2018 Project Abstract
For the Period Ending June 30, 2021

PROJECT TITLE: Mapping Avian Movement in Minnesota
PROJECT MANAGER: Alexis Grinde
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FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 03h

APPROPRIATION AMOUNT: $200,000
AMOUNT SPENT: $200,000
AMOUNT REMAINING: $0

Sound bite of Project Outcomes and Results

We used automated radio telemetry to understand habitat needs of Minnesota's birds. Specifically, we tracked birds across large and local-scales to document breeding, migratory and winter movements. Automated radio telemetry systems are useful for studying animal movements and can help to increase public awareness and impact for conservation efforts.

Overall Project Outcome and Results

We explored the use of automated radio telemetry for tracking Minnesota's birds. We documented large-scale movements along the north shore of Lake Superior with Blue Jays and Northern Saw-whet Owls, colonial waterbird behavior on Interstate Island with Common Terns, local-scale migratory stopover in the St. Louis River Estuary with Rusty Blackbirds, and winter activity levels and movements in Hartley Park with Black-capped Chickadees. Each of these studies provided us with a greater understanding of the flexibility and adaptability of automated radio telemetry technology to answer a range of questions in different situations and seasons. Overall, we found the use of this technology to document small-scale movements of Rusty Blackbirds, Black-capped Chickadees, and Common Tern to be the most valuable and suggest it as a relatively low-cost way to study local movements while potentially enhancing migration studies simultaneously. For example, using an automated telemetry station at Interstate Island allowed us to obtain additional behavioral information on breeding Common Terns before the birds left and interacted with any foreign automated radio telemetry towers registered on the Motus system. We suggest researchers that are deploying VHF tags for the purposes of long-range migratory studies strongly consider deploying automated telemetry stations like those we developed for this project in strategic locations nearby tagging sites. In this way, researchers will be able to obtain potentially large amounts of local-scale data that can then be used to inform and enhance any large-scale detections after a bird migrates from the trapping site. Bird tracking research has broad public appeal, and stories of bird migrations provide an effective way to engage non-scientists and even non-birders in understanding the many threats small migratory landbirds face.

Project Results Use and Dissemination

The preliminary results of the research were presented at eight conferences during the course of project and the study was featured on MPR in 2019. Two peer-reviewed publications are expected to be published in 2022, one focusing on Common Tern and other on Rusty Blackbirds. We set up an additional Motus station at Sax-Zim Bog in 2020 to help facilitate research in this important area of the state. We established a website for the citizen science portion of the Black-capped Chickadee study in Hartley Park. A full report for this study is available on the Natural Resources Research Institute website.

Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2018 ENRTF Final Work Plan

Today's Date: October 20, 2021

Final ReportDate of Work Plan Approval: 06/05/2018

Project Completion Date: June 30, 2021

Deleted: ¶

PROJECT TITLE: Mapping Avian Movement in Minnesota

Project Manager: Alexis Grinde

Organization: Natural Resources Research Institute, University of Minnesota Duluth

College/Department/Division: Forest and Land Initiative

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Location: Northeast Minnesota

Total Project Budget: $200,000

Amount Spent: $200,000

Balance: $0

Legal Citation: M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 03h

Appropriation Language: $200,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota for the Natural Resources Research Institute in Duluth to pilot the establishment of a network of automated radio-telemetry stations to monitor bird migration and local movements and to develop strategic plans for using the infrastructure long term to monitor animal movement for conservation. This appropriation is available until June 30, 2021, by which time the project must be completed and final products delivered.

I. PROJECT STATEMENT:

Our project will establish a network of automated radiotelemetry stations, which we will use to monitor bird migration along the north shore of Lake Superior and document local movements of Common Terns, a state threatened species, also designated a "Species of Greatest Conservation Need" (SGCN) by the Minnesota Department of Natural Resources (MNDNR). The results of this project will help to develop strategic plans to monitor animal movement within the state. With birds as the focal taxa, we will demonstrate the utility of automated tracking stations and highlight the ways in which this network can be used to track animals at multiple spatial scales throughout Minnesota.

Avian flight has long fascinated scientists and bird-lovers; however techniques for studying movement have been limited. For example, satellite transmitters are expensive and limited to use on large birds. Traditional radio-telemetry is also expensive and labor intensive because birds must be followed on the ground. Geolocators require that birds be recaptured post-migration to recover their movement data. Similarly, traditional banding is inefficient; less than 1% of songbirds banded are ever relocated. Recently a consortium of researchers developed a system of automated radiotelemetry stations that collect locations of migratory and resident birds carrying relatively inexpensive transmitters. This growing system, referred to as the Motus network, currently has its greatest density in the Eastern Great Lakes region of the United States and Canada. This technology provides an efficient and cost-effective method to gather data on bird movements over large areas.

We will join the Motus network and deploy automated radiotelemetry stations in Minnesota. The Motus towers will be set up in strategic locations in northeastern Minnesota, such as along the shores of Lake Superior and along the St. Louis River Estuary. We will focus on these areas to study migratory and local movements of birds in the region. Our project consists of two applications of Motus technology: **1)** to identify timing and migratory movements of birds in northeastern Minnesota, and **2)** to identify local movements and dispersal behavior of adult and juvenile Common Terns.

For the first application we will focus on the North Shore of Lake Superior. This area is known to be a migratory route for many species, however timing of migration and specific pathways are unknown. The Motus network will allow us to assess the duration of migration and characterize species specific migratory movements. These data will help us identify stopover areas that are used by birds during migration and increase our understanding of the effects of weather on migratory behavior. We will concentrate on common songbird and raptor species that constitute the bulk of migrating individuals, to maximize our potential to detect migratory patterns. We will partner with bird banding stations in the region, such as Hawk Ridge Bird Observatory in Duluth, to capture birds and attach transmitters.

In the second application we will focus on Common Terns, they are identified as one of the most vulnerable species at both a federal and state level and as a high priority species for conservation in the state. Interstate Island, in the St. Louis River Estuary, is one of only two breeding colonies for Common Terns in Lake Superior and one of four consistently active colonies in the state. Determining local movement, habitat use, and dispersal of adult and juvenile terns will help identify important areas in the St. Louis River Estuary. This information will greatly aid in the development of local and regional Common Tern management plans. In particular, identifying movement patterns of juvenile birds is crucial because it has not previously been feasible to monitor this age-class using traditional tracking methodologies.

