Dating Archaeobotanical Remains: A Cautionary Tale from Port au Choix, Newfoundland

Robert J. Anstey[1], Eric J. Guiry[2], M.A.P. Renouf[3], Michael Deal[3], Benjamin T. Fuller[4]

[1] Division of Archaeology, University of Cambridge, Cambridge, UK, CB2 3DZ

[2] Department of Anthropology, University of British Columbia, Vancouver, BC, V6T 1Z1

[3] Department of Archaeology, Memorial University, St. John's, NL, A1C 5S7

[4] Department of Earth System Science, University of California, Irvine, Keck CCAMS Group, B321 Croul Hall, Irvine, CA 92697, USA

*Corresponding author
Mailing address: 41 Harvey Goodwin Gardens
Cambridge, UK, CB4 3EZ
E-mail: rja73@cam.ac.uk
(19 January 2015)

Abstract

In this paper we report on the first ^{14}C-dated archaeological seeds from the island of Newfoundland, Canada. Ninety-three archaeobotanical specimens were recovered from a midden deposit adjacent to a small dwelling at Point Riche (EeBi–20), a large Dorset Palaeoeskimo site near Port au Choix, northwestern Newfoundland. These remains were collected from a seemingly secure context within the midden, but AMS ^{14}C testing of a sample of specimens produced modern ^{14}C dates indicating the remains are intrusive to the Dorset occupation. While the majority of Newfoundland-based research assumes antiquity of archaeobotanical remains, we recommend using in future archaeobotanical studies AMS ^{14}C dating and other proxy data to confirm antiquity prior to making interpretations regarding human-plant interactions.

Keywords
Newfoundland, Canada, archaeobotany, seeds, AMS-dating

Introduction

This paper presents archaeobotanical results from a midden at the Dorset Palaeoeskimo site of Point Riche (EeBi–20), Port au Choix, northwestern Newfoundland, Canada (Figure 1). Our analyses produced over 90 specimens representing 13 taxa; three specimens were carbonized. Until recently (e.g., Deal 2005, 2008; Deal and Butt 2002; Guiry et al. 2010; Hartery 2006) sediment samples from Newfoundland archaeological sites were often ignored for systematic archaeobotanical analyses. This was due in part to generally unproductive past archaeobotanical analyses (but see Dawson 1977) and the assumption of widespread poor botanical preservation across the island.

The island of Newfoundland was occupied for over 6,000 years by a series of hunter-gatherer populations. These populations derived from related groups in both the Gulf of St. Lawrence region (Amerindian) and the Arctic (Palaeoeskimo). Amerindian hunter-gatherers include Maritime Archaic Indians (MAI) (6290–3340 cal BP) and Recent Indians (2110–680 cal BP) (Renouf 2011a:272). The latter is subdivided into three cultural complexes: Cow Head (2110–930 cal BP), Beaches (1900–800 cal BP) and Little Passage (1170–300 cal BP) (Renouf 2011a:272). The Recent Indians are known in the historic period (c. 300 BP) as the Beothuk (Pastore 1992). The Palaeoeskimo population includes cultural sub-traditions Groswater (2950–1820 cal BP) and Dorset (1990–1180 cal BP) (Renouf 2011a:272). The subsistence and land-use practises of Amerindian and Palaeoeskimo groups in Newfoundland vary spatially and temporally. However a range of data including faunal, spatial, and technological show generally that while Amerindians maintained a high residential mobility and preferred broader-based foraging Palaeoeskimos focused to a greater degree on marine mammal hunting, particularly seals (*Phoca* sp.), and were relatively less mobile (Holly 2013; Renouf 2011a:272–274).

The Dorset site at Point Riche is located at the exposed southwest tip of the Point Riche peninsula, Port au Choix (Figure 1). The site consists of about 18 Dorset dwelling depressions spread over a 150 m long raised marine terrace that is bounded to the east by a freshwater stream and marsh (Anstey et al. 2010; Eastaugh 2002, 2003; Eastaugh and Taylor 2005; Renouf 1985). The site also has a minor Groswater component (Eastaugh 2002). Radiocarbon dates from three excavated dwellings span from 1870 to 1330 cal BP (Anstey 2011:11). A dwelling structure (Feature 64) and overlying midden (Feature 75) were excavated in 2010; ^{14}C dates from these features ranged from 1560 to 1330 cal BP (Anstey et al. 2010:14). The archaeobotanical remains in our study were recovered from sediment samples taken from midden Feature 75.

