M.L. 2018 ENRTF Project Abstract
For the Period Ending June 30, 2022

PROJECT TITLE: Peatland Forest Management
PROJECT MANAGER: Dr. Marcella Windmuller-Campione
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FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 03d

APPROPRIATION AMOUNT: $600,000
AMOUNT SPENT: $600,000
AMOUNT REMAINING: $0

Sound bite of Project Outcomes and Results
This project monitored 48 peatland sites for four years providing critical new information on hydrology during wet and dry years, boreal chickadee breeding habitats (some of the first data of its kind), and plant diversity. Data show regeneration harvests do not significantly impact the water table and vegetation responds quickly.

Overall Project Outcome and Results

Peatlands provide critical ecosystem services for Minnesotans, which include helping to maintain clean drinking water, providing important forest products, serving as critical habitat for many wildlife species including the boreal chickadee, and storing huge amounts of carbon. However, these are very understudied systems and climate change and other forest health threats are impacting peatland forests. Over a four year period, we've monitored 48 sites that span four different age classes and three different forest cover types (eastern larch, productive black spruce, and stagnant black spruce) to understand how vegetation, hydrology, soils, and wildlife species interact within peatland forest communities. Over the course of the 48 years, we have measured thousands of trees and hundreds of different plant species to gain a fuller picture of plant species diversity and growth within peatland forest communities. We have some of the most robust data on boreal chickadee habitat use and early survival, which is critical for this species of great conservation need in Minnesota. Finally, we have hundreds of data points over multiple years on the daily hydrology within these systems to understand how water levels change over the growing season. All of this is critical base line data that can help information management practices within peatland forest communities. Results have been shared locally, regionally, and nationally through presentations and webinars, which include the basic data and sharing how to gather collectively across multiple disciplines to inform holistic management practices within forest ecosystems. Our results show that peatlands are not negatively impacted by harvesting in the vegetation and hydrology. Additional work is needed to consider how different harvest strategies may influence wildlife use within peatland forest ecosystems.

Project Results Use and Dissemination

We are currently working on final edits and submission for two peer reviewed papers with an additional two papers in progress that will continue outside of the granting program. Results have been shared through multiple forms including local news stories, including Scientists hang 500 birdhouses in Sax-Zim Bog to study boreal chickadees, presentations to forest managers at the Research Review hosted by the Sustainable Forest Education

Cooperative, to a special symposium on wet forests which brought together researchers and managers to discuss opportunities and challenges within peatland forest communities.

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

Today's Date: October 19, 2022

Final Report

Date of Work Plan Approval: 06/05/2018

Project Completion Date: June 30, 2022

PROJECT TITLE: Peatland Forest Management

Project Manager: Dr. Marcella Windmuller-Campione

Organization: University of Minnesota

College/Department/Division: Department of Forest Resources

Mailing Address: 115 Green Hall | 1530 Cleveland Ave. N.

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Web Address: https://www.forestry.umn.edu/marcella-windmuller-campione

Location: Central, Northeastern, and Northwestern MN

Counties: Cook, Lake, St. Louis, Koochiching, Lake of the Woods, Beltrami, Clearwater, Hubbard, Cass, Crow Wing, Aitkin, Carlton, Wadena, Carlton, and Pine

Total Project Budget: $600,000

Amount Spent: $600,000

Balance: $0

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

Appropriation Language: $600,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to identify management actions to maximize benefits to wildlife, water quality, timber production, and native plant communities in peatland forests. This appropriation is available until June 30, 2022, by which time the project must be completed and final products delivered.

I. **PROJECT STATEMENT:**

Minnesotans rely on the ecosystem services and economic products derived from peatland forests. These ecosystems comprise 20% of all forestland (3 million acres) in Minnesota and range from unproductive bogs to productive peatland forests with tamarack (eastern larch*, Larix laricina*) and black spruce (*Picea mariana*). Peatland forest communities act as important filters of nutrients and pollutants, provide habitat for 100's of species of wildlife, and are home to a number of rare and threatened plants. In additional to the ecological benefits, peatlands are actively managed for a variety of forest products including black spruce decorative tops and pulp for high quality paper products ($ 4 million dollars in annual stumpage). However, due the remoteness and poor accessibility, peatland forests are vastly understudied. There is high uncertainty on how active management influences hydrology, water, and plant diversity. This uncertainty has been highlighted in two recent Minnesota Department of Natural Resources Reports.

This project is designed to provide foundational data to address uncertainty in the management of peatland forests. A network of research sites will be established in three dominant peatland forest types across three age classes and an unharvested control in northern Minnesota to assess the response of vegetation, hydrology, and wildlife change with time since harvest. This study will produce 1) foundational data in understudied peatland ecosystems for vegetation, hydrology, and wildlife and 2) integrate knowledge gained via updated management guidelines for peatland forests. There is a need for these products and we expect they will be used by natural resource managers, regardless of forest ownership, across northern Minnesota to maximize the benefits of peatland forests for multiple objectives.

II. OVERALL PROJECT STATUS UPDATES:

First Update January 31, 2019

Worked completed as of January 15th, 2019 has focused on 1). Identifying 48 fields sites for Activities 1, 2, and 3, 2). hiring personnel, 3). developing field protocols for each of the three activities that meet disciplinary specific needs in forest stand development, wildlife monitoring and use, and hydrology but are also complementary among the three primary activities.

Mid year update 2019

Work as completed as of July 31st, 2019 has focused on first year of data collection for Activities 1, 2, and 3. All 48 field sites have been identified through collaboration with our partners including MN DNR. Field protocols have been tested and implemented. Sixteen sites have been sampled for vegetation, all 36 sites have had well installed and are currently being monitored, and all sites have been sampled for wildlife. The project is on schedule.

Second January 31, 2020

Preliminary analysis of data collected during the 2019 field season related to Activities 1, 2, and 3 are on-going. Preliminary results from Activity 3 were presented as a poster at the Sustainable Forests Education Cooperative Research Review in early January 2020. Slides for the event can be found https://drive.google.com/drive/folders/1y3o_djn2xjdpPC2ORulluVBmhF7klAp5
The project is on schedule.

Mid year update 2020

Work completed as of June 30th, 2020 has focused on the second year of data collection for Activities 1, 2, and 3. Due to COVID-19 we have taken special precautions to ensure the health and safety of all individuals working on the project. This has resulted in some aspects of the project taking longer or having reduced personnel. Data collection is ongoing for hydrology, wildlife, and vegetation. Our abstract to present preliminary results from vegetation was accepted during the fall meeting for the national Society of American Foresters (SAF); this meeting will be virtual.

Amendment Request:
Due to increased travel expenses from social distancing, we wish to increase travel funds by $19,275. Funds of $12,220 will be taken from the Personnel category and $7,055 will be taken from the Equipment/Tools/Supplies Category.

Amendment Approved by LCCMR 2/9/2021

Third Update January 31, 2021

We successfully maintained the health of all individuals working on the project through our COVID 19 protocols and collected a full suite of data during the 2020 growing season. These protocols have resulted in a request for a rebudget for travel. Preliminary analysis of data collected during the 2019 and 2020 field season related to Activities 1, 2, and 3 are continuing. Preliminary results from Activity 1 were presented at the Sustainable Forests Education Cooperative Research Review - https://docs.google.com/presentation/d/1pqX9zHoeMZKVNv7B-jOYHOsiK8dxupFGxwH35wIxfCw/edit?usp=sharing

Project is on schedule

Fourth Update June 30, 2021

All parts of the project remain on track. The third season of data collection has started successfully. Analysis is ongoing for all parts of the project as we explore data from each of the individual Activities, as well as, connect the results from the individual activities into a broader, holistic analysis of peatland forest communities.

Amendment Request:
We were not able to hire a graduate student on for parts of the project, we do have a post-doc with the required skills to run analysis of the data collected and write both the peer reviewed publications and final reports. We are proposing to start him on October 1, 2021. This would be a rebudget of $66,462 from a graduate student to a post-doc. There is no change within the personnel budget line amount.
We also request to move $2,000 from the Personnel category to Equipment/Tools and Supplies, as the cost for maintaining the wells has been higher than anticipated due to wildlife damage. This would result in a total of $67,095 in the Equipment/Tools and Supplies category.

Amendment approved by LCCMR 10/4/21

Fifth Update January 31, 2022

All parts of the project remain on track. A new post-doc joining the project, Dr. Jonathan Stelling, is working through summarizing hydrologic data which will be part of a manuscript and will be used to inform other analyses related to vegetation and wildlife. Information from this project was utilized within a special symposium sponsored by the Sustainable Forest Education Cooperative on Wet Forests which included a day that focused on lowland conifers.

Amendment Request:

Due to changes with COVID including travel and equipment, we have shifted funding away from personnel into equipment/tools/supplies and travel expenses. This included final balances of $471,728 for personnel increasing the balance within equipment to $7,201; this was mainly due to animals such as bears impacting field equipment.

Amendment approved by LCCMR 12/15/22

Overall Project Outcomes and Results

Peatlands provide critical ecosystem services for Minnesotans, which include helping to maintain clean drinking water, providing important forest products, serving as critical habitat for many wildlife species, including the boreal chickadee, and storing huge amounts of carbon. However, these are very understudied systems and climate change, and other forest health threats are impacting peatland forests. Over a four year period, we've monitored 48 sites that span four different age classes and three different forest cover types (eastern larch, productive black spruce, and stagnant black spruce) to understand how vegetation, hydrology, soils, and wildlife species interact within peatland forest communities. Over the course of the 4 years and 48 sites, we have measured 1,000s of trees and 100s of different plant species to quantify plant species diversity, including number of species and diversity of structures within peatland forest communities; this includes lower plant species diversity within stagnant black spruce forest sites and higher plant diversity within eastern larch stands. We have some of the most robust data on boreal chickadee habitat use and early survival, which is critical for this species, which is a species of great conservation need in Minnesota. Finally, we have 100s of data points over multiple years on the daily hydrology within these systems to understand how water levels change over the growing season. All of this is critical base line data that can help information management practices within peatland forest communities. Results have been shared locally, regionally, and nationally through presentations and webinars, which include the basic data and sharing how to gather collectively across multiple disciplines to inform holistic management practices within forest ecosystems. Our results show that the youngest two age classes did not different in terms of hydrology and vegetation, thus current harvesting practices being completed during frozen ground is providing protection to the hydrology and understory vegetation. Additional work is needed to consider how different harvest strategies may influence wildlife use within peatland forest ecosystems.

III. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Establish a network of 48 research sites and quantify ecosystem function

Description:

With the aid of MN DNR, we will establish a network of 48 research sites across central and northern Minnesota. Sites will be selected in the three dominant peatland forest community types which have a history of regeneration harvests: Forested Rich Peatlands dominated by black spruce (FPn62 or FPn71), Forested Rich

Peatlands dominated by tamarack (FPn81 or PFn82), and Acid Peatlands (APn80 or APn81). Time since the last regeneration harvest will be grouped into three age classes and an unharvested control. There will be four replicates in each peatland community and age class category (n = 48).

