2018 Project Abstract
For the Period Ending June 30, 2022

PROJECT TITLE: Evaluate Control Methods for Invasive Hybrid Cattails
PROJECT MANAGER: Steve K. Windels, PhD
AFFILIATION: Voyageurs National Park
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FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 06c as extended by M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 18

APPROPRIATION AMOUNT: $131,000
AMOUNT SPENT: $124,036
AMOUNT REMAINING: $6,964

Sound bite of Project Outcomes and Results
Invasive hybrid cattails can be effectively controlled by mechanical treatments, creating space for native plants like wild rice and other native aquatic plants, and enhancing habitat for wetland-loving wildlife like muskrats, mink, otters, bitterns, rails, grebes, and more.

Overall Project Outcome and Results
Invasive hybrid cattails are rapidly expanding throughout Minnesota's wetlands. Hybrid cattails grow in dense stands that crowd out native plant species and create single species stands that can degrade both fish and wildlife habitat and negatively impacts biodiversity and wetland function. Starting in 2016, Park staff, securing both state and federal funding, initiated the Voyageurs Wetland Restoration Project to restore wetlands within the large lakes of the park that have been infested by invasive hybrid cattails. Through this LCCMR grant, we documented that we achieved reductions of invasive hybrid cattail cover from all six mechanical treatments that were tested. Lethal treatments showed the greatest reduction in cattail coverage with all treatments, showing approximately a 90% reduction in cattail cover up to 3-years post-treatment. Treatment of cattails increased cover and diversity of native wetland plants across all treatment types, which we lumped into 4 functional plant groups: rushes, sedges, grasses, and herbaceous plants. Our project represented the first attempt to translocate muskrats and assess post-translocation survival and movements. Additionally, our project was the first to experimentally investigate feeding preferences of muskrats and also quantify immediate foraging effects of translocated muskrat populations on T. x glauca coverage in wetlands. We found that translocated muskrats quickly established home ranges and that survival of post-translocated muskrats was similar to reported survival estimates of other established muskrat populations. Overall, our results suggest that muskrat translocations may be a viable option to re-establish or temporarily increase abundances of muskrat populations, especially in areas with a healthy beaver population. Even though we showed that muskrats do eat invasive hybrid cattails, we do not believe that muskrat densities *in our area* can be elevated to a high enough density for multiple years to where stands of invasive hybrid cattail can be eliminated or even noticeably reduced in abundance.

Project Results Use and Dissemination
This collaboration between the National Park Service's Voyageurs Wetland Restoration Project and Kansas State University produced five scientific papers and other reports. Our findings, though many are still preliminary, have influenced wetland restoration techniques throughout the U.S. and Canada through our presentations at local, state, and national scientific conferences; through our outreach efforts via print and online media; and through one-on-one consultations with others working on wetland restoration.

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

Today's Date: August 15, 2022

Date of Next Status Update Report: Final Report

Date of Work Plan Approval: June 8, 2018

Project Completion Date: June 30, 2022

Does this submission include an amendment request? _N_

PROJECT TITLE: **Evaluate Control Methods for Invasive Hybrid Cattails**

Project Manager: Steve Windels

Organization: Voyageurs National Park

College/Department/Division:

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Location: Rainy Lake, Voyageurs National Park, Koochiching and St. Louis counties

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Total Project Budget: $131,000

Amount Spent: $124,036

Balance: $6,964

Legal Citation: M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 06c as extended by M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 18

Appropriation Language:

$131,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with Voyageurs National Park to evaluate the effectiveness of mechanical harvesting and managing muskrat populations to remove exotic hybrid cattails 128.21 and restore fish and wildlife habitat in Minnesota wetlands. This appropriation is available until June 30, 2021, by which time the project must be completed and final products delivered.

M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 18. ENVIRONMENT AND NATURAL RESOURCES TRUST FUND; EXTENSIONS. [to June 30, 2022]

I. PROJECT STATEMENT:

An invasive hybrid cattail species is rapidly expanding and negatively affecting native species in wetlands across Minnesota. Voyageurs National Park (VNP) has already secured $1,175,000 in grants ($790,000 state and $385,000 federal) to begin critical on-the-ground wetland restoration efforts in Rainy and Kabetogama Lakes to deal with this growing problem. VNP will start work on this project in June 2017 that will affect >500 acres of sensitive wetlands over the next 10 years. However, resources from these grants are restricted from scientific monitoring efforts, and the true effectiveness of our work cannot be known without additional support.

Chemical herbicide treatments are prohibited in these waters by state law. As an alternative, we are using mechanical harvesting machines to remove large floating mats of hybrid cattail. We are also stocking muskrats, native herbivores that have the ability to control and reduce cattails and other wetland vegetation, as a native control of hybrid cattails. To better inform future restoration and management of cattail invaded wetlands in MN, we need a clearer understanding of the effectiveness of various control methods.

Goal 1: Evaluate how mechanical control of hybrid cattails impacts native wildlife and plants in wetlands. Because hybrid cattail grows in dense stands that crowd out other species, expanding cattail populations negatively affect wildlife and plant communities in MN. Mechanical removal techniques reduce cattail density but we don't know how this translates to improved habitat for native wildlife and plants. Using funding already secured from state and federal sources, mechanical treatment methods will begin in 2017 and continue through 2019. Some pre-treatment data has been collected for wetlands in 2016 and 2017. We will use LCCMR funds to monitor the response of native wildlife and plants 1-3 years after completion of mechanical treatments to reduce hybrid cattail abundance and restore wetland diversity and function (Fig 1).

Goal 2: Evaluate the effectiveness of muskrats as bio-restoration tool for hybrid cattail invaded wetlands. While chemical and mechanical treatments are generally effective, they are expensive, disruptive, and require periodic retreatment. Muskrats are a native species in MN that feed on hybrid cattail and other wetland plants. Muskrat populations have the documented ability to reduce and control densities of wetland vegetation, and may be a viable management alternative for expanding hybrid cattails. The usefulness of muskrats as a bio-restoration tool has not yet been evaluated. Our project will experimentally assess the effectiveness of reintroducing and enhancing muskrat populations to serve as a natural control for expanding hybrid cattails in MN (Fig 2).

Voyageurs National Park is a 218,000 protected area that presents an excellent laboratory to test different methods of invasive plant control. We anticipate that project results will be of interest to government agencies and lake associations and other non-governmental organizations interested in restoring fish and wildlife habitat in degraded wetlands. We also believe that project results will be broadly applicable to cattail-invaded wetlands throughout the state, especially those in lake habitats.

II. OVERALL PROJECT STATUS UPDATES:

First Update January 31, 2019

National Park Service staff and partners initiated project activities in May 2018, including completing the second year of ecological monitoring of >70 invaded wetlands sites as part of future assessments of efficacy of treatment methods. During this project reporting period, we initiated our muskrat trapping, tracking, and translocation operations. Muskrats were "stocked" into 5 treatment wetlands to test vegetation response to increased muskrat herbivory. We also monitored survival and movements of 23 radiomarked individuals. Early project results have been disseminated through popular media and scientific conferences.

Second Update June 30, 2019

We initiated another year of monitoring of marshbirds and semi-aquatic mammals during the reporting period. We completed a successful second round of muskrat trapping, tracking, and translocation operations in June 2019. Muskrats were again "stocked" into 5 treatment wetlands to test vegetation response to increased muskrat herbivory. We also monitored survival and movements of >40 radiomarked individuals. We completed feeding trials of 31 wild muskrats feed various species of wetland plants, including native and hybrid cattails. Early project results have been disseminated through popular media and scientific conferences. No funds have been spent from this LCCMR grant as of the timing of this June 30, 2019 update. The National Park Service and Kansas State have been expending matching funds during this first year of the project to initiate the work. However, we now have contracts in place so that our partners at Kansas State University can continue their work for the remainder of the 2019 and 2020 field seasons.

Amendment Request August 28, 2019

We are requesting funds be shifted from the Personnel, Equipment/Tools/Supplies, Travel, and Other budget lines to the Professional/Technical/Service Contracts budget line.

- Personnel budget will be reduced by $57,940 to a revised budget of $31,000
- Equipment/Tools/Supplies budget will be reduced by $1,460 to a revised budget of $18,600
- Travel budget will be reduced by $6,320 to a revised budget of $5,680
- Other budget will be reduced by $2,000 to a revised budget of $8,000
- A new budget item for $67,720 for a contract for Kansas State University has been added to the Professional/Technical/Service Contracts budget line.

These changes are necessary because a subcontract with the Kansas State University for $67,720 was intended at the start of the project but was the individual components of the subcontract were misplaced in the other budget categories instead of Professional/Technical/Service Contracts.

Amendment Approved by LCCMR 10/08/2019

Third Update January 31, 2020

The National Park Service and Kansas State University partners continued to collect field data during the latter half of the 2019 field season, primarily related to monitoring of radio-marked muskrats and completion of wetland plan monitoring. Other activities during the period included data entry, data management, and data analysis. Early project results were disseminated through popular media and scientific conferences.

Fourth Update June 30, 2020

The COVID-19 outbreak resulted in a delayed start to 2020 field activities. Starting around May 25, 2020, the National Park Service and Kansas State University partners initiated 2020 field activities, including monitoring of marshbirds and semi-aquatic mammals. By mid-June we initiated intensive muskrat trapping and marking to document the efficacy of muskrat translocation (i.e., "stocking"). Other activities during the period included data entry, data management, and data analysis. Early project results were disseminated through popular media and scientific conferences.

Fifth Update January 31, 2021

The National Park Service and Kansas State University partners continued to collect field data during the latter half of the 2020 field season, primarily related to monitoring of radio-marked muskrats and completion of wetland plant monitoring. Other activities during the period included data entry, data management, and data analysis. Early project results were disseminated through popular media and scientific conferences.

Project extended to June 30, 2022 by LCCMR 6/30/21 as a result of M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 18, legislative extension criteria being met.

Sixth Update June 30, 2021

Starting May 17, 2021, the National Park Service initiated 2021 field activities, including monitoring of marshbirds and semi-aquatic mammals. By late-June we initiated another year of vegetation surveys to document the response of cattails and other native plants to mechanical treatment types. Other activities during the period included data entry and management, data analysis, burning or wetlands, and surface cuts of remaining cattail stands. Preliminary project results were disseminated through popular media, presentations to the public, and professional consultations.

Seventh Update January 31, 2022

The National Park Service and Kansas State University partners continued to collect field data during the latter half of the 2021 field season. Staff primarily focused on wetland plant monitoring and secretive marsh bird surveys. Additionally, NPS staff and contractors were able to totally remove 16.4 acres of floating cattail and treated a total of 32.2 acres of wetlands. Other activities during the period included data entry, data management, and data analysis. Early project results were disseminated through popular media and scientific conferences.

Final Update June 30, 2022

This year's flooding caused a delay in our normal vegetation and secretive marsh bird surveys. Although reduced, the National Park Service successfully completed this year's annual marsh bird survey. With water levels receding, staff are gearing up to start vegetation and animal track board surveys. During this period 9.9 acres of rooted cattail have been mechanically removed. Other activities during the period included data entry, data management, and data analysis. Early project results were disseminated through presentations at the MN Chapter of the Wildlife Society and the Rainy Lake of the Woods Watershed Forum.

Overall Project Outcomes and Results:

Invasive hybrid cattails are rapidly expanding throughout Minnesota's wetlands. Hybrid cattails grow in dense stands that crowd out native plant species and create single species stands that can degrade both fish and wildlife habitat and negatively impacts biodiversity and wetland function. Starting in 2016, Park staff, securing both state and federal funding, initiated the Voyageurs Wetland Restoration Project to restore wetlands within the large lakes of the park that have been infested by invasive hybrid cattails. Through this LCCMR grant, we documented that we achieved reductions of invasive hybrid cattail cover from all six mechanical treatments that were tested. Lethal treatments showed the greatest reduction in cattail coverage with all treatments, showing approximately a 90% reduction in cattail cover up to 3-years post-treatment. Treatment of cattails increased cover and diversity of native wetland plants across all treatment types, which we lumped into 4 functional plant groups: rushes, sedges, grasses, and herbaceous plants. Our project represented the first attempt to translocate muskrats and assess post-translocation survival and movements. Additionally, our project was the first to experimentally investigate feeding preferences of muskrats and also quantify immediate foraging effects of translocated muskrat populations on T. x glauca coverage in wetlands. We found that translocated muskrats quickly established home ranges and that survival of post-translocated muskrats was similar to reported survival estimates of other established muskrat populations. Overall, our results suggest that muskrat translocations may be a viable option to re-establish or temporarily increase abundances of muskrat populations, especially in areas with a healthy beaver population. Even though we showed that muskrats do eat invasive hybrid cattails,

we do not believe that muskrat densities *in our area* can be elevated to a high enough density for multiple years to where stands of invasive hybrid cattail can be eliminated or even noticeably reduced in abundance.

III. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: **Evaluate how mechanical control of hybrid cattails impacts native wildlife and plants in wetlands**

Description:
Selected wetlands in Rainy Lake (VNP) will be mechanically treated to remove/reduce hybrid cattail abundance in 2017 and 2018 (using non-LCCMR funds). Wildlife and plant surveys will be conducted 1 and 2 years after treatment to evaluate the effects on native wildlife and plant species of interest. Species or groups of species selected to survey are good general indicators of the effects of treatments of native species and are expected to show short-term effects within the 2018-2021 LCCMR project timeframe.

ENRTF BUDGET: $55,000

Outcome	Completion Date
1. Establish sampling sites in mechanically-treated and control wetlands.	*9/31/2018*
2. Conduct surveys of native wildlife (crayfish, aquatic furbearers, marshbirds/ waterfowl) in wetlands for 1-2 yrs after treatment.	*9/31/2020*
3. Conduct surveys of native plants (wild rice, bulrushes, pond lilies) in wetlands for 1-2 yrs after treatment.	*9/31/2020*
4. Provide wetland management recommendations to MN land managers based on effectiveness of mechanical cattail removal to improve wildlife and plant species.	*6/30/2021*

First Update January 31, 2019
We successfully established >70 sampling sites in our treated and control wetlands. Post-management surveys will take place in 2019 and 2020, 1-2 years after management efforts completed in late 2018 and those planned for 2019.

Second Update June 30, 2019
We initiated another year of monitoring of marshbirds and semi-aquatic mammals during the reporting period.

Third Update January 31, 2020
We completed monitoring of native plants, marshbirds, and semi-aquatic mammals during the latter part of the 2019 field season.

Fourth Update June 30, 2020
We initiated another year of monitoring of native plants, marshbirds, and semi-aquatic mammals during the reporting period.

Fifth Update January 31, 2021
We completed of monitoring of native plants, marshbirds, and semi-aquatic mammals for the 2020 field season.

We saw reductions of cattail cover from all 6 mechanical treatments that were tested. However, 3 methods (total removal; back piling of spoil material; and underwater cutting of rooted cattail) saw the greatest declines of cattail with cover decreasing by 100%, 95%, and 96% from 2017/18 to 2019, respectively. Cattail cover did increase slightly from 2019 to 2020 in all treatment types, but overall cover of cattail was still >90% lower than before the initial treatments.

Mechanical treatment of cattails increased cover and diversity of native wetland plants across all treatment types. Plant composition saw the greatest increases in the surface cut, back piling spoil material, tilled/flattened, and total removal treatment areas. Further, we witnessed large increases in the amount of water surface area after treatment. Increases in open water surface area from mechanical treatments will allow the reestablishment of a robust submergent plant community as well as other emergent aquatic plants (e.g., wild rice), which are beneficial to fish and wildlife.

Three years of secretive marsh bird and semi-aquatic mammal data have been collected since 2017. These data are currently being analyzed to determine the effects of cattail treatment.

Sixth Update June 30, 2021

We initiated another year of monitoring of native plants, marshbirds, and semi-aquatic mammals during the reporting period. Data analysis is ongoing.

Seventh Update January 31, 2022

NPS staff and contractors were able to remove 16.4 acres and treated a total 32.2 acres of cattail during the 2021 field season. We completed monitoring of native plant communities in areas previously treated and in areas that will be treated in the coming years. Data collected from this field season are currently being added to previous data sets and re-analyzed. We saw significant reductions in cattails and significant increases in open water areas and native plant species composition. For example, we restored ~10 acres of wild rice in the Reuter Creek drainage on Rainy Lake that was once cattail.

Final Update June 30, 2022

Marsh bird surveys have been completed for the year and staff are gearing up for an additional year of vegetation surveys, which will begin after the end of this LCCMR project. NPS staff are analyzing data in preparation for the final report.

Final Report Summary:

Invasive hybrid cattails are rapidly expanding throughout Minnesota's wetlands. Hybrid cattails grow in dense stands that crowd out native plant species and create single species stands that can degrade both fish and wildlife habitat and negatively impacts biodiversity and wetland function. Previous research in Voyageurs National Park (VNP) has confirmed that hybrid cattails dominate most stands of cattail in VNP, with >500 acres of wetlands currently infested. Starting in 2016, Park staff, securing both state and federal funding, initiated a project to restore wetlands within the large lakes of the park that have been infested by invasive hybrid cattails. Park staff implemented multiple mechanical treatments in an "adaptive management framework" (i.e., learning by doing) to investigate and determine the best and most effective methods to use. Unfortunately, it was apparent that there was no "silver bullet" approach to this issue. We would need to implement a multi-pronged approach, incorporating multiple types of treatments with differing objectives, to reset the infestation stage to a point that would be both feasible and cost effective to manage in the future.

We initiated a pilot investigation of treatment effectiveness at our Rainy Lake Visitor Center wetland in 2017, where our data showed that six treatments were most effect at reducing cattail prevalence and increasing native plant diversity and cover. These six treatments were categorized into two groups: 1) lethal treatments where we were actively killing invasive cattail, and 2) non-lethal treatments where total removal was not possible but we could manage cattail re-growth over time. The lethal treatments consisted of: 1) Total Removal, 2) Smother, and 3) Underwater Cutting. Total Removal treatments used contracted "cookie cutter" or "swamp devil" cutting machines and floating harvesting barges to chew up floating cattail mats and collect the resulting

spoil material (Fig. 1). The spoil material was transported to shoreline areas infested with cattail and deposited. The spoil material was then pulled back onto live cattail constituting our Smother treatment. Lastly, in areas where cattail stands were rooted, we used an amphibious machine called a MobiTrac with a sickle bar cutting head to cut cattail stems below the water surface, which effectively drowns the plant. Such Underwater Cutting was performed during the high-water periods in mid-late summer and when the cattails were producing seed heads (typically July-August).

Figure 1. Invasive hybrid cattail treatments used contracted "cookie cutter" or "swamp devil" cutting machines (upper right) and floating harvesting barges (left) to chew up floating cattail mats and collect the resulting spoil material.

It was realized early on that, without the use of herbicide, it would be impossible to lethally treat cattail that grew further into the wetland, away from the water's edge, and outside of the Smother treatment area. Therefore, we developed and implemented two non-lethal treatments that would aid native plant competition and slow the spread of cattail back into restored areas. Our non-lethal treatments consisted of Surface Cutting and Prescribed Burning (Fig. #). Both treatments aimed at removing the litter component of cattail stands that suppress native plant competition. Surface cuts were implemented using the MobiTrac machine and a sickle bar cutting head (Fig. #). Prescribed burns of cattails stands were conducted in late-winter/early-spring when there was snow remaining in the uplands and the ice was still safe to reach our treatment areas.

Effects of Cattail Removal on Invasive Hybrid Cattail and Native Vegetation

To quantify treatment effectiveness, we conducted pre- and post-treatment vegetation surveys of all areas that were treated. Survey points were arranged in a grid pattern and the number of survey locations depended on the size of the wetland. We used quadrat sampling at each survey location and collected data on plant diversity and coverage.

We saw reductions of invasive hybrid cattail cover from all six mechanical treatments that were tested. Lethal treatments showed the greatest reduction in cattail coverage with all treatments showing approximately a 90% reduction in cattail cover (Fig. 2). Even more promising was that our results were still evident up to 3 years post-treatment.

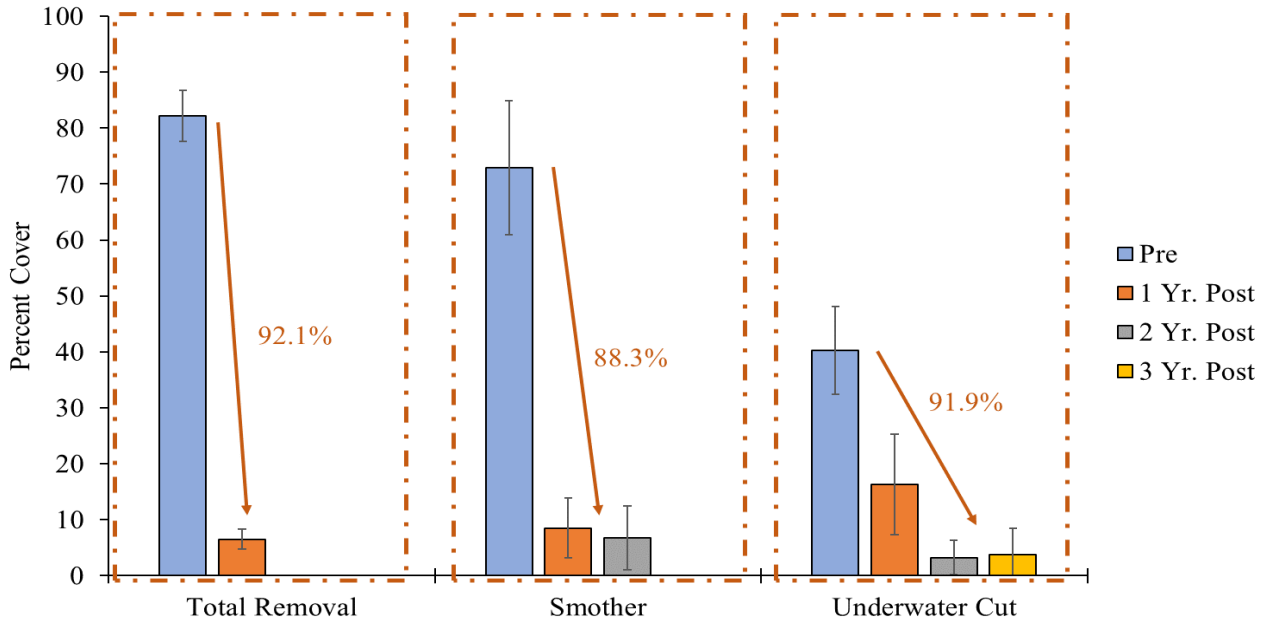


Figure 2. Reduction in invasive hybrid cattail before and after 3 different methods of lethal treatment in Voyageurs National Park, 2016-2021. In all cases, we saw >88% reduction in the cover of invasive hybrid cattail up to 3-years post-treatment.

Our non-lethal treatments also reduced the amount of invasive hybrid cattail by approximately 60% (Fig. 3). However, we feel this is an artifact of removal of the litter canopy and not a result of actual mortality from the treatment. It also stands to reason that these treated areas will eventually regress back to its original infestation state over time, though it is unclear how long that process will take. Our results suggest that these non-lethal treatments do reduce cattail coverage in the short-term, providing an opportunity for native plants to compete. These non-lethal methods can be effectively used to maintain restored areas if implemented at regular intervals over time.

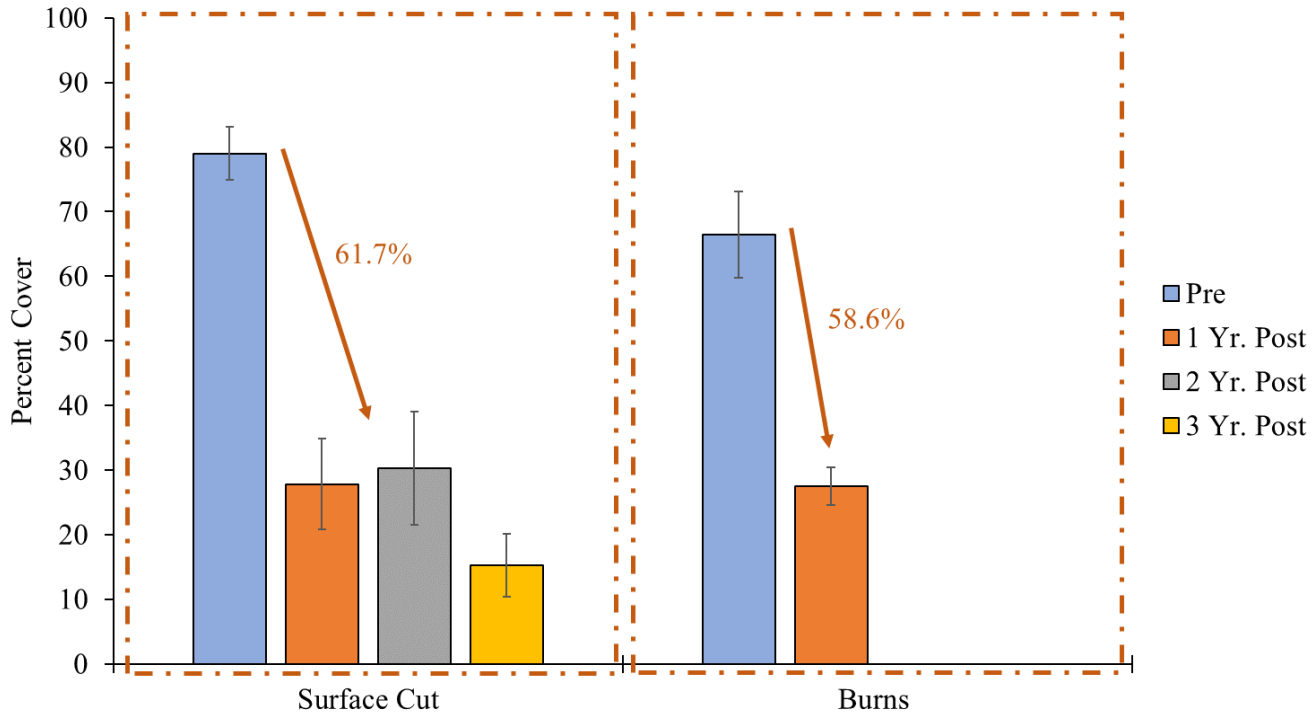


Figure 3. Reduction in invasive hybrid cattail before and after 2 different methods of non-lethal treatment in Voyageurs National Park, 2016-2021. In both cases, we saw >58% reduction in the cover of invasive hybrid cattail up to 3-years post-treatment.

