Kenauk Institute – 2020 Annual Report

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Liane Nowell
December 31, 2020

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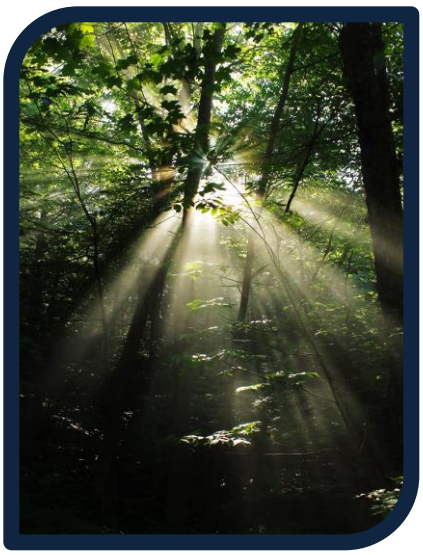
Executive Summary



The mission of The Kenauk Institute is to support, coordinate and supervise scientific research, involve local schools in environmental education, and 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 time, Kenauk will become 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.

Throughout 2020, The Kenauk Institute has seen a lot of progress which includes 21 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 74 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 of our educational programs, except for the internship program, have been postponed until 2021 or until the programs can be safely executed. In previous years the Kenauk Institute's educational programs included the Outward Bound / YMCA group, involvement in the Canadian Conservation Corps programs, a field trip from the Saint-Michel elementary school, the ISFORT M.Sc. program, programs with Bishops College School (BCS), the Sunshine Montessori School as well as our internship programs.

In 2021 we will be launching a capital campaign. The goal is to raise enough money to build a main research center and create an endowment fund to sustain long term research and educational programs. The research center would act as the main building for all research activities as well as increase our researcher accommodations and expand our capacity for hosting educational programs.

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Executive Director

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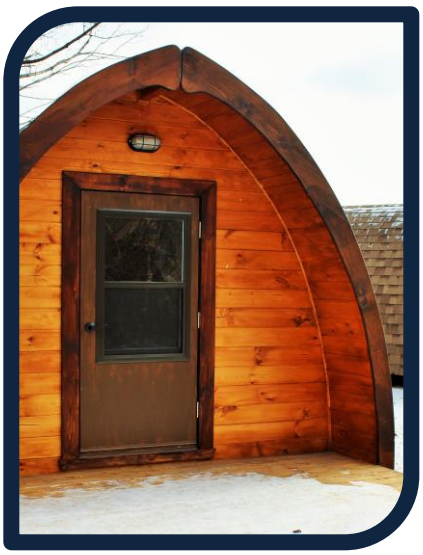
Facilities



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

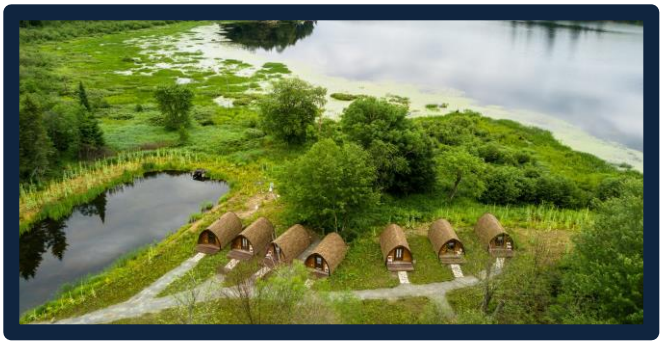
The addition of the Nature House, also located at Whitefish Lake, has expanded our facilities and provided more space for intern and researcher accommodations. It will also act as the Kenauk Institute office and includes a meeting space. We would like to recognize the members who contributed to this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

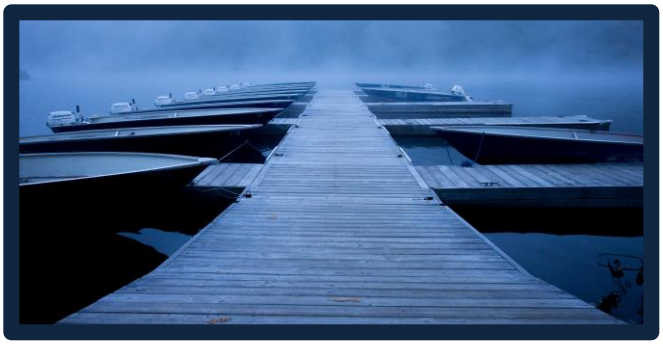
Kenauk Nature Partnership

The Kenauk Institute is also 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 building for all research activities as well as increase our accommodations and expand our capacity for hosting educational programs.





2020 Educational Programs

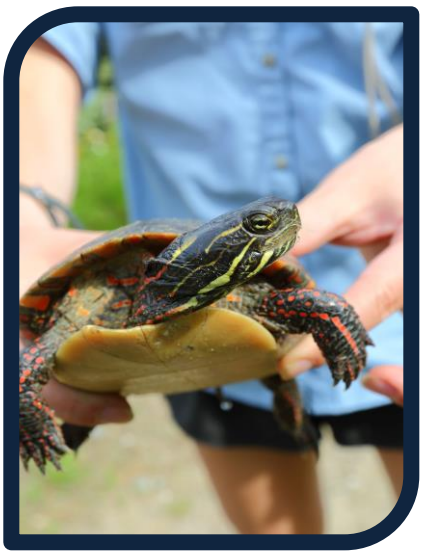
The Kenauk Institute offers educational programs for elementary schools and high schools, as well as undergraduate and graduate University classes with lessons and activities focused on every groups needs. Potential lessons and activities include: hiking, canoeing/kayaking, wilderness survival, biology, 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 2021 or until the programs can be safely executed.

1. Kenauk Institute Internship Program

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.

2020 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. Kenauks' 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.

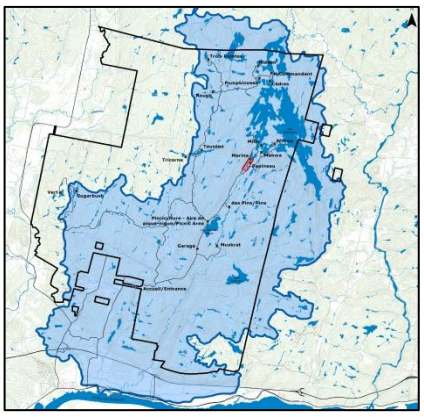


Figure 1. Kinonge watershed.

Results Summary:

- So far the presence of over 73 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.

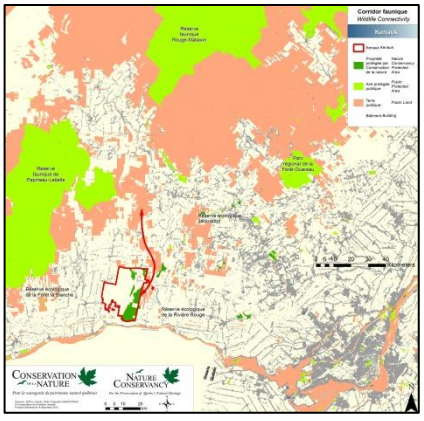
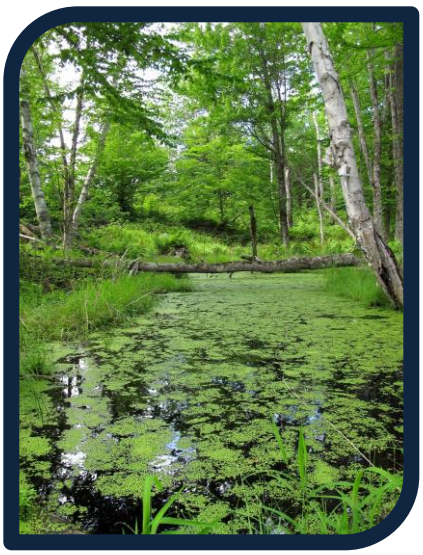


Figure 2. The wildlife corridor.

