

M.L. 2019 Project Abstract

For the Period Ending June 30, 2022

PROJECT TITLE: Artificial Den Boxes for Fishers

PROJECT MANAGER: Dr. Michael Joyce

AFFILIATION: U of MN – Duluth, Natural Resources Research Institute

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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. 03i

APPROPRIATION AMOUNT: \$190,000

AMOUNT SPENT: \$190,000

AMOUNT REMAINING: \$0

Sound bite of Project Outcomes and Results

Fishers used some den boxes, but it appears fishers find natural cavities to raise young. Den cavity availability alone is likely not causing the fisher population decline. Den boxes were used by many other wildlife species. Installing den boxes could be locally beneficial and increases public involvement with wildlife.

Overall Project Outcome and Results

The fisher population in Minnesota declined by 50% from 2000-2015. Large cavity trees are critical habitat resources that female fishers use to raise kits. Previous research on fishers in Minnesota suggested that lack of large cavity trees could be one factor limiting the fisher population. We evaluated whether den boxes could provide critical habitat for fishers where natural cavities are rare. Our objectives were to build, install, and monitor fisher den boxes to describe use of den boxes by fishers and other wildlife, determine what factors influence whether fishers use den boxes, and to develop guidelines and recommendations for using den boxes to improve habitat. We built and installed 99 den boxes during fall and winter 2019-2020 and captured over 3 million images of wildlife visiting and using den boxes. Fishers visited 41% of den boxes and used 11% of den boxes on 43 different occasions. Use by fishers was lower than in other studies. Low use rates by fishers could indicate cavity availability is not limiting fishers, but additional work is needed to more fully understand why fisher use of den boxes was low and to evaluate other potential causes of the fisher population decline. Habitat suitability at den box sites was not associated with use by fishers. Fisher presence at den boxes increased over time, and fishers should continue to find and use den boxes in the future. Martens, red squirrels, gray squirrels, flying squirrels, and weasels also used den boxes to rest, store food, avoid predators, and care for young. Frequent use of den boxes by other wildlife demonstrates the value of den boxes to wildlife despite low use by fishers. Den box plans and guidelines we developed have allowed many members of the public to build and install their own den boxes, increasing public involvement with wildlife.

Project Results Use and Dissemination

We created den box building instructions and guidelines for den box installation. Throughout the project, we shared these documents directly with 120 members of the public and resource managers who requested information on the project. Project results were disseminated to technical and non-technical audiences through presentations, print and broadcast media, social media posts, and a [Minnesota fisher den box project website](#) we developed. Results are also summarized in a master's thesis. We are currently finalizing a technical report and three manuscripts using data from this project that will be submitted to scientific journals and shared with wildlife managers.



Environment and Natural Resources Trust Fund (ENRTF)

M.L. 2019 ENRTF Work Plan Final Report

Today's Date: August 30, 2022

Final Report

Date of Work Plan Approval: June 5, 2019

Project Completion Date: June 30, 2022

PROJECT TITLE: Artificial Den Boxes for Fishers

Project Manager: Dr. Michael Joyce

Organization: U of MN - Duluth

College/Department/Division: Natural Resources Research Institute

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Location:

Region: Central, Metro, Northwest, Northeast

County Name: Aitkin, Anoka, Becker, Beltrami, Benton, Carlton, Cass, Chisago, Clay, Clearwater, Cook, Crow Wing, Douglas, Hubbard, Isanti, Itasca, Kanabec, Kittson, Koochiching, Lake, Lake of the Woods, Marshall, Mille Lacs, Morrison, Norman, Otter Tail, Pennington, Pine, Polk, Red Lake, Roseau, Sherburne, St. Louis, Stearns, Todd, Wadena, and Washington

Total Project Budget: \$190,000

Amount Spent: \$190,000

Balance: \$0

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

Appropriation Language: \$190,000 the first 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 build, install, and evaluate den boxes as habitat enhancement for fishers and other cavity-nesting wildlife in managed forests where a lack of large trees may be threatening population survival. The final outcome for the project must include guidelines and best practices for use of den boxes for fisher habitat.

I. PROJECT STATEMENT:

Overview:

The fisher population in Minnesota has declined by about 50% over the past 20 years, and we will deploy den boxes to determine if cavity trees are limiting production of kits. A recent Minnesota DNR study on fishers showed that cavity trees are critically important for female fishers to raise kits. Because large trees with cavities are rare in managed forest landscapes, the DNR study concluded that lack of large trees with cavities may be a limiting resource that contributed to the fisher population decline. Artificial den boxes could help meet the needs of female fishers where natural cavities are rare. If used by fishers, den boxes could enhance fisher habitat and promote population persistence and expansion.

Our project will use what was learned from the DNR project to address whether cavity trees are a limiting resource for fishers in Minnesota and evaluate artificial den boxes as a potential solution if cavity trees are limiting. We will build and install at least 60 den boxes in Minnesota, monitor use by fishers and other wildlife species, and determine what factors influence whether fishers use boxes. We will also use existing data from the DNR fisher study to identify areas with low fisher habitat suitability where den boxes could potentially be used to enhance fisher habitat. Finally, we will develop instructions on how to build artificial den boxes for fishers and best management guidelines for their use and disseminate our instructions and guidelines to wildlife managers, foresters, private landowners, trappers, and other members of the public interested in enhancing fisher habitat. This project will generate the knowledge necessary to develop strategic plans for fisher habitat management and could lead to a novel method for monitoring the fisher population in Minnesota.

Project Statement:

Fishers are mid-sized carnivores that live in the forested region of Minnesota. Minnesota DNR data shows that the fisher population has declined by about 50% over the last 20 years (see figure on map page).

The fisher population decline has not received as much attention as the northeast Minnesota moose population decline has, even though populations are about half of what they were 20 years ago.

In response to the fisher population decline the DNR conducted a research project from 2008-2015 to learn more about fisher ecology in Minnesota. The DNR project found that for fishers in Minnesota:

- Females raise their kits in cavities of large-diameter trees (see map page)
- Cavity trees are critically important for reproduction
- Large cavity trees are relatively scarce in managed forests

The DNR study identified denning habitat as a possible limiting factor, and concluded that a lack of suitable cavities may have contributed to the fisher population decline. Our project will use what was learned from the DNR project to address whether cavity trees are a limiting resource for fishers in Minnesota and evaluate artificial den boxes as a potential solution if cavity trees are limiting.

Fishers are the largest animal in Minnesota that requires cavities to raise their young. Large diameter trees with cavities big enough to hold fishers take years to grow. In managed forests, trees may be harvested before any tree has time to develop a heart-rot cavity, and existing cavity trees may be lost during logging or wind storms. Fishers do not use leave trees in openings in harvested forests, instead using trees in interior forests.

Artificial den boxes could help meet the needs of female fishers where natural cavities are rare. Den boxes could be used to enhance fisher habitat and promote population persistence in managed landscapes. Placing a den box on the edge of a harvested forest where prey species occur might actually create new fisher habitat. Signs that this project will benefit Minnesota wildlife include:

1. **Wildlife managers have observed fishers using wood duck nest boxes in Minnesota**
2. **Fishers have raised litters in artificial den boxes in western Canada**
3. **Den box use by fishers could be an indicator of whether cavity trees are a limiting resource**
4. **Den boxes could provide an additional method for monitoring fisher populations in Minnesota**
5. **Private landowners have requested information on building den boxes for fishers from the DNR**

At this stage, we know den boxes are used by fishers, but we do not know what influences whether individual den boxes are used or whether installing den boxes where large cavity trees are rare will allow fishers to better use areas that lack natural cavities. Results of this project could be used by wildlife managers, private landowners, trappers, and other concerned citizens to promote fisher population expansion. In the future, den boxes could be used for public engagement and might even be a way for citizen-scientists to help monitor fisher populations in Minnesota.

