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The Use of US Army Corps of Engineers Reservoirs as Stopover Sites for the Aransas–Wood Buffalo Population of Whooping Crane

Jacob F. Jung, Richard A Fischer, Chester McConnell, and Pam Bates

August 2022

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Abstract

This technical report summarizes the use of US Army Corps of Engineers (USACE) reservoirs as spring and fall migration stopover sites for the endangered Aransas–Wood Buffalo population of whooping cranes (WHCR), which proved much greater than previously known. We assessed stopover use within the migration flyway with satellite transmitter data on 68 WHCR during 2009–2018 from a study by the US Geological Survey (USGS) and collaborators, resulting in over 165,000 location records, supplemented by incidental observations from the US Fish and Wildlife Service (USFWS) and the USGS Biodiversity Information Serving Our Nation (BISON) databases. Significant stopover use was observed during both spring and fall migration, and one reservoir served as a wintering location in multiple years. Future efforts should include (a) continued monitoring for WHCR at USACE reservoirs within the flyway; (b) reservoir-specific management plans at all projects with significant WHCR stopover; (c) a USACE-specific and range-wide Endangered Species Act Section 7(a)(1) conservation plan that specifies proactive conservation actions; (d) habitat management plans that include potential pool-level modifications during spring and fall to optimize stopover habitat conditions; and (e) continued evaluation of habitat conditions at USACE reservoirs.

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Contents

Figures and Tables

Figures

Tables

Preface

This document includes Whooping Crane migration use data from the Central Flyway stretching from Canada to Texas. Data collected, managed, and owned by the US Fish and Wildlife Service were provided to the US Army Corps of Engineers as a courtesy for their use. The US Fish and Wildlife Service has not directed, reviewed, or endorsed any aspect of the use of these data. Any and all data analyses, interpretations, and conclusions from these data are solely those of the US Army Corps of Engineers.

This study was funded by Dredging Operations and Environmental Research (DOER) Threatened and Endangered Species Team (TEST) program and the Land Use and Natural Resources Program under US Army Corps of Engineers–Headquarters (HQ USACE). The program managers were Dr. Todd Bridges for DOER-TEST and Mr. Jeremy Crossland for HQ USACE.

The authors would like to thank Aaron Pearse of the US Geological Survey Northern Prairie Wildlife Research Center and Matt Rabbe of the US Fish and Wildlife Service–Nebraska Ecological Services for providing access to whooping crane location data. Special thanks to David Hoover, Kansas City District, for his assistance and coordination between USACE and Friends of the Wild Whoopers (FOTWW), as well as review of this technical report. Jeremy Crossland, Program Manager for Land Use and Natural Resources, coordinated funding for this project through HQ USACE. The staff of FOTWW and personnel from USACE districts contributed greatly to prior FOTWW reports detailing on-site conditions at numerous USACE reservoirs that provided supporting data to this report.

The work was performed by the Ecological Resources Branch of the Ecosystem Evaluation and Engineering Division, US Army Engineer Research and Development Center (ERDC), Environmental Laboratory (ERDC-EL). At the time of publication, Joseph Minter was chief, Mark Farr was division chief, and Dr. Jennifer Seiter-Moser was the technical director for the Civil Works Program. The deputy director of ERDC-EL was Dr. Brandon Lafferty and the director was Dr. Edmund Russo.

The commander of ERDC was COL Christian Patterson and the director was Dr. David W. Pittman.

The results of this study were also presented by Jacob Jung and Richard Fischer as "The Use of USACE Reservoirs as Stop-Over Sites for the Aransas-Wood Buffalo Population of Whooping Cranes (WHCR)" (webinar, Vicksburg, MS, August 31, 2021), https://corpslakes.erdc.dren.mil/employees/learning/webinars/21Aug31-WhoopingCrane.pdf.

1 Introduction

1.1 Background

The federally endangered whooping crane (*Grus americana;* WHCR) is one of the rarest bird species in the world, with only one wild population of migratory WHCR in existence (Urbanek and Lewis 2020). WHCR stand 5 ft (1.5 m)* tall with a wingspan of 7 ft (2.1 m), which makes them one of the largest birds in North America (Urbanek and Lewis 2020). Once common, the species was reduced to just 16 birds by 1941, primarily because of market hunting, indiscriminate shooting, and habitat loss. The wild population (Aransas–Wood Buffalo) of WHCR nests and rears young in Wood Buffalo National Park, Alberta and Northwest Territories, Canada, during spring and summer, and the population winters primarily at the US Fish and Wildlife Service's (USFWS) Aransas National Wildlife Refuge (NWR) on the Gulf Coast of Texas (Urbanek and Lewis 2020). After the chicks fledge on Canadian nesting grounds, WHCR migrate 2,500 mi (4,000 km) through portions of seven states in the midsection of the United States to Texas, where they spend the winter. During these long-distance migration events, WHCR averaged 11–12 nighttime stopovers and on average took 29 and 45 days to complete the migration during spring and fall, respectively (Pearse et al. 2020). Conservation efforts in the United States and Canada have contributed to a population size of an estimated 506 birds within the Aransas–Wood Buffalo population, as determined during winter 2019–2020 surveys conducted by the USFWS (Butler et al. 2020).

Historically, documentation of WHCR on US Army Corps of Engineers (USACE) water resource development projects within the migration corridor has been limited to direct observations, some of which have been reported in the Cornell Laboratory of Ornithology's eBird portal (www.ebird.org). The USFWS also maintains a database of individual sightings dating back to 1942 (CWCTP 2019). These sightings often lack the specificity of accurately mapped locations. More recently, satellite-telemetry investigations

* For a full list of the spelled-out forms of the units of measure and the unit conversions used in this document, please refer to *US Government Publishing Office Style Manual*, 31st ed. (Washington, DC: US Government Publishing Office, 2016), 248–52 and 345–47, https://www.govinfo.gov/content/pkg/GPO-STYLEMANUAL-2016/pdf/GPO-STYLEMANUAL-2016.pdf.

conducted by the US Geological Survey (USGS) have documented that migration stopover events frequently occur on USACE projects in the migration corridor.

In accordance with USACE responsibilities under Section 7(a)(1) of the Endangered Species Act (ESA)* to use existing authorities to assist in the recovery of listed species, USACE has entered into a memorandum of understanding (MOU) with the Friends of the Wild Whoopers (FOTWW) to assess migration stopover habitat at USACE lakes. FOTWW is a 501(c)(3) nonprofit conservation organization whose mission is to help preserve and protect the Aransas–Wood Buffalo population of wild WHCR and their habitat. This joint effort will identify ways to maintain existing WHCR migration stopover habitat and improve habitat where possible. This effort encompasses five USACE districts within the migration corridor, including the Omaha, Kansas City, Tulsa, Fort Worth, and Galveston Districts.

The USACE has already initiated some level of coordination to provide improved WHCR habitat within the flyway. For example, in support of the MOU and in accordance with ESA Section 7(a)(1) responsibilities, the Kansas City district is committing to

- conducting field assessments of project lands within the Aransas–Wood Buffalo population migration corridor with FOTWW biologists
- identifying current and potential migration stopover habitat
- identifying measures to maintain existing habitat
- identifying measures to improve habitat where possible
- coordinating with USFWS under ESA concerning potential habitat improvement projects
- implementing projects to maintain and improve habitat as funding allows
- monitoring existing habitat use on an annual basis to identify effectiveness of habitat maintenance and restoration projects and identify measures for further habitat improvement

In October 2017 biologists from FOTWW and Kansas City district lake project staff conducted site assessments at Harlan County Lake, Nebraska, and Wilson, Kanopolis, and Milford Lakes, Kansas. WHCRs have been

* Endangered Species Act of 1973, 16 U.S.C. 35 § 1536(a)(1), 1832. (2020). https://www.govinfo.gov/content/pkg/USCODE-2020-title16/pdf/USCODE-2020-title16-chap35-sec1536.pdf.

documented stopping over during migration on each of these lakes. Ongoing wetland and shoreline habitat management activities at both Harlan County and Milford Lakes were identified as providing important migration stopover habitat for WHCR, along with a variety of shorebirds and waterfowl. At Wilson Lake, one potential project was identified to improve habitat on an area historically used by WHCR that involved the removal of low-level woody vegetation that had developed on an island during drought conditions. At Kanopolis Lake, the Kansas City district and Ducks Unlimited partnered to develop the Big Bottoms Wetland Project (232 ac), which will provide improved WHCR migration stopover habitat.

1.2 Objectives

This study has four main objectives:

1. Identify which USACE reservoir lands and waters are used by WHCR as stopover within the migratory corridor.
2. Describe relative use among the projects.
3. Identify key stopover sites.
4. Suggest a path forward for more detailed habitat assessments at key stopover sites.

1.3 Approach

This investigation will continue to build on knowledge already collected at numerous USACE reservoirs likely to serve as stop-over habitat for WHCR. In 2015, USACE and FOTWW biologists began assessing USACE reservoir projects that historically have been used as migration stopover habitat from Texas to North Dakota (Table 1). FOTWW generated a report for each site visit, with details on areas the assessment teams visited and site-specific management recommendations. Ongoing measures currently benefitting WHCR during migration include the implementation of wetland-restoration projects on USACE lands and invasive plant species control along the lake shores. Additional areas have been identified where minor clearing of small woody vegetation along the lakeshore can provide the long line of sight for predator avoidance. These same areas provide obstacle free takeoff and landing areas, immediately adjacent to large areas of shallow water, which are preferred by migrating WHCR. FOTWW has recognized that during drought years migration stopover habitat on and adjacent to USACE reservoirs is even more important, as other resting and feeding areas desiccate. The importance of these areas was clearly evident during 2012–2014, when there was a significant increase in WHCR use of several USACE reservoirs within the migration corridor. Working together, the USACE and FOTWW are committed to ensuring that migration stopover habitat on USACE lands for the endangered WHCR will not be a neglected piece of the overall recovery strategy.

Therefore, the approach of this study is to further refine which USACE reservoirs are most important in order to focus management for recovery. We acquired historical stop-over records from the USGS and USFWS to determine which USACE reservoirs received the most usage during spring and fall migration. We summarized the total number of stop-over events for each reservoir, the duration of stop-overs, and provided general locations around reservoirs to inform managers for future actions.

Table 1. USACE reservoirs visited by Friends of the Wild Whoopers (FOTWW) and US Army Corps of Engineers (USACE) biologists to assess whooping crane (WHCR) habitat. (NWR—national wildlife refuge; OMP—operational management plan; WMA—wildlife management area)

District	USACE reservoir project	Site visit (year)	Update OMP	Invasive species control	Mark powerlines	Maintain existing wetlands	Construct additional wetlands	Shoreline shrub control	Maintain adjacent crop fields	Recommendations and comments
Fort Worth	Bardwell Lake	2017	X	—	—	—	—	X	—	Beach areas on northeast side are suitable but need clearing of shrubs
Fort Worth	Benbrook Lake	2017	X	—	—	—	—	—	—	Some areas of excellent stopover habitat and other areas with tall trees or in close proximity to human disturbance
Fort Worth	Granger Lake	2017	X	—	—	—	—	—	—	Extensive areas of suitable habitat and in some areas select tree removal would improve habitat
Fort Worth	Lavon Lake	2017	X	—	—	—	—	—	—	Potential suitable habitat (that is, Brockdale Park)
Fort Worth	Aquilla Lake	2018	X	—	—	—	—	X	—	Potential stopover habitat at Old School Area and Unit A-7 that requires some vegetation removal
Fort Worth	Navarro Mills Lake	2018	X	—	—	X	—	—	—	Wetlands in Units 1 and 2 have excellent stopover habitat
Fort Worth	Waco Lake	2018	X	—	—	—	—	—	—	Two islands have excellent stopover habitat
Fort Worth	Whitney Lake	2018	X	—	—	—	—	—	—	Three areas have excellent habitat (H-9, H-10, Noland River Access)
Fort Worth	Belton Lake	2019	X	—	—	—	—	X	—	Extensive areas of buttonbush, select areas should be removed
Fort Worth	Hords Creek Lake	2019	X	—	—	—	—	—	—	Great diversity in habitat, suitable for WHCRs

District	USACE reservoir project	Site visit (year)	Update OMP	Invasive species control	Mark powerlines	Maintain existing wetlands	Construct additional wetlands	Shoreline shrub control	Maintain adjacent crop fields	Recommendations and comments
Fort Worth	Jim Chapman Lake	2019	X	—	—	—	—	—	—	Vegetation on levees should be mowed
Fort Worth	Lake Georgetown	2019	X	—	—	—	—	X	—	Several locations provide suitable habitat, woody debris removal and select areas of buttonbush clearing
Fort Worth	Lake Ray Roberts	2019	X	—	—	—	—	X	—	Select areas of shrubby vegetation removal on gently sloping shoreline
Fort Worth	Lewisville Lake	2019	X	—	—	—	—	—	—	Close proximity to human disturbances
Fort Worth	Procter Lake	2019	X	—	—	—	—	X	—	Select areas of shrub and tree removal on shoreline and two excellent sites near Sabana WMA and Sowell Creek Park beach
Fort Worth	Stillhouse Hollow Lake	2019	X	—	—	—	—	X	—	Multiple excellent potential stopover sites, minor areas need buttonbush removed
Galveston	Addicks Lake	2015	—	—	—	—	—	—	—	Dense forested areas surround lake, low potential for WHCR use
Galveston	Barker Lake	2015	—	—	—	—	—	—	—	Dense forested areas surround lake, low potential for WHCR use
Galveston	Wallisville Lake	2015	X	—	—	—	—	—	—	Extensive areas of high-quality potential stopover habitat (areas off J.J. Mayes Trace and Old River Lake), 225 km east of Aransas NWR, potential wintering habitat
Kansas City	Harlan County Lake	2017	X	X	—	—	—	—	X	Maintain invasive species program with local partner

District	USACE reservoir project	Site visit (year)	Update OMP	Invasive species control	Mark powerlines	Maintain existing wetlands	Construct additional wetlands	Shoreline shrub control	Maintain adjacent crop fields	Recommendations and comments
Kansas City	Kanopolis Lake	2017	X	X	—	—	X	X	X	Big Bottoms Wetland Project proposed for construction
Kansas City	Milford Lake	2017	X	X	—	X	—	—	X	10 existing wetland complexes
Kansas City	Wilson Lake	2017	X	X	—	—	—	X	X	Clear woody vegetation and phragmites in Horseshoe Bend area
Omaha	Fort Peck Lake	2019	X	X	—	—	—	—	—	Excellent shoreline habitat, outside core migration corridor
Omaha	Lake Francis Case	2019	X	X	X	—	—	—	X	Extensive areas of high-quality stopover habitat
Omaha	Lake Oahe	2019	X	—	X	—	—	—	X	Extensive areas of high-quality stopover habitat
Omaha	Lake Sakakawea	2019	X	—	—	—	—	—	—	Abundant high-quality stopover habitat
Omaha	Lake Sharpe	2019	X	—	—	—	—	—	—	Extensive areas of high-quality stopover habitat
Omaha	Lewis and Clark Lake	2019	X	X	—	—	—	—		Extensive areas of high-quality stopover habitat
Omaha	Pipestem Lake	2019	X	—	—	—	—	—	—	~35% of shoreline would be good stopover habitat
Tulsa	Canton Lake	2018	X	—	—	—	—	X	—	Select areas of shrubby vegetation removal on gently sloping shoreline
Tulsa	Fort Supply Lake	2018	X	—	—	—	—	—	—	Several good stopover sites

District	USACE reservoir project	Site visit (year)	Update OMP	Invasive species control	Mark powerlines	Maintain existing wetlands	Construct additional wetlands	Shoreline shrub control	Maintain adjacent crop fields	Recommendations and comments
Tulsa	Kaw Lake	2018	X	—	—	—	—	—	—	Three potential stopover sites identified on sandbars in upstream portion of the lake
Tulsa	Skiatook Lake	2018	X	—	—	—	—	—	X	Three areas of suitable stopover habitat (that is, Tall Chief Cove)

2 Methods

2.1 Data acquisition

2.1.1 US Geological Survey (USGS) Telemetry Database

The USGS, in association with partners from the Canadian Wildlife Service, Crane Trust, Platte River Recovery Implementation Program, and the USFWS, conducted a satellite tracking study of 68 WHCR during 2009–2018 (Pearse et al. 2020; Table 2). WHCRs were captured either at their breeding grounds on or adjacent to Wood Buffalo National Park in Canada or around the wintering grounds at or near Aransas NWR, Texas. WHCR were fitted with leg-mounted transmitters that acquired locations via a GPS network and transmitted data using the Argos satellite system. Observations were logged from 11 December 2009 to 18 November 2018, with a total database of 165,541 records (Figure 1). Each location record consisted of the following data: (1) individual WHCR identifier, (2) date, (3) time, (4) season, (5) direction of movement, (6) speed, (7) quality of signal location, and (8) coordinates. Additional attributes within the data set related to error rates were used to filter out numerous records to display only those records that presented accurate locations for WHCR. This data set that included coordinates and associated attributes was added to ArcGIS 10.6 (Esri, Redlands, California) for spatial analyses in relation to USACE reservoirs.

2.1.2 US Fish and Wildlife Service (USFWS) Cooperative Whooping Crane Tracking Project (CWCTP) Database

The USFWS Nebraska Ecological Services Office provided a data set of all known WHCR sightings from 1975 to 2019 through the Cooperative Whooping Crane Tracking Project (CWCTP 2019). In addition to these records, historical sightings from past observations were also included within the database dating back to 1942, for a total of 3,433 locations. Most locations within the CWCTP are incidental sightings that lack precise GPS locations, with accuracy of point locations often dependent on nearby landmarks; therefore, interpreting data should be limited to overall usage of an area rather than a specific location or habitat. Data from the CWCTP database was acquired following acceptance of the USFWS–Nebraska Ecological Services Whooping Crane Data Use Agreement (Appendix C).

2.1.3 USGS Biodiversity Information Serving Our Nation (BISON) Database

The USGS Biodiversity Information Serving Our Nation (BISON) is a web-based federal mapping database that provides location data for species occurrence (USGS 2021). Data are contributed by "US federal and state agencies, universities, and nonprofit organizations either directly to BISON or indirectly through their participation in the Global Biodiversity Information Facility," or GBIF (USGS 2021).

Table 2. The number of WHCR with active transmitters each year and the population estimates from surveys conducted by the USFWS during winter at Aransas NWR, Texas, (Butler and Harrell 2018; Butler et al. 2020).

Years with active satellite transmitters	WHCR with active satellite-transmitters	Winter population survey season	Population estimate during winter[a]	Percentage of marked WHCR within population[d]
2009	2	—	—	—
2010	11	—	—	—
2011	35	2011–2012	254[b]	14%
2012	51	2012–2013	257[b]	20%
2013	39	2013–2014	304[b]	13%
2014	41	2014–2015	308[b]	13%
2015	29	2015–2016	329[b]/463[c]	6%
2016	14	2016–2017	431[b]/489[c]	3%
2017	11	2017–2018	505[c]	2%
2018	4	2018–2019	504[c]	1%

[a] In 2011, the refuge began using the distance sampling method to estimate the population of WHCR within a survey area. This method includes flying along transect lines set at specific distances within the survey area. From these transect lines, biologists count the individuals within each group of WHCR and mark their GPS location. The data collected are used to determine the population within the surveyed area. The wintering grounds survey area included 140,000 ac on and around the Aransas NWR.

b Population estimates derived from early-winter surveys.

c Population estimates derived from late-winter surveys.

d Percentage of WHCR population calculated as those with active transmitters divided by the highest population estimate. Note, population surveys in 2011–2012 to 2014–2015 were only conducted in early-winter; therefore, estimates are lower than if late-winter surveys had been conducted.

While the USGS-BISON data set provides a significant level of additional observational data, these data are often obtained through citizen-science (for example, eBird); therefore, the potential for individual birds to be recorded by multiple observers (that is, double counting) is possible. WHCR observations range from historical records dating back to 1860 through 2018, with 12,871 observation points recorded in North America. A total of 6,174 WHCR observations occurred within the migration corridor for the Aransas–Wood Buffalo population.

2.1.4 USACE Geospatial Data

We obtained the USACE reservoir boundaries as an ArcGIS shapefile from the USACE Geospatial database (USACE 2022). We acquired two different migration corridors from USGS for analyses of WHCR stopover use at USACE reservoirs (Figure 2). The most extensive corridor includes the area encompassing all stopover locations collected during migration (hereafter, *overall migration corridor*) (Pearse et al. 2015). The second spatial layer (Pearse et al. 2018) provides percentiles that corresponded to 50% core (that is, area between 25th and 75th percentiles); 75% core (that is, area between 12.5th and 87.5th percentiles); and 95% core (that is, area between 2.5th and 97.5th percentiles) of data along the *x* dimension (that is, west–east). After estimating percentiles for each analysis window, USGS connected vertices together to form lines outlining western and eastern extents of the corridor. USGS converted these lines to a polygon that represented 50%, 75%, and 95% core migration corridors.

Figure 1. Map of 165,541 whooping crane (WHCR) locations (*yellow circles*) recorded during the 2009–2018 USGS tracking study, where 68 WHCR were fitted with leg-mounted transmitters that acquired locations via a GPS network. *Light blue shading* indicates the migration corridor, while *green shading* indicates the Woods Buffalo nesting grounds in the north and *solid dark blue* indicates the Aransas overwintering sites in the south.

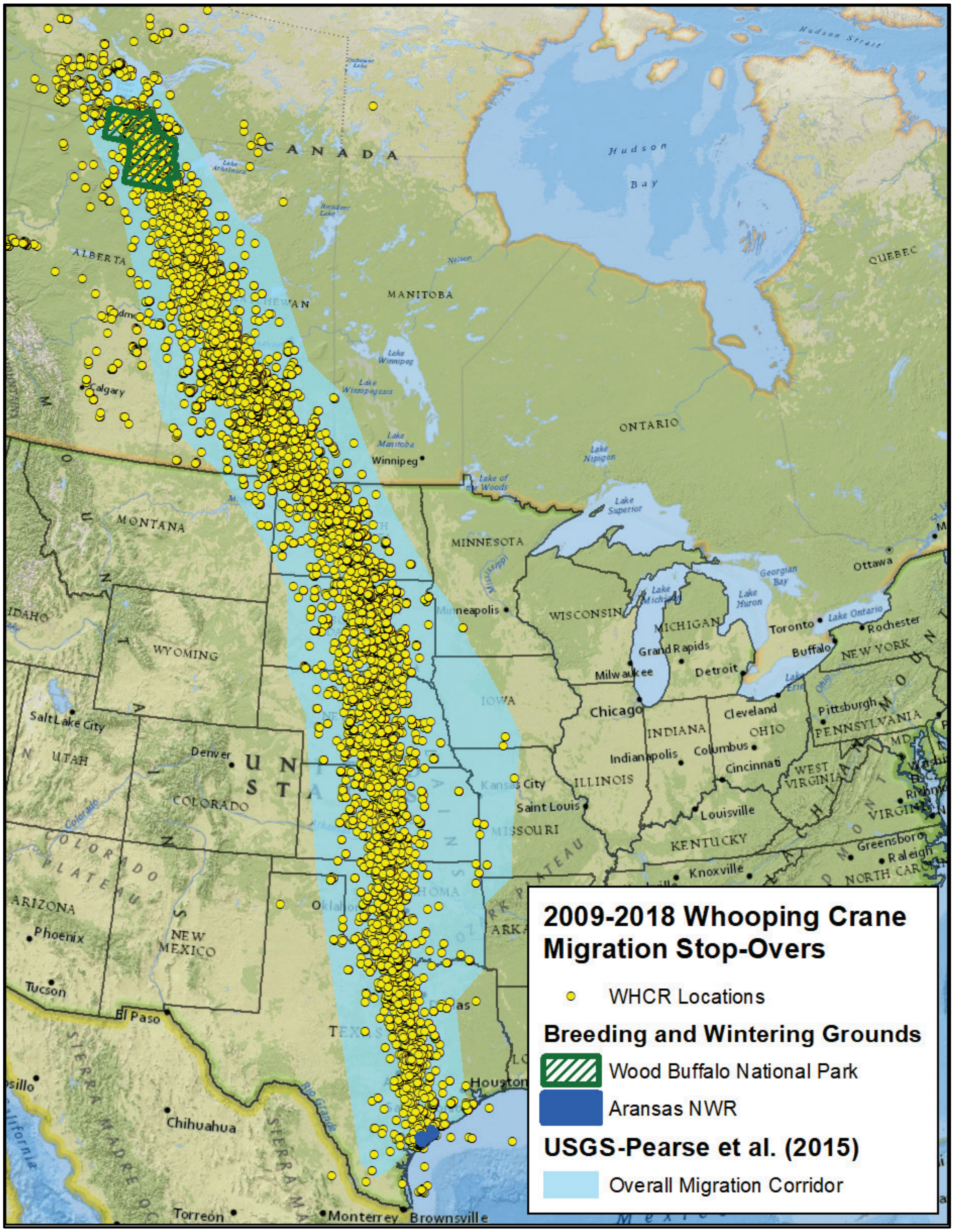
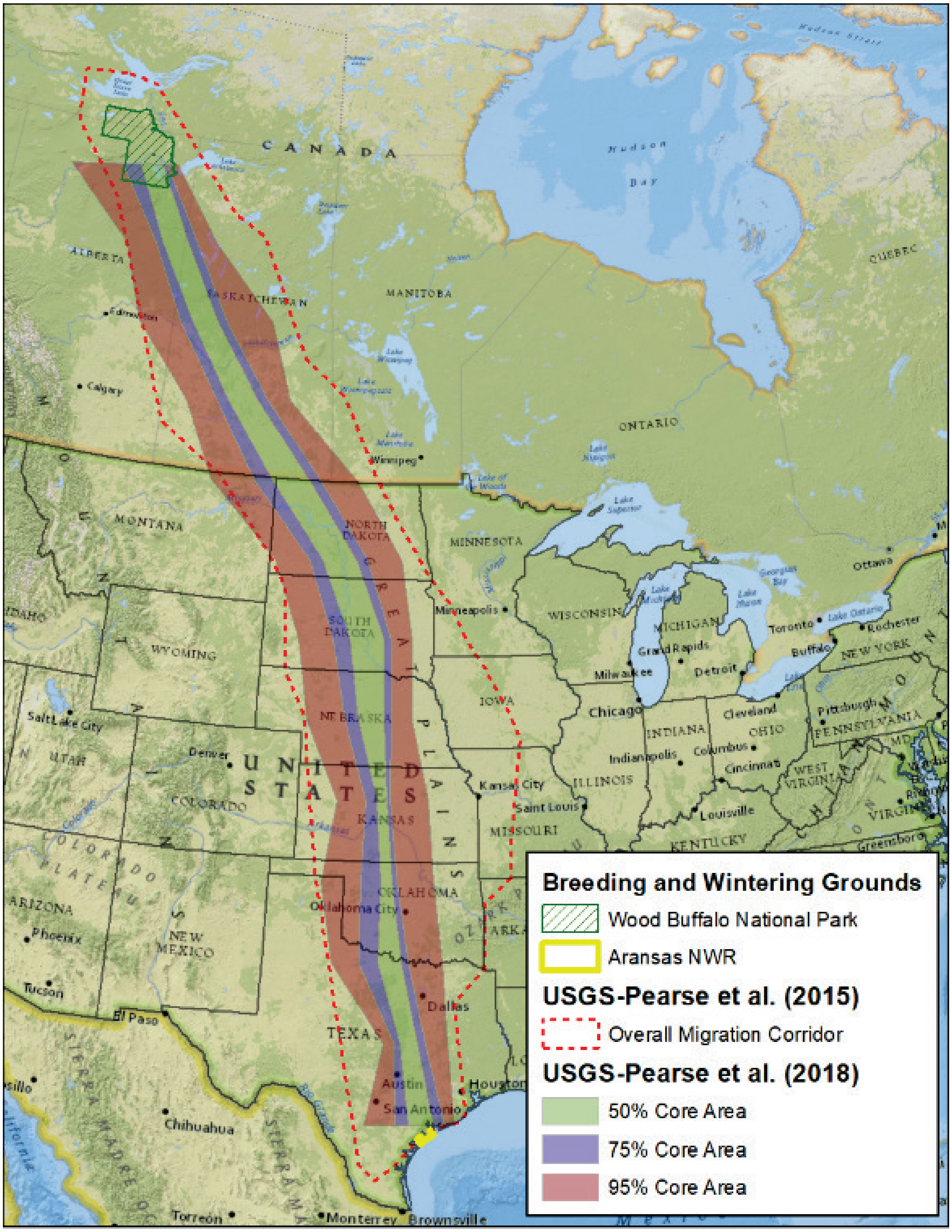


Figure 2. The spring and fall migration route between Wood Buffalo National Park and Aransas NWR for WHCRs according to the overall migration corridor and the 50%, 75%, and 95% core areas of the migration route.



