



Kenauk Institute – 2021 Annual Report



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Executive Summary

The Kenauk Institute is now the long-term custodian of the Kenauk property. Its responsibilities include: 1) To support, coordinate and supervise recreational activities and scientific research on the property and it's surrounding area, 2) Promote environmental education both locally and with key partner Universities, and 3) Connect Kenauk with the broader community. The vision is to establish a baseline inventory of biodiversity and monitor the property with a 100-year time horizon. With this vision, Kenauk is becoming a laboratory for monitoring climate change and human impacts.

Kenauk has proven to be an ideal location for a research institute because of its extensive size, its uniqueness as a pristine watershed and as a wildlife corridor. The abundance and diversity of flora and fauna in combination with the properties unique history provides endless possibilities for research and education.

In 2021 we accomplished 22 successful research projects and 1 inspiring educational program.

The foundations of our long-term monitoring mission are firmly in place with our own weather station and 150 permanent sample plots established throughout the property. Inventories of the property continue to surprise us with over 75 rare and endangered species being validated so far which is a testament to Kenauk's uniqueness. The historical and environmental significance of Papineau Lake as a pristine watershed and conservation priority also continues. We look forward to future successful partnerships, the results from our new projects and more innovative projects from incredible interns.

Due to the Covid-19 pandemic all our educational programs, except for the internship program, have been postponed until 2022 or until the programs can be safely executed. In previous years, the Kenauk Institute's educational programs included Outward Bound / YMCA groups, involvement in the Canadian Conservation Corps programs, field trips from local and regional schools, the ISFORT M.Sc. program, programs with Bishops College School (BCS) and Westover School, as well as our internship programs.

As we enter 2022 The Kenauk Institute and the Nature Conservancy of Canada are partnering in a unique capital campaign with the objective of making Kenauk and its surroundings the world's largest temperate forest dedicated to research and education, as well as establishing a permanent endowment for the Kenauk Institute.

[DONATE NOW](#)

Board of Directors

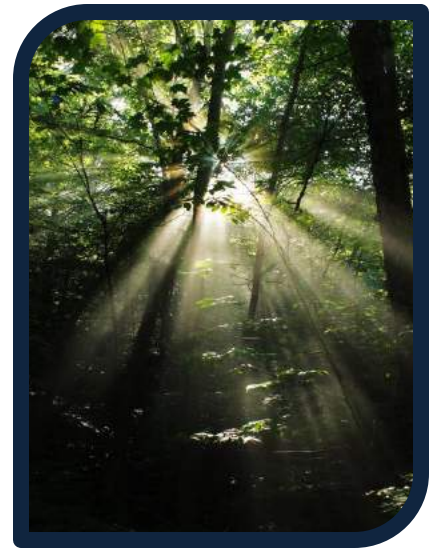
- Mr. Doug Harpur – Chair
- Ms. Sara Lydiatt – B.A., M.A.
- Dr. Altaf Kassam – B.Sc., PhD, M.B.A.
- Dr. Christian Messier – B.Sc., M.Sc., PhD
- Dr. David Philipp – B.Sc., M.Sc., PhD
- Dr. Kyle Elliott – B.Sc., M.Sc., PhD
- Mr. Patrick Pichette – B.A., M.A.

Members

- Mr. Doug Harpur
- Mr. Patrick Pichette
- Mr. Dominic Monaco
- Mr. Mike Wilson

Executive Director

- Liane Nowell – B.Sc., M.Sc.



Kenauk Companies

Kenauk is a 65,000-acre private property nestled in the pristine forest found between Ottawa and Montreal. Several companies exist on the property, where daily operations require a unique approach to management that supports the integration of multiple industries. The Kenauk Institute is the custodian of the property and, as such, informs the activities of all other Kenauk companies to ensure conservation is always a priority. The other companies that operate at Kenauk include: Kenauk Nature, the high-end outfitter with eco-tourism activities and chalets for rent; Kenauk Agriculture, the on-site fish hatchery used for stocking lakes, and; Kenauk Canada, the forestry research and operations.



Kenauk Nature - www.kenauk.com

Kenauk Nature is an outfitter that offers 23 off-grid luxurious chalet rentals as well as year-round outdoor adventure activities.

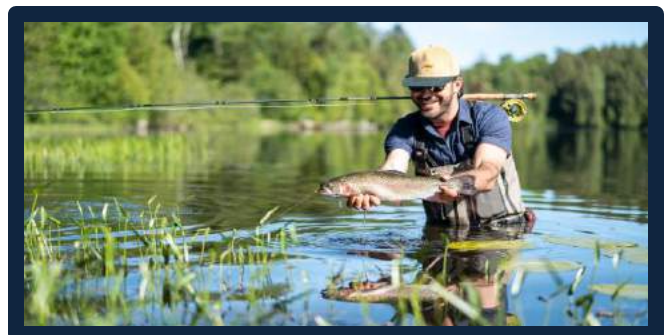
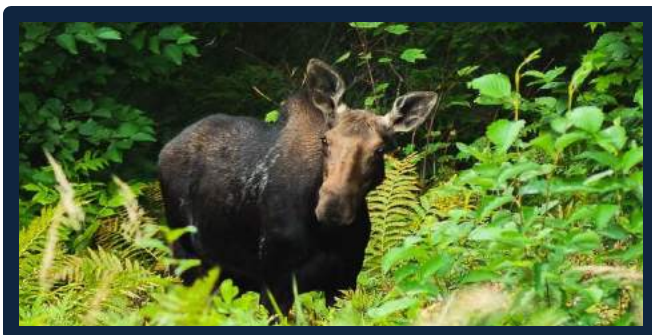
Activities include hunting and fishing, both operating with quotas under the supervision of the Kenauk Institute with the goal to promote sustainable long-term wildlife management. Many of the lakes operate catch and release fishing, while some are stocked with the fish from our own hatchery, for the benefits of our patrons.

Kenauk Agriculture - www.pisciculturekenauk.com

The fish stocked at Kenauk are raised in our own hatchery: a facility capable of producing 25 tons of rainbow, speckled, and brown trout every year (over 100,000 fish). Fish are only stocked into lakes with no native fish species to prevent competition. This land-based hatchery allows Kenauk to recycle water and protect wild populations of fish, ensuring our anglers enjoy a sustainable fishing experience year-round.

Kenauk Canada ULC - www.forests.org

Kenauk Canada ULC is dedicated to the development of a fully sustainable forestry operation with long term conservation and research initiatives. This mission includes building a profitable business that sustains local employment, fosters long-term environmental study, and allows for the recreational enjoyment of its forests. Kenauk Canada manages its operations to meet the requirements of their Sustainable Forestry Initiative (SFI) certification.



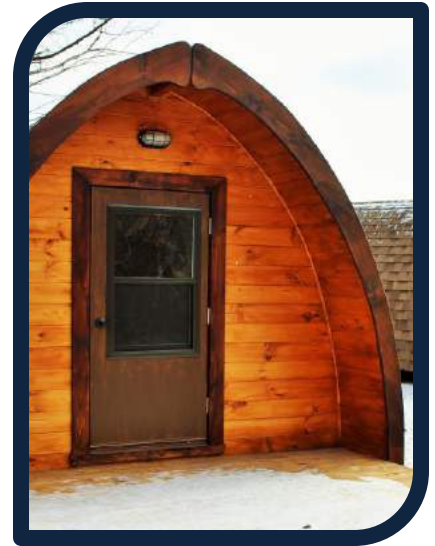
Facilities

Pods

Seven pods are installed at Whitefish Lake and act as our researcher accommodations. These pods include both professor and student accommodations. The guide shack (an existing and nearby building) includes the washroom and kitchen facilities.

Nature House

The addition of the Nature House, also located at Whitefish Lake, has expanded our facilities and provided more space for intern and researcher accommodations. It also acts as the Kenauk Institute office and includes a meeting space. We would like to recognize the members who contributed to this purchase and for their continued support in all of the Kenauk Institute's endeavors.

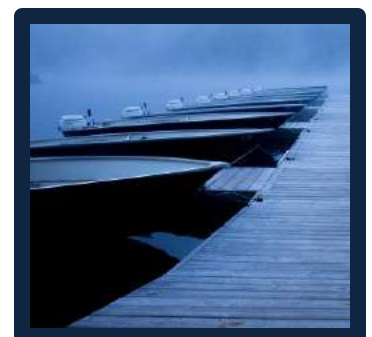
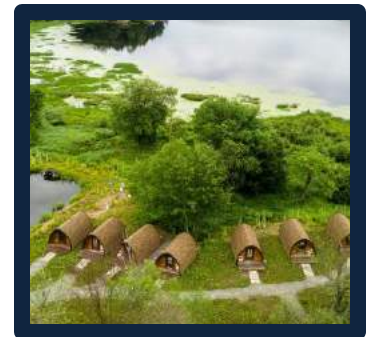


Kenauk Nature Partnership

The Kenauk Institute is fortunate to have the existing Kenauk Nature outfitting facilities at our disposal. Chalets are available for rent by educational programs as well as potential in-kind contributions for researchers. Kenauk Nature has also generously provided in-kind contributions for some industrial research project grants including the use of fishing boats and the marina, storage space, mapping data, equipment and assistance from knowledgeable personnel.

Kenauk Institute Research and Education Center

In the long term we hope to build a center to act as the main pavilion for all research activities as well as increase our accommodations and expand our capacity for hosting educational programs.



