A Palaeoecological and Archaeological Analysis of Plant Macrofossils from Monolith 4A800B3-6 at L'Anse aux Meadows, Newfoundland

by,

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"…They'll never dig coal here,

Only the waterlogged trunks
of great firs, soft as pulp.
Our pioneers keep striking
Inwards and downwards,

Every layer they strip
seems camped on before.
The bogholes might be Atlantic seepage.
The wet centre is bottomless."

S. Heaney (1969).

Abstract

Peatlands are excellent foci of study due to their ability to act as archives of palaeoecological and archaeological proxy data, as the organic materials which constitute such data do not readily decompose within these waterlogged and acidic environments. Proxy data can be analyzed to discern how peatlands came to form through internal and external processes. Both natural and cultural (i.e., anthropogenic) forces are important external influences upon peatland formation. This study seeks to discern how a peat bog area at the archaeological site of L'Anse aux Meadows, Newfoundland formed as a result of natural successional processes and anthropogenic disturbance. This is accomplished through the use of a high temporal resolution (sub-centimetre) plant macrofossil analysis and radiocarbon age-depth modelling undertaken on a monolith (4A800B3-6) retrieved from a peat bog close to the main settlement terrace at the site. Through the application of this method, it is found that human-mediated disturbance (fire and trampling) and biophysical drivers (climate) each played a role in forming the peat sequence. Several different possibilities are offered for which particular cultural groups might be behind the disturbances in the peatland—which include the Norse but also Indigenous groups.

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Research Contributions

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Chapter 1. Introduction

1.1 Human Impact, Peatlands and Archaeology

Any environment in which humans have dwelled will bear some influence from their presence (Thompson 2010). While this influence is exceedingly manifest in the current "Anthropocene" (Crutzen 2006), it can be seen to stretch back to the earliest origins of the species (Boivin et al. 2015; Ellis et al. 2021; Roebroeks et al. 2021; Thompson et al. 2021). Human influences on natural biota may be purposeful, via the alteration of local ecology through such variable means as the use of broadcast fire, species management and cultivation, or else accidentally, through unintentional nutrient enrichment in areas of human habitation or even just by walking upon the ground itself. Wherever humans exist, going about their tasks (even in the most mundane and quotidian of ways), some influence will be wrought upon the ecology and landscape within that area (Balée 1998; Crumley 1994; Kareiva et al. 2007). The record of these anthropogenic influences, where they are preserved, can be sought in soils and sediments, for it is within them that proxy data are contained; the study of which can inform upon how past ecosystems have changed through time and been influenced by humans. Physically, this may take the form of pollen grains, insect remains, plant tissues and seeds, charcoal or other organic materials (Dincauze 2000). Any and potentially all remains of organisms that were alive in the past and impacted upon by natural and anthropogenic processes may be studied as a means of discerning how and why these changes occurred (Reitz et al. 2012).

Peatlands, otherwise known as peat bogs, have long been regarded as stellar archives of palaeoecological proxy data, owing to their waterlogged and anoxic conditions (Gearey and Fyfe 2016; Godwin 1981). Organic remains that would not be preserved otherwise are prevented from decay in these environments. These include plant remains, from whole tree trunks down to the minutest particles such as pollen, the male reproductive bodies of plants (Swindles and Plunkett 2010; Dincauze 2000). Pollen is preserved in bogs and has been studied by palynologists for over 100 years (Birks 2019; Birks and Berglund 2018), but the remains of whole plants known as macrofossils (or macroremains— 'macro' implying they are visible to the naked eye) are as well (Birks 2007). Plants act as particularly important proxies of environmental change, either natural or anthropogenic. Plants invariably shift in community composition in response to changes in climate, hydrology or, importantly via disturbance (Evans 1978). Disturbances may be natural or cultural, but either way, they are important influences upon plant community succession (Huston and Smith 1987).

Peat bogs are both excellent archives of proxy data and extremely susceptible to disturbances and natural influences—making them ideal targets of study (Gearey and Fyfe 2016; Magnan et al. 2018). Peatlands have been utilized extensively by Indigenous peoples in North America, and by Europeans, including the Norse who settled in the North Atlantic. As such, they should be considered components of the 'cultural landscape'—a conceptualization of landscapes that encompasses tangible (plants, animals, place, ecology, land and plant use) and intangible aspects (heritage, meaning) and how these change through time (Andrews and Buggey 2008; O'Rourke 2018). Where peat bogs are situated close to archaeological sites, they will record activities through inputs of charcoal, insects and plant remains (the very stuff of proxy data). However, the study of plant macrofossils is well suited to studying localized changes in plant communities and, therefore, localized ecology (Rydin and Jeglum 2013). Macrofossils have already been utilized to this end in various contexts in the North Atlantic, including in Labrador, where their analysis has been applied to Ancestral Inuit sites (e.g., Roy et al. 2015; Roy et al. 2012) and to Norse sites in Iceland (e.g., Roy et al. 2018; Vickers et al. 2011), among others. An ideal peatland for such study exists at L'Anse aux Meadows (LAM), Newfoundland. It is situated in proximity to the settlement terrace, where humans are known to have lived (Ledger et al. 2019b). It is the subject of this thesis.

LAM is a large multi-component site situated at the apex of the Northern Peninsula of the island of Newfoundland, on the Strait of Belle Isle. It contains archaeological evidence for discontinuous occupation by Indigenous and European cultural groups over the last several millennia. These include the Maritime Archaic, Palaeo-Inuit cultures (Groswater and Dorset), Recent Period (Cow Head and various other complexes), as well as Norse and later Euro-Canadian occupations (Wallace 2012). The site is complex, but occupation centres on several relict beach terraces, the main one containing the well documented Norse component. There are also two peat bogs located in close proximity to the main terrace (the lower bog is situated to the west and the upper bog to the east). The lower bog has been the focus of extensive prior palaeoecological and archaeological investigation and is sometimes referred to as the *sedge bog* in earlier publications (Davis 1985; Davis et al. 1988; McAndrews and Davis 1978; Mott 1975).

The upper peat bog, sometimes called the *Sphagnum bog*, has not received near as much attention in the past, besides some investigation by Kari Henningsmoen (1985) and testing by Parks Canada (Schönbäck 1974). It has, however, been the focus of recent archaeological and palaeoecological inquiry led by Véronique Forbes and Paul Ledger from Memorial University of Newfoundland and Labrador (MUNL) in association with an international team of researchers. This endeavour initially began as a targeted paleoenvironmental investigation, focused on the Norse, but blossomed into a larger project with the discovery of a previously unidentified cultural horizon during sampling of the bog in 2018 (Ledger et al. 2019a, 2019b). It soon became apparent that the newly identified deposit would need further study, and in 2019 I was recruited to undertake a geoarchaeological analysis of it as an MA project. COVID-19 intervened in the execution of this plan, as I was not able to visit the United Kingdom to receive specialist training in the methods necessary to complete this task. Instead, an analysis of plant macrofossils from one monolith (4A800B3-6) was proposed, as this would dovetail with other analyses being undertaken on the same monolith and nearby (palynology, archaeoentomology) and give a valuable and useful view of localized bog palaeoecology and the human influence upon it. While an unplanned deviation, this change proved to be illuminating, even fun (albeit challenging) and ultimately led to the production of the thesis presented here.

1.2 Research Questions

The overall objective of this thesis is to investigate how a peat bog area formed as a result of natural successional processes and anthropogenic disturbance. This is achieved by conducting a high temporal resolution plant macrofossil analysis and performing radiocarbon age-depth modelling and chronological correlation on a monolith (4A800B3-6) taken from the peatland to the east of the settlement terrace at LAM.

More specifically this thesis will address these questions:

1. *Can radiocarbon age-depth modelling and analysis of plant macrofossils help identify discrete episodes of human activity in the peat bog sequence, and attribute them to specific cultural group(s) known to have used the site?*

2. *What are the discernable influences of disturbance and biophysical drivers on the formation of the peat bog sequence, as revealed through a study of plant macrofossils and charcoal?*

1.3 Theoretical Framework

This thesis is in a great part concerned with how humans impacted upon the environment at LAM in the past, sometimes purposefully. As such, it is necessary to use a theoretical framework that views humans as having agency in this regard—and assumes that humans shape their natural environments. Two interrelated theoretical viewpoints (historical ecology and Niche Construction Theory) provide this. Historical ecology takes an historical view towards how landscapes are formed through human action and ecological processes and sees humans as in a dialectical relationship with their environments (Watling et al. 2018). Niche Construction Theory (NCT) is an evolutionary body of theory, which views organisms as having the ability to modify their own and other species' environments and thus impact upon natural selection (Laland and O'Brien 2010). Importantly, NCT also gives agency not only to humans but to all organisms—something that must be considered here as this thesis deals with plant responses as well.

1.3.1 Historical Ecology

A primary tenet of historical ecology is that humans are a keystone species and, as such, they are primary drivers of ecological change in any and all ecosystems they inhabit (Thompson 2013). This is true both for hunter-gatherer populations and for state-level societies. The changes that humans enact may also be purposeful or incidental (Balée 1998; Thompson 2013). For instance, fire can be used with intention or can spread accidentally. Trampling of human feet can also have profound ecological impacts, which may or may not be intentional. Human intentionality is of importance in historical ecology (Balée 2006). This is expressed through the management of natural resources. Management, in this sense, refers to the purposeful manipulation of components of ecosystems to increase biodiversity (Thompson 2013). Actually, it is this process through which natural environments are turned into landscapes (Balée 1998) and ultimately how the human niche is shaped (Watling et al. 2018). Humans thus project culture onto nature (Crumley and Marquardt 1990). However, the human relationship with the natural world must still be considered as a dialogue (Balée 1998). The historical ecological perspective is useful then for thinking about how humans inhabited the landscape at LAM in the long term, acting upon it and shaping it both directly and incrementally in concert with natural processes.

As its unit of analysis, historical ecology considers landscapes (Thompson 2013), seeing them as the "material manifestation of humans and the environment" (Crumley 1994: 6). Landscapes thus form a sort of text which records cultural and natural processes and the interplay between the two (Thompson 2013). Texts, of course, can be read as well (if one is fluent in the language they are written in), and here it might be imagined that macrofossils are the language to be deciphered, holding knowledge about the dialogue between humans and nature at the site. Historical ecologists also operate at a variety of scales, with the goal being to measure the degree and kind of human impact through qualitative and quantitative means (Thompson 2013). In this thesis, a very small section of a monolith acquired from one area in the bog is analyzed, but through doing so, broader knowledge about cultural patterns of behaviour and human action is inferred.

1.3.2 Niche Construction Theory

In order to investigate how environmental interaction (and modification) played out on the level of organisms, both human and otherwise, and afford such organisms yet more agency (in an evolutionary sense), it is necessary to employ NCT. This framework views organisms as not just passive recipients of selective evolutionary pressure but rather as having the ability to influence and guide this process through the construction of their own niches, which in turn influences upon the evolutionary trajectory of other organisms (and subsequent generations of their own) through feedback loops (Laland et al. 2016; Laland and O'Brien 2010). This is an important viewpoint because it considers environmental modifications as having an evolutionary (and agential) basis, including those stemming from humans. Humans are seen as particularly prolific niche constructors (Laland and O'Brien 2010), altering virtually every ecosystem on the face of the planet (He 2019). In this sense, NCT views humans in much the same way as historical ecology, in having a dialectical relationship with nature (Watling et al. 2018). However, any and all organisms likely engage in some sort of niche construction, shaping their environments and in turn the environments of others in myriad ways (Laland and O'Brien 2010), and thus influencing selection pressure (Odling-Smee 2003). For instance, a beaver building a dam has an impact not only upon its own fitness and those of subsequent generations but also influences a multitude of other organisms (Odling-Smee et al. 2013).

Organisms can also be seen to engage in different kinds of niche construction dependent upon how and where they do so. Any change which is produced either through movement of an organism to a new environment (relocation) or in a place where that organism is already living (perturbation) can be classed as *inceptive* niche construction. Organisms may also oppose or counteract any changes either in a familiar or new environment through *counteractive* niche construction (Odling-Smee 2003). Taking an anthropogenic view, humans might engage in *inceptive* niche construction through the use of fire as a landscape modification tool. However, humans are not the only creatures that engage in this, and such processes may be augmented or even counteracted by other organisms. *Sphagnum* moss, a primary species in peatlands (Rydin and Jeglum 2013), is a prodigious habitat modifier. Once it becomes established, it will create an environment not suited to most other species (except for certain bog plants) through the release of acids and formation of waterlogged conditions (Rydin and Jeglum 2013). This will have implications for future generations as well, as they are guided and shaped by the selection pressures established within that environment by previous generations of *Sphagnum*—demonstrating feedbacks between the organism and the environment itself (Laland and O'Brien 2010). However, humans might impact upon *Sphagnum* where it occurs through trampling, cutting, drying or flooding of environments. Indeed, organisms are interconnected, which can, in some instances, lead to co-evolution (Laland et al. 2016; Laland and O'Brien 2010). NCT then can be seen as an explanation for how and why organisms change their environments. Overall, it is an important framework for investigating the construction of ecological niches (human and otherwise) at LAM.

1.4 Thesis Outline

Chapter 1 introduced the reader to the background behind the use of the plant macrofossil analysis methodology, the study of peat bogs and the general aims and objectives of the project. Chapter 1 also provided the theoretical framework. Chapter 2 serves to establish the state of knowledge necessary to address how peatlands were utilized and impacted upon by anthropogenic processes, which is necessary for answering the research questions as dealt with in the discussion (chapter 5). Chapter 2 also addresses the utility of peatlands as palaeoecological archives, which is of relevance to the thesis as a whole. Chapter 3 provides background information on the site geography, its cultural history and previous work. This overview is useful for contextualizing the current study and interpreting how this project is both similar to and differs from work undertaken in the past. Chapter 4 first explains the methods used in the project, including fieldwork and sampling, plant macrofossil analysis, charcoal and sediment analysis, radiocarbon dating and age-depth modelling. Following this, chapter 4 provides results of the various analyses undertaken and interprets them in regard to successional processes and bog formation. Chapter 5 answers the research questions by discussing how (and if) radiocarbon age-depth modelling and plant macrofossils can be used to discern anthropogenic events in the peat sequence, and the influence of disturbance and biophysical drivers on the successional history of the peat bog area. Chapter 6 provides concluding remarks. Directions for future research are also suggested.

Chapter 2. On Peat Bogs and People

This chapter serves to introduce the reader to the ecology of peat bogs and delves into what is known about their cultural uses by Indigenous peoples and Europeans (especially the Norse). Following this introduction to bogs, the value of peatlands as palaeoecological archives and disturbance processes germane to these environments are discussed. The text presented in this chapter builds on a topical literature review on the use of peat bogs by Indigenous Peoples in northern North America, which was published in the *Journal or Arctic, Antarctic and Alpine Research* as part of an article I co-authored with my supervisor (Speller and Forbes 2022). Most sections here draw from this article, however, I have edited and reformatted the text to better integrate the literature review into the thesis project as a whole, and to avoid unnecessary repetitions. Information pertinent to the Norse has also been added where appropriate. The section dealing with the peat bog at LAM specifically has been substantiated and edited, to better contextualize the original plant macrofossil analyses I conducted (chapter 4) within previous palaeoecological research at the site.

2.1 Peat Bog Ecology

Peat bogs, or "peatlands", as they are commonly referred to within the scientific literature, are a class of wetland, and as such, they are water-saturated. In fact, it is the wetness of bogs that hinders decomposition due to lack of oxygen and allows organic material to build up over time, forming deposits that are called peat. Peat deposits tend to be relatively acidic, and therefore only particular plant species can grow in peat bogs

(Johnson 1985). *Sphagnum* moss is an important contributor to bogs since it can hold large amounts of water. It grows upwards, while the bottom of the plant dies, which adds to peat accumulation (Johnson 1985). S*phagnum* also contributes to bog acidity through the release of polyuronic, humic and fulvic acids (Lavoie et al. 2005).

Peatlands form through two main processes, terrestrialization and paludification (Anderson et al. 2003 Charman 2002; Lavoie et al. 2005, Rydin et al. 2013). Terrestrialization refers to the gradual infilling of waterbodies with organic material as well as inorganic sediments (Anderson et al. 2003 Lavoie et al. 2005). Paludification is the transformation of dry land into peatland. In northern regions, including Canada, paludification was an important factor in initial bog formation (Crum and Planisek 1988). This process begins when organic material starts to accumulate at a rate that exceeds its removal through decay, which usually begins in basins but then spreads outwards across the landscape (Lavoie et al. 2005).

Peatlands are commonly divided into fens, which are rheotrophic (flow-fed) and bogs, which are ombrotrophic (rain-fed). In the strictest sense, fens tend to be more nutrient-abundant since they are enriched through inputs of water via streams or springs, whereas bogs are nutrient-poor and acidic (Moore 2002). In practice, however, many bogs may have some input from groundwater or other sources and may vary in acidity throughout their extent, with some areas being more minerotrophic (mineral-enriched) than others (Wheeler and Proctor 2000).

In Newfoundland, peatlands can be further divided into domed, plateau, blanket, basin and slope varieties. Fens consist of slope, ladder and ribbed types. As the name suggests slope fens/bogs generally form on slopes. Basin bogs form in basins in the landscape (Wells and Pollett 1983). Plateau bogs are almost flat at the centre but slope at the margins (Rydin and Jeglum 2013). Raised bogs are noticeably higher than the surrounding topography, often taking on a domed appearance in the middle (Godwin 1981; Rydin and Jeglum 2013). Blanket bogs are non-raised bogs, which can cover broad swaths of landscape owing to a surplus of localized atmospheric moisture (Rydin and Jeglum 2013). Under certain conditions fens forming on slopes can develop patterning crosswise to the slope they develop on. Varieties of patterned fens include ladder and ribbed (Rydin and Jeglum 2013: 220). Bogs are the most common type of peatland in Newfoundland; they are treeless and receive input mostly through precipitation. In some bogs peat thickness can reach up to 10m, but it is generally less. Peat thickness in Newfoundland fens is usually thinner and ranges between 1m to 3m (Wells and Pollett 1983).

2.2 Uses of Peat Bogs

Despite the relative prevalence of peatlands—Canada alone contains approximately 1,132,614 km^3 (Xu et al. 2018)—these environments have been greatly overlooked by North American archaeologists (Nicholas 1998, 2006). Consequently, there is a very slight archaeological corpus of literature to draw from when writing about peat bogs on the continent. North American ethnobotanists have paid greater heed to peatlands, if only indirectly, through describing and mentioning the Indigenous cultural use of plants sourced from them. However, it is evident, from the small body of archaeological literature and from the scattered mention of bog plants in ethnobotanical publications, that peat bogs were used extensively by Indigenous peoples, and not ignored, as has sometime been alleged (e.g., Crum and Planisek 1988: 172). Peatlands have been studied in much greater detail, by archaeologists and palaeoecologists alike, regarding their usage by Europeans (Gearey and Fyfe 2016; Gearey et al. 2010; Godwin 1981), including the Norse in the North Atlantic (Forbes et al. 2014: Ledger 2013: Simpson et al. 2003).

Through drawing upon the published literature, this section aims to demonstrate the use of peatlands by Indigenous peoples in North America, as well as by Europeans, especially the Norse. Below, examples are given for the use of particular bog plants, the use of peat and sod as construction material, the use of peatlands as occupation surfaces, for grazing, and for the extraction of bog iron. Peatlands as palaeoecological archives are then discussed, including the specific human impacts upon peatlands through the use of fire and as a consequence of trampling.

2.2.1 Harvesting and Use of Bog Plants

2.2.1.1 Berries

Indigenous groups throughout northern North America harvested berries. The presence of certain species within bogs would have been an important draw to these areas. Bog cranberry (*Vaccinium oxycoccos*) is a member of the heath family (Ericaceae) native to open, acidic bog and fen environments, which produces a small red edible fruit (Davis 2016). On the Northwest Coast, the Kaigani Haidi of southeast Alaska collected bog cranberry when the fruit was firm (Norton 1981). The Kwakwa̱ka̱'wakw in British

Columbia made use of bog cranberry, picking them in the fall and either consuming them directly or steaming them (Turner and Bell 1973). Near Nain in Labrador, bog cranberries (locally called marshberries) were also noted as being harvested by the Inuit in small quantities (Boulanger-Lapointe et al. 2019). The Napaskiak Yup'ik would also gather bog cranberries opportunistically during their salmonberry picking trips (Oswalt 1957). Amongst the Katzie (Coast Salish), cranberry bogs were owned, and outsiders had to ask permission to harvest cranberries (Suttles 1955).

As a member of the Ericaceae family, bog cranberry reappears relatively quickly after a fire since it can regenerate from rhizomes below the bog surface (Damman 1978). Fire was specifically used on cranberry bogs on the Northwest Coast to increase berry yield and manage tree growth (Anderson 2009). Biggs (1976) suggested that the Coast Salish set fire to the Burns Bog in the Fraser Delta, British Columbia, to increase the abundance of berries, which likely included bog cranberries as these were recorded as being present there (Giblett 2014). Fire was likely used elsewhere to manage blueberries as well, since they will increase in yield several years after a light to moderate burn (Lavoie and Pellerin 2007; Nelson et al. 2008).

Bog blueberry/bilberry (*Vaccinium uliginosum*) occurs predominantly in *Sphagnum* bogs. The Coast Salish on Vancouver Island would gather bog blueberries and either dry them or eat them raw (Turner and Bell 1971). The Inuit in western Alaska made extensive use of bog blueberry (Anderson 1939; Oswalt 1957). It is likely that the Norse utilized bog blueberry in Iceland as well (Svanberg and Ægisson 2012).

R. chamaemorus (commonly referred to as bakeapples or cloudberry) is a member of the Rosaceae family with a circumpolar and boreal distribution, although it also occurs further south (Thiem 2003). It is found predominantly in bogs (Karst et al. 2008). The Haida in British Columbia and Alaska were extremely fond of *R. chamaemorus* and would eat them in large quantities (Turner 2004). According to Oswalt (1957), *R. chamaemorus* was the most important plant food consumed by the Napaskiak Yup'ik in Alaska. The berries would be consumed over the winter as a principal component of *agu'tuk* (Oswalt 1957), which was produced through mixing fat with berries (Zutter 2009). Bog blueberries would sometimes be mixed into *agu'tuk* as well (Oswalt 1957).

Throughout Inuit Nunangat, which comprises the Inuit homeland in Canada, Boulanger-Lapointe et al. (2019) identified bog blueberry and bakeapple (or cloudberries) as commonly picked species, both of which occur predominantly in bogs. For instance, the Kiluhikturmiut Inuinnait picked bakeapples and bog blueberries, which were eaten raw mixed with fat (Davis and Banack 2012). Analysis of a human coprolite sample from the 18th century Inuit Uivak 1 Site (HjCl-11), near Okak in Labrador, revealed high concentrations of seeds from blueberries and crowberries (*Empetrum nigrum*) as well as black globules, which were identified as probable animal fat residues. This was interpreted as evidence of the mixing of fat with berries (Zutter 2009). In general, berries were an important secondary food source at the site, as demonstrated by the high densities of both blueberry and crowberry seeds in the house and midden (Kaplan and Woollett 2000). Crowberry (and *Vaccinium*) seeds have also been identified in archaeological fecal samples from Norse contexts in Iceland and it is likely crowberries were consumed as food there by the Norse (Ross and Zutter 2007). In Iceland, communion wine was even made from crowberries at one point, and there is archaeological evidence for their consumption in Greenland as well (Arneborg et al. 2012; McGovern et al. 1983). At Sandnes in western Greenland, crowberry and *Vaccinium* seeds were found together in small heaps, interpreted as the remains of feces (Arneborg et al. 2012).

2.2.1.2 Sphagnum

Sphagnum moss, otherwise known as peat moss due to its recognized role in forming peat bogs, is a genus of moss composed of around 300 species (Michaelis 2019). Indigenous North Americans widely used *Sphagnum* for various purposes, many of which cut across cultures, but some of which are unique. Long recognized for its absorbency, *Sphagnum* moss has been employed as a diaper material (Thieret 1956), as a feminine hygiene product (Kimmerer 2003), and for bandages (Turner 1998). Davis and Banack (2012) record that amongst the Kiluhikturmiut Inuinnait of Nunavut, Canada, *Sphagnum* was used for all three purposes. On Nunivak Island, Alaska, the Nunivaarmiut (Yup'ik) made diapers by placing dried *Sphagnum* in a seal skin (Lantis 1946). The Wet'suwet'en and Gitxsan peoples of British Columbia also made use of *Sphagnum* for diapers (Harris 2008).

Sphagnum was utilized in other diverse and imaginative ways. Indigenous Alaskans made a salve for application on cuts by mixing *Sphagnum* with animal tallow or grease (Thieret 1956). The Kiluhikturmiut Inuinnait used *Sphagnum* as insulation and as a coating on sled runners (Davis and Banack 2012). The Napaskiak Yup'ik were also known to chink their log houses with *Sphagnum* (Oswalt 1957), and the moss may also have been employed for soapstone lamp wicks (Llano 1956).

2.2.1.3 Myrica gale

Myrica gale, otherwise known as sweet gale or bog myrtle, is a deciduous shrub found in bogs (Skene et al. 2000) that was utilized in medieval Europe, including by the Norse. In particular, *M. gale* was commonly used in medieval brewing as the *gruit*, which was a substitute for hops used in order to allow beer to keep better, among other purposes (Verberg 2018; Zimmerman 2018). As a beer additive, *M. gale* was especially popular in Nordic countries (Meussdoerffer 2009). *M. gale* found at the Danish Viking Age site of Viborg Søndersø has been interpreted as being used for brewing as well as a deodorizer and for brush making (Robinson et al. 1992). It may also have been introduced to Iceland for the purposes of brewing (Sveinbjarnardóttir 1981). In Icelandic, it is called *mjaðarlyng/þors*, literally meaning mead/beer heath (Vijūnas 2007: 136). However, *M. gale* is not found in Greenland (Böcher et al. 1968). There even appears to have been a medieval European trade in *M. gale*, likely for the purposes of brewing, and the raw plant material was subject to taxation in Denmark, thus showing its economic importance (Simpson et al. 1996). There is some indication that *M. gale* was used by Indigenous people in North America as well (Kari 2020; Porter 2007), including potentially for smudging (Guedon 2000).