We have coordinated with the DNR to develop this proposal, and one of the real strengths of this project is it will help determine how artificial den boxes can be a tool for fisher habitat management. We will use den boxes to further evaluate whether cavity trees are a limiting resource that contributed to recent fisher population declines in Minnesota. The specific goals of this project on fisher artificial denning boxes are to:

- 1. Build and install at least 60 artificial den boxes in Minnesota.**
- 2. Monitor visitation and use of den boxes by fishers and other wildlife.**
- 3. Determine what factors influence use of den boxes by fishers.**
- 4. Develop guidelines and best management practices for use of artificial den boxes for fishers.**
- 5. Identify areas with low habitat suitability as potential sites for future fisher habitat management.**

II. OVERALL PROJECT STATUS UPDATES:

First Update March 1, 2020

During fall and winter 2019-2020 we built and installed 80 fisher den boxes for this project and worked with partners to build and install an additional 31 den boxes (123 total den boxes, including the 12 boxes from our pilot study). We will need to monitor wildlife use of boxes for another year and a half to fully address our objectives to document use of den boxes by fishers and other wildlife, determine what factors influence whether fishers use den boxes, identify priority areas for future den box management, and develop best management guidelines for using fisher den boxes. Nonetheless, monitoring of den boxes is ongoing and we are on track to complete this project on time based on the proposed timeline in our research addendum. Through our first several months of den box monitoring, we have obtained ~150,000 pictures from remote cameras at den boxes and documented fishers at 9% of den boxes. This rate of use is higher than what was documented in a previous fisher den box project in British Columbia. We also documented frequent use of den boxes by squirrels and mice and other wildlife visiting our boxes such as bears, raccoons, owls, and moose. We have received immense public interest in this project, and have been able to disseminate information about the project directly to over 60 individuals (largely members of the public) and to various technical and general audiences through presentations and print media.

AMENDMENT REQUEST March 4, 2020

We are requesting funds be shifted from two supply line budget items to two other supply line budgets.

- Den boxes supply line budget would increase by \$2,949 to a revised budget of \$7,749
- Camera supply line budget would decrease by \$3,450 to a revised budget of \$10,200
- Shop use supply line budget would decrease by \$130 to a revised budget of \$0
- Field supplies supply line budget would increase by \$631 to a revised budget of \$2,051

These changes are being requested because the box cost was higher than anticipated after some design modifications we made following our pilot study, because we found existing cameras from project partners that we could use instead of purchasing 75 cameras, and because lithium batteries used for the cameras were slightly more expensive than we budgeted for. The NRRI wood shop also waived the fee to use the space, so we wanted to re-allocate this money to the Field supplies supply line to help cover cost of lithium batteries.

Amendment Approved by LCCMR 3/9/2020

Second Update September 1, 2020

During spring and summer 2020 we monitored use of 80 fisher den boxes built and installed for this project and worked with partners to monitor an additional 19 den boxes. We will need to monitor wildlife use of boxes for about another 9-10 months to fully address our objectives to document use of den boxes by fishers and other wildlife, determine what factors influence whether fishers use den boxes, identify priority areas for future den box management, and develop best management guidelines for using fisher den boxes. Nonetheless, monitoring of den boxes is ongoing and we are on track to complete this project on time based on the proposed timeline in our research addendum. Through our first nine months of den box monitoring, we have obtained >1 million pictures from remote cameras at den boxes and documented fishers at 17% of den boxes. This rate of use is higher than what was documented in a previous fisher den box project in British Columbia during their first year. We also documented frequent use of den boxes by squirrels and mice and other wildlife visiting our boxes such as bears, raccoons, owls, and moose. We have received immense public interest in this project, and have been able to disseminate information about the project directly to 69 individuals (largely members of the public) and to various technical and general audiences through presentations and print media.

AMENDMENT REQUEST August 24, 2020

We are requesting funds be shifted from two supply line budget items to two other supply line budgets.

- Field supplies supply line budget would increase by \$781 to a revised budget of \$2,832.
- Personnel budget line would decrease by \$781 to a revised budget of \$151,219.

These changes are being requested because the cost of lithium batteries to power remote cameras was higher than anticipated. This money could be re-allocated from the personnel budget without affecting our ability to complete this study as proposed.

Amendment Approved by LCCMR 9/9/2020

Third Update March 1, 2021

During fall 2020 and winter 2021 we monitored use of 80 fisher den boxes built and installed for this project and worked with partners to monitor an additional 19 den boxes. We will need to monitor wildlife use of boxes for about another 3-3.5 months to fully address our objectives to document use of den boxes by fishers and other wildlife, determine what factors influence whether fishers use den boxes, identify priority areas for future den box management, and develop best management guidelines for using fisher den boxes. Nonetheless, monitoring of den boxes is ongoing. Through the first 15 months of den box monitoring, we have obtained >1.6 million pictures from remote cameras at den boxes and documented 5 species of wildlife using the boxes: fishers, martens, flying squirrels, red squirrels, and gray squirrels. Fisher detections at den boxes begin to increase late last summer, and fishers have been documented at nearly 30% of den boxes. It is taking longer than expected to analyze the large volume of pictures from den boxes, and we are asking for a 6 month no cost extension to allow more time to finish project analyses. We continue to receive immense interest in the project from the media and members of the public and have been able to disseminate information about the project directly to 78 individuals (largely members of the public) and to various technical and general audiences through presentations and print media.

AMENDMENT REQUEST February 24, 2021

We have collected over 1.6 million pictures from remote cameras at den boxes, and we estimate that we will collect an additional 300,000 to 500,000 pictures during the remainder of our field monitoring, ending May 2021. This volume of pictures is higher than we anticipated, and it is taking longer than we expected to analyze the picture data. The extra time required to process these images is due in part to the University's hiring freeze related to the COVID-19 pandemic. Consequently, it will take longer than anticipated to complete the data analyses as proposed with existing personnel. We are requesting an additional year to allow more time to analyze the pictures we have collected and complete all project components. Project outcomes in the Activity 1 table have been adjusted to meet this longer timeline. The remaining funding is sufficient to complete the project as described in this work plan.

Additionally, we are requesting funds be shifted from the personnel budget line to the travel budget line.

- Travel budget line would increase by \$2,000 to a revised budget of \$20,000.
- Personnel budget line would decrease by \$2,000 to a revised budget of \$149,219.

These changes are being requested because the cost of travel to complete den box monitoring was slightly higher than anticipated. This money could be re-allocated from the personnel budget without affecting our ability to complete this study as proposed.

Budget amendment approved by LCCMR 03/08/2021

Project Extension Amendment request dependent on legislative and LCCMR action 03/08/2021—withdrawn 3/11/2021

After additional review, LCCMR staff noted that the appropriation for this project extended to June 30, 2022 and an administrative extension to match the work plan end date to the appropriation end data was sufficient. To that end, the COVID-related legislative extension is withdrawn, and the administrative extension is approved as of 3/11/2021

Fourth Update September 2021

During spring and early summer 2021 we completed monitoring on most of the 80 fisher den boxes built and installed for this project and worked with partners to monitor an additional 19 den boxes. We have several boxes that need one final monitoring visit. We have been analyzing data throughout summer 2021 to address our objectives to document use of den boxes by fishers and other wildlife, determine what factors influence whether fishers use den boxes, identify priority areas for future den box management, and develop best management guidelines for using fisher den boxes. Through the first 21 months of den box monitoring, we have obtained >2.1 million pictures from remote cameras at den boxes and documented 5 species of wildlife using the boxes: fishers, martens, flying squirrels, red squirrels, and gray squirrels. Fisher use of den boxes has continued to increase over the last 6-10 months, and fishers have been documented at nearly 30% of den boxes. It is taking longer than expected to analyze the large volume of pictures from den boxes, but we are making progress developing a machine learning algorithm to help us analyze images more efficiently. We continue to receive immense interest in the project from the media and members of the public and have been able to disseminate information about the project directly to 90 individuals (largely members of the public) and to various technical and general audiences through presentations and print media.

AMENDMENT REQUEST September 1, 2021

We are requesting funds be shifted from two budget lines to the travel budget line.

- Field Supplies budget line would decrease by \$36 to a revised budget of \$2,796.
- Personnel budget line would decrease by \$764 to a revisited budget of \$148,455.
- Travel budget line would increase by \$800 to a revised budget of \$20,800.

