

**Late Holocene Paleovegetation and Fire History of Northern Lake  
of the Woods and the Woodland Period**

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## Abstract

This thesis analyzes two Late Holocene lake sediment cores which were collected from the vicinity of two archaeological sites in northeastern Lake of the Woods, Ontario: the Bundoran Site (DjKn-5) and the Bud Site (DjKn-6). One of these cores was collected from a small pond between these sites and the other core was collected from the middle of a large bay in Lake of the Woods northwest of the sites. Both cores contain roughly 2000 years of sedimentation and the charcoal and pollen content are used to reconstruct local- and regional-scale vegetation history, changes in fire history, and the possibility of human impacts on vegetation during this period within the study area. The pollen sequences from both cores revealed the presence of a persistent pine-dominated forest environment, however the Bundoran Pond core showed greater levels of pollen loading from grasses, likely as a result of the differences in basin size between the pond and the bay. The pollen and charcoal sequences in the Route Bay core showed evidence of disturbance towards the top of the core that was not seen at Bundoran Pond. This is interpreted as representing a period of vegetation disturbance in the wider Lake of the Woods basin, but one of vegetation continuity surrounding the pond. The Bundoran Pond core also consistently contained charcoal fragments larger than  $100 \mu\text{m}^2$ , something which was not seen in the Route Bay core. This is interpreted as possibly representing anthropogenic burning near the pond. The Route Bay core contained a maize (*Zea mays*) pollen grain in its basal interval (70-72cm below surface), which had an associated radiocarbon date of  $2120 \pm 30$   $^{14}\text{C}$  years BP (195 BCE to 105 BCE). This maize pollen grain provides the first definitive evidence of precontact maize cultivation in the Lake of the Woods region.

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## Chapter 1: Introduction

Pollen studies in the Canadian boreal forest have historically focused on capturing region-scale climatic changes and vegetation successions with little emphasis on small scale changes in forest vegetation and climatic regimes. However, these small-scale changes are often critical for understanding how humans living in the boreal forest historically related to their environment- both how it affected them and how they affected it. This thesis seeks to begin addressing this data void by focusing on two short pollen cores taken from the northern Lake of the Woods region. The first was taken from Route Bay in the Lake of the Woods itself, and the second taken from a small pond to the southeast of the first coring location. Both cores only contain sediment from the Late Holocene, and as such this study is focusing on what Late Holocene vegetation and climatic trends might be revealed by these cores. Both coring locations are also located near several archaeological sites, the most notable of which is the Bundoran Site (DjKn-5) as it contains one of only a few recorded potential Laurel house structures (Spiedel 1989). The cores' proximity to archaeological sites also allows this study to provide insights into the environments Middle and Late Woodland peoples occupied in the northeastern Lake of the Woods region. To allow for a sufficient breadth of information to be gathered from each core, both pollen and charcoal data were collected from each. This study was driven by the desire to explore precontact Indigenous interactions with the environment of northern Lake of the Woods, and how these interactions impacted local and regional vegetation. The goals of this study were as follows:

- 1) Understanding the vegetation environment that Late Holocene peoples in the Lake of the Woods region occupied, both on a local and regional scale.

- 2) Understanding how these peoples may have shaped their environment, and how this would then be reflected in a pollen core.
- 3) Addressing questions of how pollen data can aid in the study of economic plant use by precontact Indigenous peoples.

Concerning the third point, one possibility of particular interest was that Late Holocene peoples might have practiced some form of limited horticulture, based on microfossils from domesticated plants being present in carbonized food residues found on potsherds from the Lake of the Woods region. It was hoped that the pollen record might reflect if horticulture was the source of these microfossils.

Chapter 2 of this thesis describes the regional study area (the Lake of the Woods basin). It begins with a general overview of the lake basin and a brief summation of the nature of the modern lake. This is followed by a brief discussion of the hydrological and deglaciation history of the region, starting with the last deglaciation at approximately 11 000 cal. BP (Yang and Teller 2005). The chapter then broadens its scope somewhat by discussing the vegetation history of the eastern boreal forest, with a focus on previous pollen studies which have been conducted in this area. This part of the chapter covers regional vegetation successions from the initial vegetative colonization of the region after deglaciation, through to the development of modern boreal forest regimes.

Chapter 3 details the archaeological history of the Lake of the Woods basin. It highlights the archaeological traditions known from the basin, as well as providing information on a sample of archeological sites and discoveries that are relevant to this thesis. As it is part of the focus of the study, there is a detailed discussion of the Bundoran Site (DjKn-5). Finally, the chapter concludes by providing a detailed discussion of the history of cultivated plants in the Lake of the

Woods region. It includes archaeological information on their presence based on microfossils discovered in food residues, ethnographic information on the use of cultivated foods by Indigenous peoples in the region, and historical accounts of Indigenous cultivation, mostly of maize (*Zea mays*).

Chapters 4 and 5 focus on the analytical techniques employed during this study. Chapter 4 focuses on the nature of these techniques, including fossil pollen and charcoal from lake core sediments, and statistical techniques used to organize and help interpret these data. The benefits of each technique as well as the weaknesses are discussed, with a focus on how each technique can add to the suite of information being evaluated in this study, with an emphasis on how each of these techniques complement each other. Chapter 5 focuses on how the methodology discussed in Chapter 4 was employed in the study itself. This includes detailing the core collection and sampling processes, and the techniques used to analyze the resulting slides. This chapter also details the collection of several samples used to radiocarbon date a small sample of core sections from both cores.

Chapter 6 details the results of the pollen, charcoal and statistical analyses performed over the course of this study and includes stratigraphic diagrams for both cores. It summarizes the pollen types uncovered in each core, and briefly discusses trends reflected in the stratigraphic sequence. It also presents the charcoal volumes and sizes in each core and identifies peaks in charcoal presence. It also includes the results of two forms of cluster analysis run on the pollen data: chord distance cluster analysis and CONISS cluster analysis. The results of the radiocarbon dating performed on the cores are also presented in this chapter.

Chapter 7 contains my interpretations results of this study. In its first part, it focuses on the implications of the stratigraphic pollen and fire diagrams that were developed. It discusses

both how the data from the Route Bay and Bundoran Pond cores compare, and how these data complement each other to provide a multi-spatial view of the area from which they were drawn. It is noted that while both cores reflected the same overall environment, the differences in the data returns from each reflected the different spatial scales each core represented. The second part of this chapter is devoted to a maize (*Zea mays*) pollen discovered in the Route Bay core. The depth at which this pollen sample was recovered is the same depth at which the basal radiocarbon for that core was obtained. Much of the discussion in this part of the chapter focuses on the implications of such a discovery, and how these implications might be further explored in future research.

Chapter 8 concludes the thesis by summarizing the key results of this study. It discusses the usefulness of studying pollen taken from Late Holocene short cores and makes suggestions about the type of studies that might make use of this methodology in the future. It also highlights the very striking discovery of a maize pollen grain in the Route Bay core, and the possible future studies that might be developed to further discover the extent and time depth of domesticated plant cultivation in the boreal forest.

## Chapter 2: Study Setting

Lake of the Woods is a large lake which lies within the boundaries of modern Manitoba, Ontario, and Minnesota. While this study is focused on the Late Holocene vegetation and fire history of northern Lake of the Woods, this history is best understood when placed in the context of the Lake of the Woods basin. Understanding broader trends of change in the lake basin, as well as the surrounding boreal forest, can also serve to contextualize the subtle changes which are this thesis' focus.

The Lake of the Woods basin covers approximately 69 750 km<sup>2</sup> from its headwaters to its outlets (Clark and Sellers 2014). The lake is hydrologically complex and contains over 14 500 islands (Pla et al. 2005; Clark and Sellers 2014). The northern half of the basin lies on Precambrian Shield granite and greenstone bedrock (Pla et al. 2005; Mellors 2010; Clark and Sellers 2014; Teller et al. 2018), and contains many bays, inlets and the vast majority of the lake's islands (Clark and Sellers 2014). The southern half of the basin lies on Lake Agassiz sediment (Pla et al. 2005; Mellors 2010; Clark and Sellers 2014; Teller et al. 2018), and is dominated by the large and shallow Big Traverse Bay (Clark and Sellers 2014). The lake basin straddles the boundary area between the boreal forest and the Great Lakes-St. Lawrence forest, with vegetation from different zones being predominant in different parts of the basin (Clark and Sellers 2014). Certain south-facing shores within the northern half of the lake basin contain stands of vegetation endemic to the tall grass prairie to the west; Figure 1 shows an example of a stand of oak (*Quercus*) trees on the south side of an island in the northern lake. Clusters of big bluestem (*Andropogon gerardii*) with *Opuntia* cactus have also been observed in these environments (Boyd 2023 *pers comm*). The main tributary to the modern lake is the Rainy River, which provides 70% of tributary water inflow to the basin and joins the lake in the southwest



Figure 2.1: Relic stands of oak trees growing in the northern Lake of the Woods basin. Photos by Matthew Boyd

region of the basin (Pla et al. 2005). The lake drains through two outlets both located at the northern end of the basin (Yang and Teller 2005). While these outlets lie at the same elevation, in the modern day they are both fully controlled by dams; the Eastern Outlet being dammed first in 1892, followed by the Western Outlet in 1898 (Clark and Sellers 2014). This damming of the outlets led to an approximately 1.8 m increase in lake levels at the outlets (Yang and Teller 2005), which, according to a report produced by the International Joint Commission in 1917, resulted in an increase in lake levels by 1.07 m across the basin (Clark and Sellers 2014). The regional vegetation surrounding Lake of the Woods is boreal forest to the north, and mixed boundary forest towards the south (Clark and Sellers 2014). Today, the land surrounding the lake is mainly used for forestry and recreation, although extensive mining occurred historically (Clark and Sellers 2014). Traditional Indigenous use of the region will be discussed in the following chapter when the archaeological history of the region is discussed.

This region was initially deglaciated approximately 11 000 cal. BP, with the current Lake of the Woods basin being a part of the much larger Glacial Lake Agassiz (Yang and Teller 2005). Lake of the Woods remained a part of Lake Agassiz until just before 9000 cal. BP (Yang and Teller 2005), as Lake Agassiz waters shifted northwards (Leverington, Mann, and Teller 2002). This period can be identified in lake sediment cores by the appearance of diatoms and plant fragments (Teller et al. 2018). At this point, Lake of the Woods was only 20% of its current surface area, representing the northernmost regions of the current basin (Yang and Teller 2005; Hougardy and Colman 2018). By 8000 cal. BP Lake of the Woods had expanded southwards into what is now the southern portion of the lake basin (Yang and Teller 2005), although this portion of basin was not refilled completely or permanently until approximately 3800 cal. BP (Hougardy and Colman 2018). The diatom record from the northern portion of the basin indicates that modern conditions did not develop in the Lake of the Woods basin until approximately 3500 cal. BP, with prior Middle Holocene conditions being warmer and drier than present (Hougardy and Colman 2018; Rühland et al. 2018). This dryness is characterized by not only diatom changes in the basin, but also an increase in charcoal indicating more fire activity in the forests surrounding the lake (Mellors 2010).

## **2.1 Regional Vegetation History**

While the Lake of the Woods region itself has not been subject to extensive vegetation studies, the surrounding Northwestern Ontario and Minnesota boreal forest has been. Insect studies from the Rainy River Valley in Northern Minnesota indicate that the period directly after deglaciation was a time of rapid physical and environmental change throughout the region (Bajc et al. 2000). The initial vegetation environment in Northwestern Ontario/Northern Minnesota

after the region was deglaciated (between 13 370 cal. BP and 8870 cal. BP) was a tundra-parkland environment (McAndrews 1982; Ashworth and Cyancera 1983; Björk 1985; Julig et al. 1990). While data from the Rainy River Valley in Northern Minnesota indicates that this tundra-parkland consisted of dwarf shrubs, open meadows, fell fields, and scattered stands of spruce (*Picea*) (Bajc et al. 2000) and data from Weber Lake, Minnesota shows the same (Fries 1962), there is variation in these early deglacial tundra environments. Data from Lake of the Clouds, Minnesota indicates a post-glacial environment of a sedge (Cyperaceae) dominated tundra (Craig 1972), data from Glatsch Lake, also in Minnesota, indicates a sedge parkland (Wright and Watts 1969), and data from the Ojata Beach Site in North Dakota suggests an environment dominated by spruce-sedge parkland (Fisher et al. 2008), further emphasizing how dynamic early post-glacial environments were in the region.

This tundra environment was rapidly replaced by a northward migration of trees resulting in the initial forestation of the region approximately 11 870 cal. BP (Björk 1985) in Northwestern Ontario, and 12 280 cal. BP in Northern Minnesota (Bajc et al. 2000). This tree migration came in three stages. The initial stage was a mixed forest with willow (*Salix*) dominated vegetation (Björk 1985). The second stage was a combined forest-tundra environment which had birch (*Betula*) as the dominant tree taxon (Björk 1985). The third stage saw the development of an open boreal forest (Björk 1985). This open boreal forest may be represented in pollen diagrams by the presence of roughly equivalent amounts of arboreal and non-arboreal pollen, an example of which is pollen zone KL-1a from Kotiranta Lake, Minnesota (Wright and Watts 1969). The Cummins Site near Thunder Bay, Ontario shows this forest development between 11 500 and 12 500 cal. BP (Julig et al. 1990), while a pollen core taken from Hayes Lake further west shows this forest developing directly after the local retreat of Glacial Lake

Agassiz approximately 12 800 cal. BP (McAndrews 1982). This demonstrates that this forest development was not temporally uniform across the region, but instead, varied depending on glaciological and hydrological factors, a pattern which continued in the development of further vegetation regimes across the region of study. Jacobsen, Webb and Grimm (1987) note that spruce tended to colonize recently exposed landscapes on the southern margins of continental ice sheets, such landscapes being highly agreeable to the taxon, and that is likely the reason that spruce dominated the first forests after deglaciation. These early spruce forests were dominated by white spruce (*Picea glauca*) with little to no black spruce (*Picea mariana*), despite these taxa commonly appearing together in modern forests (Liu 1990). Spruce also dominated the first forests to develop on Isle Royale, Michigan (Flakne 2003). These early successional spruce forests also appeared in areas that today are dominated by prairie vegetation. The Red River Valley in North Dakota (Yansa and Ashworth 2005), Pickerel Lake in South Dakota (Watts and Bright 1968), and multiple sites across central Manitoba (Ritchie 1983) all show evidence of these early spruce forests. Pollen data from Moon Lake, North Dakota from between 13 800 cal. BP and 11 600 cal. BP also shows the presence of pine (*Pinus*) forest in a region which is now dominated by prairie taxa (Clark et al. 2001). However, macrofossil and pollen data from cutbanks at the Seminary Site (dated to 11 450 cal. BP) and the Mirror Pool Site (dated to 10 310 cal. BP) in North Dakota indicate that the area surrounding the sites was lightly forested, with the dominant vegetation regime instead being marshes and meadows (McAndrews 1967a). This indicates that while spruce forests were present near these sites at the time, they were not as dominant as they were to the east and north. Birch, juniper (*Juniperus*) and larch (*Larix*) were also present in these early spruce forests (Fries 1962; Cushing 1967; Watts 1967; Janssen 1968; Wright and Watts 1969; Craig 1972; McAndrews 1982; Ashworth and Cvancara 1983; Björk

1985; Jacobsen, Webb, and Grimm 1987; Björk 1990; Bajc et al. 2000; Teller et al. 2008). These forests indicate that the regional climate at the time was relatively wet and cold (Flakne 2003).

This spruce dominated boreal forest was succeeded by a pine dominated boreal forest, however this succession was not temporally synchronous. Björk (1985), for example, notes that while pine took over the spruce forest at Sioux Pond, Ontario at approximately 10 800 cal. BP, it was not until approximately 9800 cal. BP that this succession occurred at Indian Lake, Ontario. Further west, McAndrews (1982) dated the transition between spruce and jack/red pine (*Pinus banksiana*/*Pinus resinosa*) forest at approximately 11 500 cal. BP at Hayes Lake, while at Lake 239, in the Experimental Lakes Area, Moos and Cumming (2011) date this transition to between about 11 600 and 8600 cal. BP. In Minnesota, Craig (1972) dated this forest transition to approximately 10 400 cal. BP at Lake of the Clouds, while Janssen (1968) dated it to 11 500 cal. BP at Myrtle Lake. On Isle Royale, Flakne (2003) dated to this transition between 8000 and 7000 cal. BP. These widely varying dates from across the region emphasize the lack of temporal synchrony in the spruce/pine forest transition. Other forest changes that occurred during this period also reflect a trend of climatic warming and drying. For example, at Weber Lake pine expansion was accompanied by oak and elm (*Ulmus*) pollen reaching the highest levels they reached in the core (Fries 1962). A similar pattern was noted by Wright and Watts (1969) at Kotiranta Lake, which saw pine increasing in tandem with elm, oak, and ash (*Fraxinus*). Climatic warming trends in the Middle Holocene also led to an opening of pine forests in some areas of Northwestern Ontario/ Northern Minnesota, such as the area surrounding Experimental Lake 239, as indicated by increases in juniper and ragweed (*Ambrosia*) pollen (Moos and Cumming 2011).

This pine expansion is also associated with the expansion of hardwood taxa, most notably alder (*Alnus*) (Fries 1962; Wright and Watts 1969; Craig 1972; Björk 1985; Liu 1990; Flakne 2003; Teller et al. 2008). Fries (1962) associates increases in alder with the initial and late periods of pine dominated forests at Weber Lake, Minnesota. Wright and Watts (1969) identify increases in alder following the establishment of pine forests at Jacobsen Lake, Anderson Lake, Glatsch Lake and Rossberg Bog, all also in Minnesota. This pattern also appears in Manitoba, observed by Teller and colleagues (2008) in Pollen Zone 2 at West Hawk Lake. Craig (1972) was able to both identify and date a zone of alder expansion at Lake of the Clouds, Minnesota to approximately 9300 cal. BP. Björk (1985) suggests that alder migrated into Northwestern Ontario/Northern Minnesota via two migration paths, based on it appearing earlier in the more northerly sites he sampled. He suggests that alder migrated into the region both along the northern shore of Lake Superior and from the south through Minnesota (Björk 1985).