2.2 Identification of USACE reservoirs within the WHCR flyway

We determined the maximum range for which to select USACE reservoirs for analyses by incorporating reservoirs located within the overall migration corridor determined by Pearse et al. (2015). We conducted a spatial join in ArcGIS 10.6 for the entire USGS satellite-tracking data set (Pearse et al. 2020), with the USACE reservoirs within the overall migration corridor according to distance. We considered use of USACE reservoirs by WHCR if they occurred within 1 mi (1.6 km) of USACE reservoir boundaries (Figure 3). We determined the percentage of reservoirs that served as stopover locations within the overall migration corridor as well as the 50%, 75%, and 95% core areas within the migration corridor as defined by USGS (2018).

We also compiled records of WHCR use at each reservoir from the USGS satellite-tracking, USFWS-CWCTP, and USGS-BISON databases. We determined a single stopover event from the USGS satellite database according to the arrival and departure date and time for each marked WHCR that occurred at a reservoir during the spring or fall migration each year. A summary of each stopover event included the unique identifier of the marked WHCR; the arrival and departure date and time; season (that is, spring, fall, or winter); number of stopover days and nights, and USACE reservoir. We summarized data from all stopover events for each reservoir and by season (fall or spring migration) according to the number of individual WHCR, total number of stopovers, total number of stopover days, total number of stopover nights, mean stopover days, mean stopover nights, the minimum number of days for a stopover, the maximum number of days for a stopover, and the observation range for which WHCR occurred at a reservoir. We also determined stopover events at reservoirs for the other two databases (USFWS-CWCTP and USGS-BISON); however, we did not calculate detailed information, because these records rely solely on incidental sightings. The CWCTP considered the location of each sighting (that is, stopover event) according to the first observation of the WHCR or WHCR group, even though in many cases the group was observed at multiple locations in the local area. The USGS-BISON data set consisted of the validated reports of data contributors from location records from multiple sources (for example, eBird or published literature). However, it is possible that multiple records within the database pertain to the same individual, because different observers likely report the same WHCR during a stopover event. We report all the individual records and locations provided within the USGS-BISON database for WHCR but urge caution when interpreting these results, because the likelihood of double counting is high. The locations of all records, including multiple observations for the same individual, we plotted on maps of each reservoir to visualize WHCR stopover locations.

Figure 3. The Aransas–Wood Buffalo WHCR migration corridor (*red dotted line*), with *white circles* representing stopover sites at USACE reservoirs by individual WHCRs tracked with satellite transmitters in the USGS telemetry study during 2009–2018.

3 Results

A total of 2,128 (1.3%) of 165,541 records of WHCR locations from the USGS satellite-tracking database were recorded within 1 mi (1.6 km) of the boundary of USACE reservoirs, and 1,800 (85%) of those 2,218 records occurred within reservoir project boundaries. A total of 326 (9.5%) of 3,433 records of WHCR locations from the USFWS-CWCTP database were recorded within 1 mi (1.6 km) of the boundary of USACE reservoirs, and 116 (36%) of those 326 records occurred within reservoir project boundaries. A total of 332 (5.4%) of 6,174 records of WHCR locations from the USGS-BISON tracking database that were associated with the Aransas–Wood Buffalo population were recorded within 1 mi (1.6 km) of the boundary of USACE reservoirs, and 141 (43%) of those 332 records occurred within reservoir project boundaries.

A total of 102 USACE reservoirs occur within the overall migration corridor, 39 (38%) of which are within the core areas for WHCR migration (Appendices A and B). WHCR observations occurred at 36 (35%) of the 102 reservoirs within the overall corridor, and at 28 (72%) of 39 reservoirs within the core areas from all three data sets (Table 8, Figure 4).

Stopover events from satellite-tagged WHCR were highest in Tulsa District (72 events at 7 reservoirs), followed by Omaha District (64 events at 5 reservoirs), Fort Worth District (57 events at 9 reservoirs), and Kansas City District (24 events at 5 reservoirs) (Table 9).

Stopover events from the USFWS-CWCTP database for WHCR were also highest in Tulsa District (207 events at 8 reservoirs), followed by Omaha District (89 events at 7 reservoirs), Fort Worth District (15 events at 8 reservoirs), and Kansas City District (15 events at 5 reservoirs) (Tables 5–7). Great Salt Plains Lake in Tulsa District and Lake Oahe in Omaha District contributed to over 83% of all stopover events during fall migration. Great Salt Plains Lake alone contributed approximately 60% of all stopover events within the CWCTP for USACE reservoirs. Stopover events reported to USGS-BISON also occurred mainly at Granger Lake during the winter (63% of records or 210 out of 332) and at Great Salt Plains Lake during fall migration (13% of records or 43 out of 332; Table 8).

According to the USGS satellite database, seven lakes (Sakakawea, Oahe, Francis Case, Wilson, Great Salt Plains, Waurika, and Whitney) had at least 10 stopover events from 2009 to 2018. Nine lakes (Sakakawea, Oahe, Francis Case, Lewis and Clark, Kanopolis, Great Salt Plains, Waurika, Whitney, and Granger) had at least 25 days in which WHCR stopped over. Seven lakes (Sakakawea, Oahe, Francis Case, Lewis and Clark, Kanopolis, Great Salt Plains, and Granger) also supported at least one stopover event by a WHCR lasting 10 or more nights (Table 9).

We selected one satellite-tagged WHCR (Individual D-31) as an example to highlight results of multiple stopovers at USACE reservoirs throughout the entire migration corridor. WHCR D-31 stopped over for three different years during the fall at Great Salt Plains and Kanopolis Lakes. WHCR D-31 also stopped during two spring migration seasons at Great Salt Plains Lake. In addition, D-31 had short stopovers at four other USACE reservoirs, for a total stopover use of six reservoirs (Table 9).

Figure 4. USACE reservoirs where WHCR were observed to stopover during spring or fall migration within the overall migration corridor with *green*, *purple*, and *red* shadings representing the 50%, 75%, and 95% core areas. *Top right inset*, central region in *yellow rectangle*; *bottom right inset*, southern region in *red square*.

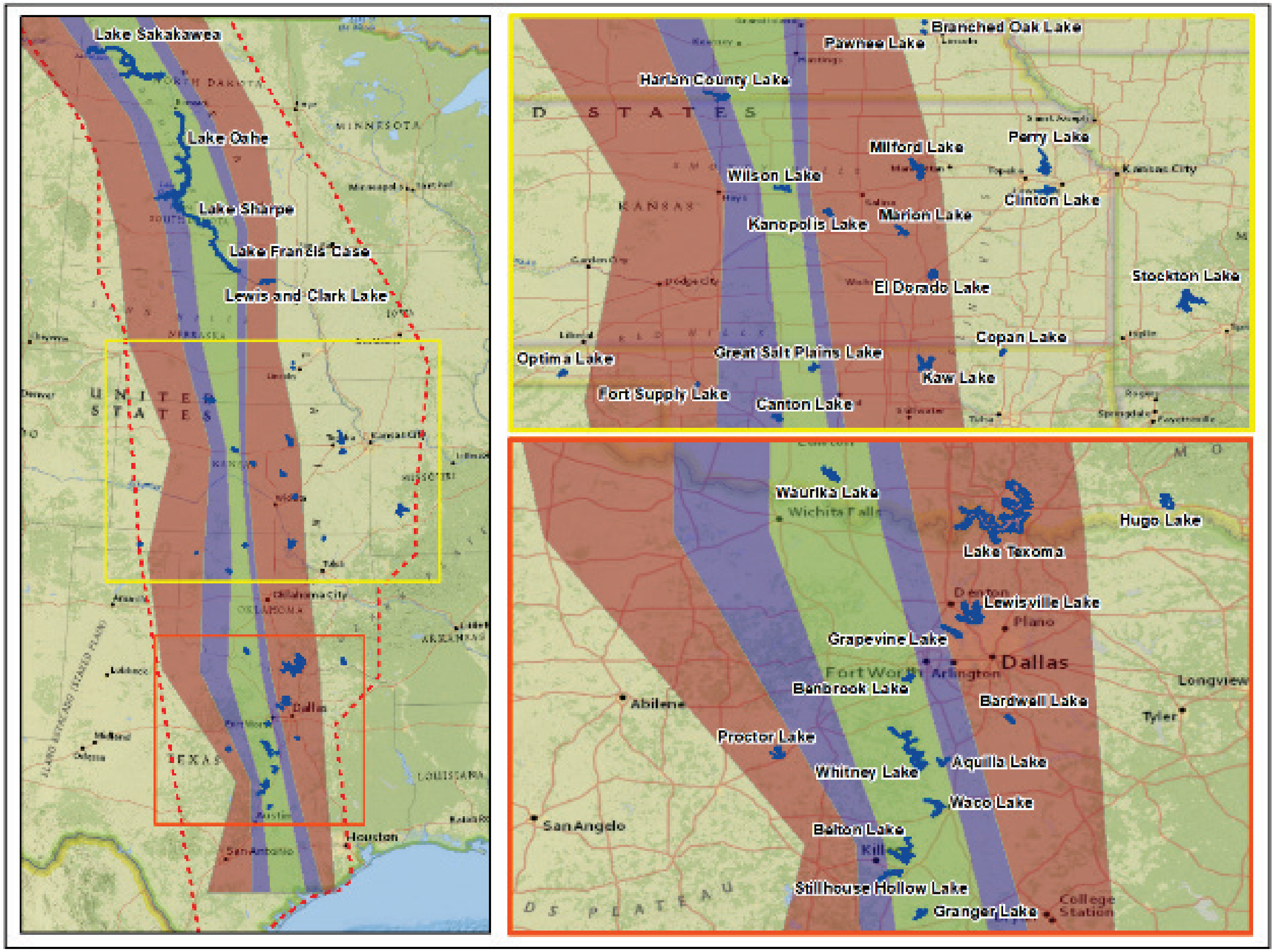


Table 3. USACE reservoirs with observed WHCR stopover events within the overall migration corridor and core areas between Wood Buffalo and Aransas NWR. (Numbers in parentheses indicate total reservoirs in specified area.)

Data set	Overall corridor (102)	50% core area (14)	75% core area (4)	95% core area (21)	Core areas combined (39)
USGS satellite	26 (25%)	14 (100%)	2 (50%)	8 (38%)	24 (62%)
USFWS-CWCTP	28 (27%)	12 (86%)	2 (50%)	8 (38%)	22 (56%)
USGS-BISON	14 (14%)	8 (57%)	1 (25%)	3 (14%)	12 (31%)
Combined	36 (35%)	14 (100%)	2 (50%)	12 (57%)	28 (72%)

Table 4. USACE reservoirs with observed stopover events by marked WHCRs within the migration corridor between Wood Buffalo and Aransas NWR during 2009–2018. Reservoirs are listed in geographical order from north to south.

Reservoir	District	Events	Days	Mean days	Maximum days	Minimum days	Nights	Mean nights	Maximum nights	Minimum nights
Sakakawea	Omaha	11	25	2.27	11	1	14	1.27	10	0
Oahe	Omaha	27	138	5.11	35	1	111	4.11	34	0
Sharpe	Omaha	2	4	2.00	2	2	2	1.00	1	1
Francis Case	Omaha	22	60	2.73	12	1	38	1.73	11	0
Lewis and Clark	Omaha	2	50	25.00	49	1	48	24.00	48	0
Harlan County	Kansas City	3	9	3.00	5	2	6	2.00	4	1
Perry	Kansas City	2	7	3.50	5	2	5	2.50	4	1
Milford	Kansas City	3	5	1.67	2	1	2	0.67	1	0
Wilson	Kansas City	11	16	1.45	2	1	5	0.45	1	0
Kanopolis	Kansas City	5	26	5.20	19	1	21	4.20	18	0
El Dorado	Tulsa	1	1	1.00	1	1	0	0.00	0	0
Kaw	Tulsa	1	1	1.00	1	1	0	0.00	0	0
Great Salt Plains	Tulsa	51	130	2.55	14	1	79	1.55	13	0
Canton	Tulsa	5	13	2.60	3	2	8	1.60	2	1
Waurika	Tulsa	12	30	2.50	4	1	18	1.50	3	0

Reservoir	District	Events	Days	Mean days	Maximum days	Minimum days	Nights	Mean nights	Maximum nights	Minimum nights
Texoma	Tulsa	1	1	1.00	1	1	0	0.00	0	0
Hugo	Tulsa	1	1	1.00	1	1	0	0.00	0	0
Grapevine	Fort Worth	1	2	2.00	2	2	1	1.00	1	1
Benbrook	Fort Worth	5	11	2.20	3	2	6	1.20	2	1
Whitney	Fort Worth	27	53	1.96	5	1	26	0.96	4	0
Proctor	Fort Worth	1	1	1.00	1	1	0	0.00	0	0
Aquilla	Fort Worth	1	2	2.00	2	2	1	1.00	1	1
Waco	Fort Worth	6	9	1.50	2	1	3	0.50	1	0
Belton	Fort Worth	7	12	1.71	2	1	5	0.71	1	0
Stillhouse Hollow	Fort Worth	2	4	2.00	2	2	2	1.00	1	1
Granger	Fort Worth	7	291	41.57	106	1	284	40.57	105	0
Total		217	902	4.16	106	1	685	3.16	105	0

Table 5. USFWS-CWCTP observations within 1 mi (1.6 km) of USACE reservoirs during fall migration, 1942–2019.

Reservoir	District	Stopover events	Adults observed	Juveniles observed	Total WHCR observed	Total days WHCR observed
Bardwell	Fort Worth	—	—	—	—	—
Belton	Fort Worth	2	6	3	9	2
Benbrook	Fort Worth	—	—	—	—	—
Branched Oak	Omaha	1	2	0	2	2
Canton	Tulsa	1	14	0	14	1
Clinton	Kansas City	—	—	—	—	—
Copan	Tulsa	—	—	—	—	—
Fort Supply	Tulsa	—	—	—	—	—
Granger	Fort Worth	1	2	1	3	1
Great Salt Plains	Tulsa	21	108	7	115	24
Harlan County	Kansas City	2	9	0	9	3
Francis Case	Omaha	5	16	0	16	7
Oahe	Omaha	19	56	2	58	49
Sakakawea	Omaha	4	7	0	7	5
Sharpe	Omaha	4	10	0	10	4
Texoma	Tulsa	—	—	—	—	—
Lewis and Clark	Omaha	—	—	—	—	—
Lewisville	Fort Worth	—	—	—	—	—
Marion	Tulsa	1	2	1	3	1
Milford	Kansas City	—	—	—	—	—
Optima	Tulsa	3	2	3	5	4
Pawnee	Omaha	1	3	0	3	1
Proctor	Fort Worth	—	—	—	—	—
Stockton	Kansas City	—	—	—	—	—
Waco	Fort Worth	—	—	—	—	—
Waurika	Tulsa	1	3	0	3	1
Whitney	Fort Worth	2	17	0	17	3
Wilson	Kansas City	1	1	0	1	1
Total		64	235	17	252	98

Table 6. USFWS-CWCTP observations within 1 mi (1.6 km) of USACE reservoirs during spring migration, 1942–2019.

Reservoir	District	Stopover events	Adults observed	Juveniles observed	Total WHCR observed	Total days WHCR observed
Bardwell	Fort Worth	1	4	0	4	5
Belton	Fort Worth	—	—	—	—	—
Benbrook	Fort Worth	2	3	0	3	3
Branched Oak	Omaha	1	4	1	5	1
Canton	Tulsa	—	—	—	—	—
Clinton	Kansas City	1	0	1	1	2
Copan	Tulsa	1	2	1	3	1
Fort Supply	Tulsa	2	3	1	4	2
Granger	Fort Worth	1	3	0	3	-
Great Salt Plains	Tulsa	173	741	93	833	283
Harlan County	Kansas City	3	5	1	6	4
Francis Case	Omaha	2	8	2	10	13
Oahe	Omaha	41	147	21	168	126
Sakakawea	Omaha	6	23	2	25	7
Sharpe	Omaha	4	18	0	18	4
Texoma	Tulsa	2	4	0	4	3
Lewis and Clark	Omaha	1	2	0	2	1
Lewisville	Fort Worth	1	2	0	2	2
Marion	Tulsa	1	2	0	2	1
Milford	Kansas City	2	5	0	5	7
Optima	Tulsa	—	—	—	—	—
Pawnee	Omaha	—	—	—	—	—
Proctor	Fort Worth	1	1	0	1	1
Stockton	Kansas City	1	1	0	1	1
Waco	Fort Worth	3	27	0	27	3
Waurika	Tulsa	1	0	1	1	11
Whitney	Fort Worth	—	—	—	—	—
Wilson	Kansas City	5	23	3	26	7
Total		256	1028	127	1154	488

Table 7. USFWS-CWCTP observations within 1 mi (1.6 km) of USACE reservoirs during spring and fall migration, 1942–2019.

Reservoir	District	Stopover events	Adults observed	Juveniles observed	Total WHCR observed	Total days WHCR observed
Bardwell	Fort Worth	1	4	0	4	5
Belton	Fort Worth	2	6	3	9	2
Benbrook	Fort Worth	2	3	0	3	3
Branched Oak	Omaha	2	6	1	7	3
Canton	Tulsa	1	14	0	14	1
Clinton	Kansas City	1	0	1	1	2
Copan	Tulsa	1	2	1	3	1
Fort Supply	Tulsa	2	3	1	4	2
Granger	Fort Worth	3	7	2	9	-
Great Salt Plains	Tulsa	194	849	100	948	307
Harlan County	Kansas City	5	14	1	15	7
Francis Case	Omaha	7	24	2	26	20
Oahe	Omaha	60	203	23	226	175
Sakakawea	Omaha	10	30	2	32	12
Sharpe	Omaha	8	28	0	28	8
Lake Texoma	Tulsa	2	4	0	4	3
Lewis and Clark	Omaha	1	2	0	2	1
Lewisville	Fort Worth	1	2	0	2	2
Marion	Tulsa	2	4	1	5	2
Milford	Kansas City	2	5	0	5	7
Optima	Tulsa	3	2	3	5	4
Pawnee	Omaha	1	3	0	3	1
Proctor	Fort Worth	1	1	0	1	1
Stockton	Kansas City	1	1	0	1	1
Waco	Fort Worth	3	27	0	27	3
Waurika	Tulsa	2	3	1	4	12
Whitney	Fort Worth	2	17	0	17	3
Wilson	Kansas City	6	24	3	27	8
Total		326	1288	145	1432	597

Table 8. USGS-BISON observations within 1 mi (1.6 km) of USACE reservoirs during the fall, spring, and winter seasons, 1974–2016.

Reservoir	District	Fall	Spring	Winter	All seasons
Belton	Fort Worth	—	2	—	2
Benbrook	Fort Worth	3	—	—	3
Granger	Fort Worth	5	23	210	238
Great Salt Plains	Tulsa	43	2	1	46
Harlan County	Kansas City	—	1	—	1
Oahe	Omaha	1	—	—	1
Texoma	Tulsa	8	—	6	14
Lewisville	Fort Worth	—	—	—	2
Milford	Kansas City	1	—	13	14
Pawnee	Omaha	—	1	—	1
Stillhouse Hollow	Fort Worth	2	—	—	2
Stockton	Kansas City	1	—	—	1
Waco	Fort Worth	1	—	—	1
Wilson	Kansas City	6	—	—	6
Total		71	29	230	332

Table 9. Example of stopover locations at USACE reservoirs by a satellite-tagged WHCR (D-31) during its spring and fall migrations.

Reservoir	Season	Days	Nights	Stopovers, multiple years	Mean days	Mean nights
Grapevine	Spring	2	1	1	2	1
Great Salt Plains	Fall	6	3	3	2	1
Great Salt Plains	Spring	4	2	2	2	1
Kanopolis	Fall	22	19	3	7.3	6.3
Kanopolis	Spring	2	1	1	2	1
Oahe	Fall	5	4	1	5	4
Milford	Spring	2	1	1	2	1
Waco	Spring	2	1	1	2	1
Total		45	32	13	3.46	2.46

4 Discussion

USACE reservoirs provide valuable stopover habitat to WHCR, and the extent to which USACE reservoirs are used as stopover habitat during migration is much greater than was previously known. Significant stopover use was observed during both spring and fall migration, and one reservoir, Granger Lake in Texas, served as a wintering location in multiple years.

The series of reservoirs along the Missouri River in North and South Dakota appear to be important stopover locations for WHCR both to and from the breeding grounds in Canada. The Missouri River flows through much of both North and South Dakota and within the core of the migration corridor, making USACE reservoirs on that river very important stopover sites for WHCR.

Great Salt Plains Lake may serve as the most important of all USACE reservoirs as stopover habitat for WHCR—especially during fall migration. Located in northern Oklahoma, Great Salt Plains Lake provides excellent roosting habitat along its northern and western sections, where shallow areas are abundant. Over half of marked WHCR population (35 individual WHCR) from the USGS satellite-tracking study stopped at Great Salt Plains Lake, collectively spending 130 days at the reservoir from 2009 to 2018. Data from USFWS-CWCTP and USGS-BISON also show similar results for the reservoir's importance within the migration corridor. The reservoir's location within the corridor, along with its suitable habitat, may be a key WHCR migration stepping-stone as birds depart the Platte River region of Nebraska and fly south towards Aransas NWR.

Granger Lake served as a wintering location in some years, a significant observation given that WHCR typically only wintered in and around Aransas NWR prior to 2011. Unusual wintering distribution of WHCR during winter 2011–2012 at Granger Lake was possibly due to extreme drought and record high temperatures in the southern and central United States (Wright et al. 2014). Three satellite-tagged WHCR that were part of the USGS tracking study wintered at Granger Lake from 2011 to 2014, and according to other incidental sightings from the CWCTP and BISON databases, additional WHCR also overwintered for a least part of the season at Granger. The three satellite-tagged WHCR spent 283 nights at Granger Lake over three winter seasons (November 2011–March 2014). Additional monitoring to document the use of Granger Lake as a wintering ground for

WHCR should be established. An assessment of habitat and water levels at Granger Lake should also be conducted, including determining which management actions could further improve roosting conditions.