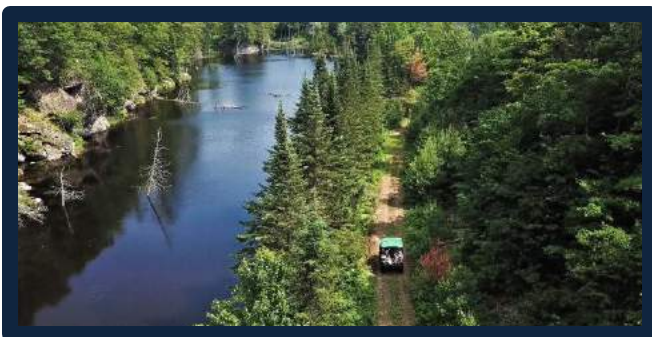
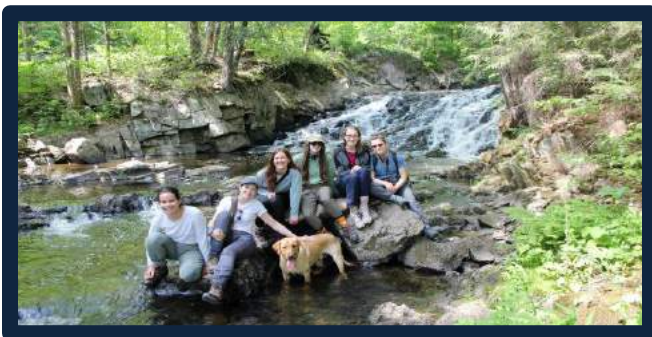
2021 Educational Programs

The Kenauk Institute offers educational programs for elementary schools and high schools, as well as undergraduate and graduate University classes with lessons and activities focused on every groups needs. Potential lessons and activities include: hiking, canoeing/kayaking, wilderness survival, biology, ecology, sustainability, team building, tours of our fish hatchery, local flora and fauna, sustainable forestry, eco-tourism, conservation management, ecosystem services, and the opportunity to experience scientific research with real hands-on data collection. Students come away engaged in the environment as active eco-citizens, with new practical skills and abilities such as autonomy and responsibility while developing self-esteem, resilience, leadership and perseverance. By combining environmental learning with time outside and play we hope to fuel a curiosity and passion for the environment while giving students valuable knowledge and skills.

Due to the Covid-19 pandemic all of our educational programs, except for the internship program, have been postponed until 2022 or until the programs can be safely executed.

1. Kenauk Institute Internship Program – [click here to view the internship video](#)

The Kenauk Institute has committed to providing undergraduate internships and a graduate senior internship for students studying biology in university. Interns are expected to juggle a variety of responsibilities that include contributing to multiple research projects, helping organize day-to-day operations, contributing to our educational programs as well as managing their own individual research project. The field experience gained during this internship is invaluable and will help individuals narrow down their research interests, as well as help them pursue their academic and career goals. Professional development sessions are held throughout the internship.



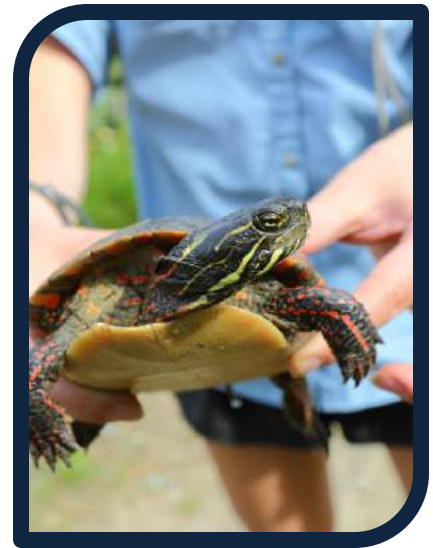
2021 Research Projects

1. NCC Biodiversity Inventory Project (#2015-1.1)

University / Organization: The Nature Conservancy of Canada

Researchers: Marie-Andrée Tougas-Tellier, Joel Bonin and countless NCC volunteers

Description: In 2014, the Nature Conservancy of Canada (NCC) began a series of inventories on the property of Kenauk. This work aims to document the rich biodiversity of this vast and iconic property, to exemplify its value and manage it accordingly (ex. identification of areas with high conservation potential, forest corridors, etc.). Research conducted in collaboration with biological specialists have confirmed the exceptional ecological richness of this site. The initial results of this inventory and a review of the scientific literature have allowed NCC to produce a species database including a list of concrete recommendations for land stewardship and the management of its natural resources. This document will serve as a framework for planning target species management and conservation action plans for Kenauk.



NCC is also prioritizing the preservation of Kenauk's ecological features to ensure its dynamic role within the landscape-scale ecosystem. Kenauk's conservation planning will therefore include a larger scale objective to protect the Kinonge watershed (Figure 1) and the wildlife corridor to the North (Figure 2). The continuous forest cover to the North of Kenauk provides suitable conditions for wildlife movement and migration. Continuous forest is important for large mammals, forest interior birds, indigenous plants and amphibians with limited dispersal capacity. The objective is to maintain landscape connectivity for free dispersal of those groups.

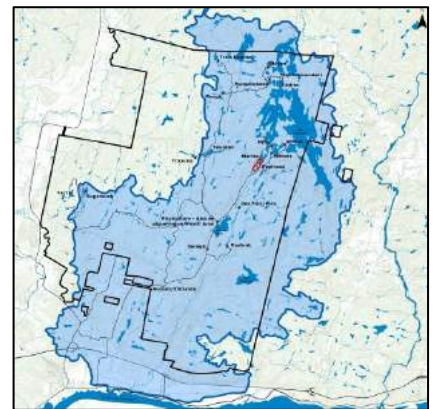


Figure 1. Kinonge watershed.

Results Summary:

- So far the presence of over 75 species at risk have been validated, including amphibians, vascular plants, arthropods, mammals, birds, fish and reptiles.
- Kenauk is home to the four-toed salamander, the walking fern and the largest black maple stand listed in Quebec.
- Old forest fragments that foster several bird species such as the eastern whip-poor-will and the wood thrush were also identified.
- Channel darters and pearlshell mussels were also found, indicator species for the quality of the riparian environment.

Status: This inventory will continue in 2022. Extensive species lists have been created which will facilitate long term monitoring, conservation and future research.

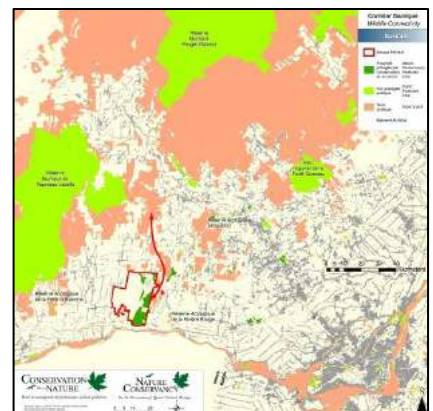


Figure 2. The wildlife corridor.

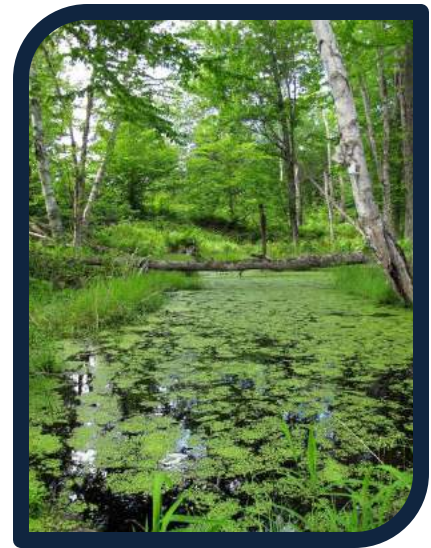
2. Vernal Pool Hydrology and Herpetology Project (#2016-1.2)

Title: Effects of even-aged vs uneven-aged silviculture and landscape quality on the hydrology and biodiversity of vernal pools.

University / Organization: Université du Québec à Montréal (UQAM) and Université du Québec en Outaouais (UQO)

Researchers: Prof. Marie Larocque and student Marjolaine Roux (UQAM) (sub-project 1), Prof. Philippe Nolet and Prof. Yann Surget Groba (UQO) (sub-project 2)

Description: Vernal pools are geographically and hydrologically isolated wetlands commonly found in the temperate forests of northeastern North America. They fill at their maximum in the spring following snowmelt and become completely dry during the summer; this hydroperiod affects faunal composition and reproduction. Vernal pools consist of very rich ecosystems and are essential to the life cycle of many organisms, however there is still very little known about these habitats. The sub-projects included are: 1) gain a better understanding of the water budget of vernal pools, as well as the links between their hydroperiod and pool morphology, in order to identify the hydrological processes that regulate them; 2) evaluate the impact of even-aged and uneven-aged silviculture on vernal pool herpetofauna; and 3) provide recommendations to decrease the impact of silviculture on vernal pools. For sub-project 1, 41 vernal pools were identified, characterized, and have been monitored for water levels. A new module was developed to better represent vernal pools in our model. This model was used to simulate pool hydrology and functions at the regional scale for current conditions and for climate change scenarios. For sub-project 2 environmental DNA is being used to estimate herpetofauna diversity.



Results Summary (sub-project 1):

- Hydroperiods are highly variable depending on meteorological conditions in late winter, spring and early summer. There is groundwater input in the spring and autumn. In the summer, pool water infiltrates the water table.
- The water budget varies seasonally but is mainly influenced by precipitation, evapotranspiration, and infiltration.
- Because vernal pools are not hydrologically isolated from the local water network, conservation of the ecosystem within the immediate watershed of vernal pools is essential to preserve their integrity.

Status: Hydrological monitoring and data analysis for this project will continue beyond the end of this project to observe long-term changes in vernal pool hydrology.

Figure 3. Example of DNA sequence to identify vernal pool species.