2.2.1.4 Other Plants

Many different plants acquired from bogs were used for myriad purposes. Common sundew (*Drosera rotundifolia*) is an insectivorous plant native to bogs (Davis 2016), which was utilized by the Kwakwa̱ka̱'wakw for removing warts, corns, and bunions. Kwakwa̱ka̱'wakw men also used it as a love charm, whereby it was mixed with salamander toes and another plant (either *Habenariaa* or *Hypopites monotropa*) (Turner and Bell 1973). The Coast Salish of British Columbia were also likely familiar with sundew since they would have encountered it when venturing to bogs to collect other plants, such as Labrador tea (*Rhododendron groenlandicum*), which on Vancouver Island only grows in *Sphagnum* bogs, and was made into a tea by the W̱SÁNEĆ and likely other Coast Salish groups as well (Turner and Bell 1971).

Cotton grass (*Eriophorum* spp.) is a genus of the sedge family consisting of several species that are tolerant of acidic bog conditions and known to grow there (Davis 2016). It is so named for the cotton-like tufts that grow on the seed head of the plant. Cotton grass was made into wicks for oil burning lamps by some European group (Svanberg 1998), including by the Norse in Iceland (Byock 2001). The use of cotton grass for making *kudlik* (soapstone lamp) wicks and bandages have also been broadly documented around the circumpolar north by Indigenous groups (Lazarus and Aullas 1992; Small and Cayouette 2016), including amongst the Labrador Inuit (Zutter 2009). Pigford and Zutter (2014) recovered cotton grass phytoliths from residues on soapstone fragments at the 18th-century Labrador Inuit site of Dog Island-Oakes Bay I (HeCg-08). According to Zutter (2009), Labrador Inuit also used sedges (*Carex* spp,) and rushes (*Juncus* spp.), which grow in bog and wetland environments for making floor coverings and woven mats.

The purple pitcher plant (*Sarracenia purpurea*) is a carnivorous perennial herb in the pitcher plant family (Davis 2016). It is endemic to bogs, poor fens and other acidic environments. It can be found along the Atlantic coast as far north as Labrador and as far west in Canada as the eastern edge of the Rocky Mountains (Ellison et al. 2004; Johnson 1985). The Mohegan folklorist Gladys Tantaquidgeon (1932: 266) noted that it was called "*alk tsotaco"* or "toad legging" by the Lac Saint-Jean Innu. The leaves of the plant were boiled, and the resulting liquid used to treat sores and children's rashes. The split leaves of the plant would be placed over affected area to treat the same ailments. The plant could also be used to relieve smallpox (Tantaquidgeon 1932).

2.2.2 Peat and Sod as Construction Materials

Throughout arctic and parts of subarctic North America, the Inuit, Ancestral Inuit and pre-Inuit built semi-subterranean houses using blocks of earth and surface vegetation (variably referred to as "sod" or "turf"), which were usually harvested from bogs or other types of wetlands. These were placed onto a framework constructed either from whalebone or wood, depending on the availability of either resource (Arnold and Hart 1992; Park 1988; Renouf 2003). This method of construction was used in many areas well after the time of European contact (Auger 1993; Beaudoin et al. 2010; Knudson and Frink 2010; Lee and Reinhardt 2003). Sometimes, peat would also be utilized in the construction of these dwellings, and there is some evidence for its purposeful selection as building material. For example, in the course of their research on the Qijurittuq Site

(IbGk-3) on Drayton Island in Quebec (where Ancestral Inuit built 13 semi-subterranean houses using peat along with other materials in the construction of the walls and roofs), Inuit elders were interviewed about traditional construction techniques and indicated that peat was employed, at least in part, because it provided good protection from the wind, and that peat was used when there was no snow (Lemieux et al. 2011). According to Barbel et al. (2019), peat was commonly used by the Ancestral Inuit to build the peripheral walls of houses since it provided good insulation from the cold, and it was shown to have been used at the Ancestral Inuit sites of Oakes Bay 1 (HeCg-08) and Koliktalik 6 (HdCg-23) in Labrador (Roy et al. 2012). Fitzhugh (2019) notes that on the Quebec Lower North Shore, the Inuit utilized peat along with sod, skins and wood for constructing houses. The mixing of peat and other materials would seem to indicate that it was employed purposefully to a particular end. Habitation sites, many of which were previously occupied by pre-Inuit groups, may also have been selected by the Ancestral Inuit, at least in part, for their proximity to peat deposits (Barbel et al. 2019). This is evident at Diana Bay, Quebec, where there are over 100 habitation sites situated adjacent to peatlands from which material could be conveniently obtained for house construction (Bhiry et al. 2016).

Like many Indigenous communities living in subarctic and arctic regions, European peoples who lived in similar settings developed specific traditions and practices to harvest and use peat and sod (or turf, as it is most commonly known in a European context) as building materials and for other purposes (Forbes et al. 2014; Milek 2006, 2012; Ólafsson and Ágústsson 2000; Stefánsson 2019; Steinberg 2004; van Hoof and van

Dijken 2008). Particularly in Iceland, but also elsewhere in the North Atlantic, the Norse constructed buildings from blocks of turf often sourced from peat bogs (Schofield et al. 2008). Longhouses and outbuildings alike could be constructed from this handy material. In Iceland, the homefield closest to the farmstead was usually enclosed in a wall made from turf, and turf could even be burned for heat (Byock 2001; Price 2020).

2.2.3 Peat Deposits as Occupation Surfaces

Archaeological work on the island of Newfoundland has revealed several instances of the surface of peat bogs being used as living spaces and/or activity areas by Indigenous groups during the Recent Period (ca. 0 to 1500 CE, Hartery 2007). Archaeological evidence for this occurs where occupation layers, formed by the accumulation of materials resulting from human occupation or activities having taken place, are identified in bogs. One such occupation surface was identified at the Gould Site (EeBi-42) at Port au Choix by Renouf et al. (2009), where it is apparent that during the site's Recent Period occupation, people were actually living on top of the peat deposit that covered the site at the time (Renouf et al. 2000; 2009; Teal 2001). Excavations uncovered charcoal, fire-cracked rock and cultural materials all contained within a thick layer of peat, in addition to several pit features that appear to have been dug into the peat layer underlying the occupation surface. Similarly, at the Peat Garden Site (EgBf-6) near Bird Cove, excavators uncovered the remains of ten hearth features sunk into the peat layer, which was the living surface during the Recent Period (Cow Head complex) occupation of the site (Hartery 2007; Hartery and Rast 2001). One of the hearths was even lined with clay, which may have been used to create a barrier with the underlying water-saturated peat (Hartery 2007). The previously undocumented cultural layer uncovered in a *Sphagnum* peat bog at LAM in 2018 (Ledger et al. 2019b), could potentially be seen to fit this pattern as well.

2.2.4 Peatlands as Grazing Areas

Peatlands were often used for grazing livestock, including by the Norse. This practice has a long history, including in Bronze Age/Neolithic Scotland (Turner 2013), and it is carried on to the present day in some locations including the Falklands (Mauquoy et al. 2020). The practice of gathering hay from fens is still carried out to some degree in Norway as well (Lyngstad et al. 2016). In Iceland, there is an historic tradition of gathering hay from sedge bogs, which extends all the way back to the medieval Norse (Ritchey 2019; Zutter 1999). Animals might even be grazed directly on bogs as they could be used year-round, with rushes and sedges targeted in the summer and woody species in the winter (Brown et al. 2012). This practice also seems to have been carried out elsewhere in the Norse North Atlantic, and it is quite possible that it extended to LAM as well (Robertson, n.d.).

2.2.5 Peat Bogs as Sources of Iron

A further resource and certainly one of great value to the late Iron Age culture of the Norse was bog iron. In bogs and associated watercourses, under specific chemical and bacterial conditions, natural iron dissolved in groundwater will form into impure concentrations known as bog iron (Wallace 2003a), which can then be turned into iron through smelting, usually in a bloomery furnace (Thelemann et al. 2017). The Norse were aware of and used this technology in the North Atlantic (Evans 1948), including at LAM (Wallace 2003a).

2.3 Peat Bogs as Archives of Human-Mediated Environmental Change

Plant macroremains/macrofossils are plant remains that are large enough to be seen by the naked eye (but usually studied under magnification) and manipulated by hand (Birks 2007; Mauquoy and Van Geel 2007). Plant macrofossils are preserved where decay is stunted, including in arid (desiccating) and anoxic environments, especially those that are waterlogged (Birks 2007). In some environments (especially alluvial ones), macrofossils can be transported some distance before deposition. However, in peatlands, macrofossils are generally representative of *in situ* deposition, as they are the remains of plants that lived and died on the bog, being subsequently transformed into peat (Birks 2007). That is why peat has been described as a sedentary (as opposed to sedimentary) deposit (Rydin and Jeglum 2013).

Because macrofossils in peat bogs remain in place, usually accruing vertically, they represent a chronostratigraphic record of how bogs formed. Therefore, they are a perfect tool for studying plant succession and disturbance in bogs. *Succession* refers to short-term directional changes in the composition of species over periods of decades; longer-term changes, for instance, over centuries or millennia, is termed *development* (Rydin and Jeglum 2013). Succession can be broken down into primary and secondary. Primary succession is the colonization of new environments by organisms (e.g., post-glaciation), whereas secondary succession is colonization as a result of disturbance (Rydin and Jeglum 2013). Disturbance quite simply is any factor, event or process that impacts upon the successional progress of an ecosystem (Wessels 1999). In peatlands, disturbances may be cultural or anthropogenic and thus can include peat extraction, climate change, fire, and nutrient deposition, among others (Andersen et al. 2013). The result of disturbance in peatlands (as in all ecosystems) is a shift in the composition and/or abundance of plant species. These changes can be directly studied by looking at macroremains from successive layers in the peat strata in order to infer how species composition changed through time in response to disturbances. Inferences regarding moisture conditions can also be made based on the plants present, since particular species are adapted to specific moisture conditions. Through this, an in-depth picture of how bogs developed can be arrived at (e.g., Barber et al. 2003). Peat bogs will also incorporate and preserve evidence of direct and indirect human impact, including fires as evidenced by charcoal horizons, plants introduced to the environment in the past by people and even artifacts, thus making them valuable archives of both palaeoecological and archaeological data.

The human presence on bogs can also have particular ecological impacts, all of which fall under the banner of disturbance. Some of these disturbance impacts are unintentional—like those that derive from trampling or wildfires. However, some can also be intentional, particularly those that result from the anthropogenic use of fire. Fire especially can be seen as an instrument of niche construction when applied purposefully (Thompson et al. 2021).

2.3.1 Trampling

Trampling can have an adverse effect on peatlands and, as such, is an important allogenic (external) disturbance factor. Frequent trampling, especially by livestock or deer (and often in association with fire and/or grazing pressure), can destroy surface vegetation leading to bare peat surfaces (Pellerin et al. 2006), making bogs susceptible to erosion (Sjögren et al. 2007). Water may run off more easily if peat pores become compacted (Bragg and Tallis 2001). Peat can also decompose more readily as a result of trampling by creating a moisture differential between depressed areas and the bog surface (Sjögren et al. 2007). Additionally, trampling can cause peat to become aerated, promoting decay (Sjögren et al. 2005). Some plants, especially *Sphagnum* moss, are susceptible to trampling and even infrequent episodes will reduce or eradicate them from bogs (Spitale 2021; Studlar 1980). While these changes are most visible (and most studied) in regard to livestock, humans can also impact upon bogs if their trespasses are frequent enough (Studlar 1980). Within some organic deposits, trampling will produce laminated surfaces and horizontally oriented materials (Rentzel et al. 2017). Specific micromorphological features may also be present, although there is some debate as to whether they remain in peat (Ismail-Meyer et al. 2013).

2.3.2 Fire

Fire constitutes an important allogenic disturbance factor in peatlands (Le Stum-Boivin et al. 2019; Väliranta et al. 2017; Zoltai et al. 1998). Its occurrence can have profound impacts upon secondary succession (Rydin and Jeglum 2013). Fires can occur naturally in peatlands (Kuhry 1994), however, fires close to known habitation sites, such as at the heavily occupied LAM, and correlated with known occupations by way of radiocarbon dating, are assumed to be cultural (Florescu et al. 2018). Ideally, cultural attribution of fire, as opposed to natural, should follow multiple lines of evidence (Bal et al. 2011). Peat will capture both charcoal from fires in the surrounding area as well as localized charcoal from *in situ* burns (microcharcoal may come from even greater distances). Therefore, some inference based on successional plant community evidence and correlation with cultural practices elsewhere is needed to discern whether charcoal peaks in peatlands signal burning of the peat surface. Couillard et al. (2019: 377) noted that “burnt bogs produce macroscopic charcoals buried concurrently in the peat deposit, often in the form of charred horizons.” Indeed, as Pitkänen et al. (2001: 599) observed, "charcoal horizons in peat are indisputable evidence of local or in-situ fires." However, only particular kinds of bog fires will leave much evidence; smouldering peat fires may leave none (Zaccone et al. 2014). Localized (*in situ*) fires that burn woody material will leave macrocharcoal as evidence (Sillasoo et al. 2011). They may also leave charred vegetation such as branches or seeds (Markgraf and Huber 2010).

If fires are strong enough, they can also impact peatland microtopography and hydrology, leading to wet shifts (replacement of dry-adapted plant species by wet-adapted ones; Sillasoo et al. 2011). Fires that are severe will level the bog topography, leading to colonization by plant communities amenable to fire disturbance and thus vegetation succession. Bog hummocks can effectively be transformed into hollows with shifts in attendant plant communities adapted to these microtopographic environments (Sillasoo et al. 2011). As opposed to autogenic successional changes, which are generally slow, successional shifts related to fire are rapid and can manifest in episodic changes in plant composition (Tuittila et al. 2007). This pattern was observed in two bogs in Estonia that were studied by Sillasoo et al. (2011), whereby charcoal peaks indicative of fire events were followed by discernable wet shifts. Depending on fire severity, species composition may shift considerably or only slightly (Sillasoo et al. 2011). Over a period of decades, plant communities will also generally revert back to their pre-fire conditions (Kuhry 1994).

Particular plants and plant communities will respond advantageously to fire. In some environments, Ericales will generally increase in abundance several years after a fire, likely owing to rhizomatic germination (Boiffin et al. 2015; Damman 1978). An increase in Ericales abundance post-fire has been noted in pollen-based research (Yeloff et al. 2006). Several plant species will opportunistically colonize burned over peat surfaces. *Polytrichum* species especially will grow on bogs several years after a fire (Bauer and Vitt 2011; Sillasoo et al. 2011). *Sphagnum* moss may also take hold following fire (Kuhry 1994), especially since it can effectively colonize through spore dispersal (Sundberg and Rydin 2002).

Peatlands often experience regular naturally generated burns at varying intervals (Kuhry 1994; Zoltai et al. 1998); however, there is also a long history of the Indigenous use of fire within North America for purposeful landscape modification, including within peatlands (Turner 2014) and in the boreal forest (Lewis and Ferguson 1988). Fire was often applied to increase the yield of particular plant species, including berries (Anderson 2009; Crum and Planisek 1988; Lacourse and Davies 2015; Lavoie and Pellerin 2007) and to manage plant succession and create habitats amenable to game animals (Cronon 2011). Many grazing species prefer open meadow-like habitats, something that the purposeful application of fire could produce (Fowler and Konopik 2007; Stewart 2002). Don Holly Jr. (2013: 149) speculated that fire had been utilized on Fogo Island to such an end by the Beothuk and their ancestors, and it would seem reasonable that this is the case elsewhere in Newfoundland and Labrador as well, including potentially at LAM.

Fire was also utilized by the Norse in the North Atlantic, including in Greenland, Iceland and the Faroes, during the *landnám* (land-taking) phase of initial settlement (Dugmore et al. 2005). It was purposefully employed to clear the land (Iversen 1934) and promote the growth of plants useful for animal fodder, especially grasses (Ledger 2013; Schofield et al. 2008). Archaeologically, this manifests as a charcoal layer found in many early field systems where the Norse established farms on the North Atlantic islands (McGovern et al. 1988). Indeed, by the time the Norse reached Newfoundland, there was already a long and established cultural pattern of the use of fire.

Chapter 3. L'Anse aux Meadows: Physical Geography, Archaeology and Palaeoecology

LAM is located at the northern tip of the island of Newfoundland (fig 1). It remains an extremely popular tourist destination in the province, with tens of thousands of visitors to the site annually (Parks Canada 2019). It has also been the focus of extensive archaeological excavation (Ingstad 1977; Wallace 2003a). Physically, the site consists of several relict beach terraces that have been the locality of settlement for various cultures over the years. On the largest terrace sits the main part of the Norse site (fig 2), but there are archaeological remains of many cultures there as well, which is why it is referred to below as the 'settlement terrace'. Directly in front (to the west) of this terrace sits the lower (sedge) bog, while behind it (to the east) sits the upper (often called the *Sphagnum*) bog, which is the focus of this project. The land rises behind the site to the east, hemming it in—a large stone ridge to the south-east further adds to this effect. To the north lies the village of L'Anse aux Meadows, and to the west, beyond the lower bog and another terrace (containing the Norse smelter shed), sits Epaves Bay (part of the larger Sacred Bay). There are also several offshore islands in the distance to the northwest offshore of LAM. A stream (Black Duck Brook) originates in a pond higher up in the hills and winds its way through the site, emptying into the bay. It is an idyllic location, and one can certainly appreciate why various cultures chose to live there in the past.

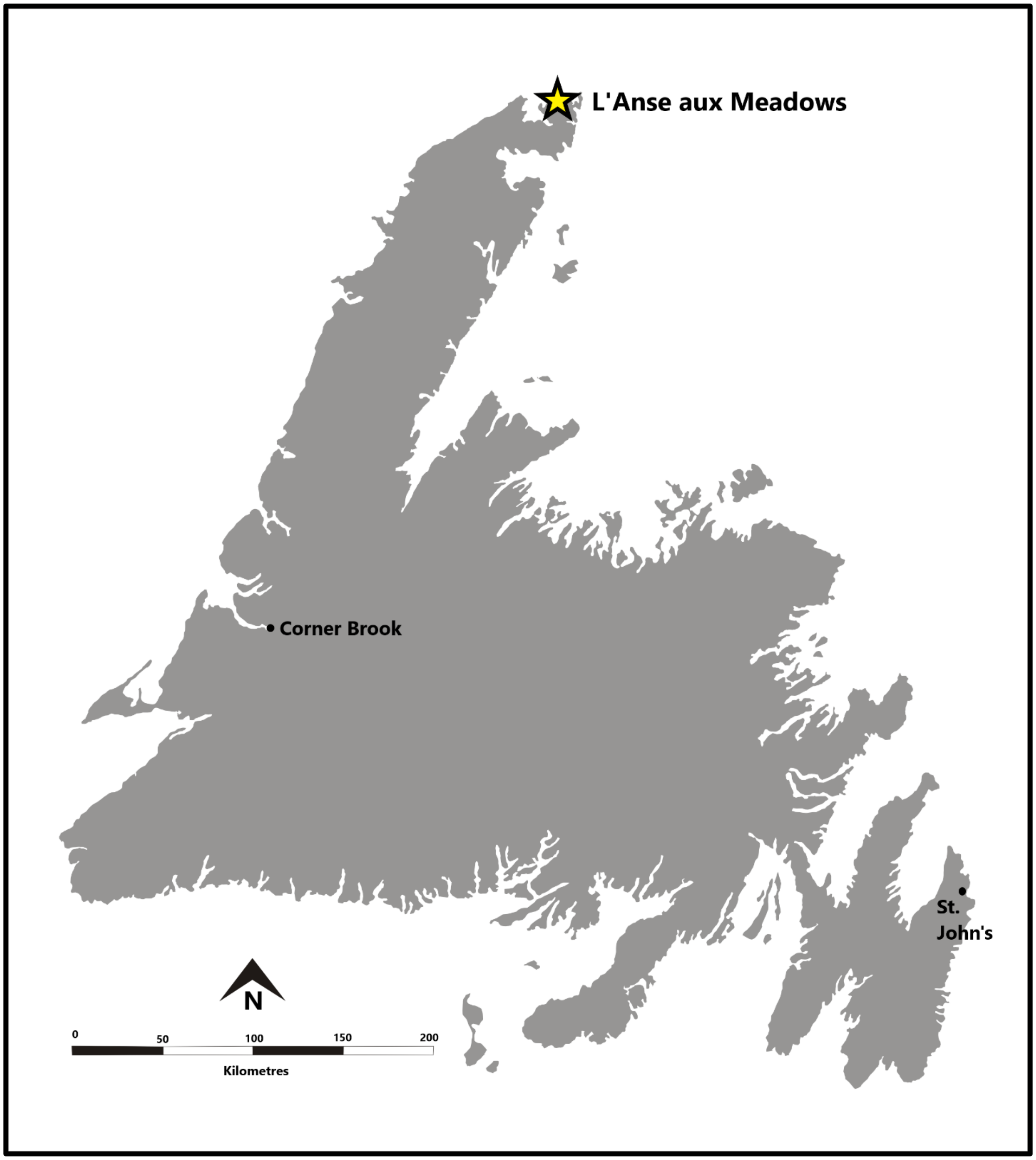

Figure 1. Map of L’Anse aux Meadows in relation to the rest of insular Newfoundland.

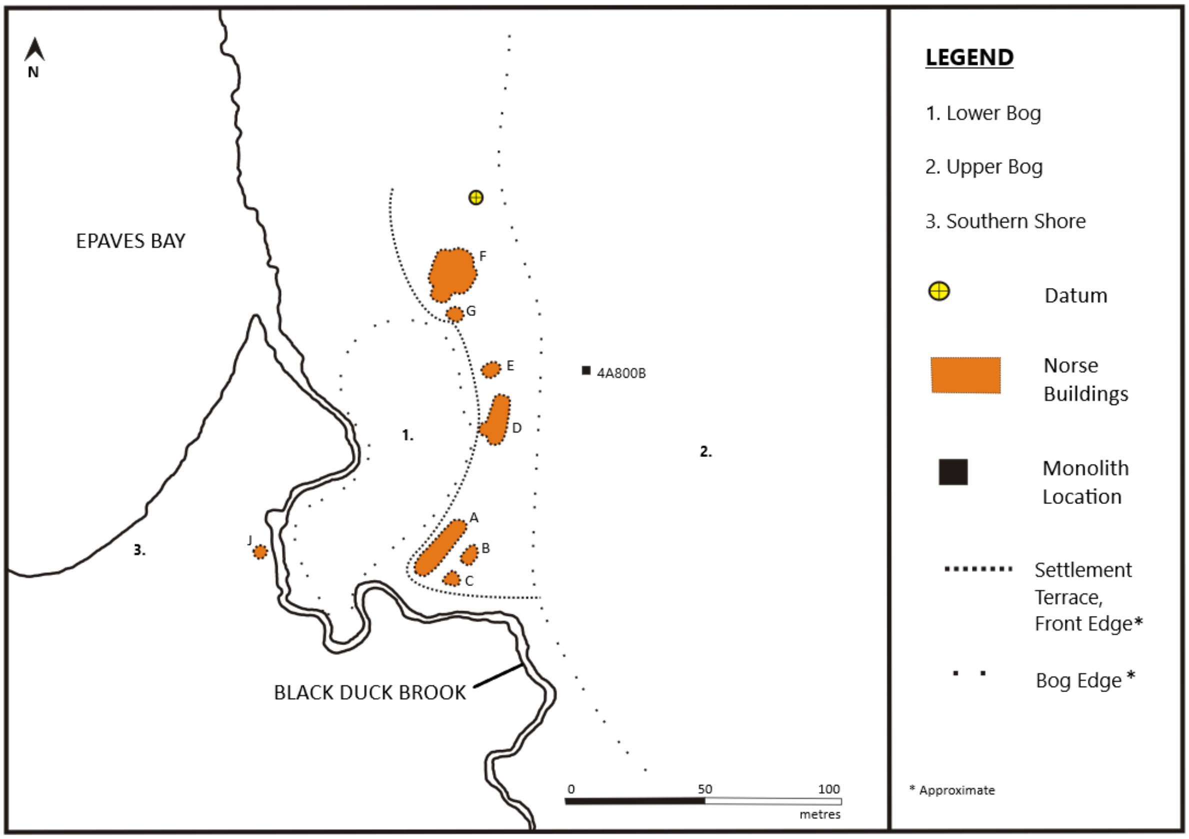

Figure 2. Map of the main site area at L'Anse aux Meadows. Based on a previous map by Bryn Tapper.

3.1 Physical Geography

The major relict beach terraces at LAM formed at least 5000 years ago (Davis et al. 1988). Relict gravel beaches are found quite far inland as well, having been left there as a result of isostatic rebound following deglaciation (Bell et al. 2000). Prior glaciation has shaped the landscape in many ways, both within the site and regionally, with subsequent changes wrought by erosional forces. Bare rock surfaces with glacial striations, areas shaped into basins and knobs and boulder erratics are common locally (Bell et al. 2000). Geologically, the low-lying areas at the site are underlain by mélange (large-scale breccia). Outcropping of the Maiden Point Formation is common, with exposed sandstone, shale, and greywacke as well as quartz pebble and conglomerates (Cumming 1975). The prominent ridge to the southwest of the settlement terrace occurs at the zone of contact between the firmer greywacke and the softer mélange. The mélange underlying the site also contains iron nodules and cubes, which are transported by groundwater and then biologically transformed into bog iron (Cumming 1975).

Organic deposits occur in many areas. Peat is quite common as a surface veneer and also occurs as deeper deposits. Locally these form bogs and fens (Grant 1992). The bogs around the LAM area can broadly be classified as basin bogs—originating in basins in the landscape. Many of these likely take the form of plateau bogs, having formed in flat basins between relict beach ridges. They contain sloping margins but have flat to undulating surfaces (Wells and Pollett 1983). So-called "flat bogs" were identified by both Davis (1980) and Gimbarzevsky (1977) at the site. The flat bogs are thought to be ombrotrophic due to thick levels of peat accumulation having raised their surfaces above the water table (Davis 1980). The slope fen variety is also quite common (Davis 1980; Gimbarzevsky 1977).

