MORTALITY OF FLEDGED WHOOPING CRANES IN THE ARANSAS-WOOD BUFFALO POPULATION

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Abstract: Maintaining accurate mortality records for endangered species is important for guiding management and conservation actions. Mortalities of whooping cranes (*Grus americana*) in the Aransas-Wood Buffalo Population (AWBP) are documented in published records from 1950 through 2010. This paper documents publicly available records of known mortalities from 2011 through 2023, and updates historic records from 1950 to 2010. Public sightings and telemetry carcass records were restricted to fledged whooping cranes from the AWBP and stratified by confirmed, suspected, and unknown causes across the annual range (i.e., summer, migration, and winter). This mortality update provides more certainty associated with available carcass data and reduces discrepancies in existing published information.

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Maintaining accurate mortality records for endangered species is important for guiding management and conservation actions. The whooping crane (*Grus americana*) was federally listed as endangered under the Endangered Species Preservation Act of 1966 (32 Federal Register 4001 [March 11, 1967]). Of the 4 non-captive whooping crane populations, only the Aransas-Wood Buffalo population (AWBP) is naturally occurring, self-sustaining, and protected as endangered. The AWBP of whooping cranes breeds in areas within and surrounding Wood Buffalo National Park (WBNP; Alberta/Northwest Territories, Canada), winters in areas within and surrounding Aransas National Wildlife Refuge (ANWR; along the Gulf Coast in Texas, USA) and migrates annually between the 2 geographic areas. The long-term annual growth rate of the AWBP has averaged 4.3% (n = 82 years; 95% confidence interval = 1.76-6.83) since the winter of 1941-42, and the population has increased to >500 individuals in 2023 (Butler et al. 2023) through targeted recovery efforts, such as protection and enhancement of breeding, migration, and wintering habitat (Canadian Wildlife Service [CWS] and U.S. Fish and Wildlife Service [USFWS] 2007). Long-lived species with low fecundity can be sensitive to changes in adult survivorship (Sæther and Bakke 2000, Masatomi et al. 2007, Wilson et al. 2016), and ~50% of the AWBP population growth variation is explained by variation in annual mortality (Butler et al. 2014).

Whooping crane mortalities in the AWBP have been documented since 1950 (Lewis et al. 1992). Stehn and Haralson-Strobel (2014) provided a comprehensive update to Lewis et al.'s (1992) summary of mortalities from 1950 to 1987 and updated recorded mortalities through 2010. Pearse et al. (2019) reviewed mortality patterns for cranes with satellite telemetry devices from 2010 through 2015. In this paper, we provide a comprehensive update of known mortalities from 2011 through 2023, and updates to historic records from 1950 through 2010 using publicly available documentation. This mortality update provides more certainty associated with available carcass data and reduces discrepancies in existing published information.

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METHODS

Verified mortalities in the form of public sightings and telemetry records for the AWBP were acquired from the USFWS, Environment and Climate Change Canada, and U.S. Geological Survey (USGS), and compared to published records (Stehn and Wassenich 2008, Stehn and Harlson-Strobel 2014, Pearse et al. 2019). We reviewed records and, when necessary to clarify data, confirmed information with alternative published sources (U.S. Department of Justice 2013*a*, *b*, 2023) and individuals known by us to be experienced with these mortality records (J. Jenniges, Nebraska Public Power District, personal communication). We restricted data to individuals that fledged and left the WBNP breeding grounds. Therefore, our methods differ from previous reports in that we do not include whooping cranes between hatching and displaying the ability to fly by leaving their natal area, which removes chicks from Stehn and Haralson-Strobel (2014) and pre-fledged juveniles from Pearse et al. (2019). Herein, we classify whooping cranes into 3 age classes. We classified whooping cranes less than 1 year old with brown contour feathers and the ability to fly as juveniles, which included the fledged juvenile age category from Pearse et al. (2019). Whooping cranes known from telemetry studies to be between 1 and 2 years of age with brown contour feathers were classified as subadults following Pearse et al. (2019). We categorized all other cranes with primarily white body plumage as adults, which included the white-plumaged age category from Stehn and Haralson-Strobel (2014).