Port au Choix is situated within the Coastal Plain ecological subregion, which is characterized by exposed limestone barrens with shallow soils and large expanses of coarse gravel (Damman 1983:182). In contrast to the acidic soils of most of Newfoundland (Deal 2005), the alkaline chemical nature of the underlying limestone bedrock in most of this region partly neutralizes the acidity of soils which provides an environment conducive to preserving bone but not macrobotanical remains (Burzynski et al. 2006:13; Damman 1983:118). In terms of climate, the region generally has short cool summers and long cold winters which provide a very limited growing season (Damman 1983). The flora of Point Riche is dominated by low-lying grasses on the main part of the site and to the south a heath comprising mainly of black crowberry (*Empetrum nigrum*). Other species present on or near the site include, juniper (*Juniperus* sp.), isolated stunted growths of spruce (*Picea* sp.) and balsam fir (*Abies balsamea*), and a plethora of calciphilic species common in the limestone barrens ecosystem such as dwarf willow (*Salix herbacea*), mountain avens (*Dryas octopetala*), cinquefoil (*Potentilla* sp.), alpine chickweed (*Cerastium alpinum*), sedge (*Carex* sp.), saxifrage (*Saxifraga* sp.) and alpine bearberry (*Arctostaphylos alpina*) (Burzynski et al. 2006).

Our study is the first to date preserved seeds from a Newfoundland archaeological site. Three specimens, including a single carbonized seed, were ^{14}C-dated as modern using accelerator mass spectrometry (AMS). The modern dates indicate that the seeds are intrusive to the Dorset occupation of the site. While these remains do not contribute to interpretations of past Dorset diet or plant use, they provide an opportunity to consider a cautionary tale that is important not only for future Newfoundland-based archaeobotanical research but also for other areas of the globe where botanical preservation is expected to be poor. In particular, these findings prompt a review of archaeobotanical studies that have sought to verify their findings by radiocarbon dating seeds but found modern dates. This preliminary review is, to our knowledge, the first reference point for this problem and affords previously unavailable insight into the nature and frequency of occurrence of modern dates from archaeological deposits. In this context our findings at Point Riche provide new, positive evidence to support the practice of AMS ^{14}C dating seeds in conjunction with a range of supplementary proxy data.

In this paper we provide a cursory review of research incorporating dated seeds and a summary of dated non-charcoal archaeobotanical remains from the island of Newfoundland. This is followed by an overview of our work at Point Riche concluding with a few brief observations about our results in the context of Newfoundland archaeobotany.

Dating archaeobotanical remains

Carbonized wood (charcoal) remains are by far the most common botanical material used in ^{14}C dating (Smart and Hoffman 1988). Other types of botanical remains including seeds have been used to a lesser extent. AMS rather than standard radiometric dating is the preferred method for measuring ^{14}C dates on seeds because it is more precise and requires smaller samples (Bronk Ramsey 2008). The following is a brief overview of the range of interpretations of dated seeds. For a broader summary of dated seed specimens see the Canadian Archaeological Radiocarbon Database (Gajewski et al. 2011) and *Archaeometry* date lists (e.g., Hedges et al. 1988, 1991; Higham et al. 2010).

Radiocarbon dates obtained on seeds have provided insight into the origins of agriculture and species domestication. A radiocarbon-dated Sacred Lotus (*Nelumbo nucifera* Gaertn.) seed (symbolizing vitality and purity) from a dried ancient lake bed at Pulantien, China, established the beginning of cultivation of these plants by Chinese Buddhists to at least 1300 years ago (Shen-Miller et al. 1995). Long et al. (1989) used AMS ^{14}C dates on a range of seed specimens from Tehuacán, Mexico, including squash (*Cucurbita* sp.), chili pepper (*Capsicum* sp.), avocado (*Persea americana*), bean (*Phaseolus* sp.), amaranth (*Amaranthus* sp.) and maize (*Zea mays*), to interpret the timing of the earliest cultivated plant species in the region (see also Piperno and Flannery 2001). Dated maize specimens have also proven useful in determining the timing of maize domestication amongst cultures further north, in the United States (e.g., Benz et al. 2006; Staller 2009) as well as Canada (e.g., Crawford et al. 1997; Jamieson 1990). Fritz (1997) reports on a cache of crop seeds – including goosefoot (*Chenopodium* sp.), squash and sunflower (*Helianthus annuus*) – from a rockshelter in Kentucky. AMS dates on a sample of these specimens confirmed plant husbandry among Terminal Archaic people. Other domesticated species that have been dated include goosefoot from eastern United States (e.g., Smith and Cowan 1987), wheat (*Triticum* spp.) in China (e.g., Dodson et al. 2013) and a variety of cereals and lentils from northwest Africa (e.g., Morales et al. 2013).

Dated seeds have been used to address general questions regarding human plant use. Based on ^{14}C dates on a sample of a large quantity of hazelnuts (*Corylus* sp.) from the Mesolithic site of Staosnaig, western Scotland, Mithen et al. (2001) were able to suggest that Mesolithic plant use might have been more intensive than previously thought. Ledger et al. (2013:814) include dated seeds of sedge, meadow buttercup (*Ranunculus acris*), and chickweed (*Stellaria media*) in their palaeoenvironmental analysis of Norse plant use and landscape impact at Vatnahverfi, Greenland. A sample of carbonized seeds, including raspberry (*Rubus* sp.) and rose (*Rosa* sp.), were recovered from a hearth at the multicomponent Saskatoon Mountain (GhQt–4) site, Alberta. These were proven to be contemporaneous with the associated occupation using AMS ^{14}C dating (Beaudoin et al. 1996:118).