These changes are being requested because the cost of travel to complete den box monitoring was slightly higher than anticipated. This change to travel funding will be sufficient to cover two days of field visits, which will allow us to complete all field work on this project. Additionally, we have no need to purchase any more field supplies. Thus, this money could be re-allocated from the field supplies and personnel budget lines without affecting our ability to complete this study as proposed.

Budget amendment approved by LCCMR 09/13/2021

Fifth Update March 2022

During fall and early winter 2021 we completed monitoring on all of the 80 fisher den boxes built and installed for this project and worked with partners to monitor an additional 19 den boxes. We have been exploring machine learning approaches for analyzing our trail camera data, summarized habitat data, and conducted GIS analyses to address our objectives to document use of den boxes by fishers and other wildlife, determine what factors influence whether fishers use den boxes, identify priority areas for future den box management, and develop best management guidelines for using fisher den boxes. Throughout our den box monitoring, we have

obtained >2.4 million pictures from remote cameras at den boxes and documented 5 species of wildlife using the boxes: fishers, martens, flying squirrels, red squirrels, and gray squirrels. Fisher use of den boxes has continued to increase over time, and fishers have been documented at nearly 35% of den boxes. It is taking longer than expected to analyze the large volume of pictures from den boxes, and machine learning approaches have yielded mixed results. We continue to receive immense interest in the project from the media and members of the public and have been able to disseminate information about the project directly to over 110 individuals (largely members of the public) and to various technical and general audiences through presentations and print media. We are on track to complete this project by the end date.

AMENDMENT REQUEST March 1, 2022

We are requesting funds be shifted from the personnel budget line to the travel budget line.

- Personnel budget line would decrease by \$26 to a revised budget of \$148,429.
- Travel budget line would increase by \$26 to a revised budget of \$20,826.

These changes are being requested to zero-out the travel budget line because travel costs were slightly higher than anticipated when we made our last amendment request. There will be no further travel costs charged to this project. All future expenses will be for personnel time to complete the analysis and reports, and this small reduction in the personnel budget line will not affect our ability to complete this project.

Amendment approved by LCCMR 3/11/22

AMENDMENT REQUEST September 1, 2022

We are requesting funds be shifted as follows.

- Personnel budget line would decrease by \$148 to a revised budget of \$148,281.
- Travel budget line would decrease by \$2 to a revised budget of \$20,824.
- Field supply budget line would increase by \$150 to a revised budget of \$2,946.

These minor changes are being requested to zero-out all categories at the end of the project. All work on this project has been completed at the time of this request.

Amendment approved by LCCMR 11/18/22

Final report June 30-August 15, 2022

The fisher population in Minnesota declined by 50% from 2000-2015. Large cavity trees are critical habitat resources that female fishers use to raise kits. Previous research on fishers in Minnesota suggested that lack of large cavity trees could be one factor limiting the fisher population. We evaluated whether den boxes could provide critical habitat for fishers where natural cavities are rare. Our objectives were to build, install, and monitor fisher den boxes to describe use of den boxes by fishers and other wildlife, determine what factors influence whether fishers use den boxes, and develop guidelines and recommendations for using den boxes to improve habitat. We built and installed 99 den boxes during fall and winter 2019-2020 and captured over 3 million images of wildlife visiting and using den boxes. Fishers visited 41% of den boxes and used 11% of den boxes on 43 different occasions. Use by fishers was lower than in other studies. Low use rates by fishers could indicate cavity availability is not limiting fishers, but additional work is needed to more fully understand why fisher use of den boxes was low and to evaluate other potential causes of the fisher population decline. Habitat suitability at den box sites was not associated with use by fishers. Fisher presence at den boxes increased over time, and fishers should continue to find and use den boxes in the future. Martens, red squirrels, gray squirrels, flying squirrels, and weasels also used den boxes to rest, store food, avoid predators, and care for young. Frequent use of den boxes by other wildlife demonstrates the value of den boxes to wildlife despite low use by fishers. Den box plans and guidelines we developed have allowed many members of the public to build and install their own den boxes, increasing public involvement with wildlife.

III. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1 Title: Determine visitation and use of artificial den boxes by fishers and other wildlife species

Description: We will build and install at least 60 den boxes in two study areas where previous fisher research has taken place. Den boxes will be installed in different forest types and ages. We will use remote cameras and field-visits to monitor visitation and use by fishers. We will visit den boxes during the breeding season to document reproduction in den boxes using an inspection camera mounted on a pole to determine whether kits are present. If kits are present, we will obtain a litter count. We will also monitor visitation and use by other wildlife species, including other cavity-dependent species such as squirrels, wood ducks, and other cavity-nesting birds. Lastly, we will use existing data from the DNR fisher study to identify areas with low fisher habitat suitability where den boxes could potentially be used to enhance fisher habitat and prioritize areas for future habitat management.

ACTIVITY 1 ENRTF BUDGET: \$190,000

Outcome	Completion Date
1. Installation of artificial den boxes	November 2019
2. Determine visitation and use of den boxes by fishers and other wildlife species	June 2021
3. Identify factors influencing use of den boxes by fishers	July 2021
4. Identify and prioritize areas with low habitat suitability where den boxes could potentially be used to enhance fisher habitat in the future	December 2021
5. Develop and disseminate instructions on how to build artificial den boxes for fishers and best management guidelines for their use	December 2021

First Update March 1, 2020

We built and installed 80 fisher den boxes during fall 2019 (40 per each of two study areas). We modified our den box design following our pilot study, which increased den box cost but will increase the longevity of the boxes. In addition to the boxes built using ENRTF funding, we worked with partners to build and install additional den boxes that will expand the project sample size to 123 total den boxes. All 123 den boxes will be monitored for two years or more to address outcomes 2, 3, and 4. Partners include UPM/Blandin, Leech Lake Band of Ojibwe, Cloquet Forestry Center, Carlton County land department, and Hubachek Wilderness Research Center. These additional boxes were built and will be monitored using non-ENRTF funding.

We have currently obtained ~150,000 images from remote cameras at den boxes, and we anticipate that we will collect 1 to 1.5 million images over this two-year project. We have analyzed preliminary data collected while monitoring these boxes to determine visitation and use of den boxes by fishers and other wildlife, but we defer a complete assessment of results for outcomes 2 and 3 until we have completed two years of monitoring and analyzed the data. Preliminary results are that fishers have visited or used 9% of the den boxes within 2 months of box installation. We have also documented numerous other wildlife using the boxes, including flying squirrels, red squirrels, gray squirrels, mice, and birds. We have also documented bears, raccoons, porcupines, and moose visiting and investigating den boxes, but these animals are too big to enter the boxes.

We have begun analyzing LiDAR data and evaluating other geospatial forest inventory data to map fisher habitat suitability to prioritize areas for future den box deployments but will require results for outcome 3 to complete outcome 4. Progress on outcome 5 is discussed in section IV. Dissemination.

Second Update September 1, 2020

We have currently obtained ~1,035,000 images from remote cameras at den boxes, and we anticipate that we will collect 2 to 2.5 million images over this two-year project. Currently, we have analyzed >220,000 (~21%) of all

pictures collected. Due to the high volume of pictures, we are exploring automated methods for sorting pictures that rely on machine learning.

We have analyzed preliminary data collected while monitoring these boxes to determine visitation and use of den boxes by fishers and other wildlife, but we defer a complete assessment of results for outcomes 2 and 3 until we have completed two years of monitoring and analyzed the data. Preliminary results are that fishers have visited or used 17% of the den boxes to date. We have also documented numerous other species of wildlife using the boxes, including flying squirrels, red squirrels, gray squirrels, mice, and birds. We have also documented bears, raccoons, porcupines, and moose visiting and investigating den boxes, but these animals are too big to enter the boxes. Mammals have visited or used 93% of den boxes, while birds have visited or used 66% of den boxes.

We have measured fisher habitat suitability at 69 out of 80 fisher den boxes to determine how habitat suitability influences whether fishers and other wildlife visit or use individual den boxes (outcome 3). We will finish measuring habitat suitability at remaining boxes by 9/1/2020.

