Université de Montréal

Insects tell a story: a web interwoven with entomology and Naskapi knowledge in Kawawachikamach

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Mémoire présenté
en vue de l'obtention du grade de Maîtrise
en Géographie

Novembre 2017

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Page d’identification du jury

Université de Montréal

Faculté des Études Supérieures et Postdoctorales

Cette thèse intitulée :

Insects tell a story: a web interwoven with entomology and Naskapi knowledge in Kawawachikamach

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a été évaluée par un jury formé des personnes suivantes :

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Résumé

Dans la région de Kawawachikamach, les insectes sont pollinisateurs et prédateurs de plantes d'importance culturelle, vecteurs de maladies, et source de nuisance pour l'humain et le caribou. Les membres de la Nation Naskapi ont exprimé leurs inquiétudes concernant des changements induits par le climat dans l'abondance, la distribution, la composition, et la phénologie des communautés d'insectes et leurs impacts sur le mode de vie naskapie. Suite à un échantillonnage d'insectes modernes et fossiles dans trois tourbières en 2015 et 2016, nous avons obtenu un aperçu de la diversité dynamique des assemblages d'insectes, les diptères, les hyménoptères, et les araignées étant les taxons les plus représentés. Étant donné que les moustiques (*Culicidae*) et les mouches noires (*Simuliidae*) maintiennent des populations denses dans la région, les insectes sont considérés comme des parasites nuisibles pour humains et animaux. Des travaux supplémentaires sont nécessaires pour déterminer si les caractéristiques des communautés d'insectes échantillonnées dépendent de la composition et la densité des fleurs à chaque site. Nos données provenant de l'échantillonnage à piège passif suggèrent que les araignées-loups (*Lycosidae*) figurent parmi l'un des plus abondants arthropodes terricoles de la région. Les travaux paléo-écologiques suggèrent le remplacement d'espèces aquatiques par des espèces non-aquatiques à l'échelle locale, parallèle à la disparition de *Cladocera*, *Trichoptera* et des acariens aquatiques *Limnozetes* et *Hydrozetes*. Des questionnaires effectués dans la communauté dévoilent l'apparition de plus gros insectes, une augmentation dans leur abondance, une émergence printanière hâtive, ainsi que l'apparition de nouvelles espèces au cours des derniers cinquante ans. Les jeunes naskapis de la communauté ont eu l'opportunité de s'impliquer dans les activités de recherche à travers des activités de plein air, une exposition d'art itinérante, et lors du festival Présence Autochtone à Montréal. À travers l'art, nous laissons s'exprimer perceptions et valeurs sur les insectes, tout en créant un espace de discours autour des relations insecte-plante-humain à travers les cultures et l'espace.

Mots-clés : Entomologie, Savoirs naskapis, Subarctique, Changements climatiques, Recherche-action-création, Paléoécologie, Ethnoentomologie, Arthropodes.

Abstract

In Kawawachikamach insects are pollinators and predators of culturally important plants, vectors of disease, and sources of annoyance for humans and culturally important animals. There is a rising concern amongst Naskapi that climate change and its effects on insect abundance, distribution, composition, and phenology impacts the ways in which people connect with the land. Insect sampling at three peatland sites during the 2015 and 2016 summer breeding seasons revealed that Diptera, Hymenoptera, and Araneae are the most represented taxa. Mosquitoes (*Culicidae*) and black flies (*Simuliidae*) sustain highly dense populations in the region and are considered to be important pests for humans and animals. Additional work is needed to determine if their abundance, distribution, composition, and phenology depends on the composition and density of flowers at the study sites. Based on results from the yellow pan trap method, wolf spiders (*Lycosidae*) are amongst the most abundant ground-dwelling arthropods in the region. Paleoecological work suggests a shift from aquatic to non-aquatic species at the local scale, concurrent with the disappearance of *Cladocera*, *Trichoptera* and the truly aquatic acarian genera: *Limnozetes* and *Hydrozetes*. Questionnaires conducted with community members reveal larger-sized insects, an increase in their numbers, an earlier spring-time emergence, and the appearance of new species over the past 50 years. Land-based activities for Naskapi youth, a traveling art exhibit, and our presence at the Montreal First Peoples' festival, were opportunities for youth and members of the community to be involved in research activities and to create a space for discourse around insect-plant-human relationships across cultures and spaces.

Keywords : Entomology, Naskapi Knowledge, Subarctic, Climate change, Research-action-creation, Paleoecology, Ethnoentomology, Arthropods.

Table of contents

List of tables

List of figures

Dédiée à ma grand-mère, qui, avec ses yeux brillants,
pouvait raconter une histoire sans mots.

Preface and acknowledgements

I started my Master's in geography having chosen one of the two paths you can take in the department of geography at the University of Montreal. Influenced by my previous experience in the natural sciences, I chose physical geography over human geography. With a Bachelor's in Biology at McGill University, I praised the natural sciences. I continued to admire the knowledge it produces as I went on to work as a marine technician on the Great Lakes, as an interpreter at Parks Canada marine sites along the St. Lawrence River, as a marine mammal technician in Iceland, as a fisheries observer on Alaskan crab fishing boats. Not once in those 7 years had I questioned the knowledge I was producing. *Why am I doing this? Who does it affect? How will it be used and interpreted?* As for many graduate students, I changed projects multiple times. Initially, I wanted to work in a 2-3 million year old fossil forest on Bylot Island. I was attracted by the idea of working in such a northern, isolated place, an adventure that I could brag about. With no funding for the Bylot Island project, and after a series of discussions with my two favourite geographers, Julie Talbot and Thora Martina Herrmann, I began a journey of healing, reflecting and critiquing my *western ways of knowing*. I am so deeply grateful for all the people who continue to play an important part in my journey. First of all, I could not ask for better mentors: Julie Talbot and Thora Martina Herrmann, at times when I could feel my fire dying out, it is your presence and your support that re-ignited the flames from my embers. Writing letters of support, talking about daycares, sharing baby clothes, spending time together and getting to know each other out in the field… no wonder I was able to succeed as a young mother in academia. Patricia Martin, Violaine Jolivet, and my wonderful colleagues at the Concordia Ethnography Lab, you have guided me through the histories of geography and you have been the spark igniting my thoughts and critiques on the production of knowledges in academia. I have been warmly welcomed on Naskapi lands and territories, a place and space that is rich in past, present, and future stories of joy, laughter, anger, and sadness. These stories shape Naskapi identity, one that will continue to stay strong for generations to come. I would like to acknowledge the wonderful presence and the beginning of long-lasting friendships with Tshiueten Vachon and Cheyenne Vachon. You are both inspiring people with ideas that have made this project rich and beautiful. George Guanish, Ruby Robinson, and the 2016 Naskapi Summer Day Camp team, your hard work and your amazing presence have merited a space at the Montreal First Peoples' festival, a place and space to share Naskapi identity with people from around the world. I would like to warmly thank the Naskapi Development Corporation and the Naskapi Nation Office who have been central to the organization of all research activities. Jérémie Masse-Maillé, Mathieu Roy, Cloé Fortin and Louise Watson, your passion and skills as early-career researchers are reflected through this article's main findings and conclusions. A big thank you to the wonderful 2015 & 2016 field team members: Thora Martina Herrmann, Philippe Major, and Morgane Bonamy. Our time in the field has been fruitful and an opportunity to share wonderful moments together. And finally, I want to acknowledge the people at the core of my journey: my little family. Mathieu, you are my favourite person. It is with your unimaginable support, knowledge and love that I have become the person I am today. This journey has not been mine alone but it has been ours. My son, your love and laughter has brought warmth to my heart.

Thank you all for your support, your kindness, and your guidance.

Chapter 1: Introduction

"*Our knowledge is the product of our observation of the environment during thousands of years and of these observations, influenced by our beliefs, values and customs*"

- Naskapi Elder (Lévesque, 2016: pg. 65)

Climatic changes in northern Quebec affect subarctic flora and fauna, and thereby the way of life of Northern people. Increases in mean air temperatures and alterations in precipitation and snow cover patterns are the main phenomena affecting Quebec subarctic ecosystems (Royer et al., 2013; Brown & McNeil, 2010). The variability in local and regional weather events shifts wildlife and vegetation patterns, and alters resource availability and accessibility for humans and non-humans alike (Rapinski, 2017; Henry et al. 2012; Kellogg et al. 2009; Payette & Delwaide, 2004). Northern Indigenous communities that live interdependently with the land are confronted with colonially-driven environmental change that is entrenched in a history of violation of land and bodies (Mitchell & Todd, 2016; Adger et al. 2014). For example, Indigenous lands have been expropriated and destroyed, peoples have been displaced to fuel capital speculation, and violent state policies have fractured inter-generational knowledge translation of living, adapting, and caring for the environment (Whyte, 2017; Mitchell & Todd, 2016; Cameron, 2012; Turner & Clifton, 2009; Cruikshank, 2005). It is clear that climate-induced shifts in the accessibility of culturally important plants and animals affect the integrity of Indigenous cultures and economies (Callison, 2017).

The Naskapi First Nation of Kawawachikamach is one of many northern Indigenous communities living in subarctic Quebec that need to cope with social, cultural, and economic consequences from changes in their environment and society (Mameamskum et al. 2014). Members of the Naskapi Nation have identified multiple changes in climatic conditions that affect the animals and plants living on their lands and territories (Mameamskum et al. 2014). Such climatic changes are affecting the plants, the animals, and Naskapi way of life which is closely linked to the land. For instance, in the summer, an increase in biting insects may affect animal and plant-gathering activities (Rapinski et al. 2017). In the winter, access to country foods in the winter is increasingly difficult, as: "[…] *changes in ice and temperature on lakes make it harder to practice ice fishing...*" (Naskapi elder, Rapinski et al. 2017: 7). A loss in accessibility and availability of country food has serious repercussions on community health and wellness (Rapinski et al. 2017; Royer et al. 2013).

As regards to insect populations, there is a rising concern that climate-driven changes in their abundance, distribution, composition, and phenology has the potential to affect Naskapi way of life (Mameamskum et al. 2014; Lévesque et al. 2012; Hagen et al. 2007; Nickels et al. 2005; Garibaldi & Turner, 2004). These community concerns stem from the impacts of climate change on subarctic Québec peatlands which are home to a number of culturally-important plants. *Rhododendron* spp. (Labrador tea), *Vaccinium* spp. (blueberries), and *Rubus chamaemorus* (bakeapple berries) are some of the many plants harvested by Naskapi. These plants rely on insect pollination to reproduce and propagate (Ferland, 2014; Henry et al. 2012; Brown & McNeil, 2009). Very little is known about insect and plant relationships in Québec subarctic peatlands (Lévesque et al. 2012). This has led us to ask: *How do entomology and Naskapi perceptions, values, and knowledges contribute to discourses on climate change in Kawawachikamach?* To respond to this overall research question, this Master research project was guided by three main objectives: 1) to describe insect diversity in peatlands near Kawawachikamach; 2) to investigate changes in insect assemblages over time; and 3) to explore Naskapi observations, values, and knowledges of insects and changes in insect populations.

This Master's thesis is divided into five chapters which together constitute one research article. In the next chapter, I will synthesize the literature on varying perspectives and knowledges of climate change and arthropods in Northern communities of Canada. In chapter 3, the methodological framework will be presented for the three main research approaches, i.e. entomology, paleoecology and ethnozoology. In chapter 4, results will be presented following the 3 main objectives, which will lead to concluding remarks as presented in chapter 5.

Together, the chapters of this dissertation bridge the physical and human dimensions of research in geography, leaving a legacy of one publication about insect (paleo)ecology, Naskapi knowledges, and participatory research through land-based activities.

Chapter 2: Literature Review

In this chapter, I present a brief background of scientific and Indigenous research on arthropods and climate change in subarctic and arctic zones. I introduce climate change research in subarctic regions of Quebec followed by a brief discussion on the biology of peatlands in these zones. Next, I build on this compilation of scientific information of landscapes of Northern regions and perceived changes through time to introduce the biology and ecology of arthropods in these places and spaces, and more specifically in subarctic peatlands. With a better understanding of the role of arthropods in these ecosystems, I have compiled knowledge from science and from people residing in Northern communities to address the types of changes occurring within arthropod populations. Finally, the last section presents knowledge, stories and art of arthropods in Northern Indigenous communities. For many Inuit and First Nations, animals play an important role spiritually and culturally in everyday life (Todd, 2014; Bird et al. 2005). Oral histories communicate and mobilize values, attitudes, and beliefs of relationships between humans, animals, plants and the land (Herrmann et al. 2013; Cruikshank, 2005; Absolon & Willett, 2004). However, with colonization, the state empowered the written word (i.e. science) as the most valid representation of facts and First Nations and Inuit oral histories were dismissed as legends, myths, and folklore (Cruikshank, 2005; Absolon & Willett, 2004). In this chapter, we mobilize local observation and cultural perception of First Nations and Inuit communities as it can generate new and culturally more meaningful methods in observation, data analysis and interpretation of climate change-biodiversity research.

2.1 Climatic changes in subarctic regions of Quebec

The regional climate of North America's subarctic regions has changed in living memory (Rapinski et al. 2017; Ford et al. 2012; Hinzman et al. 2005). In the eastern Canadian province of Quebec, scientific evidence and local knowledge from the subarctic suggest that winter air temperatures are warmer, the quantity of snow is diminishing, freeze-up occurs later in the fall and precipitation patterns are changing (Rapinski et al. 2017; Royer et al. 2013; Brown 2010).

2.1.1 Changes in the landscape

Between 1960 and 2005, mean air temperature increased in southern Québec by 0.2 to 0.4 °C per decade (Yagouti et al. 2008). At the Boniface River watershed (57˚45' N, 76˚00' W) in northern Quebec, Payette & Delwaide (2004) have documented lake and peatland expansion in subarctic wetland forests as a result of high water levels in the 19th and 20th centuries. It has been suggested that wetter conditions are linked to changes in atmospheric circulation patterns which in turn affects the region's snow and fire regimes (Payette & Delwaide, 2004; Bégin 2001; Rouse 1991). However, higher temperatures will increase the evapotranspiration of wetland ecosystems, which could contribute to generally drier conditions locally (Zhang et al. 2018; Price et al. 2013). For example, in the Umiujaq region of northern Quebec, the extent of tall vegetation cover (e.g. spruce and tall shrubs) is increasing, the area covered by water bodies is decreasing and lakes have been disappearing (Beck et al. 2015). Regional climatic changes such as temperature-induced precipitation lead to changes in the hydrology of bodies of water, and result in spatial rearrangements of vegetation and animals in wetland ecosystems (Levison et al. 2014; Payette & Delwaide, 2004).

2.1.2 Changes in the vegetation

Although there is evidence of reforestation in the southern forest-tundra of Quebec (Gamache & Payette, 2005), harsh wind-exposure conditions, drought, and spruce beetle outbreaks are limiting factors for the northward expansion of white spruce (*Picea glauca*) above the current treeline (Payette, 2007). In Umiujaq, residents and scientists report an overall increase in tall woody vegetation which could explain the observed depletion of berry shrubs across vast areas of land (Cuerrier et al. 2015; Provencher-Nolet et al. 2015). Similarly, in the James Bay Region, the Fort Albany First Nation is noticing a decline in *Vaccinium uliginosum* (blueberry), *Vaccinium oxycoccos* (cranberry) and *Rubus idaeus* (raspberry; Tam et al. 2013). A change in the plant landscape of subarctic Quebec affects the microclimate, shelter availability, and food availability for animal communities (Rich et al. 2013). For instance, tree cover can induce the replacement of Sphagnum moss by feather moss (Pleurozium schreberi) and Cladina lichen species (Vitt et al. 2000). Tree cover also reduces snow crust, making ground lichens more accessible to woodland caribou (Bradshaw et al. 1995).

2.1.3 Changes in animal communities

Predator-prey asynchronies in Quebec, such as a mismatch between nesting dates of insectivore birds and the peak abundance of their major insect prey, may explain the decline in the growth rate of arctic-nesting shorebird populations (Bolduc et al. 2013; McKinnon et al. 2012). In the Eastern James Bay region, residents are noticing a decrease in woodland caribou population size, the absence of eelgrass on shorelines, changes in animal behavior (i.e. polar bears are interacting more with villages and Canada geese are modifying their flight paths), and new species - pelican and white-tailed deer - in the region (Herrmann et al. 2012). Additionally, climate projections indicate that caribou from the *Rivière-aux-Feuilles* herd (western subarctic/arctic Quebec) may encounter unfrozen lakes more frequently during their migrations, forcing them to travel longer distances to circumvent water bodies (Leblond et al. 2016).

2.1.4 Predicted changes

According to the Ouranos, Consortium on Regional Climatology and Adaptation to Climate Change, projections for the 2041-2070 period (compared to the 1971-2000 period) indicate warmer temperatures, especially in the winter, and increased precipitation throughout Quebec (Allard & Lemay, 2012; Desjarlais, 2010; MacDonald, 2010; Sottile et al. 2010). Allard & Lemay (2012) predicts that in 2050, the snow and ice cover season will be shortened by 3-4 weeks, the growing season will be 2-3 weeks longer and there will be increases in precipitation of 15-25%, most of which will be rainfall. Across subarctic regions, a rise in temperature by more than 4–5 °C is predicted for 2090 (Costello et al. 2009; Warren & Egginton, 2008). Changes in the intensity, frequency and magnitude of extreme weather events could also be felt throughout Quebec (IPCC, 2014)

2.1.5 Implications for northern communities

The eastern subarctic is comprised of a number of physical landscapes and geographical territories that interweave with the local histories of northern communities (Nuttall, 2012). As such, with differing socio-economic identities, Quebec First Nations and Inuit communities hold unique experiences of climate change (Wolf et al. 2013; Downing & Cuerrier, 2011;

Duerden, 2004). For the Naskapi Nation as for other Indigenous Peoples in Northern Canada, changes in air temperature, precipitation, and snow and ice conditions affect traditional way of life since many cultural activities are dependent on climate-sensitive resources (Rapinski et al 2017; Royer et al. 2013; Ford et al. 2012; Weatherhead et al. 2010; Ford 2009; Laidler et al. 2009; Hinzman et al. 2005; Krupnik & Jolly, 2002). Empowering Indigenous histories and narratives within specific socio-economic contexts and linking Naskapi knowledge and western scientific knowledge in cooperative research programs are ways in which subarctic communities may develop culturally-adapted capacity to changing environments (Rapinski et al. 2017; Royer et al. 2013; Gearheard et al. 2011; Pearce et al. 2009; Tremblay et al. 2008).