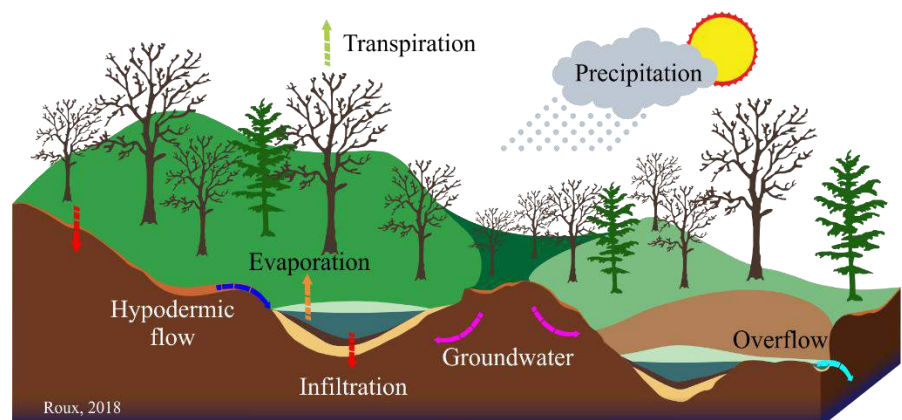


Figure 4. Conceptual vernal pool hydrological model (Roux, 2018).

3. Tree Growth and Productivity Project (#2016-1.3)

Title: Effects of even-aged vs uneven-aged silviculture on tree growth and forest productivity.

University / Organization: Université de Québec à Montréal (UQAM), Université de Québec en Outaouais (UQO) and Centre d'Enseignement et de Recherche en Foresterie (CERFO)

Researchers: Philippe Nolet (UQO), Guy Lessard (CERFO), Dr. Christian Messier (UQO/UQAM)

Description: The aim of this project includes assessing the effects of even vs. uneven forestry approaches compared to unmanaged stands on: 1) forest productivity and regeneration; 2) floristic and soil biodiversity; 3) verify whether forest productivity and regeneration (Obj. 1) is related to floristic and soil biodiversity (Obj. 2); and 4) identify the advantages of each approach in terms of forest resilience to global change. This project will contribute to the permanent sample plot network at Kenauk. Each plot provides detailed information on the various parameters identified in Objectives 1 and 2. Specifically, forest productivity will be assessed through growth ring analyses and resilience through an evaluation of functional diversity and tolerance to drought (the most important risk related to climate change) of seedlings found in the sample plots.



Results Summary:

- 150 plots (in 50 sites) were sampled for tree, shrub and plant diversity, structure and composition. The 50 sites were distributed amongst old growth, even and uneven forests.
- Trees:** Differences in tree species dispersion, abundance and composition, but not richness, was found between all forest types.
- Plants:** Many important plant species are affected by forestry; some do not recover (30+) years after forestry. Species richness and abundance is highest in old growth forests.

Figure 5. A) Even-aged forestry; strip or clear cutting. B) Uneven-aged forestry; selective cutting.

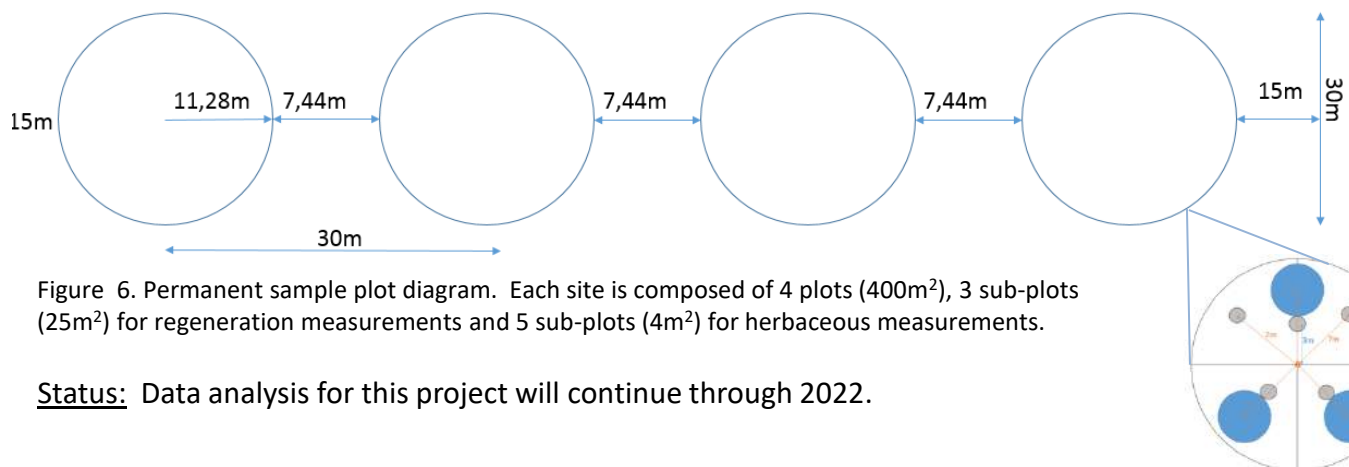


Figure 6. Permanent sample plot diagram. Each site is composed of 4 plots (400m²), 3 sub-plots (25m²) for regeneration measurements and 5 sub-plots (4m²) for herbaceous measurements.

Status: Data analysis for this project will continue through 2022.

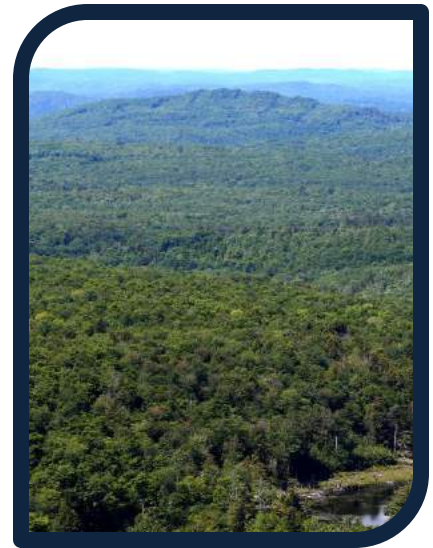
4. Carbon Reserves Through Phenology and Ontogeny in Sugar Maple Trees Project (#2021-3.1)

Title: Study of the interaction between ontology and phenology on non-structural carbohydrates in sugar maples, *Acer saccharum*.

University / Organization: Université de Québec en Outaouais (UQO), Université du Québec à Chicoutimi (UQAC)

Researchers: Prof. Sylvain Delagrange (UQO), Prof. Yann Surget Groba (UQO), Arthur Danneels (UQO), Annie Deslauriers (UQAC)

Description: We know that the development in size (ontogeny) leads to great modifications in the structure and functioning of trees. The goal of this project is to study the variation of sugar content in the tissues of sugar maple trees and its allocation to growth according to its stage of development (age) and to the season. This will allow us to broaden our understanding of carbon management in trees, the potential for maple syrup production as well as the ability of the tree to respond to stressors throughout its life (from sapling to adult). To complete this project, trees of different stages (ages) in a gradient of light conditions will be tested. These trees can be found in the old forestry strip cuts present on the property of Kenauk. Measurements will include taking leaf, branch and trunk samples, approximately once a month for the next year to measure the sugar content in the different parts of the tree across the four seasons.

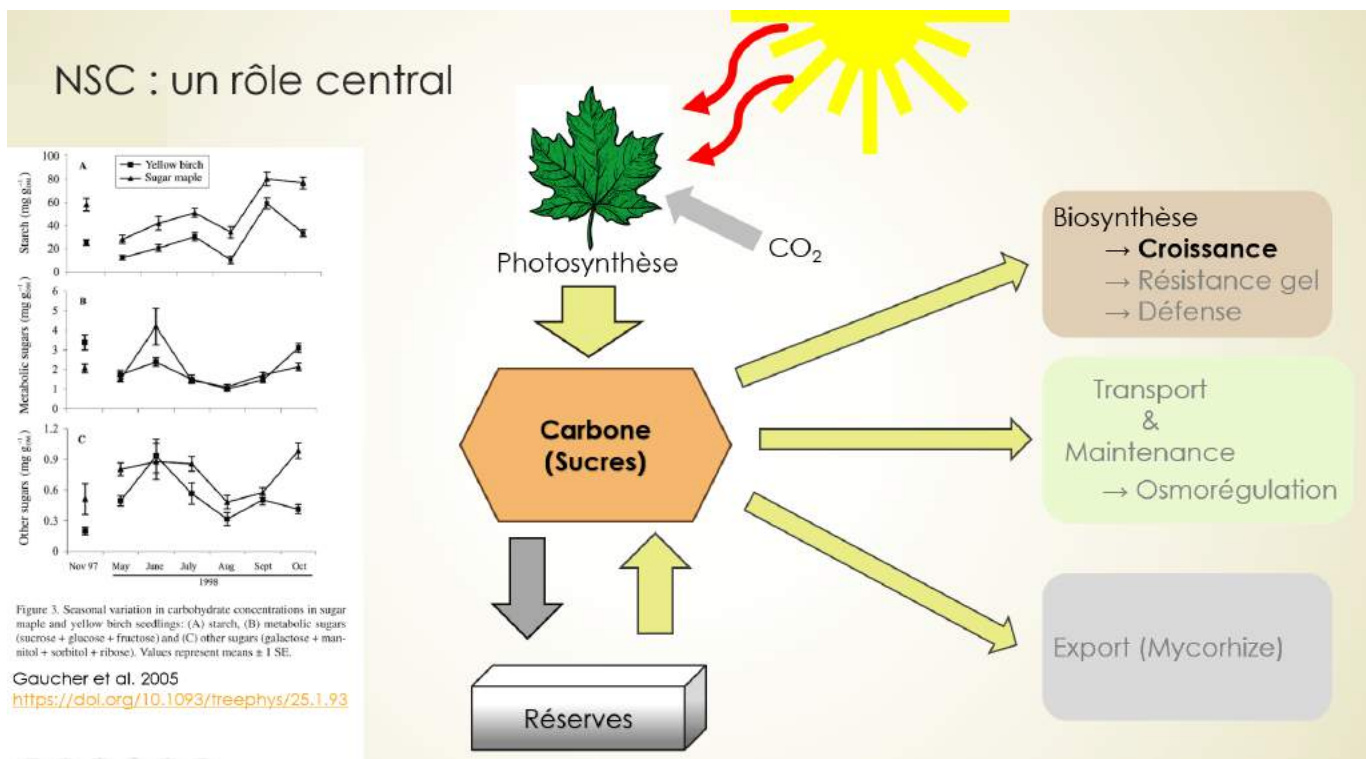


Results Summary:

- Data collection and analysis are in progress.