We will use standard forest inventory methods to assess the multiple layers of vegetation on the 48 different sites. Vegetation layers that will be assessed include: overstory, regeneration, understory including non-woody plants, herbaceous species, and bryophytes, and down dead wood. On a subset of tree we will use an increment borer to quantify tree ages through tree cores. Tree cores will be processed using standard dendrochronological methods at U of MN Silviculture Lab.

Based on data collected, we will be able to assess patterns in stand development through time. For each site we will use summary statistics, diameter distributions, and other statistical methods to explore impacts of harvesting through time in the three different peatland forest types. We will use this data when developing the forest management strategies (Activity 4).

ENRTF BUDGET: $ 172,483

Outcome	Completion Date
1.Finalize selection of 48 field sites	September 2019
2. Field measurements at 48 sites in 3 peatland forest community types across 4 age classes	September 2021
3. Evaluation of management effects on plant communities and productivity	January 2022

First Update January 31, 2019

We have received the updated Forest Inventory and Monitoring Database from our collaborators at the MN DNR to use in site selection of the 48 sites. From this large database, we have identified a subset of sites which have been visited for evaluation or are in the process of field verification (Figure 1 & Figure 2). Sampling design and sampling strategies have been finalized. A qualified PhD student was not able to be recruited for this project. However, we have successfully recruited and hired a researcher (no change in personnel cost) who will be starting in mid-March.

Mid year update 2019

As of July 31st, 16 field sites have been sampled for overstory inventory with a minimum of 64 plots placed across the sites. An example of a site with plots can be found in Figure 1.3. At each site overstory, understory, and herbaceous data has been collected. Approximately 250 tree cores have been taken to analyze age data and about 100 woody and herbaceous species have been identified. Sampling will continue in August.

Second January 31, 2020

All data collected in summer 2019 has been entered (112 plots, 19 sites). Sites covered six Minnesota counties (Figure 1.4). Overstory and understory data is currently being summarized; close to 6,000 trees were stem mapped for analysis. The 280 tree cores collected this summer are currently being mounted and processed to determine stand age structure.

Mid year update 2020

Initial analysis of data collected during the summer 2019 growing season is on going. We are observing interesting differences among sites in terms of structure and composition (Figure 1.6 & 1.7). Summer sampling began in early June; an example of one site visited (Figure 1.8). While the initial goal is to complete vegetation sampling during the summer 2020 sampling season, this may not happen due to logistics regarding COVID-19. Since sampling has started 53 plots have been completed; there are 123 plots left to complete.

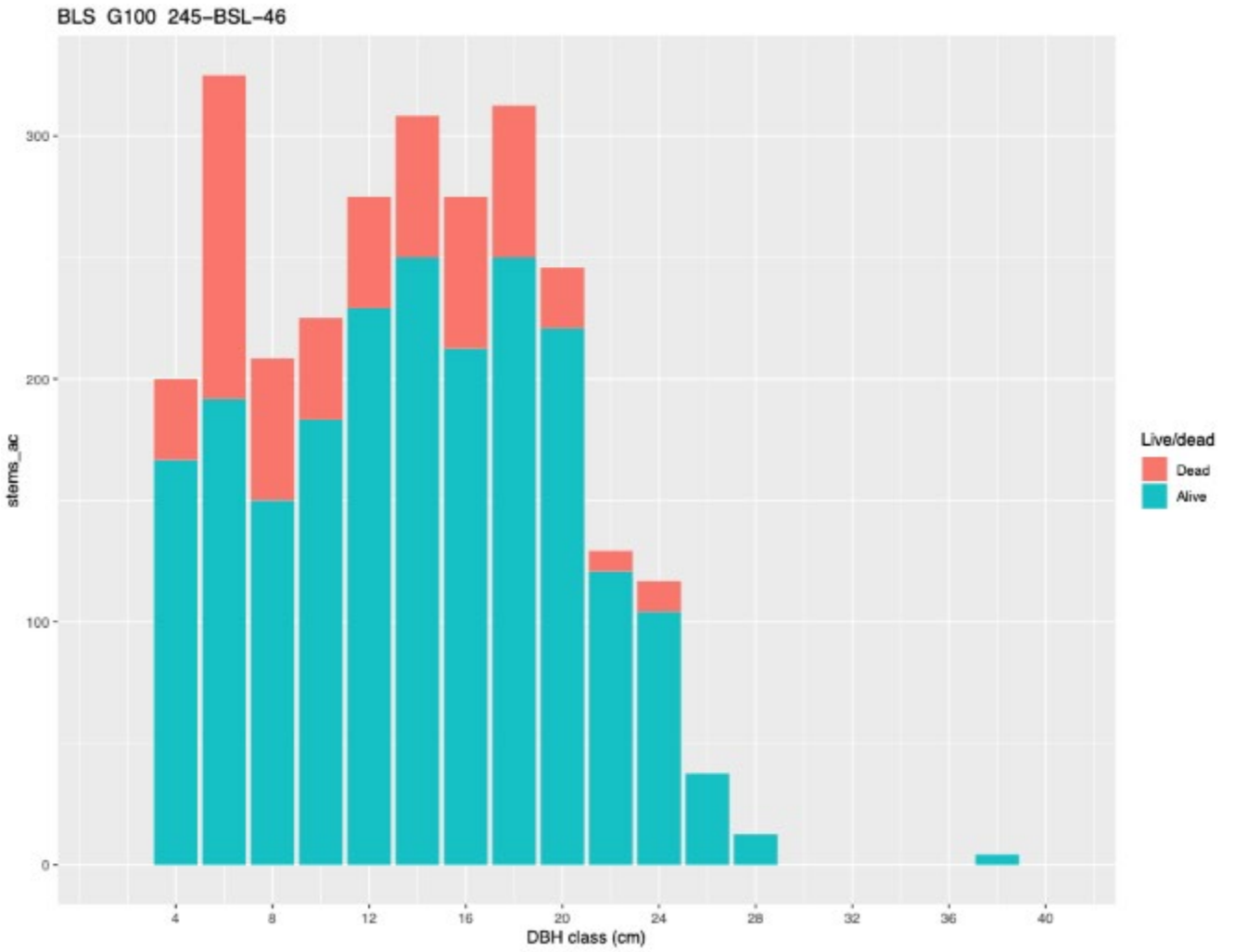

Figure 1.6 Black spruce diameter distribution for live and dead trees for one stand in the greater than 100 year age class. Note some diameter classes have high amounts of mortality (dead trees).

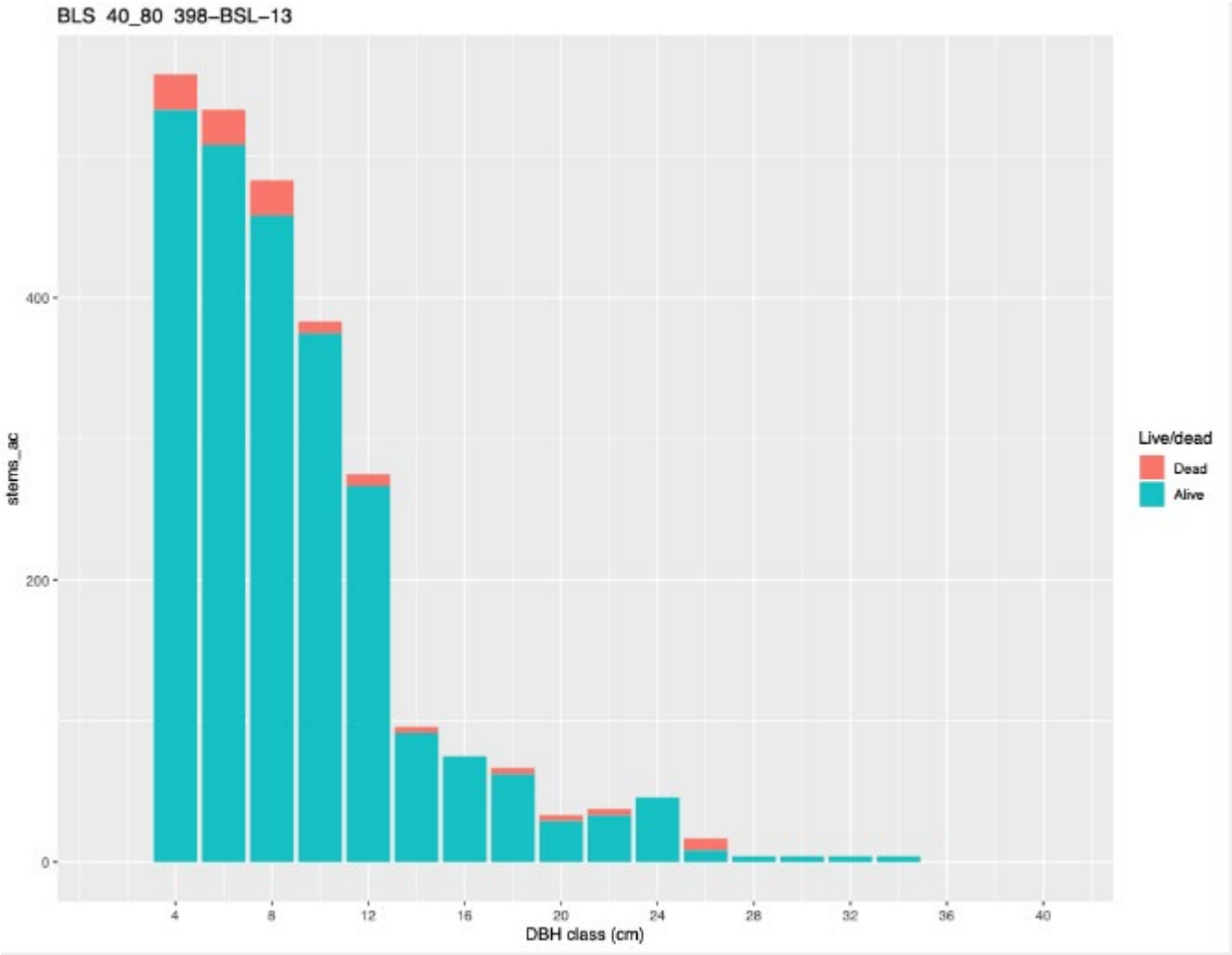

Figure 1.7 Black spruce diameter distribution for live and dead trees for one stand in the 40 to 80 year age class. Note few dead trees and many smaller diameter individuals.