2.2 Biology of subarctic peatlands

Peatlands (i.e. peat-covered terrains) occupy 12% of Canada's land area with the majority (97%) occurring in boreal and subarctic regions (Tarnocai, 2009). After the regression of the Tyrrell Sea, approximately 6000–7000 cal. yr. BP, cool and humid climates, and water-logged conditions led to the formation of peatlands in the western subarctic regions of Quebec (Beaulieu-Audy, 2008; Bhiry et al. 2007; Warner & Asada, 2006; Payette, 2001). In the central-eastern subarctic regions of Quebec (i.e. in the Schefferville region), peatlands may have formed after the removal of the last remnant of the Laurentide ice sheet, approximately 6000 years B.P. (Brixel, 2010; Bhiry et al. 2007).

Radiocarbon dating of organic material near bottom peat layers suggest that peatland inception in the region took place soon after the removal of the last remnant of the Laurentide ice sheet, approximately 6000 years B.P. (Bhiry, Payette et al. 2007). 25-30% of the Schefferville region's land surface is estimated to be covered by peatlands (National Wetland Working Group 1997). Fens and bogs are the dominant types of subarctic peatland complexes (Payette & Rochefort, 2001; Tarnocai et al. 1995; Zoltai & Tarnocai, 1975; Allington, 1961). Relying on surplus soil moisture, their distribution is largely dependent on topography and precipitation patterns (Warner & Asada, 2006).

Peat is the accumulation of plant and animal remains in anoxic, water-saturated conditions. Hydrology and water chemistry affect the composition of plants and animals that will occur in the peatland. Together, they influence the production, decomposition and accumulation of organic matter. Rydin & Jeglum (2013) characterize peatland hydrology by its water balance, which is defined by variations in precipitation, inflow, outflow, evapotranspiration, and water storage of a peatland. These are largely dependent on interactions between local lithology (i.e. geology, soil, and topography) and the climate, making peatlands sensitive to changes in temperature and precipitation (Payette & Rochefort, 2001).

Due to the dominance of *Sphagnum* mosses, Northern temperate and boreal peatlands are extremely acidic (Rydin & Jeglum, 2013). They are home to a diversity of vegetation, microorganisms, insects, birds, and other animals (Warner & Asada, 2006). Heterotrophic microorganisms, mainly bacteria and fungi, contribute to peat decomposition as they feed on organic remains (Thormann, 2006). Their unicellular predators, ciliates and testate amoebas, are common in *Sphagnum* and play an important role in nutrient-release, and in the regulation of bacteria populations (Gilbert and Mitchell, 2006).

Local and regional changes in hydroclimatic conditions can be reconstructed using peat profiles. Paleo-ecological studies traditionally use palynology and vegetal macro-remains (Talbot et al. 2010; Beaulieu-Audy, 2009), as well as thecamoebians which are good indicators of water table fluctuations (Woodland et al. 1998; Elliott et al. 2012). As indicators of past hydroclimatic conditions, arthropods are valuable because they are well preserved, diverse, abundant, sensitive to climatic changes, and hold important relationship to plants (Eggermont & Heiri, 2012; Walker & Cwynar, 2006; Solhoy & Solhoy, 2000; Schelvis, 1990).

2.3 Arthropod biology and ecology in Northern regions

An arthropod is an invertebrate with articulated appendices on a segmented body. Its body is covered in a chitinous cuticle, constituting the exoskeleton. Moulting is necessary to arthropod growth and metamorphosis. Many northern species of insects are small in size, are hairy, and have a dark pigment to raise body temperatures when basking in the sun and to protect from possible cell damage caused by ultraviolet rays (Zellmar et al. 2004). In response to a cold climate, subarctic insects survive long, cold winters in a variety of different ways. Some are freeze-tolerant, meaning that they spend the winter in a frozen state (Danks, 2004;

Danks et al. 1994; Strathdee & Bale, 1998). Others avoid freezing by supercooling, which means that they remain unfrozen even at extremely low temperatures (Strathdee & Bale, 1998; Danks et al. 1994). Some species are tolerant to dehydration, allowing them to resist freezing by eliminating the water present in their tissues (Danks, 2004). Other than physiological adaptations, the overwintering site is critical to the survival of most insect species. Snow and vegetation are good insulators and help resist desiccation from the cold climate. Some insects will lay their overwintering eggs in areas that thaw earliest to ensure it completes its life cycle prior to the next winter (Danks, 2004).

Arthropods occupy all trophic levels of Arctic food webs (Tableau I; Schmidt et al. 2017; Hodkinson & Coulson, 2004). They provide a wide variety of ecosystem services including pollination, predation, parasitism, nutrient cycling, decomposition of organic matter, and food for predaceous arthropods and vertebrates (Prather et al. 2013; Danks 1992). To our knowledge, the most abundant and diverse taxon of the subarctic fauna is Diptera (flies and mosquitoes). Most certainly, Lepidoptera (butterflies and moths) and Hymenoptera (bees, wasps, and ants) are the other two largest orders (Danks, 1988).

Tableau I. Overview of main arthropod orders found in northern ecosystems.

Order	Examples
Diptera	House flies, non-biting midges, mosquitoes, horse flies, big-headed flies
Hymenoptera	Parasitoid wasps, bees, ants
Lepidoptera	Butterflies, moths
Coleoptera	Beetles
Hemiptera	Water striders, aphids
Phthiraptera	Lice
Orthoptera	Grasshoppers, crickets
Trichoptera	Caddisflies
Arachnida	Wolf spiders, mites
Collembola	Springtails
Cladocera	Water fleas
Amphipoda	Side swimmers

Amongst the dipterans, the Muscidae (house flies and relatives) are one of the most diverse families of Arctic insects and are key pollinators in the High Arctic (Tiusanen et al. 2016). The Chironomidae (non-biting midge) are frequently the most abundant group of insects in northern freshwater environments and are known to specialize in a large variety of environmental conditions including drought, anoxia/hypoxia, and extreme temperatures (Pinder, 1986; Danks, 1981).

Amongst the hymenopterans, parasitoid wasps often dominate the fauna, depending on the availability of host insects (Rich et al. 2013; La Salle, 1993). For example, in the northern Yukon Territory, a high incidence of parasitism by the ichneumonid *Gelis* implies that there is an abundant source of wolf spiders (Bowden & Buddle, 2012). Since *Gelis* destroys the contents of the egg sac, Bowden & Buddle (2012) suggest that parasitoids play an important role in the reproductive fitness of northern spider species.

Some dipterans are also parasitoids. For example, Pipunculidae (the big-headed fly) is found worldwide, and has been collected on snow patches in alpine-tundra habitats of Alaska (Edwards, 1972) and in peatlands of subarctic Quebec (this study, Figure 1). Because its larvae are endoparasitoids of homopterans (e.g. leafhoppers and planthoppers) and of tipulids (craneflies), these flies are important predators of plant-feeding insects (Skevington, 2008).

Figure 1. Pipunculidae (big-headed fly) captured in a peatland near Kawawachikamach, QC in July 2016. Photo: Jérémie Masse-Maillée, 2017.

Other insect orders found in the subarctic include and are not limited to Coleoptera (beetles), Hemiptera (water striders, aphids, etc.), Orthoptera (grasshoppers, crickets, etc.), Trichoptera (caddisflies), and Phthiraptera (lice). Although not considered insects in entomology, it is important to note the presence of other arthropods which are often placed in the culturally determined *insect* category (Costa-Neto & Magalhães, 2007). These are Arachnida (spiders and mites), Collembola (springtails), Cladocera (water fleas), and Amphipoda (side swimmers) (Blair, 2013; Danks, 1992, 1990).

In northern regions, wolf spiders (Lycosidae) and more specifically, the genera *Arctosa*, *Pirata*, *Pardosa*, and *Trochosa* are common and abundant especially in open tundra habitats (Glime, 2017; Rich et al. 2013). In Nunavut, microhabitat type and seasonal change play important roles in structuring spider communities: wet habitats harbour more individuals than dry habitats, microhabitats support specialized spiders, and early July seems to be a period of peak abundance for spiders on Victoria Island (Cameron & Buddle, 2017).

2.4 Arthropods in peatlands

Most arthropods inhabit peatlands because bryophytes retain moisture, provide shelter from the heat and light of the sun, are a location for food, and a refuge from predation (Glime, 2017). The micro-topography of a peatland is complex and determines the distribution and composition of its arthropod communities. In raised bogs, arthropod communities differ between hummocks and hollows (Markkula, 1986). The presence of peat pools adds habitats for an aquatic fauna. Spitzer & Danks (2005) distinguish four insect categories in relation to boreal peatlands: 1) tyrphobionts are species exclusive to peatlands; 2) tyrphophiles are species characterized but not limited to peatlands; 3) tyrphoneutrals reside in a number of habitats, including peatlands; and 4) tyrphoxenes are species that cannot live in peatlands.

Dipterans, acarians and crustaceans are the most frequently-occurring animal remains in peat and are useful zoological indicators of past environmental events at the local and/or regional scales (Smol et al. 2001). Diptera are among the most diverse group of freshwater invertebrates. They are found in a wide range of habitats including terrestrial, semi-terrestrial, freshwater, and euryhaline waters. Subfossil remains of freshwater midges (Diptera: Chironomidae, Ceratopogonidae & Chaoboridae) are valued indicators of limnological and climatic changes. They are used as indicators of temperature, dissolved oxygen levels, and salinity levels in bodies of water (Brooks & Birks, 2001; Dickson et al. 2014; Eggermont & Heiri, 2012; Larocque, 2008).

Acaria are micro-arthropods (0.13 mm - 1 mm) with a chitinous exoskeleton. Because they are small and robust, they are abundant and diverse in peatland habitats (Van Geel, 1989). They are used as paleo-indicators for vegetation and climatic analyses (Solhoy & Solhoy, 2000). In Canadian peatlands, humidity/moisture is an important factor affecting the spatial distribution of oribatid mites (Behan-Pelletier & Bisset, 1994). Microhabitat and resource heterogeneity are also important factors structuring oribatid mite communities (Mumladze et al. 2013). For example, as active surface predators, the Trombidiformes are often associated with tundra settings and the less mobile Sarcoptiformes are often associated with forested settings (Young et al. 2012).

The Crustacea are distinguished from other arthropods by their two-parted limbs (biramous) and a life cycle that includes a nauplius larva stage. Cladocera, an aquatic crustacean, swims using its antennae. Some species are able to use the film of water from the capillary spaces and leaf surfaces of bryophytes (Glyme, 2017). Like insects, cladocerans have a chitinous exoskeleton, making them valuable paleo-environmental indicators for temperature, paludification, and levels of ultraviolet exposure (Duigan & Birks, 2000; Korhola, 1990; Nvalainen & Raution, 2014).

2.5 Changes in insect populations in Northern regions of Canada

2.5.1 Knowledge in entomology

Owing to their sensitivity to climatic and hydrological change, peatlands are susceptible to experiencing changes in their arthropod fauna (Parish et al. 2008). In subarctic ecosystems, extreme winter warming events are the dominant drivers of change for soil micro-arthropod communities (Bokhorst et al. 2015). The metabolic rate of an insect tends to double with an increase in temperature of 10˚C (Clark & Fraser, 2004; Gillooly et al. 2001). Therefore, higher temperatures affect and amplify insect fecundity, survival, generation time, and dispersal (Dukes et al. 2009; Bale et al. 2002). Additionally, a forecasted reduction of water storage in northern peatlands (IPCC, 2014) has the potential to affect insect taxa that rely on moisture supply to complete their life cycle (Lévesque et al. 2012).

Impact of climatic changes on arthropod abundance

Springtails (*Collembola*) are key actors in the decomposition of organic matter in northern peatlands (Krab et al. 2010). Significant declines in the abundances of springtails have been recorded during extreme drought events at the local level (Callaghan et al. 2004**)**. However, decades of experimental warming have shown that springtail abundances and species richness are not significantly affected at the regional level, suggesting that local heterogeneity plays an important role in buffering the effects of forecasted climatic changes (Alatalo et al. 2015).

Craneflies (Diptera: Tipulidae) are important insect herbivores and decomposers, and are nutritious prey for birds (Buchanan et al., 2006; Pearce-Higgins, 2010). They are dependent on soil moisture to maintain large population numbers (Carroll et al. 2011; Holden et al. 2007). As such, an increase in the frequency of summer droughts has the potential to cause a decline in cranefly abundances (Carroll et al., 2014, 2011).

In Zackenberg, Northeast Greenland (74° 28′ N, 20° 34′ W), an observed shortening and earlier onset in the flowering season between 1996 and 2006 is linked to a decline in the number of visiting flies (i.e. Muscidae and Chironomidae), implying that temporal asynchrony of insect and plant life cycles may be a consequence of a warmer climate (Hoye et al. 2013).

Impact of climatic changes on arthropod distribution

As ectotherms, insects are limited in their range by climatic factors (Danks, 1992). As such, with increasing temperatures in subarctic regions, southern species are expanding their northward range (Schaefer, 2011; Jespen et al. 2008; Hickling et al. 2006). In Britain, Hickling et al. (2005) has recorded a northward shift in the range of 37 Odonata (dragonflies and damselflies) species between 1960 and 1995, most likely due to increased climatic suitability, i.e. warmer temperatures, of northern study sites. Another insect with an aquatic larval stage, *Culex pipiens* (mosquito) is forecasted to expand its range towards the northern regions in Canada. This is of concern in the public health sector since *Cx. pipiens* and other species are known carriers of mosquito-borne pathogens including West Nile Virus and St. Louis Encephalitis Virus (Hongoh et al. 2012).

Impact of climatic changes on parasite outbreaks

A warmer winter increases the survival of insect populations and increases the abundance of active parasitic pests (Bourassa & Auzel, 2012; Callaghan et al., 2004; Bale et al. 2002; Ayres & Lombardero, 2000). Temperature, wind, and precipitation are the most important climatic factors affecting parasitoid and/or biting fly presence (Mörschel, 1999; Downes et al. 1986). It is predicted that an increase in temperatures in subarctic Quebec will intensify the abundance, phenology, and longevity of biting fly seasons (Witter et al. 2012; Callaghan et al. 2004; Brotton & Wall, 1997). In Northern Quebec, the emergence of the protozoan parasite *Besnoitia tarandi* in caribou corresponds with high temperatures and biting insect outbreaks, which suggests that arthropods are its main vectors of transmission (Ducrocq et al. 2013; Kutz et al. 2009). However, since the lifecycle of *B. tarandi* is not very well-known, there is no evidence that its emergence is linked to climatic changes (Kutz et al. 2009).

Harassment and parasitism from warble flies (*Diptera: Oestridae*), botflies (*Diptera: Oestridae*), black flies (*Diptera: Simuliidae*), horseflies (*Diptera: Tabanidae*), mosquitoes (*Diptera: Culicidae*), and subcutaneous protozoa *Besnoitia tarandi* are a major driver for caribou (*Rangifer*) herd health, behavior, and migrations (Mallory & Boyce, 2017; Ducrocq et al. 2013; Witter et al. 2012; Weladji et al. 2010), as they seek relief from insect harassment on windy hilltops and on snowy patches (Vistnes et al. 2008; Skarin et al. 2004; Hagemoen & Reimers, 2002). For example, the warble fly *Hypoderma tarandi* is an obligate parasite of reindeer and caribou (Åsbakk et al., 2014). It lays its eggs on the hairs of caribou in mid-summer. Once the eggs hatch, the larvae penetrate the skin of the caribou. The growth and emergence of the larvae and the buzzing of the adults around the caribou are a source of harassment which may lead to a decline in the body mass of caribou (Ballesteros et al. 2011). A warming climate creates favorable conditions for *H. tarandi* population growth and parasitism, reducing the health and reproductive success of caribou (Pachkowski et al., 2013; Witter et al., 2012).

Elsewhere in the world, subarctic regions are also experiencing changes in their insect populations. In Fenno-Scandinavia, mosquitoes (*Culicidae*: *Aedes, Anopheles*) and hornflies (*Haematobia* spp.) are known vectors for the filarioid nematode *Setaria tundra* (Laaksonen & Oksanen, 2009). In 1973, 2003-2006, and 2014, outbreaks of *S. tundra* caused the death and slaughter of thousands of reindeer (Laaksonen & Oksanen, 2009; Nikander et al. 2007). These outbreaks were associated with high mean summer temperatures exceeding 14 °C and high humidity which increased the abundance and range expansion of *S. tundra*'s mosquito hosts (Enemark et al. 2017; Laaksonen et al. 2017, 2010). Filarioid nematodes affect the appearance, texture and quality of reindeer meat, an important source of food and income for Sámi (Laaksonen et al. 2017).

2.5.2 Northern residents' knowledge

From the west coast to the east coast of Canada, northern residents are noticing changes in their insects since the 1950s (Cuciurean et al. 2010; Government of Nunavut, 2005; Nickels et al. 2005). Through a series of climate change workshops held in 23 Indigenous communities across the Canadian Arctic between 2005 and 2017, new insects have been reported, including ants, bees, beetles, red bugs, carpet bugs, butterflies, dragonflies, flies, grasshoppers, hornets/wasps, mosquitoes, parasites, long-legged spiders, and aquatic worms (Table 2-1). Workshop participants mentioned that warmer temperatures, a higher frequency of forest fires in the south, and the presence of exotic insects among boat and train cargo, are reasons for the increased presence of unusual insects in their community. The disappearance of lice has been noted in 3 arctic, coastal communities (Tableau II). One participant mentioned that this loss is linked to a "healthier" lifestyle, with doctors and nurses regulating lice populations (Mallory, 2012). In Nain (Nunatsiavut, Labrador and Newfoundland), it was mentioned that lice would suck the bad blood and bring good health (Communities of Labrador et al. 2005). It was also used in medicine to get rid of eye puss (Communities of Labrador et al. 2005) and to treat snow blindness, i.e. photokeratitis (Cuerrier & the Elders of Kangiqsualujjuaq, 2012).