Treatment of cattails increased cover and diversity of native wetland plants across all treatment types, which we lumped into 4 functional plant groups: rushes, sedges, grasses, and herbaceous plants. We saw the greatest increases in native plant cover in areas that received Surface Cut, Smother, and Total Removal treatments (Fig. 4). Further, we witnessed large increases in the amount of open water area after treatment. Increases in open water area from mechanical treatments allow for the reestablishment of a robust submergent plant community as well as other emergent aquatic plants (e.g., wild rice), which are beneficial to fish and wildlife.

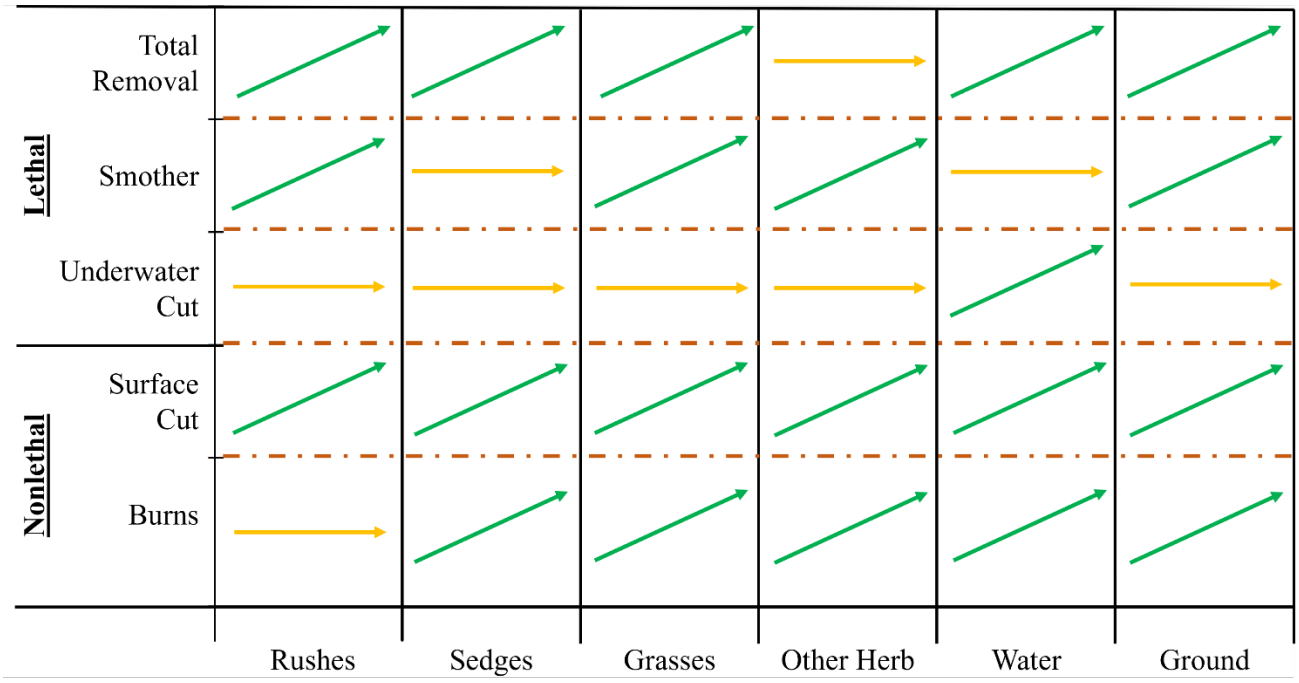


Figure 4. General changes in percent cover of native plant groups, open water, and bare ground before and after 5 different methods of cattail control in Voyageurs National Park, 2016-2021. Most treatment types resulted in positive increases in the cover of desired native plants, though some treatments did not show any net change (either positive or negative).

Field observations do suggest that the invasive hybrid cattail is exceptionally well suited at outcompeting and overtaking native wild rice stands. Wild rice is an important component of the emergent wetland plant community, where it prefers shallow water depths (1-3ft deep) and soft mud bottoms. Our total removal and underwater cutting treatments showed drastic increases in open water, freeing the ideal growth zone for wild rice from cattail control. The Reuter Creek drainage on Rainy Lake is a perfect example of how our restoration efforts positively benefited wild rice stands. In areas where we removed floating cattail mats and wild rice was an existing component of that same wetland, we saw a more than 5-fold increase in wild rice coverage the following year (Fig. 5)! This dramatic increase provided us with two insights to the wild rice/cattail issue. First, even if wild rice is overtaken and outcompeted by the invasive hybrid, their seeds are robust enough to last in the seed bed for a long period of time and, if released, will germinate and reoccupy the area. Secondly, our results were mixed when compared across all areas that received lethal cattail treatments. In areas that did not have a historical wild rice component, we saw little to no wild rice establishment post-treatment, including areas that were seeded with wild rice for up to 2 successive years. Managers wanting to restore wild rice should prioritize areas that either have a current wild rice component or where wild rice beds were thought to occur historically.

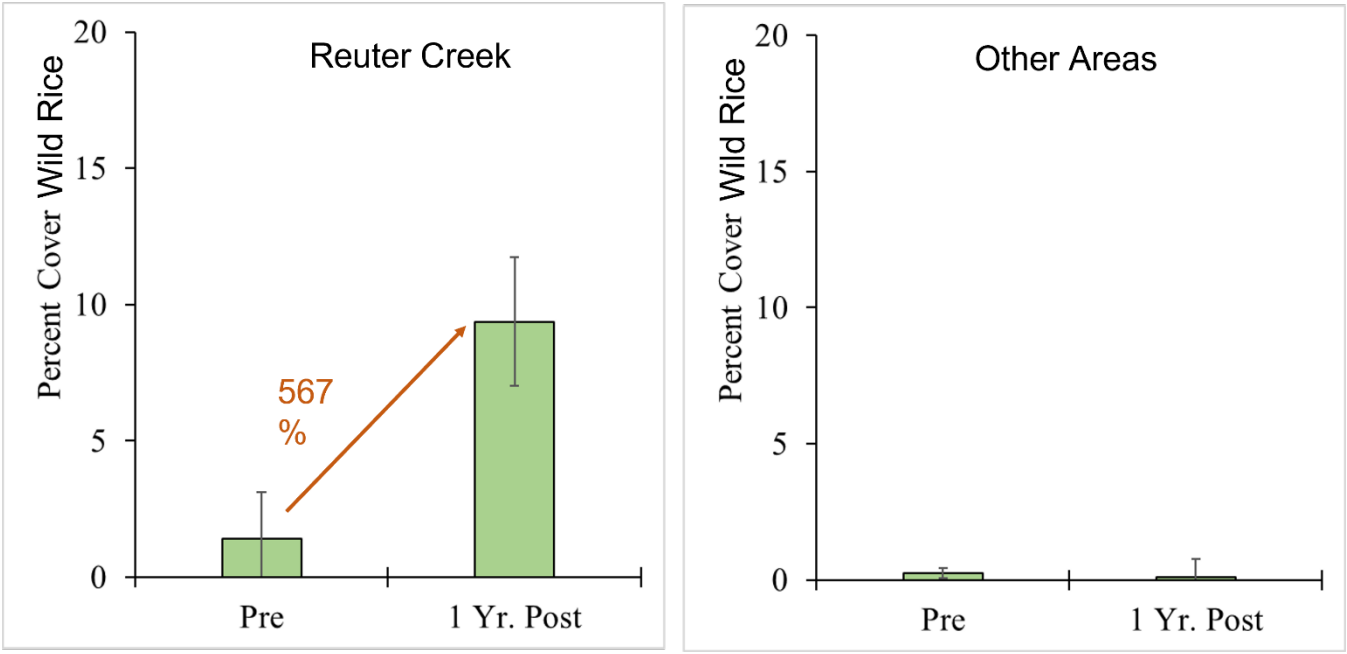


Figure 5. Comparison of wild rice cover pre- and post-treatment between Reuter Creek drainage of Rainy Lake (left) and several other areas that received total removal treatments (right). The Reuter Creek area had some wild rice currently growing in the wetland at the time of treatment, and lethal removal of invasive hybrid cattails allowed for an explosion of wild rice in that stand the following year.

Effects of Cattail Removal on Semi-Aquatic Mammals

Several species of semi-aquatic mammals are good indicators of aquatic ecosystem health, specifically muskrats, American mink, and river otters. Further, muskrats are an obligate wetland species that are known to eat cattails and use them for building their huts, which can alter the amount of cattail coverage in the wetlands they inhabit. We monitored the presence of these 3 species in 71 wetland sites across Rainy and Kabetogama Lakes, Voyageurs National Park, using standardized methods including trackboard (or raft) surveys (Fig. 6) and walking sign surveys.

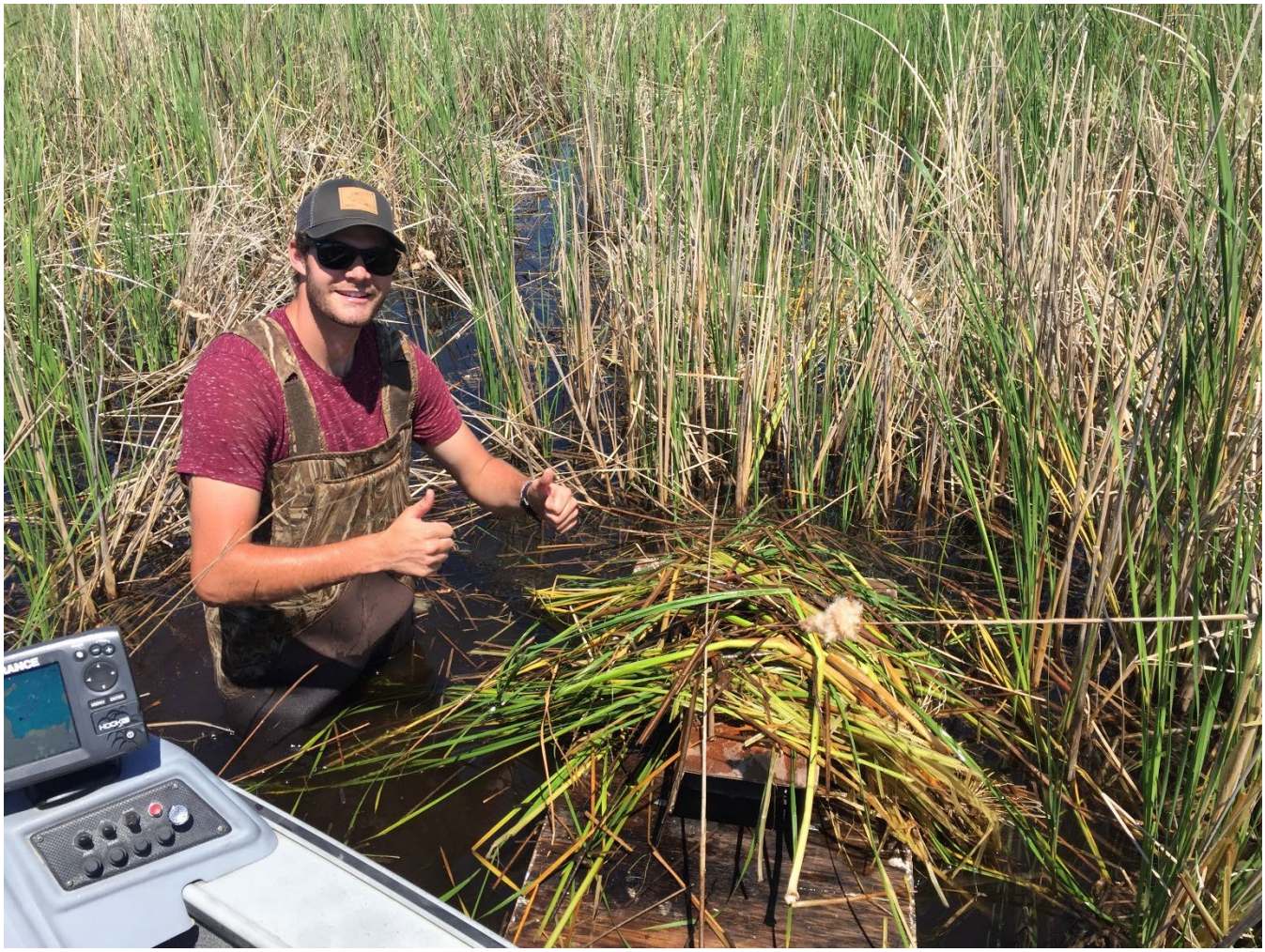


Figure 6. Trackboard-style survey technique used to detect presence of semi-aquatic mammals such as muskrats, mink, and river otters. NPS photo.