Third Update January 31, 2021

Collection of stand structure and understory composition data was completed for the remaining stands; this data collection is now complete for all 48 study sites as of October 2020. Initial findings from this research were shared at two virtual conferences: the Society of American Foresters National Convention (October 29-31) and the UMN Sustainable Forest Education Cooperative Forestry and Wildlife Research review (January 12-14). Tree cores taken from 864 trees are currently being processed (approximately 25% complete as of 1/21) and will be further analyzed to determine stand age structure. Field data from 2019 and 2020 field seasons has been entered and is currently being summarized (See Table 1.1 and Figure 1.8).

Table 1.1. Field data collected in 2019 and 2020 field seasons.

Overstory trees measured and stem-mapped	20,787
Seedlings and saplings counted	13,628
Individual understory species identified	~125

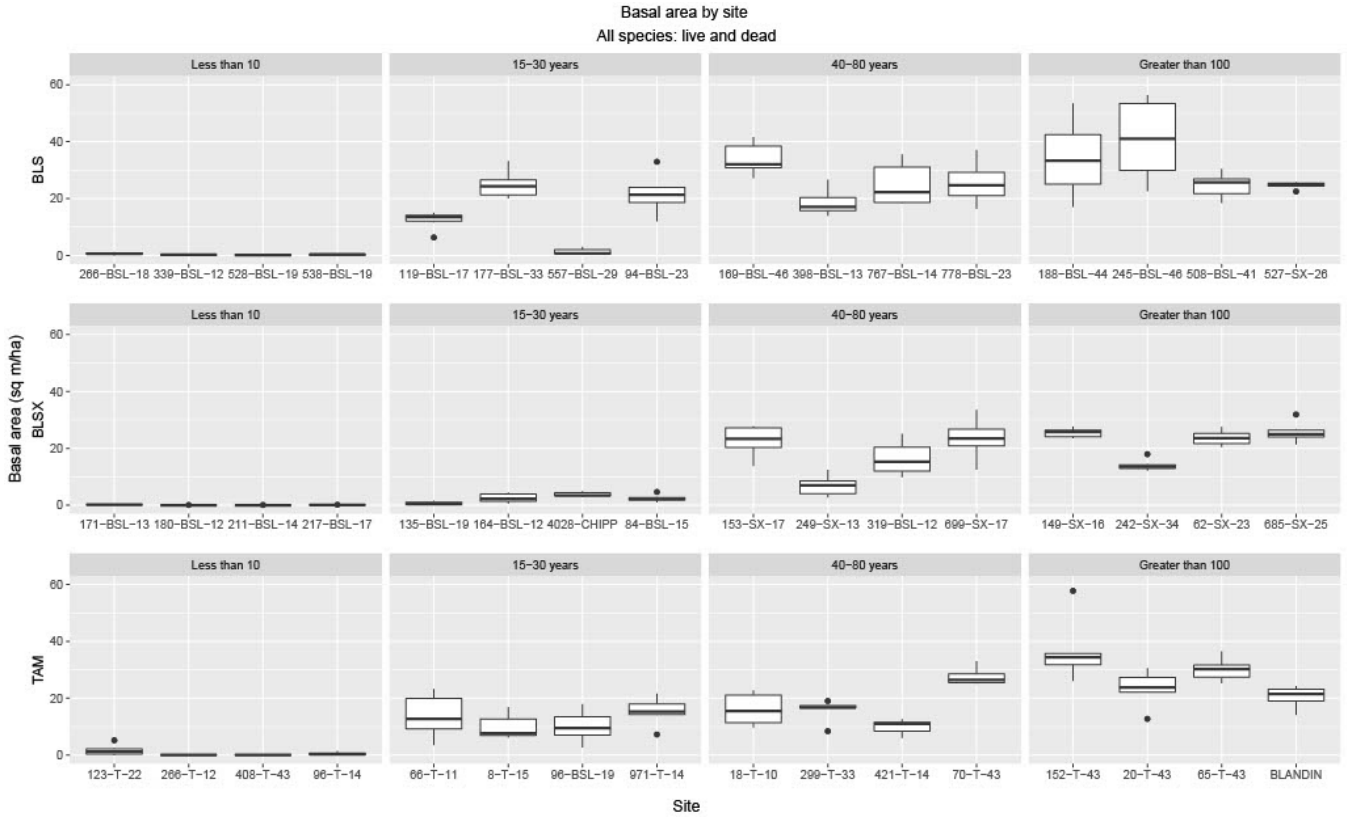

Fig 1.8. Basal area (sq m/ha) of all live and dead overstory trees (dbh≥10 cm) by site, cover type, and age class. Cover types definitions are BLS=productive spruce, BLSX=stagnant spruce, and TAM=tamarack.

Fourth Update June 30, 2021

Analysis of vegetation data is on-going as we explore stand structure and composition of peatland forest communities. Preliminary results will be shared in a planned special symposium on wet forest in October which is hosted by the Sustainable Forest Education Cooperative. This will allow discussion of holistic management related to Activity 4.

Fifth Update January 31, 2022

All field data has been collected, entered, and summarized. Patterns by age and forest cover type are beginning to emerge. For example, species richness was shown to be low in all stagnant spruce stands, but increased with age in productive spruce stands and was higher but more variable in tamarack stands (Figure 1.9). Tree cores taken from 864 trees have been mounted and sanded; high quality images of the cores will be taken this spring and rings will be counted and measured to analyze stand age structure and growth rates (Figure 1.10). Stem maps have been created for each of 288 plots (Figure 1.11).

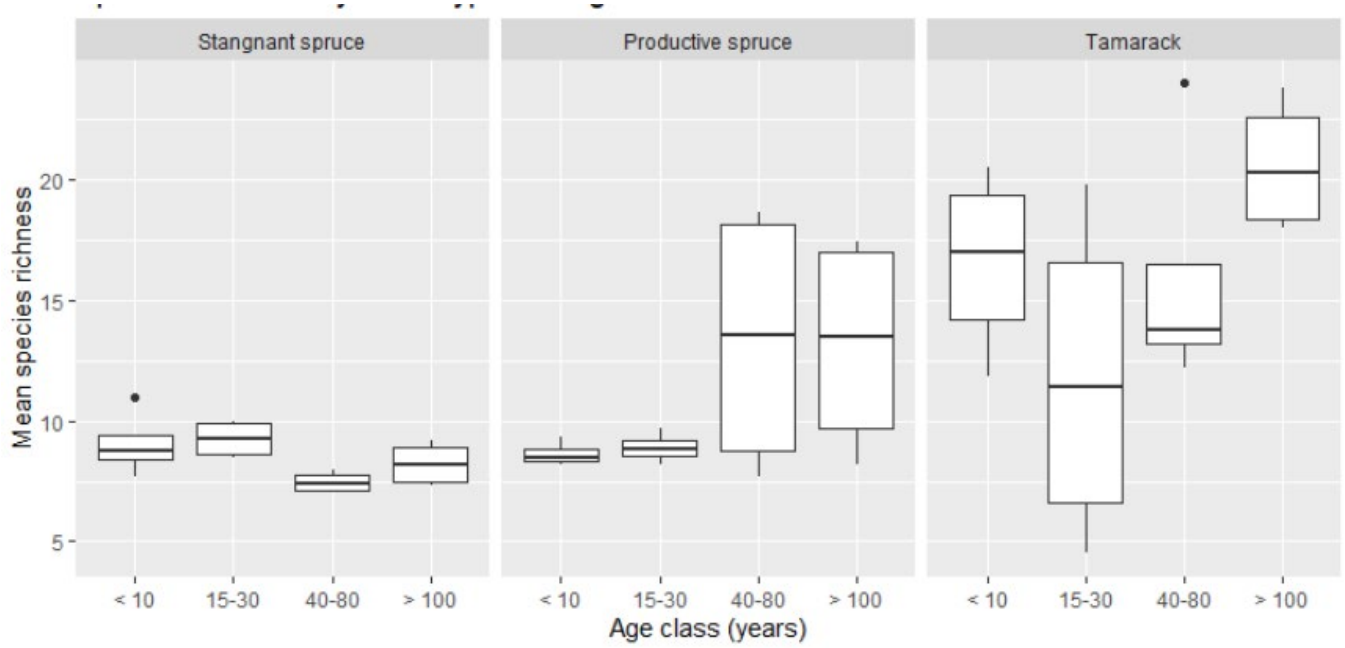

Figure 1.9. Mean plot-level species richness by forest cover type and age class. Higher species richness means more unique species were present in a plot.

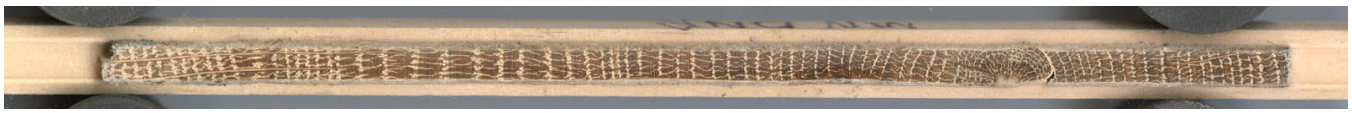

Figure 1.10. Example of a high-quality scan of a tree core. All cores from this study will be scanned and analyzed using dendrochronology software.