All USACE reservoirs within the 50% core area of the migration corridor should be examined further to determine which management opportunities are available to better promote stopover habitat for WHCR. This study shows the importance of maintaining habitat within this narrow corridor, as every USACE reservoir within the 50% core area was observed as a stopover location for WHCR. The most frequented reservoirs within this core zone included the four northern reservoirs along the Missouri River (Lake Sakakawea, Lake Oahe, Lake Sharpe, and Lake Francis Case) as well as Wilson Lake, Great Salt Plains Lake, Waurika Lake, and Whitney Lake.

While most stopovers may occur at different locations over several seasons (Pearse et al. 2020), the case with WHCR D-31 clearly shows that some individuals may choose to stop over at the same locations year after year if conditions are favorable. More research will refine our understanding of when and where WHCR stopover occurs on USACE reservoir projects.

Two records from USGS-BISON are for a group of WHCR at Lewisville Lake, Texas, in July; however, further investigation into these records determined that seven WHCR from the Louisiana WHCR population contributed to sightings at both Lewisville Lake and Lake Ray Hubbard (Harrell and Bidwell 2013). The certainty of which birds are from Louisiana or the Aransas–Wood Buffalo population of WHCR at some USACE reservoirs on the eastern edge of the migration corridor in Texas is unknown for the USFWS-CWCTP and USGS-BISON databases.

While the satellite-tagging data represent a significant portion of the entire wild population of WHCR, the vast majority of migrating WHCR in any given year are not tracked. Therefore, use of USACE reservoirs is likely much higher than what is documented in this report. The USFWS-CWCTP and USGS-BISON databases supplement that assumption, but numbers in tables and figures still underrepresent total use. Eight reservoirs were documented to be stopover sites from either the USFWS-CWCTP or USGS-BISON but did not encounter stopovers by WHCR with transmitters.

5 Future Management Goals and Objectives

WHCR migration monitoring should continue at USACE reservoirs, and all reservoirs with significant stopover use by WHCR should develop a management plan if one is not currently in place. We also recommend investigating habitat management that includes potential pool-level modifications during spring and fall to optimize stopover habitat conditions. Coordination between USACE, FOTWW, USFWS, USGS, other state and federal agencies, and nongovernmental organizations on conservation efforts facilitated by a workshop or other similar effort would likely result in positive benefits to all. Finally, USACE managers, together with FOTWW, should continue efforts to evaluate conditions at USACE reservoirs and work towards developing a range-wide Section 7(a)(1) plan for the Aransas–Wood Buffalo population of WHCR.

We recommend collecting the following data at sites managed for WHCR stopover habitat:

1. Accurately record footprint of each stopover site to be managed. We recommend digitizing area for recording in a spatial format (for example, shapefiles or geodatabase) for use within a geographic information system, or GIS.
2. Prior to habitat manipulation, collect high-quality digital photos of site for documentation. Record the dominate vegetation types (for example, shrubs, trees, cattail) prior to habitat manipulation and a coverage estimate of each vegetation type (for example, 0.5 ac of shrub-scrub)
3. Collect photos of site following habitat management and provide an updated description of site, including forms of management (for example, physical removal of shrubs, herbicide, prescribed burning)
4. Monitor site on an annual basis and document changes.
5. Repeat habitat management as necessary to maintain area with clear sight lines for roosting WHCR.

Habitat data collected pre- and postmanagement at stopover sites will be combined with the existing 2009–2018 USGS WHCR tracking telemetry database occurrences at stopover locations and compared to stopover usage at sites following habitat management with future telemetry studies already initiated by USGS and partners. In addition to habitat manipulation at stopover sites, USACE intends to monitor reservoir water levels to determine optimal conditions for stopover by WHCR and provide management recommendations for raising or lowering lake levels according to what is feasible during the spring or fall migration period.

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Appendix A: Summary of WHCR Use at Individual USACE Reservoirs (Arranged from North to South in Migration Corridor)

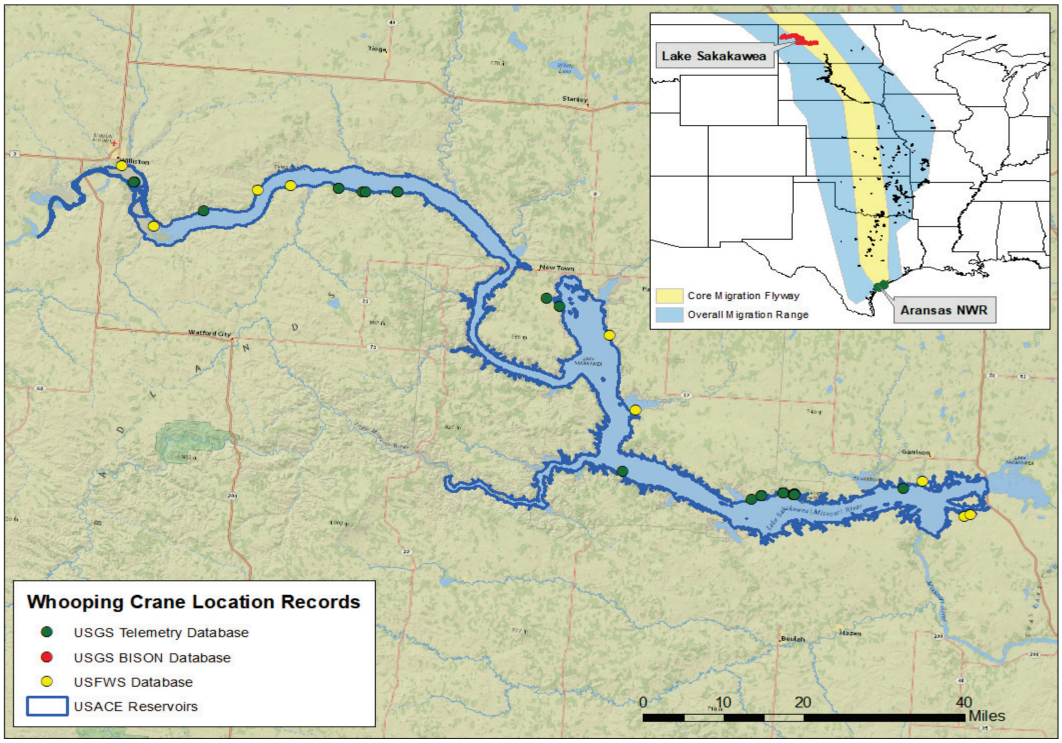
A.1 Lake Sakakawea

Lake Sakakawea is the northernmost USACE reservoir within the WHCR flyway and serves as an important stopover site. A total of 21 stopover events have been documented between data sets provided by the USGS telemetry database (11 records), USGS-BISON portal (0 records), and USFWS database (10 records).

Table A-1. Stopovers by satellite-tagged WHCRs at Lake Sakakawea, North Dakota, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	4	6	8
Total	4	7	11
Total days	5	20	25
Total nights	1	13	14
Mean days	1.25	2.86	2.27
Mean nights	0.25	1.86	1.27
Minimum days	1	1	1
Maximum days	2	11	11
Observation range	4 April–19 May	16 October–6 November	—

Figure A-1. General locations of WHCRs at Lake Sakakawea, North Dakota, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



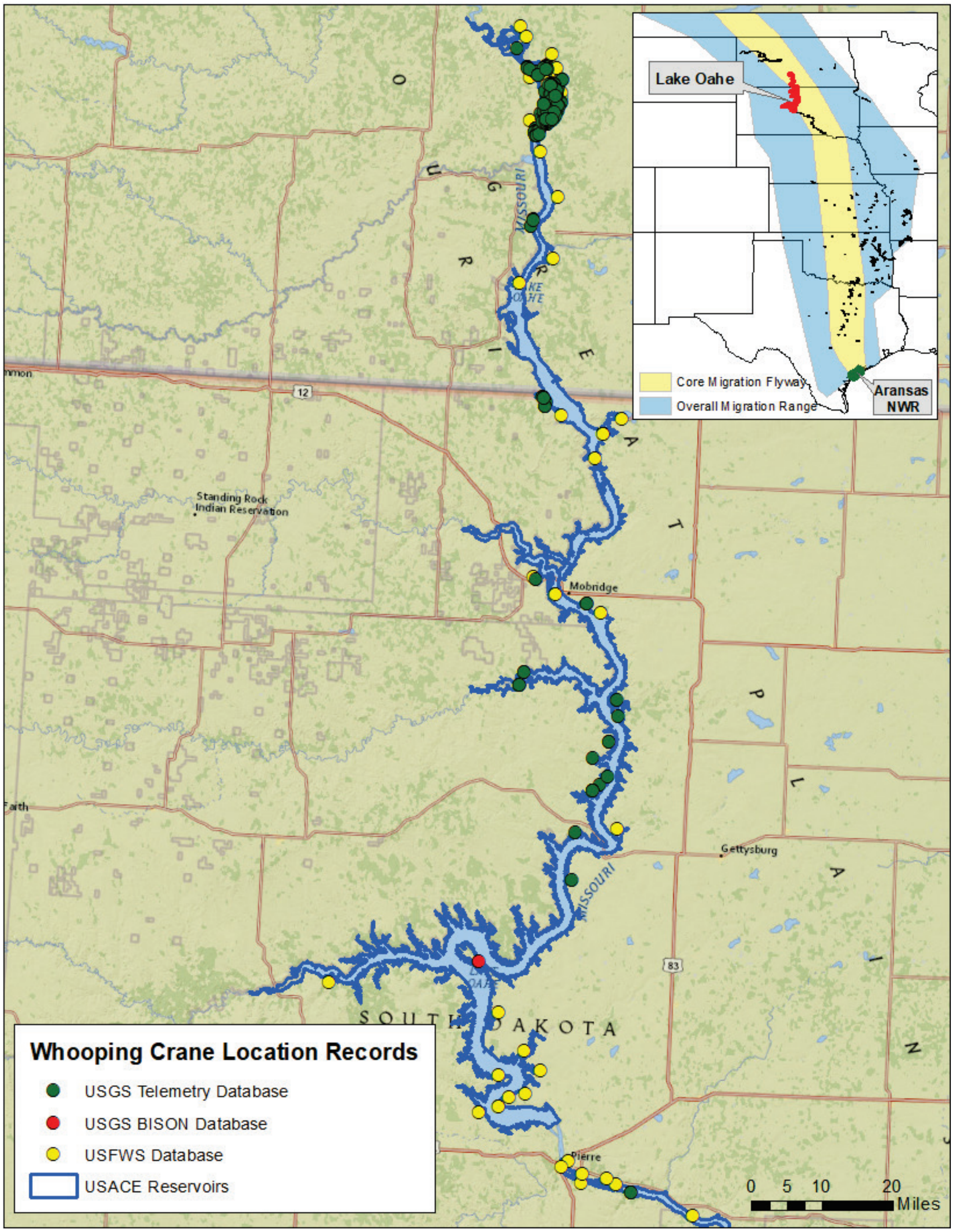
A.2 Lake Oahe

Lake Oahe is directly south of Lake Sakakawea and serves as an important stopover site. A total of 88 stopover events have been documented between data sets provided by the USGS telemetry database (27 records), USGS-BISON portal (1 record), and USFWS database (60 records).

Table A-2. Stopovers by satellite-tagged WHCRs at Lake Oahe, North Dakota, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	7	15	19
Total	9	18	27
Total days	51	87	138
Total nights	42	69	111
Mean days	5.67	4.83	5.11
Mean nights	4.67	3.83	4.11
Minimum days	1	1	1
Maximum days	23	35	35
Observation range	27 March–17 May	12 October–22 November	—

Figure A-2. General locations of WHCRs at Lake Oahe, North Dakota, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



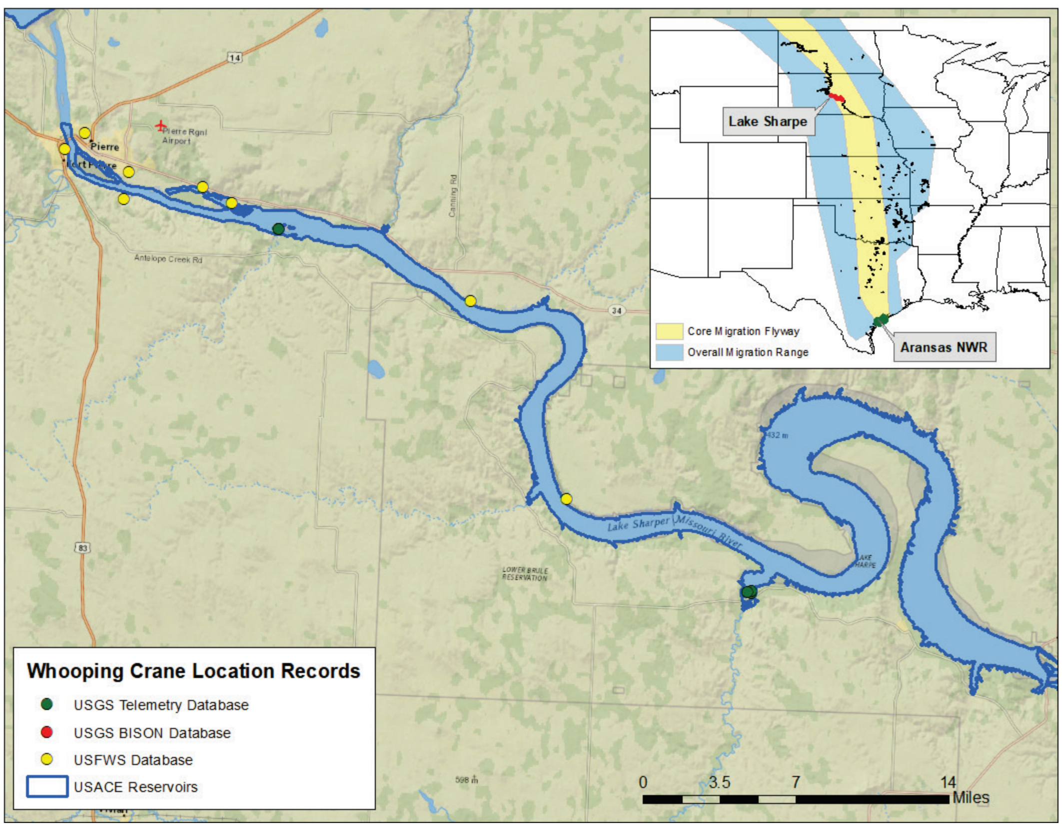
A.3 Lake Sharpe

Lake Sharpe is located within the northern section of the migration corridor and serves as an important stopover location on occasion for WHCRs. A total of 10 stopover events have been documented between data sets provided by the USGS telemetry database (2 records), USGS-BISON portal (0 records), and USFWS database (8 records).

Table A-3. Stopovers by satellite-tagged WHCRs at Lake Sharpe, South Dakota, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	1	1	1
Total	1	1	2
Total days	2	2	4
Total nights	1	1	2
Mean days	2.0	2.0	2.0
Mean nights	1.0	1.0	1.0
Minimum days	2	2	2
Maximum days	2	2	2
Observation range	10–11 May	4–5 November	—

Figure A-3. General locations of WHCRs at Lake Sharpe, South Dakota, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



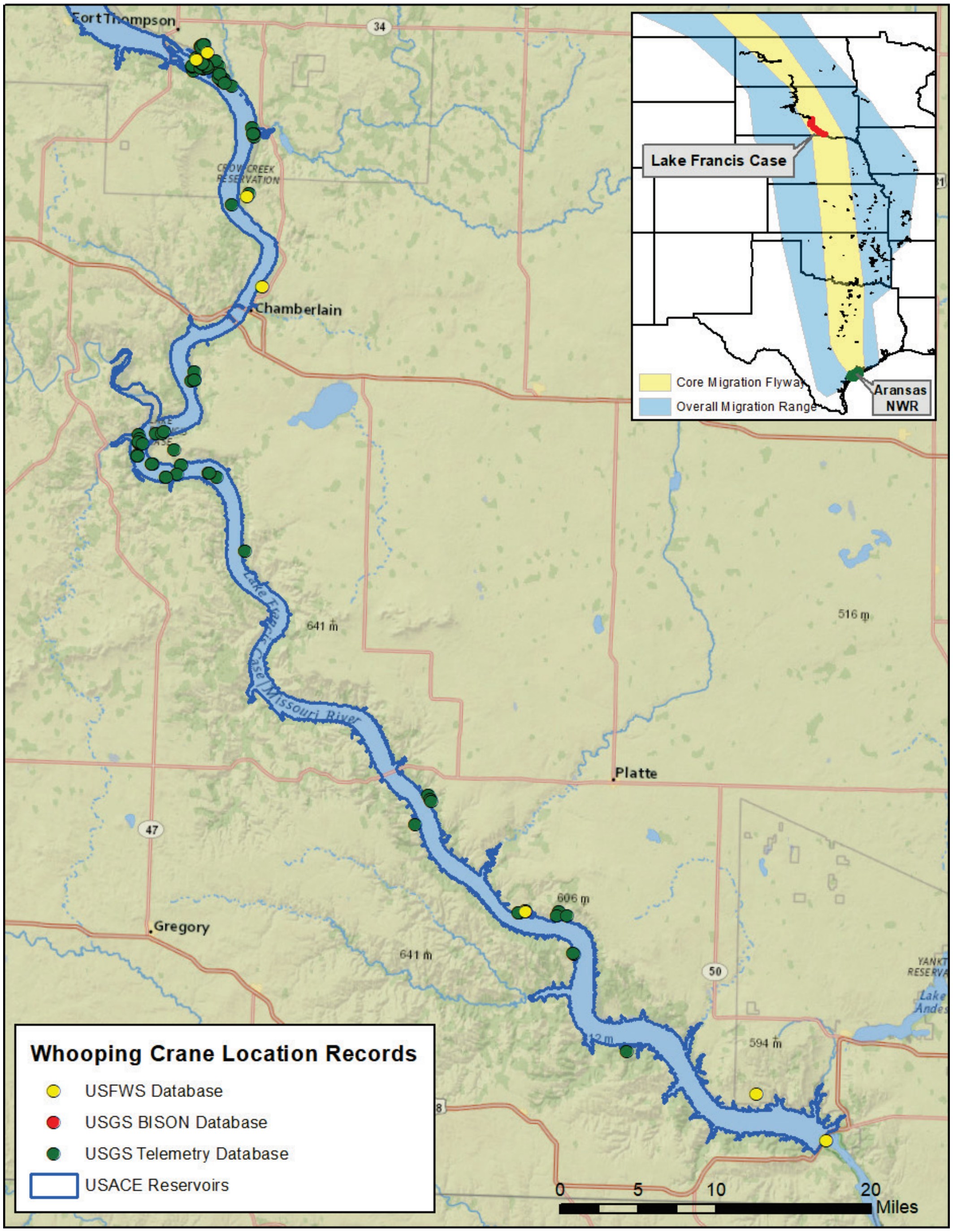
A.4 Lake Francis Case

Lake Francis Case is located within the northern section of the migration corridor along the Missouri River and serves as an important stopover location for WHCR in most years. A total of 29 stopover events have been documented between data sets provided by the USGS telemetry database (22 records), USGS-BISON portal (0 records), and USFWS database (7 records).

Table A-4. Stopovers by satellite-tagged WHCRs at Lake Francis Case, South Dakota, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	10	10	18
Total	12	10	22
Total days	23	37	60
Total nights	11	27	38
Mean days	1.9	3.7	2.7
Mean nights	0.9	2.7	1.7
Minimum days	1	1	1
Maximum days	7	12	12
Observation range	30 March–22 April	12 October–22 November	—

Figure A-4. General locations of WHCRs at Lake Francis Case, South Dakota, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



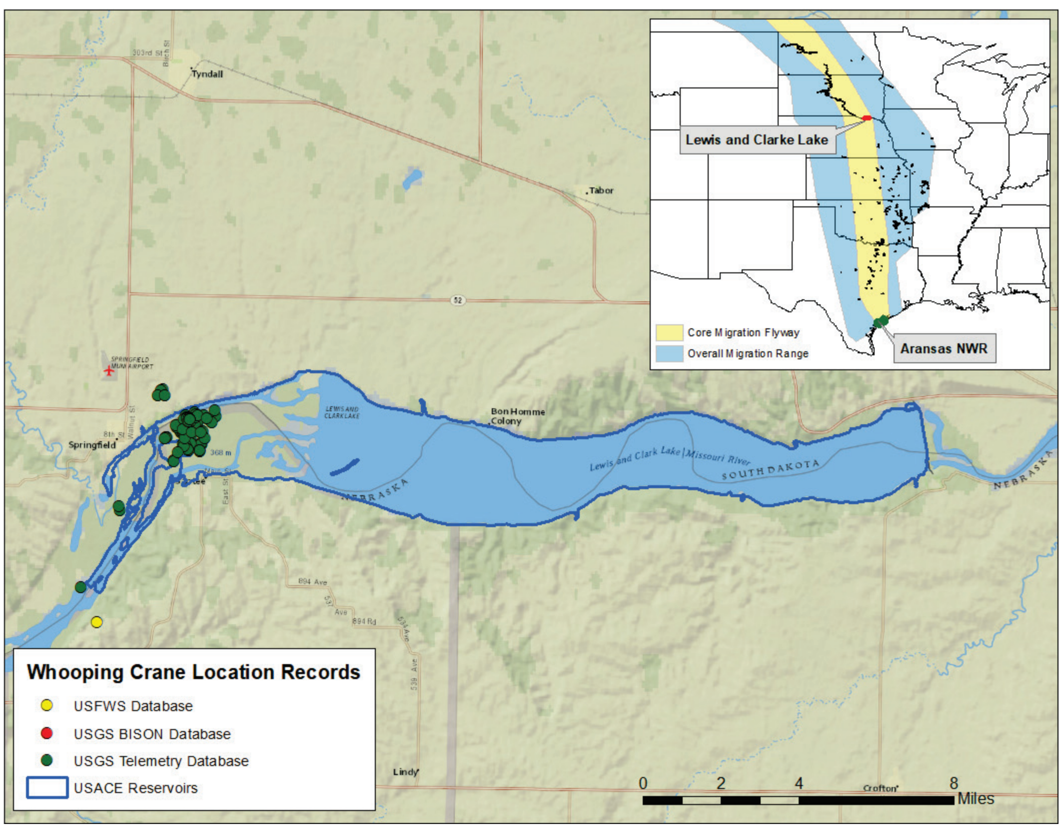
A.5 Lewis and Clark Lake

Lewis and Clark Lake is located on the Missouri River near the border of South Dakota and Nebraska within the core section of the migration corridor. Lewis and Clark Lake has served as a stopover location for WHCRs along the westernmost section of the reservoir. A total of 3 stopover events have been documented between data sets provided by the USGS telemetry database (2 records), USGS-BISON portal (0 records), and USFWS database (1 record).

Table A-5. Stopovers by satellite-tagged WHCRs at Lewis and Clark Lake along the border of South Dakota and Nebraska during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	1	1	2
Total	1	1	2
Total days	49	1	50
Total nights	48	0	48
Mean days	49.0	1.0	25.0
Mean nights	48.0	0.0	24.0
Minimum days	49	1	1
Maximum days	49	1	49
Observation range	16 March–3 May	19 November	—

Figure A-5. General locations of WHCRs at Lewis and Clark Lake along the border of South Dakota and Nebraska according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



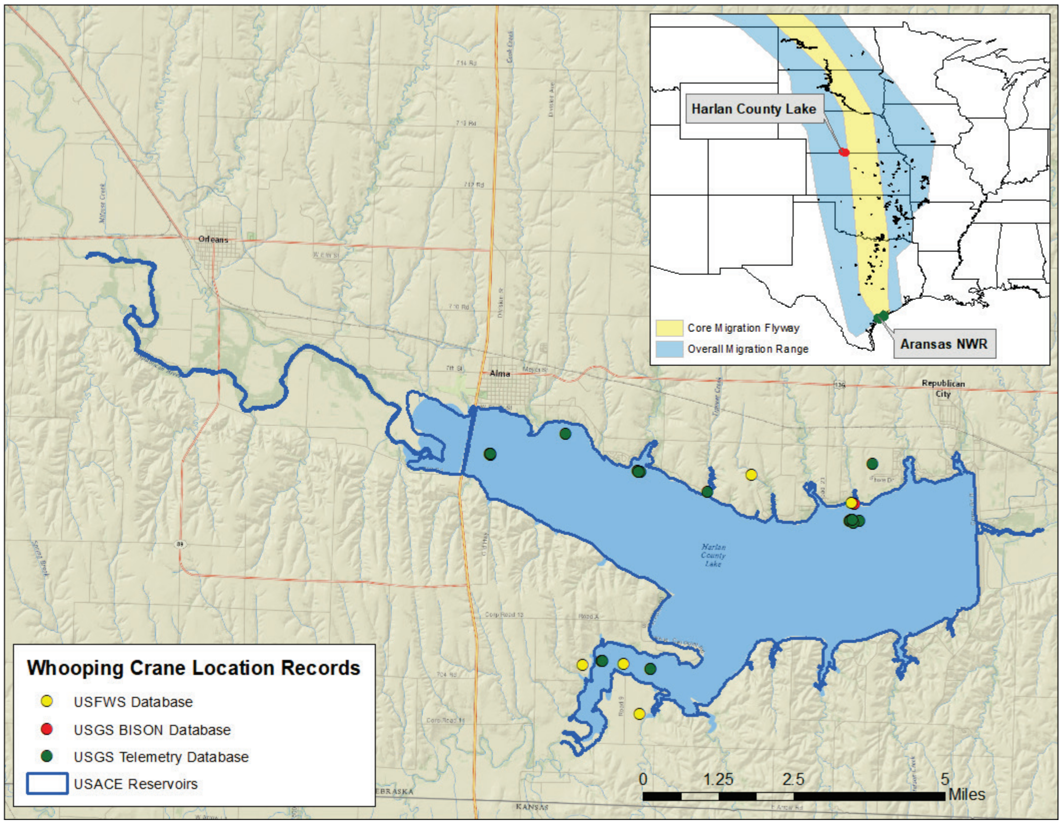
A.6 Harlan County Lake

Harlan County Lake is located along the border of Nebraska and Kansas. Harlan County Lake has received multiple stopover events by WHCR. A total of 9 stopover events have been documented between data sets provided by the USGS telemetry database (3 records), USGS-BISON portal (1 record), and USFWS database (5 records).