Mortalities were categorized by season across the range: summer, fall migration, winter, and spring migration. Seasons were assigned based on time of year, carcass location, and, when applicable, migration behavioral patterns from Global Positioning System transmitters. During our review, no historical records were reassigned to a different season category from the original publication record. Summer season mortalities were those that occurred between May and October within the WBNP or ANWR (if the birds did not migrate), or, if the birds were telemetered, the northern point of annual locations. Fall migration mortalities were those happening between October and November and located within the flyway outside of wintering and summering grounds. If the birds were telemetered, fall migration was identified by southernly movements from summering grounds. Winter season mortalities were those that occurred between October and April within the ANWR, counties along the Gulf Coast of Texas, USA, or, if telemetered, remaining at a southern terminus for >3 weeks. Spring migration mortalities were those that occurred between April and June and located within the flyway outside of wintering and summering grounds. If the birds were telemetered, spring migration was identified by northerly movements from wintering grounds. Additionally, injuries reported as the proximal cause of death on a later date (e.g., died in captivity) were categorized as the season in which the injury was believed to have occurred based on the time and location the bird was found.

The scale of resolution for reported carcass location varied. Carcasses were reported by specific locations (e.g., ANWR, WBNP); by nearest city, county, or rural municipality; or by state, province, or territory. We provided the most specific confirmed location. For suspected mortalities, location refers to the last known location of the bird. Date of death for carcasses could not always be assigned based on the condition of the carcass; in these circumstances, we reported estimated month of death.

Cause of death for each mortality was based on necropsy information conducted by the Canadian Cooperative Wildlife Health Centre (Saskatoon, Saskatchewan, Canada), USGS National Wildlife Health Center (Madison, Wisconsin, USA), or USFWS Clark R. Bavin National Fish and Wildlife Forensics Laboratory (Ashland, Oregon, USA). Necropsy reports were not available for all birds; necropsies may not have been practical on carcass remains in poor condition or that were incomplete (e.g., bones and feathers only). In some instances, a necropsy was conducted, but the cause of death could not be determined due to the condition of the carcass. The term "unknown" was assigned when a cause of death was inconclusive or when a necropsy was not performed.

Cause of death categories were consolidated into the following groups: gunshot; trauma, which includes power line collision, aircraft collision, and trauma of unknown source; disease, which consolidated all etiologies; predation; other, in which mortalities were attributed to the causes other than the previous categories (i.e., capture myopathy, captivity stress, starvation, leg injury/exposure, trap); and unknown.

Details of the original cause of death from previous publications were added as a note to each mortality record. In a few cases, we recategorized the cause of death, when appropriate, based on additional details provided in the whooping crane tracking project public sightings database (Nebraska Ecological Services Field Office, USFWS, unpublished data) or necropsy reports (Clark R. Bavin National Fish and Wildlife Forensics Laboratory, USFWS, unpublished data) or to conform with our classifications. When previous publications or mortality records indicated a specific cause of death to be "likely" or "possible," we recategorized as confirmed or unknown depending on the level of detail provided. Additionally, suspected mortalities based on circumstantial evidence were separated from confirmed mortalities where a carcass was recovered to differentiate these records.

During our review, we corrected data discrepancies among previous publications or from the original data source (e.g., date of death) and adjusted terminology for consistency in the reported data. We tracked which details were updated so that our work can be compared to previous publications. When necessary, we provided additional comments on the cause of death from published reports to provide further clarification in cause of death designations.

RESULTS

From 1950 through 2023, 69 whooping crane mortalities were confirmed across the AWBP range, of which ~35% (n = 24) were telemetered cranes. Cause of death was determined for ~67% of the confirmed mortalities (n = 46; Table 1). Of the deaths with known causes, the primary causes of death reported were gunshot (32.6%, n = 15) and trauma (n = 15), which was composed of collisions with power lines (21.7%, n = 10), unknown source of trauma (8.7%, n = 4), and collisions with aircraft (2.2%, n = 1). Disease was reported for 13.0% (n = 6) of known cause of death mortalities, which included avian tuberculosis, septicemia, chronic salpingitis, and bacterial infections. Predation was the cause of 10.9% (n = 5) of reported mortalities. The remaining 5 known causes of deaths each included 1 mortality record.

Table 1. Cause of confirmed mortalities of fledged whooping crane in the Aransas-Wood Buffalo population, 1950-2023.

Cause of death	Fall	Spring	Winter	Summer	Total
Gunshot	8	3	4	0	15
Trauma	5	6	4	0	15
Power line collision	4	4	2	0	10
Aircraft collision[a]	0	1	0	0	1
Unknown source of trauma	1	1	2	0	4
Predation	1	1	2	1	5
Disease	2	1	3	0	6
Other	1	1	3	0	5
Capture myopathy	0	0	1	0	1
Captivity stress	0	0	1	0	1
Leg injury/exposure	1	0	0	0	1
Starvation	0	0	1	0	1
Trap	0	1	0	0	1
Unknown cause	3	1	12	7	23
Total known causes	17	12	16	1	46
Total confirmed mortalities	20	13	28	8	69

[a] Collision with aircraft in flight.