The specific goals of this project are to:

1) Develop a network of Motus stations along the St. Louis River Estuary and the shores of Lake Superior,
2) Identify migratory movements, timing, and pathways of migration along Lake Superior for songbird and raptor species, and
3) Deploy Motus towers along the St. Louis River Estuary to track local movements, foraging locations, and dispersal of Common Terns, to inform management strategies.

II. OVERALL PROJECT STATUS UPDATES:

Amendment Request (02/05/2019)
We are requesting to change the Principal Investigator from Gerald Niemi to Alexis Grinde. Dr. Gerald Niemi, will retire effective on June 9, 2019, however will be "Professor Emeritus" at the University of Minnesota Duluth after this time. We recommend Dr. Alexis Grinde be the lead Principal Investigator position on this project, Dr. Grinde has been the primary project manager and has developed, managed, administered, and implemented this project from the beginning. Amendment Approved by LCCMR 2/11/2019.

First Update January 1, 2019
We are well ahead of our intended timeline for this project; we built and deployed nine Motus stations in fall 2018. Work completed as of December 15, 2018 has focused on the following activities: 1.) Motus station site selection, 2.) Building automated telemetry units for Motus stations, 3.) Deployment of Motus stations, and 4.) Capturing and tagging Blue Jays during fall migration.

Second Update July 1, 2019
Work completed since the last update has focused on Activity 2, assessing local movements and dispersal behavior of Common Terns in the St. Louis River Estuary. We deployed a Motus station on Interstate Island to track the local movements of adult and juvenile Common Tern and have tagged eight adult breeding pairs so far this breeding season.

Third Update January 1, 2020
Work since the last update has focused on deploying tags on juvenile Common Tern and analyzing data to track them on the Motus network. There are currently 29 active tags on Common Terns, 16 on adult birds and 13 on juvenile birds. We have detected 14 individuals at Motus stations since deployment and the last detection was of a female juvenile on 11-02-19 at a station near Long Point National Wildlife Refuge in Ontario. We also tagged three Blue Jays in September during fall migration.

Fourth Update July 1, 2020
The second field season for assessing local movements and dispersal behavior of Common Terns in the St. Louis River Estuary is on-going. We deployed a Motus station on Interstate Island again this year to track the dispersal timing and local movements of juvenile Common Tern.

Fifth Update January 1, 2021
Work completed since the last update included deployment of radio transmitters on 35 juvenile Common Terns in the St. Louis River Estuary (SLRE; July-Aug, 2020) and recovery of radio transmitters placed on adult terns in the 2019 field season. October – November, 2020 we deployed six temporary Motus stations along the Minnesota portion of the SLRE to document migration stopover use of the river by Rusty Blackbirds.

Work to be completed: We will deploy nine temporary Motus stations in Hartley Park, a city park in Duluth MN (January – March, 2021) and will deploy 30 radio transmitters on Black-capped Chickadees to document winter movement in an urban-forested landscape to document winter flocking behavior and movement relative to supplemental food supplies.

Final Update June 30, 2021

We explored the use of automated radio telemetry for tracking Minnesota's birds. We documented large-scale movements along the north shore of Lake Superior with Blue Jays and Northern Saw-whet Owls, colonial waterbird behavior on Interstate Island with Common Terns, local-scale migratory stopover in the St. Louis River Estuary with Rusty Blackbirds, and winter activity levels and movements in Hartley Park with Black-capped Chickadees. Each of these studies provided us with a greater understanding of the flexibility and adaptability of

automated radio telemetry technology to answer a range of questions in different situations and seasons. Overall, we found the use of this technology to document small-scale movements of Rusty Blackbirds, Black-capped Chickadees, and Common Tern to be the most valuable and suggest it as a relatively low-cost way to study local movements while potentially enhancing migration studies simultaneously. For example, using an automated telemetry station at Interstate Island allowed us to obtain additional behavioral information on breeding Common Terns before the birds left and interacted with any foreign automated radio telemetry towers registered on the Motus system. We suggest researchers that are deploying VHF tags for the purposes of long-range migratory studies strongly consider deploying automated telemetry stations like those we developed for this project in strategic locations nearby tagging sites. In this way, researchers will be able to obtain potentially large amounts of local-scale data that can then be used to inform and enhance any large-scale detections after a bird migrates from the trapping site. Bird tracking research has broad public appeal, and stories of bird migrations provide an effective way to engage non-scientists and even non-birders in understanding the many threats small migratory landbirds face.

III. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Assess migratory timing for Minnesota's migrating birds along Lake Superior
Description:
We will establish a network of 8 Motus towers along the shore of Lake Superior to identify migration pathways and timing of migration for songbird and raptor species. We will identify priority locations for these stations based on proximity to Lake Superior and accessibility. We will identify and contact partners in these locations that can help maintain the towers. Potential partners include local schools, environmental research centers, tribal and state agencies, and private land owners.

We will contact established bird banding stations in the area to coordinate their on-going banding efforts with our transmitter deployment; potential partners include Hawk Ridge Bird Observatory, Sugarloaf Cove, and Wolf Ridge Environmental Learning Center. The locations of these banding stations will allow us to track tagged individuals along Lake Superior using the Motus towers.

An emphasis will be placed on attaching transmitter tags on several common species such as Blue Jay and Sharp-shinned Hawk. These species migrate in high density along Lake Superior and will provide sufficient sample sizes to assess migratory patterns. Use of these transmitters has been shown to not negatively affect survival rates of birds. All necessary approvals from the Bird Banding Laboratory and University of Minnesota (IACUC) will be obtained to capture, handle, and attach transmitters.

ENRTF BUDGET: $ 99,675

Outcome	Completion Date
1. Identify government, academic, NGO, and private partners to host Motus stations along the shores of Lake Superior.	December 2018
2. Partner with banding stations to place a minimum of 80 transmitters (40 per year) on songbirds and raptors.	October 2020
3. Document timing of migration along Lake Superior for songbirds and raptors and assess ability of Motus towers to track migratory movements.	June 2021

First Update January 1, 2019

A total of nine Motus stations were built and deployed along the shores of Lake Superior in northern Minnesota (5 stations) and Wisconsin (4 stations) from August-October 2018 (Figure 1.1). The location of the stations were strategically placed to track migration along the north shore and to detect birds as they migrate along the south

shore in Wisconsin. These locations will allow us to determine if and how birds tagged in Minnesota cross Lake Superior during migration and importantly to track tagged Common Terns as they leave the St. Louis River estuary for fall migration. The stations are hosted by a variety of partners including Lutsen Mountains Ski and Summer Resort, Minnesota Power, Wolf Ridge Environmental Learning Center, City of Beaver Bay, Two Harbors High School, National Estuarine Research Reserve, and two private land owners.

