BLAZING STAR ENVIRONMENTAL

Empowering Henvey Inlet First Nation Youth to Lead the Long-term Monitoring and Artificial Habitat Restoration of At-Risk Reptiles on HIFN Lands

Interim Report
Contribution Agreement No. 2024-03




Prepared by:
Blazing Star Environmental

Prepared for:
Ganawenim Meshkiki

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Executive summary

Since 2019, Blazing Star Environmental (BSE) has partnered with Henvey Inlet First Nation (HIFN), Laurentian University, and McMaster University to design a broad scale assessment of the impacts of the 2018 PAR033 forest fire and the construction and operation of the Heney Inlet Wind Energy Centre (HIWEC) on the species at risk (SAR) reptiles that live on HIFN Reserve #2. The intention of this unprecedented long-term monitoring program is to understand how SAR reptiles respond to a) the impacts of construction and operation of HIWEC, b) various stages of landscape succession post-fire, c) climate change, and d) mitigation and habitat improvement measures implemented as a condition of the Species at Risk Act permit.

From the outset, this program has aimed to help build capacity within the HIFN community so that they may gradually take over the implementation and management of this project. As the project has grown, it has become clear that continuing to support in HIFN capacity building and expanding into a two-eyed seeing approach is vital to understand the impacts that the forest fire and wind farm have had on SAR reptiles and other wildlife within and around the community's lands. To date, the program has been a resounding success, however, since its inception, the program has expanded its goals to include a recurring framework of activities and long-term studies that build capacity within the HIFN community and adopt a two-eyed seeing approach to monitor ecological responses, habitat recovery, and conservation effectiveness over time.

The project goals are to:

- Understand how abundance, habitat use, and body condition of SAR reptiles respond to the impacts of construction and operation of HIWEC, various stages of landscape succession post-fire, climate change, and to the mitigation and habitat improvement measures implemented as a condition of the Species at Risk Act permit.
- Aid in building capacity within HIFN to actively train youth to learn conservation ecology techniques.
- Exchange knowledge with HIFN elders and knowledge keepers and adopt a two-eyed seeing approach to answer the study questions.
- Conduct monitoring to retain our ability to evaluate trends.

- Assess the effectiveness of artificial overwintering habitat that has been created on HIFN Reserve #2.

This will be accomplished through activities and studies including:

1) Exchanging knowledge with HIFN elders and knowledge keepers, training HIFN youth in conservation ecology techniques, and exchanging project information and results with HIFN community members.
2) A long-term mark recapture study including mark recapture and vegetation surveys to assess how populations and their habitat respond to disturbances caused by wind turbine development and wildfires, offering key insights into their resilience and conservation needs.
3) Assessing and monitoring artificially created habitat use and success compared to natural habitat through visual encounter surveys, mark-recapture, radiotelemetry and monitoring of ecohydrological characteristics.

This seventh field season of this program was a resounding success, and this report summarizes the project activities completed through the end of the 2025 season.

The following deliverables have been accomplished in 2025:

- Population estimates are being updated during winter 2025/26.
- Ecohydrological monitoring stations were maintained at 13 constructed and 12 natural wetlands and recorded data at 15-minute intervals. Data from previously installed weather stations were also recorded at 30-minute intervals.
- Vegetation and moss surveys were conducted at these sites once every 4 weeks from May – October 2025.
- 22 visual encounter surveys were conducted at 10 constructed wetlands, and throughout 2 larger natural wetlands (each containing multiple overwintering hummocks).
- Temperature profiles were maintained at 65 overwintering sites from December 2024 – spring 2025.
- A total of 192 person-hours of Massasauga mark-recapture survey effort was conducted in the sixth field season of this mark-recapture study.
- 12 massasaugas were captured and processed as part of mark-recapture surveys.
- 6 Blanding’s and 3 spotted turtles were captured and processed and had VHF and/or GPS devices attached for tracking.

Deviations from the project goals or final deliverables are as follows:

- Due to unforeseen challenges with staffing in 2025, knowledge transfer sessions, capacity building and project information sharing did not occur in 2025. However, BSE has made the decision to postpone any fieldwork in 2026 to focus the entirety of the year on knowledge gathering, capacity building, and community information sharing.
- In 2024, BSE made the decision to postpone the long-term monitoring study (including large scale mark recapture and vegetation surveys) until 2025 to focus on other studies. In 2025, large scale massasauga mark recapture surveys did take place, but large scale turtle mark recapture survey were postponed to continue to focus on, and wrap up, other project studies. However, some turtle surveys still occurred in specific sites in order to find the appropriate number and species of turtles to complete radiotelemetry objectives. Population estimates for both turtles and snakes will be updated in 2026.
- Due to permitting denials, BSE could not attach transmitters to, and track 10 Massasaugas. Instead, BSE plans to undertake a targeted social media campaign to directly reduce mortalities of Massasaugas by actively changing the behaviours and mindset of individuals and groups that would persecute or harm them. This will include market research into the most effective strategies to actively change minds and viewpoints, as well as identifying the target audience.

The seventh field season of this monitoring program was a success as the program continues to evaluate the effects of wind turbine development, wildfire, and climate change on reptile populations and habitats. As this multi-decade initiative progresses, its adaptive framework and seven-year review cycle will ensure that conservation strategies remain robust, data-driven, and reflective of evolving ecological and community priorities. These efforts will not only contribute to the recovery of SAR reptiles but also set a precedent for long-term ecological monitoring in Canada, providing a valuable model for balancing infrastructure development with conservation.

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1 Introduction

Since 2019, Blazing Star Environmental (BSE) has partnered with Henvey Inlet First Nation (HIFN), Laurentian University, and McMaster University to design a broad scale assessment of the impacts of the 2018 PAR033 forest fire and the construction and operation of the Heney Inlet Wind Energy Centre (HIWEC) on the species at risk (SAR) reptiles that live on HIFN Reserve #2. Target species include massasauga (*Sistrurus catenatus*), spotted turtle (*Clemmys guttata*), and Blanding's turtle (*Emydoidea blandingii*). Secondary target species include eastern foxsnake (*Pantherophis gloydi*), eastern hog-nosed snake (*Heterodon platirhinos*), and eastern musk turtle (*Sternotherus odoratus*). These species are secondary because they do not occur in high enough densities on the site to establish accurate population estimates. The intention of this unprecedented long-term monitoring program is to understand how SAR reptiles respond to a) the impacts of construction and operation of HIWEC, b) various stages of landscape succession post-fire, c) climate change, and d) mitigation and habitat improvement measures implemented as a condition of the Species at Risk Act permit.

From the outset, this program has aimed to help build capacity within the HIFN community so that they may gradually take over the implementation and management of this project. Despite engagement efforts being hampered by COVID-19, HIFN youth have demonstrated a keen interest in conservation ecology, and we anticipate that community members will continue to grow and eventually lead this program. As the project has grown, it has become clear that continuing to support in HIFN capacity building and expanding into a two-eyed seeing approach is vital to understand the impacts that the forest fire and wind farm have had on SAR reptiles and other wildlife within and around the community's lands.

To date, the program has been a resounding success, however, since its inception, the program has expanded its goals to include a recurring framework of activities and long-term studies that build capacity within the HIFN community and adopt a two-eyed seeing approach in order to monitor ecological responses, habitat recovery, and conservation effectiveness over time. This is intended to generate robust, long-term datasets that guide adaptive management and conservation decisions. With a longer-term view in mind, we have developed a plan that has three cycles of repeated activities and studies that coincide with meaningful time frames for change within turtle and snake communities and the length of the existing EGBI program.

It is important to note that post-impact monitoring of this scale and duration has never been conducted in Canada. Weaving western science with traditional knowledge while building the capacity of HIFN to coordinate the project on their land will be critical in understanding how populations of long-lived species respond to disturbance. It will also provide data to inform mitigation strategies to recover SAR populations and will demonstrate how much more can be achieved when adopting a two-eyed seeing approach.

In 2025, the seventh year of the long-term monitoring program was completed. The survey team was made up of staff members from Blazing Star Environmental (BSE), McMaster University, University of Waterloo and Henvey Inlet First Nation. The field season would not have operated as effectively without meaningful collaboration from HIFN community members. Two team members are HIFN #2 community members: Jason Ashawasegai and Anthony Ashawasegai.