Across their range, ~48% of 69 mortalities were documented during fall (n = 20; Table 2) or spring (n = 13; Table 3) migration, 41% during winter (n = 28; Table 4), and 12% during summer (n = 8; Table 5). Deaths with known causes were more frequently reported during fall and spring migration. Migration mortalities were documented throughout the whooping crane migration corridor (Pearse et al. 2018) in Texas, Oklahoma, Kansas, Nebraska, South Dakota, North Dakota, USA, and Saskatchewan, Canada, with an additional mortality documented outside the core migration corridor in Missouri, USA .

Table 2. Fledged whooping crane mortalities in the Aransas-Wood Buffalo population during the fall migration season. Alphanumeric codes indicate carcasses of birds marked for telemetry and numeric codes indicate carcasses of banded birds

Year	Date	Location[a]	Age[b]	Cause of death	Comments	Change from previous publication(s)[b]
1952	Oct	Sharon, Kans.	A	Unknown	Had dislocated wing; died in route to San Antonio Zoo.[c]	None.
1955	Fall	Sioux Falls, S.D.	A	Gunshot	Shot by snow goose (*Anser caerulescens*) hunter.[c,d]	Recovered changed to Yes from No[c] as a carcass is needed when an arrest is made. Age changed to A from WP[c] for consistency.
1965	Nov	Rawlins City, Kans.	SA	Trauma, power line	Collision with distribution (3-wire) line.[c,e]	Cause of death changed to trauma, power line[c,e] from power line for consistency.
1982	Oct	Oglesby, Tex.	A	Trauma, power line	Collision with distribution (4-wire, <8 meters) line.[c,e]	Cause of death changed to trauma, power line[c,e] from power line for consistency.
1985	Jan	Linton, N.D.	A	Trauma, power line	Male with multiple fractures in wing was captured in Oct 1984, but later died in Jan 1985 from complications due to collision with power line during the fall migration. Male also had aspergillosis and partial paralysis from running into captive fence during handling.[c]	Date corrected to Jan 1985 from Oct 1984[c]. Cause of death changed to trauma, power line from power line[c] for consistency. Additional comments on cause of death.
1989	Oct	Stratton, Nebr.	SA	Trauma, power line	Collision with distribution (12-kilovolt) line[e]; flew into 2-wire distribution line and found dead.[c]	Cause of death changed to trauma, power line from power line[c,e] for consistency. Power line type corrected to distribution[e] from transmission line.[c]
2003	Nov	Dallas, Tex.	A	Gunshot	Shot.[c]	None.
2004	Nov	Quivira NWR, Kans.	SA	Gunshot	Leg amputated; died due to complications in captivity 9 Nov.[c]	None.
2004	Nov	Quivira NWR, Kans.	SA	Gunshot	Fractured humerus repaired; died due to complications mid-Nov.[c]	None.
2005	Oct	Sask., Canada	A	Disease	Bird 599-09801 (banded).[f] Chronic salpingitis and peritonitis led to malnutrition; poor to emaciated body condition. Individual was oldest whooping crane in flock at time of death.	None.
2005	Dec	Mo.	Juv	Disease	Bacterium was obstructing the larynx[c].	Cause of death changed to disease from bacterium[c] for consistency. Age corrected to Juv from chick.[c]
2011	8 Nov	Ransom, Kans.	Juv	Unknown	Bird C19.[g] No necropsy was attempted; no direct or indirect evidence of power line collision.[h]	Age changed to Juv from FJ[g] for consistency.

Table 2. Continued.

Year	Date	Location[a]	Age[b]	Cause of death	Comments	Change from previous publication(s)[b]
2017	14 Oct	Sask., Canada	Juv	Predation	Bird 4A.[f] Died soon after separating from parents. Field evidence indicates predation as cause of death.	None.
2021	5 Nov	Kiowa Co., Okla.	A	Gunshot	Discovered by hunters near Tom Sneed Lake; died in transport to veterinary clinic.[i,j]	None.
2021	5 Nov	Kiowa Co., Okla.	A	Gunshot	Bird 14G.[i,j]	None.
2021	5 Nov	Kiowa Co., Okla.	A	Gunshot	Evidence discovered while investigating the location of radioed crane (Bird 14G) that was also shot in the area.[i,j]	None.
2021	5 Nov	Kiowa Co., Okla.	A	Gunshot	Evidence discovered while investigating the location of radioed crane (Bird 14G) that was also shot in the area.[i,j]	None.
2022	Nov	Sask., Canada	Juv	Unknown	Bird 2J.[f] Suspected to have died between 8 and 10 Nov. Only feathers were recovered.	None.
2022	18 Nov	Clark, S.D.	A	Leg injury/ exposure	Bird 5H.[k] Leg-mounted transmitter became iced during severe winter conditions resulting in leg injury.	None.
2023	Nov	Elba, Nebr.	A	Trauma, unknown source	Carcass discovered 4 Nov.[h] Trauma of unknown origin. Distance from power lines indicated that collision was unlikely to be cause of trauma.	Cause of death changed to trauma, unknown source from trauma[h] for consistency.