Status: Data collection for this project will continue through 2022.

Figure 7. Diagram representing the project and the central role of sugars in trees.



5. Beech Tree Invasion and Maple Stands Project (#2020-3.1)

Title: The management of sugar maple tree stands in southern Quebec when faced with the beech tree invasion and drought.

University / Organization: Université du Québec en Outaouais (UQO), Ministère des Forêts, de la Faune et des Parcs du Québec

Researchers: Audrey Maheu, David Rivest, Philippe Nolet, Frédérik Doyon (UQO)

Description: In southern Quebec, the temperate forest faces two threats: the large-leaved beech invasion of maple groves and the expected increase in the frequency and severity of droughts with climate change. This research project aims to: 1) identify areas of beech invasion, 2) understand the effects of that invasion on resource availability in a changing climate, and 3) assess the effects of development on beech invasion. First, the project will develop tools for detecting areas of beech invasion using mobile land LiDAR and aerial LiDAR. Managers will thus be able to better take this issue into account in forest planning. Second, the project will study the effect of beech invasion on regeneration, hydrological flows and soil properties. A precipitation exclusion system will also be put in place to simulate severe drought conditions and better understand the joint impact of beech invasion and drought. Finally, the project will identify the conditions and disturbances associated with the stagnation of forest ecosystems using field surveys and remote sensing data and will model the risk of ecosystem collapse with climate change. The knowledge and tools acquired will enable stakeholders in the forest industry involved in planning or harvesting to set up a management strategy for beech invasion adapted to climate change.

Results Summary:

- Tree transpiration and canopy interception of precipitation were monitored at 3 sites invaded by beech trees and 3 sites not invaded.

Status: Data collection and analysis for this project will continue in 2022.

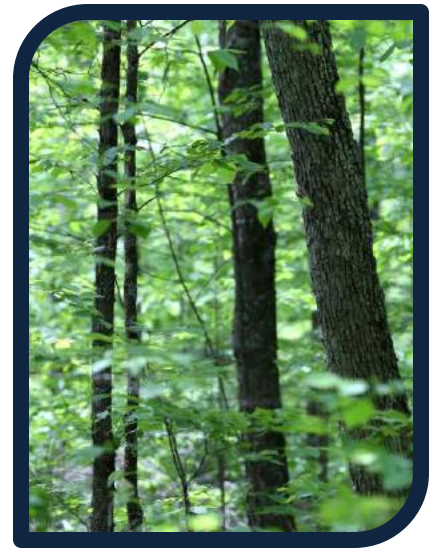


Figure 8.
Precipitation exclusion system to simulate severe drought conditions.



Figure 9.
Monitoring tree transpiration using sensors that measure sap flow.

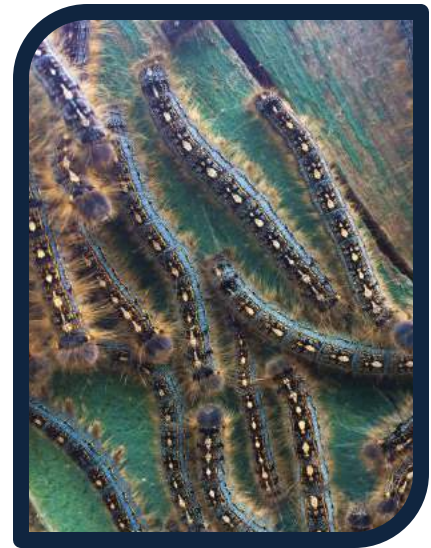
6. Herbivore Damage Patterns Project (#2021-44.1)

Title: What drives herbivory patterns in a sugar maple forest?

University / Organization: Concordia University

Researchers: Dr. Emma Despland, Mahsa Hakimara (PhD), Colette Ethier (Concordia), Isabel Fournier (McGill)

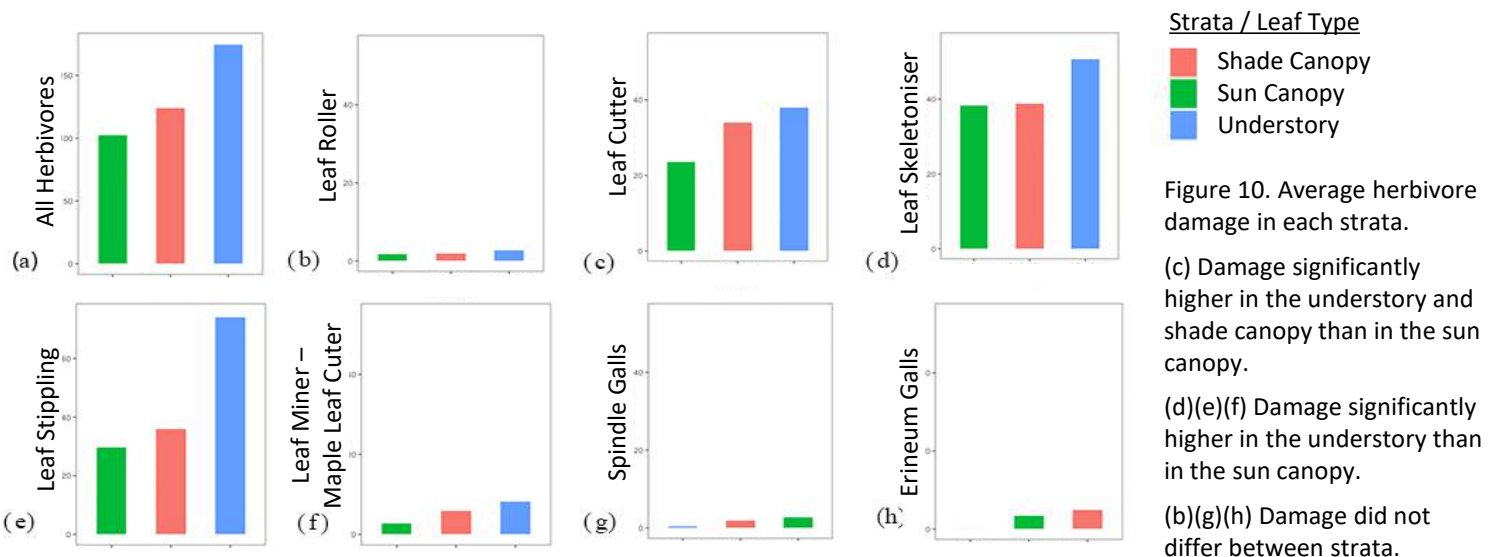
Description: Insect herbivores have long been recognized as important drivers of forest ecosystems by damaging leaves, weakening, or even killing trees and decreasing forest productivity. Sugar maple (*Acer saccharum*) forests in Quebec are declining. First, this project will evaluate the extent to which herbivores may contribute to this decline and second to document insect biodiversity supported by maples that could be threatened by this decline. The distribution of herbivorous insects in forests is expected to vary due to different biotic and abiotic factors associated with forest structure. One important but poorly studied aspect of structural diversity of temperate forests is the vertical gradient which provides several microhabitats with different levels of light, temperature, humidity, leaf quality and predator activity. Therefore, the objectives of this project are: 1) determine if vertical stratification effects herbivory, 2) understand how this stratification effect varies between different herbivore guilds and 3) show how this vertical stratification affects bottom-up (plant traits as the herbivore host) and top-down (predators and parasitoids) trophic relationships that shape herbivory patterns in a tree. The methods include assessing environmental factors, herbivory damage and leaf quality in three strata (sun canopy, shade canopy, and understory) of 12 sugar maple trees.



Results Summary:

- Overall herbivory damage decreased moving up the vertical gradient from the understory to the shade canopy and sun canopy. Individual herbivore damage per strata can be seen in figure 10.
- Moving from the understory to the sun canopy, light intensity and leaf thickness increased, making leaves harder for herbivores to feed on; variation in leaf traits (a bottom-up force on herbivory).

Status: Sampling and data analysis for this project will continue through 2022.