LAM falls within the Northern Peninsula climatic zone as defined by Banfield (1983). Within this zone, long cold winters with continuous snow cover and short cool summers are the norm. Extreme cold temperatures can reach as low as -37.5°C in the winter and as high as 30°C in the summer (Bell and Renouf 2011). However, temperatures are generally more moderate. Annual precipitation near the Strait of Belle Isle averages between 760-900mm annually, and 900-950mm elsewhere near the coast (Bell and Renouf 2011). On the Northern Peninsula up to 300cm of this may fall as snow.

There are generally 120 days a year without frost, beginning around June 10 (Banfield 1983). Due to climate change, the average annual temperate of the Northern Peninsula and Newfoundland as a whole is rising (King 2020).

The entirety of the park is influenced by the cold Labrador Current and has an Arctic character in terms of vegetation (Gimbarzevsky 1977), lying within a transitional region between the tundra and boreal forest (Davis 1980). Major vegetation communities consist of those defined as forest, tuckamore, heath, snowbed, wetland, coastal and anthropogenic (Davis 1980; Gimbarzevsky 1970). Wetland communities occupy over 30% of the park and occur on poorly drained areas with high organic accumulations. They can be further broken down into marshes (fluvial, lentic and tidal) as well as fens (slope fen and patterned fens) and *Sphagnum* bogs (Gimbarzevsky 1977). Slope fen communities are predominant, occurring on organic land types composed mostly from sedge peat. Aquatic sedges (*Carex aquatilis* and *Scirpus cespitosus*) dominate, as well as dwarf shrubs (*Myrica gale*, *Kalmia polifiolia*, *Andromeda glaucophylla*). Bryophytes are dominated by *Sphagnum* mosses (Davis 1980; Gimbarzevsky 1977). Flat bog communities occur on poorly drained lowlands where organic deposits have formed from the remains of decomposed *Sphagnum* species. Dominant plant species on flat bogs include Ericales, especially black crowberry (*Empetrum nigrum*), bakeapple (*Rubus chamaemorus*), Labrador Tea (*Rhododendron groenlandicum*), partridgeberry (*Vaccinium vitis-idaea*) and blueberry (*Vaccinium uliginosum*) (Davis 1980). Club rush (*Scirpus cespitosus*) and *Cladonia* genus lichens are also common (Gimbarzevsky 1977).

The site area under study (4A800B) and, indeed, the entire archaeological site and shoreline along Sacred Bay, is situated on a marine plain about 1 km-wide extending backwards from the coast (Gimbarvesky 1977). Within this area, coarse textured marine gravels, organic peat and areas of exposed bedrock are common. Vegetation consists of a mixture of wetland, rock and soil barren communities, and coniferous marginal forest. There are also several lakes (Gimbarvesky 1977). The upper bog area was initially classified as a palsa bog by Henningsmoen (1985) due to the presence of ice ridges. Gimbarvesky (1977) also noted frozen ground occurring in the first week of august. However, this no longer appears to be the case.

3.2 Brief History of Research at LAM

The history of archaeological research at LAM can be seen to begin in 1960, when Helge Ingstad landed nearby and was led by George Decker, a prominent local man (Ingstad 2013), to what he referred to as the "Indian Mounds" (Lewis-Simpson 2020: 562). Ingstad recognized the grassy mounds as similar to Norse ruins he had seen in Greenland, and excavations were planned for the following year, under the direction of Anne Stine Ingstad—who had been trained in archaeology at the University of Oslo (Wallace 2000a, 2006). The Ingstads were not the first to hypothesize or even search for a Norse presence in the area—indeed, such speculation goes back to at least the 19th century—but they were the first to identify Norse remains at LAM (Crocker 2020; Wallace 2006).

Between 1961 and 1968, the Ingstads, their retinue, an international crew of archaeologists and hired locals, would excavate all of the known Norse structures at the site (Ingstad 1985, 2013), as well as several depressions once thought to be boat sheds (Christiansen 1985). During the course of this work, most of the major Norse diagnostic artifacts would be unearthed, including a piece of gilded copper, and a bone needle in House D (Ingstad 2013; Petré 1985); a whetstone, a stone door pivot/lamp and a steatite spindle whorl in House F (Bird, n.d.; Ingstad 1985, 2013;), and a bronze ring pin in House A (Ingstad 2013, 1985; Wallace 2006). Importantly, the Norse building remains would be excavated, and their interior layouts discerned and mapped (Ingstad 2013). Many Indigenous features were identified and excavated (Ingstad 1985) and palaeoecological work undertaken as well (Henningsmoen 1985). The overview of this work would be published in a site monograph in 1977, later republished in 1985 (Ingstad 1977, 1985).

Except for Anne Stine's (2013) observations on the availability of bakeapples, the bogs at the site seem to have mostly been ignored by the Ingstads, with their investigations focused generally on the discernible Norse building remains instead. However, some of their excavation trenches do appear to have touched the upper and lower bogs (see Ingstad 1985) and bog ore was noted as being found when digging drainage trenches on the upper bog margin south of Houses B and C (Ingstad 1985: 274). Petré (1985: 70) also notes digging between the bog and an old brook slope (but not within the bog itself). Overall, besides Henningsmoen's (1985) palaeoecological investigations in the upper bog, the peatlands at the site appear to have been neglected by the Ingstad expedition.

In 1968 a deal was struck to transfer control of the site from Newfoundland to the federal government and place it under Parks Canada management for development into a National Historic Site (Lindsay 1975, 1977; Wallace 2005, 2006). An 82 km^2 area, which also encompassed Great Sacred Island and Foirou Island, was set aside (Wallace 2005). Due to the fact that Parks Canada had no experience in Norse archaeology, in 1972, the site was placed under the direction of an international advisory committee, which decided how the site would be protected and presented to the public (Wallace 2005). The advisory committee would continue to meet until around 1975 (Ingstad 2017). It was under this committee that further excavation work was recommended, the goal of which was to resolve many of the unanswered questions that still remained about the site. Bengt Schönbäck of the Swedish Museum of Antiquities was chosen as excavation director, a role in which he served from 1973 to 1975. Birgitta Wallace, who initially served as his assistant, then took over in 1976 (Wallace 2005). Charles S. Lindsay was also involved in this work from 1973 to 1975

Under Parks Canada, focus on the bogs increased, particularly the lower bog. Indeed, one of the initial research objectives was discerning whether the lower bog had always been there or if it had once been a lagoon (Wallace 2005), which was found to likely not be the case (Wallace 2012). It was also realized that given the waterlogged conditions in the lower bog, artifact preservation was likely, thus making it an excellent target for research (Wallace 2012). Investigations began in this area in 1973 with the digging of trenches, which revealed worked wood (Schönbäck 1974). The trenches dug in 1973 extended from the terrace all the way to Black Duck Brook (Kuc 1975: 146).

In 1974, a major part of the research program focused on investigating the lower bog. The margin between the settlement terrace and the lower bog were also included in this work (Schönbäck 1974). Digging in this area revealed a layer of worked wood outside of House A, which could be followed on a downslope into the bog. Further worked wood was identified outside of House D, which has been interpreted as carpentry debris (Schönbäck 1974; Wallace 2012), as well as a layer of twigs possibly put down to try and keep the ground surface dry. A cylindrical container made of birch bark and sown together with spruce roots was recovered as well (Schönbäck 1974; Wallace 2003a, 2005). The bog was also found to have continued forming up the walls of Houses A and D, following Norse site abandonment (Schönbäck 1974; Schönbäck et al. 1976). Additionally, the upper bog was tested in 1974. The goal of digging this trench (4A67T-W) was to reach the base of the bog, discern the stratigraphy in this area, and find evidence for past tree growth (Schönbäck 1974). The upper bog appears to have been neglected otherwise.

In 1975 excavation of the lower bog was greatly expanded with over 20 trenches dug. These were mostly 2m wide by 10m in length. These trenches were located west of the area between Houses A and D, west of House D, and west of the area between buildings E and F (Schönbäck et al. 1976). All trenches were excavated to the base of the peat deposit, which at the foot of the downslope from the terrace was found to be 80cm to 100cm thick. Deposits of wood up to 50cm thick were unearthed at the base of the peat—these were interpreted at the time as driftwood deposited on the former beach and then covered with peat through time (Schönbäck et al. 1976). These wood deposits were later re-interpreted as the possible remains of *in situ* tree roots killed by paludification (Davis and McAndrews 1978; Davis et al. 1988; Robertson 1978). At between 35 and 55cm, a distinct zone of cultural material was noted of up to 20cm in thickness, but generally less. It was found to consist of charcoal, wood and bark, but mostly of twigs and branches that had been cut or burned at one or both ends, plus many wood chips. No lithic material was recovered. It was also found to be in greatest concentration within 5m to 6m of the settlement terrace, and thus likely Norse (Schönbäck et al. 1976). A noted exception to this was a pile of twigs found west of House D, which was dated later in time. It was initially thought that this pile might stem from later Norse site usage, potentially relating to later wood gathering expeditions (Schönbäck et al. 1976) as are attested to in period documents (Price 2020). However, Wallace thought this pile could be Indigenous in origin (Wallace 1989). Several worked wooden artifacts were also recovered from the bog. These include: a piece of wood with a hole in one end(Schönbäck et al. 1976), a probable boat plank consisting of a piece of wood with two holes; one of which contained a dowel (Schönbäck et al. 1976), a piece of wood identified as being from a bow drill (Wallace 2005), a wooden finial (Schönbäck et al. 1976; Wallace 2012), a potential furniture part, and an object resembling a blunted wooden arrow (Schönbäck et al. 1976). All the above wooden objects were presumed to be Norse due to their form, stratigraphic position and radiocarbon ages (Schönbäck et al. 1976). However, it was also realized that several cultures had used the bog and that further work would be needed to clarify the relationship between deposits (Wallace 1977).

In 1976, the final Parks Canada field season of the 1970s, work in the lower peat bog focused on trying to clarify the relationship between deposits of presumed Norse and Indigenous material (Wallace 1977). Three areas were investigated. West of House D, seven 10m long by 2m wide trenches were dug as well as three 1m baulks left over from 1975. West of House A, eight 10m long by 2m wide trenches were excavated (Wallace 1977). Between the two houses, two 10m long by 2m wide trenches were dug and three 1m baulks. In the area west of House D, more twigs were unearthed, although not cut like the other pile found nearby. Several pieces of worked wood were also uncovered, as was a Norse nail. Notably, coiled roots likely used for lashing materials together were found (Wallace 1977), which have subsequently been associated with the Norse occupation (Wallace 2012). West of House A, coniferous roots were uncovered *in situ* up to 30cm below the surface and interpreted as indicating the presence of trees on the bog at one time. Building sods interpreted as originating from the collapse of House A were also unearthed, as were pieces of worked wood and iron slag. Deposits of what were thought at the time to be driftwood were found as well (Wallace 1977). As elsewhere in the bog, these driftwood deposits may potentially, in fact, be the remains of tree roots (Davis and McAndrews 1978; Davis et al. 1988; Robertson 1978). Excavation between Houses A and D uncovered an extension of the root and so-called driftwood layers. Cut wood was uncovered at the interface with the terrace and amongst the presumed driftwood. Many pieces were found close to House D and thought to, therefore, be in association with it (Wallace 1977). Chemical samples were also taken from the peat bog to try and test for the chemical signatures of former midden deposits (Wallace 1977) as only wood persevered in the acidic conditions of the bog. This was seen as unfortunate (Schönbäck et al. 1976). However, the preservation of so much wood should be seen as a testament to the preservative ability of peat bogs and relatively wet conditions at the time of deposition (Wallace 2012). For such wonderful artifacts/ecofacts as a burl of white walnut, *Juglans cinerea* (also known as butternut), several butternuts themselves and a hexagonal wooden piece interpreted as a possible barrel lid were all discovered in the lower bog (Wallace 2003a).

It should be noted that Wallace (1977, 2012) ultimately divided the cultural deposits in the lower bog into three groupings (upper, middle, bottom). Some of the wood pieces in the middle layer were found to be cut with metal tools through analysis by Paul Gleeson (1979), and therefore likely Norse. Various pieces of wood from the bottom and upper layers were thought to be cut with stone tools and thus Indigenous in origin (Wallace 2012).

In 1978 LAM was declared the first World Heritage Site by UNESCO due to its importance as having the only confirmed evidence of Norse habitation in the so-called 'New World' (Fife 2004; Morris 1989; Wallace 2005). Several fieldwork endeavours would also be conducted at the site following the Parks Canada campaigns of the 1970s. This included Parks Canada-led fieldwork supervised by Wallace (2003), Jenneth Curtis (2007, 2009, 2011) and the two combined (Wallace and Curtis 2008), as well as underwater survey (Dagneau and Moore 2009, 2010). Research was also undertaken by Todd Kristensen (in association with Priscilla Renouf) from MUNL (Kristensen and Renouf 2009).

3.3 Overview of the Site's Cultural History

LAM is believed to contain evidence for Indigenous occupation by the Maritime Archaic, the Groswater and Dorset Palaeo-Inuit cultures, various Recent Period complexes including Cow Head, as well as the Norse. The archaeological understanding of these groups and their documented presence at the site is discussed below in temporal order, as well as later Indigenous and European site history. The information contained in this summary is drawn from several sources. This includes archaeological reports contained within the original site monograph (Ingstad 1985). Wallace's research has been relied upon as well (Wallace 1989, 2005, 2006, 2012). Varied sources, ranging from the Ingstads (2001, 2013) to Parks Canada reports (Schönbäck et al. 1976) and later reanalyses (Kay 2012; Kuitems et al. 2021) are also utilized. While the archaeological work undertaken at LAM is generally of a high quality, it encompasses a vast amount of literature, of both grey and white varieties, and includes work undertaken over 50 plus years of study—with a (sometimes marked) shift in methods from the time of earlier fieldwork. Much of the existing cultural site history is also based on correlation of archaeological data (artifacts and features) with a radiocarbon chronology that, while ample in terms of the number of dates, is often problematic (Ledger et al. 2019b). Many of the early dates for the site were obtained prior to AMS and required mixing of different charcoals together (Wallace 1989) to achieve the sample sizes necessary for the time (Godwin 1981). Early dates were also obtained on driftwood, bulk turf, and marine mammal (whale) bone (Ingtsad 1985; Nydal 1989), all materials which have later been found not to be ideal for radiocarbon dating (e.g., Ledger et al. 2016). Recalibration against the bristlecone pine (Ingstad 1985) and other curves (Nydal 1989) have been attempted but this does not adequately address the underlying issues. Consequently, valid concerns have been raised about the chronology at the site (Ledger et al. 2019b; Nydal 1989). More recent work has improved upon this, especially in regard to the Norse occupation (Kuitems et al. 2022), but much still remains unknown about the chronology at LAM. This does not mean that all dates should be dismissed, but rather taken critically and reassessed with new methods as necessary.

The cultural site framework presented below represents an understanding of the site derived through prior fieldwork. It is presented here as an overview of the conventional thinking on the cultural history of LAM, with the goal of ultimately informing upon interpretations undertaken in chapter 5 of this thesis. Given this, there are no individual maps provided for each culture's use of the site, nor is there a timeline. Instead, an overview of the site's interpreted culture history is presented. First, a brief overview of the presently understood archaeological chronology for the Island of Newfoundland and the Norse settlement of the North Atlantic is given.

3.3.1 Archaeological Chronology for Insular Newfoundland

The earliest documented inhabitants on the island of Newfoundland were the Maritime Archaic culture (Betts and Hrynick 2021; Renouf 2006). This culture is archaeologically documented from as early as 8000 BP in southern Labrador, and by 6000 BP evidence for their presence is found on the island. The Maritime Archaic people were well adapted to utilizing marine resources (Holly 2013; Tuck 1976), and the prevalence of woodworking tools including gouges may indicate the production of dugout canoes (Holly 2013). It is likely that the interior of Newfoundland was utilized as well (Renouf and Bell 2006). Around 3500 BP, the Maritime Archaic culture region began to contract, and within 300 years they had abandoned insular Newfoundland (Wolff and Holly 2019).

The next culture to take up residence on the island were the Palaeo-Inuit, Groswater culture (Holly 2019; Holly and Erwin 2009). They are believed to have developed from an earlier Palaeo-Inuit culture in Labrador (Hartery 2007; Holly 2013). The Groswater people are thought to have been mostly coastally situated, but there is some evidence for interior/riverine utilization to hunt caribou and obtain other resources (Holly and Erwin 2009). On the coast, seals were an important resource, as well as fish and seabirds (Holly 2013). According to Melnik (2007) the Groswater Palaeo-Inuit were likely present on the island of Newfoundland from around the beginning of the 1st millennium BCE to the 1st century CE. The next Palaeo-Inuit group to inhabit the region were the Dorset culture, who migrated in from the north (Betts and Hrynick 2021; Leblanc 2010). Dorset subsistence was very much focused on marine resources, in particular seal (especially harp seal) but also walrus and sea birds, with some minor utilization of terrestrial game including caribou and beaver (Holly 2013; Wolff and Holly 2019). The Dorset people ranged across the island, and likely had regionalized cultural expressions (Holly 2013; Leblanc 2010). It is unclear whether the Dorset culture replaced the Groswater culture or whether the Groswater people were subsumed into the Dorset people (Hartery 2007). The prevailing archaeological belief is that the Dorset Palaeo-Inuit appear to only have been active on the island of Newfoundland from the 1st to 8th

centuries CE, which constitutes the Middle Dorset period (Dussault et al., 2016; Holly 2013).

At around the start of the 1st century CE, there is evidence on the island of Newfoundland for a First Nation complex known as the Cow Head (Betts and Hrynick 2021; Hartery 2007). Their presence on the island can be seen to begin the archaeological Recent Period (Hartery 2007). The Cow Head complex is thought to have persisted until the end of the 1st millennium CE (Renouf et al., 2011). Hartery (2007) hypothesised that the Cow Head people were somewhat sedentary and had a high degree of storage.

The later part of pre-contact Indigenous (First Nation) cultural history on the island of Newfoundland consists of two archaeological complexes: the Beaches and Little Passage. The Beaches complex first appears around the middle of the 1st millennium CE (Betts and Hrynick 2021). By the start of the 2nd millennium CE archaeological evidence for the Beaches complex ceases to exist; however, it is believed that they transitioned into the subsequent Little Passage complex (Cridland 1998). At around 1500 CE during the time of sustained European contact, stone tools disappear from the archaeological record being replaced by metal ones, thus constituting the end of the Recent Period and the beginning of the historic Beothuk tenure on the island (Cridland 1998; Holly 2013). Shawnadithit, the last Beothuk person of written historical record, died in St John's in 1829 (Marshall 1996).

The Norse were an agrarian/pastoral culture that incorporated wild foodstuffs into their diet in varying ways and adapted their agricultural practices to suit the local environments of the North Atlantic islands (Dugmore et al., 2012; McGovern et al., 2006). They were also a rigidly hierarchical culture with great differences in status based on land and wealth (Bolender and Johnson 2018; Vésteinsson 2007). In the centuries following the year 800 CE they spread outwards from their Scandinavian homeland in a great diaspora (Price 2020). Within this period several of the North Atlantic islands were settled, including the Faroes (C. 825 CE; if not earlier, Curtin et al., 2021), Iceland (c. 870 CE) and Greenland (c. 985 CE) with Newfoundland reached shortly after (Fitzhugh 2000).

3.3.2 Maritime Archaic

According to Wallace (1989, 2006, 2012) there is some evidence for a Maritime Archaic occupation at LAM; namely, several disturbed hearths on the upper terrace just east of and partially below Norse House D (Wallace 1989, 2006). Attribution of these hearths to the Maritime Archaic is based upon a single radiocarbon date obtained on charcoal (Wallace 1989), which Wallace (2012) places at approximately 3950 BCE. The use of a single radiocarbon date is evidently problematic, especially given some of the concerns regarding the precision of radiocarbon dates that have been raised at LAM (Ledger et al. 2019b). This date was even totally dismissed by Beaton (2004). Fortunately, several probable Maritime Archaic artifacts were also found across the site, notably a ground stone adze made from green chert considered to be diagnostic of the period (Wallace 1989, 2006).

3.3.3 Groswater Culture

It is thought that the Groswater Palaeo-Inuit culture were at LAM due to the recovery of diagnostic chert artifacts, including high-notched end blades, and more ambiguous lithics from the terrace and across the site—including those found amongst a palimpsest of features from different cultures and periods on the southern shore of Epaves Bay (Wallace 1989, 2012). Attribution of many of the artifacts and features to the Groswater culture is based on radiocarbon dating alone (Wallace 1989, 2012). Several pieces of wood, including the bottom layer of worked wood in the lower bog, have been attributed to them through this method (Wallace 1989), as have a few hearths on the terrace (Wallace 2012), and fireplaces and features on the southern shore (Wallace 1989). Based on this, the Groswater Palaeo-Inuit have been placed at the site between approximately 1000 to 400 BCE (Kristensen and Curtis 2012; Wallace 2005, 2012).

3.3.4 Dorset Culture

According to Wallace (Wallace 1989, 2005) the Dorset Palaeo-Inuit component at LAM is mostly centred around the beach edge on the southern shore of Epaves bay, where a number of tent rings and fireplaces (including axial features) were uncovered (Curtis and Wallace 2008; Wallace 2006). It is thought that their camp was positioned close to the shore to take advantage of the spring harp seal migration (Wallace 1989: 41). In general, the Dorset component is badly disturbed (Wallace 1989), but a number of features indicative of habitation were identified (Wallace 2012). As with the Groswater Palaeo-Inuit, attribution of many of these features to the Dorset culture is based on radiocarbon dating, with stone rings, circular stone concentrations, charcoal patches and hearth boxes being assigned to them through this method (Wallace 1989). Based on the derived radiocarbon chronology, the Dorset have been interpreted as being at the site from approximately 400 to 800 CE (Wallace 1989, 2006).

The assemblage of Dorset culture artifacts comes from disturbed contexts, which complicates interpretation (Wallace 1989). There are, however, some important diagnostic artifacts recovered from diverse find spots across the site, thus implying wider site usage, including on the settlement terrace (Wallace 2012). Notably, two triangular, tip-fluted end-blades, both made of mottled fine grain chert were uncovered; one in 1976 near Building J and the other in 1963 about 30m to the west of House F (Wallace 1989). A Dorset lamp was also recovered from Building J (Eldjárn 1985; Ingstad 2013), likely having been moved there by later site inhabitants (Wallace 1989: 53).

3.3.5 Cow Head/Early Recent Period Complexes

A Cow Head complex component was also identified at LAM, owing to the presence of diagnostic lithic artifacts, especially large ovate bifaces and associated features (Hartery 2007; Kristensen and Curtis 2012). Notably, two large cooking pits were identified, one on the smithy terrace by the Black Duck Brook (Pit I) and the other (Pit II) northwest of House F on the settlement terrace (Eldjárn 1985). The pits were ascribed to the Cow Head complex through radiocarbon dating (Kristensen and Curtis 2012). However, Pit II did contain debitage made from brown chert considered to be characteristic of the Cow Head complex (Kristensen and Curtis 2012). A nearby feature, interpreted as a knapper's station due to the presence of numerous flakes (Bareis and

Winston 1985), also contained lithics made from the same brown chert as well as six bifaces, which are thought to be Cow Head (Hartery 2007).

There are also a variety of scattered artifacts and features from across the site that are more ambiguous in form, including linear hearths constructed from piles of stones on the southern shore that cannot be assigned to any particular complex and have thus simply been assigned to the earlier part of the Recent Period (Kristensen and Curtis 2012; Wallace 1989, 2012). This is of course an interpretation, based also on radiocarbon dating. Wallace (2012) places the earlier part of Recent Period occupation at the site between approximately 730 and 900 CE.

Site usage during the early Recent Period has been variably interpreted. Hartery (2007) argues that the presence of cooking pits and numerous bifaces would likely indicate that large animals were processed and cooked, and that the site functioned for some period of time as an occupation site. However, Kristensen and Curtis (2012) posit birds were hunted at the site and bifaces and other tools were manufactured for use elsewhere. Given the nebulous nature of the early Recent Period archaeological remains at LAM, it is possible that both interpretations are true.

3.3.6 Norse

At LAM, the documented Norse remains consist of three main clusters of buildings (A-B-C, D-E, F-G), which are aligned in a north-south direction on the building terrace and evenly spaced about 30m apart (Lindsay 1975; Wallace 2005). Each complex consists of a large building (a hall) flanked by a smaller structure or two. Besides this, there is also the smelter shed (Building J), located on its own terrace by Black Duck Brook (Wallace 2000a). Several depressions on the southern shore were also excavated by Christensen (1985) in 1968 and interpreted as Norse boat sheds; however, these were subsequently found to be natural features formed through erosion during storm events (Schönbäck et al. 1976).

All the Norse structures lacked stone foundations. However, they were built in a sturdy fashion given the available materials—with thick sod walls reinforced with a core of sand, gravel and earth placed on top of a wooden frame (Kay 2012; Wallace 2000a, 2006). The outbuildings were of much simpler construction. Wallace (2006: 51) describes them as "pits with roofs", whereby the fill produced from digging out the pit was thrown up into a high berm, and the roof supported by slender poles. However, Building C was likely built just from sods (Wallace 2006; Kay 2012). It would have taken considerable effort and materials to build them, requiring around 1000 cubic metres of sod for each of the halls, plus many large trees for support posts and smaller branches woven into the rafters to support the sods (Wallace 2000a). The halls (A, D, F) appear to have been built in one episode, as sods in the walls connecting rooms interlock (Kay 2012). The houses are also evenly spaced, and functions are integrated between each, all of which suggests contemporaneity (Wallace 2005: 177). The houses were thought to have been set ablaze at some point (Ingstad 1985: 79; Ingstad 2013: 103), possibly by the Norse upon abandonment (Wallace 2013).

