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Abstract: Reintroduction of an Eastern Migratory Population (EMP) of whooping cranes (*Grus americana*) in the United States by release of captive-reared individuals began in 2001. As of 2020, the EMP has approximately 21 breeding pairs and has had limited recruitment of wild-hatched individuals, thus captive-reared juveniles continue to be released into breeding areas in Wisconsin to maintain the population. We investigated the effects of release techniques on survival, behavior, site fidelity, and conspecific associations of 42 captive-parent-reared whooping cranes released during 2013-2019 into the EMP. Individuals were monitored intensively post-release, then as a part of a long-term monitoring program, locational, behavioral, and habitat use data were collected and analyzed. Most cranes roosted in water post-release; however, we documented 4 parent-reared cranes roosting on dry land. Most cranes eventually associated with other whooping cranes; however, juveniles released near single adult cranes were less likely to associate with other whooping cranes during their first migration or winter than juveniles released near other types of whooping crane pairs or groups. Parent-reared and costume-reared whooping cranes had similar rates of survival 1 year post-release (69.0% and 64.4%, respectively). The highest risk of mortality was within the first 100 days post-release, and the leading known causes of death were predation and impact trauma due to powerline or vehicle collisions. Both costume- and parent-reared cranes had strong fidelity to release sites. We advise releasing parent-reared cranes near pairs or groups of whooping cranes and taking measures to reduce the risk of mortality during the immediate period after release (e.g., predator aversion training, marking powerlines).

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Key words: behavior, captive-rearing, conspecific association, *Grus americana*, migration, parent-rearing, reintroduction, release technique, survival, whooping crane, Wisconsin.

Captive-reared whooping cranes (*Grus americana*) have been released since 2001 into the Eastern Migratory Population (EMP) in the historic range of the species where they had previously been extirpated (Canadian Wildlife Service [CWS] and U.S. Fish and Wildlife Service [USFWS] 2005). The Whooping Crane Eastern Partnership (WCEP) is a group of governmental, academic, and non-governmental organizations committed to the reintroduction of whooping cranes in the EMP. WCEP personnel have used a variety of rearing, release, and management techniques over the course of this 20-year effort (Urbanek et al. 2014, Thompson et al. 2022). The EMP must consist of at least 100 individuals, 25 breeding pairs, and be self-sustaining in order to meet the U.S. Fish and Wildlife Service criteria as an additional population of whooping cranes in the wild and ultimately contribute to the downlisting of this endangered species (CWS and USFWS 2005). As of December 2020, the EMP was made up of approximately 80 whooping cranes, most of which spend the breeding season in Wisconsin and winter in various locations across the southeastern U.S. from southern Indiana to Florida (WCEP 2020*b*). There were at least 21 breeding pairs and the EMP had some recruitment of wild-hatched individuals but was not yet self-sustaining (WCEP 2019*a*, WCEP 2019*b*, WCEP 2020*a*). Low recruitment rates remained a challenge to the success of this population. From 2006 through 2020, a total of 153 chicks are known to have hatched in the wild, but only 27 have survived to fledging (Thompson et al. 2022).

One hypothesis is that the captive-rearing process is influencing the behavior of whooping crane parents and hindering their ability to raise and protect wild-hatched chicks. Both costume- and parent-reared whooping cranes have been released in the EMP. During 2001-2015, most cranes in the EMP were costume-reared, in which humans in whooping crane costumes raise chicks (Wellington et al. 1996, Hartup 2019). In 2013, WCEP

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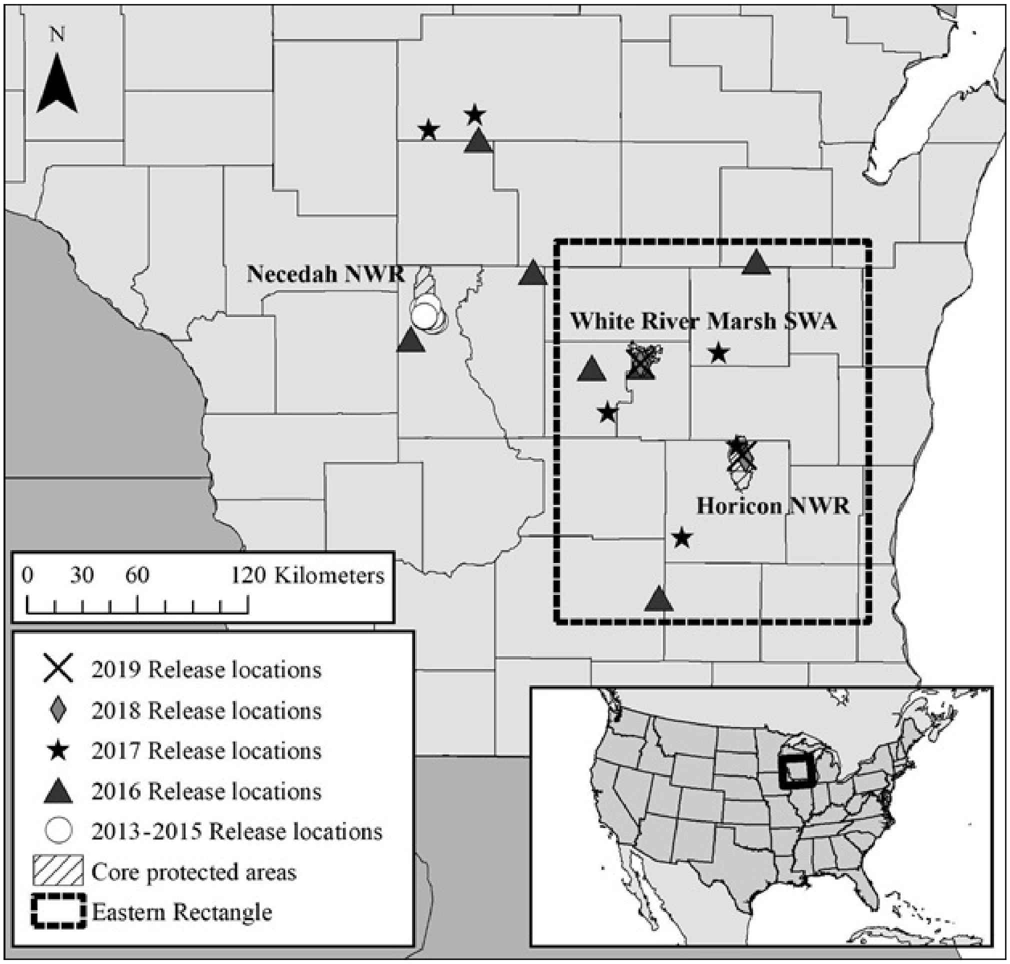

Figure 1. Release areas of parent-reared whooping cranes in the Eastern Migratory Population used during 2013-2019 in southern Wisconsin. Core protected areas are from west to east: Necedah National Wildlife Refuge (NWR), White River Marsh State Wildlife Area (SWA), and Horicon NWR. One additional release in southwestern Indiana in fall 2019 is not shown. Parent-reared whooping cranes were released at White River Marsh SWA during 2016-2019 and at Horicon NWR during 2017-2019.

partners began using parent-rearing techniques, in which captive whooping cranes parent or foster-parent chicks (Wellington et al. 1996, Hartup 2019, Olsen and Converse 2018). If costume-reared cranes did not learn the same behaviors as parent-reared cranes in captivity prior to release and ultimately lacked appropriate parenting behavior as adults, this could contribute to low reproductive success in the EMP (Converse et al. 2019). Ellis et al. (1999) examined the effects of captive-rearing methods by comparing the survival rates of costume- and parent-reared Mississippi sandhill cranes (*Grus canadensis pulla*) released in groups. Costume-reared Mississippi sandhill cranes released in a mixed cohort with parent-reared cranes had higher survival rates than parent-reared cranes within the mixed cohorts, as well as cranes released in parent-reared-only or costume-reared-only cohorts. In the same study costume-reared sandhill cranes released in non-mixed groups also survived better than parent-reared cranes released in non-mixed groups. In a summary of post-release survival of captive-reared sandhill cranes by Nagendran et al. (1996), 53.4% of parent-reared cranes survived through migration or for 1 year, compared to 28.9% of hand-reared cranes, and 83.1% of costume-reared cranes. However, there has not been a formal evaluation of the effects of rearing technique on reproductive success for Mississippi sandhill cranes.

