - Lowland	No
11/13	11/14	447438	4504816	1	Wetted Channel	Yes
11/29	11/30	541008	4512856	2	Grassland - Lowland	No
11/29	11/30	516443	4505148	2	Wetted Channel	Yes

Discussion

During 2023, we observed one of the most unique seasons of fall whooping crane stopover use during the Program's history. We documented the highest number of crane use days (584 days) when not adjusting metrics for the 5th and 95th percentile dates of group observations (Fig. 5a). When adjusting crane use days for the 5th and 95th percentile dates, we observed the second highest number of fall crane use days (412 days) since 2007 (Figs. 5, 6). This record number of crane use days was due, in part, to exceptionally long stopover durations by individual groups. Stopover duration ranged between one and 73 days (mean = 14.4; median = 11; SE = 5.1). Even when not including the one group that stayed 73 days, the maximum stopover length was 19 days with a mean of 9.5 days. The group that stayed for 73 days initially arrived on the AHR as a group of four adults on October 30. Two adults left on November 21 with the remaining two individuals finally leaving the AHR on January 10, 2024.

Fall whooping crane stopover metrics on the AHR of the central Platte River as determined through PRRIP's surveys have demonstrated considerable annual variability (Figs. 5, 6). During three of the past five years (i.e., 2019; 2021; 2023), we have observed the highest proportions of the population stopping on the AHR during fall since 2007 (Figs. 5, 6). During 2021 and 2023, we documented the highest number of crane use days since 2007 (Figs. 5, 6). In between these years of high use, we have observed historical lows in both stopover metrics (Figs. 5, 6). Because of these recent years of high use, we found a significant, positive temporal trend in the adjusted number of fall crane use days during 2007–2023 when using a regression modeling approach. When using a nonparametric Spearman's rank correlation, we found a non-statistically significant relationship between the adjusted number of crane use days and year (p-value = 0.060). We found no relationship between the adjusted proportion of population stopping on the AHR during fall and year during 2007–2023 using either a Spearman's rank correlation or regression modeling approach. The high amount of interannual variability in stopover metrics is likely due to whooping cranes demonstrating low fidelity to individual stopover sites across the migration corridor (Pearse et al. 2020). Individual cranes that use the AHR as a stopover site in one year may not necessarily use the AHR as a stopover site the following year.

Most whooping crane groups observed during PRRIP's fall 2023 surveys were distributed on the eastern half of the AHR, which was similar to that observed during spring 2023 and in previous years of monitoring (Figs. 3, 4; PRRIP 2023). Seven of the 13 unique groups were observed in the eastern half of the AHR. However, when considering the 173 total group locations recorded by PRRIP, only 17 groups were observed west of Kearney (Fig. 3). The distribution and higher intensity of use of the eastern half of the AHR by whooping cranes is likely due to differences in river channel geomorphology, habitat characteristics in and surrounding the river, and position of the eastern AHR relative to the primary migratory flyway for whooping cranes (Johnson 1994, Murphy et al. 2004, Farnsworth et al. 2018, Pearse et al. 2018, PRRIP 2022).

Whooping crane groups that had longer stay lengths were generally associated with a range of low to high discharge at the nearest gage (Figs. 7–10). During the standard October 9 through November 15 fall monitoring period, discharge at the Grand Island gage was highest during October 27 through November 8 (Fig. 10). During this period when discharge was ≥1,000 cfs, multiple groups arrived (Fig. 12) and remained through a period of lower discharge (<600 cfs) that

lasted until late November (Fig. 10). Across the entire AHR, we observed a bimodal distribution in the frequency of occurrence of group observations relative to discharge at the nearest gage (Fig. 11). Although these discharge measurements are not independent and lack spatially explicit information of river depth and flow at the whooping crane group location itself, they do provide an indication of river conditions during the stopover. Given the high variability in flow and depth in portions of the Platte River, especially in reaches with braided channels, whooping cranes may select stopover sites that combine shallow depths, more gentle flow, and habitat attributes preferred for predator protection within an area characterized by deeper, faster flow during periods of high discharge (Faanes et al. 1992, Baasch et al. 2019).

Finally, in this report we also assessed how the 5th and 95th percentiles of dates of fall whooping crane group observations from the USFWS public sighting database for Nebraska varied over time, whether PRRIP fall survey dates during 2007 through 2023 were within these percentiles, and adjustments to stopover metrics to correspond with observations recorded only during dates corresponding to the 5th through 95th percentiles. We found PRRIP surveys during 2007 through 2023 did include the 5th percentile date for the corresponding 10-year period evaluated (Table 4). Six years of PRRIP surveys (2007; 2013; 2014; 2018; 2019; 2020) did not include the 95th percentile date for the corresponding period (Table 4). However, in five of the years surveys ended one or two days before the 95th percentile date. In 2013, surveys ended three days before the 95th percentile date. Use of the 5th and 95th percentiles of dates to calculate whooping crane stopover metrics resulted in adjustments being made to metrics in 2009, 2012, 2015, 2017, 2019, 2021, and 2023 (Figs. 5, 6). The adjustments were minor in four of these years (Fig. 6). However, we made large adjustments to the number of crane use days in 2015 (decreased by 20 days), 2017 (decreased by 46 days), and 2023 (decreased by 172 days) due to cranes staying on the AHR beyond the 95th percentile date.

Incidental Take

The USFWS in its 2006 Biological Opinion (USFWS 2006) and 2018 Supplemental Biological Opinion (USFWS 2018) on the Program developed an incidental take statement addressing incidental take for whooping cranes associated with monitoring and research as well as land management and habitat restoration conducted in the Platte River basin covered by the Program. Such take includes harm caused by harassment of individuals, and effects to fitness of adults resulting in loss of productivity. Six instances of take in the form of harassment of whooping cranes is exempted during the First Increment and 13-year Extension of the Program. The total amount of take that would remove an individual from the migrating population (i.e., lethal or crippling) exempted is one whooping crane during the First Increment and 13-year Extension of the Program. The USFWS requires documentation of any human activity that occurred in the proximity of whooping cranes that could constitute "take" as defined by the Endangered Species Act (i.e., "…*to harass, harm, pursue, hunt, shoot, wound, kill, capture, or collect, or attempt to engage in any such conduct"*). Because harassment interrupts essential feeding or sheltering behaviors, the definition includes disturbance of whooping cranes sufficient to result in cranes taking flight. Since the Program's initiation in 2007, the Program has not observed take (lethal, crippling, harm, harassment, etc.) of any whooping cranes due to monitoring or research activities or due to habitat restoration and land management activities.

During the fall 2023 monitoring period, PRRIP documented no instances of take as defined above. Specifically:

- *Lethal or crippling take*

There were no observations of crippling or lethal take of whooping cranes this season resulting from the monitoring conducted by PRRIP.

- *Harassment*

PRRIP staff did not observe or engage in any activity that could be construed as harassment as defined by USFWS.

- *Public disturbance*

PRRIP staff did not observe any incident of public disturbance of whooping cranes.

Past Research Synthesis

In addition to implementation of the Program's monitoring protocol, directed research has been conducted by the Program since 2007 to provide data to evaluate the Program's management objectives and priority hypotheses. Design and implementation of research activities was guided by the Program's EDO and Technical Advisory Committee (TAC), reviewed by the Program's Independent Scientific Advisory Committee (ISAC), and ultimately approved by the Program's Governance Committee (GC). Whooping crane monitoring and research conducted along the central Platte River were designed and implemented to provide information on an array of topics relevant to species management, including:

- Methods for monitoring whooping cranes and using detection data for drawing conclusions
- Whooping crane use of the central Platte River and the Great Plains migratory corridor
- Identification and characterization of riverine use sites
- Identification and characterization of diurnal use sites
- Whooping crane habitat selection analyses
- Management of river hydrology and morphology for whooping crane habitat
- Whooping crane use of off-channel palustrine wetlands

Links to these studies and other research relevant to the Program's objectives for whooping cranes can be found in Appendix E. Previous data and analyses are included in seasonal reports produced by the Platte River Cooperative Agreement (2001–2006) and the Program (2007–present), and are available in the Program's online Public Library (https://platteriverprogram.org/program-library), located by selecting "whooping crane" as the target species and using "Monitoring Report" as the Title Keyword Search terms. Long-term monitoring and research are used to evaluate progress toward the management objective and to support adaptive management decisions related to our target species (see Appendix E which provides a synthesis of past Program research). Data collected by the Program are available in published form or upon request for use by other programs to provide information on whooping crane use of the central Platte River that may be helpful for broader scale interpretation of migratory habitat use and factors to be considered when making management decisions.

Supplements

QA/QC of database was performed by PRRIP EDO staff.
Original datasheets – Retained at PRRIP EDO office.

References Cited

Baasch DM, Farrell PD, Howlin S, Pearse AT, Farnsworth JM, Smith CB. 2019. Whooping crane use of riverine stopover sites. PLoS ONE 14(1): e0209612. https://doi.org/10.1371/journal.pone.0209612

ESRI. 2023. ArcGIS Pro 3.1.1. ESRI, Inc., Redlands, California.

Faanes CA, Johnson DH, Lingle GR. 1992. Characteristics of whooping crane roost sites in the Platte River. *In* Stahlecker DW (Editor), Proceedings of the Sixth North American Crane Workshop, October 3-5, 1991, Regina, Saskatchewan. North American Crane Working Group 6:90–94.

Farnsworth JM, Baasch DM, Farrell PD, Smith CB, Werbylo KL. 2018. Investigating whooping crane habitat in relation to hydrology, channel morphology and a water-centric management strategy on the central Platte River, Nebraska. Heliyon 4:e00851. https://doi.org/10.1016/j.heliyon.2018.e00851

Johnson WC. 1994. Woodland expansion in the Platte River, Nebraska: patterns and causes. Ecological Monographs 64:45–84. https://doi.org/10.2307/2937055

Murphy PJ, Randle TJ, Fotherby LM, Daraio JA. 2004. Platte River channel: history and restoration. Bureau of Reclamation, Technical Service Center, Sedimentation and River Hydraulics Group, Denver, Colorado.

Neter J, Kutner M, Nachtsheim CJ, Wasserman W. 1996. Applied linear statistical models. McGraw-Hill, New York, New York.

Pearse AT, Rabbe M, Juliusson LM, Bidwell MT, Craig-Moore L, Brandt DA, Harrell W. 2018. Delineating and identifying long-term changes in the whooping crane (*Grus americana*) migration corridor. PLoS ONE 13(2):e0192737. https://doi.org/10.1371/journal.pone.0192737

Pearse AT, Metzger KL, Brandt DA, Bidwell MT, Harner MJ, Baasch DM, Harrell W. 2020. Heterogeneity in migration strategies of whooping cranes. Ornithological Applications 122:1–15. http://doi.org/10.1093/condor/duz056

Pinheiro JC, Bates DM. 2000. Mixed-effects models in S and S-PLUS. Springer, New York, New York. doi:10.1007/b98882

Pinheiro JC, Bates DM, R Core Team. 2023. *nlme*: linear and nonlinear mixed effects models. R package version 3.1-162. https://CRAN.R-project.org/package=nlme

Platte River Recovery Implementation Program (PRRIP). 2017a. Platte River Recovery Implementation Program Data Synthesis Compilation Whooping Crane (*Grus americanus*) Habitat Synthesis Chapters. https://platteriverprogram.org/sites/default/files/PubsAndData/ProgramLibrary/PRRIP%20Whooping%20Crane%20Habitat%20Synthesis%20Chapters.pdf

Platte River Recovery Implementation Program (PRRIP). 2017b. Platte River Recovery Implementation Program Whooping Crane Monitoring Protocol – Migrational Habitat Use in the Central Platte River Valley revised June 08, 2017. https://platteriverprogram.org/internal-document/prrip-whooping-crane-monitoring-protocol-migrational-habitat-use-central-platte

Platte River Recovery Implementation Program (PRRIP). 2020. 2019 State of the Platte – Adaptive Management Plan (AMP) 2019 "Big Question" Assessments February 20, 2020. pp. 13. https://platteriverprogram.org/sites/default/files/2020-08/FINAL%202019%20PRRIP%20State%20of%20the%20Platte.pdf

Platte River Recovery Implementation Program (PRRIP). 2021a. Final Platte River Recovery Implementation Program Cooperative Agreement, Attachment 3 – Adaptive Management Plan. pp. 20. https://platteriverprogram.org/sites/default/files/2021-09/PRRIP%20Full%20Program%20Document%20Updated%209_14_2021.pdf

Platte River Recovery Implementation Program (PRRIP). 2021b. Implementation of the whooping crane monitoring protocol. 2021 Fall. https://platteriverprogram.org/sites/default/files/2022-07/Implementation%20of%20the%20Whooping%20Crane%20Monitoring%20Protocol%20-%20Fall%202021%20FINAL.pdf

Platte River Recovery Implementation Program (PRRIP). 2021c. Platte River Recovery Implementation Program Cooperative Agreement, Attachment 3 – Adaptive Management Plan. Appendix F. Protocols. pp. 233. https://platteriverprogram.org/sites/default/files/2021-09/PRRIP%20Full%20Program%20Document%20Updated%209_14_2021.pdf

Platte River Recovery Implementation Program (PRRIP) 2022. First Increment Extension Science Plan. https://platteriverprogram.org/document/prrip-extension-science-plan

Platte River Recovery Implementation Program (PRRIP) 2023. Implementation of the whooping crane monitoring protocol. 2023 Spring.

R Core Team. 2022. R: a language and environment for statistical computing. R Foundation for Statistic Computing, Vienna, Austria. Version 4.2.2. https://www.R-project.org/

United States Fish and Wildlife Service (USFWS). 2006. Biological Opinion on the Platte River Recovery Implementation Program. https://platteriverprogram.org/sites/default/files/2020-03/Platte_River_FBO%28June16%29.pdf#page=320

United States Fish and Wildlife Service (USFWS). 2018. Platte River Recovery Implementation Program Final Supplemental Biological Opinion. https://platteriverprogram.org/sites/default/files/2020-02/final_prrip_extension_supplemental_opinion.pdf#page=125

United States Fish and Wildlife Service (USFWS). 2023. Whooping crane survey results: Winter 2022–2023. https://www.fws.gov/media/whooping-crane-update-winter-2022-2023

United States Geological Survey (USGS). 2023a. United States Geological Survey National Water Information System: Web Interface. USGS 06768000 Platte River near Overton, Nebraska. https://waterdata.usgs.gov/usa/nwis/uv?site_no=06768000

United States Geological Survey (USGS). 2023b. United States Geological Survey National Water Information System: Web Interface. USGS 06770200 Platte River, Cottonwood Ranch near Elm Creek, Nebraska. https://waterdata.usgs.gov/ne/nwis/uv/?site_no=06768035&PARAmeter_cd=00065,00060

United States Geological Survey (USGS). 2023c. United States Geological Survey National Water Information System: Web Interface. USGS 06770200 Platte River near Kearney, Nebraska. https://waterdata.usgs.gov/usa/nwis/uv?site_no=06770200

United States Geological Survey (USGS). 2023d. United States Geological Survey National Water Information System: Web Interface. USGS 06770500 Platte River near Grand Island, Nebraska. https://waterdata.usgs.gov/usa/nwis/uv?site_no=06770500

Appendix A. Whooping Crane Extension Big Questions and Hypotheses

EBQ #4 What factors influence WC decision to stop or fly over the AHR?

Management Hypothesis: Probability of WC stopping within the AHR is a function of discharge.

Underlying Physical Processes Hypothesis – The probability of a WC stopover is a function of the relationship between wetted width and the percent of the channel that is of suitable depth for roosting (< 1 ft deep).

Alternative Hypotheses:

- Time of day is the primary driver of WC stopovers with probability of use increasing with decreasing time until dark.
- The probability of WC stopping over is a function of MUCW and unforested corridor width.
- The probability of WC stopping over is a function of land cover or habitat suitability within a biologically relevant radius of flyover location.
- Weather (wind speed and direction, precipitation, temperature) encountered since the last stopover is an important predictor of WC stopovers with the probability of use of the AHR increasing as weather conditions become less favorable for flight.
- Length of stay at previous stopover (inverse relationship) and distance traveled since last stopover (direct relationship) are important predictors of WC stopovers.
- Point in migration (proportion of migration completed) is an important predictor of WC stopovers with the probability of use of the AHR demonstrating a quadratic relationship with proportion of migration completed.

Extension Big Question #5: What factors influence WC stopover length within the AHR?

Management Hypothesis: Length of WC stopover within the AHR is a function of discharge.

Underlying Physical Processes Hypothesis – WC stopover length is a function of the relationship between wetted width and the percent of the channel that is of suitable depth for roosting (< 1 ft deep).