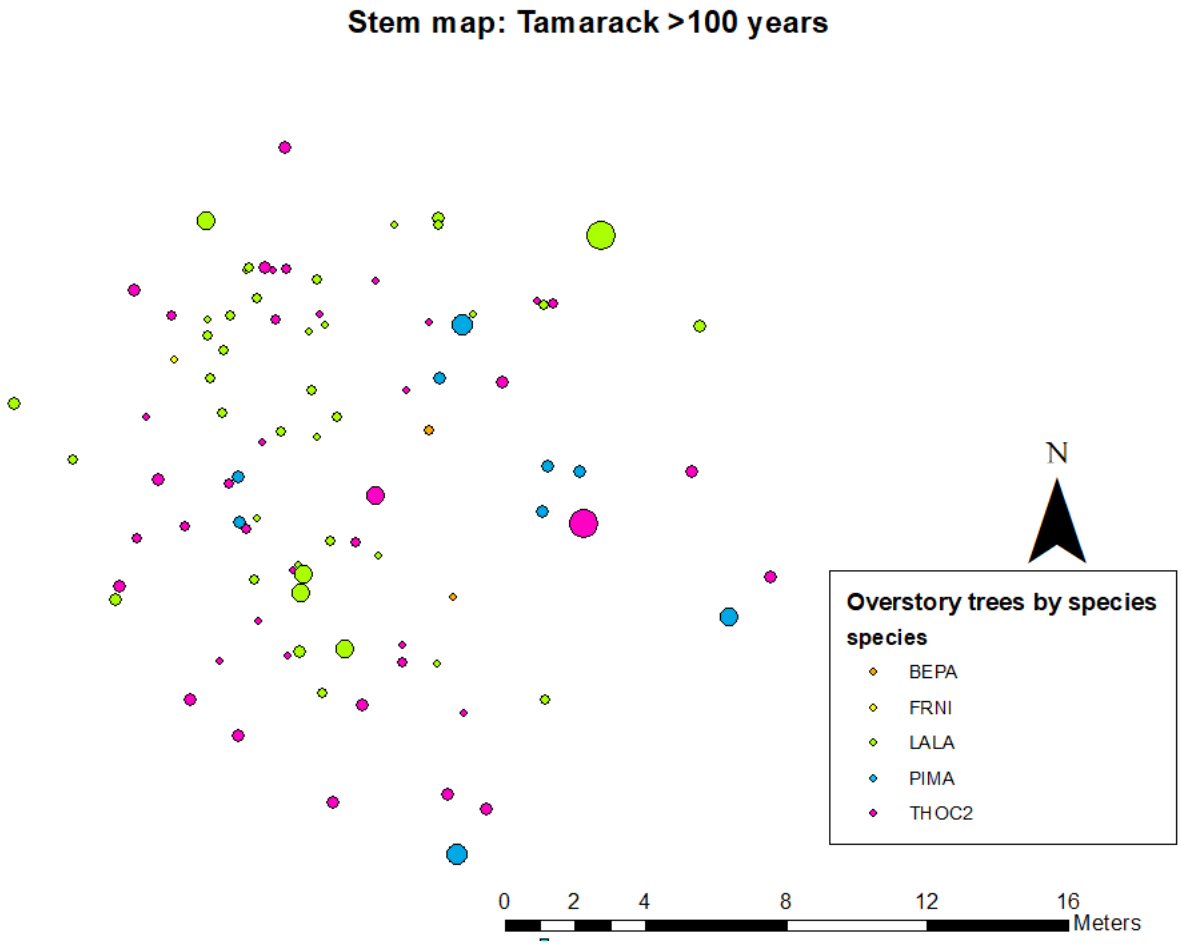

Figure 1.11. Example of a stem map of one plot at a tamarack site >100 years old. Different colors represent different species, size represents tree diameter at breast height.

Final Report Summary

This study consisted of 48 study sites in lowland conifer forests in northern Minnesota, USA evenly distributed between three cover types (productive *Picea mariana*, stagnant *Picea mariana*, and *Larix laricina*) and four age classes (less than 10 years, 15-30 years, 40-80 years, and greater than 100 years).

Each study site contained six plots located systematically approximately 140-200 meters apart depending on the shape of the stand. At each 400 m^2 plot species, diameter at breast height (DBH), live/dead status, and distance and azimuth from plot center were recorded for all overstory trees (≥10 cm DBH). The same measurements were taken for saplings (≥2.5 cm to <10 cm DBH) on a 200 m^2 plot located at plot center. Seedlings of merchantable tree species were tallied by species in three height classes at three circular subplots located 5 m from plot center at 0, 120, and 240 degrees. Large seedling (height ≥1 m, DBH <2.5 cm) subplots were 20 m^2 and small and emergent seedling (small seedlings: 30 cm ≤ height < 1 m; emergent: < 30 cm) subplots were 7 m^2. See Fig. 1 for plot sampling design

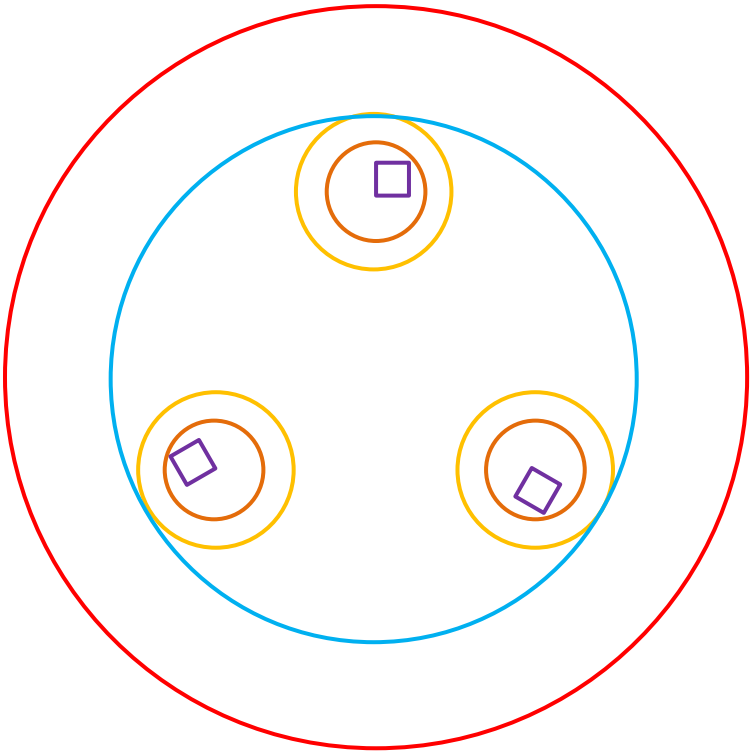

Figure 1. Vegetation plot sampling design. Overstory trees (≥10 cm DBH) were sampled in the entire 400m^2 plot (red circle). Saplings (≥2.5 cm to <10 cm DBH) were measured in a 200 m^2 plot (blue circle). Seedlings of merchantable tree species were tallied by species in three height classes at three circular subplots located 5 m from plot center at 0, 120, and 240 degrees. Large seedling (height ≥1 m, DBH <2.5 cm) subplots were 20 m^2 (yellow circle) and small and emergent seedling (small seedlings: 30 cm ≤ height < 1 m; emergent: < 30 cm) subplots were 7 m^2 (green circle). Ground layer plants were sampled in three square 1m^2 subplots (purple squares).

Ground layer plant subplots were 1m^2 and located in the same place as seedlings subplots (Fig. 1). At each understory subplot, cover of all mosses and lichens, herbaceous plants, and shrubs was estimated by species using the Braun-Blanquet cover classes (Braun-Blanquet 1932). Due to time constraints, some functional groups were not identified to species. Mosses and lichens were combined into one functional group and not identified, the same was true for all graminoids. Other species were identified to genus if identification to species was not possible.

One tree core was taken at breast height for four trees at each plot. At each plot, researchers paced 10 meters in each cardinal direction and then cored the nearest dominant or codominant tree of the same species as the stand cover type (*Picea mariana* or *Larix laricina*). Increment cores were prepared for analysis using standard dendrochronological techniques (Speer 2012). Age at breast height was determined using a microscope.

All data was summarized to the plot and then the stand level for the following measures of overstory and understory density and diversity. Basal area ($m^2 \cdot ha^{-1}$) was calculated for overstory trees and saplings. Stem density (trees per hectare, TPH) was calculated for overstory trees, saplings and seedlings. Species richness (number of species per plot), Shannon-Wiener index of diversity (Shannon and Weaver 1949), and evenness (Pielou 1969) were calculated for seedling by size class as well as for ground layer plant species. Analysis of variance (ANOVA) was used to determine differences among age classes within cover types for overstory and understory measures of density and diversity. When significant effects of age class were found, Tukey's HSD was used to determine pairwise differences between age classes. . Data analysis is on-going for this portion of the project and a peer-review article will be submitted spring 2023, and two additional articles are expected to be submitted fall 2023.

Main Take-aways

- Within the 48 sites, the two youngest age classes (less than 10 years and 15-30 years) had the least variability in the age structure which was consistent across the three forest cover types.
- The most variability in age structure was found in the oldest age class (greater than 100 years) and was especially difficult to find stands consistently past this age for the tamarack forest cover type.
- High amount of regeneration (< 10,000 stem/ha) were observed in the stagnant black spruce and productive black spruce forest type in both the small seedling and large seedling size class for all age classes except for the 40 -80 year old stands. The majority of this regeneration was black spruce but aspen was also common in the stagnant black spruce cover type.
- Less regeneration was observed in tamarack stands (on average less than 10,000 stems/ha) across all age classes but included a wider variety of species including paper birch, northern white cedar, and many other species. The 15-30 year old age class had a large amount of small saplings including eastern larch.
- Overstory density was greatest in the productive black spruce (ages 40 – 80 and greater than 100 years) and tamarack (greater than 100 years). Density quickly increased for the productive black spruce between the 15 – 30 age class and the 40 – 80 age class.
- Density was lowest in the stagnant black spruce forest cover type across all age classes.
- Tamarack forests in all but the 15 – 30 year old age category had high ground layer plant species richness. The productive black spruce and the stagnant black spruce did not vary greatly over time or between forest cover types.

These findings have important implications for policy in management:

- Tamarack ecosystems are extremely diverse in tree species and ground layer diversity. As eastern larch beetle impacts Minnesota's tamarack forests, it will be important to have this baseline data to compare beetle impacted stands with measurements from healthy tamarack forests to see if eastern larch beetle has resulted in community shifts or other impacts to the tamarack community.
- There is a huge amount of regeneration occurring in stagnant black spruce stands. This can be important opportunities to explore the long-term stand development in these systems and how these understudied species develop in terms of the growth rate.
- As all of the forest types increase in age, there are shifts in forest structure and composition. For tamarack, the stem exclusion phase of stand development may be happening earlier than black spruce (15 – 30 years compared to 40 – 80 years) which could influence the timing of management.
- There is high variability in stand structure and composition across stands. This data are important to link with hydrology and wildlife use (more in Objective 4).
- This type of baseline data are not currently readily available for these ecosystems; increased availability of this information will allow for better baseline information when making forest management and policy decisions.

ACTIVITY 2: Assess relationships between water and management

Description:

Peatland hydrology will be primarily assessed with water table monitoring wells to calculate annual water budgets and estimate daily evapotranspiration. Hydrology measurements will occur at three of the four replications for each peatland forest community type and age class. At each of the selected sites, a well with two pressure transducers will be installed to measure groundwater tables and barometric pressure during the growing season. A tipping bucket rain gauge will also be deployed at each site during the growing season of each year to record precipitation inputs and air temperature.

Raw data will be processed using standard techniques to calculate daily, weekly, and seasonal trends for the different forest types and stand ages. We will use multiple statistical techniques including mixed model repeated measures to assess differences among forest types. We will use standard calculations to estimate evapotranspiration, net groundwater flow, and net change in the daily water table. Results will be incorporated into the forest management strategies developed in Activity 4.

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ENRTF BUDGET: $ 199,899

Outcome	Completion Date
1. Monitoring wells and precipitation gauges installed at 36 sites	October 2019
2. Site hydrology and water budget measurements completed for the 48 research sites	October 2021
3. Hydrologic assessment completed and classification scheme for alteration completed	January 2022

First Update January 31, 2019

We have developed and finalized the sampling design and strategies. The location of wells and precipitation gauges will be based on the finalize sites selected for the study. Some of the equipment for hydrology measurements is in the process of being purchased in anticipation of early spring deployment.

Mid year update 2019

Work associated with this activity is currently ahead of schedule. All equipment for hydrology measurements was purchased by April 2019. Sites were scouted and potential well locations identified at 36 of the 48 sites in early May. Monitoring wells and precipitation gauges were installed from mid May until mid June, and water levels are currently being monitored with pressure transducers at each of the 36 sites. Wells will be revisited in July to ensure that data is being properly recorded at each one.