We conducted 1,238 independent surveys (284 in 2016; 276 in 2017; 218 in 2018; 184 in 2019; 276 in 2020) for mink, otter, and muskrat (Fig 7). Sampling was not conducted in 2021 because of staffing limitations due to the COVID19 pandemic and other factors. As a result, we are currently limited in the rigorous analyses that we can conduct to detect differences in semi-aquatic mammal distribution before and after invasive hybrid cattail removal. However, from these extensive annual sign surveys across VNP, we found that semiaquatic mammals were widely dispersed before, during, and immediately after years we implemented mechanical control of cattails in our a subset of our treated wetlands. Occupancy for all species varied by sampling year and with the type of survey technique used. Coarsely, muskrat distributions expanded between 2016-2018 (i.e., pre-treatment) and 2019-2020 (i.e., post-treatment). However, this resulted in confounded by the implementation of our translocation study in 2018-2019. See Activity 2 report for more details.

At this time of this report, sampling for semi-aquatic mammals is being conducted in 2022, and more sampling is planned for 2023. By that time, we anticipate having enough before-after treatment data to better understand how invasive hybrid cattail removal can affect these species of interest.

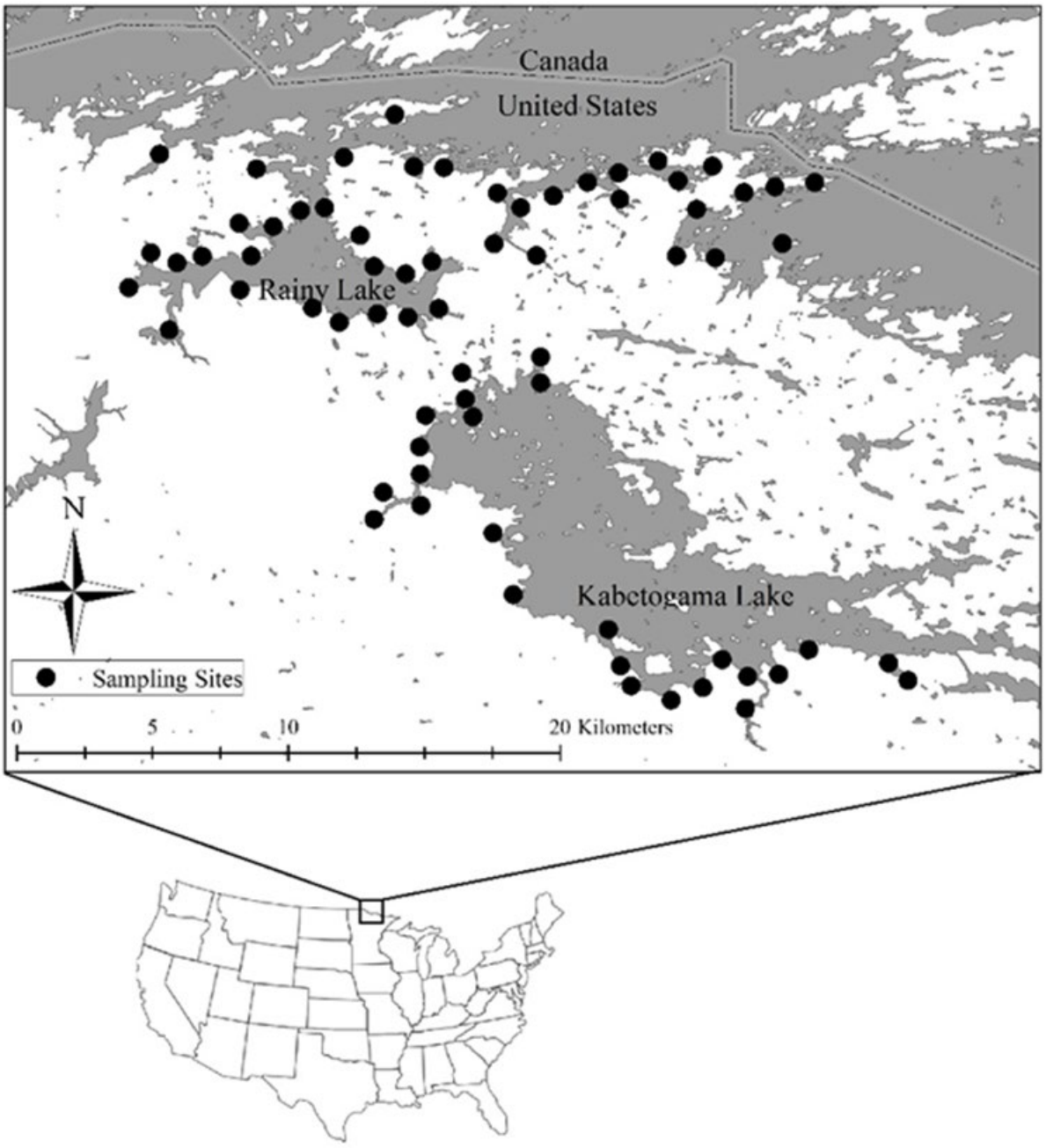


Figure 7. Location of all wetland sites (n = 71) used to assess the effectiveness of two non-invasive survey techniques (trackboards and walking surveys) for determining habitat occupancy by American mink, river otter, and muskrat. We conducted surveys in wetlands in Rainy and Kabetogama Lakes in Voyageurs National Par, 2016-2020.

Effects of Cattail Removal on Secretive Marshbirds

Secretive marshbirds can be sensitive indicators of wetland ecosystem health. We wanted to understand how wetland restoration techniques, specifically invasive hybrid cattail removal, affected the marshbird community

in Voyageurs National Park. We conducted annual monitoring of selected wetlands of Rainy and Kabetogama Lakes to detect presence of marshbirds during the breeding season, using passive listening and playback calls in a standardized point-count format. The 9 species of interest included American and least bitterns, yellow rail, Virginia rail, sora, pied-billed grebe, red-necked grebe, black tern, and American coot. All species, except American coot, were detected in both treated and control wetlands. Most detections were of the relatively common American bitterns, Virginia rails, and soras, but we also had a surprising number of detections for the rare species least bitterns and yellow rails. We did not have enough detections of either grebe species, black terns, or American coots to make any evaluations of treatments effects.

There were no statistical differences in marshbird abundance before and up-to-3 years after cattail removal (Fig. 8). However, we acknowledge that our study design was made for longer-term monitoring impacts (>5 years) and our ability to detect changes in shorter time spans (e.g., <3 years) may be limited. Generally, we detected fewer marshbirds in the year immediately following lethal control of cattail (such as Total Removal) but then detections seemed to rebound in years 2 and 3 (where data was available). This result was expected, as the first year after removal typically resulted in more open water and less native vegetation that was found in successive years. While our results to date do not provide definitive results that wetland restoration techniques such as total removal of invasive hybrid cattail will enhance populations of secretive marshbirds, we feel confident that our methods will not cause any long-term *declines* in any of the populations of the species of interest.

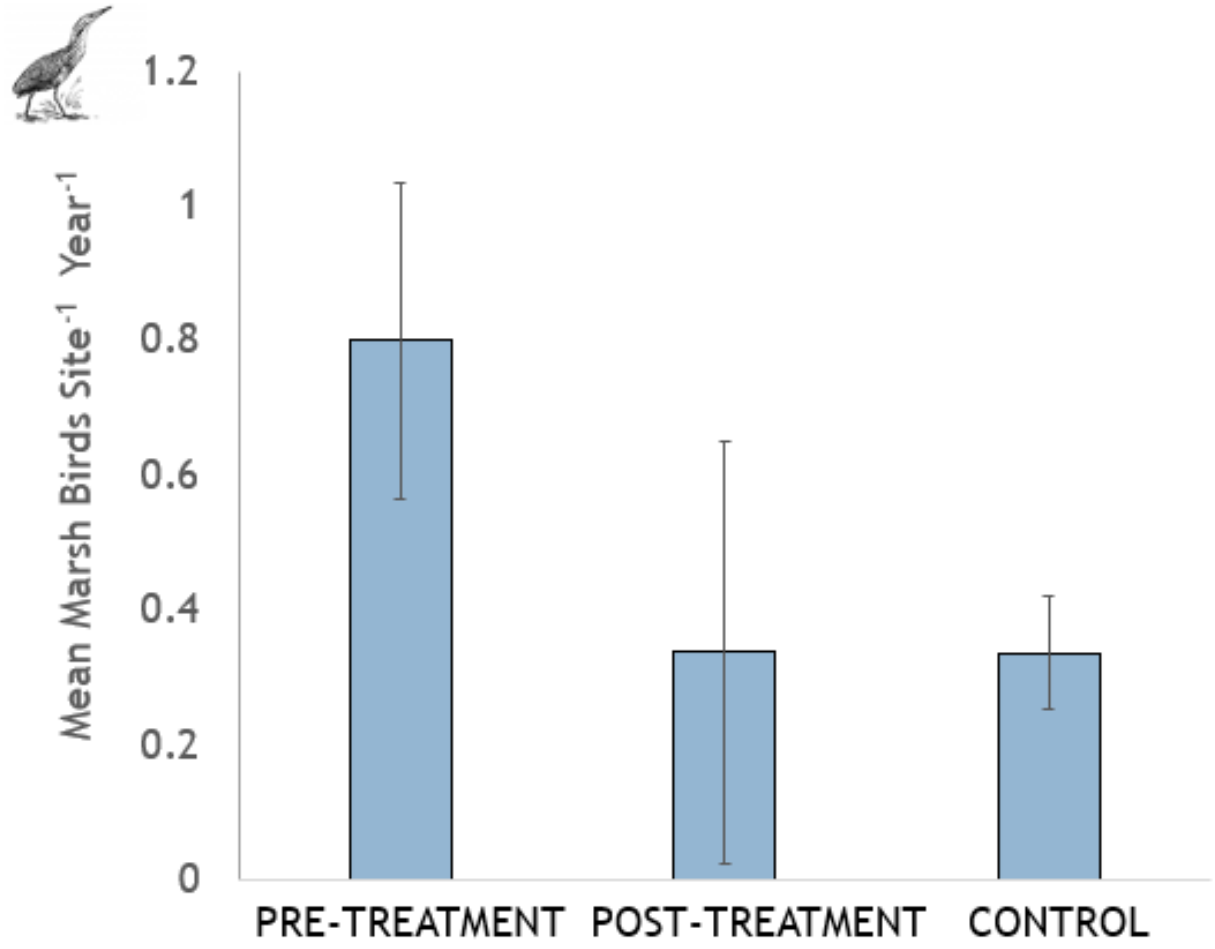


Figure 8. Comparison of marshbird presence at pre- and post-treatment (up to 3 years) of invasive hybrid cattail. Results from a control site, where no restoration has occurred, is also included. Though marshbird

abundance did decline between pre- and post-treatment surveys, they were similar to control sites, demonstrating the limits of our study design to detect short-term changes in these species.