Alternative Hypotheses:

- Length of stay within the AHR has an inverse relationship with length of stay at the previous stopover and a direct relationship with distance traveled since last stopover.
- WC stopover length is inversely related to daily variability in flow.
- WC stopover length is a function of MUCW and unforested corridor width.
- WC stopover length is a function of land cover or habitat suitability within a biologically relevant radius of use location.
- Weather (wind speed and direction, precipitation, temperature) is an important predictor of WC stopover length with the length of stay within the AHR increasing as weather conditions become less favorable for flight.
- The length of a WC stopover within the AHR is longer during the Fall migration. Stopover length within the AHR recapitulates the overall migratory pattern with longer Fall stopovers than Spring stopovers.
- Point in migration (proportion of migration completed) is an important predictor of WC stopover length with stopover length demonstrating a quadratic relationship with proportion of migration completed.
- WC group size, composition (adults, sub-adults, juveniles), and whether or not they are associated with sandhill cranes are important predictors of WC stopover length.

Extension Big Question #6: Why is Spring WC use of the AHR greater than Fall use?
Management Hypothesis: WC use of the AHR in the Spring is greater than during the Fall due to higher flows during the Spring.
Underlying Physical Processes Hypothesis – WC use of the AHR is a function of the relationship between wetted width and the percent of the channel that is of suitable depth for roosting (<1 ft deep).
Alternative Hypotheses: • WC use of the AHR in the Spring is greater because WC do not stage in other areas prior to reaching the Platte, WC are further along in migration when they arrive, distance traveled since last stopover is longer, and stay length at previous stopovers is shorter when compared to Fall migration. • WC stay longer in the AHR during Spring migration because daily variability in flow is lower. • WC use of the AHR in the Spring is greater because proportional wetland landcover is greater. • WC use of the AHR in the Spring is greater due to more expansive unobstructed views (wider MUCW, reduced vegetation cover, lower vegetation heights, trees without leaves) that together increase perceived area of both on and off-channel suitable habitat during this period when compared with the Fall • WC use of the AHR in the Spring is greater because they encounter the AHR later in the day during this migratory season than they do during the Fall migratory season, increasing the probability of a stopover. • WC use of the AHR in the Spring is greater because weather (wind speed and direction, precipitation, temperature) conditions are less favorable for flight (heading into colder conditions, not away from them). • WC use of the AHR in the Spring is greater because group sizes are larger, more numerous and longer stopovers by juveniles and subadults (non-reproductive), and because of the presence of sandhill cranes (more abundant with longer stopovers within the AHR in the Spring).

Appendix B. Whooping Crane Group Observations

Tables of details of whooping crane group observations recorded during fall 2023 along the Associated Habitat Reach of the central Platte River between Lexington and Chapman, Nebraska. One table is provided for each group based on the unique USFWS group identification (ID) number. Provided for each group is the unique color-coded group icon that corresponds to icons provided in tables and figures throughout the report; the USFWS group ID; date(s) of observations of the group; number of adult and juvenile whooping cranes in the group; the PRRIP group ID number; use site number; UTM x and y coordinates (zone 14N); and type of observation. When more than one observation of a whooping crane group was made in the same day, then letters (e.g., A, B, C) are placed following the group ID. Use site numbers are provided when the whooping crane group was observed in riverine, lacustrine, or palustrine land cover types. When whooping crane groups were observed in a land cover type or environment that was not riverine, lacustrine, or palustrine, then the appropriate land cover type is provided (i.e., Ag-agriculture; beans; corn). If the group was sighted in flight, then "AIR" is provided for the use site number. Observation types are provided as systematic (Sys), opportunistic (Opp), aerial (flight), and ground.

Table B.1. Data for whooping crane group USFWS ID 23B-30.

Unique group icon	USFWS group ID	Date	No. of whooping cranes (adults: juveniles)	PRRIP group ID	Use site no.	UTM x	UTM y	Observation type
	23B-30	10/29/2023	3:0	2023FA01	1	521452	4507176	Sys-Flight
	23B-30	10/30/2023	3:0	2023FA03	3	520282	4506661	Opp-Ground
	23B-30	10/30/2023	3:0	2023FA03B	Corn	519659	4506137	Sys-Flight
	23B-30	10/31/2023	3:0	2023FA08	3	520282	4506661	Opp-Ground
	23B-30	11/1/2023	3:0	2023FA10	9	517963	4505561	Sys-Flight
	23B-30	11/2/2023	3:0	2023FA19	17	520326	4506663	Sys-Flight
	23B-30	11/3/2023	3:0	2023FA26	22	519128	4506330	Sys-Flight
	23B-30	11/4/2023	3:0	2023FA33	Corn	520536	4506054	Sys-Flight
	23B-30	11/5/2023	3:0	2023FA39	30	516835	4505173	Sys-Flight
	23B-30	11/6/2023	3:0	2023FA47	Corn	515771	4503908	Sys-Flight
	23B-30	11/7/2023	3:0	2023FA52	36	515627	4504332	Sys-Flight
	23B-30	11/8/2023	3:0	2023FA55	39	517719	4505448	Sys-Flight

Table B.2. Data for whooping crane group USFWS ID 23B-31.

Unique group icon	USFWS group ID	Date	No. of whooping cranes (adults: juveniles)	PRRIP group ID	Use site no.	UTM x	UTM y	Observation type
	23B-31	10/30/2023	2:0	2023FA02	2	448520	4503877	Sys-Flight
	23B-31	11/1/2023	2:0	2023FA14	AIR	450442	4502908	Sys-Flight
	23B-31	11/2/2023	2:0	2023FA15	13	453442	4503519	Sys-Flight
	23B-31	11/3/2023	2:0	2023FA21	AIR	452472	4503242	Sys-Flight
	23B-31	11/3/2023	2:0	2023FA21B	Corn	452200	4502654	Sys-Flight
	23B-31	11/4/2023	2:0	2023FA28	Corn	452497	4502739	Opp-Ground
	23B-31	11/5/2023	2:0	2023FA40	Corn	452497	4502739	Opp-Ground
	23B-31	11/6/2023	2:0	2023FA41	Corn	452497	4502739	Sys-Flight
	23B-31	11/7/2023	2:0	2023FA53	Corn	451835	4502451	Opp-Ground
	23B-31	11/8/2023	2:0	2023FA54	38	452049	4503123	Sys-Flight

Table B.3. Data for whooping crane group USFWS ID 23B-32.

Unique group icon	USFWS group ID	Date	No. of whooping cranes (adults: juveniles)	PRRIP group ID	Use site no.	UTM x	UTM y	Observation type
	23B-32	10/30/2023	4:0	2023FA04	Corn	557832	4520646	Sys-Flight
	23B-32	10/31/2023	4:0	2023FA07	6	557606	4520656	Sys-Flight
	23B-32	10/31/2023	4:0	2023FA07B	7	559099	4522933	Sys-Flight
	23B-32	11/1/2023	4:0	2023FA13	12	559864	4523472	Sys-Flight
	23B-32	11/2/2023	4:0	2023FA17	15	558681	4521997	Sys-Flight
	23B-32	11/3/2023	4:0	2023FA23	Corn	559852	4522634	Sys-Flight
	23B-32	11/4/2023	4:0	2023FA34	28	559616	4523298	Sys-Flight
	23B-32	11/5/2023	4:0	2023FA36	29	559812	4523621	Sys-Flight
	23B-32	11/6/2023	4:0	2023FA43	32	559429	4523273	Sys-Flight
	23B-32	11/7/2023	4:0	2023FA49	Beans	559470	4522280	Sys-Flight
	23B-32	11/8/2023	4:0	2023FA57	Corn	559559	4522165	Sys-Flight
	23B-32	11/9/2023	4:0	2023FA62	Corn	559635	4522264	Sys-Flight
	23B-32	11/10/2023	4:0	2023FA69	Corn	559479	4522290	Sys-Flight

Table B.3—continued

Unique group icon	USFWS group ID	Date	No. of whooping cranes (adults: juveniles)	PRRIP group ID	Use site no.	UTM x	UTM y	Observation type
	23B-32	11/11/2023	4:0	2023FA75	48	560006	4523860	Opp-Ground
	23B-32	11/12/2023	4:0	2023FA78	51	559989	4523839	Sys-Flight
	23B-32	11/13/2023	4:0	2023FA84	54	559586	4523418	Sys-Flight
	23B-32	11/14/2023	4:0	2023FA88	AIR	559784	4523499	Sys-Flight
	23B-32	11/15/2023	4:0	2023FA92	Corn	559962	4522600	Sys-Flight
	23B-32	11/16/2023	4:0	2023FA97	61	559378	4523233	Sys-Flight
	23B-32	11/17/2023	4:0	2023FA101	Corn	559487	4522258	Sys-Flight
	23B-32	11/18/2023	4:0	2023FA103	65	560132	4523990	Sys-Flight
	23B-32	11/19/2023	4:0	2023FA108	70	560034	4523803	Opp-Ground
	23B-32	11/20/2023	4:0	2023FA109	68	559980	4523760	Opp-Ground
	23B-32	11/21/2023	4:0	2023FA112	Corn	559581	4522263	Sys-Flight
	23B-32	11/22/2023	2:0	2023FA113	70	560034	4523803	Sys-Flight
	23B-32	11/23/2023	2:0	2023FA114	71	558593	4521820	Sys-Flight
	23B-32	11/24/2023	2:0	2023FA115	Corn	559906	4522586	Sys-Flight
	23B-32	11/26/2023	2:0	2023FA116	Corn	559571	4522370	Sys-Flight
	23B-32	11/27/2023	2:0	2023FA117	71	559440	4523203	Opp-Ground
	23B-32	11/27/2023	2:0	2023FA117B	Corn	559861	4522592	Sys-Flight
	23B-32	11/28/2023	2:0	2023FA118	Corn	559831	4522593	Sys-Flight
	23B-32	11/29/2023	2:0	2023FA131	Corn	559835	4522576	Sys-Flight
	23B-32	11/30/2023	2:0	2023FA120	73	559440	4523203	Sys-Flight
	23B-32	12/1/2023	2:0	2023FA121	73	559440	4523203	Sys-Flight
	23B-32	12/2/2023	2:0	2023FA122	51	559989	4523839	Sys-Flight
	23B-32	12/4/2023	2:0	2023FA123	74	559493	4523313	Sys-Flight
	23B-32	12/4/2023	2:0	2023FA123B	Corn	559843	4522640	Sys-Flight
	23B-32	12/5/2023	2:0	2023FA124	75	558683	4522013	Sys-Flight
	23B-32	12/6/2023	2:0	2023FA125	76	559483	4523343	Sys-Flight
	23B-32	12/7/2023	2:0	2023FA126	77	560246	4523853	Sys-Flight
	23B-32	12/8/2023	2:0	2023FA127	78	559833	4523507	Sys-Flight

Table B.3—continued

Unique group icon	USFWS group ID	Date	No. of whooping cranes (adults: juveniles)	PRRIP group ID	Use site no.	UTM x	UTM y	Observation type
	23B-32	12/9/2023	2:0	2023FA128	79	559910	4523795	Sys-Flight
	23B-32	12/10/2023	2:0	2023FA129	80	560101	4523882	Sys-Flight
	23B-32	12/11/2023	2:0	2023FA130	81	559707	4523610	Sys-Flight
	23B-32	12/13/2023	2:0	2023FA132	82	559782	4523643	Sys-Flight
	23B-32	12/14/2023	2:0	2023FA133	83	559758	4523491	Opp-Ground
	23B-32	12/15/2023	2:0	2023FA134	83	559758	4523491	Opp-Ground
	23B-32	12/16/2023	2:0	2023FA135	83	559758	4523491	Sys-Flight
	23B-32	12/17/2023	2:0	2023FA136	85	559923	4523482	Sys-Flight
	23B-32	12/18/2023	2:0	2023FA137	84	560070	4523699	Sys-Flight
	23B-32	12/19/2023	2:0	2023FA138	86	559541	4523391	Sys-Flight
	23B-32	12/20/2023	2:0	2023FA139	86	559895	4523727	Opp-Ground
	23B-32	12/22/2023	2:0	2023FA140	86	559541	4523391	Opp-Ground
	23B-32	12/23/2023	2:0	2023FA141	51	559989	4523839	Sys-Flight
	23B-32	12/29/2023	2:0	2023FA142	52	559840	4523686	Sys-Flight
	23B-32	12/30/2023	2:0	2023FA143	53	559919	4523695	Sys-Flight
	23B-32	12/31/2023	2:0	2023FA144	54	560190	4524005	Sys-Flight
	23B-32	1/1/2024	2:0	2023FA145	87	559895	4523727	Opp-Ground
	23B-32	1/2/2024	2:0	2023FA146	87	559895	4523727	Sys-Flight
	23B-32	1/3/2024	2:0	2023FA147	88	559904	4523745	Sys-Flight
	23B-32	1/7/2024	2:0	2023FA148	89	559907	4523770	Sys-Flight
	23B-32	1/10/2024	2:0	2023FA149	90	559971	4523826	Sys-Flight

Table B.4. Data for whooping crane group USFWS ID 23B-33.

Unique group icon	USFWS group ID	Date	No. of whooping cranes (adults: juveniles)	PRRIP group ID	Use site no.	UTM x	UTM y	Observation type
	23B-33	10/31/2023	2:1	2023FA05	4	564881	4530159	Sys-Flight
	23B-33	11/1/2023	2:1	2023FA11	10	564781	4530031	Sys-Flight
	23B-33	11/2/2023	2:1	2023FA16	14	565359	4530641	Sys-Flight
	23B-33	11/2/2023	2:1	2023FA16B	Corn	566399	4533810	Sys-Flight
	23B-33	11/3/2023	2:1	2023FA22	19	564432	4529493	Sys-Flight
	23B-33	11/4/2023	2:1	2023FA29	24	564843	4530005	Sys-Flight
	23B-33	11/5/2023	2:1	2023FA35	Corn	564534	4528693	Sys-Flight
	23B-33	11/6/2023	2:1	2023FA42	24	564843	4530005	Sys-Flight
	23B-33	11/7/2023	2:1	2023FA48	Corn	565041	4528608	Sys-Flight
	23B-33	11/8/2023	2:1	2023FA58	40	564859	4530117	Sys-Flight
	23B-33	11/9/2023	2:1	2023FA63	Corn	564889	4528589	Sys-Flight
	23B-33	11/10/2023	2:1	2023FA70	14	565359	4530641	Sys-Flight
	23B-33	11/11/2023	2:1	2023FA72	46	563787	4529026	Sys-Flight
	23B-33	11/12/2023	2:1	2023FA77	50	565088	4530246	Sys-Flight
	23B-33	11/13/2023	2:1	2023FA86	55	565122	4530435	Opp-Ground
	23B-33	11/14/2023	2:1	2023FA87	56	565248	4530481	Sys-Flight
	23B-33	11/15/2023	2:1	2023FA94	59	565142	4530314	Opp-Ground
	23B-33	11/16/2023	2:1	2023FA96	24	564843	4530005	Sys-Flight
	23B-33	11/18/2023	2:1	2023FA102	64	564625	4529863	Sys-Flight

Table B.5. Data for whooping crane group USFWS ID 23B-34.

Unique group icon	USFWS group ID	Date	No. of whooping cranes (adults: juveniles)	PRRIP group ID	Use site no.	UTM x	UTM y	Observation type
	23B-34	10/31/2023	5:2	2023FA06	5	561885	4526901	Sys-Flight
	23B-34	11/1/2023	2:1	2023FA12	11	561060	4525985	Sys-Flight
	23B-34	11/2/2023	2:1	2023FA16	14	565359	4530641	Sys-Flight
	23B-34	11/2/2023	2:1	2023FA16B	Corn	566399	4533810	Sys-Flight
	23B-34	11/3/2023	2:1	2023FA22	19	564432	4529493	Sys-Flight
	23B-34	11/7/2023	2:1	2023FA48	Corn	565041	4528608	Sys-Flight
	23B-34	11/8/2023	2:1	2023FA58	40	564859	4530117	Sys-Flight
	23B-34	11/9/2023	2:1	2023FA64	41	565060	4530259	Sys-Flight
	23B-34	11/10/2023	2:1	2023FA70	14	565359	4530641	Sys-Flight
	23B-34	11/11/2023	2:1	2023FA72	46	563787	4529026	Sys-Flight
	23B-34	11/12/2023	2:1	2023FA77	50	565088	4530246	Sys-Flight
	23B-34	11/13/2023	2:1	2023FA86	55	565122	4530435	Opp-Ground
	23B-34	11/14/2023	2:1	2023FA87	56	565248	4530481	Sys-Flight
	23B-34	11/15/2023	2:1	2023FA94	59	565142	4530314	Opp-Ground
	23B-34	11/16/2023	2:1	2023FA119	Corn	564920	4528751	Sys-Flight
	23B-34	11/18/2023	2:1	2023FA102	64	564625	4529863	Sys-Flight

Table B.6. Data for whooping crane group USFWS ID 23B-48.