Additionally, Liu (1990) notes that the initial pine migration into Northwestern Ontario/Northern Minnesota was dominated by jack/red pine, though a more specific taxonomic determination could not be made as these taxa cannot be distinguished from each other based on pollen morphology (Liu 1990). These trees were later succeeded by white pine, which favours even warmer/drier conditions than jack/red pine (Liu 1990). Craig (1972) notes such a transition at Lake of the Clouds. While the initial pine forest which developed in the region surrounding the lake at approximately 10 400 cal. BP was dominated by jack/red pine, it was replaced at approximately 7400 cal. BP by a white pine (*Pinus strobus*) dominated forest (Craig 1972). A decrease in jack/red pine and an increase in white pine was also noted by Wright and Watts (1969) at Jacobsen Lake. Björk (1985) notes that the peak of white pine corresponds with the altithermal period of the Middle Holocene. He also suggests it immigrated to the region via two

different migration paths, similar to what has been suggested of the entry of alder into the region. He proposes that one migration path was along the north shore of Lake Superior, while the other was north through Wisconsin, due to the taxon appearing earlier at more northerly sites (Björk 1985). This presence of increasing pine and declining spruce across Northwestern Ontario and Northern Minnesota indicates either warming climatic conditions or increased fire activity during that period (Witlock, Bartlein, and Watts 1993; Björk 1985; Liu 1990; Booth, Jackson, and Thompson 2002), a Middle Holocene pattern widely noted through multiple data sets and palaeoenvironment proxies. For example, Laird and others (1996; 1998) observed a decline in spruce and increase in deciduous taxa around Moon Lake, North Dakota approximately 7300 years ago that coincides with a drastic increase in basin salinity. This increased salinity was the result of climatic drying which caused the lake basin to become closed. Nelson and Hu (2008) noted a sharp increase in aridity on the prairies approximately 8000 years ago, Lewis and colleagues (2008) noted a drying trend between 8770 and 8290 cal. BP, and Grimm (2001) noted an increase in ragweed pollen in the Dakotas during the Middle Holocene indicating higher levels of ground disturbance, likely caused by climatic drying and increased drought. This increase in weedy taxa during the Middle Holocene was also observed at Jacobsen Lake and Kotiranta Lake (Wright and Watts 1969).

In some areas in the region of Northwestern Ontario/Northern Minnesota the warming trend, represented in other areas by the expansion of pine and hardwoods, was instead represented by the transgression of prairie-typical deciduous trees and herbaceous vegetation into what is in the modern day boreal forest. Jacobsen, Webb, and Grimm (1987) note that this transition was especially rapid and, according to Williams, Shuman, and Bartlein (2009), reached its maximum extent between 7000 and 6000 years ago. This expansion was noticed by Grimm,

Donovan, and Brown (2011) in pollen spectra from Kettle Lake, North Dakota, and dated to approximately 9250 years ago in the region represented by this pollen spectra. At Myrtle Lake, Minnesota, Janssen (1968) identified a period between 8900 and 7800 cal. BP where herbaceous and deciduous tree pollen replaced jack/red pine as the dominant pollen taxa. Such a replacement was also observed by Wright and Watts (1969) at Rossberg Bog, Minnesota, and by Clark and colleagues (2001) at Demming Lake, Minnesota. In the latter case this transition was dated to 8000 cal. BP (Clark et al. 2001). Janssen (1968) also identified the presence of lowland fens during this period of herbaceous and deciduous dominance, supporting that this expansion in herb pollen occurred during a warm and dry climatic period.

After the end of the altithermal, modern vegetation regimes began to develop, being established in much of the southern Lake Agassiz basin by approximately 4500 cal. BP (Ashworth and Cyancera 1983). After 5000 cal. BP, wetter and cooler conditions developed resulting in the southerly movement of spruce forests back into large swaths of Northwestern Ontario/ Northern Minnesota (Flakne 2003), although as with the initial appearance of pine, this transition was not temporally synchronous across the region. Part of the reason for this is that unlike the abrupt shift to arid conditions at the beginning of the Middle Holocene, the transition to wetter conditions in the Late Holocene was gradual (Grimm, Donovan, and Brown 2011). Lake of the Clouds pollen data shows pine forests persisted until approximately 3200 cal. BP when they were replaced by forests dominated by spruce and cedar (*Thuja*) (Craig 1972). Spruce, fir (*Abies*) and larches made up the dominant arboreal taxa in the Late Holocene section of the Weber Lake Core (Fries 1962). While pine remains the dominant tree taxon in the region surrounding Experimental Lake 239, spruce did still resurge, and this resurgence indicates climatic cooling and forest closing (Moos and Cumming 2011).

In areas of the region where spruce forests do not recur, there is still evidence of a cooling and wetting of the climate during the late Holocene. Janssen (1968) saw herbaceous and deciduous taxa replaced by a white pine forest at Myrtle Lake, Minnesota around 3200 cal. BP. A similar pattern, though undated, was observed by Wright and Watts (1969) in the uppermost pollen zone -Pollen Zone 4- from Jacobsen Lake, Kotiranta Lake, and Rossberg Bog, Minnesota. This white pine forest pollen zone also contained the highest amount of fir pollen in the Myrtle Lake column, and the lowest amount of herb and deciduous tree pollen (Janssen 1968). While deciduous forests persisted at Demming Lake, Minnesota, there was also a gradual increase in white pine observed throughout the Lake Holocene (Clark et al. 2001).

One specific Late Holocene discovery of note is a fossil bison skull uncovered near Kenora, Ontario, situated near the outlets of Lake of the Woods (McAndrews 1982). The sediments surrounding and within the skull have been radiocarbon dated to approximately 5580 cal. BP (McAndrews 1982; Martindale et al. 2016), and contain plant macrofossils and plant microfossils that indicate the bison died in a pine-poplar woodland (McAndrews 1982). This discovery implies some manner of bison mobility into the fringes of the boreal forest from the prairies to the west, and is indicative that the area surrounding Lake of the Woods was one of ecotonal mixing between species from both biomes, a feature which the area maintains into the present day.

European contact and later settlement into the regions of Northwestern Ontario and Northern Minnesota, as well as the prairies to the west of these regions is noted to have had a distinct impact on vegetation regimes. One change that is readily reflected in pollen cores is an increase in ragweed pollen, both because European settlement introduced several species of ragweed to North America, and because it is a weedy taxon that thrives in disturbed ground, an

environment that increased in prevalence due to European agricultural settlement. Pollen spectra from multiple ponds in the Ithasca Region of Minnesota, for example, have their top 25cm showing high levels of ragweed (McAndrews 1967b). Pollen records from Pickerel Lake show ragweed pollen increasing from 5% to 40% of the total pollen sample as a result of European settlement, with *Chenopodium* (Chenopodiineae) pollen increasing at the same time to 20% of the total sample (Watts and Bright 1968).

In summary, the vegetation history of Northwestern Ontario/ Northern Minnesota since glaciation has seen a progression of glacier-front tundra, to early successional spruce forests, to a diversification into a suite of vegetation regimes throughout the Middle and Late Holocene. These regimes include jack/red pine and white pine forests, mixed deciduous forests and tall or mixed grass prairie, with the extent of each ecotone in the region waxing and waning with changing climatic conditions.

### Chapter 3: Archaeological History of Lake of the Woods

While there is a dearth of data regarding the vegetation history of Lake of the Woods region, it has a well-recorded archaeological record dating back to the Plano period (~10 000 to ~8000 BCE). The Plano period across the Plains and Eastern Boreal Forest is defined by lanceolate projectile points accompanied by various other stone and bone tools (Irwin and Wormington 1970; Dawson 1983). The vast majority of known Plano sites in North America are hunting kill sites (Irwin and Wormington 1970). As such the Plano people are thought to have been large game hunters in the plains (Irwin and Wormington 1970), but more generalized hunters in the boreal forest (Dawson 1983). The Archaic period in the Canadian Shield (~8000 BCE to ~200 BCE) is generally defined by the appearance of triangular corner- and side-notched projectile points, groundstone tools, and in some instances, copper tools and objects (Wright 1972; 1981). Archaic occupations near Lake of the Woods tend to appear in sheltered waterways and other nearshore environments, with an economic focus on fish and exposed lithic outcrops (Wall 1980). It should be noted, however, that nearshore environments have been much more extensively documented both on Lake of the Woods and elsewhere in the boreal forest, so this apparent Archaic focus on such environments may instead reflect a modern sampling bias (Wall 1980).

Woodland Period cultures (~200 BCE to contact) that are known to have occupied the Lake of the Woods region include the Middle Woodland Laurel culture, the Late Woodland Blackduck and Selkirk cultures, and the Late Woodland/ Late Precontact Sandy Lake culture. The Laurel culture in Northwestern Ontario was first defined by Lloyd Wilford (1941; 1955), based on materials recovered from the Smith Site Mounds, the McKinsty Mounds and the Pike Bay Mounds in Minnesota. The Laurel culture appeared in the Lake of the Woods region

sometime between 300 BCE and 1200 CE (Spiedel 1989). The Laurel culture is mainly defined by pottery vessels, which are conical, plain-bodied with decorated, typically dentate-stamped, rims (Stoltman 1973; Spiedel 1989). Another defining feature is the coiling construction technique and crushed rock temper used in their manufacture (Stoltman 1973; Spiedel 1989). Other material culture considered indicative of the Laurel culture includes lithic materials such as stemmed and notched projectile points and an increased number of end scrapers in the lithic sample of any given site as well as socketed and perforated antler harpoons (Stoltman 1973). Some Laurel sites in the Lake Superior region also utilized native copper, however this usage was less frequent in more westerly Laurel sites (Stoltman 1973). The Laurel people are interpreted to have been seasonally mobile hunter-gatherers, with their subsistence following a seasonal round, with a possible focus on aquatic and nearshore protein sources (Stoltman 1973; Spiedel 1989). Georgina Pastershank (1989) noted that Laurel sites in the Sabaskong Bay of Lake of the Woods tended to cluster around wild rice stands, suggesting a local focus on the gathering of this aquatic plant resource.

Late Woodland pottery in boreal forest regions reflects a shift in vessel form from the conical vessels of the Middle Woodland towards globular vessel forms (MacNeish 1958; Cooper and Johnson 1964; Lugenbeal 1978; Taylor-Hollings 1999), with the specific ceramic culture of these vessels being determined largely through variations in decoration. Blackduck ceramics tend to be decorated with either cord-wrapped paddle or fabric impressions on the body of the vessel, with the rims and lips of the vessels displaying variable combinations of cord-marking, cord-wrapped stick impressions, and punctates and bosses (MacNeish 1958; Cooper and Johnson 1964; Lugenbeal 1978). Selkirk ceramics are mainly distinguished by the fabric impression upon the body of vessels, which leaves the vessel surface “marked by a series of small ovoid

impression, spaced fairly close together” (MacNeish 1958, 163), with the majority of vessels having their surfaces smoothed after this fabric impression was completed (MacNeish 1958). Vessel necks or lower rims are also typically decorated with punctates (MacNeish 1958). Sandy Lake ceramics tend to have cord-wrapped body decorations, although some may have smooth surface finishes (Taylor-Hollings 1999). They also tend to exhibit either vertical cord-marking or no decoration on the exteriors of vessel rims (Cooper and Johnson 1964; Taylor-Hollings 1999). The interior of vessel rims tends to be decorated with a tool-impressed notch just below the lip of the vessel (Cooper and Johnson 1964; Taylor-Hollings 1999). Northern Sandy Lake vessels may also be decorated with punctates and bosses (Arthurs 1978; Taylor-Hollings 1999). It should be noted that due to similarities in vessel decoration between boreal Woodland pottery cultures, and the fragmentary nature of many pottery recoveries, Late Woodland/ Late Precontact pottery may not be able to be designated to a specific culture. These pottery cultures may also be mistaken for each other (Lugenbeal 1978; Meyer and Hamilton 1994; Taylor-Hollings 1999). As with the Laurel culture of the preceding Middle Woodland, all these boreal Late Woodland cultures are assumed to have been generalized hunter-gatherers who gathered resources based on a seasonal round.

The region of Northwestern Ontario that includes Lake of the Woods has been subjected to geographically expansive archaeological reconnaissance based on the waterways present in it. These include: the West Patricia Surveys (Reid and Ross 1981; Ross 1982), the Berens River System Survey (Pelleck 1980) and a survey covering the Stephen, Cameron, Flint, and Kakagi Lakes (Halverson 1988). There are also a considerable number of sites known throughout the Lake of the Woods basin, largely due to the efforts of former Kenora regional archaeologist C.S.

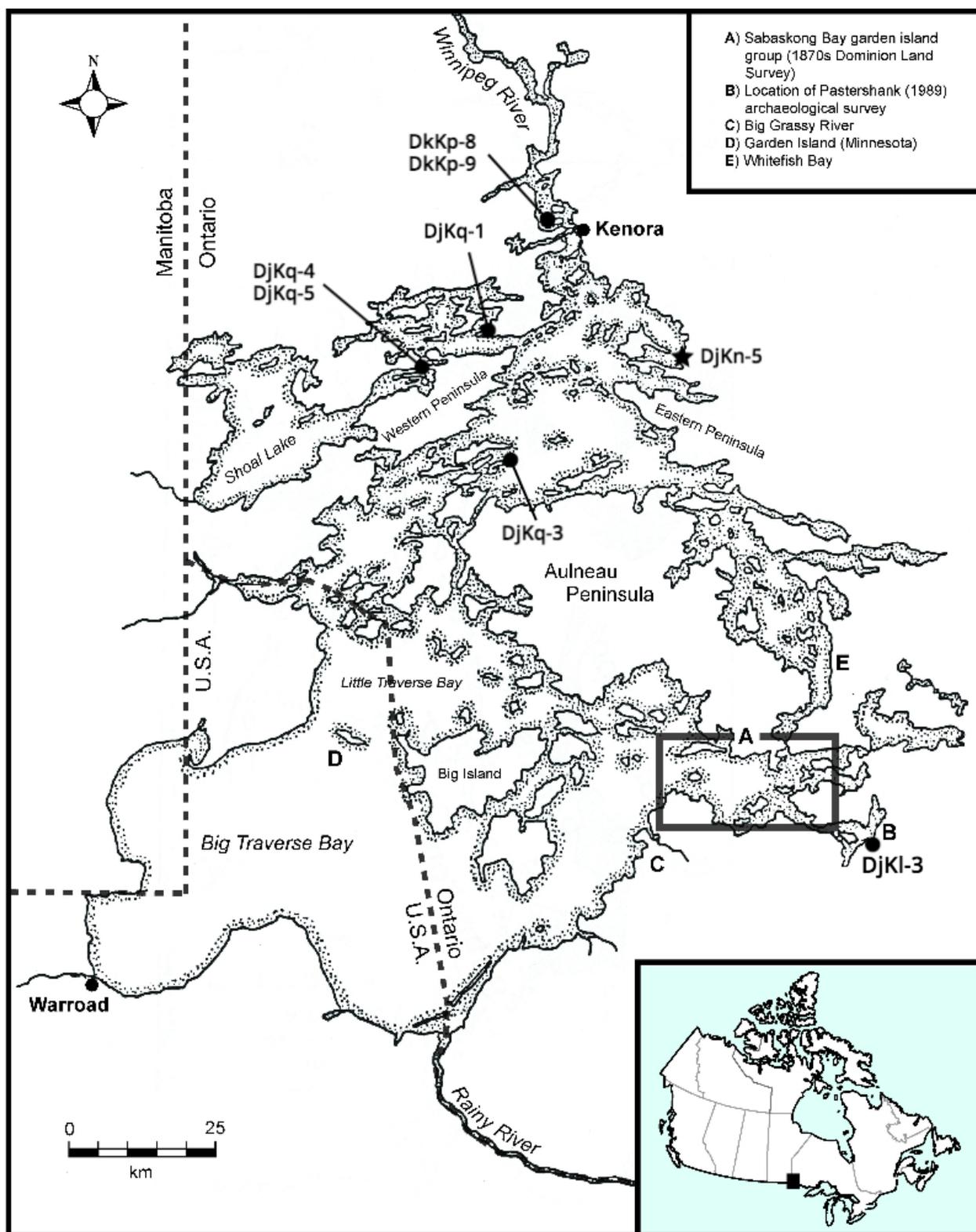


Figure 3.1: Map of the Lake of the Woods basin showing the locations of a selection of the archeological sites located in the area, including the Bundoran Site (DjKn-5) which is the focus of this thesis

“Paddy” Reid and his associates. These efforts include surveys of the northeastern portion of Sabaskong Bay undertaken by Georgine Pastershank (1989) and surveys of the Winnipeg River undertaken by Jacqueline Rusak (1989). Figure 3.1 shows the locations of several significant Lake of the Woods region archaeological sites, most of which were discovered as part of these explorations and surveys.

Woodland Sites in the Lake of the Woods basin tend to be multicomponent sites. The Nestor Falls Site (DgKl-3) contains Laurel, Blackduck, and Selkirk components, as well as a historic component (Pastershank 1989; Halverson 1992). The Meek Site (DjKq-3) includes a Laurel, a Blackduck, a Selkirk, and a Sandy Lake component (Rajnovich and Reid 1978; Balmer 1983). The Spruce Point site (DjKq-1) contains Laurel, Blackduck, Selkirk, and Sandy Lake components (Rajnovich 1983). The Ash Rapids Sites (DjKq-4 and DjKq-5) have components from the Laurel, Blackduck, Selkirk, and Sandy Lake cultures. They also contain materials from the archaic, fur-trade, and recent historic periods (Arthurs 1978; Reid 1978). The Ballynacree Site (DkKp-8) contains Laurel, Blackduck, Selkirk, and Sandy Lake components. It also has a postcontact component that represents continual occupation until 1952 (Rajnovich and Reid 1987). The Woodland aspect of the Ballinamore Site (DkKp-9) contains Laurel, Blackduck, and Selkirk components (Pelleck 1985). This site also has an Archaic component, and a postcontact component that represents both the fur-trade and the recent historic (Pelleck 1985). The Ballysadare Site (DkKp-10) site has Laurel and Blackduck components (Rajnovich 1980). The Bundoran Site itself contains Laurel, Blackduck, Selkirk, and postcontact components (Spiedel 1989). Even the Bud Site (DjKn-6) which is only known from a survey conducted by James Mahon during the late summer/early autumn of 1976, contains Archaic, Laurel, Blackduck, and Selkirk components (Mahon and Reid 1977).