1.1 Project goals

The goal of our project is to understand how abundance, habitat use, and body condition of SAR reptiles respond to the impacts of construction and operation of HIWEC, various stages of landscape succession post-fire, climate change, and to the mitigation and habitat improvement measures implemented as a condition of the *Species at Risk Act* permit. In the current proposal we plan to focus on capacity building within HIFN to actively train youth to learn conservation ecology techniques, conduct monitoring to retain our ability to evaluate trends, and assess the effectiveness of artificial overwintering habitat that has been created on HIFN Reserve #2.

From 2024 – 2026, we aim to accomplish the project goals through the following activities and studies:

1. HIFN Community Capacity Building and Knowledge Weaving

- By training local HIFN youth and using a two eyed seeing approach using Traditional Ecological Knowledge (TEK) with scientific data, this initiative aims to foster community involvement and ensure that the program reflects cultural values and local expertise. This collaborative approach builds capacity for long-term conservation efforts and strengthens ties between researchers and the community. The long-term aim of this capacity building will be for management of the project to be led entirely by local community members.

2. Long-term Monitoring Study

- Mark-Recapture Surveys: These surveys will provide essential data to estimate population sizes, survival rates, and health metrics of target reptile species. Monitoring these factors over time will reveal how populations respond to disturbances caused by wind turbine development and wildfires, offering key insights into their resilience and conservation needs.

- **Vegetation Monitoring Surveys**: Tracking habitat recovery post-disturbance will help assess the effectiveness of natural regeneration, and monitoring vegetation concurrently with mark recapture surveys can provide insights into how habitat changes may influence target species populations.

3. Artificial Habitat Effectiveness Monitoring

- This study will evaluate the use and ecological success of constructed artificial habitats compared to natural ones. Through methods like visual encounter surveys, mark-recapture, and radiotelemetry, it will assess whether target species are utilizing newly created artificial habitats, and how their spatial movements within the artificial treatment compare to natural areas. This also includes improving artificially constructed habitats and comparing ecohydrological characteristics of the artificial habitats with natural overwintering wetland habitat. The findings of this will inform the design and implementation of effective habitat restoration projects.

1.2 Alignment with EGBI Objectives

This conservation project aligns closely with EGBI's objectives in the following ways:

1. Knowledge of how SAR respond to and recover from impacts including construction and operation of HIWEC, and the wildfire of 2018 will be acquired. This knowledge will improve management of the target SAR and their habitat across their range.
2. This improved management will lead to increased biodiversity in the eastern Georgian Bay region.
3. This project contributes to the survival and recovery of the following EGBI's targeted species:
    - Massasauga rattlesnake (*Sistrurus catenatus*)
    - Spotted turtle (*Clemmys guttata*)
    - Blanding's turtle (*Emydoidea blandingii*)
    - Eastern foxsnake (*Pantherophis gloydi*)
    - Eastern hog-nosed snake (*Heterodon platirhinos*)
    - Eastern musk turtle (*Sternotherus odoratus*)

1.3 Study area

Five treatment areas of varying levels of impact were chosen to conduct the program studies and monitor population size of the three target species over time (Figure 1):

1. Control: the area north of the Key River and east of the fire footprint, and the area to the south of HIWEC will be studied as unimpacted control sites (green).
2. Wind: the area south of Henvey Inlet that was affected by construction, but not the fire (blue).
3. Burn: the area immediately north of the Key River that was affected by the fire, but not construction (orange).
4. Wind+Burn: the area north of Henvey Inlet and south of the Key River impacted by the fire and construction (yellow).
5. Artificial: the area at the southern boundary of HIWEC with a high density (n=10) of created massasauga overwintering habitats (purple).

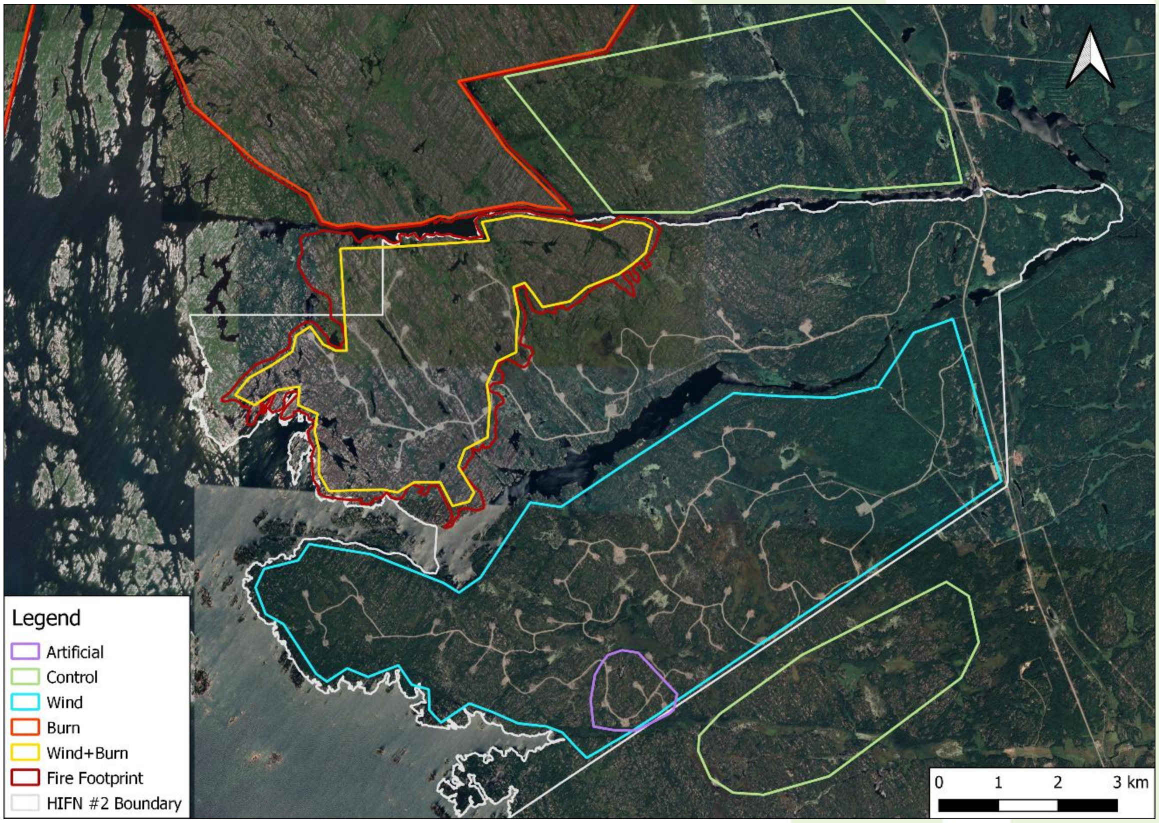

Figure 1. Long-term mark-recapture study treatment areas identified on and surrounding HIFN #2 (white) include Control (green), Wind (blue), Burn (orange), Wind+Burn (yellow), and Artificial (purple). Red indicates the boundary of the 2018 PAR033 wildfire.

2 Project progress

2.1 HIFN Community Capacity Building and Knowledge Weaving

Knowledge Gathering

Conduct knowledge gathering sessions with elders and knowledge keepers.

Weave together traditional knowledge and western science methods based on knowledge transfer sessions.

Due to unforeseen challenges with staffing in 2025, knowledge transfer sessions did not occur. However, BSE has made the decision to postpone any fieldwork in 2026 to focus the entirety of the year on knowledge gathering, capacity building, and community information sharing.

Capacity Building

6 HIFN youth engagement events.

Evaluate success of HIFN youth engagement events and update methods as needed.

Due to unforeseen challenges with staffing in 2025, capacity building within the HIFN community did not occur. However, BSE has made the decision to postpone any fieldwork in 2026 to focus the entirety of the year on knowledge gathering, capacity building, and community information sharing.

Community Information Sharing

Year end summary presentation conducted.

Due to unforeseen challenges with staffing in 2025, community information sharing did not occur. However, BSE has made the decision to postpone any fieldwork in 2026 to focus the entirety of the year on knowledge gathering, capacity building, and community information sharing.

2.2 Long Term Mark Recapture Study

Mark Recapture Surveys

Conduct mark-recapture survey for turtles across all four treatment areas.

Conduct mark-recapture survey for snakes across all four treatment areas.

In 2024, BSE made the decision to postpone the long-term monitoring study (including large scale mark recapture and vegetation surveys) until 2025 to focus on other studies. In 2025, large scale massasauga mark recapture surveys did take place, but large scale turtle mark recapture survey were postponed to continue to focus on, and wrap up, other project studies. However, some turtle mark-recapture surveys still occurred in specific sites in order to find the appropriate number and species of turtles to complete radiotelemetry objectives.