Unique group icon	USFWS group ID	Date	No. of whooping cranes (adults: juveniles)	PRRIP group ID	Use site no.	UTM x	UTM y	Observation type
	23B-48	11/1/2023	3:0	2023FA09	8	540579	4512247	Sys-Flight
	23B-48	11/2/2023	3:0	2023FA18	16	541122	4512574	Sys-Flight
	23B-48	11/2/2023	3:0	2023FA18B	Corn	541357	4511377	Sys-Flight
	23B-48	11/3/2023	3:0	2023FA25	21	541664	4512805	Opp-Ground
	23B-48	11/4/2023	3:0	2023FA31	26	542011	4513010	Sys-Flight
	23B-48	11/5/2023	3:0	2023FA37	Corn	539645	4511275	Sys-Flight
	23B-48	11/6/2023	3:0	2023FA45	34	539626	4511595	Sys-Flight
	23B-48	11/6/2023	3:0	2023FA45B	Corn	539836	4511350	Sys-Flight
	23B-48	11/7/2023	3:0	2023FA50	Corn	539833	4511298	Sys-Flight
	23B-48	11/8/2023	3:0	2023FA56	Corn	539799	4511280	Sys-Flight
	23B-48	11/9/2023	3:0	2023FA60	Corn	539700	4511320	Sys-Flight
	23B-48	11/10/2023	3:0	2023FA66	43	542081	4513154	Sys-Flight
	23B-48	11/11/2023	3:0	2023FA71	45	538163	4511426	Sys-Flight
	23B-48	11/12/2023	3:0	2023FA80	Corn	537768	4512006	Sys-Flight

Table B.7. Data for whooping crane group USFWS ID 23B-49.

Unique group icon	USFWS group ID	Date	No. of whooping cranes (adults: juveniles)	PRRIP group ID	Use site no.	UTM x	UTM y	Observation type
	23B-49	11/2/2023	1:0	2023FA20	18	549519	4515409	Sys-Flight
	23B-49	11/3/2023	1:0	2023FA24	20	549775	4515563	Sys-Flight
	23B-49	11/4/2023	1:0	2023FA30	25	549146	4515316	Sys-Flight
	23B-49	11/6/2023	1:0	2023FA44	33	544937	4514711	Sys-Flight
	23B-49	11/9/2023	1:0	2023FA61	Corn	543258	4512552	Opp-Ground
	23B-49	11/10/2023	1:0	2023FA67	44	544450	4514453	Sys-Flight
	23B-49	11/11/2023	1:0	2023FA73	AIR	546229	4513134	Sys-Flight
	23B-49	11/11/2023	1:0	2023FA73B	47	545081	4514722	Sys-Flight
	23B-49	11/12/2023	1:0	2023FA79	52	544174	4514212	Sys-Flight

Table B.8. Data for whooping crane group USFWS ID 23B-50.

Unique group icon	USFWS group ID	Date	No. of whooping cranes (adults: juveniles)	PRRIP group ID	Use site no.	UTM x	UTM y	Observation type
	23B-50	11/3/2023	4:1	2023FA27	23	539274	4511411	Sys-Flight
	23B-50	11/4/2023	4:1	2023FA32	Corn	539868	4511401	Opp-Ground
	23B-50	11/5/2023	4:1	2023FA37	Corn	539645	4511275	Sys-Flight
	23B-50	11/6/2023	4:1	2023FA45	34	539626	4511595	Sys-Flight
	23B-50	11/6/2023	4:1	2023FA45B	Corn	539836	4511350	Sys-Flight
	23B-50	11/7/2023	4:1	2023FA50	Corn	539833	4511298	Sys-Flight
	23B-50	11/8/2023	4:1	2023FA56	Corn	539799	4511280	Sys-Flight

Table B.9. Data for whooping crane group USFWS ID 23B-63.

Unique group icon	USFWS group ID	Date	No. of whooping cranes (adults: juveniles)	PRRIP group ID	Use site no.	UTM x	UTM y	Observation type
	23B-63	11/7/2023	2:0	2023FA51	35	520267	4506725	Sys-Flight

Table B.10. Data for whooping crane group USFWS ID 23B-64.

Unique group icon	USFWS group ID	Date	No. of whooping cranes (adults: juveniles)	PRRIP group ID	Use site no.	UTM x	UTM y	Observation type
	23B-64	11/7/2023	2:0	2023FA59	37	509113	4502137	Sys-Flight
	23B-64	11/10/2023	2:0	2023FA82	42	509713	4502386	Sys-Flight

Table B.11. Data for whooping crane group USFWS ID 23B-65.

Unique group icon	USFWS group ID	Date	No. of whooping cranes (adults: juveniles)	PRRIP group ID	Use site no.	UTM x	UTM y	Observation type
	23B-65	11/9/2023	2:1	2023FA65	Corn	517146	4504280	Sys-Flight

Table B.12. Data for whooping crane group USFWS ID 23B-66.

Unique group icon	USFWS group ID	Date	No. of whooping cranes (adults: juveniles)	PRRIP group ID	Use site no.	UTM x	UTM y	Observation type
	23B-66	11/10/2023	5:1	2023FA68	Corn	558554	4520498	Sys-Flight
	23B-66	11/11/2023	5:1	2023FA71	45	538163	4511426	Sys-Flight
	23B-66	11/12/2023	5:1	2023FA80	Corn	537768	4512006	Sys-Flight
	23B-66	11/13/2023	5:1	2023FA83	53	538284	4511391	Sys-Flight
	23B-66	11/14/2023	5:1	2023FA89	Corn	539316	4511101	Sys-Flight
	23B-66	11/15/2023	5:1	2023FA93	58	538380	4511385	Sys-Flight
	23B-66	11/16/2023	5:1	2023FA98	53	538284	4511391	Sys-Flight
	23B-66	11/17/2023	5:1	2023FA100	63	540365	4512141	Sys-Flight
	23B-66	11/18/2023	5:1	2023FA104	Corn	539327	4511124	Sys-Flight
	23B-66	11/19/2023	2:1	2023FA106	Corn	539339	4511087	Opp-Ground
	23B-66	11/19/2023	3:0	2023FA107	Corn	538573	4510646	Opp-Ground
	23B-66	11/20/2023	5:1	2023FA110	Corn	536373	4511411	Opp-Ground
	23B-66	11/21/2023	5:1	2023FA111	69	538219	4511423	Sys-Flight

Table B.13. Data for whooping crane group USFWS ID 23B-67.

Unique group icon	USFWS group ID	Date	No. of whooping cranes (adults: juveniles)	PRRIP group ID	Use site no.	UTM x	UTM y	Observation type
	23B-67	11/11/2023	2:0	2023FA76	49	469381	4503830	Sys-Flight
	23B-67	11/13/2023	2:0	2023FA81	Corn	475460	4500397	Opp-Ground
	23B-67	11/14/2023	2:0	2023FA90	AIR	468890	4503511	Sys-Flight
	23B-67	11/15/2023	2:0	2023FA91	57	469516	4503849	Sys-Flight
	23B-67	11/16/2023	2:0	2023FA95	57	469516	4503849	Sys-Flight
	23B-67	11/17/2023	2:0	2023FA99	57	469516	4503849	Sys-Flight
	23B-67	11/18/2023	2:0	2023FA105	66	470987	4504023	Sys-Flight

Appendix C. Enlarged Maps of Whooping Crane Use Locations and Photographs of Groups

Maps of whooping crane group use locations observed during fall 2023 are presented from west to east beginning with Fig. C1 and ending with Fig. C10. The distribution of historical fall observations of whooping crane groups by PRRIP during 2001–2023 are provided online at https://hwcorp.maps.arcgis.com/apps/mapviewer/index.html?webmap=ab525e32ac22460faa6fa87148fc16d6. Photographs of the first systematically collected observation from each unique group are provided in Fig. C11 through Fig. C23.

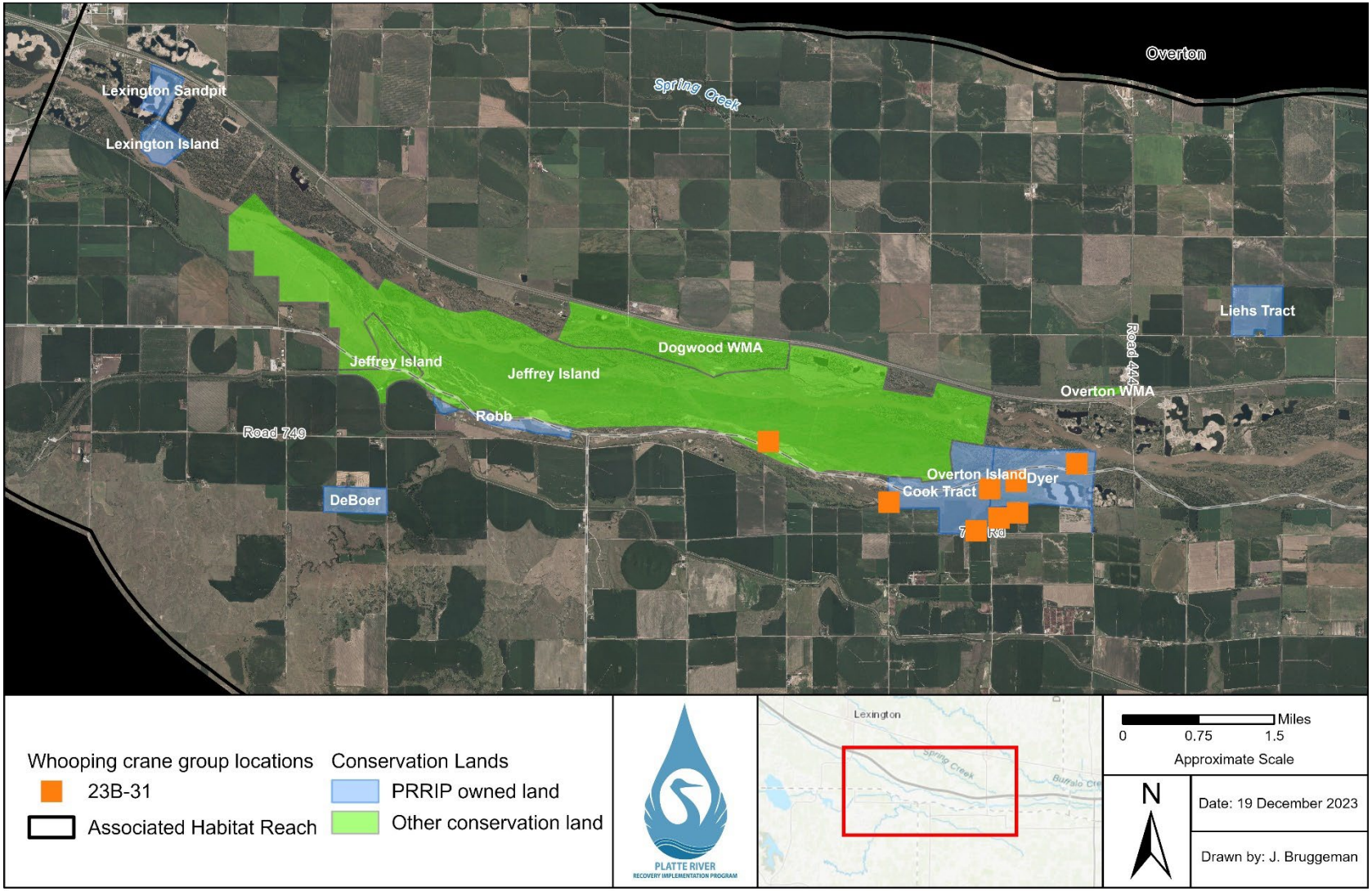


Figure C1. Whooping crane group USFWS ID 23B-31 (PRRIP IDs 2023FA02, 2023FA14, 2023FA15, 2023FA21, 2023FA21B, 2023FA28, 2023FA40, 2023FA41, 2023FA53, 2023FA54; sighted 10/30–11/8) observed southwest of Overton, Nebraska along the Associated Habitat Reach of the central Platte River during fall 2023. PRRIP aerial imagery from July 2023 is displayed for reference.

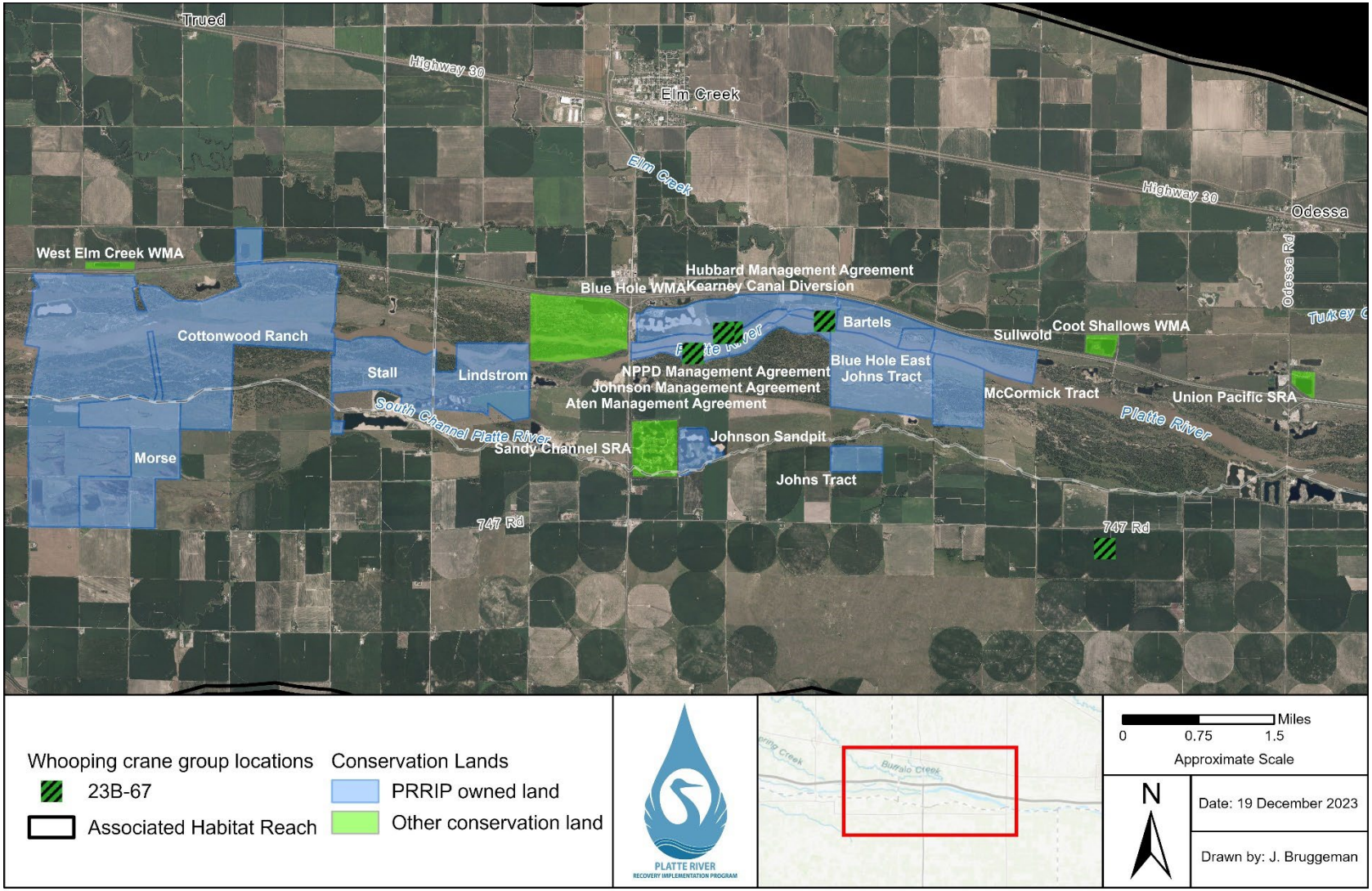


Figure C2. Whooping crane group USFWS ID 23B-67 (PRRIP IDs 2023FA76, 2023FA81, 2023FA90, 2023FA91, 2023FA95, 2023FA99, 2023FA105; sighted 11/11–11/18) observed south of Elm Creek, Nebraska along the Associated Habitat Reach of the central Platte River during fall 2023. PRRIP aerial imagery from July 2023 is displayed for reference.