Status: This inventory will continue in 2021. Extensive species lists have been created which will facilitate long term monitoring, conservation and future research.

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)

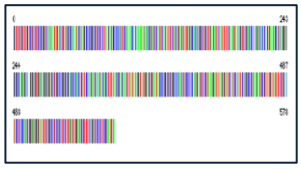
Researchers: Prof. Marie Larocque and student Marjolaine Roux (UQAM) (sub-project 1), Prof. Philippe Nolet and Prof. Yann Surget Groba (UQO) (sub-project 2)

Description: Vernal pools are geographically and hydrologically isolated wetlands commonly found in 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. Despite their ecological importance, there is still very little known about these habitats. In order to accomplish this project, it has been divided into multiple sub-projects: 1) gain a better understanding of the water budget of forest 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 silvicuture on vernal pool herpetofauna diversity, abundance and connectivity; and 3) provide recommendations to decrease the impact of silviculture on vernal pools and their associated herpetofauna. For sub-project 1, 41 vernal pools (16 in 2016, 14 in 2018, and 11 in 2019) were identified, characterized, and have been monitored for water levels. 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.

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



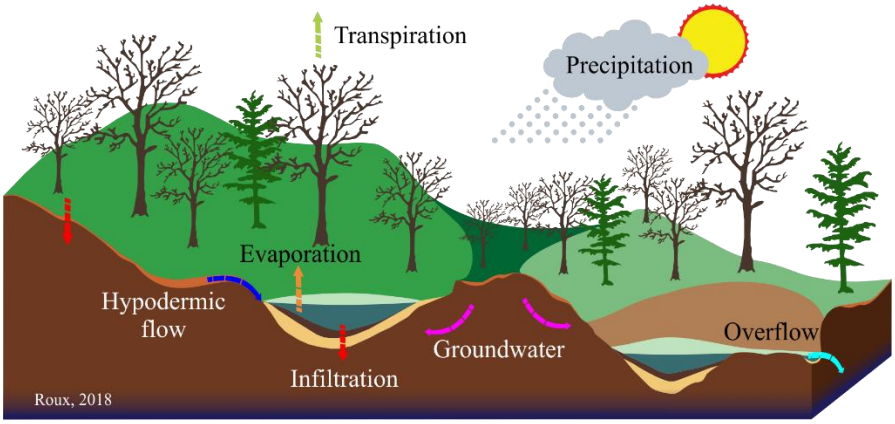


Figure 4. Conceptual vernal pool hydrological model (Roux, 2018).

Status: Hydrological monitoring (three sites) and data analysis for this project will continue through 2021.

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)

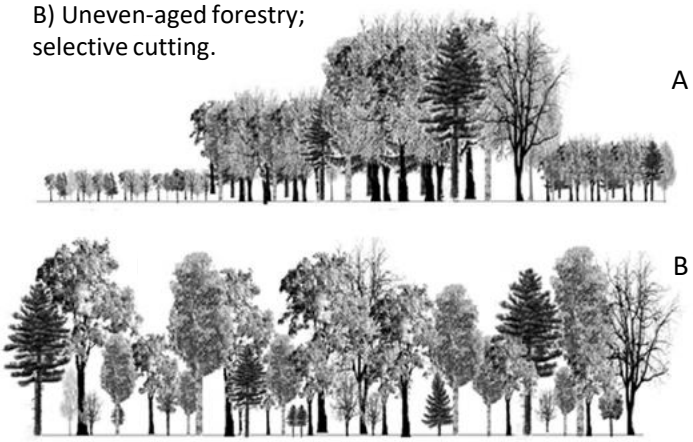
Researchers: Philippe Nolet (UQO), Guy Lessard (CERFO), Dr. Christian Messier (UQO/UQAM)

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 will provide 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.



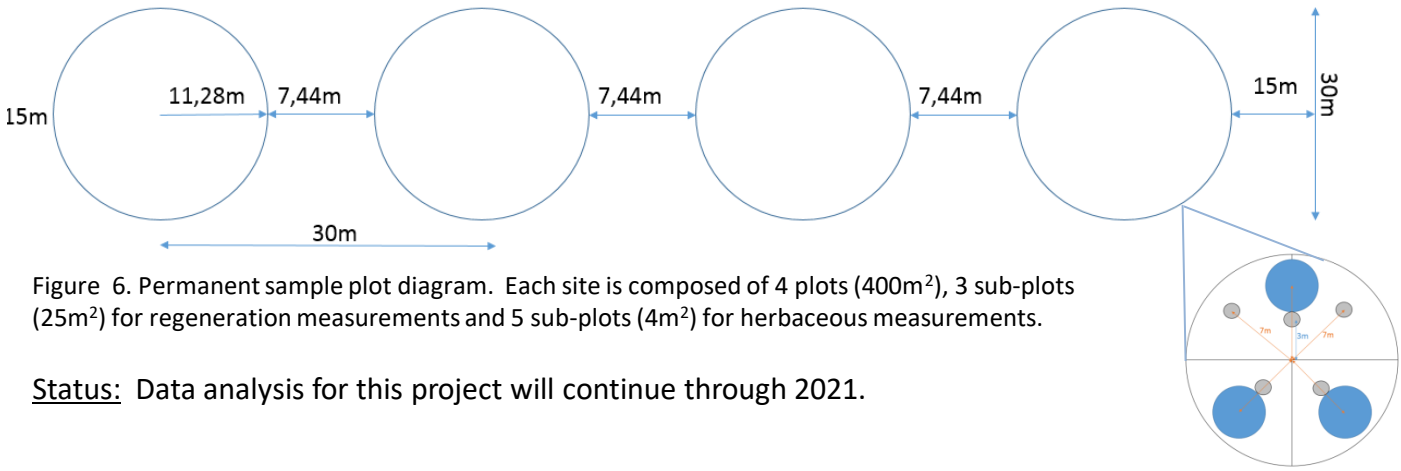


Figure 6. Permanent sample plot diagram. Each site is composed of 4 plots (400m^2), 3 sub-plots (25m^2) for regeneration measurements and 5 sub-plots (4m^2) for herbaceous measurements.

Status: Data analysis for this project will continue through 2021.

4. Forest Resilience Project (#2016-1.4)

Title: Determine the best management strategies that increase the overall resilience of forests to invasive pests, disease and climate change.

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

Researchers: Dr. Christian Messier (UQO/UQAM), Dr. Frédérick Doyon, Philippe Nolet and Rebeca Cordero Montoya (UQO), Guy Lessard (CERFO)

Description: Forests are increasingly being managed for a multitude of ecosystem services occurring at both the stand and landscape scales. However, these services are being threatened by rapidly changing biotic and abiotic factors such as invasive diseases, insects and climate change. For example, in the last 40 years the Kenauk forests have been invaded by dutch elm, beech bark and ash-borers which are decimating important tree species. Many more insects and diseases, already found in the north-eastern US, are also likely to move into Kenauk in the next 40 years. This is occurring simultaneously with rapidly changing climates and increasing human demands. To respond to these challenges, forest managers are required to develop new management strategies aimed at maintaining or increasing the overall resilience of the forest to sustain their vital ecosystem services. This project will use simulation models to evaluate the best management strategies to ensure forests will continue to provide ecosystem services. Part of this objective will be accomplished by comparing tree mortality patterns between even and uneven aged forest stands using novel ground-based mobile LiDAR technology. It is hypothesized that stand dynamics will influence tree vulnerability to stressors.

