2019 Project Abstract
For the Period Ending June 30, 2024

Project Abstract
For the Period Ending June 30, 2022
PROJECT TITLE: Minnesota Trumpeter Swan Migration Ecology and Conservation
PROJECT MANAGER: David Andersen
AFFILIATION: U.S. Geological Survey (USGS), Minnesota Cooperative Fish and Wildlife Research Unit (MN CFWRU) and University of Minnesota
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FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 03d

APPROPRIATION AMOUNT: $300,000
AMOUNT SPENT: $297,078
AMOUNT REMAINING: $2,922

Sound bite of Project Outcomes and Results
We tracked the movements of trumpeter swans throughout Minnesota and the greater Midwest, demonstrating that trumpeter swans have high individual variability in their seasonal migration patterns. Our project provides important ecological information on this charismatic waterfowl species that was successfully reintroduced to Minnesota.

Overall Project Outcome and Results
Trumpeter swans currently breed throughout most of the western Great Lakes region. However, beyond approximate estimates of population trends and distribution, there is relatively little recent information about their ecology, hindering conservation decision-making. To address this need, we marked 50 trumpeter swans in Minnesota with GPS-GSM transmitters to track their annual movements, and also leveraged financial and personnel support from other state, provincial, and federal wildlife agencies to capture an additional 75 trumpeter swans from 5 other U.S. states and a Canadian province (Manitoba, Wisconsin, Iowa, Michigan, Ohio, and Arkansas). Our increased sample size allowed us to provide a more comprehensive overview of the movement ecology of the entire Interior Population of trumpeter swans. Individual tracking data revealed that IP trumpeter swans are partial migrants, with a continuum of strategies each year, from local movements to long-distance migration. At the individual level, 59% of swans moved to distant non-breeding period areas (long-distance migration defined as moving >100 km from the breeding site); 16% exhibited regional migration (>25 km and <100 km from breeding site); 19% exhibited non-migratory, local movements (<25 km from breeding site); and 6% exhibited multiple migration strategies across years. Much of the variability in movement patterns was related to factors tied to natural history demands (e.g., breeding status) and response to environmental conditions (e.g., through associations with breeding latitude).

Project Results Use and Dissemination
We presented project findings through oral presentations, online websites, and a mix of media outlets (e.g., newspaper, TV, radio, podcasts). We gave 11 research presentations for professional conferences at the state, regional, national, and international levels. We gave 6 invited public presentations to a variety of audiences and venues (e.g., youth birding groups, local Audubon chapters, master naturalist groups, wetland working groups,

University field course). Our study was featured in 8 newspaper articles, 7 local TV news segments, 2 popular science periodicals, 3 nature-based podcasts, 4 online agency news releases, and 2 radio interviews. We published 1 peer-review journal article and are currently in the process of submitting 3 other manuscripts for peer-reviewed publications, and all aspects of the project are described in detail in David Wolfson's Ph.D. dissertation. Our project website, which provides tracking information on all swans collared during the project, has been viewed >30,000 times by ~20,000 users from >60 countries.

Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2019 ENRTF Work Plan Final Report

Today's Date: 15 August 2024

Final Report

Date of Work Plan Approval: 5 June 2019

Project Completion Date: 30 June 2024

PROJECT TITLE: Minnesota Trumpeter Swan Migration Ecology and Conservation

Project Manager: David E. Andersen

Organization: U.S. Geological Survey, Minnesota Cooperative Fish and Wildlife Research Unit and University of Minnesota

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Location: Statewide

Total Project Budget: $300,000

Amount Spent: $297,078

Balance: $2,922

Legal Citation: M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 03d

Appropriation Language: $300,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota to document the movement and habitat use of Minnesota trumpeter swans to provide foundational information necessary for trumpeter swan management and conservation. This appropriation is available until June 30, 2023, by which time the project must be completed and final products delivered.

I. PROJECT STATEMENT:

Trumpeter swans (*Cygnus buccinator*) have high intrinsic and economic value in Minnesota (MN) as a protected wildlife species. MN citizens enthusiastically invested in the restoration of trumpeter swans through the check off donation and other funding sources to the MN Department of Natural Resources (MNDNR) Nongame Program since the mid-1980s. The Interior Population of trumpeter swans (of which MN swans comprise ~63%) has increased dramatically since they were re-established in the 1960s and 1970s and both population size and distribution have expanded significantly in MN since the MNDNR Alaska-egg project began in 1986. The original MN reintroduction goal of 15 breeding pairs and the revised interim goal of 500 individuals by 2001 have been greatly exceeded, with a current estimate of nearly 17,000 swans (an average annual finite rate of increase of ~1.20 since 2000) (Fig 1). Better understanding of trumpeter swan ecology will be extremely useful in developing future management strategies for this growing population.

In MN, trumpeter swans currently breed throughout most of the state, but beyond recent estimates of population size and trend and distribution, relatively little is known about their ecology, hindering conservation decision-making. To address current information needs, we propose to mark a sample of Interior Population trumpeter swans in MN with GPS-GSM transmitters. These transmitters record high-resolution, high frequency location and related data and transmit those data through cellular phone networks, and will allow us to:

1. Evaluate year-round swan movements, including determining what proportion of trumpeter swans winter outside of the state, the locations where swans spend the winter, and the timing and duration of their movements.
2. Determine whether and where trumpeter swans make molt migrations.
3. Evaluate year-round habitat use and selection patterns of trumpeter swans.
4. Estimate annual survival rates of trumpeter swans, if sample sizes are adequate and fates (i.e., mortality events) can be determined.

Results of this study will inform current and future trumpeter swan conservation in MN by providing basic information about migration, year-round movements, mortality risks, and use of agricultural landscapes. The data from the project will be archived with Movebank (https://www.movebank.org/) and made available to the public via a website that summarizes trumpeter swan movements and habitat use. Thus, the project will also offer the opportunity to actively engage and inform MN citizens about how their past investment in conservation made a positive difference to MN's natural heritage today.

II. OVERALL PROJECT STATUS UPDATES:

First Update 1 April 2020

We captured seven trumpeter swans during July and August 2019 and equipped them with GPS/GSM transmitters. We partnered with staff from the Minnesota DNR, U.S. Fish and Wildlife Service, and Three Rivers Park District to locate and capture trumpeter swans using a variety of techniques including nightlighting and daytime capture from airboats and square-stern canoes. We also partnered with the Michigan DNR, Michigan State University, and USDA Wildlife Services to deploy 12 GPS/GSM transmitters (donated in-kind) on trumpeter swans in Michigan.

We plan to deploy ~30 transmitters on trumpeter swans across Minnesota during June-September 2020. We have engaged a host of other agencies to partner with us on this study, allowing for the expansion of the study area to most of the Interior Population breeding range. Collaborators include Iowa DNR, Iowa State University, Wisconsin DNR, Great Lakes Indian Fish and Wildlife Commission, Ohio DNR, Canadian Wildlife Service, and

Manitoba Wildlife and Fisheries Branch. These partners expect to purchase and deploy an additional 45 transmitters across the Great Lakes region.

Second Update 31 December 2020

We deployed 40 GPS-GSM transmitters on trumpeter swans in Minnesota during June-September 2020. We partnered with staff from the Minnesota DNR and Three Rivers Park District to locate and capture trumpeter swans throughout Minnesota using a jon boat with a long-tail mud motor. We implemented COVID-19 safety protocols throughout the summer, which necessitated single-occupancy vehicles, reduced numbers of field staff, social distancing, and use of personal protective equipment.

Partnering agencies captured and collared 38 trumpeter swans in Manitoba (n=10), Iowa (n=9), Wisconsin (n=5), Michigan (n=2) and Ohio (n=12). Partners plan to deploy 18 additional collars during summer 2021 and 3 collars in Arkansas during winter 2021-2022.

