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 sixth field season of this program was a resounding success, and this report summarizes the project activities completed through the end of the 2024 season.

The following deliverables have been accomplished in 2024:

- Partnerships with the HIFN are being established and event planning is occurring for elder/knowledge keeper information exchange sessions, youth training and community engagement.
- It is important to note that ideas for these events are ideas only, and that the final outreach and event plan and what is included in it is subject to change and will ultimately depend on the feedback, knowledge, and wishes of the HIFN elders, knowledge keepers and community members.
- Population estimates are being updated during winter 2024/25 and will be used to inform survey effort in 2025.
- Ecohydrological monitoring stations were established at 13 constructed and 12 natural wetlands and are recording data at 15-minute intervals. Data from previously installed weather stations are also being recorded at 30-minute intervals.
- Sphagnum moss plugs were inserted in 13 constructed overwintering wetlands, and vegetation and moss surveys were conducted at these sites once every 4 weeks from May – October 2024.

- 5 visual encounter surveys were conducted at 10 constructed wetlands, and throughout 5 larger natural wetlands (each containing multiple overwintering hummocks).
- Temperature profiles were installed at 65 overwintering sites and are being monitoring throughout 2024 – 2025.
- A total of 594 person-hours of mark-recapture and radio telemetry survey effort were conducted in the sixth field season of this mark-recapture study within the artificial and control treatment areas.
- 31 target species were captured and processed in 2024, and 29 of these turtles had VHF and/or GPS devices attached for tracking.
- A total of 267 radio locations were collected and individuals were located and average of 11 times.

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

- Due to field season timing and to ensure BSE is conducting knowledge gathering and exchange events, youth training, and community outreach with success, BSE did not conduct knowledge gathering, youth training, or community events in 2024. Time in 2024 was spent learning, establishing partnerships and planning for events in 2025. 2 knowledge exchange events, up to 11 youth training events, and various community engagement events using multiple methods will occur in 2025.
- In 2024, BSE made the decision to postpone the long-term monitoring study (including large scale mark recapture and surveys and vegetation monitoring) until 2025 to focus on other studies, primarily radiotelemetry and assessing artificial habitat effectiveness. Large scale mark recapture surveys will occur in 2025, and the location and quantity of these surveys will be informed by updated population estimates
- 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.
- 2 spotted turtles were discovered predated in a wetland where multiple otter observations have been noted, 3 transmitters fell off turtles (1 Blanding's, 2 spotted), 1 spotted turtle had a transmitter removed as a health precaution, and 1 spotted turtle had its

transmitter malfunction. Additional turtles will be captured and tagged in the 2025 season to meet tracking deliverables.

- Reduced radio-tracking frequency due to logistical challenges of getting to sites, increased survey effort needed to capture target individuals, and site access/safety issues surrounding winter tracking. The reduced tracking frequency will not impact the quality of the data or our ability to analyze it.

The sixth 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. The integration of Traditional Ecological Knowledge and active involvement of the Henvey Inlet First Nation (HIFN) community will strengthen the program's cultural and scientific relevance. 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 2024, the sixth 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, and University of Waterloo. The field season would not have operated as effectively without meaningful collaboration from HIFN community members. Three team members are HIFN #2 community members: Jason Ashawasegai, Mike Ashawasegai, and Anthony Ashawasegai. Two of these community members remain employed and are helping with other project components including, but not limited to, planning for next field season and community outreach. The continued involvement and support from the HIFN community is essential to the success of this collaborative monitoring study.

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).