Table A-6. Stopovers by satellite-tagged WHCRs at Harlan County Lake along the border of Nebraska and Kansas during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	1	2	3
Total	1	2	3
Total days	5	4	9
Total nights	4	2	6
Mean days	5.0	2.0	3.0
Mean nights	4.0	1.0	2.0
Minimum days	5	2	2
Maximum days	5	2	5
Observation range	9–13 April	3–8 November	—

Figure A-6. General locations of WHCRs at Harlan County Lake along border of Kansas and Nebraska according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



A.7 Perry Lake

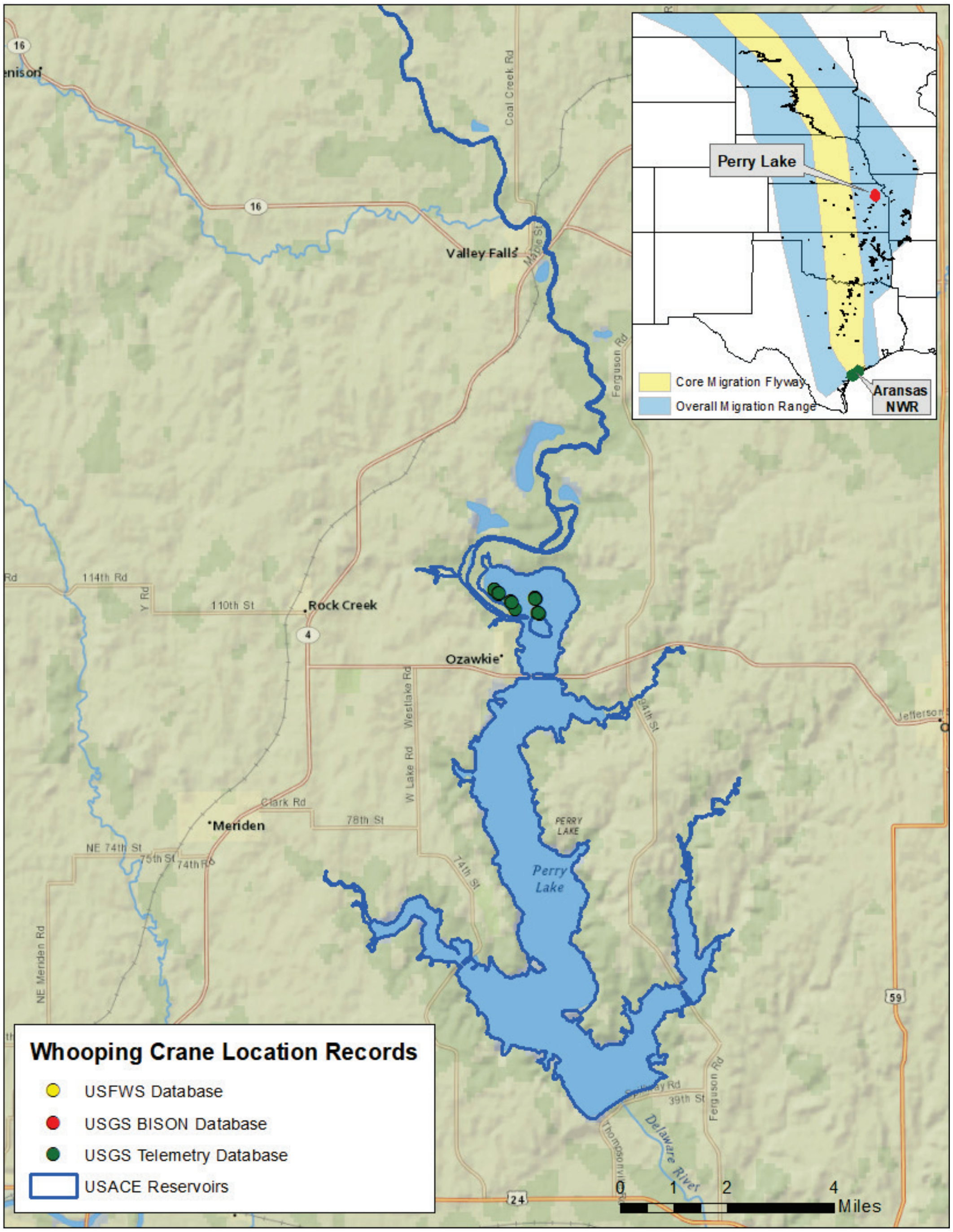
Perry Lake is located within the central section of the migration corridor and appears to serve as a minor stopover location for WHCRs during the fall. A total of 2 stopover events have been documented between data sets provided by the USGS telemetry database (2 records), USGS-BISON portal (0 records), and USFWS database (0 records).

Table A-7. Stopovers by satellite-tagged WHCRs at Perry Lake, Kansas, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	—	2	2
Total	—	2	2
Total days	—	7	7
Total nights	—	5	5
Mean days	—	3.5	3.5
Mean nights	—	2.5	2.5
Minimum days	—	2	2
Maximum days	—	5	5

Stopovers	Spring	Fall	All seasons
Observation range	—	7–17 November	—

Figure A-7. General locations of WHCRs at Perry Lake, Kansas, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



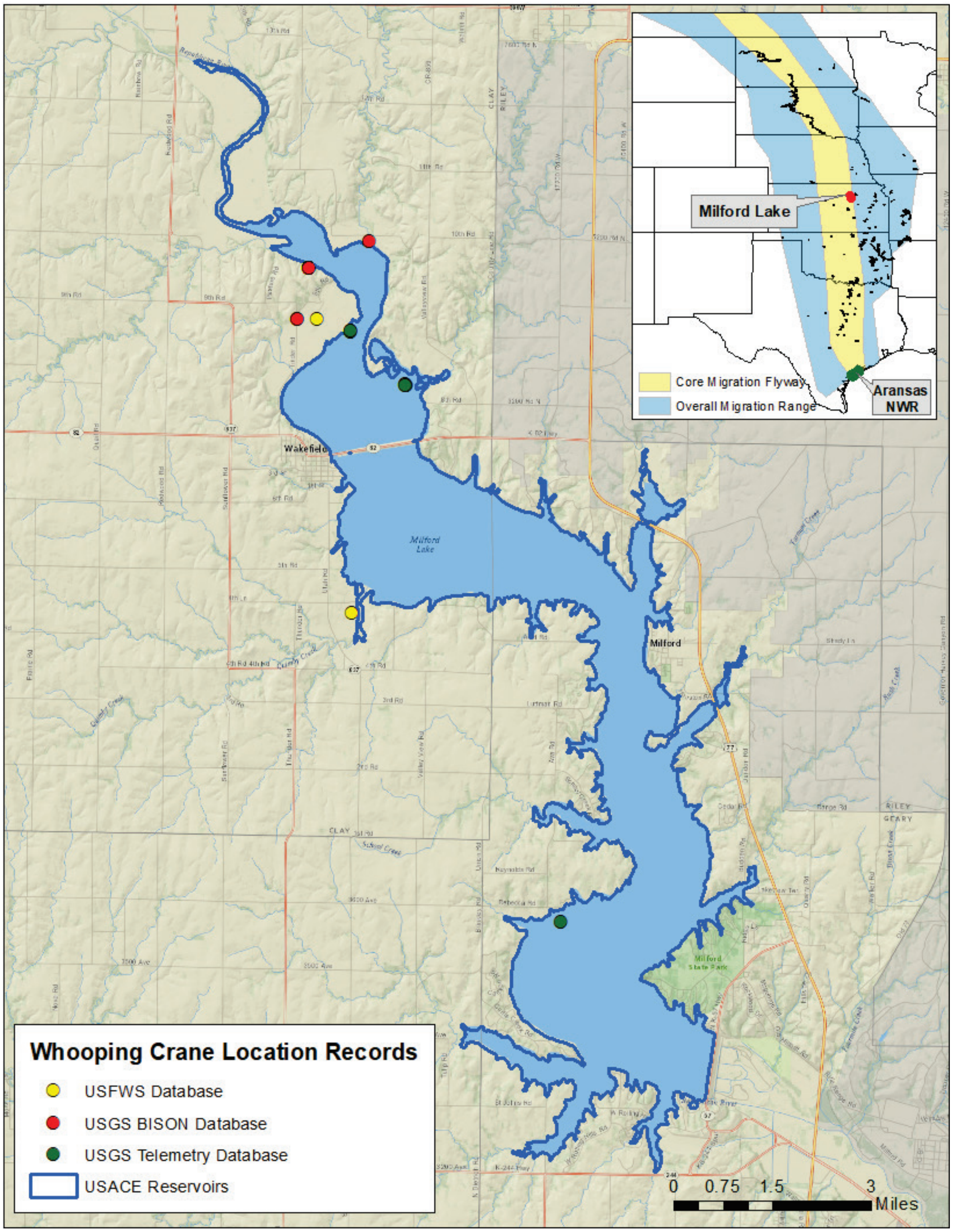
A.8 Milford Lake

Milford Lake is located within the central section of the migration corridor and serves as an occasional stopover location for WHCRs. A total of 10 stopover events have been documented between data sets provided by the USGS telemetry database (3 records), USGS-BISON portal (5 records), and USFWS database (2 records).

Table A-8. Stopovers by satellite-tagged WHCRs at Milford Lake, Kansas, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	1	2	3
Total	1	2	3
Total days	2	3	5
Total nights	1	1	2
Mean days	2.0	1.5	1.7
Mean nights	1.0	0.5	0.7
Minimum days	2	1	1
Maximum days	2	2	2
Observation range	21–22 April	5–13 November	—

Figure A-8. General locations of WHCRs at Milford Lake, Kansas, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



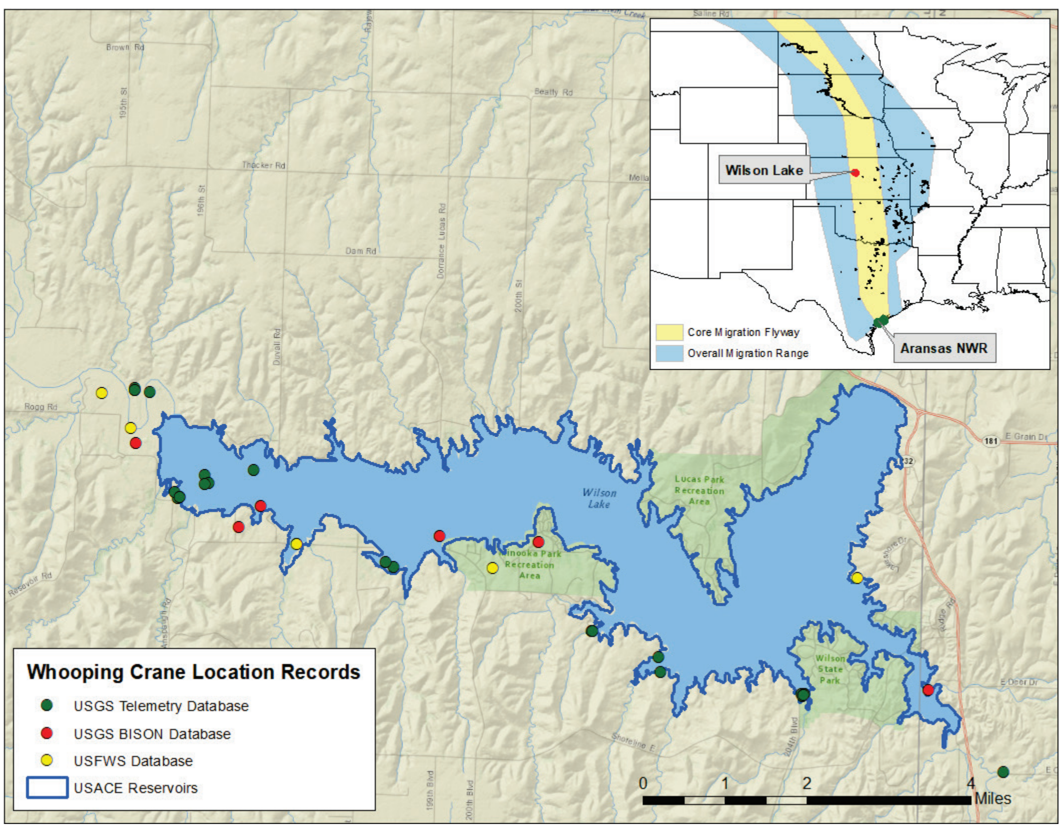
A.9 Wilson Lake

Wilson Lake is located within the central section of the migration corridor and serves as an important stopover location for WHCRs during fall migration. A total of 21 stopover events have been documented between data sets provided by the USGS telemetry database (11 records), USGS-BISON portal (4 records), and USFWS database (6 records).

Table A-9. Stopovers by satellite-tagged WHCRs at Wilson Lake, Kansas, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	1	10	11
Total	1	10	11
Total days	1	15	16
Total nights	0	5	5
Mean days	1.0	1.5	1.5
Mean nights	0.0	0.5	0.5
Minimum days	1	1	1
Maximum days	1	2	2
Observation range	16 March	18 October–15 November	—

Figure A-9. General locations of WHCRs at Wilson Lake, Kansas, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



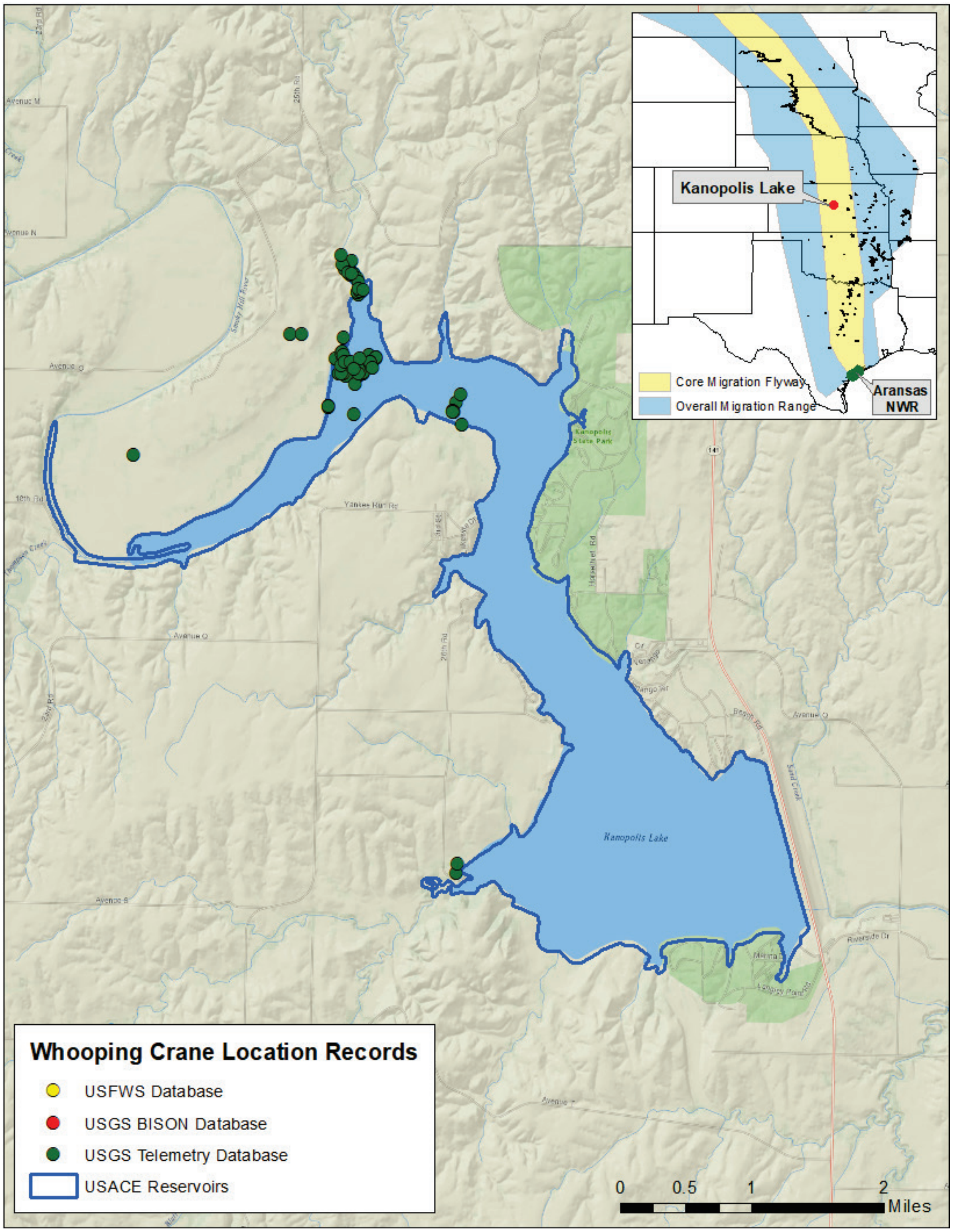
A.10 Kanopolis Lake

Kanopolis Lake is located within the core of the migration corridor and serves as an occasional stopover location for WHCRs. A total of 5 stopover events have been documented between data sets provided by the USGS telemetry database (5 records), USGS-BISON portal (0 records), and USFWS database (0 records).

Table A-10. Stopovers by satellite-tagged WHCRs at Kanopolis Lake, Kansas, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	2	1	2
Total	2	3	5
Total days	4	22	26
Total nights	2	19	21
Mean days	2.0	7.3	5.2
Mean nights	1.0	6.3	4.2
Minimum days	2	1	1
Maximum days	2	19	19
Observation range	31 March–9 April	10 November–6 December	—

Figure A-10. General locations of WHCRs at Kanopolis Lake, Kansas, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



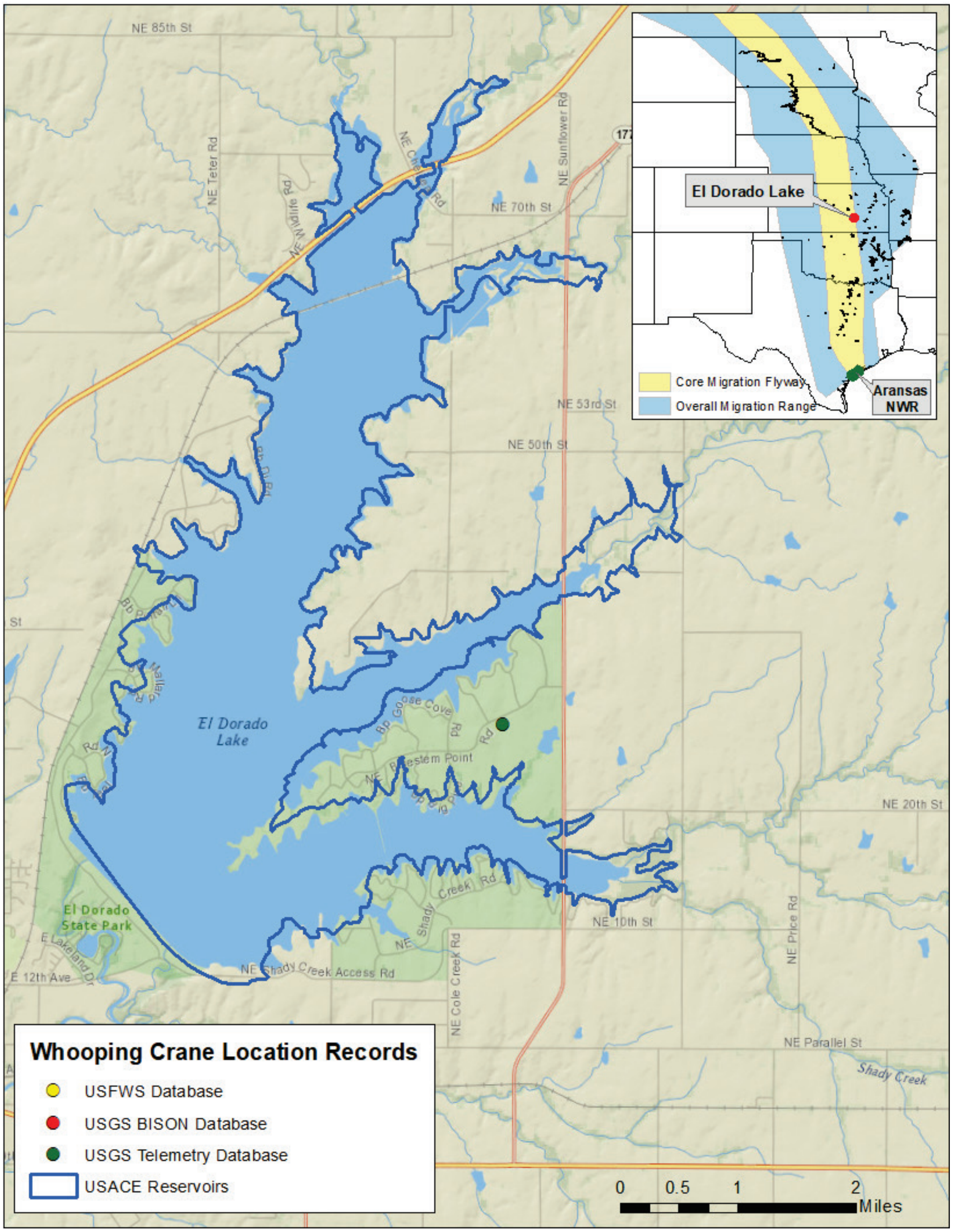
A.11 El Dorado Lake

El Dorado Lake is located within the central section of the migration corridor and may serve as a minor stopover location for WHCRs; however, only one record of a WHCR has been reported. A total of 1 stopover event has been documented between data sets provided by the USGS telemetry database (1 record), USGS-BISON portal (0 records), and USFWS database (0 records).

Table A-11. Stopovers by satellite-tagged WHCRs at El Dorado Lake, Kansas, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	—	1	1
Total	—	1	1
Total days	—	1	1
Total nights	—	0	0
Mean days	—	1.0	1.0
Mean nights	—	0.0	0.0
Minimum days	—	1	1
Maximum days	—	1	1
Observation range	—	7 November	—

Figure A-11. General locations of WHCRs at El Dorado Lake, Kansas, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



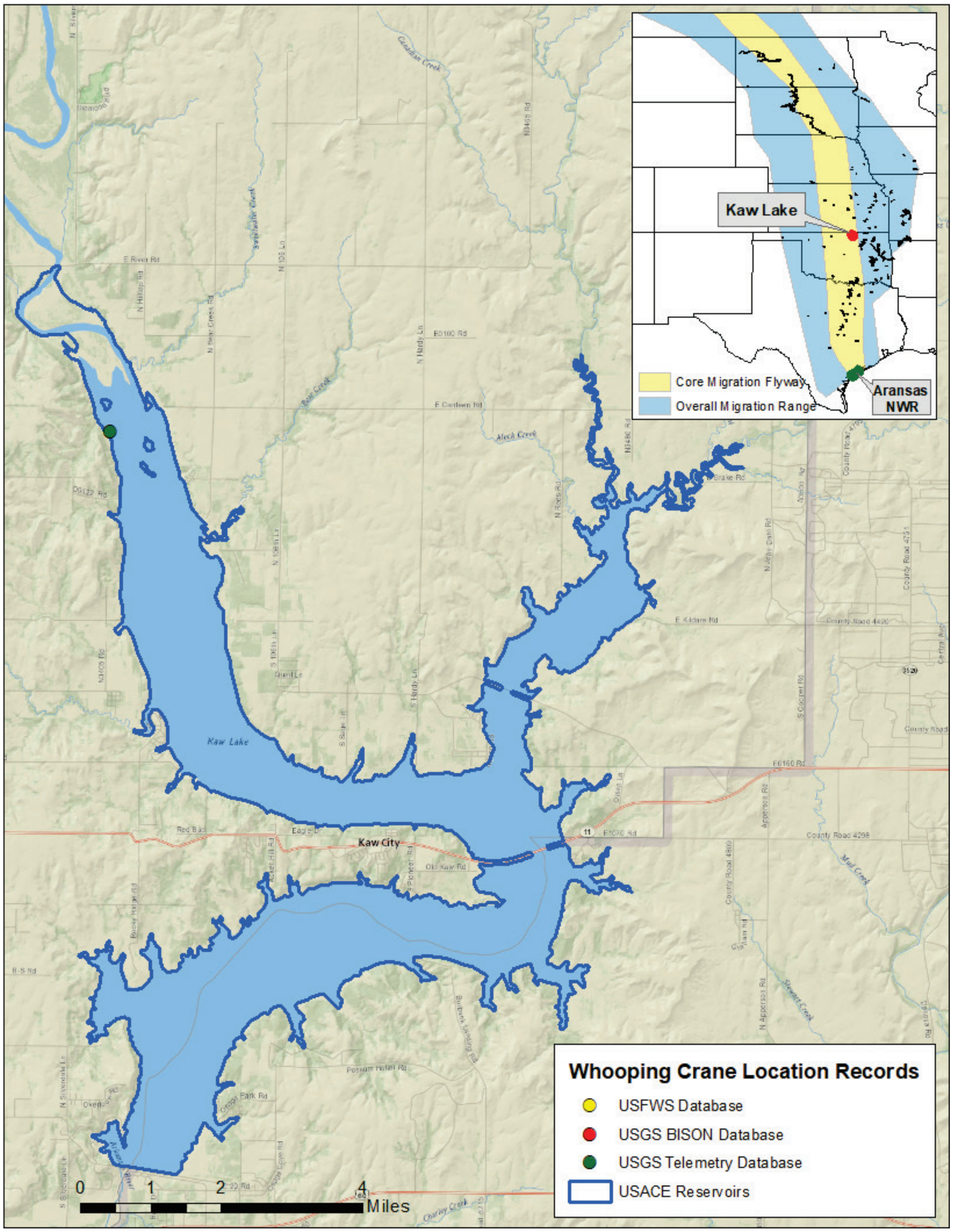
A.12 Kaw Lake

Kaw Lake is located within the central section of the migration corridor and may serve as a minor stopover location for WHCRs; however, only one record of a WHCR has been reported. A total of 1 stopover event has been documented between data sets provided by the USGS telemetry database (1 record), USGS-BISON portal (0 records), and USFWS database (0 records).