Second January 31, 2020

We were able to successfully monitor water level and precipitation across the 36 sites throughout the growing season of 2019. Datalogger retrieval at the end of the season was challenging because of early freezing temperatures and snowfall. Because of this, we were unable to retrieve two dataloggers that were frozen solid in the monitoring wells. Despite this setback, we have done some initial analysis on the data and are encouraged by its quality and initial trends which are similar across the treatment plots (Figure 2.1).

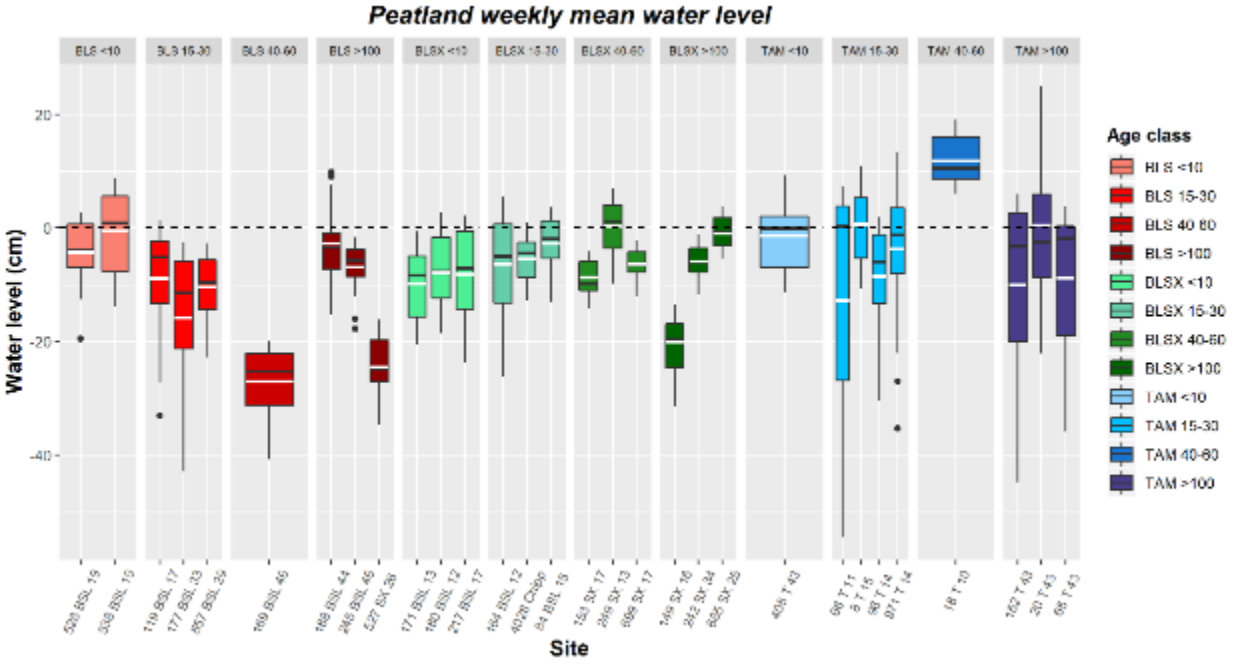

Figure 2.1 Data from data loggers collected in 2019.

Mid year update 2020

Dataloggers were successfully deployed in late April at all of the sites. One of the sites was harvested over the winter, but the well was not disturbed. We intend to maintain monitoring at the harvested site, but also installed a new well and datalogger at one additional site in early July. We were able to retrieve the two dataloggers that were frozen in the wells last fall and successfully download the data from last years monitoring season. Data analysis continues including calculations for daily water levels, evapotranspiration, and net flow from 2019 (Figure 2.2 & 2.3). A database has also been developed to manage the large amounts of data we are acquiring throughout the project period.

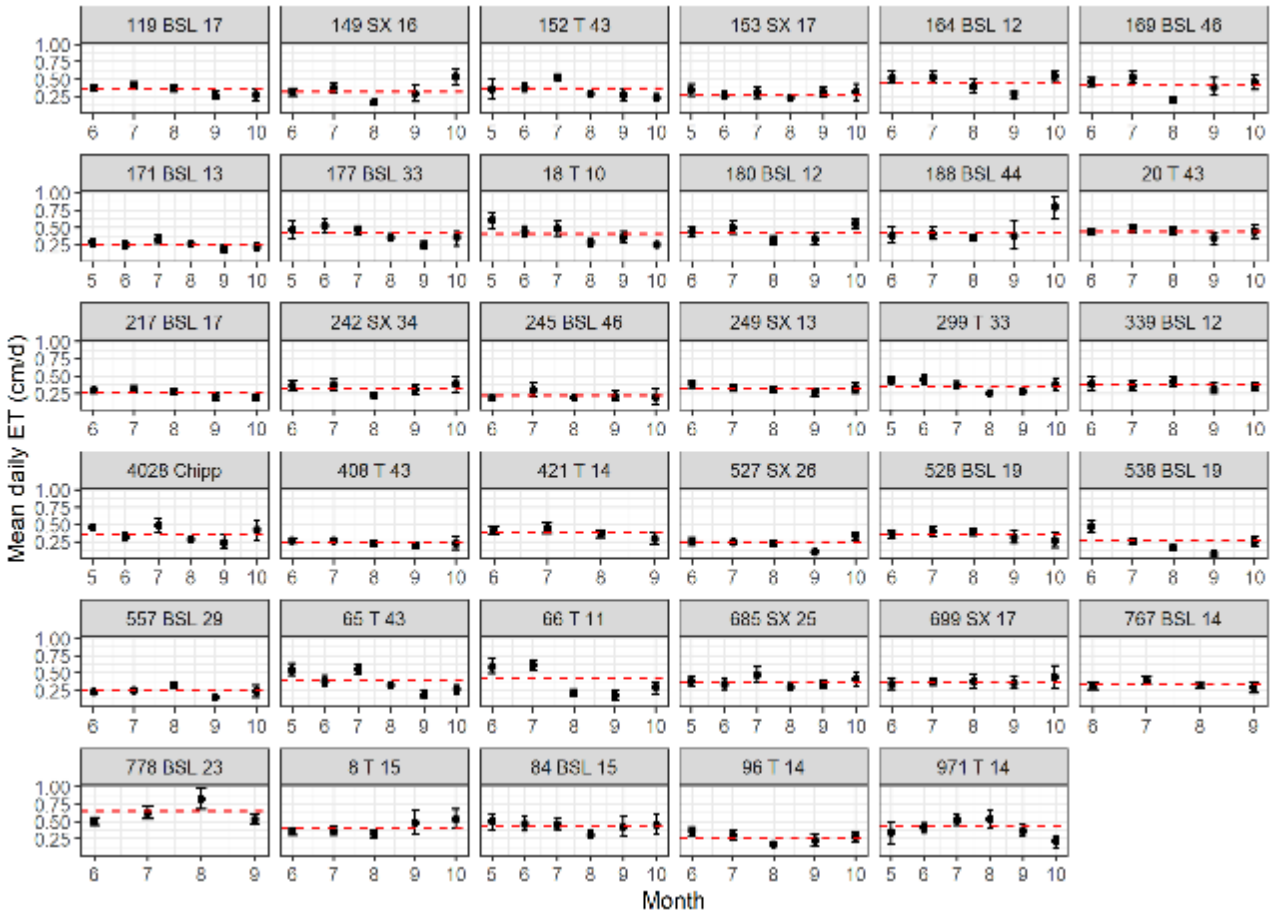

Figure 2.2 Monthly average values from June through September for mean daily evapotranspiration across sites.

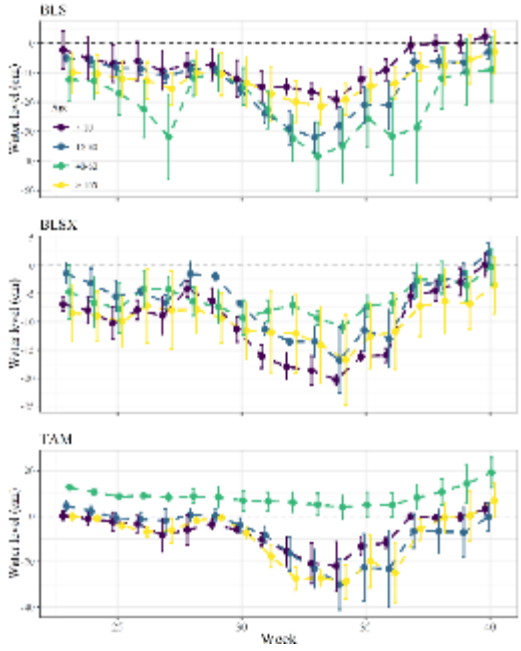

Figure 2.2 Weekly average measurement of daily water levels, evapotranspiration, and net flow

Third Update January 31, 2021

Progress on Activity 2 continues on schedule, with no problems or complications to report. A monitoring well was installed and instrumented to replace the site that was inadvertently harvested last year. Water level dataloggers and precipitation gauges were all retrieved in late October, and data has been downloaded and checked for quality and processing. One datalogger was lost due to animal activity and will be replaced in the spring deployment. The 2020 data will be analyzed in early 2021.

Fourth Update June 30, 2021

Activity 2 is on schedule and all related work has occurred as planned. Well dataloggers and precipitation gauges were redeployed in April with no reported problems or issues. We are currently compiling all the data from the 2020 measurement period and will have updated data analysis completed in mid summer

Fifth Update January 31, 2022

Hydrology data collection was completed in the fall, with no problems to report. A post doc was recruited to develop and conduct analytical approaches for the large dataset, and much progress has been made to date including data cleaning, summarization, and development of new models for estimation of hydrologic components. Early results indicate that max evapotranspiration varies by peatland ecosystem, but we still need to determine the net effect on overall hydrologic response. Current efforts are focused on compiling and analyzing precipitation data collected during the project period.

Final Report Summary

Activity 2 Final Report Summary

Monitoring wells and precipitation gauges were successfully installed at each of 36 sites in the fall of 2018, and water table depths and rainfall were measured continuously during the growing season of the project period. There were a few issues with data collection (e.g., some dataloggers were frozen in place, one of the sites was inadvertently harvested), but overall the data record across sites was complete and of high quality. In addition to measurements outlined in Activity 2, we were also able to conduct measurements of peat depth at each of the sites, as we expected peat depth to have a large influence on water table dynamics. Water table measurements were used to calculate mean weekly and annual WT depths and indirectly estimate evapotranspiration to determine if differences existed among the peatland cover types and age classes. A severe drought in 2021 allowed us to evaluate the influence of seasonal precipitation on site hydrology and assess any differences among cover types and age classes. Key findings from this work are:

- Mean annual water tables were deepest in productive black spruce peatlands, intermediate in stagnant spruce peatlands, and shallowest in tamarack peatlands (most noticeably in the 40-80 year old peatlands). Peat depth had a significant influence on water table depths – it was greatest in stagnant spruce (1.76 m) and similar in depth at the productive spruce and tamarack peatlands (1.1 m and 1.24 m respectively).
- In most instances, water tables were similar across age categories within each peatland type. Two exceptions were 1) consistently deeper WT in the 40-80 age class in the black spruce cover type compared to other age classes within that type, and 2) consistently shallower WT depth in the 40-80 age class in the tamarack cover type compared to other age classes. Water tables at all sites were ~3-5 times deeper in the 2021 drought year compared to other years.