Due to concerns about the potential effects of costume-rearing on the population's breeding success, WCEP has focused on releasing parent-reared whooping cranes into the EMP since 2016 (Fasbender et al. 2015, Converse et al. 2019). However, the potential effects of release techniques on parent-reared whooping cranes have not been assessed. For whooping cranes to become reproductive members of the EMP, they must first reach maturity, associate and eventually pair with other whooping cranes, and demonstrate appropriate behaviors in the wild (e.g., foraging, vigilance, habitat selection, migration). This study investigates the effects of release techniques on the short-term survival, behavior, site fidelity, and conspecific associations of parent-reared whooping cranes in the EMP released during 2013-2019. We also present preliminary comparisons of post-release measures of success (survival rates, return rates, breeding success) with costume-reared whooping cranes released during the same time frame (2013-2017).

STUDY AREA

Releases of parent-reared whooping cranes in the EMP were within the state of Wisconsin and on protected public or private lands with suitable habitat either for roosting, foraging, or both. During 2013-2015, all parent-reared cranes were released at Necedah National Wildlife Refuge (NWR) in Juneau County, Wisconsin (Fig. 1). Release sites at Necedah NWR were either in emergent marshes or adjacent to the marsh, all of which were within established whooping crane breeding territories. After 2015, releases of parent-reared cranes were conducted outside of Necedah NWR with a concentration in eastern Wisconsin in a region referred to as the Eastern Rectangle (Fig. 1). The Eastern Rectangle was chosen as a release area due to smaller populations of detrimental ornithophilic black flies (*Simulium* spp., associated with nest abandonment) than found at Necedah NWR and the presence of expansive areas of emergent wetland (Van Schmidt et al. 2014, Adler et al. 2019). The Eastern Rectangle is a very large area covering most of eastern and central Wisconsin, within which 7 sites were sampled for black flies (Adler et al. 2019). Protected areas in the Eastern Rectangle included Horicon NWR, which was sampled for black flies, and White River Marsh State Wildlife Area (WRM), which was not sampled (Adler et al. 2019). During 2013-2017, all costume-reared whooping cranes were released at Horicon NWR or WRM. Here we will refer to Necedah NWR and the Eastern Rectangle as the "core areas" where most cranes were released (Fig. 1). Wisconsin counties where parent-reared juveniles were released were Marathon, Juneau, Adams, Marquette, Green Lake, Outagamie, Wood, Winnebago, Dodge, and Dane. Release sites outside of Necedah NWR were also in whooping crane territories in a variety of upland (agricultural or grassland) and wetland habitats (emergent vegetation, mud flats, or forested wetlands). The release of 1 juvenile (no. 80-19) in 2019 was delayed due to an injury in captivity. When the injury had healed, most whooping cranes had already left Wisconsin, and no. 80-19 was released in an emergent marsh roost site on the wintering grounds of adult whooping cranes at Goose Pond Fish and Wildlife Area in Greene County, Indiana (see below).

METHODS

Whooping Crane Rearing and Release Techniques

Parent-reared whooping cranes in the EMP were reared in breeding centers by adult whooping cranes that acted as foster parents or that hatched and reared chicks from their own eggs. During 2013-2015, all juveniles were reared at the U.S. Geological Survey (USGS) Eastern Ecological Science Center (formerly Patuxent Wildlife Research Center [PWRC]), Laurel, Maryland (Hartup 2019). During 2016-2017, juveniles were reared at either PWRC or the International Crane Foundation (ICF) in Baraboo, Wisconsin. In 2018-2019, juveniles were reared at ICF, the Calgary Zoo in Alberta, Canada, and White Oak Conservation in Yulee, Florida. No parent-reared cranes were released during 2020 due to constraints on breeding centers related to the human coronavirus (COVID-19) pandemic. Breeding centers have slightly different facilities, protocols, and procedures for raising parent-reared cranes, which were not assessed in this study. Captive adult cranes that acted as foster parents were chosen based on their previous ability to raise chicks. If the pair was currently incubating an egg, aviculturists would either let the pair hatch the egg or replace the egg with a pipped egg and let the pair hatch and raise the resulting chick (Wellington et al. 1996). If the pair was not incubating, a young chick may have been introduced to the adult(s); however, this method was only used once and has a higher risk of mortality for the chick or of the adoption not being successful (Wellington et al. 1996).

With the exception of 2 birds released during spring as 1-year-olds (see below), once parent-reared juveniles had reached at least 101 days ($\bar{x} = 121.1 \pm 2.0$ days) and had the ability to fly, they were separated from the foster parents. Parent-reared juveniles were then transported to release areas and released during fall (25 Aug - 16 Nov) near adult whooping cranes. All juveniles were released in proximity to adult whooping cranes to encourage interaction and migration with older birds. Juveniles were released as early as possible after they were able to fly to maximize time on the breeding grounds to acclimate and build flight muscles prior to migration.

The WCEP used a structured decision-making framework (SDM) to determine the details of the releases of parent-reared whooping cranes during 2016-2019 (Converse 2016, WCEP 2017). The SDM was developed during 2016 after the initial parent-reared releases at Necedah NWR during 2013-2015. The SDM prioritized the type of target adult whooping crane(s) near which to release juveniles, site characteristics, and other release techniques. One component of the SDM was whether the release was "hard" or "soft". Hard release refers to the abrupt release of birds, directly into the release site. Soft release refers to situations when individuals were held in an outdoor enclosure set up in the release area to allow acclimation to the environment before full release. In this case, a temporary acclimation pen was set up in a release area with food provided to supplement available natural foods until the doors of the pen were opened and the cranes were free to walk out. During 2013-2016, cranes were kept in soft-release pens for 1-10 days before release (Olsen and Converse 2016, WCEP 2017, Olsen and Converse 2018, WCEP 2018*a*). No soft-release pens were used in 2017-2019 (with 1 exception, see unique releases below). Cranes were not reared in the pens as described by Hartup (2019), but the pens were used temporarily to allow acclimatization prior to release.

The SDM framework also considered characteristics of the target bird(s) and the number of individuals to release in the same area. In order of priority, juvenile cranes were released near a breeding pair, non-breeding pair, juvenile group, or single adult whooping crane(s). Release areas in the Eastern Rectangle (Fig. 1) were prioritized over areas outside of core areas, and the lowest priority option was a release within the refuge boundaries of Necedah NWR. Lastly, the SDM framework also prioritized releasing 1 juvenile at each release site, and if there were not enough release site options, or if a released juvenile did not associate with the target pair, a second juvenile could be released in the same area. In some cases, 2 juveniles were released together, and in others a second juvenile was released in an area with a previously released juvenile. We released 3 juveniles at the same location in 2016 due to a limited number of release site options. Breeding centers did not socialize the juveniles together prior to their transport to release areas. Although not outlined in the SDM framework, during 2017-2019 WCEP prioritized releases at roosting areas of the target bird(s) due to concerns about juveniles not following adults from foraging areas to roosting areas and juveniles roosting in non-suitable upland habitats in 2016.

Costume-reared whooping cranes hatched at captive breeding centers and were transferred to Horicon NWR (2013, 2015) or WRM (2013-2015, 2017) as pre-fledged chicks. After fledging, costume-reared juveniles were either released during fall near other whooping cranes in a program called Direct Autumn Release (DAR; 2013, 2015, 2017) or were led south by ultralight aircraft (UL; 2013-2015) and were released on the wintering grounds at St. Marks NWR in Wakulla County, Florida (Thompson et al. 2022). More detailed descriptions of costume-rearing and release techniques can be found in Duff (2019), Hartup (2019), and Urbanek et al. (2010).