[a] Co. = County, NWR = National Wildlife Refuge.
[b] A = Adult, FJ = Fledged juvenile, Juv = Juvenile, SA = Subadult, WP = White-plumaged.
[c] Stehn and Haralson-Strobel (2014).
[d] McNulty (1966).
[e] Stehn and Wassenich (2008).
[f] Canadian Cooperative Wildlife Health Centre (unpublished data).
[g] Pearse et al. (2019).
[h] Nebraska Ecological Services Field Office, U.S. Fish and Wildlife Service (unpublished data).
[i] Godfrey (2022).
[j] U.S. Department of Justice (2023).
[k] National Fish and Wildlife Forensics Laboratory, U.S. Fish and Wildlife Service (unpublished data).

Table 3. Fledged whooping crane mortalities in the Aransas-Wood Buffalo population during the spring migration season. Alphanumeric codes indicate carcasses of birds marked for telemetry.

Year	Date	Location[a]	Age[b]	Cause of death	Comments	Change from previous publication(s)
1956	May	Lampasas Co., Tex.	SA	Trauma, power line	Transmission line[c]; broken wing tip.[d]	Cause of death changed to trauma, power line from power line[c,d] for consistency.
1967	Apr	Russell Co., Kans.	A	Trauma, power line[e]	Collision with distribution (3-wire) line.[c]	Date corrected to 1967[c,f] from 1968.[d] Cause of death changed to trauma, power line from power line[c] for consistency.
1982	Jun	Minot, N.D.	Unknown	Trauma, aircraft	Feathers identified on military tanker aircraft. Hit while taking off.[d]	Location corrected to Minot, N.D. from Minton, S.D.[d] Cause of death changed to trauma, aircraft from aircraft[d] for consistency. Additional comments on cause of death.
1983	May	Edam, Sask, Canada	SA	Disease	Observed by farmer for 1 week prior to death; necropsy indicated disease was likely cause of death.[d]	Recovered corrected to Yes from No[d] as a necropsy was conducted. Cause of death changed to disease from possibly disease[d] for consistency. Additional comments on cause of death.
1990	19 Apr	Leoville, Sask., Canada	A	Gunshot[e]	Individual observed with crane in back of truck at gas station; not convicted because he was "unknowingly" in possession of an endangered species.	Terminology changed from hunter[d] to individual.
1991	Apr	Bend, Tex.	A	Gunshot	Shot.[d]	None.
2002	Apr	De Leon, Tex.	A	Trauma, power line	Distribution[c] line strike[d]; found under power line.[f]	Cause of death changed to trauma, power line from power line[c,d,f] for consistency. Additional comments on cause of death.
2007	7 Apr	N.D.	A	Unknown	Collision with a blunt object.[d] The whooping crane public sightings database[f] states "…died mid-air and fell to ground, possible broken neck. Nearest power line was too far away".	Cause of death changed from collision to unknown. Additional comments on cause of death; conclusion was it died in flight not from a blunt object.
2012	Apr	Miller, S.D.	A	Gunshot	Shot by an individual near Miller, S.D.[g]	Terminology changed from hunter[g] to individual.
2013	8 Apr	Miller, S.D.	A	Predation	Bird A01.[h] Predation.	None.
2019	May	Sask., Canada	A	Trauma, unknown source	Broken leg at foot appeared to be most likely cause of death.[i]	Cause of death changed to trauma, unknown source from trauma[i] for consistency.
2020	22 Apr	Mountrail Co., N.D.	Juv	Trauma, power line	Bird 18E.[f] Carcass was found beneath a transmission line. Radio telemetry indicates death occurred at ~0130.	Cause of death changed to trauma, power line from power line[f] for consistency.
2022	Apr	S.D.	A	Trap	Possible cause of death indicated it to be from being caught in a muskrat (*Ondatra zibethicus*) trap.[j]	None.