Tableau II. Newly observed insect species in Northern Canada. Data obtained from climate change workshops (2005-2017) in the Yukon (YT), Northwest Territories (NWT), Nunavut (NU), Quebec (QC), and Labrador (NL). Data from Cuerrier et al. 2015; Mameamskum et al. 2014; Mallory, 2012; Cuciurean et al. 2010a,b; Nickels et al. 2005; Communities of Labrador et al. 2005; Government of Nunavut, 2005.

Common name	Latin name	New / Disappeared	Community	Province / Territory
Ants	Formicidae	New	Aklavik	NWT
			Inuvik	NWT
		Disappeared	Kugaaruk	NU
Bees	Apoidea	New	Iqaluit	NU
			Tuktoyaktuk	NWT
			Kangiqsualujjuaq	QC
			Kangiqsujuaq	QC
Beetles	Coleoptera	New	Sachs Harbour	NWT
Red bugs		New	Baker Lake	NU
			Holman Island	NWT
Carpet bugs	Dermestidae	New	Gwich'in Settlement	NWT
			Region	YT
Butterflies	Lepidoptera	New	Kangiqsualujjuaq	QC
			Umiujaq	QC
Dragonflies	Odonata	New	Kugluktuk	NU
			Holman Island	NWT
			Ivujivik	QC
			Kangiqsujuaq	QC
Flies	Diptera	New	Kugaaruk	NU
			Repulse Bay	NU
			Sachs Harbour	NWT
			Ivujivik	QC
			Kangiqsujuak	QC
			Puvirnituk	QC
			Makkovik	NL
Grasshoppers	Orthoptera	New	Aklavik	NWT
			Paulatuk	NWT
Hornets / wasps	Apocrita	New	Aklavik	NWT
Lice	Phthiraptera	Disappeared	Kugaaruk	NU
			Taloyoak	NU
			Nain	QC
Mosquitoes	Culicidae	New	Gwich'in Settlement	YT
			Region	NWT
Parasites		New	Old Crow	YT
			Iqaluit	NU
			Kawawachikamach	QC
Long-legged spiders	Arachnida	New	Goose Bay	NL
			Northwest River	NL
Timberflies		Disappeared	Hebron	NL
Aquatic worms		New	Kugaaruk	NU
			Repulse Bay	NU
Freshwater arthropods		Disappeared	Kugaaruk	NU
			Puvirnituq	QC

Shorter winters, longer summers and more water are thought to have caused an increase in the number of insects in Sachs Harbour (Inuvialuit Settlement Region, western Canadian Arctic), and led to the arrival of new species (Ashford & Castleden, 2001). In the Gwich'in Settlement Region (NWT & Yukon), new insects have been observed, including carpet bugs and a new, slightly yellow/tan colour mosquito (Benson & Ernst, 2017). A change in insect abundances, such as a decrease in the number of dragonflies, caterpillars/butterflies and town-dwelling beetles[1], and an increase in the number of mosquitoes has been observed in the area (Benson & Ernst, 2017). Insect populations seem to be more variable year to year. In the summer of 2016, residents noticed fewer mosquitoes, some smaller flies, and larger-sized sandflies/blackflies (Benson & Ernst, 2017). Similarly, there is consensus among residents of Kangiqsujuaq that mosquito abundance has been decreasing (Cuerrier et al. 2015). This may be linked to a decrease in ground moisture in recent years. Although not yet in the area, as the climate warms, people are expecting to encounter ticks, bed bugs, and wood-boring beetles which eat, and kill, spruce trees (Benson & Ernst, 2017).

There is concern in the literature on the role of insects as pollinators and predators of culturally important plants, as vectors of diseases, and as sources of annoyance for humans and culturally important animals (Mameamskum et al. 2014; Lévesque et al. 2012; Hagen et al. 2007; Nickels et al. 2005; Garibaldi & Turner, 2004). Thus, in 2012, during a climate change workshop held in Kawawachikamach, Naskapi Elders identified changes in insect and berry populations (Tableau III). Both insects and plants are undergoing change, affecting the production and quality of berries (Mameamskum et al. 2014), and in turn affecting plant and animal harvesting, key cultural activities tightly linked to Naskapi identity.

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[1] The presence of beetles in town has dwindled, most likely due to a decrease in the use of wood boardwalks and untreated hydro poles in Aklavik (Benson & Ernst, 2017).

Tableau III. Changes in insects and berries observed by the Naskapi in 2012 (Mameamskum et al. 2014: 20-21).

Insects	Berries
Flies and mosquitoes that were commonly observed in the region are now seen less often. *"In summer, specific birds eat insects, now these birds are gone."*	Berries are much dryer, they are of not good quality, and they are smaller. *"The coloration of berries changes from red to orange/yellow."* *"Animals feed on berries; less berries has an impact on their food availability."* *"Berries are not growing anymore at the airport."*

Overall, most communities mentioned that flies are emerging earlier in the spring: *"Black flies and mosquitoes now emerge at the same time. Before, mosquitoes arrived first, followed by black flies"* (Cuerrier et al. 2015: 386); some insects are leaving later in the fall; the mosquito and fly season is longer and more taxing on caribou; and mosquitoes and flies seem to be getting larger (Mameamskum et al. 2014; Mallory, 2012; Cuciurean et al. 2010a,b; Government of Nunavut, 2005; Nickels et al. 2005). Literature also reports an increase in harassment by insects while berry picking caused by an increase in the number of biting flies, making harvesting a more challenging activity (Nickels et al. 2005).

2.6 Insect knowledge, stories and art in Northern Indigenous communities in Canada

Naskapi Elders believe that knowledge, stories and art need to be passed on to the young "*to preserve the Naskapi culture*" (Lévesque, 2016: 65) and because "*young people have to know about nature so that they can find means of survival.*" (Lévesque, 2016: 65). These teachings have been kept alive through story-telling and through time spent out on the land. Naskapi (Quebec, Canada) and Sámi (Sápmi, northern Europe) share a traditional livelihood and identity based on the same species *Rangifer tarandus* (caribou in Canada / reindeer in Europe). Therefore, the following sub-chapter is a compilation of written knowledge, stories and art featuring insects from the circumpolar regions of the world, and includes Sámi stories and legends to mobilize inter-cultural ways of knowing.

2.6.1 Ants

Ants are a critical animal that lives out on the land. They come out from dead trees, rotten logs, and buildings (Benson & Ernst, 2017). In Kawawachikamach, the Naskapi Development Corporation has re-possessed an archive of audio material from ethnographic work conducted in the 1960s (Peastitute, 2015: Appendix). One of these is a Naskapi legend told by John Peastitute where two grandmothers disturb a hibernating ant colony while gathering firewood in the winter (Peastitute, 2014). Consequently the whole village has a sleepless night. This relates to an important Naskapi teaching: *to respect nature and everything in it* (Ch. Vachon, personal communication, July 2015).

2.6.2 Bees, flies, and butterflies

Insects such as bees and flies are important pollinators, which allow berries to form every year. Good berry years are important nutritionally and culturally for Gwich'in communities (Benson & Ernst, 2017). Since the bumblebee is known for feeding on the nectar of flowers, in Kangiqsualujjuaq, certain plants (e.g. fireweed - *igutsait niqingit*) are named after *igutsaq***,** the Inuktitut name for bumblebee (Cuerrier & the Elders of Kangiqsualujjuaq, 2012). In Arviat (Nunavut), an Inuit Elder recalled that 2 adult bees and 1 baby bee were placed in a pouch in each mitten: "*These were there so that when a woman in labor had complications I could help ease the delivery*" (Bennett and Rowley 2004; Laugrand & Oosten, 2010). In Rankin Inlet (Nunavut), "*someone would wipe the butterfly on the back of the parka of a young girl or boy*" to help them come home (Laugrand & Oosten, 2010; Oosten & Laugrand, 2002).

Across the Atlantic Ocean in Sápmi (northern Europe), Ante Aikio, a Sámi scholar, writer, and reindeer herder is currently working on a series of books on Sámi folklore (Goranus, 2013). In his book *Aigi: fathoms of the fen lake*, Aikio (2015) describes Njavezan, a fey in Sámi legends, as the guardian of light and the one who rules the sunny side of the fells (Figure 2). Njavezan created hoverflies and other pollinating insects, to provide people and animals with an abundance of berries to eat and to preserve for the winter. Her most faithful friend is Zuovga, a little butterfly that is always at her side (Aikio, 2015; Goranus, 2013).

Figure 2. Jussi Pirttioja, 2014, Njavezan, 70x50 cm, oil colors.

2.6.3 Lice

Similar to knowledge of lice in Nain, Elders in Turnunuirmiut (Nunavut) have mentioned that lice control and remove illness by sucking out the old blood, and they were used to alleviate blindness (Cuerrier & the Elders of Kangiqsualujjuaq, 2012; Laugrand & Oosten, 2010; Therrien & Laugrand, 2001). Saimaiyu Akesuk is an Inuk artist from Iqaluit. Her work of art entitled *Artic lice* portrays lice, an important and abundant northern arthropod (Figure 3).

Figure 3. Cee Pootoogook, 2015, Artic lice, 76.3cm × 57cm, Cape Dorset. 2015 Cape Dorset Print Collection. Retrieved from http://www.gevik.com/gallery-phillip/inuit-prints/capedorset/cd2015/

2.6.4 Mosquitoes

Before insect repellant, fires were used to smudge mosquitoes and flies away (Benson & Ernst, 2017). An Elder from Rankin Inlet (Nunavut) related that a big mosquito appearing in his dreams would predict a death (Laugrand & Oosten, 2010; Oosten & Laugrand, 2007). At Qamanittuaq [Baker Lake], Nunavut, babies were exposed to mosquitoes so that later on in their life they would not be devoured by them (Laugrand & Oosten, 2010). According to an Elder from Qamanittuaq, mosquitoes are a sign that the caribou are coming (Laugrand & Oosten, 2010; Mannik, 1998). Mosquitoes can be very taxing to caribou, as the herd spends the whole summer shaking, to fight them off (Benson, 2015). In the Kitikmeot region of Nunavut, Inuit indicate that when there are too many mosquitoes, caribou gather and walk in circles to get rid of them (Laugrand & Oosten, 2010; Thorpe, 2000).

In Kangiqsualujjuaq, *kitturiaq* refers to mosquitoes of swampy areas. It is believed that they are more numerous and larger when there has been a lot of snow, that individuals react differently to their bites and that if they are killed while in the process of drawing blood, the itch will be more intense (Cuerrier & the Elders of Kangiqsualujjuaq, 2012). Here is a story from Kangiqsualujjuaq about respecting all animals, even those that bite:

> *"Everyone loses patience with mosquitoes, and it is easy to lose your mind if there are a lot of them. This is what happened to an Inuk who decided to catch one in a jar so that he could let it go in January, the coldest month. He set to work trying to keep the mosquito alive; it had become his companion. January came, and the Inuk went outside to put his plan into action. He went far away from his house to let the mosquito go. He then began to run home for shelter before the mosquito could catch up to him. While running to his house, he stopped, frozen in place. The mosquito overtook him and returned inside the house. The Inuk died. This story reminds us of the concept of respect. If we do not show respect, something will happen to remind us of it."*
>
> (Cuerrier & the Elders of Kangiqsualujjuaq, 2012:15)

Pitseolak Ashoona (1904/08 - 1983) is an Inuk artist from Nunavut. She grew up in semi-nomadic hunting camps throughout southern Qikiqtaaluk (Baffin Island) until the late 1950s when she moved to Kinngait (Cape Dorset). By the 1970s her artwork was exhibited across North America and in Europe (Lalonde, 2013). *In summer there were always very big mosquitoes* relates the abundance and importance of mosquitoes in Inuit daily life (Figure 4).

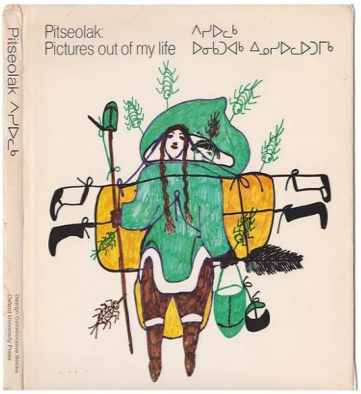


Figure 4. The first edition of Pictures Out of My Life, published in 1971, features Pitseolak's In summer there were always very big mosquitoes, 1970, coloured felt-tip pen, 68.6 x 53.5 cm, Art Gallery of Ontario, Toronto. Retrieved from https://www.aci-iac.ca/pitseolak-ashoona/biography

2.6.5 Spiders

In Kangiqsualujjuaq, two Inuktitut names are known for spiders. The larger ones are known as *aasivalaaq* and the smaller ones are known as *mitjuajuk*. Both are ground-dwellers that spin webs and hunt insects. In Taloyoak, there are stories of rubbing spiders on a newborn's hand. It was thought that doing so, the child would grow up to be swift and good hunters (Mallory, 2012). This practice was called *aannguat*. In the Gwich'in Settlement Region (NWT & YT), it is said that "*if* [you] *had a little spider,* [you] *would never kill them or else it will rain* (cited in Benson & Ernst, 2017).

Saimaiyu Akesuk is an Inuk artist from Iqaluit (Nunavut). Her work of art *Hot spider* portrays a spider, an important and abundant northern arthropod (Figure 5).

Figure 5. Saimaiyu Akesuk, 2015, Hot spider, 76cm × 56.7cm, Cape Dorset. 2015 Cape Dorset Print Collection. Retrieved from http://www.gevik.com/gallery-phillip/inuit-prints/cape-dorset/cd2015/

2.6.6 Parasites and other pests

For the Inuit *qupirruit* is a word used for insects, worms and other arthropods. At present, Inuit and scientific knowledge remain isolated and cannot be reconciled with certainty (Cuerrier & the Elders of Kangiqsualujjuaq, 2012; Randa, 2003). People fear to consume *qupirruit* or *pamiulik* of the lakes, so they do not drink stagnant water, but boil it first (Laugrand & Oosten, 2010).

The emergence of warble fly larvae (*Hypoderma tarandi*) is known to create hundreds of holes or scars in the hides of affected animals. According to Benson & Ernst (2017), caribou skins from the fall are the best for clothing as they do not have insect holes in them.

Some furbearers, such as lynx, rabbit, and wolf, have parasites like fleas in their furs, perhaps due to the willows they live in (Benson & Ernst, 2017). Waterfowl may also have external parasites, which need to be cleaned before the down is used (Jenkins et al. 2013). Mosquitoes are generally considered to be the biggest insect pest. They'll pester and bite people, especially around the water's edge (Benson & Ernst, 2017).

In Sámi legends, Hahtezan is an evil guardian spirit of darkness, who still rules the night side of the fells (Figure 6). Her most faithful friend is Zahpe, a big dung/corpse beetle. She hates the summer; that is why she created the mosquitoes, warble flies, midges, and other evil insects to pick on humans and reindeer (Aikio, 2015, Goranus, 2013). When winter comes, she sends her insects to sleep under the snow. When summer returns, these pests are once more feeding on the blood of humans, reindeer, and other inhabitants of the land of the Living (Aikio, 2015, Goranus, 2013).

Figure 6. Jussi Pirttioja, 2013, Hahtezan, 70x50 cm, oil colors

2.6.7 Insects and Shamanism

Insects served as *tuurngait*, helping spirits of the shamans in Inuit culture with mentions of the use of *nanujak* (spider) and *qukluriak* (caterpillar), worm, and bumblebee (Laugrand & Oosten, 2010). In Arviat (Nunavut), Laugrand & Oosten (2010) recorded the use of insects in the becoming of an *angakkuq* (medicine man, shaman). Moss containing insects, caterpillars, and other living beings was placed on the skin, and "*you had to be able to stay still when these living things started sucking on your arm, on your blood*." (Laugrand & Oosten, 2010: 16).

The work *Shamans* c*ompeting* by Inuk artist from Garry Lake (Nunavut), relates to a story about two shamans who had a competition to see who could travel fastest (Figure 7). For their race, one shaman travelled overland and one went underground. The winner was the shaman who travelled underground in the form of a worm (Wight, 2000; Marion Scott Gallery, n.d.; Spirit Wrestler Gallery, 2017).

Figure 7. Nick Sikkuark, 1996, Shamans competing. whalebone, caribou antler, 5.5 x 7 x 4.25 in. Retrieved from http://www.expandinginuit.com/artists/nick-sikkuark

2.6.8 Teachings

Many First Nations and Inuit Elders consider that all small life forms have to be treated with respect. In Kangiqsualujjuaq, The concept of *qikkutik* is associated with respect and is present in many stories and legends about animals (Cuerrier & the Elders of Kangiqsualujjuaq, 2012). In the Gwich'in Settlement Region, children are taught this value at an early age. For example, a workshop participant remembered having stepped on a beetle and being told: *"now who is going to feed the family?"* (Benson & Ernst, 2017). In Iglulik and Kugaaruk (Nunavut) Elders explain that, "… [the souls of small life forms] *are very strong. That is why we should* *not mistreat them*" (Laugrand & Oosten, 2010: 4). Similarly, in Kawawachikamach, a Naskapi elder explained the power of life:

> "*even something that is so small, like an insect. It is so small that when you hold it, you are holding its heart. You can't even see its heart. Yet, it still lives and has such a big effect on everything around it. We should connect everything.*"
>
> - Interview # 2, Kawawachikamach, July 2016

The climate of subarctic regions is changing rapidly, affecting living organisms, ecosystems as well as human communities that inhabit these landscapes. Changes in arthropod communities are especially noticed by Inuit and First Nations whose knowledge and values of nature is vital to successful hunting, trapping, fishing, and gathering activities. In response to a very limited data set on the role of arthropods in subarctic regions of Quebec, in the following chapters I explore changes in arthropod communities in peatlands surrounding the subarctic Quebec Naskapi First Nation of Kawawachikamach. Using a combination of methods derived from entomology, paleoecology and ethnobiology, the goal is to provide baseline data on arthropod diversity and abundance, to explore changes in arthropod assemblages over time, and to characterize values related to changes in arthropod assemblages and its implications for land-based-activities.