Prebble and Wilmshurst (2009) dated rat-knawed seed cases of miro (*Prumnopitys ferruginea*) from multiple islands in Remote Oceania. They used the knawed seeds as proxies for initial human colonization of the islands and for determining the ecological implications of agriculture and Pacific rat introduction on previously uninhabited insular ecosystems (Prebble and Wilmshurst 2009:1529; Wilmshurst and Higham 2004). Their dates proved that the Pacific rat arrived at the same time as the initial human settlement of Remote Oceania.

Dated seeds have complemented palaeoenvironmental reconstructions. Matthews et al. (1990) dated seeds of tumbleweed (*Corispermum hyssopifolium*) from subtill deposits as a means to define the age of the McConnell Glaciation in central Yukon. Lacourse et al. (2012:577) used AMS ^{14}C dates obtained on crowberry (*Empetrum nigrum*) seeds in their reconstruction of vegetation history of Richardson Island, Haida Gwaii, British Columbia. Similarly, Boyd et al. (2003) used dated specimens of buckbean (*Menyanthes trifoliate*) in their analysis of Folsom land-use in relation to palaeovegetation patterns.

Dating archaeobotanical remains in Newfoundland

In comparison, a relatively small amount of archaeobotanical material (non-charcoal) from Newfoundland and Labrador has been dated using absolute dating methods (Table 1). In the majority of cases (for a complete review of archaeobotanical research in Newfoundland, see Deal 2005, 2008; Deal and Butt 2002; Guiry et al. 2010), undated carbonized seeds have been assumed to be contemporary with associated cultural occupations. For example, 137 carbonized seeds were recovered from hearth features inside three Beothuk dwellings at the Beaches site (DeAk–1) (Figure 1), yet only five carbonized seeds were recovered from four non-cultural control samples (Deal and Butt 2002:19). This is standard practice in archaeobotany (Lepofsky et al. 2001:50; Lyons and Orchard 2007; Minnis 1981:147). Uncarbonized seeds have often been interpreted as ancient based on evident wear, analogy with ethnohistoric accounts of plant use, as well as their contextual association with other datable (either by absolute or relative methods) cultural remains (for summary of such cases see Deal 2005:132ff, 2008; Deal and Butt 2002; Guiry et al. 2010:45ff). While Deal and Butt (2002:25) recommend using AMS to date carbonized seeds from Newfoundland archaeological sites, there have yet to be any dates measured on specimens from the island.

The majority of dated non-charcoal archaeobotanical specimens were recovered from a peat bog at L'Anse aux Meadows (EjAv–1) (Figure 1), on the tip of the Great Northern Peninsula of Newfoundland. This site is best known for its Norse occupation but also has Groswater, Dorset and Recent Indian components (Wallace 2006). While a reasonable quantity of seeds was recovered from the site in a pilot archaeobotanical analysis, none were dated (Dawson 1977). A total of 60 archaeobotanical specimens from the site was dated, including worked and unworked pieces of spruce and fir wood as well as a quantity of unidentified botanical remains (Nydal 1989). Also present in this assemblage are a rod-shaped artefact made of fir as well as a Groswater harpoon mainshaft made of larch (*Larix laricina*) (Wallace 2006:87). Radiocarbon dates on the specimens range from modern to 7580 cal BP (Gajewski et al. 2011).

Prior to the present study, six archaeobotanical specimens from Port au Choix were dated (Gajewski et al. 2011; Renouf 2011b). Two unidentified wood specimens from natural pits at the MAI/Recent Indian Gould site (EeBi–42) (Figure 1) returned anomalously recent dates (Renouf 2011b). A cut spruce log recovered at the bottom of a peat layer and associated with MAI tools was dated to 3900–3490 cal BP (Renouf 2011b). Carbonized birch (*Betula* sp.) bark and a piece of unidentified wood associated with a chunk of bog iron were recovered from MAI burials at Port au Choix-3 (EeBi–2) (Figure 1) and returned date ranges of 3980–2880 cal BP and 6180–5610 cal BP, respectively (Renouf 2011b; Tuck 1976:162). The burials were dug into the sandy limestone substratum.

Further east, two samples of logs associated with a waterlogged platform at the Fleur de Lys-1 (EaBa–1) (Figure 1) Dorset soapstone quarry were dated to 1690–1370 cal BP and 1530–1320 cal BP (Erwin 2001:198). A small sample of unidentified wood associated with MAI lithic tools and a shallow hearth consisting of charcoal, orange ash and burnt soil at the Back Harbour-3 (DjAq–5) (Figure 1) MAI site in Twillingate was dated as modern (Gajewski et al. 2011; Temple 2008:40).

In sum, ^{14}C dates on seeds recovered from a wide range of archaeological as well as natural contexts have the potential to offer insight into a variety of interpretive issues, particularly temporal dynamics of human plant use. While a notable quantity of archaeobotanical material has been dated no seeds from Newfoundland archaeological sites have been dated. Preserved wood comprises the majority of dated archaeobotanical material.