Table A-12. Stopovers by satellite-tagged WHCRs at Kaw Lake, Texas, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	—	1	1
Total	—	1	1
Total days	—	1	1
Total nights	—	0	0
Mean days	—	1.0	1.0
Mean nights	—	0.0	0.0
Minimum days	—	1	1
Maximum days	—	1	1
Observation range	—	11 November	—

Figure A-12. General locations of WHCRs at Kaw Lake, Kansas, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



A.13 Great Salt Plains Lake

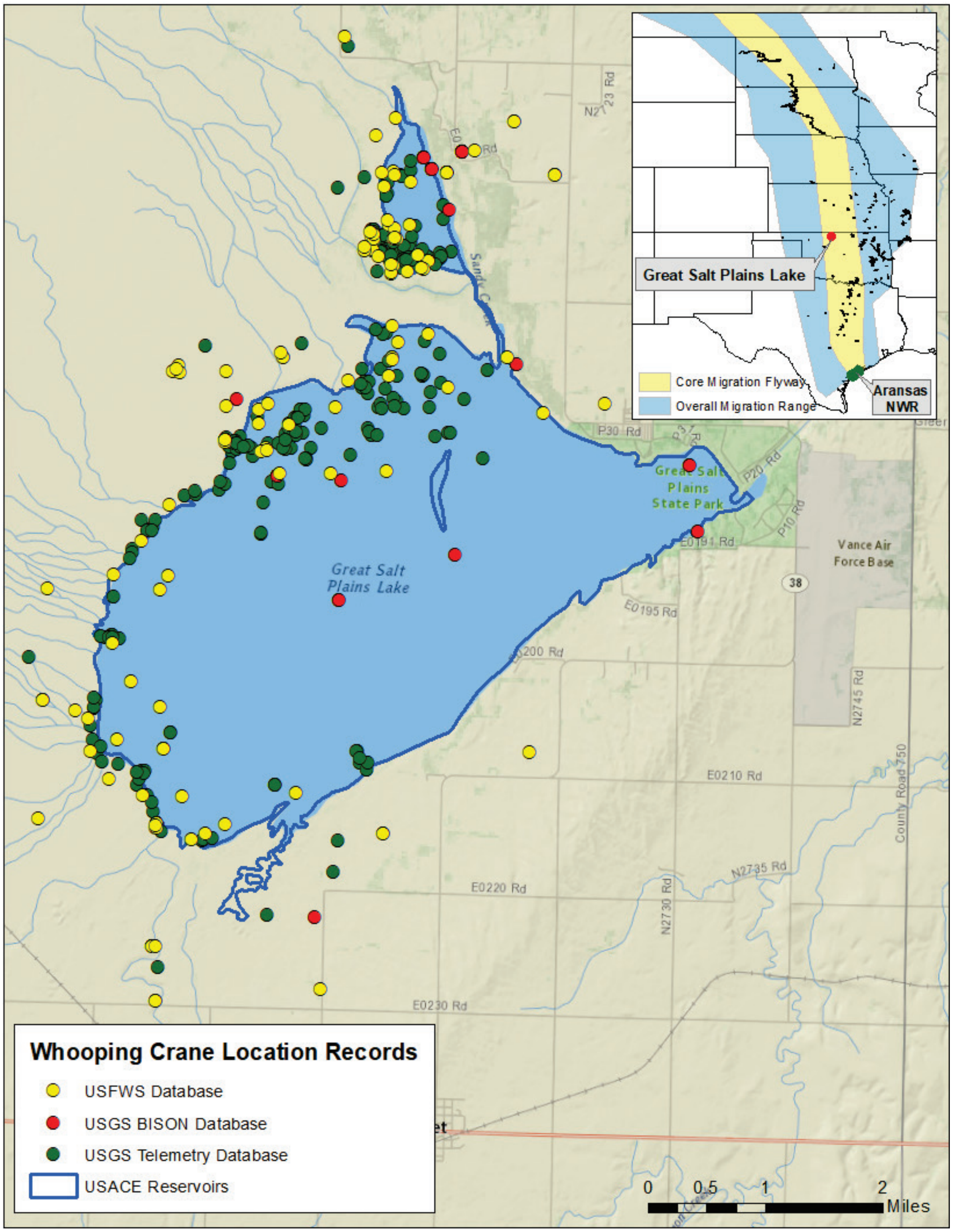
Great Salt Plains Lake is located within the central section of the migration corridor and serves as an important stopover location for WHCRs with approximately half of marked population stopping at this location. A total of

279 stopover events have been documented between data sets provided by the USGS telemetry database (51 records), USGS-BISON portal (34 records), and USFWS database (194 records).

Table A-13. Stopovers by satellite-tagged WHCRs at Great Salt Plains Lake, Oklahoma, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	15	27	35
Total	17	34	51
Total days	33	97	130
Total nights	16	63	79
Mean days	1.94	2.85	2.55
Mean nights	0.94	1.85	1.55
Minimum days	1	1	1
Maximum days	3	14	14
Observation range	5 March–16 April	14 October–7 December	—

Figure A-13. General locations of WHCRs at Great Salt Plains Lake, Oklahoma, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



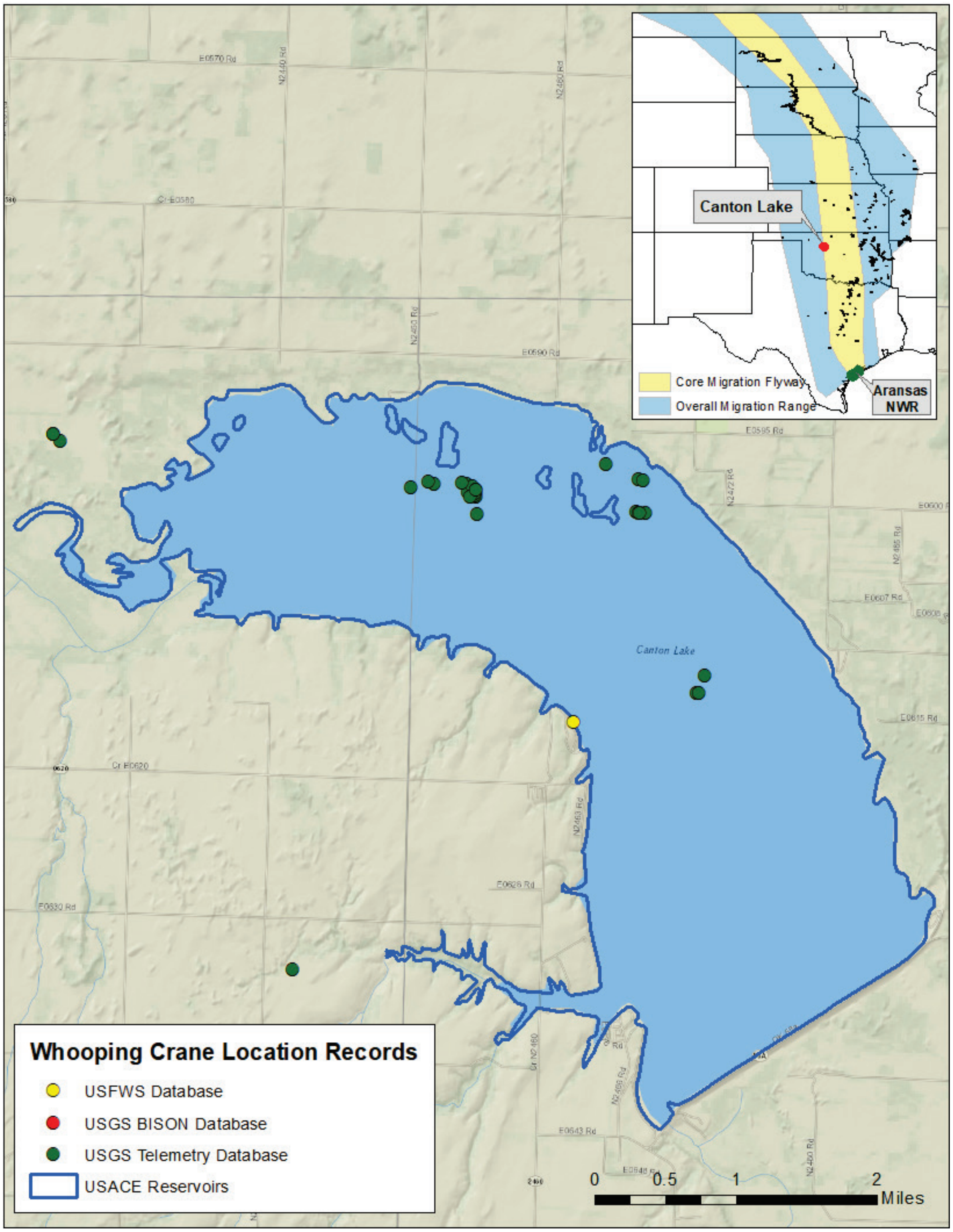
A.14 Canton Lake

Canton Lake is located on the periphery of the core migration corridor and appears to serves as an occasional stopover location in some years for WHCRs. A total of 6 stopover events have been documented between data sets provided by the USGS telemetry database (5 records), USGS-BISON portal (0 records), and USFWS database (1 record).

Table A-14. Stopovers by satellite-tagged WHCRs at Canton Lake, Oklahoma, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	2	3	5
Total	2	3	5
Total days	5	8	13
Total nights	3	5	8
Mean days	2.5	2.7	2.6
Mean nights	1.5	1.7	1.6
Minimum days	2	2	2
Maximum days	3	3	3
Observation range	6–21 April	30 October–12 November	—

Figure A-14. General locations of WHCRs at Canton Lake, Oklahoma, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



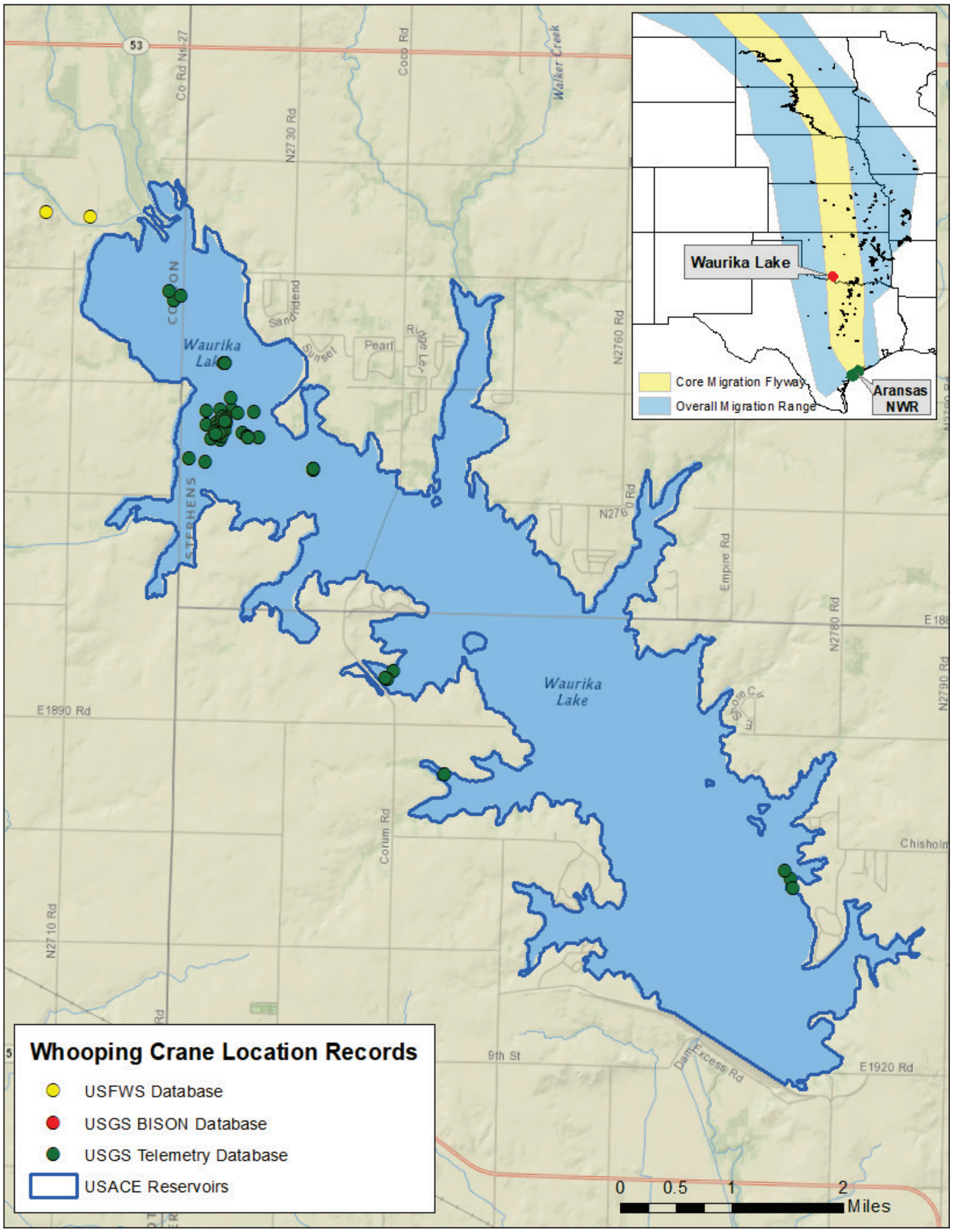
A.15 Waurika Lake

Waurika Lake is located in southern Oklahoma within the core of the migration corridor. Waurika Lake serves an important stopover location for WHCRs, especially during fall migration. A total of 14 stopover events have been documented between data sets provided by the USGS telemetry database (12 records), USGS-BISON portal (0 records), and USFWS database (2 records).

Table A-15. Stopovers by satellite-tagged WHCRs at Waurika Lake, Oklahoma, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	4	8	12
Total	4	8	12
Total days	8	22	30
Total nights	4	14	18
Mean days	2.0	2.8	2.5
Mean nights	1.0	1.8	1.5
Minimum days	2	1	1
Maximum days	2	4	4
Observation range	28 February–6 May	31 October–14 November	—

Figure A-15. General locations of WHCRs at Waurika Lake, Oklahoma, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



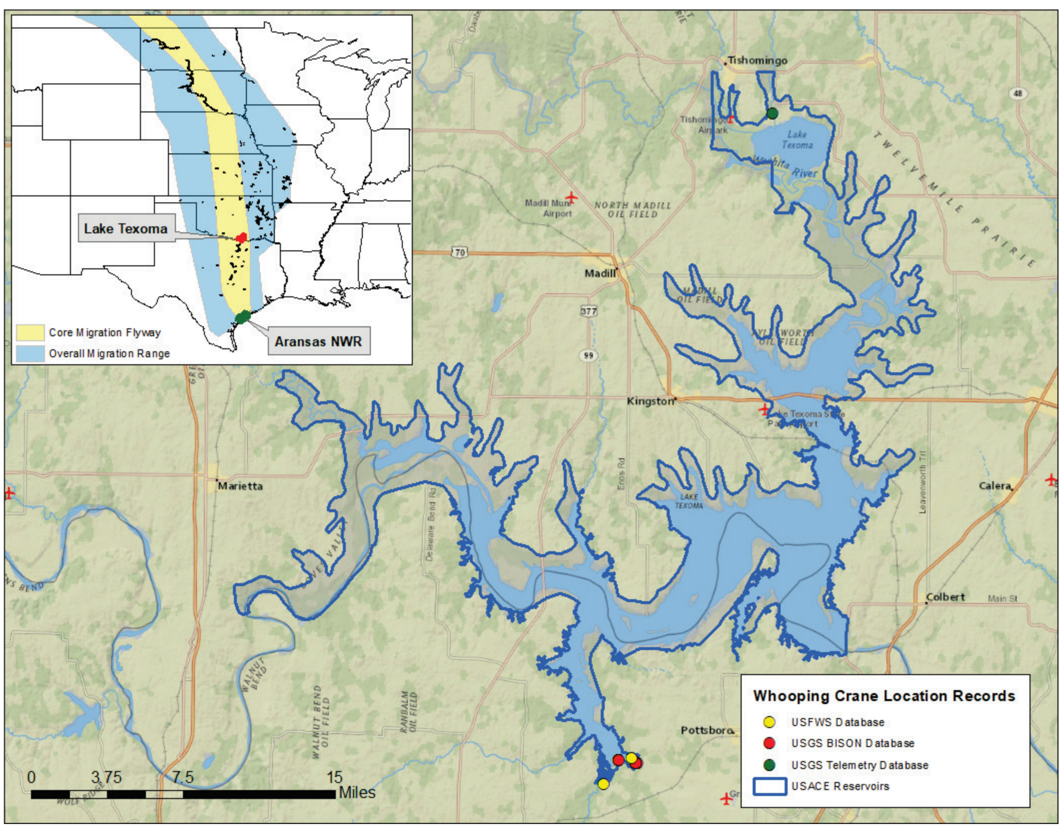
A.16 Lake Texoma

Lake Texoma is located within the southern section of the migration corridor and may only serve as a minor stopover location for WHCRs. A total of 17 stopover events have been documented between data sets provided by the USGS telemetry database (1 record), USGS-BISON portal (14 records), and USFWS database (2 records).

Table A-16. Stopovers by satellite-tagged WHCRs at Lake Texoma, Oklahoma, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	—	1	1
Total	—	1	1
Total days	—	1	1
Total nights	—	0	0
Mean days	—	1.0	1.0
Mean nights	—	0.0	0.0
Minimum days	—	1	1
Maximum days	—	1	1
Observation range	—	5 November	—

Figure A-16. General locations of WHCRs at Lake Texoma, Oklahoma, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



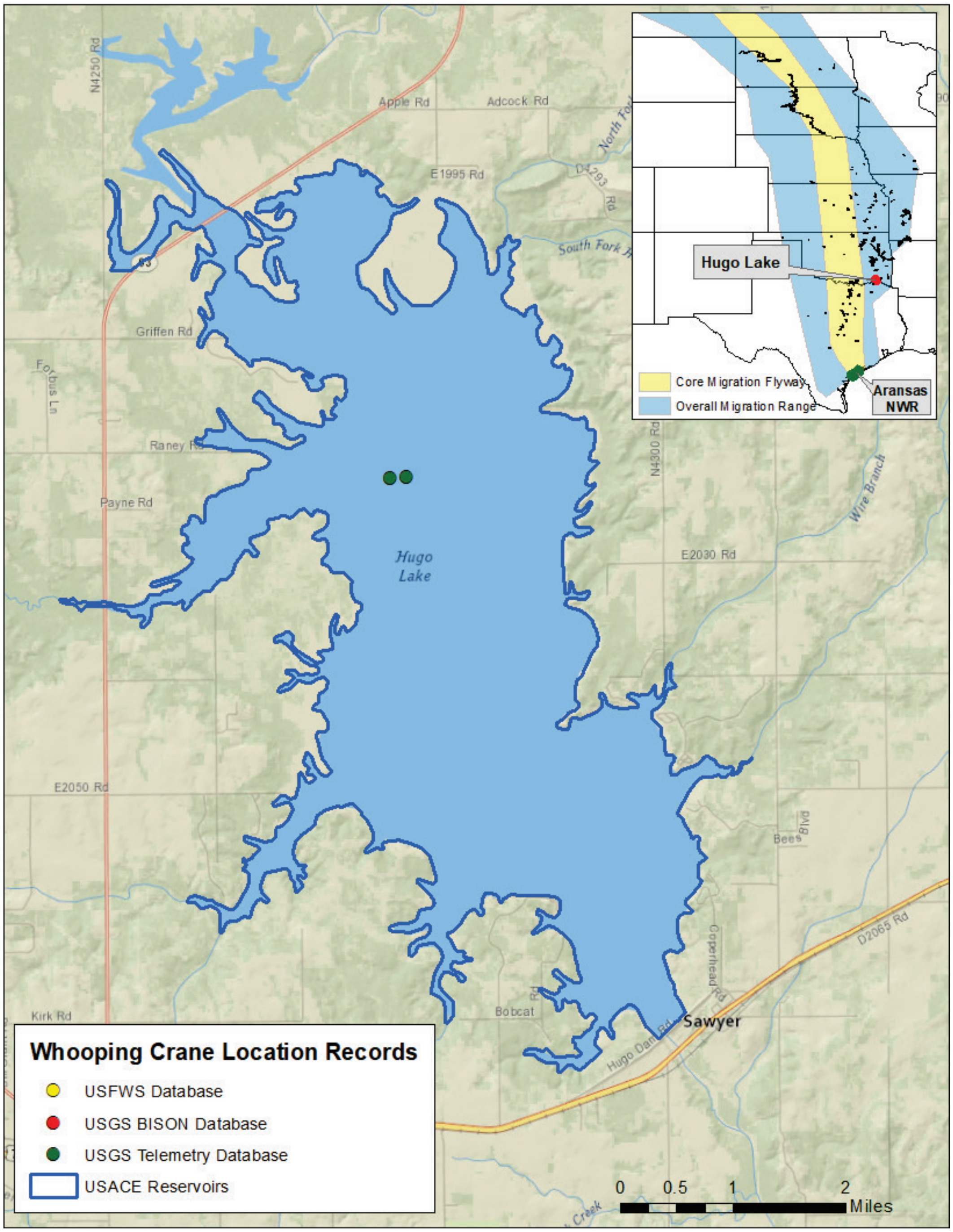
A.17 Hugo Lake

Hugo Lake is located within the southern section of the migration corridor and may only serve as a minor stopover location for WHCRs. A total of 2 stopover events have been documented between data sets provided by the USGS telemetry database (2 records), USGS-BISON portal (0 records), and USFWS database (0 records).

Table A-17. Stopovers by satellite-tagged WHCRs at Hugo Lake, Oklahoma, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	—	1	1
Total	—	1	1
Total days	—	1	1
Total nights	—	0	0
Mean days	—	1.0	1.0
Mean nights	—	0.0	0.0
Minimum days	—	1	1
Maximum days	—	1	1
Observation range	—	13 November	—

Figure A-17. General locations of WHCRs at Hugo Lake, Oklahoma, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



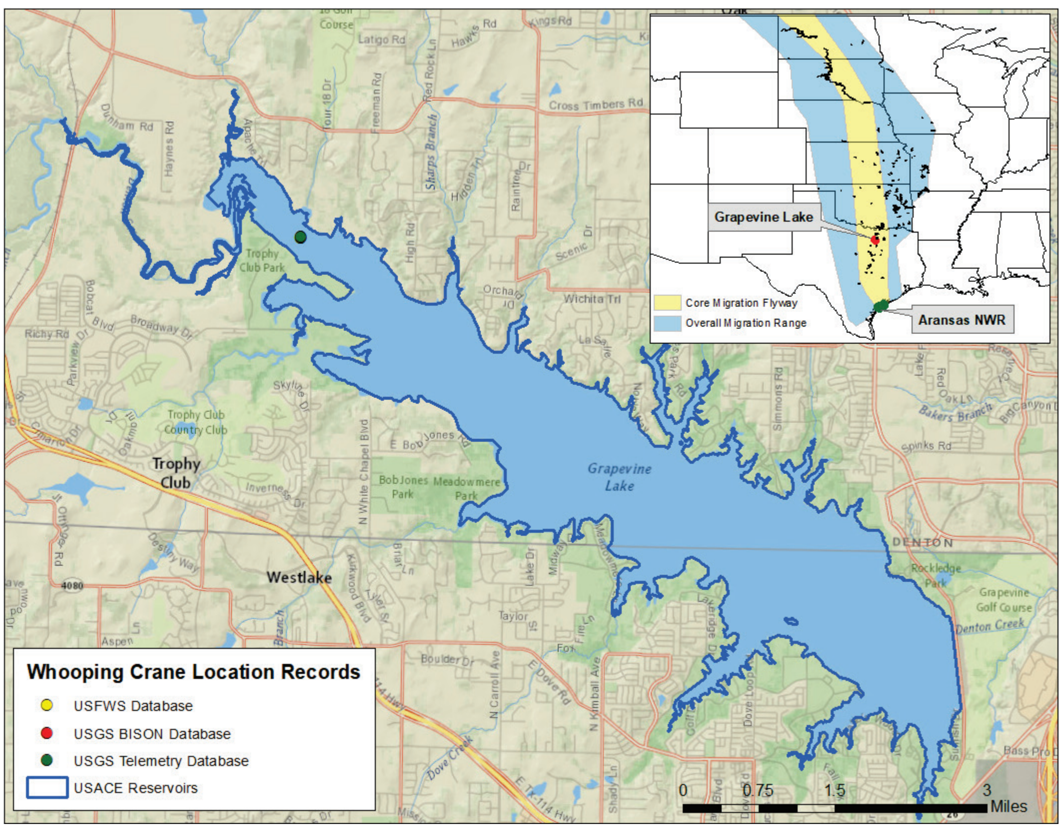
A.18 Grapevine Lake

Grapevine Lake is located within the southern section of the migration corridor and may only serve as a minor stopover location for WHCRs. A total of 1 stopover event has been documented between data sets provided by the USGS telemetry database (1 record), USGS-BISON portal (0 records), and USFWS database (0 records).