[a] Co. = County
[b] A = Adult, Juv = Juvenile, SA = Subadult
[c] Stehn and Wassenich (2008)
[d] Stehn and Haralson-Strobel (2014)
[e] Carcass was not recovered.
[f] Nebraska Ecological Services Field Office, U.S. Fish and Wildlife Service (unpublished data).
[g] U.S. Department of Justice (2013*b*).
[h] Pearse et al. (2019).
[i] Canadian Cooperative Wildlife Health Centre (unpublished data).
[j] National Fish and Wildlife Forensics Laboratory, U.S. Fish and Wildlife Service (unpublished data).

Table 4. Fledged whooping crane mortalities in the Aransas-Wood Buffalo population during the winter season. Alphanumeric codes indicate carcasses of birds marked for telemetry.

Year	Date	Location[a]	Age[b]	Cause of death	Comments	Change from previous publication(s)[b]
1951	Nov	Ratama Mill, ANWR, Tex.	A	Gunshot	Shattered joint between femur and tibiotarsus, assumed shot on migration; died at San Antonio Zoo.[c]	None.
1951	Dec	West St. Charles, ANWR, Tex.	A	Trauma, unknown source	Unknown; missing 1 foot, leg broken at tibiotarsus.[c]	Cause of death changed to trauma, unknown source trauma[c] for consistency.
1961	Dec	Matagorda Island, ANWR, Tex.	Unknown	Unknown[d]	Ranch foreman discovered carcass[c]. The ANWR manager learned of the discovery months later; the foreman stated he would "...sooner be caught with an illegal whiskey still than have anything to do with a dead whooping crane[e]."	Additional comments on cause of death.
1964	Mar	ANWR, Tex.	Unknown	Unknown	Bones, feathers, and skin recovered; was 1 of twin chicks; lab detected minute traces of dichlorodiphenyltrichloroethane (commonly, DDT).[c]	None.
1968	Jan	ANWR, Tex.	A	Gunshot	Shot by goose hunter.[c]	None.
1984	Nov	ANWR, Tex.	SA	Trauma, unknown source	Neck trauma. Probable avian predation (radioed bird, unknown ID).[c]	Cause of death changed to trauma, unknown source from neck trauma[c] for consistency. Additional comments on cause of death.
1989	3 Jan	ANWR, Tex.	A	Gunshot	Mistaken for snow goose by hunters on San Jose Island.[c]	Additional comments on cause of death.
1989	Apr	ANWR, Tex.	SA	Disease	Avian tuberculosis.[c]	Cause of death changed to disease from avian tuberculosis[c] for consistency. Avian tuberculosis moved to comments.
1992	Jan	ANWR, Tex.	A	Unknown	Pile of feathers in burn area.[c]	None.
2001	Jan	ANWR, Tex.	SA	Unknown	Skull and feathers found.[c]	None.
2008	Dec	ANWR, Tex.	A	Starvation	Injured knee leading to starvation.[c]	Death appears to be starvation associated with knee injury. Cause of death changed to starvation from starvation, knee.[c] Age changed to A from WP[c] for consistency.
2009	Mar	ANWR, Tex.	A	Unknown	Pile of feathers.[c]	Age changed to A from WP[c] for consistency.
2011	30 Nov	ANWR, Tex.	Juv	Disease	Bird C20.[f] Potential bacterial infection.	Age changed to Juv from FJ[f] for consistency. Cause of death changed to disease from potential bacterial infection[f] for consistency. Potential bacterial infection moved to comments.
2011	Dec	ANWR, Tex.	A	Predation	Found between 6 and 10 Dec at Williams Windmill. Puncture wounds on neck.[g]	None.
2012	6 Jan	Calhoun Co., Tex.	Juv	Unknown	Bird C18.[f] Cause of death could not be determined due to state of remains.	Age changed to Juv from FJ[f] for consistency. Cause of death changed to unknown from undetermined.[f] Additional comments on cause of death.
2012	12 Jan	Aransas Co., Tex.	Juv	Gunshot	Shot by sandhill crane (*Antigone canadensis*) hunter.[h]	None.
2012	9 Feb	Calhoun Co., Tex.	Juv	Unknown	Bird C14.[f] Cause of death could not be determined due to state of remains.	Age changed to Juv from FJ[f] for consistency. Cause of death changed to unknown from undetermined.[f] Additional comments on cause of death.

Table 4. Continued.