Our project website now displays movements of 97 swans, summarizing data from 1.5 million GPS points. Half of the trumpeter swans marked in Minnesota migrated out of state during the autumn of 2020, traveling an average of 620 km south of their breeding site. Swans that that stayed in Minnesota traveled an average of 55 km south and resettled on either flowing rivers that were ice-free or ponds with aerators that artificially kept the water open. The longest observed migration was ~1,300 km to central Arkansas.

Third Update 1 April 2021

We completed deployment of GPS-GSM transmitters in Minnesota in September 2020. The only potential future deployments in Minnesota would come from collars retrieved from mortalities. Project partners plan to deploy 18 additional collars in Wisconsin, Iowa, Ohio, and Arkansas in 2021–2022. Second-generation Ornitela collars (deployed in 2020) appear to be functioning as designed, with no known collar failures to date. We are continuing to collect GPS locations from collared swans, visualize movements on the project website, and archive data on the Movebank data repository. We are also planning to solicit project collaborators and volunteers to monitor radio-marked swans this spring and summer, to help identify transitions in behavior (e.g., initiation of incubation) and estimate those transitions for swans not under observation.

AMENDMENT REQUEST 14 May 2021
We are requesting funds be shifted from the supplies and travel budget lines to personnel.
- GPS-GSM budget would be reduced by $57,913 to a revised budget of $35,687
- Miscellaneous supplies budget would be reduced by $2,500 to a revised budget of $1,160
- Lodging budget would be reduced by $9,600 to a revised budget of $0
- Food and supplies budget would be reduced by $2,250 to a revised budget of $0
- Personnel budget would be increased by $72,263 to a revised budget of $214,193

We are requesting these changes because costs associated with GPS-GSM transmitters were substantially less than originally estimated due to advancements in technology and because personnel and mileage costs associated with transmitter deployment were less than anticipated due to development of efficient capture methodology. Covid-related safety protocols increased travel costs in 2021 (especially related to University of Minnesota requirements for single occupants per vehicle) but were offset by reductions in transmitter and field technician costs, and costs associated with travel (meals and lodging). We therefore are requesting to move those cost savings to personnel costs to provide support for the Ph.D. student working on this project.

Fourth Update 31 December 2021
We redeployed 9 GPS-GSM transmitters in Minnesota during July–August 2021. Eight of the 9 redeployed transmitters were recovered from mortalities in Minnesota or other parts of the study. Project partners deployed 13 new GPS-GSM transmitters and redeployed 2 transmitters (1 recovered from mortality, the other to replace a cracked collar panel) in Wisconsin (n=4), Ohio (n=8), Iowa (n=2), and Manitoba (n=1). Project partners deployed 4 additional collars during late December 2021 at a site in Arkansas where swans are known to congregate in the winter.

We are continuing to collect GPS locations from collared swans, visualize movements on the project website, and archive data on the Movebank data repository.

We designed an online data-collection form that volunteers used to contribute data from visual observations of swans during March–November 2021. We collected 341 observations from 32 GPS-tagged swans. We are currently exploring whether these data may be useful for identifying transitions in behavior (e.g., nest initiation or incubation) for swans that were not visually observed.

Fifth Update 1 April 2022

We are continuing to collect GPS locations from collared swans, visualize movements on the project website, and archive data on the Movebank data repository. There were no additional collar deployments during this period.

We are currently working on an analysis to quantify year-round swan movement patterns. Aspects of this analysis include estimating migration timing and duration, and the extent to which the population winters outside of Minnesota. We are evaluating the relationships between capture latitude, breeding status, sex, and migration patterns.

AMENDMENT REQUEST 15 June 2022
We are requesting funds be shifted from the Professional/Technical/Service Contracts and supplies budget lines to personnel.
- Cellular data fees budget would be reduced by $31,400 to a revised budget of $4,000
- Miscellaneous supplies budget would be reduced by $458 to a revised budget of $702
- Personnel budget would be increased by $31,858 to a revised budget of $246,051

We are requesting these changes because anticipated costs associated with data fees for GPS-GSM transmitters are substantially less than originally estimated, based on realized rates of remote data download. Furthermore, we anticipate no future supplies costs, because we have completed deploying transmitters, except for possible redeployment of transmitters retrieved from mortalities. We therefore are requesting to move those cost savings to personnel costs to provide support for the Ph.D. student working on this project, hiring a student employee to help with data entry and analyses, and providing additional summer salary for assistance in data analysis.
Amendment approved by LCCMR 7/5/22

Sixth Update 31 December 2022

We are continuing to collect GPS locations from collared swans, visualize movements on the project website, and archive data on the Movebank data repository. There were no additional collar deployments during this period.

Our current analytical efforts primarily involve quantifying annual movement of collared trumpeter swans. Preliminary results suggest that Interior Population trumpeter swans exhibit partial migration (where each year some individuals migrate and others do not) and that there is considerable variability among the migration patterns of individuals.

Amendment request 31 December 2022:
We are requesting an extension of the end of the project period from 30 June 2023 to 30 June 2024. We are requesting this change to allow for data collection to continue for another migration period (fall 2023 through spring 2024) for IP trumpeter swans with functioning GPS/GSM transmitters (n = 42). Tracking these birds through another migration period will allow us to more fully evaluate variation within individuals across years in migration strategy. In addition, we have been able to secure supplemental funding to support the graduate student heading this project, and extending the project period through 30 June 2024 will allow us to support the student to conduct additional analyses and prepare manuscripts for dissemination of project results.
1/27/2023: LCCMR approval pending legislative action

Seventh update 1 April 2023

We are continuing to collect GPS locations from collared swans, visualize movements on the project website, and archive data on the Movebank data repository. There were no additional collar deployments during this period.

Eighth update 1 December 2023

We are continuing to collect GPS locations from collared swans, visualize movements on the project website, and archive data on the Movebank data repository. We have been using piecewise regression to segment swan location data into periods of the annual cycle and estimate migration metrics (e.g., departure and arrival dates, migration extent and duration). There were no additional collar deployments during this period. We have also developed a partnership with the U.S. Fish and Wildlife Service to assist in developing a habitat suitability map based on characteristics of swan breeding locations from swans marked as part of this project.

Ninth update 1 April 2024

We are continuing to collect GPS locations from collared swans, visualize movements on the project website, and archive data on the Movebank data repository. There were no additional collar deployments during this period. We have been finalizing manuscripts and reports summarizing project results.

AMENDMENT REQUEST 1 April 2024

We are requesting funds be shifted from the **Travel expenses in Minnesota** budget line to **Personnel** and **Professional/Technical/Service Contracts** budget lines.
- Cellular data fees budget would be increased by $279 to a revised budget of $4,279
- Travel expenses in Minnesota budget would be reduced by $1,945 to a revised budget of $11,615
- Personnel budget would be increased by $1,666 to a revised budget of $247,717

We are requesting these changes because costs associated with data fees for GPS-GSM transmitters are now fully paid and we have a final cost for those. Similarly, we have completed all field components of this project (deployment and recovery of transmitters) and there will be no further travel-related expenses. We are requesting to move remaining funds in the Travel expenses in Minnesota budget line to the **Personnel** budget line to provide support for the Ph.D. student working on this project to complete data analysis and final report preparation.