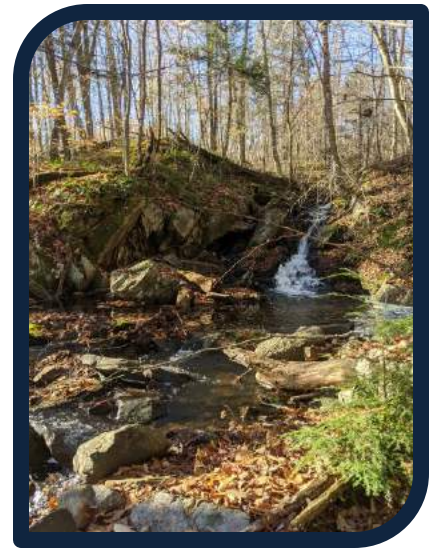
7. Connectivity of Ecosystems Project (#2021-1.1)

Title: Connectivity of forest lotic ecosystems

University / Organization: Université du Québec à Montréal (UQAM), Université du Québec en Outaouais (UQO), Institut national de recherche scientifique (INRS-ETE) and Université de Montréal (UdeM)

Researchers: Prof. Marie Larocque, Audrey Maheu (UQO), Katrine Turgeon (UQO), Éric Harvey (UdeM), André St-Hilaire (INRS-ETE), Laureline Berthot (post-doc UQAM), Mathieu Auffray (PhD UQAM)

Description: The goal is to understand how hydrological and structural connectivity, biodiversity and the functioning of lotic ecosystems in the temperate forest of the Canadian Shield are affected by forestry and climate change. This project will provide recommendations for concrete actions to include water connectivity in forest management and restore connectivity under current and future conditions in Canada and other similar regions.



Results Summary:

- The project was launched in spring 2021 and will run for four years. During this first summer, five watersheds (Surprise, Taunton, Jackson, La Croix and La Croix sub-basin) in the north-west of the Kenauk property were instrumented with hydrometric stations for monitoring flow rates (figure 12).
- Thermographs to record water temperatures have been installed in all rivers (figure 11).
- The Surprise, La Croix, and La Croix sub-basin watersheds, have been equipped with piezometers to monitor groundwater levels.
- Meteorological stations have been installed near the limnimetric water level stations (figure 12).

Status: Hydrological modeling aimed at quantifying connectivity indicators will begin in winter 2022. The installation of piezometers near all rivers will be completed in spring 2022 and hydrological monitoring will continue throughout the duration of the project. Determining biological connectivity indicators will begin in spring 2022.

Figure 11. A diagram of the equipment installed for each hydrometric station.

- ① Limnimetric station
- ② Thermograph
- ③ Limnimetric ruler
- ④ Camera
- ⑤ Rain Gauge
- ⑥ Piezometer

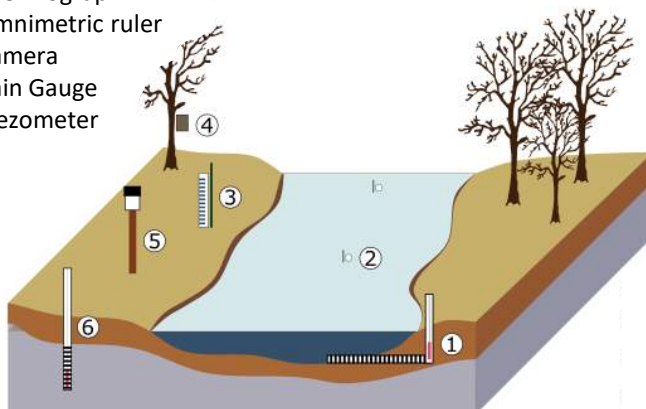
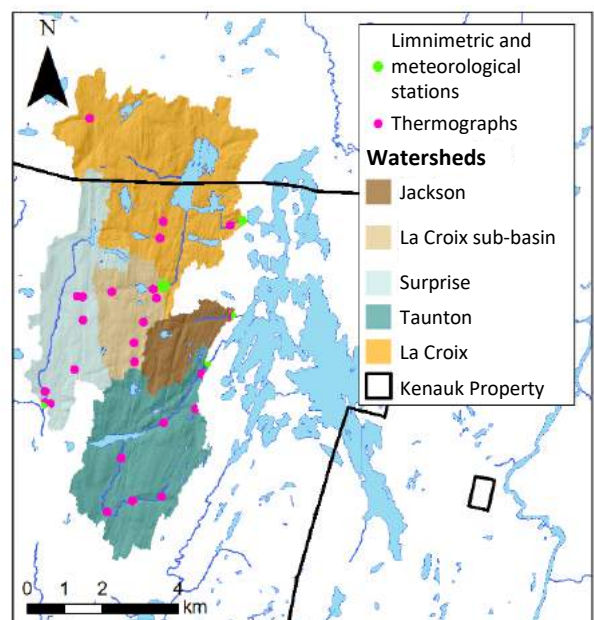


Figure 12. A map of the 5 watersheds being monitored for the project.



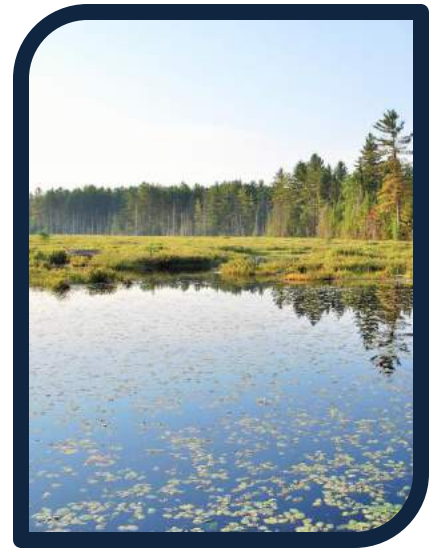
8. Papineau Lake Hydrology Project (#2016-2.1)

Title: Dynamics and long-term resilience of a lake and its wetlands.

University / Organization: Université de Québec à Montréal (UQAM), Université de Québec à Trois Rivières (UQTR), Montreal Botanical Gardens (IRBV), The Nature Conservancy of Canada (NCC), The Ouranos Consortium

Researchers: Prof. Marie Larocque (UQAM), Prof. Raphaël Proulx (UQTR), Prof. Stéphanie Pellerin (IRBV), and countless students

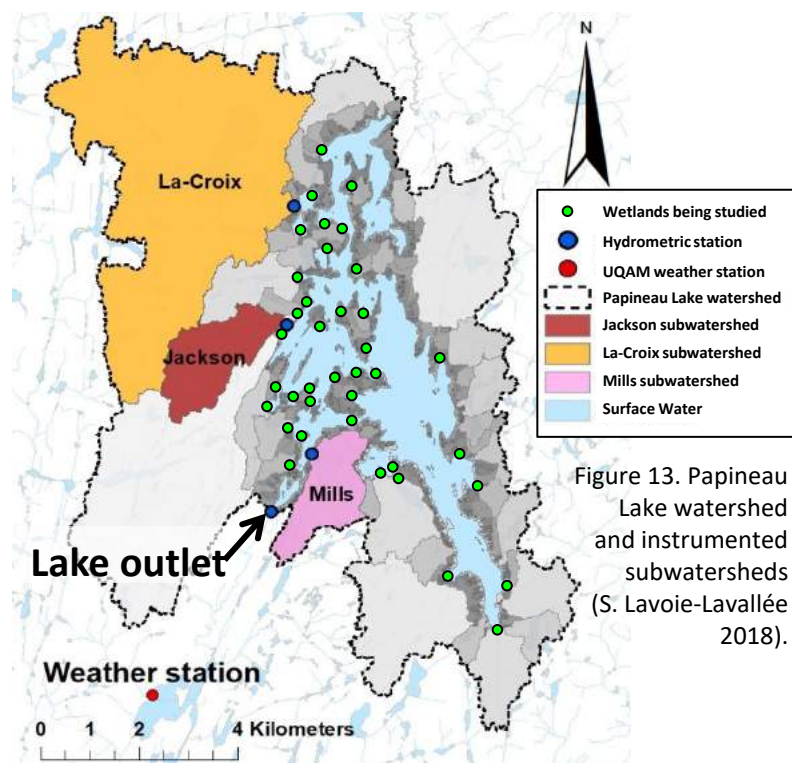
Description: The goal of this project is to understand the hydrologic dynamics of Papineau Lake and how those dynamics are related to shoreline wetlands using three specific objectives. 1) Establish a monitoring network and hydrological alert system around Papineau Lake (Figure 13). Quantifying the lakes hydrodynamics will allow an estimation of how the lake will be affected in the long-term by land use changes and climate change. Probes that measure water levels and inflow/outflow volumes were installed throughout the lake for long term monitoring as well as a weather station. A hydrological model is also being developed to understand the processes regulating the lake's hydrology and the watershed but also to simulate the impacts of future scenarios, such as climate change. 2) Locate and characterize the lake's shoreline wetlands and identify the anthropogenic pressures they face. Indicator species, species at risk and insect bioacoustic signatures will be identified in these areas so as to designate them as protection zones. The natural and anthropogenic pressures these wetlands face will be identified, with a specific focus on shoreline thermal regimes and shoreline erosion by waves. 3) Create a list of recommendations to prevent / mitigate the negative effects of these pressures on the wetlands of Papineau Lake. An eco-nautical map of Papineau showing areas of specific concern will be created along with a set of regulations to help reinforce the conservation of the entire lake and watershed.



Results Summary:

- A wealth of information has been collected on the lake hydrology and 100 wetlands.
- Vascular vegetation was sampled in 38 wetlands; 9 were identified as unique, meaning they have a distinct species composition and harbour many rare and disturbance-sensitive species.
- The resilience of three wetland types (37 total) to different water level change scenarios has been evaluated. While peatlands and alder swamps appear more resilient to water level changes, ash swamps can be greatly affected.
- The different types of wetlands have also been shown to support distinct ecosystem functions and services, with important variations linked to the biodiversity of taxa and hydrology.

Status: Hydrological models will be done in 2022.