For all mark-recapture surveys, field crews entered target habitats (overwintering, foraging, gestation, basking) at the appropriate time of active season, searched for target species and captured and processed any observed individuals. In-field training for survey methods and processing procedures were provided to all team members by experienced Blazing Star Environmental staff including Siobhan Galway, Meagan Morey, and Jason Ashawasegai.

Since spring is the ideal survey window for capturing turtles, massasaugas that were encountered during the spring were recorded, but not captured, to allow sufficient time to survey and capture turtles for the radiotelemetry objectives. Any data that could be collected from a massasauga without capturing it was recorded. When turtle activity began to decrease in late June, survey effort was shifted to suitable massasauga gestation and foraging habitat. Surveys for massasauga were completed at all treatment areas.

Snake Visual Encounter Surveys (VES) followed Survey Protocol for Ontario's at Risk Snakes (OMNRF, 2016). To maximize detection, VES were conducted during periods when target species were expected to be basking, and thus more visible. Snake surveys were conducted by slowly walking through suitable habitat and watching for basking and foraging snakes and searching areas containing microhabitat features preferred by massasauga. VES for snakes were carried out under sunny conditions with air temperatures between 10-25 °C and 15-30 °C during overcast conditions.
Each captured individual was given a unique identifier. PIT (Passive Integrated Transponder) tags were inserted for snakes and a unique notch in marginal scutes was used for turtles. Captured massasaugas also had a rattle segment painted with non-toxic nail polish to indicate that they had been previously captured within the project and field season, and as a result, different nail polish colours were used for each season. Red nail polish was used in 2019, blue was used in 2020, purple was used in 2021, light blue was used in 2022, orange was used in 2023, and light green was used in 2025. All nail polish colours were carried in the field in case a massasauga from 2019-2023 was recaptured and needed its rattle repainted. In addition, every captured snake had a variety of characteristics measured (e.g., size, sex, mass, injuries,

behaviour, etc.). Finally, weather and habitat characteristics were recorded (e.g., vegetation, precipitation, temperature, etc.) for each capture event.

In 2025, massasauga mark recapture surveys began on July 9 and ended on August 29. A total of 192 person-hours of mark-recapture survey effort were carried out in 2025 (Table 1). Attempts were made to balance the survey effort across each of the four main treatment areas (Control, Burn, Wind, and Wind+Burn), however, the highest survey effort was conducted in the treatment areas within HIWEC; Wind (70 person-hours), Wind+Burn (57 person-hours), Control (20 person-hours), Burn (45 person-hours). Given the increased risks associated with working in remote sites, areas outside of HIWEC (Burn and Control) received less survey effort as remote areas were avoided during unsafe conditions (e.g., wildfire smoke, extreme heat, thunderstorms).

Table 1. Survey effort in each of the treatment areas from July 9 – August 29 2025.

Treatment area	Survey effort (person- hours) 2025
Control	20
Burn	45
Wind	70
Wind+burn	57
Total	**192**

A total of 12 unique massasaugas were captured in 2025, with 2 being recaptures from previous years. 4 were found in the Control (Figure 2), 3 were found in the Burn (Figure 3), and 5 were found in the Wind (Figure 4). No massasaugas were observed in the Wind+Burn treatment. 1 snake from the Burn treatment was not pit-tagged because it was too small.

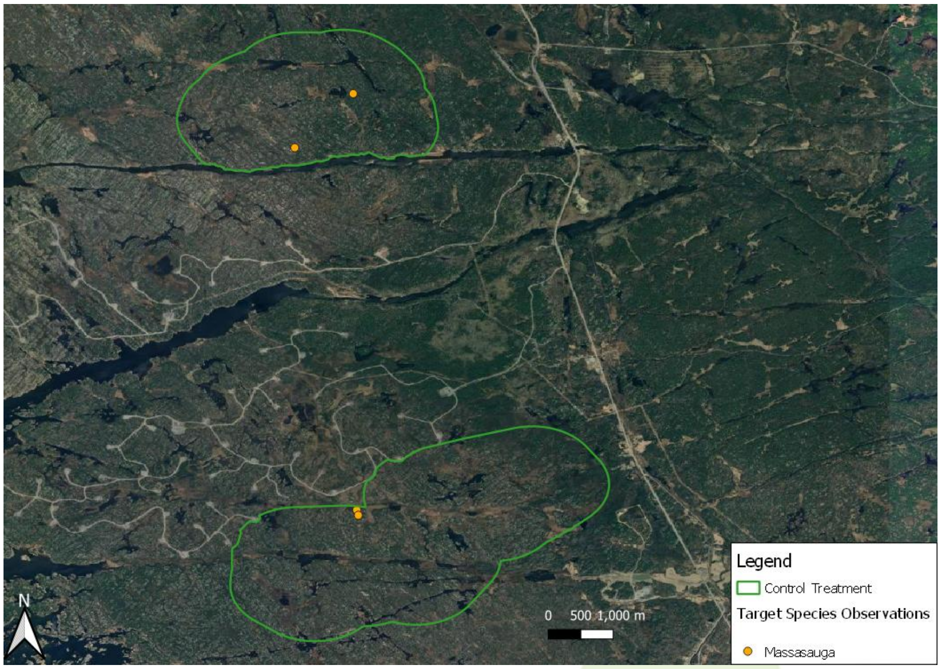

Figure 2. Locations of the 4 animals captured in the Control treatment area in 2025 (a) north of the Key River and east of the fire footprint and (b) to the south of HIWEC. Due to the large size of the study area and the observation of many animals in clustered locations, all individual observations are not independently distinguishable.

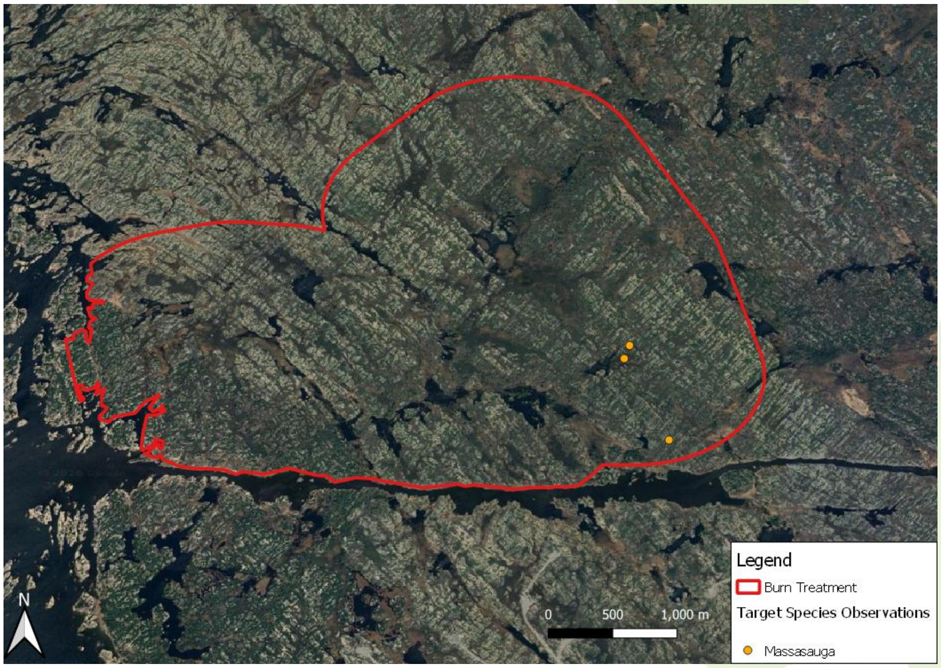

Figure 3. Locations of the 3 animals captured in the Burn treatment area in 2025. Due to the large size of the study area and the observation of many animals in clustered locations, all individual observations are not independently distinguishable.