Materials and methods

Fieldwork

In 2010 70 m^2 was excavated covering dwelling Feature 64 and an area adjacent to it. The techniques for excavation and recording followed the standard protocol of the Port au Choix Archaeology Project (see Anstey et al. 2010; Renouf 2002). The stratigraphy of the site is comprised of four main soil layers. The site is covered by a 3-5 cm thick sod layer (Level 1) which consists of a brown silty clay with many roots and occasional small pea-sized gravel inclusions. This is underlain by a 5-10 cm thick brown-black peaty and rooty soil (Level 2) that is slightly more compacted than the sod layer. The majority of cultural material is found in this layer. The midden deposit (Feature 75) lies within Level 2 and is comprised of a black, greasy, charcoal and artefact-rich soil 5-10 cm thick; a small quantity of preserved animal bone is also present. The greasy nature of the midden sediment is thought to originate from seal fat and food-related refuse (Renouf 2002). Level 3 is a <5 cm thick light brown-grey clay that produces a small amount of cultural material. It is underlain by Level 4 which is sterile limestone bedrock.

In addition to 315 low-volume sediment samples (see Anstey et al. 2010:4), three bulk sediment samples were collected from different locations in the excavation area (Figure 2). Bulk sediment samples N–135 E–15 and N–136 E–14 were collected at 5-8 cm depth from a secure context in midden Feature 75, and were expected to yield plant remains deriving from food and refuse disposal. A third bulk sediment sample (N–131 E–13) was taken at 10 cm depth (Level 2) from outside the midden and dwelling.

Laboratory processing

Before we processed the samples, sediment characteristics were documented and sample weight and volume were recorded. Following current archaeobotanical methods (Pearsall 2001:93; Wagner 1982), a known quantity (n=100) of carbonized *Papaver somniferum* (opium poppy) seeds, which are non-native and easily identifiable, was introduced to the sample to help assess seed recovery rate. An IDOT-style flotation device was used for the recovery of plant remains (Pearsall 2001:30). The IDOT apparatus consists of two U-shaped aluminum flanges covered with 0.5 mm copper mesh. Sediment samples were added to this unit, lowered into a plastic container which was filled three quarters full with water, and then agitated. This process separated the sediment into three components: a buoyant lighter fraction (the flot) which was skimmed from the surface; a coarse fraction that settled to the bottom of the screen; and a fine fraction which fell through the screen mesh. Each fraction was collected, given time to dry, and then dry-sieved with 1.7 mm, 500μ, and 250μ geological sieves. A dissecting microscope was used to analyse the flot, which normally contains the bulk of plant remains, and a small portion of the coarse and fine fractions. Plant specimens collected were placed in individual thin-walled plastic capsules for storage. Species were identified by comparison with a reference collection of more than 500 modern species and using seed identification manuals and other guides (Martin and Barkley 1961; Meades et al. 2000; Montgomery 1977; Rouleau 1978).

Radiocarbon dating

Seeds deriving from edible and non-edible plants as well as charred and non-charred seeds were selected for ^{14}C measurements. These included one large, fully carbonized bakeapple seed (*Rubus chamaemorus* [UCIAMS 134367]), one partial section of an uncarbonized pin cherry stone (*Prunus pensylvanica* [UCIAMS 134368]), and four partial uncarbonized violet (*Viola* sp.) seeds (UCIAMS 134369). The charred bakeapple, a historically well-documented food species, was selected to provide a reference point for interpreting the dates from the non-charred seeds. We had also anticipated that edible species such as pin cherry would most likely have derived from a cultural deposition event because of the regional environment in which the deposit was located (the nearest present day occurrence of pin cherry is several kilometers away), the security of the context in which it was found, and the fact that charred pin cherry stones (non-dated) have been found in association with Dorset archaeological contexts elsewhere in Newfoundland (e.g., Guiry et al. 2010; Howse and Drouin 2000). Violet seeds were selected to represent a species that was less likely to have been used as a food source and because their relative abundance in the sample could provide adequate material (in terms of mass) for dating.

Seeds were ^{14}C dated at the KCCAMS Facility at the University of California Irvine. Samples were pre-treated using an acid-base-acid protocol (UCI KCCAMS Facility 2011a). Briefly, samples were sequentially soaked for 30 minutes at a time (at 70ºC) in hydrochloric acid (1N), sodium hydroxide (1N), and then hydrochloric acid (1N) once more. Approximately 1.7 mg of dried sample was combusted to CO_2 at 900ºC for three hours in a flame-sealed quartz tube under vacuum in the presence of 60mg of copper oxide and silver wire. Resulting CO_2 was graphitized on an iron catalyst using the hydrogen reduction method (UCI KCCAMS Facility 2011b). The graphite samples were loaded into aluminum targets and $^{14}C/^{12}C$ ratios were measured via AMS. Measured ^{14}C dates were calibrated with OxCal 4.2 (Bronk Ramsey and Lee 2013) using the post-bomb 13 NH1 calibration curve (Hua et al. 2013).