9. Papineau Lake Telemetry Project (#2017-2.1)

Title: Towards sustainable recreational fisheries on Papineau Lake

University / Organization: Carleton University, University of Waterloo, University of Vermont, University of Illinois and the Fisheries Conservation Foundation (FCF)

Researchers: Dr. Steven Cooke, Benjamin Hlina, Danny Glassman (Carleton U), Dr. Ellen Marsden (U of Vermont), Dr. David Philipp (U of Illinois), Julie Claussen (FCF), Dr. Mike Power (U of Waterloo)

Description: The goal of this project is to understand the spatial ecology, population dynamics and fishery for lake trout, rainbow trout and black bass in Papineau Lake. This project will provide the data and tools to identify sustainable conservation strategies that will help ensure high quality fishing on Papineau Lake while protecting its natural assets for future generations. Five specific objectives will contribute to this goal. 1) Identify the life history characteristics for lake trout specific to different sub-populations and/or ecotypes. 2) Characterize how adult lake trout and bass use different habitats (ex. depth and thermal habitat) on a seasonal basis (ex. spawning and overwintering locations). 3) Identify the level of reproductive success for lake trout and bass. 4) Determine why most lake trout in Papineau Lake fail to attain body mass greater than ~2kg. 5) Document the level of angler effort/harvest and their preferences and opinions for different management strategies.

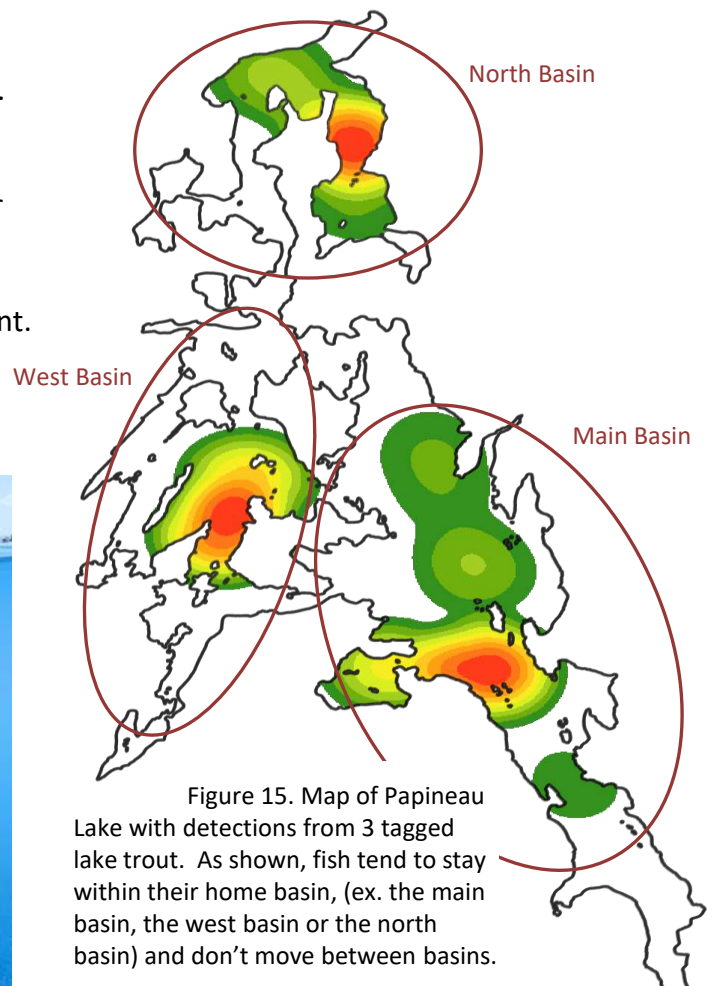
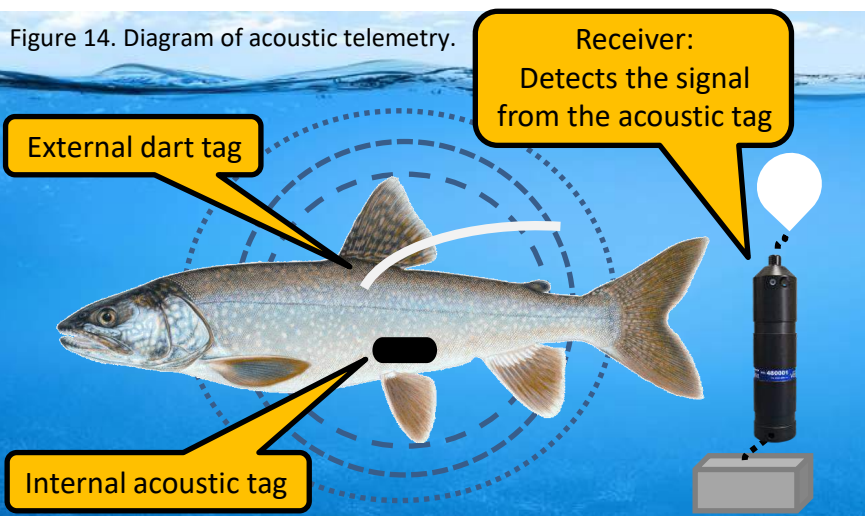
Results Summary:

- Tags have been implanted in 66 lake trout and 56 bass.
- 4 spawning sites have been identified in the lake.
- Small and large lake trout have been identified. Large lake trout seem to be solely cannibalistic while smaller lake trout feed on zooplankton and aquatic insects.
- Results will be shared with community members to promote sustainable recreational fisheries management.

Status: Analysis of ageing structures, diet and spatial habitat use is ongoing.



Figure 14. Diagram of acoustic telemetry.



10. Multiscale Bat Habitat Selection and Population Trends Project (#2020-7.1)

Title: Multiscale bat habitat selection and population trends at maternity colonies and hibernacula in Southwestern Quebec.

University / Organization: McGill University, Le ministère des Forêts, de la Faune et des Parcs (MFFP)

Researchers: Jade Legros (MSc), Amelie Fontaine (PhD), Dr. Kyle Elliott (McGill)

Description: Bats comprise one of the most diverse orders of mammals (Chiroptera) and are unique as the only mammals capable of true flight. They are important in their ecosystems for pollinating flowers, dispersing seeds and consuming insect pests. The white-nose syndrome, a fungal disease, has caused a decline of up to 90% of cave-dwelling bat populations in North America. With no existing cure, the protection of remnant populations and their habitat might be our only remaining conservation tool. Thus, conservation of maternity roosts (where bats reproduce), hibernacula (where bats hibernate over winter), and their surrounding habitats are essential. This project will evaluate landscape scale habitat selection by bats at maternity roosts and hibernacula and analyze large-scale population trends for bat species across Quebec. The BatWatch citizen science database and known hibernacula will be used to map the distribution of roosts in Quebec and GIS software will be used to extract surrounding landscape-scale features. We will then use drone-based acoustics to survey key bat habitats at Kenauk, to identify and protect the bats on the property. Finally, BatWatch will be used to record bat population trends relative to the onset of the white-nose syndrome to better understand what bat species to target for protection. The study will develop a protocol using community science, GIS and drone-based acoustics that can aid land managers who face difficult decisions when managing land use and wildlife conservation.



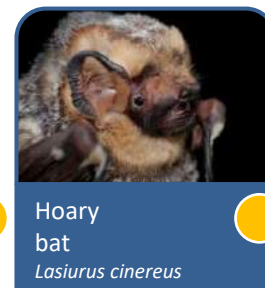
Results Summary:

- Stay tuned for results.

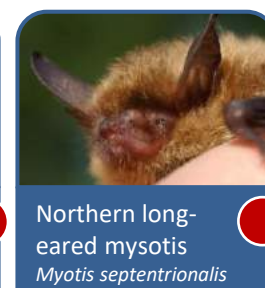
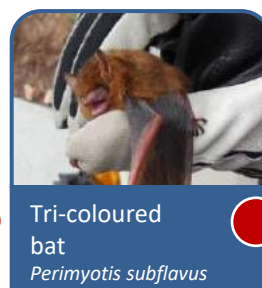
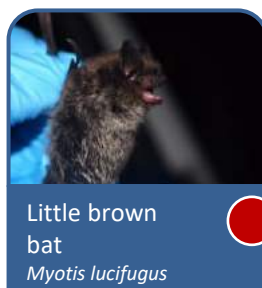
Status: Data collection for this project will continue through 2022.

Figure 16. The eight bat species found in Quebec and their provincial status. Yellow = vulnerable, Red = critically endangered

MIGRATE



HIBERNATE



Credit: batwatch.ca

11. Small Mammal Monitoring Project (#2020-1.1)

Title: Population dynamics of small rodents in the mixed forests of eastern Canada.

University / Organization: Canadian Museum of Nature (CMN), Laval University

Researchers: Dr. Dominique Fauteux (CMN), Dr. Pierre Legagneux (U Laval), David Bolduc (U Laval), Justine Fontaine-Topaloff (CMN)

Description: The regular and irregular outbreaks of micro-mammals (body mass <100 grams) are a stimulating component of ecosystems, especially the most northern ones. In the Arctic, the cycles of lemming abundance occurs every 3-4 years and is known to create faunal pulsations through their beneficial effect on predators and on other prey that share the same predators. Few studies have been carried out in the eastern part of the country in both boreal and temperate forests where long-term time series in vole abundances are rare. The objective of this study is to carry out long-term monitoring of the annual densities of micro-mammals at Kenauk and thus better understand the population dynamics of these species in southern Quebec and their impact on their predators. This project will conduct inter-site comparisons to gain a better understanding of the role of small rodents in the functioning of forest ecosystems in Eastern Canada. It will also compare the observed fluctuation patterns to those of Bylot Island, Nunavut, where the mechanisms leading to lemming abundance cycles have been studied for nearly 30 years.