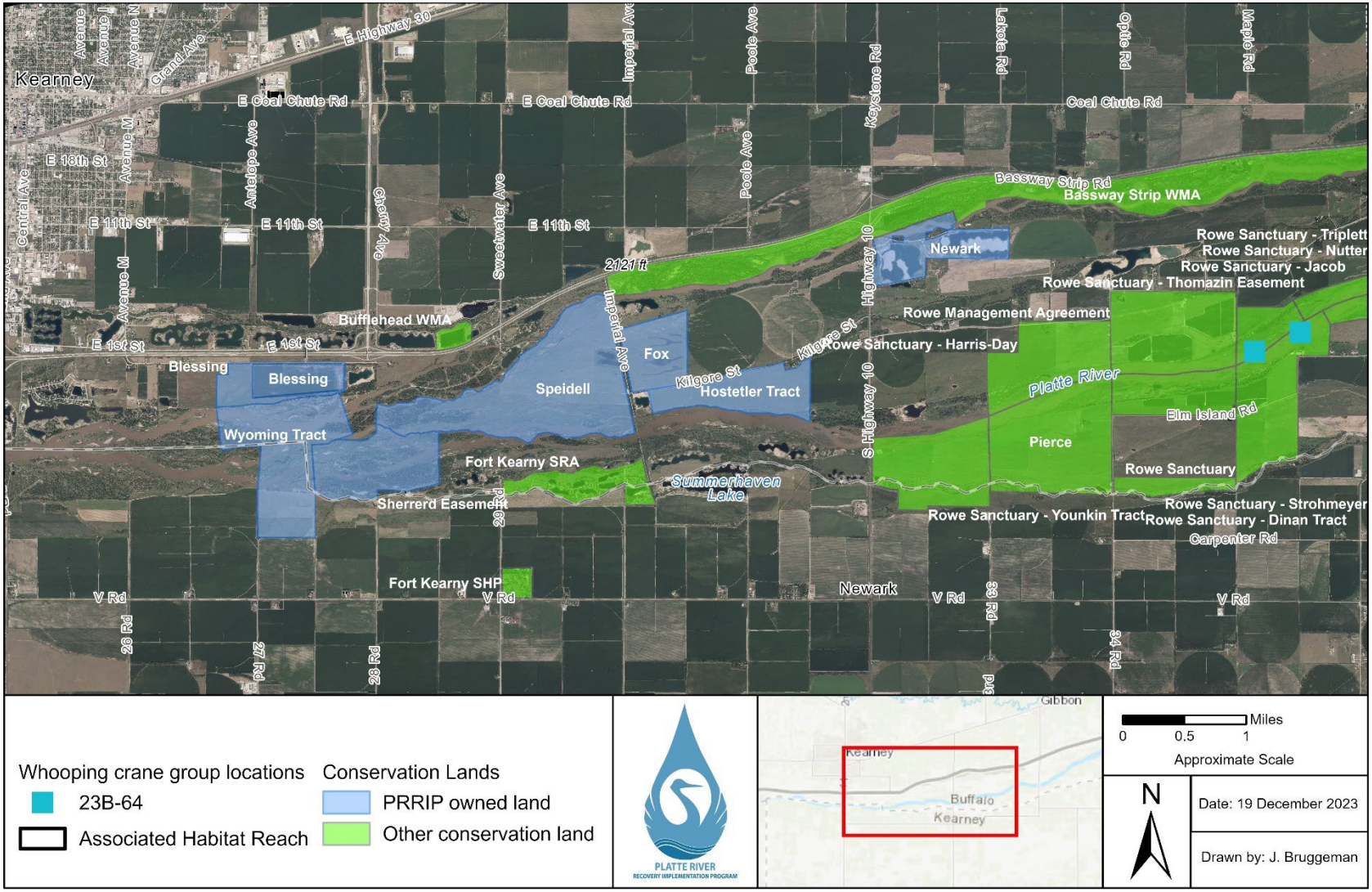


Figure C3. Whooping crane group USFWS ID 23B-64 (PRRIP IDs 2023FA59, 2023FA82; sighted 11/7 and 11/10) observed east of Kearney, Nebraska along the Associated Habitat Reach of the central Platte River during fall 2023. PRRIP aerial imagery from July 2023 is displayed for reference.

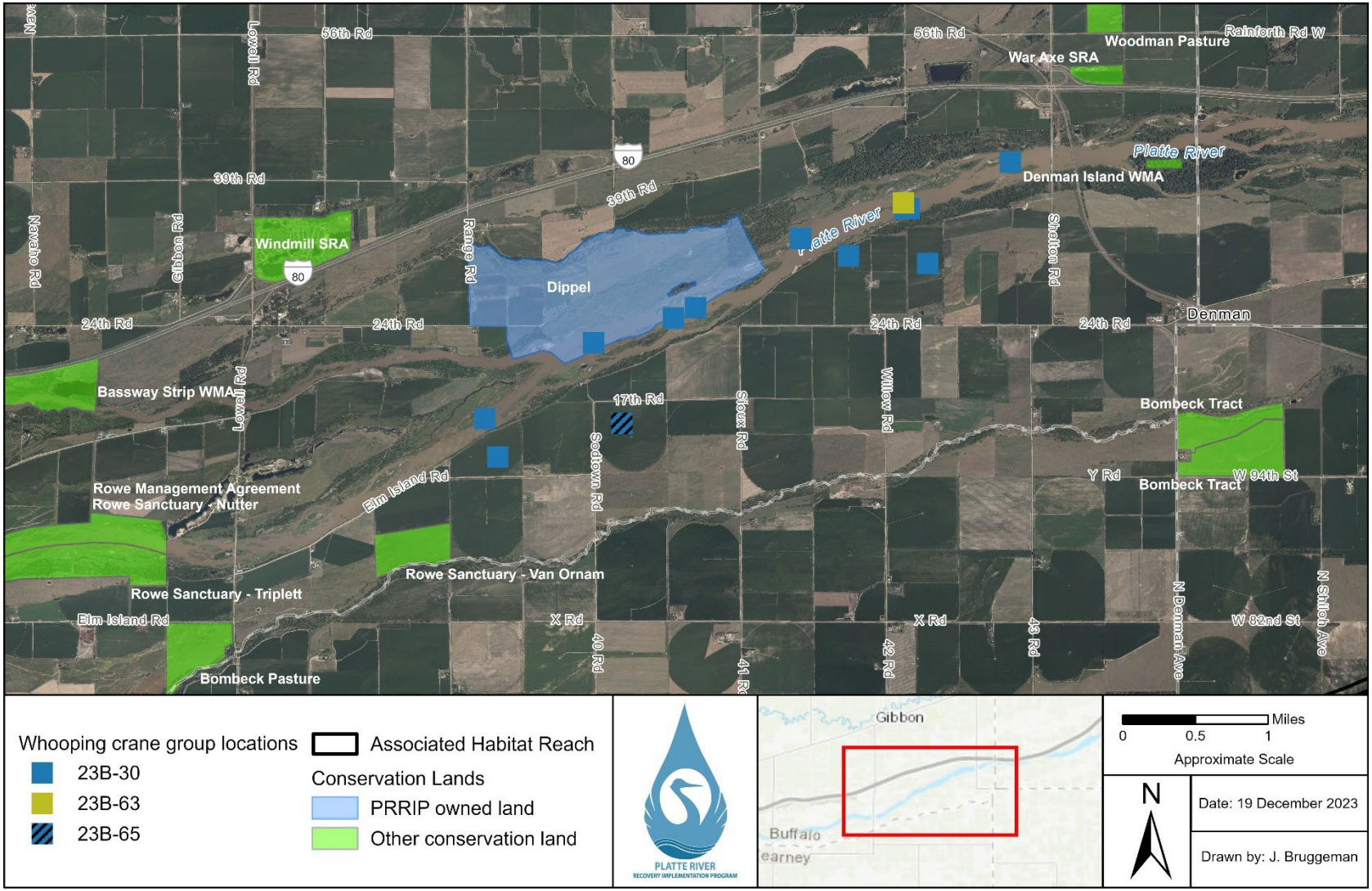


Figure C4. Whooping crane groups USFWS ID 23B-30 (See Appendix B Table B.1 for PRRIP IDs; sighted 10/29–11/8); USFWS ID 23B-63 (PRRIP ID 2023FA51; sighted 11/7); and USFWS ID 23B-65 (PRRIP ID 2023FA65; sighted 11/9) observed southeast of Gibbon, Nebraska along the Associated Habitat Reach of the central Platte River during fall 2023. PRRIP aerial imagery from July 2023 is displayed for reference.

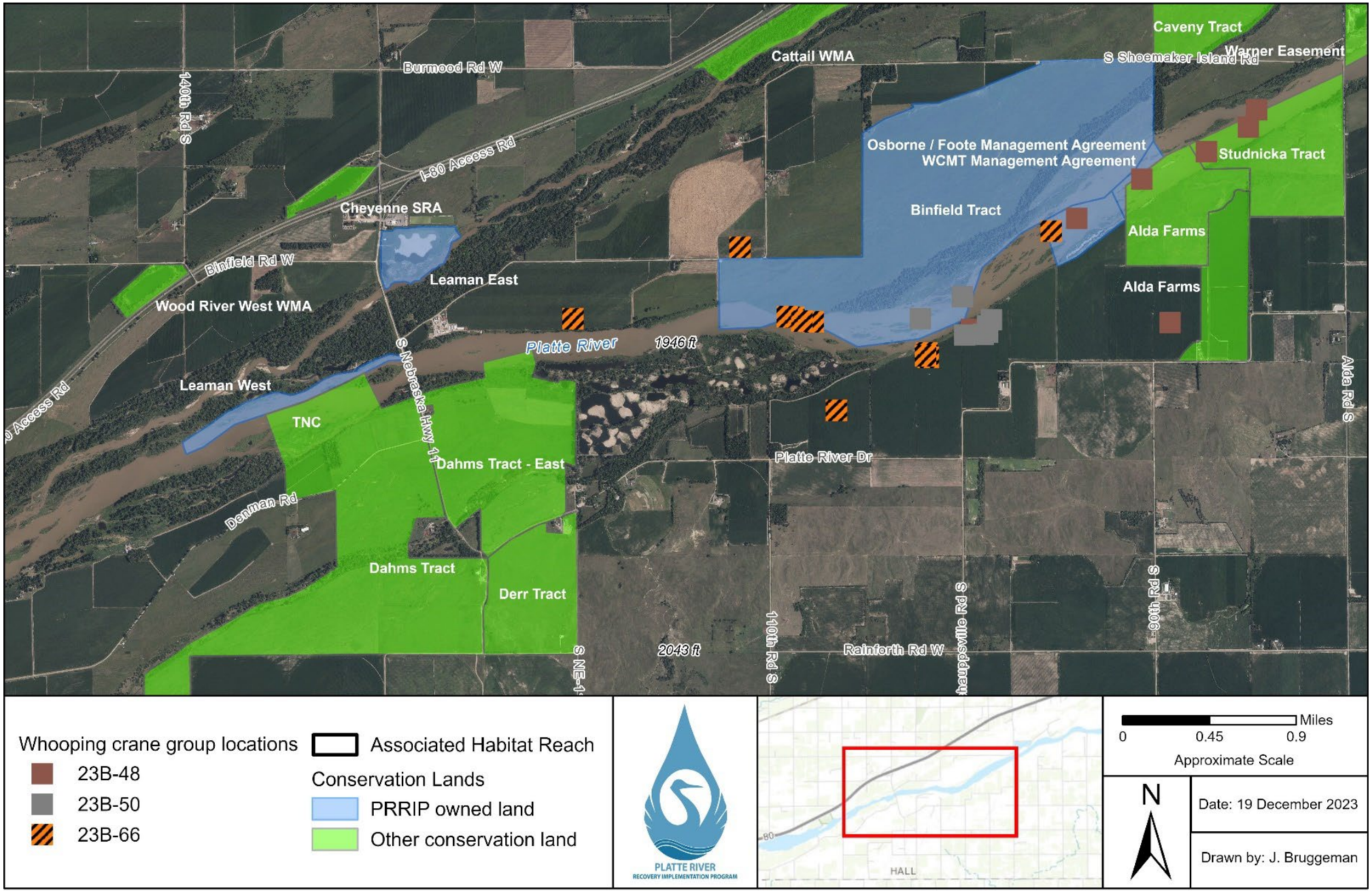


Figure C5. Whooping crane groups USFWS ID 23B-48 (See Appendix B Table B.6 for PRRIP IDs; sighted 11/1–11/12); USFWS ID 23B-50 (See Appendix B Table B.8 for PRRIP IDs; sighted 11/3–11/8); and USFWS ID 23B-66 (See Appendix B Table B.12 for PRRIP IDs; sighted 11/10–11/21) observed southeast of Wood River, Nebraska along the Associated Habitat Reach of the central Platte River during fall 2023. PRRIP aerial imagery from July 2023 is displayed for reference.

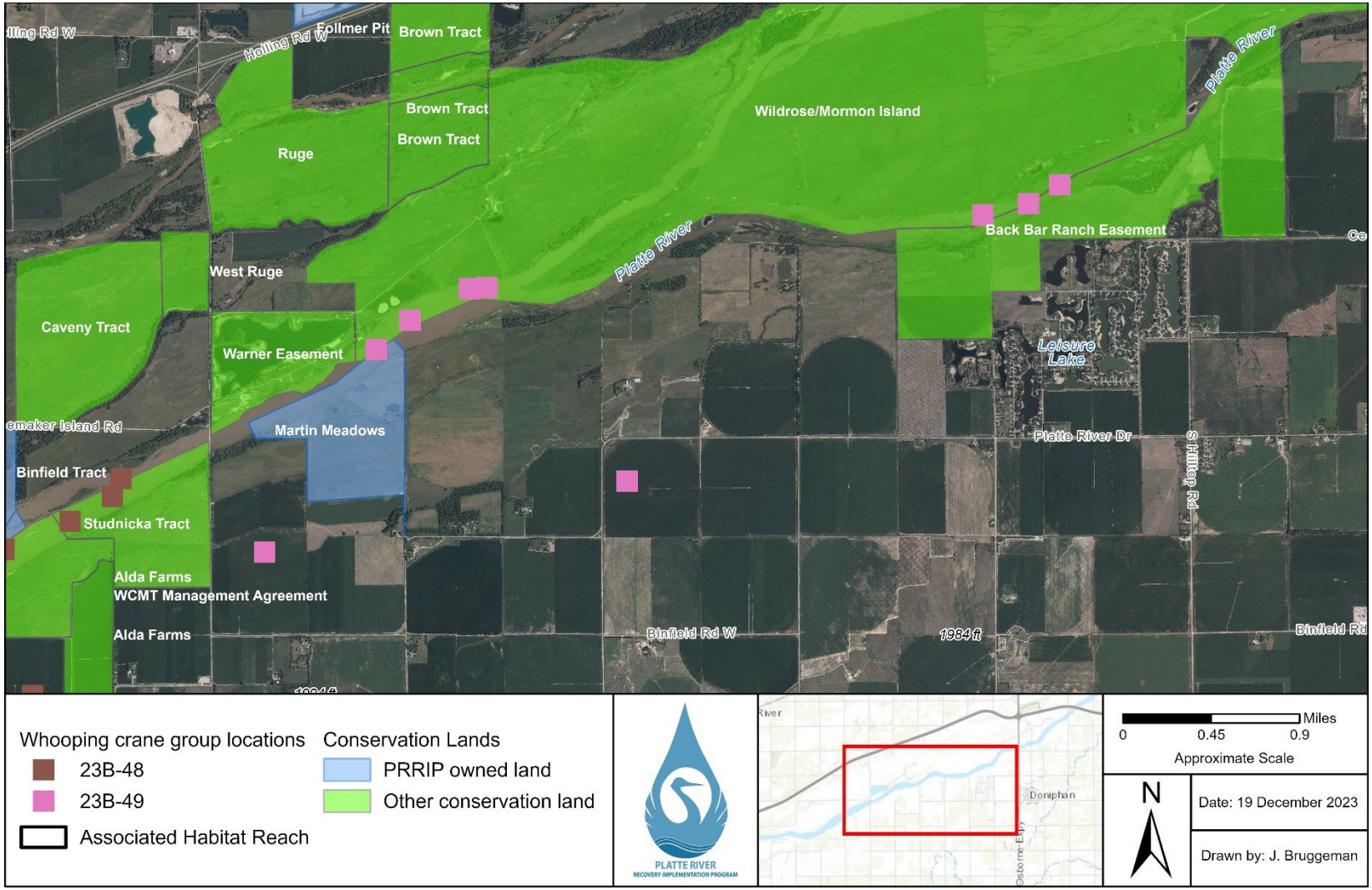


Figure C6. Whooping crane groups USFWS ID 23B-48 (See Appendix B Table B.6 for PRRIP IDs; sighted 11/1–11/12) and USFWS ID 23B-49 (See Appendix B Table B.7 for PRRIP IDs; sighted 11/2–11/12) observed southeast of Wood River, Nebraska and near the Mormon Island area along the Associated Habitat Reach of the central Platte River during fall 2023. PRRIP aerial imagery from July 2023 is displayed for reference.