Year	Date	Location[a]	Age[b]	Cause of death	Comments	Change from previous publication(s)[b]
2013	Feb	ANWR, Tex.	A	Unknown	Bird D40.[f] Last known alive location on 31 Dec 2012, determined to be dead on 5 Feb. Cause of death could not be determined due to state of remains.	Cause of death changed to unknown from undetermined.[f] Additional comments on cause of death.
2013	Dec	ANWR, Tex.	A	Predation	Found incidentally on the Tatten Unit near a pumped water hole (circular canal).[g]	None.
2013	Dec	Aransas Co., Tex.	SA	Captivity stress	Bird D26.[f] Arrived in Tex. with approximately half of lower leg (tarsus) missing. Captured and taken to San Antonio Zoo where it died within a few weeks. Cause of injury was unknown, but it likely occurred during migration.	Cause of death changed to captivity stress from injury.[f]
2014	Jan	Aransas Co., Tex.	A	Disease	Septicemia.[i]	Cause of death changed to disease from septicemia[i] for consistency. Septicemia moved to comments.
2014	3 Feb	ANWR, Tex.	SA	Unknown	Bird E50.[f]	None.
2014	4 Feb	ANWR, Tex.	SA	Unknown	Bird E54.[f]	None.
2014	Oct	Calhoun Co., Tex.	A	Unknown	Bird C05.[f] Date of death is estimated based upon location and condition of remains found in June 2015.	None.
2015	30 Mar	ANWR, Tex.	SA	Unknown	Bird D41.[f] Cause of death suspected to be predation.[i]	Cause of death changed to unknown from undetermined.[f] Additional comments on cause of death.
2019	26 Nov	Aransas Co., Tex.	Juv	Trauma, power line	Bird 3E.[g] Collided with transmission line.	Cause of death reported as trauma, power line for consistency.
2022	9 Mar	Calhoun Co., Tex.	Juv	Capture myopathy	Bird 13H.[g] Died during attempted capture to be marked for telemetry; no proximate cause of death was determined.	None.
2023	Feb	Aransas Co., Tex.	A	Trauma, power line	Photographs document distribution line strike. Supporting information indicate a flushing event at a deer feeding station near distribution line.[j]	Cause of death reported as trauma, power line for consistency.

[a] ANWR = Aransas National Wildlife Refuge, Co. = County.
[b] A = Adult, FJ = Fledged juvenile, Juv = Juvenile, SA = Subadult, WP = White-plumaged.
[c] Stehn and Haralson-Strobel (2014).
[d] Carcass was not recovered.
[e] McNulty (1966).
[f] Pearse et al. (2019).
[g] A. T. Pearse (personal observation).
[h] U.S. Department of Justice (2013a).
[i] National Wildlife Health Center Laboratory, US. Geological Service, Information Management System, retrieved 28 June 2023.
[j] A. Caven, International Crane Foundation (personal communication, including photographs).

Table 5. Fledged whooping crane mortalities in the Aransas-Wood Buffalo Population during the summer season. Alphanumeric codes indicate carcasses of birds marked for telemetry.

Year	Date	Location[a]	Age[b]	Cause of death	Comments	Change from previous publication(s)[b]
1951	Aug	North Mullet Bay, ANWR, Tex.	A	Unknown	Carcass much decayed.[c]	None.
1986	24 May	WBNP, Canada	A	Unknown	Male found dead at nest.[c]	None.
1991	Jun	WBNP, Canada	A	Unknown	Cause unknown due to decay; not submitted for necropsy.	Age changed to A from WP[c] for consistency.
2011	12 Jun	WBNP, Canada	A	Unknown	Bird C01.[d] Radio and leg bone found covered in teeth marks. Cause of death suspected to be predation.	Additional comments on cause of death.
2011	5 Aug	WBNP, Canada	SA	Predation	Bird B01.[d] The Global Positioning System transmitter functioned erratically and ceased transmitting on breeding grounds on 5 Aug 2011 (estimated date of death). Field evidence indicates predation as cause of death.[e]	Marked bird of known age; age corrected to SA[d] from Juv.[c] Cause of death changed to predation from undetermined.[d]
2011	5 Oct	WBNP, Canada	SA	Unknown	Bird B09[d]. Cause of death could not be determined due to state of remains.[e]	Marked bird of known age; age corrected to SA[d] from Juv.[c] Cause of death changed to unknown from undetermined.[d] Additional comments on cause of death.
2012	7 Jun	WBNP, Canada	SA	Unknown	Bird C17.[d] Remains retrieved 31 Jul 2012; radio not found. Cause of death could not be determined due to state of remains.[e]	Marked bird of known age; age corrected to SA[d] from Juv.[c] Cause of death changed to unknown from undetermined.[d] Additional comments on cause of death.
2012	18 Aug	WBNP, Canada	SA	Unknown	Bird C16.[d] Died between 1153 on 17 Aug and 0919 on 18 Aug 2012 after a significant move. Cause of death could not be determined due to state of remains.[e]	Marked bird of known age; age corrected to SA[d] from Juv.[c] Cause of death changed to unknown from undetermined[d]. Additional comments on cause of death.