Results Summary:

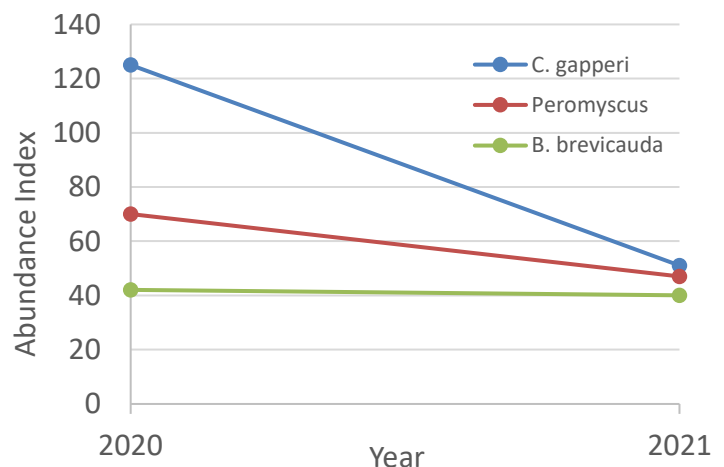
- In September 2021, 6 trapping grids with 60 live capture traps were deployed for 3 days and nights.
- A total of 230 small mammals were caught, much fewer than the 380 caught in 2020.
- The capture of 4 woodland voles was a nice surprise since this species has never before been recorded in the Outaouais region, except among thousand-year-old fossils in Gatineau Park.
- Compared to 2020, there was a marked decline in *C. gapperi* and *Peromyscus* while the number of large shrews remained stable (figure 18).

Status: Data collection will continue in 2022.

Figure 17. All micro-mammal species captured to date.

Common Name	Scientific Name
Southern red-backed vole	<i>Clethrionomys gapperi</i>
<i>Peromyscus sp.</i>	<i>Peromyscus sp.</i>
Woodland jumping mouse	<i>Napaeozapus hudsonius</i>
Meadow vole	<i>Microtus pennsylvanicus</i>
Woodland vole	<i>Microtus pinetorum</i>
Northern short-tailed shrew	<i>Blarina brevicauda</i>
Cinereous shrew	<i>Sorex cinereus</i>

Figure 18. Relative abundance of the most common micro-mammal species found at Kenauk.



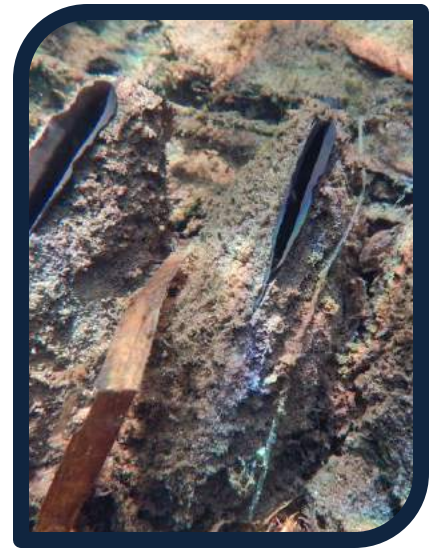
12. Mussel Inventory Project (#2018-3.1)

Title: A survey of native freshwater mussels (superfamily: Unionacea) and fishes comprising six families at Kenauk

University / Organization: Canadian Museum of Nature (CMN), Technische Universität München (TUM), Ministère des Forêts de la Faune et des Parcs du Québec (MFFP)

Researchers: André Martel, Noel Alfonso, Jacqueline Madill (CMN), Jürgen Geist, Sofie Hemprich (TUM), Annie Paquet, Guillaume Canac-Marquis (MFFP)

Description: Freshwater mussels play vital ecological roles in river and lake ecosystems, including nutrient cycling, water filtration, substrate oxygenation and providing habitat. Freshwater mussels and fishes are linked in two significant ways: fish are an essential link in mussel life history and both groups face significant conservation pressures. Freshwater mussels are amongst the most threatened faunal groups globally, with nearly 30% of Canada's species considered at risk. The main causes of the decline for both groups include habitat loss, fragmentation and degradation, overexploitation, non-native species, and climate change. This project will survey Kenauk for mussel and fish species with an emphasis on the Eastern pearlshell recently discovered in the Kinonge Main and the Kinonge West Branch Rivers. We will also aim to determine whether brook trout are the host fish used for metamorphosis and dispersal.



Results Summary:

- Major discoveries about Eastern Pearlshell mussels at Kenauk to date
 - Genetic analysis: a distinct population in North America
 - Distribution: this is the western-most population in Canada for this species
 - Host fish for reproduction: presumed to be Brook Trout
 - Kinonge River West Branch: the only branch in the Kinonge river where brook trout were found, along with the highest densities of Pearlshell mussels – a key area for conservation
- Fish inventories were carried out in the two rivers to better understand the links between freshwater mussels and fishes at Kenauk. Approximately seven new fish species were inventoried.

Status: Data collection for this project will continue in 2022.

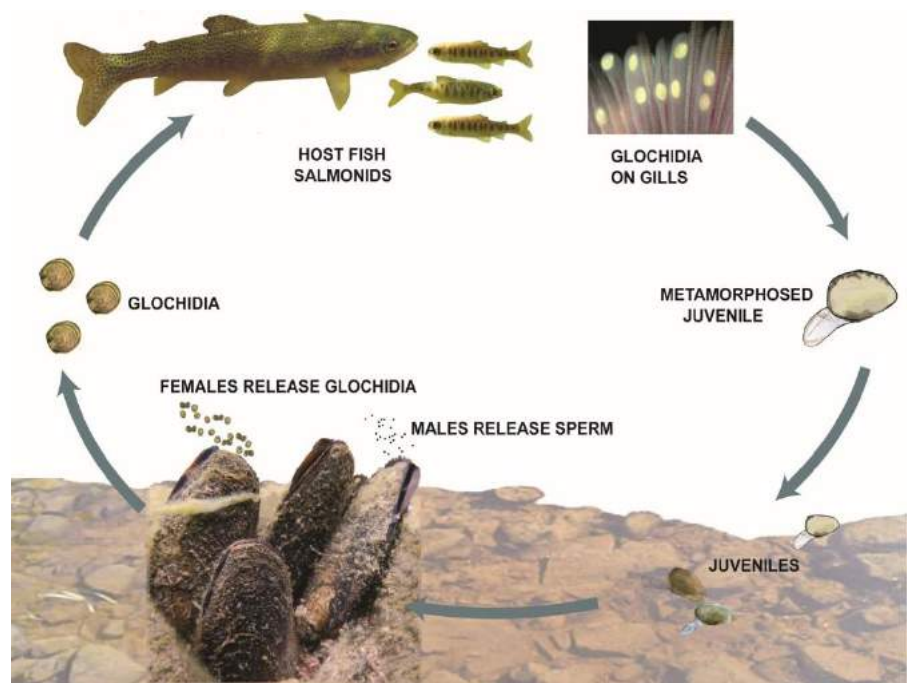


Figure 19. The life cycle of Pearlshell Mussels (Freshwater Mollusc Conservation Society). They can grow 10-13cm in length and live an average of 93 years, although the oldest Pearlshell mussel was found to be 280 years old.

13. Milfoil Inventory Project (#2020-5.1)

Title: Invasive Eurasian Milfoil Inventory and Removal Project.

University / Organization: Nature Conservancy of Canada (NCC), The Kenauk Institute

Researchers: The Kenauk Institute interns and many volunteers

Description: Eurasian milfoil (*Myriophyllum spicatum*) is an invasive aquatic plant introduced to North America in the 19th century. Today it's one of the most widespread invasive plants on the continent and brings with it a suite of negative impacts for humans and ecosystems. Milfoil invades the coastal zone of lakes; impeding swimming, water sports, water quality and biodiversity. Papineau Lake has been invaded by milfoil, so in an effort to protect the lake and the rest of the watershed, the invasive plant colonies were inventoried and mapped (figure 20). In 2021 we continued our milfoil removal efforts, as well as surveyed the lake trout spawning sites to ensure their protection.



Figure 20. Map of Papineau Lake; milfoil colonies in red.



14. Tick Inventory Project (#2019-2.1)

Title: Education about the prevention and risks of Lyme disease as well as inventorying ticks (*Ixodes scapularis*) at Kenauk.

University / Organization: The Kenauk Institute

Description: The objective of this project is to inform people on the preventative measures for Lyme disease, to sample *Ixodes scapularis* ticks on the property of Kenauk to monitor local risk as well as contribute to the National Lyme Disease Surveillance Program. The ticks collected are genetically tested for lyme disease, the Babesia microti pathogen and other common infections through Geneticks.ca. Babesia microti is a pathogen that causes a disease called babesiosis, a malaria-like disease which causes fever and hemolysis.

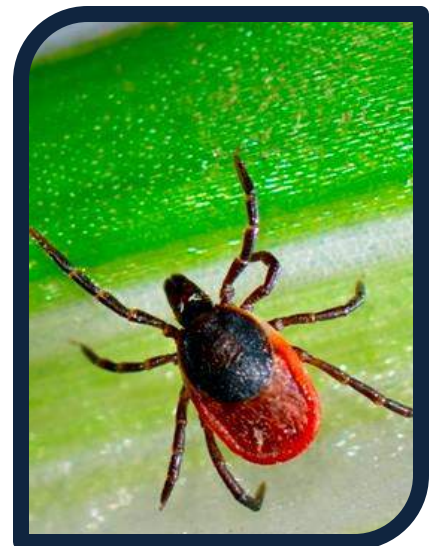


Figure 21. The number of ticks genetically tested every year and the percentage of positive results for lyme disease and other pathogens such as Babesia microti. 2021 results to come.