Wallace (2000b) estimated that the entire settlement could have been constructed in two months by 60 individuals, or a month and half by 90 individuals, plus whatever time it would have taken to cut the sod. Upon completion, the site could likely have housed between 70 to 90 people (Wallace 2000c). Based on the presence of gendered artifacts (especially the spindle whorl and whetstone) the inhabitants would likely have included men and women (Wallace 2003a). According to Wallace (2006) there would also probably have been individuals drawn from different social strata including: elites, their retainers, skilled trades people/commoners and slaves.

Wallace (2005, 2012) interpreted LAM as a gateway site, a logistical waystation, perched on the edge of a broader resource acquisition area. This interpretation is based on the fact that the buildings at the site were constructed in a sturdy fashion, implying year-round occupation; yet there is a lack of archaeologically discernable byres, barns or animal pens as would be expected from a more permanent settlement (Wallace 2000a, 2003a, 2012). According to Wallace (2005), the site would simply have acted as place for crews to overwinter between summer sojourns into the broader Vínland region—Vínland being the name given to the lands mentioned in the Vínland sagas and explored by the Norse, which contained self-sowing wheat and grapes (Ingstad and Ingstad 2001; Kunz and Sigurðsson 2008). Boats would also be repaired at LAM as attested to by the boat repair shed outside of House F (Wallace 2005, 2012). This interpretation might be further contextualized through the lens of Norse *shielings*, out-buildings traditionally associated with the seasonal tending of livestock, but further expanded to encompass different types of sites that do not fit within traditional interpretative schemas of Norse land use (Catlin 2021). For instance, Madsen (2019) has argued that the Greenland Norse used *marine* *shielings*, specialized locations directed towards seafaring and marine resource exploitation, and that LAM might be included within this.

The Norse occupation has been the target of an extensive radiocarbon dating program since the early days of excavation. Despite the large number of radiocarbon dates, a great degree of variation exists within the actual dates themselves. This is now understood to be the result of the use of old wood, dates obtained prior to AMS, and other biases (Kuitems et al. 2021; Ledger et al. 2019b; Wallace 2005, 2012). Despite the spread in dates, the Norse component has been dated to approximately 980-1030 CE (Lewis-Simpson 2020). Many of the dates centre around the year 1000 CE (Wallace 2005), in agreement with the sagas (Ingstad and Ingstad 2001; Kunz and Sigurðsson 2008). A reanalysis of the dates from the site by Ledger et al. (2019b) using Bayesian modelling confirmed that the Norse were likely present at the site around 1000 CE. However, they also discerned that the existing radiocarbon chronology could not, on its own, rule out the possibility of a longer Norse occupation. In fact, their modelling suggested the Norse occupation may have begun between Cal 910–1030 CE and lasted until Cal 1030–1145 CE, a potential duration of 195 years (Ledger et al. 2019b: 15432). Recent high precision chronological modelling has also discerned that the Norse were present there during the year 1021 CE (Kuitems et al. 2021). Based on the small size of the middens present, the supposed dearth of vegetation disturbance and the lack of a church or graveyard, Wallace (2003a; 2006) felt that the site was only occupied a short while by the Norse, and recent studies (Kuitems et al. 2021; Ledger et al. 2019b) are in agreement with this interpretation

3.3.7 Later Recent Period Complexes

There are thought to be a number of later Recent Period features, artifacts and activity areas at LAM (Kristensen and Curtis 2012; Wallace 2012). Due to ambiguities, archaeologists have generally resisted assigning these to the Beaches or Little Passage complexes. Hull (2002) has also posited that the broader Strait of Belle Isle region was a shared interaction sphere during this time, with a blending of traits seen amongst cultures on the Quebec Lower North Shore, Labrador and the Northern Peninsula (Hull 2002). Therefore, the later Indigenous archaeology at the site might simply be attributed to the later Recent Period (*sensu* Kirstensen and Curtis 2011) with an understanding that it relates to peoples ancestral to the historic Beothuk and Innu (Wallace 2006).

As is the case with much of the other archaeological remains at the site, cultural attribution of some features to the later Recent Period has been made based on radiocarbon dating. Certain features have also been assigned to the later Recent Period by stratigraphic association or similarity in form. For instance, several hearths in House D overlying the Norse layer were attributed to later Recent Period occupation, in this manner (Eldjárn 1985; Petré 1985; Wallace 1989). Wallace (1989) also speculated some of the hearth features from the palimpsest on the southern shore could date to this time (Wallace 1989).

Amongst the features attributed to the later Recent Period at LAM are a number of probable habitation structures—including what has been interpreted as a tent or hut floor around 30m west of House F (Wallace 1989). A hearth within this feature contained a piece of oak charcoal, and it has been suggested that the oak came from barrel staves from the whaling station at Red Bay, Labrador (Wallace 2006). The date assigning this feature to the later Recent Period is somewhat suspect since it was obtained on mixed charcoal (Wallace 1989). A feature (Operation 60) consisting of a series of humps forming a low ridge with three associated postholes about 5m east of House D, and attributed to the later Recent Period (Wallace 1989), has been interpreted as the potential remains of a wigwam or *mamateek* (Wallace 1989, 2006). Operation 60 is located in proximity to where archaeological work was undertaken in the bog in 2018 and 2019 (Forbes et al. 2022; Ledger et al. 2019b).

There are a number of hearths across the site that contain Norse boat nails (Curtis 2011; Kristensen and Renouf 2009; Wallace 2003b), which has been interpreted as indicating the scavenging of wood (that had been used by the Norse for building structures or boats) for fuel and, therefore, the Indigenous use of the site quite soon after Norse abandonment (Curtis 2011; Holly 2013). A side-notched projectile point lodged in the wall of Hall A was also interpreted as being shot there by the same, or a related, group of people (Wallace 2006, 1989). However, it may have ended up in the wall through variable means, including as an inadvertent inclusion in cut sod (for examples of such instances see Auger 1993; Knecht and Jordan 1985; Milek 2006).

There is also probable evidence for later Recent Period use of the lower peat bog. A layer of worked wood was attributed to this time period through radiocarbon dating and based on its stratigraphic position, as well as a nearby pile of twigs (Wallace 1989, 2006). Interestingly, many of the contexts interpreted as being from this period have yielded bird bones including goose/duck, cormorant, and black guillemot as well as bear and other mammals (Wallace 1989, 2006). Wallace (2012) places the later Recent Period peoples at the site between approximately 1200 and 1600 CE.

3.3.8 Later Site Inhabitants

Permanent Euro-Canadian settlement at the village of LAM dates from at least the early 1800s (Ingstad 2013; Wallace 2012). There was also a historically attested occupation by Innu from Labrador who stayed there on a yearly basis; however, there is no definite archaeological evidence of this (Wallace 2006). Inuit are also known from historical documents to have visited the Northern Peninsula during the 17th to 18th centuries (Pope 2015).

3.4 Palaeoecology

3.4.1 Brief History of Research

Over the years there have been a wide range of projects that have analyzed environmental data from the site and employed a diversity of specialists from various disciplines. Much of this work was carried out in the 1970s and later by Parks Canada, but some began early in the research program. Notably, there have been a few important palaeoecological studies using plants (mostly microfossils). Kari Henningsmoen (1985) conducted palynological research as a member of the Ingstad expedition in the 1960s. The goal of her work was to discern Norse impact, but in practice took the form of a much broader palaeoecological landscape reconstruction, as she tested diverse areas mostly at some distance from the Norse site itself—including both peatlands and ponds. Mott (1975) also conducted palynological work at the site, with a focus on the lower bog area.

Davis and McAndrews (1978) undertook a palynological study of three monolith cores from the lower bog with the goal of reconstructing the local vegetation over the last 2500 years. Further palynology was done by Davis (1985). Davis et al. (1988) then retested the lower bog, undertaking palynological research on cores retrieved from this area—with the goal of refining an understanding of human-environmental impacts.

Macrofossils have not been studied in a high temporal resolution way at the site before, (i.e., through employing small increment subsamples to discern palaeoecological processes on a finer scale *sensu* Joosten and de Klerk 2007). However, Kuc (1975) did make some use of macrofossils in his work on discerning biostratigraphic trends in the lower bog—analyzing a massive amount of material in the process—by gluing some dried macrofossils to boards to recreate the monoliths they came from and microscopically analyzing others. He then produced highly detailed but rather confusing diagrams reconstructing and defining the biostratigraphy and lithology in the lower bog, on both the horizontal and vertical planes. Robertson (1978) also analyzed macrofossils (in the closest fashion to this thesis) in his botanical-chemical analysis of the lower sedge bog. He broke the macroremain assemblages into broad categories, which were ultimately assigned to two soil groups (feno-fibrisols and silvo-fibrosols) based on the 1972 Canadian soil classification system. This was further supplemented with chemical testing, with the goal of discerning successional trends and anthropogenic influence. Additionally, palaeoethnobotanical analysis was conducted by Mike Deal and students from MUNL on soil samples obtained in 2008 from the site (Marche and Wilson 2008).

There have also been a wide range of palaeoenvironmental studies undertaken by Parks Canada, including on ecofacts and worked and unworked wood from the bog, but also geological, chemical, biological and faunal studies, among others. These are too numerous to list and summarize here but can be found listed in Wallace (2000), with much of the work summarized in Gimbarzevsky (1977). Later analyses have also tried to discern how LAM might be impacted by rising sea levels and erosion due to climate change (e.g., Pollard-Belsheim et al. 2014; Westley et al. 2011).

3.4.2 Summary of Key Findings and Re-Evaluation in Light of Advances in North Atlantic Palaeoecology

Prior palaeoecological work at the site, mostly of a palynological nature, failed to discern any major anthropogenic impacts upon vegetation or site ecology (Bell et al. 2000). Speaking about the Norse, Davis et al. (1988: 62) stated, "The pollen record indicates no large scale or long-term impact on the local and regional vegetation." Likewise, Henningsmoen (1985: 348) found no *landnám* signal, such as in Greenland or Iceland, and stated, "Obviously the Norse settlement was too small and short lived to leave its mark on the vegetation." Henningsmoen's assessment was based on a number of pollen diagrams constructed from cores taken at various locations at the site and its environs, including the same bog where samples analyzed for this thesis came from. One of these sampling points was a good distance away (in the centre of the so-called *palsa* bog); however, one was much closer (30m east of House F). Despite being close to the settlement terrace, Henningsmoen (1985) employed a very low temporal resolution in her work, averaging around 10cm per sample. It is unsurprising then that no Norse signal was discerned. Not enough samples were analyzed to pick out any subtleties within the profile, and charcoal was all but missed or ignored, as was common for the time. Similarly, Davis et al. (1988) did not quantify charcoal either, instead relying on radiocarbon dates taken on bulk peat (which as noted can confound results) to correlate biostratigraphic layers with cultures. However, they did have the benefit of a layer of worked wood, which they attributed to the Norse. While Davis et al. (1988) appear to have employed a finer resolution analysis than Henningsmoen (1985), their study was ultimately compromised by choosing to look at the lower bog. By their own admission, this area "is subject to … occasional flooding by Black Duck Brook" (Davis et al. 1988: 56), which probably would have been even more prevalent in the past before extensive peat buildup. This is significant because it likely indicates the influx of secondary pollen from the catchment, which became mixed with local pollen, confusing the signal—giving an indication of the broader environment rather than localized trends. It is unfortunate that other palaeoecological studies have also focused on this area (e.g., Davis 1985; Mott 1975). Furthermore, Davis et al. (1988) and Henningsmoen (1985) both searched for European introductions and major shifts in plant abundance, which turned out to be elusive targets.

Macrofossil analysis is generally well suited to understanding *in situ* succession and disturbance as it directly studies the remains of plants that lived and died on the bog (Birks and Birks 2000). It is notable, then, that no one has undertaken a macrofossil study of the upper bog prior to this one. The macrofossil analyses undertaken on the lower bog (Kuc 1975; Robertson 1978) are also of a much lower resolution, despite studying multiple monoliths and using bigger sample volumes (over 1000 pounds of wet material in Kuc's case). Both Kuc (1975) and Robertson (1978) were focused on landscape-scale reconstructions using coarse-grained methodologies, which were in keeping with the standards of the time. Given when they were conducted, neither of these studies had the benefit of age-depth modelling (Bayliss et al. 2007). Instead, both studies made use of a handful of dates on dispersed deposits, obtained either by themselves or others, to make chronological estimates of peat formation. Charcoal, if present, was also not considered—and, therefore, successional changes could not be correlated with anthropogenic events (although, Robertson 1978 does make some interpretations on the Norse use of the bog).

Unfortunately, the upper bog as a site of activity has been mostly overlooked until recently. If a detailed macrofossil analysis targeting this area had been applied before, there surely would have been a prior recognition of how the bog ecology shifted in response to people. Furthermore, most Indigenous influence on the site environment has been overlooked in the past. Admittedly, it is only recently that there has been widespread recognition of a hunter-gatherer (i.e., Indigenous) impact on local ecology (e.g., Ledger 2018; Lightfoot et al. 2013; Loughlin et al. 2018), but it is now apparent that Indigenous peoples have had an influence upon many if not all ecosystems, especially if such impacts were long term. Their presence may even result in increases in biodiversity (Oberndorfer et al. 2020). As discussed in chapter 2, Indigenous peoples treated peat bogs as components of the cultural landscape, living on, utilizing, and influencing these environments in the process (Speller and Forbes 2022). Therefore, Indigenous peoples must rightly be considered as active agents of influence on the landscape at LAM, just as much as the Norse.

3.4.3 Overview of Ongoing Research

The ongoing research at LAM initially began as a post-doctoral research project undertaken by Paul Ledger, in association with Edward Schofield, Kevin Edwards and Birgitta Wallace. The initial goal was to study pre- and post-Norse period landscape changes at LAM, and contextualize it within the results of recent palaeoecological research undertaken on the North Atlantic Islands (Edwards et al. 2012; Ledger et al. 2013, 2014, 2015, 2017; Schofield et al. 2013; Schofield and Edwards 2011). During summer 2018, small-scale fieldwork targeting the upper peat bog at the site was undertaken by Paul Ledger, Véronique Forbes and Linus Girdland-Flink, with the goal to retrieve samples for palaeoenvironmental analysis (pollen, non-pollen palynomorph, plant macrofossil and insect). One trench (4A800B) was excavated (Ledger et al. 2019b). During the digging of this trench a compressed layer containing laminated surfaces, charred materials, insects, wood and patches of charcoal was inadvertently encountered. It was initially suspected that this was a Norse *landnám* layer, similar to those on other Norse sites in the North Atlantic and relating to the first period of settlement (Ledger et al. 2018). However, subsequent radiometric dating of the layer showed that it was actually deposited between the 12^{th} to 13^{th} centuries and could, therefore, potentially be associated with a later Indigenous site use (Ledger et al. 2019b). Water ingress into the unit, and the unexpectedness of this discovery, hampered detailed investigation in 2018, but it was clear that the layer would need to be investigated further (Ledger et al. 2018).

Due to the discovery of the layer, an expanded research program began in 2019 that was more archaeologically focused, but also integrated researchers from diverse backgrounds and using varied methodologies to better understand both the archaeology and the environment at the site. These include: geoarchaeology/micromorphology, palynology, archaeobotany, archaeoentomology, geophysics, tephrochronology, aDNA, among others. Fieldwork, including both archaeological excavation and sampling were also undertaken in 2019, headed by Véronique Forbes (PI). The goals of the 2019 field season were to investigate the extent of the new cultural horizon identified in 2018 and collect peat samples for paleoenvironmental analysis (Forbes et al. 2022). Five 1m x 1m units were opened in the upper bog area: 4A800B, 4A800D, 4A800E, 4A800F and 4A800G. The work in 2019 established that the cultural layer encountered in 2018 was not very thick, and that it extended northward and eastward (as shown by excavations in these areas) but that it was not present to the south or west (Forbes et al. 2022).

Beginning in 2020, the project was yet again expanded when the Biocultural and Archaeological Legacies at L'Anse aux Meadows (BALL) Project received funding from SSHRC. Unfortunately, fieldwork planned for the summer of 2020 had to be cancelled due to the COVID-19 Pandemic. However, outreach and experiential survey work was undertaken in 2021. Further work is planned from 2022 onwards, and the results presented in this thesis informed the planning of the 2022 field season.

Chapter 4. Analysis of Plant Macrofossils from Monolith 4A800B3-6

4.1 Methodology

4.1.1 Fieldwork and Sampling

The monolith (4A800B3-6) that this study is based upon was obtained during the August 2019 field season at LAM from Unit 4A800B (Forbes et al. 2022). The monolith captured the peat strata from 22cm to 62cm below ground level (bgl). The monolith tin itself consisted of a stainless steel box, which was hammered into the profile and carefully extracted using a cake knife, spade and trowel (Forbes et al. 2022). Following field extraction, the monolith was transported back to St. John's and kept in refrigerated storage in the Archaeology Department at Queen's College, Memorial University.

Monolith 4A800B3-6 was subsampled in the Palaeoecology, Environmental Archaeology and Timescales (PEAT) Laboratory by Paul Ledger. A single, contiguous 1cm increment sample was taken from between 23cm and 24cm bgl. The rest of the tin was sampled in half centimetre increments from the top (22cm bgl) to the bottom (62cm bgl), in order to obtain peat samples in known stratigraphic order for subsequent palaeoenvironmental and chronological analyses. Samples were obtained with the aid of a ruler, cake knife, and scalpels and were placed into labelled plastic bags. The monolith was also photographed in the lab prior to sampling (fig 3).

Figure 3. 4A800B3-6 monolith in the lab prior to sampling. Sample was extracted from the left side. Image by Paul Ledger.

4.1.2 Plant Macrofossil Analysis

Plant macrofossil analysis was performed following the method laid out by Mauquoy et al. (2010). For each sample analyzed, 3ml of peat was used. This was measured through volumetric displacement using a 25ml graduated cylinder. Following this, the contents of the cylinder were poured into a lab beaker and disaggregated by adding a small amount of a solution composed of 2% Sodium Hydroxide (NaOH) and water. This mixture was left underneath a fume hood for 10 minutes, which allowed the mildly caustic NaOH to break apart the intertwined peat. The resulting mixture was poured through a fine mesh (125 µm) screen and washed under cold tap water in order to separate the discarded fine section (micro-remains and sediment) from the retained coarse section (macroremains, charcoal and mineral grains). The material that remained in the screen was placed into a labelled pot with some tap water. The process was repeated until disaggregated material had been acquired from every selected sample.

Abundance counting of plant macrofossils was performed following the quadrat method outlined by Barber et al. (2004). For this stage of analysis, using a plastic pipette, a small amount of material was placed in a shallow glass petri dish (enough to allow one to see the constituent parts of the sample). A Colusa Science brand grid reticle (10mm total, 100 SQ., 1mm per square, 25mm diameter) was placed in the right eyepiece of a Nikon SMZ800N stereomicroscope, so that the field of vision was divided into 100 squares of equal size (1mm x 1mm) contained within a 10mm x 10mm square. A location within the petri dish was randomly selected as a starting point. Using the reticle grid as a sampling area or quadrat, all the plant macrofossils contained within it were counted. The number of voids or empty squares was noted as well. This process was repeated ten times for each petri dish, in order to give an averaged count. An Excel spreadsheet was used to record the count information. The totals for each category were then tallied in order to obtain an average across the ten subsamples. At this point, given that they had no interpretive value, the voids were corrected for, to remove them and proportionately increase all the other categories. If this was done correctly, the sum of all the categories would equal 1000. Each spreadsheet was kept separate at this stage in preparation for combination into a master spreadsheet later on.

Plant identifications were made by making comparisons against a reference collection containing common subarctic flora, which had partly been collected locally in Newfoundland by myself and partly in Alaska by Paul Ledger. Several published sources were also used to make identifications, including: Birks 2007, Lévesque et al. 1988, and Mauquoy and Van Geel 2007. Using this methodology, it was sometimes possible to make identifications down to the family or even species level. However, given the overarching goal of discerning trends in local ecological change through time, it was deemed adequate initially to identify to order level. For this reason, high-ranking taxonomic categories such as “monocots,” “Ericales,” and “brown moss” were used. However, where distinct species were identifiable, these were noted during the counting process and added into the Excel spreadsheet as necessary.

Once the ten abundance counts had been done, peculiar, enigmatic, or notably abundant macroremains were also pulled out and set aside for later detailed analysis—when time could be devoted to their identification. The results of these identifications were not added into the abundance data but were instead kept separate and noted as a simple *presence* where these materials occurred. Seeds and fungal sclerotia were also pulled out, set aside and identified using the Digital Seed Atlas of the Netherlands (Digital Plant Atlas 2021). The counts for these were included in the final diagram, listed by the number of individuals. The entire pot from which each sample was drawn was visually sorted through to make sure that any and all plant macroremains of interest were captured, as well as charcoal.

4.1.3 Charcoal and Sediment Analysis

Charcoal, which was usually first apparent during the initial count, was counted for abundance per size class (<0.5mm, 0.5-1mm, 1-1.5mm, 1.5-2mm, >2mm), per number of individuals within each of those classes. Count information was recorded on paper to facilitate ease of recording and then later transferred onto the same Excel spreadsheet as the plant macrofossil abundance information. The number of charcoal pieces per millilitre was calculated by dividing the number of pieces of charcoal in each size category by three. Charcoal peaks, where they occurred were presumed to indicate a human presence.

Where they were present, mineral grains were also counted by number of individuals; however, no formal effort was made to measure their size. Mineral grain information was also tallied to allow comparison across the profile and against loss on ignition (LOI), which was calculated by taking sequential, weighed peat samples at half centimetre increments and burning them to determine the percentage of organics and carbonates (Dean 1974). The plant macroremains and associated materials (including insects) from the sorted pots was retained for later archaeoentomological analysis by Véronique Forbes.

4.1.4 Numerical Analysis

Once all the macroremain counts had been done, all the separate, completed Excel count sheets were combined into a final Excel spreadsheet. The counts were double checked and the totals out of 1000 were converted to a percentage out of 100 for each category within a sample. This information was then exported into Tilia/TGView software (Grimm 1993, 2013), which was used to make a final percentage/summary diagram. Constrained incremental sums of squares cluster analysis (CONISS) (Grimm 1987) was then applied in the plant macroremain dataset to discern biostratigraphic zones.

4.1.5 Radiocarbon Dating and Age-Depth Modelling

While several radiocarbon dates had already been obtained for 4A800B3-6, further dates were necessary to refine the chronological sequence. Therefore, a series of samples from between 23cm to 50cm bgl were visually surveyed to discern the degree of *Sphagnum* present—*Sphagnum* being preferable for radiocarbon dating due to its short lifespan and presumed non-movement within the profile (Nilsson et al. 2001; Rydin and Jeglum 2013). No samples were surveyed below 50cm bgl due to the visible degree of humification, which signalled the unlikelihood that any datable *Sphagnum* would be obtained from these levels.

The selected samples (23cm – 50cm bgl) were disaggregated, washed and stored in pots following the same method described above and outlined by Mauquoy et al. (2010). The only difference being that a random amount of peat was used, as volume standardization was not necessary. Ten samples were selected for their abundance of *Sphagnum*: 23-24, 25-25.5, 26.5-27, 31.5-32, 32-32.5, 32.5-33.0, 33.5-34.0, 34.5-35.0, 36.0-36.5, 37.5-38cm bgl. Each of these samples was then sorted through under magnification, using forceps to obtain *Sphagnum* leaves and branches for dating purposes. Given the imperative to keep these samples clean, in order to derive accurate radiocarbon dates, scrupulous cleanliness principles were observed. Using plastic pipettes, the extracted *Sphagnum* leaves and branches (100 mg by weight) were placed in plastic vials, which were then sent to the Lalonde AMS facility in Ottawa, Canada for radiocarbon dating.

All received radiocarbon dates were calibrated with OXCAL 4.4 calibration software (Ramsey 2009), using the IntCal20 calibration curve (Reimer et al. 2020). The chronology was also refined further through Bayesian modelling using *Bacon* software (Blaauw and Christen 2013). Through this, an age-depth model was produced for 4A800B3-6.

4.2 Results and Interpretation

4.2.1 Lithostratigraphy

LOI values are generally high throughout, displaying a trend of increasing upwards through time (fig 4). Between 24.0cm and 38.0cm bgl, they never fall below 97% percent and are generally higher (>98%). Lower down, between 38.0cm and 47.50cm bgl, they range from >94% to >99%, with a general trend of decreasing downwards slightly. The lowest LOI value (<92%) occurs at 38.75cm bgl.

Mineral grains were also counted during analysis and tallied for each layer that was analyzed (fig 4). Predictably, there is a correlation between an increase in the number of mineral grains and lower LOI values (i.e., the lowest LOI value corresponds with the highest mineral grain value). It is tempting to associate the high values of mineral grains and LOI low values directly with humans, and indeed this may be the case as grains might be tracked into the bog on feet or brought in other ways. Certainly, low LOI values are associated with anthropogenic erosion (Edwards et al. 2008), which has been associated with the Norse in Greenland (Fredskild 1992). However, it is also possible that there is a natural origin for the large mineral grains in the bog as they also occur in great abundance at the base of the section analyzed (101 grains in 47.25cm bgl and 28 grains in 46.75cm bgl, respectively). One possibility is that these grains were carried into the bog as a result of flooding, which can deposit natural silt and sand in peat bogs (Szopa et al. 2020). Henningsmoen (1985) speculated that the sand which had accrued in House A was the result of flooding of the Black Duck Brook, and there is even evidence that the Norse may have built a wall to try and prevent water incursion onto the terrace (Ingstad 1985: 191). Indeed, it is possible that humans had a hand in initiating this hypothesized flooding as deforestation can result in increased freshets (Cronon 2011). Peat cutting for sods could also have altered the bog's hydrology and increased erosion potential. However, it might be considered that natural cycles of flooding periodically charged the upper bog area with freshwater and sediment. The grains may also have been deposited as a result of extremely severe marine storms (Hotes et al. 2001), potentially having an aeolian origin (Vandel et al. 2019). Henningsmoen (1985) observed that there was sand in many of the house sods and underlying the walls, so there was certainly some sand around nearby. This is, of course, all quite speculative but could be explored in more depth using other proxies and sedimentological analysis.