Several of these Woodland multicomponent sites also contain evidence of possible dwelling structures, including a possible Laurel house found in the Bundoran Site (Spiedel 1989). This house structure is discussed later in this chapter when the Bundoran Site is covered in depth. The most notable of the Lake of the Woods sites containing house structures is the Ballynacree Site as it contains multiple Laurel house structures. The first was reported by Paddy Reid and Grace Rajnovich in 1983, with two more being uncovered and reported later (Rajnovich and Reid 1987; Reid and Rajnovich 1991). These three houses are interpreted by Rajnovich and Reid (1987) to be contemporaneous with each other, due to the outlines of the houses not overlapping and the artifact scatter associated with them being reminiscent of the “Brunswick Pattern” of villages defined by Stanley South (1977; from Rajnovich and Reid 1987). All three houses consist of an oval outline of post moulds with visually distinct changes in soil colour between the interior and exterior areas (Rajnovich and Reid 1987). They all contain an interior hearth and a variable number of interior storage pits, with three storage pits in Houses #1 and #3, and one storage pit in House #2 (Rajnovich and Reid 1987). There are three radiocarbon dates associated with House #1, all derived from charred wood within the house structure (Rajnovich and Reid 1987). Two samples from the house floor yielded dates of 660 cal. BP and 634 cal. BP, and a sample from the hearth yielded a date of 657 cal. BP (Rajnovich and Reid 1987; Martindale et al. 2016). These dates place the time of at least House #1’s occupation towards the end of the Laurel period at Lake of the Woods. Another potential Laurel house structure occurs at the Ballysadare Site (Rajnovich 1980). This site includes a feature consisting of a curved line of rocks surrounding a grey loam lens associated with a charcoal derived radiocarbon date of 2070 cal. BP (Rajnovich 1980; Martindale et al. 2016). If this line of rocks represents the edges of a house structure, it would be the earliest of the Lake of the Woods

Laurel houses (Rajnovich 1980). A similar rock feature was uncovered at one of the Ash Rapid Sites (DjKq-4) (Petch 1984). Rajnovich (1983) also identified possible house structures at the Spruce Point Site, however these houses cannot be definitively tied to any particular Woodland culture as the stratigraphy of the Spruce Point Site is mixed.

### 3.1 The Bundoran Site (DjKn-5)

The Bundoran Site is a multicomponent Woodland/Historic site located at 49°39'41" N 94°17'42" W, 20 km south of the town of Kenora (See Figure 3.1; Spiedel 1989). This site is important because it is adjacent to both pollen core locations (See Figure 3.2), contains multiple Woodland components, possible house structures, and was documented in detail. The area surrounding the site consists of "moderately broken uplands" (Spiedel 1989, 3) dominated by Canadian Shield bedrock outcrops. The site itself is located on a strip of land west of the mouth of the Rushing River, with the site area itself resting on a rocky bedrock knoll (Spiedel 1989). The forest vegetation surrounding the site is transitional and includes such boreal forest taxa as jack pine (*Pinus bankisana*), black spruce (*Picea mariana*), balsam fir (*Abies balsamea*), trembling aspen (*Populus tremuloides*), and white birch (*Betula papyrifera*), as well as boundary forest taxa including red pine (*Pinus resinosa*), white pine (*Pinus strobus*), balsam poplar (*Populus balsamifera*), large tooth aspen (*Populus grandidentata*), Manitoba maple (*Acer negundo*), red maple (*Acer rubrum*), basswood (*Tilia*), burr oak (*Quercus macrocarpa*), and white elm (*Ulmus laevis*) (Spiedel 1989). Located nearby is the Bud Site (DjKn-6), which is on a south-facing beach south of both the Bundoran Site and a small pond from which this project drew a core. However, this site has not been as well documented and explored as the Bundoran

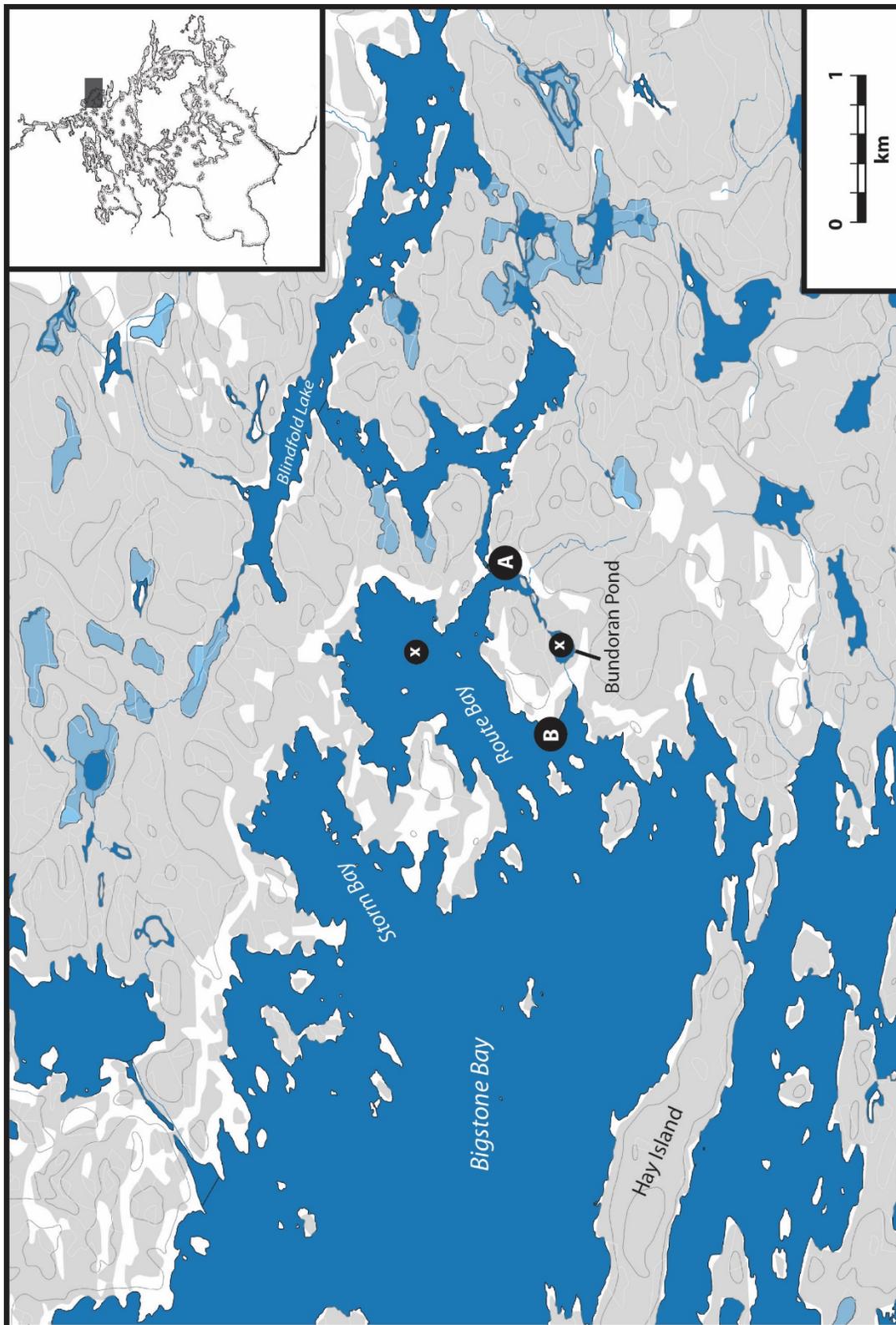


Figure 3.2: Map showing the locations from which this study's cores were obtained. X denotes a coring location. A indicates the location of the Bundoran Site (DjKn-5). B indicates the location of the Bud Site (DjKn-6)

Site, which was excavated between 1977 and 1978, and is interpreted to be a campsite/fishing site (Spiedel 1989).

The Woodland component of the Bundoran Site includes the Laurel, Blackduck and Selkirk cultures, with the historic component including both fur-trade and recent historic-period artifacts. The recent historic component of the site consists of an ash dump dated to the 1940s (Spiedel 1989). Despite the extensive excavations, the Woodland components of the Bundoran Site have only ever been dated through ceramic seriation (Spiedel 1989). There was an attempt to derive a radiocarbon date from the base of a postmold from a presumed Laurel house structure (described below), however, this sample suffered from extensive rootlet contamination and so the resulting date of 482 cal. BP (~1470 CE) was rejected by the reporting author as being uncharacteristically young (Spiedel 1989). He instead reported a series of seriation dates that place the Laurel component as occurring around 900 CE, the Blackduck component as occurring around 1100 CE, and the Selkirk component as occurring around 1500 CE (Spiedel 1989), however these dates should be treated with caution as they are based solely on ceramic typology.

Recoveries at the Bundoran Site include lithic artifacts, ceramic artifacts, historic artifacts and faunal remains (Spiedel 1989). The site also contains several notable features, including the aforementioned possible Laurel house structure. The lithic recoveries from Bundoran total 3332 items, the vast majority (2590) of which were non-utilized lithic debitage (Spiedel 1989). Of the utilized lithics, 238 were utilized flakes and the remaining 504 were identifiable stone tools (Spiedel 1989). These tools included: scrapers, lithic reduction cores or core fragments, knives, awls/drills, projectile points or point blades, choppers, blades, hammerstones, a spall, a spokeshave, a pipe plug, and a groundstone object (Spiedel 1989). The lithic raw materials were mainly local quartzes, rhyolites, and cherts; the non-local materials consisting of Hudson Bay

Lowland chert, green recrystallized chert, Swan River chert, and Knife River flint (Spiedel 1989). Additionally, 363 grams of red ochre was recovered from the site (Spiedel 1989).

Ceramic recoveries included 3911 potsherds, 3471 of which were body sherds, 276 of which were neck sherds, and 163 of which were rim sherds (Spiedel 1989). Of the body sherds, 963 were plain, (probably Laurel) with remaining 2508 being fabric-impressed or paddled, and thus Late Woodland (Spiedel 1989). The neck sherds were also grouped by the reporting author based on whether they were plain or fabric-impressed before the decorative elements were added, with the plain sherds being designated Laurel and the fabric impressed/paddled sherds being designated Late Woodland (Spiedel 1989). However, further research conducted after the Bundoran Site was excavated has shown that Late Woodland pottery may also have plain neck sherds (Taylor-Hollings 1999), so it possible some sherds Spiedel designates as Middle Woodland may in fact be Late Woodland. The sherds designated Laurel numbered 118 and the sherds designated Late Woodland numbered 89 (Spiedel 1989). The rim sherds were able to be differentiated to the specific pottery culture which created them: 50 were Laurel, 45 were Blackduck, and 67 were Selkirk (Spiedel 1989). Residue analysis performed on a sample of ceramics from the Bundoran Site uncovered maize (*Zea mays*) phytoliths on one Blackduck sherd and one undifferentiated Late Woodland sherd (Surette 2008; Boyd and Surette 2010). The residue from the Blackduck sherd also contained maize starch (Surette 2008; Boyd and Surette 2010). Most interestingly, these residues contained a large grass pollen grain, possibly also from maize (Boyd 2023 *pers comm.*). Additionally, one Laurel sherd yielded wild rice (*Zizania*) phytoliths and one Selkirk sherd yielded common bean (*Phaseolus vulgaris*) starch (Surette 2008; Boyd and Surette 2010). These residue data indicate that cultivated plants were at least

consumed at the Bundoran Site during the Late Woodland, although these data do not indicate whether these plants were acquired through trade or locally grown.

Historic artifacts recoveries from the Bundoran Site include a wide variety of materials: blue seed beads, small animal traps, square spikes, coarse earthenware, square nails, yellow glass, shotgun shell casings, various metal fragments, wire fragments, buckles, melted glass, phonograph record fragments, buttons, blue and white earthenware, pipe stems, mirror fragments, safety pins, mirror fragments, coloured melted glass, some mortar, some porcelain, combs and stoneware (Spiedel 1989). The faunal recoveries number 469 specimens, most of which were only identifiable so far as whether they were mammalian, avian, or piscine (Spiedel 1989). The few identifiable faunal remains included a clam shell, a turtle (Testudines) shell, a muskrat (*Ondatra zibethicus*) femur, a beaver (*Castor canadensis*) vertebrae, and a black bear (*Ursus americanus*) molar (Spiedel 1989). The site also yielded a single faunal artifact, a unilaterally barbed harpoon (Spiedel 1989).

Features at the Bundoran Site included an oval-shaped feature interpreted as a refuse pit, the 1940s ash dump, and, most significantly, a semi-circular alignment of rocks with associated hearths, post-moulds, and artifacts which Spiedel (1989) interpreted to be a Laurel house structure, based on similarities between this feature and other Laurel house structures uncovered elsewhere around Lake of the Woods, including the Ballynacree site mentioned above. This possible house feature weighed significantly when the site was chosen to be the focus of the environmental investigations in this thesis, as it indicates the Bundoran Site was possibly used as a habitation site for at least part of the year. In combination with the residue data above, indicating the consumption both of wild rice and cultivated plants at the site, painted it as a good candidate for reconstructing the environmental setting of boreal Woodland habitation and diet.

### 3.2 Cultivated Plants in the Lake of the Woods Region: Archaeological Evidence

Residue analysis on Middle and Late Woodland ceramics from the Lake of the Woods region has consistently yielded evidence of the consumption of cultivated plants. Figure 3.3 shows the names and locations of Woodland sites throughout Northwestern Ontario and Southern Manitoba that have yielded maize microfossils in carbonized food residues. Many of these sites are located in the Lake of the Woods basin. Table 3.1 goes into detail on these recoveries. In addition to maize, a Blackduck potsherd from the Spruce Point Site (DjKq-1) yielded evidence of squash (*Cucurbita*), and a Laurel potsherd from the Ash Rapids East (DjKq-4) yielded evidence of common bean (*Phaseolus vulgaris*) (Surette 2008; Boyd and Surette 2010).

These cultivated plants were likely consumed in tandem with a conventional boreal hunter-gatherer diet, similar to dietary patterns seen in regions to the southeast of Lake of the Woods (Dunham 2014; Kooiman 2018). At the Cloudman Site in Michigan Kooiman (2018) uncovered a pattern of mixing wild and cultivated foods in the diets of both Middle and Late Woodland peoples, a pattern which seems to be replicated at Lake of the Woods. Notably, however, while the diets of the people at the Cloudman Site included a variety of cultivated plants (Kooiman 2018), the cultivated plant microfossils in the Lake of the Woods region consist primarily of maize (Surette 2008; Boyd and Surette 2010). While there is some evidence of the consumption of common bean and squash (Surette 2008; Boyd and Surette 2010), microremains from these plants occur much more rarely in Lake of the Woods area food residues than maize. This may indicate that bean and squash were less frequently consumed by Woodland peoples living near Lake of the Woods than they were by Woodland peoples living elsewhere, or that

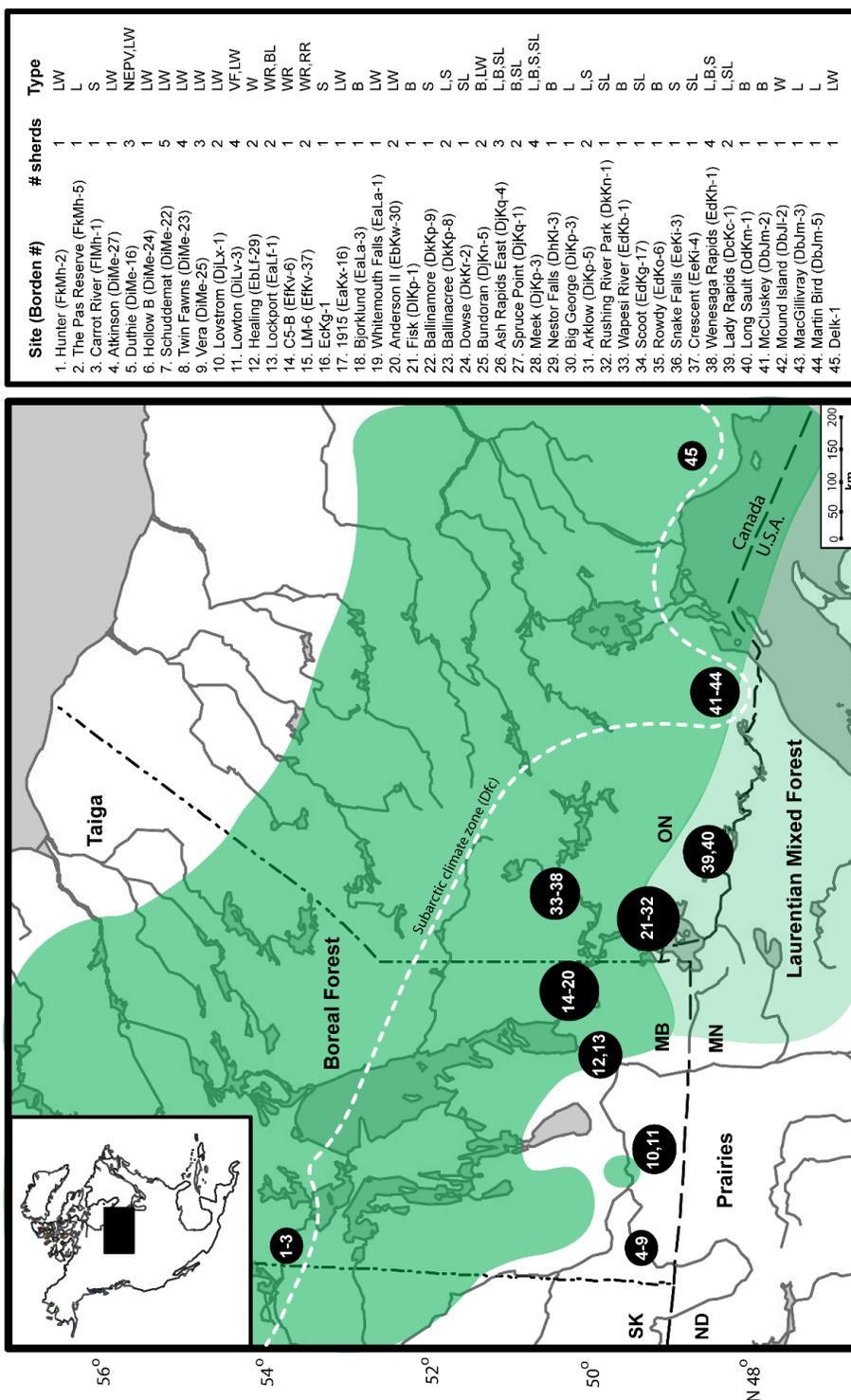


Figure 3.3: Map showing the locations of Woodland sites in Northwestern Ontario and Southern Manitoba that have yielded maize microfossils. The numbers on the map correspond to the numbers assigned to the sites on the right. Type refers to the cultural affiliation of tested potsherds. B= Blackduck, BL = Bird Lake, L = Laurel, LW = undifferentiated Late Woodland, NEPV = Northeastern Plains Village, RR = Rainy River, S = Selkirk, SL = Sandy Lake, VF = Vickers Focus, W = undifferentiated Woodland, WR = Winnipeg River. From: Boyd and Surette 2010

Table 3.1: Plant Microfossil Content of Carbonized Food Residues (From: Boyd and Surette 2010). Locale refers to the general area in which sites are located, as this thesis is mainly concerned with the Lake of the Woods region, only that locale is represented (Locale 6). An S in the “Maize?” column indicates that maize starch recovered from carbonized residue, a P indicates that phytoliths were recovered.