Year	# Ticks Tested	# Ticks Tested Positive	
		Lyme Disease	Babesia microti
2020	34	2 (6%)	2 (6%)
2021	237	TBD	TBD

Status: Data collection will continue in 2022.

15. Papineau Lake Water Quality Monitoring Project (#2015-3.1)

University / Organization: The Kenauk Institute

Description: Papineau Lake is a registered lake in the Volunteer Lake Monitoring Program (VLMP) of the Government of Quebec. The Kenauk Institute will periodically take water samples throughout each summer with the goal to establish a long-term monitoring protocol for water quality with annual comparisons.

Results Summary:

- Papineau Lake is classified oligotrophic; it has few to no signs of eutrophication and warrants protection. Preventative measures are needed to limit anthropogenic nutrient input.

Figure 22. Water quality parameters of Papineau Lake (annual averages) and it's corresponding trophic classification.



16. Papineau Lake Loon Nesting Project (#2015-4.1)

University / Organization: The Kenauk Institute

Description: While loon populations are currently stable, many threats loom, including human encroachment and pollution. Loons select nest sites in quiet, protected areas along shorelines and often reuse the same nesting site annually which makes them particularly sensitive to boat traffic. By mapping nesting loons, we hope to monitor and protect their population.

Results Summary / Observations:

- Loon pairs H & G now thought to be the same.
- Identification of new loon pair L.
- Nest D had no loons observed all summer.

Status: Data collection will continue in 2022.

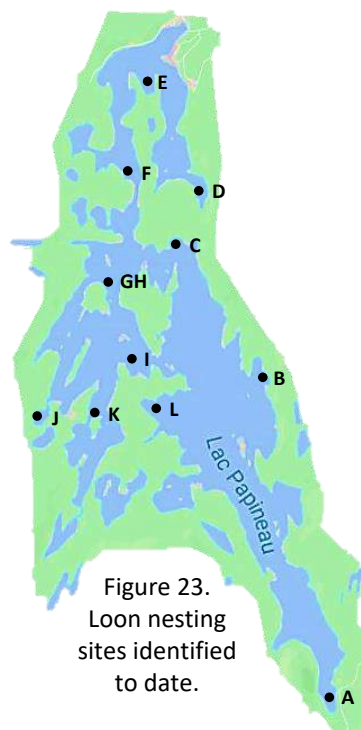


Figure 23.
Loon nesting sites identified to date.

Figure 24. Loon observations 2021.

Nest ID	Loon Pair	# of Chicks
A	✓	0
B	1 loon observed	
C	1 loon observed	
D	-	-
E	✓	1
F	✓	1
GH	✓	0
I	✓	0
J	✓	1
K	✓	1
L	✓	1

17. Papineau Lake Weir Monitoring Project (#2015-2.1)

University / Organization: The Kenauk Institute

Description: In 2015 the Papineau lake dam was converted into a weir to improve fish access and aquatic habitats. A weir is a low dam structure that can be used to increase the availability of quality habitats for fish reproduction, foraging, and spawning by facilitating fish passage while still maintaining water levels. This weir will improve the river for fish spawning and circulation in terms of ideal flow rates, water depths, oxygenation and habitat diversity. In order to monitor the Kinonge watershed as well as the success of the weir in maintaining water levels; a probe was installed above the weir that measures water depths hourly throughout the year.

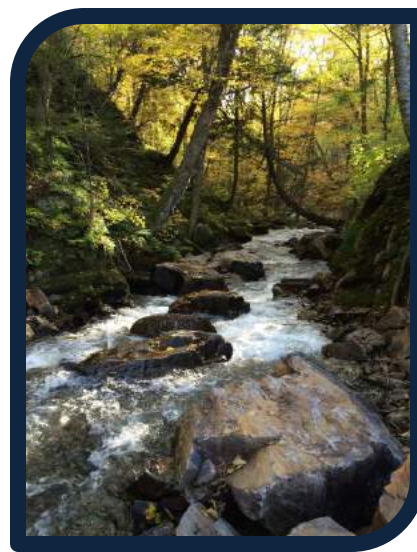


Figure 25. Annual variations in water depth and water temperatures at the weir.

Results Summary:

	2016	2017	2018	2019	2020	2021
Temperature Range (°C)	1.2 – 26.8	1.3 – 25.9	1.5 – 27.8	0.9 – 27.1	0.6 – 28.3	1.6 – 28.1
Variation in Depth (m)	0.66	0.53	0.49	0.95	0.70	0.97

18. Weather Station Data (#2016-3.1)

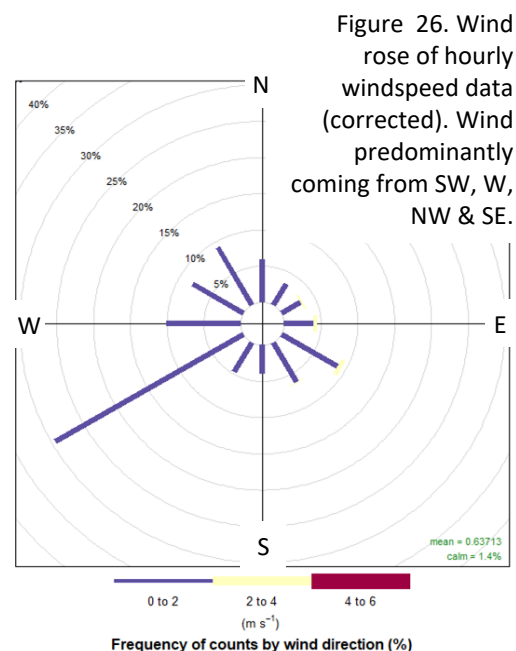
University / Organization: Université de Québec à Montréal (UQAM), The Kenauk Institute

Description: The weather station at Whitefish Lake collects hourly data on temperature, relative humidity, net radiation, wind speed and direction, barometric pressure, rain and snow. Having property-specific data on weather factors benefits all the research projects associated with the Kenauk Institute and supports our long-term monitoring mandate.

Results Summary: 2021 results incomplete, end date October 5.

	2017	2018	2019	2020	2021
Max Temperature (°C)	32.6	33.6	32.7	34.7	32.3
Mean Temperature (°C)	5.80	5.45	4.92	8.62	8.28
Min Temperature (°C)	-31.5	-33.6	-29.7	-25.7	-29.3
Max Wind Speed (m/s)	11.6	11.0	11.5	9.92	9.43
Max Rain / Day (mm)	47.5	67.1	29.2	44.7	36.8
Total Rain / Year (m)	0.90	1.13	0.83	0.87	0.41
Max Snow Depth (m)	0.68	0.75	0.90	0.65	0.85
Mean Relative Humidity (%)	76.7	75.8	74.2	72.4	71.5

Status: Data collection will continue in 2022.



Kenauk Institute Intern Projects

19. Invertebrates on native vs invasive macrophytes. (#2020-5.1) – Diana Todd, Dr. Jesse Vermaire (Carleton University)

Eurasian milfoil, *Myriophyllum spicatum*, is an invasive macrophyte that outcompetes native macrophytes and is a nuisance for lake users. The impact of this invasive species on invertebrate communities and ultimately aquatic food webs is of interest. The goal of this study is to determine if there is a difference between invertebrate density and diversity on native macrophytes versus invasive Eurasian milfoil. This study was carried out by counting and identifying invertebrates on two native potamogeton species and Eurasian milfoil in Papineau lake.



20. The effect of vertical stratification on herbivorous damage patterns in sugar maple trees. (#2021-4.1) – Isabel Fournier, Mahsa Hakimara (PhD), Dr. Emma Despland (Concordia University)

Temperate forests host an array of herbivorous arthropods which can defoliate trees and inflict damage. Their distribution within deciduous trees can be affected by variations in abiotic conditions such as light exposure between vertical strata and developmental tree stages. The goal of this project was to determine herbivory patterns in sugar maple trees (*Acer saccharum*) by comparing herbivore damage in leaves collected at different strata: understory, shaded and sun canopy. Identifying herbivory patterns in deciduous trees can help explain arthropod distribution and the impact of defoliation on ecosystems.

21. The effect of drones on bats and their use to survey bat populations. (#2020-7.1) – Catriona Daley, Dr. Kyle Elliott (McGill University)

Bats comprise one of the most diverse orders of mammals (Chiroptera), yet because of their cryptic habits, relatively little is known about the population dynamics for many species. A new way to census bat populations may be possible with advancements in drones. However, bats can be sensitive to drones, especially with their preference for dark, quiet environments. Furthermore, because they communicate with ultrasounds and high frequencies, bats may also be disturbed by overlapping drone frequencies. This study aimed to determine the viability of drone use for bat research by measuring the effects of drone flight on acoustic bat detections and comparing bat activity in response to varying drone models.

22. Arthropod sampling using UAVs to compare abundance and diversity in various habitats. (#2021-5.1) – Jamie Madden, Dr. Kyle Elliott (McGill University)

Described by some as “the last biological frontier”, the forest canopy is one of the least accessible of the terrestrial habitats. Little is known about the insect communities in the forest canopy, due mainly to the difficulties that come with sampling at that height. While current methods work, sampling by climbing is tedious and difficult to replicate, and canopy infrastructure requires time and commitment. A potential alternative to these is the use of drones. By manufacturing an insect sweep net that can attach to a drone, insects can be collected in inaccessible places, such as above the canopy or above bodies of water. With an estimated 40% of insect species in decline worldwide, it is imperative now more than ever to define and study insect populations. This study was the first collection of canopy insects using drones to date.

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