Results Summary:

- In total 42 sites were scanned using ground-based mobile LiDAR (sites = 0.4-0.8 hectares). So far, the data from 22 sites have been extracted.
- Preliminary conclusions: For similar size classes, tree mortality is higher in Uneven-Aged Stands (UEAS) than in Even-Aged Stands (EAS). Current competition does not explain this higher mortality so it seems that trees growing in UEAS are more vulnerable to stressors than the ones in EAS.

Status: Data analysis for this project will continue through 2021.

Management	Alive	Dead
EAS 30	3,984	70
UEAS 30	2,345	112
UEAS 15	2,792	164
Total	**9,121**	**346**

Figure 7. Inventory of 22 sites including Even-Aged Stands (EAS) and Uneven-Aged Stands (UEAS) that are 15 or 30 years old. Data extracted from mobile LiDAR.

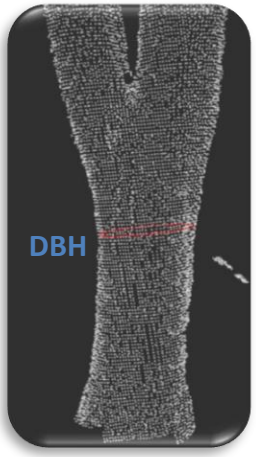
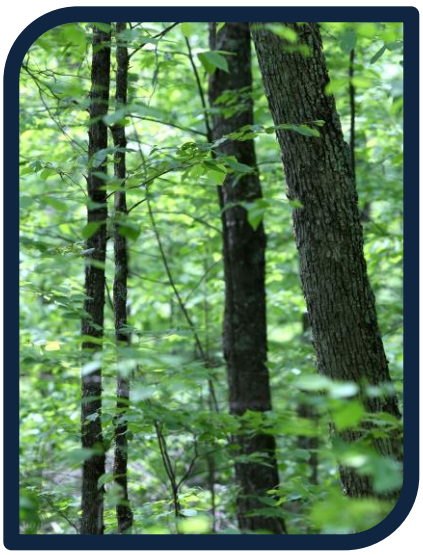


Figure 8. Tree size is measured using Diameter Breast Height (DBH) which is standardized across all forestry.

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 acquired and the tools developed will enable stakeholders in the forest industry involved in planning or harvesting to set up a management strategy for beech invasion adapted to the context of climate change.

Results Summary:

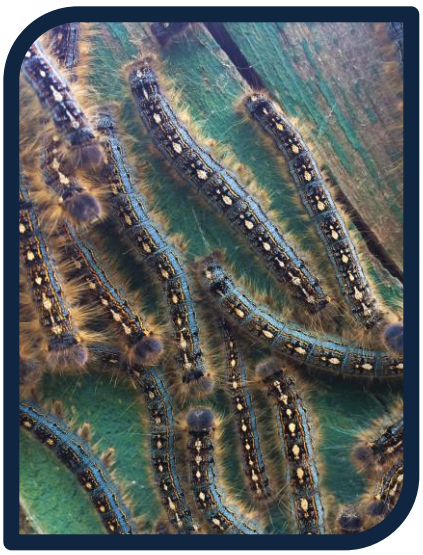
- Tree transpiration and canopy interception of precipitation were monitored at 3 sites invaded by beech trees and 3 sites not invaded during the summer of 2020.

Status: Data collection and analysis for this project will continue in 2021.

Figure 9. Monitoring precipitation interception by the forest canopy.

Figure 10. Monitoring tree transpiration using sensors that measure sap flow.

6. Forest Tent Caterpillar Project (#2018-1.1)



Title: Interaction between forest tent caterpillars and forest composition: Role of predation in outbreak dynamics and effects on litter, soil and tree regeneration.

University / Organization: Université de Québec en Abitibi-Témiscamingue (UQAT), Université de Québec à Montreal (UQAM), and Concordia University

Researchers: Dr. B. Lafleur (UQAT), Dr. E. Despland, Dr. J.P. Lessard and Anne-Sophie Caron (Concordia), Dr. T. Handa (UQAM)

Description: The forest tent caterpillar (FTC) (*Malacosoma disstria*) is a frequent and significant defoliator of hardwood forests across Canada. Historically, severe outbreaks have occurred at ~10 year intervals and lasted 1-3 years (Figure 11). They cause a reduction in tree growth, an increase in tree mortality, a decrease in forest productivity, accelerated forest succession and influence stand composition. With the potential for increases in the frequency and severity of outbreaks from climate change, more than ever we need to understand the factors that regulate the dynamics of FTC populations and the effects of FTC outbreaks on forest ecosystems. The objectives of this project are to: 1) measure the role of predation in controlling FTC population dynamics in both the forest canopy and understory and 2) characterize the effects of FTC outbreaks on soil ecology and forest regeneration. In the long term, this project will contribute to the development of silvicultural approaches that take into account the trophic effects of FTC outbreaks.

Results Summary:

- 1) No difference in FTC larval mortality between defoliated sites (from 2016-2017 FTC outbreak) and non-defoliated sites, 2) No difference between the canopy and the understory, 3) There is a difference in ant abundance and activity in non-defoliated sites, 4) No difference in ant community composition at the genus level, but species level identification is pending.

Status: Data analysis for this project will continue through 2021.

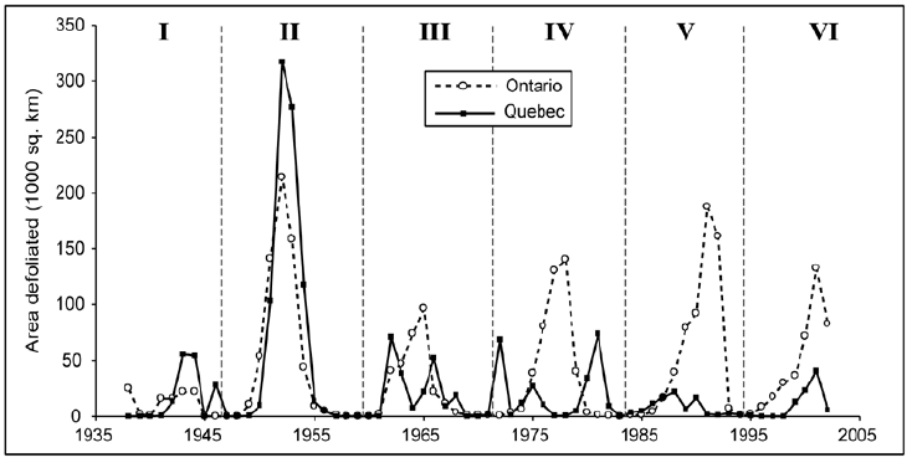


Figure 11. The distribution of FTC defoliation during six outbreak cycles in Ontario and Quebec (Cooke, Lorenzetti and Roland 2009).