Chapter 3: Methodological framework

In this chapter I present the study area where the research took place, and the general characteristics of three selected field sites used for paleo- and entomology work. The methods are outlined for each type of work: entomology, paleoecology, and ethnoentomology.

3.1 Site selection

The Naskapi Nation of ᑲᐚᐚᒋᑲᒪᒡ Kawawachikamach (54.8634° N, 66.7611° W) is located at the Québec-Labrador border. Numerous lakes, bogs, and fens stretch out across its ridge-valley landscape. The ridge-tops are covered with tundra and alpine plant communities, while the valleys are covered in open woodlands and forests. In the Köppen-Geiger climate classification, central Québec-Labrador comes under the "Dfc" type climate which is characterized by long, cold winters and short, cool summers (Peel et al. 2007). Mean annual air temperature is -5.3°C, and annual precipitation is 823 mm, 54 % of which is falling as snow (Canadian Climate Normals, 1971-2000). In the Kawawachikamach area, continental polar air dominates the circulation at most times of the year (Lotz and Nebiker, 1957). After Hudson Bay freezes over, these air masses are generally cold and very stable but during the summer and autumn, continental polar air brings cool weather along with considerable cloud and precipitation (Gardner, 1965). In the context of climatic changes, alterations in air mass dominance patterns become important, particularly to precipitation (Rouse et al. 1997). Between 1990 and 2009, Kawawachikamach has experienced an increase in mean annual temperature (MAT) by 2.62 °C and an increase in total annual precipitation (TAP) of 270 mm, with a statistically significant increase in precipitation in July (Rapinski et al. 2017).

The sites are located in three different peatlands to capture insect diversity across a multitude of micro-habitats (Figure 8). Other factors considered for site selection were the level of anthropogenic disturbance, suitability for paleo-ecological analyses and usage by the Naskapi for plant harvesting.

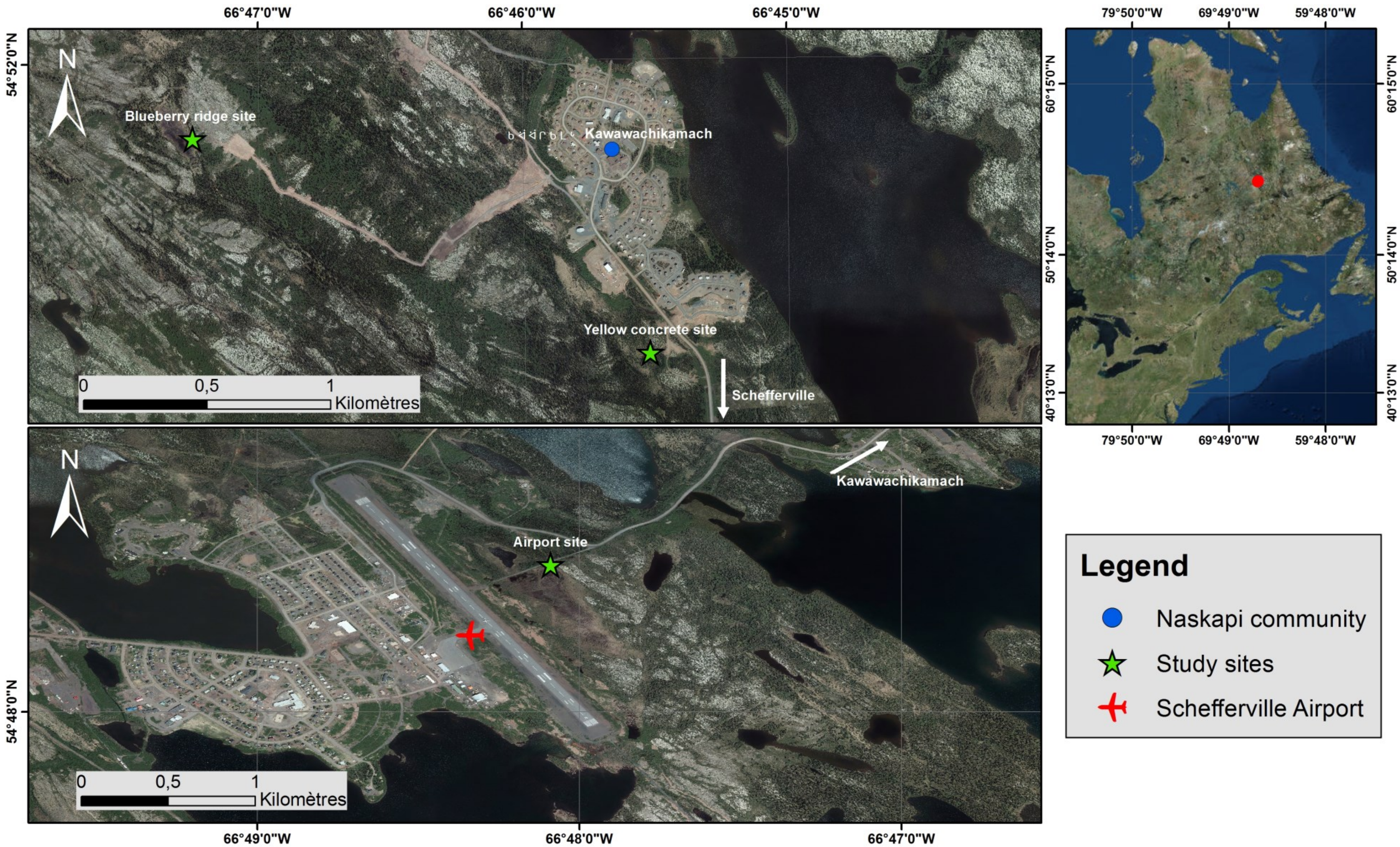


Figure 8. Selected study sites for sediment coring (2015) and arthropod sampling (2015 & 2016). Mosaic of orthophotographs of Schefferville, 2012 (20cm resolution). Source : Ministère de l'Énergie et des Ressources naturelles, Quebec (QC). Date of metadata : 2017-01-30T15:03:51

The *airport site* (54°48'27.33"N, 66°48'5.37"O) is located adjacent to the Schefferville Airport. At the northeast edge of the bog, graminoids and bushes dominate the landscape and a man-made trail cuts the scenery as it passes through *Cladonia* – dominated lichen woodlands. At the end of the trail are ghostly remnants of past scientific research: a weather tower, a now useless wooden bridge leading onto the peatland, and a transect of metal rods that cuts through the peatland. The perimeter area is dominated by Labrador tea (*Rhododendron groenlandicum*), birch (*Betula glandulosa*), tamarack (*Larix laricina*), bog laurel (*Kalmia*), bog rosemary (*Andromeda*), moss (*Sphagnum*), and a number of culturally-important berry shrubs including bog bilberry (*Vaccinium* spp.), crowberry (*Empetrum nigrum*), and cloudberry (*Rubus chamaemorus*). The central area is dominated by sedges (*Carex*). On June 28 2015, the water table depth was approximately 6 cm deep at the location of the peat core.

The *blueberry ridge site* (54°51'50.10"N, 66°47'15.10"O) is nestled between hills. Some members of the Naskapi Nation refer to the hill on its eastern edge as the "blueberry ridge behind manikin", because during the summer months, the summit's bushes become heavy in blueberries. The peatland is surrounded by a black spruce (*Picea mariana*) lichen woodland. The perimeter area is dominated by Labrador tea (*Ledum groenlandicum*), birch (*Betula glandulosa*), bog laurel (*Kalmia*), bog rosemary (*Andromeda*), sundew (*Drosera*), and moss (*Sphagnum*). The central area is dominated by sedges (*Carex*). On June 29 2015, the water table depth was approximately 5 cm deep.

The *yellow concrete site* (54°51'21.60"N, 66°45'31.70"O) is located just across the main road from Kawawachikamach. Of all three sites, it is the site the most laden with construction garbage including canisters and concrete blocks. It is also distinct from the two other sites by the scattered presence of hummocks and hollows, as well as small but relatively deep pools (up to 40 cm deep) and low current streams. On June 28 2015, the water table depth was approximately 5 cm deep. The site was dominated by black spruce (*Picea mariana*), Labrador tea (*Ledum groenlandicum*), birch (*Betula glandulosa*), tamarack (*Larix laricina*), moss (*Sphagnum*), sedges (*Carex*), and a surprisingly large abundance of flowering cloudberry (*Rubus chamaemorus*). The latter is of particular importance as it is a highly-valued berry picked by Naskapi harvesters only when found in high abundance (personal communication, Kawawachikamach, June 2015).

3.2 Methods in entomology

We observed and collected arthropods in 2015 during the cloudberry (*Rubus chamaemorus*) flowering season (June 28-29, 2015) and in 2016 during the labrador tea (*Ledum groenlandicum*), crowberry (*Empetrum nigrum*), and bog bilberry (*Vaccinium uliginosum*) flowering season (July 16-17, 2016). Arthropod communities on culturally-important plants (e.g. Labrador tea) were qualitatively described. Ground-dwelling arthropods and low-flying insects were captured using 10 yellow pan traps at each site. The yellow pan trap is a widely used technique which allows for the capture of a high diversity of arthropods, including unique species (Ernst et al. 2016; Roslin et al. 2013).

Although ground-flush yellow pan traps tend to reduce observer and/or collector bias (Westphal et al., 2008), it is subject to other biases such as under-sampling bee species richness and abundance when floral resource availability is high (Baum & Wallen, 2011) and under-representing bees that forage in tall vegetation (Cane et al. 2000). Although yellow and white pan trap tend to catch a rich set of species, they may under-represent statistically 'rarer', i.e. infrequently trapped species that may be caught using other colours such as red and violet (Vrdoljak & Samways, 2012). In addition, the success of particular colours varies across bioregions and habitats (Saunders & Luck, 2013). Both trap- and habitat- type play an important role in determining the abundance, richness, and assemblage composition of arthropods collected (Ernst et al. 2016).

The construction of a yellow pan trap involves filling a 12 oz. circular yellow plastic bowl with water until its ¾ full, then adding a few droplets of unscented dish soap and removing any bubbles that may have formed at the surface of the water. The soap reduces water tension which prevents arthropods from escaping the trap (Ernst et al. 2016) At each site, a total of 10 pan traps were nestled in peat moss (*Sphagnum* sp. - dominated), in lichen (*Cladonia* sp. - dominated), and in graminoids (*Carex* sp. - dominated) for a 24 hour sampling period. Upon trap retrieval, contents of the trap were passed through a 10cm² piece of netting, arthropods were rinsed thoroughly with water to remove soap residues and were transferred to ethanol-containing Whirl-Pak sample bags. Once back in the lab, collected arthropods were identified (Figure 9) and preserved according to University of Montreal's Ouellet-Robert

Entomology Collection standards (http://qmor.umontreal.ca/welcome/). Identified arthropods were placed in one of four trophic level categories for trophic level analyses: predator/insectivore, blood-feeder, herbivore, or nectarivore/palynivore/parasitoid.

Figure 9. Lycosidae eye arrangement. Specimen collected in a yellow pan trap in 2016.

3.3 Methods in paleoecology

Using a 60 cm length, 4 in. diameter polyvinyl chloride pipe with a sharpened edge, we collected and analyzed one sediment core at the Airport site (Table IV).

Tableau IV. Length of sediment core retrieved at the Airport site.

Site	Name of sediment core	Total length of core
Airport site (54°48'27.33"N, 66°48'5.37"O)	B1	55.5 cm

Based on paleoecological dating from two boreal peat bogs of the Eastmain River watershed (52° N, 76° W), James Bay lowlands, Québec, we estimate that the bottom sediments used for this study (sediment core B1, 55.5 cm) date to the 13th-16th century (Loisel & Garneau, 2010). The core therefore likely records 500-750 years of history. In the lab, 6 cm^3 sediment samples were taken at 2 cm intervals along the top and the bottom of the core. The samples were broken up by heating them in a 5% potassium hydroxide (KOH) solution for 30 minutes at a temperature of approximately 30˚C. They were then passed through a 120 µm sieve, to capture arthropods and fragments of arthropods with a size of 120 µm and larger. This allowed us to collect small arthropods (e.g. *Acaria, Diptera)*, as well as large arthropods *(e.g. Coleoptera, Araneae, Trichoptera, Diptera)*. The > 120 µm fraction was examined under a x25 magnification for arthropod sorting. Arthropod fragments were nestled between a microscope slide and a slip cover, to be identified and photographed under a x400 magnification.

Photographic collections of various subfossil remains are important tools in paleo-entomology to maintain taxonomic consistency. There exist many online photographic collections which provide a permanent record of representative specimens encountered worldwide. For example, Walters et al. (2017) has developed a *North American Aquatic Macroinvertebrate* digital reference as a tool to help verify the identification of aquatic macroinvertebrate specimens.

Acarian identification followed *The Oribatid Alamanc of Alberta* (Walter et al. 2013) and A *Manual of Acarology* (Krantz & Walter, 2009). Dipteran identification followed *An Introduction to the Aquatic Insects of North America* (Merritt & Cummins, 2008), *The WWW Field Guide to Fossil Midges* (Walker, 2007), *Chironomidae of the Holarctic region* (Wiederholm, 1983), and Cranston (2010)'s *ChiroKey webpage* which is a compilation of scanned photographic prints of representative dipteran specimens. Using '*rioja*', an *R* package for the analysis of Quaternary science data (Juggins, 2017; R Core Team, 2017), we created stratigraphic diagrams for terrestrial, semi-terrestrial and aquatic acarian, cladoceran, and chironomid taxa.

Reconstructions based on peat cores provide useful information on past environments. However, when interpreting the data, one has to be mindful of the potential biases. We obtain a sampling bias because arthropod taxa that are not well preserved in peat sediments are under-represented or misidentified (Mitchell et al. 2008). Also, because we used a 4 in-diameter corer, we obtain a relatively small volume of sediment, especially because we are working with large-size insects and arthropods. Therefore, large-size arthropods (e.g. coleopterans) are under-represented and small arthropods (e.g. acarians) are over-represented. In addition, it is likely that we obtained data biased towards species that live or build retreats within the sphagnum layer (Scott, 2003). Since only one core was analyzed from one site, the resolution of our data is weak and we are limited in our ability to represent the peatland as a whole (Morlan & Matthews, 1983). Finally, only one site was analyzed, limiting us to interpretations at the local scale.

3.4 Methods in ethnoentomology

Ethnoentomological data was gathered in 2015 (June 27-30) and in 2016 (July 12-19) with community members and Naskapi Summer Day Camp youth. Research activities included the distribution of a questionnaire (Appendix I), informal interviews, and participation in a 3-day insect-themed workshop (July 12-14, 2016).

3.4.1 Questionnaires and informal semi-structured interviews

Questionnaires provide insights into social trends, processes, values, attitudes, and interpretations by posing standardized, formally structured questions to a group of individuals (Goeldner-Gianella & Humain-Lamoure, 2010). In this study, the questionnaire had two main objectives: to explore Naskapi perceptions, values, and knowledges of insects and to investigate observed changes in insect assemblages over the past 20 years. A total of 41 community members, 21 women and 16 men, participated. Questions were analyzed using QDA Miner and Excel to obtain count data and to test variations between different age groups and gender using chi-square analyses. Since chi square analyses showed no significant differences between age groups and gender ($p > 0.05$), we proceeded to grouping the data set thematically.

Informal semi-structured interviews are social encounters where participant and researcher co-create knowledge for the community (Rapley, 2001). In this study, interviews took place in the Tshiuetin Rail Transportation passenger train[2], at the Naskapi Nation Office, the Naskapi Development Corporation, and at the community center during the monthly elder's BBQ. Three main themes guided the interview process: 1) Naskapi experiences, perceptions, values, and knowledges of insects, 2) Observed changes in insect assemblages, and 3) Impacts of changes in insects on way of life. Eight members of the Naskapi Nation participated in the interviews (5 men / 3 women, aged from 7 to 60+ years old). The interviews were transcribed

[2] The Tshiuetin Rail Transportation, an indigenous-owned short-line railway (formerly the Menihek Subdivision of the Quebec North Shore and Labrador Railway), provides service twice weekly between Schefferville and Sept-Îles.

and a thematic analysis was used to identify overarching key themes (Braun & Clarke, 2006). Interview results supported the answers obtained from the questionnaire.

3.4.2 Insect-themed art

In addition to answering the questionnaire, 20 respondents shared insect-themed art. 12 Naskapi youth were too young (i.e. less than 9 years old) to answer the questionnaire but contributed insect-themed art, for a total of 32 artists. In conjunction with the questionnaire, the art was analyzed using Excel and QDA miner to decipher values, meanings and perceptions of insects, and to assess knowledge and interest level of insects. For example, the depicted elements were identified and described, providing insight in the origin of the species, i.e. native or exotic to Kawawachikamach. We also analyzed the perspectives in which the insects were represented; the drawing-to-paper ratio; the mediums, colors, and textures; along with the presence of symbols and/or anthropomorphism. Analyzed here as a whole, the illustrations affirm the importance of raising curiosity and awareness about insects to monitor environmental change and to create inter-generational dialogue that underlines the importance of respecting and valuing the presence of insects in past, present and future generations.