We have begun analyzing LiDAR data and evaluating other geospatial forest inventory data to map fisher habitat suitability to prioritize areas for future den box deployments but will require results for outcome 3 to complete outcome 4. Progress on outcome 5 is discussed in section IV. Dissemination.

Third Update March 1, 2021

We have currently obtained ~1.6 million images from remote cameras at den boxes, and we anticipate that we will collect 2 to 2.5 million images over this two-year project. Currently, we have analyzed >340,000 (~22%) of all pictures collected. Due to the high volume of pictures and inefficiencies of manual photo analysis, we are testing a new automated method using machine learning for sorting pictures. The method can analyze ~2,000 pictures per minute. Testing the new method should be completed in late March 2021.

We have analyzed preliminary data collected while monitoring these boxes to determine visitation and use of den boxes by fishers and other wildlife and measured fisher habitat quality at all den boxes, but we defer a complete assessment of results for outcomes 2 and 3 until we have completed two years of monitoring and analyzed the data. Preliminary results are that fishers have visited or used almost 30% of the den boxes to date. We have also documented numerous other species of wildlife using the boxes, including flying squirrels, red squirrels, gray squirrels, and martens. We have also documented bears, raccoons, porcupines, and moose visiting and investigating den boxes, but these animals are too big to enter the boxes. Mammals have visited or used 93% of den boxes, while birds have visited or used 70% of den boxes.

We have measured fisher habitat suitability at all 80 fisher den boxes to determine how habitat suitability influences whether fishers and other wildlife visit or use individual den boxes (outcome 3). Habitat data has been entered, and we have begun analyzing habitat suitability at boxes where fishers have currently been detected.

We have begun analyzing LiDAR data and evaluating other geospatial forest inventory data to map fisher habitat suitability to prioritize areas for future den box deployments but will require results for outcome 3 to complete outcome 4. Progress on outcome 5 is discussed in section IV. Dissemination.

Fourth Update September 2021

We have currently obtained ~2.1 million images from remote cameras at den boxes, and field monitoring of boxes is nearly completed. Currently, we have analyzed >450,000 (~21%) of all pictures collected. Due to the high volume of pictures and inefficiencies of manual photo analysis, we are testing a new automated method using machine learning for sorting pictures. The method can analyze up to 2,000 pictures per minute. Testing is ongoing, but machine learning is expected to be incorporated into our processing workflow in early September.

We have analyzed preliminary data collected while monitoring these boxes to determine visitation and use of den boxes by fishers and other wildlife and measured fisher habitat quality at all den boxes, but we defer a complete assessment of results for outcomes 2 and 3 until we have completed analysis of trail camera images. Preliminary results are that fishers have visited or used about 30% of the den boxes to date. We have also documented numerous other species of wildlife using the boxes, including flying squirrels, red squirrels, gray squirrels, and martens. We have also documented bears, raccoons, porcupines, and moose visiting and investigating den boxes, but these animals are too big to enter the boxes. Mammals have visited or used 93% of den boxes, while birds have visited or used 70% of den boxes. We have also seen drastic differences in detections of wildlife species between our two primary study areas. We anticipate completing Outcome 2 in early- to mid-Fall 2021 and Outcome 3 in mid- to late-Fall 2021.

We have measured fisher habitat suitability at all 80 fisher den boxes to determine how habitat suitability influences whether fishers and other wildlife visit or use individual den boxes (outcome 3). Habitat data has been entered, and we have begun analyzing habitat suitability at boxes where fishers have currently been detected. We are waiting to finish Outcome 2 before finalizing this analysis.

We have begun analyzing LiDAR data and evaluating other geospatial forest inventory data to map fisher habitat suitability to prioritize areas for future den box deployments and we have made preliminary GIS maps of fisher habitat suitability across our study areas. However, it will require results for outcome 3 to complete outcome 4. Progress on outcome 5 is discussed in section IV. Dissemination.

Fifth Update March 1, 2022

We have obtained >2.5 million images from remote cameras at den boxes, and field monitoring of boxes has been completed. Currently, we have analyzed >500,000 (~20%) of all pictures collected. Due to the high volume of pictures and inefficiencies of manual photo analysis, we tested a machine learning method for automated image analysis. The original method we tested did not work, but we have tested another method that is ~85% accurate at identifying images with fishers. We are working to automate processing for most of the remaining images that have not been analyzed.

We have analyzed preliminary data collected while monitoring these boxes to determine visitation and use of den boxes by fishers and other wildlife and measured fisher habitat quality at all den boxes, but we defer a complete assessment of results for outcomes 2 and 3 until we have completed analysis of trail camera images. We continue to see fishers visiting boxes where they were not detected in previous years.

We measured fisher habitat suitability at all 80 fisher den boxes to determine how habitat suitability influences whether fishers and other wildlife visit or use individual den boxes (outcome 3). We have calculated habitat suitability indices for all den boxes and have begun analyzing habitat suitability at boxes where fishers have currently been detected. We are waiting to finish Outcome 2 before finalizing this analysis.

We continue to analyze LiDAR and other geospatial data to support outcome 4, but must finalize outcome 3 in order to complete outcome 4. Progress on outcome 5 is discussed in section IV. Dissemination.

Final report June 30-August 15, 2022

Outcome 1. Installation of fisher den boxes

We built and installed 80 fisher den boxes during fall 2019 (40 per each of two study areas). We also installed 7 den boxes during our pilot study and worked with the following partners to install additional den boxes: Carlton County Land Department (4 boxes), Cloquet Forestry Center (4 boxes), Hubachek Wilderness Research Center (2 boxes), Leech Lake Band of Ojibwe (12 boxes). Results summarized here are from all of these den boxes except those installed by Leech Lake Band of Ojibwe. We modified our den box design following our pilot study, which

increased den box cost but will increase the longevity of the boxes. Den boxes built and installed with partners were built and monitored using non-ENRTF funding.

Outcome 2. Determine visitation and use of den boxes by fishers and other wildlife species

We obtained >3.3 million images from remote cameras at den boxes. Due to the high volume of pictures and inefficiencies of manual photo analysis, we tested several machine learning approaches for automated image analysis. After full evaluation, none of the methods we tested were accurate enough for automated image analysis. We fully analyzed 30% of images and analyzed a subsample of the remaining images. We also used other monitoring methods (glue strips for hair, temperature loggers inside boxes, inspection of the box interior for depressions or other sign of use by fishers, martens, or squirrels) to ensure that we detected all uses of den boxes by fishers. Some den box visits by species such as squirrels, martens, and birds were missed in our analysis methods.

We defined a camera event as any image or series of images triggered by the same animal or non-animal cause with no gaps greater than 30 minutes. We defined a visit as the presence of any animal at or near the den box. If animals were detected in the site surrounding the box but did not visit the actual box, we did not consider these occurrences to be visits. We defined a use as an animal entering and remaining inside the den box for at least 30 minutes or use of the den box for another discrete purpose (e.g., storing food). We analyzed over 30,000 events.

We documented 14 species of mammals visiting den boxes: fisher, American marten, southern flying squirrel, northern flying squirrel, red squirrel, gray squirrel, short-tailed weasel, deer mice or white-footed mice, porcupine, black bear, raccoon, eastern chipmunk, least chipmunk, moose, unidentified bats, and bobcat. We also detected deer, wolf, badger, gray fox, and hare in the vicinity of den boxes. We consider moose visitors because they generally inspected the boxes when detected at sites. We also had 36 bird species visit den boxes, but no birds were documented using den boxes. Fishers were detected at 41% of den boxes, while flying squirrels, red squirrels, and birds were detected at almost all den boxes. Throughout the study, every box had at least one species visit it.

Only a subset of animals detected at den boxes were documented using them. We documented fishers using 11 den boxes (~11%) on 43 separate occasions. The most frequent use of den boxes by fishers was for resting. Female fishers also used den boxes to rest with their kits, to select mates (i.e., female fishers were inside the box while males wanted to mate, and females used their secure position to elect not to mate), and to cache prey they had killed. The number of uses at each box was variable. Three boxes used by fishers were used a single time, three boxes were used twice, 1 box was used 3 times, 2 boxes were used 6 times by fishers, 1 box was used 8 times, and 1 box was used 11 times. The box used 11 times had a total of 80 fisher camera events. Three additional boxes had 40 or more fisher camera events, while most boxes had fewer fisher camera events.