Table A-18. Stopovers by satellite-tagged WHCRs at Grapevine Lake, Texas, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	1	—	1
Total	1	—	1
Total days	2	—	2
Total nights	1	—	1
Mean days	2.0	—	2.0
Mean nights	1.0	—	1.0
Minimum days	2	—	2
Maximum days	2	—	2
Observation range	6–7 April	—	—

Figure A-18. General locations of WHCRs at Grapevine Lake, Texas, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



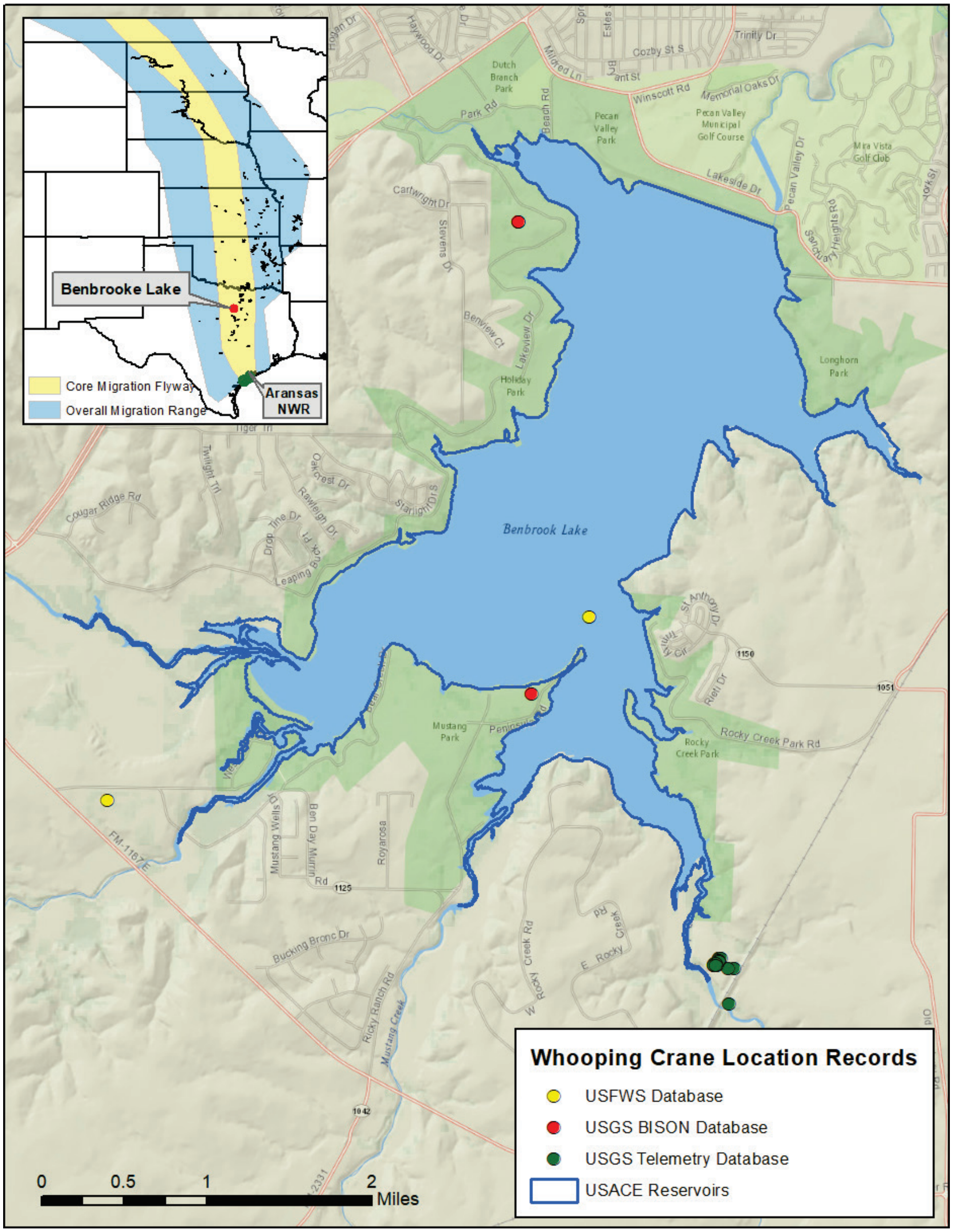
A.19 Benbrooke Lake

Benbrooke Lake is located in the southern section within the core of the migration corridor. Benbrooke Lake may serve as an important stopover location for WHCRs during the fall migration. A total of 9 stopover events have been documented between data sets provided by the USGS telemetry database (5 records), USGS-BISON portal (2 records), and USFWS database (2 records).

Table A-19. Stopovers by satellite-tagged WHCRs at Benbrooke Lake, Texas, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	—	5	5
Total	—	5	5
Total days	—	11	11
Total nights	—	6	6
Mean days	—	2.2	2.2
Mean nights	—	1.2	1.2
Minimum days	—	2	2
Maximum days	—	3	3
Observation range	—	7–11 November	—

Figure A-19. General locations of WHCRs at Benbrooke Lake, Texas, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



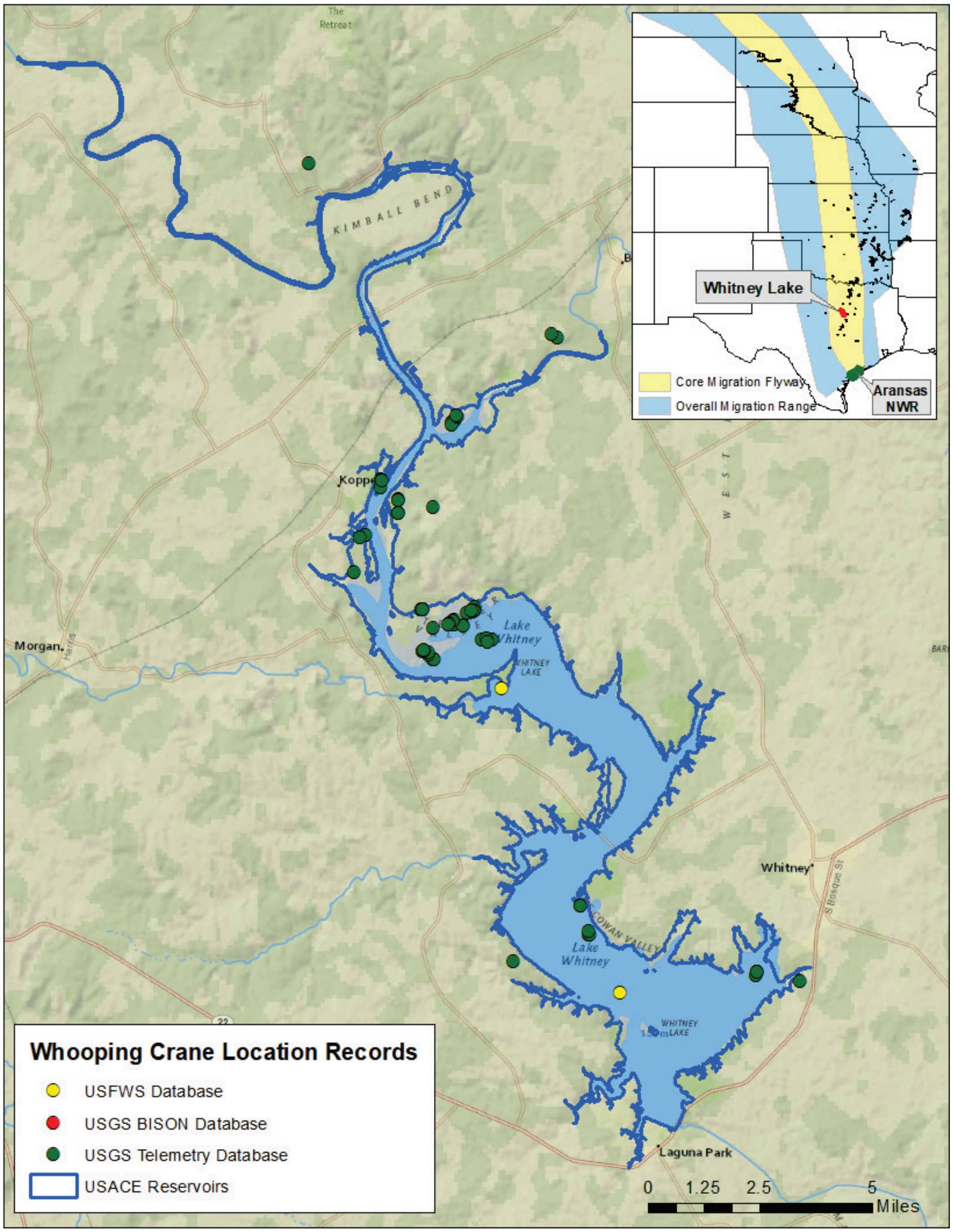
A.20 Whitney Lake

Lake Whitney is located at the southern extent of the migration corridor, approximately 260 mi (418 km) north of Aransas NWR, serves as an important stopover site, and may function as an important stepping-stone to and from the wintering grounds at Aransas NWR. A total of 29 stopover events have been documented between data sets provided by the USGS telemetry database (27 records), USGS-BISON portal (0 records), and USFWS database (2 records).

Table A-20. Stopovers by satellite-tagged WHCRs at Whitney Lake, Texas, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	8	15	18
Total	9	18	27
Total days	18	35	53
Total nights	9	17	26
Mean days	2.00	1.94	1.96
Mean nights	1.00	0.94	0.96
Minimum days	1	1	1
Maximum days	3	5	5
Observation range	22 March–22 April	28 October–19 November	—

Figure A-20. General locations of WHCRs at Whitney Lake, Texas, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



A.21 Proctor Lake

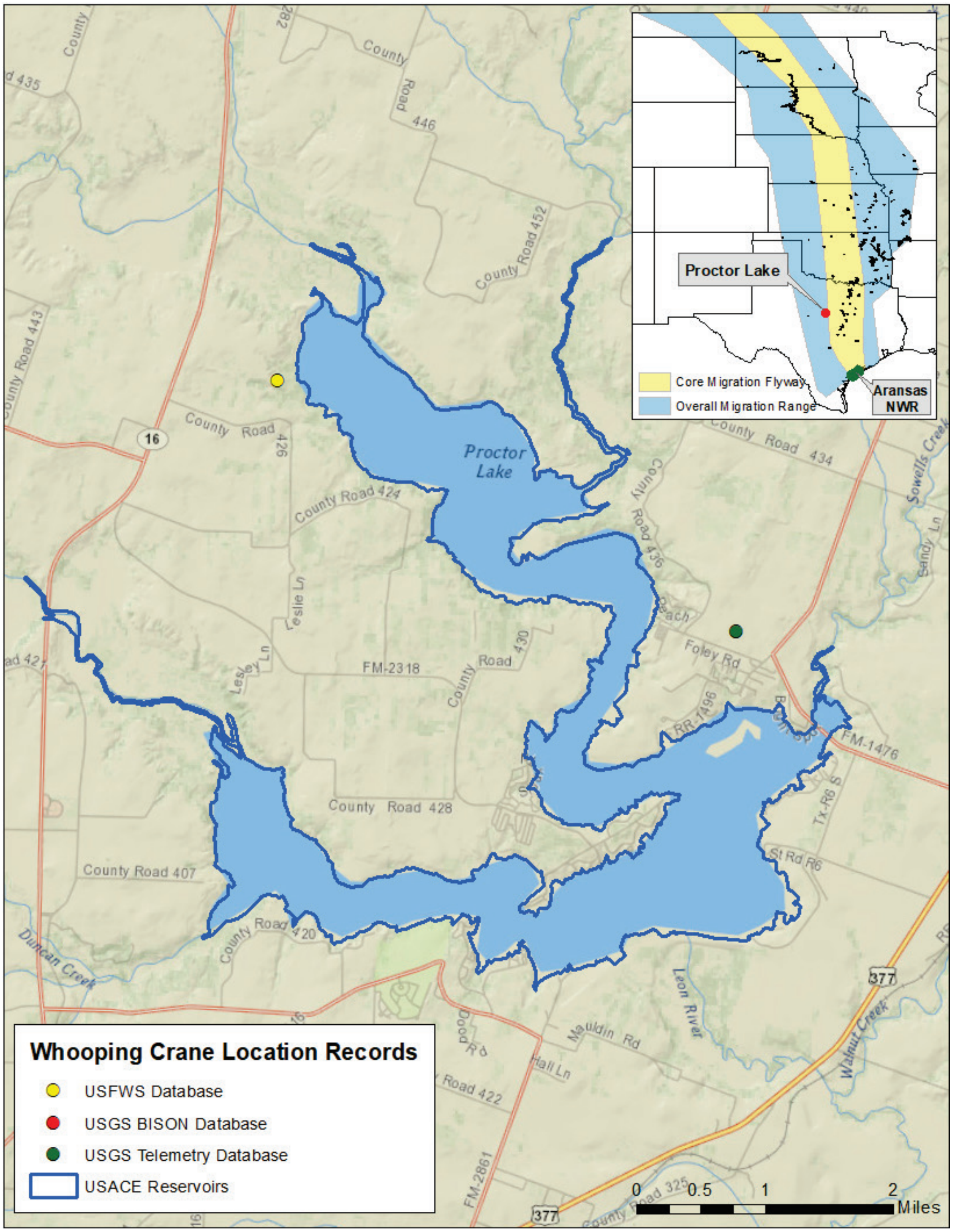
Proctor Lake is located within the central section of the migration corridor and may only serve as a minor stopover location for WHCRs. A total of 2 stopover events have been documented between data sets provided by the

USGS telemetry database (1 record), USGS-BISON portal (0 records), and USFWS database (1 record).

Table A-21. Stopovers by satellite-tagged WHCRs at Proctor Lake, Texas, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	1	—	1
Total	1	—	1
Total days	1	—	1
Total nights	0	—	0
Mean days	1.0	—	1.0
Mean nights	0.0	—	0.0
Minimum days	1	—	1
Maximum days	1	—	1
Observation range	7 April	—	—

Figure A-21. General locations of WHCRs at Proctor Lake, Texas, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



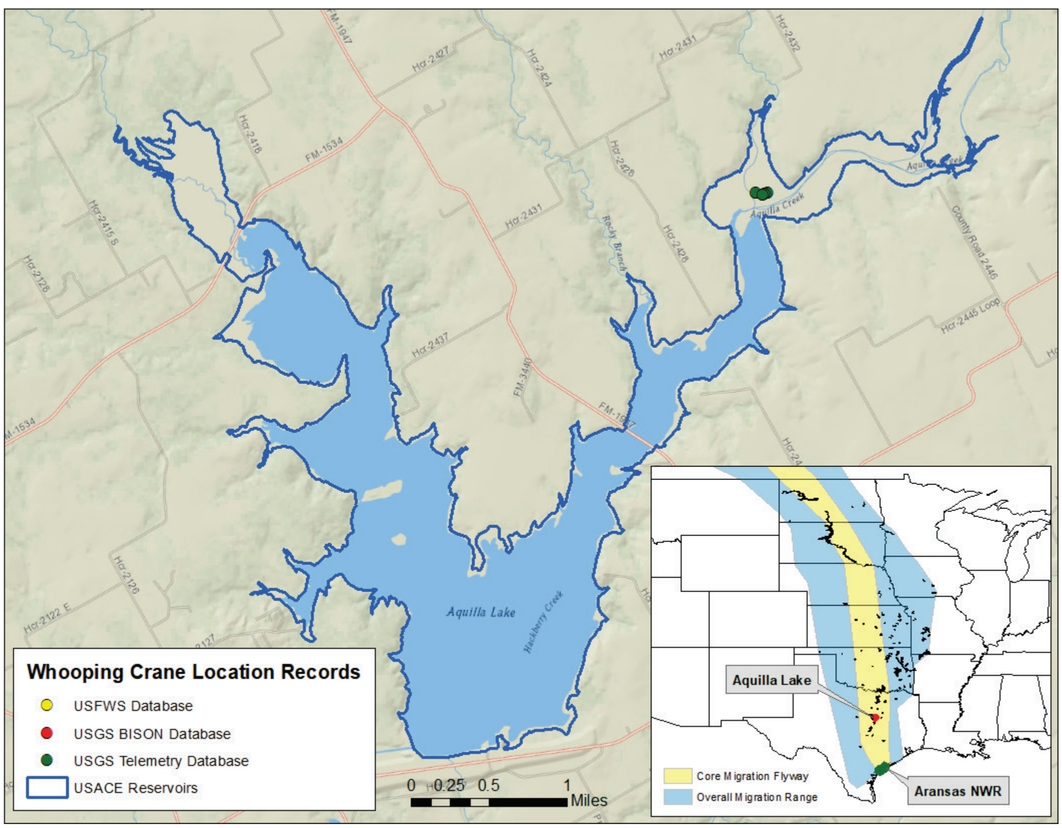
A.22 Aquilla Lake

Aquilla Lake is located within the southern section of the migration corridor and serves as a minor stopover location for WHCRs. A total of 1 stopover event has been documented between data sets provided by the USGS telemetry database (1 record), USGS-BISON portal (0 records), and USFWS database (0 records).

Table A-22. Stopovers by satellite-tagged WHCRs at Aquilla Lake, Texas, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	1	—	1
Total	1	—	1
Total days	2	—	2
Total nights	1	—	1
Mean days	2.0	—	2.0
Mean nights	1.0	—	1.0
Minimum days	2	—	2
Maximum days	2	—	2
Observation range	5–6 May	—	—

Figure A-22. General locations of WHCRs at Aquilla Lake, Texas, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



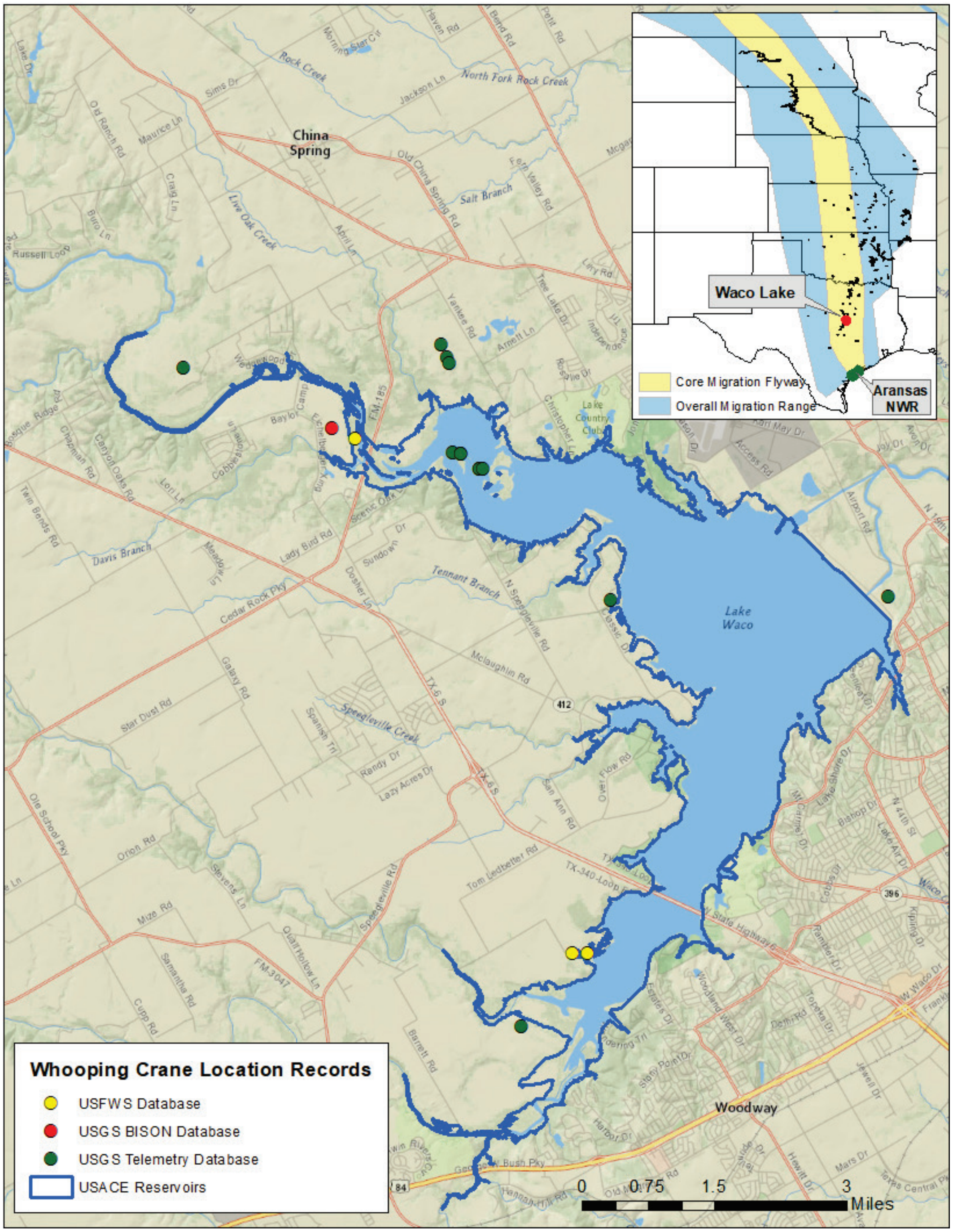
A.23 Waco Lake

Waco Lake is located within the southern section of the migration corridor and serves as an occasional stopover location for WHCRs. A total of 10 stopover events have been documented between data sets provided by the USGS telemetry database (6 records), USGS-BISON portal (1 record), and USFWS database (3 records).

Table A-23. Stopovers by satellite-tagged WHCRs at Waco Lake, Texas, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	3	3	6
Total	3	3	6
Total days	4	5	9
Total nights	1	2	3
Mean days	1.3	1.7	1.5
Mean nights	0.3	0.7	0.5
Minimum days	1	1	1
Maximum days	2	2	2
Observation range	3–10 April	31 October–24 November	—

Figure A-23. General locations of WHCRs at Waco Lake, Texas, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



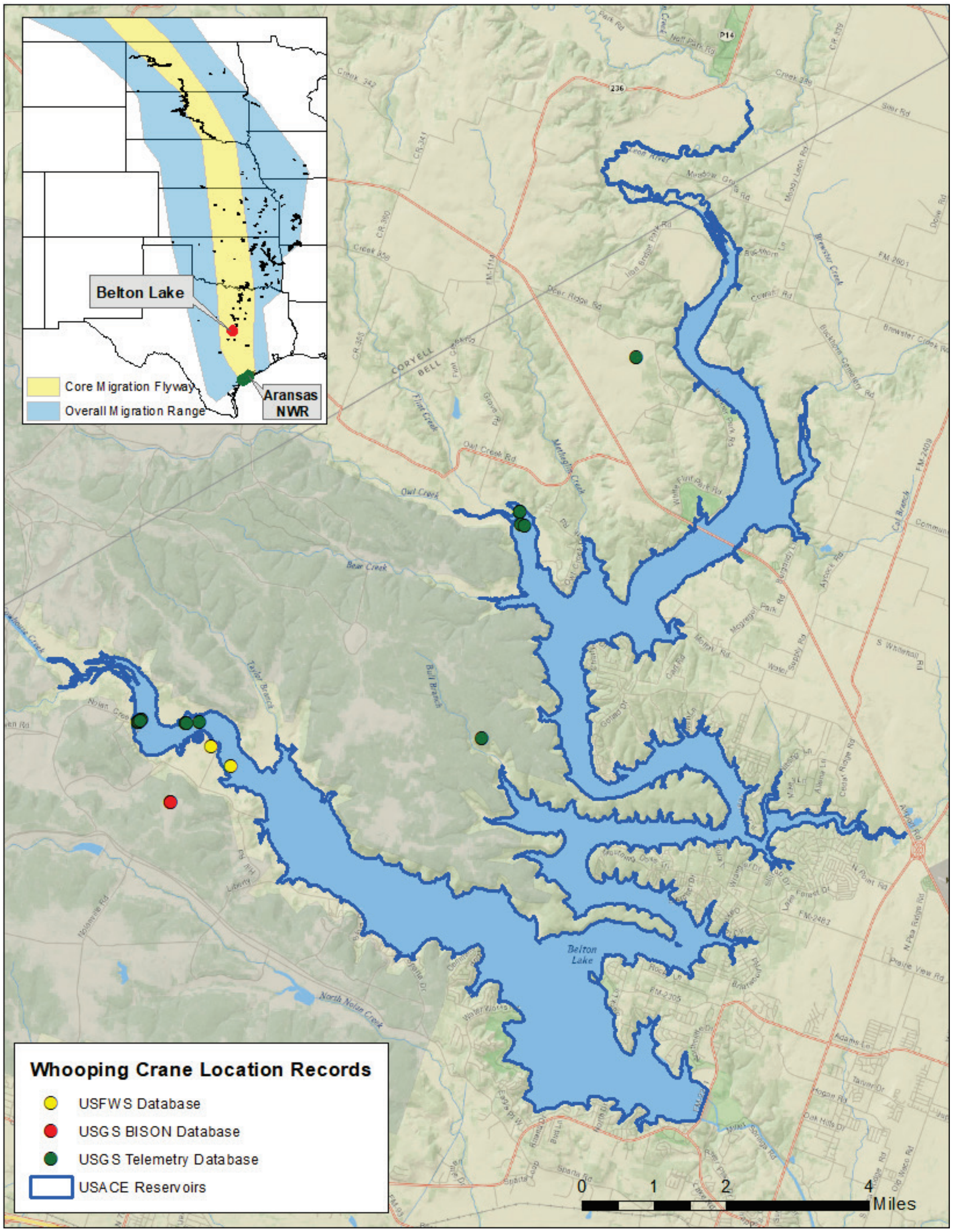
A.24 Belton Lake

Belton Lake is located within the southern section of the migration corridor and serves as an important stopover location during the spring for WHCRs. A total of 11 stopover events have been documented between data sets provided by the USGS telemetry database (7 records), USGS-BISON portal (2 records), and USFWS database (2 records).