In addition to the targeted secretive marshbird species, we did detect a number of other birds species using restored wetlands, both during our standardized surveys and during anecdotal observations. Most notably, we detected a pair of sandhill cranes performing their mating ritual on the restored wetland near the Rainy Lake Visitor Center in Summer 2021, a rare site in Voyageurs National Park (Fig. 9).

Figure 9. Sandhill cranes performing part of the mating ritual on the restored Rainy Lake Visitor Center wetland, Voyageurs National Park. NPS photo.

Effects on Other Indicator Species

Crayfish were initially selected as another indicator species that could be monitored in a cost-effective way using minnow traps. We discontinued this practice after the 2017 season, however, when we realized that crayfish were universally rare in all of our soft-bottomed wetland sites, and thus monitoring would not provide any usable information on the effects of our cattail removal on this taxa.

Waterfowl were also initially selected as an indicator species. We were not able to develop a cost-effective monitoring protocol for waterfowl based on the resources available. Most waterfowl that use VNP-area wetlands do so during spring (April/May) and fall (Oct/Nov) migration, during which we have 1) limited seasonal staff, and 2) unpredictable ice coverage that limits access to field sites. We do believe this is an important taxa to monitor and we are working to develop a method that can be reliably completed for the duration of the Voyageurs Wetland Restoration Project.

Conducting research in the water-based environment of VNP is challenging, and consequently expensive. In-kind and cash contributions from VNP for Activity 1 are conservatively estimated to exceed $90,000, which mainly came in the form of paid staff time for field work, project administration, and boat/vehicle maintenance; boat and vehicle usage and gas; use of trapping and collaring equipment; field supplies, including pharmaceuticals for capture; office space and computer use; and lab and storage space. In-kind contributions from other partners, specifically the Kansas State University, were important, but estimates were not available at the time of this final report.

ACTIVITY 2: **Determine the effectiveness of muskrats as a native biocontrol for cattails**

Description:
We will identify selected wetlands in VNP in which to stock muskrats (trapped elsewhere in MN) at various densities (Fig.2). This approach will let us test how many muskrats are required to sufficiently reduce hybrid cattail abundance or, alternatively, create open water spaces that muskrats and other wildlife species need. We will also study survival and movements of stocked muskrats to understand how sustainable such stocking methods are. We will also conduct feeding trials with wild muskrats to understand how they prefer hybrid cattail relative other native plants such as wild rice, bulrush, and pond lilies. Stocking and radio implantation efforts will begin in 2018 and continue in 2019, allowing 1-2 yrs of study of short-term effects of muskrat stocking on hybrid cattails.

ENRTF BUDGET: $76,000

Outcome	Completion Date
1. Identify wetland sites within VNP that are heavily invaded with hybrid cattail.	*7/31/2018*
2. Stock muskrats into selected wetlands at 1, 2, and 3x of natural densities and monitor effects to hybrid cattail and other native plants.	*9/31/2020*
3. Fit 60 muskrats with implanted radio-transmitters to monitor survival and movements after stocking.	*9/31/2020*
4. Investigate food preferences of native muskrats on invasive hybrid cattail vs. other native plant species.	*9/31/2020*
5. Report summarizing the effectiveness of muskrats as natural control of hybrid cattail	*6/30/2021*

First Update January 31, 2019
We identified 10 heavily invaded wetland sites in VNP: 5 treatment and 5 control sites. We captured and released 25 muskrats into each of the 5 treatment sites, including 23 muskrats implanted with radio transmitters. We monitored survival and movements of radiomarked muskrats until the first week of November, when significant ice formed on the study lakes. Seventeen (35%) of 23 radiomarked muskrats were relocated >1x after release, and 35% of muskrats stayed within the release site. Radiomarked muskrats moved an average of 2.2km from their release site. Eleven muskrats were confirmed to have died (6 predation, 5 unknown). Probability of survival was low, even by the standards of a short-lived species such as a muskrat. 2019 activities will explore ways to improve survival of translocated muskrats.

Second Update June 30, 2019

We completed a successful second round of muskrat trapping, tracking, and translocation operations in June 2019. Muskrats were again “stocked” into 5 treatment wetlands to test vegetation response to increased muskrat herbivory. We also monitored survival and movements of >40 radiomarked individuals. Initial survival of translocated muskrats was much improved over 2018 results, primarily a result of use of a ‘soft release’ technique where we provided muskrats with temporary artificial muskrat huts after release. Monitoring will continue through October 2019.

We initiated feeding trials of wild muskrats feed various species of wetland plants, including native and hybrid cattails. Trials will continue through August 2019.

Third Update January 31, 2020
We monitored survival and movements of >40 radiomarked individuals through the end October, when ice conditions prevented access by boat. Initial survival of translocated muskrats was much improved over 2018 results, primarily a result of use of a 'soft release' technique where we provided muskrats with temporary artificial muskrat huts after release.

We completed feeding trials initiated in 2019 of wild muskrats fed various species of wetland plants, including native and hybrid cattails.

Fourth Update June 30, 2020
In 2018 and 2019, muskrats were "stocked" into 5 treatment wetlands to test vegetation response to increased muskrat herbivory. In mid-June, 2020 we initiated an intensive muskrat trapping and marking program designed to better assess the efficacy of translocation as a means to increase local muskrat densities one year after the cessation of stocking. Trapping was conducted in the 5 treatment areas and also in 5 control sites where no muskrats were stocked in 2018 or 2019. Each site will receive 3 days of trapping effort each month for June, July, and Aug 2020.

Fifth Update January 31, 2021
We completed our analysis of some factors that affect the efficacy of translocation efforts, summarized in the *Wildlife Biology* journal article "Assessing translocation effects on the spatial ecology and survival of muskrats (Ondatra zibethicus)." In brief, muskrats translocated short-distances (ave. = 18km) from within the same watershed did not exhibit any homing behavior (i.e., they don't return to their original trapped location) but they did move an average of 2.2km from the site of translocation. Survival of translocated muskrats was variable, but was improved by 1) access to existing beaver lodges, and 2) use of soft-release techniques that improved conditions in the 24hrs immediately after release.

Final analyses regarding efficacy muskrats to control non-native vegetation are in progress.

Sixth Update June 30, 2021

Investigation of the efficacy of muskrats to control non-native cattail is ongoing. However, preliminary results suggest that percent composition of cattail remains unchanged between control and treatment wetlands across years. Average percent composition of cattail was ~50% for both treatment and control wetlands. We did witness increased percent composition of sedges and open water in treatment wetlands. However, we believe this to be a product of observer error and differences in water levels between years.

Seventh Update January 31, 2022

We are currently organizing and analyzing wetland vegetation data from all treatment and control sites. Additionally, we are formalizing analyses from our feeding experiment which suggests, when forced to choose between native cattails (*T. latifolia*) and hybrid cattails (*T. x glauca*), muskrats choose to eat hybrid cattails. We are also completing other analyses from data derived from this project (e.g., identifying best survey methods for muskrats and other semiaquatic mammals in lacustrine systems, assessing live-trap lure effectiveness for capturing muskrats in lacustrine systems).

Final Update June 30, 2022

Similar to the last update, we are currently organizing and analyzing wetland vegetation data from all treatment and control sites. Additionally, we are formalizing analyses from our feeding experiment which suggests, when forced to choose between native cattails (*T. latifolia*) and hybrid cattails (*T. x glauca*), muskrats choose to eat

hybrid cattails. We are also completing other analyses from data derived from this project (e.g., identifying best survey methods for muskrats and other semiaquatic mammals in lacustrine systems, assessing live-trap lure effectiveness for capturing muskrats in lacustrine systems).

Final Report Summary:

While chemical and mechanical treatments of invasive hybrid cattail are generally effective, they are expensive, disruptive, and require periodic retreatment. Muskrats are a native species in Minnesota that feed on wetland plants, including hybrid cattails. Muskrat populations have the documented ability to reduce and control densities of wetland vegetation, though the usefulness of muskrats as a natural control technique had not yet been evaluated before our project.

Translocating muskrats as a bio-restoration tool

Our project experimentally assessed the effectiveness of relocating and enhancing muskrat populations at select wetlands in VNP to serve as a natural biocontrol for expanding hybrid cattails in Minnesota. We selected 10 similar wetland sites on Rainy Lake in VNP, and randomly assigned 5 as "Treatment" wetlands where we translocated muskrats, and 5 as "Control" wetlands where no translocation or other restoration techniques were undertaken (Fig. 10).

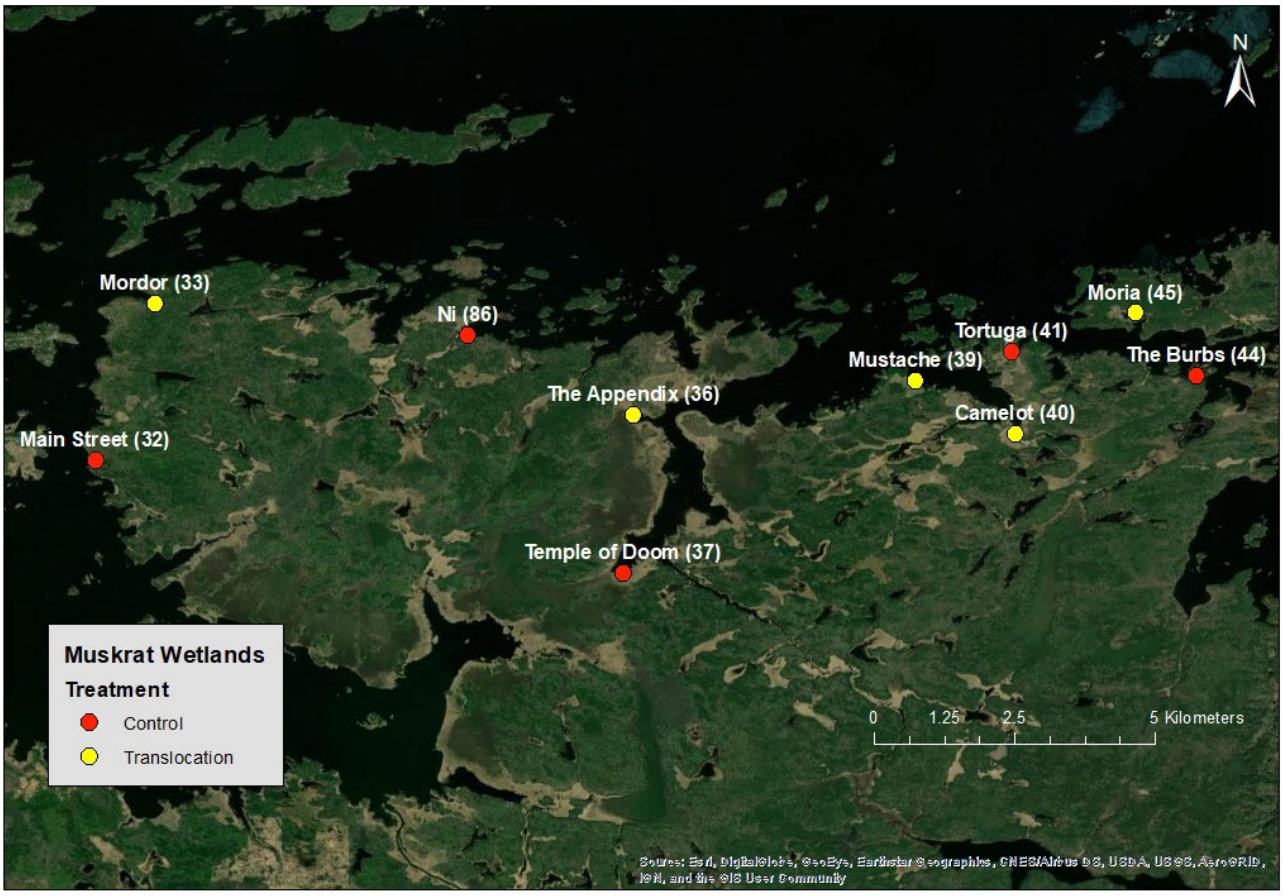


Figure 1. Wetlands selected for muskrat assessment trapping in Voyageurs National Park, MN during the Summer 2020. Yellow circle represents wetlands where muskrats were translocated to (aka Treatment Sites). Red circles represent control sites that did not receive translocated muskrats.