Unique Releases

During 2018-2019, there were 3 releases of parent-reared whooping cranes that did not follow the normal rearing and release techniques. One pair of juveniles (73-18 and 74-18) was released in fall 2018 with their parents, 1 of which had not previously been released (female 18-12). The adult male of this family group (16-11) was released at Horicon NWR in fall 2011. He established a territory but did not find a whooping crane mate. Instead, he nested in multiple years with a female sandhill crane. In an attempt to "re-pair" him with a whooping crane mate, he was captured and brought back into captivity in 2016. He and an adult female were socialized in a large enclosure at White Oak Conservation in Yulee, Florida. During spring 2018, they nested and hatched and reared 2 chicks. In fall, all 4 birds were transported back to Horicon NWR, kept in an acclimation pen overnight, and released into the male's previous territory (WCEP 2018*a*). Unfortunately, the adult female died from emaciation within 30 days post-release (WCEP 2019*a*). There was no other target pair of adults at the release site for the 2 juveniles; however, they did migrate and winter with their male parent.

The second unconventional release was of 2 parent-reared cranes from the 2018 cohort, which were released as 1-year-olds in spring 2019. These 2 juveniles hatched and were reared according to normal parent-rearing techniques at the Calgary Zoo. However, due to transportation difficulties crossing the international border, they were not released in fall 2018 with the rest of the cohort but were released in spring 2019. They were kept in a soft-release pen for 14 days and released at Horicon NWR, Dodge County, Wisconsin USA. There was no specific target pair in the release area; however, there were at least 3 adult whooping cranes on the refuge at the time of release. Although they were hatched in 2018, these 2 juveniles (75-18 and 78-18) are considered part of the 2019 release cohort.

Lastly, 1 of the parent-reared juveniles slated for release in fall 2019 (80-19) sustained a bill injury prior to her release. Her release was postponed until she received veterinary clearance as her bill appeared to be healing normally. When the decision was made to release her, most whooping cranes had already migrated, so she was released on the wintering grounds of a group of adult whooping cranes at Goose Pond Fish and Wildlife Area in Greene County, Indiana, in November 2019.

Long-term Monitoring

Each whooping crane in the EMP, except 3 wild-hatched birds which have not been captured, was identified by a unique combination of colored legs bands, VHF, and sometimes a GPS transmitter (platform transmitting terminal or cellular transmitter; Urbanek 2018). WCEP personnel captured and marked wild-hatched birds when they were close to fledging or post-fledging and marked captive-reared birds prior to release. The unique identifiers facilitated re-sighting of individuals and aided in monitoring of the population. Sightings by WCEP members, volunteers, and the public were collected throughout the year and entered into a long-term database for WCEP. Individuals fitted with a VHF radio transmitter can be tracked using radio telemetry from the ground or with aerial surveys, while cranes with a GPS transmitter can be tracked remotely. Individual cranes, pairs, and family groups were monitored throughout the year by using these methods. If an individual was not seen in a typical area or with birds with which it had previously associated, or if GPS or VHF signals indicated a lack of movement, attempts were made to observe the bird and confirm if it was alive and healthy. When a mortality was known or suspected, WCEP personnel attempted to collect the carcass as soon as possible, record location and site characteristics, and estimate date of death. Carcasses in good condition were then submitted to the USGS National Wildlife Health Center for necropsy. Most carcasses were collected within a week (15 of the 24 confirmed mortalities) of a suspected mortality event, although there was some variability due to either an inability to find the carcass or difficulties accessing the area.

Behavior Data Collection

During 2013-2015, parent-reared juveniles were monitored by USGS staff post-release (Olsen and Converse 2018), a variety of WCEP personnel collected post-release data in 2016 and 2017, and ICF staff monitored cranes post-release in 2018 and 2019. Here we focus on post-release behavioral data collected in 2017 and 2018. During this time frame, parent-reared juveniles were monitored intensively for an average of 8 days post-release. The initial intensive monitoring period involved recording a data point once per hour from the time of the bird's morning roost until evening roost. After this intensive period, for the following 8 days, typically we shortened the observation period to 1 roost point and a half day of monitoring, for example from AM roost until mid-day or from mid-day until PM roost. After approximately 2 weeks post-release, we would check on the juveniles at least twice per week until they migrated south.

The goal of post-release behavioral data collection was to inform any decisions made by WCEP to intervene or attempt to alter crane behaviors or habitat use. Every data point consisted of collecting a GPS location, either through visual observation or triangulating of the VHF signal using techniques described by Mech (1983). When a visual observation of the bird was possible, we recorded habitat type, behavior, and associations with adult target pair or other whooping or sandhill cranes (Table 1). We recorded data using the mobile application Survey123 for ArcGIS (Esri, Redlands, CA, USA), which allows creation of specific forms that can be filled out efficiently in the field and uploaded to a

Table 1. Habitat categories and behaviors recorded during observations of whooping cranes during 2013-2019. These categories are used by members of the Whooping Crane Eastern Partnership for the long-term monitoring database.

Habitat categories		Behaviors
General	Specific	
Aquatic Bed	Ag Field Plowed	Alert/Alarm Calling
Barren Land	Burn Area	Comfort–Agitated
Cultivated Crops	Corn Emergent	Comfort–Normal
Developed–High Intensity	Corn Germinated	Forage
Developed–Medium Intensity	Corn Stubble	Locomotion–Fly
Developed–Low Intensity	Cranberry Reservoir	Locomotion–Walk
Forest Deciduous	Cranberry Bed	Nest Building/Maintenance
Forest Evergreen	Ditch	Parenting–Brooding
Forest Mixed	Gravel Pit	Parenting–Incubating
Grassland/Herbaceous	Mud Flat	Parenting–Provisioning
Open Water	Other	Resting
Other	Peanut	Social–Copulation
Pasture	Riverine/Riverine Wetland	Social–Other
Shrubland	Road–Improved	Social–Threat
Unknown	Road/Dike–Unimproved	Social–Unison Calling
Wetland Emergent Herbaceous	Sewage Treatment	Unknown
Wetland Forested	Soy	
Wetland Scrub/Shrub	Unknown	

database in real time, reducing opportunity for human transcription error.

During 2016, when parent-reared cranes were released near foraging areas of target adults, there were a few instances in which the juveniles did not fly with the adults to their roost location. In 1 case, a juvenile was predated the day after release while roosting in upland habitat. This caused concerns about captive-reared juveniles' abilities to fly and choose appropriate roosting habitat, thus here we summarize observations of flight and roosting behavior. For the purposes of this study, short flights were considered circling and landing in same place, going to a different spot in same field, flying <1.6 km (1 mi) away or for <1 min and long flights were considered flying out of sight, ≥1.6 km away, or ≥1 min. We also recorded if cranes were roosting in water or on uplands. If the cranes were not visible at roost, we estimated their roost habitat by triangulating their VHF radio signal, then comparing the resulting GPS point with a satellite image to determine possible habitat. Observers also recorded behaviors such as comfort, which included times of non-vigilance, lying down, sleeping, and preening; alert behaviors including times of vigilance; and social behaviors including any interactions with whooping cranes or sandhill cranes. The goal of behavioral data collection during the intensive monitoring period was not to compare behaviors between groups of birds, but simply to monitor for any inappropriate or potentially dangerous behaviors, such as roosting on dry land or using areas close to human development. Therefore, we did not conduct any analyses regarding behavioral data and only report observations used to inform management actions or interventions taken to change whooping crane behaviors.

WCEP partners decided to take intervening actions when inappropriate behaviors of parent-reared cranes were observed post-release. Interventions included flushing cranes from upland habitats after twilight to encourage roosting in water and flushing cranes off of roads. Additionally, based on observed behaviors post-release during 2016, some changes were made to the rearing and release processes in subsequent years, including increasing water exposure opportunities in an effort to encourage roosting in water while still in human care. Due to some individuals roosting on land during 2016 and therefore facing a higher risk of predation, we also exclusively released cranes near water in 2017-2019.