- Evapotranspiration estimates in black spruce aligned with the water table results (i.e., higher ET in the 40-80 age class compared to other classes), but not for tamarack (ET estimates were similar across age classes).
- Mean annual WT depth was positively correlated with cumulative precipitation for all cover types, but the relationship was most pronounced for the tamarack cover type. Differences among age classes within a cover type were not obvious, but in general the stagnant black spruce peatlands were less influenced by precipitation than the other cover types.

These findings have important implications for policy in management:

- The similarity in water table depths across age classes indicates that there is limited lasting impact of forest harvesting on water table dynamics. In a few instances, ET was lower in the <10 year age class which could be associated with reductions in transpiration following harvesting, but this effect was not reflected in the water table response. From a hydrologic perspective, it appears that forest management does not unduly affect hydrologic functions over time.
- The lower water tables and higher ET observed in the 40-80 black spruce age class align with stand developmental stages associated with that age class, and could be used to refine water budgets for watersheds with a range of peatland age classes.
- The relationships between precipitation and mean annual water table are not entirely surprising, but do demonstrate that these peatlands may be susceptible to changes in precipitation that may occur in the future with climate change. The much lower water tables observed in the 2021 drought support this.
- Based on the findings, it appears that tamarack peatlands may be most susceptible to changes in precipitation, and stagnant black spruce the least. Further work is needed to determine how any related changes in water table depths influence other ecosystem functions such as carbon storage and forest productivity.
- We were fortunate that the study period included a significant drought year to observe how it influenced hydrologic response; these ecosystems are incredibly variable and a much longer monitoring record is needed to inform the development of management and policy recommendations.
- We only sampled 3 of the 4 replications in each cover type*age class combination because of limited resources available. Future studies (or continuation of this one) should have at least 4 replications of each treatment for valid and meaningful interpretation of the responses.

ACTIVITY 3: Assess relationships between wildlife and management

Description:

Wildlife surveys will focus on characterizing data on the most abundant wildlife species which are the amphibian and avian communities. Data collection will occur in the spring and summer at the 48 research sites. We will use digital audio recorders (DARs) to remotely survey amphibian and bird communities from February to July. This survey method will allow us to detect different species, the presence and absence of types of species, and provide a permanent recording. This permanent recording will be important to compare among years for this study and provide important data for future researchers on current wildlife species in peatland forests. Birds will be recorded during the breeding season using standard point count techniques which used highly trained research associates to watch and listen for different bird species. Using the DARs and point count surveys will provide a comprehensive picture of wildlife species in peatland forests.

A subset of research sites will be targeted to gather additional data throughout the breeding cycle of two Species of Greatest Conservation Need, Connecticut Warbler and Boreal Chickadee. We will search for nests using standard nest searching methods. When nests are found, we will use cameras to monitor the progress. If the nest produces fledglings, we will tag the juveniles with radio-transmitters to monitor survival, habitat use, and general preferences during the post-fledgling period. This will

give us information on what type of habitat these important birds species are and are not using. These data will provide important information that will help identify conservation priorities for Species in Greatest Conservation Need. We will use this data when developing the forest management strategies (Activity 4).

ENRTF BUDGET: $ 177,890

Outcome	Completion Date
1. Amphibian and bird community composition and diversity measured for 48 research sites. Connecticut Warbler and Boreal Chickadee habitat data collected at selected sites.	August 2021
2. Evaluation of management effects on amphibian and bird communities	September 2021

First Update January 31, 2019

We have developed avian and amphibian survey methods for the broad suite of species and the specific nest searching methods for both the Connecticut Warbler and Boreal Chickadee. To maximize the potential of finding and monitoring successful Boreal Chickadee nests, we built and deployed a total of 275 Boreal Chickadee nest boxes; 215 in the Sax-Zim bog area and 150 is the Agassiz Lowland region. We set up nest boxes in areas with relatively high Boreal Chickadee densities and in forest stands that fit the overall experimental design (Figure 3.1) We will begin monitoring the nests for activity in mid-march. We have also obtained the Federal Bird Banding Permit (Permittee: Annie Bracey; Permit Number: 24165) required for capturing, banding, and attaching radio-transmitters on focal species.

Figure 3.1: Boreal Chickadee nest box locations.

Mid year update 2019

We conducted point count surveys in the study sites in May to detect early-breeding (resident species and short-distance migrants) and again in June to quantify breeding bird communities. We deployed digital audio recorders in 24 sites, stratified by plant community and age, to collect data on breeding birds and amphibians.

Research on the focal species, Boral Chickadee and Connecticut Warbler was conducted in the Sax-Zim bog area. We identified 11 Boreal Chickadee breeding territories and deployed radio transmitters on four juveniles. One of the juveniles was predated but we were able to track the remaining three individuals for 33 days. Juvenile Boreal Chickadees were tracked twice daily (morning and afternoon) after they were 10 days old. We identified 23 Connecticut Warbler territories that were defending by singing males (Figure 3.2), however females were confirmed at only 10 of the territories. We found two Connecticut Warbler nests (Figure 3.3), one nest had complete mortality but we were able to track one juvenile for approximately 15 days. Vegetation surveys were conducted at "used" locations and paired "non-used" locations for both species, this information will help identify habitat characteristics that are important in the post-breeding period.

Second January 31, 2020

Initial analysis of the point count and digital audio recorder 2019 field season data has been complete. Over 80 species of birds and six amphibian species were documented on either point count surveys or on digital audio recorders. Preliminary results of these data show that peatland bird communities differ between age class and cover type (Figure 3.4).

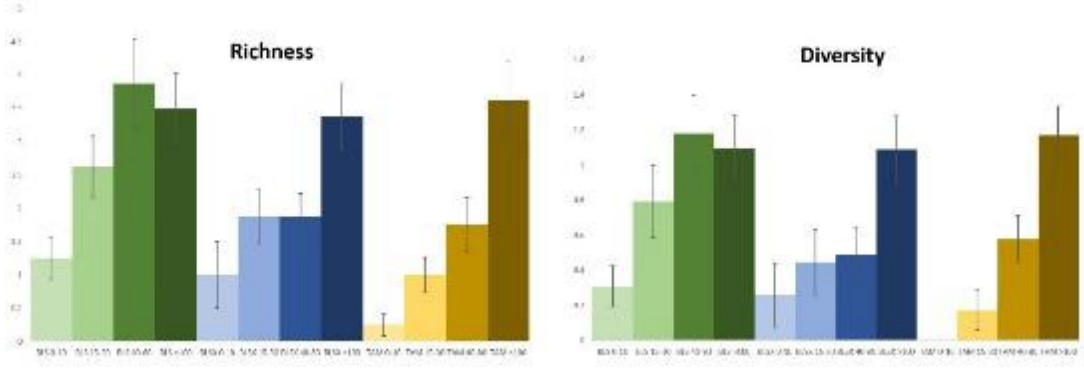

Figure 3.4. Species richness and diversity of 17 peatland-dependent breeding bird species in the 48 sites during the 2019 breeding season. BLS = productive black spruce; BLSX = stagnant black spruce; TAM = tamarack.

Initial analyses of the post-breeding dispersal for the Boreal Chickadee juveniles, show a strong preference for dense black spruce stands with little sub-canopy structure and a think moss understory. The juveniles seemed to avoid tamarack stands that were interspersed throughout the forest matrix and also avoided forest edges (Figure 3.5). In the summer of 2020, we plan to study Boreal Chickadees and Connecticut Warblers in the Red Lakes Wildlife Management Area within the Agassiz Lowland region where breeding densities for both species are higher. When placing additional Boreal Chickadee boxes in this area in fall of 2019, we documented chickadee nests in at least seven preexisting nest boxes. With a total of 245 boxes in this area now, we are confident that many will be used in summer 2020. We will begin monitoring boxes in April.

Mid year update 2020

We conducted point count surveys in the study sites in May to detect early-breeding (resident species and short-distance migrants) and again in June to quantify breeding bird communities. We deployed digital audio recorders in 24 sites, stratified by plant community and age, to collect data on breeding birds and amphibians. Study locations for Boreal Chickadees and Connecticut Warblers include the Red Lakes Wildlife Management Area within the Agassiz Lowland region where breeding densities for both species are higher densities.

As of June 30, 2020 the current status of the focal species portion of the study are as follows:

- Boreal Chickadee. There were at total of 18 nest boxes being used by Boreal Chickadees in the 2020 study area. We have color banded a total of 84 juveniles and are tracking 13 broods. We have a total of 150 telemetry locations so far this year and are adding approximately 10 points daily. Vegetation surveys are being conducted at telemetry locations to assess habitat features associated with juvenile movements.
- Connecticut Warbler. We have found a total of eight nest and we are tracking the movements of two broods. There are currently three active nests that are being monitored.

Third Update January 31, 2021

We completed all point count surveys and deployment of autonomous recording units (ARU) for this project. We detected a total of 107 species and 7180 individuals during the point count surveys. We are currently in the process of analyzing the data. ARU recordings from the field season are also being processed.

During the 2020 field season, we banded a total of 97 Boreal Chickadees, place radio-transmitters on 22 individuals, and tracked them for an average of 28 days after they fledged from the nest boxes. Overall, we collected 309 habitat use locations and conducted 618 vegetation surveys to assess habitat characteristics for birds during this time period. We found a total of nine Connecticut Warbler nests during the 2020 breeding season and placed transmitters on 11 individuals, we collected 31 habitat locations for this species and conducted 62 vegetation surveys to assess habitat. We are in the process of summarizing and analyzing data for these species. We plan to continue the Boreal Chickadee portion of the study in the 2021 field season.

Fourth Update June 30, 2021

We finished the analyses of the ARU data that was collected in 2019 and 2020 at the 48 study sites. We focused on Boreal Chickadee ecology in the Red Lake Peatlands during the 2021 field season. In May, a total of 25 active nests were documented and 11 of the nests had eggs. Only seven of the nests hatched, however three of the nest boxes were predated before young birds were able to leave the nests, the remaining four nests successfully fledged young. A total of 20 nestlings were banded and seven birds were tagged with radio telemetry units for tracking; however four of them were predated right after fledge. We ended up tracking only three broods this season, each brood was tracked for a minimum of 29 days (41 days max). A total of 103 telemetry points were documented, vegetation surveys were completed at each "used" site. Drought was extreme in the study area and may have contributed to increased predation pressure. Data entry and analysis is on-going.