We radiomarked 65 translocated muskrats between 2018–2019 in VNP, and assessed how translocation affected weekly survival probabilities and patterns of space-use. Muskrats did not exhibit homing behavior to their capture location though muskrats moved an average of 2.2 km (1.3 mi) from translocation sites and established home ranges an average of 8 days post-translocation. Weekly survival probabilities (0.95, i.e., a 95% chance of surviving from the start to the end of a week) and average home-range sizes (2.52 ha [or 5.4 ac]) of translocated muskrats were similar to other studies of non-translocated muskrats. Our known-fate survival model suggests translocated muskrats using beaver lodges had greater weekly survival probabilities than those that did not use beaver lodges. Weekly muskrat survival varied between 2018-2019 indicating that our novel soft-release technique applied in 2019 enhanced survival probabilities of post-translocated muskrats. Our findings of this component of the research is summarized in the publication "Matykiewicz et al. 2021. Assessing translocation effects on the spatial ecology and survival of muskrats (*Ondatra zibethicus*). *Wildlife Biology* 2: 1-11."

We also tested whether translocation of muskrats into selected wetlands would result in sustained higher densities of muskrats into those wetlands. In the summers of 2018 and 2019, a total of 177 muskrats, including the 65 muskrats with radio transmitters, were translocated into the 5 treatment wetlands in Rainy Lake. In the summer of 2020, we trapped muskrats in the 5 treatment and 5 control wetlands in each of 3 periods over June-August to assess the population status of muskrats after translocation efforts had ceased (Fig. 11). We caught a total of 68 unique individuals, 28 in the treatment wetlands and 40 in the control wetlands, suggesting that translocation efforts *did not* result in sustained higher densities of muskrats 1-2 years post-translocation. Of the 68 muskrats captured in 2020, none were individuals which had been tagged and translocated in 2018 or 2019, providing further evidence that overwinter muskrat survival was relatively low. Using data collected from our vegetation surveys (see Activity 1), we did not see any statistical differences in abundance of cattails in the areas where we translocated muskrats (Treatment Sites) or control sites.

Figure 11. Muskrats were live-trapped, tagged, and released using live traps as part of a population assessment in 2020. NPS photo.

Muskrat feeding patterns on invasive hybrid cattails and other native plants

Muskrats are known to eat a variety of aquatic plants, including native and invasive hybrid cattails. However, it was unknown what muskrats preferred to eat when presented with a variety of different food types. In 2019, we conducted experimental feeding trials with live muskrats temporarily placed into 6'x6' plywood boxes with food and water available (Fig. 12). Muskrats were video-taped during the 2-hr feeding trial to document how much of each species muskrats consumed during the trials. Trial 1 consisted of muskrats being offered 6 different species: hybrid cattail, native cattail, arrowhead, bulrush, sweet flag, and wild rice. Trial 2 consisted of muskrats only being offered hybrid and native cattails. At the end of the trial, muskrats were then translocated into selected wetlands as described above.

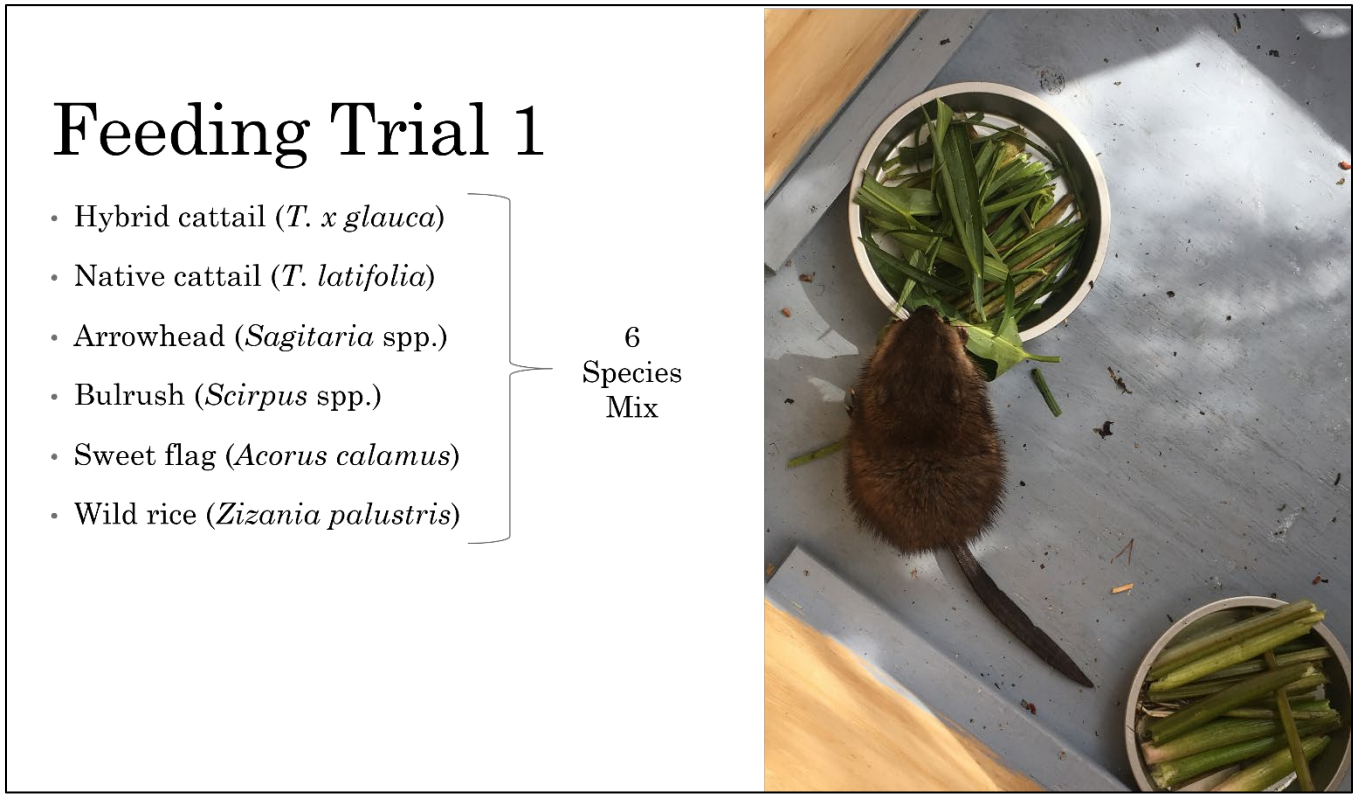


Figure 12. Live muskrats were used in experimental feeding trials to test food preferences of area muskrats, including the 6 species listed here under Trial 1. NPS photo.

A total of 34 individual feeding trials were conducted, though only 20 provided both complete video and vegetation data that could be used in analysis. In Trial 1, where we offered 2 species of cattail and 4 other native plants that muskrats were thought to consume, muskrats consumed bulrush and wild rice the most, with the cattails and other species consumed less (Fig. 13). In Trial 2, where we only offered the 2 species of cattails, both species were eaten in relatively similar proportions (Fig. 14). Interestingly, when comparing between the more diverse 6-species diet vs. the cattail only diet, muskrats were able to consume a great amount of forage, and thus more nutrients, in the more diverse diet. This lends some further evidence that wetlands where cattail dominates are likely less suitable for muskrats from a nutritional perspective.

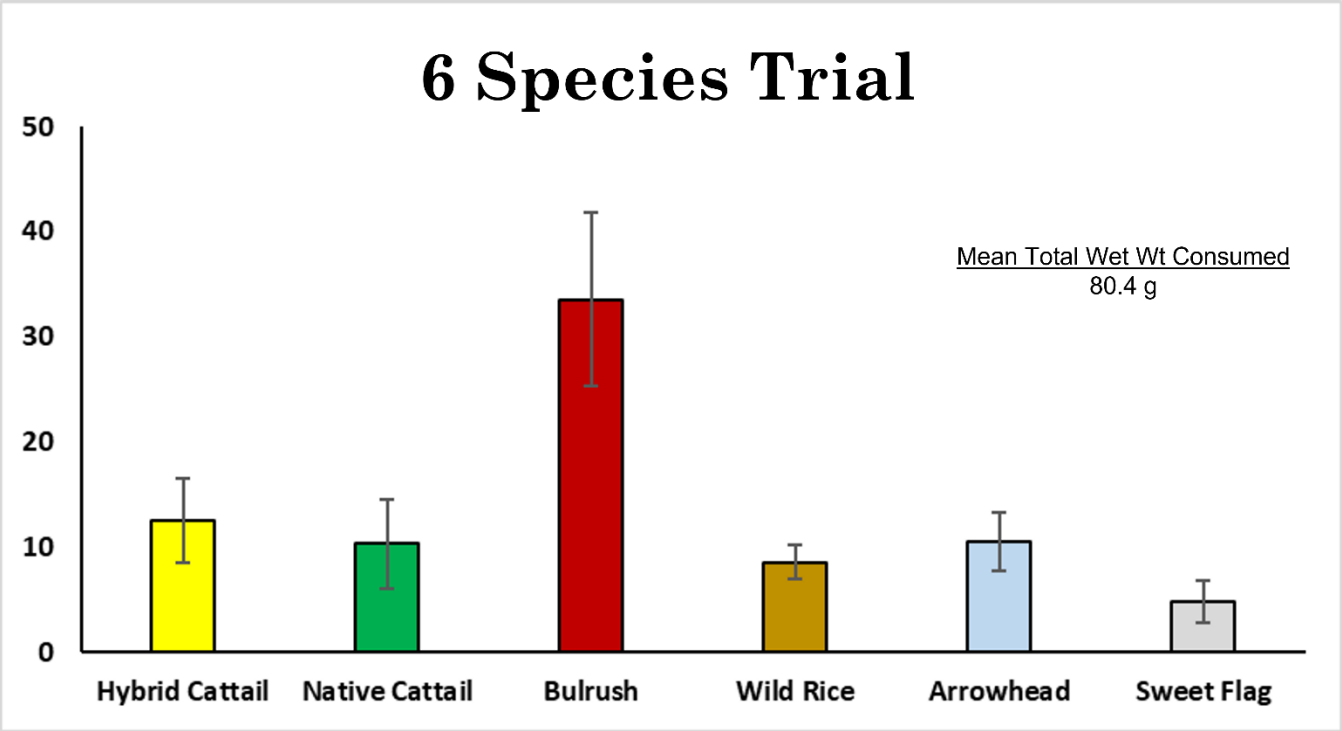


Figure 13. Results from Trial 1, where 6 species of muskrat foods were experimentally offered to capture muskrats. Native species like bulrush and wild rice were consumed the most.

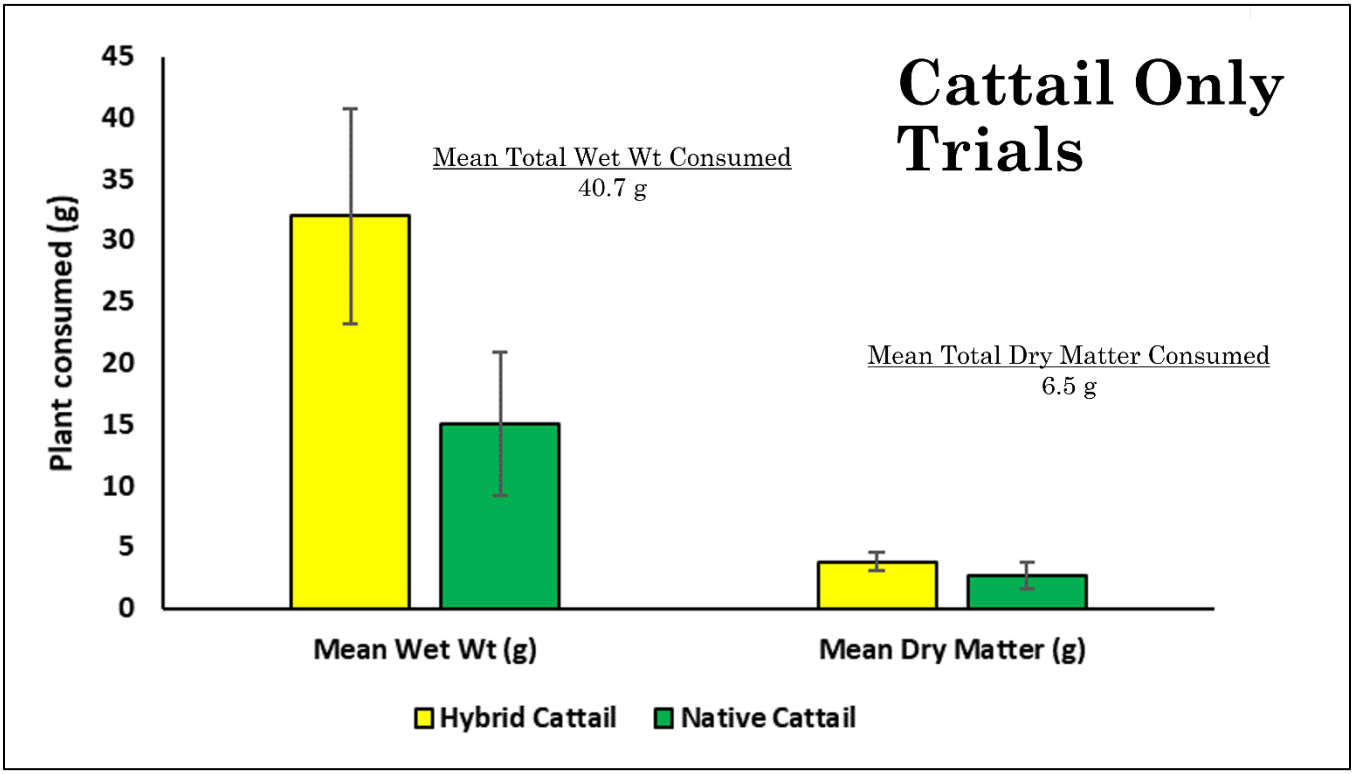


Figure 14. Results from Trial 2, where only 2 species of cattails were experimentally offered to capture muskrats. Both species were eaten in relatively similar amounts.