Figure 1.1. Map of Motus station locations. The yellow ovals indicate the detection radii (~15 km) for the antennae associated with each Motus station.

Each Motus station was built by researchers at the Natural Resources Research Institute (NRRI), building the stations provided cost savings and will allow us to troubleshoot and maintain the units over time. Motus stations are comprised of a minicomputer called a Sensorgnome, 9-element Yagi antenna arrays, and mounting equipment for the antennae. The Sensorgnome is comprised of several components: a Raspberry Pi single board computer, FUNcube Dongles (FCDs), and a power source converter (Figure 1.2). The Sensorgnome is then connected to an antenna array; each antenna has an approximate range of 15 kilometers (Figure 1.1). The FCDs are software-defined radios that listen for the signals from the tags placed on birds, the antennas amplify listening strength, and the Raspberry Pi collects and stores the data from each antenna including time of detection and signal strength along with relevant metadata about the Sensorgnome. This information allows us to track birds and identify timing of movements along the shore.

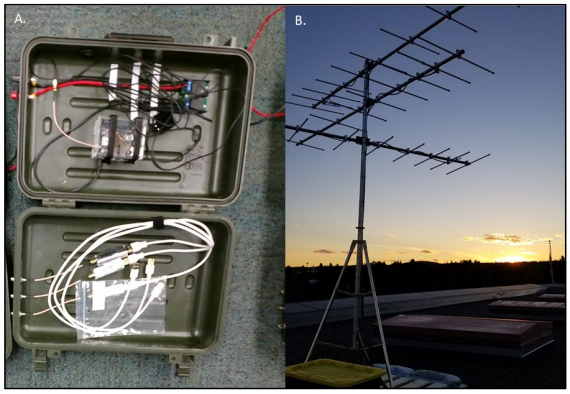

Figure 1.2. Components of a Motus station. A.) Sensorgnome components including a Raspberry Pi, three FUNcube Dongles, and power converter, B.) Motus station mounted on the roof of Two Harbors High School, Two Harbors MN.

We obtained the Federal Bird Banding Permit (Permittee: Annie Bracey; Permit Number: 24165) required for capturing, banding, and attaching radio-transmitters on focal species. We also obtained approval from the Institutional Animal Care and Use Committee (IACUC) of the University of Minnesota for our protocol for the project (PI: Alexis Grinde; Protocol ID: 1806-36074A). Due to timing considerations associated with migration and Motus station deployment we decided to focus on Blue Jay migration this fall, as this species is known to migrate down the North Shore and thus will help assess the functionality of the Motus stations. We used a wire box trap with manual door-pull mounted on a feeder platform to capture Blue Jays at a private residence about 10 miles north of Lutsen, MN. The birds were banded and fitted with nanotags from Lotek (http://www.lotek.com/nanotag.htm) using a leg loop harness (Figure 1.3). Nanotags are coded radio transmitters that release a unique signal so individual birds can be identified by any Motus station. A total of 10 Blue Jays were tagged: two birds were hatch year birds (juveniles) and eight were after hatch year birds (adults), and body weight and fat levels were recorded. Birds were not able to be sexed because male and female plumages do not differ.

Figure 1.3. Blue Jay fitted with a nanotag transmitter.

We collected data from five of the Motus stations in November 2018. At present, we have processed the data for one of our tagged birds. Our data show the bird was tagged at our banding location on September 24, 2018, was then detected on the Motus station near Schroeder on September 25, 2018, and was detected at the Beaver Bay Motus station on September 28, 2018. Together, these detections show us the bird traveled southwest down the north shore of Lake Superior from the banding location north of Lutsen to Schroeder at an average speed of 1 km/ hour (~ 28 km over a 30 hour time frame), but then traveled from Schroeder to Beaver Bay at an average of 0.6 km/ hour (~ 41 km in a three day period).

Second Update July 1, 2019

We performed routine maintenance to ensure stations were functional and structurally sound in spring 2019. We will be deploying transmitters on migrating birds again August- October.

Third Update January 1, 2020

We collected data from the Motus stations and performed routine maintenance in August 2019. We established a new banding station in Grand Marais closer to the shore than the 2018 location to capture and band Blue Jays

to better target migrating Blue Jays. Despite several days of trapping effort we were able to capture and tag only three individuals. There were two main reasons for the low capture rate, the first is the migrating birds were reluctant to come to the feeders and very weary of the trap. The second reason for the low capture rate was related to weather and migration. The bulk of Blue Jays moved through the Grand Marais area within three days due to a series of stormy weather, thus limiting our trapping window. We are considering expanding our focal species for fall migration 2020 to increase our tagging success rates.

Fourth Update July 1, 2020
We performed routine maintenance to ensure stations were functional and structurally sound in June 2020. We will be deploying transmitters on migrating birds again August- October.

Fifth Update January 1, 2021
We continued to perform routine maintenance of the Motus stations deployed along the north and south shores of Lake Superior. Stations were last visited and data downloaded in October, 2020. All stations were functioning properly and detection data was uploaded to the Motus server. In August - October, 2020 we deployed radio transmitters on Blue Jay, Northern Saw-whet Owl, and Rusty Blackbirds in NE Minnesota.
As in 2019, we attempted to target migrating Blue Jays near Grand Marais, MN. We had a difficult time capturing birds using feeder traps in 2019 but assumed the low capture rates were an anomaly. However, our capture rates in 2020 at the same location were even lower. We were only able to successfully trap and fit one bird with a transmitter although we attempted to capture them for several weeks. There is no apparent reason the capture rates were so low, observing a large number of Blue Jays moving through the area, so we decided not to attempt to capture any more birds as the fall season progressed. We were instead able to deploy the radio transmitters intended for Blue Jay on Northern Saw-whet Owl (n = 7) to document movement of birds during fall migration. We need to visit Motus station on the north and south shore again to download detection data to determine whether any of these tagged owls were detected along the lake or elsewhere.