3.4.3 Ethical considerations

The research process of this project was guided and mentored by a local coordinator, Tshiueten Vachon, whose involvement in all steps of the research has sparked a number of opportunities and events for the Naskapi Nation. Together and with key members of the Naskapi Development Corporation and the Naskapi Nation Office, we discussed the importance of going out on the land with youth and maintaining a connection to local wildlife. Having worked with youth before, and considering this research deals with insects, I adjusted my project to take these matters into consideration. With Tshiueten, the local coordinator, I facilitated a 3 day workshop for the 2016 Naskapi Summer Day Camp, giving youth the opportunity to go out on the land to observe and catch insects using sweep nets and magnifying boxes (Figure 10, B). Youth also went out on the water to observe aquatic insects using homemade aquascopes. Workshop materials provided by the University of Montreal Biogeography Lab (i.e. sweep nets, magnifying boxes, aquascopes, and insect collection materials) were donated to the Naskapi community center in July 2016 for future insect workshops. Naskapi Youth's perceptions, values, and knowledge of insects were reflected in these different activities including insect identification and preservation in the form of an insect collection, insect-themed art creation for a travelling exhibit, the creation of a short-film based on the Naskapi legend *The Dancing Ants* (Peastitute, 2014), and LandArt which is an ephemeral work of art involving the use of rocks, wood, plant, garbage, or other materials found in proximity to the installation (Kastner & Wallis, 1998).

Approval of the research project was obtained from the *Naskapi Nation of Kawawachikamach* in October 2014 and from the *Comité d'éthique de la recherché en arts et en science (CÉRAS)* in April 2015 (Appendix II).

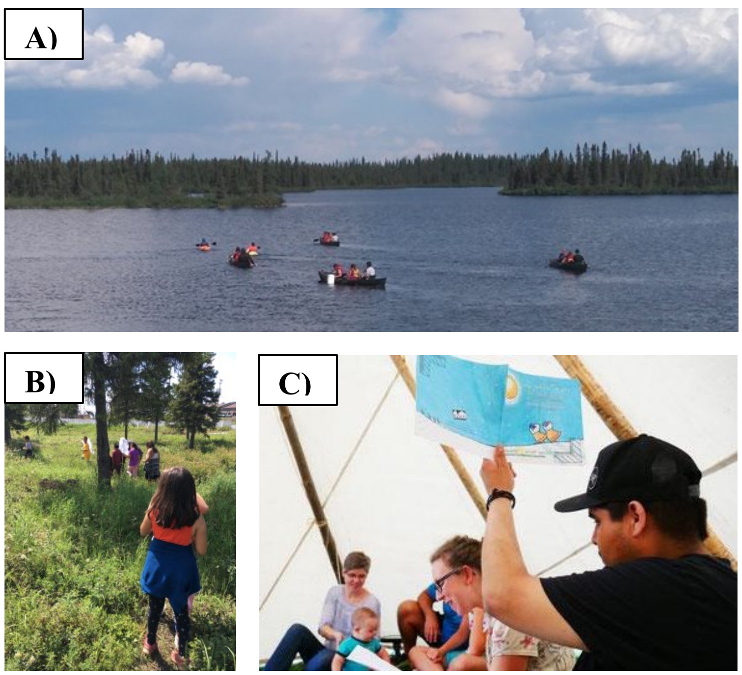


Figure 10. A-B) Examples of activities during the 3-day insect workshop: A) underwater observations with homemade aquascopes and B) insect hunting with Naskapi Summer Day Camp youth. C) Example of activity at the Montreal First Peoples' festival, i.e. Naskapi Storytime with Tshiueten Vachon. Photos: A) Phillipe Major, 2016; B) Thora Martina Herrmann, 2016; C) Louise Watson, 2016.

Chapter 4: Results and Discussions

4.1 Entomology

The following section is an account of the main findings of the entomology work we conducted in 2015 and 2016 at our three field sites in the Kawawachikamach area. Overall insects that were captured in the Kawawachikamach region are known to play important roles as pests for humans and animals, vectors for parasites, parasitoids and predators of others arthropods, and as pollinators for culturally-important plants.

4.1.1 Composition of arthropods

For all three sites (*airport site, blueberry ridge site*, and *yellow concrete site*), and for both field seasons (2015 and 2016), the composition of arthropods captured by yellow pan traps was most represented by Diptera, Hymenoptera, and Araneae (Figure 11). A total of 590 arthropods from 11 orders were collected and identified for all three sites (Tableau V).

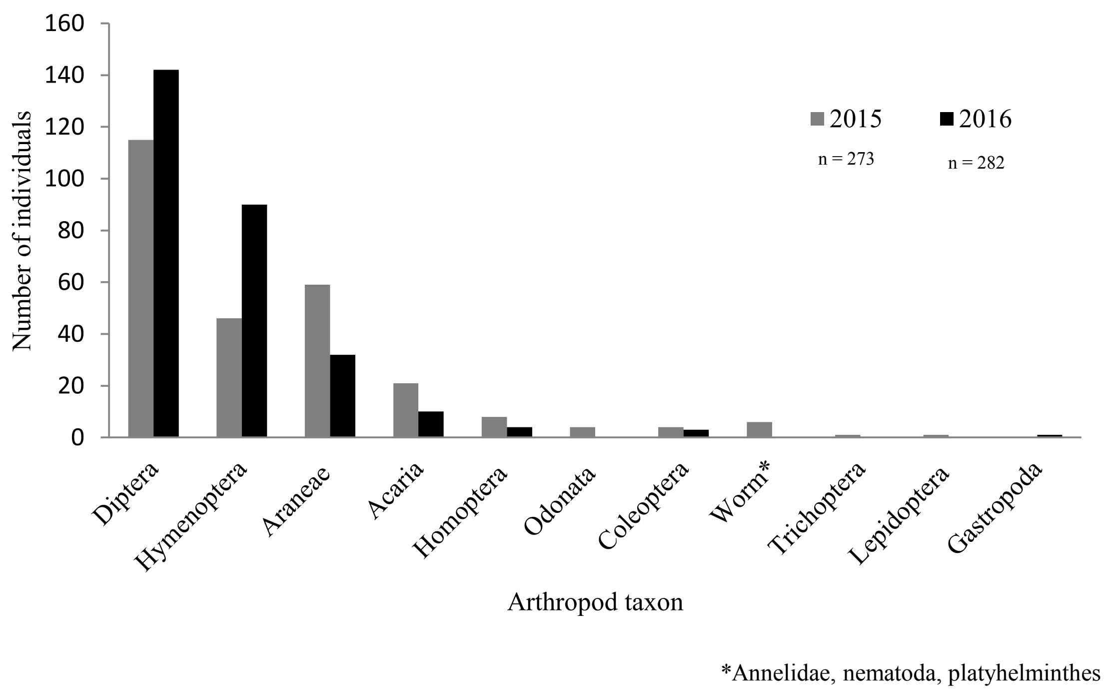


Figure 11. Total number of identified arthropod taxa captured using a 24h-sampling yellow pan trap technique in 2015 (June 28-29) and 2016 (July 16-17) at the airport site and the yellow concrete site.

The majority of individuals (n=316) were collected at the *airport site*. To ensure accurate results, we used only those individuals that were confidently identified to the family level. Overall, we analyzed 156 individuals, representing a total of 25 arthropod families. Due to inter-site differences and insufficient data from the *blueberry ridge site* (i.e. due to rainy weather conditions), the arthropod count data from the *airport site* and the *yellow concrete site* were pooled together to compare inter-year differences. The number of arthropods collected varied from two to fifty-one individuals per pan trap, which largely depended on weather conditions during the 24-h sampling period (e.g. less arthropods were collected in rainy conditions). During the 2015 field season, four traps at the *yellow concrete site* were not properly installed (i.e. not enough detergent was used). Therefore, the water surface tension was retained and arthropods were able to escape capture. As a result, we most likely underestimated the overall abundance and diversity of arthropods in 2015 and at the *yellow concrete site*.

In our study we found Diptera to be the most representative insect taxon, with black fly *Simuliidae* (21) and mosquito *Culicidae* (10) as the dominant families (Tableau V). Similarly, Schaffer (2011) notes that the dominant families of northern biting flies in 2010 were: black flies (*Simuliidae*), mosquitoes (*Culicidae*), and horse- and deer flies (*Tabanidae*). The larvae from these families develop in flowing streams and rivers, in standing ponds and pools, and in wet-soil habitats respectively, making the Kawawachikamach area an ideal region for biting fly proliferation (Figure 12; Currie & Hunter, 2008; Wood, 1985). Since mosquitoes and black flies sustain highly dense populations in the region, as pests and hosts for parasites, they can have significant negative impacts on humans and wild and domestic animals (Franke et al. 2016; Toupin et al., 1996; Solheim et al., 2013).

Tableau V. Arthropod families collected across 2015 and 2016 field seasons, using a 24h-sampling yellow pan trap technique at the airport site and the yellow concrete site.

Name in English	**Name in Naskapi**	**Order**	**Family**	**2015** Number of individuals	**2016** Number of individuals
Spider	ᑲᒥᒐᑎ:ᑲᑕᑦ kaamiihchaatikwaataat	Araneae	Lycosidae	33	17
			Thomisidae	3	1
			Amaurobiidae	1	-
			Clubionidae	2	-
			Mimetidae	1	-
Mite		Acaria	Camisiidae	-	1
			Charletonia	3	-
Midge		Diptera	Chironomidae	-	3
Black fly	ᐅᒐᐤ uchaaw		Simuliidae	13	8
Mosquito	ᔪᒋᒪᐤ shujimaaw		Culicidae	3	7
Hoverfly			Syrphidae	-	1
Horsefly	ᒥᐢᒐᐤ mischaaw		Tabanidae	-	2
Robber fly			Asiidae	1	-
Crane fly			Tipulidae	7	-
Leafhopper		Homoptera	Cicadellidae	2	4
Froghopper			Cercopidae	2	-
Plant lice			Psyllidae	1	-
Ant	ᐊᓂᐢᑯᐙᔨᒄ aniskuwaayikw	Hymenoptera	Formicidae	16	4
Parasitoid			Braconidae	10	-
Wasp	ᒥᐢᒐᐧᒄ mischaahkw		Ichneumoidea	1	-
Bee	ᐊᒧᐤ aamuw		Megachilidae	1	-
Beetle		Coleoptera	Elateridae	1	-
			unknown	3	3
Dragonfly	ᒋᐢᑕᐙᓱᐤ chiistaawaasuw	Odonata	Libellula	3	-
			Leucorrhinia	1	-
Butterfly	:ᑲ:ᑲᐱᓯᐢ kwaakwaapisiis	Lepidoptera	Boloria	1	-
Snail, slug		Gastropoda	unknown	0	1
Caddisfly		Trichoptera	unknown	1	-
Worm			unknown	6	-

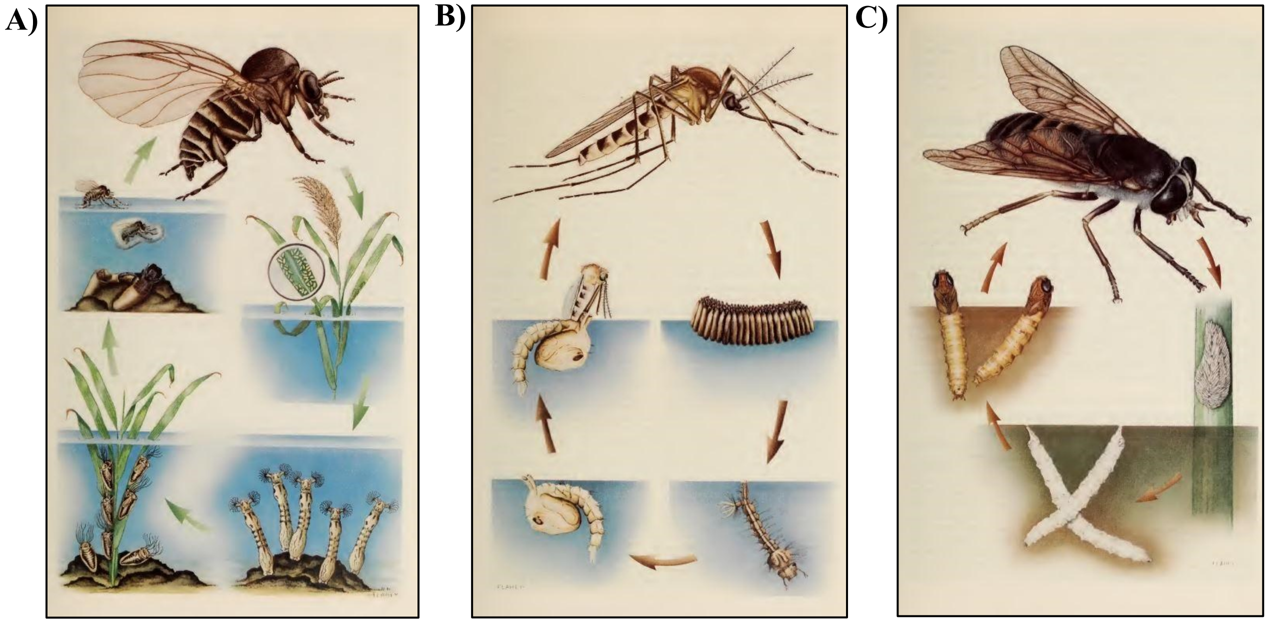


Figure 12. Life cycle involving an aquatic larval and pupal stage for: A) Simuliidae, B) Culicidae, and C) Tabanidae. Artwork retrieved from Wood (1985).

4.1.2 Trophic classes

The 156 arthropod individuals representing 25 arthropod families are comprised of herbivorous (11), nectivorous/palynivorous (16), hematophagous, i.e. blood-sucking (33), and predatory/insectivorous (96) species (Figure 13). A high proportion of predatory arthropods were captured using the yellow pan trap technique in 2015 (66%) and in 2016 (54%), most likely due to their particular locomotion, habitat use, and acute vision. Similar to findings in Rich et al. (2013), because of the pan trap/pitfall trap method, our results most likely overestimated the proportion of active ground dwellers and underestimated the actual abundance of flying arthropods. The most abundant ground-dwelling arthropods captured in Kawawachikamach area (this study) and in other northern communities in Quebec (Ernst et al. 2016; Bolduc et al. 2013) are the hunting spiders of the family *Lycosidae* (wolf spiders). Wolf spiders generally prefer open canopy habitats (Muff et al. 2009; Nordstrom & Buckle, 2002; Buddle et al. 2000) therefore an increase in tree or shrub cover in subarctic Quebec (McManus et al. 2012; Gamache & Payette, 2005) is likely to decrease the abundance of ground dwelling spiders (Rich et al.

2013). However, a longer growing season and earlier snow melt could increase the body size of some species and increase their reproductive output (Høye et al. 2010; Simpson 1993).

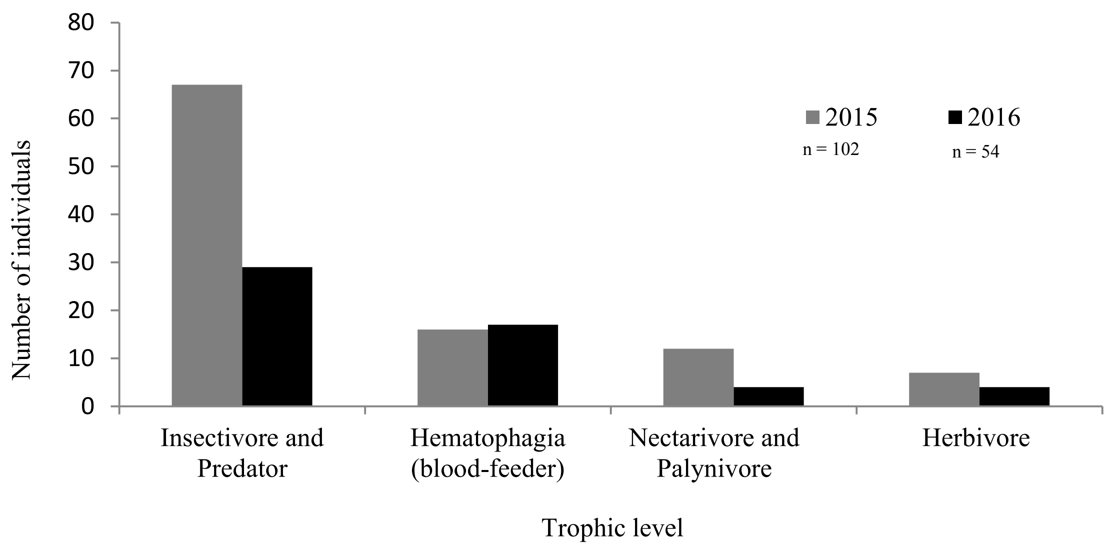


Figure 13. Proportion of arthropod individuals identified as belonging to a specific trophic class. Arthropods were captured using a 24h-sampling yellow pan trap technique in 2015 (June 28-29) and 2016 (July 16-17) at the airport site and the yellow concrete site.

4.1.3 Arthropods and flowering phenology

The dominance of dipterans in 2015 (43%), during the cloudberry (*Rubus chamaemorus*) flowering season (see Figure 4-1), could be explained by the important role that these insects play in the pollination of cloudberries (Brown & McNeil, 2009). The 2016 sampling period was characterized by the presence of a high density and diversity of flowers (Tableau VI) including Labrador tea (*Rhododendron groenlandicum, Rhododendron tomentosum*), crowberry (*Empetrum nigrum*), Canada bunchberry (*Cornus canadensis*), bog laurel (*Kalmia polifolia*), bog bilberry (*Vaccinium spp.*), and bog rosemary (*Andromeda polifolia var. glaucophylla.*). We observed a greater abundance of hymenopterans in 2016 (32%) than in 2015 (17%), most likely due to higher blossom density, an important factor in determining hymenopteran activity (Hegland & Boeke, 2006).

Although it was not part of our methodological framework, our observations in the field lead us to hypothesize that the composition and density of flowers plays an important role in determining the composition of insects. Flying hymenopterans of small size were abundant across all sites in both 2015 and 2016. Most hymenopteran species, at the larval stage, parasitize other insects (Borror & White, 1991), and as adults they are important pollinators. For example, *Pseudochalcura gibbosa* is a parasitic bog wasp which requires Labrador tea to complete its life-cycle. Its eggs overwinter on the plant until spring when the larvae emerge and parasitize ant larvae and pupae (Liesch, 2016). Parasitoids usually show high host specificity, making them sensitive to environmental changes, and regulators of host populations (Hance et al. 2007; Hawkins, 2005).