Sample	Borden #	Site name	Locale	Cultural affiliation	Maize?	Other Taxa
62	DgKl-3	Nestor Falls	6	Blackduck	S/P	Wild rice ( <i>Zizania</i> sp.)
63	DiKp-3	Big George	6	Laurel	P	
64	DiKp-3	Big George	6	Late Woodland		
65	DiKp-5	Arklow	6	Selkirk	P	
66	DiKp-5	Arklow	6	Laurel	S/P	
67	DjKn-5	Bundoran	6	Selkirk		cf. <i>Phaseolus vulgaris</i>
68	DjKn-5	Bundoran	6	Late Woodland	P	
69	DjKn-5	Bundoran	6	Laurel		Wild rice ( <i>Zizania</i> sp.)
70	DjKn-5	Bundoran	6	Blackduck	S/P	Wild rice ( <i>Zizania</i> sp.)
71	DjKp-3	Meek Site	6	Sandy Lake	P	
72	DjKp-3	Meek Site	6	Selkirk	P	
73	DjKp-3	Meek Site	6	Laurel	P	
74	DjKp-3	Meek Site	6	Blackduck	P	Wild rice ( <i>Zizania</i> sp.)
75	DjKq-1	Spruce Point	6	Sandy Lake	P	
76	DjKq-1	Spruce Point	6	Blackduck	S/P	cf. <i>Curcubita</i>
77	DjKq-1	Spruce Point	6	Selkirk		
78	DjKq-4	Ash Rapids East	6	Blackduck	P	Wild rice ( <i>Zizania</i> sp.)
79	DjKq-4	Ash Rapids East	6	Selkirk		Wild rice ( <i>Zizania</i> sp.)
80	DjKq-4A	Ash Rapids East	6	Sandy Lake	P	Wild rice ( <i>Zizania</i> sp.)
81	DjKq-4A	Ash Rapids East	6	Laurel	S/P	cf. <i>Phaseolus vulgaris</i>
82	DkKn-1	Rushing River Park	6	Sandy Lake	S/P	
83	DkKp-8	Ballynacree	6	Blackduck		
84	DkKp-8	Ballynacree	6	Selkirk	P	
85	DkKp-8	Ballynacree	6	Laurel	P	

86	DkKp-9	Ballinamore	6	Laurel		
87	DkKp-9	Ballinamore	6	Selkirk	P	Wild rice ( <i>Zizania</i> sp.)
88	DkKr-2	Dowse	6	Sandy Lake	P	
89	DkKr-4	Mud Portage Channel	6	Laurel		
90	DIKp-1	Fisk Site	6	Laurel		Wild rice ( <i>Zizania</i> sp.)
91	DIKp-1	Fisk Site	6	Blackduck	P	

evidence of these foods is underrepresented in Lake of the Woods samples due to lower amounts of starch in these plants when compared to maize. Additionally, potsherds from multiple Lake of the Woods archaeological sites, namely Nestor Falls (DgKl-3), Bundoran (DjKn-5), Meek (DjKp-3), Ash Rapids East (DjKq-4), and Ballinamore (DkKp-9), showed maize and wild rice (*Zizania*) microremains in the same residues/vessels. It should be noted, however, that this may be the result of different plant foods being cooked in the same pot at different times, rather than both plants being cooked together as part of the same meal. From this evidence it is clear that cultivated plants, maize in particular, were present in the Woodland diet for Lake of the Woods peoples.

### 3.3 Ethnohistorical Evidence for Indigenous Cultivation at Lake of the Woods

In addition to the food residue data, there is ethnohistorical data that indicates the Indigenous peoples of the Lake of the Woods region traditionally practiced plant cultivation alongside hunting and gathering. The Anishinaabek living around Shoal Lake, located immediately northwest of Lake of the Woods, have a traditional forest management system that includes several possible managed fire cycles, one of which is the cycle from *nopming* (forest) to *ishkwaakite* (newly burned trees) to *gitigaam* (planting or gardening) (Berkes and Davidson-

Hunt 2006). Under this land management system, *gitigaam* were traditionally burned in the spring to prepare for planting which took place in early summer (Roberts 2005; Berkes and Davidson-Hunt 2006). Islands in Shoal Lake possessing loamy soil suitable for cultivation are called *gitigaam minis* (gardening islands) by local Indigenous peoples (Berkes and Davidson-Hunt 2006). The people of Iskatewizaagegan No. 39 Independent First Nation used a series of five islands called the Garden Islands for cultivation up until the 1960s (Roberts 2005). Of these, the most significant to the community is called Potato Island (Foley 2004; Roberts 2005). During an interview with Christa Foley, a member of the community named Les Ainspac said of Potato Island and the gardening islands:

Dating back to 1610 when the first European came into the Shoal Lake watershed our people did a lot of farming and this is one of the islands, one of the 52 islands that were developed for that agricultural purpose. There were other First Nations that used to live here that did the same long before the fur trade came in and spread up everything. Yeah there was the Dakota Sioux, Pawnee, Cree and Ojibway and we all did our agriculture on these islands. Trade kind of changed that, and war broke out and we ended up being here. (Foley 2004, 29)

Elders from Iskatewizaagegan No. 39 Independent First Nation report that island cultivation was an extensive practice on both Shoal Lake and Lake of the Woods (Roberts 2005). Elder Jimmy Redsky further elaborated that the islands were used in a rotational pattern, both as a way to allow the land to rest to ensure continued sustainable farming and as a way for groups to avoid detection by enemy tribes (Roberts 2005). The island cultivation practiced by the people of Iskatewizaagegan No. 39 Independent First Nation was integrated into a seasonal hunting and gathering round, with planting and crop management on the islands interspersed with resource gathering activities. After crops were planted on the islands people dispersed to blueberry patches to pick berries, before returning to the islands after the harvest to manage their gardens (Roberts 2005). Both Elder Jimmy Redsky and Les Ainspac also indicated that fishing nets

would be placed near islands containing gardens, allowing the nets to be checked in conjunction with garden maintenance (Roberts 2005).

There is a wealth of written historical documents supporting the oral histories of local Indigenous groups regarding their practice of gardening on islands in Lake of the Woods. John Tanner, an American man kidnapped as a child and raised among the Ottawa and Ojibway documents the establishment of gardens on an island called Me-nau-zhe-taw-naun in Lake of the Woods (James 1956). Tanner also details how the gardens were integrated into a hunting and gathering round:

...I remained in the village until the corn was planted; then we went to collect and dry the blue berries which grow in great quantities in that country. Afterwards to the rice swamps; then we returned to gather our corn. Thus we were busy during all of the summer. (James 1956, 205)

He also details that hunting and fishing were carried out alongside caring for the maize crops in the gardens (James 1956, 211). Surveyor S.J. Dawson (1968) noted the presence of Indigenous maize gardens during his survey of the region between the Red River Settlement, now Winnipeg, and Lake Superior, with the added note that this gardening had been occurring for some time prior to his survey. He also makes note of wild rice gathering and fishing as summer subsistence activities carried out alongside the tending of these maize gardens (Dawson 1968). In his 1869 pamphlet *The Red River Country, Hudson's Bay and North-West Territories Considered in Relation to Canada with the Last Report of S.J. Dawson, Esquire, C.E. on the Line of Route between Lake Superior and the Red River Settlement, Illustrated with a Map*, Alex J. Russell reiterates Dawson's point about the longevity of maize gardening on Lake of the Woods (14) and adds that: "On the shores and islands of the Lake of the Woods, there are patches of good land, where the Indians have gardens, and have raised Indian corn without failure for many years" (Russell 1869, 16). Henry Youle Hind's (1971) account of the 1857 Canadian Red River

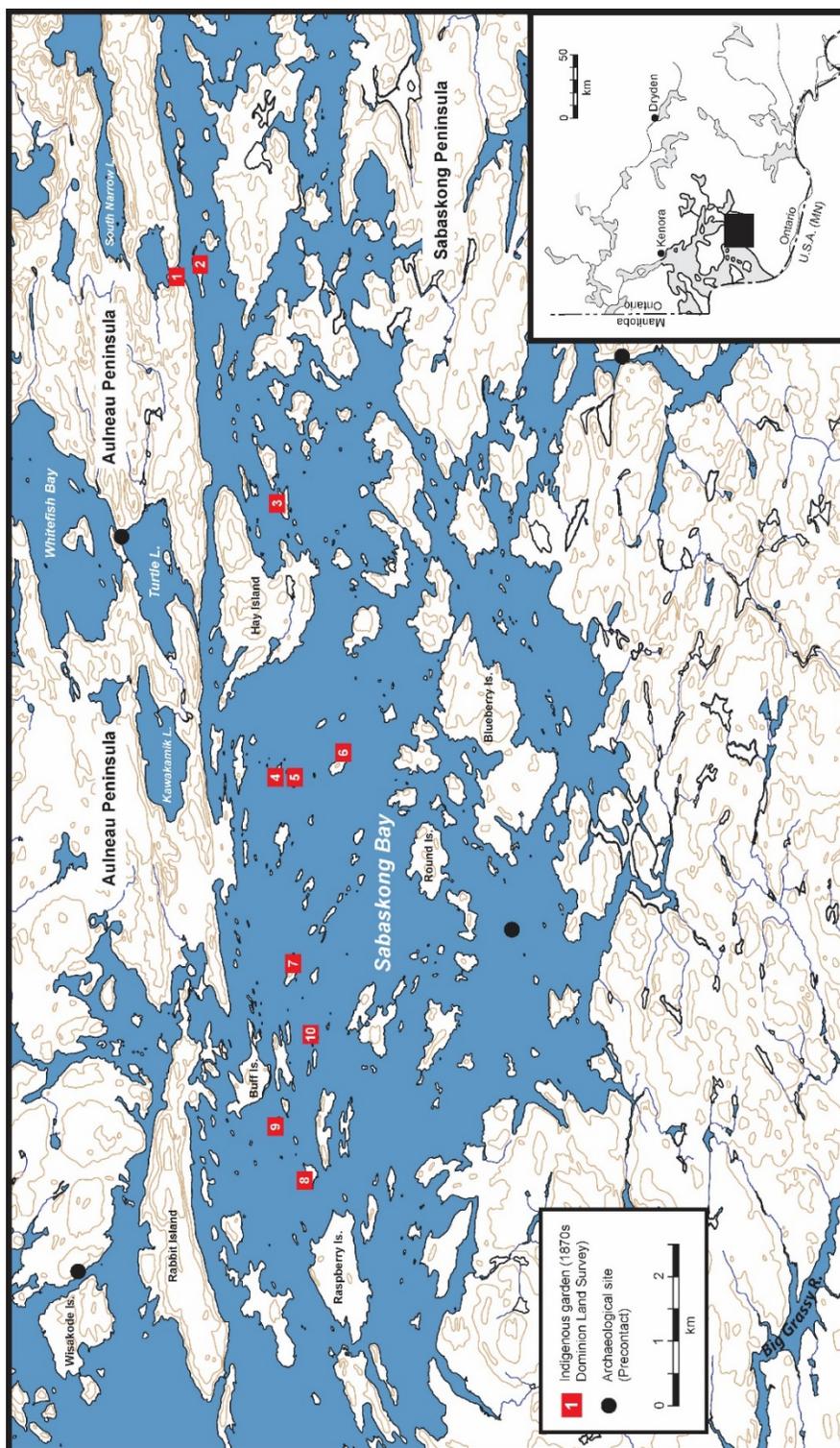


Figure 3.4: Map of Sabaskong Bay showing the locations of Indigenous gardens documented by the Dominion Land Survey as well as the locations of Precontact archeological sites in that area. Boyd in prep.

Expedition includes an account of the expedition's visit to Garden Island in Lake of the Woods. He noted various garden patches containing maize, as well as smaller patches containing potatoes and squashes (Hind 1971). This cultivation was focused on the eastern portion of the island (Hind 1971). The western half remained wooded and contained a variety of wild plant foods which Indigenous peoples would also gather (Hind 1971). Hind also reports that conversations with Indigenous peoples living on Lake of the Woods revealed that cultivation in the region extended beyond what the expedition observed at Garden Island (Hind 1971). Figure 3.4 shows a map made by Matthew Boyd showing the garden islands documented in the Sabaskong Bay region of Lake of the Woods during the 1870-80s Dominion Land Survey.

During the treaty period gardening on the islands of Lake of the Woods was a significant enough economic activity for the Anishinaabe people living the area that Treaty #3 included provisions for the support of Indigenous agriculture in the region (Waisberg and Holzkamm 1993). The largest gardens from this period of which records still exist were located on Garden Island (Holzkamm and Waisberg 1993), which was located along a major Lake of the Woods travel route (Hind 1971). The Anishinaabek using the gardens on this island are known to have grown all of the Three Sisters (maize, beans, and squash) (Moodie and Kaye 1969). This gardening was part of a diversified economy that combined agriculture with foraging, hunting, trapping, and fishing (Holzkamm 1986; Holzkamm and Waisberg 1993). One of the benefits of gardening to the Anishinaabe peoples living on and near Lake of the Woods was the additional food security provided by the gardens, especially during wet years when the wild rice crop failed due to flooding (Holzkamm 1986). Clearly, food cultivation in favourable lakeshore and island microclimates is a longstanding economic activity for the Indigenous peoples of the Lake of the

Woods region, in addition to the evidence of a longstanding practice of the consumption of cultivated plant foods.

## Chapter 4: Pollen and Charcoal Data in Palaeoenvironmental Study

The analysis of pollen and charcoal from lake cores has a long history of use in palaeoenvironmental reconstruction. They are often used together because the information they provide is complementary. Pollen data reflects the plant taxa surrounding a lake basin, while charcoal data provides information regarding the frequency and spatial proximity of fire which occurred in the vicinity of the basin. This combination is especially useful for human impact studies (Edwards and MacDonald 1991). However, both types of data also have notable limitations in what can be inferred. The nature and limitations of each type of analysis are elaborated upon below.

### 4.1 Fossil Pollen Data

The identification of fossil pollen through light microscopy is based on visual characteristics of the pollen grain. These include: (1) the size and shape of the full pollen grain, (2) the number, size, form, and arrangement of apertures in the grain, (3) the thickness of the grain membrane, and (4) the surface texture of the grain (Godwin 1934). Pollen preserves best in waterlogged and unaerated deposits (Godwin 1934), which is the reason most pollen analysis is performed on sediments from lake cores. Additionally, different pollen taxa have different resistances to decay, with certain pollen taxa such as *Juniperus* and *Larix* being easily destroyed (Godwin 1934).

One important consideration is that different genera produce pollen in different magnitudes, which translates into highly productive taxa being consistently overrepresented in pollen assemblages when compared to their presence in the vegetation assemblage the pollen is reflecting (Godwin 1934; Davis 2000). For example, pine (*Pinus*) pollen tends to be greatly over-

represented compared to other arboreal taxa, even if in the vegetation assemblage it is present in smaller numbers (Davis 1963). In boreal assemblages, this often translates into pine pollen being more abundant in pollen assemblages than spruce (*Picea*) pollen, even if spruce is the predominant tree taxa in the forest assemblage (Björk 1985). Conversely, tree taxa such as poplar/aspen (*Populus*) are consistently under-represented in pollen assemblages compared to their presence in the life assemblage (Davis 1963; McAndrews 1967b). Pollen from cultigens also tends to be consistently under-represented in pollen diagrams due to it tending to only be deposited very near the source plant (Pearsall 2000). Tree taxa in general tend to dominate forest pollen assemblages compared to non-arboreal taxa, typically comprising more than 75% of the sample (McAndrews 1967b).

The source area for pollen in lake cores is known to vary with the surface area of the basin from which any given core was drawn (Seppä and Bennett 2003), which has resulted in the establishment of theoretical models for investigating the source area of pollen from lake cores (Prentice 1985; Prentice 1988; Sugita 1993; Sugita 1994). Generally speaking, pollen assemblages from cores have two components: a local component and a regional component (Janssen 1984; Davis 2000). The local pollen component tends to include pollen types that are shed almost directly onto the ground, while extralocal and regional components tend to include anemophilous (wind-borne) pollen (Janssen 1984). The larger the lake or bog, the more the pollen assemblage from a core taken from that lake or bog is influenced by extralocal and regional pollen influx (Tauber 1965; Janssen 1966; Anderson 1970; Janssen 1973; Tauber 1977; Bradshaw 1981; Jacobsen and Bradshaw 1981; Parsons and Prentice 1981; Heide and Bradshaw 1982; Bradshaw and Webb 1985; Prentice 1985; Prentice 1988; Schwartz 1989; Jackson 1990; Jackson 1991; Sugita 1993; Davis 2000). This is because the percentage of pollen from local taxa

in a core decreases with increasing shoreline length, while regional pollen loading remains consistent (Janssen 1984; Sugita 1994). The distribution of plant species on a landscape will affect their impact on the pollen record (Davis 1963). One reason for this is that the strength of the pollen signal from individual trees is distance-weighted (Davis 2000). Another is that different pollen taxa have different aerodynamic properties (Davis 2000), which affects the radius from its source plant a given pollen taxa is able to travel before being deposited. Due to these factors, the Sugita (1993) model for determining pollen source area suggests that the source area for light pollen types could be 100 times greater than that of heavier types. Some pollen types can also be transported great distances by wind and moving water (Godwin 1934). Additionally, a later refinement of this model suggests that within the same landscape, pollen percentages are highly variable in forest hollows and small ponds, but uniform in larger lakes (Sugita 1998). This is due to the increased pollen loading from taxa immediately adjacent to small basins when compared to large ones. Sampling location when coring a lake or pond is also an important consideration, as the further towards the centre of a lake basin a sample is taken, the less the pollen loading in that core is affected by lakeside plant taxa (Sugita 1993).

#### **4.2 Approaches to Pollen Analysis**

Pollen data is typically presented in the form of a stratigraphic pollen diagram, with the amount of pollen of different genera being presented as a percentage of total taxa (Godwin 1934). Additionally, these diagrams are often divided into “pollen zones”. Pollen zones are bodies of sediment that have distinct assemblages of fossil pollen and spores (Cushing 1963; Cushing 1964; Cushing 1967; Birks 1972; Gordon and Birks 1972). These are often used to represent and characterize changes in regional vegetation over the time period represented by the

core. Additionally, by comparing pollen diagrams from several sites within the same geographic region, it is possible to identify vegetation development and human impact on different spatial scales (Berglund et al. 1991; Prøsch-Danielson and Simonsen 2000; Davies and Tipping 2004; Fyfe et al. 2004; Lagerås 2006; Fyfe et al. 2008; Overland and Hjelle 2009; Nielson and Odgaard 2010; Hjelle et al. 2012). Additionally, comparing fossil pollen assemblages to modern pollen assemblages can be useful for determining the environmental conditions that contribute to vegetation regimes (Jackson and Williams 2004).