Overall, our results suggest that muskrat translocations may be a viable option to re-establish or temporarily increase abundances of muskrat populations, especially in areas with a healthy beaver population. Even though we showed that muskrats do eat invasive hybrid cattails, we do not believe that muskrat densities *in our area* can be elevated to a high enough density for multiple years to where stands of invasive hybrid cattail can be eliminated or even noticeably reduced in abundance.

In-kind and cash contributions from VNP for Activity 2 are conservatively estimated to exceed $90,000, which mainly came in the form of paid staff time for field work, project administration, and boat/vehicle maintenance; boat and vehicle usage and gas; use of trapping and collaring equipment; field supplies, including pharmaceuticals for capture; office space and computer use; and lab and storage space. In-kind contributions from other partners, specifically the Kansas State University, were important, but estimates were not available at the time of this final report.

IV. DISSEMINATION:

Description: Project progress and results will be shared with the public in a number of ways. While field work is ongoing, outreach will include newsletter articles; articles in local, regional, and state newspapers; posts on Voyageurs National Park's Facebook page; presentations to interested stakeholder groups (e.g., Voyageurs National Park Association or Rainy Lake Property Owners Association); presentations at scientific conferences; and peer-reviewed literature in quality journals.

First Update January 31, 2019

List of Dissemination/Outreach during reporting period:

- Presentations at Regional, National, or International Conferences
    - Matykiewicz, B.R., S.K. Windels, B.T. Olson, T.M. Wolf, and A.A. Ahlers. Testing the effectiveness of muskrats as a native biocontrol of invasive hybrid cattails. The Wildlife Society Annual Meeting, Cleveland, OH, September 2018.
    - Larreur, M., S.K. Windels, B.T. Olson, and A.A. Ahlers. Quantifying the impacts of hybrid cattails on the spatial distribution of muskrats. Kansas Natural Resources Conference, Summer 2018.
- Popular press:
    - "Muskrats to the Rescue", National Parks Conservation Magazine, Fall 2018. https://www.npca.org/articles/1919-muskrats-to-the-rescue

Second Update June 30, 2019

List of Dissemination/Outreach during reporting period:

- Manuscripts submitted or published in peer-reviewed science journals
    - Larreur M, Windels SK, Olson BT, and Ahlers AA. *Submitted*. Cross-scale interactions and non-native cattails influence spatiotemporal distributions of a wetland-obligate species. Landscape Ecology.
- Presentations at Regional, National, or International Conferences
    - Matykiewicz BR, Windels SK, Olson BT, Wolff TM, and Ahlers AA. Testing the effectiveness of muskrats as a native biocontrol of invasive hybrid cattails. Kansas Natural Resources Conference. Manhattan, KS
    - Matykiewicz BR, Windels SK, Olson BT, Wolff TM, and Ahlers AA. Survival and movements of post-translocated muskrats in a lacustrine ecosystem. Joint Southeast and Midwest Furbearer Conference. Enid, OK

- Larreur M, Windels SK, Olson BT, and Ahlers AA**.** Assessing non-invasive survey techniques for semiaquatic mammals in lentic wetlands. Joint Southeast and Midwest Furbearer Conference. Enid, OK
- Matykiewicz BR, Windels SK, Olson BT, Wolff TM, and Ahlers AA. Testing the effectiveness of muskrats as a native biocontrol of invasive hybrid cattails. Minnesota Chapter of The Wildlife Society Annual Meeting. Duluth, MN
- Larreur M, Windels SK, Olson BT, and Ahlers AA. Cross-scale interactions shape the spatial distribution of a wetland-obligate species. 99th Annual Meeting of the American Society of Mammalogists. Washington, DC

Third Update January 31, 2020

List of Dissemination/Outreach during reporting period:

- Presentations at Regional, National, or International Conferences
  - Matykiewicz BR, Windels SK, Olson BT, Wolff TM, and Ahlers AA. Survival and Post-Release Movements of Translocated Muskrats. 2020 Kansas Natural Resources Conference. Manhattan, KS.
  - Aarrestad O, Matykiewicz B, Windels S, Ahlers AA, Wolf T. Characterizing the health of a translocated population of muskrats (Ondatra zibethicus) in northern Minnesota. Points of Pride Research Day. St. Paul, MN. 2019.

Fourth Update June 30, 2020

List of Dissemination/Outreach during reporting period:

- Manuscripts submitted or published in peer-reviewed science journals
  - Benjamin Matykiewicz. M.S., Department of Horticulture and Natural Resources, Kansas State University. *Thesis*: Post-translocation spatial ecology and survival of muskrats (*Ondatra zibethicus*) in lacustrine wetlands. Completed May 2020.
  - Aarrestad O, Matykiewicz BR, Windels SK, Ahlers AA, Olson BT, Rendahl A, Burton E, and Wolf TM. 2020. Baseline physiologic and hematologic health in wild-caught muskrats (Ondatra zibethicus) from a near-pristine ecosystem in northern Minnesota. Journal of Zoo and Wildlife Medicine.
  - Ahlers AA, Wolf TM, Aarrestad O, Windels SK, Olson BT, Matykiewicz BR, and Dubey JP. 2020. Survey of Toxoplasma gondii exposure in muskrats in a relatively pristine ecosystem. Journal of Parasitology 106: 346-349.
  - Larreur M, Windels SK, Olson BT, and Ahlers AA. 2020. Cross-scale interactions and non-native cattails affect the spatial distribution of a wetland-obligate species. *Landscape Ecology* 35: 59 68.
- Presentations at Regional, National, or International Conferences
  - Matykiewicz BR, Windels SK, Olson BT, Wolff TM, and Ahlers AA. Survival and Post-Release Movements of Translocated Muskrats. Minnesota Chapter of The Wildlife Society 2020 Meeting. Willmar, MN.
  - Larreur M, Windels SK, Olson BT, and Ahlers AA. Cross-scale interactions shape the spatial distribution of a wetland-obligate species. Kansas Natural Resources Conference. Manhattan, KS.
  - Matykiewicz BR*, Windels SK, Olson BT, Wolf TM, and Ahlers AA. Post-translocation survival and movements of muskrats in a lacustrine system. Kansas Natural Resources Conference. Manhattan, KS.

- Windels SK, Matykiewicz BR*, Wiley CL, Plumb RT, Ahlers AA. Do muskrats eat hybrid cattail? An experimental approach using feeding trials with wild-caught muskrats. Minnesota Chapter of The Wildlife Society Annual Meeting. Willmar, MN.
- Plumb RT, Windels SK, and Olson BT. Hybrid Cattail Removal and Wetland Restoration in Voyageurs National Park: A Project Update. Minnesota Chapter of The Wildlife Society Annual Meeting. Willmar, MN.
- Plumb RT, Windels SK, Wiley CL, and Olson BT. Hybrid Cattail Removal and Wetland Restoration in Voyageurs National Park: A Project Update. Rainy Lake of the Woods Watershed Forum. International Falls, MN.
- Plumb RT, Windels SK, Wiley CL, and Olson BT. Restoration of Wetlands Infested with Hybrid Cattail in Voyageurs National Park. Upper Midwest Invasive Species Conference.

- Presentations to the public
  - Plumb, RT. Voyageurs National Park Wetland Restoration Project. Voyageurs Conservancy Pints for the Park.
  - Plumb, RT. Voyageurs National Park Wetland Restoration Project Overview. Point Pelee Provincial Park.

Fifth Update January 31, 2021

List of Dissemination/Outreach during reporting period:

- Manuscripts submitted or published in peer-reviewed science journals
  - Matykiewicz BR, Windels SK, Olson BT, Plumb RT, Wolf TM, and Ahlers AA. 2021. Assessing translocation effects on the spatial ecology and survival of muskrats (Ondatra zibethicus). Wildlife Biology.
- Media outreach, newsletters, etc
  - Plumb RP and Warmbold J. Not All Cattails are Created Equal: Typha x glauca the Silent Invader. MN Water Garden Society: Waterlog Article.
- Presentations to the public
  - Prairie Research Institute, Illinois Natural History Survey (Urbana, IL - virtual); “Can muskrats save a National Park?: A bold plan to restore wetlands & save an ecosystem”

Sixth Update June 30, 2021

- Media outreach, newsletters, etc
  - “Crews work to remove islands of invasive cattails in Voyageurs National Park.” Minnesota Public Radio.
  - “VNP manages floating cattail mat”. Falls Daily Journal.
  - 20 posts on Voyageurs National Park Facebook page related to the Wetland Restoration Project, including posts on marshbird monitoring, plant monitoring, and wild rice restoration.
- Presentations to the public
  - Plumb, RT and Jerry Warmbold. “Restoration of VOYA’s Border Water Wetlands.” Kabetogama Town Hall Meeting
  - Plumb, RT and Jerry Warmbold. “Voyageur’s Wetland Restoration Project: A Project Update.” Voyageurs Conservancy.
- Professional Consultation Related to Wetland Restoration/Cattail Removal

- Rainy Lake Property Owner's Association/Koochiching County Soil and Water Conservation District
- City of Warroad, MN
- South Dakota State University/Natural Resource Conservation Service Extension

Seventh Update January 31, 2022

- Presentations to the public
  - Tour of Reuter Creek and Q/A about the project with the Voyageurs Conservancy Board
- Public Involvement
  - Wild Rice Seed Collection Volunteer Day in VNP
- Professional Consultation Related to Wetland Restoration/Cattail Removal
  - Rainy Lake Property Owner's Association/Koochiching County Soil and Water Conservation District were successful in obtaining a CPL grant from MN DNR using this project as a model

Final Update June 30, 2022

- Presentations at Regional, National, or International Conferences
  - Plumb, RT, JW Warmbold, and SK Windels. 2022. "Restoring hybrid cattail infested wetlands in Voyageurs National Park: What have we learned?" 2022 International Rainy-Lake of the Woods Watershed Forum (Virtual).
  - Windels, SK, BT Olson, RT Plumb, and JW Warmbold. "Detachment, Dispersal, and Destinations of Floating Cattail Mats in Large Lake Environments. 2022 International Rainy-Lake of the Woods Watershed Forum (Virtual).
  - Plumb, RT, JW Warmbold, and SK Windels. 2022. "Restoring hybrid cattail infested wetlands in Voyageurs National Park: What have we learned?" Minnesota Chapter of The Wildlife Society 2022 Meeting (Virtual).
  - Warmbold, JW, RT, Plumb, SK Windels, and BT Olson. 2022. "Secretive Marsh Bird Abundance and Tolerance to Wetland Restoration". Minnesota Chapter of The Wildlife Society 2022 Meeting (Virtual).

Final Report Summary:

The following outreach was completed as part of the research funded by this LCCMR grant. Additional peer-reviewed manuscripts summarizing the research are still in progress. While the lists of publications and presentations are complete, the accounting of media attention garnered is likely incomplete due to the number of stories written and reprinted elsewhere.

Four (4) Peer-Reviewed Publications:

1. Aarrestad O, Matykiewicz BR, Windels SK, Ahlers AA, Olson BT, Rendahl A, Burton E, and Wolf TM. 2021. Baseline physiologic and hematologic health in wild-caught muskrats (*Ondatra zibethicus*) from a near-pristine ecosystem in northern Minnesota. *Journal of Zoo and Wildlife Medicine* 52: 698-703.
2. Matykiewicz BR, Windels SK, Olson BT, Plumb RT, Wolf TM, and Ahlers AA. 2021. Assessing translocation effects on the spatial ecology and survival of muskrats (*Ondatra zibethicus*). *Wildlife Biology* 2: 1-11.