Tableau VI. Plant species that were in flowers during the 2015 and 2016 arthropod sampling period.

Plant name in English	Plant/berry name in Naskapi	Plant name in Latin	Flowers present (P) 2015	2016
Bakeapple berry	ᓯᑯᑖᐤ (sikutaaw)	*Rubus chamaemorus*	P	
		Kalmia sp.	P	
Labrador tea	ᐃᐧᑯᑕ (iihkuuta)	*Rhododendron sp.*		P
Crowberry	ᐊᔅᒋᒥᓐ (aschiimin)	*Empetrum nigrum*		P
Canada bunchberry		*Cornus canadensis*		P
Bog laurel		*Kalmia polifolia*		P
Bog bilberry	ᐃᔨᒥᓐ (iiyimin); ᓂᔅᒋᒥᓐ (nischimin)	*Vaccinium spp.*		P
Bog rosemary		*Andromeda sp.*		P

4.1.4 Arthropod communities on Labrador tea

In comparison to some berry shrubs, insect pollination is probably less critical to the reproduction of Labrador tea since it mainly reproduces though vegetative growth (Hébert & Thiffault, 2011; Hébert et al. 2010). Leaf characteristics such as a thick cuticle, condensed tannins, terpenes, and pubescence of the Labrador tea shrub may act as physical and chemical deterrents to insect herbivory (Reader, 1979). Its nectar is exploited by many species, especially bumblebees (*Bombus*), bees (*Apis*), and butterflies (*Lepidoptera*; Hébert & Thiffault, 2011). Our personal observations in the field lead us to believe that the flowers of Labrador tea host an even more diverse community of insects than previously recorded, including flies (*Diptera*), beetles (*Coleoptera*), parasitic wasps (*Hymenoptera*), tachinids (*Tachinidae*), and longhorn beetles (*Cerambycidae*) (Figure 14).

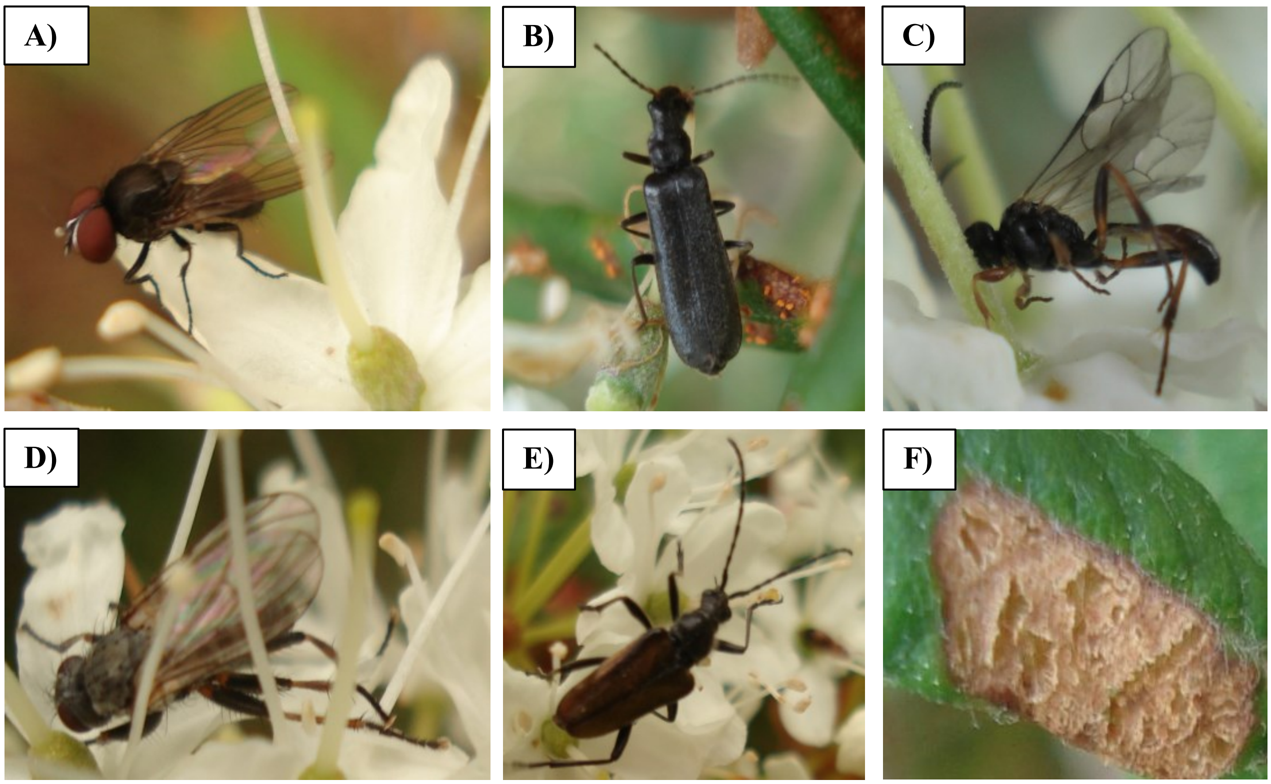


Figure 14. Insect diversity and traces of herbivory on Labrador tea plants during the 2016 flowering season (July 16-17, 2017). A) Diptera, B) Coleoptera, C) Hymenoptera, D) Tachinidae, E) Cerambycidae, F) unknown herbivory. Photos: Marion Carrier, 2015, 2016.

4.2 Paleoecology

A total of 311 arthropod fragments were extracted from the BUG1 peat core collected at the *airport site* in 2015 (Table VII). Mites (Acaria) and flies (Diptera) are the most represented subfossil arthropods in the peat core, reflecting the sturdiness of their chitinous exoskeleton against decomposition, and their small size which allows them to be present in very large numbers per volume of peat (Figure 15). Overall, juvenile acarians (Figure 15A) are found in top and bottom sediments of peat core BUG1 (Figure 16), indicative of a well-established, successfully reproducing acarian community in past and present sediments.

Tableau VII. Types and frequency of arthropod fragments extracted from peat core BUG1.

Type of fragment	Taxon	Frequency
Unknown	unknown	68
Whole body	*Acaria*	53
Body shell	*Cladocera*	44
Head capsule	*Diptera*	34
Head capsule	*Insecta*	30
Sternite/tergite	*Insecta*	28
Leg	*Arthropoda*	24
Whole body	juvenile *Acaria*	8
Egg	*Arthropoda*	7
Clypeus	*Trichoptera*	3
Pupae	*Diptera*	3
Spider eyes	*Araneae*	3
Egg sac	*Arthropoda*	1
Head capsule	*Coleoptera*	1
Mandible	*Arthropoda*	1
Mandible	*Cladocera*	1
Whole body	*Psocoptera*	1
Wing	*Coleoptera*	1
Total		**311**

4.2.1 Surface sediments

In addition to mites and flies, surface sediments (0-10 cm) contained subfossil fragments of spiders (Araneae), beetles (Coleoptera), and book lice (Psocoptera). *Clubionidae,* a spider known to live in wet places and in sphagnum moss (Glime, 2017), was found at a 2-4cm depth and was also captured in 2015, in two of our yellow pan traps. Diptera larvae found in surface sediments were composed of genera considered to be semi-terrestrial to terrestrial, including *Metriocnemus fuscipes* and *Paraphaenocladius* (Namayandeh et al. 2016; Cranston, 2010;

Larocque & Rolland, 2006; Armitage et al. 1995). Acari collected from surface sediments were composed of genera known to live in peatlands as semi-terrestrial or terrestrial species including *Oribatulidae, Malaconothridae, Thyrisomidae, Eremaeus,* and *Nothridae* (Glime, 2017; Walter et al. 2013; Walter & Proctor, 1999; Behan-Pelletier & Bissett, 1994; Seyd, 1981).

4.2.2 Bottom sediments

In bottom sediments (52-55.5 cm), the fossil community was dominated by waterfleas (Cladocera) - an aquatic crustacean (Rydin & Jeglum, 2013), by flies (Diptera), and by mites (Acaria). A few beetles (Coleoptera) and caddisflies (Trichoptera) were also identified. Bottom sediment layers held truly aquatic acarian genera, *Limnozetes* and *Hydrozetes*, known to live in aquatic habitats such as peatland pools (Schatz & Behan-Pelletier, 2008). Diptera larvae found in bottom sediments was composed of genera that are obligate to aquatic environments: *Microtendipes* lives in warm and humic waters as well as in submerged moss and sediments; *Cricotopus* is found in standing waters and is frequently associated with aquatic macrophytes, algae, and sometimes cyanobacteria; *Psectrocladius* is almost exclusively lentic; *Tanytarsus* occurs primarily in shallow water; *Procladius* prefers muddy substrata; and *Larsia* lives in lotic and lentic waters (Armitage et al. 1995; Cranston, 2010; Laroque & Rolland, 2006).

4.2.3 Arthropod reconstruction

We observe an important change in arthropod assemblages characterized by changes from aquatic to non-aquatic species. Elias (1982) has inferred similar hydrological trends from caddisfly fossils in a bog near Umiakoviarusek Lake in northeastern Labrador (57˚19'N, 62˚21'W). Requiring an open water habitat to complete its life cycle, the disappearance of caddisfly larvae from the bog 500 BP and an increase in the number of tundra dwelling insects suggests a transition from open water towards denser mats of mosses, sedges, and other semiaquatic plants. In a peatland near Kuujjuarapik, subarctic Québec (55°13′N, 77°41′W), testate amoeba assemblages indicate an overall slight lowering of the water-table since ca. 140 cal. BP and a return to peat accumulation especially since the early 20th century (Lamarre et al. 2012). A possible change in the hydrology of peatlands at the regional scale could be associated to increasing temperatures in the subarctic region, changes in precipitation and in snow patterns temporally and geographically, and/or changes in vegetation (van Bellen et al. 2013). Since very little work in paleo-entomology exists for Quebec subarctic fauna, future research is needed to assess if these hydrological changes are occurring at the local or at the regional scale (Elias, 2010).

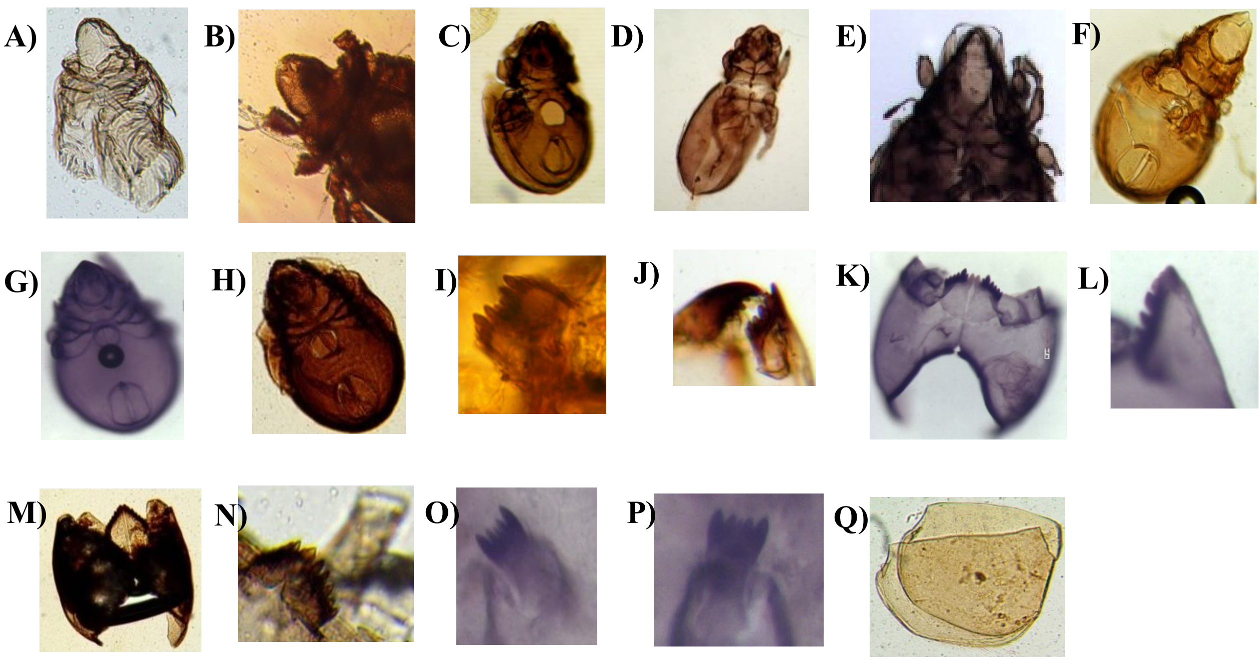
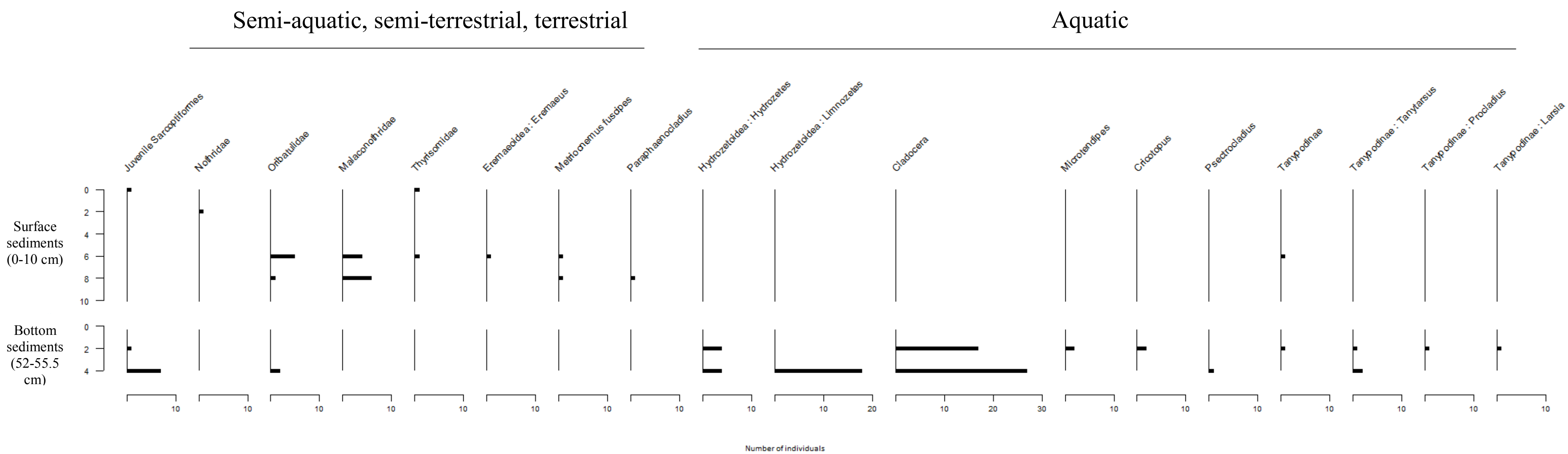


Figure 15. Images of subfossil Acari, Diptera, and Cladocera collected from sediment core BUG1 at the Schefferville aiport site. A) Juvenile Sarcoptiformes, B) Nothridae, C) Oribatulidae, D) Malaconothridae, E) Thyrisomidae, F) Eremaeus, G) Hydrozetes, H) Limnozetes, I) Metriocnemus fuscipes, J) Paraphaenocladius, K) Microtendipes, L) Cricotopus, M) Psectrocladius, N) Tanytarsus, O) Procladius, P) Larsia, Q) Cladocera. Photos: Marion Carrier 2015, 2016.



Taxon D=Diptera larvae A=Acari	**Depth** S=Surface; B=Bottom	**Number of individuals collected**	**Habitat type**	**References**
(A) *Oribatulidae*	S, B	8	In mesophilous habitats and peatlands.	Behan-Pelletier & Bissett, 1994
(D) *Tanypodinae*	S, B	2		
(A*) Malaconothridae*	S	10	In aquatic mosses and detritus.	Glime, 2017
(D) *Metriocnemus fuscipes*	S	2	In lentic, lotic, and semi-terrestrial environments, including damp moss	Cranston, 2010
(A) *Thyrisomidae*	S	2	In moss, litter, and lichens.	Seyd, 1981
(A) *Eremaeus*	S	1	Migrates in the soil to optimize moisture and temperature. Known among bryophytes	Glime, 2017
(A) *Nothridae*	S	1	In mesophilous habitats, bogs, wet forests, and compost.	Walter et al. 2014
(D) *Paraphaenocladius*	S	1	Terrestrial or semi-terrestrial, in damp soil, meadows, and springs.	Cranston, 2010

Taxon D=Diptera larvae A=Acari C=Crustacean	**Depth** S=Surface; B=Bottom	**Number of individuals collected**	**Habitat type**	**References**
(C) *Cladocera*	B	44	Aquatic. Often on bottom sediments of peatland pools.	Rydin & Jeglum, 2013
(A) *Limnozetes*	B	18	Truly aquatic. All stages of its life occur in freshwater.	Schatz & Behan-Pelletier, 2008
(A) *Hydrozetes*	B	8	In peatland pools.	Smith, 1987
(D) *Tanytarsus*	B	3	In shallow waters and in a variety of aquatic habitats.	Cranston, 2010
(D) *Cricotopus*	B	2	In all types of standing water bodies.	Cranston, 2010
(D) *Larsia*	B	2	In many habitats including streams, small standing waters and the littoral zone of lakes.	Cranston, 2010
(D) *Microtendipes*	B	2	In shallow, warm, and humic waters. In sediments and submerged mosses.	Larocque & Rolland, 2006
(D) *Psectrocladius*	B	1	Lentic. In standing waters ranging from small to the largest lakes.	Cranston, 2010
(D) *Procladius*	B	1	In muddy substrata of standing or slowly flowing water bodies, especially ponds and small lakes.	Cranston, 2010

Figure 16. Stratigraphic diagram of the Acaria, Cladocera, and Diptera taxa shown as number of individuals in 6 cm^3 sediment. Left) cluster of terrestrial, semi-terrestrial, and semi-aquatic genera. Right) cluster of aquatic genera.