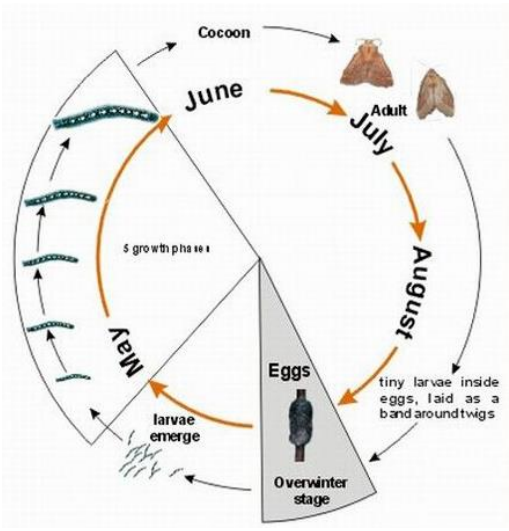


Figure 12. FTC life cycle.

7. Invasive Slug Project (#2016-4.1)

Title: How to explain the invasive success of introduced slug species?

University / Organization: Université du Québec en Outaouais (UQO), Institut des Sciences de la Forêt Tempérée (ISFORT)

Researchers: Dr. Angélique Dupuch, Anna Mazaleyrat

Description: The goal of this project was to determine the ecological factors that facilitate the successful invasion of non-indigenous slugs. In Canada there are almost 40 species of slugs and approximately half of them are introduced. This project tested whether habitat disturbances, like logging, helps invasive species proliferate. To do so, we evaluated the abundance of an introduced slug species, *Arion fuscus*, and that of indigenous species in managed forests in the Outaouais region. It was hypothesized that logging would create habitats more suitable for *A. fuscus* while decreasing habitat quality for indigenous species in the Philomycus genus.

Results Summary:

- The species of slugs identified at Kenauk so far include: *Pallifera dorsalis, Deroceras laeve, Philomycus carolinianus, Philomycus flexuolaris, Philomycus venustus, Philomycus togatus* (indigenous), and *Arion fuscus* (invasive).
- *P. venustus* has never been found in Canada and *P. carolinianus* has never been found in Quebec (to our knowledge) and is listed as threatened by COSEWIC.
- As expected, *A. fuscus* was more abundant in logged areas than in mature stands while the opposite was observed for Philomycus species. This suggests that logging facilitates the invasion of introduced slug species but it detrimental to indigenous slugs (figure 13).

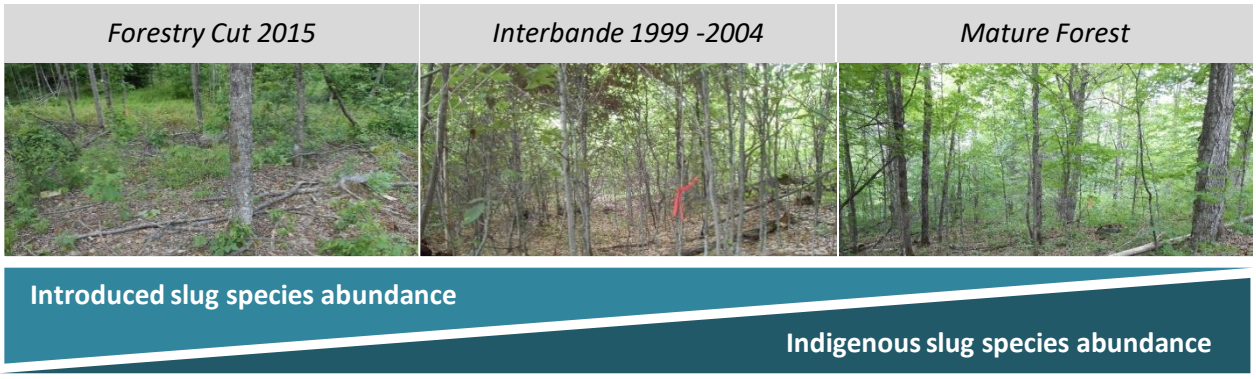
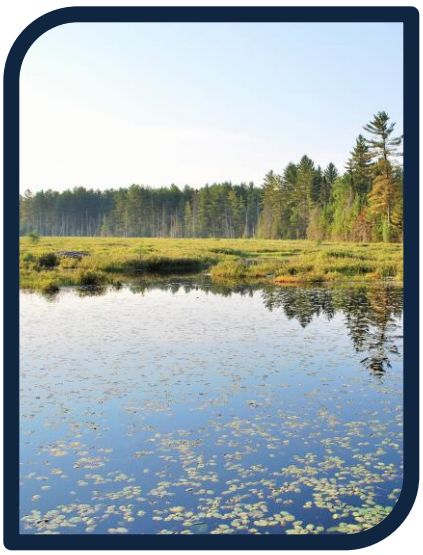


Figure 13. Characterizing slug communities in forest stands with various levels of forestry disturbance.

Status: This project is now complete. It has provided valuable data on the slug species at Kenauk and helped us understand the role of habitat disturbance, such as logging, in facilitating the invasion of introduced animals.

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 14). 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:

- There are 4 concurrent graduate students working on 4 research aspects of this project.
- A wealth of information has been collected including lake volumes, the characterization of all its wetlands (there are over 100), weather station data, lake levels and inflows, surface runoff, groundwater levels, horizontal and vertical temperature profiles and more.
- Vascular vegetation was sampled in 38 wetlands; 9 of which were identified as unique, meaning they have a special and distinct species composition compared to the other sites. These unique wetlands (mostly peatlands) harbour many rare and disturbance-sensitive species.

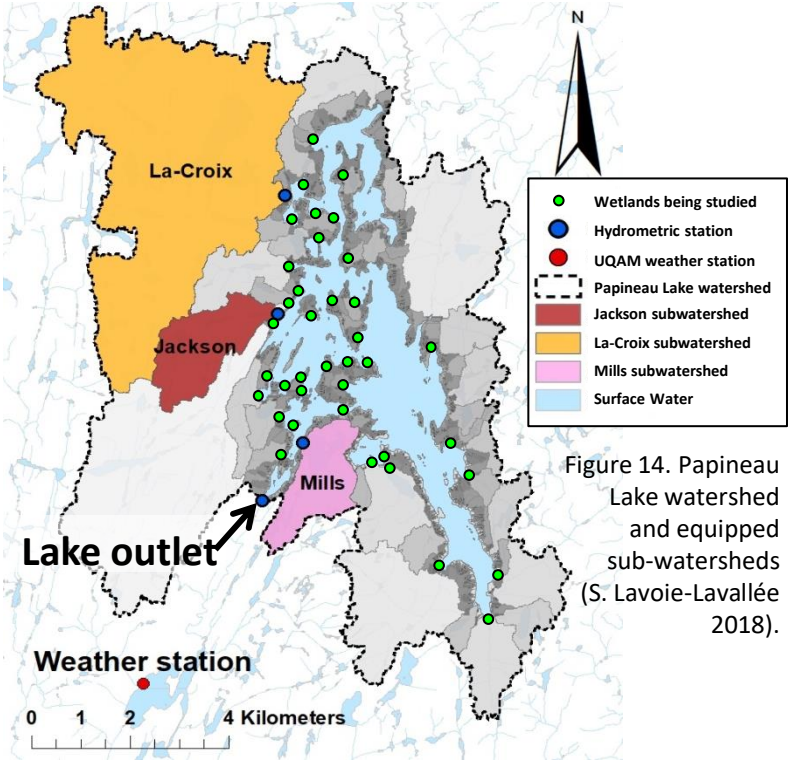


Figure 14. Papineau Lake watershed and equipped sub-watersheds (S. Lavoie-Lavallée 2018).

Status: Data collection and development of hydrological models will continue in 2021.

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.