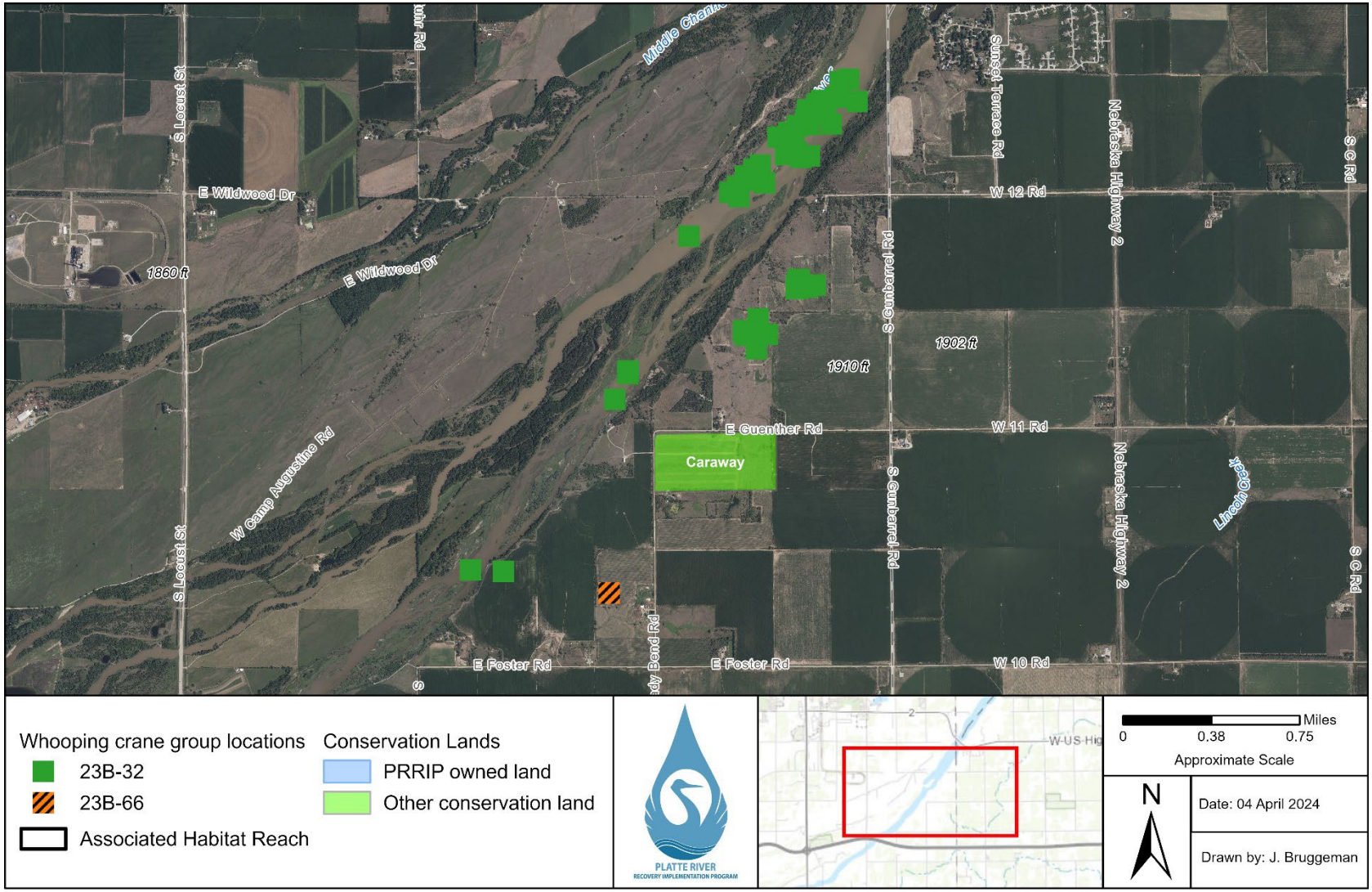


Figure C7. Whooping crane groups USFWS ID 23B-32 (See Appendix B Table B.3 for PRRIP IDs; sighted 10/30/23–1/10/24) and USFWS ID 23B-66 (See Appendix B Table B.12 for PRRIP IDs; sighted 11/10–11/21) observed south of Grand Island, Nebraska along the Associated Habitat Reach of the central Platte River during fall 2023. PRRIP aerial imagery from July 2023 is displayed for reference.

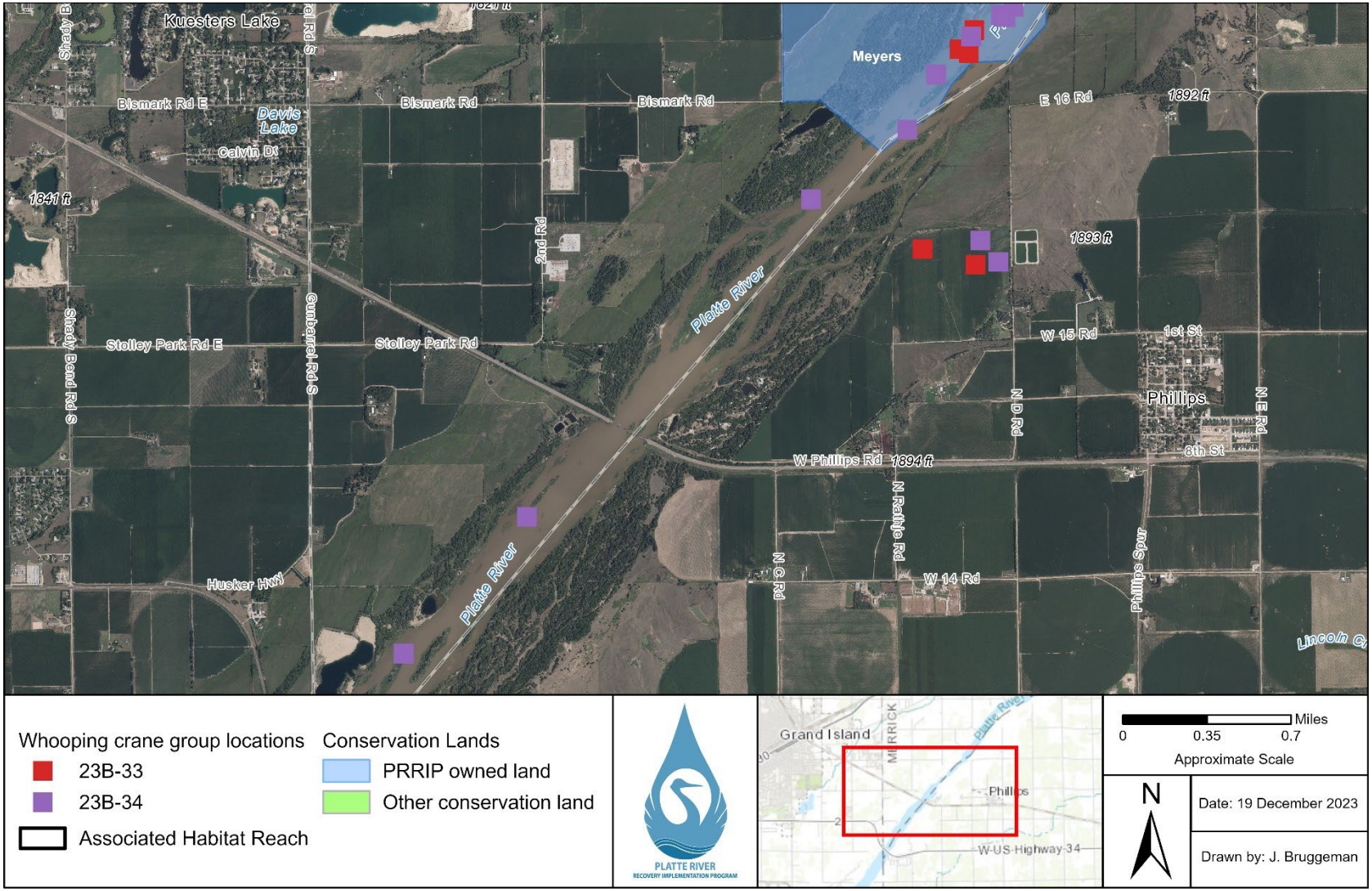


Figure C8. Whooping crane groups USFWS ID 23B-33 (See Appendix B Table B.4 for PRRIP IDs; sighted 10/31–11/18) and USFWS ID 23B-34 (See Appendix B Table B.5 for PRRIP IDs; sighted 10/31–11/18) observed west of Phillips, Nebraska along the Associated Habitat Reach of the central Platte River during fall 2023. PRRIP aerial imagery from July 2023 is displayed for reference.

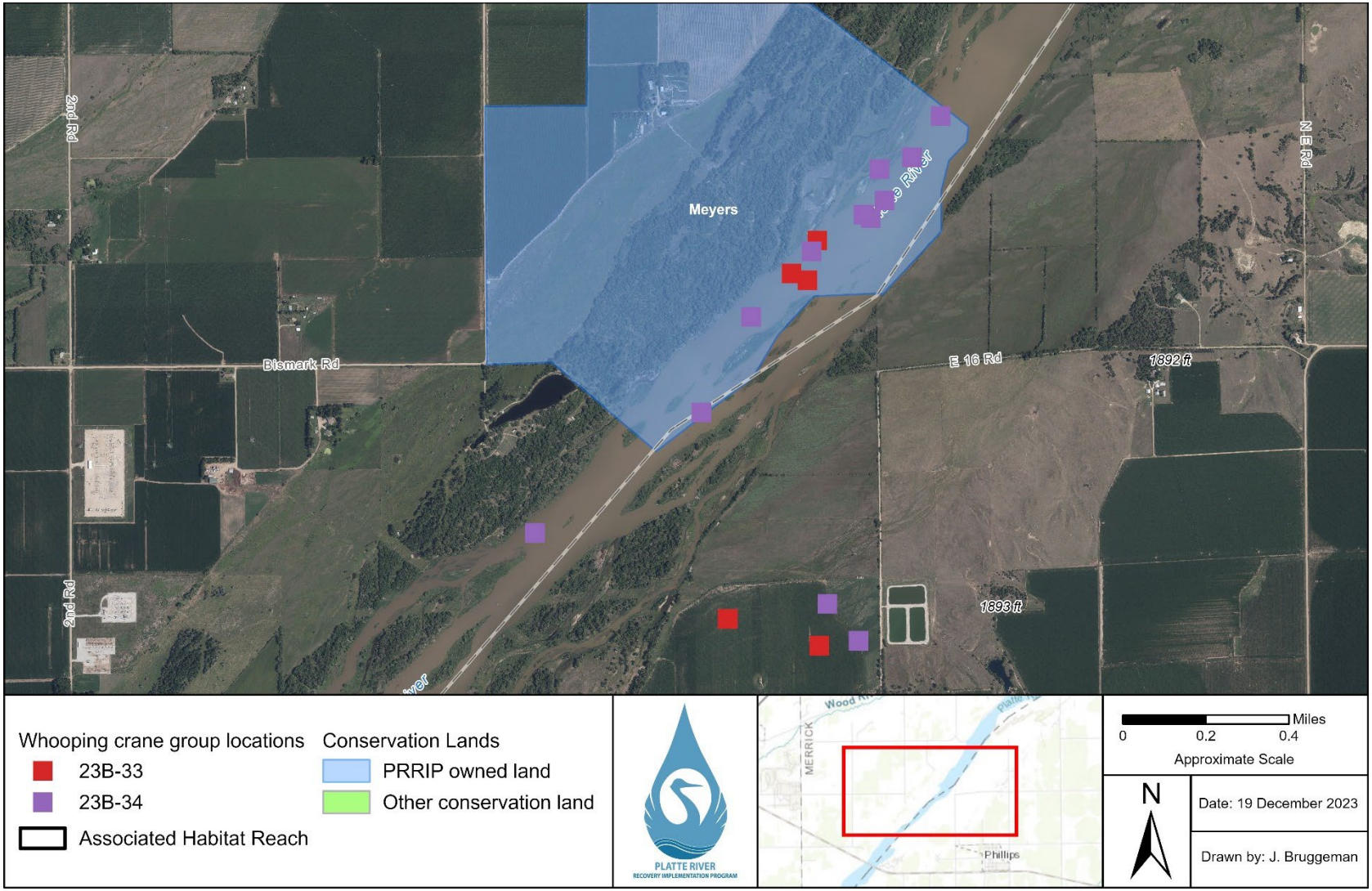


Figure C9. Whooping crane groups USFWS IDs 23B-33 (See Appendix B Table B.4 for PRRIP IDs; sighted 10/31–11/18) and 23B-34 (See Appendix B Table B.5 for PRRIP IDs; sighted 10/31–11/18) observed north of Phillips, Nebraska along the Associated Habitat Reach of the central Platte River during fall 2023. PRRIP aerial imagery from July 2023 is displayed for reference.

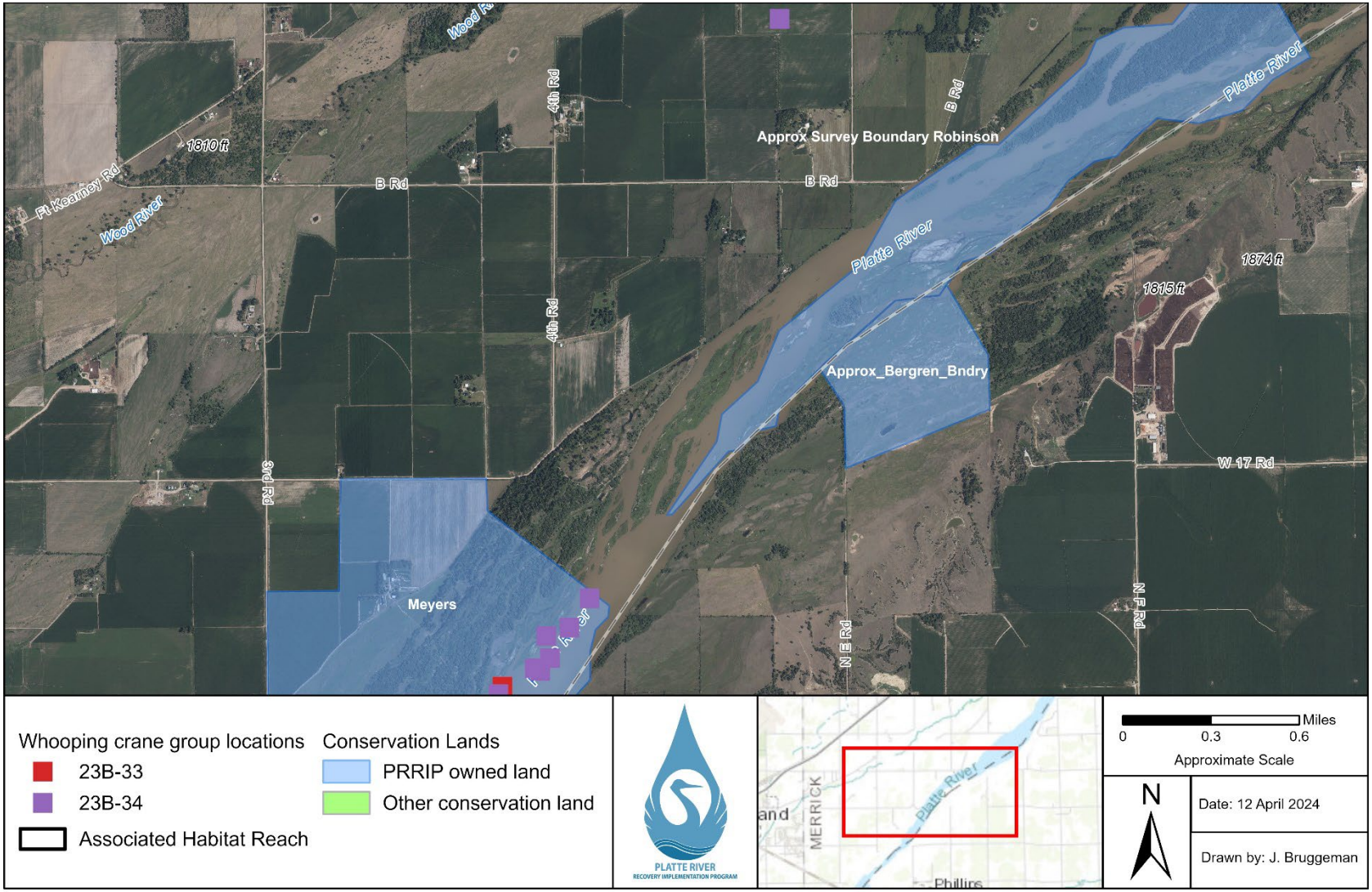


Figure C10. Whooping crane groups USFWS IDs 23B-33 (See Appendix B Table B.4 for PRRIP IDs; sighted 10/31–11/18) and 23B-34 (See Appendix B Table B.5 for PRRIP IDs; sighted 10/31–11/18) observed northeast of Phillips, Nebraska along the Associated Habitat Reach of the central Platte River during fall 2023. PRRIP aerial imagery from July 2023 is displayed for reference.

Figure C11. Photograph of whooping crane group PRRIP ID 2023FA01 (USFWS ID 23B-30) on 10/29/2023. The whooping crane group was observed during systematic aerial surveys.

Figure C12. Photograph of whooping crane group PRRIP ID 2023FA02 (USFWS ID 23B-31) on 10/30/2023. The whooping crane group was observed during systematic aerial surveys.

Figure C13. Photograph of whooping crane group PRRIP ID 2023FA04 (USFWS ID 23B-32) on 10/30/2023. The whooping crane group was observed during systematic aerial surveys.

Figure C14. Photograph of whooping crane group PRRIP ID 2023FA05 (USFWS ID 23B-33) on 10/30/2023. The whooping crane group was observed during systematic aerial surveys.