One useful way of objectively separating stratigraphic pollen diagrams into pollen zones is through cluster analysis. While there are several types of cluster analysis which are used in numeric pollen zonation, all methods used are forms of constrained agglomerative cluster analysis (Gordon and Birks 1972; Grimm 1987). Agglomerative cluster analysis merges elements if their dissimilarity coefficients are over a certain value, with this value starting at zero. The analysis is completed when all elements are merged into a single group (Gordon and Birks 1972). The addition of stratigraphic constraints to agglomerative cluster analysis ensures that only adjacent elements are considered for grouping (Gordon and Birks 1972; Grimm 1987), allowing these forms of cluster analysis to avoid grouping elements that are not temporally synchronous. While oftentimes these methods agree with zonations made by visual inspection, the main advantage of using a computerized numeric method of delineating pollen zones alongside the visual inspection of diagrams is that it eliminates any potential bias on the part of a human researcher (Gordon and Birks 1972). As a numeric method of pollen zonation considers only the fossil pollen data, it is not influenced by extraneous factors such as sedimentological changes in the column, known periods of climatic change, or preconceived notions of the vegetation succession at a given location (Gordon and Birks 1972). Other advantages of using

numeric methods of pollen zonation include: the consistency and repeatability of results, the precise zonation requirements used by computer programs, the rapidity of computer processing, the lack of bias towards changes in specific taxa, and the ability to reveal pollen zones which may have been overlooked or dismissed by a human researcher (Gordon and Birks 1972). That being said, these methods do have some trouble detecting pollen zones characterized by small but stratigraphically consistent changes in fossil pollen frequency (Gordon and Birks 1972). This is an especially important consideration for the study being undertaken in this thesis, as both sediment cores being analyzed were taken from basins in a pine dominated mixed forest, and so any pollen zonation that might be present in these cores has a distinct possibility of being delineated by such subtle changes.

#### **4.3 Limitations of Pollen Analysis**

As useful as pollen analysis is, it does have some key limitations. Often, plant taxa can only be identified to the genus or family level, whereas other methods of identifying past vegetation regimes such as the study of identifiable plant macroremains can reach the level of species or subspecies (Godwin 1934; Ritchie 1995; Seppä and Bennett 2003; Jackson and Williams 2004). Of particular issue is the family Gramineae (grasses), which contains a wide variety of taxa. These taxa include many key indicator and economic plant taxa, however individual species and genera often cannot be distinguished from each other (Godwin 1934; Seppä and Bennett 2003). Methods have been developed to identify economic plant species such as maize (*Zea mays*) (Tsukada and Rowley 1964; Whitehead and Langham 1965; Irwin and Barghoorn 1965) and wild rice (*Zizania*) (Lee et al. 2004; Nurse et al. 2017). Another major issue arises during the analysis of pollen data, as pollen assemblages do not directly reflect past

vegetation assemblages. As described in the previous section, different plant taxa release pollen in different amounts, resulting in certain plants being consistently under- or over-represented in pollen assemblages when compared to the life assemblage (Godwin 1934; Davis 2000). A related issue is that some taxa present in life assemblages may not end up being represented in pollen assemblages at all, depending on issues of differential production, distribution, and preservation (Godwin 1934; Jackson and Williams 2004). In truth, there is no single pollen community that is directly linked to one vegetation community (Jackson and Williams 2004). It is possible both for different vegetation communities to produce similar pollen assemblages (referred to as convergence), and a single vegetation community to produce multiple, distinct pollen assemblages (referred to as divergence) (Jackson and Williams 2004). As with differential representation of pollen, this convergence and divergence can arise because fossil pollen assemblages are determined by a number of intervening factors including pollen productivity, pollen dispersal, depositional environment, and pollen preservation (Godwin 1934; Jackson and Williams 2004). Sedimentary pollen assemblages tend to be heavily biased towards anemophilous taxa with high pollen productivity (Jackson and Williams 2004). Depending on the environment, the difference in source elevation between trees and shrubs/herbaceous plants can also affect pollen dispersal, and therefore representation in pollen assemblages (Sugita, Gaillard, and Brostrom 1999). However, these limitations can be mitigated through the use of larger pollen counts per pollen slide to better capture the rare pollen taxa that might be present in the assemblage, and to gain a more representative sample of the taxa that are present. Another is being mindful of taxa which are consistently over- or under-represented, and accounting for that when interpreting data.

#### 4.4 Approaches to Charcoal Analysis

Analysis of microscopic charcoal from lake cores largely provides information on fire events which have occurred over the time period represented by the core, in combination with pollen data from the same core this allows a lot of valuable information to be inferred (Kangur 2002). Charcoal, when compared to pollen, is produced in larger quantities at irregular intervals (Patterson, Edwards, and Maguire 1987). This is due to requiring the presence of fire in the environment surrounding a lake basin to be present in lake sediment cores, as opposed to pollen which is produced at regular intervals as the result of plant reproductive cycles (Patterson, Edwards, and Maguire 1987). The nature of a given fire event will determine the nature of the charcoal it produces; these factors include: the type of material being burnt, the intensity of the fire, the duration of the fire, and the temperature of the fire (Patterson, Edwards, and Maguire 1987). The most important factor in determining the character of charcoal fragments found in a pollen core is the relative location of the source fire compared to the location the core was taken. This is because, when dispersed by wind, charcoal particles which are larger/denser will travel much shorter distances than smaller and/or less dense particles, and a similar pattern is presumed to occur with water transport (Patterson, Edwards, and Maguire 1987). Because of this, local fire peaks are most visible when studying charcoal particles greater than  $100 \mu\text{m}^2$  in surface area, with smaller sized particles representing a combination of local, extra-local and regional fire (Tinner et al. 1998; Rull 1999). As a result, microscopic charcoal assemblages tend to be dominated by very small charcoal particles (Patterson, Edwards, and Maguire 1987). When analyzing charcoal data, it is generally assumed that smaller charcoal particles represent regional fires while larger particles are considered to represent local fires (Patterson, Edwards, and Maguire 1987; Sarmaja-Korjonen 1992; Tinner et al. 1998; Rull 1999; Kangur 2002).

One aspect of charcoal analysis from pollen slides in particular that should be noted is that it more readily reflects regional fire patterns than local fire patterns (Cancaillet et al. 2001). This is due to this particular methodology being more biased towards the inclusion of very small charcoal particles when compared to sieving, with these very small particles in turn being more readily carried long distances via wind transport (Cancaillet et al. 2001). However, as this thesis is analyzing charcoal data from two different basins, and charcoal deposition in a basin varies with basin size in a similar pattern to pollen, some inferences about the differences in fire patterns on different spatial scales surrounding the study locations should still be able to be made.

#### **4.5 Limitations of Charcoal Analysis**

Charcoal analysis does have a few limitations. Fossil charcoal fragments are fragile, and so may become fragmented during slide preparation, resulting in more numerous, smaller charcoal particles appearing on the slide, which can affect the inferences made from the data (Kangur 2002). Additionally, due to the filtration performed during pollen slide preparation, these slides generally only record very small charcoal particles (Tinner et al. 1998). This study mitigates this limitation by doing charcoal analysis from “kerogen” slides, which are taken from the same material as the pollen slides, but extracted and mounted prior to the filtration process, preserving larger particles.

## **Chapter 5: Field and Laboratory Methods**

As the goal of this study is to analyze the vegetation setting of an archaeological site of interest on multiple spatial scales, it was decided that two distinct lake sediment cores would be analyzed for their fossil pollen and charcoal contents, as if these cores were extracted from waterbodies of different sizes, they would represent more strongly data from different spatial scales. It was decided that a core from Route Bay in Lake of the Woods already housed at Lakehead University would be used to represent regional data, while cores from smaller waterbodies meant to represent local data would be extracted over the course of this study. Both cores were to be analyzed under light microscopy separately, and then the resulting pollen and charcoal diagrams were to be compared to each other.

### **5.1 Sample Collection**

The two short lake sediment cores used in this study both came from locations near the Bundoran Site (DjKn-5) (See Figure 3.2). The first was collected from the Route Bay in Lake of the Woods, located roughly 1300 metres northwest of the site, and the second from a small pond located roughly 750 metres south of the site. This small pond will be referred to as Bundoran Pond for the remainder of this thesis. A third core was taken from Blindfold Lake located roughly 1200 metres east of the Bundoran Site, but was ultimately not included in this analysis. Both coring locations were chosen for their proximity to the Bundoran Site. The Bundoran Site in turn was chosen to be the focus of this thesis due to the presence of a possible Laurel house structure at the site (Spiedel 1989), and the recovery of microfossils from domesticated plants and wild rice from potsherds collected there (Surette 2008; Boyd and Surette 2010). Additionally, the area surrounding both the Bundoran Site and the two coring locations contains

a wild rice stand near the mouth of Rushing River where it enters Lake of the Woods. In combination, these factors made the area likely to yield information about the presence and thus potential use of economic plants in the boreal forest, in addition to information about the broader Late Holocene environment of the area.

The lake sediment core from Route Bay was collected prior to this study, extruded in the field with each 2 cm interval being stored frozen in sealed plastic bags. Pollen extraction and mounting was performed by Global Geolab Limited at the time this core was collected. Over the course of this study, 5.9 g of bulk sediment from the base (70-72 cm below surface) of the Route Bay core was collected for radiocarbon dating. The choice to use bulk sediment dating was made based on the nature of the sediment in this section (black sapropel) and the lack of intact and identifiable organic macroremains in the core (only sparse decomposed wood fragments, algae, fine cellulose, and fine fragments of herbaceous material were present). While there is a risk of hard water effects occurring when using bulk sediment dating on cores from freshwater lakes, these effects mainly occur in sediments derived from carbonaceous bedrock (Grimm, Maher, and Nelson 2009). As such, the risk of a hard water effect was determined to be minimal because the sediment used was extracted from an area of Lake of the Woods that overlays non-carbonaceous Canadian Shield bedrock. This bulk sediment sample was sent to Beta Analytic in Miami, Florida for processing and dating. Calibrations on the dates returned were obtained using the INTCAL13 database and reported as a mean plus/minus two standard deviations.

#### 5.1.1 The Bundoran Pond Core

Bundoran Pond was first identified as a potential coring location on bathymetric maps of the Lake of the Woods region, which indicated it was a moderately deep pond connected to Lake of the Woods by a narrow inlet. These maps indicated this inlet to be extremely shallow,

meaning it was likely flooded by the damming of the lake in the late 19th century. Both of these observations were confirmed in the field. The pond was measured to be 11 feet (about 3.4 metres) deep at its centre. Aside from its small inlet from Lake of the Woods, it was surrounded by bedrock. The inlet is itself also surrounded by bedrock, and bordered by two vacation homes, one on the east side of the inlet, and one on the west side. The inlet from Lake of the Woods into Bundoran Pond is shallow enough that the bottom was visible from the surface. This inlet also contains considerable emergent plant growth, including wild rice (*Zizania palustris*). This growth was so dense that a handheld sonar water depth instrument was unable to measure the depth of the inlet. However, given the visibility of the channel bottom and the presence of such dense growth of emergent plant taxa, prior to the lake's damming Bundoran Pond would have most likely been separated from Lake of the Woods.

Bundoran Pond is located at a latitude of 49.65618N, and a longitude of 94.30082W. The outer edges of the pond are covered by floating vegetation consisting of multiple aquatic taxa including: marsh reed grass (*Calamagrostis canadensis*), bogbean (*Menyanthes trifoliata*), cattails (*Typha*), white pond lily (*Nymphaea odorata*), yellow pond lily (*Nuphar lutea*), and wild rice. The bedrock surrounding the pond is covered by a mixed boreal forest consisting of jack pine (*Pinus banksiana*), white pine (*Pinus strobus*), white spruce (*Picea glauca*), aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), and more rarely cedar (*Thuja*) and black spruce (*Picea mariana*). The understory of this forest includes chokecherry (*Prunus virginiana*) and common juniper (*Juniperus communis*).

The Bundoran Pond core was taken on July 4th, 2019, from the centre of Bundoran Pond. The water depth in this area of the pond was about 3.4 metres. An ARI piston corer was used to collect the core off the side of an anchored boat. The resulting core was 98 cm long. It was

described in the field as consisting of a massive sapropel throughout, with further description in laboratory conditions confirming it as consisting entirely of an amorphous, black sapropel. This indicates that the centre of Bundoran Pond was permanently saturated for the entire length of time represented by the core. The core was extruded and separated into 2 cm thick samples that were continuous with each other. Extrusion was done using an ARI core extruding apparatus and was conducted immediately after core collection to ensure that mixing of the sediment did not occur. Laboratory analysis of material from the core under a light microscope showed it to contain considerable herbaceous plant material, as well as fungal spores, pollen grains, phytoliths, algal cells and spores, chitinous insect remains, *Chara* (algae) oogonia, and Cladocera (water fleas). While most of the sediment in the core was organic in nature, the light microscope analysis also did uncover the presence of some fine clastic material, most likely representing a very fine sand. Two cubic centimetres of material from each core section were collected in the lab using clean syringes and sent to Global Geolab in Medicine Hat, Alberta for pollen processing.

As the Bundoran Pond core contains identifiable herbaceous plant macroremains and aquatic plant seeds throughout, the radiocarbon dates taken for this core were obtained from these plant macroremains, rather than the bulk sediment used for dating the Route Bay core. The first sample was taken from the basal portion of the core (96-98 cm below surface) and consisted of 5.6 mg of material. This material included: wood fragments, carbonized wood fragments, herbaceous stem fragments, charcoal, a sedge (*Carex*) paraginium, a birch (*Betula*) seed, a pondweed (*Potamogeton*) seed, a sedge (*Scirpus*) seed, and a sedge (*Scirpus*) seed fragment. The second sample was taken from the 46-48 cm interval in roughly the middle of the core and consisted of 5.5 mg of material. This material included: wood fragments, carbonized wood

fragments, herbaceous stem fragments, a leaf fragment, charcoal, a pondweed seed, a water-nymph (*Najas*) seed, and multiple water-nymph seed fragments. As with the sample from the Route Bay core, the radiocarbon dating of these samples was performed by Beta Analytic, and the calibrations on the dates returned were obtained using the INTCAL13 database and reported as a mean plus/minus two standard deviations.

## 5.2 Pollen Analysis

The pollen slides developed from both the Route Bay and Bundoran Pond cores were analyzed using an Olympus BX 51 light microscope at a 400x magnification. This was done using differential interface contrast (DIC) rather than unpolarized light as, while DIC does slightly obscure subtle shape features in a pollen grain, it greatly enhances the visibility of pollen surface textures (Sivaguru et al. 2012), which are key in identifying boreal pollen. In order to allow for this use of polarized light, neither of the sets of pollen slides used were stained with safranin-o. Pollen taxa identified from these slides were counted to a total of 600 discrete pollen samples per slide, with no slides yielding a smaller total pollen count than this number. 600 was chosen as the target pollen count because while highly abundant pollen types can be representatively sampled in pollen counts of 150 or fewer (Lytle and Wahl 2005; Djamali and Cilleros 2020), small-scale changes in boreal forest vegetation are most likely to be reflected by moderately abundant, uncommon, and rare pollen types, which require large pollen counts to be representatively sampled. Pollen identification was done using a boreal forest pollen key published by McAndrews, Berti, and Norris (1974), along with the comparative pollen collection housed at Lakehead University. The differentiation between white spruce (*Picea glauca*) and black spruce (*Picea mariana*) was made based on the characteristics detailed by Hansen and

Engstrom (1985). As both are economically important, maize (*Zea mays*) and wild rice (*Zizania palustris*) were also both considered in analysis based on characteristics published by other authors. Maize was considered based on the size parameters detailed by Whitehead and Langham (1965), and the pore/axis ratio detailed by Irwin and Barghoorn (1965). Wild rice pollen was distinguished based on the characteristics of this pollen detailed by Nurse and colleagues (2017). After pollen data were collected, they were subjected to two forms of cluster analysis in the computer program ZONE (Juggins 1992): chord distance cluster analysis and CONISS cluster analysis. Pollen biostratigraphic diagrams were produced for both cores using the computer program C2.

### **5.3 Charcoal Analysis**

The charcoal analysis in this study was performed on “kerogen” slides, rather than pollen slides. This is because kerogen slides are developed from the same material as pollen slides, but extracted prior to material filtration and chemical digestion allowing greater numbers of large charcoal fragments, if they are present, to be preserved. The kerogen slides were analyzed for charcoal fragments under normal light at 500x magnification, again using an Olympus BX 51 light microscope. The slides were analyzed in totality, and every identified charcoal fragment on these slides was counted. These fragments were also sorted into size categories using a grid reticle to measure their surface area. These categories included fragments of the following sizes:  $<10 \mu\text{m}^2$ ,  $10\text{-}50 \mu\text{m}^2$ ,  $50\text{-}100 \mu\text{m}^2$ ,  $100\text{-}150 \mu\text{m}^2$ ,  $150\text{-}200 \mu\text{m}^2$ ,  $200\text{-}250 \mu\text{m}^2$ ,  $250\text{-}300 \mu\text{m}^2$ ,  $300\text{-}350 \mu\text{m}^2$ ,  $350\text{-}400 \mu\text{m}^2$ ,  $400\text{-}450 \mu\text{m}^2$ ,  $450\text{-}500 \mu\text{m}^2$ , and  $>500 \mu\text{m}^2$ . As counting every charcoal fragment on a slide resulted in vast disparities between the number of charcoal fragments on any given slide, these data were normalized to charcoal counts of 500 per slide for the purposes of

analyzing differences is charcoal size distribution both through time within a single core and between cores.

## Chapter 6: Results

The results in this chapter are presented by analysis and data type. Radiocarbon dates are presented first, followed by the pollen data and the charcoal data.

### 6.1 Radiocarbon Dating

The radiocarbon dates from the Route Bay and Bundoran Pond cores indicate that both cores contain sediment dating to the Late Holocene. The Route Bay core dated to  $2120 \pm 30$   $^{14}\text{C}$  years BP at the base of the core, which is located 70-72 cm below the surface level sediments, placing the start of the sequence represented by this core as occurring between 195 BCE and 105 BCE. The date from the base of the Bundoran Pond core is younger, dating to  $1930 \pm 30$   $^{14}\text{C}$  years BP or between 4 CE and 130 CE. There was also a date taken from 46-48 cm below the surface of the Bundoran Pond core, which is towards the middle of that core. This section was dated to  $1230 \pm 30$   $^{14}\text{C}$  years BP, or between 760 CE and 882 CE.