We also documented movement of Rusty Blackbirds migrating through the St. Louis River Estuary (SLRE) in Duluth, MN (Figure 1.4). Rusty Blackbirds are among the most rapidly declining bird species in North America, but the reasons driving these declines have confounded researchers. One hypothesis is that suitable habitat during the migratory and nonbreeding seasons is limited. Rusty Blackbirds rely on forested wetlands for nesting, foraging, and roosting during every part of their life cycle. Tens of thousands of Rusty Blackbirds use the north shore of Lake Superior and the SLRE as a migration corridor each spring and fall; this concentration of migrants is rarely seen in other parts of its range. The relative importance of sites within the SLRE to Rusty Blackbirds is poorly understood. During the fall of 2020, in an effort to document the temporal and geographic use of the SLRE by individual Rusty Blackbirds, we fitted 35 birds with radio telemetry tags and deployed six automated telemetry stations to assess the duration of stay and movements within the estuary.

Preliminary results suggest that individual Rusty Blackbirds exhibited high levels of stopover site fidelity and remained within the SLRE for up to 24 days (Figure 1.5), far longer than a typical migratory bird stopover. Also, although some of the birds detected at North Bay used the location as an overnight roosting site, many of the birds detected at that site were only detected during daylight hours, which suggests that many of the birds are likely using other locations within the SLRE to roost at night, potentially some of the small wet forested island habitats in the upper river. Our research highlights the critical importance of forested wetlands in the SLRE to declining Rusty Blackbird populations and emphasizes the need to protect and conserve this habitat. It also highlights the need for additional research in the estuary that can elucidate the fine-scale habitat needs of Rusty Blackbirds during this important phase of their annual cycle.

Figure 1.4. Rusty Blackbird fit with radio transmitter (nanotag) using leg-loop harness attachment at North Bay in the St. Louis River Estuary, Duluth, MN in October 2020.

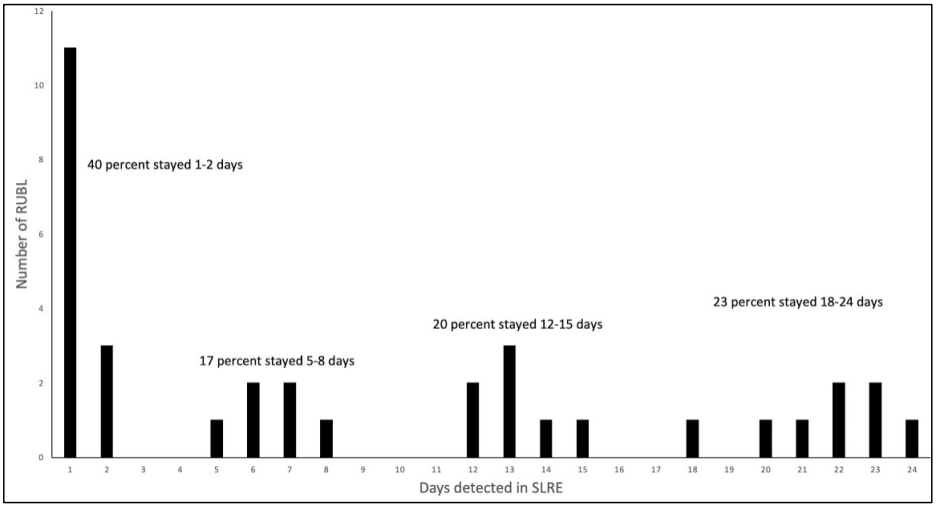

Figure 1.5. Duration of stay, in days, for Rusty Blackbirds (RUBL) fit with radio transmitters at North Bay in the St. Louis River Estuary (SLRE), Duluth, MN.

Final Update June 30, 2021

Our goal was to assess the utility of using Motus automated telemetry technology at various spatial scales and on a variety of species to study different ecological questions. First, to study timing and behavior of fall migration along the shores of Lake Superior we focused on two species: Blue Jay (*Cyanocitta cristata*) and Northern Saw-whet Owl (*Aegolius acadicus*). These species are common in the area, yet there is a dearth of knowledge related to their migratory movements and habitat use. Second, we focused on Rusty Blackbirds in the St. Louis River Estuary (SLRE) to document the temporal and geographic use during their fall migratory

stopover. Rusty Blackbirds are among the most rapidly declining bird species in North America, but the reasons driving these declines are unknown (Greenberg et al. 2011); a lack of suitable habitat during the migratory and non-breeding seasons is likely a contributing factor. Thousands of Rusty Blackbirds use the north shore of Lake Superior and the SLRE as a migration corridor each spring and fall, yet habitat use and duration of stopover is poorly understood. For this reason, we used automated radio tracking technology to document stopover duration of individual birds in relation to minimum daily temperature and to assess potential differences between sex and age. Third, we focused on documenting winter movement patterns of Black-capped Chickadees (*Poecile atricapillus*) in an urban-forested landscape: Hartley Park, Duluth MN, USA, to assess how detection rates related to minimum daily temperature and food availability at feeding stations. Black-capped Chickadees are an abundant resident species in our study area and have broad public appeal but are relatively understudied in the winter, particularly in urban settings. We provide a summary of the overall results below but additional information and analyses are provided in the full technical report available at https://hdl.handle.net/11299/224855.

Motus Stations Results

- **Blue Jay**. A total of 14 Blue Jays were trapped and tagged over the course of the study (10 in 2018, 3 in 2019, 1 in 2020). Overall, only 3 of these 14 Blue Jay tags were documented by the Motus network. A Blue Jay tagged near Lutsen on 24 September 2018 was detected at the Schroeder station the next day on 25 September (26.9 km/day) and at the Beaver Bay station a few days later on 28 September (12.7 km/day). The overall speed of this bird from Lutsen to Beaver Bay was 16.8 km/day. A second Blue Jay banded in Grand Marais on 18 September 2019 was detected at the Beaver Bay station on 26 September 2019 (14.4 km/day). Finally, a Blue Jay banded on 19 September 2019 in Grand Marais was detected at the Two Harbors High School Motus station on 22 October 2019 (3.84 km/day). All birds flew in a southwesterly direction "down" the shore after banding. No Blue Jays were detected by Motus stations outside of the local Lake Superior array.