When we started this project, we thought that den sites might be limiting fisher reproduction. If there are not enough natural den site cavities, then female fishers would use den boxes to raise kits. Frequent use of several den boxes indicates fishers were able to find the den boxes and supports past research showing fishers are willing to use den boxes. However, we found relatively low rates of fishers visiting and using our den boxes both in terms of number of boxes with fishers detected and relatively few revisits for many of the boxes where fishers were detected. This result is similar to a previous fisher den box study in British Columbia: they documented fishers visiting or using 48% of den boxes within the first 3 years, while we found fishers visiting or using 41% of den boxes within 2.5 years of monitoring. One difference between that study and ours is that they documented fishers raising kits in 15% of their boxes (10 total reproductive uses), while we only documented kits at 3% of our boxes and all of these were in mid-summer through early fall when kits were already semi-independent. Previous studies on closely-related martens also generally documented higher rates of martens visiting and using boxes than the rates we documented for fishers. There are a few possible explanations for the relatively low use rates and lack of use for raising dependent kits.

First, presence but low rates of revisits or uses could suggest that sufficient natural cavities are available. The fact that a female fisher brought her kits to one of our den boxes two years in a row but did not use the box to give birth or care for kits suggests that at least where that box was located, other options are available and preferred. Given the recent decrease in the fisher population and resulting lower fisher density, unoccupied habitat could be available, and fishers should be able to avoid areas where cavities are locally rare. Data from our ongoing ENRTF-funded study on bobcat and fisher interactions will help further evaluate this explanation. By deploying GPS collars on female fishers near den boxes, we can determine where they are giving birth and raising kits instead of den boxes.

A second potential explanation is that fishers may not have been present at every site where den boxes were installed. We used past radio-telemetry and harvest data to select general areas for den box deployment that had historical records of fisher presence, but we could not verify fisher presence in each stand we installed a den box in. Several observations are consistent with this explanation, at least for a subset of the boxes. First, fishers were not detected at over half of the boxes. This includes from camera data, and from searches we did for fisher sign (e.g., snow tracks) while driving throughout the study area, walking to den boxes, and while at the den box site. Second, the Minnesota DNR experienced low capture rates in some of the areas we installed den boxes towards the end of their fisher study. Third, boxes with a single fisher visit or use across the roughly 2.5-year monitoring period could represent transient and not resident fishers. It is likely that both explanations probably contributed to the low use of artificial den boxes by female fishers with kits in Minnesota.

The low use rates by fishers have several important implications that need to be further evaluated. First, they provide evidence that cavity availability may not be the primary factor limiting the fisher population in Minnesota. One other factor that could cause a decline in the fisher population that was identified by the Minnesota DNR was predation by bobcats. We are currently evaluating bobcat and fisher interactions through a separate ENRTF-funded project. Cavity availability may be high in habitats bobcats use, increasing predation risk for female fishers, and the bobcat and fisher study should help us evaluate that. Second, although our results support the hypothesis that natural cavity availability is not limiting the fisher population in Minnesota, we did not measure cavity availability. Recently, methods have been developed that could be used to quantify and map cavity availability, and future research could use these methods to evaluate cavity availability more directly. We intend to pursue future funding to address this important knowledge gap.

Martens used den boxes on 25 occasions. Martens used den boxes primarily for resting but also used den boxes to cache prey. Red, gray, and flying squirrels frequently used boxes, but camera images were not always sufficient to determine whether boxes were being visited or used. Flying squirrels used many den boxes as communal winter rest sites and for storing mushrooms to eat later. Red squirrels built nests, mated on den boxes, cached cones inside boxes, and used den boxes to raise juveniles at least one time. Gray squirrels rested in boxes, used a box to escape predators, and used the box to raise at least one litter. A weasel cached prey inside one den box on 4 different occasions. Den boxes were also used by wasps and bumblebees to build nests, although we did not quantify how many times this happened.

The frequent use of den boxes by species other than fishers demonstrates that fisher den boxes also provided habitat for many Minnesota wildlife species. Thus, the boxes installed by this project helped protect, conserve, and enhance Minnesota's wildlife.

Outcome 3. Identify factors influencing use of den boxes by fishers

We evaluated factors influencing use of den boxes by fishers in several ways: 1) we compared presence of fishers and other wildlife at boxes in our two main study areas to determine whether use was dependent on location; 2) we determined how long it took fishers and other wildlife to first visit and use den boxes to evaluate how time since deployment affects den box use; and 3) we determined whether fisher habitat suitability influenced whether fishers visited or used den boxes to evaluate where den boxes should be installed to have maximum impact.

Wildlife presence at den boxes varied between our two main study areas. Fishers were detected at more than twice as many boxes in the Superior National Forest, with 7x more events at that study area. Martens were only detected at boxes in the Superior NF, while gray squirrels were basically only detected at boxes in the Chippewa NF. In both cases, this is a reflection of where martens and gray squirrels live in the state. Red squirrels were detected at more boxes in the Superior NF, while weasels and flying squirrels were detected at similar numbers of boxes in each study area. It is not clear whether the fisher results are due to their being fewer fishers in the Chippewa National Forest study area, but anecdotal data suggests this might be the case. A previous fisher den box study in British Columbia also found variable rates of fisher presence at boxes they deployed in different areas, so these results are not completely unexpected.

Fishers took much longer to be documented at den boxes than other animals that used den boxes. The fastest fisher detection occurred 21 days after box installation, while the time to fastest detection was less than a week for the other 4 species. The longer time to detection for fishers is probably due to the larger space requirement and lower density of fishers relative to these smaller species. Given the slow and approximately linear trend for fishers using den boxes, we expect fishers will continue to find and use den boxes in the future. These results are also important to communicate how quickly fishers may find and use boxes with members of the public that are interested in building and installing den boxes.

We installed boxes using a stratified random approach that allowed us to install den boxes in a range of forest conditions with different suitability to fishers. This design allowed us to explicitly test the effect of habitat suitability on fisher use of boxes. If fishers preferred boxes, we expected to find high use rates regardless of habitat quality. If cavity trees were limiting, we either expected use to be higher in high quality habitat to reflect where fishers would be most likely to find and use boxes or for boxes to get the most use if they were in stands that had other habitat resources such as prey but that lacked natural cavities. We did not put any boxes in non-habitat where fishers would have been unlikely to be present or to use boxes.

We did not find a strong pattern between habitat suitability and whether fishers visited or used den boxes. Boxes fishers visited and used had a slightly higher median suitability score than those they were not detected, but fishers also visited and used boxes in stands with low estimated suitability. Presence of fishers across a range of suitability values is not likely due to fishers moving into lower quality habitat due to an abundance of fishers. Instead, it could indicate that the habitat suitability index we used does not represent suitability of an area for female fishers to rest or raise kits.

Outcome 4. Identify and prioritize areas with low habitat suitability where den boxes could potentially be used to enhance fisher habitat in the future

During this project, we developed methods to map habitat suitability for fishers so that we could identify and prioritize areas where den boxes could potentially be used to enhance fisher habitat. However, low use rates of den boxes by fishers and lack of a predictable relationship between habitat suitability and fisher use of den boxes have prevented us from being able to objectively identify and prioritize areas where fisher den boxes could be used to enhance fisher habitat. Future work aimed at directly quantifying and mapping cavity availability could provide a better basis for establishing areas where fisher den boxes could be used to increase cavity availability.

Outcome 5. Develop and disseminate instructions on how to build artificial den boxes for fishers and best management guidelines for their use

We created den box building instructions and worked with Carlton County Land Department to create recommendations on how and where to install fisher den boxes. These documents are attached to this report. We have disseminated these documents to 120 members of the public and wildlife managers throughout the project, and these documents will soon be posted on our website so they can be disseminated into the future.