Core	Depth	Lab #	$^{14}\text{C}$ Date	Calendar Date
RB	70-72 cm	Beta-527910	$2120 \pm 30$	195-105 BCE
BP	96-98 cm	Beta-543567	$1930 \pm 30$	4-130 CE
BP	46-48 cm	Beta-543568	$1230 \pm 30$	760-882 CE

### 6.2 Pollen Results

The pollen diagram developed for the Route Bay core can be seen in Figure 6.1, and the pollen diagram developed for the Bundoran Pond core can be seen in Figure 6.2.





### 6.2.1 Route Bay Pollen Results

The pollen diagram for the Route Bay core contains only two major pollen types, *Pinus* sp., which comprises between 21 and 35% of the total pollen in a given core sample, and *Pinus bankisana/resinosa*, which comprises between 21 and 37% of the total pollen in the core samples. Moderately abundant pollen types seen in this core included: *Picea* sp. (0-6%), *Thuja* sp./*Juniperus* sp. (6-13%), *Betula* sp. (3-7%), *Betula papyrifera* (0-5%), *Alnus* sp. (4-10%), *Quercus* sp. (1-6%), and *Ambrosia* sp. (0-6%). Minor pollen types which occurred in this core included: Pinaceae (0-3%), *Pinus strobus* (0-2%), *Picea glauca* (0-3%), *Picea mariana* (0-2%), *Larix laricina* (0-3%), *Tsuga* sp. (0-3%), *Salix* sp. (0-2%), Chenopodiineae (0-3%), Gramineae (0-2%), *Nymphaea* sp. (0-3%), *Nuphar* sp. (0-2%), *Typha latifolia* (0-2%), and *Myriophyllum exalbescens* type (0-2%). All other pollen types seen in the core occurred in trace amounts (less than 1% of the total pollen sample for any given core section), and often also occurred very rarely with many pollen types only appearing in one or two core sections. The most likely cause of this is the long-distance transport of many of these pollen taxa by wind.

A large monoporate pollen grain was recovered from a depth of 70-72 cm. It is scabrate with a strongly annulate pore. The annulus is 3.72  $\mu\text{m}$  thick. The shape of the annulus is irregular, resembling a string of pearls. The inner pore margin is smooth. The polar margin is thin. The grain has a diameter of 86.8  $\mu\text{m}$  and a pore/axis ratio of 3:7. When checked using the McAndrews, Berti, and Norris (1974) key this pollen grain fit the outlined characteristics of no taxon other than *Zea mays* spp. *mays*. Further comparisons against the characteristics published by Whitehead and Langham (1965) and Irwin and Barghoorn (1965) confirmed this identification. While both the diameter and pore/axis ratio of this grain overlap with the wild

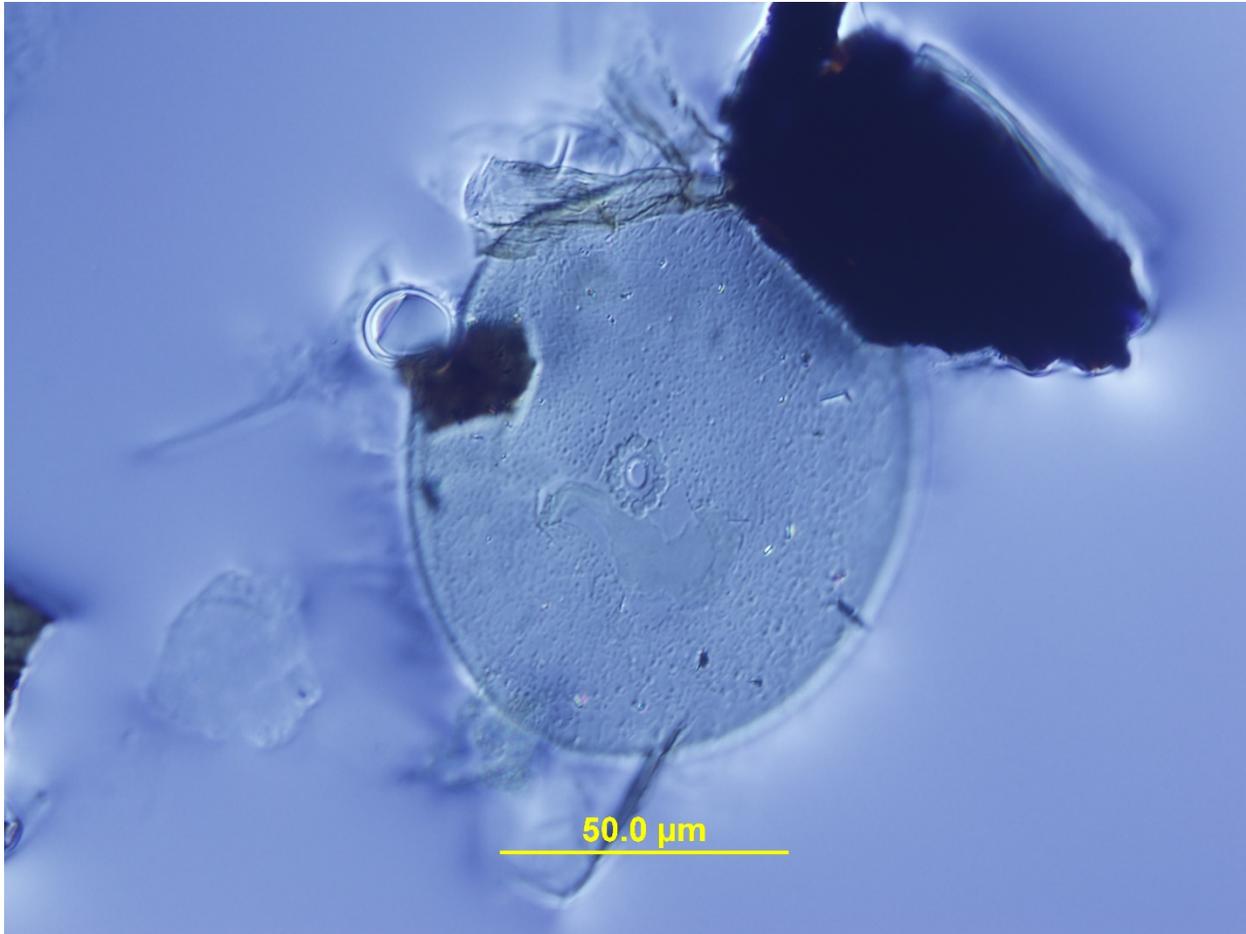


Figure 6.3: High contrast image of the *Zea mays* pollen grain recovered from the Route Bay Core depth interval of 70-72cm.

grasses teosinte (*Zea mays* spp. *huehuetenangensis*, *Zea mays* spp. *mexicana*, and *Zea mays* spp. *parviglumas*) and *Tripsacum*, neither of these plants is native to the study area. Fortuitously, this sample occurred in the interval of the Route Bay core which was selected for radiocarbon dating prior to microscopic analysis of the core sections, allowing this pollen sample to be securely dated to  $2120 \pm 30$   $^{14}\text{C}$  years BP, or between 195 BCE and 105 BCE.

The pollen diagram developed for the Route Bay core shows only subtle changes over time, with most major and moderately abundant taxa experiencing no change or very subtle changes in abundance over time. Plant taxa which experienced such subtle changes include alder (*Alnus*), spruce (*Picea*), cedar/juniper (*Thuja/Juniperus*), birch (*Betula*), and grasses. Alder

experiences a slight decrease in abundance above a depth of 40-42 cm below surface, from ~9% of the total pollen sample, to ~7% of the total pollen sample. Spruce pollen increases in abundance above a depth of 60-62 cm below surface from ~2% of the pollen total to ~7% of the pollen total. Cedar/juniper pollen starts out at ~7% of the total pollen sample before increasing to ~11% towards the middle of the core, and decreasing back to ~7% towards the top of the core. Birch pollen gradually increases from ~5% of the total pollen sample to ~6% of the total pollen sample between 50-52 cm below surface and 46-48 cm below surface. Grass pollen increased in abundance, from being trace (<1%) to comprising ~1.5% of the total pollen in a given sample, above the 44-46 cm below surface interval.

Chord distance and CONISS cluster analysis divided the data into two groups, with the separation between the two groups occurring at ~16 cm, after which ragweed (*Ambrosia*) pollen becomes notably more abundant, with a smaller increase in the abundance of *Chenopodium* (Chenopodiineae) pollen also occurring. There is also a slight decrease in the abundance of white spruce (*Picea glauca*) pollen and jack/red pine (*Pinus banksiana/resinosa*) pollen at this time. The change in ragweed pollen abundance at this time represents the most dramatic change in abundance displayed by a pollen taxon in the Route Bay core. At this time, the abundance of this pollen type roughly doubled, from ~3% of the total pollen sample to ~6% of the total pollen assemblage. This is the only pollen type to experience such a change in abundance, as mentioned and described above, other changes in pollen type abundance seen in this core were slight, subtle, and gradual. As such, this change in ragweed abundance is the most likely change in the entire Route Bay core to reflect a significant change in the vegetation composition of the region surrounding Lake of the Woods, and allows the Route Bay data to be separated into two clusters

representing a period of low ragweed abundance which comprises the majority of the column, and a period of high ragweed abundance comprising the very top of the column.

### 6.2.2 Bundoran Pond Pollen Results

The pollen diagram developed for the Bundoran Pond core contains five major pollen types: *Pinus* sp., comprising 17 to 31% of the pollen in a given core sample; *Pinus bankisana/resinosa*, comprising 15 to 25% of the pollen in a given core sample; *Betula* sp., comprising 11 to 21% of the pollen in a given core sample; *Alnus* sp., comprising 6 to 16% of the pollen in a given core sample; and Gramineae comprising 2 to 22% of the pollen in a given core sample. The minor pollen types in this core include: *Pinus strobus* (0-2%), *Picea* sp. (0-4%), *Picea glauca* (0-3%), *Larix laricina* (0-2%), *Thuja* sp./*Juniperus* sp. (1-6%), *Betula papyrifera* (1-6%), *Quercus* sp. (0-4%), *Salix* sp. (0-2%), *Ambrosia* sp. (0-4%), Chenopodiineae (0-2%), *Nymphaea* sp. (1-5%), *Nuphar* sp. (0-7%), *Myriophyllum exalbescens* type (0-2%), *Myriophyllum alterniflorum* (0-2%) and Cyperaceae (0-6%). All other pollen types are found in only trace amounts. Notably, the pollen assemblage is less diverse than the Route Bay core; specifically, it lacks many of the rare, trace pollen taxa seen in that core.

Interestingly, this core contains a small subset of large grass pollen grains which have proven to be somewhat enigmatic in origin. They do not fit the shape characteristics detailed by Nurse and colleagues (2017) which would indicate them to be *Zizania palustris*, as they are round instead of ovular. Further comparisons of these grains to the samples of *Zea mays* and *Zizania palustris* housed in the Lakehead University comparative collection found these grains to have a grain size that fell outside the range of variation seen in *Zizania palustris*, but that did overlap slightly with the lower end of the range of variation for *Zea mays*, with 200 samples of each taxon being measured for comparison, consistent with the number of

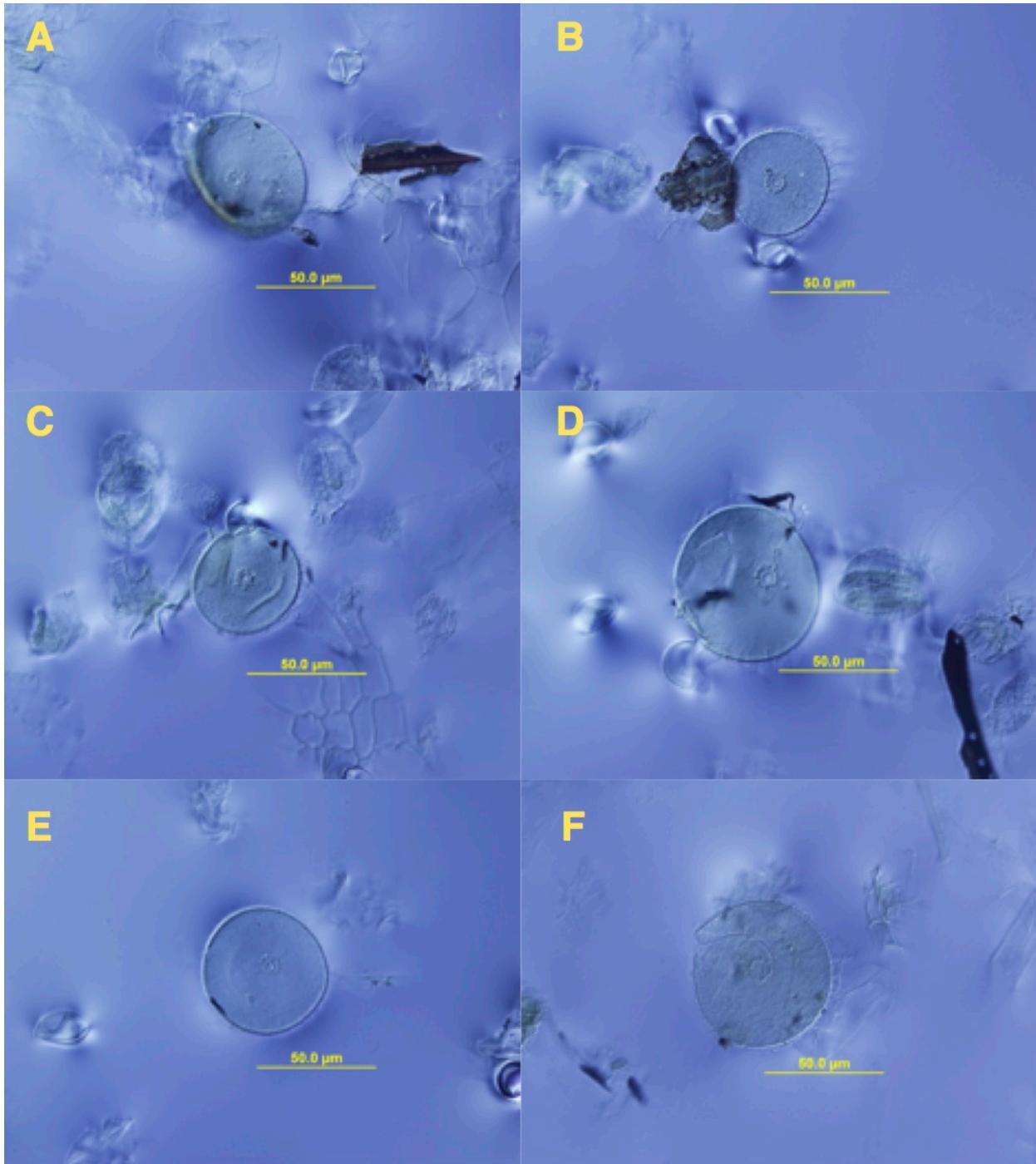


Figure 6.4: A selection of the large grass pollen grains found in the Bundoran Pond core. A) Recovered from a depth of 6-8 cm. B) Recovered from a depth of 26-28 cm. C) Recovered from a depth of 26-28 cm. D) Recovered from a depth of 28-30 cm. E) Recovered from a depth of 38-40 cm. F) Recovered from a depth of 90-92 cm.

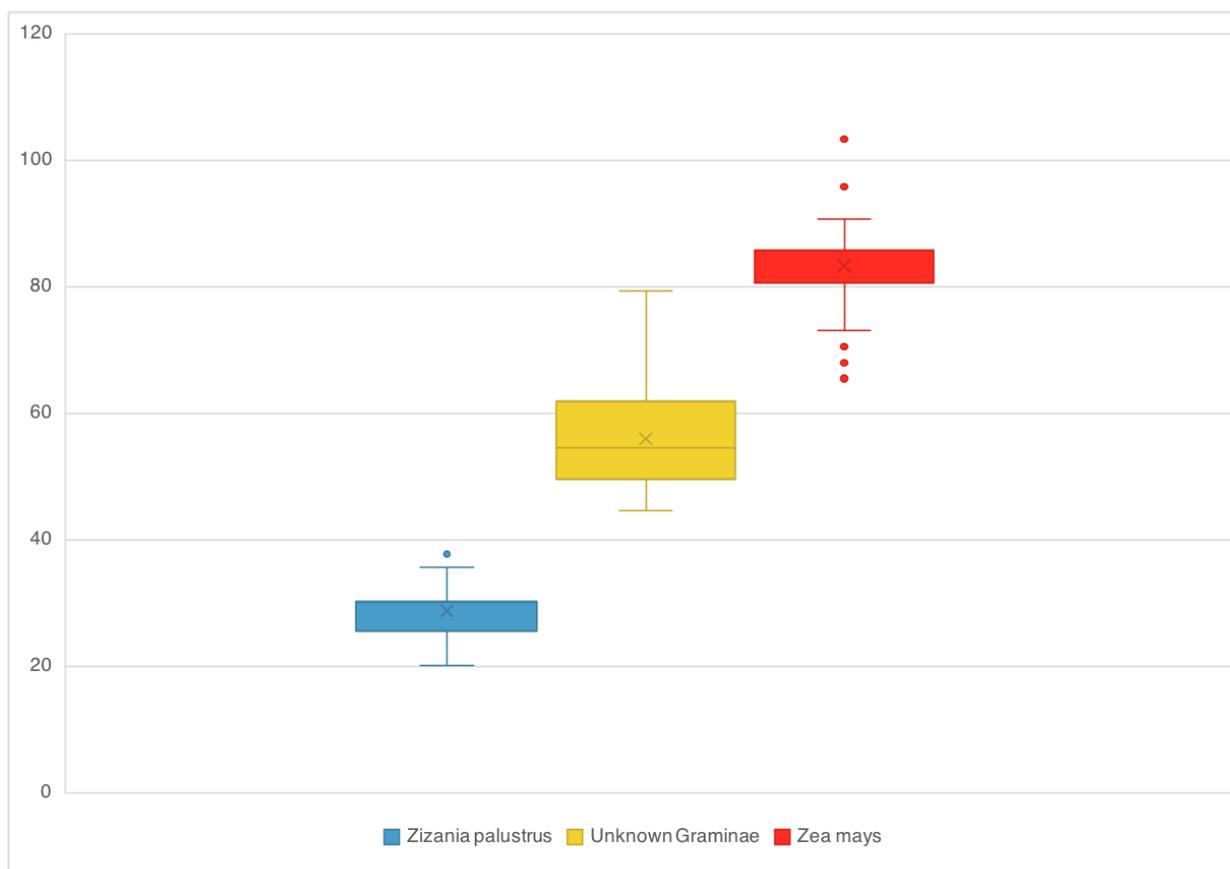


Figure 6.5: A box and whisker plot comparing the grain size distributions of the unknown grass pollen from the Bundoran Pond Core with those of *Zizania palustris* and *Zea mays*. *Zizania palustris* and *Zea mays* pollen were sampled from the Lakehead University comparative collection and counted to a total of 200 pollen grains each.

comparative samples used by Lee and colleagues (2004) in their study of wild rice grain size variation. A box and whisker plot of these results can be seen in Figure 6.5. Further investigations into pollen size for data published in the literature regarding wild grasses which appear in the study area (Geisler 1945; Lee et al. 2004) found that the only wild grasses whose range of variation these unknown large pollen grains fall into are wild rice (*Zizania*) and rattlesnake manna grass/Canada manna grass (*Glyceria canadensis*). Even for these pollen types, the grains in question would be unusually large, falling on the extreme high end of their published ranges of variation. As such, this thesis considers these pollen grains to be possible *Zea mays* pollen grains, based on their size overlap with that taxon, the presence of a confirmed

*Zea mays* pollen grain in the Route Bay core, and the consistent presence of maize (*Zea mays*) microfossils on potsherds from the Lake of the Woods basin. However, because these grass pollen grains cannot be confidently identified to a particular species, they will only be discussed minimally in the remainder of this thesis. Ongoing work is being done on the Bundoran Pond sediments to better understand the grass component of the microfossil assemblage.