- **Northern Saw-whet Owl**. Seven Northern Saw-whet Owls were trapped and fitted for nanotags in fall of 2020.
- **Foreign detections.** Four individuals of three species tagged by unaffiliated migration projects were documented on our Motus stations. A Sora (*Porzana carolina*) that was tagged near the Patuxent River in eastern Maryland on 5 May 2021 was detected at the Bark Point Motus station on the south shore of Lake Superior on the night of 23 May 2021. A second Sora also tagged at the same site in Maryland on 30 April 2021 was detected at the National Estuarine Research Reserve Motus station in the early morning hours of 24 May 2021. A Swainson's Thrush (*Catharus ustulatus*) tagged in British Columbia, Canada on 29 August 2019 was detected at the Beaver Bay Motus station just before sunrise on 22 September 2019. A Short-billed Dowitcher (*Limnodromus griseus*) that was tagged near Churchill, Manitoba on 19 June 2021 was detected at the Bark Point Motus station in the late afternoon of 17 July 2021.

Automated Telemetry Stations Results

- **Rusty Blackbird**. We deployed 35 tags on Rusty Blackbirds on four days in the fall of 2020. The six automated telemetry stations placed along the SLRE to track Rusty Blackbird stopover accumulated over 145,000 detections of all 35 birds between early October and mid November. Of the 35 Rusty Blackbirds tagged, 18 (51.4%) were only ever detected at the tagging location (North Bay), 15 (42.9%) were detected 1.2 km away at Perch Lake, and 2 (5.7%) were detected 1.8 km away at Radio Tower Bay. The average stopover duration in the SLRE was 9.4±1.4 days and ranged from 1 to 24 days. Juvenile (hatch year) birds tended to have a longer stopover duration than adult (after hatch year) birds, but this difference was not significant. Likewise, female Rusty Blackbirds had marginally longer stopover

durations than males, but this was also not significant. Rusty Blackbirds tended to remain on migratory stopover in the SLRE, when daily minimum temperatures were relatively stable, and typically departed one to three days after a drop in daily minimum temperatures.

- **Black-capped Chickadees**. We deployed 23 tags on Black-capped Chickadees in the winter of 2021 in Hartley Park. The nine automated telemetry stations placed in Hartley Park to track Black-capped Chickadee winter movements and activities accumulated over 1,368,000 detections of all 23 birds between late January and late February. We were able to detect activity level changes at the feeding stations in relation to days when the feeding stations were stocked. Typically, chickadee activity increased one or two days after feeding. There was no relationship between Black-capped Chickadee activity levels detected at the telemetry stations and temperature. We received multiple reports of color-banded Black-capped Chickadees from Duluth citizen scientists. Color-banded chickadees were reported visiting bird feeders at two different private residences near Hartley Park. One citizen scientist who was hiking in Hartley obtained a cell phone image of a color-banded chickadee and sent it in an email to the project account. Additionally, color-banded chickadees were observed six times by researchers when they were placing seed on the feeding platforms.

ACTIVITY 2: Assess local movements and dispersal behavior of Common Terns in the St. Louis River Estuary.
Description:
We will establish a minimum of six Motus towers along the St. Louis River Estuary and south shore of Lake Superior. These Motus towers will allow us to identify local movement of Common Terns nesting on Interstate Island, located in the Duluth-Superior harbor. We will identify priority locations for these stations which maximize coverage of potential tern foraging habitat. We will identify and contact partners in these locations that can help maintain the towers; potential partners include National Estuarine Research Reserve, Minnesota Pollution Control Agency, MNDNR, and private land owners.

In collaboration with MNDNR, we will place transmitters on adult and juvenile Common Terns from the Interstate Island breeding colony. We will coordinate our transmitter deployment with their on-going monitoring and banding efforts. We will summarize movement data for adult Common Terns during the breeding and post-breeding seasons. These data will help us to identify foraging locations and quantify site level information associated with food sources which terns depend on during the breeding season.

Juvenile Common Terns fledge in late July; Motus towers will allow us to determine habitat use and post-fledgling movement patterns. Mortality is greatest for juvenile birds; the information obtained from the Motus network will allow us to determine important habitats used by juveniles. Additionally, these data can provide insight into the timing of migration and increase accuracy of survival estimates for this age class. Overall, this project will provide critical information to prioritize conservation and restoration efforts and target management strategies for this species.

ENRTF BUDGET: $ 100,325

Outcome	Completion Date
1. Establish a network of Motus receivers along the St. Louis River Estuary and south shore of Lake Superior to determine local movements and dispersal of adult and juvenile Common Terns.	October 2020
2. Band and tag a minimum of 50 (25 each year) Common Terns for two breeding seasons. Note 20 tags will be purchased with LCCMR funds and 30 additional tags from a previous study will be used for this outcome.	October 2020

Outcome	Completion Date
3. Incorporate movement and habitat use information into Common Tern recovery plans.	June 2021
4. Assess usefulness of Motus network and develop strategic plan for long-term network in Minnesota.	June 2021

First Update January 1, 2019
We obtained approval from the Institutional Animal Care and Use Committee (IACUC) of the University of Minnesota for our protocol for the project (PI: Alexis Grinde; Protocol ID: 1806-36074A). Common Tern banding on Interstate Island has been conducted under the federal permit number 05322 for many years, and to simplify the permitting process we are seeking permission from the Breeding Bird Laboratory to add attachment of radio transmitters using leg-loop harnesses to the current permit. This request is currently under review.

The four Motus stations deployed on the south shore of Lake Superior are a vital component of tracking dispersal of juvenile Common Tern. This spring we will test the signal strength of transmitters along the estuary to identify where additional stations are needed to track the local movements of Common Terns.

Second Update July 1, 2019
We installed one Motus station with an omnidirectional antenna (Figure 2.1) at the Interstate Island Common Tern breeding colony in the Duluth-Superior Harbor in May 2019. As of June 25, 2019 we have deployed radio transmitters on 16 breeding adult birds (Figure 2.2). The Motus station was activated on May 30 and radio transmitters were deployed on 3 nesting pairs (i.e. 6 adult birds) on May 31 and 5 nesting pairs (10 adult birds) on June 6. We have visited to the island twice weekly since deployment to monitor nesting activity and to observe behavior of radio-marked birds to ensure transmitters are not negatively affecting breeding/nesting behavior. All 16 birds fitted with radio transmitters have been actively incubating eggs, feeding partners, and hatching young.

Figure 2.1. Omnidirectional Motus station placed on Interstate Island on May 30, 2019. This station is listening for and recording signals from radio transmitters placed on Common Terns breeding at the island 24hr/day.

Figure 3.2. Attachment of radio transmitters to adult Common Terns breeding on Interstate Island. Radio transmitters were fitted using a leg-loop harness attachment technique and given auxiliary color bands (black bands with white letters: K00-K99 series and yellow bands) to easily identify individuals using a spotting scope. Transmitters will send a signal every 30 minutes for up to 2 years.