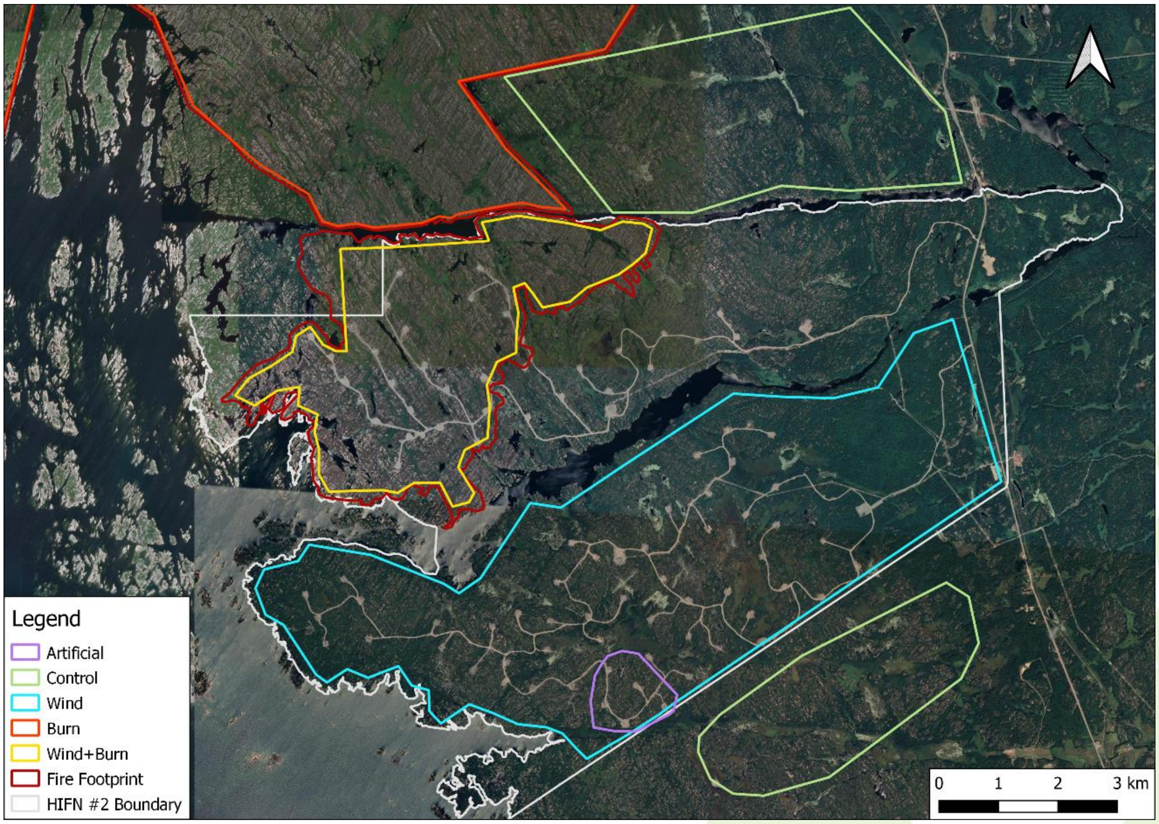

Figure 1. Long-term mark-recapture study treatment areas identified on and surrounding HIFN #2 (white) include Control (green), Wind (blue), Burn (orange), Wind+Burn (yellow), and Artificial (purple). Red indicates the boundary of the 2018 PAR033 wildfire.

2 Project progress

2.1 HIFN Community Capacity Building and Knowledge Weaving

2.2 Long Term Mark Recapture Study

2.3 Assess Artificial Habitat Effectiveness

Improve, assess and monitor artificial habitat

Add ecohydrological monitoring stations to 7 constructed wetlands.

Ecohydrological monitoring of 10 constructed and 10 control wetlands.

Ecohydrological monitoring stations were established at 3 additional artificial stations for a total of 13 stations instead of 10. Similarly, monitoring stations were established 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 2). 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 has been collected through 2024, and will continue in 2025.

Figure 2: 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 3). *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.