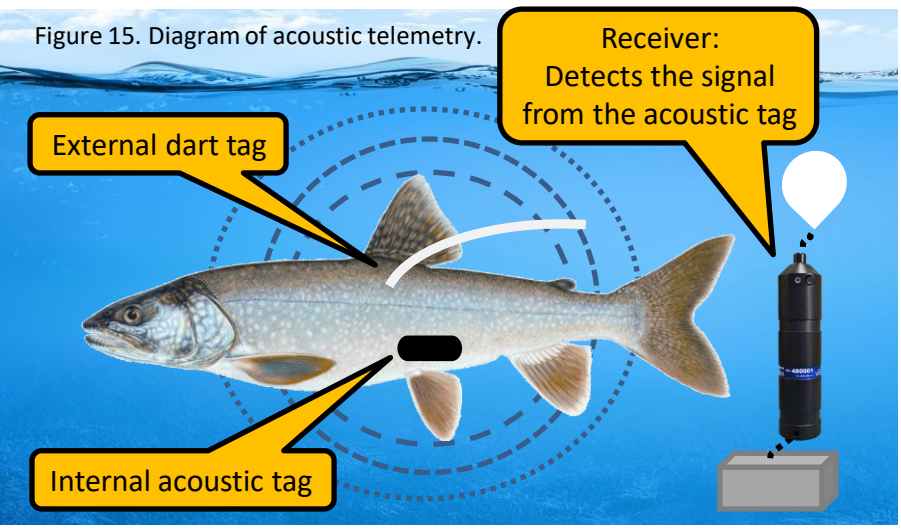


Figure 15. Diagram of acoustic telemetry.

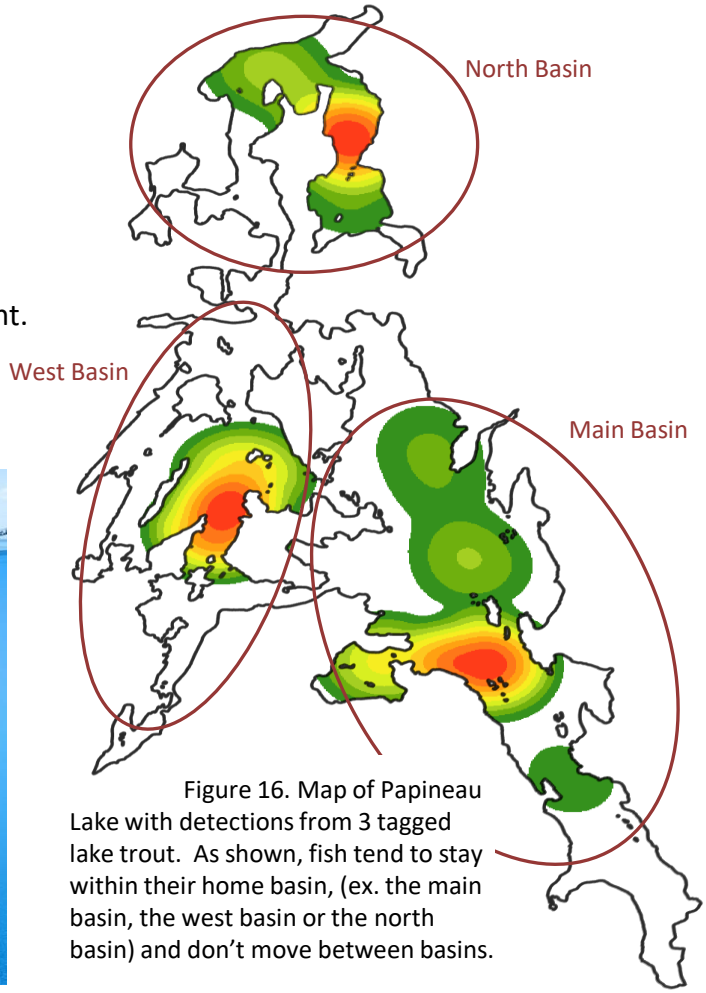


Figure 16. Map of Papineau Lake with detections from 3 tagged lake trout. As shown, fish tend to stay within their home basin, (ex. the main basin, the west basin or the north basin) and don't move between basins.

10. Rainbow Trout Catch-and-Release Project (#2020-4.1)

Title: Investigating temperature-dependent responses to catch-and-release angling in Rainbow Trout (*Oncorhynchus mykiss*).

University / Organization: Carleton University, University of Massachusetts Amherst

Researchers: Dr. Steven Cooke, Auston Chhor, Jessica Reid (Carleton), Dr. Andy Danylchuk (UMass Amherst)

Description: Catch-and-release angling (C&R) is an emerging conservation technique that focuses on returning fish to their environment following capture. These fish are assumed to return to their normal behaviour; however, we know this is not the case. Following a fisheries interaction, fish may experience stress and become impaired. This impairment can manifest as compromised decision making, inability to avoid predation, inability to seek refuge or in extreme cases, fish may also perish. The goal of this project is to determine the influence of surface water temperature on post-release behavioural impairments in angled Rainbow Trout, and to investigate the use of holding devices that are designed to facilitate recovery. The project aims to provide anglers with the knowledge to make handling-related decisions that maximize the survival of released fish. To accomplish this, two primary research questions were investigated: (1) What is the influence of surface water temperature, fight time, and air exposure on post-release recovery? And (2) When is it beneficial for anglers to assist fish in their recovery after an angling event, and what methods are the most beneficial?

Results Summary:

- Trout experience the most substantial behavioural changes such as equilibrium loss when water temperatures exceed 22°C.
- Deeply hooked fish have high mortality rates - barbless hooks can help reduce dehooking time.
- Assisted recovery is only beneficial when the water used in the recovery tank is significantly colder than surface water temperatures.
- At the height of summer water temperatures (25°C +), holding fish in a recovery box or cooler for 3 minutes using 18°C water significantly decreased equilibrium impairments upon release.

Status: This project is now completed.

Figure 17. A rainbow trout being released after a catch and release treatment with an attached biologger to record swimming behaviour.

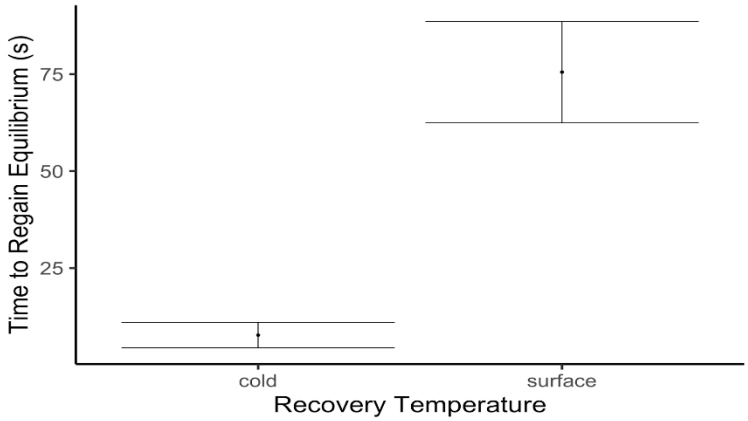


Figure 18. Time for fish to regain equilibrium after assisted recovery in cold vs surface temperature water.

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), Marianne Valcourt, Ilona Grentzmann, Maëliss Hoarau, Mathilde Poirier (graduate students U Laval)

Description: The regular and irregular outbreaks of micromammals 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. Vole cycles in forest environments have been observed mainly in Boreal Fennoscandia, but they are rarer in the boreal forests of North America. However, few studies have been carried out in the eastern part of the country in both boreal and temperate forests where fluctuations in voles' abundance are unknown. The objective of this study is to carry out long-term monitoring of the annual densities of voles and forest mice on the Kenauk property 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, in the Arctic where the mechanisms leading to lemming abundance cycles have been studied for nearly 30 years.