Final Report between project end (30 June) and 15 August 2024

Trumpeter swans currently breed throughout most of the western Great Lakes region. However, beyond approximate estimates of population trends and distribution, there is relatively little recent information about their ecology, hindering conservation decision-making. To address this need, we marked 50 trumpeter swans in Minnesota with GPS-GSM transmitters to track their annual movements, and also leveraged financial and personnel support from other state, provincial, and federal wildlife agencies to capture an additional 75 trumpeter swans from 5 other U.S. states and a Canadian province (Manitoba, Wisconsin, Iowa, Michigan, Ohio, and Arkansas). Our increased sample size allowed us to provide a more comprehensive overview of the movement ecology of the entire Interior Population of trumpeter swans. Individual tracking data revealed that IP trumpeter swans are partial migrants, with a continuum of strategies each year, from local movements to long-distance migration. At the individual level, 59% of swans moved to distant non-breeding period areas (long-distance migration defined as moving >100 km from the breeding site); 16% exhibited regional migration (>25 km and <100 km from breeding site); 19% exhibited non-migratory, local movements (<25 km from breeding site); and 6% exhibited multiple migration strategies across years. Much of the variability in movement patterns was related to factors tied to natural history demands (e.g., breeding status) and response to environmental conditions (e.g., through associations with breeding latitude).

III. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1 Title: Capture and mark 36 trumpeter swans with GPS-GSM transmitters in MN, including graduate student and field technician support

Description: We propose to mark 36 trumpeter swans in MN with GPS-GSM transmitters, distributed across the state and on both breeding and non-breeding swans. In cooperation with the MNDNR, Three Rivers Parks, and the U.S. Fish and Wildlife Service, we will capture swans and monitor their movements via transmission of high-resolution location data collected at 15-minute intervals throughout the year via cellular networks. Capturing and marking swans will be conducted by a graduate student and field technicians during 2019 through 2021.

ACTIVITY 1	**ENRTF BUDGET:**	**$163,394**
	Amount Spent:	**$130,381**
	Balance:	**$33,013**

Outcome	Completion Date
1. Mark 16 swans with GPS-GSM transmitters	December 2020
2. Mark an additional 20 swans with GPS-GSM transmitters	December 2021

First Update 1 April 2020

We captured swans during the Definitive Prebasic Molt period when adults are flightless. In Minnesota during 2019, we used a variety of watercraft to evaluate the efficacy of different capture methods; these included airboats, jon-boats, and square-stern canoes with either an outboard or long-tail mud motor. We hand-captured

swans using a shepherd's crook pole. Collaborators captured swans in Michigan using a step deck transom boat with a surface drive motor and a shoulder-mounted netlauncher (CODA Enterprises, Mesa, Arizona, USA). All capture and handling methods were approved by the University of Minnesota Institutional Animal Care and Use Committee (Protocol #1905-37072A).

We marked seven swans in Minnesota with 55-g neck collars with GPS/GSM transmitter incorporated into the collar housing (Model OrniTrack-N62 3G, Ornitela, Vilnius, Lithuania; see Fig 2). Collaborators marked twelve swans in Michigan with 140-g GPS transmitters (Model CTT-ES400, Cellular Tracking Technologies, Rio Grande, New Jersey, USA) that were adhered to 64-mm neck collars (Haggie Engraving, Crumpton, Maryland, USA; see Fig 3). All swans marked in 2020 will be fitted with Ornitela collars. Neck collars for all swans in this study also had a unique 2-character, alpha-numeric code (black characters on a white background) to facilitate visual identification if individual swans.

Second Update 31 December 2020

We completed Activity 1 (trumpeter swan capture and GPS-marking) in September 2020. Due to additional funds contributed from outside research partners, we were able to deploy 11 more GPS-GSM collars than originally planned. In addition to the 7 collars deployed on trumpeter swans in Minnesota in 2019, we deployed 40 collars during June-September 2020 (Fig. 5). We spent approximately 700 person-hours locating swans and deploying GPS-GSM collars.

During the winter of 2019-2020, 8 of the deployed GPS-GSM collars failed due to extreme temperatures and/or water penetration. To address this issue, we worked with the manufacturer during the off-season to amend the collar design for the next generation of collars we deployed in 2020. We replaced the lightweight foam insulation within the collar housing with a high-density epoxy that is more weather-resistant.

Although project collaborators plan to deploy 18 additional collars during 2021 in Iowa, Wisconsin, Ohio and Arkansas, the only potential future deployments in Minnesota would come from mortalities for which we were able to recover the collar in working order and redeploy it on a different swan.

Third Update 1 April 2021

We completed all original deployments of GPS-GSM transmitters in September 2020. The only potential future deployments in Minnesota would come from collars retrieved from mortalities, and the location of deployment will be decided on a case-by-case basis. The 'second-generation' of Ornitela collars that were deployed during the 2020 field season included reinforced collar housing and showed much better performance. All transmitters deployed during autumn/winter 2020 still appear to be functioning properly.

Fourth Update 31 December 2021

We redeployed 9 GPS-GSM transmitters in Minnesota during July–August 2021. Eight of the 9 redeployed transmitters were recovered from mortalities in Minnesota or other parts of the study. The second-generation design of GPS-GSM transmitters from Ornitela continue to function well.

Fifth Update 1 April 2022

There were no additional transmitter deployments (or redeployments) during this period.

Sixth Update 31 December 2022

There were no additional transmitter deployments (or redeployments) during this period.

Seventh update 1 April 2023

There were no additional transmitter deployments (or redeployments) during this period.

Eighth update 1 December 2023

There were no additional transmitter deployments (or redeployments) during this period.

Ninth update 1 April 2024

There were no additional transmitter deployments (or redeployments) during this period.

Final Report between project end (30 June) and 15 August 2024

We captured IP swans from 2019–2022 throughout their current breeding during the breeding period, plus 4 swans captured in Arkansas during the non-breeding period. We deployed transmitters on IP trumpeter swans as far north and west as southern Manitoba (51.1° N, 99.7° W), as far south as Arkansas (35.5° N, 91.9° W), and as far east as Ohio (41.4° N, 80.7° W). Capture locations occurred in a mix of Laurentian Mixed Forest, Prairie Parkland, Eastern Broadleaf Forest, and Aspen Parklands.

We captured all swans during the definitive prebasic molt period (except for 4 captured in Arkansas using snares during the non-breeding period) when adult swans replace their remiges and are therefore flightless, using a combination of jon boats, airboats, step deck transom boats, and square-stern canoes. We primarily used long-tail mud motors (Powell Performance Fab, Hutchinson, Minnesota, USA) to navigate shallow wetlands where swans were located, though we captured some swans using boats with surface-drive motors (Gator-Tail, Loreauville, Louisiana, USA) or non-motorized canoes and kayaks. We hand-captured most swans using shepherd's crook poles or large landing nets. We predominantly targeted adult swans, which have higher survival rates than juveniles, to maximize the longevity of telemetry data collection.

We marked swans with two types of collars: 55-g neck collars with GPS-GSM transmitters incorporated into the collar housing (Model OrniTrack-N62 3G, Ornitela, Vilnius, Lithuania) and 140-g GPS transmitters (Model CTT-ES400, Cellular Tracking Technologies, [CTT], Rio Grande, New Jersey, USA) that were adhered to 64-mm neck collars (Haggie Engraving, Crumpton, Maryland, USA). All collar and transmitter types weighed <3% of the marked individual's body weight, as per animal care requirements. Both types of neck collars contained a unique alpha-numeric code for visual identification. Swans captured in Michigan were fit with CTT collars and all other swans in the study were fit with Ornitela collars. In the United States, we leg-banded each swan with a U.S. Geological Survey butt-end aluminum band, and in Canada we banded each swan with a stainless steel locking-tab leg band. We determined sex via cloacal examination and assigned a breeding status to each swan at the time of capture depending on if a mate and one or more cygnets were present ('breeder' status), if a mate was

present but no cygnets were observed ('paired' status), or if neither a mate nor cygnets were present ('non-breeder' status).