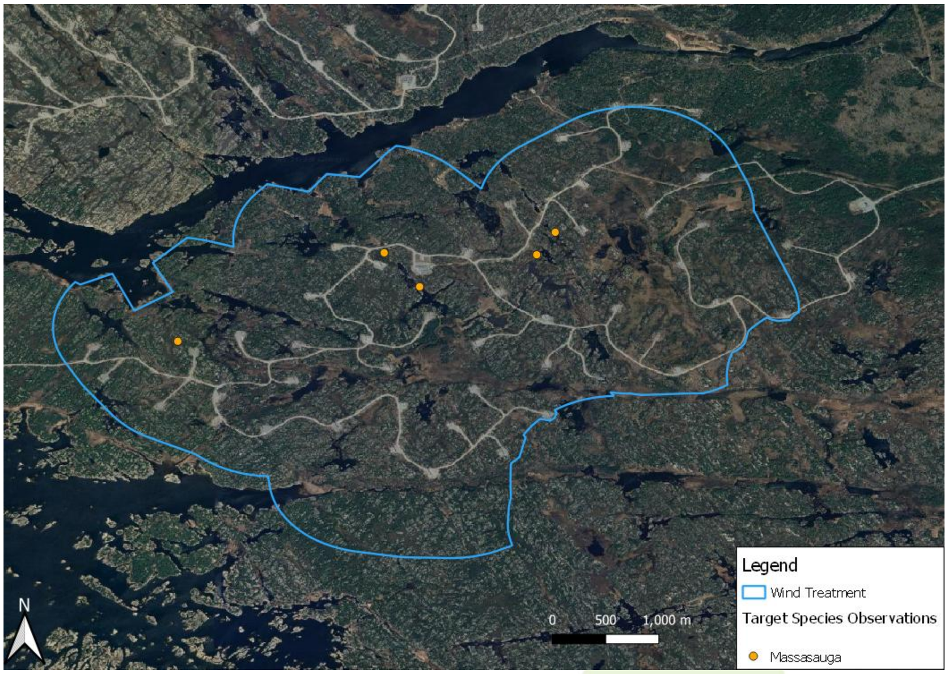

Figure 4. Locations of the 5 animals captured in the Wind treatment area in 2025. Due to the large size of the study area and the observation of many animals in clustered locations, all individual observations are not independently distinguishable.

Population Estimates

Calculate population size estimates for turtles and snakes in the four treatments.

Population estimates for all species in all treatment areas are currently being updated.

Vegetation Surveys

Conduct vegetation surveys at 24 established plots.

Vegetation surveys were conducted in four treatment areas (Control, Wind, Burn, Wind+Burn) with the purpose of measuring vegetation species abundance and composition after wildfire and/or construction.

Sites were selected within wetlands and rock barrens used by the target species. Rock barrens sites were selected based on confirmed massasauga gestation habitat and wetland vegetation sites were selected based on confirmed spotted turtle overwintering habitat since this type of habitat is the most sensitive and important habitat required for survival of all target species. Overwintering wetlands used by spotted turtles were chosen because this habitat type is characterized by a moderate degree of wetness when compared to the massasauga (drier) and Blanding's turtle (more wet) overwintering wetlands. Therefore, each spotted turtle overwintering habitat is likely to be used by two or three target species.

Vegetation surveys were performed in accordance with the survey protocol developed by McMaster University's Ecohydrology Group. In each pre-defined site, ten 1 m x 1 m quadrats were randomly placed throughout the site to accurately represent the diversity of vegetation. Surveyors recorded the percentage cover of all species of lichen and moss, vascular plants (e.g., shrubs, trees, herbs), litterfall, and bare rock or soil. For vascular plants, canopy height and the number of individuals were also recorded. Lastly, microforms such as hummocks, hollows, and lawns were recorded. Photos of each quadrat were taken to compare changes in vegetation over years.

Initial vegetation monitoring plots were established in rock barren and overwintering wetland habitat in 2019. However, as the mark-recapture site complexes were further refined and selected, new vegetation plots were added and some were dropped until the final number and locations of the long-term vegetation monitoring sites were determined in 2022 (Figure 5).

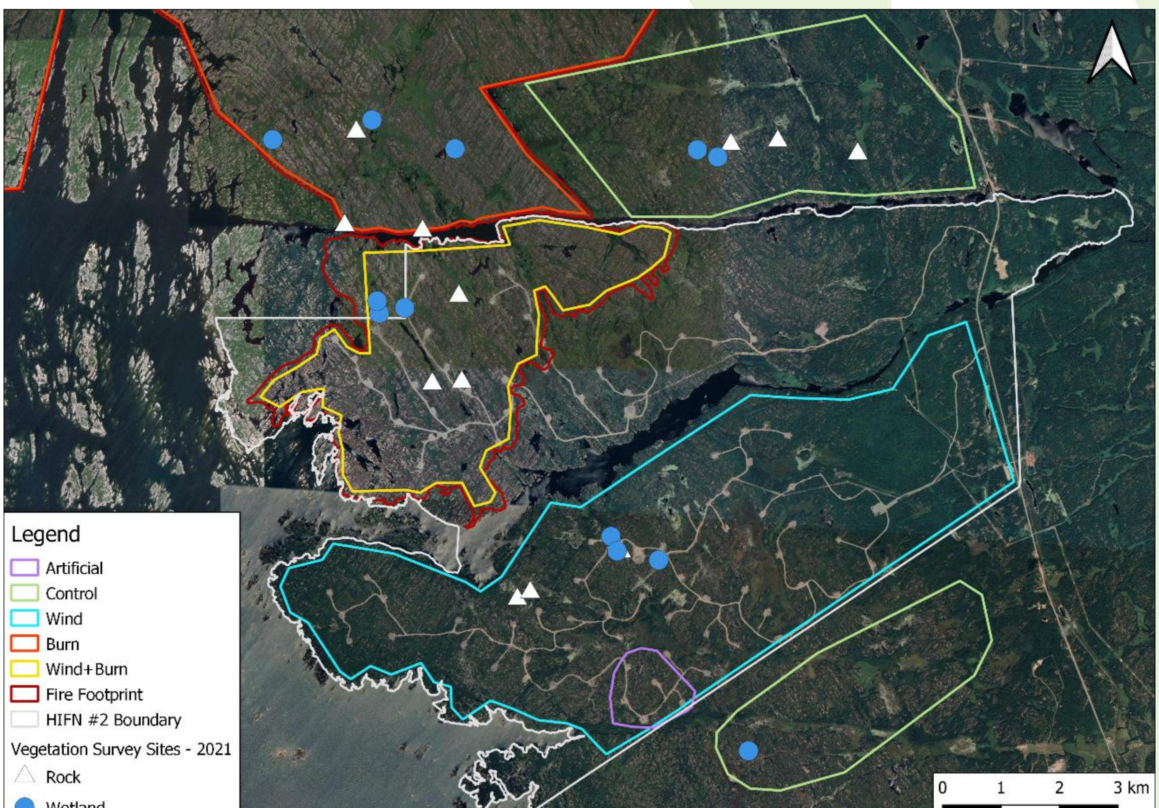

Figure 5. Location of long-term vegetation monitoring sites including 12 wetland sites and 12 rock barrens sites finalized in 2022.

In 2025, vegetation surveys were conducted in each treatment from August – October. Analysis of the vegetation data will occur in 2026 and will be included in the Final Report.

2.3 Assess Artificial Habitat Effectiveness

Improve, assess and monitor artificial habitat

Add ecohydrological monitoring stations to constructed wetlands.

Ecohydrological monitoring of 10 constructed and 10 control wetlands.

Ecohydrological monitoring stations were established and maintained at 3 additional artificial stations for a total of 13 stations instead of 10. Similarly, monitoring stations were established and maintained at 12 natural sites (rather than 10), with 6 on HIWEC and 6 offsite. 3 of the HIWEC sites were previously established and monitored, and 4 new sites were selected and instrumented with groundwater wells. These new sites were identified as spatially heterogeneous natural wetland systems that support species co-occurrence of turtles (e.g., Blanding's turtle, spotted turtle, Midland painted turtle, snapping turtle) and Massasauga. Wetlands that support co-occurrence have peatland microtopography associated with snake overwintering habitat and open water areas consistent with turtle overwintering habitat (Markle et al. 2020a). Each natural wetland has confirmed co-occurrence observations based on historical spring visual encounter surveys conducted prior to the development of the wind farm (2017). These data indicate the presence of both snakes and turtles within 400 m of each designated natural wetland site. This was a key determinant of natural site designation, as reptiles exhibit site fidelity and seek previously used refugia within the same geographic locations (e.g., Markle and Chow-Fraser 2017; Yagi et al. 2020). Accessibility of the site was also crucial in natural site selection, as instrumented areas must be navigable throughout the year to permit safe data collection, especially in the winter.