Fifth Update January 31, 2022

Recent activities we have completed include the following: data related to Connecticut Warbler breeding habitat have been analyzed and a manuscript is in preparation; Boreal Chickadee telemetry movement data have been analyzed; and point count and ARU datasets have been analyzed and a manuscript related to these data is in preparation.

Final Report Summary

We conducted wildlife surveys to characterize community composition and biodiversity metrics in relation to peatland forest community type and time since harvest. Ten-minute point count surveys were conducted at the 48 study sites during the peak of the avian breeding season in June 2019 and 2020. Each site survey consisted of two point count locations; point counts were conducted by trained observers from approximately 0.5 hours before to 4 hours after sunrise on days with little wind (< 15 km hr−1) and little or no precipitation. All birds heard or seen from the point count locations were recorded, along with their spatial location within the plot and estimated distance from the observer to avoid double counting birds. Analyses included only birds observed within a 100 m radius; data were summed over the two survey years. Automated recording units (ARUs) were deployed at a randomly chosen point count location (one per site); 24 were deployed in 2019 and 24 were deployed in 2020. Data from ARU recordings were sub-sampled and virtual point counts were conducted once per week for five weeks throughout the breeding season.
A total of 107 bird species and 7180 individuals were detected at the study sites in the 2019 and 2020 breeding seasons. The most common bird species were Nashville Warbler (*n*= 504), White-throated Sparrow (*n*= 285), Common Yellowthroat (*n*= 177), Palm Warbler (*n*= 128), Lincoln Sparrow (*n*= 108) and Hermit Thrush (*n*= 101). Preliminary results indicate that bird species that are considered lowland conifer specialists (13 species) were significantly associated with both productive and stagnant black spruce stands that were 40 years or older. Data analysis is on-going and a peer-review article will be submitted fall 2022.
Focal species

Connecticut Warbler and Boreal Chickadee are listed as Species in Greatest Conservation Need (SGCN) in Minnesota. Preserving and restoring quality breeding habitat is critical for conservation of these species, but there is a significant knowledge gap associated with basic breeding ecology and breeding and post-fledging habitat requirements for both species. To develop effective conservation, additional information about their basic ecological needs is necessary to help identify forest and habitat characteristics that influence full- life-cycle events such as nest success, juvenile survival, and habitat needs of post-fledgling birds.

Connecticut Warbler. To better understand the breeding ecology of Connecticut Warblers, we studied their nesting and post-fledging habitat use and survival in northern Minnesota at two study sites in 2019 (Sax Zim Bog) and 2020 (Red Lake Peatlands). We mapped territories of 49 singing males, located and monitored 11 nests, and tracked the post-fledging movements of individuals from 5 broods. Results for 13 individuals tracked 0-7 days post-fledging had a mean daily distance from nests of 35.5 m and a maximum range of dispersal of 104 m during that time period. Connecticut Warblers were not observed making movements of greater than 55 m/day until day 8 or movements of 100 m/day until day 19 post-fledge. Our findings indicate that micro-site areas with high stem density were important features for post-fledgling birds and that the same habitats were used for breeding and the post-fledging time period. Results from this study can be used by land managers to develop and promote conservation strategies that will provide critical habitat to support this species. Data analysis has been completed for this portion of the project and a peer-review article will be submitted fall 2022.

Boreal Chickadee. Boreal Chickadees are cavity-nesting species and readily use nest boxes for breeding. Therefore, we deployed nest box arrays in two study areas located in the Sax Zim Bog (2019) and the Red Lake Peatlands (2020- 2022). Nest boxes allowed us to control for potential differences in cavity availability between study areas and sites within the study areas. Study sites had similar forest cover types (predominantly mature black spruce) but were different ages and have varying degrees of fragmentation in the surrounding landscape. To quantify differences in habitat quality between sites, we documented nest density, parental provisioning rates, and nestling body condition and growth rates, as well as post-fledging movement and juvenile survival.

During the 2020, 2021, and 2022 breeding seasons we documented outcomes of 33 nests, tagged 58 fledglings from 24 broods, and collected data at 1,274 habitat vegetation points. The overall nest success (one or more individuals fledged) has been high (80%), with Red Squirrel (*Tamiasciurus hudsonicus*) and Pine Marten (*Martes americana*) predation as the leading cause of nest failure (20%). The highest risk of post-fledge mortality is within the first three days after leaving the box. During this time period survival is 58%; we estimated that 66% of mortality was caused by predation and the remaining 33% due to exposure to the elements (e.g., strong storms the night after fledging). Very few mortality events occurred after 4 days post-fledgling. Through our tracking of juveniles we have learned a lot about their behaviors during the post-fledging time period. For example, the broods typically stay with both parents and move around together for the first 21 days post-fledging. Daily movement distance averaged 100 m (328 feet) during the first 10 days after leaving the nest and increased to 200 m (656 feet) as the juveniles grew and became more proficient fliers. In general, the broods remain relatively close to the home range of the parents and would avoid large openings and hard-edged transitional areas of the black spruce forest. Once the juveniles reached approximately 21 days post-fledge, the broods split from the parents and began to make longer movements of, on average 300 m, (984 ft) from the "core" post-fledgling area and tended to join up with mixed-species flocks consisting of juvenile Ruby-crowned and Golden-crowned Kinglets, Dark-eyed Juncos (*Junco hyemalis*), and Nashville (*Leiothlypis ruficapilla*) and Yellow-rumped Warblers. (*Setophaga coronata*) We also frequently were able to document juvenile Boreal Chickadees from multiple broods joining a single mixed-species flock. Much longer daily movements of up to 1.7 km (a little over 1 mile) also occurred during this period, presumably as Boreal Chickadees sought suitable available (i.e., unoccupied) habitat. Around 40 days after fledging, the Boreal Chickadee juveniles typically settled into a regular area and started to make less frequent large movements (approximately 200 m average daily movement) across the landscape. These data are being

used to provide breeding cycle habitat recommendations for managing forested landscapes to maximize productivity and prioritize conservation efforts. Data analysis is on-going for this portion of the project and a peer-review article will be submitted spring 2023, and two additional articles are expected to be submitted fall 2023.

ACTIVITY 4: Develop forest management strategies to maximize peatland forest benefits

Description:
Peatland forests are actively managed. However, the management guidelines for black spruce have not been updated since 1977. There is increased interest in understanding how peatland forest management impacts multiple ecosystem functions. There currently exists a lack of data to update management guidelines. Activity 1, 2 and 3 will provide this data. The development of updated guidelines will be a collaborative effort. We will establish a Peatland Forest Stakeholders group, which will draw from multiple forest land management agencies and disciplines within Minnesota to create updated management recommendations for peatland forests which incorporate multiple benefits: water, vegetation, and wildlife. The Stakeholder group will be established by May of 2020. This will allow for the group to set guidelines and objectives, discuss current knowledge of peatland forests, and then integrate results from this study into management recommendations.

ENRTF BUDGET: $ 49,728

Outcome	Completion Date
1. Compilation and integration of vegetation, hydrology, and wildlife assessments	January 2022
2. Management strategies to maximize benefits for peatland forests completed	June 2022

First Update January 31, 2019

Limited work has been completed associated with this activity other than researching and reviewing current management guidelines in peatlands.

Mid year update 2019

Limited work has been completed associated with this activity other than researching and reviewing current management guidelines in peatlands.

Second January 31, 2020

Limited work has been completed associated with this activity other than researching and reviewing current management guidelines in peatlands.

Mid year update 2020

Limited work has been completed associated with this activity other than researching and reviewing current management guidelines in peatlands.

Third Update January 31, 2021

Limited work has been completed associated with this activity other than researching and reviewing current management guidelines in peatlands. This part of the project is on schedule to be completed.

Fourth Update June 30, 2021

A special symposium is undergoing planning that will bring forest managers and researchers together to discuss wet forests in October hosted by the Sustainable Education Cooperative. One of the days will be specifically focused on lowland conifer forests and will include a holistic exploration of how vegetation, wildlife, and hydrology are influenced over time and with management.

Fifth Update January 31, 2022

The special symposium on Wet forests offered in collaboration with the Sustainable Forests Education Cooperative was offered October 26 – 28, 2021 which included multiple breakouts on facilitated discussion regarding management. Members of the group have been invited to contribute a chapter on the ecological management of lowland conifer forests in the Lake States for a book being led by Drs. Brian Palik and Tony D'Amato entitled *Ecological Silvicultural Systems*. Members of this group have also contributed to the development of the MN DNR's Lowland Conifer Old Growth Evaluation Process.

Final Report Summary

Summary of Effort

Work in this area is ongoing and COVID greatly shifted our engagement with stakeholders, which was planned to begin in May of 2020. With COVID, we focused on gathering data and working on analyses for Activity 1, 2, and 3. As COVID restrictions have shifted and more folks have become more comfortable with online meetings we were able to host meetings, hear thoughts, and share feedback. One of the most successful events was a lowland conifer forest cover type workshop hosted in collaboration with the US Forest Service and UMN Sustainable Forests Education Cooperative which included over 50 people joining over a 3-day period. The goal of the workshop was to share research, to hear thoughts and ideas regarding management (we discussed vegetation, hydrology, and wildlife, as well as the integration of the three), and consider future threats. Feedback for the workshop was excellent. We have also presented results from the 3 activities and the integration of the three activities at local, regional, and national conferences. We expect a shared paper merging the 3 activities will be submitted in 2024.

Finally, we are working on incorporating our finding from our work into the chapter on ecological silviculture of lowland conifer ecosystems. Within that chapter, we highlight the importance of gap dynamics and the importance of below ground processes in maintaining carbon storage. We recommend the use of expanding irregular shelterwood system managing at the landscape scale. This would be a shift from working within an individual 20 ha stand to grouping multiple lowland (and upland) systems to increase structural and compositional complexity. The irregular shelterwood can capture the potential disturbance dynamics which fire and windthrow may have impacted lowland conifer systems. By varying the density, shape, and spacing of reserve trees, reserve trees may serve multiple purposes with scattered individual trees serving as future down dead wood and more clumped patches providing seed source and acting as refugia. The expanding nature of the shelterwood would allow areas to be managed in more even-aged systems and others to progress through understory reinitiation.

While this system is more complex than a clearcut silvicultural system, the implementation of this system would be feasible, given advances in technology and would not require too much additional painting/marking. It would require investment in foresters and silviculturists walking the stands in the growing season to see the nuance in site conditions, the slight changes in elevation, and note areas were reserves may be placed. This information can then be translated and shared through mapping platforms (e.g. Arc or Avenza) and shared with logging professionals.