Additional outcomes

This project also resulted in several un-anticipated outcomes that added value to the project beyond what we expected when we began the project. These outcomes are summarized below.

Temperature logger data from den boxes was used by M.S. student Taylor Velander for his thesis (Mechanisms underlying American marten winter rest site selection across the Western Great Lakes Region, 2022) on the thermal ecology of den boxes and cavities. Taylor used the temperature data to develop a mathematical model to predict cavity and den box internal temperatures and used the model to evaluate how temperature influenced American marten winter rest site selection and energetics. These measurements showed that the foam insulation we put in the den boxes helped make temperature more stable and comparable to temperatures in natural tree cavities. The model also allowed us to compare the thermal environment provided by den boxes to that provided by natural tree cavities fishers previously used in Minnesota. We are preparing to submit a manuscript describing his mathematical model to a scientific journal.

We also used temperature logger data to develop a novel method to use temperature loggers to monitor use of den boxes. The method works because fishers and other animals using den boxes alter the temperature within den boxes in predictable ways. The method identified all instances when fishers used den boxes. These results suggest that temperature loggers could be a cost-effective alternative to using trail cameras to monitor den boxes, although using them with trail cameras could enhance the type of data practitioners could gain from den box monitoring. We are preparing a manuscript describing this method that will be submitted to a scientific journal.

The lack of a pattern between habitat suitability at den boxes and use by fishers may suggest that the habitat suitability index we used does not adequately represent fisher reproductive habitat in Minnesota. This is a topic that current Ph.D. student Michael McMahon will explore as part of his thesis project, building on the results of this project.

This project also documented high rates of den box use by squirrel species, including 3 species of squirrels using the same box at different times. Additionally, the camera data we collected during this project allowed us to identify several areas where northern and southern flying squirrels were both present. There is regional concern about the conservation status of northern flying squirrels. The scientific literature suggests that these two species may not use the same stands, so this finding was unexpected and may have implications for flying squirrel density and interactions. We have used these sightings to inform a new proposal we recently submitted for ENRTF funding.

IV. DISSEMINATION:

Description: We will create a website to distribute information to the public, but this will be done after the project starts. The website will be modelled after other websites we maintain (e.g., www.nrri.umn.edu/moose or www.nrri.umn.edu/bats).

We will also use our results to develop and disseminate instructions on how to build artificial den boxes for fishers and best management guidelines for their use. These instructions and guidelines will be intended for use by wildlife managers, foresters, private landowners, trappers, and other members of the public interested in enhancing fisher habitat. We will share our instructions and guidelines directly with these groups and also post it on our website.

In addition, we will present project results at local and regional scientific meetings and prepare and submit papers for publication in peer-reviewed journals.

We will likely have periodic contact with print and broadcast media. These contacts will be documented as they occur.

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 March 1, 2020

We are in the process of creating a website to distribute information to the public, but have not launched the website yet due to ongoing work on other aspects of the project (i.e., deploying and monitoring den boxes). We anticipate the website will be live by May 2020 based on current progress.

We will not create best management guidelines for using den boxes until the end of this project, once our full results are available. We have developed instructions on how to build den boxes for internal use and will be creating den box plans during summer 2020 to disseminate to those interested in building their own artificial den boxes for fishers.

We have received requests from 61 different members of the public and wildlife managers wishing to build their own den boxes since January 2019. Requests have mostly come from individuals living in Minnesota (49), Michigan (2), and Wisconsin (5), but we have also received requests from individuals living in Pennsylvania (2) and Maine (3).

To date, we have given 5 presentations on this project at scientific meetings and 6 presentations to non-technical audiences. Presentations have focused on project background, objectives, and preliminary results. Presentations were given at the following scientific meetings: American Society of Mammalogists (July 2019), Cloquet Forestry Center Forestry and Wildlife Research Review (January 2020), Midwest Fish and Wildlife Conference (January 2020), Minnesota Chapter of The Wildlife Society (February 2020), Minnesota Chapter of the Society for American Foresters (February 2020). Presentations to non-technical audiences were given to the following groups: Legislative delegation visit to NRRI (August 2019), Cloquet Forestry Center Open House (August 2019), Forest Resource Association's visit to NRRI (September 2019), CFANS visit to NRRI (December 2019), Lake Superior College Ecology Class (December 2019), Duluth Chapter of the Izaak Walton League (February 2020). We have not prepared any technical reports or papers as results are still preliminary.

There were 6 articles written about the project by print media:

- "UMD researchers build news dens for forest fishers: a shortage of big trees to nest in may be one factor in the big decline in Minnesota's fisher population over the last decade", Duluth News Tribune, October 27, 2019.
- "Den boxes could help falling numbers of fishers in Minnesota's north woods", Quetico Superior Wilderness News, October 29, 2019.
- "Den boxes provide nesting habitat for fishers", Natural Resources Research Institute News, November 1, 2019.
- "A future for fisher? Research to test potential of artificial nest boxes for reversing the decline in fisher numbers", Timberjay, November 21, 2019.
- "Fisher den box project", 1854 Treaty Authority Newsletter, December 2019.
- "9 wins for Minnesota in 2019", Minnesota Lottery Website, December 16, 2019.

Second Update September 1, 2020

We have created a draft version of a website to distribute information to the public, and it is in the final stages of review and revision before the website goes live. We anticipate the website will be live by September 2020 based on current progress. Additionally, we have shared 2 brief project updates with the public via social media. These posts have generated a lot of interest: the first post was “liked” over 100 times and shared >40 times. The second post was “liked” over 120 times and shared >10 times.

We will not create best management guidelines for using den boxes until the end of this project, once our full results are available. We have developed instructions on how to build den boxes for internal use. We are currently in the process of creating den box plans to disseminate to those interested in building their own artificial den boxes for fishers. We anticipate these instructions being completed during Fall 2020.

We have received requests from 69 different members of the public and wildlife managers wishing to build their own den boxes since January 2019. This includes an additional 8 requests since the last progress update. Requests received since the last update have come from individuals living in Minnesota (6), Michigan (2).

To date, we have given 6 presentations on this project at scientific meetings and 8 presentations to non-technical audiences. Presentations have focused on project background, objectives, and preliminary results. Presentations were given at the following scientific meetings: American Society of Mammalogists (July 2019), Cloquet Forestry Center Forestry and Wildlife Research Review (January 2020), Midwest Fish and Wildlife Conference (January 2020), Minnesota Chapter of The Wildlife Society (February 2020), Minnesota Chapter of the Society for American Foresters (February 2020), Minnesota Forest Resources Partnership (June 2020, virtual meeting). Presentations to non-technical audiences were given to the following groups: Legislative delegation visit to NRRI (August 2019), Cloquet Forestry Center Open House (August 2019), Forest Resource Association’s visit to NRRI (September 2019), CFANS visit to NRRI (December 2019), Lake Superior College Ecology Class (December 2019), Duluth Chapter of the Izaak Walton League (February 2020), Fond du Lac Tribal Community College (March 2020), Sugarloaf Cove Nature Center (July 2020). We have not prepared any technical reports or papers as results are still preliminary.

There were 6 articles written about the project by print media, all of which are listed in the last progress update. Additionally, Dr. Michael Joyce was interviewed by Rob Drieslein for Outdoor News Radio about fishers, including the ongoing fisher den box project.

Third Update March 1, 2021

We have created a draft version of a website to distribute information to the public, and it is in the final stages of review and revision before the website goes live. We have not finalized the website yet to allow us to spend more time analyzing trail camera images, but the website is scheduled to be finalized in early March 2021. Additionally, we have shared 4 brief project updates with the public via social media. These posts have generated a lot of interest, as discussed in the Second Update on September 1, 2020.

We will not create best management guidelines for using den boxes until the end of this project, once our full results are available. We have developed instructions on how to build den boxes for internal use. We are currently in the process of creating den box plans to disseminate to those interested in building their own artificial den boxes for fishers. Those plans are in the final stages of editing and should be finished in March 2021.

We have received requests from 78 different members of the public and wildlife managers wishing to build their own den boxes since January 2019. This includes an additional 9 requests since the last progress update. Requests received since the last update have come from individuals living in Minnesota (7), Michigan (1), and Maine (1).