ACTIVITY 2 Title: Acquire movement and habitat data for radio-marked swans

Description: Beginning with transmitter deployment in 2019, we propose to acquire high-resolution location data for trumpeter swans marked in MN and evaluate local and regional movements and habitat use. Transmission of high-resolution location data will commence with transmitter deployment in 2019 and continue through 2023.

ACTIVITY 2

ENRTF BUDGET: $136,606
Amount Spent: $166,697
Balance: ($30,091)

Outcome	Completion Date
1. Acquire high-resolution GPS-GSM data for marked swans	June 2023
2. Acquire local habitat data	June 2023
3. Assess survival and year-round habitat use and selection patterns of trumpeter swans	June 2023

First Update 1 April 2020

We began collecting GPS location data from the seven swans marked in 2019 immediately following their capture. Transmitters are programmed to collect GPS locations at 15-min intervals throughout the 24-hr daily period. Locations are stored on-board in internal transmitter memory. Once a day, the transmitters attempt to upload the entire batch of locations to the back-end database of the manufacturer via a GSM cellular network. All new locations from both companies' databases are uploaded daily to a data repository at Movebank for archiving and future processing.

On the project website (https://trumpeterswan.netlify.com/index.html) we created an interactive map that is regularly updated with GPS data from marked swans. Users can see where each swan was captured and the full trajectory of movements since then (Fig 4). This visualization will allow the general public to track the movements of each swan during the course of the study.

Second Update 31 December 2020

There are currently 84 trumpeter swans with active GPS-GSM collars marked as part of this collaborative project, which upload ~7,000 locations each day to the back-end database. We have compiled ~1.5 million locations on the Movebank data repository. We are continuing to host a project website showing the full summary of movement data and other project information. We have started the process of annotating the location data with remote sensing environmental variables, to facilitate future movement and habitat-selection analyses.

With only 4 mortalities so far, survival of collared swans has been high. One swan died as a result of a collision with a power line in Michigan, one swan was hit by a car in Ohio, one swan was killed by a predator in Minnesota, and one swan died from Aspergillosis (a fungal infection of the respiratory tract) in Iowa.

Swan movements in fall of 2020 suggest 3 zones of migration based on breeding latitude (Fig 6). Swans that bred at latitudes ≥ 48° N (n=13) all migrated long distances ($\bar{x} = 767$ km, $s = 364$ km, range = 262—1,330 km). Swans that bred in the middle latitudes of our study area, between 43° and 48° N (n=55), showed a variety of migration strategies, with some traveling over 1,250 km while others stayed within 5 km of their breeding territory ($\bar{x} = 293$ km, $s = 349$ km, range = 5—1,287 km). Swans that bred or were captured during the breeding season at southern latitudes, below 43° N ($n = 15$), all stayed within 22 km of their breeding territories ($\bar{x} = 8$ km, $s = 6$ km, range = 1—21 km).

Third Update 1 April 2021

We are continuing to collect GPS locations from collared swans, visualize movements on the project website, and archive data on the Movebank data repository.

There have been 9 mortalities so far on the project. Since the last update (Second Update), 2 swans were killed by predators (one in central Minnesota and the other in northwestern Indiana) and 3 died of unknown causes.

Fourth Update 31 December 2021

We are continuing to collect GPS locations from collared swans, visualize movements on the project website, and archive data on the Movebank data repository. We have collected more than 4.5 million GPS locations from collared swans and are currently working on movement analyses.

There have been 15 confirmed mortalities so far during the project. Since the last update (Third Update), 2 swans were likely killed by predators, 1 swan died from having fishing line wrapped around its bill, 1 swan died from a powerline strike, and 2 died of unknown causes.

Fifth Update 1 April 2022

We are continuing to collect GPS locations from collared swans, visualize movements on the project website, and archive data on the Movebank data repository.

There have been 19 confirmed mortalities so far during the project. Since the last update (Fourth Update), 1 swan died from a powerline strike and 3 died of unknown causes.

Sixth Update 31 December 2022

We are continuing to collect GPS locations from collared swans, visualize movements on the project website, and archive data on the Movebank data repository.

There have been 23 confirmed mortalities so far during the project. Since the last update (Fifth Update), 1 swan died from a powerline strike and 3 died from unknown causes.

Preliminary results from analysis of annual movements suggest that migration trends vary substantially among different zones within the breeding range of the IP. Collared swans that bred furthest north (e.g., Manitoba) were primarily obligate long-distance migrants. Collared swans that bred furthest south (e.g., Ohio) were primarily residents that did not make long-distance movements during the migratory period (with the exception

of some long-distance dispersals from non-breeding individuals). Collared swans that bred at middle latitudes (e.g., much of Minnesota) showed a mix of migration patterns including long-distance migration, residency, and shorter-distance regional migrations.

Breeding status was an important factor in the timing of annual movements, with breeding swans departing later for fall migration and returning earlier for spring migration than non-breeding individuals. These differences are likely due to the requirements of parental care during fall migration and the need to defend breeding territories during the spring.

Seventh update 1 April 2023

We are continuing to collect GPS locations from collared swans, visualize movements on the project website, and archive data on the Movebank data repository.

There are currently 32 trumpeter swans with active GPS-GSM collars. The majority of migratory swans have started moving north towards breeding territories.

Eighth update 1 December 2023

We are continuing to collect GPS locations from collared swans, visualize movements on the project website, and archive data on the Movebank data repository. We have been using piecewise regression to segment swan location data into periods of the annual cycle and estimate migration metrics (e.g., departure and arrival dates, migration extent and duration). Due to the transition of cell phone networks from 3G to primarily 4G and 5G bandwidths, many swan collars are no longer able to transmit location data uploads through the GSM network, and we currently have approximately 10 active GPS-GSM collars.

Ninth update 1 April 2024

We are continuing to collect GPS locations from collared swans, visualize movements on the project website, and archive data on the Movebank data repository. We have been using piecewise regression to segment swan location data into periods of the annual cycle and estimate migration metrics (e.g., departure and arrival dates, migration extent and duration). Due to the transition of cell phone networks from 3G to primarily 4G and 5G bandwidths, many swan collars are no longer able to transmit location data uploads through the GSM network, and we currently have approximately 8 active GPS-GSM collars. For some marked swans, we are receiving reports of visual observations from the public, and are able to determine their status through those observations.

Final Report between project end (30 June) and 15 August 2024

We deployed 113 collars with GPS-GSM transmitters on 126 trumpeter swans (including 13 redeployments using collars recovered from mortalities) from July 2019 to August 2022, resulting in 252 unique 'swan-year' telemetry datasets. All transmitters were programmed to collect GPS locations at 15-min intervals throughout the 24-hr daily period. Of the 126 swans, 78 were female and 48 were male; 73 were breeding adults (cygnets present), 22 were adults with mates present but no cygnets observed at time of capture, 24 were non-breeding adults captured while in large groups, and six were cygnets at the time of capture.

Annual movements of IP swans were highly variable in their extent and timing, with a continuum of movements exhibited each year. Much of this variability was related to factors tied to natural history demands (e.g., breeding status) and response to environmental conditions (e.g., through associations with breeding latitude). After filtering out 31 swan-year datasets from 27 individuals with incomplete coverage to estimate annual movement trends, 59% (n=68) of remaining IP swans (n=116 individuals) made seasonal movements to distant non-breeding areas (long-distance migration defined as moving >100 km from breeding site during the non-breeding period), 16% (n=19) underwent regional migration (25–100 km), 19% (n=22) exhibited local movements (<25 km), and 6% (n=7) exhibited multiple migration strategies across different years: regional and long-distance (n=3), and local and regional (n=4).