In December 2024, eleven additional groundwater monitoring stations were installed in wetlands selected by Blanding's and spotted turtles for overwintering. Wetlands were chosen for instrumentation based on December species at risk (SAR) locations determined through radio telemetry. The presence of physical barriers such as bedrock ridges or beaver dams also guided installation, as these features may suggest differential water table (WT) fluctuations among wetlands which are disconnected from one another.

At each site (13 created, 12 natural, 11 reptile occupied), one groundwater or surface water well has been installed (Figure 6). Wells were preferentially placed in open water areas near the center of the wetland to most accurately monitor changes in water table position (i.e., in the deepest location), however depending upon site characteristics, wells were installed on the peat surface if open water was not present (i.e., the install site had a WT below the peat surface). Each well consists of a 2-inch PVC casing tube containing a Solinst Levellogger Junior pressure transducer (Solinst, Georgetown, ON), which has been programmed to record water table position (cm below surface) at 15-minute intervals. Continuous data was collected through 2024 and 2025 and is currently being analyzed.

Figure 6: Well monitoring locations at created wetland sites (red circles), natural wetland sites (green circles), and reptile occupied sites (purple circles) within HIWEC. Each well has recorded water table (WT) position (cm below surface) at 15-minute intervals occurring throughout 2024 and into 2025. Note that only the 6 HIWEC natural sites are shown here (6 offsite wetlands not shown).

Within the HIWEC landscape, rainfall (mm), air temperature (° C), and relative humidity (%) are recorded every 30 minutes using a previously installed Campbell Scientific GRWS100 automated weather station (Campbell Scientific, Inc., Logan, UT), which is maintained by McMaster University. Environmental data have been recorded at variable frequency, ranging from every 30 minutes to five times per day. To determine duration and extent of snow cover, time-lapse imagery has been captured six times per day (hourly from 9:00 until 14:00) by Stealth Cam XS16 16 MP cameras. These snow cameras were installed at three of the created sites and are maintained in collaboration with McMaster University. However, we have encountered some difficulties with the snow stakes falling over because of shallow peat depths (stakes are not stable) and windy conditions.

Complete improvements for 10 constructed overwintering wetlands.

Conduct vegetation and moss surveys at 10 constructed wetlands.

Each of the 13 created sites have some exposed or bare peat rather than *Sphagnum* moss cover. *Sphagnum* has not been found to readily recolonize bare peat surfaces when left to regenerate naturally after disturbance, thus the active reintroduction of *Sphagnum* is suggested as the first essential action to restore peatland function (Rochefort 2000; Gorham and Rochefort 2002). McMaster University and University of Waterloo has developed a moss reintroduction technique to maximize *Sphagnum* groundcover within created sites, as mosses are foundational in maintaining ecohydrological feedbacks within peatlands due to their ability to uptake and hold moisture (McCarter and Price 2014; Waddington 2015). Thus, it is critical to reestablish moss cover to further promote moisture retention at the hummock scale and enhance Massasauga overwintering habitat suitability.

Experimental and reference plots were located and surveyed until fall using the following protocol. Three plots consisting of at least 61% naturally established, visually healthy Sphagnum ground cover were identified in each created site (classified as “Sphagnum control plots”; total of 39 plots; PLOT ID 7–9). A 1 x 1 m quadrat was placed on each plot with the flat sides of the quadrat facing the cardinal directions, and GPS coordinates of the plot’s center were recorded. A fluorescent orange plot marker was added to the north-east corner of each quadrat to aid in locating surveyed plots and ensure that quadrats are placed in the same location upon each survey. The percent cover (%) of groundcover species was visually estimated to a sum of 100% (including any groundcover under vascular plant canopy). Species level was recorded when possible, however genus or functional group was recorded for all quadrats. Standing on the north side of the plot and facing south, photographs of each plot were taken parallel to the ground, including a clear label of quadrat and site details (e.g., type of plot, PLOT ID). Canopy openness photographs were also captured from the ground surface above the center of the plot, recorded in the Gap Light Analysis Mobile Application (GLAMA) on a designated mobile tablet.

Additionally, six plots with at least 41% exposed peat were identified and surveyed in each of the 13 wetlands in 2023 (total of 78 plots). When identifying these plots, quadrats were placed to maximize the area of bare peat exposed within the selected area. In May 2024, two healthy *Sphagnum* plugs harvested within a designated natural wetland complex were planted within three of these plots (“peat restore plots”; total of 39; PLOT ID 1–3), with the remaining three plots remaining bare (“bare peat control plots”; total of 39; PLOT ID 4–6; Figure 7). *Sphagnum* control and bare peat control quadrats perform as experimental reference plots and were monitored for changes in percent moss cover and vegetation composition (e.g., moss groundcover, vascular species). Each quadrat was surveyed once every four weeks from May to October 2024 and April to September 2025.

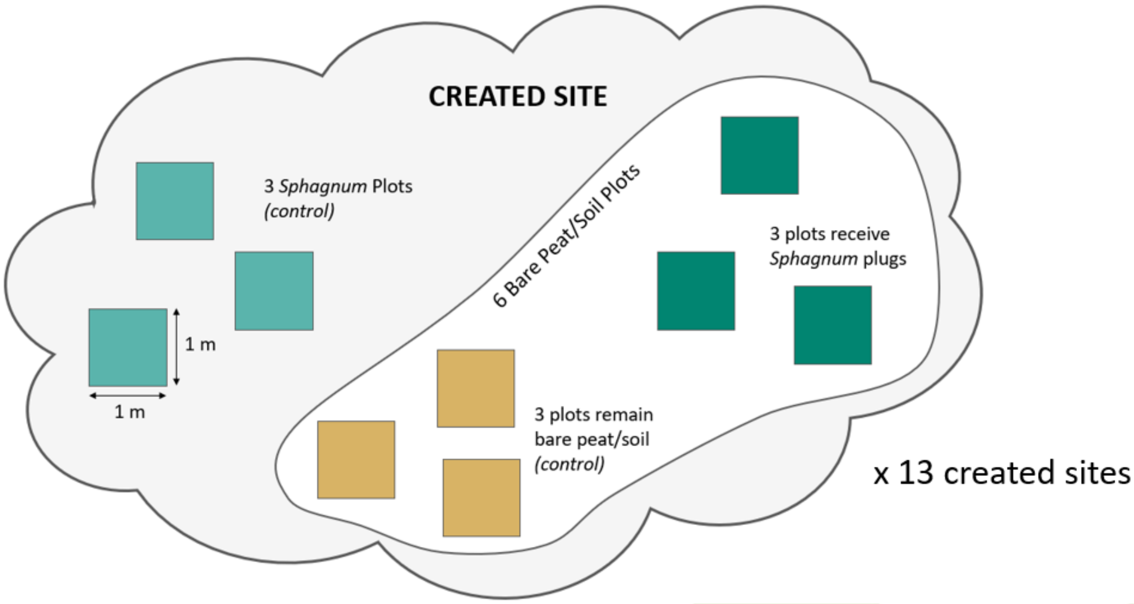

Figure 7: Schematic diagram showing moss restoration design, including six experimental bare peat/soil plots (three of which remain bare, three receive Sphagnum plugs) and three Sphagnum control plots.

Six donor sites were identified in April 2024 and were preferentially selected based on visual extent and health of *Sphagnum* cover, proximity to experimental sites, and accessibility of travel for monitoring. To begin, a 1 x 1 m quadrat was established on hummock or lawn microtopography within the donor wetland, with hollows and areas of dense vascular vegetation being avoided. A GPS point was located using the Geode GNSS Receiver and a "before harvest" photograph was taken, then ground cover (%) and vegetation cover (%) were recorded. Areas comprised of continuous and moist *Sphagnum palustre* or *Sphagnum magellanicum* were identified. These *Sphagnum* species were selected as they are commonly found within and around the created sites and surrounding natural wetlands, and grow primarily on hummocks and lawns. Using a serrated peat knife or trowel, a plug (10 cm diameter, 10 cm length including live and decomposed material) was removed from the plot. To standardize plug sizes, a 10 x 10 cm aluminum cylindrical duct connector was used as a cutting guide. This cylinder was placed on the moss surface, carefully cut around, and slowly pushed into the subsurface to ensure accuracy and uniformity of plug dimensions while caution was used to avoid compressing the *Sphagnum*. When the inserted cylinder was flush with the moss surface, it was carefully pulled out of the ground with the moss plug inside, using a hand to cover the bottom and hold the *Sphagnum* in place. Remaining within the cylinder used for excavation, plugs were placed within a tub and carefully transported to created sites immediately for transplanting. This process was then repeated, with two plugs being harvested per plot. An “after harvest” photograph of the donor plot was taken following excavation, and a plot marker was installed to facilitate relocation for future surveys. To monitor the recovery of donor areas, we assessed each donor plot during moss surveys every four weeks from May to October 2024 and April to September 2025. In addition to recording pre-existing groundcover and vascular vegetation cover, we took three diameter and three depth measurements (cm) at each plug excavation site (two holes per plot).