To date, we have given 7 presentations on this project at scientific meetings and 8 presentations to non-technical audiences. Presentations have focused on project background, objectives, and preliminary results. Presentations given at the scientific meetings since the last update include UW Stevens Point student chapter of The Wildlife Society (October 2020, virtual). No presentations were given to non-technical audiences since the last update. We have not prepared any technical reports or papers as results are still preliminary, but we are currently working on a paper on den box monitoring methods.

Since the last update, Dr. Michael Joyce was interviewed live on the radio as part of KUMD's Green Visions program on November 18, 2020. Additionally, Dr. Michael Joyce was recently interviewed by Javier Serna for Outdoor News (article published in the February 19 issue) and Bob Timmons with the Star Tribune (article planned for March 2021). All interviews and articles were related to this project.

Fourth Update September 2021

We have not yet finalized our draft website. We have delayed finalizing this website again to allow us to spend more time analyzing trail camera images, but we plan to finalize it in October or November 2021.

We will not create best management guidelines for using den boxes until the end of this project, once our full results are available, but we have begun to create draft versions of those guidelines. We have developed instructions on how to build den boxes for internal use. We are currently in the process of creating den box plans to disseminate to those interested in building their own artificial den boxes for fishers. Those plans will be shared with the public via our website when it goes live later this fall.

We have received requests from 90 different members of the public and wildlife managers wishing to build their own den boxes since January 2019. This includes an additional 10 requests since the last progress update. Requests received since the last update have come from individuals living in Minnesota (9) or Denmark (1). The individual from Denmark, where fishers do not live, found a news article on the project online and wanted info so that he could make den boxes for European pine martens. Dr. Joyce shared information on pine marten den boxes along with information about the fisher den box project.

To date, we have given 9 presentations on this project at scientific meetings and 11 presentations to non-technical audiences. Presentations have focused on project background, objectives, and preliminary results. Presentations given at the scientific meetings since the last update include two presentations given at the American Society of Mammalogists' annual meeting (June 2021, virtual), one focusing on den box monitoring techniques and a second focusing on the thermal environment within den boxes and tree cavities. Presentations given to non-technical audiences since the last update include a presentation given to the Ely Field Naturalists' Tuesday Group (April 2021, virtual), the Whitewater State Park HOP program (June 2021, virtual), and a guest lecture given to undergraduate students at the University of Minnesota (August 2021, in person). We have not prepared any technical reports or papers as results are still preliminary, but we are currently working on a paper on den box monitoring methods.

Since the last update, the Star Tribune article by Bob Timmons that was highlighted during the last update was published on March 4, 2021. Dr. Joyce also worked with project partner Dr. Roger Powell to write an article about the project that was published in the Ely Summer Times (Summer 2021 issue).

Fifth Update March 2022

We have not yet finalized our draft website. We have delayed finalizing this website again to allow us to spend more time analyzing trail camera images. We planned to finalize our website in October/November 2021, but NRRI was creating a new website at that time, so we delayed our launch to take advantage of the new website structure to host our den box web site. We are currently working with our Marketing and Communication staff to migrate our draft website to the new format.

The status of our efforts to create management guidelines and building instructions are unchanged from the last update. We will finalize these after other work is complete, but we have made progress on draft versions.

We have received requests from 116 different members of the public or wildlife managers wishing to build their own den boxes since January 2019. Requests received since the project started have come from individuals living in Minnesota (91), Wisconsin (7), Maine (4), Michigan (4), New York (3), Pennsylvania (3), Canada (1), Denmark (1), the United Kingdom (1), and from unknown location (1).

To date, we have given 10 presentations on this project at scientific meetings and 12 presentations to non-technical audiences. Presentations have focused on project background, objectives, and preliminary results. Presentations given at scientific meetings since the last update include one presentation given to the Great Lakes Native American Fish and Wildlife Society meeting in late September 2021 in Manistee, Michigan (conference travel was paid for by NRRRI and not with ENRTF funding since the travel was out of state). Presentations given to non-technical audiences since the last update include a presentation given to the West Metro Chapter of the Minnesota Master Naturalists. We have not prepared any technical reports or papers as results are still preliminary, but we are currently working on a paper on den box monitoring methods. Additionally, a manuscript using the temperature data we collected is in the final stages of preparation before submission to a scientific journal.

Final report June 30-August 15, 2022

Throughout the project, we have heard from many individuals expressing interest in the project and requesting information on how to build and install fisher den boxes. We have disseminated den box building plans and preliminary guidelines to at least 120 different individuals, including members of the public and wildlife managers wishing to build their own den boxes. Most of these requests have come from people living in Minnesota (95), but we have also heard from people living in Wisconsin (7), Maine (4), Michigan (4), New York (3), Pennsylvania (3), Canada (1), Denmark (1), the United Kingdom (1), and from an unknown location (1).

As noted above, we developed den box building plans and guidelines for their installation. We have created a [website for the Minnesota fisher den box project](#) to help disseminate project information, results, images, den box building plans and guidelines for installing den boxes. We will continue to maintain the website and updated it as needed (e.g., as publications and our technical report are finished).

We have given numerous presentations about the project at both scientific conferences and presentations to non-technical audiences. Presentations have focused on project background, objectives, and preliminary results. The following is a complete list of the 13 presentations given at scientific conferences during this project:

- Evaluating artificial den boxes as a habitat management tool for fishers in Minnesota, Minnesota Chapter of the Wildlife Society Annual Meeting, February 2019
- Modeling thermal properties of fisher reproductive dens: implications for artificial den boxes, American Society of Mammalogists Annual Meeting, June 2019
- Evaluating artificial den boxes as a habitat management tool for fishers in Minnesota, Presentation for Chippewa National Forest and Minnesota DNR, June 2019
- Minnesota fisher den box project update, Forestry and Wildlife Research Review, January 2020
- Improving forest management to conserve habitat for cavity-obligate wildlife: fishers as a case study, Midwest Fish and Wildlife Meeting, January 2020
- Minnesota fisher den box project update, Minnesota Chapter of the Wildlife Society Annual Meeting, February 2020
- Minnesota fisher den box project update, Minnesota Chapter of the Society of American Foresters, February 2020

- Minnesota fisher den box project: preliminary results, Minnesota Forest Resources Partnership, Spring 2020
- Fisher research project update, presentation to National Forest Biologists, February 2021
- Using temperature loggers to monitor use of artificial den boxes by fishers, American Society of Mammalogists Annual Meeting (virtual), June 2021
- A dynamic thermal model for predicting internal temperature of tree cavities and den boxes, American Society of Mammalogists Annual Meeting (virtual), June 2021
- Evaluating fisher den boxes as a habitat management tool, Great Lakes Native American Fish and Wildlife Society meeting, September 2021
- Fisher research project update, presentation to National Forest Biologists, March 2022

The following is a complete list of the 12 presentations given to non-technical audiences during this project:

- Minnesota fisher den box project, Minnesota Legislators and University of Minnesota Leadership, August 2019
- Wildlife research program overview, Forest Resources Association, October 2019
- Fishers in Minnesota: history, status, and current research. Lake Superior College ecology students, December 2019
- Fishers in Minnesota: past, present, and future. W.J. McCabe Chapter (Duluth) of the Izaak Walton League, February 2020
- Fishers in Minnesota, University for Seniors Program, University of Minnesota Duluth, February 2020
- Minnesota Ojiiig (fisher) den box project, Fond Du Lac Tribal Community College, March 2020
- Fishers in Minnesota: history, status, and current research. Sugarloaf Cover Nature Center, July 2020
- Fishers: cryptic carnivores of the Northwoods, UW-Stevens Point student chapter of The Wildlife Society, October 2020
- Fisher ecology and ongoing fisher research in Minnesota, Ely Field Naturalists Tuesday Group, February 2021
- Fishers in Minnesota: history, status, ecology, and ongoing research. Whitewater State Park HOP program, June 2021
- A tale of two predators: bobcat and fisher history, ecology, and ongoing research. West Metro Master Naturalists, February 2022 [also discussed ongoing ENRTF-funded study on bobcat and fisher habitat use and interactions]
- Fishers in Minnesota: history, status, and ongoing research. Mississippi River Valley Audubon Center, June 2022

We will give additional presentations following the completion of this project.