Table A-24. Stopovers by satellite-tagged WHCRs at Belton Lake, Texas, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	6	1	6
Total	6	1	7
Total days	10	2	12
Total nights	4	1	5
Mean days	1.7	2.0	1.7
Mean nights	0.7	1.0	0.7
Minimum days	1	2	1
Maximum days	2	2	2
Observation range	12 March–7 April	1–2 November	—

Figure A-24. General locations of WHCRs at Belton Lake, Texas, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



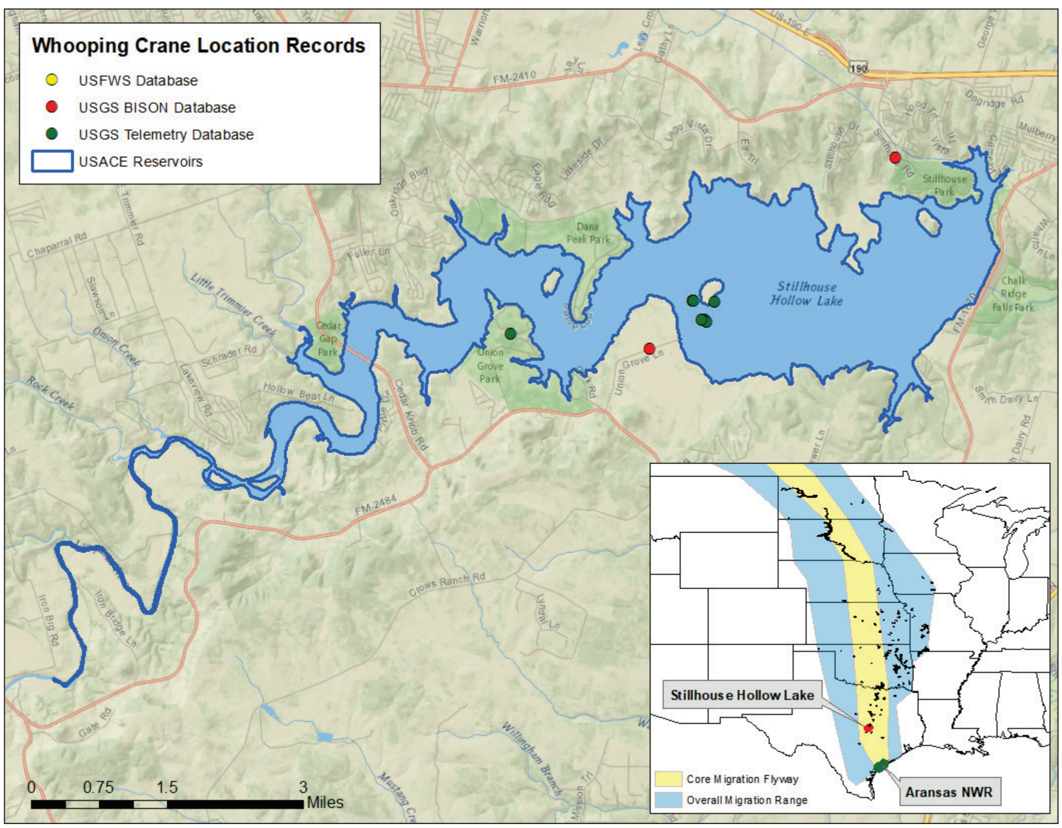
A.25 Stillhouse Hollow Lake

Stillhouse Hollow Lake is located within the central section of the migration corridor and serves as a minor stopover location for WHCRs. A total of 4 stopover events have been documented between data sets provided by the USGS telemetry database (2 records), USGS-BISON portal (2 records), and USFWS database (0 records).

Table A-25. Stopovers by satellite-tagged WHCRs at Stillhouse Hollow Lake, Texas, during the spring and fall migration period, 2009–2018.

Stopovers	Spring	Fall	All seasons
Individuals	—	2	2
Total	—	2	2
Total days	—	4	4
Total nights	—	2	2
Mean days	—	2.0	2.0
Mean nights	—	1.0	1.0
Minimum days	—	2	2
Maximum days	—	2	2
Observation range	—	5–13 November	—

Figure A-25. General locations of WHCRs at Stillhouse Hollow Lake, Texas, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



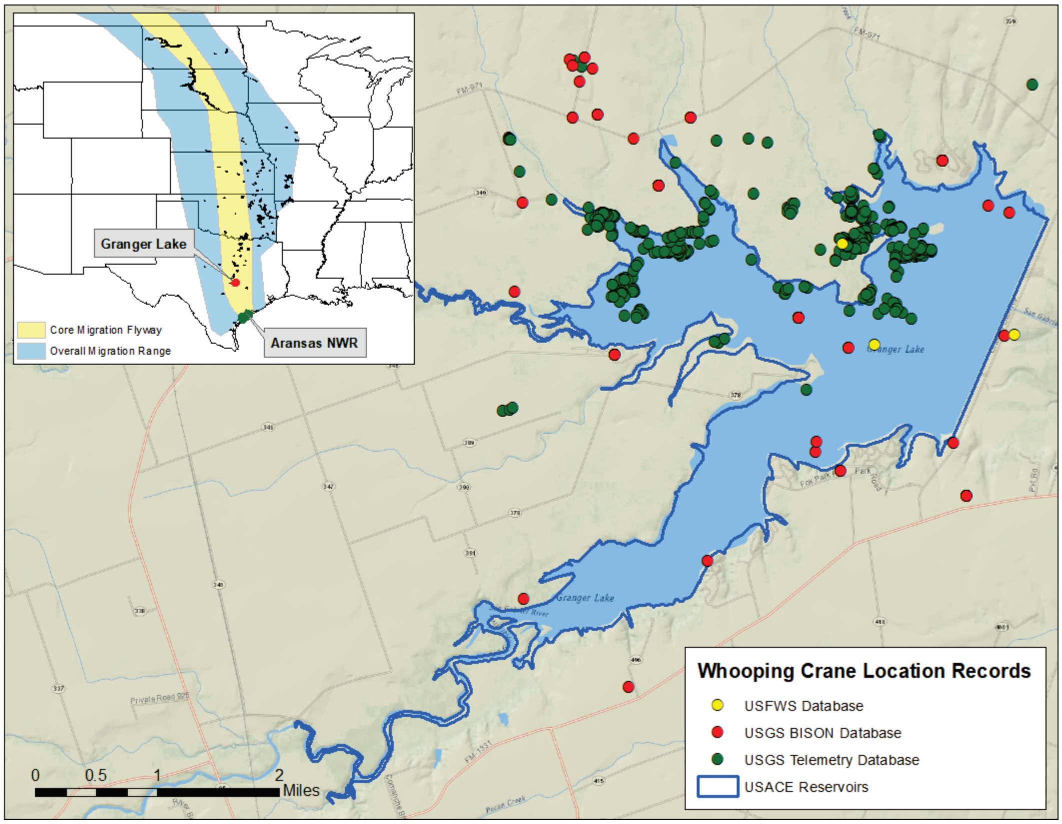
A.26 Granger Lake

Granger Lake is located at the southern extent of the migration corridor, approximately 170 mi (273 km) north of Aransas NWR. Granger Lake serves as an important stopover site and may function as an important wintering site in years where conditions are not as favorable at Aransas NWR. Future research should include investigating the importance of Granger Lake as an alternate site for wintering by WHCRs. A total of 127 stopover events have been documented between data sets provided by the USGS telemetry database (7 records), USGS-BISON portal (117 records), and USFWS database (3 records). It is likely that many (most) of the 117 records that resulted in a total of 238 observations reported through USGS-BISON resulted from double counting of the same individual over multiple days, because, for example, the USGS telemetry study recorded 750 observations among 5 individual WHCRs at Granger Lake.

Table A-26. Stopovers by satellite-tagged WHCRs at Granger Lake, Texas, during the migration period and during winter, 2009–2018.

Stopovers	Spring	Fall	Winter	All seasons
Individuals	1	1	3	5
Total	1	1	5	7
Total days	1	2	288	291
Total nights	0	1	283	284
Mean days	1	2	57.6	41.57
Mean nights	0	1	56.6	40.57
Minimum days	1	2	2	1
Maximum days	1	2	106	106
Observation range	23 April	8–9 November	17 November–13 March	—

Figure A-26. General locations of WHCRs at Granger Lake, Texas, according to the USGS telemetry, USGS-BISON, and USFWS-CWCTP data sets.



Appendix B: Additional USACE Reservoirs

The following USACE reservoirs were also frequented by WHCR according to USGS-BISON and USFWS-CWCTP databases, but they were not documented with satellite-tagged cranes.

Figure B-1. Bardwell Lake.

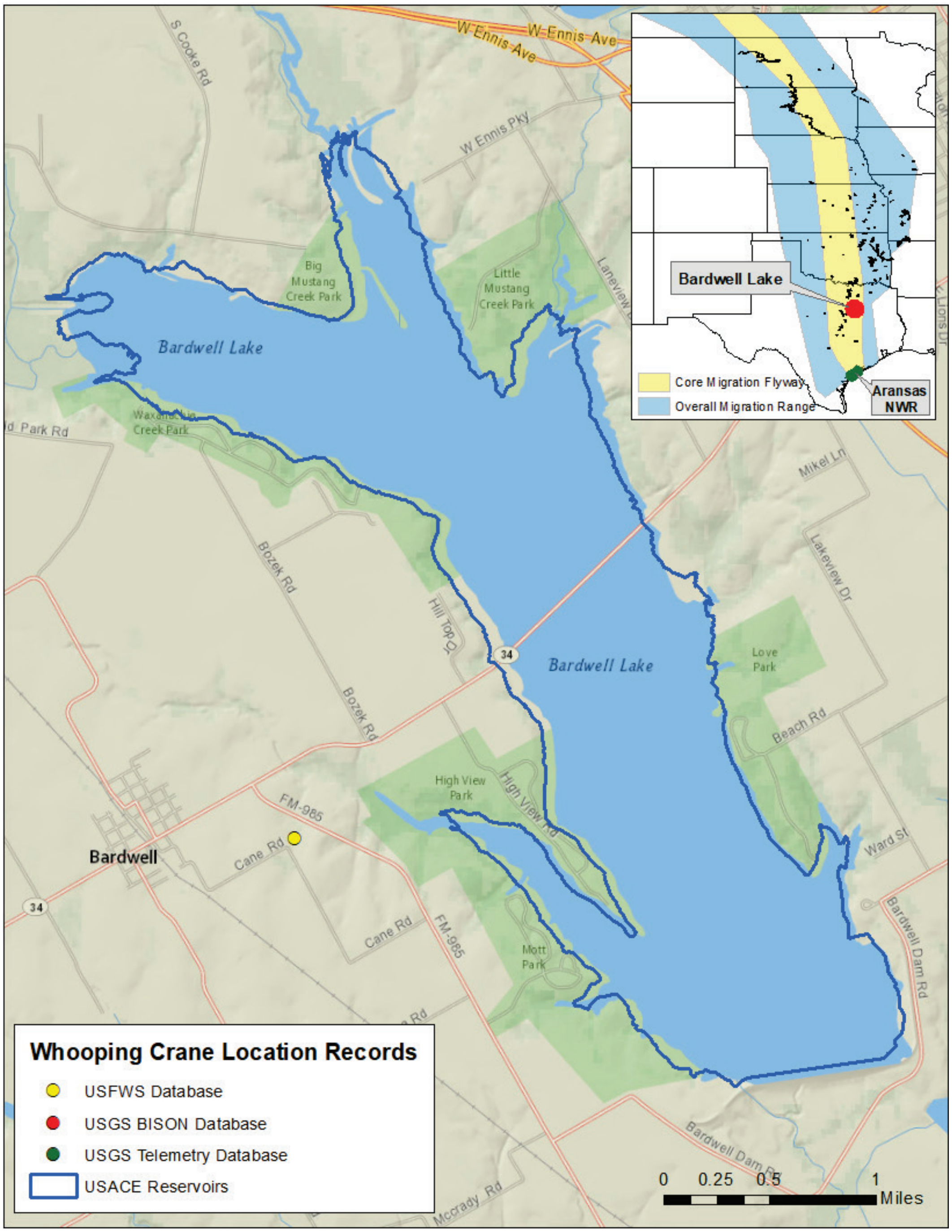


Figure B-2. Branched Oak Lake.

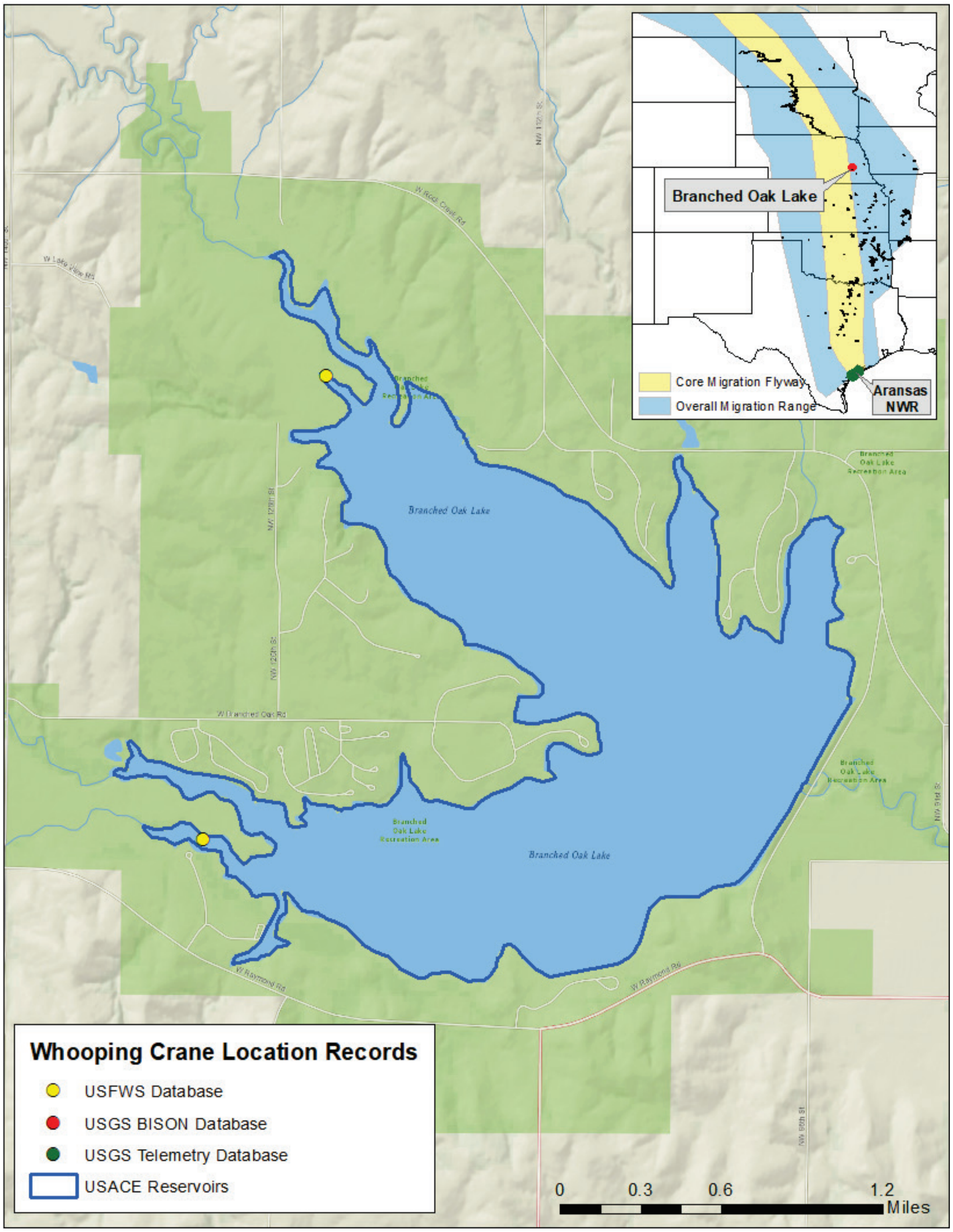


Figure B-3. Clinton Lake.

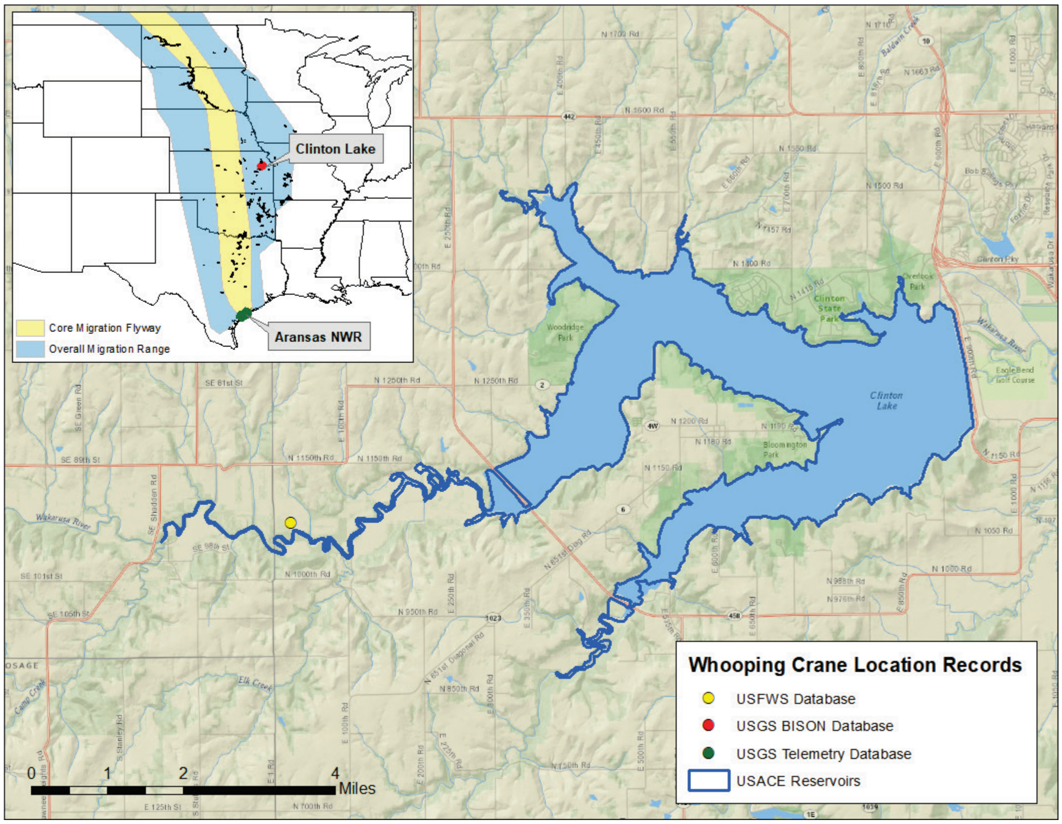


Figure B-4. Copan Lake.

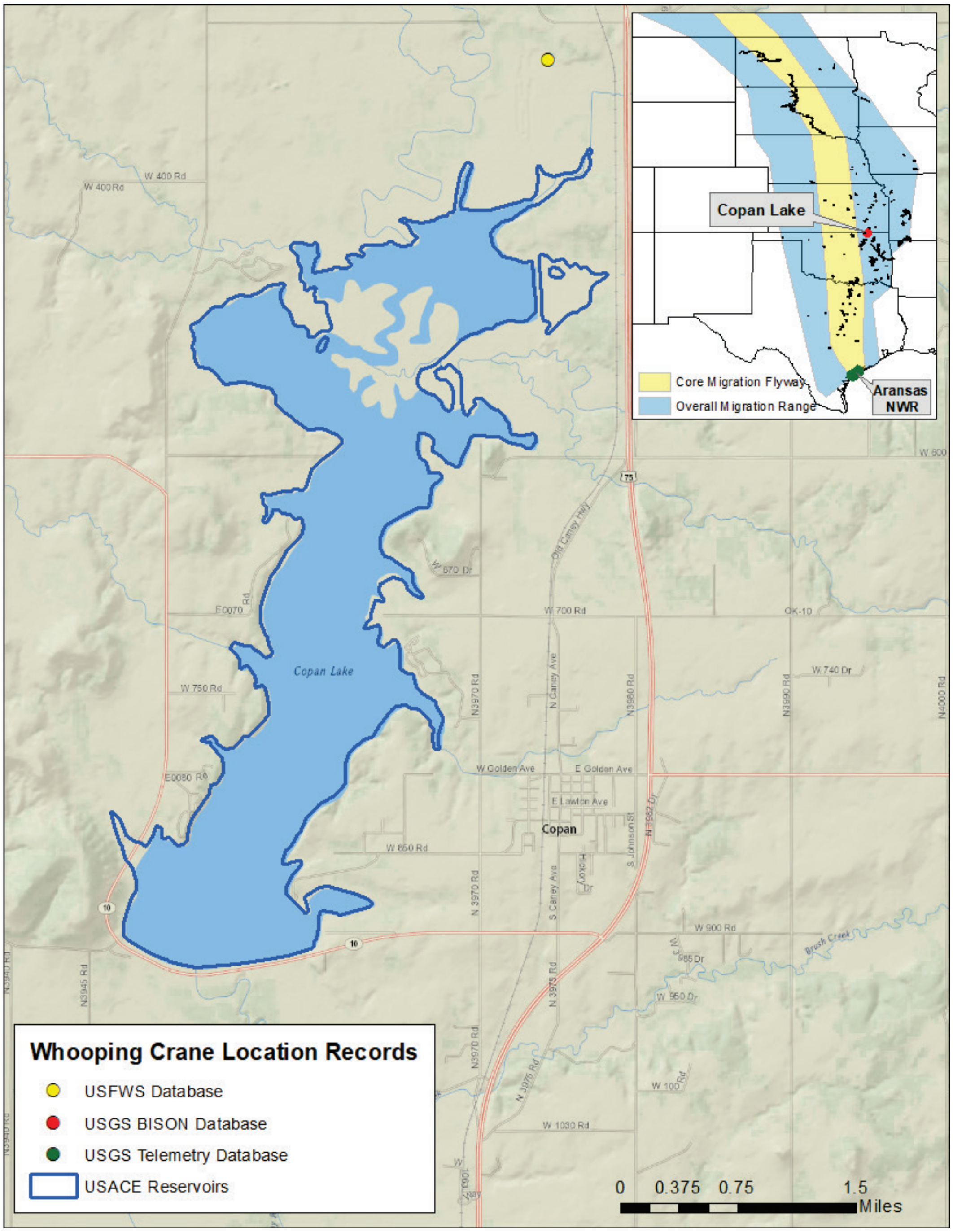


Figure B-5. Lake Lewisville.