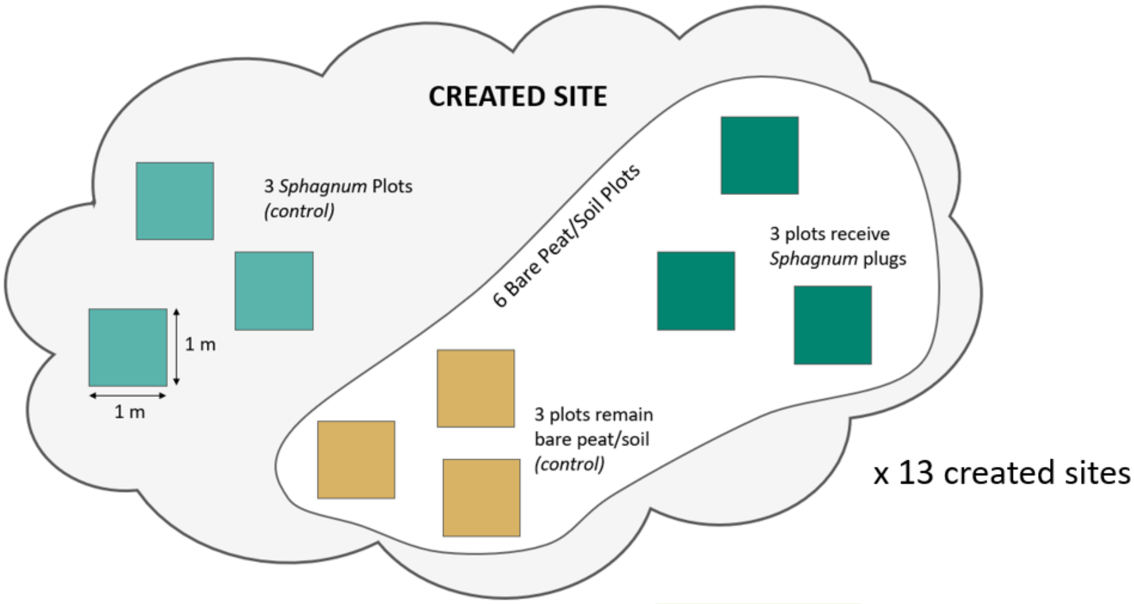

Figure 3: Schematic diagram showing moss restoration design, including six experimental bare peat/soil plots (three of which remain bare, three receive Sphagnum plugs) and three Sphagnum control plots.

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. 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 4). 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.

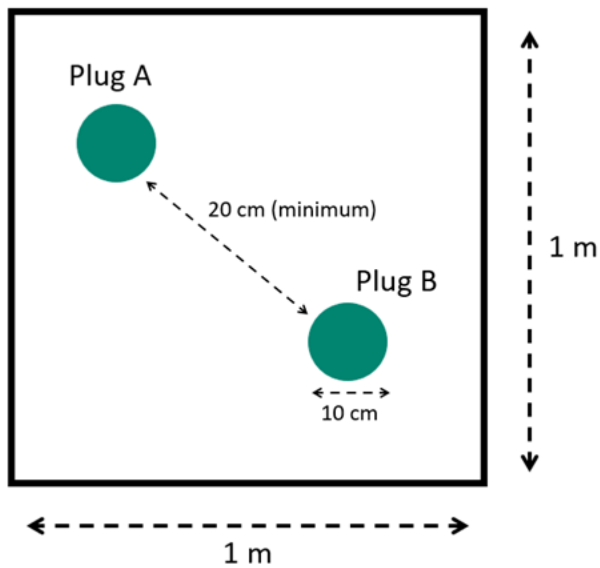

Figure 4: Schematic diagram representing Sphagnum moss transplant plot dimensions, including a 1 x 1 m quadrat, 10 x 10 cm diameter moss plugs, and a minimum 20 cm distance between plugs A and B. These dimensions were implemented for both donor plots (i.e., moss plug excavation locations) and experimental 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. 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.

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

Beginning in late August, snakes and turtles return to their overwintering habitat. Consequently, survey effort shifted at this time to suitable overwintering habitat for Massasaugas and Spotted Turtles. During October 2024, 5 visual encounter surveys were conducted in the areas immediately surrounding 10 constructed wetlands within the artificial treatment area (Figure 5). 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.