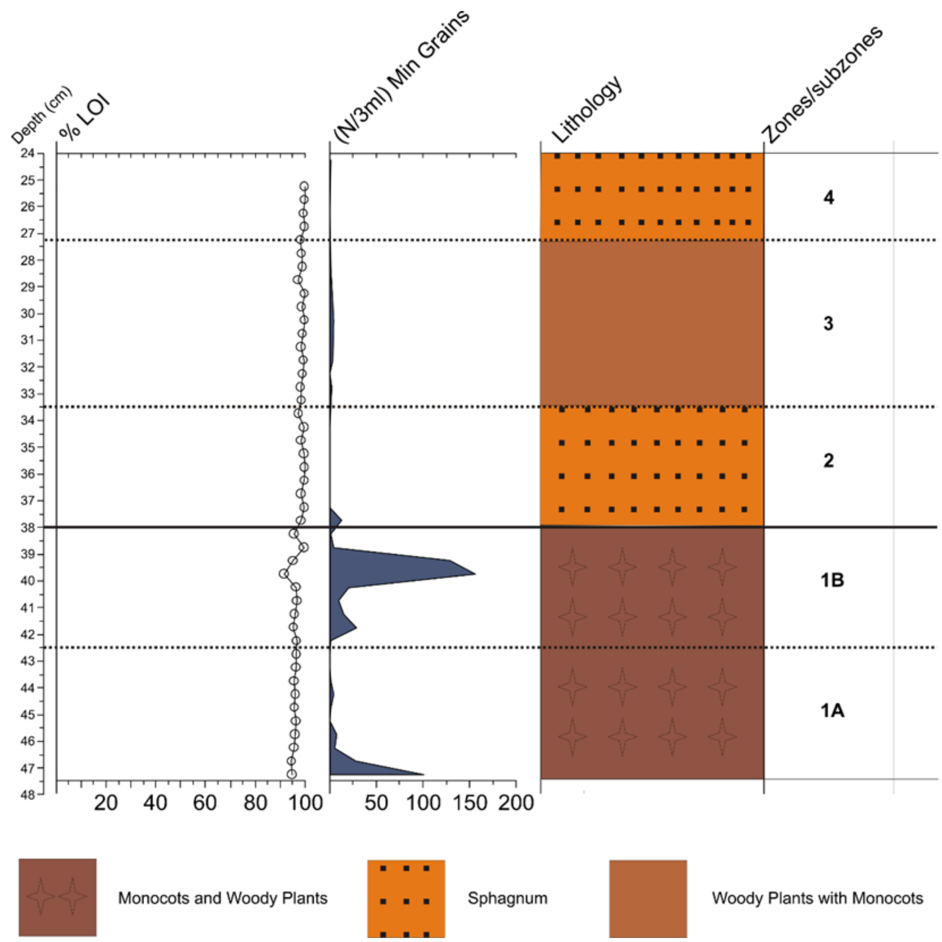

Figure 4. Loss on Ignition, lithology and sedimentary data.

4.2.2 Charcoal

Charcoal has long been used as an important and interpretable indicator of fire where it occurs in sedimentary deposits (Mooney and Tinner 2011). Where defined charcoal layers occur, they can be considered indicative of fire events and separable from the regular influx of background charcoal. However, inputs of charcoal may continue for some time after a fire event (Whitlock and Millspaugh 1996). There is some debate regarding the size class threshold for discerning localized fires (Cui et al. 2020). Large-scale conflagrations can send macrocharcoal 5 km or more (Tinner et al. 2006) through being transported by thermal buoyancy associated with the smoke plume (Fisher 2020; Pisaric 2002). Microcharcoal (c. 10–200 µm), owing to its small size, can be borne by wind for incredibly long distances, even up to thousands of kilometres (Conedera et al. 2009). However, it is usually useful in discerning fire events at the regional scale of 20-100 km (Mooney and Tinner 2011). Generally speaking, macroscopic charcoal, like the plant macrofossils to which it has an affinity, will not be transported far from its point of origin (Birks 2002; Pisaric 2002). Studies that look at the distribution of charcoal from documented fires have discerned that macroscopic charcoal (c. >100-200 µm) will usually only be deposited within a few hundred metres (Clark and Royall 1995; Conedera et al. 2009 Pitkänen et al. 1999; Whitlock and Millspaugh 1996). For this reason, macroscopic charcoal is useful for discerning fire events at the local scale. Mooney and Maltby (2006) found that charcoal particles over 250 µm should reflect fire at small spatial scales. Indeed, large charcoal fragments (>1-2mm) generally derive from an area of a few hundred to a few thousand square metres in size (Conedera et al. 2009; Tinner et al. 2006). Peatlands act as important repositories of charcoal, and macroscopic charcoal layers in peat bogs can generally be considered indicative of *in situ* or nearby fire activity (Pitkänen et al. 2001; Sillasoo et al. 2011; Zaccone et al. 2014). Importantly, charcoal layers in peat can often be linked with human activity by employing multiple lines of evidence (Bal et al. 2011). As is argued below, the charcoal deposits that occur in the peat sequence can be seen to be linked with a human presence in the area, and likely on the bog itself, and therefore with disturbance.

There are three major charcoal peaks. These peaks are easily separable from the irregular occurrence of background charcoal—sporadic, small pieces (<1mm) of macrocharcoal—as they occur as significant contiguous concentrations within the monolith. Unlike individual pieces of background charcoal, which may be redeposited long after a fire event or be carried some distance by wind or water (Whitlock and Millspaugh 1996), the charcoal concentrations (peaks) are interpreted as representing localized fire activity, either on the bog surface or nearby as they contain large pieces, in concentration, which cannot travel far (Finsinger et al. 2014). The nature of these fires and their disturbance impacts are greatly expanded upon in chapter 5. While it is certainly possible that these concentrations result from natural fires (i.e., forest fires) in the catchment area, as natural fires can produce similar charcoal concentrations (Kuhry 1994), it is unlikely. The assignment of a cultural origin for these peaks rests squarely on several lines of evidence. The area from which the monolith was obtained (4A800B) was excavated in 2018 and then again in 2019, during which time a cultural layer (4A800B7) consisting of "finely laminated…apparently trampled surfaces containing charcoal, wood debitage, and charred plant remains" was identified (Ledger et al. 2019b:15341). Below this was a "poorly humified peat deposit of laminated structure, containing occasional charcoal and frequent twigs and rootlets oriented horizontally" (Forbes et al. 2022: 9), indicating trampling. It is not possible to say what caused this trampling; however, such lamination of deposits as observed in the field would not happen in natural peat. For this reason, the excavators confidently term 4A800B7 a "cultural deposit" (Forbes et al. 2022: 9) and have published on it as such (Ledger et al. 2019b). The charcoal peaks are not separate from but instead correlate with the trampled deposits identified in the field

(Forbes et al. 2022). This suggests an anthropogenic origin for the peaks. Furthermore, while this thesis focuses exclusively on the plant macrofossils data, this interpretation is supported by the study of pollen and associated proxies and beetle remains from the same samples. These analyses are currently underway but almost complete, and the results of the plant macrofossil analyses will be integrated with them in a future publication.

The lowermost charcoal deposit, which is termed the Lower Charcoal Peak, occurs between 43.75cm bgl and 46.25cm bgl, with the greatest concentration between 44.25cm bgl and 44.75cm bgl. There is a very small amount of charcoal below this. It is possible, but unlikely, that the Lower Charcoal Peak represents *in situ* fire activity.

The middle charcoal deposit, called the Middle Charcoal Peak, extends from 39.25cm bgl to 40.75cm bgl, with the greatest concentration of charcoal between 39.75cm bgl and 40.25cm bgl. There are also minor amounts of charcoal between the two lower peaks (except for 41.75cm bgl and 42.75cm bgl where there is none). Given the intensive usage of the site (Kristensen and Curtis 2012) some of this charcoal is surely the result of fires elsewhere, having been deposited in the bog through being carried there by wind or runoff. It is possible that charcoal may have migrated upwards or downwards in the profile as well. Charcoal may also have been deposited some years after fire events elsewhere in the catchment area (Whitlock and Millspaugh 1996). There is no charcoal above 39.25cm bgl until the uppermost peak in the sequence. It is thought that the Middle Charcoal Peak represents *in situ* fire activity.

The top charcoal peak is referred to as the Upper Charcoal Peak and extends across one contiguous centimetre (98 pieces total of macrocharcoal in 32.75cm bgl and 16 total in 32.25cm bgl). This peak contains much less charcoal than those below it. However, no samples were analyzed for one centimetre underneath, so the charcoal may extend lower (with potential implications for the understanding of shifts in bog ecology as well). It is possible, but probably unlikely, that the Upper Charcoal Peak represents *in situ* fire activity.

Due to the nature of these deposits and their ambiguous relationship with the cultural chronology of the site (that based on previous work and described in section 3.3), the charcoal peaks have not immediately been assigned to particular cultural groups. Instead, they are simply referred to by their Lower, Middle and Upper Charcoal Peak monikers below. However, the potential relationship of these peaks to specific cultural groups, the anthropogenic use of fire, and *in situ* fire activity is discussed in chapter 5. Age-depth modelling of radiocarbon data was also used to discern approximate time of deposition of the charcoal concentrations, which is described directly below.

4.2.3 Chronology

The results of radiocarbon dating are presented in table 1. All dates fall within the last two millennia and, therefore, within the "CE" range. Overall, the results appear to demonstrate an accurate time series. Only one date demonstrates a potential reversal, 34.5-35cm (UOC-14541; cal 890-1020 AD). However, the range for this date does overlap with those above and below, and it may be that it is not congruent at 95.4% probability. For this reason, it has not been excluded. As noted, sampling depths were chosen for the abundance of datable material and not for association with charcoal peaks (which are believed to be cultural). Therefore, since abundant *Sphagnum* was available in association with the Upper Charcoal Peak, several dates were taken for it—securely dating it. The Middle Charcoal Peak could not be directly dated; however, one date, 37.5-38.0cm (UOC-14543; cal 1028 to 1198 AD), sits directly above it. Similarly, no dateable material was found in direct association with the Lower Charcoal Peak. While this is not ideal, enough dates exist for the profile to give an idea of the chronostratigraphic position of the deposits of interest and provide a secure time sequence.

Bayesian age-depth modelling using *Bacon* (Blaauw and Christen 2013) was used to further refine the chronology (fig 5). Estimates (95.4% probability) were also produced for the ages of the sediment in 1cm increments between 34cm bgl and 45cm bgl (table 2). Included within this range is the Middle Charcoal Peak (39.25cm to 40.75cm bgl) as well as the main (highest concentration) part of the Lower Charcoal Peak (44.0cm to 45.0cm bgl).

Table 1. Radiocarbon dates from 4A800B3-6

Depth (cm)	Lab code	Material	14C year BP	Error (±1σ)	Cal AD (2 ±σ)
23.0-24.0	UOC-14534	*Sphagnum*	595	36	1299 – 1414
25.0-25.5	UOC-14535	*Sphagnum*	502	46	1321 – 1471
25.5-26.0	UOC-11524	?	593	23	1305 – 1407
26.5-27.0	UOC-14536	*Sphagnum*	572	42	1301 – 1430
31.5-32.0	UOC-14537	*Sphagnum*	925	33	1033 – 1208
32.0-32.5	UOC-14538	*Sphagnum*	898	40	1040 – 1220
32.5-33.0	UOC-14539	*Sphagnum*	873	42	1044 – 1263
33.5-34.0	UOC-14540	*Sphagnum*	895	32	1042 – 1221
34.5-35.0	UOC-14541	*Sphagnum*	1090	32	890 – 1020
36.0-36.5	UOC-14542	*Sphagnum*	1002	33	991 – 1157
37.5-38	UOC-14543	*Sphagnum*	938	33	1028 – 1198
55.0-56.0	UOC-11525	Bark fragments, *E. nigrum* twigs	1742	25	245 – 401
58.5-60.0	UOC-11526	*Sphagnum,* bark, *E. nigrum* leaf frags	1801	22	210 – 330

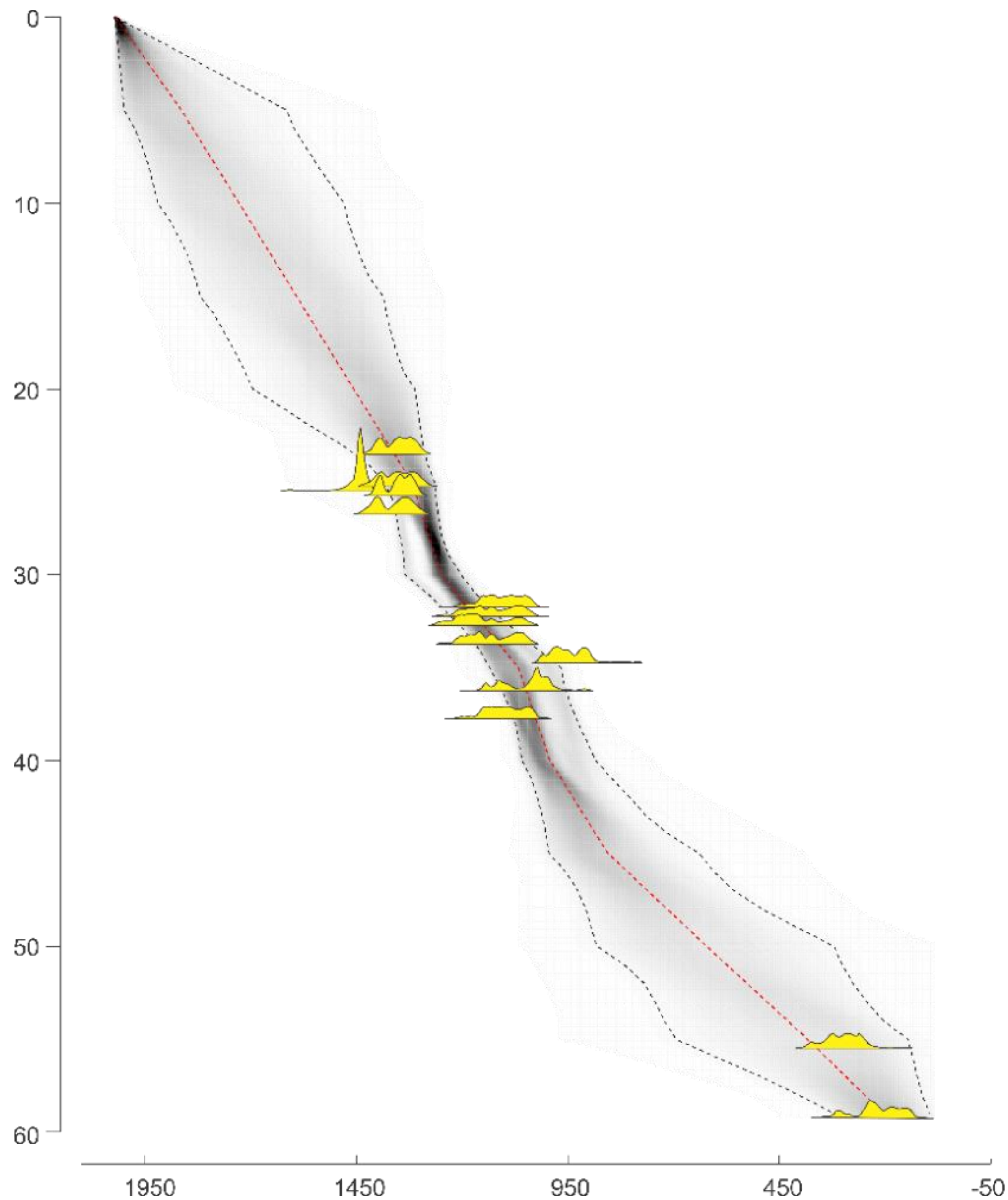

Figure 5. Age-depth model for 4A800B3-6. The grey shaded area represents all possible age-depth models, and the dotted lines indicate the possible age range at 95.4% probability. The darker areas indicate increased certainty, and the dashed red line indicates the weighted mean of the model.

Table 2. 95.4% probability estimates of select sediment ages in 4A800B3-6.

Depth (cm)	Oldest	Median	Mean	Youngest
34	1021	1106	1103	1159
35	966	1071	1066	1135
36	957	1059	1051	1110
37	944	1046	1037	1090
38	925	1032	1022	1074
39	904	1018	1007	1065
40	884	1005	992	1058
41	845	971	965	1036
42	802	939	937	1022
43	764	914	910	1011
44	709	890	882	1001
45	639	868	855	994

4.2.4 Plant Macrofossil Analysis

Within this section plant macrofossils are described by abundance and organized by zone and subzone (as identified by CONISS), beginning at the bottom of the profile and moving upwards. CONISS revealed four distinct Zones (1, 2, 3, 4). Zone 1 extends from 47.5cm bgl to 38.0cm bgl. It is divided into two subzones: 1A (47.5cm bgl to 42.5cm bgl) and 1B (42.5cm bgl to 38.0cm bgl). Above this are Zone 2 (38.0cm bgl to 33.5cm bgl), Zone 3 (33.5cm bgl to 27.25cm bgl), and Zone 4 (26.5cm bgl to 24.0cm bgl). Interpretation is also given on what the presence (and preservation condition) of particular plant macrofossils implies about the succession history of the bog area, and disturbance. Images are provided for pertinent plant macroremains in order to show what they look like. The overview of all plant macrofossils identified in monolith 4A800B3-6 is shown directly below in the summary diagram (fig 6).

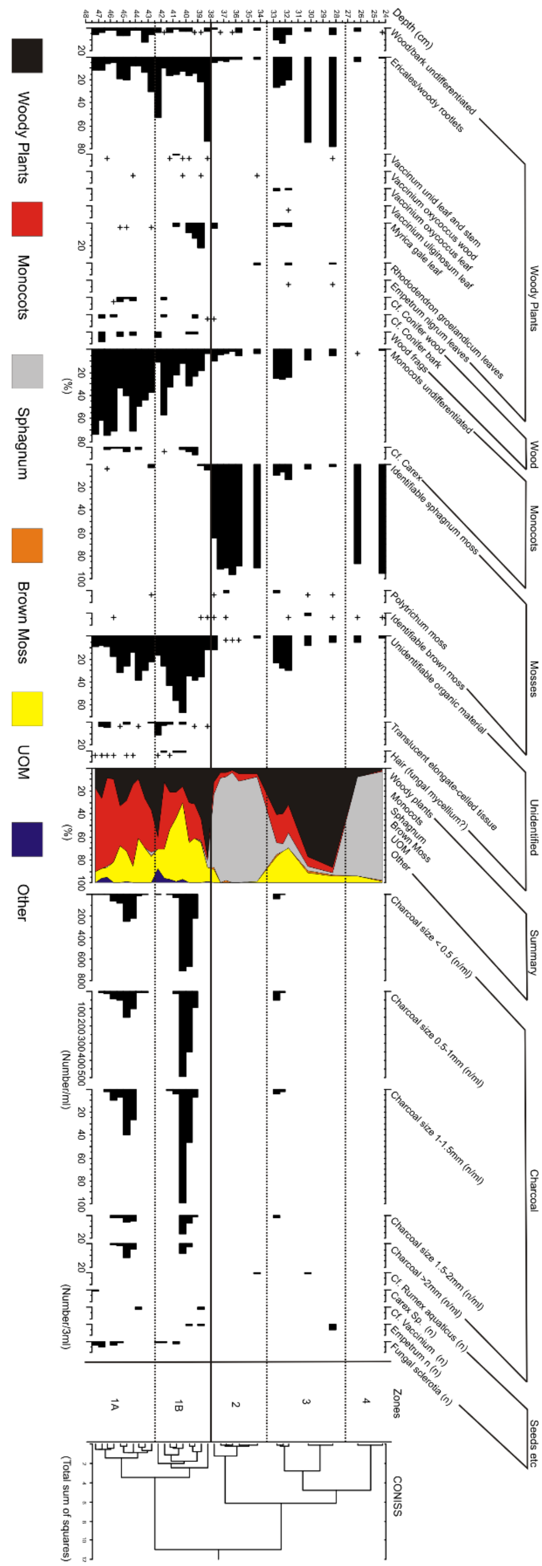

Figure 6. Summary diagram showing plant macrossil and charcoal abundance.

4.2.4.1 Zone 1

Zone 1 (47.5cm bgl to 38.0cm bgl) consists of a relatively to considerably humified monocot peat containing Ericales and woody plant remains in variable quantities. It also contains the Lower and Middle Charcoal Peaks. Zone 1 might be classified as a fen peat (monocots with woody plants). Given the relative similarity between subzones 1A and 1B, they will be described as one lithostratigraphic unit with reference to specific features, events, and changes.

Zone 1 is characterized by the presence of monocots (fig 7a), with a greater abundance lower down and a general decrease in abundance going upwards. In 1A they are especially prevalent (33.6% to 73.4% per sample). There is a reduction in 1B (3.5% to 56.8% per sample), but they are still quite common. Plant macroremains belonging to the sedge genus *Carex* (Lévesque et al. 1988) were identified throughout Zone 1, but not above (fig 7b). One *Carex* seed was identified from 47.25cm bgl (fig 7c). A translucent elongated celled tissue (figs 7d, 8) that was abundant in this zone but could not be identified, may be a monocotyledon as well. Prevalent monocots, and especially sedges, are often indicative of fen environments (Bauer and Vitt 2011; Väliranta et al. 2017). Compared to bog peats, fen peats are often more decomposed due to differing ecohydrological conditions and more effective humification processes (Ronkainen et al. 2014). Accordingly, Zone 1 displays a relatively high degree of humification as shown through abundant unidentifiable organic matter (UOM), which demonstrates a general trend of increasing abundance upwards through time (up to 40.25cm bgl, after which point it plateaus and then decreases rapidly). Within 1A, UOM varies between 9.2% to

38.4% per sample. In 1B, there is an overall increase in UOM (12.2% to 66.7% per sample). Beyond an autogenic (internally stimulated) origin, some of the UOM may stem from anthropogenically-mediated processes related to the two periods of occupation within this zone (see discussion). The presence of high UOM, abundant monocots and Ericales can be equated with drier conditions (Barber et al. 2003). Henningsmoen (1985) also interpreted the lower sections of this bog as being more minerotrophic indicating a fen, albeit at greater depth and thus age.

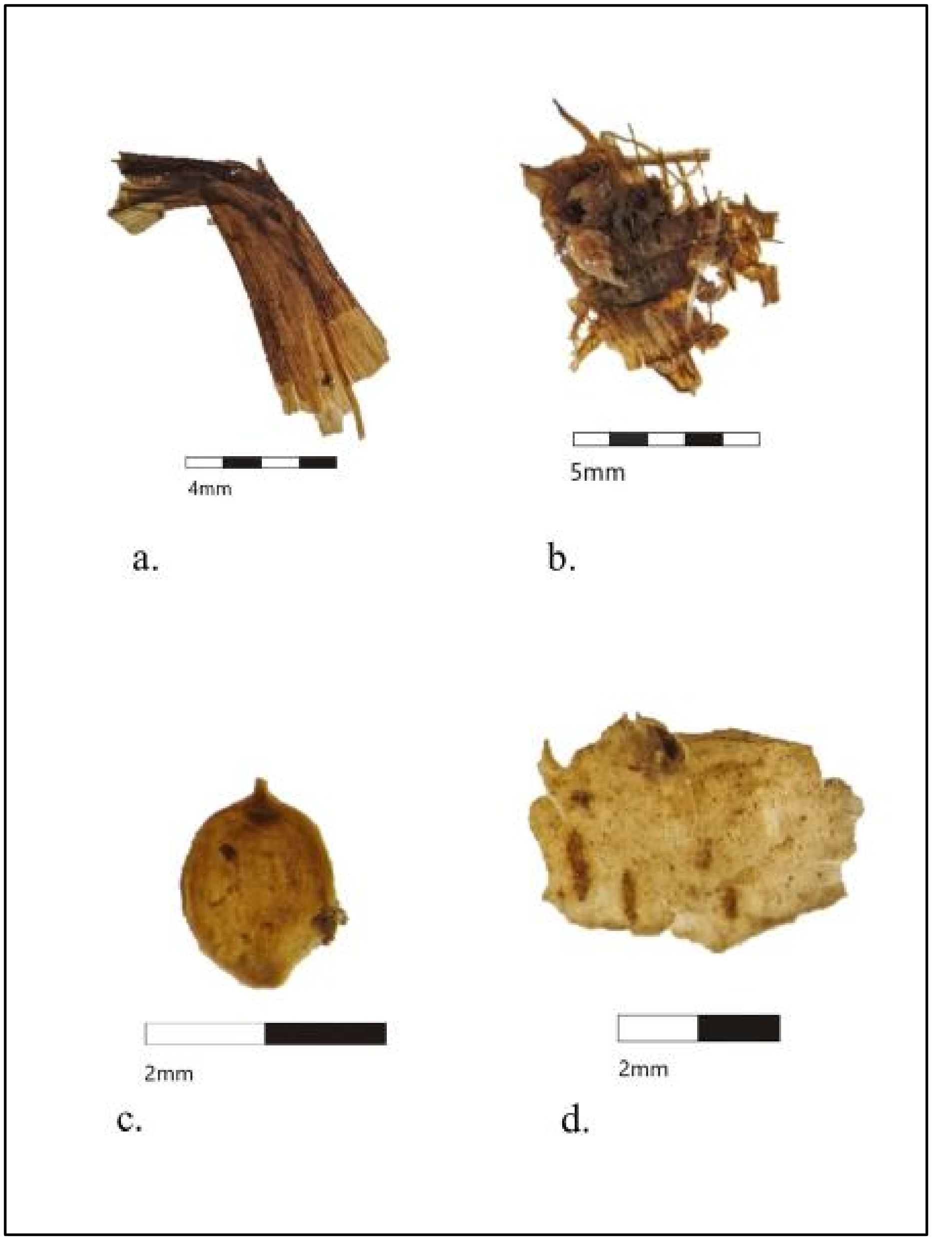

Figure 7. (a) Monocot sheath x20. (b) *Carex* rhizome x10.5. (c) *Carex* seed x10.5. (d) Unidentified, elongated-celled tissue x30.