There was a strong association between breeding latitude (mostly between 43 and 53 degrees North latitude) and the extent of migration. Yet, many swans with breeding sites between 40 and 45 degrees North latitude exhibited minimal movement during the non-breeding period. We considered these individuals to exhibit local seasonal movements, with most of these swans leaving their breeding territory or increasing their overall space use during the non-breeding period, likely to increase access to ice-free water or to food.

We did not observe seasonal movements consistent with molt migration in our sample of adult IP trumpeter swans. Following the year of capture, we were unable to determine breeding status for most marked swans and therefore assigned breeding status in subsequent years to be the same as in the year of capture. It is likely that some of our marked swans that bred in the first year failed to rear young in later years, which would potentially lead them to make a molt migration (as is thought to be the case in other waterfowl). Yet, we did not observe any marked swans moving away from breeding areas during the summer consistent with molt migration. Thus, we suspect that groups of swans observed in the IP range during this period are likely not part of the breeding population.

To date, our assessment of habitat use has been restricted to general patterns at the landscape scale throughout the annual cycle (e.g., access to open water during winter)—the primary focus of our study. However, the spatial resolution and frequency of location data obtained in our study can facilitate additional analyses focused on habitat use and preference at smaller spatial scales, and these analyses may be especially useful for identifying locations that are not currently occupied but have suitable ecological conditions and could support breeding trumpeter swans. To that end, we are working with partners in the U.S. Fish and Wildlife Service to develop resource selection functions that can be used to predict the potential future range of IP trumpeter swans.

We documented 23 confirmed mortalities during the study. Causes of death included collisions with power lines (n=4) and a car (n=1), predator or likely predator kills (n=5), Aspergillosis (a fungal infection of the respiratory tract; n=1), fishing line wrapped around the bill (n=1), and unknown causes (n=11). Conversion from 4G to 5G cell phone systems and the concurrent retirement of 3G technology later during our study period resulted in most of our transmitters becoming unable to transmit location data, limiting our ability to estimate IP trumpeter swan annual survival rates. We therefore have not estimated annual survival rates as part of this study.

Finally, additional details for all aspects of this project are included in David Wolfson's Ph.D. dissertation, which is provided as supplemental material associated with this project and final report.

IV. DISSEMINATION:

Description:
Results of this project will provide information about MN trumpeter swans that will be disseminated to state and federal management agencies, published in the peer-reviewed literature, included in a Ph.D. dissertation, and made available to the general public via a website and popular articles. The public education component, with up to 36 stories of individual trumpeter swans (where they nest, winter, migrate and stop along the way,

how far they travel, how much time they spend in wetlands, fields, rivers and lakes) is an excellent engagement tool to support and even increase the interest of MN citizens in its natural resources.

The Minnesota Environment and Natural Resources Trust Fund (ENRTF) will be acknowledged through use of the trust fund logo or attribution language on project print and electronic media, publications, signage, and other communications per the ENRTF Acknowledgement Guidelines.

First Update 1 April 2020

From August 2019-March 2020, we presented project overviews to a variety of stakeholders at the Mississippi Flyway Council Technical Meeting in Duluth, Minnesota; the 25th Trumpeter Swan Society Meeting in Alton, Illinois; the 80th Midwest Fish and Wildlife Conference in Springfield, Illinois; the Northwest Minnesota, Minnesota Department of Natural Resources Managers Meeting in Norris Camp, Minnesota; and the Annual Meeting of the Minnesota Chapter of The Wildlife Society in Willmar, Minnesota.

To facilitate public engagement with project objectives and ongoing results we created a project website (https://trumpeterswan.netlify.com). Site content includes a project summary of objectives, background on trumpeter swan research, project reports, and an interactive map with up-to-date location data for each tagged swan.

This April, we were scheduled to present a project summary presentation to staff and volunteers of Three Rivers Park District and a research talk at the Minnesota Waterfowl Association Annual Meeting. Unfortunately, these events have been cancelled due to public health measures associated with the COVID19 pandemic.

Second Update 31 December 2020

To disseminate information about this project, we have participated in a variety of public outreach activities. We made 5 research presentations to wildlife professionals at the state, regional, and national level. The project was featured in 4 local television news segments, 7 newspaper articles, and the press releases of 4 state natural resource agencies. We also were interviewed in 3 different podcast series.

Since adding an analytics-tracking feature to the project website on 10 September 2020, we tracked 4,137 visitation sessions from 2,605 unique users in 20 different countries.

Lastly, we shared data from the first fall of the study with a 7th grade student at High View Middle School in New Brighton, MN who constructed a storyboard summarizing the study's objectives and swan movements for an ArcGIS Online competition.

Third Update 1 April 2021

We contributed an oral presentation at the Midwest Fish and Wildlife Conference on trumpeter swan migration patterns in February 2021, and the Minnesota Conservation Volunteer, a popular science magazine, featured the research project (https://www.dnr.state.mn.us/mcvmagazine/issues/2021/jan-feb/dispatch.html) in their January–February 2021 issue.

To date, 4,663 unique users have visited the project website during 7,969 online sessions.

Fourth Update 31 December 2021

During July 2021, the project was featured during an interview on the Conservation Conversations segment of KWLM, a radio station broadcasting from the greater Willmar, Minnesota area. In November 2021, we gave a virtual presentation to the Iowa Young Birders group about trumpeter swans and this project.

To date, 7,581 unique users from 48 countries have visited the project website during 13,930 online sessions.

Fifth Update 1 April 2022

During January 2022, we gave a virtual presentation to the West Metro Chapter of Minnesota Master Naturalists group about the history of trumpeter swans, the Interior Population, and the aims of this project. In February 2022, the project was featured in a newspaper article in the Lakes Area Review, a periodical that has previously published on the project. We gave an update on preliminary project results and the current activities of swans in southern Minnesota. In March 2022, we gave a virtual presentation to the North Metro Chapter of Minnesota Master Naturalists group about the history of trumpeter swans, the Interior Population, and the aims of this project.

To date, 9,033 unique users from 51 countries have visited the project website during 16,966 online sessions.

Sixth Update 31 December 2022

We gave oral presentations summarizing research findings on annual movement of collared swans at the 7th International Swan Symposium in October 2022 and the 29th Annual Meeting of The Wildlife Society in November 2022.

The project was featured in the spring 2022 edition of Our Mississippi, a publication of the U.S. Army Corps of Engineers that serves as a regional public outreach and education tool for projects within the Mississippi River basin. This publication features partnerships including state and federal agencies and non-governmental organizations that promote the environmental integrity of the Mississippi River.

To date, 10,823 unique users from 56 countries have visited the project website during 20,669 online sessions.

Seventh update 1 April 2023

To date, 15,673 unique users from 57 countries have visited the project website during 26,320 online sessions.

Eighth update 1 December 2023

To date, 18,560 unique users from 60 countries have visited the project website during 29,656 online sessions. David Wolfson presented results at the 2023 Annual Conference of The Wildlife Society from a companion project on genetics of Interior Population trumpeter swans based on tissue samples collected as part of this project. David Wolfson also gave a presentation at the Gordon Research Conference on Animal Movement in Luca, Italy in July 2023 describing the use of piecewise regression to segment movement trajectories.

Ninth update 1 April 2024

Due to recent changes in the Google Analytics tracking platform, we are no longer tracking visitation to the project website. David Andersen presented an overview of this project to the Wildlife River Audubon Society in March 2024. David Wolfson will present the research findings of the project to the Minnesota River Valley Audubon Chapter and a lecture about the project to the Michigan State University Field Ornithology Course in April 2024.