Results

Botanical remains

A total of 2.5L was processed from three units (Table 2), with sample N–135 E–15 comprising the bulk of sediment processed. While this sample produced plant remains, samples N–136 E–14 and N–131 E–13 were found to be sterile. A total of 93 botanical specimens was collected from sample N–135 E–15 including one charred conifer needle fragment as well as two charred and 90 uncharred seeds and seed fragments (Table 3). The carbonized *Papaver somniferum* (opium poppy) test indicated a seed recovery rate of 89%. We also found in all three samples relatively large quantities of sclerotia (*Cenococcum* spp.), which are tiny resting bodies of mycorrhizal fungi that attach to plant roots (McWeeney 1989:228), a small quantity of insect parts, and in the two midden samples there was a considerable quantity of micro- and macro-debitage and degraded bone.

Radiocarbon dates

Measured ^{14}C dates on the sample of three seeds are all modern (Table 4). The dates on the uncharred seed specimens of pin cherry and violet range from Cal AD 1960 to 1980. The single carbonized bakeapple seed dated to Cal AD 1670–1960.

Discussion and conclusions

Our results provide the basis for a number of observations. The seeds from Feature 75 at Point Riche were ^{14}C-dated as modern and are thus not associated with the Dorset occupation of the site. By extension, the other botanical specimens in the assemblage are also most likely intrusive. Accepting their modernity, there are several potential explanations for their presence within this seemingly undisturbed archaeological context.

There seems to be few explanations in the relevant literature for the occurrence of modern seeds in secure archaeological deposits. A review of *Archaeometry* date lists, for instance, provides some examples of how the presence of such problematic finds is explained. In most cases modern-dated seeds are simply interpreted as intrusive. Hedges et al. (1988:298) report modern dates obtained on uncarbonized samples of dock (*Rumex* sp.) recovered from a well-sealed deposit at an Iron Age site in Stromness, Orkney. The presence of a modern-dated seed in the deposit was suggested to be the result of burrowing by voles, whose bones were common in the excavation. In a later date list Hedges et al. (1991:288) report on modern-dated samples of grape (*Vitis* sp.) taken at >1 m depth from an apparently uncontaminated Bronze Age deposit near Dorchester, Dorset. The seeds were suggested to have been taken down through the deposit by earthworm activity. The finding of modern-dated seeds in archaeological deposits must be more common than the literature alludes to but it is possible that most of the time archaeologists discard such negative evidence because they think it is unpublishable or, perhaps, because they do not want to publicize the modern contamination of a particular site. However it is important to include rather than discard modern-dated botanical materials as they can potentially provide important details regarding formation processes and contextual security of sites, allowing archaeologists to critically review such issues and redress any assumptions related to them.

The presence of seeds in Feature 75 could be explained by natural formation processes outlined by Miksicek (1987) and others. The cool, moist soils of the site attract earthworms and other insects. Earthworms may have transported the seeds down through the soil layers as they are known to commonly line their tunnels with seeds (Miksicek 1987:231). Similarly, ants also might have transported the seeds down through the soil following the edge of a large limestone boulder which was close to the surface and adjacent to the soil sample containing the seeds (Beattie and Culver 1982; Keepax 1977:225). Other mobile animals like birds or small rodents may have deposited the seeds with their excrement, particularly in the case of the pin cherry seeds given the absence of pin cherry shrubs on or near the site. The general summer climate of the 2010 field season at Point Riche was very wet. On the odd day of sunshine, the wet excavated soil layers would dry leaving small fissures. The seeds might have blown onto the site into these crevices (Keepax 1977:225; Miksicek 1987:232). The three carbonized specimens possibly derive from recent natural or man-made fire events (cf. Miksicek 1987:233). It is possible the seeds were blown onto the site from the ashes of two nearby historic buildings known to have burned in recent history (c. 130 years ago). The measured ^{14}C date range, cal AD 1670–1960, for the carbonized bakeapple seed is consistent with this hypothesis. It is therefore important when collecting sediment samples for archaeobotanical analysis to monitor and document onsite characteristics of the natural environment including the activities and behaviour of resident animals.

Most archaeobotanical studies in Newfoundland equate carbonized plant remains with cultural origin. Uncarbonized remains are less often assumed to be ancient. While accepting carbonization as a standard for cultural use, we think the use of supplementary proxies, particularly relative preservation conditions, ethnohistoric analogy and stratigraphic and spatial information, would be conducive to fuller and more accurate interpretations of association between recovered botanical remains and human use.

Regional and site-specific preservation conditions are useful considerations when interpreting the antiquity of botanical remains. While soils in eastern Canada generally tend to be acidic (Deal 2005:132), preservation conditions vary across the island of Newfoundland. Sites with well-preserved archaeobotanical remains like the acidic peat bog at L'Anse aux Meadows (Dawson 1977) and the waterlogged deposit at Fleur de Lys-1 (Erwin 2001) have great potential for contributing to understanding the dynamics of human-plant interactions. Caution must be taken particularly when interpreting botanical remains – especially uncarbonized specimens – recovered from sites where environmental conditions are not conducive to their preservation.