4.3 Ethnoentomology

Most people living in Kawawachikamach find insects and bugs annoying. In the summer, the *buzz* - the sound of an insect's flight - resonates in your ears, in your mind, and in your dreams. Some bugs bite and sting you - it hurts. Others look like little monsters made of only eyes and legs - you shiver. Yet some of them are beautiful and you can't help but think that they are important. Who are these little ones that live in this world with you?

To explore Naskapi perspectives, values, and knowledges of insects, a questionnaire was distributed in the community. The questionnaire was divided in two main themes: 1) Naskapi experiences, perceptions, values, and knowledges of insects and 2) Observed changes in insect assemblages over the past 20 years.

4.3.1 Naskapi experiences, perceptions, values, and knowledges of insects

The first time I asked the question *"Do you remember the first time you saw an insect?"* I was answered by a roaring laugh that muffled the sound of the words: [laughing] *'a mosquito bite! Everyone will answer this.'* (pers. comm. June 29, 2015). As anticipated, mosquitoes (6), spiders (6), and bees (3) were the most marking insect encounters at a young age (approx. 4-10 years old). The majority (76%) of these encounters were associated to a negative memory (Figure 17) including being bit by a mosquito, stung by a bee, or frightened by a crawling spider. Humans have a tendency to project attitudes of disgust, fear, and disdain on those animals associated to the culturally determined *insect* category (Costa-Neto & Magalhães, 2007; Kellert, 1993). The reactions and responses to our questions were similar to those in Costa-Neto & Magalhaes (2007), where the simple mention of an *insect* during interviews brought back memories of being injured, directly or indirectly by an insect.

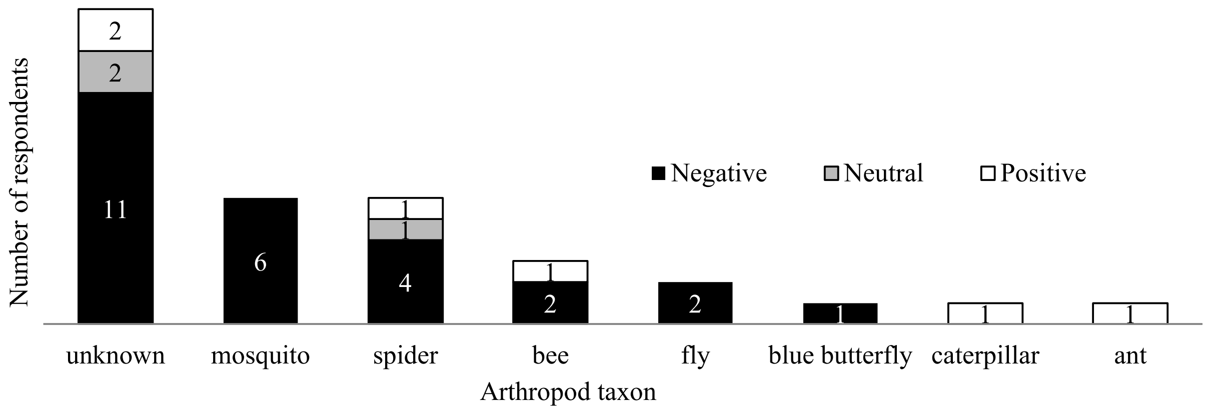


Figure 17. Feelings associated with one's first encounter with an insect (n=35).

When asked to use three words to describe a dream with insect(s), most respondents used words that were nightmarish and dominated by feelings of disgust, fear, and annoyance (Figure 18). In conjunction with nightmarish descriptors, many respondents (8) mentioned the presence of a spider in their dream. Younger (7-12 years old) and older generations (60+ years) were the only age groups that expressed some elements of their dream as being neutral or positive, with mentions of flowers, leaves, butterflies, and superstitions.

According to Drews (2002), attitudes toward animals are formed through the values, knowledge, perceptions, and nature of the interactions that are established between human beings and animals. Those who know more about insects seem to have a more rational and positive attitude towards them than those who know less (Drews 2002). During the 2016 insect workshop in Kawawachikamach, youth already had knowledge of certain insects. Their curiosity to learn more might relate to their positive attitudes towards this group of animals:

> "*Insects are important for our environment. We are connected to the same environment and everything is important big or small. One insect can affect you in a big way…*"
>
> - Interview # 7, Kawawachikamach, July 2016

Elders have a long-lived experience and knowledge of insects and animals, which influences their current belief system of insects: "*My grandfather used to say to not* [squash a mosquito]. *Just let it bite and drain out the bad blood*" (interview # 1, Kawawachikamach, July 2016).

With a profound understanding of the relationships between humans, animals, and non-human entities that make up the Naskapi spiritual world, Elders were able to interpret the signs of nature (Lévesque et al. 2016). For instance, dreams of caribou and animals are sung and played on the drum before a hunting expedition because "*…when an elder beats the drum, they listen and they know according to the sound, where the caribou is*" (Lévesque et al. 2016:69).

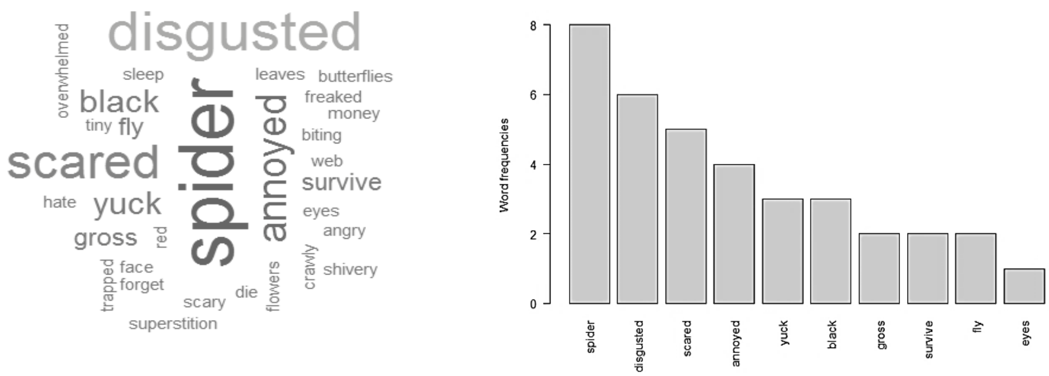


Figure 18. Word cloud visualization of the frequency of words used to describe a dream about insects. Computed using R software.

To explore which insects are liked by the community, out of a choice of 9 arthropod taxa, respondents were asked to circle any of the ones they like. Butterflies (40), dragonflies (14), beetles (8), and worms (4) were the most circled, i.e. the most liked insects (Figure 19).

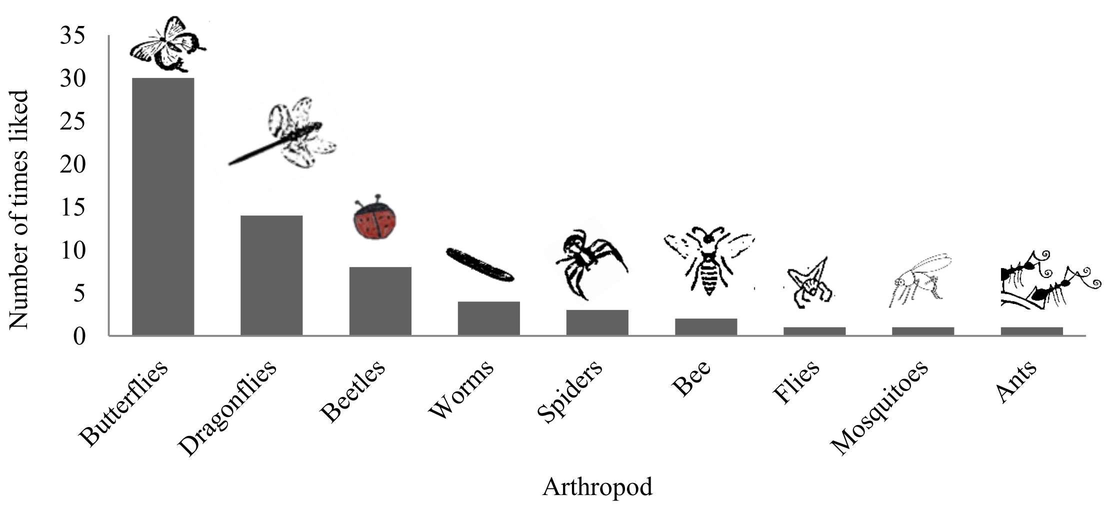


Figure 19. Number of times each arthropod taxon was liked by 2016 questionnaire respondents. n = 64

Two species of butterfly, *Boloria bellona toddi* and *Celastrina ladon*, are abundant in the community. They are well-known, harmless, and considered aesthetically beautiful. Dragonflies like *Leucorrhinia hudsonica* and oligochaete worms are well-known and culturally-important animals because they are used as bait to catch fish. One respondent mentioned the importance of these insects amongst others, in providing food for the community: *"Fish eat insects which sustain them and in turn the fish sustains us"* (interview # 7, Kawawachikamach, July 2016). Although not present in the community, ladybugs are amongst the most liked insects, most likely due to its re-occurring presence in media (Snaddon & Turner, 2007). Butterflies, dragonflies, and lady bugs are known to be a charismatic animals at the center of conservation programs, citizen science initiatives, festivals, and eco-touristic activities worldwide (Breuer et al., 2015; Schlegel et al., 2015; Lemelin, 2013; Devictor et al. 2010; Hvenegaardet al. 2010).

Pardosa, *Pirata*, and *Xysticus* are genera of wolf spiders that generally don't spin webs but rather hide among debris (Mallory, 2012). These were abundantly found in two peatlands near Kawawachikamach and one peatland near Schefferville. Contradicting with the popular fear of spiders recorded in the literature (Gerdes et al. 2009), three questionnaire respondents reported that they like spiders. The spider holds symbolic meanings in many cultures, including its divinatory function as a weaver of reality (Chevalier & Gheerbrant, 2005). In Kawawachikamach, it is said that "*dreaming of spiders means money*" (interview # 8, Kawawachikamach, July 2016). During the 3-day insect workshop held in the community in 2016, a Naskapi youth depicted his dream, which he did not describe as being a nightmarish one: "*this is the little spider on my face that I saw in my dream*" (Figure 20). Another youth's art work of a weaving spider in its environment depicts the spider's interconnectedness with other beings and places/spaces, as well as its place in religion and the spiritual world (Figure 4-10). The common sighting of spiders in the region, along with the good omen they represent in Naskapi dreams, may explain the high presence of spiders in dreams and in art.

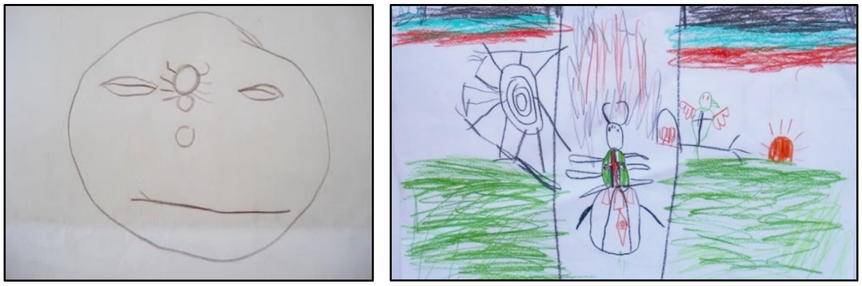


Figure 20. Left: Depiction of a dream about an insect: “*this is the little spider on my face that I saw in my dream*”. Naskapi youth, July 2016, Kawawachikamach. Right: Insect art for *awaasis* exhibit. Naskapi youth, July 2016, Kawawachikamach.

When out on the land, Naskapi observe their insects, particularly when these are present on harvested plants and animals (Table VIII). Parasites have been observed in caribou and ptarmigan, maggots have been noticed in harvested meats, and insects have been observed flying and eating carcasses (interview # 4, Kawawachikamach, July 2016).

Tableau VIII. Number of respondents observing specific insect behaviours during plant (e.g. berries, Labrador tea) and animal (e.g. caribou, ptarmigan, fish) harvesting activities, n=37.

Insect behavior	Harvested plants	Harvested animals
Eating	20	16
Hiding	23	7
Flying	24	18
Resting	19	9
Crawling	21	16
Total	**107**	**66**

Insect parasites have been reported by hunters, herders, and researchers across the polar circumpolar region. In Norway and Sweden, some herders consider warble fly larvae (*Hypoderma tarandi*) and bot fly larvae (*Cephenemyia trompe*) as the most common diseases in their reindeer (Tryland et al, 2016). Therefore in the fall, anti-parasite medication is given to reindeer (Turunen et al. 2016). In Inuvik (NWT), it has been noticed in the last 30 years that some caribou are infected with parasites and worms that burrow in their flesh (Nickels, 2005). In Nain, there are reports of worms in char, black worms in the throat of caribou (most likely *Cephenemyia trompe*) and parasites that look like rice grains in caribou meat (most likely *Hypoderma tarandi*; Communities of Labrador et al. 2005). In 2005, inhabitants of the Sahtu, Gwich’in, and Inuvialuit regions reported increased evidence of *green/yellow/tea-colored* *slimy/wet stuff* under the skin of harvested caribou (Kutz et al. 2009). Since 2006, indigenous hunters and outfitters in northern Quebec are seeing a high number of sick caribou with poor coats and ulcerated limbs, possibly linked to severe infections of protozoan parasite *B. tarandi* (Kutz et al. 2009). For most respondents (21), the presence of insect pests negatively impacts their practice of traditional activities (Figure 21): *"...mosquitoes bug us, which affects the hunting. They use our blood to grow their numbers"* (interview # 7, Kawawachikamach, July 2016).

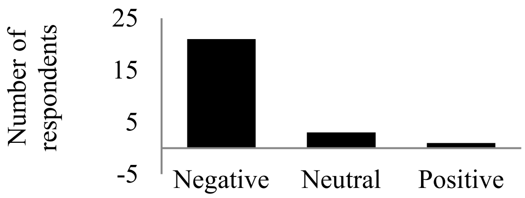


Figure 21. Impact of insect presence on the practice of Naskapi traditional activities. n = 25

Similarly, in Inuvik, an increase in the number of insects has contributed to a decline in the practice of berry harvesting (Nickels, 2005). In the Inuvialuit Settlement Region (ISR), communities have discussed the need for better protection against insects, including mosquito screens, protective clothing, and insect repellents (Nickels, 2005). With the potential to swarm, infest and infect, mosquitoes are rarely considered as companion species for humans (Beisel, 2010; Raffles, 2010; Twinn, 1950). In subarctic regions of Canada, mosquitoes and black flies interfere greatly with human comfort and activity during the summer season to the extent upon which the Defense Research Board led an investigation into what was called "the biting fly problem in the North" (Twinn, 1950).

4.3.2 Observed changes in insect abundance, morphology, life cycle, and composition over the past 20 years

According to the majority of questionnaire respondents (63%), over the past 20 years there have been significant changes in insect communities of the Kawawachikamach region (Table IX). The most important changes have been larger-sized insects (69%), an increase in their numbers (61%), and an earlier spring-time emergence (50%).

Tableau IX. Proportion of respondents having observed more/bigger (↑), less/smaller (↓), earlier (e), later (l) phenomena on changes in insect over the past 20 years in Kawawachikamach.

Insect abundance	No. observations (n = 29)	Proportion (%)
Mosquitoes	7 ↑ ; 1 ↓	24 ↑ ; 3 ↓
Flies	2 ↑	7 ↑
Bees	1 ↑	3 ↑
Horseflies	1 ↓	3 ↓
Ants	1 ↓	3 ↓
minitusis in general	7 ↑, 2 ↓	24 ↑ ; 7 ↓
Totals		
Changes observed	17 ↑, 5 ↓	59 ↑ ; 17 ↓
No changes observed	7	24

Insect emergence	No. observations (n = 6)	Proportion (%)
Flies	1 (e)	17 (e)
minitusis in general	5 (e)	83 (e)
Totals		
Changes observed	6 (e)	100 (e)
No changes observed	0	0

Insect hibernation	No. observations (n = 4)	Proportion (%)
minitusis in general	4 (l)	100 (l)
Totals		
Changes observed	4 (l)	100 (l)
No changes observed	0	0

Insect size	No. observations (n = 30)	Proportion (%)
Mosquitoes	5 ↑	17 ↑
Flies	2 ↑	7 ↑
Bees	1 ↑	3 ↑
Ants	1 ↑	3 ↑
minitusis in general	12 ↑, 1 ↓	40 ↑ ; 3 ↓
Totals		
Changes observed	21 ↑, 1 ↓	70 ↑, 3 ↓
No changes observed	8	27

New species	No. observations (n = 19)	Proportion (%)
Lady bug	4	21
Yellow butterfly	1	5
Darker blue butterfly	1	5
Unknown orange-red *minitusis*	1	5
Unknown orange-black *minitusis*	1	5
Unknown new *minitusis*	2	11
Totals		
Changes observed	10	53
No changes observed	9	47

Changes in abundance

Mosquitoes (*Culicidae* spp.) are mentioned by a number of people (7) as having increased in numbers in and around Kawawachikamach. This may be co-related to changes in temperature, precipitation, wind, and humidity, which are important regulating factors of mosquito abundance (Chuang et al. 2012; Toupin et al. 1996; McCall & Primack, 1992; Service, 1980).

While traveling on the train I met a Naskapi hunter. I asked, “Have you noticed worms in the caribou?” He answered, “One change I have noticed is that there are fewer horseflies because there is less caribou.” (Interview # 4, Tshiuetin Railway train, July 2016). It was mentioned twice, by two different interviewees that since tabanids feed on the blood and flesh of caribou, a decrease in the number of tabanids is related to the disappearance of caribou from the region. Some Naskapi hunters are particularly attentive to changes in tabanid populations because they use tabanid clouds (i.e. from swarming behavior) to track and locate caribou (interview # 6, Kawawachikamach, July 2016).