Masters graduate student Taylor Velandar (UM-Duluth, Integrated BioSciences Graduate Program) completed his thesis using data from the den box project in July 2022. We are also in the process of completing one technical report and 3 manuscripts to be published in peer-reviewed journals from this project. The thesis, report, and manuscripts in progress are listed below:

- T.B. Velandar. 2022. Mechanisms underlying American marten (*Martes americana*) winter rest site selection. M.S. Thesis, University of Minnesota Duluth, Integrated BioSciences Graduate Program. [Used fisher den box data to develop and test a mathematical model to predict temperature within natural cavities and den boxes]

- M.J. Joyce, M.C. McMahon, T.B. Velander, R.A. Moen. Use of den boxes by fishers and other wildlife. NRRI Technical Report. *Expected completion fall 2022.*
- T.B. Velander, M.J. Joyce, R.L. Sanders, A.K. Kujawa, P.W. Keenlance, R.A. Moen. A dynamic thermal model for predicting internal temperature of tree cavities and den boxes. *To be submitted to Ecological Modeling October 2022.*
- M.J. Joyce, T.B. Velander, M.C. McMahon, M. Swingen, R. Olesiak, T. Roerick, S. Mortenson, R.A. Moen. Factors influencing use of den boxes by fishers and other wildlife. *To be submitted to Wildlife Biology.*
- T.B. Velander, M.J. Joyce, M.C. McMahon, R.A. Moen. Using temperature loggers to monitor occupancy of den boxes. *To be submitted to Wildlife Society Bulletin.*

The Minnesota fisher den box project was featured in the print and broadcast media 11 times:

- Field Notes: New dens for fishers. Minnesota Conservation Volunteer, Jan-Feb 2019 issue.
- UMD researchers build new dens for forest fishers: a shortage of big trees to nest in may be one factor in the big decline in Minnesota’s fisher population over the last decade. Duluth News Tribune, 10/27/2019 (Sunday Outdoors Section).
- Den boxes could help falling numbers of fishers in Minnesota’s north woods. Quetico Superior Wilderness News, 10/29/2019.
- Den boxes provide nesting habitat for fishers. NRRI Newsletter, 11/1/2019.
- A future for fisher? Research to test potential of artificial nest boxes for reversing the decline in fisher numbers. Timberjay, 11/21/2019.
- Fisher den box project. 1854 Treaty Authority Newsletter, December 2019.
- 9 wins for Minnesota in 2019. Minnesota Lottery, December 2019.
- Fisher den boxes: helping rebuild populations...and a whole lot of monkey business. KUMD Green Visions Radio interview and article, November 2020.
- Trail cams keep tabs on researchers’ fisher denning boxes. Outdoor News Minnesota, February 2021.
- Researchers deploy den boxes as possible tool to aid mysterious fishers. Star Tribune, 3/4/2021.
- Will den boxes help fishers? Ely Summer Times, Summer 2021.

Additionally, we have used NRRI’s social media to share images of various wildlife at den boxes. We have acknowledged the ENRTF in accordance with guidelines during dissemination activities.

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:

Enter Total Estimated Personnel Hours for entire duration of project: 4,827	Divide total personnel hours by 2,080 hours in 1 yr = TOTAL FTE: 2.32
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Total Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation:

Enter Total Estimated Contract Personnel Hours for entire duration of project: N/A	Divide total contract hours by 2,080 hours in 1 yr = TOTAL FTE: N/A
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VI. PROJECT PARTNERS:

A. Partners outside of project manager's organization receiving ENRTF funding N/A

B. Partners outside of project manager's organization NOT receiving ENRTF funding

Dr. John Erb (MN DNR) will provide input and in-kind support on this project, with intent to use results to help inform fisher habitat management recommendations.

VII. LONG-TERM- IMPLEMENTATION AND FUNDING:

This proposal is part of a larger effort to understand fisher and pine marten ecology in Minnesota. We envision this as a project that builds off the results of the DNR fisher project and develops techniques to enhance fisher habitat. This project will generate the knowledge necessary to develop strategic plans for fisher habitat management. Den boxes will last many years and could provide a new method for monitoring fisher populations in Minnesota.

We will use our results to develop guidelines for use of fisher den boxes, including instructions on how to build boxes. These guidelines and instructions are meant to be used by wildlife managers, private land owners, trappers and other members of the public interested in enhancing fisher habitat. The Land Resources Department in Carlton County has already deployed one fisher den box that we built after hearing about our project, and they have already indicated that they would like to deploy more boxes in 2018. We expect interest by other agencies and the public as well.

This project could lead to a future opportunity for public engagement through a large-scale citizen-science project. Using what we learn in this project, we could establish a network of fisher den boxes that could be maintained and monitored by citizens to collect samples and data to contribute to fisher habitat and population monitoring efforts.

VIII. REPORTING REQUIREMENTS:

- Project status update reports will be submitted March 1 and September 1 each year of the project
- A final report and associated products will be submitted between June 30 and August 15, 2022

IX. SEE ADDITIONAL WORK PLAN COMPONENTS:

A. Budget Spreadsheet: See Attachment A

B. Visual Component or Map: See Attachment B

C. Parcel List Spreadsheet: N/A

D. Acquisition, Easements, and Restoration Requirements: N/A

E. Research Addendum: Research Addendum will be submitted by September 14, 2018.

Attachment A:

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. 03i

Project Manager: Dr. Michael Joyce

Project Title: Artificial Den Boxes for Fishers

Organization: U of MN - Duluth

Project Budget: \$190,000

Project Length and Completion Date: 3 Years, June 30, 2022

Today's Date: Septembert 1, 2022



ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Revised Budget 9/1/2022	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	\$ 148,281	\$ 148,281	\$ 0
Michael Joyce, Principal Investigator: \$94,059 \$94,033 (fringe rate 36%); ~57% FTE each year for 2			
Ron Moen, Project Partner: \$3,173 (fringe rate 33.5%); 1% FTE each year for 2 years			
Technician: \$29,755 (fringe rate 27.2%); ~27.5% FTE each year for 2 years			
Undergraduate Research Assistant: \$14,476 (100% salary); 29% FTE each year for 2 years			
Temp/Casual: \$1,000 (fringe rate 8.2%); ~1% FTE			
Graduate Student: \$5,992 (fringe rate 16.1%), 25% FTE each summer for 2 years			
Equipment/Tools/Supplies			
Den boxes (80 @ \$97/box): includes materials for building and hanging boxes and temperature loggers	\$ 7,749	\$ 7,749	\$ -
Cameras (60 @ \$170). Additional cameras will come from project partners	\$ 10,200	\$ 10,200	\$ -
Field supplies (e.g., batteries for cameras, bug dope, gps, GoPro and pole for den box checks)	\$ 2,946	\$ 2,946	\$ (0)
Travel expenses in Minnesota			
Travel for fieldwork, including mileage (75%) and lodging for technician, researcher, and undergraduate research assistant. Mileage will be reimbursed at \$0.58/mile (U of M rate). Lodging is estimated between \$90 and \$110 per night, less if camping is possible. Some trips will involve longer-distance travel and require overnight expenses (camping or motel) and food expenses.	\$ 20,824	\$ 20,824	\$ 0
COLUMN TOTAL	\$ 190,000	\$ 190,000	\$ -

OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)		Spent	Balance
Non-State:		\$ -	\$ -	\$ -
State:		\$ -	\$ -	\$ -
In kind:		\$ -	\$ -	\$ -
Unrecovered indirect: 54% on total direct costs (\$190,000 base)	Secured	\$ 102,600		\$ 102,600
In-kind support from DNR biologist John Erb: 80 hours of in-kind support over 2 years	Secured	\$ 4,500	\$ 4,500	\$ -
HOBO temperature loggers (30 @ \$60)	Secured	\$ 1,800	\$ 1,800	\$ -

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