Multiple lines of evidence can be used to support a case for human-plant interactions. A number of Newfoundland-based archaeobotanical studies have linked their results to ethnohistorical analogues of plant use. This is a useful way of establishing a basis for assessing the possible cultural uses of botanical remains recovered from archaeological sites (cf. Moerman 2010). For instance, Deal and Butt (2002:24) link the recovery of carbonized grape (*Vitis* sp.) seeds from a hearth at the Russell's Point (CiAj-1) Beothuk site in Trinity Bay (Figure 1) to an ethnohistoric account where grapes had been traded to Beothuk in the region by European settlers (Gilbert 1992:7-10). Microwear patterns on and condition of specimens have also been used to a lesser extent for suggesting antiquity of botanical remains (e.g., Deal 2005:147; Guiry et al. 2010:54). Stratigraphic and spatial association of botanical remains with directly datable remains, such as stylistically diagnostic tools or charcoal samples, are other useful proxies for dating botanical remains.

As shown by the variety of cases outlined above, AMS ^{14}C dating is the most direct and accurate method to determine the age and association of botanical remains. AMS is preferred over standard radiometric ^{14}C analysis for dating seeds and other small organic remains because of its capability of dating exceptionally small samples of organic material and because it is also much more precise (Bronk Ramsey 2008). An obvious drawback of using

AMS to date seeds is that very small seeds are effectively destroyed during the measuring of ^{14}C. The AMS method can require multiple seeds – if a single specimen is less than ≈<1 mg (UCI KCCAMS Facility 2010) – for an adequate sample to date. AMS analyses are also more expensive than radiometric analyses; dating multiple specimens of an archaeobotanical assemblage can thus be quite costly. Despite the minor drawbacks of ^{14}C dating, it is essential to confirm the antiquity of archaeobotanical remains prior to interpreting human-plant interactions.

To summarize, we present the first dated archaeological seeds from Newfoundland. While our results do not provide insight into Dorset plant use, they are an example of the importance of dating botanical remains recovered from not only Newfoundland archaeological sites but also environments where preservation conditions are poor. We encourage the future collection and archaeobotanical analysis of sediment samples from the island but with the caveat that archaeobotanical remains are not necessarily contemporary with respective cultural occupations. To confirm the antiquity of botanical remains we recommend using AMS ^{14}C dating supplemented with a range of pertinent proxy data.

Acknowledgements

This research was conducted during Anstey's Masters research at Memorial University, which was funded by the Social Sciences and Humanities Research Council of Canada, Memorial University, the Canada Research Chairs Program, Parks Canada, the Institute for Social and Economic Research and the Provincial Archaeology Office. Vaughan Grimes, Memorial University, paid for the AMS dates and reviewed a draft of this paper. In addition to Anstey and Renouf, the 2010 excavation crew at Point Riche included Tom Farrell, Mariane Hardenberg, Dominique Lavers, Susan Penney, Tessa Plint and site supervisor Patricia Wells. We would like to thank John Southon and Hector Martinez at the Keck AMS lab for their assistance and insight in preparing and running our samples and also Joe Hepburn at the University of British Columbia for his help with processing seeds for AMS dating. Finally, we would like to thank the Associate Editor and two anonymous reviewers for their helpful comments.

References

Anstey, RJ (2011) The Dorset Palaeoeskimo sites of Point Riche and Phillip's Garden, Port au Choix, northwestern Newfoundland: Investigating social and functional connections. Master's thesis, Department of Archaeology, Memorial University, St. John's

Anstey, RJ, Renouf MAP, Wells PJ, D Lavers (2010) A report of the 2010 archaeological field season at the Port au Choix National Historic Site: Excavations at Point Riche. Prepared for Parks Canada, Western Newfoundland and Labrador Region, Rocky Harbour

Beattie, AJ, Culver DC (1982) Inhumation: How ants and other invertebrates help seeds. Nat 297:627.

Beaudoin, AB, Wright M, Ronaghan B (1996) Late Quaternary landscape history and archaeology in the 'Ice-Free Corridor': Some recent results from Alberta. Quat Int 32:113–126

Benz BF, Cheng L, Leavitt SW, Eastoe C (2006) El Riego and early maize agricultural evolution. In Staller JE, Tykot RH, Benz BF (eds) Histories of maize, Academic Press, Amsterdam, pp 73–82

Boyd M, Running GL, Havholm K (2003) Paleoecology and Geochronology of glacial Lake Hind during the Pleistocene–Holocene transition: A context for Folsom surface finds on the Canadian prairies. Geoarchaeol 18(6):583–607

Bronk Ramsey C (2008) Radiocarbon dating: Revolutions in understanding. Archaeometry 50(2):249–275

Burzynski M, Marceau A, Nichols W, Hermanutz L (2006) Discovering the limestone barrens of western Newfoundland. Memorial University Botanical Garden, St. John's

Bronk Ramsey C, Lee S (2013) Recent and planned developments of the program OxCal. Radiocarbon 55(2):720–730

Crawford GW, Smith DG, Bowyer VE (1997) Dating the entry of corn (*Zea mays*) into the lower Great Lakes region. Am Antiquity 62:112–119

Damman AWH (1983) An ecological subdivision of the island of Newfoundland. In South GR (ed) Biogeography and ecology of the island of Newfoundland, W. Junk Publishers, Boston, pp 163–206