While out on the land with Naskapi youth for the 2016 insect workshop, youth got a better look at ᒥᐢᒑᐤ mischaaw (horse fly). Even if they bite, many were amazed at the fly’s beauty, with its spotted wings and metallic eyes. Hybomitra and Chrysops were the most collected tabanids in the Schefferville area in 1990-1991 (McElligott, 1992), in 2010-2011 (Schaefer, 2011), and now in 2016, during the 3-day insect workshop. This suggests that even after 26 years, tabanid communities continue to be dominated by Hybomitra and Chrysops individuals.

According to Speck (1977), another species of tabanid, Tabanus affinis, torments fishermen with her stings to warn them against the wastefulness of the flesh. To those who do not waste, the fish will continue to come. The entanglement of these multispecies interactions in various activities and locales are likely to change with differing insect abundances.

Changes in phenology

According to McElligott (1992), in the early 1990s, *Hybomitra* was most abundant in July and August, and *Chrysops* was most active in late July to early August in the Schefferville area. At present day, in 2016, the Naskapi are observing earlier tabanid activity, i.e. in June: *"Before, the big ones* [tabanid flies] *used to come in August! Now they come in June."* (Interview # 3, Kawawachikamach, July 2016). During the same interview, it was said that one reason for this may be that "*there's much less snow than before and it starts piling up later."* Although loss of insulating snow cover can expose overwintering insects to extreme and fatal weather conditions (Pauli et al. 2013), warmer temperatures allow for faster and earlier development and emergence (Forrest, 2016; Valtonen et al. 2013; White et al. 2009), which might explain the earlier emergence of tabanid flies in Kawawachikamach.

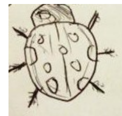
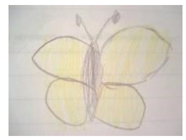
Changes in morphology

Most insects reach smaller adult sizes when reared at warmer temperatures, suggesting a community-level shift towards smaller species at warmer temperatures (Kingsolver & Huey, 2008). The contrary is observed in Kawawachikamach, where mosquitoes (5), flies (2), bees (1), ants (1), and other insects (12) are observed to be larger than before. This could be explained by newly incoming insect species rather than a change in their size. For most respondents it was somewhat challenging to distinguish between truly new species versus those becoming bigger. For instance, mosquitoes were reported by the majority (88%) of participants as being bigger than before, and by others (12%) as newly established, different species: *"sometimes it seems that the mosquitoes are getting bigger. Or I just noticed more and more variety of insects"* (questionnaire respondent #30, Kawawachikamach, July 2016).

Changes in community composition

Newly observed insects in Kawawachikamach include a lady bug (*Coccinellidae*), a yellow butterfly (*Lepidoptera*), a blue butterfly that seems to have a darker colour than usual, and at least two other unidentified species (Table IX & X). Some butterflies and bumble bees (*Bombus* spp.) of the northern hemisphere, have exhibited northward shifts in their southern range limits (Kerr et al. 2015; Parmesan et al. 1999) which might explain the presence of new butterfly species and a larger bee species in the community.

Tableau X. Newly observed insects in Kawawachikamach (n=8).

Naskapi	English	Latin	Drawing	Mentions
	Lady bug	Coleoptera : Coccinellidae	 	**4** (were together when saw it)
ᑹᑹᐱᓰᔅ kwaakwaapisiis	Butterfly	Lepidoptera		**1** yellow butterfly **1** dark blue butterfly
Unknown	Unknown	Unknown	 	**1** orangish reddish insect (left) **1** black-orange insect (right)

In 1947, the *Act to Incorporate the Quebec North Shore and Labrador Railway Company* opened the subarctic Quebec to the international iron ore industry. As the extent, volume, and efficiency of the transportation of people and freight increase, a greater diversity of species are introduced in new areas, which increases the number of potential arthropod invasions (Ascensão & Capinha, 2017). By clinging onto a train, by flying around in the freight, or by unintentionally being loaded with the train or plane cargo, unusual insects could more easily make an appearance in the Kawawachikamach area.

Naskapi mothers have expressed concern regarding the development of allergies in their children, and especially in babies, as a result of insect stings (interview # 5, Kawawachikamach, July 2016). It is possible that this fear of allergies stems from an increase in the abundance of biting/stinging insects in the community. Similarly, in the Yukon, CBC News (2017, August 11) reports a high incidence of insect stings coinciding with an increase in yellow jacket wasps (*Vespula*), bald-faced hornets (*Dolichovespula maculate*) and European honeybees (*Apis*). In Alaska, more people are receiving medical treatment for insect-related allergies, possibly as a result of warming temperatures (Demain & Gessner, 2008).

4.4 Interweaving knowledges from entomology, paleoecology, and ethnoentomology

The aim of this study was to gather knowledges from three differing perspectives and methodologies, to contribute alternate stories to current climate change discourses. To obtain a more holistic view of the impacts of climatic changes on insects and therefore on the well-being of northern communities, we adopted an inter-disciplinary approach to describe contemporary and historical changes in insect populations and to obtain insight on how these changes may affect human-insect-plant relationships in an around Kawawachikamach. Borrowing methodologies from the fields of entomology, paleoecology, and ethnozoology, we obtain three parallel stories that inter-weave to capture and co-create knowledges that would otherwise be unseen and/or forgotten if only one methodology had been used.

The ethnozoological approach offers a re-centering of the research on human-insect relations and covers a significant time period over large spatial areas. Since this approach provides little detail on arthropod taxonomy, we complemented it with entomology to provide baseline data and a current profile of arthropod biodiversity. However, since the entomological approach is limited by time and space, with paleoecology we were able to go back in time in relatively high detail and resolution, but only at a very small spatial scale. With ethnozoological methodologies we are able to address the spatial weakness of paleoecological studies hereby creating a web of methods that complement each other with their strengths and weaknesses.

Data from arthropod field sampling showcases a high diversity of taxa living and/or interacting with peatlands. Due to their important presence on the land and as an integral part of Naskapi culture, residents of Kawawachikamach hold important relationships with many of these taxa. Our findings from stratigraphic analyses reveal an observable and noticeable change in the arthropod assemblages of a subarctic peatland, from aquatic to non-aquatic species. In a similar way, local Naskapi observations reveal significant changes in the abundance, morphology and composition of arthropod communities in the Kawawachikamach region. The most important changes have been larger-sized arthropods, an increase in their numbers, an earlier spring-time emergence and the arrival of new species. Arthropod-related values were manifold among local Naskapi. Aesthetical ones were shown to play a key role in people's positive and rather negative attitudes.

Data on arthropod assemblages and associated cultural values has the potential to inform environmental health policies and programs in regards to the role of arthropods as deterrents of summer-time land-based activities. As a pioneer in its field, this project developed a methodology and baseline data for future research on insect ecology in the subarctic. In addition, the community has been equipped to establish a long-term monitoring program of insects in Kawawachikamach.

Chapter 5: Conclusions

Although they are small, insects are everywhere, often in high abundance. Whether negative, positive or ambivalent, the type of relationship a human has with a particular insect is often determined by visual, auditory, and olfactory cues; early childhood experiences; dreams; and the portrayal of the insect in media, at school, and at home. Naskapi Elders and knowledge holders teach youth that they must respect all living beings, even those that bite and sting. As pests, vectors of disease, pollinators, decomposers, and predators/parasitoids of unwanted pests, insects have the potential to alter the landscape and the well-being of Northern communities. In this study we have presented an analysis of Naskapi observations of changes in the arthropod assemblages. Together with data from arthropod field sampling and stratigraphic analyses of peat cores we provide baseline data on arthropod diversity and abundance in three Quebec subarctic peatlands to enable us to explore changes in arthropod assemblages over time, and to characterize Naskapi knowledge, values and perceptions of the implications of such changes for land-based activities.

Data from arthropod field sampling showcases 11 different orders and 25 arthropod families mainly composed of Diptera, Hymenoptera, and Araneae taxa. Our findings suggest an observable and noticeable change in the insect populations of a subarctic peatland over the past century, from aquatic to non-aquatic species. Future research is needed to assess if these hydrological changes are occurring at the local or at the regional scale, especially since very little work in paleo-entomology exists for Quebec subarctic fauna. Many insect species seem to be increasing in numbers and undergoing changes in their seasonal activity. Additionally, the arrival of new species has raised concerns among members of the Naskapi Nation regarding the future wellness of the animals, the plants, and the community. Future research directions include exploring the underlying causes of the detected changes in arthropod assemblages especially in light of accelerating climatic and socio-environmental changes (i.e. infrastructure development in Kawawachikamach and railway construction in Schefferville) which increases the number of potential arthropod invasions as well as the appearance of new insects in the Kawawachikamach area.

Given the role of research in informing programs and policies and capacitating future environmental stewards, engaging youth in research activities was of key concern (Bird-Naytowhow et al. 2017). Thus, in the summer of 2016, we organized a 3-day workshop for the Naskapi Summer Day Camp, giving youth the opportunity to observe insects on the land and on the water. These land-based activities were an important outreach of this research as they created a new space for youth to practice and maintain the Naskapi culture and language, and learn more about insects. As an outreach outcome of this project, we are currently working on developing a section on insects for the Naskapi lexicon, as an educational tool and as a safe-keeper of the Naskapi language (Appendix III). We also now have a website, awaasis.jimdo.com, to document and showcase the research for other communities.

As a white settler woman living on unceded First Nations territories, my role as a scholar is not to lead the work of decolonization but rather to stand in solidarity, to facilitate, and to support decolonial discourses and actions that challenge ongoing colonial violence. Community consultations, sharing of information and building relationships of trust and friendships in Kawawachikamach have been important ethical considerations in our project. One outcome of these relationships is the annual participation of the Naskapi Nation at the Montreal First Peoples' festival, an important artistic and cultural event where Montreal becomes a point of convergence for First Nations, and a meeting place where Naskapi artists and knowledge holders come to share Naskapi culture, language, and identity. In the past year, we have assisted to a number of community consultations with Naskapi representatives to communicate results from this research project and to collaboratively build future community-based participatory research projects.

Our results suggest that future climate change-biodiversity research needs collaborative research teams with local communities. By linking environmental phenomena with local observation and cultural perception, such research can generate new and culturally meaningful methods in observation, data analysis and interpretation. By doing so, we gain a more wholistic perspective on the impacts of environmental change on subarctic environments and its residents.

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Appendix I: Ethnoentomology Questionnaire

BUGS QUESTIONNAIRE

Circle your answer

Sex: male female

Age range: 8-12 13-18 19-30 31-45 46-59 +60

Where are you from? ______________________________

PART 1 – INSECTS

1) **Do you remember the first time you saw an insect? Can you name it or describe it?**

____

2) **How did this insect make you feel?** (you can circle more than one answer)
    a. Scared, angry, disgusted
    b. Happy, fascinated, curious
    c. Annoyed
    d. Hurt (i.e. in physical pain)
    e. Other: ____________________

3) **Do you know any stories, legends, and songs about insects?**
    Yes No

    ➢ **If yes, can you tell me?**

____

4) **Have you ever dreamed about insects?**
    Yes No

    ➢ **When you think about your dream, what are the first 3 words that come to mind?**

_____________________ ; _____________________ ; _____________________

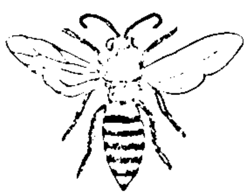
5) Choose one insect. Write its name and meaning in English and in Naskapi.

	English	Naskapi
Name of insect		
Meaning of its name		

- **Why did you choose this insect?**

  ____

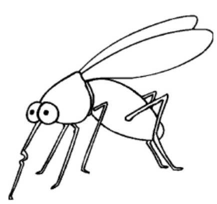
6) Circle the bugs you like (you can circle more than one insect)**:**



Bees

Butterflies

Flies



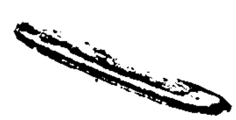
Mosquitoes

Dragonflies

Beetles

Ants

Spiders and mites



Worms

- Other bugs you like: ____

7) **How many kinds of insects do you know?**
   a. 0
   b. 1-5
   c. 5-10
   d. >10

8) **Have you ever used insects for:** (you can circle more than one answer)
   a. Food
   b. Medicine
   c. Art
   d. Play (toys, pranks, etc)
   e. Other ____________________

PART II – INSECTS OUT ON THE LAND

9) **When you are out on the land, in the middle of the summer, how do you feel about insects?**
   - I don't care about them.
   - They are beautiful and it's nice to see all the different kinds of insects.
   - It's annoying! I don't like insects buzzing around me.
   - Other: ____

10) **Please put a √ in all the boxes that apply:**

Have you ever seen an insect…	In or on **harvested** berries and plants	In or on **harvested** meat and fish
Eating		
Resting		
Hiding		
Flying		
Crawling		
Other: _________________________		

PART III - CHANGES IN INSECTS

11) Have you noticed changes in the insects in and around Kawawachikamach over the last 20 years?

Yes No I don't know

- **If yes, describe the biggest change you have seen:**

____

____

____

12) Do you think some insects have disappeared?

Yes No I don't know

- **If yes, which insect?**

____

____

13) Have you noticed any new insects?

Yes No I don't know

- **If yes, can you draw it?**

14) Please tick if you agree with the statement:

___ There are more insects here than before   If yes, please tell which one:_________

___ There are less insects here than before   If yes, please tell which one:___________

___ Insects are here earlier than before (in the spring)

___ Insects are going away later than before (in the fall)

___ Insects are bigger than before

___ Insects are smaller than before

___ Insects are a different colour than before

- what colour? ___________

15) How do insects affect your life and your activities?
(e.g. plant gathering, berry picking, hunting, fishing, etc)

____

____

____

____

____

____

____

16) Is there anything else you would like to share with me?

____

____

____

____

INSECT & PLANT DRAWING

Draw an insect and a plant. Maybe your drawing will make it to the awaasis exhibit.

Please describe your drawing:

Would you like to receive updates on the research project and the awaasis art exhibit?

Yes No

- If yes, please write your e-mail address here:_________________________

chiniskumitin **Thank you!**

Appendix II: Ethics Certificate

Université de Montréal

N° de certificat
CERAS-2014-15-292-P

Comité d'éthique de la recherche en arts et en sciences

CERTIFICAT D'APPROBATION ÉTHIQUE

Le Comité d'éthique de la recherche en arts et en sciences (CÉRAS), selon les procédures en vigueur, en vertu des documents qui lui ont été fournis, a examiné le projet de recherche suivant et conclu qu'il respecte les règles d'éthique énoncées dans la Politique sur la recherche avec des êtres humains *de l'Université de Montréal.*

Projet	
Titre du projet	**Insectes et petits fruits : conséquences écologiques et sociales des changements climatiques dans un environnement subarctique du Québec / Bugs and berries : ecological and social implications of climate change in a Québec subarctic environment**
Étudiante requérante	**Marion Carrier** Étudiante à la maitrise, FAS-Département de géographie
Sous la direction de	Julie Talbot, Professeure adjointe, FAS-Département de géographie, Université de Montréal & Thora Martina Herrmann, Professeure agrégée, FAS-Département de géographie, Université de Montréal.

Financement	
Organisme	Centre de la science de la biodiversité du Québec (CSBQ)
Programme	
Titre de l'octroi si différent	
Numéro d'octroi	
Chercheur principal	
No de compte	

MODALITÉS D'APPLICATION
Tout changement anticipé au protocole de recherche doit être communiqué au CÉRAS qui en évaluera l'impact au chapitre de l'éthique.

Toute interruption prématurée du projet ou tout incident grave doit être immédiatement signalé au CÉRAS.

Selon les règles universitaires en vigueur, un suivi annuel est minimalement exigé pour maintenir la validité de la présente approbation éthique, et ce, jusqu'à la fin du projet. Le questionnaire de suivi est disponible sur la page web du CÉRAS.

Comité d'éthique de la recherche en arts et en sciences
Université de Montréal

21 avril 2015
Date de délivrance

31 janvier 2018
Date de fin de Validité

Appendix III: Addition to Naskapi Lexicon

English	**Naskapi syllabics**	**Roman**	**Variations** (2015 questionnaire)	**Meaning**
Insect	ᒥᓂᑐᓯᔅ	minitusis		
Spider	ᑳᒥᒐᑎᑿᑕᑦ	kaamiihchaatikwaataat	kamamichatukatat; kamitauutakat; kamichatukatat; kamichjatukatat.	The one with many legs.
Mosquito	ᓯᒋᒪᐤ	sichimaaw shejimao	shujimaaw; shitshemaou; shitshimaow; shetshemau; shijimau; shichimow.	(The rest) to be confirmed.
Fly; housefly; blackfly	ᐅᒐᐤ	uchaaw	uujaawa; oochow; utsheu.	
Bee; bumblebee	ᐊᒧᐤ	aamuw	amo; ochaw; uchaw; amoo; amu.	
Horsefly; big fly	ᒥᔅᒐᐤ	mischaaw		
Crane fly	ᑲᑲᓄᑲᑕᑦ	kaakaanukaataat		
Louse	ᐃ·ᒃ	iihkw		
Nit (louse egg)	ᒋᒋᓇ·ᑯᔅ	chiichinaahkus		
Ant	ᐊᓂᔅᑯᐚᔨᒃ	aniskuwaayikw		
Ants (plural)	ᐊᓂᔅᑯᐚᔨᑯᐨ		aniskuwaayikuch.	
Butterfly	ᑿᑿᐱᓯᔅ	kwaakwaapisiis		
Dragonfly	ᒋᔅᑕᐚᓱᐤ	chiistaawaasuw	ka chistawastsd; kachistashu; chaikipinay.	The stinger.
Grasshopper, locust (Bible word)	ᑿᔅᑯᑎᔅ	kwaaskuuhtiis		Little jumper.
Termite	ᒧᑕᐤ	muuhtaaw		