Final Report between project end (30 June) and 15 August 2024

We presented project findings through oral presentations, online websites, and a mix of media outlets (e.g., newspaper, TV, radio, podcasts). We gave 11 research presentations for professional conferences at the state, regional, national, and international levels. We gave 6 invited public presentations to a variety of venues (e.g., youth birding groups, local Audubon chapters, master naturalist groups, wetland working groups, University field course). Our study was featured in 8 newspaper articles, 7 local TV news segments, 2 popular science periodicals, 3 nature-based podcasts, 4 online agency news releases, and 2 radio interviews. We published 1 peer-review journal article and are currently in the process of submitting 3 other manuscripts for peer-reviewed publications. David Wolfson successfully defended and submitted his Ph.D. dissertation at the University of Minnesota in July 2024. Our project website, which provides tracking information on all swans collared during the project, has been viewed >30,000 times by ~20,000 users from >60 countries.

V.   ADDITIONAL BUDGET INFORMATION:
A. Personnel and Capital Expenditures

Explanation of Capital Expenditures Greater Than $5,000: N/A

Explanation of Use of Classified Staff: N/A

Total Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation:

1.81

Total Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation:

N/A

VI. PROJECT PARTNERS:

This project will be conducted cooperatively through the MN Cooperative Fish and Wildlife Research Unit at the University of MN. Project partners include University of MN principal investigators, MNDNR biologists, U.S. Fish and Wildlife Service biologists, Three Rivers Park District, and the Trumpeter Swan Society. Funds received from this Environmental and Natural Resources Trust Fund (ENRTF) request will be through an agreement with the University of MN with Drs. Andersen and Fieberg as co-Principal Investigators.
Receiving ENTRF funding:
        Associate Professor John Fieberg, University of MN, Department of Fisheries, Wildlife, and Conservation
        Biology
Not receiving ENTRF funding:
        David E. Andersen, U.S. Geological Survey, MN Cooperative Fish and Wildlife Research Unit, University of
        MN

Steve Cordts, *Christine Herwig*, *Carrol Henderson*, MNDNR
Tom Cooper, U.S. Fish and Wildlife Service
John Moriarty, Three Rivers Park District

VII. LONG-TERM- IMPLEMENTATION AND FUNDING:

The proposed project period is July 2019 – June 2023. We will work with project partners (U.S. Fish and Wildlife Service, MNDNR, Three Rivers Park District, and the Trumpeter Swan Society) to acquire funding to support marking an additional 14 swans, focused on the larger Interior Population. This will increase our sample size to 50 as indicated in our original proposal (the current smaller sample size in this work plan reflects changes in response to reduced funding recommended by LCCMR). Given the timing and availability of project support (the beginning of a state fiscal year) from the ENRTF, we propose marking a small number of swans with partner funds in 2019 and the remainder of our sample in 2020 and 2021, with movement data collection through June 2023. Results of this project will provide information about MN trumpeter swans that will be disseminated to state and federal management agencies, published in the peer-reviewed literature, included in a Ph.D. dissertation, and made available to the general public via a website and popular articles. The public education component, with up to 36 (contingent upon partner funding) stories of individual Interior Population trumpeter swans (where they nest, winter, migrate and stop along the way, how far they travel, how much time they spend in wetlands, fields, rivers and lakes) is an excellent engagement tool to support and even increase the interest of MN citizens in its natural resources.

Through amendment to the original work plan, the project period was extended through June 2024.

VIII. REPORTING REQUIREMENTS:

- Project status update reports will be submitted 1 April and 31 December each year of the project
- A final report and associated products will be submitted between 30 June 2023 and 15 August 2024

IX. SEE ADDITIONAL WORK PLAN COMPONENTS:

A. Budget Spreadsheet
B. Visual Component or Map
C. Parcel List Spreadsheet N/A
D. Acquisition, Easements, and Restoration Requirements N/A
E. Research Addendum *Approved January 2020*

Environment and Natural Resources Trust Fund
M.L. 2019 Budget Spreadsheet
Legal Citation: M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 03d
Project Manager: David E. Andersen
Project Title: Minnesota Trumpeter Swan Migration Ecology and Conservation
Organization: U.S. Geological Survey Minnesota Cooperative Fish and Wildlife Research Unit *and* University of Minnesota
Project Budget: $300,000
Project Length and Completion Date: 5 years, June 2024
**Today's Date:** 15 August 2024

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 246,051	$ 245,074	$ 977
Ph.D. Graduate Research Assistant $174,762 (50% Research Assistantship, 50% FTE for 4 years, 54.9% stipend, 8.2% benefits, 36.8% tuition)			
University of Minnesota Assistant Professor John Fieberg, quantitative ecologist $34,118 (4.5–9% FTE for 3 years, 66.3% salary, 33.7% fringe)			
1 (2020–2021) field technicians @ 11 weeks per year $5,313 (21% FTE, 92.1% salary, 7.9% fringe)			
Professional/Technical/Service Contracts (cellular phone contracts for download of satellite transmitter data)			
Cellular data fees ($300 per transmitter per year; 16 data contracts in 2019, 36 data contracts in 2020, 36 data contracts in 2022, and 30 data contracts in 2023; data include GPS locations at 15-minute intervals, transmitter status, temperature, and other parameters, stored onboard devices until connecting and downloading data when in range of cellular networks)	$ 4,000	$ 4,000	$ -
Equipment/Tools/Supplies			
GPS-GSM transmitters (36 @ $2,600 each; 16 deployed in 2019–2020 and 20 deployed in 2020–2021)	$ 35,687	$ 35,687	$ 0
Miscellaneous supplies (neck collar materials and neck collars, rocket nets, rocket-net propellant, etc.)	$ 702	$ 702	$ -
Travel expenses in Minnesota			
4-wheel drive vehicle mileage [1 (2019–2020) or 2 (2020–2021) vehicles @ $0.565/mile x 100 miles/day x 80 days/year] for swan capture activities	$ 13,560	$ 11,615	$ 1,945
Lodging for 1 (2019–2020) or 2 (2021–2020) field crews 1-2 rooms per night @ $40 per night x 80 nights x 2 field seasons) for swan capture activities	$ -	$ -	$ -
Field crew food and supplies [$75 (2019–2020) or $150 (2020–2021)/week x 10 weeks/year] for swan capture activities	$ -	$ -	$ -
COLUMN TOTAL	$ 300,000	$ 297,078	$ 2,922

OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State: U.S. Fish and Wildlife Service, Migratory Birds ($60,000)	Secured	$ 60,000	$ 19,048	$ 40,952
State: University of Minnesota, Minnesota Cooperative Fish and Wildlife Research Unit, University of Minnesota Doctoral Dissertation Fellowship (2022–2023)	Secured	$ 15,000	$ 68,738	$ (53,738)
In kind: U.S. Geological Survey, David E. Andersen salary and benefits (1 month/year; $42,000) Minnesota Department of Natural Resources, Wildlife (1 month/year; $15,000) Minnesota Department of Natural Resources, Nongame (1 month/year; $15,000) U.S. Fish and Wildlife Service (1 month/year; $15,495)	Secured	$ 87,495	$ 128,459	$ (40,964)

PAST AND CURRENT ENRTF APPROPRIATIONS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Current appropriation: N/A		$ -	$ -	$ -
Past appropriations: N/A		$ -	$ -	$ -

Attachment B: Visual component or map.