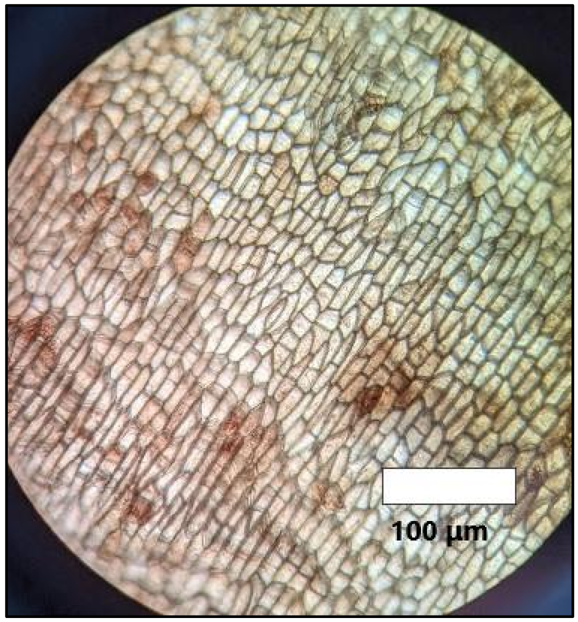

Figure 8. Elongated-celled tissue under light microscope (x200).

Woody plants occur throughout Zone 1. Wood/bark from woody plants is slightly more abundant in subzone 1A (1.8% to 12.4%) than 1B (0.4% to 3.6%). However, when all categories of woody plant macrofossils (bark, leaves, rootlets etc.) are added together, they are more prevalent in 1B. Regardless, they are present throughout, showing that woody shrubs were a consistent feature of the fen. Interestingly, the abundance of Ericales/woody plant rootlets appears relatively uniform throughout (5.1% to 30.7%). However, Ericales/woody plant rootlets abundance spikes twice, first at 42.25cm bgl (53%) and then again at 38.25cm bgl (74%). Each spike occurs above a large charcoal peak thought to be associated with human site occupation. Increases in Ericales (which constitute the bulk of the rootlets category) have been observed elsewhere post-fire disturbance (Boiffin et al. 2015; Pearson 2001) and may also be correlated with surface dryness (Hall and Mauquoy 2005). However, since some vascular plants can root deeply in bogs (Rydin and Jeglum 2013), some of these rootlets may also be related to plants growing above.

There is an increase in particular woody plant taxa in 1B. *Vaccinium* (unidentified leaves and stems) go from occurring in one sample (0.5%) in 1A to 5 out of 9 samples (0.3% to 1.1%) in 1B. *Vaccinium oxycoccos* (wood) also becomes slightly more prevalent—but is still rare (fig 9a). There is also an exponential increase in *Myrica gale* (figs 9b, 9c), from (0.1% to 0.3%) in three samples in 1A, to (3.0% to 21.9%) in four samples in 1B. This may be related to a shift in wetness at this time since *M. gale* often occurs in boggier conditions (Skene et al. 2000). Their presence may also have cultural implications. One *Empetrum nigrum* seed (fig 9d) was identified at 39.75cm bgl, and another one at 38.75cm bgl. Two *Vaccinium* seeds (species unknown) were identified at 38.75cm bgl (fig 9e). An unidentifiable berry was also found in 38.25 (fig 9f).

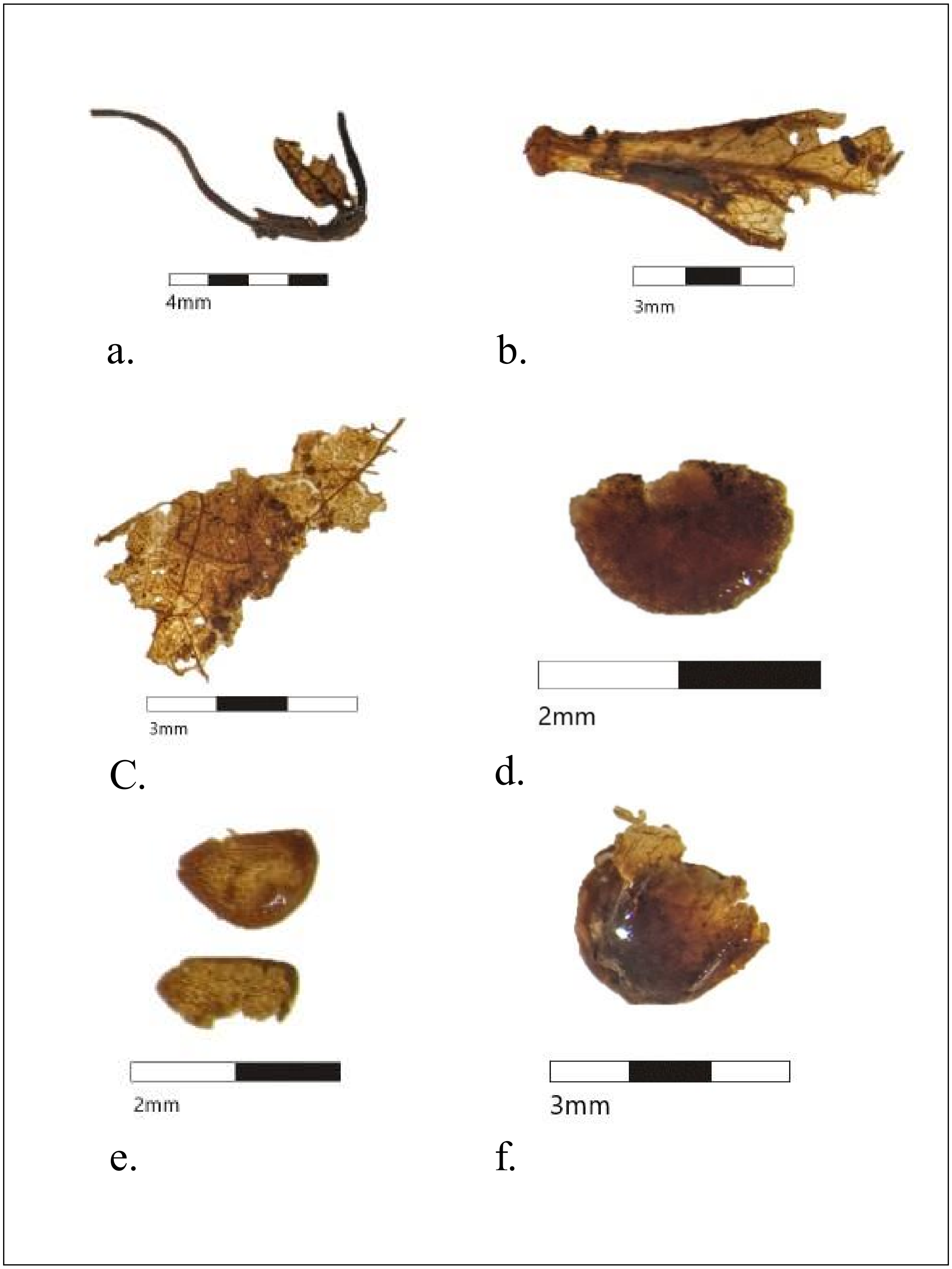

Figure 9. (a) *V. oxycoccos* wood and leaf x20. (b) *M. gale* leaf base x30. (c) *M. gale* leaf, (note glands) x40. (d) *E. nigrum* seed x60. (e) Cf. *Vaccinium* seeds x50. (f) Unidentified berry x30.

In Zone 1, a hair-like material (fig 10) believed to be fungal hyphae (mycelium) was identified. It occurs between 47.25cm bgl and 40.25cm bgl, but not above. It differs in abundance from 0.3% to 1.1% per sample and occurs in 11 out of 15 samples, with an increase in abundance upwards. There also appears to be some association with plant tissues. Given these characteristics, it is probable that it is *Cenococcum geophilum*, a globally distributed ectomycorrhizal fungus with a wide habitat range. It is found both within arid and wet poorly drained soils (Fernández-Toirán and Águeda 2007), including within peatlands (Mauquoy et al. 2020; Van Geel 1978). However, there does appear to be some association between the growth of *C. geophilum* and drier conditions, such as those which are often found in fens (Hughes 2000; Van der Linden and Van Geel 2006). The fungus has been found to colonize many different plant species, especially woody plants but also Cyperaceae (Obase et al. 2017), both of which occur in Zone 1. Ectomycorrhizal fungi form symbiotic relationships with plant species. They produce a hyphal mantle over root tips in order to form an extracellular connection between the plant cells, soil/sediment and fungus (Pena et al. 2014). In *C. geophilum* the fungal mantle is darkly melanized (Fernández-Toirán and Águeda 2007). One such (probable) fungal mantle was photographed during analysis (fig 11), and similar melanized tissue were seen sporadically throughout Zone 1 (but not counted).

A number of fungal sclerotia (the dormant resting body of the fungus) were also noted in Zone 1 (fig 12). These took the form of small black spherical bodies roughly 1.5mm in diameter, which meet the morphological criteria for *C. geophilum* sclerotia (Obase et al. 2017). *C. geophilum* sclerotia have been observed in peatlands (Van Geel

1978; Mauquoy et al. 2020). They were also identified elsewhere at LAM in two locations, one in an Indigenous hearth feature on the shore of Epaves Bay and from an area northwest of House F (Marche and Wilson 2008). The sclerotia occur in Zone 1 between 47.25cm bgl and 40.75cm bgl, disappearing around the same time as the probable fungal mycelium (40.25cm bgl). As such, it would appear that they are related and, therefore, both likely *C. geophilum*. Since fungal sclerotia are formed under dry conditions, Van der Linden and Van Geel (2006) interpreted the presence of *C. geophilum* sclerotia in a Swedish peat bog as evidence of secondary decomposition linked to an (anthropogenically-mediated) lowering of the local water table. It could be that something similar is occurring here.

Alternatively, the hair-like material may be dark septate endophytes (DSE), another septate fungus known to grow in peatlands (Thormann et al. 1999; Weishampel and Bedford 2006). Regardless, it is evident there is fungal activity within Zone 1 and that it ends at 40.25cm bgl to 40.75cm bgl. Indeed, fungal activity is only seen in Zone 1. Interestingly, it has been discerned that *Sphagnum* colonization inhibits mycorrhizal colonization of Ericaceae through the release of phenolics (Binet et al. 2017; Chiapusio et al. 2018), demonstrating one potential reason why fungi may disappear here, as *Sphagnum* begins to proliferate. Anthropogenic processes can also impact upon fungi in peatlands (Sun et al. 2016). Given the abrupt cessation of fungal activity where the Middle Charcoal Peak occurs, it is possible that humans had a direct hand in this. Fire has been found to sharply reduce fungal biomass and abundance (Andersen et al. 2013; Bergner et al. 2004). Because the Middle Charcoal Peak is thought to represent *in situ* fire (see chapter 5), this could be why fungal activity ceases here. Water table draw down (which can be human-mediated) may also impact upon fungal communities and can lead to a reduction in density of some species, although it may also benefit others (Andersen et al. 2013). Further proxies should be applied in future to understand water table fluctuation, its cause, and impact upon fungal communities in the lower part of the bog.

Figure 10. Dark septate strands underneath the light microscope (x400). Note branching (green arrow) and segmentation (yellow arrow).

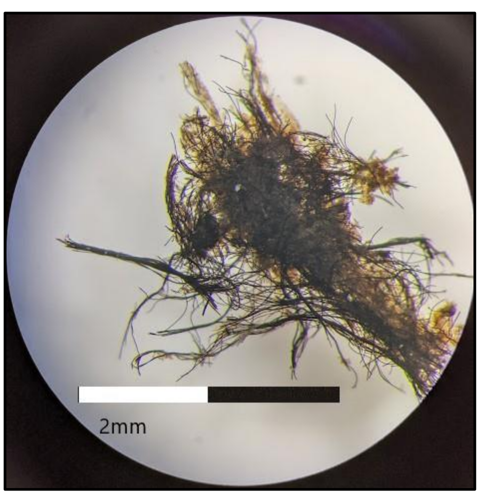

Figure 11. *Cenococcum geophilum* mantle? x60.

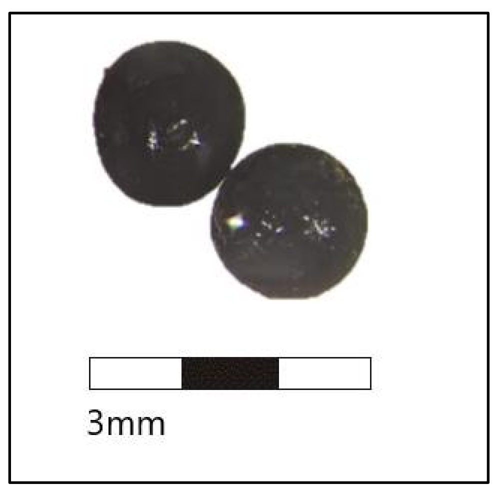

Figure 12. Fungal Sclerotia x30.

In the middle of Zone 1, there is evidence for site abandonment or at least non-usage of the bog area. 42.75cm bgl contains no charcoal (and there is very little directly above or below it). Importantly, in 1A, *Sphagnum* only occurs above and below the Lower Charcoal Peak, it is present at 46.25cm bgl (0.5% of the sample) and in 42.75cm bgl (3% of the sample). In 1B, *Sphagnum* (fig 13a) is present at 38.75cm bgl (1.5% of the sample) and directly above at 38.25cm bgl (5.2% of the sample), occurring after the Middle Charcoal Peak. *Sphagnum* moss is intolerant of trampling (Studlar 1980), making it a good indicator of site abandonment. The presence of *Sphagnum* can also be seen to correlate with wetter surface conditions (Schouwenaars and Gosen 2007). Brown moss (fig 13b) also occurs in 38.25cm and 38.75cm bgl, in amounts under 1% per sample. It is also found below at 45.75cm bgl (0.1% of the sample). *Polytrichum* moss (fig 13c, 13d) is another indicator of site non-usage since it emerges in recently disturbed areas (Groeneveld et al. 2007). It is only present within Zone 1 in 42.75cm bgl at (0.4% of the sample). Interestingly, at LAM in 2021 *Polytrichum* was observed colonizing areas disturbed during archaeological fieldwork in 2019.

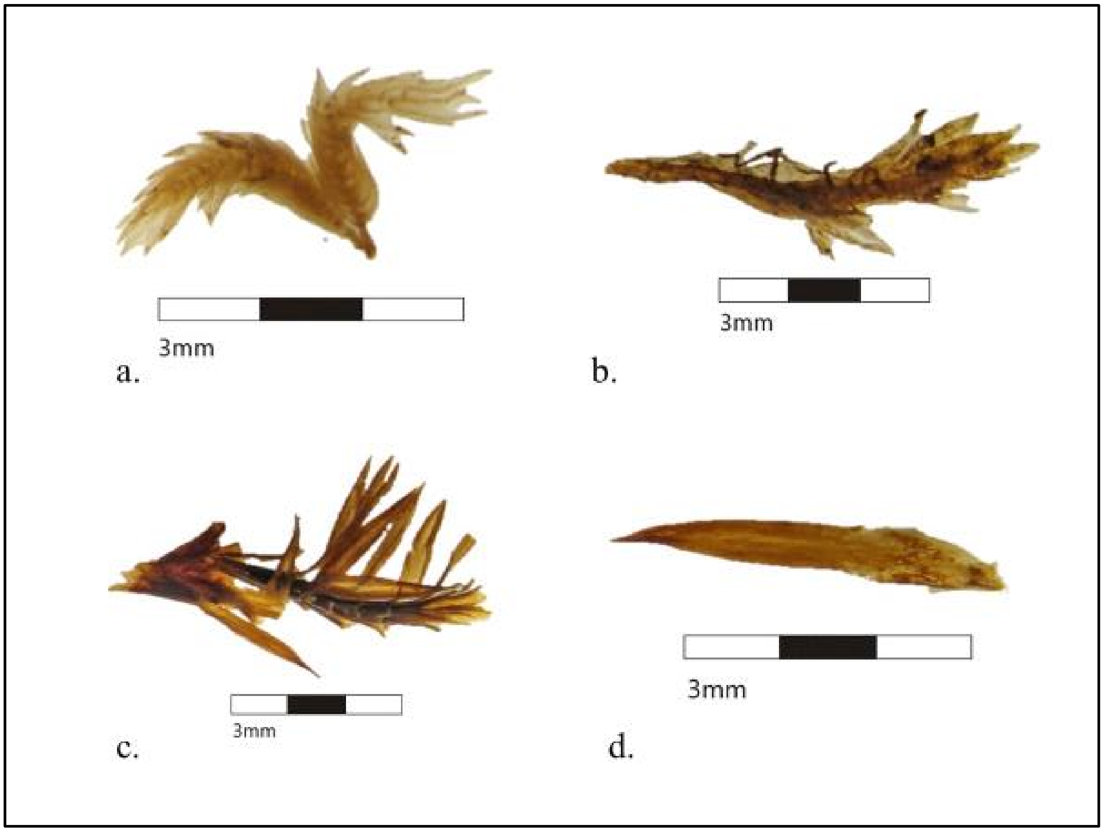

Figure 13. (a) *Sphagnum* (example) x40. (b) Brown moss (example) x30. (c) *Polytrichum* x30. (d) *Polytrichum* leaf x40.

Within Zone 1 there is the notable occurrence of wood fragments, some of which appear to be anthropogenically modified (fig 14a). Some are even partially burned (fig 14b). Generally, these seem to occur in association with the charcoal peaks. In relation to the uppermost charcoal peak, wood fragments occur at 39.25cm bgl (1.3% of the sample) and at 39.57cm bgl (1.7% of the sample). In association with the underlying peak, they occur at 44.25cm bgl (2.8% of the sample) and at 45.25cm bgl (3.6% of the sample). Two significant concentrations are also found above and below the charcoal peaks at 42.25cm bgl (4.3% of the sample) and at 46.75 (8.0% of the sample), respectively. These pieces of wood are quite large in size and may be the biproduct of anthropogenic wood working on the bog surface or nearby. This is supported by the large amount of worked wood debris that has been recovered in the lower bog at LAM (Wallace 1989, 2005). Material identified as conifer wood (fig 14c) and conifer bark (fig 14d) has also been identified sporadically throughout Zone 1. In subzone 1A conifer wood is only found between 44.25cm bgl and 45.75cm bgl (2.2% to 0.1% per sample). Conifer bark occurs at 45.75cm bgl and below at 46.75cm bgl. There is a small amount of conifer bark associated with the Middle Charcoal Peak (2.1% of the sample) at 39.25cm bgl. Conifer bark also occurs at 38.25cm bgl (0.8% of the sample). While most of this conifer bark and wood is likely the result of human processing of wood, some may also be from locally growing conifers. Conifers are known to grow locally on peat deposits (Davis 1980), and their presence at LAM in the past has been speculated on (Davis et al. 1988; Mott 1975).

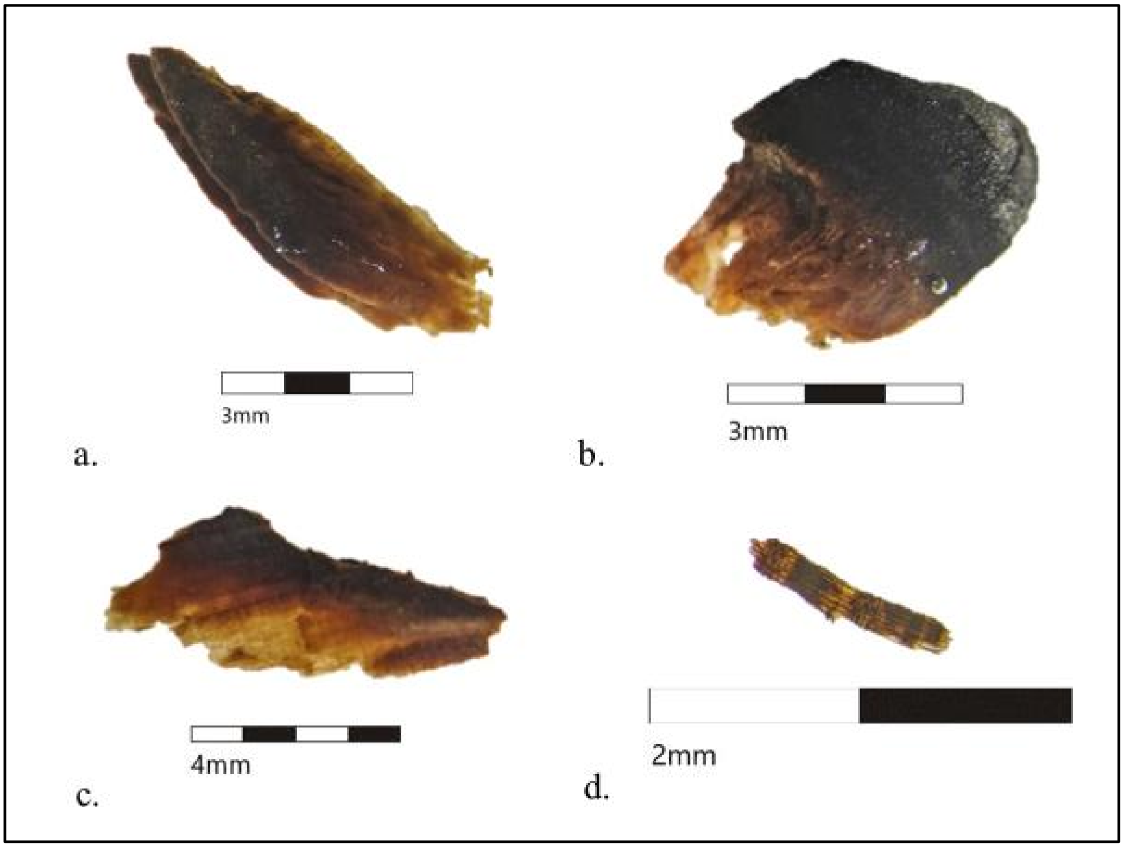

Figure 14. (a) Cut wood? x30. (b) Partially burned wood chip x30. (c) Conifer wood x20. (d) Conifer bark x80.

There is a notable change in the uppermost layers of Zone 1 (38.25cm bgl and 38.75cm bgl) likely indicating a transition to ombrotrophic conditions. Monocots decrease significantly, as does UOM. Importantly, both brown moss and *Sphagnum* are present in small quantities, indicating the beginning of a shift in the plant community composition of the fen, demonstrating a successional trend towards acidic bog conditions and an increase in surface moisture. Brown mosses can co-occur with *Sphagnum* during early succession (Lavoie et al. 2009) but once acidification increases *Sphagnum* will predominate (Granath et al. 2010), as demonstrated here. Many northern peatlands begin as fens before turning into ombrotrophic peat bogs later on (Frolking et al. 2001), including elsewhere in Newfoundland (Hughes et al. 2006) and at LAM (Davis 1984).

Indeed, both Robertson (n.d.) and Henningsmoen (1985) believed the lower part of the upper bog showed a successional change from minerogenic fen to ombrotrophic bog. Ombrotrophication may arise autogenically, through shifts in hydrology and peat accumulation, which raise the bog surface above the water table and permits ombrotrophy to take over, thus allowing Sphagna the ability to dominate, which causes the bog to acidify to the detriment of many plant species (Davies et al. 2021; Zobel 1988). It may also occur through allogenic (external) factors, both natural and anthropogenic (Tsyganov et al. 2019). Shifts between fens and bogs can occur rapidly (Granath et al. 2010). Hughes (2000) suggested that in sedge-dominated fens, a shift in hydrology caused by an allogenic factor can cause rapid ombrotrophication. Such factors could include shifts in catchment hydrology, river channel changes or anthropogenic influence—all of which can quickly lower the local water table. One salient anthropogenic influence is peat extraction, which can impact upon hydrology even if it is carried out elsewhere in the peatland (Van der Linden and Van Geel 2006). Local deforestation can as well (Speranza et al. 2000), among other human impacts. The shift between fen and peat bog here is rapid, and given its association with a charcoal peak, it is possible that the change is human-mediated. Regardless of cause, the border between Zone 1 and Zone 2 marks the transition between a fen into a bog and a shift from dry to wet conditions (Barber et al. 2003).

4.2.4.2 Zones 2, 3, 4

Together, Zones 2, 3 and 4 extend from 38.0cm bgl to 24.0cm bgl. Despite differences in composition, all samples contain *Sphagnum* moss in varying amounts. There are also other constituents: woody plants, monocots, brown moss and *Polytrichum*. This suggests that the upper part of the sequence reflects peat formation in an ombrotrophic setting (Rydin and Jeglum 2013). However, the composition of plants on the bog does shift, sometimes markedly, through time, likely indicating shifts in moisture regime (Swindles et al. 2007). These shifts resulted in changes to the plant communities present and thus the composition of the peat layers. Therefore, owing to biostratigraphic differences, the upper part of the sequence is divided into three distinct zones and described separately. Zone 3 contains the Upper Charcoal Peak, which is the only charcoal peak found in this zone.

4.2.4.3 Zone 2

Zone 2 (38.0cm bgl to 33.5cm bgl) is described as a very slightly humified *Sphagnum* peat. Accordingly, Zone 2 is characterized by the prevalence of *Sphagnum* moss, indicating the fulfillment of the *Sphagnum* colonization and ombrotrophication process seen to begin at the very end of subzone 1B. *Sphagnum* makes up 64.4% of the sample in 37.75cm bgl, but otherwise it constitutes between 88.2% (35.75cm bgl) to 95.4% (36.25cm bgl) of each sample. Brown moss is also found in very minor amounts in Zone 2 (0.9% in 37.75cm bgl and 0.3% in 36.75cm bgl). As noted above brown moss can co-occur with *Sphagnum* under particular conditions (Granath et al. 2010). Where brown moss occurs in Zone 2, *Polytrichum* occurs as well in minor amounts (0.6% in 37.75cm bgl and 2.0% in 36.75cm bgl). There is also an associated (slight) drop in *Sphagnum* (64.4% in 37.75cm bgl, 90.0% in 36.75cm bgl) compared to the samples between (91.6% in 37.25cm bgl) and above (95.4% in 36.25cm bgl), suggesting potential shifts in moisture conditions in the bog (Granath et al. 2010; Skre and Oechel 1981) or an allogenic factor such as nutrient availability (Paulissen et al. 2004). However, some *Polytrichum* species will grow in *Sphagnum* hummocks (Bauer and Vitt 2011; Šoltés and Školek 2010). 37.75cm bgl contains both conifer bark and *Myrica gale*, thus concluding a pattern begun in Zone 1 (neither of these occur again within Zone 2). In Zone 2, monocots occur in varied abundances (ranging from 10.2% at 37.75cm bgl, to 1.9% at 36.25cm bgl). As expected, the plant macroremains are well preserved in Zone 2 as demonstrated by very little UOM. There are also small amounts of wood/bark from woody plants throughout, which peaks at 3.5% at 35.75cm bgl. Ericales/woody plant rootlets are present in low abundance in Zone 2 (1.9% to 5.3% per sample). *Vaccinium oxycoccos* wood is present in one sample (34.25cm bgl at 0.1%). A single seed identified as being from *Rumex aquaticus* (fig 15) was found at 34.25cm bgl showing the presence of open shallow water nearby, such as a pool (Gould et al. 2013). Abundant *Sphagnum* and low UOM show wetter conditions within this subzone (Barber et al. 2003).