[a] ANWR = Aransas National Wildlife Refuge, WBNP = Wood Buffalo National Park.
[b] A = Adult, Juv = Juvenile, SA = Subadult, WP = White-plumaged.
[c] Stehn and Haralson-Strobel (2014).
[d] Pearse et al. (2019).
[e] Canadian Cooperative Wildlife Health Centre (unpublished data).

There were 5 suspected mortalities reported in previous publications where a carcass was not recovered (Table 6) and 2 additional records from previous publications removed from AWBP mortality records provided herein. The first removed record included a whooping crane from Louisiana that was released in ANWR in the spring of 1950 and died the following September (Stehn and Haralson-Strobel 2014). This bird was not part of the AWBP; thus, the mortality record was not included in our dataset. The second record included a bird found in Nebraska in October 1988 (Stehn and Wassenich 2008, Stehn and Haralson-Strobel 2014). In this instance, a local landowner with no previous experience or expertise in bird identification reported that a whooping crane struck a power line on the landowner's property. The landowner indicated the bird went to the ground, and after a brief period of time, got up and flew away, apparently unharmed. This bird was "postulated [to be] 1 of [the] birds that failed to show up on wintering grounds" (Stehn and Wassenich 2008:28). This record was never included in the USFWS database of confirmed whooping crane sightings (USFWS, unpublished data), instead a report was noted as a "probable" whooping crane sighting as the reporting landowner was not qualified to positively identify a whooping crane. We were unable to verify how this bird was mistakenly included as a confirmed whooping crane mortality in previous publications as the original report and source of information did not support this determination. This bird was neither confirmed to be a whooping crane, nor did circumstantial evidence support the conclusion that the bird died of causes related to collision. For these reasons, this mortality record was removed entirely from our dataset.

Table 6. Suspected whooping crane mortalities in the Aransas-Wood Buffalo population during the fall and spring migration seasons. For all records, no carcass was recovered, and mortality is not confirmed. Alphanumeric codes indicate birds marked for telemetry.

Year	Date	Season	Location[a]	Age[b]	Suspected cause of death	Comments	Change from previous publication(s)[b]
1957	Oct	Fall	Ketchum, Okla.	A	Trauma, unknown source	Crippled bird was seen, then it was lost from sight[c].	Age changed to A from WP[c] for consistency. Suspected cause of death changed to trauma, unknown source from trauma[c] for consistency. Separated from confirmed carcass mortality tables.[c]
1977	Apr-May	Spring	Sask., Canada	A	Trap	Unconfirmed mortality of death in a muskrat (*Ondatra zibethicus*) trap[c].	Cause of death changed to trap from muskrat trap[c] for consistency. Separated from confirmed carcass mortality table.[c]
1998	Nov	Fall	Quivira NWR, Kans.	A	Trauma, unknown source	Last seen with broken leg; mate appeared at Aransas NWR without her[c].	Suspected cause of death changed to trauma, unknown source from broken leg[c] for consistency. Separated from confirmed carcass mortality table.[c]
2004	Nov	Fall	Quivira NWR, Kans.	SA	Gunshot	Shot at, red spot seen on breast, not captured, stayed in area and was last observed in Dec; mortality was assumed.[c]	Separated from confirmed carcass mortality table.[c]
2012	Nov	Fall	Wood River, Nebr.	Juv	Unknown	Bird D29.[d] Mortality suspected but not confirmed	Age changed to Juv from FJ[d] for consistency

[a] NWR = National Wildlife Refuge.
[b] A = Adult, FJ = Fledged juvenile, Juv = Juvenile, SA = Subadult, WP = White-plumaged.
[c] Stehn and Haralson-Strobel (2014).
[d] Pearse et al. (2019).

We updated 33 mortality records based on cause of death category consolidation (n = 29) or additional information (n = 4). For example, a cause of death marked as a "collision with a blunt object" was changed to unknown. In this instance, the whooping crane tracking project public sightings database (Nebraska Ecological Services Field Office, USFWS, unpublished data) indicated the bird is believed to have died mid-air and fell to the ground and it was noted to have a broken neck. The database also notes the nearest powerline was too far away to be the probable cause of collision. Thus, the conclusion was that the whooping crane died in flight, and not from blunt force trauma.