Higher than normal nest predation has occurred at the Interstate Island colony this breeding season due to record high water levels which have inundated much of the island and reduced the nesting area for Ring-billed Gulls (a nest site competitor), which has led to more gulls attempting to nest in the tern nesting area and increased predation rates on tern eggs and chicks. As of June 24, 5 of the 8 nests of radio-marked adults have been predated (both eggs and young). Two of the 5 nesting pairs have been observed attempting to renest in the colony. The remaining active nests are being incubated and one nest successfully hatched one young, which has been marked with a yellow leg band. We will continue to look for renesting pairs of radio-marked birds in the coming weeks and will mark any new nests to monitor through the remainder of the breeding season.

Due to high predation rates on all common tern nests (not just radio-marked birds), if there are no surviving fledglings of radio-marked adults, we will plan to put transmitters on any fledglings that survive past 15 days. We plan to deploy a total of 14 transmitters on fledglings this year. On June 12, we downloaded data from the Motus station on Interstate Island and determined that all radio-marked adults are still present on the island, so we will have lots of daily movement data to analyze from adult birds during the breeding season in addition to any signals recorded at other Motus stations during migration and winter.

Third Update January 1, 2020

Nanotags were deployed on 16 adult Common Tern nesting on Interstate Island (May 31 and June 6) and on 13 hatch-year birds between July 5 and August 2. The Motus station placed on Interstate Island, had over 10,000 detections, these data will allow us to determine differences in colony attendance between adult nesting pairs as well as dates individuals depart the island post-breeding. The last signal detected from our nanotags on Interstate Island was September 4, 2019.

There are currently 29 active tags on Common Terns, 16 on adult birds and 13 on juvenile birds. We have detected 14 individuals at Motus stations since deployment and the last detection was of a female juvenile on

11-02-19 at a station near Long Point National Wildlife Refuge in Ontario. As of November 2019, three juvenile birds have been detected on the Motus network; this is the first known data we have on juvenile Common Tern during migration and is an exciting result for the project. We are eagerly awaiting additional Motus stations across the country to upload detection data.

Figure 4.3. Track of 14 Common Terns that were fitted with nanotags in the Duluth-Superior Harbor (May-Aug 2019) that were detected on the Motus network (July 2019- November 2019).

Fourth Update July 1, 2020
Six adult birds that were fitted with radio transmitters in 2019 returned to Interstate Island this year, they were all caught and the transmitters were removed. All birds were healthy and the transmitters did not seem to cause any issues for the birds. At this point of the season, nest success and juvenile survival is relatively high. At the time of this report, the first set of juveniles are approaching the age at which they will be able to carry a transmitter and we anticipate attaching 30 transmitters on juveniles the second and third weeks of July.

Fifth Update January 1, 2021
In 2020, we fit radio transmitters on 30 juvenile common terns between July 7 – 15. Because of supply issues associated with COVID-19, we were unable to obtain custom-made alpha numeric color bands for the 2020 field season. Therefore, birds with transmitters were fitted with only basic color bands (all yellow) to identify birds as those fit with transmitters readily when revisiting the colony but not would not allow us to identify individuals. None of the birds fitted with transmitters were subsequently found dead at the colony in 2020 and many were observed for several weeks after deployment being fed by adults along the shoreline of the island.

We did not anticipate detecting any juvenile birds that were fitted with radio transmitters in 2019 due to deferred breeding. However, juvenile terns are known to return to natal colonies in years prior to breeding to gain experience and prospect other potential breeding colonies. In 2020, there were multiple detections of terns that were fitted with transmitters as juveniles in 2019 at the Motus station set up on Interstate Island (their

natal colony). However, those detections have not yet been verified to ensure they are not false positives, but it is possible that some birds came back as non-breeders late in the breeding season in 2020.

Of the 30 juvenile birds fitted with transmitters in 2020, birds were detected at the breeding colony until September 2. On average birds were last detected on August 4th, with 40% of birds last detected on August 8th. Of these 30 birds, 76% (*n* = 23) were only detected at the breeding colony (Interstate Island) with no subsequent detections outside of that station. The remaining 24% of birds (*n* =7) were all detected at various stations along the shores of Lake Erie between August 18 and November 7, 2020 (Figure 2.4). So far only one juvenile bird tagged in 2020 has been detected outside of the breeding colony or Lake Erie and that bird was detected on November 17, 2020 at the Hobe Sound NWR Motus station located just north of West Palm Beach, Florida. We will deploy a Motus station on the breeding colony again in May 2021 to see if any birds fitted with radio transmitters in previous years return and we will remove any transmitters from adult birds that return to breed and can be captured on a nest.

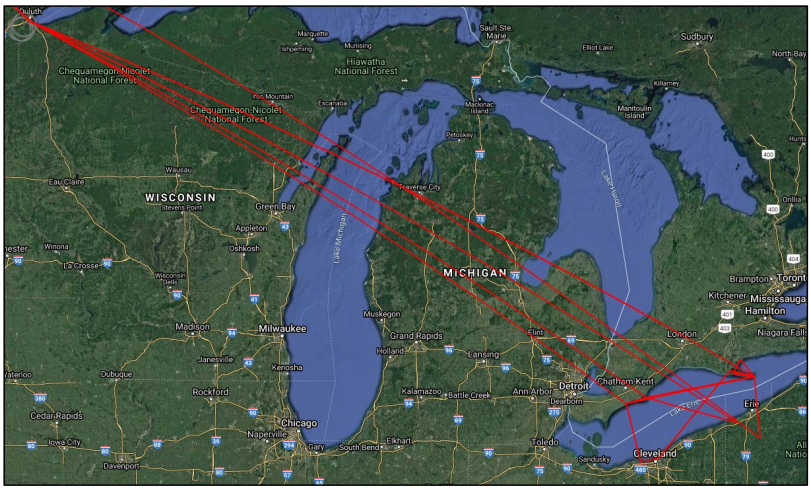

Figure 2.4. Observation of juvenile Common Terns fitted with radio transmitters in the Duluth-Superior Harbor in July 2020. Many individuals (*n* = 7) were detected at various Motus stations located along the shores of Lake Erie (Aug 18 –Nov 7, 2020).