Dawson JE (1977) Identification of samples of archaeological seeds from L'Anse aux Meadows, Newfoundland. Prepared for Parks Canada, Western Newfoundland and Labrador Region, Rocky Harbour

Deal M (2005) Palaeoethnobotanical research at Port au Choix. Nfld and Lab Stud 20(1):131–154

Deal M (2008) Paleoethnobotanical research in the Maritime Provinces. North Atl Archaeol 1:1–23

Deal M, Butt A (2002) The great want: Current research in Beothuk palaeoethnobotany. In Mason SLR, Hather JG (eds) Hunter-gatherer archaeobotany: Perspectives from the northern temperate zone, Institute of Archaeology, University College London, pp 15–27

Dodson JR, Li X, Zhou X, Zhao K, Sun N, Atahan P (2013) Origin and Spread of Wheat in China. Quat Sci Rev 72:108–111

Eastaugh EJH (2002) The Dorset Palaeoeskimo site at Point Riche: An intra-site analysis. Master's thesis, Department of Archaeology, Memorial University of Newfoundland, St. John's

Eastaugh EJH (2003) A Middle Dorset semi-subterranean dwelling at Point Riche, Newfoundland. Études/Inuit/Stud 27(1-2):451–471

Eastaugh EJH, Taylor J (2005) Geophysical survey of the Dorset Palaeoeskimo site of Point Riche. Nfld and Lab Stud 20(1):157–173

Erwin JC (2001) A prehistoric soapstone quarry in Fleur de Lys, Newfoundland. PhD dissertation, University of Calgary, Alberta

Fritz GJ (1997) A 3,000-year-old cache of crop seeds from Marble Bluff, Arkansas. In Gremillion KJ (ed) People, plants, and landscapes: Studies in paleoethnobotany, University of Alabama Press, Tuscaloosa, pp 42–62

Gajewski K, Munoz S, Peros M, Viau A, Morlan R, Betts M (2011) The Canadian archaeological radiocarbon database (CARD): Archaeological ^{14}C dates in North America and their paleoenvironmental context. Radiocarbon 53(2):371–394

Gilbert W (1992) 'Great good done': Beothuk/European relations in Trinity Bay, 1612 to 1622. Nfld Q 87(3):2–10

Guiry EJ, Deal M, Kiraly (2010) Paleoeskimo paleoethnobotany: Research from the Port au Port site (DdBq–1), Newfoundland. North Atl Archaeol 2:43–66

Hartery L (2006) A microscopic approach to Paleoeskimo plant use. In Rankin L (ed) From the Arctic to Avalon: Papers in honour of Jim Tuck, BAR International Series, Oxford, pp 71–79

Hedges REM, Housley RA, Law IA, Perry C, Hendy E (1988) Radiocarbon evidence from the Oxford AMS system Archaeometry datelist 8. Archaeometry 30(2):291–305

Hedges REM, Housley RA, Bronk CR, Van Klinken GJ (1991) Radiocarbon dates from the Oxford AMS system: Archaeometry datelist 13. Archaeometry 33(2):279–296

Higham TFG, Bronk Ramsey C, Brock F, Baker D, Ditchfield P (2010) Radiocarbon dates from the Oxford AMS system: Archaeometry datelist 34. Archaeometry 53(5):1067–1084

Holly DH (2013) History in the making: The archaeology of the eastern Subarctic. Altamira Press, Lanham

Howse L, Drouin B (2000) Paleoethnobotanical analysis of the Dorset component at Parke's Beach. Student paper, on file, Department of Archaeology, Memorial University, St. John's

Hua Q, Barbetti M, Rakowski AZ (2013) Atmospheric radiocarbon for the period 1950-2010. Radiocarbon 55(4):2059–2072

Jamieson JB (1990) The archaeology of the St. Lawrence Iroquoians. In Ellis, CJ, Ferris, N (eds) The archaeology of southern Ontario to A.D. 1650, Ontario Archaeological Society, London, pp 385–404

Keepax C (1977) Contamination of archaeological deposits by seeds of modern origin with particular reference to the use of flotation machines. J Archaeol Sci 4:221–229

Lacourse T, Delepine JM, Hoffman EH, Mathewes RW (2012) A 14,000 year vegetation history of a hypermaritime island on the outer Pacific coast of Canada based on fossil pollen, spores and conifer stomata. Quat Res 78:572–582

Ledger PM, Edwards KJ, Schofield JE (2013) Shieling activity in the Norse Eastern Settlement: Palaeoenvironment of the 'Mountain Farm', Vatnahverfi, Greenland. The Holocene 23:810–822

Lepofsky D, Moss ML, Lyons N (2001) The unrealized potential of paleoethnobotany in the archaeology of northwestern North America: Perspectives from Cape Addington, Alaska. Arct Anthropol 38(1):48–59

Long A, Benz B, Donahue D, Jull A, Toolin L (1989) First direct AMS dates on early maize from Tehuacán, Mexico. Radiocarbon 31(3):1035–1040

Lyons N, Orchard TJ (2007) Sourcing archaeobotanical remains: Taphonomic insights from a midden analysis on Haida Gwaii, British Columbia. Canadian J Archaeol 31:28–54

Martin AC, Barkley WD (1961) Seed identification manual. University of California Press, Berkeley

Matthews JV, Schweger CE, Hughes OL (1990) Plant and insect fossils from the Mayo Indian Village section (central Yukon): New data on Middle Wisconsinan environments and glaciation. Géogr phys Quat 44(1):15–26

McWeeney L (1989) What lies lurking below the soil: Beyond the archaeobotanical view of flotation samples. North Am Archaeol 10:227–230

Meades SJ, Hay SG, Brouillet L (2000) Annotated checklist of vascular plants of Newfoundland and Labrador.