Once an experimental plot was relocated in a created site, details including site number, plot type, and plot ID were recorded. Following the aforementioned survey protocol, percent cover of each groundcover species was determined, as well as vegetation species and percent cover of each. A “before transplant” photograph was taken of the plot, and canopy cover was recorded. Two 10 cm transplant locations were chosen within each plot, with each location being comprised of and surrounded by bare peat, void of dense vascular vegetation or obstructions (e.g., root masses, rocks), and being situated at least 20 cm apart from one another (Figure 8). A 10 x 10 cm hole was dug in each transplant location, using a hand trowel and the cylindrical cutting guide to ensure accuracy and uniformity. One *Sphagnum* plug was then inserted within each hole (two plugs per plot), and was gently pat down to ensure contact with the bottom of the hole. The position of the plug was then recorded and each plug was labeled (A or B), and microtopography was documented. An “after transplant” photograph was taken, and groundcover was reassessed (moss species and percent cover of each groundcover). To quantify *Sphagnum* health, each plug was assessed independently. To examine lateral growth over time, the diameter of each individual plug was measured across three diameter lines upon each monthly assessment survey. We have implemented a variation of the crank wire technique (Clymo 1970) to assess vertical growth, in which bristles are affixed to the base of the wire to enhance stability and reduce the risk of wire subsidence (e.g., Bengtsson et al. 2016; Filippova and Kosykh 2024). We installed a 20 cm wire brush in the center of each moss plug, leaving a known length of 10 cm exposed upon insertion.

In sloped or uneven areas (e.g., upon the sides of hummocks), wires were inserted perpendicular to the plug surface. The length of exposed wire (cm) was measured during each survey. Additionally, the percent of living *Sphagnum* was classified to quantify plug health, with a rating of 1, 2, 3, and 4 corresponding to percent of moss in the plug classified as living ranging from >75%, 5–75%, 1–5%, and <1%, respectively. For all pre-existing *Sphagnum* within the plot, the percent living was also classified.

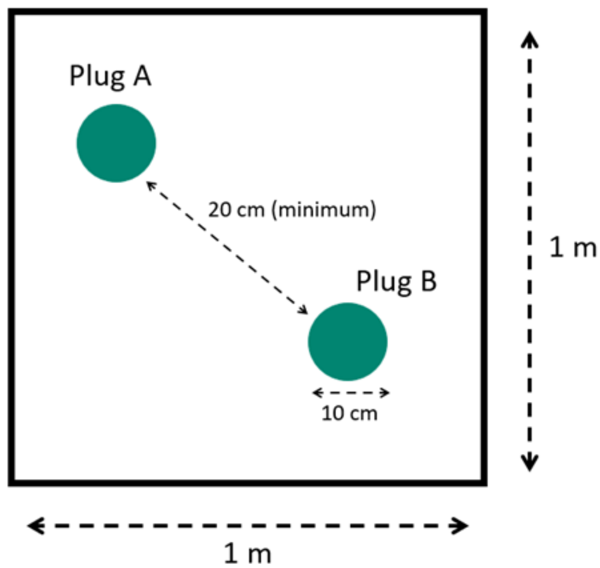

Figure 8: Schematic diagram representing Sphagnum moss transplant plot dimensions, including a 1 x 1 m quadrat, 10 x 10 cm diameter moss plugs, and a minimum 20 cm distance between plugs A and B. These dimensions were implemented for both donor plots (i.e., moss plug excavation locations) and experimental plots (i.e., bare peat plots which received moss plugs).

In four of the created sites, a HOBO USB Micro Station data logger with five Onset EC-5 soil moisture smart sensors (Onset Computer Corporation, Bourne, MA, USA) was installed during *Sphagnum* plug transplants to examine volumetric water content (m^3/m^3). To capture variability among created wetlands, instrumented sites included the wettest and driest sites (determined via presence and extent of open water, type and extent of vascular vegetation, pre-existing *Sphagnum* health), as well as two intermediate sites. In each site, one moisture sensor was installed within healthy *Sphagnum*, two sensors were installed in proximal bare peat, and the remaining two sensors were installed in an experimental/transplant plot (one sensor in Plug A, one sensor in Plug B). To ensure that the 5 cm probes were measuring conditions within respective moss plugs, they were positioned horizontally in the middle of the plug (i.e., 5 cm depth, 5 cm width). To minimize disturbance, each probe was carefully inserted through the side of the moss and the electrical wire was buried to minimize chewing or disruption from wildlife. To mitigate the risk of moisture damage due to rain, a plastic bag was taped to the Micro Station and a desiccant packet was placed within the panel.

In July 2024, in collaboration with McMaster University, tensiometers were installed in experimental/transplant plots (“peat restore plots”; total of 39) to measure peat near surface tension at a 5 cm depth. These were maintained in 2025. To capture variability among sites, tensiometers were installed in eight of the 13 created sites, including the two wettest sites, the two driest sites, and four intermediate sites. One tensiometer was installed in each transplant plot, for a total of nine tensiometers per site. In bare peat control plots and Sphagnum control plots, tensiometers were installed into the corresponding surface cover type. In experimental plots, bare peat adjacent to the plugs was instrumented. This represents the near surface tension which the Sphagnum plug must overcome to maintain hydrologic connectivity with surrounding peat. Three tensiometers were installed within each of the six donor sites, adjacent to excavation holes caused by harvesting the plugs. A total of 93 tensiometers were installed and intensively surveyed over a period of drought. To quantify rainfall over the survey period, a total of four manual rain gauges were installed within created sites. 50 mm of mineral oil was poured into rain gauges upon installation to facilitate accurate readings. Tensiometers were installed between June 10 and 14, and were filled with deionized water on July 11, following 18 mm of rain on July 10. Ten measurements were taken between July 12 and July 23, after which there was 16 mm of rainfall. Over the measurement period, a total of 2 mm of rain was recorded. The order of site measurements was randomized over the survey period to mitigate potential bias associated with the time of day in which measurements were recorded. Measurements included near surface tension recorded with a SMS Infield 7 Tensicorder with 1 hPa (1 mbar) sensitivity (Soil Measurement Systems, Huntington Beach, CA, USA), and moisture from 0–3 cm and 0–6 cm recorded using a ML3 ThetaProbe Soil Moisture Sensor with ± 1% soil moisture accuracy (Delta-T Devices Ltd., Cambridge, UK). Furthermore, 1 cm and 5 cm temperature were recorded with an AccuTemp digital thermometer (AccuTemp Products Inc., New Haven, IN, USA), and Sphagnum moss health was assessed visually on a scale from 0–2. An additional moss health level of -1 was included for Sphagnum moss identified as being in poorest condition. Peat depth, tensiometer height and length, surface cover type, and the microtopography at each tensiometer location was also recorded. Within donor sites, manual measurements of water level were taken from a slotted PVC groundwater monitoring well at the time of each tensiometer measurement to facilitate comparison with continuous groundwater monitoring wells in created sites. The data from these activities are currently being analyzed.

Conduct visual encounter surveys at 10 constructed and 10 control wetlands.

From April - October 2025, 6 visual encounter surveys were conducted in the areas immediately surrounding 10 constructed wetlands within the artificial treatment area (Figure 9). These wetlands were created when the HIWEC was built and are meant to provide overwintering habitat for species such as Massasauga and Spotted Turtle. The purpose of the surveys was to better understand the effectiveness of constructed wetlands by comparing the number of target species using natural and constructed wetlands during periods of ingress and egress.