Figure 1. Minnesota trumpeter swan population size estimated from waterfowl surveys conducted over approximately 39% of the area of the state (MN DNR, unpublished data). The trumpeter swan population in Minnesota has increased substantially, dramatically exceeding original and interim population goals, and is currently growing at an annual rate of ~1.20.
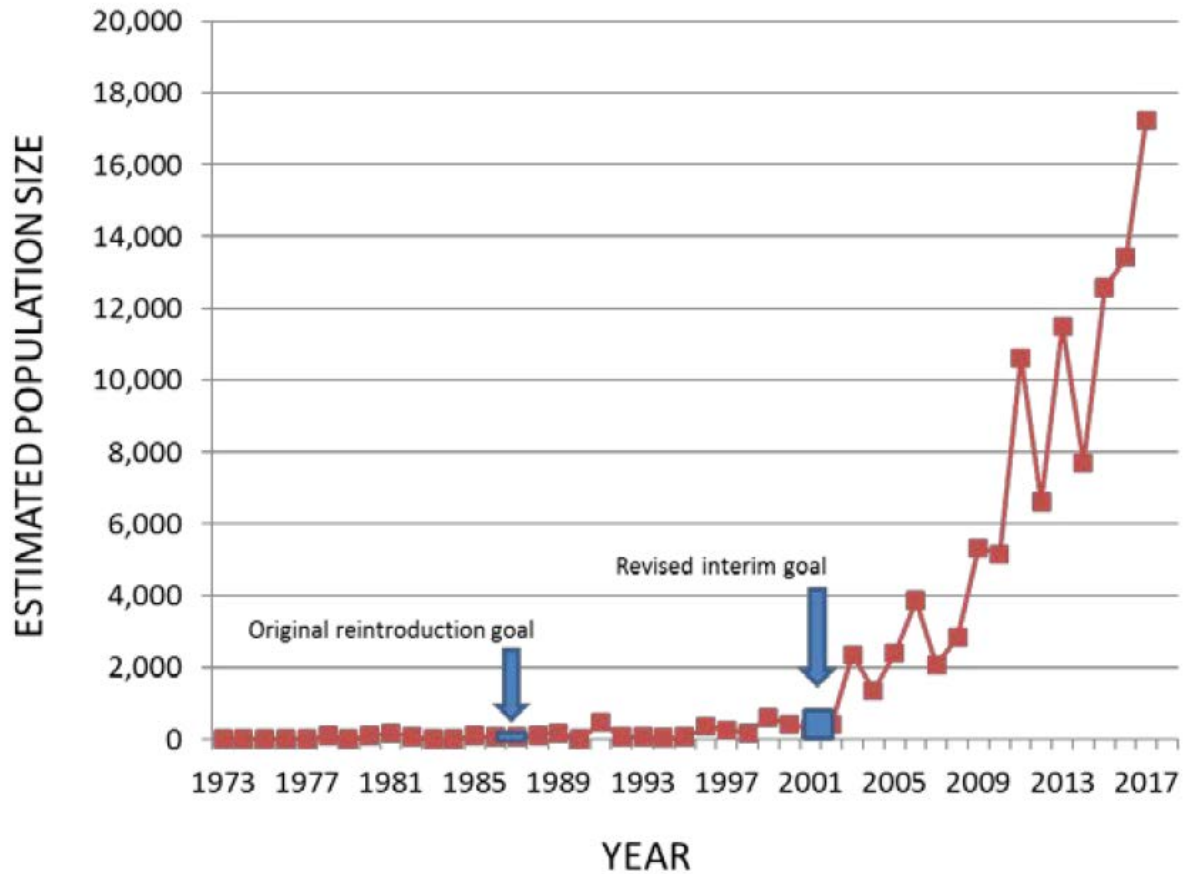
Figure 2. An example of the Ornitela OrniTrack-N62 collars with GPS/GSM transmitter incorporated into the internal housing that were deployed in Minnesota during 2019. All new deployments in 2020 will be this design.

Figure 3. An example of the Cellular Tracking Technology CTT-ES400 model transmitters affixed to neck collars that were deployed on trumpeter swans in Michigan during 2019.