Data Analysis

Using the long-term monitoring data set, we summarized site fidelity, associations, and behaviors of each released parent-reared whooping crane in the EMP. We recorded if cranes returned to Wisconsin or to their general release area after their first winter to assess site fidelity. We considered juveniles to have returned to their release area after their first winter if they returned to the county where they were released at any point in their lives following their first winter. We used a combination of visual observations and locations from GPS transmitters and may have missed a crane returning to their exact release site. Therefore, we used the release county as a proxy, assuming if the crane returned to the general area, it could have also returned to the release site. A juvenile was considered to be associating with other cranes if they were visually observed in the same area and moving as a group or directly interacting in some way. We recorded if each crane was seen with the target pair at least 1 time, if they migrated with another whooping crane (target pair or otherwise), if they wintered with another whooping crane, if they were seen with another whooping crane at some point after their first winter, or if they were ever seen with another whooping crane at any point post-release. We also recorded if cranes migrated and wintered with sandhill cranes, whooping cranes, alone, or if they were never observed during migration or winter. For survival analyses, we recorded if individuals survived fall migration, their first winter, and their first year. For the comparisons of survival rates 1- and 3-years post-release for costume-reared and parent-reared whooping cranes, we considered the release date of UL cranes to be when they reached the wintering grounds, were in a pen with no top net, and could freely leave captivity. To calculate return rates of costume-reared cranes, we considered the release area to be where they were reared in Wisconsin (Horicon NWR or WRM).

We assessed these measures of post-release "success" (site fidelity, associations, and survival) in relation to characteristics of the individual's release. Release characteristics were the release type (hard vs. soft), the region in which they were released (Necedah NWR, the Eastern Rectangle, or outside core areas), the number of cranes released together (1, 2, or 3), if they were released into the target pair's roosting or foraging area, the status of the target bird(s) (breeding pair, non-breeding pair, juvenile group, single adult), the sex of the released individual, and the age at which they were released (days). The releases of cranes during 2013-2015 were before the SDM process or the decision to prioritize releases at roosting areas over foraging areas of target birds. These cohorts were released within breeding territories of adult cranes at Necedah NWR but were not specifically released on roosting or foraging areas of the pairs, and were not included in our analyses of release areas (roosting vs. foraging).

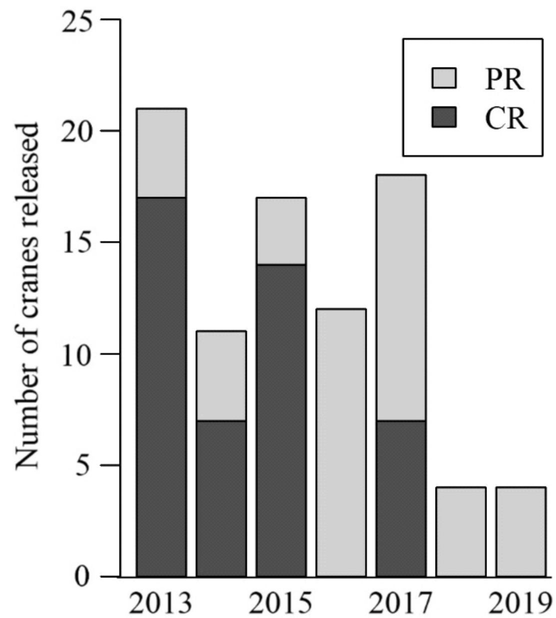

Figure 2. The number of parent-reared (PR) and costume-reared (CR) whooping cranes released in the Eastern Migratory Population, 2013-2019.

In the case of the unique releases or cranes that died before 1 year post-release, we excluded them from some analyses if they were not relevant. For example, we excluded from target-bird analyses that assessed target bird(s) characteristics the 2 juveniles that were released with their parents and the 2 hatch-year 2018 birds released as 1-year-olds that were not released near other whooping cranes. Similarly, the juvenile (80-19) released on the wintering grounds in Indiana in 2019 was not included in any of our analyses assessing fall migration survival or conspecific associations during fall. We did include 80-19 in the analysis of the effect of release region on juveniles interacting with target bird(s) at least 1 time and during winter; the release area in Indiana was considered outside of core areas. We also did not include birds in specific analyses if we could not confirm outcomes of their release. For example,

Table 2. Survival and reproductive behavior of parent-reared cohorts of whooping cranes released during 2013-2019 in the Eastern Migratory Population. Values are numbers of cranes.

Year released	Released (male/ female)	Survived					Paired	Nested	Hatched chicks	Alive as of Dec 2020
		First fall migration	First winter	First spring migration	1 year post-release	3 years post-release				
2013	4 (2/2)	2	2	2	2	1	0	0	0	0
2014	4 (0/4)	3	3	3	3	2	3	3	2	1
2015	3 (2/1)	2	2	2	2	2	0	0	0	1
2016	12 (7/5)	9	8	8	8	3	2	2	0	3
2017	11 (4/7)	10	9	8	8	4	3	2	2	4
2018	4 (2/2)	3	3	3	3	NA	1	0	0	3
2019	4 (1/3)[a]	2[b]	3	3	3	NA	NA	NA	NA	2
Total	42 (18/24)	31[b]	30	29	29	12	9	7	4	14

[a]This includes 2 cranes hatched in 2018 that were released during spring 2019 as 1-year-olds.

[b]This does not include 80-19, which was released on the wintering grounds and did not complete a fall migration as a juvenile.

if a crane was never observed during winter, we did not include it in our analyses of conspecific attraction during winter.

All of our statistical analyses were done using R version 3.6.0 (R Core Team 2019). We used a series of Pearson's Chi-squared tests, ANOVA, and Welch's 2-sample *t*-tests to assess the effects of release techniques, rearing techniques (costume- or parent-reared), and bird characteristics (sex and age) on the survival, site fidelity, and social associations of parent-reared whooping cranes in the EMP. We also used post-hoc chi-squared tests to do pairwise comparisons of groups using the 'pairwiseNominalIndependence' function in the 'rcompanion' package (Mangiafico 2019, R Core Team 2019). Our results reported here are mean values with associated standard error.

RESULTS

During 2013-2019, 42 parent-reared and 45 costume-reared juvenile whooping cranes were released into the EMP (Fig. 2, Appendix A). As of December 2020, 14 of the 42 released parent-reared cranes were alive, 9 were at least 3 years old, 9 paired (1 paired as a 2-yr-old), 7 nested, and 4 hatched chicks (Table 2). We deployed 42 VHF radio transmitters and 41 GPS transmitters on released parent-reared birds to monitor their movements post-release. Through a team of staff, volunteers, interns, and partner organizations, we collected a total of 5,383 visual observations of parent-reared whooping cranes during 2013-2020 (1-385 observations per individual), which we used here to assess behaviors, site fidelity, survival, and associations with other cranes. We collected 1,089 additional visual and locational data during intensive post-release monitoring periods during 2017-2018.

Conspecific Association

At least half (22 of 38, or 57.9%) of parent-reared juvenile whooping cranes released near adult whooping crane(s) were visually observed at least once in the same area as the target bird(s). Ten juveniles were never observed with the target bird(s) (26.3%), and 6 were not visible and we do not know if they ever associated with the target adult crane(s) (15.8%). Of the surviving cranes, at least 17 (56.7%) associated with at least 1 other whooping crane on their first southward migration in fall, and 23 (74.2%) associated with another whooping crane during their first winter. Most (26, 89.7%) of the parent-reared whooping cranes that survived at least 1 year post-release associated with another whooping crane at some point after their first winter. Of all of the parent-reared whooping cranes released into the EMP during 2013-2019, 38 birds (90.5%) associated with another whooping crane at some point in their lives since release, 1 bird (2.4%) was never seen with another whooping crane, and 3 birds (7.1%) were never visible to observers to determine if they associated with other cranes. The 3 birds that were not visible were in the

Table 3. Results (*P*-values) of ANOVAs, Pearson's Chi-squared tests, and Welch 2-sample *t*-tests assessing effects on post-release survival and associations of parent-reared juveniles and adult whooping cranes (WHCR) in the Eastern Migratory Population, 2013-2019. Whooping cranes were released at Necedah National Wildlife Refuge, outside core areas, or in the Eastern Rectangle, Wisconsin. *P*-values of less than 0.05 are considered significant and are in bold text. Sample size (*n*) for each test is listed in parentheses.