Figure C15. Photograph of whooping crane group PRRIP ID 2023FA06 (USFWS ID 23B-34) on 10/31/2023. The whooping crane group was observed during systematic aerial surveys.

Figure C16. Photograph of whooping crane group PRRIP ID 2023FA09 (USFWS ID 23B-48) on 11/1/2023. The whooping crane group was observed during systematic aerial surveys.

Figure C17. Photograph of whooping crane group PRRIP ID 2023FA20 (USFWS ID 23B-49) on 11/2/2023. The whooping crane group was observed during systematic aerial surveys.

Figure C18. Photograph of whooping crane group PRRIP ID 2023FA27 (USFWS ID 23B-50) on 11/3/2023. The whooping crane group was observed during systematic aerial surveys.

Figure C19. Photograph of whooping crane group PRRIP ID 2023FA51 (USFWS ID 23B-63) on 11/7/2023. The whooping crane group was observed during systematic aerial surveys.

Figure C20. Photograph of whooping crane group PRRIP ID 2023FA59 (USFWS ID 23B-64) on 11/7/2023. The whooping crane group was observed during systematic aerial surveys.

Figure C21. Photograph of whooping crane group PRRIP ID 2023FA65 (USFWS ID 23B-65) on 11/9/2023. The whooping crane group was observed during systematic aerial surveys.

Figure C22. Photograph of whooping crane group PRRIP ID 2023FA68 (USFWS ID 23B-66) on 11/10/2023. The whooping crane group was observed during systematic aerial surveys.

Figure C23. Photograph of whooping crane group PRRIP ID 2023FA76 (USFWS ID 23B-67) on 11/11/2023. The whooping crane group was observed during systematic aerial surveys.

Appendix D. Aransas-Wood Buffalo Population Estimates

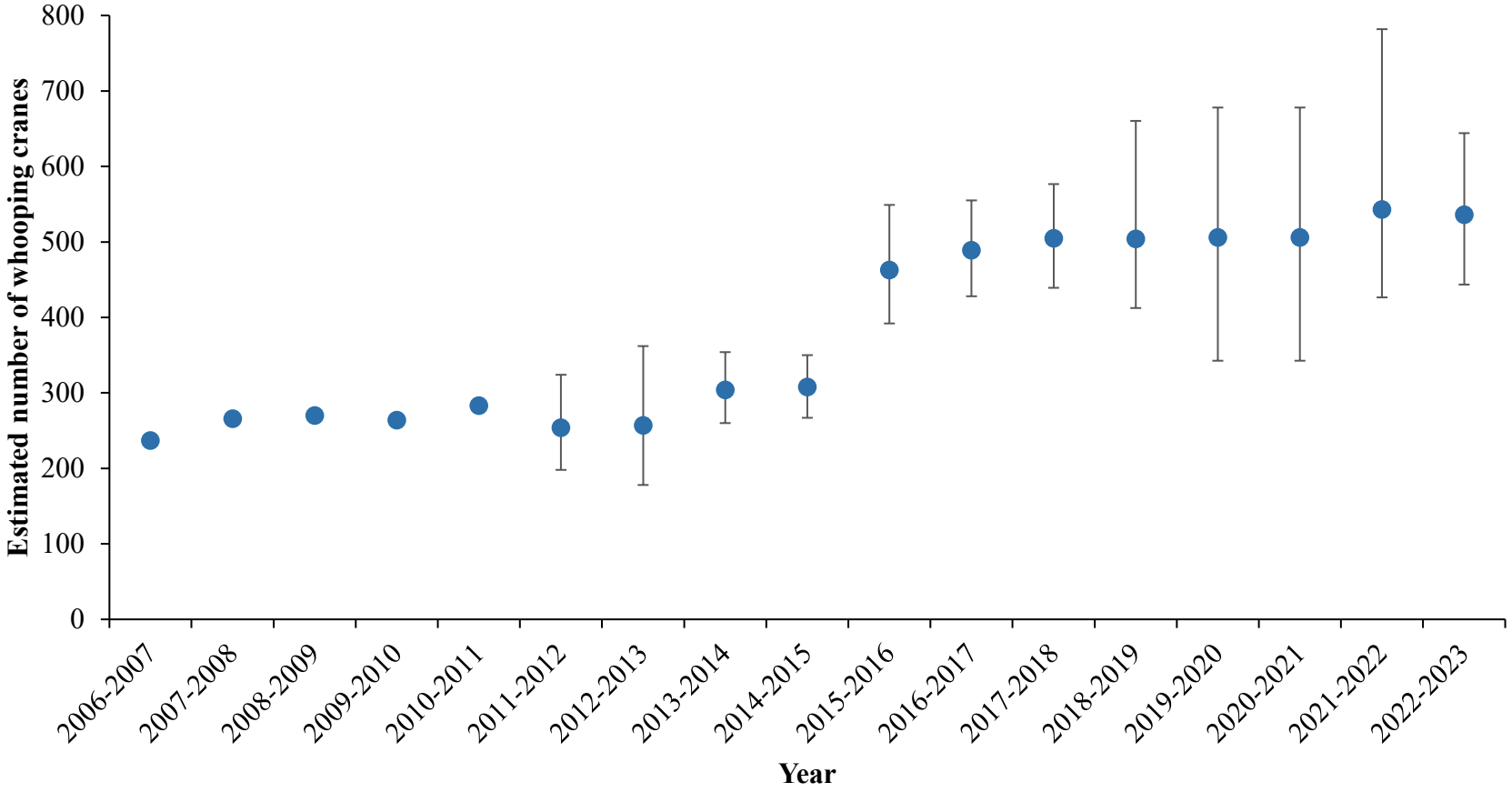


Figure D1. Estimated size of the migratory Aransas-Wood Buffalo whooping crane population based on surveys on the winter range on the Texas Gulf Coast of Mexico during 2007–2023 (USFWS 2023). A change in survey methodology occurred after 2014–2015, which resulted in an increase in the number of whooping cranes observed during 2015–2016. 95% confidence intervals are provided for 2011–2023. For the 2020–2021 estimate, the estimated AWB population from winter 2019–2020 was used (506 birds) because no winter survey was completed during 2020–2021. No USFWS survey was conducted during winter 2023–2024.

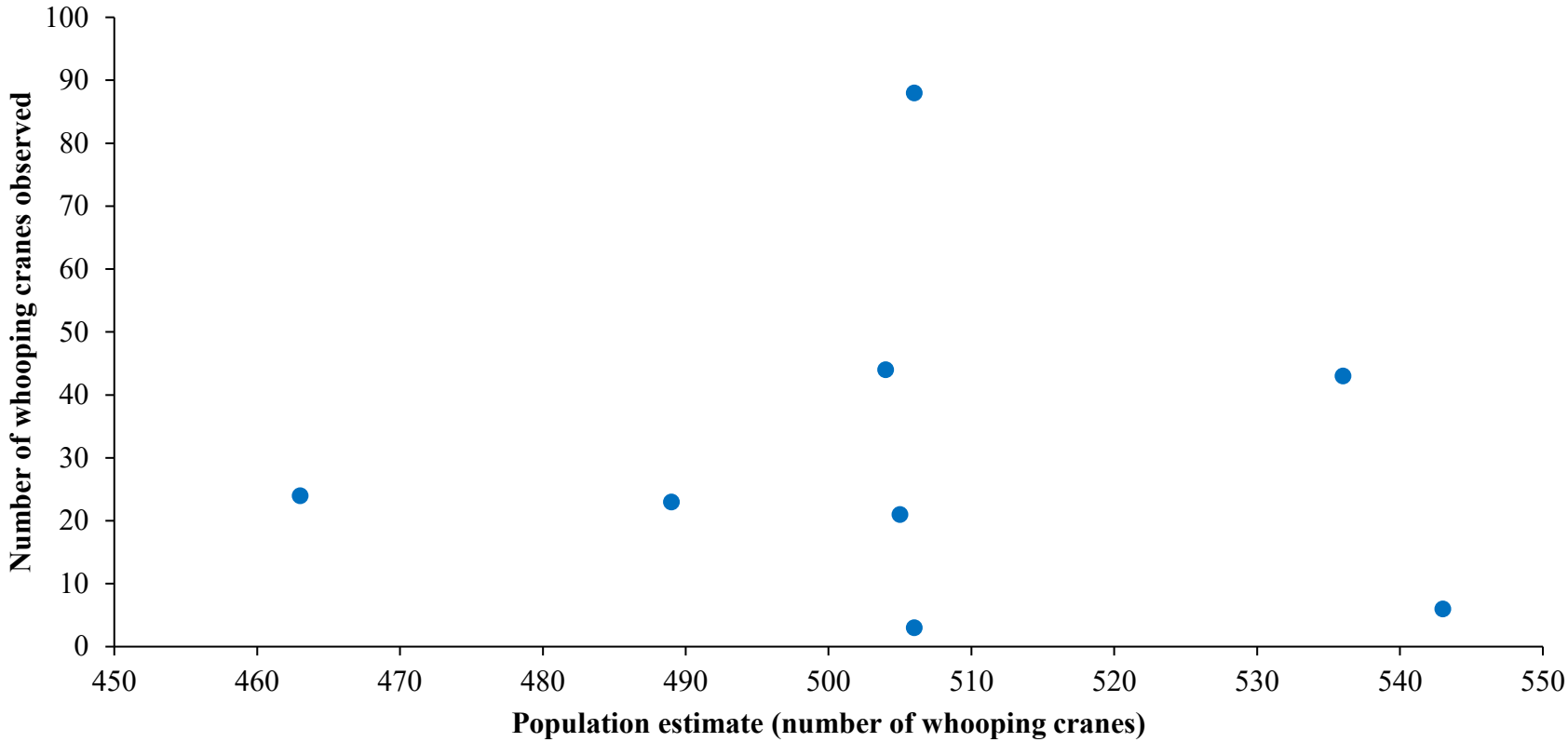


Figure D2. Relationship between the number of individual whooping cranes enumerated during PRRIP fall surveys on the Associated Habitat Reach of the central Platte River and the estimated size of the Aransas-Wood Buffalo population based on surveys on the winter range during 2016–2023. For the 2020–2021 estimate, the estimated AWB population from winter 2019–2020 was used (506 birds) because no winter survey was completed during 2020–2021.

Appendix E. Past Research Synthesis

Published	Study Topic	Document Title	Summary	Principal Findings	Citation
2023	Group size	Record-sized flock of whooping cranes (*Grus americana*) observed staging in the central Platte River valley during autumn 2021	46 whooping cranes gathering as a single flock during autumn 2021	The paper summarizes how the large aggregation of 46 whooping cranes formed from five smaller groups. The authors speculated drought and hydrologic conditions before and during this event affected the formation of the large group	Baasch DM, Rabbe M, Medaries AH, Schaaf MR, Ostrom BL, Wiese JD, Malzahn JM, Smith TI. 2023. Record-sized flock of whooping cranes (*Grus americana*) observed staging in the central Platte River valley during autumn 2021. Waterbirds 45(4):484–491. https://doi.org/10.1675/063.045.0413
2023	Migratory behavior	Differential shortstopping behaviour in whooping cranes: habitat or social learning?	Documented shortstopping behavior during migration (i.e., shifting wintering grounds closer to breeding grounds) in the eastern reintroduced whooping crane population, but did not find evidence of shortstopping in remnant population.	Authors did not find shortstopping behavior in the Aransas Wood Buffalo migratory whooping crane population, but did with the reintroduced Eastern Migratory Population. Because juveniles from the reintroduced population did not associate with older conspecifics in nearly half of observed wintering events, the authors suggested the social transmission of winter migration behaviors might be less effective in the reintroduced population. In contrast, juveniles from the Aransas Wood Buffalo population overwintered with their parents, suggesting social learning may play a role in migratory behavior and strategies.	Mendgen P, Converse SJ, Pearse AT, Teitelbaum CS, Mueller T. 2023. Differential shortstopping behaviour in whooping cranes: habitat or social learning? Global Ecology and Conservation 41:e02365. https://doi.org/10.1016/j.gecco.2022.e02365

Published	Study Topic	Document Title	Summary	Principal Findings	Citation
2023	Conservation and endangered species	Biological case against downlisting the whooping crane and for improving implementation under the Endangered Species Act.	In response to potential downlisting of WCs from endangered to threatened status by the USFWS, the authors examined the status of WCs in the context of population status and current threats. The authors concluded that proposed downlisting is unwarranted before WC recovery plan population criteria have been met.	The authors examined the current status of WCs in the context of Endangered Species Act (ESA) threat factors, USFWS's Species Assessment framework, and similar avian downlisting actions to determine if downlisting the WC from endangered to threatened is biologically warranted. The authors noted that WCs are the rarest of 15 crane species worldwide with 702 birds estimated in fall 2022. The authors noted five major threats to WCs including habitat loss, environmental conditions, physical harm, disease, and pollution. The authors documented 17 avian species that have been downlisted under the ESA and found only one was downlisted from endangered status with a population <3,000 birds. The authors concluded WCs are facing an intensification of threats across their ranges, the population is still small relative to other crane species and most avian species of conservation concern, and that downlisting before WC population criteria for recovery have been met would be inconsistent with previous population management actions for avian species under the ESA. The authors concluded that downlisting WCs is objectively unwarranted.	Caven AJ, Thompson HL, Baasch DM, Hartup BK, Hegg AM, Schmidt, SM, Louque I, Allen CR, Crouch CG, Davis CA, Jorgensen JG, Austin, JE, Ostrom, BL, Beilfuss RD, Archibald GW, Lacy AE. 2023. Biological case against downlisting the whooping crane and for improving implementation under the Endangered Species Act. Papers in Natural Resources 1655. https://digitalcommons.unl.edu/natrespapers/1655?utm_source=digitalcommons.unl.edu%2Fnatrespapers%2F1655&utm_medium=PDF&utm_campaign=PDFCoverPages

Published	Study Topic	Document Title	Summary	Principal Findings	Citation
2023	Diurnal behavior	Whooping crane diurnal behavior and natural history during migration in the central Great Plains: summary report—Spring 2019 – Fall 2022	Studied WC diurnal activity and behavior in south-central Nebraska during the spring 2019 through fall 2022 migration seasons. Documented behaviors in different land cover types, responses to disturbance, and species on which WCs were foraging.	Used scan sampling to study WC activity and responses to disturbance and predators during 2019–2022. Observed 69 WC groups comprised of 248 birds and collected 5,017 instantaneous cane samplings totaling 23,676 individual behaviors. WC were observed foraging on multiple species, including fish, frogs, turtles, and arthropods. WC exhibited more alert and defensive behaviors in cornfields than other land cover types. WC were documented loafing and preening more often in palustrine and lacustrine wetland land cover types. Observed 15 aircraft-WC interactions involving 90 WCs with 57 birds having no reaction, 30 birds exhibiting alert responses, and three birds flushing. Baasch suggested wetland habitats provide valuable habitat for WCs to forage and rest, and provide security to perform important social interactions.	Baasch DM. 2023. Whooping crane diurnal behavior and natural history during migration in the central Great Plains: summary report—Spring 2019 – Fall 2022. Final Report, Platte River Whooping Crane Maintenance Trust, Inc. Wood River, NE. https://cranetrust.org/file_download/684f620c-2142-429a-a0e2-d70a04f376c9
2023	Wind energy and bird conservation	Forecasting suitable areas for wind turbine occurrence to proactively wildlife conservation	Identified conservation priority areas for WC, golden eagles, and lesser prairie-chickens across an eight-state region using a combination of a wind turbine suitability model with animal movement, relative abundance, and population density models.	Authors used GPS locations from WC tagged with satellite transmitters from 2009–2018 to estimate whooping crane space use along migration corridor. They used a biased random bridge estimator to estimate utilization distributions of WCs during spring and fall migration. Multiplied spring and fall utilization distributions with wind turbine suitability predictions to develop a joint probability of intensity of use and wind turbine suitability, and considered areas with highest joint probabilities as high conservation priority areas. Fig. 8 in the paper provides spatially explicit maps of conservation priority areas in relation to wind turbine suitability.	Boggie MA, Butler MJ, Sesnie SE, Millsap BA, Stewart DR, Harris GM, Broska JC. 2023. Forecasting suitable areas for wind turbine occurrence to proactively wildlife conservation. Journal for Nature Conservation 74(2023) 126442. https://doi.org/10.1016/j.jnc.2023.126442