Final Update June 30, 2021

We assessed the utility of automated radio telemetry to study breeding behavior of Common Terns (*Sterna hirundo*). Common Tern are identified as one of the most vulnerable species at both a federal and state level in the region and as a high priority species for conservation in the state (Bracey et al. 2018, USFWS 2021). Interstate Island, located in the SLRE, is one of only two breeding colonies of Common Terns in Lake Superior. Movement of juvenile birds is also a critical piece of the life-history of Common Terns that is not well understood due to previously existing limitations of tracking this age class. The ability to track individuals using the Motus network, which does not require re-encountering the individual to retrieve data, is a huge advancement in tracking of juvenile birds. Documenting breeding behavior and dispersal of adult and juvenile terns will help inform population dynamics, which is particularly important for at-risk and declining populations. We provide a summary of the overall results below but additional information and analyses are provided in the full technical report available at https://hdl.handle.net/11299/224855.

In 2019, 16 adult Common Terns were fitted with radio transmitters at Interstate Island. Juvenile Common Terns were fitted with transmitters at Interstate Island in 2019 (*n = 14*) and 2020 (*n = 30*). The number of receiving

stations where Common Terns were detected ranged from one (Interstate Island) to 10, with birds being detected on an average of four stations across the Motus network. The longest tracking duration was for an adult that was detected up to 79 days post-deployment. The median number of days detected was 55, with a range of 20 – 79 d. In 2020, we recaptured and removed radio transmitters from eight adult birds. Two of the birds recaptured were mated in 2019 (M7); all others were mated with new partners, and their mates from 2019 were not observed during the breeding season. Only two of eight transmitters still had antenna attached, and none of the tags were still functioning (i.e., none of the birds that returned to nest in 2020 were detected on the Interstate Island station or any other stations). In 2021, two additional adult birds that were tagged in 2019 were recaptured and transmitters were removed; one was captured at Interstate Island and one was captured at Ashland Island in Wisconsin. A third bird fitted with a transmitter was observed late in the nesting season at Interstate Island and never attempted to nest, so we were unable to recapture it. Of the 10 transmitters removed, none were still functioning.

All 16 adult birds fitted with nanotags in 2019 were detected at at least one station outside of the breeding colony. The median departure date for adult birds in 2019 was August 3; departures ranged from June 12 to August 24, with the caveat that the receiving station battery was down between August 25 and August 30, 2019. Therefore, birds listed as last detected on August 24 (n =2) may have departed anywhere between August 24 through August 30. When only including the last detection day at Interstate Island for each bird, a total of 140 detections were recorded, 124 of which occurred at stations outside of Interstate Island. Of those 124 detections, 73% occurred at stations in Lake Erie (*n* = 9 birds), with the remaining detections occurring at stations along the south shore of Lake Superior (20 detections (*n* = 6 birds) and the remaining 11 detections (*n* = 6 birds) occurring along the coasts of South Carolina, Georgia, Florida, and Texas (*n* = 8 birds). Many adult Common Terns were picked up at more than one Motus station and nine were detected at the Long Point Tip Motus station in northern Lake Erie between August 5 and August 20. Two of the birds were mates that were detected at that location within 4 days of each other and with one of the two individuals detected twice 11 days apart. Adult Common Terns were detected at 17 Motus stations along the shores of Lake Erie from July 26 to October 13, 2019. These detections are evidence that use of radio transmitters is effective in obtaining more fine-scale information than that of geolocation data, especially during migration.

A total of 23 juvenile birds fitted with nanotags in 2019 – 2020 were detected at at least one Motus station outside of the breeding colony. The number of receiving stations where individuals were observed ranged from 2 to 10, with an average of 3. The longest detection period was 62 days, with the latest detection occurring on February 27, 2021. The median number of days detected was 22, with a range of 5 – 62 d. When only including the last detection at Interstate Island for each bird, a total of 261 detections were recorded in 2019 – 2020, 216 of which occurred at stations outside of Interstate Island. Of those 216 detections, 81% occurred at stations in Lake Erie (*n* = 13 birds), with the remaining detections occurring at stations along the south shore of Lake Superior 7 detections (*n* = 7 birds) and the remaining 35 detections (*n* = 6 birds) occurring along the Atlantic and Gulf coasts from Connecticut to Florida and Texas (*n* = 14 birds). Juvenile Common Terns were detected at 20 Motus stations along the shores of Lake Erie from August 1 to November 3.

IV. DISSEMINATION:

Scientific publications: We expect that this project will produce at least 1 peer reviewed journal article focusing on avian movement.

Presentations: Results will be disseminated through local, regional, and national conferences.

Publically available data will be hosted through the Natural Resources Research Institute website.

Description:

First Update January 1, 2019
Alexis Grinde presented an invited overview and status update of the project at the Minnesota Ornithological Union (MOU) Paper Session on December 1, 2018. There is considerable interest among MOU members in this project, especially from several nature centers in Minnesota. We also submitted an abstract for a poster presentation at the Minnesota Chapter of The Wildlife Society meeting that will be held February 19- 21, 2019 in Duluth, MN. Other materials are not ready to disseminate at this point in the project.

Second Update July 1, 2019
We presented a poster at the Minnesota Chapter of The Wildlife Society meeting that was held February 19- 21, 2019 in Duluth, MN.

The Common Tern portion of the project was featured on Minnesota Public Radio on June 12, 2019, the story can be found at https://www.mprnews.org/story/2019/06/12/saving-the-terns-of-interstate-island-gulls-mn-wis-lake-birds. Other materials are not ready to disseminate at this point in the project.

Third Update January 1, 2020
We have been working with several project partners in attempt to expand the Motus network in strategic areas throughout the state. Specifically, we hope to help to establish new stations in Sax-Zim bog in coordination with Friends of the Sax-Zim Bog and with the MNDNR to establish stations in the Red Lake Peatlands area of the state.

Other materials are not ready to disseminate at this point of the project.

Fourth Update July 1, 2020
We set up a new Motus station at the Sax-Zim visitor center in May, 2020. Other materials are not ready to disseminate at this point of the project.

Fifth Update January 1, 2021

As a result of the work completed on this project, Dr. Grinde was asked to join the steering committee for the Midwest Migration Network https://midwestmigrationnetwork.org/ and the International Rusty Blackbird Working Group https://rustyblackbird.org/working-group/purpose/. Involvement in these groups will facilitate the dissemination and increase the impact of this research.