Release characteristic	Survived first fall migration	Survived first winter	Survived 1 year post-release	Observed at least once with target pair	Migrated with WHCR	Wintered with WHCR	Seen with WHCR after first winter
Target pair status	0.290 (37)	0.316 (38)	0.720 (38)	**0.022 (32)**	**0.029 (22)**	0.064 (28)	0.508 (26)
Release type (hard vs. soft)	0.408 (41)	0.406 (42)	0.665 (42)	0.225 (32)	0.158 (26)	0.260 (31)	1.000 (29)
Release area (foraging vs. roosting)	0.699 (26)	0.562 (27)	0.836 (27)	0.105 (26)	0.568 (16)	0.076 (21)	0.607 (19)
Release region	0.371 (41)	0.794 (42)	0.892 (42)	**0.015 (32)**	0.528 (26)	0.051 (31)	0.245 (29)
Number of birds released together	0.777 (41)	0.924 (42)	0.994 (42)	0.158 (32)	0.106 (26)	0.578 (31)	0.848 (29)
Sex of released bird	0.166 (41)	0.257 (42)	0.162 (42)	0.501 (32)	0.410 (26)	0.761 (31)	1.000 (29)
Age at release	0.570 (41)	0.758 (42)	0.766 (42)	0.876 (32)	0.237 (26)	0.409 (31)	0.594 (29)

vicinity of other whooping cranes; however, we could not confirm if they associated with each other.

The status of the target whooping crane(s) near which juveniles were released had the largest effect on whether released birds associated with adult whooping cranes (χ^2_3 = 9.6 and *P* = 0.022 for association with target pair at least 1 time; χ^2_2 = 7.1 and *P* = 0.029 for association with a whooping crane on migration; Table 3). Fewer juveniles released near single adults associated with other whooping cranes during their first migration than did juveniles released near breeding pairs, non-breeding pairs, or juvenile groups; however, pairwise comparisons were not significant, likely due to small sample sizes (*P* > 0.05 for all pairwise comparisons, Table 3). Juveniles released near single adults were also less likely to ever be seen with the target bird than juveniles released near breeding or non-breeding pairs (Table 3, *P* = 0.049 and 0.026 for the comparison of single adult to breeding and non-breeding pairs as the target bird(s), respectively; *P* > 0.05 for all other pairwise comparisons). There was no difference in the associations of juveniles with adult whooping cranes after their first southward migration between birds released near different types of target bird(s) (*P* > 0.05 for associations during and after their first winter, Table 3).

Juvenile whooping cranes released outside of core areas (outside both Necedah NWR and the Eastern Rectangle) were more likely to associate at least once with the target bird(s) than cranes released in the Eastern Rectangle (χ^2_2 = 8.4 and *P* = 0.015 for the effect of region on association, *P* = 0.013 for the pairwise comparison between outside core areas and in the Eastern Rectangle, Table 3). However, there was no difference in the likelihood of cranes to associate at least once with the target bird(s) between cranes released at Necedah NWR and either of the other release regions (*P* > 0.05 for both pairwise comparisons). Additionally, there was no effect of release region on whether juveniles migrated or wintered with adult cranes or associated with them after their first winter (*P* > 0.05 for all comparisons). Lastly, release type, sex of the juvenile, age at release, whether they were released into a roosting or foraging area, and the number of juveniles released together had no influence on conspecific associations (*P* > 0.05 for all comparisons, Table 3). Sample sizes for all comparisons are relatively small and may affect some of these results (Table 3).

Post-release Behavior

During the intensive monitoring periods post-release and before migration, the 15 parent-reared birds released in 2017 and 2018 were within sight of the observer during 44.4% (range 9-88%) of all monitoring periods per bird. Fourteen of the 15 parent-reared juvenile whooping cranes released in 2017 and 2018 were observed flying before migration. About half (51.7%) of these documented flights were short. Long flights were observed in 23% of documented flights, and the remaining observations did not specify a flight length. Of the 18 long flights observed, 9 were within 4 days post-release, 8 long flights were observed 5-8 days post-release, and 1 additional long flight was observed 14 days post-release.

Twelve of the 15 juveniles were monitored during roosting time to determine if they were in water. Eight juveniles were visually confirmed at least once to be roosting in water and the other 4 were assumed to be in water at least once when their triangulated location was in wetland habitat. There was 1 instance of a juvenile visually observed to be roosting on a mudflat and 4 juveniles were visually observed at least once to be roosting on upland habitat and not in water. Three juveniles were observed roosting on dry land within 4 days post-release and 1 juvenile was roosting on dry land 9 days post-release. In some cases, when juveniles were observed roosting on dry land they were flushed to encourage them to move into the marsh; however, this intervention did not always result in the desired movement and birds sometimes continued to roost in uplands. All 4 birds eventually roosted in water at the release sites prior to migration. During 2017-2018, no mortalities occurred while cranes were roosting on dry land.

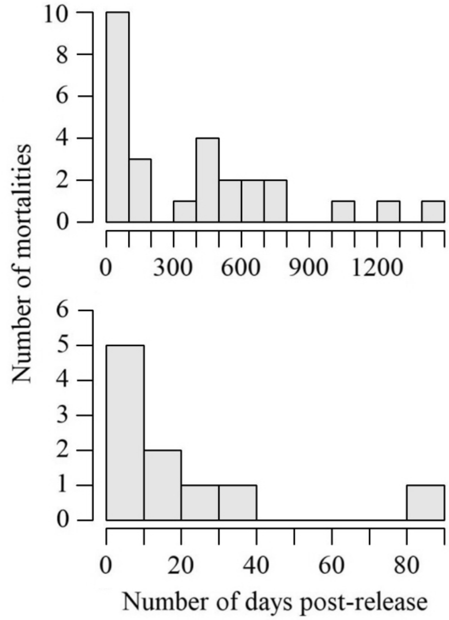

Figure 3. The number of days after release of confirmed mortalities of all (top) parent-reared whooping cranes in the Eastern Migratory Population, 2013-2020, and confirmed mortalities of cranes within 100 days post-release (bottom).

Site Fidelity

Of the 29 birds that survived through their first northward migration in spring, 28 birds (96.6%) returned to Wisconsin and 22 birds (75.8%) returned to the county in which they were released. Of the 22 birds that returned to their release county, 20 were documented at the release site, 1 returned to within 10 km, and 1 bird was within 30 km. None of the release characteristics, nor sex of the bird or age at release affected if cranes ever returned to the county in which they were released, or if they returned to Wisconsin ($P > 0.05$ for all comparisons). This is likely due to high return rates of cranes to Wisconsin and their release county. The 1 crane that did not return to Wisconsin (70-16) was originally released in Wisconsin but was then translocated south to Wheeler National Wildlife Refuge in Alabama in fall due to a lack of migratory behavior when other cranes in the area had already migrated (Thompson et al. 2022). Male 70-16 presumably did not know the route back to Wisconsin the following spring and summered in Kentucky. One juvenile released in 2017 (38-17) did not migrate south during her first fall post-release and overwintered in Wisconsin with food provided by WCEP partners. During the next fall, 2018, 38-17 had begun associating with an adult male and migrated south with him that winter (Thompson et al. 2022).