Results Summary:

- In September 2020, 6 trapping grids with 60 live capture traps were deployed for 3 days and nights.
- A total of 380 small mammals were caught including 214 red-backed voles, 108 Peromyscus mice, 42 large shrews, 13 chipmunks, 2 field voles and 1 Cooper's lemming vole.
- Preliminary results point to a year of relatively high abundance of small mammals, but this will need to be confirmed using future inter-annual comparisons.

Status: Data collection for this project will continue through 2021.

Figure 19. Common vole.

Figure 20. A tagged deer mouse.

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 2021.

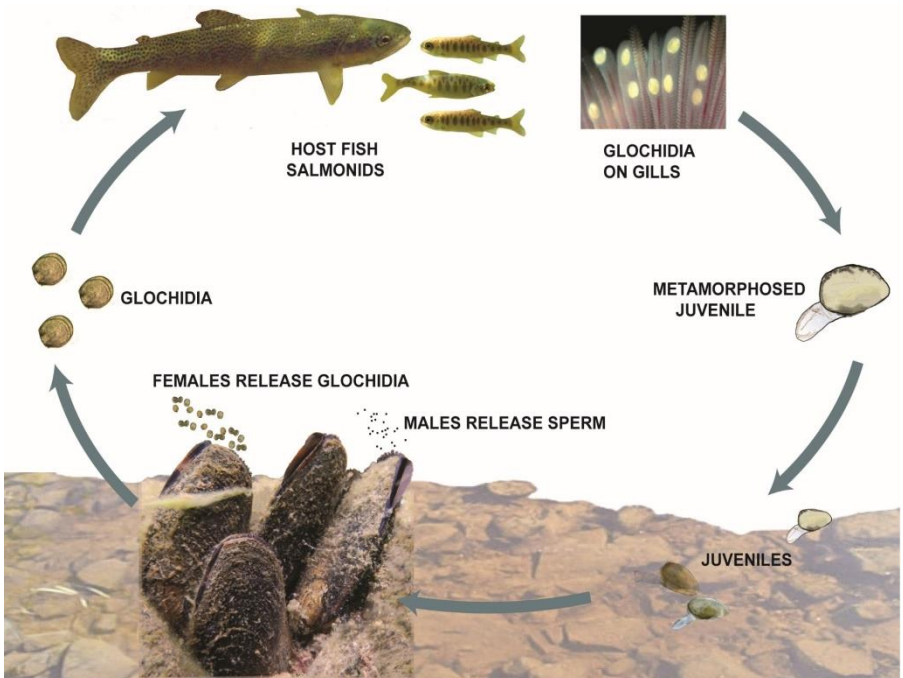


Figure 21. The life cycle of Pearlshell Mussels (Freshwater Mollusc Conservation Society). They can grow to 10-13cm in length and live an average of 93 years, although the oldest Pearlshell mussel was found to be 280 years old.

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: Jean-Marie Mondor (NCC), The Kenauk Institute interns, and countless 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. It was recently discovered that Papineau Lake has been invaded by milfoil, so in an effort to protect the lake and the rest of the watershed, the Kenauk Institute and NCC conducted an inventory of the lake for the invasive plant (figure 22). This summer Kenauk hosted milfoil experts that trained us on how to effectively remove the invasive plant as well as helped us remove a large number of plants (~731 pounds worth) in 2 of the colonies on the lake.

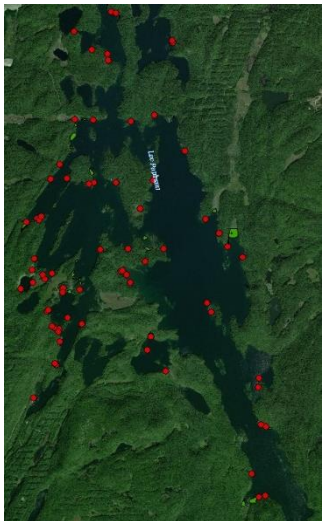


Figure 22. Map of Papineau Lake; milfoil colonies in red.

14. Tick Inventory Project (#2019-2.1)

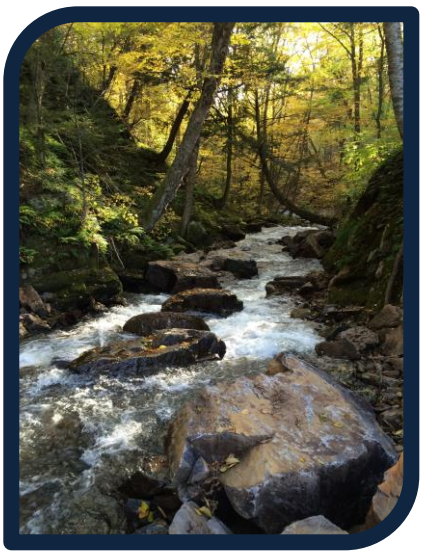
Title: Education about the prevention and risks of Lyme disease as well as inventorying ticks (*Ixodes scapularis*) at Kenauk.

University / Organization: The Kenauk Institute

Description: The overall objective of this project is to inform people on Lyme disease, including prevention measures, and to sample *Ixodes scapularis* ticks in the environment safely. We collected ticks from sample areas on the property of Kenauk to document local risk and contribute to the National Lyme Disease Surveillance Program. The Kenauk Institute performed several surveys on the property and collected 34 ticks over the summer which were genetically tested for lyme disease and other common infections. Of the 34 ticks, 2 tested positive for lyme disease (~6%) and 2 tested positive for babesia microti (~6%). Babesia microti is a pathogen that causes a disease called babesiosis, a malaria-like disease which also causes fever and hemolysis. It's transmitted by the nymph stage of ticks, which need to be attached to a person for 36-48 hours and there are effective treatments.

Status: Data collection and long-term monitoring for both projects will continue for many years.

15. 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 used to locally modify the hydraulic characteristics of rivers. They 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 physical and chemical condition of the river for fish spawning and circulation in terms of ideal flow rates, water depths, oxygenation and habitat diversity. The goals of this project include monitoring: 1) fish movement between the Kinonge River and Papineau Lake, 2) spawning grounds, 3) the number of fish that return to Papineau Lake and 4) fish circulation and sustainability. In order to monitor the success of the weir in maintaining water levels; a probe has been installed above the weir that measures water depth hourly throughout the year. Comparisons between water level fluctuations before and after the weir installation will allow Kenauk to monitor the success of the weir as well as contribute to the overall monitoring of the Kinonge watershed.