We have shared the results of our study at several virtual meetings this year including:

- Bracey, AM. Common Tern Movement in a Changing World. December 5, 2020. Conference: 2020 Paper Session. Sponsoring Organization: Minnesota Ornithologists' Union.
- Bracey, AM. Motus Network in the western Great Lakes Region. September 10, 2020. Sponsoring Organization: St. Paul Audubon.
- Bracey, AM. Common Tern tracking in Minnesota. July 22, 2020. Conference: Connecting birds and people in the Midwest. Sponsoring Organization: Midwest Migration Network

Additionally, Steve Kolbe will be presenting the results of the research in March 2021.

- Kolbe, S. March 1, 2021. Rusty Blackbird migratory stopover in the St. Louis River Estuary. Conference: 11th Annual St. Louis River Summit. Sponsoring Organization: Lake Superior National Estuarine Research Reserve.

Final Update June 30, 2021
We shared the results of our study at the following virtual events:

- Grinde, A. April 4, 2021. Rusty Blackbirds: A case for conserving stopover habitat. Sponsoring Organization: Duluth Audubon.
- Bracey, A. April 28, 2021. Ecology and Conservation of Common Terns (*Sterna hirundo*) Breeding in the North American Great Lakes Region

We also established a website for the citizen science portion of the Black-capped Chickadee study in Hartley Park.

A full report for this study is hosted on the Natural Resources Research Institute website, and can be accessed at https://hdl.handle.net/11299/224855 .

Project Results Use and Dissemination
The preliminary results of the research were presented at eight conferences during the course of project and the study was featured on MPR in 2019. Two peer-reviewed publications are expected to be published in 2022, one focusing on Common Tern and other on Rusty Blackbirds. We set up an additional Motus station at Sax-Zim Bog in 2020 to help facilitate research in this important area of the state. We established a website for the citizen science portion of the Black-capped Chickadee study in Hartley Park. A full report for this study is available on the Natural Resources Research Institute website.

V. PROJECT BUDGET SUMMARY:

A. Preliminary ENRTF Budget Overview: See attached budget spreadsheet

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:

Enter Total Estimated Personnel Hours: 2,028	Divide by 2,080 = TOTAL FTE: 0.975

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

Enter Total Estimated Personnel Hours: 0	Divide by 2,080 = TOTAL FTE: 0

B. Other Funds:

SOURCE OF AND USE OF OTHER FUNDS	Amount Proposed	Amount Spent	Status and Timeframe
Other Non-State $ To Be Applied To Project During Project Period:			
	$ n/a	$ n/a	
Other State $ To Be Applied To Project During Project Period:			
	$ n/a	$ n/a	

SOURCE OF AND USE OF OTHER FUNDS	Amount Proposed	Amount Spent	Status and Timeframe
Past and Current ENRTF Appropriation:			
	$ n/a	$ n/a	
Other Funding History:			
	$ n/a	$ n/a	

VI. PROJECT PARTNERS:

A. Partners receiving ENRTF funding

Name	Title	Affiliation	Role
n/a			

B. Partners NOT receiving ENRTF funding

Name	Title	Affiliation	Role
Matthew Etterson, PhD	Board of Directors	Hawk Ridge Bird Observatory	Coordination of banding efforts

VII. LONG-TERM- IMPLEMENTATION AND FUNDING: This proposal is a part of a larger effort to understand avian migration in Minnesota. The major advantage of the Motus system is that the receivers are small, portable, and can be easily redeployed. This will allow us the flexibility to monitor local and migratory movements at various locations throughout the state and to move receivers based on the research question being posed. This project will create the infrastructure and provide foundational information that can be used by researchers throughout the state and will greatly improve our understanding of migration for multiple taxa including bats, dragonfly, and butterfly movements in MN. Additionally, the equipment used in this study will be built and maintained by NRRI and can be utilized for future research projects.

VIII. REPORTING REQUIREMENTS:

- **The project is for 3 years, will begin on July 1, 2018 and end on June 30, 2021.**
- **Periodic project status update reports will be submitted January 1 and July 1 of each year.**
- **A final report and associated products will be submitted between June 30 and August 15, 2021.**

IX. SEE ADDITIONAL WORK PLAN COMPONENTS:

A. Budget Spreadsheet
B. Visual Component or Map
C. Parcel List Spreadsheet
D. Acquisition, Easements, and Restoration Requirements
E. Research Addendum

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2018 Budget Spreadsheet

Project Title: Mapping Avian Movement in Minnesota
Legal Citation: M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 03h
Project Manager: Alexis Grinde
Organization: Natural Resources Research Institute, University of Minnesota Duluth
College/Department/Division: Forest and Land Initiative
M.L. 2018 ENRTF Appropriation: $200,000
Project Length and Completion Date: 3 years, June 30, 2021
Date of Final Report: 10-20-2021

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	TOTAL BUDGET	TOTAL SPENT	TOTAL BALANCE
BUDGET ITEM			
Personnel (Wages and Benefits)	$141,000	$141,000	$0
Gerald Niemi, Principal Investigator (66.5% salary, 33.5% benefits); 1% effort each year for 3 years. $5,985			
Alexis Grinde, Co-Investigator (66.5% salary, 33.5% benefits); 5% effort each year for 3 years. $19,100			
Annie Bracey, Co-Investigator (66.5% salary, 33.5% benefits); 8% effort each year for 3 years. $24,718			
Research Scientist, Fieldwork, Data Collection and Analysis (66.5% salary, 33.5% benefits); 19% cumulative effort each year for 3 years. $91,197			
Equipment/Tools/Supplies: $56,000			
14 sensor gnome telemetry receivers @ $1500 ea. These receivers will be deployed by project partners and will be used on buildings that have access to power supply. Additional $4,000 added for antennae and receiver repair. $32,000	$32,000	$32,000	$0
100 transmitters ($200 ea.) to attach to birds to track movements. $20,000	$20,000	$20,000	$0
Motus registration fees. $1500 / year to register Motus stations on Motus network + $25 for each transmitter deployed to track birds on Motus receivers outside of Minnesota. $4,000	$4,000	$4,000	$0
Travel expenses in Minnesota	$3,000	$3,000	$0
Travel for fieldwork, including mileage (75%) and lodging (25%) for researchers and banders. Mileage will be reimbursed at $0.535/mile (University of MN rate). Travel is largely associated with large-scale (state-wide) deployment and maintenance of the Motus receivers during the spring and fall migration. Lodging is estimated between ($90-$130 per night). $3,000			
COLUMN TOTAL	**$200,000**	**$200,000**	**$0**