Survival

We collected 24 carcasses from known mortalities and submitted 18 for necropsy. There were an additional 4 suspected mortalities, as indicated by repeated GPS locations in the same area without visual confirmation of the bird, or a lack of sightings in their normal summering and wintering areas; however, carcasses were not found. Ten of the 28 confirmed or suspected mortalities occurred within 100 days after the release of the individual, and 5 mortalities occurred within 10 days post-release (Fig. 3). Of the 24 known mortalities, we were able to determine a likely cause of death for 21 individuals, either based on necropsy results or conditions found at the mortality site during carcass collection (Table 4). The leading cause of death was predation (10 birds), followed by impact trauma (7 birds). Four birds died due to collision with a vehicle, and 3 mortalities were due to powerline collision. Lastly, 1 bird died due to electrocution from a powerline strike, 1 bird was euthanized due to an injury, 1 died from

Table 4. Known mortalities of parent-reared whooping cranes released in 2013-2019 in the Eastern Migratory Population. Date of death listed in italics was estimated; otherwise, date of death was known.

Crane ID[a]	Sex	Release date	Date last confirmed alive	Mortality date	Mortality location	Necropsy conducted	Cause of death
20-13	F	24 Sep 2013	9 Oct 13	*12 Oct 2013*	Juneau Co., Wis.	Yes	Likely predation
21-13	F	25 Sep 2013	1 Oct 2013	2 Oct 2013	Juneau Co., Wis.	Yes	Vehicle collision
22-13	M	25 Sep 2013	22 May 2015	*10 Sep 2015*	Juneau Co., Wis.	Yes	Likely predation
20-14	F	22 Sep 2014	29 Jun 2017	*3 Jul 2017*	Juneau Co., Wis.	Yes	Likely predation
21-14	F	22 Sep 2014	28 Sep 2014	*29 Sep 2014*	Juneau Co., Wis.	Yes	Impact trauma (possible vehicle collision)
16-15	M	21 Sep 2015	2 Oct 2015	6 Oct 2015	Juneau Co., Wis.	Yes	Predation
29-16	M	24 Sep 2016	15 Aug 2018	*17 Oct 2018*	Juneau Co., Wis.	No	Unknown
32-16	F	17 Sep 2016	17 Sep 2016	18 Sep 2016	Outagamie Co., Wis.	Yes	Likely predation
34-16	F	23 Sep 2016	6 Oct 2016	7 Oct 2016	Adams Co., Wis.	Yes	Predation
37-16	M	23 Sep 2016	15 Oct 2016	17 Oct 2016	Juneau Co., Wis.	Yes	Predation
38-16	M	20 Sep 2016	8 Mar 2017	8 Mar 2017	Poinsett Co., Ark.	No	Vehicle collision
39-16	M	24 Sep 2016	8 Aug 2018	*22 Aug 2018*	Adams Co., Wis.	No	Unknown
70-16	M	16 Nov 2016	4 Feb 2018	4 Feb 2018	Knox Co., Ky.	Yes	Injury and euthanized
71-16	F	30 Sep 2016	28 Mar 2018	*31 Aug 2018*	Winnebago Co., Wis.	No	Unknown
19-17	M	14 Sep 2017	7 May 2019	9 May 2019	Marathon Co., Wis.	Yes	Powerline collision
25-17	M	14 Sep 2017	18 Jan 2019	18 Jan 2019	Jackson Co., Ala.	No	Powerline collision injury then euthanasia
26-17	F	18 Sep 2017	3 Nov 2017	*25 Nov 2017*	Wabash Co., Ill.	No	Likely predation
30-17	F	5 Oct 2017	16 Feb 2018	*19 Apr 2018*	Lake Co., Ill.	Yes	Likely predation
36-17	F	9 Oct 2017	16 Nov 2018	19 Nov 2018	Wayne Co., Ky.	Yes	Vehicle collision
37-17	F	9 Oct 2017	8 Nov 2017	*13 Nov 2017*	Juneau Co., Wis.	Yes	Powerline collision
39-17	F	5 Oct 2017	7 Apr 2019	5 May 2019	Manitoulin District, Ont.	Yes	Gunshot
75-18	M	13 Jun 2019	21 Sep 2020	*29 Sep 2020*	Dodge Co., Wis.	Yes	Lead poisoning
76-18	F	2 Oct 2018	2 Oct 2018	*12 Oct 2018*	Green Lake Co., Wis.	Yes	Likely predation
78-18	F	13 Jun 2019	11 Nov 2019	*12 Nov 2019*	Woodford Co., Ill.	Yes	Electrocution due to powerline strike

[a] ID code is unique for each whooping crane. The first 2 digits are relative order within a hatching sequence, and the last 2 are the last 2 digits of hatch year.

lead poisoning, and 1 died from illegal gunshot. Three carcasses were collected after the body had decomposed too much to identify the cause or date of death. Of the 10 mortalities within the first 100 days post-release, 7 were due to predation, 2 were due vehicle collision, and 1 was due to powerline collision (Fig. 3, Table 4). Of the 5 mortalities within the first 10 days post-release, 3 were due to predation and 2 were due to vehicle collision (Table 4).

Of the 42 parent-reared cranes released in the EMP, 31 survived their first fall migration (75.6%, not including 1 crane released on the wintering grounds), 30 survived the first winter (71.4%), and 29 survived at least 1 year post-release (69.0%, Table 2). Of the 34 parent-reared cranes released 2013-2017, 12 have survived at least 3 years post-release (35.3%, Table 2). We did not find any influences of release characteristics (sex, age at release, target pair status, region of release, release type, release in roosting or foraging area, or the number of juveniles released together) on the probability individuals would survive their first fall migration, their first winter, or 1-year post-release ($P > 0.05$ for all tests, Table 3). Additionally, we did not find any effect of conspecific association on probability of survival ($P > 0.05$ for all comparisons). Thus, we found no evidence that the association of juvenile cranes with other whooping cranes premigration, during migration, or during their first winter, improved their chances of survival at these stages.

Costume-reared Whooping Cranes

As of December 2020, 18 of the 45 costume-reared cranes released during 2013-2017 were alive, all of which were at least 3 years old, 19 paired, 14 nested, and 8 hatched chicks. Of the 34 costume-reared birds that survived through their first northward migration in spring, 33 birds (97.1%) returned to Wisconsin and 28 birds (82.4%) returned to the county in which they were released. Costume-reared cranes returned to Wisconsin

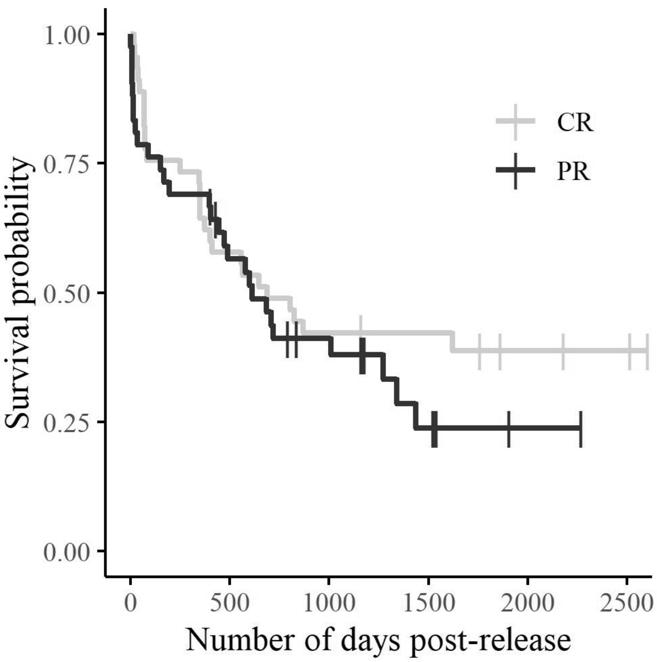

Figure 4. Survival probabilities of parent-reared (PR, *n* = 42) and costume-reared (CR, *n* = 45) whooping cranes released in the Eastern Migratory Population, 2013-2019. Vertical bars along the survival curves indicate ages of cranes that were alive as of December 2020.

or to their release county at similar rates as parent-reared cranes ($\chi^2_1 = 0.000$ and $P > 0.005$, $\chi^2_1 = 0.000$ and $P > 0.005$, respectively). Of the 28 birds that returned to their release county, 26 were documented at the release site, and 2 birds were within 40 km. Of the 45 costume-reared cranes released in the EMP, 24 were DAR birds released in fall near other cranes, and 21 were UL cranes released on the wintering grounds. Sixteen DAR and 13 UL cranes survived at least 1 year post-release (26 total, 64.4%), and 12 DAR and 7 UL cranes survived at least 3 years post-release (19 total, 42.2%). There were no differences in survival rates at 1- and 3-years post-release between costume-reared and parent-reared whooping cranes ($\chi^2_2 = 2.9$ and $P = 0.235$, $\chi^2_1 = 0.242$ and $P = 0.623$, respectively; Fig. 4). For individuals released in 2013-2017 and that had survived at least 3 years post-release by 2020, costume-reared and parent-reared whooping cranes were equally likely to have paired ($\chi^2_1 = 2.49$, $P = 0.114$), to nest ($\chi^2_1 = 0.916$ and $P = 0.339$), or hatch chicks ($\chi^2_1 = 0.341$ and $P = 0.559$).