Figure 4. Locations of all marked swans are regularly uploaded to a project website that allows users to interactively visualize swan movements. Capture and end locations are represented by colored points. Lines connecting these points show individual movement trajectories observed thus far. For a real-time version go to: https://trumpeterswan.netlify.com/locations.app
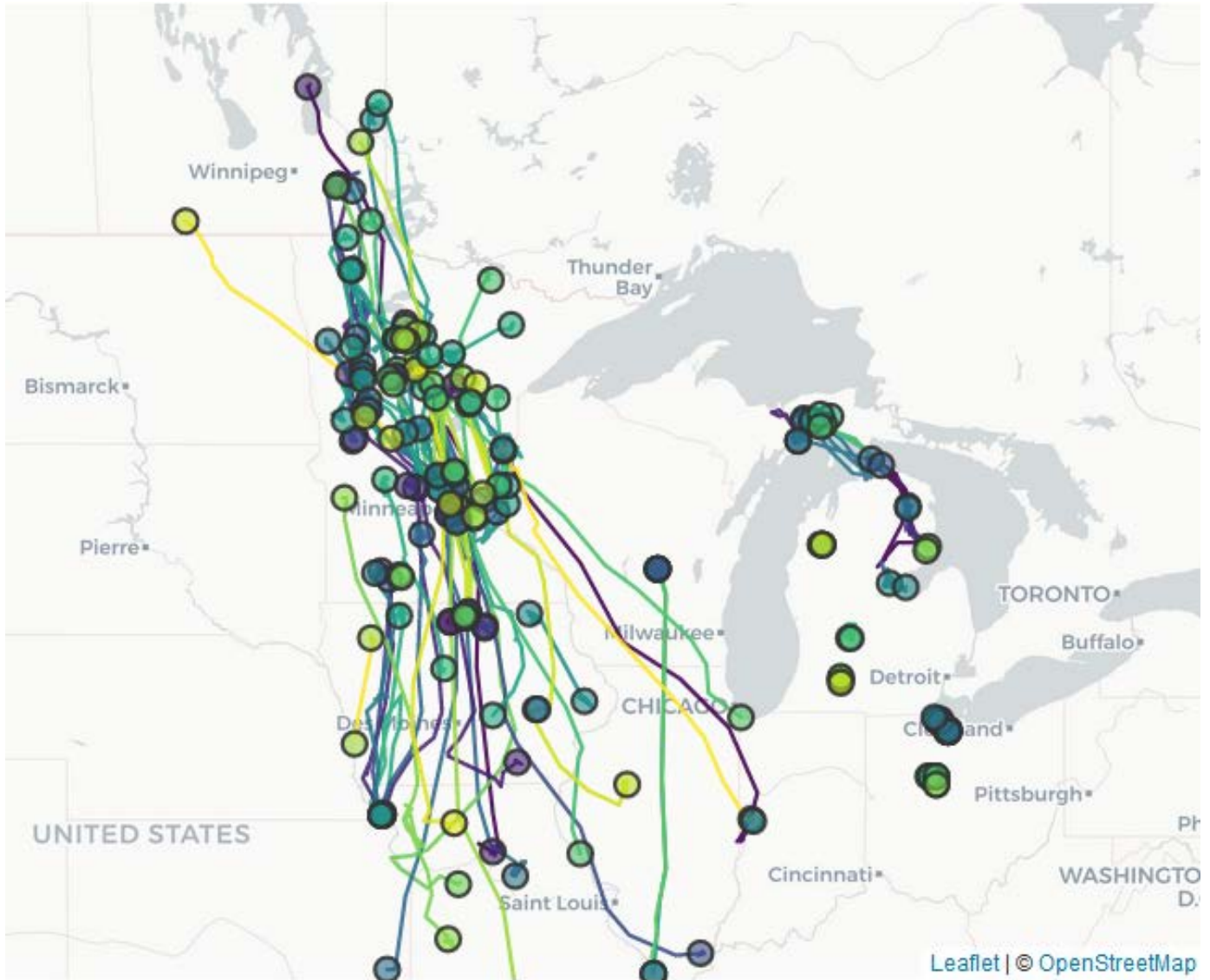
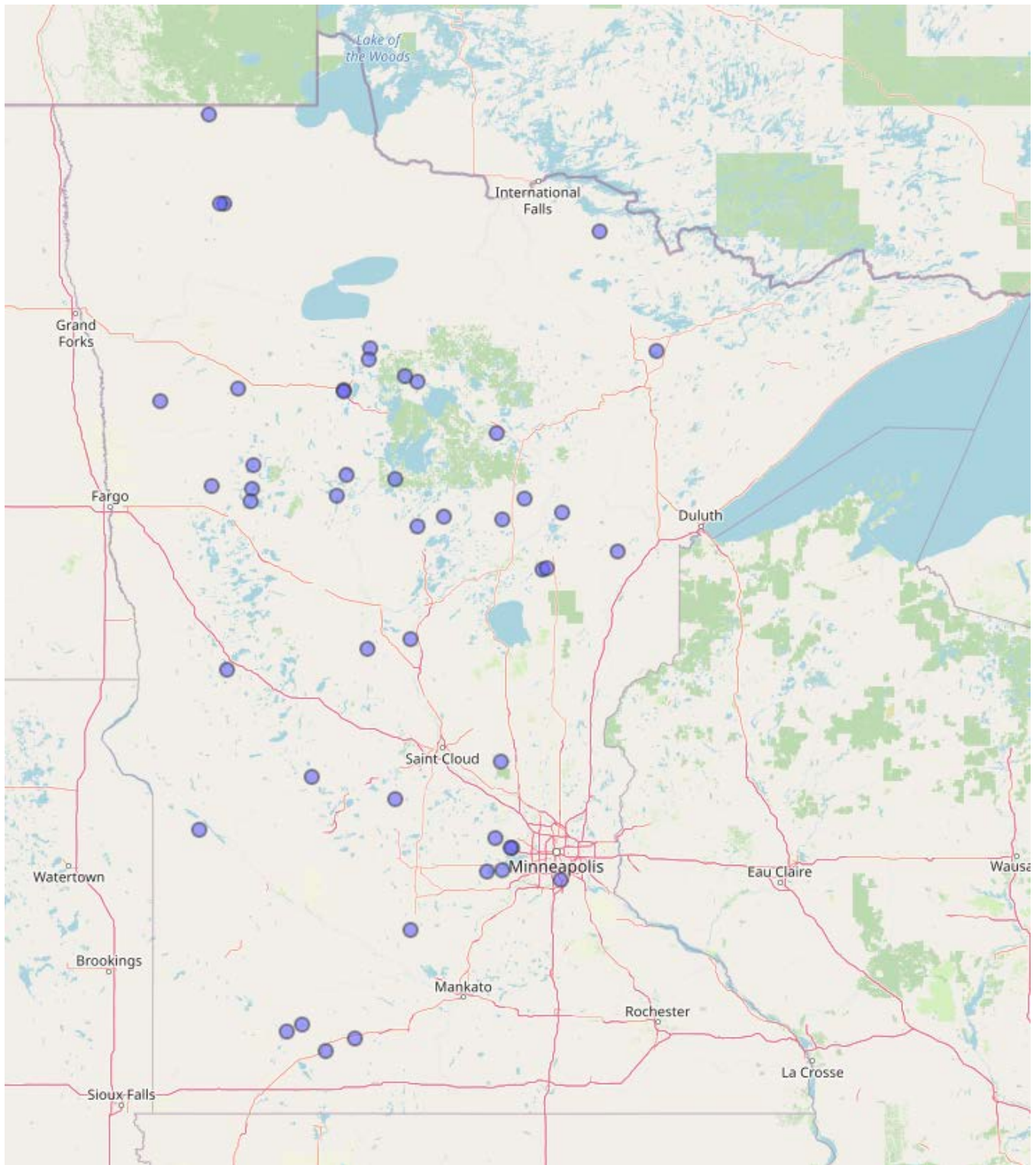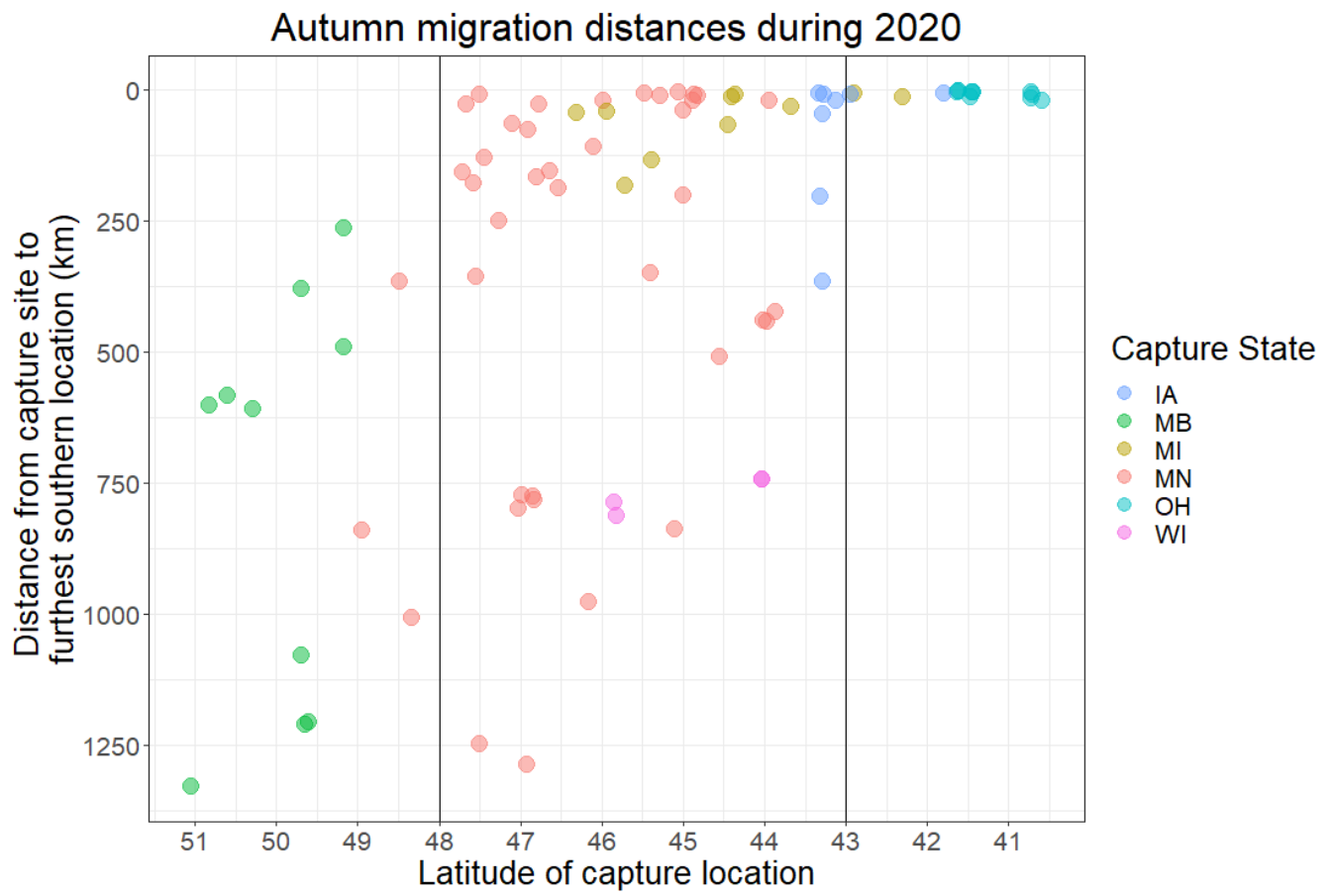**Figure 5**. Map of all Minnesota trumpeter swan capture locations.

Figure 6. Autumn migration distances of GPS-marked swans during 2020.

Attachment A:
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