Published	Study Topic	Document Title	Summary	Principal Findings	Citation
2022	Habitat use	Whooping crane (*Grus americana*) use patterns in relation to an ecotope classification in the central Platte River Valley, Nebraska, USA	Evaluation of ecotope-based landcover at 400 m and 1000m spatial scales to predict WC use of the central Platte River.	Integrated both landcover classification and hydrological factors into a finer scale ecotope data layer. USFWS public sighting WC use locations were characterized utilizing this ecotope data layer with a 400 m and a 1000 m buffer around each locational data point. Generalized linear mixed-effects models were used to assess the effects of ecotope composition, flooding frequency, and wetland status on the probability of whooping crane use. Ecotopes at the 1000 m scale explained nearly 40% of the variation in WC use. WC were present more frequently in wetland portions of both agriculture fields and grassland communities, and less likely to use upland portions of these landcover types. Use was positively associated with proximity to the main channel of the Platte River. The probability of WC use was predicted to decrease as the proportion of developed landcover increased and distance to nearest road decreased.	Baasch DM, Caven AJ, Jorgensen JG, Grosse R, Rabbe M, Varner DM, LaGrange T. 2022 Whooping Crane (*Grus americana*) use patterns in relation to an ecotope classification in the Central Platte River Valley, Nebraska, USA. https://ace-eco.org/vol17/iss2/art35/
2022	Power line collision mitigation	Mitigating avian collisions with power lines through illumination with ultraviolet light.	Tested effectiveness of two avian collision avoidance systems (ACASs) at reducing collisions of large-bodied avian species. Whooping cranes were not documented as part of this study.	ACAS illumination and environmental variables were important predictors of avian collisions with power lines. ACAS illumination reduced collisions at focal power line by 88%. Collisions were more likely at moderate wind speeds.	Baasch DM, Hegg AM, Dwyer JF, Caven AJ, Taddicken WE, Worley CA, Medaries AH, Wagner CG, Dunbar PG, Mittman ND. 2022 Mitigating avian collisions with power lines through illumination with ultraviolet light. Avian Conservation and Ecology 17(2):9. https://doi.org/10.5751/ACE-02217-170209

Published	Study Topic	Document Title	Summary	Principal Findings	Citation
2022	Wintering habitat use	Whooping and sandhill cranes visit upland ponds proportional to migration phenology on the Texas coast	Evaluated whooping and sandhill crane use of constructed freshwater ponds as alternative water sources during drought on wintering grounds.	Used camera traps to estimate visits/month of 7 constructed ponds over 3 winters with drought conditions. Used generalized linear mixed-effects models to evaluate the effect of pond type, pond salinity, distance to saltmarsh, bay salinity, tide levels, rainfall, time of year, and migration phenology on the probability of pond use each month. Examined daily activity patterns of crane use at ponds. The best fitting models (both at the pond and broader scale) suggested more whooping crane group visits occurred in January when most whooping cranes were on the wintering grounds. More whooping cranes visited ponds on the mainland than on Matagorda Island. Whooping cranes were not observed at ponds prior to sunrise and infrequently after sunset, thus upland ponds were visited by whooping cranes diurnally.	Butler MJ, Metzger KL, Sanspree CR, Cain JW, Harris GM. 2022. Whooping and sandhill cranes visit upland ponds proportional to migration phenology on the Texas coast. Wildlife Society Bulletin 46(3): e1290. https://doi.org/10.1002/wsb.1290
2022	Wintering habitat use	Space use and site fidelity of wintering whooping cranes on the Texas Gulf Coast	Evaluation of AWB whooping crane winter home ranges through time and in relation to age, sex, reproductive status, and drought.	Used telemetry data from 57 individual telemetered whooping cranes from 2009-2017 and autocorrelated kernel density estimation (AKDE) to explore variation in home range size in relation to age, sex, reproductive status, and drought. Examined overlap in and distance between home range centroids through time to examine site fidelity. Estimated 95% AKDE mean as 30.1 km^2. Home range estimates did not differ for groups with vs. without juveniles. Sub-adult male home ranges were similar in size to those of family groups. Home ranges of sub-adult females were approximately double that of family groups. Home ranges increased in size during drought on the wintering grounds. From one year to the next, home range site fidelity averaged 68% overlap, but as the number of years increased between home ranges of an individual adult whooping crane, they overlapped less. Fidelity to juvenile winter home range declined with age through the 4^{th} winter, but the limited data available beyond the 4^{th} winter suggested that older individuals may return to within 2 km of their juvenile home range.	Butler MJ, Stewart DR, Harris GM, Bidwell MT, Pearse AT. 2022. Space use and site fidelity of wintering whooping cranes on the Texas Gulf Coast. Journal of Wildlife Management 86(5): e22226. https://doi.org/10.1002/jwmg.22226

Published	Study Topic	Document Title	Summary	Principal Findings	Citation
2022	Stopover duration	Whooping crane stay length in relation to stopover site characteristics	Examined the relationship between habitat characteristics and stopover duration during whooping crane migration.	Quantified habitat characteristics at 605 use locations from 449 stopover sites obtained through telemetry from 58 individual whooping cranes. Performed random forest regression to estimate importance of landcover variables for predicting stopover stay length. Mean stopover duration was 3.1 days. Over half of the stopover sites assessed for habitat characteristics were used only a single day or less. Landscape level variables explained 43% of variation in stay length, whereas site level variables explained 9%. Stay length increased with latitude, proportion of land cover as open-water slough with emergent vegetation, proportion of landcover as alfalfa, and longitude. At the site level, wetted width combined over all wetland classes, landcover of nearest shoreline, distance to terrestrial bank from a wetland use location, and wetland class were better predictors of variability in stay length. Stay length increased with wetted width at riverine sites but decreased with wetted width at lacustrine and palustrine sites.	Caven AJ, Pearse AT, Brandt DA, Harner MJ, Wright GD, Baasch DM, Brinley Buckley EM, Metzger KL, Rabbe MR, Lacy AE. 2022. Whooping crane stay length in relation to stopover site characteristics. Proceedings of the North American Crane Workshop 15:6-33. https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1387&context=nacwgproc
2022	Habitat use	Balancing future renewable energy infrastructure siting and associated habitat loss for migrating whooping cranes	Evaluation of functional migratory habitat across the Great Plains relative to renewable energy infrastructure, human development and disturbance, and drought.	Used locational data from 57 individual telemetered whooping cranes from 20101-2016 in the US Great Plains to assess habitat selection and avoidance of disturbance (including renewable energy infrastructure) during migration relative to drought conditions. Land use within 800 m were the best predictors of WC use. Zones of influence distances were determined for disturbance variables. Relationships between WC use and predictor variables were compared under drought and non-drought conditions. An optimization analysis was performed to select potential sites for new wind energy development that minimize habitat loss for whooping cranes while maximizing wind energy potential.	Ellis KS, Pearse AT, Brandt DA, Bidwell MT, Harrell W, Butler MJ, Post van der Burg M. Balancing future renewable energy infrastructure siting and associated habitat loss for migrating whooping cranes. Frontiers in Ecology and Evolution 10:931260. https://doi.org/10.3389/fevo.2022.931260

Published	Study Topic	Document Title	Summary	Principal Findings	Citation
2022	Wintering habitat	Spatial and temporal predictions of whooping crane (*Grus americana*) habitat along the US Gulf Coast	Study mapping the historical spatial transformation of whooping crane habitat in and around Aransas National Wildlife Refuge.	Used exploratory spatial data analysis to document areas used by whooping cranes and how this space use has changed over time from 1990-2009. Developed a time series of ecological niche models to identify environmental factors (biotic and abiotic) correlated with crane habitat use and how importance has changed over time. Utilized multitemporal models to forecast areas along the US Gulf Coast that may provide additional wintering habitat for an expanding whooping crane population and where habitat may be lost due to rising sea levels predicted with climate change.	Golden KE, Hemingway BL, Frazier AE, Scholtz R, Harrell W, Davis CA, Fuhlendorf SD. 2022. Spatial and temporal predictions of whooping crane (*Grus americana*) habitat along the US Gulf Coast. Conservation Science and Practice 4(6): e12696. https//doi.org/10.1111/csp2.12696
2022	Agricultural land cover as habitat	Winners and losers of land use change: A systematic review of interactions between the world's crane species (*Gruidae*) and the agricultural sector	Meta-analysis of published literature on crane use of agricultural landcover and importance of agricultural crops in the diet of cranes to evaluate the bilateral effects of land use change.	Reviewed 135 articles describing 285 crane-agriculture interactions. Agricultural crops are an important dietary component for the majority of crane species with corn and wheat making the largest proportional contribution to the crane diet). Crane use of cropland as foraging habitat was identified in one-third of studies reviewed, but crop damage was identified in only ten percent of studies. Study identified two potential effects of increasing agricultural land cover: 1) habitat loss with negative effects on crane species dependent upon specific non-agricultural habitats and 2) superabundant food availability beneficial for opportunistic crane species able to utilize these resources.	Hemminger K, König H, Månsson J, Bellingrath-Kimura SD, Nilsson L. 2022. Winners and losers of land use change: A systematic review of interactions between the world's crane species (*Gruidae*) and the agricultural sector. Ecology and Evolution 12(3): e8719. https://doi.org.10.1002/ece3.8719
2022	Migratory habitat	The use of US Army Corp of Engineers reservoirs as stopover sites for the Aransas-Wood Buffalo population of whooping crane	Summary of AWB whooping crane use of USACE reservoirs as stopover sites.	Assessed AWB whooping crane stopover use of USACE reservoirs within the migratory corridor. Utilized WC stopover locations from USGS Telemetry Database from 2009-2018 together with USFWS Cooperative Whooping Crane Tracking Project database and USGS Biodiversity Information Serving Our Nation database to document significant stopover use of USACE reservoirs in both spring and fall migratory seasons. One reservoir was used as a wintering location in multiple years.	Jung JF, Fischer RA, McConnell C, Bates P. 2022. The use of US Army Corp of Engineers reservoirs as stopover sites for the Aransas-Wood Buffalo population of whooping crane. US Army Engineer Research and Development Center, Vicksburg, MS. https://apps.dtic.mil/sti/pdfs/AD1176388.pdf

Published	Study Topic	Document Title	Summary	Principal Findings	Citation
2022	Migratory habitat	Differential shortstopping behavior in whooping cranes: habitat or social learning?	Characterizes shortstopping winter habitat utilized by the Eastern migratory population (EMP) to estimate the amount of potential shortstopping wintering habitat available to the Aransas Wood Buffalo population (AWBP) within the Great Plains migratory corridor. Tests habitat availability and social learning as potential drivers leading to the difference in wintering behavior between the EMP and the AWBP populations.	Based upon habitat characteristics of shortstopping sites used by the EMP, an estimated 31.4% of the AWBP migratory corridor is suitable for wintering, reducing the likelihood that insufficient habitat suitability limits shortstopping during fall migration by the AWBP. Limited interactions among adults and juveniles of the EMP may reduce social learning of and adherence to established migratory behavior, leaving room for experience with and uptake of novel migratory behaviors such as shortstopping.	Mendgen, P, Converse SJ, Pearse AT, Teitelbaum CS, Mueller, T. 2022. Differential shortstopping behavior in whooping cranes: habitat or social learning? Global Ecology and Conservation 41: e02365. https://doi.org/10.1016/j.gecco.2022.e02365
2021	Behavior	Whooping crane diurnal behavior and natural history during migration in the central Great Plains: Interim report – Fall 2020.	Used long-range photography/videography, spotting scopes, and binoculars to document whooping crane activity, response to aircraft, and response to potential predators via scan sampling.	Observed 10 whooping crane groups, including 27 individuals. Documented foraging, preening, loafing, social, and defensive behaviors over both on and off-channel environments. Foraging/drinking was the most common behavior observed. Loafing and preening occurred most often in open-water wetland land classes. Alert or defensive behaviors were most often observed in cornfields.	Baasch DM, Caven AJ, Krohn B. 2021. Whooping crane diurnal behavior and natural history during migration in the central Great Plains: Interim report – Fall 2020. Crane Trust, Wood River, NE. https://cranetrust.org/who-we-are/what-we-do/conservation/research/publications.html
2021	Diet and foraging behavior	Whooping crane (*Grus americana*) family consumes a diversity of aquatic vertebrates during fall migration stopover at the Platte River, Nebraska	Used long-range photography, videography, and behavioral scan sampling to document forage items consumed by whooping cranes.	During an 11-day stopover along the central Platte River during the fall of 2019 three adults- and one colt were observed. They consumed 16 individual vertebrates of at least 6 different species during the stopover. The research documented 7 channel catfish (*Ictalurus punctatus*), 5 ray-finned fish (Actinopterygii), 1 sunfish (Centrarchidae), 1 carp/minnow relative (Cypriniformes), 1 perch relative (Percidae), and 1 leopard frog relative (Lithobates sp.) consumed by whooping cranes.	Caven AJ, Koupal KD, Baasch DM, Brinley Buckley EM, Malzahn J, Forsberg ML, Lundgren M. 2021. Whooping crane (*Grus americana*) family consumes a diversity of aquatic vertebrates during fall migration stopover at the Platte River, Nebraska. Western North American Naturalist 81(4): 592-607. https://digitalcommons.unl.edu/natrespapers/1460/

Published	Study Topic	Document Title	Summary	Principal Findings	Citation
2021	Habitat selection	Migrating whooping cranes avoid wind-energy infrastructure when selecting stopover habitat	Used telemetry locations from 57 whooping cranes to detect potential avoidance of wind-energy infrastructure.	Examined how wind energy infrastructure may affect stopover locations. Used whooping crane ground locations and compared habitat characteristics within a buffer around each use and 19 available locations. Predictor variables included percentage wetland, percentage cropland, road density, distance from center of migratory corridor, and distance from energy tower. Zone of influence analysis demonstrated reduced probability of use of areas within 5 km of wind towers.	Pearse AT, Metzger KL, Brandt DA, Shaffer JA, Bidwell MT, Harrell W. 2021. Migrating whooping cranes avoid wind-energy infrastructure when selecting stopover habitat. Ecological Applications 31(5): e02324. https://doi.org.10.1002/eap.2324
2021	Habitat use	Disposition of non-complex palustrine wetlands	Used PRRIP whooping crane use locations from PRRIP monitoring and telemetry data from the whooping crane tracking partnership to assess use of the off-channel non-complex palustrine wetlands managed by the Program.	Whooping Cranes have not been documented to date using the non-complex palustrine wetlands managed by the Program.	PRRIP. 2021. Diposition of Non-Complex Palustrine Wetlands. https://platteriverprogram.org/system/files/2021-10/03-Palustrine%20Wetland%20Memo_0.pdf
2020	Migratory group sizes	Trends in the occurrence of large whooping crane groups during migration in the Great Plains, USA	Used public sighting database to examine trends in migrating whooping crane group sizes over time and space.	Whooping crane group size and the amount of variation in group size has increased over time and in relation to an increasing whooping crane population with the strongest trend observed in the increasing number of groups with 7-9 and ≥10 individuals. Large groups tended to occur within the 50% migratory corridor, at staging areas closer to the ends of the migratory corridor, and disproportionately on conservation-managed habitat.	Caven AJ, Rabbe M, Malzahn J, Lacy AE. 2020. Trends in the occurrence of large whooping crane groups during migration in the Great Plains, USA. Heliyon 6(4): E03549. https://doi.org/10.1016/j.heliyon.2020.e03549

Published	Study Topic	Document Title	Summary	Principal Findings	Citation
2020	Migratory habitat	Identifying, protecting, and managing stopover habitats for wild whooping cranes on U.S. Army Corps of Engineers lakes	Evaluation of USACE lakes within the AWB population migratory corridor as potential whooping crane habitat for management.	Thirty-four USACE lakes within the migratory corridor were evaluated using the following criteria: lake, pond, wetland ≥ 0.12 ha, with shallow area 12-25 cm deep for roosting, and gradual, sloping shorelines; little/no submerged/emergent vegetation in potential roost area; glide path clear of obstruction, no trees or tall, dense vegetation, open landscape with extensive horizontal visibility; and ≥ 275 m from human development/disturbance. Within the 34 lakes, 624 locations were identified as potential whooping crane stopover sites within North and South Dakota, Nebraska, Kansas, Oklahoma, and Texas with commitments to manage the identified habitat as resources allow.	McConnell, C. 2020. Identifying, protecting, and managing stopover habitats for wild whooping cranes on U.S. Army Corps of Engineers lakes. bioRxiv 12.30.424870. https://doi.org/10.1101/2020.12.30.424870
2020	Wintering habitat	Identifying sustainable winter habitat for whooping cranes	Predicting future wintering habitat quality and quantity under scenarios of sea level rise and urban development. Calculation of potential carrying capacity over wintering habitat.	Whooping cranes used salt marsh, areas >15 km from development, and < 2 km from estuarine water more frequently. Area of salt marsh changed over time with sea rise. One to three percent of suitable habitat was predicted to be lost to urbanization by 2100. Under the scenario of higher coastal urbanization over time, carrying capacity of wintering habitat for whooping cranes was predicted to initially increase with a 0.6 m rise in sea level, but decrease as sea level rose by 1-2 m through time.	Metzger KL, Lehnen SE, Sesnie SE, Butler MJ, Pearse AT, Harris G. 2020. Identifying sustainable winter habitat for whooping cranes. Journal for Nature Conservation 57. https://doi.org/10.1016/j.jnc.2020.125892
2020	Diet	A characterization of the diets of wild and reintroduced whooping cranes (*Grus americana*)	Inventoried proventriculus and ventriculus contents from dead birds to compare diet between Wisconsin-Florida (eastern migratory) population and the Aransas-Wood Buffalo population.	Wisconsin-Florida and Aransas-Wood Buffalo populations had similar dietary compositions, including benthic invertebrates, beetles, crabs/crayfish, vegetation, seeds, mollusks and unidentified vertebrates.	Neri H. 2020. A characterization of the diets of wild and reintroduced whooping cranes (*Grus americana*). MS Thesis, Department of Environmental Biology, Hood College, Frederick, MD. http://hdl.handle.net/11603/18389