DISCUSSION

The objective of this study was to investigate the effects of release techniques on survival, behavior, site fidelity, and conspecific associations of parent-reared juvenile whooping cranes in the EMP. The techniques and suggestions presented here can serve managers involved in reintroduction programs of cranes or possibly other taxa. Most cranes exhibited normal behaviors post-release, including flying and roosting in water. We documented a few instances of cranes roosting on dry land, thus we suggest continued presence of ponds in all captive enclosures, releases at wetland roost sites, as well as post-release monitoring to potentially flush birds from upland areas in an attempt to encourage roosting in water.

Overall, most parent-reared cranes exhibited site fidelity and returned to their release area or at least somewhere in Wisconsin. None of the release techniques had an effect on short-term survival or site fidelity in this study. Site fidelity is potentially important for promoting pair formations (van Heezik et al. 2009, Nagata and Yamagishi 2016) since the majority of the EMP summers in central Wisconsin, near the release sites. Additionally, most parent-reared cranes associated with other whooping cranes at some point in their life, even if they were never seen with the target bird(s) near which they were released, which could also have potential implications for pairing and reproduction (Servanty et al. 2014). In this study, conspecific associations were affected by target bird(s) status and release region. Cranes released near single adults were less likely to associate with conspecifics, therefore future releases could focus on breeding pairs, non-breeding pairs, or juvenile groups as target birds. However, these results are based on small sample sizes and these effects should be re-evaluated once more parent-reared cranes have been released into the EMP.

Costume-reared whooping cranes in the EMP exhibited similar rates of survival as parent-reared cranes released during 2013-2019. Survival rates 1 year post-release of costume-reared cranes (64.4%) and parent-reared cranes (69.0%) in this study were comparable or higher than those of captive-reared whooping cranes released in the Florida Nonmigratory Population (FNMP; 45.5% for costume-reared cranes, 25% for parent-reared cranes, Nesbitt et al. 1997; 50%, Nesbitt et al. 2001; 55%, Kreger et al. 2006) and comparable to Mississippi sandhill cranes (80%, Ellis et al. 1999; 77% for costume-reared cranes, 68% for parent-reared cranes, Ellis et al. 2001). Previous studies of cranes have found mixed results on the effect of rearing technique on post-release survival (Nagendran et al. 1996, Hartup 2019). Greater sandhill cranes foster-reared in the wild by Florida sandhill cranes had lower survival rates (39%) than captive-reared cranes released in Florida (56%) (Nesbitt and Carpenter 1993). The latter cranes were parent-reared (S. Hereford, U.S. Fish and Wildlife Service, personal communication). Ellis et al. (1999) found costume-reared Mississippi sandhill cranes survived better than parent-reared cranes, whether in mixed or un-mixed cohorts. One possible explanation is that parent-reared sandhill cranes in this study had acclimated to motor vehicles and humans while in captivity and were less wary of humans or predators post-release (Ellis et al. 1999). Although costume-reared whooping cranes had slightly better survival rates than parent-reared cranes, rearing techniques did not significantly affect 1-year survival rates in the FNMP (Nesbitt et al. 1997, Kreger et al. 2006). However, parent-reared whooping cranes in Florida were in larger groups and were more vigilant post-release than costume-reared cranes, which may be an antipredator strategy that could ultimately affect survival or reproductive success (Kreger et al. 2005). Similar to our study, the highest rates of mortality in the FNMP were during the first month post-release (Nesbitt et al. 1997, Kreger et al. 2006). Both parent- and costume-reared whooping cranes in the EMP have paired and raised and fledged chicks as of 2020 (Thompson et al. 2022). Ultimately, the success of the population depends on successful breeding and rearing of young in the wild, so it will be important to continue to evaluate the effects of rearing and release techniques on reproductive success and chick survival rates.

The use of an acclimation pen and rearing techniques did not affect site fidelity of captive-reared whooping cranes in the EMP. Release pen type also did not affect site fidelity of whooping cranes in the FNMP (Nesbitt et al. 1997). Whooping cranes in the FNMP released from temporary pens rather than the permanent soft-release pen had better first-year survival rates (50.0% compared to 30.6%), although this may be attributed to differences in habitat quality at the pen sites (Nesbitt et al. 1997). Sandhill cranes released without the use of an acclimation pen tended to have low post-release survival rates and a lack of site fidelity (Nesbitt 1979, Drewien et al. 1982, Ellis et al. 1992). However, whooping cranes in the EMP had strong site fidelity and comparable survival rates regardless of release type (hard vs. soft) or rearing technique.

In order to reduce the risk of mortality in the first 100 days post-release, while cranes are acclimating to their surroundings, WCEP personnel could focus on the 2 main causes of death, predation and impact trauma. Approaches to reduce predation include reducing predator populations in release areas, releasing in areas with fewer predators, teaching antipredator response behaviors in captivity prior to release, or modifying habitat at release sites to increase visibility of predators or decrease predator use of the area. Predator removal has been used at Mississippi Sandhill Crane NWR, where a contracted hunter removed mammalian predators of cranes and crane nests, such as coyote (*Canis latrans*), bobcat (*Lynx rufus*), red fox (*Vulpes vulpes*), and raccoon (*Procyon lotor*) (Hereford and Dedrickson 2018, Woolley et al. 2022). Fledging rates for Mississippi sandhill cranes were higher when more bobcats were trapped on the refuge in the previous season (which was used as a proxy for bobcat population size), suggesting predation of chicks by bobcats affected fledging rates (Woolley et al. 2022). Large-scale predator removal in the EMP may not be feasible due to the expansive area in which cranes are released, but it could be examined further at specific breeding or release sites, as was done for bobcats at Chassahowitzka NWR, Citrus County, Florida, for UL cranes (Urbanek et al. 2010). Predator aversion training is a technique that has been used in reintroductions of other species (Griffin et al. 2000) but also has not been done on a large scale in the EMP. Mississippi sandhill cranes were taught antipredator response behaviors in captivity prior to release, and cranes learned the appropriate agonistic behaviors; however, after multiple exposures to the predator, the cranes became habituated (Howard et al. 2018). Howard et al. (2018) suggest it is possible for antipredator training to be effective, but there must be further examination of the importance of reinforcement of response behaviors over time, controlled exposure to predators, and possibly multiple trainings focused on different types of predators. Further studies could be done on predator populations near release sites, as well as habitat modifications that might limit predator use of the area or improve cranes' abilities to identify and respond to potential predators.

To reduce powerline or vehicle collisions, releases could occur in areas with a low density of roads or powerlines. Marking powerlines near release sites could also reduce collisions prior to migration (Brown and Drewien 1995, Barrientos et al. 2011, Murphy et al. 2016, Dwyer et al. 2019). To reduce vehicle collisions, "wildlife crossing" road signs could be put near release sites, local people could be informed of cranes in the area, and the possibility of conditioning cranes pre-release to avoid roads or vehicles could be explored (Proppe et al. 2017). Breeding centers may also consider ways in which to minimize vehicle or road noise near pen sites of captive-reared cranes.