As with the Route Bay core, the abundances of the pollen types seen in the Bundoran Pond core tend not to vary much over time, with the vast majority of the pollen types seen in the core maintaining consistent abundances over time, or experiencing very subtle changes. An example of one such subtle change is the slight decrease in the abundance of alder pollen above 90-92 cm below surface. Another example of a subtly changing pollen taxon is ragweed which experienced a slight decrease in abundance at a depth of 82-84 cm below surface, and a slight increase in abundance at a depth of 18-20 cm below surface. Spruce likewise experienced a decline in abundance at a depth of 84-86 cm below surface, from ~4% of the total to ~1% of the total, before recovering towards the top of the core. In the case of spruce, this recovery began at a depth of 34-36 cm below surface, before becoming more pronounced 12-14 cm below surface. Poplar/aspen (*Populus*), despite only being present in the core in trace amounts, showed a trend of subtly increasing in abundance towards the top of the core.

The most dramatic changes in pollen abundance in the Bundoran Pond core occur with grass pollen. This taxon shows a marked trend of gradually increasing in abundance above 78cm below surface, going from ~5% of the total pollen to ~9% of the total pollen, before gradually decreasing in abundance above 12 cm below surface, going from ~9% of the total to ~6% of the total. There are also two spikes in the abundance of grass pollen in the middle of the core, highlighting that this taxon is at its most abundant during this period. The first of the grass spikes

occurs in the 46-48 cm interval, in which grass pollen comprises ~18% of the total pollen in the section, and the second occurs in the 38-40 cm interval, in which grass pollen comprises ~22% of the total pollen in the section.

Likely as a result of how subtle changes in pollen abundances tended to be in this core, the Bundoran Pond core saw chord distance and CONISS analyses cluster their data very differently. Chord distance analysis broke the data into five clusters with separations occurring at ~38 cm, ~48 cm, ~72 cm, and ~94 cm. CONISS analysis also broke the data into five clusters, but placed the separations in the data at ~14 cm, ~38 cm, ~60 cm, and ~82 cm. The most likely explanation for these differences is that chord distance and CONISS cluster analysis are sensitive to different types of changes in data frequency, and the Bundoran Pond column is so uniform that these changes do not tend to occur at the same time. As such, the Bundoran Pond data is considered to consist of a single pollen zone, with several significant points of within-cluster variation.

### **6.3 Charcoal Results**

Figure 6.6 shows the trends in charcoal size through time in the Route Bay core, and Figure 6.7 shows the changes in charcoal abundance through time in this core. Figure 6.8 shows the trends in charcoal size through time in the Bundoran Pond core and Figure 6.9 shows the changes in charcoal abundance through time in this core.

#### **6.3.1 Route Bay Charcoal Data**

The charcoal samples in the Route Bay core tend to be extremely small charcoal grains of  $<50 \mu\text{m}^2$  in surface area, with grains in this range constituting more than 90% of the charcoal sample in any given depth interval. Charcoal grains larger than this, when they do appear,

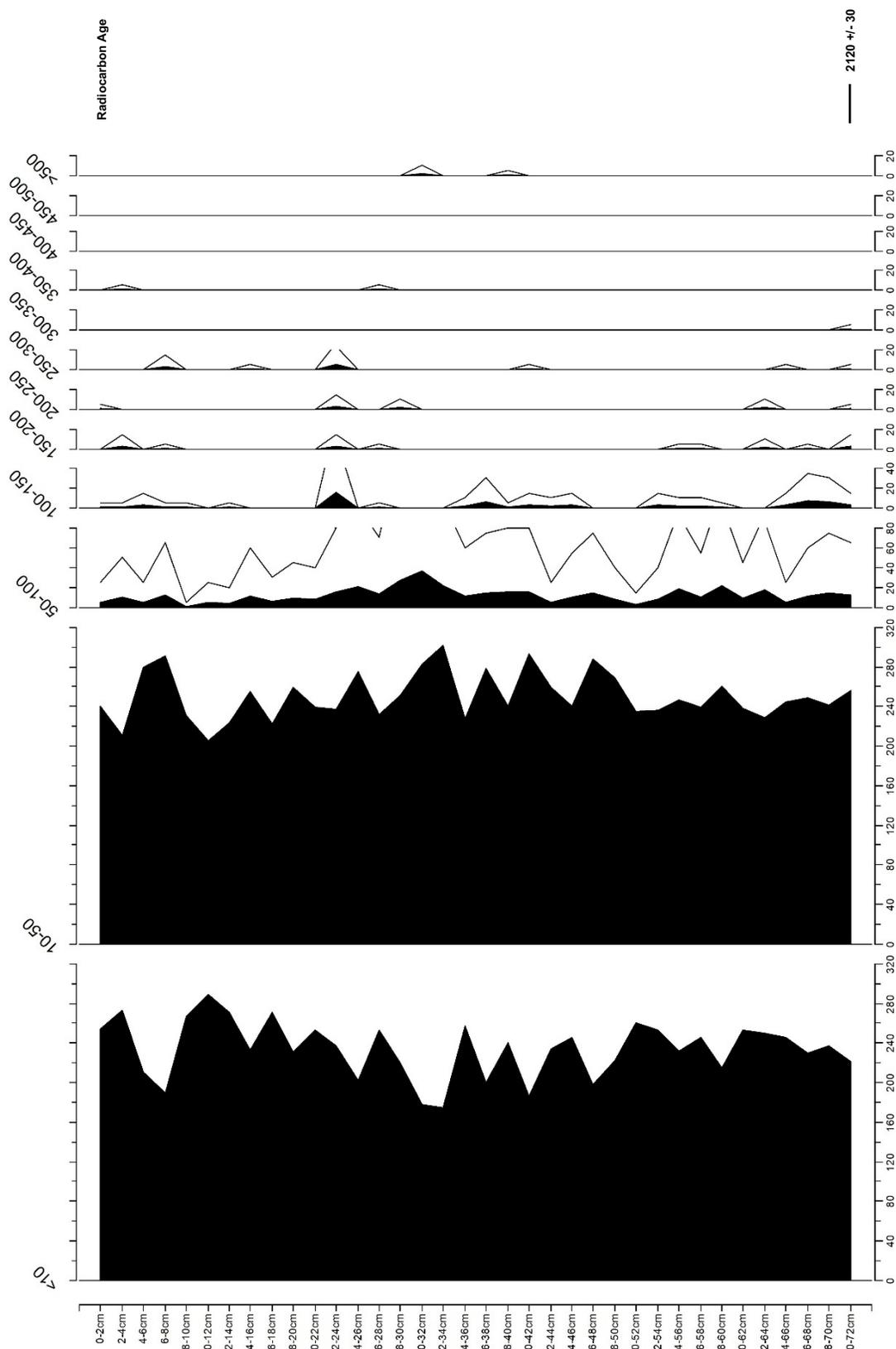


Figure 6.6: Stratigraphic charcoal diagram for the Route Bay core. Charcoal sizes are in  $\mu\text{m}^2$ . 5x exaggeration lines added

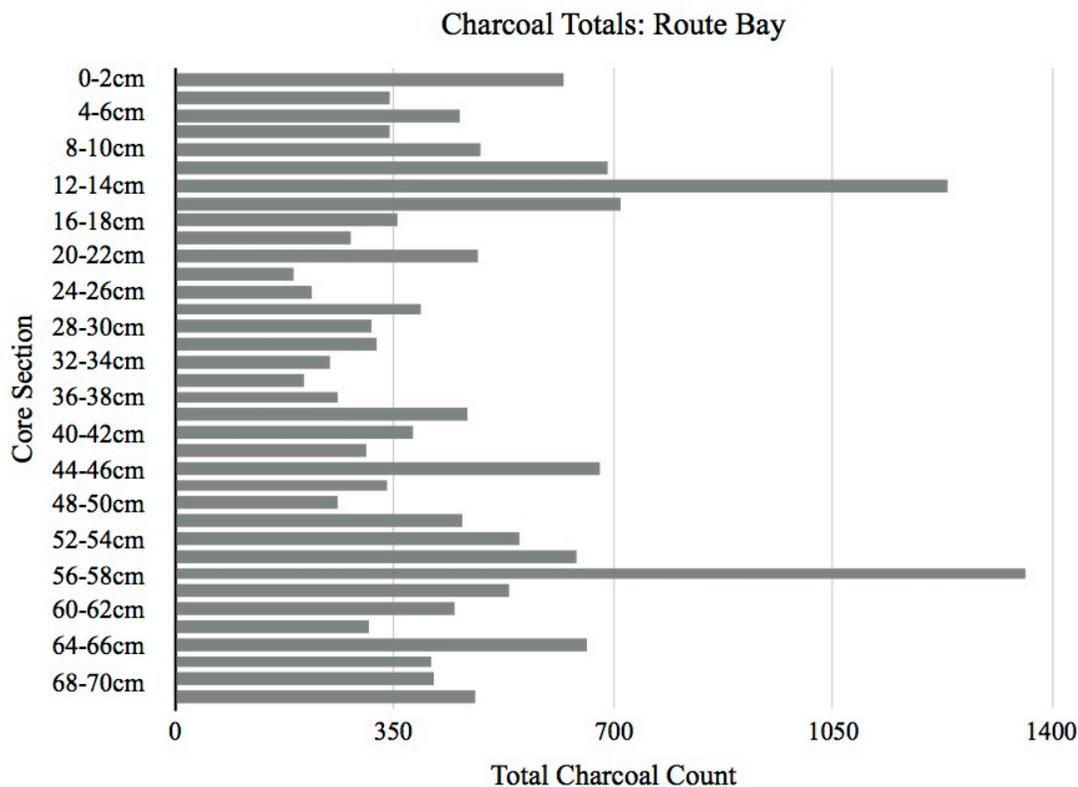


Figure 6.7: Total charcoal granules at each depth of the Route Bay Core

sharply increase in abundance for one or two depth intervals before decreasing again. Charcoal grains larger than  $100 \mu\text{m}^2$  in surface area occur extremely rarely, and appear more often towards the top of the core. Charcoal grains larger than  $500 \mu\text{m}^2$  in size only occur in two depth intervals, 30-32 cm below surface and 38-40 cm below surface. Charcoal becomes more abundant in this core after a depth interval of 14-16 cm below surface, either due to an increase in fire or an increase in sedimentation rate in the bay. There are two major spikes and one minor spike in the overall amount of charcoal present in the Route Bay core. The first major charcoal spike occurs at a depth of 56-58 cm below surface, and the second major charcoal spike occurs at a depth of 12-14 cm below surface. The minor charcoal spike occurs at a depth of 60-62 cm below surface.

6.3.2 Bundoran Pond Charcoal Data

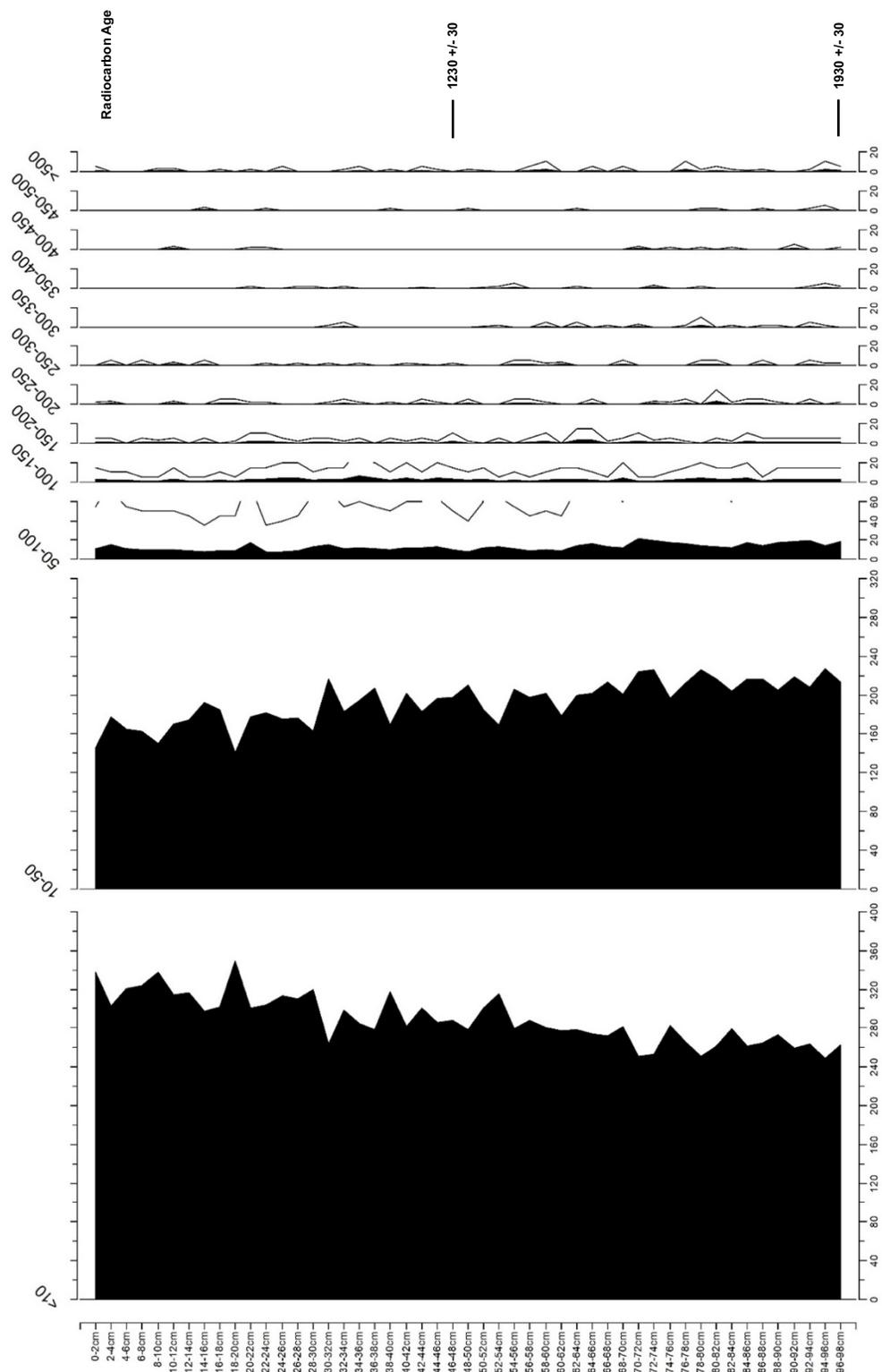


Figure 6.8: Stratigraphic charcoal diagram for the Bundoran Pond core. Charcoal sizes are in  $\mu\text{m}^2$ . 5x exaggeration lines added

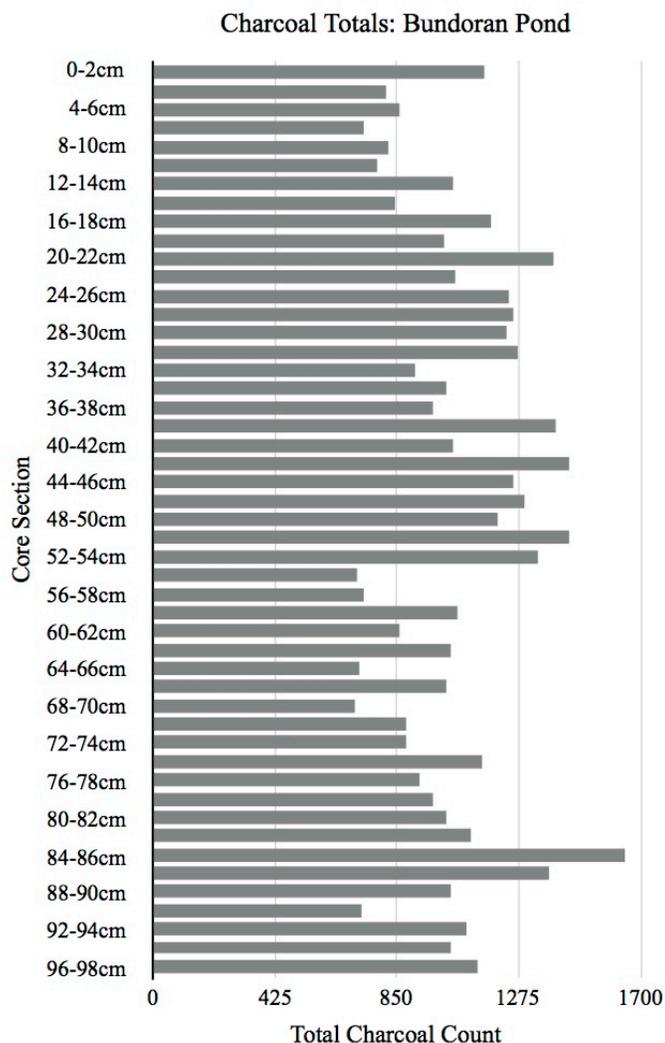


Figure 6.9: Total charcoal granules at each depth of the Bundoran Pond Core

The Bundoran Pond core contains more charcoal overall than the Route Bay core, most likely due to the greater sedimentation rate in the pond as compared to the bay (as indicated by the radiocarbon dating). As with the Route Bay core, charcoal samples from along the entire core sequence tend to be  $<50 \mu\text{m}^2$  in surface area ( $<90\%$  of the total charcoal per interval), but there are relatively more large charcoal fragments in this sequence when compared to Route Bay, although these still appear in trace amounts. Also unlike the Route Bay core, the appearance of these larger charcoal fragments is consistent; rather than waxing and waning, they are

consistently present at low levels. This includes charcoal fragments  $>500 \mu\text{m}^2$  in size. This relatively greater number of these large ( $>500 \mu\text{m}^2$ ) charcoal fragments is most pronounced towards the bottom of the core, with large charcoal fragments becoming a less frequent occurrence moving up the sequence.