Published	Study Topic	Document Title	Summary	Principal Findings	Citation
2020	Migration telemetry	Location data for whooping cranes of the Aransas-Wood Buffalo population, 2009-2018 (data set).	Telemetry tracking locational dataset for AWB migratory population of whooping cranes from 2009-2018.	Telemetry tracking locational dataset for AWB migratory population of whooping cranes from 2009-2018.	Pearse AT, Brandt DA, Baasch DM, Bidwell MT, Conkin JA, Harner MJ, Harrell W, Metzger KL. 2020. Location data for whooping cranes of the Aransas-Wood Buffalo population, 2009-2018 (data set). US Geological Survey. https://doi.org/10.5066/P9Y8KZJ9
2020	Migration strategy	Heterogeneity in migration strategies of whooping cranes	Used telemetry to assess variation in migration strategies among 58 whooping cranes and the variables associated with those differences.	Whooping cranes showed little consistency in stopover sites used among migration seasons. Timing of migration showed consistency among age classes and reproductive cycles. Time spent at stopover sites was positively associated with distances traveled and negatively associated with time spent at previous stopover sites.	Pearse AT, Metzger KL, Brandt DA, Bidwell MT, Harner MJ, Baasch DM, Harrell W. 2020. Heterogeneity in migration strategies of whooping cranes. The Condor 122(1): 1-15. https://academic.oup.com/condor/article/122/1/duz056/5700702
2019	Riverine habitat selection	Whooping crane use of riverine stopover sites	Analyzed habitat characteristics for riverine stopover sites in the Great Plains and on the Platte River using telemetry locations for the Great Plain analysis and both PRRIP systematic aerial monitoring and telemetry for the Platte River analysis.	This analysis found that whooping crane use on riverine sites was maximized at 200m for unobstructed channel width (656 ft. UOCW), 160m for nearest forest (524ft NF), and suggested managing for unforested corridor widths of 330m (1,082ft UFCW).	Baasch DM, Farrell PD, Howlin S, Pearse AT, Farnsworth JM, Smith CB. 2019. Whooping crane use of riverine stopover sites. PLoS ONE 14 (1): e0209612. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0209612

Published	Study Topic	Document Title	Summary	Principal Findings	Citation
2019	Diurnal habitat selection	Diurnal habitat selection of migrating whooping crane in the Great Plains	This study used telemetry marked whooping cranes to assess diurnal use of landcover types throughout the U.S. migration corridor.	Diurnal habitat selection by whooping cranes was found to be influenced by land-cover type and distance to roads. Avoidance of roads varied based on land cover type. At 200 m from any road, all water-based land-cover types (river, open water, and semipermanent wetlands) were estimated to be at least three times as likely and lowland grassland was more than twice as likely to be selected as diurnal use sites than other non-water-based land-cover types (upland grass, corn, wheat, and other agriculture). Corn and semipermanent wetlands were more than 3 times as likely to be selected for at 1 km compared to 200 m from any road, whereas open water and riverine were similarly selected at 1km and 200 m from any road. Semi-permanent wetland was the only water-based land-cover type that was influence by avoidance of roads and was almost 3 times as likely selected at 1 km compared to 200m.	Baasch DM, Farrell PD, Pearse AT, Brandt DA, Caven AJ, Harner MJ, Wright GD, Metzger KL. 2019. Diurnal habitat selection of migrating Whooping Crane in the Great Plains. Avian Conservation and Ecology 14(1):6. https://doi.org/10.5751/ACE-01317-140106
2019	Diet and foraging	Adult whooping crane (*Grus americana*) consumption of juvenile catfish (*Ictalurus punctatus*) during the avian spring migration in the Central Platte River Valley, Nebraska, USA.	First observation of whooping crane consumption of fish in the Platte River.	22 March 2018 observation and photo documentation of an adult whooping crane consuming five juvenile channel catfish.	Caven AJ, Malzahn J, Koupal KD, Brinley Buckley EM, Wiese JD. 2019. Adult whooping crane (*Grus americana*) consumption of juvenile catfish (*Ictalurus punctatus*) during the avian spring migration in the Central Platte River Valley, Nebraska, USA. Monographs of the Western North American Naturalist 11(2). https://scholarsarchive.byu.edu/mwnan/vol11/iss1/2/?utm_source=scholarsarchive.byu.edu%2Fmwnan%2Fvol11%2Fiss1%2F2&utm_medium=PDF&utm_campaign=PDFCoverPages

Published	Study Topic	Document Title	Summary	Principal Findings	Citation
2018	Riverine habitat management	Investigating whooping crane habitat in relation to hydrology, channel morphology and a water-centric management strategy on the central Platte River, Nebraska	This study used annual aerial imagery to monitor effectiveness of sediment augmentation, mechanical/chemical vegetation clearing, channel consolidating, and short duration high flow releases to maintain suitable unobstructed channels for whooping cranes.	This study found 40-day mean peak discharge, wetted width of the channel, disking and herbicide application to be the best predictors of total unvegetated channel width (TUCW). Maximum unvegetated channel width (MUCW) was best explained by 40-day duration peak discharge and wetted width of the main channel. Disking and herbicide application were also included in the top model. Implementation of a short duration high flow release in a given year was predicted to increase TUCW by 0.0 – 6.7 m and MUOCW by 0.0 – 4.6 m depending on baseline river discharge at the time of the release.	Farnsworth JM, Baasch D, Farrell PD, Smith CB, Werbylo KL. 2018. Investigating whooping crane habitat in relation to hydrology, channel morphology and a water-centric management strategy on the central Platte River, Nebraska. Heliyon 4(10): E00851. https://doi.org/10.1016/j.heliyon.2018.e00851
2018	Diurnal habitat selection	Opportunistically collected data reveal habitat selection by migrating Whooping Cranes in the U.S. Northern Plains.	The study combined opportunistic whooping crane sightings from the USFWS public sightings database with landscape data to identify correlates of whooping crane occurrence along the migration corridor in North and South Dakota, USA.	The study found whooping cranes migrating through North and South Dakota select diverse wetland communities and upland (cropland) foraging opportunities. A 1.2 km buffer (radius around use and available locations) for quantification of habitat metrics was the spatial scale with best model support. Road density and distance to increased survey area were found to be important variablesto incorporate into the model to account for detection bias in the public sightings database.	Niemuth ND, Ryba AJ, Pearse AT, Kvas SM, Brandt DA, Wangler B, Austin JE, Carlisle, MJ. 2018. Opportunistically collected data reveal habitat selection by migrating Whooping Cranes in the U.S. Northern Plains. The Condor 120(2):343-356. https://doi.org/10.1650/CONDOR-17-80.1

Published	Study Topic	Document Title	Summary	Principal Findings	Citation
2017	Riverine and diurnal use site selection	Correlates of whooping crane habitat selection and trends in use in the central Platte River	Using PRRIP systematic aerial monitoring data from 2001-2014, distance to nearest forest and unobstructed channel widths were important predictors of whooping crane use. However, distance to nearest obstruction was in the top five models. The proportion of population using the Platte River is increasing faster than the population during spring migration but not for fall. Neither spring nor fall migration has a significantly increasing trend.	Statistical modeling of habitat use indicated unobstructed channel width and nearest forest were the most important predictor variables for management purposes. Nearest obstruction was in all top five models but was not included in the management list as it cannot be managed for. Statistical modeling of diurnal habitat use indicated the full model for diurnal use containing all four covariates including nearest obstruction, nearest disturbance, proximity to roosting location, and land cover. Based upon PRRIP monitoring data from 2001- 2014, statistical modeling indicated a significant increase in the proportion of the Aransas-Wood Buffalo population of whooping crane using the Platte River in spring through time. However, the statistical modeling for fall use indicated a decreasing trend through time but was not statistically different than zero. These same trends for proportion of population were seen as well for crane use days for spring and fall migration, but neither were statistically different from zero.	Howlin S, Nasman K. 2017. Correlates of whooping crane habitat selection and trends in use in the central Platte River, Nebraska. https://platteriverprogram.org/sites/default/files/PubsAndData/ProgramLibrary/Correlates%20of%20Whooping%20Crane%20Habitat%20Selection%20and%20Trends%20in%20Use%20in%20the%20Central%20Platte%20River.pdf
2017	Roost and diurnal use sites	Evaluation of nocturnal roost and diurnal sites used by whooping cranes in the Great Plains, United States	This document used telemetry marked whooping cranes to locate roost and diurnal use sites in the great plains. Characteristics of each site were measured to develop criteria to help identify habitat along the central Platte River for restoration, conservation, and management actions.	Whooping cranes were able to tolerate a wider range of habitat metrics in the larger portion of the migration corridor than defined by the Program's initial habitat criteria thresholds for the Platte River except for distance to nearest disturbance. Whooping cranes appeared to be more tolerant of disturbances on the Platte River than they were when analyzing the entire corridor.	Pearse AT, Harner MJ, Baasch DM, Wright GD, Caven AJ, Metzger KL. 2017. Evaluation of nocturnal roost and diurnal sites used by whooping cranes in the Great Plains, United States: U.S. Geological Survey Open-File Report 2016–1209, 29 p., https://pubs.usgs.gov/of/2016/1209/ofr20161209.pdf

Published	Study Topic	Document Title	Summary	Principal Findings	Citation
2017	Habitat selection	PRRIP whooping crane habitat synthesis chapters	Used Program systematic monitoring along with telemetry datasets to identify riverine habitat for whooping cranes in the Great Plains and central Platte River.	Unable to establish a relationship between whooping crane use and river flow metrics or total channel width but identified unobstructed channel width and distance to nearest forest as good predictors of whooping crane use. Selection for unobstructed channel width was maximized around 650ft and unforested corridor width was maximized at 1,000 ft. Short-duration high-flow releases will not create or maintain favorable whooping crane riverine habitat in the central Platte River.	PRRIP. 2017. Whooping crane (*Grus americana*) habitat synthesis chapters. https://platteriverprogram.org/sites/default/files/PubsAndData/ProgramLibrary/PRRIP%20Whooping%20Crane%20Habitat%20Synthesis%20Chapters.pdf
2015	Use site intensity throughout the migration corridor	Whooping crane stopover site use intensity within the Great Plains	Used five years data from 58 telemetry marked whooping cranes to analyze use site intensity throughout the migration corridor to identify landscapes important to whooping cranes during migration.	Twenty percent of the grid cells contained one or more stopovers. Thirty percent received only fall stopovers and 47% exclusively spring use. Twenty-three percent had use during both migration seasons. Lands with some type of protection covered approximately 10 percent of the migration corridor used by whooping cranes and approximately 27% of the core corridor. Based on the derived centerline of the migration corridor, 75% of stopover sites occurred within 59 km, 85% within 82 km, and 95% within 144 km of the centerline. Results were similar to those obtained from public sightings data (with known observational bias based upon location) supporting the idea that public sightings data may have value in large scale evaluation.	Pearse AT, Brandt DA, Harrell WC, Metzger KL, Baasch DM, Hefley TJ. 2015. Whooping crane stopover site use intensity within the Great Plains: U.S. Geological Survey Open-File Report 2015–1166, 12 p., https://pubs.er.usgs.gov/publication/ofr20151166

Published	Study Topic	Document Title	Summary	Principal Findings	Citation
2014	Species distribution modeling	Correction of location errors for presence-only species distribution models	Analyzed sampling bias of whooping crane locations and the effects those errors had on species distribution models.	Whooping cranes avoid development within 100 and 250 m radius but are indifferent to development at 500 m. Species distribution models rely on accurate species locational data as well as accurate measurement of environmental covariates included in the model postulated to be important for species distribution. Errors in location data can lead to biased regression coefficients for species distribution modeling. Regression calibration can reduce this bias, but can increase variance surrounding parameter estimates, widening confidence intervals associated with variables predicting species distribution. Managers should consider whether there is enough location error (either random or systematic) to warrant correction in light of the increase in uncertainty around resulting parameter estimates. Recording accurate locations from the field will greatly increase the accuracy of models.	Hefley TJ, Baasch DM, Tyre AJ, Blankenship EE. 2014. Correction of location errors for presence-only species distribution models. Methods in Ecology and Evolution 5: 207-214. https://besjournals.onlinelibrary.wiley.com/doi/epdf/10.1111/2041-210X.12144
2013	Population dynamics and recovery planning.	Influence of whooping crane population dynamics on its recovery and management	Modeled 73-year time series of WC abundance to estimate the probability of downlisting. Source for USFWS best estimates of AWB population 1938-2011 obtained through winter surveys.	AWB population experiences periodic population declines but is unlikely to go extinct if future conditions remain similar to those experienced in the past. Provides information for evaluating recovery timelines, habitat conservation targets, management triggers, and monitoring frequency.	Butler MJ, Harris G, Strobel BN. 2013. Influence of whooping crane population dynamics on its recovery and management. Biological Conservation 162: 89-99. https://www.sciencedirect.com/science/article/pii/S0006320713000980

Published	Study Topic	Document Title	Summary	Principal Findings	Citation
2013	Species distribution modeling	Non-detection sampling bias in marked presence-only data	Used whooping crane data to develop a method that corrects for non-detection sampling bias when using presence-only locational data for species distribution modeling.	Developed a marked inhomogeneous Poisson point process species distribution model that accounted for non-detection and aggregation behavior. Correcting for non-detection sampling bias requires estimates of the probability of detection which must be obtained from auxiliary data, as presence-only data do not contain information about the detection mechanism. The number of detections required may be relatively small to result in adequate correction of non-detection sampling bias. Studies documenting the relationship between environmental features and species distribution of abundance must consider the grouping behavior of individuals.	Heffley TJ, Tyre AJ, Baasch DM, Blankenship EE. 2013. Non-detection sampling bias in marked presence-only data. Ecology and Evolution 3(16):5225-5236. https://onlinelibrary.wiley.com/doi/epdf/10.1002/ece3.887
2012-present	USFWS whooping crane survey results: winter 2012 - present	USFWS Whooping crane survey results: winter 2012 - present	Source for USFWS annual estimates of AWB population obtained through winter surveys 2012-present.	The USFWS estimated the abundance of whooping cranes in the AWB population for the winter of 2021–2022 as 543 whooping cranes (95% CI = 426.5–781.8; CV = 0.182) inhabiting the primary survey area. This estimate included at least 31 juveniles (95% CI = 20.2–50.8; CV = 0.255) and 196 adult pairs (95% CI = 153.4–282.9; CV = 0.182).	Butler MJ, Harrell W. Bradley SN, Sanspree CR, Moon JA 2012-2022. Whooping crane survey results: Winter 2012 – present. https://ecos.fws.gov/ServCat/Collection/Profile/1206

Published	Study Topic	Document Title	Summary	Principal Findings	Citation
2008	Summary of WC use of central Platte River from 2001-2006	Whooping crane migrational habitat use in the central Platte River during the Cooperative Agreement period, 2001-2006	Used data collected from systematic aerial surveys during the cooperative agreement to answer five objectives related to whooping crane use of the AHR.	During the cooperative agreement period, average predicted probability of detection for each survey ranged from 0.34 to 0.78. The average distance moved (straight line distance between two consecutive locations) across the 13 crane groups was 3.22 miles, ranging from 0.49 – 21.64 miles. There was no trend found in the index of WC use during this monitoring period. Feeding behaviors were the most common activity observed during crane group monitoring. The second most observed behavior was resting. WC selected channels with large unobstructed views with probability of use maximized when unobstructed width was 343 meters (1,125 ft). A flow dependent selection model indicated that wetted width at suitable depth increased the probability of WC use, maximizing probability of selection at a wetted width of 319 meters and proportion of channel at suitable depth or sand being 0.48.	Howlin S, Derby C, Strickland D. West, Inc. 2008. Whooping crane migrational habitat use in the central Platte River during the Cooperative Agreement period, 2001-2006. https://platteriverprogram.org/system/files/Internal%20Pubs%202/WEST%20Inc.%202008_WC%20Migrational%20Habitat%20Use%20%282001-2006%29.pdf
2001-present	Annual spring and fall whooping crane monitoring reports for the central Platte River	Platte River Recovery Implementation Program: implementation of the whooping crane monitoring protocol	Results from systematic aerial monitoring of the AHR on the central Platte River for spring and fall migration.	Results from systematic aerial monitoring of the AHR on the central Platte River for spring and fall migration.	Platte River Recovery Implementation Program (PRRIP). 2001-Present. https://platteriverprogram.org/program-library?field_document_category_ref_target_id=11&field_document_focus_area_ref_target_id=17&field_document_type_ref_target_id=All&field_document_species_ref_target_id=24&title=Monitoring+Report&items_per_page=20