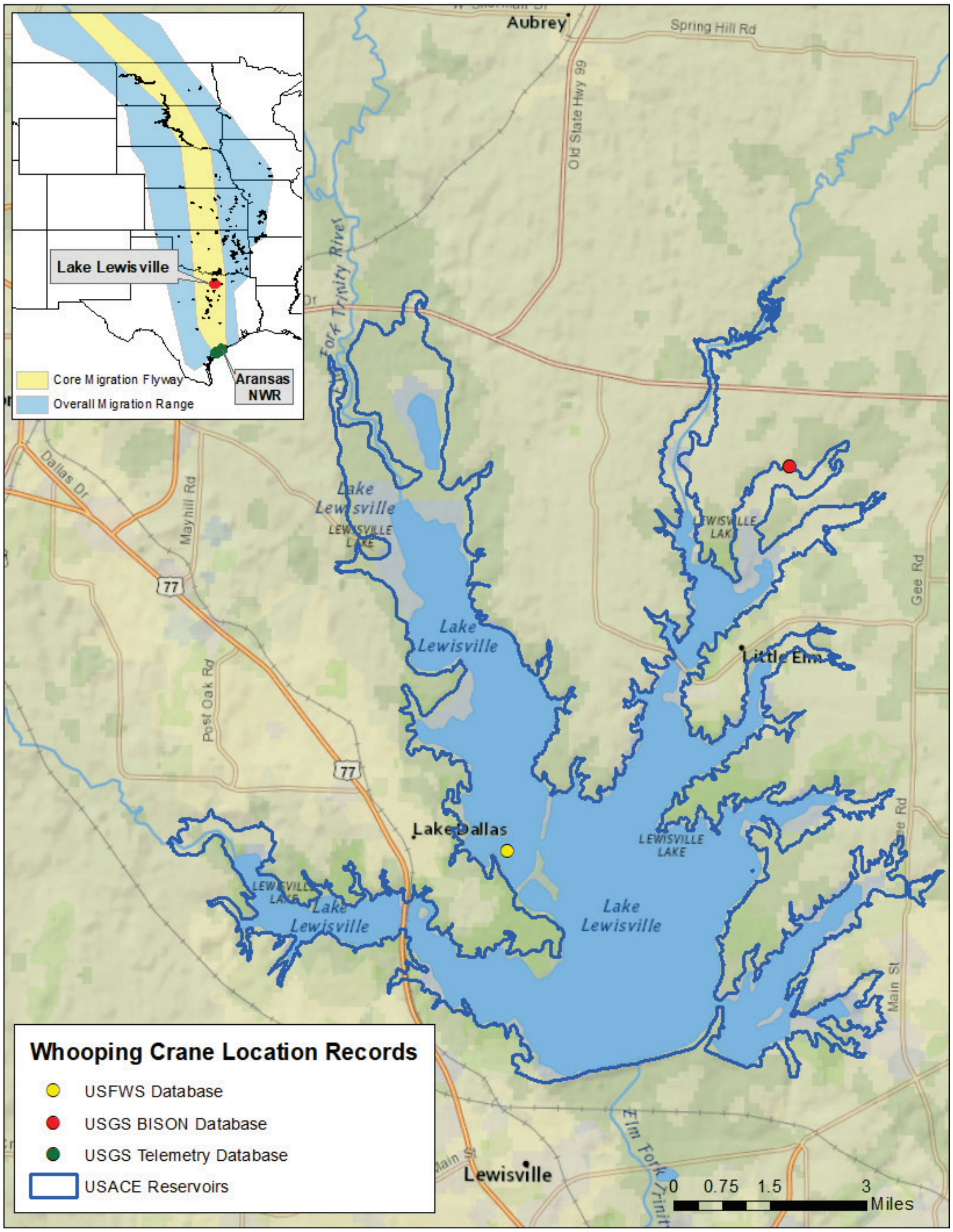


Figure B-6. Marion Lake.

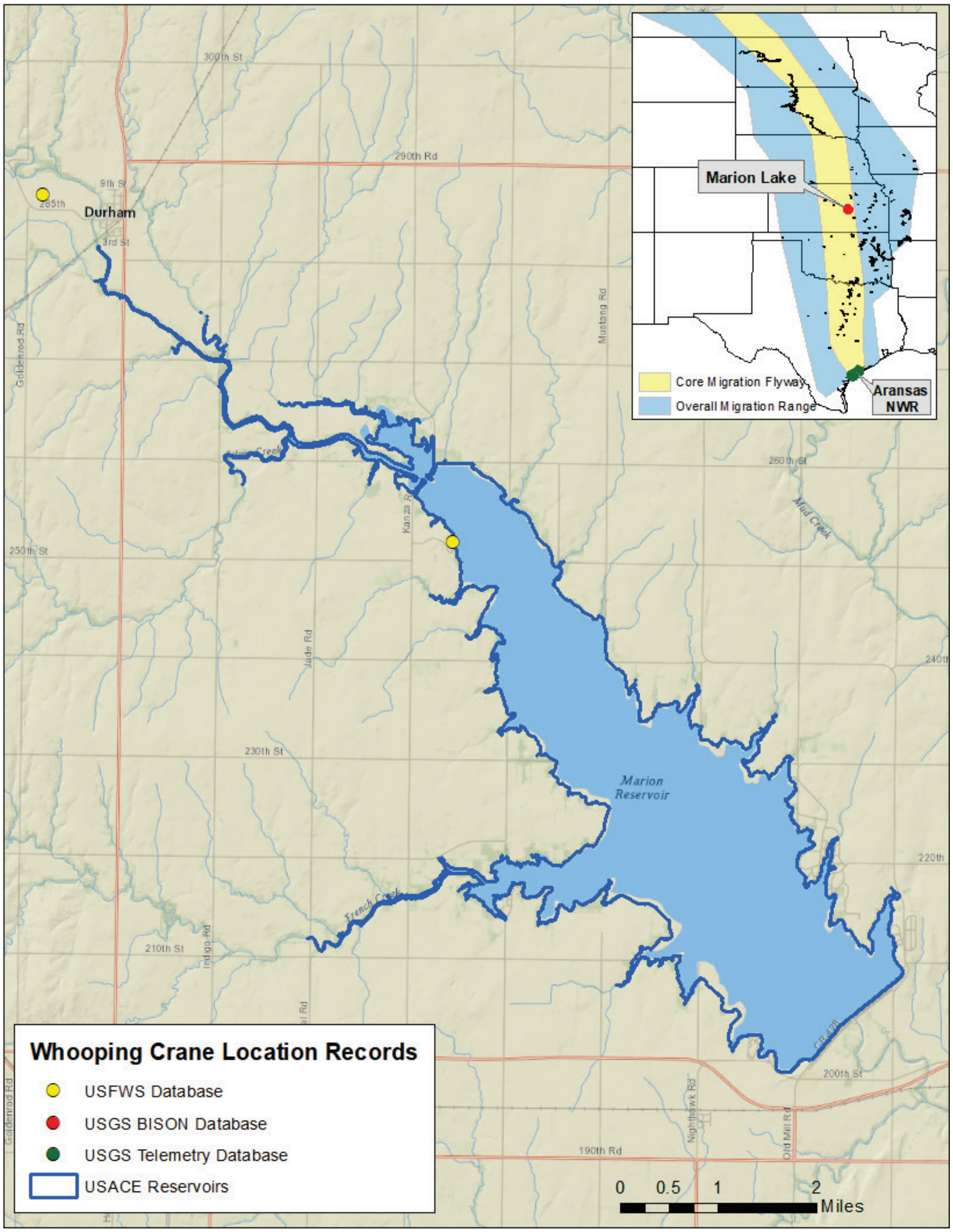


Figure B-7. Pawnee Lake.

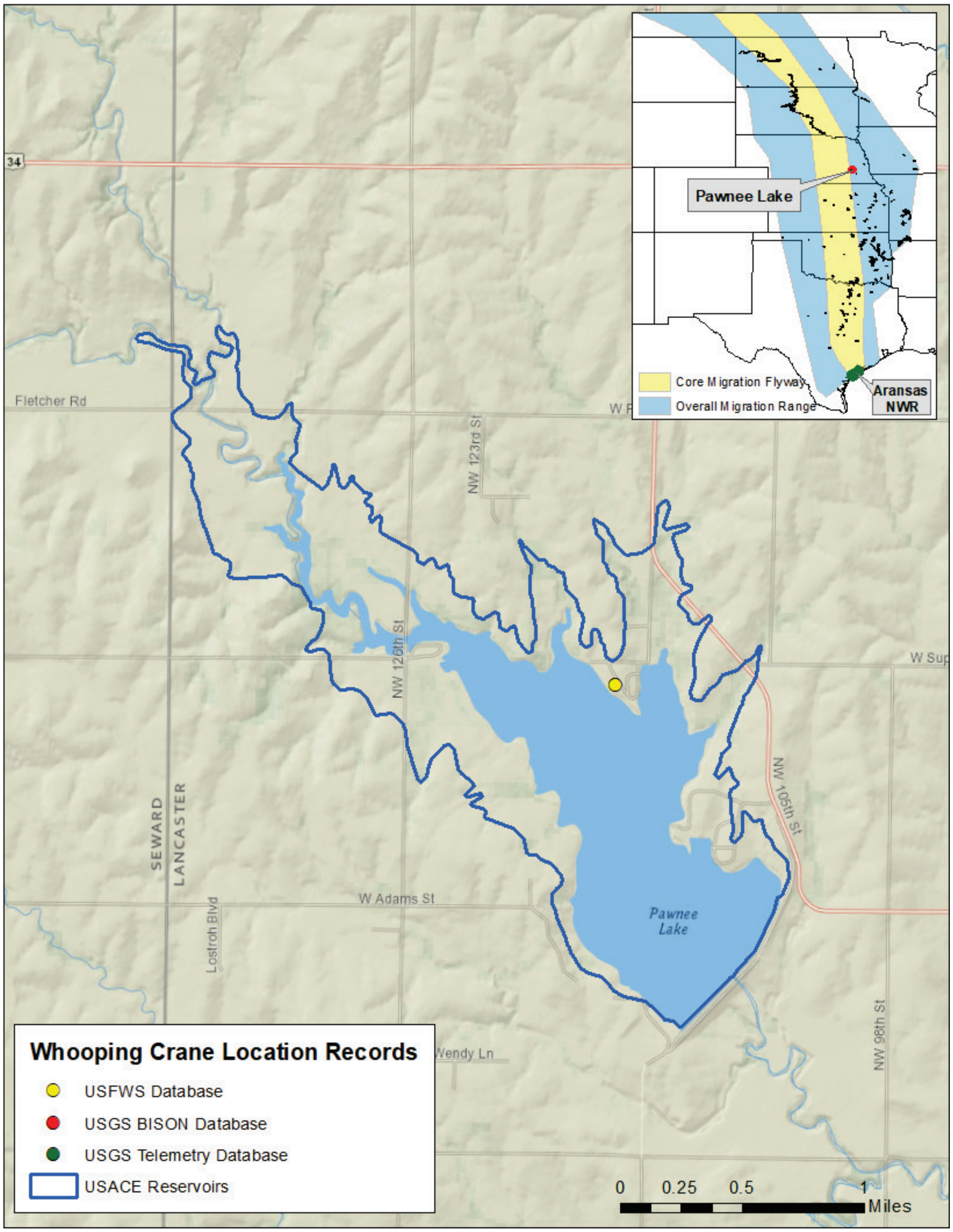
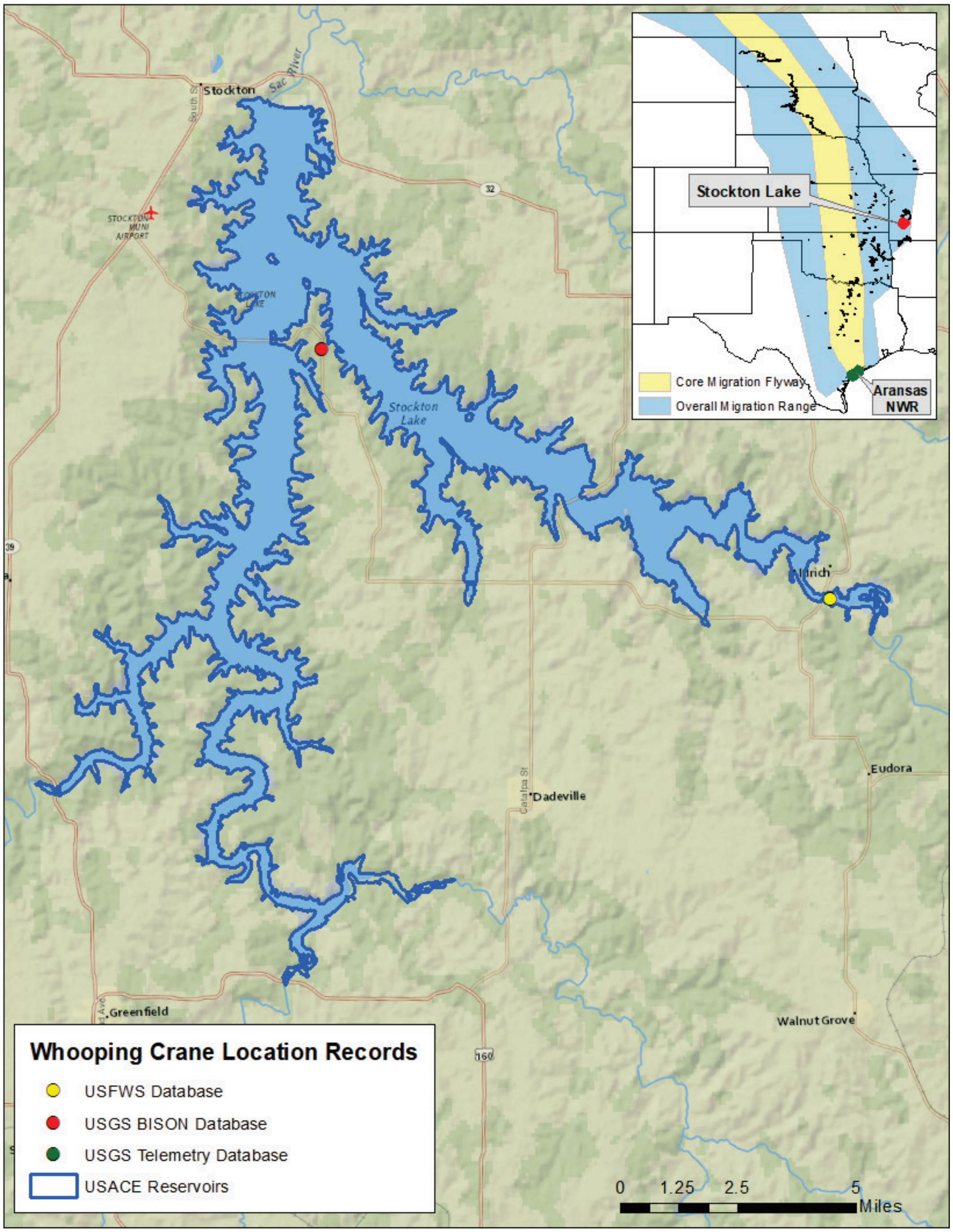


Figure B-8. Stockton Lake.



Appendix C: US Fish and Wildlife Service Nebraska Ecological Services Whooping Crane Data Use Agreement

U.S. Fish and Wildlife Service Nebraska Ecological Services Whooping Crane Data Use Agreement

Data from the U.S. Fish and Wildlife Service Nebraska Ecological Services Whooping Crane Database, herein referred to as Data, is being provided to the data user specified at the end of this agreement. To protect threatened and endangered species and landowner privacy, we have a policy of maintaining confidentiality with regards to exact location information about these species. We require that you abide by the following stipulations:

1. Data are provided to the Data User solely for internal use and data shall not to be released or distributed.
2. The Data remains the property of the U.S. Fish and Wildlife Service and is provided only to the Data User as a temporary loan.
3. Any requests to the Data User to release the Data shall be referred to the U.S. Fish and Wildlife Service Nebraska Ecological Services Office.
4. The Data User must protect and maintain the confidentiality of the Data.
5. Any products (for example, maps, reports) that are developed by the Data User from these data and distributed to external entities shall not provide specific whooping crane use locations.
6. Data used in any document, report, presentation, or any communication (excluding products intended for publication) shall properly cite "U.S. Fish and Wildlife Service Nebraska Ecological Services Field Office". The Data User shall also acknowledge that any analyses, interpretation and/or conclusions from any Data were neither reviewed nor endorsed by the U.S. Fish and Wildlife Service. Specific requirements for specific mediums are as follows:

Documents: Any document in which Data are used, a disclaimer shall be provided in 14-point Times New Roman font on the first page referencing or using the data of said document.

Power Point or other projected presentation: Any presentation in which the Data are used a disclaimer shall be provided in 28-point Times New Roman font, centered both vertically and horizontally on the slide, with no other content, on one of the first five slides of said presentation.

Verbal presentation: Any verbal presentation in which the Data are used a disclaimer shall be provided during the introduction or within the first 500 words spoken.

The Disclaimer, referred to above, shall state the following, without modification:

> This document or presentation includes Whooping Crane migration use data from the Central Flyway stretching from Canada to Texas, collected, managed and owned by the U.S. Fish and Wildlife Service. Data were provided to the "(insert Data User Organization identified on the following signature page)" as a courtesy for their use. The U.S. Fish and Wildlife Service has not directed, reviewed, or endorsed any aspect of the use of these data. Any and all data analyses, interpretations, and conclusions from these data are solely those of the "(insert Data User Organization identified on the following signature page)".

7. Any person(s) or institution(s) using the data resulting from this project should provide relevant USFWS staff the opportunity to participate in the authorship of manuscripts resulting from said research submitted to peer-reviewed journals or other mediums. The USFWS retains ownership of data.

The U.S. Fish and Wildlife Service maintains high standards of data quality control, but it makes no warranty as to the fitness of these data for any purpose or that these data necessarily are accurate and complete.

Moreover, data have inherent limitations. Data recorded at any one time and place are dependent on a suite of variables. This includes variables present in the environment that may or may not affect bird's presence and/or status (e.g., staging, migrating) and those related to human's ability to detect the metrics of interest. Data should be considered and reviewed with caution and with an understanding of limitations. Prior to working with the data, a review of Attachment 1 below titled **"Required Reading for Users of the Whooping Crane Tracking Project Database**" covering the species' biology, survey methods, and limitations is required to ensure that data are used appropriately. Additionally, the Data User must sign, date and return this agreement via email to Matt Rabbe, Whooping Crane Tracking Database Coordinator, at the following email- matt_rabbe@fws.gov.

Matt Rabbe 10JUN22
Matt Rabbe Date
US Fish and Wildlife Service

Data User Name (Printed): Jacob Jung

Signature and Date: Jacob Jung 10JUN22

Data User Organization: US Army Engineer Research and Development Center

Data User Address: 3909 Halls Ferry Road Vicksburg, MS 39182

Appendix D: Attachment 1

Required Reading for Users of the Whooping Crane Tracking Project Database

CWCTP-GIS data or derivatives thereof (for example, shape files, jpegs) may not be distributed or posted on the Internet without inclusion of this explanatory document.

The Cooperative Whooping Crane Tracking Project (CWCTP) was initiated in 1975 to collect a variety of information on whooping crane migration through the U.S, portion of the Central Flyway. Since its inception in 1975, a network of Federal and State cooperating agencies has collected information on whooping crane stopovers and funneled it to the US Fish and Wildlife Service (Service) Nebraska Field Office where a database of sighting information is maintained. The CWCTP database includes a hardcopy file of whooping crane sighting reports and a digital database in various formats based on those sighting reports. A subset of the database along with sight evaluation (habitat) information collected between 1975 and 1999 was summarized by Austin and Richert (2001).*

In the Fall of 2007, the CWCTP database was converted to a GIS format (ArcGIS 9.2) to facilitate input, updates, and provide output options in a spatial context. During this process, inconsistencies between the digital database and sighting report forms were identified and corrected. Location information in various formats was derived from data in the corrected database, and new fields were added to the corrected database (for example, latitude and longitude in decimal degrees, an accuracy field, and location comment field). The attached updated file contains observation data through the 2010 Spring migration.

The appropriate use of the CWCTP-GIS is constrained by limitations inherent in both the GIS technology and bias inherent in any database comprised of incidental observations. Without an understanding of the

* Austin, E.A. and A.L. Richert. 2001. A comprehensive review of observational and site evaluation data of migrant whooping cranes in the United States, 1943–99. US Geological Survey. Northern Prairie Wildlife Research Center, Jamestown, North Dakota, and State Museum, University of Nebraska, Lincoln, Nebraska. 157 pp.

assumptions and limitations of the data, analyses and output from the spatial database can result in faulty conclusions. The following assumptions and characteristics of the database are crucial to interpreting output correctly. Other, unknown biases also may exist in the data.

First and foremost, the database is composed of incidental sightings of whooping cranes during migration. Whooping cranes are largely, though not entirely, opportunistic in their use of stopover sites along the Central Flyway, and will use sites with available habitat when weather or diurnal conditions require a break in migration. Because much of the Central Flyway is sparsely populated, only a small percentage of stopovers are observed, those observed may not be identified, those identified may not be reported, and those reported may not be confirmed (only confirmed sightings are included in the database). Based on the crane population and average flight distances, as little as 4 percentage of crane stopovers are reported. ***Therefore, absence of documented whooping crane use of a given area in the Central Flyway does NOT mean that whooping cranes do not use that area or that various projects in the vicinity will not potentially adversely affect the species.***

- In the database, the location of each sighting is based on the first observation of the crane group even though, in many cases, the group was observed at multiple locations in a local area. For this and other reasons described below, only broad-scale analyses of whooping crane occurrences are appropriate. GIS **cannot** be legitimately used with this database for measurements of distance of whooping crane groups from various habitat types or geographic entities (that is, using various available GIS data layers). In addition, point locations of whooping crane groups known to roost in various wetlands or rivers may not coincide with those wetlands. The user needs to refer to the attribute table or contact the Nebraska Field Office, USFWS, for more specific information on individual observations.
- Precision of the data: When a "Cadastral" location (Township, Range, Section, ¼-Section) was provided on the original sighting form, the geographic point representing that sighting was placed in the center of the indicated Section or ¼-Section and the latitude and longitude of that point were recorded in degrees, minutes, and seconds (DMS). These records are indicated by "Cadastral" in the accuracy field. When Cadastral information was lacking, DMS latitude and longitude were derived by adding seconds (00) to the degrees and minutes of latitude

and longitude originally estimated and recorded on the observation form. These observations are identified by “Historic” in the accuracy field. GPS latitude and longitude were used when available, but when none of the above were reported, the point was placed based on text description of location (for example, 3 miles* N of Denton) points on a map, and identified in the accuracy field with “Landmark”. Given the inability to detect the exact GPS coordinates, when GPS coordinates were provided, they are assumed to have been recorded based on landmark features and estimated using Google Earth or an equivalent coordinate mapping tool. DMS latitude and longitude were converted to decimal degrees, which were used to populate the GIS data layer. Subsequent to the 2007–08 initial database conversion, decimal degrees of the sighting location were obtained from ArcMap following manual placement of the point in the dataframe using location information supplied with the report.

- Bias: Bias is an inherent characteristic of any data obtained through incidental sightings. That is, for the subset of crane use that is recorded, relatively more sightings are recorded in areas such as national wildlife refuges where knowledgeable observers are available to look for cranes and report their presence. Conversely, areas of high use may not be documented due to the absence of observers. However, use of areas such as national wildlife refuges is also determined to some extent by habitat management on the areas and availability of alternative habitat in the region. For these reasons, representations of the crane migration corridor based on percentage of confirmed sightings should be interpreted conservatively, particularly in Oklahoma and Kansas where a high percentage of sightings occur on a few national wildlife refuges. whooping crane migration patterns and subsequent observations were also likely influenced by regional weather patterns such as wind and precipitation, as well as local farming practices which influence food availability. Factors such as these vary among regions and years and were not considered in this database.

The CWCTP-GIS will be updated annually following the Fall migration and distributed to State cooperators and Fish and Wildlife Service Ecological Services Field Offices in the Central Flyway. Contact information for these offices can be found at http://www.fws.gov. Federal regulatory agencies and project proponents should contact the appropriate Fish and Wildlife

* 4.8 km

Service for help in evaluating potential project impacts to the endangered whooping crane.

Abbreviations

BISON	Biodiversity Information Serving Our Nation
CWCTP	Cooperative Whooping Crane Tracking Project
ESA	Endangered Species Act
FOTWW	Friends of the Wild Whoopers
MOU	memorandum of understanding
NWK	US Army Corps of Engineers Kansas City District
NWR	National Wildlife Refuge
NWT	US Army Corps of Engineers Tulsa District
OMP	operational management plan
SWF	US Army Corps of Engineers Fort Worth District
SWG	US Army Corps of Engineers Galveston District
USACE	US Army Corps of Engineers
USFWS	US Fish and Wildlife Service
USGS	US Geological Survey
WHCR	whooping cranes

REPORT DOCUMENTATION PAGE

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14. ABSTRACT
This technical report summarizes the use of US Army Corps of Engineers (USACE) reservoirs as spring and fall migration stopover sites for the endangered Aransas–Wood Buffalo population of whooping cranes (WHCR), which proved much greater than previously known. We assessed stopover use within the migration flyway with satellite transmitter data on 68 WHCR during 2009–2018 from a study by the US Geological Survey (USGS) and collaborators, resulting in over 165,000 location records, supplemented by incidental observations from the US Fish and Wildlife Service (USFWS) and the USGS Biodiversity Information Serving Our Nation (BISON) databases. Significant stopover use was observed during both spring and fall migration, and one reservoir served as a wintering location in multiple years. Future efforts should include (a) continued monitoring for WHCR at USACE reservoirs within the flyway; (b) reservoir-specific management plans at all projects with significant WHCR stopover; (c) a USACE-specific and range-wide Endangered Species Act Section 7(a)(1) conservation plan that specifies proactive conservation actions; (d) habitat management plans that include potential pool-level modifications during spring and fall to optimize stopover habitat conditions; and (e) continued evaluation of habitat conditions at USACE reservoirs.

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