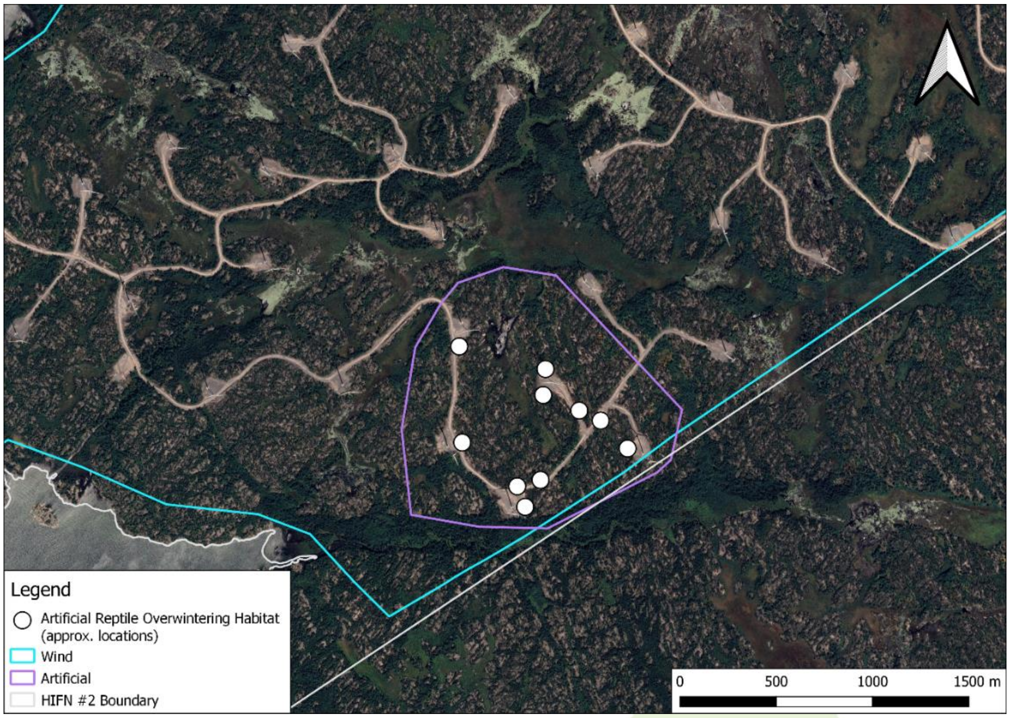

Figure 5: Locations of the created reptile overwintering habitat (white circles) surveyed in 2024.

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, 5 overwintering surveys were also completed in five 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 6). 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 6: 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 will be monitored until spring 2025. 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 7).

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.