Results Summary:

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

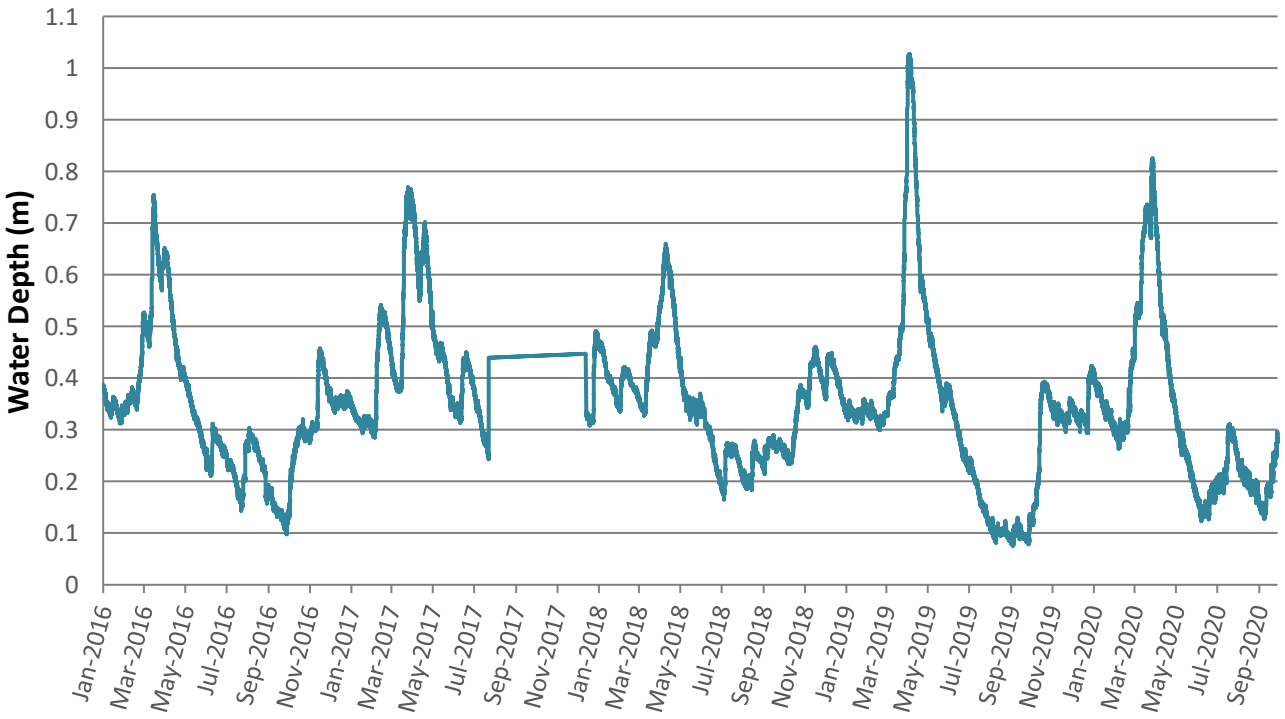
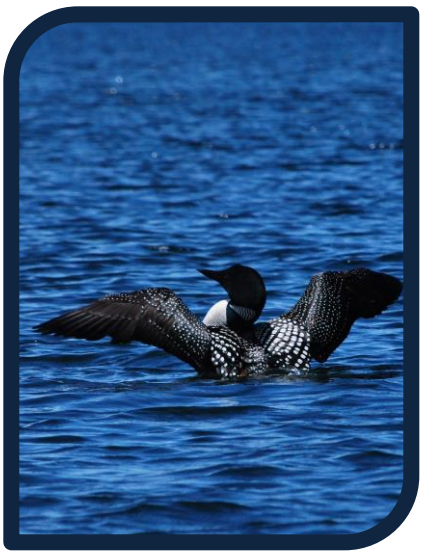


Figure 23. Water depth above the weir. *Note that water depth was compensated for barometric pressure and the data for 2020 does not include the whole year yet (data ranges from Jan 1 to Oct 16, 2020).

Status: Data collection for this project will continue through 2021.

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



University / Organization: The Kenauk Institute

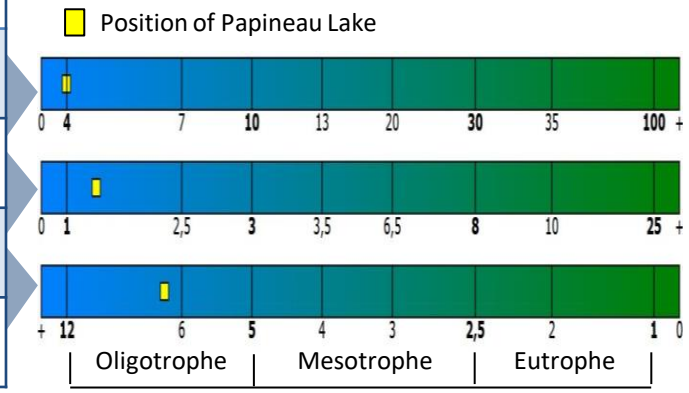
Description: Papineau Lake is a registered lake in the Volunteer Lake Monitoring Program (VLMP) of the Government of Quebec. The Kenauk Institute will periodically take water samples throughout each summer with the goal to establish a long-term monitoring protocol for water quality with annual comparisons.

Results Summary:

- Based on multiple factors including the high water transparency, 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 24. Water quality parameters of Papineau Lake (annual averages) and it's corresponding trophic classification.

	2014	2015	2016	2017	2018	2019
Total Phosphorus (µg/L)	6.00	5.18	3.50	3.05	4.15	4.40
Chlorophyll a (µg/L)	1.30	0.87	1.45	1.20	1.45	2.10
Secchi (m)	6.13	6.20	6.30	6.90	6.55	7.15
Organic Dissolved Carbon (mg/l)			3.65	3.30	2.95	3.45



17. 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:

- First hatching the week of June 24th.
- Second hatching the last week of July.

Status: Data collection will continue in 2021.

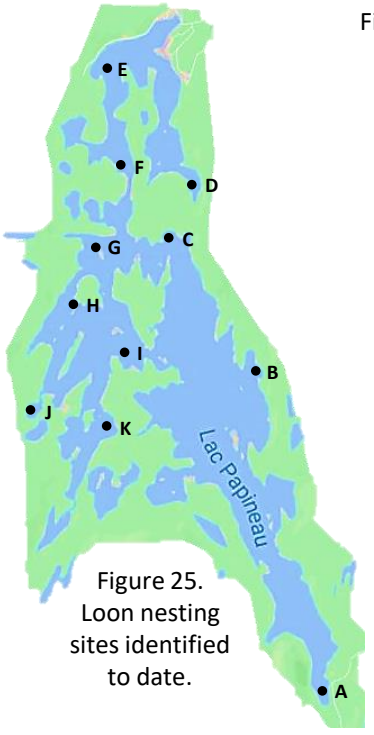
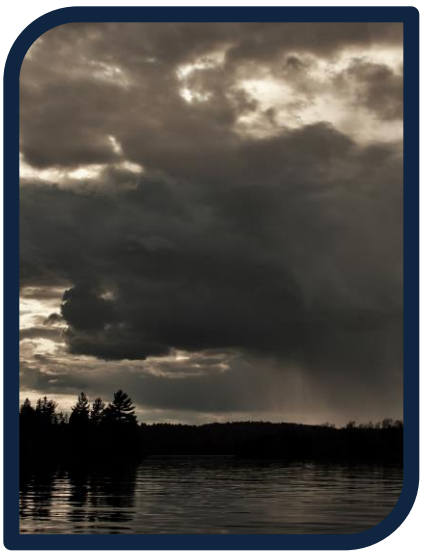


Figure 25. Loon nesting sites identified to date.

Figure 26. Loon observations 2020.