DISCUSSION

Most documented mortalities of fledged whooping cranes occurred on migration and wintering grounds. Similarly, more mortalities with known causes were reported during the winter and migratory seasons than the summer season. Previous studies relying mostly on publicly reported whooping crane mortalities estimated that most mortalities occurred during migration (>60%; Lewis et al. 1992, Stehn and Haralson-Strobel 2014), whereas estimates from telemetered whooping cranes indicated migration may contribute the least proportionally to annual mortality and pose a similar to slightly reduced risk to whooping cranes relative to winter and summer seasons (Pearse et al. 2019). These discrepancies have been identified in past studies and explained by the fact that whooping cranes are more likely to be encountered and reported in locations accessible to humans and where human population density is greater (i.e., public sightings throughout most of the migration corridor and Aransas National Wildlife Refuge). Due to the inaccessibility of the WBNP (summer breeding grounds), carcasses are less likely to be located for public reporting and are likely underrepresented in the available data (Stehn and Haralson-Strobel 2014, Pearse et al. 2019). Of the 7 whooping crane mortalities documented at the WBNP, 5 were telemetered (Table 5); however, the period of record for telemetered birds is a fraction of the overall period without telemetered birds. Further, when a carcass was found in WBNP, deteriorated conditions generally inhibited determination of a cause of death. Given the size of the AWBP and the annual mortality rate of whooping cranes, the number of unreported mortalities must be much greater than those reported; however, all reported mortalities have been investigated.

Of the deaths with known causes, gunshot incidents were the most frequent cause and occurred across the flyway from Texas, USA, to Saskatchewan, Canada, outside of the summering grounds (likely due to the inaccessibility of the WBNP). Thirteen whooping crane shooting mortalities occurred after whooping cranes were listed as endangered in 1967; 9 of these 13 cranes were shot between 2003 and 2023. Trauma from collisions with a power line were the second most frequent cause of death. During migration, 6 power line collision mortalities were documented between 1956 and 1989 and 2 were reported in more recent decades (2002 and 2020). During the winter season, 2 power line collision mortalities were documented outside of the ANWR in 2019 and 2023. Minimal opportunities for power line interactions exist within the ANWR wintering grounds. However, whooping cranes have been documented overwintering in inland habitat outside of the primary wintering grounds (Butler et al. 2023), which may increase the potential for collision risk due to proximity and greater exposure to anthropogenic infrastructure. For example, the 2023 power line collision occurred after a flushing event at a deer feeding station outside of ANWR. Proximal causes of other types of traumas were mostly unknown. When available, we noted evidence of power line collisions (i.e., external wounds, proximity to nearest power line); therefore, we suspect mortalities from trauma from an unknown source were unlikely to be caused by a collision with a power line (e.g., collision with a fence, vehicle, or woody vegetation, predation, trap).

Predation of fledged individuals was reported most often during the summer and winter but occurred throughout the annual cycle. The specific predators could not be identified for these mortalities. Mortalities due to disease resulted from several known and unknown etiologies, with carcasses recovered in Texas and Missouri, USA, and Saskatchewan, Canada. Other causes of death included leg injury from an iced-over transmitter leading to exposure, starvation associated with an injured knee of unknown trauma source, capture myopathy, captivity stress, and caught in a muskrat trap. Overall, our updates to the published record will enable future work on cause- and seasonal-specific mortality rate estimates.

MANAGEMENT IMPLICATIONS

Preparation of this update required consolidation of information from different primary sources, as well as confirming data with alternative published sources and consultation with individuals known by us to be experienced with these mortality records. Nonetheless, we are uncertain if we have included all known mortalities of fledged AWBP whooping cranes. Because of the effort required and this uncertainty, there may be opportunities for the agencies tasked with recovery of the species to develop and maintain a master list of all known mortalities so that future updates could be simpler to compile and complete. Potential points of contact may include the species recovery coordinators for the CWS and USFWS. As these individuals and/or agencies prepare an annual report on the recovery of the species, agencies may find it valuable to include information on known whooping crane deaths from each whooping crane population. Reducing mortality rates is an important recovery action in the Whooping Crane Recovery Plan (CWS and USFWS 2007) and the inclusion of mortality factors allows agencies to monitor both new and existing threats over time. Further, the consolidation of these data can be integrated into modeling to obtain more accurate demographic parameters, such as survival and abundance estimates.

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