The results of this study can be used to improve or inform reintroduction efforts with other species of cranes. Reintroduction programs for Siberian cranes (*Grus leucogeranus*), red-crowned cranes (*G. japonensis*), sarus cranes (*G. antigone*), white-naped cranes (*G. vipio*) (Davis 1998), Eurasian cranes (*G. grus*), sandhill cranes (Urbanek and Bookhout 1992, Nagendran et al. 1996, Ellis et al. 1999), and a Louisiana non-migratory population of whooping cranes (Zakaib 2011, Gomez 2014) have all released captive-reared individuals to bolster or establish wild populations. A multitude of rearing and release techniques have been used in these populations, and evaluations of all reintroduction techniques are important to make decisions about future reintroduction projects for cranes.

MANAGEMENT IMPLICATIONS

Based on data collected during this study, we have multiple suggestions to improve the releases of juvenile whooping cranes into the EMP. The status of the adult target pair affected conspecific associations; therefore, the first suggestion is that releases could focus on breeding pairs, non-breeding pairs, or juvenile groups rather than single adults as the target bird(s), to maximize the possibility of juveniles associating with other whooping cranes. Our second suggestion is to take preventative measures to reduce mortality in the first 100 days after release. Specifically, releasing in areas with low road and powerline densities could be done whenever possible. Additional measures such as educating the public about whooping cranes in the area, and predator and road aversion training while juveniles are in captivity could also be beneficial and should be explored further (Proppe et al. 2017, Howard et al. 2018, Griffin et al. 2000). As of December 2020, we have not seen major differences in survival or reproductive success between costume- and parent-reared whooping cranes in the EMP.

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Appendix A. Details of releases of all parent-reared whooping cranes in the Eastern Migratory Population, 2013-2019. All release counties are in Wisconsin unless otherwise specified.

Crane ID	Sex	Release date	Age at release (days)	Target bird(s) status	Release county	Region	Release area	Release type	Group size	Released with (ID)
20-13	F	24 Sep 2013	114	Breeding pair	Juneau	Necedah NWR	N/A[a]	Soft	1	
21-13	F	25 Sep 2013	114	Breeding pair	Juneau	Necedah NWR	N/A[a]	Soft	1	
22-13	M	25 Sep 2013	112	Breeding pair	Juneau	Necedah NWR	N/A[a]	Soft	1	
24-13	M	23 Sep 2013	105	Breeding pair	Juneau	Necedah NWR	N/A[a]	Soft	1	
19-14	F	23 Sep 2014	112	Breeding pair	Juneau	Necedah NWR	N/A[a]	Soft	1	
20-14	F	22 Sep 2014	109	Breeding pair	Juneau	Necedah NWR	N/A[a]	Soft	1	
21-14	F	22 Sep 2014	108	Breeding pair	Juneau	Necedah NWR	N/A[a]	Soft	1	
27-14	F	22 Sep 2014	101	Breeding pair	Juneau	Necedah NWR	N/A[a]	Soft	1	
14-15	F	21 Sep 2015	120	Breeding pair	Juneau	Necedah NWR	N/A[a]	Soft	1	
16-15	M	21 Sep 2015	119	Breeding pair	Juneau	Necedah NWR	N/A[a]	Soft	1	
20-15	M	21 Sep 2015	116	Breeding pair	Juneau	Necedah NWR	N/A[a]	Soft	1	
29-16	M	24 Sep 2016	134	Breeding pair	Adams	Outside core areas	Foraging	Soft	3	34-16, 39-16
30-16	M	23 Sep 2016	130	Non-breeding pair	Green Lake	Rectangle	Foraging	Hard	1	
31-16	M	22 Sep 2016	124	Non-breeding pair	Green Lake/ Marquette	Rectangle	Foraging	Soft	2	38-16
32-16	F	17 Sep 2016	115	Non-breeding pair	Outagamie	Rectangle	Foraging	Soft	1	
33-16	F	26 Sep 2016	121	Breeding pair	Juneau	Outside core areas	Foraging	Soft	2	37-16
34-16	F	23 Sep 2016	121	Breeding pair	Adams	Outside core areas	Foraging	Hard	3	29-16, 39-16
37-16	M	23 Sep 2016	118	Breeding pair	Juneau	Outside core areas	Foraging	Soft	2	33-16
38-16	M	20 Sep 2016	111	Non-breeding pair	Marquette	Rectangle	Foraging	Soft	2	31-16
39-16	M	24 Sep 2016	111	Breeding pair	Adams	Outside core areas	Foraging	Soft	3	29-16, 34-16
69-16	F	7 Oct 2016	139	Single bird	Jefferson	Rectangle	Foraging	Hard	1	
70-16	M	16 Nov 2016	174	Non-breeding pair	Wood	Outside core areas	Foraging	Hard	1	
71-16	F	30 Sep 2016	120	Non-breeding pair	Green Lake	Rectangle	Roosting	Hard	1	
19-17	M	14 Sep 2017	120	Non-breeding pair	Marathon	Outside core areas	Roosting	Hard	2	25-17
24-17	F	20 Sep 2017	124	Single bird	Dodge	Rectangle	Roosting	Hard	1	
25-17	M	14 Sep 2017	117	Non-breeding pair	Marathon	Outside core areas	Roosting	Hard	2	19-17
26-17	F	18 Sep 2017	120	Breeding pair	Marquette	Rectangle	Roosting	Hard	2	28-17
28-17	M	18 Sep 2017	118	Breeding pair	Marquette	Rectangle	Roosting	Hard	2	26-17
30-17	F	5 Oct 2017	132	Single bird	Winnebago	Rectangle	Roosting	Hard	1	
36-17	F	9 Oct 2017	123	Non-breeding pair	Marathon	Outside core areas	Roosting	Hard	2	37-17
37-17	F	9 Oct 2017	115	Non-breeding pair	Marathon	Outside core areas	Roosting	Hard	2	36-17
38-17	F	5 Oct 2017	109	Single bird	Dodge	Rectangle	Roosting	Hard	2	39-17
39-17	F	5 Oct 2017	105	Single bird	Dodge	Rectangle	Roosting	Hard	2	38-17
72-17	M	26 Sep 2017	126	Single bird	Winnebago	Rectangle	Roosting	Hard	1	
73-18	F	25 Aug 2018	121	N/A[b]	Dodge	Rectangle	N/A[b]	Soft	2	74-18, 16-11, 18-12
74-18	M	25 Aug 2018	119	N/A[b]	Dodge	Rectangle	N/A[b]	Soft	2	73-18 16-11, 18-12
76-18	F	2 Oct 2018	121	Non-breeding pair	Green Lake	Rectangle	Roosting	Hard	1	

Appendix A. Continued.

Crane ID	Sex	Release date	Age at release (days)	Target bird(s) status	Release county	Region	Release area	Release type	Group size	Released with (ID)
77-18	M	11 Oct 2018	128	Non-breeding pair	Green Lake	Rectangle	Roosting	Hard	1	
75-18	M	13 Jun 2019	378	N/A[c]	Dodge	Rectangle	N/A[c]	Soft	2	78-18
78-18	F	13 Jun 2019	366	N/A[c]	Dodge	Rectangle	N/A[c]	Soft	2	75-18
79-19	F	8 Oct 2019	129	Breeding pair	Green Lake	Rectangle	Roosting	Hard	1	
80-19	F	5 Nov 2019	149	Juvenile Group	Greene (Ind.)	Outside core areas (Ind.)	Roosting	Hard	1	

[a]Releases of parent-reared cranes during 2013-2015 were done prior to the structured decision-making process. Releases were done within territories of breeding pairs but were not specifically at a foraging or roosting site.

[b]Released with sibling and their parents and not near a target bird.

[c]Released together with cohort member as 1-yr-olds and not near a target bird.