Nest ID	Loon Pair	# of Chicks
A	Unconfirmed	
B	Unconfirmed	
C	Unconfirmed	
D	√	-
E	√	2
F	√	1
G	√	2
H	Unconfirmed	
I	√	0
J	√	2
K	√	1

18. Weather Station Data (#2016-3.1)



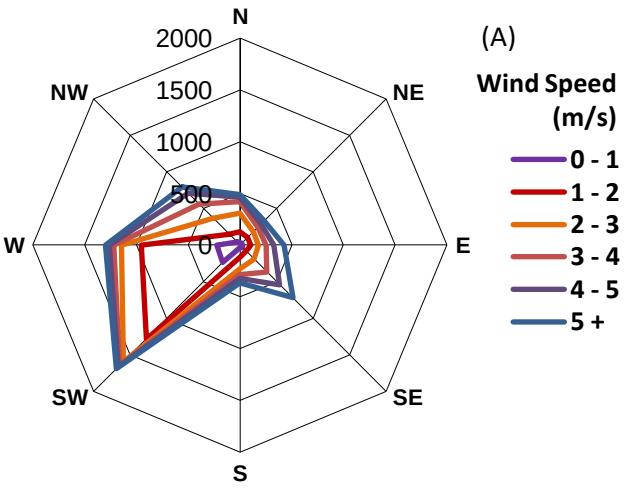
University / Organization: Université de Québec à Montréal (UQAM), The Kenauk Institute

Description: In partnership with UQAM, Kenauk has a weather station installed at Whitefish Lake. This weather station 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:

- See graphs below for data collected by the weather station.

	2017	2018	2019	2020
Max Temperature (°C)	32.6	33.6	32.7	34.7
Mean Temperature (°C)	5.80	5.45	4.92	10.8
Min Temperature (°C)	-31.5	-33.6	-29.7	-25.7
Max Wind Speed (m/s)	11.6	11.0	11.5	11.2
Max Rain / Day (mm)	47.5	67.1	29.2	44.7
Total Rain / Year (m)	0.90	1.13	0.83	0.69
Max Snow Depth (m)	0.68	0.75	0.90	0.65
Mean Relative Humidity (%)	76.7	75.8	74.2	70.9



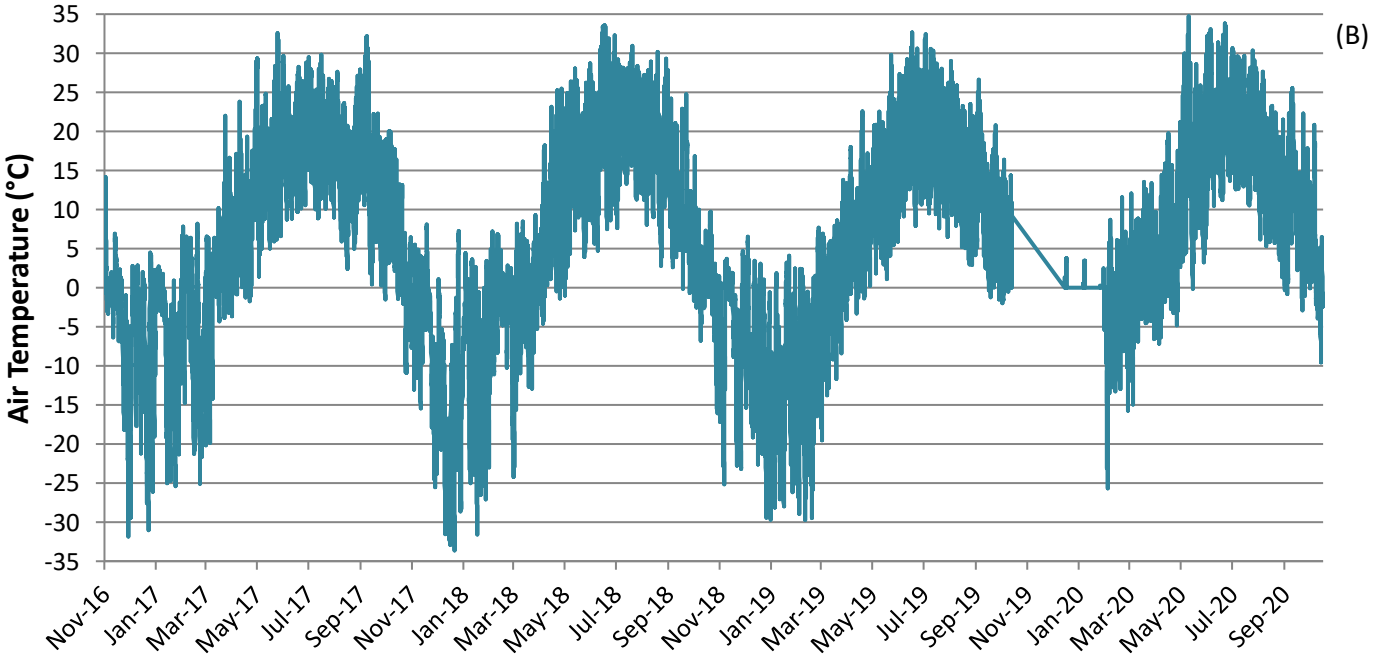
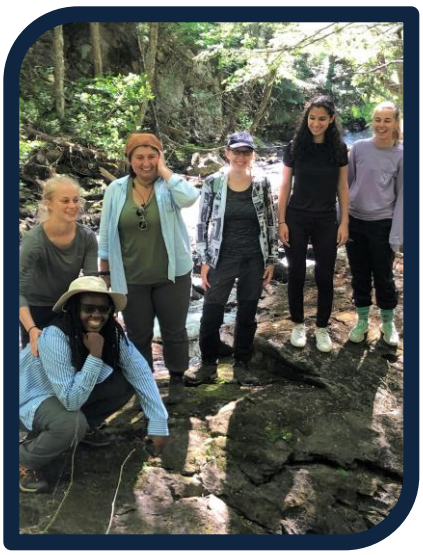


Figure 27. (A) The maximum wind speed in m/s for 2020. (B) The average air temperature in °C from 2016 to 2020.

Kenauk Institute Intern Projects

19. The effect of roads on scavenger activity. (#2020-7.1)
– Katherine Peacock, Dr. Steven Cooke (Carleton University)



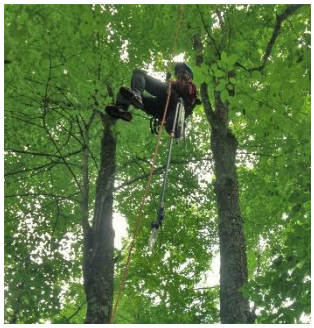
For decades, anthropogenic activity has posed increasing threats to ecosystems. Roads have long been researched due to the barriers they create causing ecosystem fragmentation. Kenauk provides a unique location where semi-naturalized roads can be studied without the presence of heavy traffic. The goal of this project was to study semi-aquatic and aquatic scavenging activity using baited trail cameras by comparing the scavenger frequency and type in locations near and far from main roads. Preliminary results show that the roads at Kenauk do not have a significant effect on scavenging activity. This research can be used in future development plans for the property, and in urban and rural infrastructure planning.

20. The effect of vertical stratification on herbivorous damage patterns in sugar maple trees. (#2020-9.1)
– Colette Ethier, 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 stratas 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. Results show higher herbivore damage in the understory compared to the canopy, especially in sun leaves. 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. (#2020-8.1)
– Kayla Nicole Kuhlmann, Mailys Laprevotte, 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 determined 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.





Research and Educational Partnerships

Donors and Grantors

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- American Friends of Canadian Nature (AFNC)
- Nature Conservancy of Canada (NCC)
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- Department of Fisheries and Oceans from the Government of Canada
- Sustainable Forestry Initiative
- Ducks Unlimited Canada
- Mathematics of Information Technology and Complex Systems (MITACS)
- Ministère de la Forêt, de la Faune et des Parcs (MFFP)