Figure 15. *Rumex aquaticus* seed x30.

4.2.4.4 Zone 3

Zone 3 (33.5cm bgl to 27.25cm bgl) appears to represent another rapid shift in the plant community in the bog area, as this zone is dominated by woody plants and monocots. It is described as a slightly to medium humified woody plant peat with monocots. With Zone 3, Ericales/woody rootlets range from 78.5% to 19.8% per sample, while woody plant wood/bark occurs in concentrations between 2.7% and 12.8% per sample. A wide range of woody plants are present to some degree within this zone. These include, *Vaccinium oxycoccos* (leaf) 1.5% at 32.75cm bgl and 1.1% at 31.75cm bgl. *Empetrum nigrum* (leaf) also appears at 31.75cm bgl, at 0.4% of the sample (fig 16a) and at 28.25cm bgl (1.0% of the sample) where five seeds were also present. *Rhododendron groenlandicum* (leaf) is present at 31.75cm bgl at 1.5% of the sample (fig 16b) and at 28.25cm bgl (1.0%). *Vaccinium* (unidentified leaf and stem) comprise 0.8% of 28.25cm bgl, and also, *Vaccinium uliginosum* (0.4% at 31.75cm bgl). *Myrica gale* (leaf) occurs here as well (2.6% at 32.75cm bgl; 1.6% at 32.25cm bgl and 3.0% at 31.75cm bgl), but not above or directly below. Monocots range between 5.0% and 26.4% per sample, with a greater prevenance lower down in the zone. Barber et al. (1994) state that the co-occurrence of Ericaceae, high amounts of monocots and very little *Sphagnum* can indicate drier surface conditions. Zone 3 does contain relatively little *Sphagnum*, with levels varying between 13.5% and 2.1% (with a reduction in the upper part of the zone). Conversely, brown mosses increase (0.2% in 31.75cm bgl, 0.7% in 28.25cm bgl, and 1.8% in 30.25cm). *Polytrichum* is also present, which appears at 1.7% of the sample at 32.75cm bgl, and in decreased amounts in the upper part of the zone (0.1% per sample in 30.25cm bgl and 28.25cm bgl). Overall, the decrease in *Sphagnum* and increase in brown mosses (and the reappearance of *Polytrichum*) can potentially be seen to signal drier conditions moving upwards (Daley and Barber 2012; Potvin et al. 2015). It is not unusual for bryophytes to occur in small amounts with vascular plants during dry shifts (Barber et al. 2003), such as is the case here. The co-occurrence of monocots, Ericales and high UOM have also been found elsewhere to indicate shifts towards dry conditions (Barber et al. 2004).

However, in Zone 3 UOM actually decreases in the top of the zone ranging from 5.9% to 8.5%, whereas it occurs between 23.1% and 30.1% per sample in the lower part. A shift towards low UOM is traditionally associated with increasingly wet conditions (Charman et al. 1999; Langdon et al. 2003). Similarly, monocots also decrease towards the top of the zone (5.0% to 8.9%) as opposed to 24.3% to 26.4% per sample below. Reductions in monocots are also associated with wetter conditions (Barber et al. 2003). A single seed of *Rumex aquaticus* was found at 28.25cm bgl likely signalling that there is standing water nearby (Gould et al. 2013). Interestingly, *R. aquaticus* is of uncertain status in Newfoundland and could potentially be an anthropogenic introduction (Ledger et al. 2019b). It is difficult to reconcile the difference between the wet and dry indicators in Zone 3. It may be that variable wet/dry conditions prevail here. However, to clarify this conclusively, *Sphagnum* would need to be identified to species (since specific species can inform on moisture conditions) and likely other proxies applied as well (Rydin and Jeglum 2013).

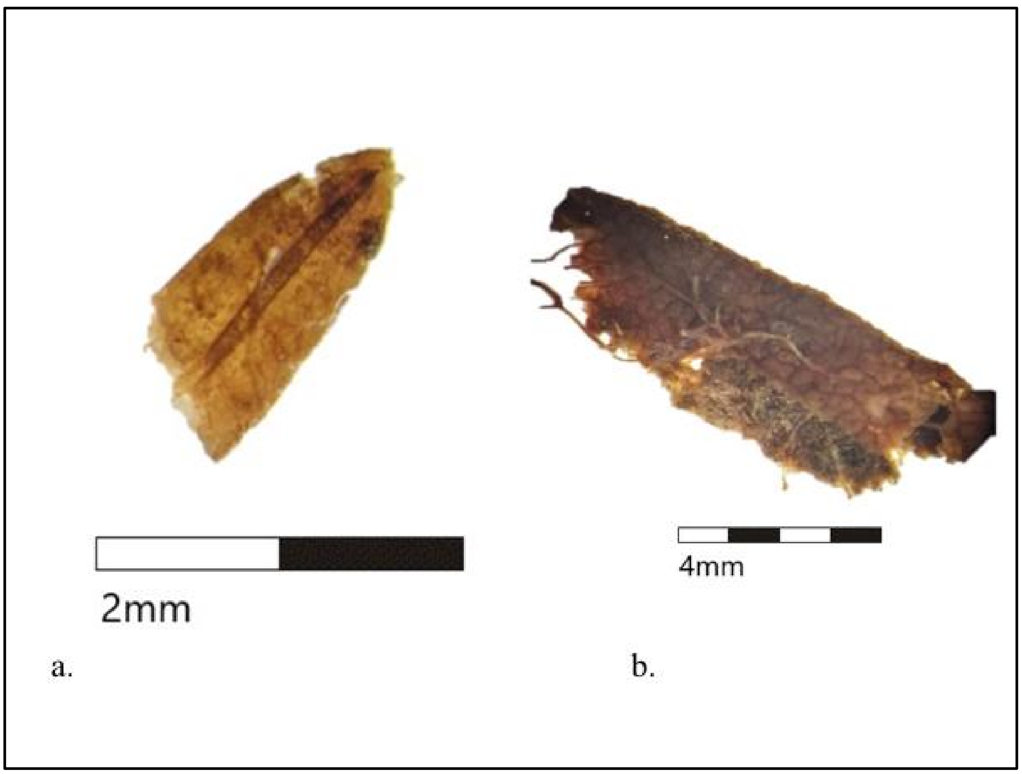

Figure 16. (a) *E. nigrum* leaf x50. (b) *R. groenlandicum* leaf x20.

Alternatively, it could be that Zone 3 only appears to be indicative of a successional shift in the peatland but is actually an anthropogenic deposit. If this is the case, then the variety of wet and dry adapted plant taxa found here could represent the intentional (or unintentional) addition of organic material to the bog, which is possible, as they appear in association with charcoal (the Upper Charcoal Peak), indicating a probable human presence at this point. Schönbäck (1974) thought that material had also been added to the lower bog to try and dry the surface. Fire may have been set to the bog surface as well. This could help to explain the presence of *Polytrichum* (Bauer and Vitt 2011; Sillasoo et al. 2011) and potentially the abundance of Ericales rootlets seen higher up in the zone (Boiffin et al. 2015; Mann and Plug 1999). A burned seed, possibly Apiaceae (see fig 19), recovered from 31-32cm bgl, hints at the landscape's modification with fire but could equally indicate the dumping of burned material on the bog surface—perhaps during winter. It is argued below that human trampling had a significant effect on this deposit as well. Another issue plaguing the interpretation of Zone 3 is low resolution. Only five half centimetre samples were analyzed for Zone 3 (which extends across 6.25cm). This is a very low resolution compared to that employed underneath. Therefore, it may be difficult to discern what is going on in this zone based on the available data.

4.2.4.5 Zone 4

Zone 4 (26.5cm bgl to 24.0cm bgl) is described as a slightly humified *Sphagnum* peat. It is characterized by a move towards *Sphagnum* domination and thus a definite shift towards wetness (Barber et al. 2003; Swindles et al. 2007). Within Zone 4, *Sphagnum* occurs at 86.5% in 26.25cm bgl and at 95.1% at 24.25cm bgl.

There are small amounts of brown moss in both 26.25cm bgl (0.3%) and 24.25cm bgl (0.5%). Brown moss and *Sphagnum* can survive together under specific conditions (Lavoie et al. 2009). There is a precipitous drop in Ericales/woody rootlets from the previous subzone. Here they occur in concentrations between 1.7% and 4.3%. There is a small amount of woody plant wood/bark, which decreases upwards (3.0% in 26.25cm bgl to 0.2% in 24.24cm bgl). UOM is present in small amounts (5.7% in 26.25cm bgl to 1.5% in 24.25cm bgl) and decreases upwards as well. There is a small amount of monocots present (0.2% to 1.0%). High amounts of *Sphagnum*, few monocots, little Ericales/woody plants and low amounts of UOM point towards this being a wet phase (Swindles et al. 2007).

Chapter 5. Discussion

In this thesis I have sought to discern how a peat bog sequence at LAM formed as a result of natural successional processes and anthropogenic disturbance. To do this, a high temporal resolution macrofossil analysis and radiocarbon age-depth modelling have been employed. The application of this approach has revealed broad successional trends and hydrological shifts as evidenced by the plant macrofossils present within the peat sequence. Additionally, the presence of three charcoal peaks thought to be indicative of past human site occupation have been discerned. Within this section, I build upon the results and interpretations presented in the previous chapter in order to answer the research questions posed in chapter 1. First, I discuss whether the charcoal peaks can be assigned to particular cultures through a combined approach using age-depth radiocarbon modelling and plant macrofossils. Second, the influence of disturbance and biophysical drivers on the succession history of the peat sequence is discussed.

5.1 Discerning Episodes of Human Activity

Can radiocarbon age-depth modelling and analysis of plant macrofossils help identify discrete episodes of human activity in the peat bog sequence, and attribute them to specific cultural group(s) known to have used the site?

Radiocarbon age-depth modelling and plant macrofossil analysis can be used to give some indication of who was responsible for indicators of human activity being deposited within the peat deposits. Within this section, the age-depth model for the sequence (see fig 5) is compared against the standard cultural radiocarbon chronology for LAM (fig 17), and the results of the plant macrofossil analysis are compared against the review of cultural uses of bog plants undertaken in chapter 2, in order to make inferences about which cultural groups were responsible for the production of the charcoal peaks. However, as discussed below, these methods are only tools for making inferences; they provide lines of evidence, not definitive answers.

5.1.1 Radiocarbon Age-Depth Modelling

When working with a number of calibrated radiocarbon dates derived from a sedimentary sequence, age-depth modelling can be used to provide a relatively precise chronology, which can give a timescale for events and processes (Blaauw and Heegaard 2012). It is a powerful tool as it allows the assignment of age to deposits that have not been directly dated and, as such, has found application in various disciplines concerned with the assigning of age to stratigraphy (Ferbrache 2019). In palaeoecological investigation, age-depth modelling can be used to discern the chronostratigraphic and spatiotemporal relationship between different strata and proxies and thus provide a more stable foundation for the building of inferences (Lovelace et al. 2022). Archaeologists have used age-depth modelling to discern the age of cultural deposits (e.g., Levchenko 2013). It has also been used on peat-bearing sites to identify the relationship between deposits and the impacts of human occupation in the area (e.g., Albert et al. 2021). Importantly, it has been employed as a tool in making comparisons between site deposits, including those composed of macrofossils, and known regional archaeological chronologies (Schlütz and Bittmann 2016; Tarasov et al. 2021). It is used towards this end here, whereby the age-depth model produced for the sequence (see fig 5) is utilized as a guide in discerning the ages of particular deposits—which are then compared against the known Indigenous site chronology (fig 17).

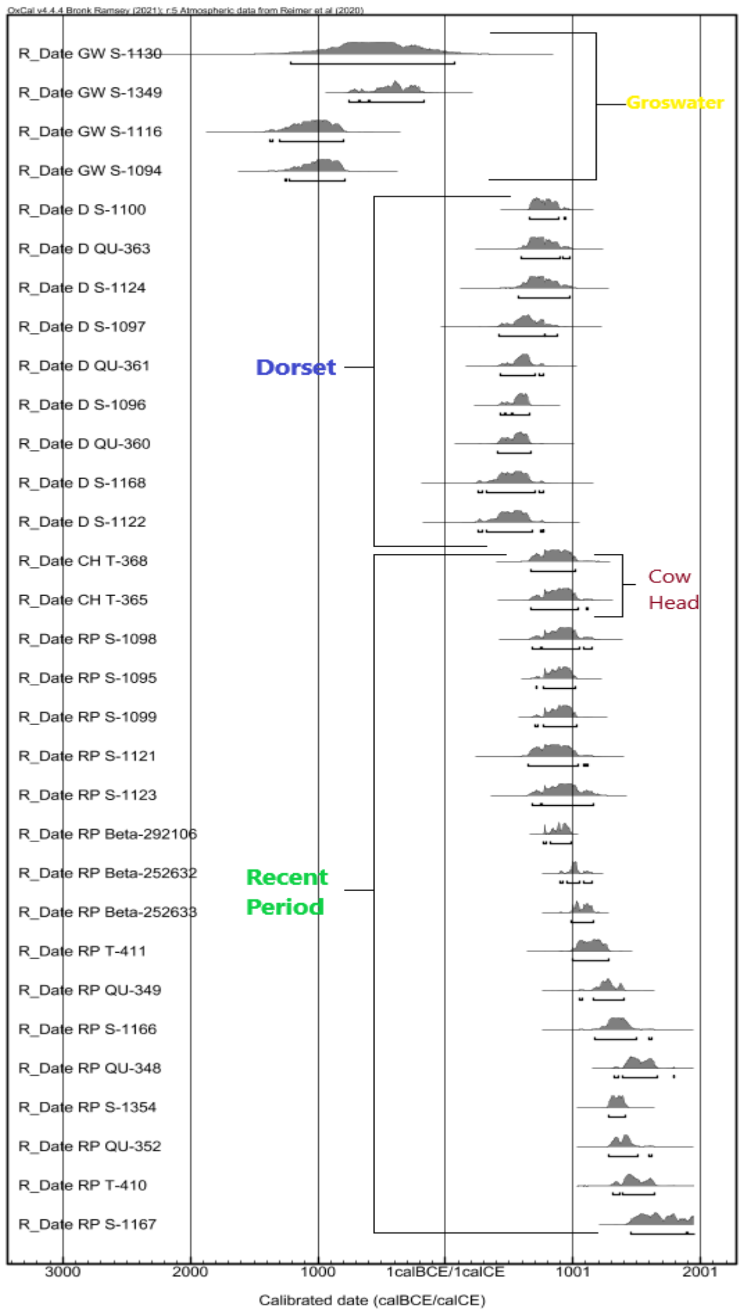

Figure 17. Multiplot showing radiocarbon dates for site occupation by Indigenous cultures at LAM (Wallace 2012) during the time the peat sequence was forming. Dates were obtained from Wallace (1989), Kristensen and Curtis (2012) and from a spreadsheet compiled by Paul Ledger. Some dates assigned to cultures in the past have been excluded here based on the materials dated (bulk peat, whale bone), provenience, or because they were far outside of the range for the stated culture. The Maritime Archaic culture have been excluded as too early for the purpose of this thesis. The two Cow Head complex dates represent the two cooking pits (Kristensen and Curtis 2012). Dates were plotted and calibrated in OxCal (Ramsey 2009) using the Reimer (2020) calibration curve.

5.1.2 Lower Charcoal Peak

The Lower Charcoal Peak occurs in 1A between 43.75cm bgl and 46.25cm bgl, with the greatest concentration of charcoal between 44.25cm bgl and 44.75cm bgl. Based on the age-depth model (see fig 5), it was likely deposited at some point during the 8th to 9th centuries CE. Probability estimates (95.4%) for the ages of the main part of the peak (44cm bgl to 45cm bgl) indicate that deposition probably occurred in the late 9th century CE (table 2), with the underlying charcoal concentrations, evidently, being of greater age. A Norse origin of this peak can be excluded, given that the Norse did not settle Greenland until around 985 CE (Fitzhugh 2000). It was deposited during a time associated with Indigenous site usage (Kristensen and Curtis 2012; Wallace 2012) and is, therefore, likely Indigenous in origin. However, to which particular Indigenous group (or groups) it relates is somewhat ambiguous. While a Groswater culture origin can be dismissed, it was deposited during a time when both the Dorset people and the Cow Head complex or other Recent Period groups could have been using the site based on the conventional radiocarbon chronology (fig 17). However, the Dorset culture dates for the site (fig 17) do extend somewhat beyond the currently accepted terminus of Dorset Palaeo-Inuit occupation on the island of Newfoundland (c. 780 CE, Bell and Renouf 2008), thus indicating that a Recent Period origin for the peak may be more likely. As discussed in chapter 2, there is some precedent for Recent Period usage of peat bogs in the province, as they are thought to have used the top of the bog at the Gould Site near Port au Choix as an occupation surface—leaving a deposit of charcoal there as well (Renouf et al. 2000, 2009; Teal 2001). The Cow Head people also used the peat bog at the Peat Garden site for the same purpose (Hartery 2007; Hartery and Rast 2001). However, Palaeo-Inuit groups may have used peat bogs as well (Bell et al. 2005). Unfortunately, unlike some artifacts, charcoal in and of itself is not indicative of any one culture. Partially burned wood chips are likewise not informative in this regard. Cultural attribution of deposits must always follow multiple lines of evidence. Since the evidence is insufficient here to distinguish one group from another as the creators of this deposit, it is simply seen to be an Indigenous accumulation related to site usage prior to the Norse and thus referred to as the Lower Charcoal Peak.

5.1.3 Middle Charcoal Peak

The Middle Charcoal Peak occurs in 1B and extends from 39.25cm bgl to 40.75cm bgl, with the greatest concentration of charcoal between 39.75cm bgl and 40.25cm bgl. Based on the age-depth model, the Middle Charcoal Peak was deposited during the early 11th century (see fig 5), around the time when the Norse are known to have been at the site (Kuitems et al. 2021; Ledger et al. 2019b). The median (95.4% estimate) date for 40cm bgl of 1018 CE (table 2) is actually quite close to the 1021 CE date proposed by Kuitems et al. (2021) for Norse site occupation. However, based on the model, it is possible that it was deposited somewhat earlier or later (see fig 5). It is also likely that it is, at least in part, the result of *in situ* fire, which bears similarities to other Norse *landnám* layers seen in the North Atlantic (McGovern et al. 1988). Based on the Indigenous site chronology (fig 17), the Middle Charcoal Peak was also deposited during a time when Recent Period groups could have been at the site. As noted in chapter 3, hearths containing boat nails have been interpreted as the Indigenous scavenging of Norse wood for fuel after they had abandoned LAM (Curtis 2011; Kristensen and Renouf 2009; Wallace 2003b). It is also possible that Indigenous Recent Period people were at the site directly before the Norse occupation and set fire to the bog then. They certainly would have had cause to, in order to promote the growth of particular plants or facilitate hunting (Cronon 2011; Holly 2013; Stewart 2002). Based on the dates, they may have even been there at the same time as the Norse—although there is no other evidence for this (Lewis-Simpson 2020; Wallace 2012). The Middle Charcoal Peak also bears similarities to deposits seen in the lower bog attributed to the Norse (Davis et al. 1988; Schönbäck 1974; Schönbäck et al. 1976) but also to Indigenous groups (Wallace 1989). Therefore, it is hard to say precisely which group the Middle Charcoal Peak belongs to. However, its deposition during a time when Norse occupation was known to have taken place at LAM does point towards the Norse as those responsible for it, but an Indigenous origin cannot be completely ruled out based on the data presented here. Further study employing additional proxies and alternate methods could help to clarify this conclusively.

5.1.4 Upper Charcoal Peak

Zone 3 contains the only charcoal peak in the upper part of the peat sequence (above Zone 1). It is referred to as the Upper Charcoal Peak and extends across one contiguous centimetre (98 pieces total of macrocharcoal in 32.75cm bgl and 16 total in 32.25cm bgl). Based on the age-depth model, it was likely deposited between the 12th and 13th centuries (see fig 5). Ledger et al. (2019) hypothesized that the layer (4A800B7) they identified in the bog, which corresponds with this peak, was likely related to Recent Period Indigenous activity. Given the date, this seems entirely plausible, as the Upper

Charcoal Peak would have been deposited during a time when Recent Period peoples could have been at the site (fig 17). Wallace (1989, 2012) certainly felt that the later Indigenous presence at LAM encompassed this time period. However, Ledger et al. (2019) also hypothesized that, while unlikely, the Norse could have been responsible for layer 4A800B7. Given that the Norse were in Greenland until the 15th century (Dugmore et al. 2007) and that later voyages to an area the Norse referred to as Markland (likely Labrador) for the purposes of wood harvesting were noted as occurring into the 14th century (Guðmundsdóttir 2021; Price 2020), it is possible. Schönbäck et al. (1976) did speculate that a twig pile in the lower bog could have been related to a later Norse wood gathering expedition. It is also likely that knowledge of Vínland lived on in social memory for some time (Price 2020). A probable reference to Markland was even recently found in a 14th century (circa 1340 CE) Italian document, showing just how far knowledge of North America may have extended through time and space (Chiesa 2021). However, given the available evidence, the Upper Charcoal Peak cannot definitively be assigned to a particular culture at this time, although it is likely that it is Indigenous in origin given the later intensive usage of the site and the Northern Peninsula by Recent Period Indigenous groups (Hull 2002; Kristensen and Curtis 2012).

5.1.5 Plant Macrofossils

Beyond their application in radiocarbon dating (Strunk et al. 2020), macrofossils can also be employed as an interpretative tool in discerning which cultural groups were at the site and responsible for the charcoal peaks in the peat bog. Many plants had cultural uses, and their presence (as macroremains) may hint at how the bog was used and by whom. This is especially true when plant macrofossils can be correlated with charcoal, thus linking the two cultural signals together. Therefore, plant macrofossils, which occur in association with the charcoal peaks, are considered here.

5.1.5.1 Berries

Analysis has revealed ample evidence of the presence of berries, and it is quite likely this resource was made use of by all groups to inhabit the site. A crowberry seed (*Empetrum nigrum*) was identified in association with the Middle Charcoal Peak, which is thought to potentially constitute the Norse horizon. Given what is known about their crowberry usage (Arneborg et al. 2012; McGovern et al. 1983), *Empetrum nigrum* may very well have been a utilized resource at LAM. Indigenous groups are known to have used crowberry as well (Zutter 2009). *Vaccinium oxycoccos* occurs in relation to the Lower and Upper Charcoal Peaks, which are thought potentially to be Indigenous. *V. Oxycoccos* was known to be used by a variety of different Indigenous groups (Anderson 2009; Boulanger-Lapointe et al. 2019; Norton 1981; Oswalt 1957; Turner and Bell 1973). The additional presence of *Vaccinium* seeds occurring at 43.75cm bgl, atop the Lower Charcoal Peak, certainly attests to the availability of berries for the Indigenous group (or groups) inhabiting the site at this point. Interestingly, there is some association between the anthropogenic use of fire and the propagation of berries (Anderson 2009; Biggs 1976). However, this may or may not be the case here.

5.1.5.2 Myrica gale

Myrica gale was utilized extensively in medieval brewing (Verberg 2018; Zimmerman 2018). It occurs in some concentration in several places in the profile but is especially prevalent around the Middle Charcoal Peak, during a period when, based on the age-depth model, the Norse would have been at the site. There is no evidence at LAM for the use of *M. gale* for brewing, but it is tempting to think of it in this capacity, especially since it is abundant around the time of Norse presence. As noted, *M. gale* may have had Indigenous uses as well (Guedon 2000; Kari 2020; Porter 2007), and it does occur in association with the Upper Charcoal Peak in some quantity—perhaps having been intentionally added to the deposit with other organic materials by humans.

5.1.5.3 Cyperaceae and Monocots

The bog would also have provided the Norse with sods for building. It has generally been assumed that sods were taken from the lower sedge bog (Wallace 2012: 50), likely owing to the presence of sedge pollen in some of them, although it was also found that they may have come from several different locations at the site since the composition of wall sods varied (Henningsmoen 1985). Some of the sods in House A were found to be quite similar in composition to Zone 1 as they lacked *Sphagnum* and contained Cyperaceae and Gramineae (Henningsmoen 1985), which both occur in this zone. While the sequence within 4A800B3-6 does not contain evidence for truncation as would be expected with sod stripping (Ledger 2018), it is possible that sedge sods were gathered in the upper bog—something which has not been considered before.

The Norse are known to have had cattle, sheep, goats, pigs, dogs and horses in Iceland and Greenland (Campana et al. 2014; Dugmore et al. 2007; Mainland and Halstead 2005). According to the Vínland sagas (Kunz and Sigurðsson 2008), the Karlsefni expedition brought livestock with them to Vínland, which would have required fodder and grazing pasture—perhaps only pasturage as well since the sagas mention that the animals were kept out all winter. The lower "sedge bog," as the name implies (Wallace 2012: 31), would have been amenable grazing territory. As demonstrated here, Zone 1, which would have been the exposed land surface in the upper bog at the time of Norse arrival (regardless of who created the Middle Charcoal Peak), would have as well. A relatively dry surface and the presence of monocots (including Cyperaceae), likely improved somewhat by fire, would have made this ideal for grazing. Some grazing may certainly have taken place in the upper bog, albeit later on and perhaps by caribou, as *Sporormiella*-type fungal spores (coprophilous fungi associated with grazing herbivores) were discerned higher up in the peatland (Ledger et al. 2019b). It is also evident that cows were grazed widely on the site area in the more recent past, as their presence was noted by Anne Stine (Ingstad 2013).