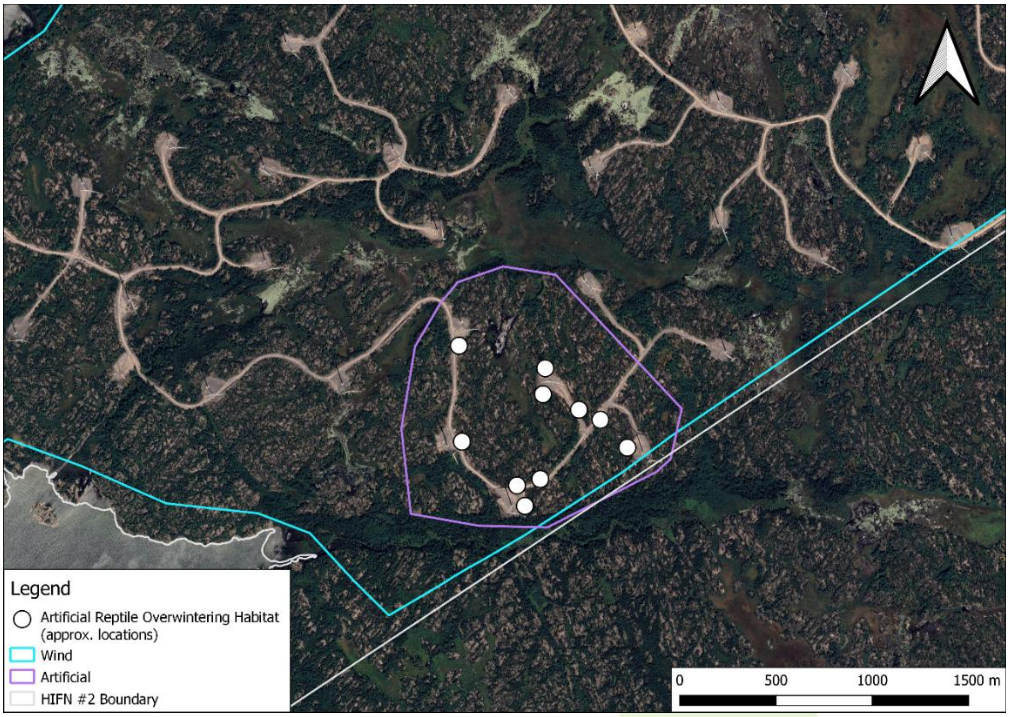

Figure 9: Locations of the created reptile overwintering habitat (white circles) surveyed in 2025.

The constructed wetlands are small (approximately 7 x 3 m) and require time without disturbance for vegetation to become established. Therefore, surveys were conducted on foot in 30 m buffers surrounding the constructed wetlands, but not directly within the wetlands. However, observers could look into the constructed wetlands while staying within the 30 m buffer.

In addition to the VES surveys in the area surrounding the constructed overwintering sites, 16 surveys were also completed in two large natural wetlands. These wetlands were near the south side of the wind treatment area. The purpose of these surveys was to locate natural wetlands used by the target species for overwintering. These naturally occurring wetlands are large and well-established on the landscape, allowing surveyors to walk carefully through suitable overwintering habitat within these wetlands.

In both constructed and naturally-occurring wetlands, surveyors could use a snake hook to improve Massasauga detection by gently disturbing vegetation to elicit a rattle response. The location of any Massasaugas or Spotted Turtles detected during a survey could be recorded, but the animal was not captured or handled. No target species were observed during these surveys. Additional information recorded during surveys included environmental conditions such as wind speed, air temperature, and survey duration.

Install temperature profiles at 60 overwintering wetlands including 30 occupied, 15 random and 15 constructed sites.

Monitor condition at 60 overwintering sites.

In 2024 a total of 30 thermal loggers were placed within occupied turtle and Massasauga overwintering wetlands and created wetlands (Figure 10). Of these 30 locations, 22 reptiles occupied profiles were installed within 1 m of turtle overwintering locations as turtles were radio tracked in 2024. Turtles were tracked and profiles were installed in the first week of December 2024. Since snakes were not radio tracked in 2024, 8 snake profiles were placed within confirmed snake overwintering wetlands.

Figure 10: Turtle and snake temperature profile locations in created and occupied/natural wetland sites within HIWEC for winter 2024/2025. Blue circles represent sites with turtle profiles, and orange circles represent sites with snake profiles. Yellow circles represent sites instrumented with both turtle and snake temperature profiles. Temperature profiles were installed in December 2024 and are recording subsurface temperature at 30-minute intervals.

To quantify subsurface temperature (° C) and examine the vertical column which reptiles may inhabit, thermal profiles were installed within created and natural sites and were monitored until spring 2025 when they were removed. Each thermal profile consists of a ½ inch PVC tube with four temperature loggers screwed into place at specified depth intervals (HOBO Pendant MX Water Temperature Data Logger, Onset Computer Corporation, Bourne, MA, USA). As snakes and turtles exhibit different overwintering habitat requirements, two groups of thermal profiles were deployed to appropriately examine both habitat types (Figure 11).

To analyze overwintering habitat pertaining to snakes, PVC tubes were instrumented with loggers to measure depths of 5 cm, 15 cm, 25 cm, and 50 cm below the surface (referred to as a "snake profile"). A total of 19 snake profiles were installed throughout the sites (11 profiles in created sites, 8 profiles in natural sites) in December 2024. Each profile was manually installed in an individual hummock which appeared to offer optimal snake overwintering characteristics, based on relevant literature (e.g., Smolarz et al. 2018; Yagi et al. 2020; Markle et al. 2020b) and previous field observations of habitat use within the study area. This included hummock surface height of at least 50 cm above the water table, and nearly 100% healthy Sphagnum moss cover. In areas where peat was too difficult to push through by hand due to extensive vascular root mass or frozen organic material, a thin soil auger was used to aid in profile installation.

To examine turtle overwintering habitat within the sites, "turtle profiles" were deployed to record water column and substrate temperature within open water areas. To construct turtle profiles, a screw was installed in the mid-point of a 120 cm piece of PVC. Upon installation at the site, this mid-point is placed at the sediment-water interface. Temperature loggers were installed 7 cm and 40 cm above and below the sediment-water interface line. A measurement of 7 cm is examined in accordance with preceding studies (e.g., Edge et al. 2009; Markle and Chow-Fraser 2017), with this depth representing the approximate height of a turtle's shell when sitting on the bottom of the wetland. Furthermore, previous literature suggests that approximately 40 cm of water is the minimum amount required to prevent freezing and support a turtle resilience zone (RZ), and adequate substrate depth is required to facilitate burying (Ultsch 2006; Edge et al. 2009; Markle et al. 2020a). A total of 16 turtle profiles were installed throughout the sites (8 profiles in created sites, 8 profiles in natural sites) in December 2024. Ice augers were used to break through open water areas which had frozen. To mitigate the risk of pseudoreplication, no more than two of each profile type were installed within the same site. When determining appropriate areas for profile installation within a wetland, we preferentially sought locations which provided at least 40 cm of water in December 2024. In areas where 40 cm of water was not available (i.e., one of the 13 constructed sites), the top data logger was moved down 10 cm to remain within the water column, and note was taken of the site conditions. To mitigate the risk of turtle profiles tipping or slanting due to soft sediment and to ensure ease of profile detection, a piece of slotted 2-inch PVC tube was placed over each turtle profile with the top 30–40 cm of material emerging from the water. This slotted PVC also allows water to flow through and around each logger to ensure accurate water temperatures are being recorded. As all Spotted Turtles were found to overwinter in hummock microhabitats on floating mats in December 2024, profiles were adapted to capture the temperature gradient descending from the moss surface rather than above and below the sediment-water interface line. These profiles were constructed to record temperature at depths of 5 cm, 30 cm, 55 cm, and 80 cm below the surface. For both snake and turtle profiles, loggers were programmed to record temperature at 30-minute intervals beginning in December 2024. Loggers collected data from Decembre 2024 – Spring 2025 when they were removed. Data for these activities are currently being analyzed.