The Bundoran Pond sequence contains fewer isolated spikes in charcoal abundance than the Route Bay core. Instead, both positive and negative trends in the charcoal abundance in the Bundoran Pond sequence are often gradual and sustained. The only sharp spike in charcoal abundance which occurs in the Bundoran Pond core occurs at a depth of 84-86 cm below surface. A significant amount of charcoal with a surface area between  $50 \mu\text{m}^2$  and  $100 \mu\text{m}^2$  is present at this depth.

## Chapter 7: Interpretations and Discussion

### 7.1 Pollen and Charcoal Data from the Route Bay and Bundoran Pond Cores

Both the Route Bay and Bundoran Pond cores ultimately reflect the presence of a persistent forest in the northern Lake of the Woods region throughout the time periods represented by both cores. This forest included a mix of tree taxa including: pine (*Pinus*), spruce (*Picea*), birch (*Betula*), alder (*Alnus*), oak (*Quercus*), willow (*Salix*), poplar/aspens (*Populus*), and tamarack (*Larix laricina*). However, the differently sized water bodies the cores were collected from did have some effect on the pollen and charcoal assemblages from each core. The Route Bay core contained a much wider variety of pollen taxa than the Bundoran Pond core, reflecting the wider catchment area of this body of water. Most notably, it contained a far greater variety of trace deciduous tree pollen taxa, likely derived from wind transport of pollen from forests to the south and east of Lake of the Woods. The Bundoran Pond core, in contrast, had much stronger pollen signals from nearshore deciduous tree taxa, particularly birch and alder, and emergent and aquatic plants such as white pond lily (*Nymphaea*), yellow pond lily (*Nuphar*), and sedges (Cyperaceae). It also contains more pollen from grasses (Gramineae). This reflects the stronger local pollen signal known to appear in smaller basins. The far greater presence of grasses in particular most likely results from a combination of aquatic grasses living in the pond itself, and terrestrial grasses growing in disturbed and exposed areas on the land near Bundoran Pond due to the increased localized fire reflected by the charcoal levels seen in that core.

Basin size is also the most likely cause of the difference in charcoal signals in the two cores. While the charcoal in both cores is generally extremely small, the Bundoran Pond core does contain a relatively higher number of larger charcoal fragments. The Route Bay core most likely contains charcoal created by large region-scale fires, while the Bundoran Pond core may

contain some charcoal from localized burning in addition to that from region-scale fires. This localized burning appears have occurred at a low-intensity throughout the period of time represented by the Bundoran Pond core, as that core consistently contains larger charcoal fragments. Larger charcoal fragments in the Route Bay core, in contrast, appear sporadically. This is likely due to the charcoal in the Route Bay core reflecting large regional wildfires, which only occur rarely, whereas the Bundoran Pond core is reflecting consistent local-scale burning. Interestingly, the two different fire patterns displayed by the Route Bay and Bundoran Pond pollen cores are reminiscent of the differences described by Lewis and Ferguson (1988) between natural and anthropogenic fire in the boreal forest. They write that: “Natural fire mosaics are characterized by larger, less frequent but usually hotter burned stands of vegetation; man-made fire mosaics, at least those fire-maintained by hunter-gatherers, entail smaller, more frequently, and lightly-burned patches of growth” (Lewis and Ferguson 1988, 58). Given the consistent presence of larger charcoal fragments in the Bundoran Pond core, is it possible that some of the local-scale burning it is reflecting is anthropogenic, especially towards the bottom of the core when charcoal fragments  $>500 \mu\text{m}^2$  occur more frequently. The local fire surrounding Bundoran Pond being anthropogenic to some degree is also supported by the presence of multiple recorded Woodland period archaeological sites in the area surrounding the pond, and local Anishinaabe peoples’ traditional use of fire for land management (Berkes and Davidson-Hunt 2006).

The difference in catchment area reflected by the two cores is also the most likely cause of the Route Bay core being separated into two data clusters by cluster analysis, while the Bundoran Pond core remained a single cluster throughout its sequence. The data cluster at the top of the Route Bay core is characterized by an increase in ragweed (*Ambrosia*) pollen, and a slight decrease in coniferous tree pollen. This data cluster is also associated with the increased

charcoal abundance in the Route Bay core above a depth of 14-16 cm below surface. There are two possible scenarios which could account for these data. The first is that the ragweed-abundant pollen zone at the top of the Route Bay core reflects a time of increased regional fire, and ragweed was growing in areas of disturbed ground created as a result of burning. The other is that this zone is reflecting increased logging activity in the area surrounding the lake brought on by European settlement. Logging would also create the disturbed ground in which ragweed thrives, and it would also increase soil erosion in the area surrounding the lake, potentially inputting more charcoal and sediment into the basin. In either case, these data indicate that the top of the Route Bay core reflects a time period where the region surrounding the Lake of the Woods was experiencing a heightened level of vegetation disturbance. Interestingly, this pattern is not seen in the Bundoran Pond core. At no point does ragweed pollen become elevated towards the top of the core, and the top 16 cm of the Bundoran Pond core reflects a period of low charcoal abundance. This implies the area nearby Bundoran Pond was not subject to the increased vegetation disturbance experienced by Lake of the Woods at a regional level. Which, in turn, reflects how regional environments consist of mosaics of local-scale environments, and that oftentimes the forces shaping vegetation environments on a regional scale are different from those shaping environments at the local scale.

Overall, while both the Route Bay and Bundoran Pond cores reflected a Late Holocene mixed forest environment, each core highlighted different aspects of that environment. The Route Bay core reflected the wider region, while the Bundoran Pond core reflected the local environment. Due to this, the Route Bay core was able to highlight regional changes in fire activity and vegetation disturbance that were invisible in the Bundoran Pond core, while the Bundoran Pond core was able to emphasize a local-scale vegetation continuity that would be

impossible to infer from the core taken from Route Bay. In this way, short sediment cores taken from waterbodies of varying size can highlight the fact that any environment, past or present, is a mosaic of smaller vegetation communities. Significant regional changes can occur while local pockets of vegetation remain largely unchanged. Additionally, in areas where the regional pollen rain is dominated by a single highly productive taxon, as is the case in forests containing even moderate amounts of pine, extracting sediment cores from smaller waterbodies can allow for the presence of other local taxa to be more readily noted, especially those local taxa which exist in a nearshore or aquatic environment. In this way, the taking of sediment cores, both short and long, from smaller waterbodies in boreal, mixed, and Great Lakes-St. Lawrence forests may serve to highlight the local vegetation diversity in an ecosystem that can appear to be a pine monolith in pollen studies.

## **7.2 The Implications of the Presence of a Maize (*Zea Mays*) Pollen Grain in Lake of the Woods Lake Sediment**

The maize pollen uncovered in the Route Bay core represents the first direct evidence of precontact maize plant growth in the Lake of the Woods region, as maize pollen is large, heavy, and unlikely to travel far from its originating plant (Burden, McAndrews, and Norris 1986; McAndrews 1988; McAndrews and Boyko-Diakonov 1989; Fearn and Liu 1995). This fact has been previously used to help identify the presence of an Iroquoian village site near Crawford Lake after maize pollen was uncovered in a core from that lake (McAndrews and Boyko-Diakonov 1989). The likely origin of this pollen being endozoochorous transport by Canada geese (*Branta canadensis*) (McAndrews and Turton 2007). While long distance endozoochorous transport of plant material by waterbirds is possible, it is exceptionally rare, with most such

transport being primarily local-scale (Viana et al. 2013a). A model for endozoochorous transport of seeds in ducks (*Anas*) developed by Viana and colleagues (2013b) found that the median transport distance for ingested plant material was between 21 and 64 km depending on species. Additionally, a common goose (*Branta*) foraging strategy is to feed on fields during the day before spending the night on waterbodies, releasing their excreta at this time (Buij et al. 2017). It is this behaviour that is theorized to have caused the deposition of maize pollen by Canada geese at Crawford Lake (McAndrews and Turton 2007). Even in cases of long-distance endozoochorous transport during migrations, ingested plant material is unlikely to be transported more than 300 km from its source, as at that point a waterbird's gut contents have been mostly discarded (Clausen et al. 2002). As such, this suggests that there was some level of maize cultivation occurring in the Lake of the Woods region which allowed maize pollen to be deposited in Route Bay at the time represented by the 70-72 cm interval in the core.

The core section in which the pollen was discovered dates to between 195 BCE to 105 BCE, placing the time of its deposition in either the late Archaic or the early Middle Woodland. The presence of maize in the Lake of the Woods region during the Middle Woodland is corroborated by the presence of maize microfossils on Laurel pottery from The Big George Site (DiKp-3), The Arklow Site (DiKp-5), The Ash Rapids East Site (DjKq-4), and the Ballynacree Site (DkKp-8) (Surette 2008; Boyd and Surette 2010). The combination of these microfossils with the pollen discovered in the Route Bay core suggests that some maize cultivation was being practiced in the Lake of the Woods region during the Middle Woodland period. Furthermore, the consistent presence of maize microfossils on Late Woodland pottery from the Lake of the Woods region (Surette 2008; Boyd and Surette 2010), suggests that maize cultivation may have been a repeated feature of Indigenous economies long before the contact period when archaeologists

currently assume it to have first developed (Waisberg and Holzkamm 1993). Gardening may have been undertaken in favourable microclimatic zones on islands and south-facing lakeshores, as has been observed with contact era Indigenous horticulture in the region (Waisberg and Holzkamm 1993). These lakeshores and islands also would have possessed enough soft sediment to allow for gardening. These same areas continue to support prairie vegetation in an area that otherwise consists of forests.

The age of the maize pollen discovered in the Route Bay core,  $2120 \pm 30$   $^{14}\text{C}$  years BP (195 BCE to 105 BCE), is aligned with other evidence of early maize consumption and horticulture found elsewhere in more southerly areas of eastern North America. The pollen from Route Bay is only slightly younger than a maize pollen collected from a sediment core taken from Dismal Swamp, Virginia, which is estimated to date from between 309 BCE and 104 BCE (2200  $^{14}\text{C}$  years BP) (Whitehead 1965). There is also a maize pollen from Bigbee Lake, Mississippi dating from between 594 BCE and 390 BCE (2400  $^{14}\text{C}$  years BP) (Whitehead and Sheehan 1985). Additionally, Delacourt and colleagues (1986) documented maize pollen in cores from Tuskegee Pond, Tennessee, from at least 591 CE (1600  $^{14}\text{C}$  years BP). There has also been a maize pollen found in Southern Alabama dated to earlier than 1683 BCE (3000  $^{14}\text{C}$  years BP) (Fearn and Liu 1995). The antiquity of the Alabama pollen grain is contested, however.

There is other maize microfossil data from northeastern North America that is roughly contemporaneous with the maize pollen uncovered in the Route Bay core: maize phytoliths and starches found in carbonized food residues. While there have been reports of Middle Woodland maize macrofossils in northeastern North America (Johnson 1976; Crites 1978; Ford 1981; Chapman and Crites 1987; Ford 1987; Adair 1990; Scarry 1990; Riley et al. 1994; Crawford, Smith, and Bowyer 1997), more recent re-evaluations have either re-dated or disqualified many

of the specimens previously considered to be Middle Woodland maize microfossils (Simon 2017; Simon, Hollenbach, and Redmond 2021). Middle Woodland maize microfossils have been dated more securely, though the potential for contamination means that starch is considered to be a less reliable indicator of archaeological maize than phytoliths. A carbonized food residue from the Vinette Site in the Finger Lakes region of New York containing maize phytoliths dates to between 311 BCE and 206 BCE ( $2270 \pm 35$   $^{14}\text{C}$  years BP) (Hart, Brumbach, and Lustek 2007). Similar food residues containing phytoliths date maize consumption on Brock Island, Rhode Island to at least 350 BCE (2300 cal. BP) (Dotzel 2021). There is also a directly dated potsherd from the Winter Site on the Garden Peninsula in Northern Lake Michigan from between 203 BCE and 1 CE that displays evidence of maize microfossils in its residues (Albert et al. 2018). Raviele (2010) reported maize starch in cooking residues dated to between 208 BCE and 41 BCE ( $2120 \pm 40$   $^{14}\text{C}$  years BP) from the Schultz Site in the Saginaw River Valley of Michigan. Raviele (2010) also reported residues dating between 50 BCE and 90 CE that contained both maize and wild rice (*Zizania*) microfossils from Site 20SA1276, also in Michigan. There are also a series of early Middle Woodland dates on carbonized food residues that contained maize microfossils from Southern Quebec (St. Pierre and Thompson 2015). These dates range from 400 BCE to 200 BCE, with the vast majority coming from the Hector-Trudel Site (St. Pierre and Thompson 2015). Considering these dates, the Middle Woodland age of the maize pollen from the Route Bay Core is not anomalous. Rather, it fits into a broader pattern of microscopic evidence for Middle Woodland maize that has appeared across Northeastern North America earlier than archaeologists have traditionally assumed.

Middle Woodland maize pollen being present in Lake of the Woods re-contextualizes maize microfossil data uncovered from food residues in that region (Surette 2008; Boyd and

Surette 2010). It suggests that some of the maize being eaten by Woodland peoples at Lake of the Woods was locally grown instead of being acquired through trade. It certainly demands further investigation.

While only a single definitive precontact maize pollen grain has so far been recovered from the Lake of the Woods basin, and additional research is needed to understand the nature and extent of maize cultivation in the region, precontact maize pollen being present in any capacity allows for some speculation in this regard. In my opinion the most likely scenario is that the precontact peoples who were cultivating maize on Lake of the Woods were seasonally mobile, and integrated some small-scale horticulture into their seasonal subsistence rounds. It has been well-established in ethnographic literature that horticultural communities still utilize wild resources (Zvelebil and Rowley-Conway 1986; O'Shea 1989; O'Shea 2003), with much of the early history of northern maize in particular being linked to at least seasonally mobile groups (Chilton 1999; Hart and Lovis 2013). In addition to John Tanner's 1830 account of maize cultivation as part of a seasonal round of subsistence activities in the Lake of the Woods region (James 1956), there are also accounts of Anishinaabek people who lived near Sault St. Marie leaving planted fields after sowing them to pursue other economic activities, returning to them at harvest time (Kinietz 1940). Other Indigenous groups are also known to have both cultivated maize and remained at least partially mobile (Will and Hyde 1917; Day 1978). Elizabeth Chilton (2006) notes that: "extant archaeological evidence [in New England] supports a model of mobile farming and the continuation of hunting and gathering by native peoples well into the historical period" (539), indicating that seasonally mobile maize horticulture is at least one of the economic models that was practiced by Indigenous peoples who adopted the plant. There is also

dietary evidence of the coexistence of maize horticulture and hunting and gathering economies (Schoeninger 2009).

In the case of Lake of the Woods in particular, it is possible maize represented what Halstead and O'Shea (1989) refer to as the buffering mechanism of diversification. Diversification means the reduction of subsistence risk through a broadening of the subsistence base available to a group (Halstead and O'Shea 1989). It is possible Woodland peoples in the Lake of the Woods region used maize as a second starchy grain to supplement the wild rice harvest, analogous to how maize in the American Northeast supplemented the starchy grains available in the Eastern Agricultural Complex (Hart and Lovis 2013). There are historical records of maize being used as such during the contact period, especially in wet years when the wild rice crop failed (Holzkamm 1986), so it is possible maize may have been used in a similar way during the Woodland period.

## Chapter 8: Conclusions

The purpose of this study was to attempt to address the dearth of local scale vegetation analysis in the boreal forest by analyzing a pair of short pollen cores taken from two different basins in the Lake of the Woods region, and analyzing them to see what environmental information they contained. In the process, this study demonstrates the potential usefulness of Late Holocene pollen cores in the study of domesticated plant cultivation in northern North America. In the more general sense, this thesis demonstrates the benefits of studying multiple pollen cores from the same general area taken from water bodies of differing basin sizes. The different spatial trends that differently-sized basins can highlight can prove especially useful when trying to understand human impacts on localized vegetation by both highlighting these localized trends and placing them in the context of larger regional changes. Additionally, even short cores taken from apparently stable environments can reflect notable changes in regional vegetation, as the Route Bay core did in recording a transition from a forest environment with little disturbance to one that had significant disturbance. Studies looking into the environmental effects of European contact and settlement on the environment of the boreal forest, as well as that of other North American ecotones, could benefit from the analysis of short pollen cores based on this ability to reflect region-wide vegetation changes in a relatively short timeframe.

Perhaps the most striking result of this study was the discovery of a maize (*Zea mays*) pollen grain at the bottom of the Route Bay core, which provides the first unambiguous evidence of some level of maize cultivation occurring in the Lake of the Woods region prior to European contact. It also provides an example of cultivation occurring in a marginal environment, as the pollen diagrams developed by this study show that the Lake of the Wood region has been vegetated by mixed forests for the entirety of the Late Holocene. As such, maize cultivation was

likely accomplished by using microclimates present on islands and south-facing lakeshores such as those which today hold stands of relict prairie vegetation and that have been used historically by the ancestors of Indigenous peoples now living in the region.

Such a discovery opens up multiple possible avenues of future research. One such area would be taking pollen samples from sediment cores taken from other areas of the Lake of the Woods basin to assess the spatial extent of maize cultivation in the region. It would also be fruitful to assess longer sediment cores than the short cores used in this study, to better understand the full time-depth of maize cultivation in the basin, as this study was unable to ascertain such information. Pollen cores could also be extracted from other areas of Northwestern Ontario that have yielded evidence of maize consumption by Woodland peoples, evidence of which has been associated with every pottery producing culture in the boreal forest (Boyd and Surette 2010). Such investigations could be used to help determine if maize cultivation was a common practice among Woodland peoples in the region, or if the growing of maize was limited to a few select areas with the crop then being disseminated across the wider region through trade, similar to the pattern seen with postcontact Anishinaabek people (Holtzkamm 1986). One location that I believe would yield interesting data in this respect would be Whitefish Lake. This is because one of the sites located on an island in that lake, the Martin-Bird Site (DbJm-5), is a multicomponent Woodland/Historic site that has yielded what are interpreted to be maize roasting features (Dawson 1987; Barry 2017; Boyd and Hamilton 2018). Maize having been processed at that site, it may have been grown nearby. The study of short sediment cores in the hopes of discovering the presence of maize pollen in those cores could also help to clear up ambiguities in the timing of the entry of maize cultivation to a region, such as those that are seen in the Northeastern United States, where microfossil evidence of maize

precedes macrofossil evidence by hundreds of years. In all cases, this study has proven to be an unexpected first step into a new understanding of the adoption of plant cultivation in North America, and has proven that older methods of studying past environments can still bring forth new insights if utilized in novel ways.

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