Importance to policy

Bringing stakeholders together to talk about management issues and opportunities in lowland conifer ecosystems represents an opportunity to bring multiple disciplines together and to also consider current and future management decisions and policies.

IV. DISSEMINATION:

Description:

Scientific publications: We expect that Activities 1, 2 and 3 will produce at least 2 peer reviewed journal articles in the fields of forest management, stand dynamics, hydrology, avian and amphibian population dynamics and management.

Presentations: Results will be disseminated through online webinars in coordination with the Sustainable Forest Education Cooperative and through local, regional, and national conferences.

Publically available data hosted through The Data Repository for University of Minnesota (DRUM) (https://conservancy.umn.edu/handle/11299/166578)

Formation of Peatland Forest Stakeholder Group and the development of Management Recommendation for peatland forests which will incorporate multiple ecological functions including vegetation, water, and wildlife. The guidelines will be distributed to all stakeholders and will be made available through the Internet as a Department of Forest Resources Staff Paper Report.

First Update January 31, 2019

Materials are not ready to be distributed.

- The process for selecting and setting up the study was featured in the Duluth News Tribune in October 2018 and as part of the NRRI progress report, the articles can be found at the following links
    - https://www.duluthnewstribune.com/news/science-and-nature/4516137-scientists-hang-500-birdhouses-sax-zim-bog-study-boreal-chickadees#.W8nZ_XeUpYc.link
    - https://www.nrri.umn.edu/natural-resources-research-institute/news/boreal-chickadees

Second Update June 30, 2019

Materials are not ready for distribution and no presentations, papers, or outreach activities have been preformed.

Third Update January 31, 2020

A poster was presented on preliminary results from Activity 3 were presented as a poster at the Sustainable Forests Education Cooperative Research Review in early January 2020. Slides can for the event can be found https://drive.google.com/drive/folders/1y3o_djn2xjdpPC2ORuIluVBmhF7klAp5

Mid year update 2020

Due to COVID-19 there were few opportunities to disseminate research. An abstract on vegetation results was accepted the fall national meeting at the Society of American Foresters.

Third Update January 31, 2021

Preliminary data on the vegetation has been presented at two conferences Society of American Foresters and the Sustainable Forests Education Research Review.

Fourth Update June 30, 2021

No additional material have been distributed for this project.

Fifth Update January 31, 2022

No additional material have been distributed for this project.

Final Report Summary

We are currently working on final edits and submission for two peer reviewed papers with an additional two papers in progress which will continue outside of the granting program. Results have been shared through multiple forms including local news stories Scientists hang 500 birdhouses in Sax-Zim Bog to study boreal chickadees, presentations to forest managers at the Research Review hosted by the Sustainable Forest Education Cooperative, to a special symposium on Wet forests which brought together researchers and managers to discuss opportunities and challenges within peatland forest communities.

V. PROJECT BUDGET SUMMARY:

A. Preliminary ENRTF Budget Overview: See attached budget spreadsheet

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

Explanation of Use of Classified Staff: N/A

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

Enter Total Estimated Personnel Hours: **8.4**	Divide by 2,080 = TOTAL FTE
Windmuller-Campione: 480 (4 wks. for 3 years)	0.23
Grinde: 720 (6 wks. for 3 years)	0.35
Grad students (2 people half time for 3 years)	3.00

Research scientist (1 person three quarters time for 3 years)	2.25
Bird bander (1 person for 1 mos. for 2 years)	0.15
Undergraduate field technicians (3 people for 14 wks for 3 years)	2.42

Total Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation: *None*

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

B. Other Funds:

SOURCE OF AND USE OF OTHER FUNDS	**Amount Proposed**	**Amount Spent**	**Status and Timeframe**
Other Non-State $ To Be Applied To Project During Project Period: *N/A*			
	$	$	
Other State $ To Be Applied To Project During Project Period: *N/A*			
	$	$	
In-kind Services To Be Applied To Project During Project Period: Total amount $483,874 (Secured)			
In-kind salary and fringe for Dr. R. Slesak over course of project: $24,000			
In-kind support from DNR Division of Ecological and Water Resources Division, Division of Forestry, and Division of Fish and Wildlife: $36,800			
In-kind assistance with periodic lodging at Div. Wildlife field station: $18,000			
Potetial use of Argo, truck, and trailer for site assess and transportation: $6,000			
Unrecovered indirect costs@ 54% (2018, 2019, 2020) of total direct cost $668,003: $376,628			
Past and Current ENRTF Appropriation: *N/A*			
	$	$	
Other Funding History: *N/A*			
	$	$	

VI. PROJECT PARTNERS:

A. Partners receiving ENRTF funding

Name	**Title**	**Affiliation**	**Role**
Marcella Windmuller-Campione	Assistant Professor	University of Minnesota, Twin Cities	Project Manager, Oversee all project activities, Lead on Activity 1 & 4

Alexis Grinde	Research Program Manager, Wildlife Ecologist.	Natural Resources Research Institute, University of Minnesota Duluth	Oversee Wildlife Work Activity 3.
Robert Slesak	Adjunct Assistant Professor Program Manager	University of Minnesota, Twin Cities Minnesota Forest Resources Council	Oversee Hydrology Work Activity 2

B. Partners NOT receiving ENRTF funding

Name	Title	Affiliation	Role
MN DNR (Divisions of Ecological Water Resources, Forestry, and Fish and Wildlife)	Multiple	MN DNR	Assist with site selection for Activities 1, 2, & 3. Assist with the development of colloborative partnership in Activity 4

VII. LONG-TERM- IMPLEMENTATION AND FUNDING:

The project will produce results in four key areas: forest stand development, hydrology, wildlife use, and management recommendations. A systematic study investigating vegetation, wildlife, and water has not been completed for forest peatlands in Minnesota. By studying these three components simultaneously, the final piece – management recommendations – will provide a holistic assessment of how forest management will influence each of the three components: vegetation, wildlife, and water.

The specific deliverables for the project will be (1) the establishment of a network of peatland forest sites distributed across forest types and age classes; (2) a dataset that will allow for the holistic assessment of forest vegetation development, hydrology, and wildlife ; (3) the formation of a collaborative partnership among stakeholders in peatland forest systems to provide guidance in the development of forest management guidelines which account for the multiple ecosystem services peatland forest communities provide; and (4) increased understanding of the importance of peatland forest communities by policy-makers, natural resource managers, and the public through educational and outreach opportunities via online material and webinars, seminars, reports, and conferences.

The increased knowledge of peatland forests will likely lead to additional questions including what are potential alternative forest management options that increase economic and ecological resilience and how does the timing of treatment influence other objectives including wildlife? The use of a collaborative partnership with the development of the management recommendations will lead to future opportunities to increase of understanding of this complex but understudied ecosystem.

VIII. REPORTING REQUIREMENTS:

- **The project is for 4 years, will begin on July 01, 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 - NA

D. Acquisition, Easements, and Restoration Requirements - NA

E. Research Addendum – Separate document

006-A Maximizing Wildlife, Water, and Productivity in Peatland Forests — Windmuller-Campione

Research Team: Marcella Windmuller-Campione (Department of Forest Resources, UMN); Alexis Grinde (Natural Resources Research Institute); Robert Slesak (MN Forest Resources Council)

Collaborators: MN DNR (Divisions of Ecological and Water Resources, Forestry, & Fish & Wildlife)

Rationale

- Peatland forests cover **20% (3 million acres) of all forest land** and 30% (1.5 million acres) of state land
- Minnesota has the most peatland forests in the lower 48.
- Peatlands are critical resource for wildlife, timber products, water quality, and biodiversity but are threatened by land-use conversion, altered hydrology, and forest pests
- DNR has a critical information need to guide integrated management of timber, wildlife, and water on state lands (see letter of support).
- Project team provides expertise in each of the 3 forest resources

Approach

- Develop network of sites that span a range of ages and conditions
- Determine how wildlife, water, and timber production vary with time and site conditions

Outcomes

- Integrated approaches for multi-resource management in peatland forests
- Strategies to address threats to peatland forests functions
- Continued supply of wildlife, water, and timber from remaining peatland forests.

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

Project Title: Peatland Forest Management
Legal Citation: M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 03d
Project Manager: Dr. Marcella Windmuller-Campione
Organization: University of Minnesota
College/Department/Division: Dept. Forest Resources
M.L. 2018 ENRTF Appropriation:
Project Length and Completion Date: 4 years, June 30, 2022
Date of Report: 9/30/22

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Amendment Request 11/21/22	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$471,728	$471,728	$0
M. Windmuller-Campione, project manager: $35,197 (75% salary, 25% benefits), 8% FTE for years 1, 2, and 3. No salary during year 4.		$41,753	
A. Grinde, research program manager at Natural Resources Research Institute: $39,396 (75% salary, 25% benefits), 12% FTE for years 1, 2, and 3. No salary during year 4		$39,252	
P&A Thomas Cianciolo, Laura Reuling, Alan Toczydlowski		$153,078	
Two graduate research assistants : $252,313 (52% salary, 48% benefits during academic year, 85% salary and 15% benefits during summer), 50% FTE for 3 years		$22,144	
Research Scientist at Natural Resources Research Institute: $103,915 (80% salary, 20% benefits), 75% FTE for 3 years		$172,688	
Bird bander: $5,938 (92.3% salary, 7.7% benefits), 8% FTE for 2 years		$16,435	
Three undergraduate research assistants: $66,092 (100% salary, 0% benefits summer, 92% salary 8% benefit acedmic year), 0.2 FTE for 3 years		$26,378	
Equipment/Tools/Supplies	$74,296	$74,296	$0
Forest inventory equipment (Activity 1): increment borers 2 @ $250.00 each, laser hypsometer 1 @ $1,500 each, calipers 2 @ $125 each (Total estimated amount $2,250)		$10,261	
Pressure transducers for continuous water table monitoring - 2 at each of 36 sites (Activity 2): 72 @ $350.00 each (Total estimated amount $2,250)		$5,146	
Tippping bucket rain gauges to continuously measure precipitation at 36 sites (Activity 2): 36 @ $450.00 each (Total estimated amount $16,200)		$25,916	
15 Digitial Audio Recorders for longer-term monitoring of amphibian and bird communities at field sites (Activity 3): DARs; $900.00 each. We will also use 15 DARs purchased for previous LCCMR project. (Total estimated amount $28,500)		$32,973	
Travel expenses in Minnesota	$53,975	$53,975	$0
Travel to 48 research sites multiple times each year to collect data related for Activity 1, 2, and 3. We estimate over 5000 miles traveled each year due to remote site location, long distances between sites, and many of the protect team members being based in the Twin Cities with sites located in northern Minnesota.Travel expenses includes lodging and meal allowance for graduate students, research associates, and field technicians		$53,975	
COLUMN TOTAL	$600,000	**$600,000**	$0