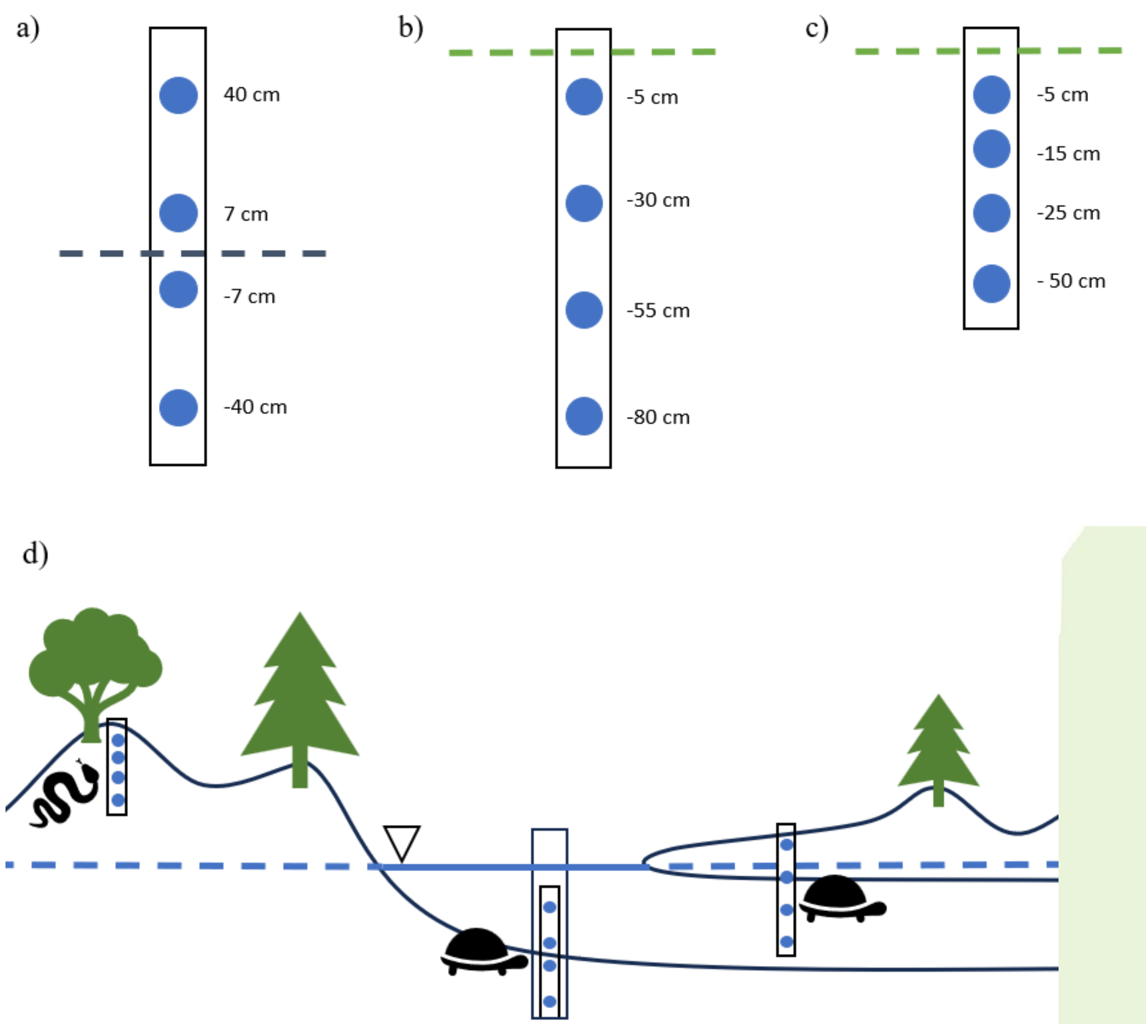

Figure 7: Schematic diagram depicting thermal profiles including a) turtle, b) modified turtle, and c) snake profiles. Blue circles represent temperature loggers which are affixed to a PVC tube. Snake profiles have been constructed to measure temperatures at depths of 5 cm, 15 cm, 25 cm, and 50 cm below 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.

Excluding Massasaugas, the radio-telemetry program used to assess artificial habitat use and success focused on Blanding's Turtles and Spotted Turtles in 2024. Mark-recapture surveys were conducted in 2024 to capture the necessary number of target individuals for our tracking objectives. Surveys began on May 3, 2024, with the first capture occurring on May 7, 2024. Regularly-occurring surveys ended on October 23, 2024, but due to mild weather, occasional radiotelemetry surveys continued into November.

In-field training was provided to all team members by senior staff, including Ori Urquhart and Senior Herpetologist, Siobhan Galway. Turtle surveys followed the OMNRF Survey Protocols for Blanding's Turtles (Ontario Ministry of Natural Resources and Forestry, 2015) and Spotted Turtles (Ontario Ministry of Natural Resources and Forestry, 2015). For all mark-recapture surveys, field crews entered target habitats (overwintering, foraging, basking) at the appropriate time of active season, searched for target species and captured any observed individuals. Initial reptile surveys focused on suitable overwintering habitat for Spotted Turtles and Blanding's Turtles. As the season progressed and turtles migrated to foraging habitat, turtle surveys were conducted in suitable turtle foraging habitat for both turtle species. Massasaugas were not the focus of the program in 2024, so any that were encountered during the spring were recorded, but not captured. Any data that could be collected from a Massasauga without capturing it was recorded.

A total of 594 person-hours of mark-recapture and radio-telemetry survey effort were conducted in the sixth field season of this mark-recapture study within the artificial and control treatment areas (Table 2).

Table 2. Survey effort in each of the control and treatment areas from May 3 – October 23 2024. Survey effort is expressed in person-hours.

Treatment area	Survey effort (person-hours) 2024
Control	286
Artificial	308
Total	**594**

Trained BSE staff captured and processed all target turtle species encountered, when possible. If species were unable to be captured in hand, the location, species, and any other information able to be gathered was recorded. Turtle surveys followed the OMNRF Survey Protocols for Blanding's Turtles (Ontario Ministry of Natural Resources and Forestry, 2015) and Spotted Turtles (Ontario Ministry of Natural Resources and Forestry, 2015). 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.