3. Ahlers AA, Wolf TM, Aarrestad O, Windels SK, Olson BT, Matykiewicz BR, and Dubey JP. 2020. Survey of *Toxoplasma gondii* exposure in muskrats in a relatively pristine ecosystem. *Journal of Parasitology* 106: 346-349.
4. Larreur M, Windels SK, Olson BT, and Ahlers AA. 2020. Cross-scale interactions and non-native cattails affect the spatial distribution of a wetland-obligate species. *Landscape Ecology* 35: 59 68.

One (1) Student Thesis:

1. Benjamin Matykiewicz. Post-translocation spatial ecology and survival of muskrats (*Ondatra zibethicus*) in lacustrine wetlands. M.S. Completed May 2020 (Kansas State University).

Twenty (20) Presentations at Scientific Conferences:

1. Plumb, RT, JW Warmbold, and SK Windels. "Restoring hybrid cattail infested wetlands in Voyageurs National Park: What have we learned?" 2022 International Rainy-Lake of the Woods Watershed Forum (Virtual).
2. Windels, SK, BT Olson, RT Plumb, and JW Warmbold. "Detachment, Dispersal, and Destinations of Floating Cattail Mats in Large Lake Environments. 2022 International Rainy-Lake of the Woods Watershed Forum (Virtual).
3. Plumb, RT, JW Warmbold, and SK Windels. "Restoring hybrid cattail infested wetlands in Voyageurs National Park: What have we learned?" Minnesota Chapter of The Wildlife Society 2022 Meeting (Virtual).
4. Warmbold, JW, RT, Plumb, SK Windels, and BT Olson. "Secretive Marsh Bird Abundance and Tolerance to Wetland Restoration". Minnesota Chapter of The Wildlife Society 2022 Meeting (Virtual).
5. Matykiewicz BR, Windels SK, Olson BT, Wolff TM, and Ahlers AA. Survival and Post-Release Movements of Translocated Muskrats. Minnesota Chapter of The Wildlife Society 2020 Meeting. Willmar, MN.
6. Larreur M, Windels SK, Olson BT, and Ahlers AA. Cross-scale interactions shape the spatial distribution of a wetland-obligate species. Kansas Natural Resources Conference. Manhattan, KS.
7. Matykiewicz BR*, Windels SK, Olson BT, Wolf TM, and Ahlers AA. Post-translocation survival and movements of muskrats in a lacustrine system. Kansas Natural Resources Conference. Manhattan, KS.
8. Windels SK, Matykiewicz BR*, Wiley CL, Plumb RT, Ahlers AA. Do muskrats eat hybrid cattail? An experimental approach using feeding trials with wild-caught muskrats. Minnesota Chapter of The Wildlife Society Annual Meeting. Willmar, MN.
9. Plumb RT, Windels SK, and Olson BT. Hybrid Cattail Removal and Wetland Restoration in Voyageurs National Park: A Project Update. Minnesota Chapter of The Wildlife Society Annual Meeting. Willmar, MN.
10. Plumb RT, Windels SK, Wiley CL, and Olson BT. Hybrid Cattail Removal and Wetland Restoration in Voyageurs National Park: A Project Update. Rainy Lake of the Woods Watershed Forum. International Falls, MN.
11. Plumb RT, Windels SK, Wiley CL, and Olson BT. Restoration of Wetlands Infested with Hybrid Cattail in Voyageurs National Park. Upper Midwest Invasive Species Conference.
12. Matykiewicz BR, Windels SK, Olson BT, Wolff TM, and Ahlers AA. Survival and Post-Release Movements of Translocated Muskrats. 2020 Kansas Natural Resources Conference. Manhattan, KS.
13. Aarrestad O, Matykiewicz B, Windels S, Ahlers AA, Wolf T. Characterizing the health of a translocated population of muskrats (Ondatra zibethicus) in northern Minnesota. Points of Pride Research Day. St. Paul, MN. 2019.

14. Matykiewicz BR, Windels SK, Olson BT, Wolff TM, and Ahlers AA. Testing the effectiveness of muskrats as a native biocontrol of invasive hybrid cattails. Kansas Natural Resources Conference. Manhattan, KS.
15. Matykiewicz BR, Windels SK, Olson BT, Wolff TM, and Ahlers AA. Survival and movements of post-translocated muskrats in a lacustrine ecosystem. Joint Southeast and Midwest Furbearer Conference. Enid, OK.
16. Larreur M, Windels SK, Olson BT, and Ahlers AA. Assessing non-invasive survey techniques for semiaquatic mammals in lentic wetlands. Joint Southeast and Midwest Furbearer Conference. Enid, OK.
17. Matykiewicz BR, Windels SK, Olson BT, Wolff TM, and Ahlers AA. Testing the effectiveness of muskrats as a native biocontrol of invasive hybrid cattails. Minnesota Chapter of The Wildlife Society Annual Meeting. Duluth, MN.
18. Larreur M, Windels SK, Olson BT, and Ahlers AA. Cross-scale interactions shape the spatial distribution of a wetland-obligate species. 99th Annual Meeting of the American Society of Mammalogists. Washington, DC.
19. Matykiewicz, B.R., S.K. Windels, B.T. Olson, T.M. Wolf, and A.A. Ahlers. Testing the effectiveness of muskrats as a native biocontrol of invasive hybrid cattails. The Wildlife Society Annual Meeting, Cleveland, OH, September 2018.
20. Larreur, M., S.K. Windels, B.T. Olson, and A.A. Ahlers. Quantifying the impacts of hybrid cattails on the spatial distribution of muskrats. Kansas Natural Resources Conference, Summer 2018.

Print/Other Media (not be a complete list)

1. "Muskrats to the Rescue", National Parks Conservation Magazine, Fall 2018. https://www.npca.org/articles/1919-muskrats-to-the-rescue.
2. "Crews work to remove islands of invasive cattails in Voyageurs National Park." Minnesota Public Radio.
3. "VNP manages floating cattail mat." Falls Daily Journal.
4. Plumb RP and Warmbold J. Not All Cattails are Created Equal: Typha x glauca the Silent Invader. MN Water Garden Society: Waterlog Article.

V. PROJECT BUDGET SUMMARY:

A. Preliminary ENRTF Budget Overview:

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

Enter Total Estimated Personnel Hours: 2040	Divide by 2,080 = TOTAL FTE: 1.0

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

Enter Total Estimated Personnel Hours: 2040	Divide by 2,080 = TOTAL FTE: 1.0

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:			

Voyageurs National Park	$ 80,000	$80,000	Secured; July 1, 2018-June 30, 2019
Other State $ To Be Applied To Project During Project Period:			
Initiative Foundation	$430,000	$430,000	Secured; July 1, 2018-June 30, 2019
In-Kind Services To Be Applied To Project During Project Period:			
Voyageurs National Park	$ 64,400	>$100,000	Pending; July 1, 2018-June 30, 2021
Kansas State University	$ 7,780	$7,780	Secured; July 1, 2018-June 30, 2021
Kansas State University	$ 32,365	>$30,000	Pending; July 1, 2018-June 30, 2021
Minnesota Dept. of Natural Resources	$ 4,500	$0	Pending; July 1, 2018-June 30, 2021
Past and Current ENRTF Appropriation:			
N/A	$	$	
Other Funding History:			
Voyageurs National Park	$765,000	$765,000	Secured
US Geological Survey	$70,000	$70,000	Secured
Kansas State University	$56,420	$56,420	Secured

VI. PROJECT PARTNERS:

A. Partners receiving ENRTF funding

Name	Title	Affiliation	Role
Adam Ahlers	Asst. Professor	Kansas State University	Will provide advice on all aspects of the project, particularly on aspects related to research, translocation, and monitoring of muskrats, and will mentor one graduate student.

B. Partners NOT receiving ENRTF funding

None

VII. LONG-TERM- IMPLEMENTATION AND FUNDING:

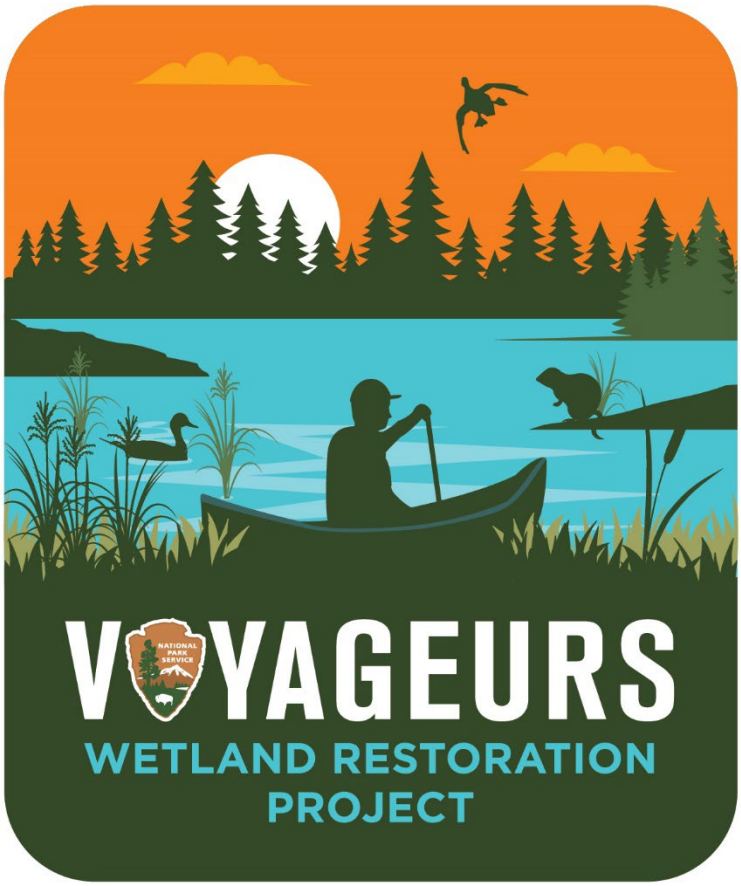
Our study will evaluate the cost-effectiveness of two control methods of invasive hybrid cattails expansions. Land managers from VNP, MN Department of Natural Resources, and other agencies will use this information to move forward with immediate removal of invasive hybrid cattails and subsequent long-term restoration efforts. As with other invasive plants, control efforts will need to be reapplied over time. The timing of future management is unknown, but we expect this project to provide information that will inform the long-term effectiveness of mechanical removal and bio-restoration tools like muskats for treatment of hybrid cattail.

VIII. REPORTING REQUIREMENTS:

- **The project is for 4 years, will begin on July 1, 2018, and end on June 30, 2022.**
- **Periodic project status update reports will be submitted January 31 and June 30 of each year.**
- **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
B. Visual Component or Map
C. Parcel List Spreadsheet
D. Acquisition, Easements, and Restoration Requirements
E. Research Addendum



Environment and Natural Resources Trust Fund
Final M.L. 2018 Budget Spreadsheet

Project Title: Evaluate Control Methods for Invasive Hybrid Cattails
Legal Citation: M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 06c as extended by M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd.
Project Manager: Steve Windels
Organization: Voyageurs National Park
College/Department/Division:
M.L. 2018 ENRTF Appropriation: $131,000
Project Length and Completion Date: 4 years, June 30, 2022
Date of Report: August 15, 2022

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Revised Budget (06/30/2019)	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits) - Overall	$31,000	$30,999	$ 1.00
1 Wildlife Technician (93% salary, 7% benefits), NPS; 50% FTE for 2 years; field assistant for data collection, muskrat telemetry, etc.(Total estimated amount $31,000)			
Professional/Technical/Service Contracts	$67,720	$65,902	$ 1,818
Kansas State University: 1 Grad Research Asst for data collection, analysis, writing; 50% fte, 94.5% salary/5.5% fringe ($46,460); Grad Research Asst tuition and fees for 2 years ($11,480); field supplies ($1,460); travel ($6,320); page charges ($2,000); (Total estimated amount $67,720)			
Equipment/Tools/Supplies - Overall	$18,600	$18,600	$ 0
60 VHF transmitters @$200 ea for tracking muskrat survival and movements (Total estimated amount $12,000)			
60 surgical transmitter implant kits/drugs @$110 ea (Total estimated amount $6,600)			
Travel expenses in Minnesota	$5,680	$536	$ 5,144
Vehicle rental for local travel, lodging for technician, NPS (Total estimated amount $5,680)			
Other	$8,000	$8,000	$ -
Flight time for fall aerial muskrat and vegetation surveys, monthly flights to track radio transmitters ($100/hr for 80 hours; aircraft + fuel cost) (Total estimated amount 8,000)			
COLUMN TOTAL	$131,000	$124,036	$6,964