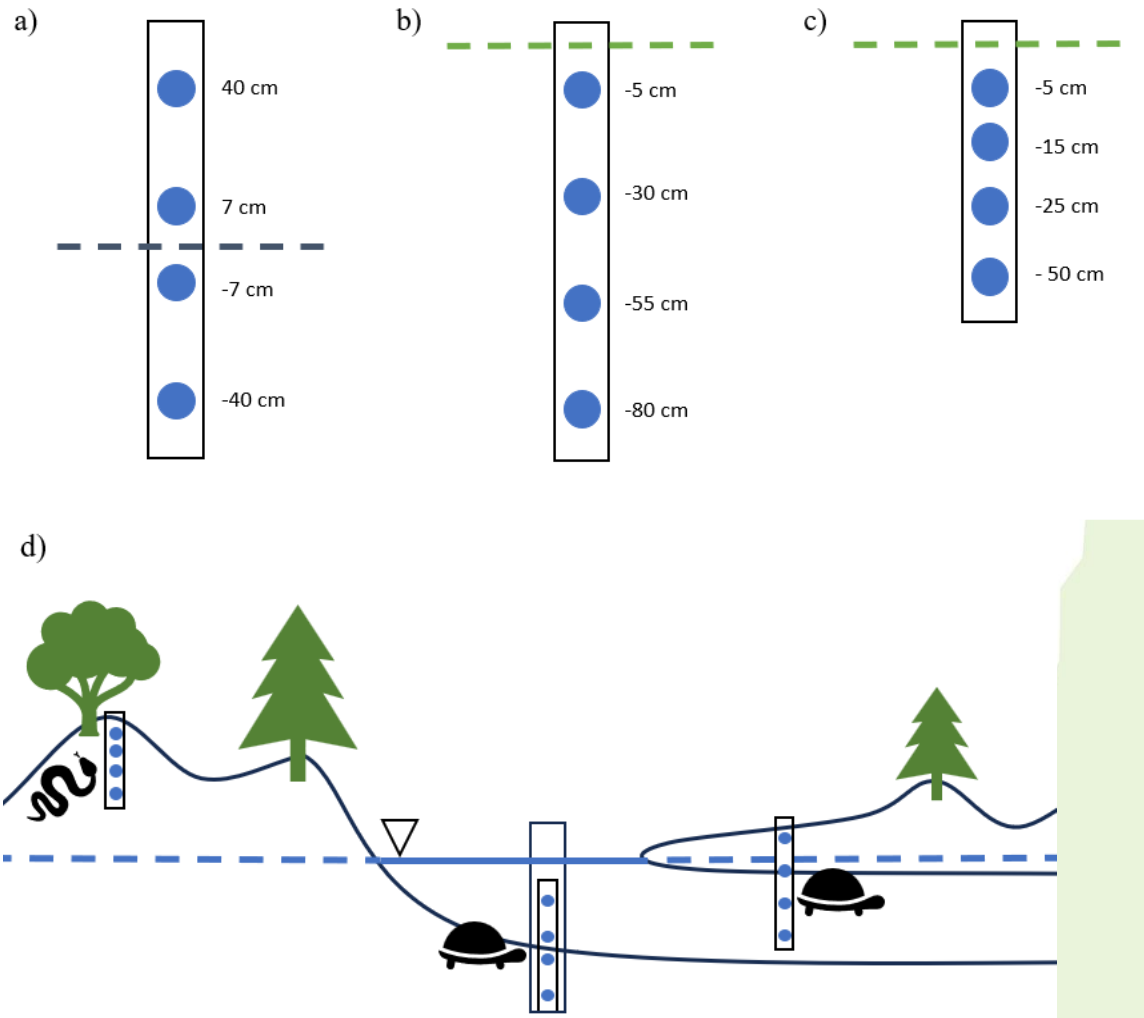

Figure 11: Schematic diagram depicting thermal profiles including a) turtle, b) modified turtle, and c) snake profiles. Blue circles represent temperature loggers which

are affixed to a PVC tube. Snake profiles have been constructed to measure temperatures at depths of 5 cm, 15 cm, 25 cm, and 50 cm below the hummock surface (green dashed line). Turtle profiles measure temperatures at 7 cm and 40 cm above and below the sediment-water interface (grey dashed line). Modified turtle profiles were constructed to accommodate spotted turtle overwintering locations beneath floating mats, recording temperatures at depths of 5 cm, 30 cm, 55 cm, and 80 cm below the mat surface (green dashed line). Panel d) includes a conceptual diagram representing thermal profiles installed within a complex, spatially heterogeneous wetland. Snake profiles are installed in hummocks above the water table (blue dashed line), and turtle profiles are installed within open water areas (solid blue line). Turtle profiles are encased in an external PVC casing to aid in profile location upon retrieval. Modified turtle profiles are installed through floating mats to represent spotted turtle overwintering microhabitat. Turtle and snake icons represent suitable overwintering habitat for each respective species.

Radio-telemetry study

Track target species 1-2x/week during the active season (May – October) including 10 massasauga, 10 Blanding's turtles, and 10 spotted turtles.

Track target species 1x/month during the inactive season (November – April) including 10 massasauga, 10 Blanding's turtles, and 10 spotted turtles.

Due to permitting denials, BSE could not attach transmitters to, and track 10 Massasaugas. Instead, BSE plans to undertake a targeted social media campaign to directly reduce mortalities of Massasaugas by actively changing the behaviours and mindset of individuals and groups that would persecute or harm them. This will include market research into the most effective strategies to actively change minds and viewpoints, as well as identifying the target audience. In 2025, only the areas in the Artificial treatment were targeted for turtle surveys. As with 2024, the aim of these turtle surveys was not to update our population estimates, but to capture enough Blanding's and spotted turtles for our radiotracking objectives.

Turtle surveys began on May 26, 2025. In-field training was provided to all team members by experienced staff, including Siobhan Galway, Senior Ecologist and Meagan Morey, Ecologist. Turtle surveys focused on suitable overwintering habitat for turtles. As the season progressed and turtles migrated to foraging habitat, turtle surveys were conducted in suitable turtle foraging habitat for both turtle species.

At the end of 2024, 8 Blanding's turtles remained with GPS devices and VHF transmitters, and 4 spotted turtles remained with VHF transmitters. For 2025, crews aimed to find 7 Blanding's to be outfitted with GPS devices and VHF transmitters, and 6 spotted turtles for a total of 15 Blanding's turtles and 10 spotted turtles. 6 new Blanding's turtles and 3 spotted turtles were captured and tagged in 2025, for a total of 14 Blanding's turtles and 7 spotted turtles tracked in 2025.

Each captured turtle individual was given a unique identifier (notch in marginal scutes) and had a variety of characteristics measured (e.g., size, sex, mass, injuries, behaviour, etc.). These characteristics will be assessed to determine how health of the populations change over time. Additionally, in order to assess an improve the effectiveness of artificially constructed habitats and determine the spatial movements and gene flow of Blanding's turtles, VHF transmitters were attached to Spotted Turtles and Blanding's Turtles. All Blanding's Turtles that received a VHF transmitter also received a GPS device. All captured animals were released exactly where they were found. At the end of the season, 11 of the 14 GPS and VHF transmitters on the tracked Blanding's turtles and were removed. However, 3 could not be removed as the transmitters failed or were accidentally turned off during the field season. 3 Blanding's turtles remain in the Artificial treatment with GPS and VHF transmitters. All transmitters were removed from the spotted turtles tracked throughout 2025. Radio-telemetry data is currently being analyzed.

3 Deviations from project proposal and goals

3.1 Postpone knowledge gathering/exchange sessions and youth engagement events and project presentations until 2026

- Due to unforeseen challenges with staffing in 2025, knowledge transfer sessions, capacity building and project information sharing did not occur in 2025. However, BSE has made the decision to postpone any fieldwork in 2026 to focus the entirety of the year on knowledge gathering, capacity building, and community information sharing.

3.2 Postponed mark recapture surveys

- In 2024, BSE made the decision to postpone the long-term monitoring study (including large scale mark recapture and vegetation surveys) until 2025 to focus on other studies. In 2025, large scale massasauga mark recapture surveys did take place, but large scale turtle mark recapture survey were postponed to continue to focus on, and wrap up, other project studies. However, some turtle surveys still occurred in specific sites in order to find the appropriate number and species of turtles to complete radiotelemetry objectives.
- Population estimates for both turtles and snakes will be updated in 2026.

3.3 Reduced number of tracked target species

- Due to permitting denials, BSE could not attach transmitters to, and track 10 Massasaugas. Instead, BSE plans to undertake a targeted social media campaign to directly reduce mortalities of Massasaugas by actively changing the behaviours and mindset of individuals and groups that would persecute or harm them. This will include market research into the most effective strategies to actively change minds and viewpoints, as well as identifying the target audience.

4 Conclusion

The seventh field season of this monitoring program was a success as the program continues to evaluate the effects of wind turbine development, wildfire, and climate change on reptile populations and habitats. As this multi-decade initiative progresses, its adaptive framework and seven-year review cycle will ensure that conservation strategies remain robust, data-driven, and reflective of evolving ecological and community priorities. These efforts will not only contribute to the recovery of SAR reptiles but also set a precedent for long-term ecological monitoring in Canada, providing a valuable model for balancing infrastructure development with conservation.

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