During the sixth year of this program, 31 new turtles (n = 10 Spotted Turtles, n = 21 Blanding's Turtles) were captured (Figure 8). Of the 31 turtles (10 Spotted Turtles, 19 Blanding's Turtles) captured this season, 29 were outfitted with a VHF transmitter. The 19 Blanding's Turtles were additionally outfitted with a GPS device. Two turtles were not outfitted with transmitters as they did not meet the weight requirements set out in in our animal care protocol. Individuals with transmitters were tracked throughout the field season. Figure 9**Error! Reference source not found.** outlines the number of each target species captured in the control and artificial treatments.

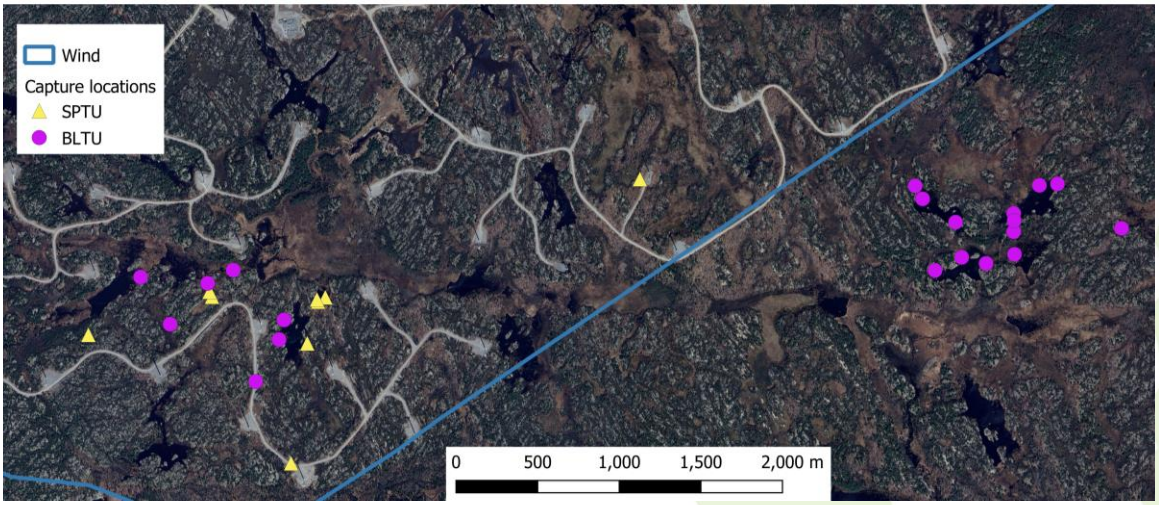

Figure 8. Locations of the captured turtles in 2024. Due to the large size of the study area and the observation of many animals in clustered locations, not all individual observations are independently distinguishable on the map.

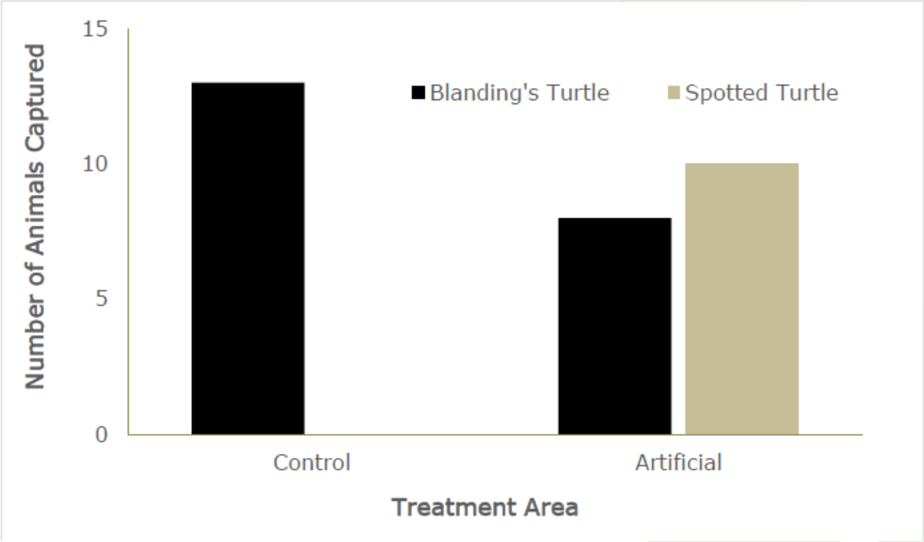

Figure 9. Quantity of Spotted and Blanding's Turtles captured in the Control and Artificial treatment area in 2024.