Finally, Indigenous groups are also known to have made use of Cyperaceae. As noted, the Labrador Inuit, in particular, used *Carex* to make mats (Zutter 2009); *Carex* being particularly prevalent in Zone 1. There is no evidence of an Inuit occupation at the site, but they could have been employed to this end.
Similarly, *Sphagnum* is known to have been well used by Indigenous groups (Kimmerer

2003) and is present in quantity in the monolith, but it does not mean it was used to that end here.

5.1.6 Macrofossils and Charcoal: Summarizing Evidence Associated with Human Activity

Together, macrofossils and charcoal provide lines of evidence through which the identity of those who were responsible for the formation of anthropogenic deposits in the bog at LAM might be inferred. Charcoal Concentrations, or peaks (Upper, Middle, Lower) as they have been referred to here, act as biostratigraphic markers thought to be indicative of human activity. Using the age-depth model, these peaks have been interpreted as events and given a chronological position, which has been compared against the standard site chronology in order to interpret which groups might be behind their formation. However, what has emerged from this analysis are only *possibilities*; they are not definite answers about which cultures were responsible for the peaks in the bog or used the site area in the past. One reason for this is the nature of the methods employed and, consequently, data generated. While age-depth modelling is undoubtedly a powerful tool for producing informed estimates of the ages of deposits (Blaauw and Heegaard 2012), it is not free of issues, some of which are inherent within the method itself (Lacourse and Gajewski 2020; Telford et al. 2004; Trachsel and Telford 2017). Further, while there is precedent for it (e.g., Schlütz and Bittmann 2016; Tarasov et al. 2021), comparison and correlation against a standard radiocarbon chronology, as has been employed here, is also somewhat problematic—especially considering some of the concerns that have been raised for the site chronology (Ledger et al. 2019b). Similarly, the macrofossils discussed here were not recovered in direct archaeological contexts, such as structures, as would be preferable (Celant et al. 2015), but rather occurred in association with the charcoal peaks. Given this context, they may or may not have had cultural uses—although their presence is still intriguing and potentially informative. Age-depth modelling and plant macrofossils are also only two lines of evidence; more could and should be applied to discerning who created the deposits, with the observations generated here acting as guides for further (more refined) interpretation. Indeed, what has really been generated here are *possibilities* or potential *realities*. One *possibility* is that the Lower Charcoal Peak is Indigenous, the Middle Charcoal Peak Norse and the Upper Charcoal Peak also Indigenous in origin. This has been the probable *reality* put forth here, but it is only one of a few possible scenarios. Just as more than one radiocarbon model may be applied to a sequence (Blockley et al. 2007), there may also be more than one interpretive scenario. Furthermore, it may be alright to be *unsure* about whom the peaks relate to. Gavin Lucas (2017: 189) argued that we should "preserve an element of ignorance about the past" so as not to make interpretations derived from our privileged position, which affords us the ability of hindsight—of being able to look backwards and knowing what should happen where and when. Such an ability can actually cloud interpretation by creating expectation. According to Lucas (2017), we should be open to unpredictability and randomness and thus move beyond expectation. This is sage wisdom which might find application here, for while we know there are charcoal peaks and there are groups known to have used the site at particular times, whether these correlate with each other remains unknown. Instead, we are left with *possibilities,* which are entirely adequate from an interpretative standpoint, even if we are still ultimately unsure about the identity of those responsible for the charcoal peaks.

5.2 Factors Governing Successional Changes in The Bog

What are the discernable influences of disturbance and biophysical drivers on the formation of the peat bog sequence, as revealed through a study of plant macrofossils and charcoal?

While there are several theories behind peatland succession (i.e., how exactly peatlands form and change through time), in a simple sense, they might be seen to form through the combined influence of autogenic (internal) and allogenic (external) forces (Rydin and Jeglum 2013). Allogenic influences are of particular interest, as these include both disturbance, which may be natural or anthropogenic (Andersen et al. 2013) and biophysical drivers, which are 'natural' (e.g., Jouffray et al. 2019). In peatlands, a disturbance such as fire can be impactful enough that it can override autogenic succession and other strong allogenic influences alike (Väliranta et al. 2007). Trampling is a further significant disturbance in some peat bogs, which along with fire, may be human-mediated. Amongst biophysical drivers, climate can be seen as an important allogenic driver of change in ombrotrophic peatlands (Charman et al. 2002; Rydin and Jeglum 2013). There is an extensive body of literature discussing the influence of fire, trampling, and climate on peatland succession, some of which has been drawn upon in this thesis (e.g., Barber et al. 2000; Barber and Langdon 2007; Pellerin et al. 2006; Ronkainen et al. 2013; Ryberg et al. 2022; Sillasoo et al. 2011; Sjögren et al. 2007; Spitale 2021; Studlar 1980; Tuittila et al. 2007; Väliranta et al. 2017). How these three influences (fire, trampling, climate) contributed to the successional history of the peat sequence captured within 4A800B3-6 is discussed below.

5.2.1 Fire

Fire is an important disturbance factor in many northern peatlands (Turetsky et al. 2002). Fire can even dictate when wet and dry shifts occur by altering the bog hydrology and shaping successional plant communities (Sillasoo et al. 2011). Given that wet and dry shifts are seen within the profile (as demonstrated by the particular plant microfossils present), and charcoal peaks also occur (with a potential association between the two), it does need to be considered as an influence on peatland succession—and one that is human-mediated. Fires that occur on or near peatlands will generally leave distinct charcoal layers within the peat strata (Couillard et al. 2019; Pitkänen et al. 2001). However, the most definitive signal of *in situ* fire is charred vegetation (Markgraf and Huber 2010). Three charcoal peaks occur in the profile, yet charred vegetation does not always occur in association with them. Therefore, it must be considered whether they are indicative of fire disturbance or else another disturbance associated with the human presence they imply (for instance, trampling). Both occur in the profile, albeit not for all deposits.

5.2.1.1 Middle Charcoal Peak

The greatest evidence for *in situ* fire in the profile is associated with the Middle Charcoal Peak and occurs between 39.0 and 41.0cm bgl. There are 191 pieces of charcoal over 1mm in size (per millilitre) within these two consecutive centimetres. 179 of these pieces are located within 39.75 and 40.25cm bgl. Given the high number of large charcoal pieces, it is probable that the bog surface was set fire to directly. This is further evidenced by a burned twig (fig 18) recovered from 40-40.5cm bgl and tentatively identified as being from *Rhododendron groenlandicum*. The charcoal peak was also visible in the monolith prior to sampling, and slightly charred plant matter was observed during analysis but not quantified—both of which lend credence to the proposition that this was an *in situ* fire (Leifeld et al. 2018; Sillasoo et al. 2011; Wallenius et al. 2004). If this charcoal concentration and the prescribed burning it implies was associated with the Norse, then it was evidently a major fire event and certainly comparable with those seen elsewhere in the Norse North Atlantic during *landnám* (Iversen 1934). They may have used fire to try and stimulate the growth of grasses for grazing animals, as seen in Greenland (Ledger 2013). There is an increase in monocots at 39.75 cm bgl, albeit at proportions well underneath those seen below. As monocots were already well represented in this area, there may have been little incentive or need to try and stimulate their growth. Alternatively, fire may have been used here as a tool for land clearance, which is also found in Greenland (Edwards et al. 2008). Henningsmoen (1985) felt that a small amount of charcoal found in turf samples from the base of the wall in House F could have come from the Norse burning of the landscape to remove shrubby vegetation. There is a slight reduction in woody plants/Ericales rootlets. However, woody plants overall are steady through the presumed Norse period and then increase afterwards, shedding doubt on this theory (or at least its successful execution). *Myrica gale* actually increases in prevalence where the Middle Charcoal Peak occurs in the sequence. Given its value (Verberg 2018; Zimmerman 2018) and abundance at the site, it is possible that *M.*

gale was propagated for human use by the Norse. An increase in *M. gale* has been interpreted elsewhere to correlate with the use of fire for landscape management (Dodson and Bradshaw 1987). Notably, in their study of a burned moor in Japan, Tsuda et al. (1989) found a slightly higher number of *M. gale* seedlings in burned over plots than in unburned ones. Therefore, it is possible that fire could have been utilized in the management of this resource. However, the *M. gale* may also be associated with a shift towards increasing wetness at this time since *M. gale* often occurs in boggier conditions (Skene et al. 2000).

Figure 18. Charred twig (likely *R. groenlandicum*) x40

Alternatively, the Middle Charcoal Peak may also relate to Indigenous use of fire, potentially as a landscape management tool. The presence of ericaceous species in association with this peak may be related to fire, as Ericales will often increase in abundance after a burn (Boiffin et al. 2015; Damman 1978), and fire was used elsewhere to this end by Indigenous groups (e.g., Anderson 2009; Turner 2014). Particular ericaceous plants, especially those that produce berries, would have been valuable food resources and had medicinal uses as well (Weber 2022). They may also have acted as a draw for some bird species (Davis 2011). Given the high degree of Recent Period bird hunting at the site (Kristensen and Curtis 2012), the landscape may have been intentionally altered to attract birds to the area. This is not without precedent, as in the UK, bogs are often burned in order to manage heath and produce habitats attractive to grouse (Garnett et al. 2000). Other animals might also be attracted to a burned-over landscape, potentially including caribou (Silva et al. 2020). Either Recent Period groups or the Dorset Palaeo-Inuit might have had cause to burn the bog at LAM.

Admittedly, the extremely high degree of UOM associated with the Middle Charcoal Peak complicates the clear understanding of exactly what the effects of fire are on succession since plant remains that might otherwise be preserved are decomposed and unrecognizable (potentially due to taphonomic processes linked to fire or other disturbance factors). However, it is apparent that following the burning episode, there is an increase in Ericales, which is likely related to fire disturbance (Boiffin et al. 2015; Damman 1978; Mann and Plug 1999; Pearson 2001; Yeloff et al. 2006).

The *Polytrichum,* which occurs above the Middle Charcoal Peak, can be seen to be as well (Bauer and Vitt 2011). The inferred burning event can also be seen to potentially trigger a wet shift in the bog (*sensu* Sillasso et al. 2011), whereby *Sphagnum* begins to colonize the surface (in subzone 1B) and quickly becomes dominant (in Zone 2). Indeed, at least here, burning might be seen as the catalyst for this change, as it happens rather quickly. However, autogenic factors and other allogenic factors, both natural and anthropogenic, may have played a role too (see trampling and climate). As noted by Hughes (2000), there is more than one pathway from oligotrophic fen to ombrotrophic bog, even if an anthropogenic cause is ascribed.

5.2.1.2 Upper and Lower Charcoal Peaks

As demonstrated by the presence of two other charcoal peaks (Upper and Lower), fire may also have been applied elsewhere in the sequence with potential attendant impacts upon succession. However, the evidence is far from unequivocal for the occurrence of *in situ* fire events. The Lower Charcoal Peak, which is thought to be Indigenous, extends across multiple centimetres (43.75cm bgl to 46.25cm bgl) and contains ample charcoal (between 44.25cm bgl and 45.75cm bgl there are over 100 pieces of charcoal 1mm or more in size, per millilitre). There is also a spike in monocots at 44.25 (71.3% of the sample), which could be correlated with fire (Hobbs 1984). The increase in Ericales seen at 44.75cm bgl could be as well. The brief appearance of both *Sphagnum* and *Polytrichum* at 42.75cm bgl may constitute a “wet pulse” (Barber et al. 1998: 522) or a very brief wet shift stemming from a fire event (Sillassoo et al. 2011). However, this may equally not be the case, as both species can colonize peatlands after many types of disturbance (Groeneveld et al. 2007; Sundberg and Rydin 2002). The appearance of *Sphagnum* especially may simply be associated with the absence of humans (as implied by the lack of charcoal in 42.75cm bgl). Importantly, no charred plant macrofossils were noted during analysis for this peak, as is considered indicative of localized fire (Markgraf and Huber 2010; Sannel and Kuhry 2008; Tolonen 1985). Without this piece of evidence, it is difficult to say whether fire was set here. Large pieces of charcoal and partially burned wood chips do imply the nearby use of fire, either on the bog or elsewhere at the site, but it does not provide the necessary evidence for *in situ* fire. Further analysis should be undertaken to discern how this deposit formed.

The Upper Charcoal Peak may also be the result of *in situ* fire; however, this is unlikely. There is a relatively small amount of large charcoal associated with this deposit (only 8 pieces of charcoal 1mm and over per millilitre were recovered). It is possible that this charcoal may have been added to the bog along with plant matter in an effort to dry the surface. This is not without precedent, as Bishop et al. (2013) identified a charcoal layer in Greenland as being the result of the dumping of charcoal and not landscape fire, as would have been assumed otherwise. One charred plant macroremain was identified, this being a charred seed thought to be Apiaceae (fig 19), recovered from 32-32cm bgl. However, no other charred plant material was noted during analysis, and the seed could easily have entered the deposit with other added material. Furthermore, whereas the literature often associates *in situ* fire events with the initiation of wet shifts (Ronkainen et al. 2013; Ryberg et al. 2022; Sillasoo et al. 2011; Tuittila et al. 2007; Väliranta et al. 2017), the Upper Charcoal Peak actually sits atop a wet shift, which appears to be arrested at the time of deposition. It is suggested that this apparent hydrological dry shift was, in fact, the result of another disturbance factor, likely trampling (Spitale 2021), which is discussed in more detail below. Indeed, at 38cm bgl, the bog rapidly transitions from being composed almost entirely of *Sphagnum,* to a mixed assemblage of woody plants, monocots, and minor amounts of bryophytes. While a fire event could be responsible for an increase in Ericales (Yeloff et al. 2006), given the strange mix of plant taxa present, including both dry and wet adapted species, it is instead likely that this deposit represents the addition of plant material to the bog. Further study should be undertaken to discern how it was deposited.

Figure 19. Possible Apiaceae seed x50.

While an important allogenic disturbance in peatlands, fire can only be directly linked to the Middle Charcoal Peak within the sequence. It may even have spurred a major wet shift and initiated ombrotrophy at this point. Fire could have had an impact elsewhere in the profile as well. However, the evidence is unclear. Instead, influence on the profile might be sought from the allogenic impacts of climate and trampling, which are discussed below.

5.2.2 Trampling

During excavation, laminated and relatively compacted surfaces with horizontally aligned organic materials were noted in the field and associated with cultural occupation layers (Forbes et al. 2022; Ledger et al. 2019a). During peat disaggregation, the peat associated with charcoal peaks (and therefore cultural occupations) was also notably denser. Therefore, it is likely that trampling impacted the site deposits. The spikes in UOM associated with the three charcoal peaks are probably a result of the trampling of the peat surface. Trampling, in association with other disturbance factors, such as burning and shifting moisture regimes, can easily humify peat (Hope and Nanson 2015). This is especially true in regard to the Middle Charcoal Peak, which contains abundant UOM in association with the deposit and below it. If this deposit is, in fact, Norse in origin, the high amount of UOM could be related to the high number of people thought to be on the site and the potential presence of livestock (Wallace 2012).

It is also possible that the biostratigraphic switch (and potential associated dry shift) that is demonstrated in association with the Upper Charcoal Peak is related to trampling, as *Sphagnum* reduces in abundance quite rapidly and then increases afterwards (in Zone 4) when charcoal ceases to be present (indicating abandonment). Similarly, following the underlying Lower Charcoal Peak and before the Middle Charcoal Peak (in 1A), *Sphagnum* makes a brief appearance in the absence of charcoal before disappearing again (when charcoal reappears, indicating a renewed human presence). Further study should be applied to the cultural layers with geoarchaeological analyses and especially micromorphology in order to confirm this, but it does appear that trampling, or its absence, had a distinct impact upon perseveration conditions and the plants present (particularly *Sphagnum*) within the peat sequence.

5.2.3 Climatic Forcing

Some palaeoecologists have associated shifts in climate with successional changes observed in peatlands (e.g., Barber et al. 2000; Barber and Langdon 2007). Therefore, the issue of climate bears discussion here. Interestingly, the time which is seen to coincide with the Medieval Warm Period (MWP) at LAM is also when increased *Sphagnum* growth appears, a phenomenon usually associated with wetter and sometimes cooler climatic conditions (Jong 2006). This also marks the boundary of where ombrotrophication is hypothesized to have taken place. Based on the chronological understanding of the site, which places the Norse there in the early 11th century and on the chronostratigraphic understanding of the profile based on the age-depth model (see fig 5), it is apparent that while the beginning of these changes might be seen to be coeval with the Norse (in 1B), they accelerate after abandonment (in Zone 2). According to Finkenbinder et al. (2022), lower offshore sea surface temperatures and inferred cooling based on recent oxygen isotope research ($\delta^{18}O$ anomalies) from Norman's Pond in west-central Newfoundland have been detected from around 1000 CE onwards, indicating lower terrestrial temperatures, which would help to explain increased *Sphagnum* growth. Indeed, the Labrador Current, which impacts the temperature of Newfoundland (Bell et al. 2000), was found to be cooler from 1000 to 1350 CE (Sicre et al. 2014), and it is likely that the entire western North Atlantic region was colder during the MWP, with interspersed decadal periods of warming (Young et al. 2015). Finkenbinder et al. (2022) even directly suggest that it was cooler during the time the Norse were at LAM.

The MWP is followed by the Little Ice Age (LIA). Within 4A300B3-6, based on the age-depth model, the start of this cooling trend might be seen to correlate with the possible dry shift that occurs at approximately 33cm bgl (in Zone 3). However, a brief warming trend, which raised the temperature of the Labrador current, is also believed to have occurred around this time (Lapointe and Bradley 2021). Warmer conditions may have persisted up to 1480 CE, followed by a sharp decline in temperatures (Finkenbinder et al. 2022). In some locations, the LIA has been shown to correspond with peatland wet shifts (Anderson 1998; Schofield et al. 2008), and *Sphagnum* domination does return again in the profile (Zone 4), which may potentially indicate some influence.

Without detailed local climate data that covers the site itself, no direct climatic causation should be applied to the peat profile; however, there certainly may have been some contribution. Instead, influence on the formation of the bog area can be more readily sought (and found) in the direct disturbances and autogenic succession factors evidenced by the macrofossils themselves.

5.2.4 Climatic and Anthropogenic Disturbance Considered Together

To understand how the peat sequence formed it is necessary to consider the interaction between the forces of climate and disturbance upon the successional and depositional history of the profile. Considered over the long term, the interaction between these two allogenic forces (and the history of the peat sequence) might have manifested as described below.

The peat deposit in the area probably began as a monocot (likely sedge), and woody plant dominated minerogenic fen. At some point during the 8th to 9th centuries, an Indigenous group (likely either the Recent Period or Dorset peoples) disturbed this environment slightly. Indigenous people were certainly active at the site, or its environs, as shown by the small amounts of background charcoal in the lower part of the sequence (see fig 6). However, what is demonstrated between 44.0cm bgl to 46.0cm bgl constituted a disturbance event. They appear to have worked wood in this area and had localized fires, they may even have set fire to the bog, but this is unclear. Their presence certainly left a charcoal peak in the sequence (Lower Charcoal Peak), and the disturbance they caused likely resulted in brief *Sphagnum* and *Polytrichum* growth. This may have constituted a brief wet pulse (*sensu* Barber et al. 1998), before returning to prior conditions with an increase in Ericaceae. At some point around the start of the 11th century, another group of people, likely the Norse or perhaps people from the Cow Head or another Recent Period Indigenous complex, disturbed the bog again. It may even have been a combination. Regardless, they burned the landscape and influenced it further by intensive trampling, which appears to have impacted upon moisture conditions. They also likely worked wood on the bog surface and created the Middle Charcoal Peak as a consequence of these various actions. The water table in the bog may have been anthropogenically or naturally lowered by other means during this period as well (Van der Linden and Van Geel 2006). For a time, Ericaceae increased again. However, a wet shift was initiated with a discernable switch from fen to *Sphagnum* bog and thus likely to ombrotrophic conditions. Cooler, wetter climatic conditions are thought to have occurred during this period (Finkenbinder et al. 2022), which may have been an influence as well.

Sphagnum dominated for a while, without any human interference, as shown by an absence of background charcoal (see fig 6). However, at some point during the 11th to 12th centuries, *Sphagnum* growth was quickly arrested when another group of people disturbed the bog creating the Upper Charcoal Peak. This was likely a Recent Period Indigenous group, although it may also have been a later visit to the site by the Norse. This group trampled the bog surface, compacting the deposit. They may also have dumped plant matter on the bog surface in an effort to dry it. It is also possible but unlikely that they set fire to the bog directly. The increase in Ericales in association with monocots and bryophytes seen during this period (see fig 6) may also be linked to fluctuating hydrological conditions in the peatland or stem from climatic influence. Whatever the cause, the dry shift did not last, nor is there a human presence seen above this deposit as background charcoal disappears again. *Sphagnum* domination (and wet conditions) then returned, both owing to a lack of human presence and potentially cooler temperatures associated with the LIA. Indeed, ultimately, the sequence as it appears here (24.0cm bgl to 46.0cm bgl) was capped in a layer of *Sphagnum* moss, not to be disturbed again by humans—except by those bearing trowels many centuries on.

Chapter 6. Conclusions and Directions for Future Research

6.1 Conclusions

The upper peat bog at LAM contains a remarkable sequence of cultural layers composed of charcoal, wood, plant macrofossils and other organic and inorganic constituents. However, it has only been recently that the understanding of the cultural use of the upper bog has developed (Ledger et al. 2019b). Unfortunately, much more attention has been paid to the lower bog, and lower resolution methodologies employed in the past. This thesis has instead employed a high temporal resolution macrofossil analysis coupled with radiocarbon age-depth modelling to discern how the peat sequence within monolith 4A800B3-6 developed. It has been shown here to have developed through the combined action of autogenic and allogenic forces, which have both contributed in kind to the successional history of the sequence. Amongst the allogenic forces are biophysical drivers (climate) and disturbance factors (fire and trampling). Importantly, these two disturbances can be considered to be anthropogenic and, as such, humans can be seen to have had an impact on the formation history of the peat sequence and likely the wider cultural landscape at LAM. This is important, as previous studies have found little or no evidence for human impact on the environment at the site (Bell et al. 2000), whereas this thesis, and lager project of which it is a part, has. While the methods employed were unsuccessful at assigning the charcoal peaks (Upper, Middle, Lower) in the sequence to particular cultures, various *possibilities* have been raised for future appraisal by different methodologies. Importantly, amongst these *possibilities* are several scenarios implicating Indigenous peoples as important influences on bog ecology. This is something that has not been much considered at the site before, with most focus instead being on the Norse presence (Crocker 2020; Lewis-Simpson 2020), but should be, given the length of Indigenous tenure at the site compared to the Norse (see fig 17). However, the Norse should be considered as important influences on the bog and landscape at LAM as well. Indeed, it is entirely possible that this was a shared zone of interaction for some time with both cultures contributing (Ledger et al. 2019b). What this study has ultimately revealed is the interplay between natural and anthropogenic factors, which together brought about the formation of the peat sequence seen in monolith 4A800B3-6.

6.2 Future Directions

My research has raised some important areas of consideration to be addressed in subsequent studies. A greater understanding of formation processes is of utmost importance. To this end, charcoal analysis should be employed. An anatomical analysis of charcoal could discern whether it relates to anthropogenically imported wood/driftwood or else to species endemic to the bog or surrounding area (Mooney 2016a, 2016b). This could help clarify the prevalence of *in situ* burning and also give insight into wood use patterns on the site in the past. Further methods, particularly those drawn from geoarchaeology and geochemistry, should be used to identify how the cultural layers in the peat sequence formed. Micromorphology especially should be employed as this method can discern formation and post-depositional processes (Davidson et al. 2002; Macphail and Goldberg 2018) and should be able to identify if fire events occurred on the bog surface (Davidson and Carter 1998; Simpson et al. 2003). The combined use of Attenuated total reflectance (ATR), Fourier Transform Infrared (FTIR) and Raman spectroscopy (and other spectroscopic techniques) might also be applied to reconstruct the burning intensity of *in situ* peat fires at the site (Constantine IV et al. 2020; Mauquoy et al. 2020). Geochemical analysis should be utilized as a complement to micromorphology in order to identify the chemical makeup of the deposits and how humans may have impacted them, for instance, by increasing phosphorus (Bintliff and Degryse 2022). Lipid biomarker analysis may be used as well to test for the presence of dung and identify it to species (Harrault et al. 2019). Sedimentological analysis might also be undertaken on the mineral grains in the sequence, as such analysis can reveal the source of the grains and discern whether they are wind (Costa et al. 2013) or water transported (Badapalli et al. 2022). In addition to this, further palaeoecological work employing additional proxies should be undertaken as well. In particular, testate amoeba analysis should be applied to the sequence and elsewhere, as this can be used to clarify moisture conditions in the bog and affirm wet/dry shifts (Booth 2002; Hughes et al. 2006) as well as disturbances (Gałka et al. 2017; Marcisz et al. 2019). Any further research employing plant macrofossils should also identify *Sphagnum* to species as this can inform on moisture as well (Rydin and Jeglum 2013). More precise site-specific palaeoclimatic data is needed for LAM and its environs, some of which should be provided by the palynological and archaeoentomological research that is planned for the near future in association with other methodologies (geoarchaeology/micromorphology, palynology, archaeobotany, archaeoentomology, geophysics, tephrochronology, aDNA etc.). The application of additional proxies and methods, some of which is currently underway, will also further demonstrate that the charcoal peaks discussed in this thesis are cultural in origin.

This thesis is but the first targeted, detailed study in a host of projects planned both for the bog and broader LAM area—including a geoarchaeological analysis to be performed by myself as part of a PhD project. The bog and wider landscape at LAM are an exquisite archive holding marvellous details, which are sure to be revealed as different methods are used. Indeed, further analyses employing multiple lines of evidence may even be able to identify what cultures the charcoal peaks in the sequence belong to and thus discern which of the *possibilities* identified in this thesis are true.

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