10 spotted turtles and 9 Blanding's turtles were located in the artificial treatment, and the remaining turtles were located in the control. Only 22

turtles (18 Blanding's, 4 spotted) were consistently tracked throughout the season. 2 spotted turtles were discovered predated in a wetland where multiple otter observations have been noted, 3 transmitters fell off turtles (1 Blanding's, 2 spotted), 1 spotted turtle had a transmitter removed as a health precaution, and 1 spotted turtle had its transmitter malfunction. Additional turtles will be captured and tagged in the 2025 season to meet tracking deliverables.

A total of 267 radio locations were collected (Figure 10). Of the 22 turtles that are currently equipped with radio tags, individuals were located an average of 11 times (± 4.05 SD). Blanding's turtles in the control were located an average of 10 times (± 2.22 SD), while Blanding's turtles in the impact site were located an average of 13 times (± 5.23 SD). Tracking frequency was reduced from 1-2x per week throughout the active season to 2x per month throughout the active season. The deviation of tracking frequency from the project proposal is due to the logistical challenges of accessing the sites, and the increased difficulty of navigating Blanding's habitat and capturing Blanding's compared to spotted turtles. The elimination of high frequency tracking during the active season reduced the strain on resources, allowing the team to capture as many new individuals as possible while still maintaining a high quality of data capable of answering the study question. Due to access issues and safety concerns, tracking frequency during the winter will be reduced from 1x per month. With milder weather in November, multiple tracking events took place, and in lieu of regular tracking once a month, BSE will track all tagged individuals as soon as the snow melts as early as possible in spring 2025.

Figure 10: All radio locations in HIWEC from the 2024 tracking season. Pink circles represent both spotted and Blanding's turtle locations. This figure includes data collected by both BSE and UW.

No tagged individuals are overwintering in a created site, however, over the course of the 2024 summer tracking season, 5 spotted turtles were found in created sites. One such tagged spotted turtle is overwintering 375 m east of the created site in a natural wetland. Blanding's turtles with GPS tags which were downloaded at minimum once a month. GPS tags were set to 1 fix/4 hours, total of 1793 additional locations were recorded from GPS devices (Figure 11). During October 2024 tracking, the team winterized the GPS tags by turning fixes off and charging the battery to full. Only one GPS was not winterized because from October to December 2024, the turtle could not be caught due to deep water (>2 m).

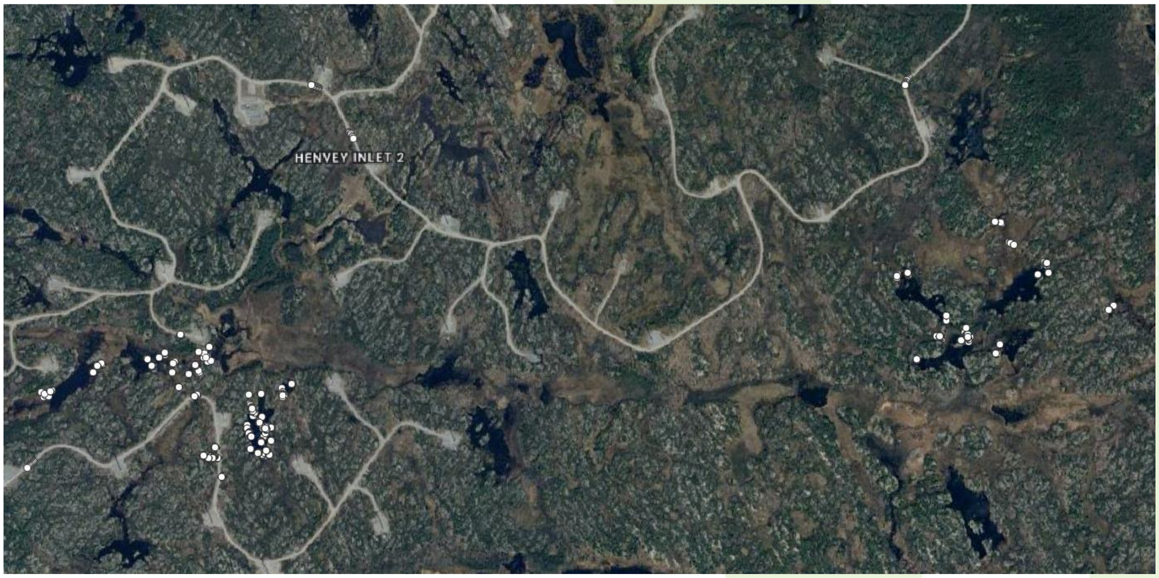

Figure 11: All GPS points in HIWEC from the 2024 tracking season. White circles represent Blanding's turtle locations. Note that some of the points along the access roads are from GPS units in testing (data cleaning is ongoing).

3 Deviations from project proposal and goals

3.1 Postpone knowledge gathering/exchange sessions and youth engagement events and project presentations until 2025

- In order to ensure BSE is conducting knowledge gathering and exchange events with the appropriate respect and practices for HIFN elders and knowledge keepers, BSE did not conduct any knowledge gathering events in 2024. Rather, the team has spent the winter months taking the necessary time to learn, discuss best approaches with community members, and plan, so that two successful knowledge transfer sessions can be held in 2025, rather than one. One session will occur in spring

2025, and the second will occur in fall 2025. Following these sessions, knowledge gained will be weaved with project methods, analysis and youth engagement events.

- Similarly, due to the contract being awarded mid field season as well as the time needed to plan, coordinate and execute successful and engaging events for youth and community members, BSE decided to postpone the youth engagement events and community project information sharing until 2025, where an increased number of events and varied methods for outreach will occur.
- Up to 11 youth engagement and training events will occur in 2025, and various methods will be used to share project information with and engage community members in the project. These include: reptile presentations, project update FB posts or newsletters articles, booths, and project presentations.
- However, it is important to note that these events are ideas only, and that the final outreach and event plan and what is included in it is subject to change and will ultimately depend on the feedback, knowledge, and wishes of the HIFN elders, knowledge keepers and community members.

3.2 Postpone mark recapture surveys to 2025

- In 2024, BSE made the decision to postpone the long-term monitoring study (including large scale mark recapture and surveys and vegetation monitoring) until 2025 to focus on other studies, primarily radiotelemetry and assessing artificial habitat effectiveness. Large scale mark recapture surveys will occur in 2025, and the location and quantity of these surveys will be informed by updated population estimates.

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.
- During the 2024 tracking season, 29 individuals (19 Blanding’s, 10 spotted turtles) were fitted with tags (10 spotted turtles and 9 Blanding’s turtles were located in the artificial treatment). However, only 22 turtles (18 Blanding’s, 4 spotted) were consistently tracked throughout the season. 2 spotted turtles were discovered predated in a

wetland where multiple otter observations have been noted, 3 transmitters fell off turtles (1 Blanding's, 2 spotted), 1 spotted turtle had a transmitter removed as a health precaution, and 1 spotted turtle had its transmitter malfunction. Additional turtles will be captured and tagged in the 2025 season to meet tracking deliverables.

3.4 Reduced tracking frequency due to logistical challenges of accessing sites

- Tracking frequency was reduced from 1-2x per week throughout the active season to 2x per month throughout the active season. The deviation of tracking frequency from the project proposal is due to the logistical challenges of accessing the sites, and the increased difficulty of navigating Blanding's habitat and capturing Blanding's compared to spotted turtles. The elimination of high frequency tracking during the active season reduced the strain on resources, allowing the team to capture as many new individuals as possible while still maintaining a high quality of data capable of answering the study question.
- Due to access issues and safety concerns, tracking frequency during the winter will be reduced from 1x per month. With milder weather in November, multiple tracking events took place, and in lieu of regular tracking once a month, BSE will track all tagged individuals as soon as the snow melts as early as possible in spring 2025.

4 Conclusion

The sixth 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. The integration of Traditional Ecological Knowledge and active involvement of the Henvey Inlet First Nation (HIFN) community will strengthen the program's cultural and scientific relevance. 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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