Department of Forest Resources and Agro Foods, Parks Canada and Western Newfoundland Model Forest Inc., Sault Ste. Marie

Miksicek CH (1987) Formation processes of the archaeobotanical record. Adv Archaeol Method and Theory 10:211–247

Minnis PE (1981) Seeds in archaeological sites: Sources and some interpretive problems. Am Antiquity 46:143–152

Mithen S, Finlay N, Carruthers W, Carter S, Ashmore P (2001) Plant use in the Mesolithic: Evidence from Staosnaig, Isle of Colonsay, Scotland. J Archaeol Sci 28:223–234

Moerman DE (2010) Native American food plants: An ethnobotanical dictionary. Timber Press, Portland

Montgomery FH (1977) Seeds and fruits of plants of eastern Canada and northeastern United States. University of Toronto Press, Toronto

Morales J, Pérez-Jordà G, Peña-Chocarro L, Zapata L, Ruíz-Alonso M, López-Sáez JA, Linstädter J (2013) The origins of agriculture in North-West Africa: Macrobotanical remains from Epipalaeolithic and Early Neolithic levels of Ifri Oudadane (Morocco). J Archaeol Sci 40:2659–2669

Nydal R (1989) A critical review of radiocarbon dating of a Norse settlement at L'Anse aux Meadows, Newfoundland, Canada. Radiocarbon 31(3):976–985

Pastore, RT (1992) Shanawdithit's people. Atlantic Archaeology, St. John's

Pearsall DM (2001) Paleoethnobotany: A handbook of procedures. Emerald Group Publishing, Cornwall

Piperno DR, Flannery KV (2001) The earliest archaeological maize (*Zea mays* L.) from highland Mexico: New Accelerator Mass Spectrometry dates and their implications. Proc Natl Acad Sci 102:1147–1151

Prebble M, Wilmshurst JM (2009) Detecting the initial impact of humans and introduced species on island environments in Remote Oceania using palaeoecology. Biol Invasions 11(7):1529–1556

Renouf MAP (1985) Archaeology of the Port au Choix National Historic Park: Report of 1984 activities. On file, Parks Canada, Archaeology, Atlantic Division, Halifax

Renouf MAP (2002) Archaeology at Port au Choix, northwestern Newfoundland 1990-1992. Occasional Papers in Northeastern Archaeology No. 12. Copetown Press, St. John's

Renouf MAP (2011a) The life history of Port au Choix landscapes. In Renouf MAP (ed) The cultural landscapes of Port au Choix, Springer, New York, pp 271–300

Renouf, MAP (2011b) Radiocarbon dates from Port au Choix. In Renouf MAP (ed) The cultural landscapes of Port au Choix, Springer, New York, pp 301–316

Rouleau E (1978) List of the vascular plants of the province of Newfoundland (Canada). Oxen Pond Botanic Park, St. John's.

Shen-Miller J, Mudgett MB, Schopf JW, Clarke S, Berger R (1995) Exceptional seed longevity and robust growth: Ancient sacred lotus from China. Am J Bot 82(11):1367–1380

Smart TL, Hoffman ES (1988) Environmental interpretation of archaeological charcoal. In Hastorf CA, Popper VS (eds) Current Palaeoethnobotany, University of Chicago Press, Chicago, pp 167–205

Smith BD, Cowan CW (1987) Domesticated *Chenopodium* in prehistoric eastern North America: New accelerator dates from eastern Kentucky. Am Antiquity 52:355–357

Staller J (2009) Maize cobs and cultures: History of Zea mays L. Springer, New York

Stuiver M, Polach HA (1977) Discussion of reporting of ^{14}C data. Radiocarbon 19(3):355–363

Temple B (2007) The 1966–69 archaeological excavations at Back Harbour, North Twillingate Island, Newfoundland. On file, Provincial Archaeology Office, Government of Newfoundland and Labrador, St. John's.

Tuck JA (1976) Ancient people of Port au Choix. Institute of Social and Economic Research, St. John's

UCI KCCAMS Facility (2010) Sample submission. Electronic document,

http://www.ess.uci.edu/group/ams/sample-submission. Department of Earth System Science, University of California

UCI KCCAMS Facility (2011a) Acid/base/acid (ABA) Sample pre-treatment. Electronic document, http://www.ess.uci.edu/group/ams/files/aba_protocol.pdf. Department of Earth System Science, University of California.

UCI KCCAMS Facility (2011b) Graphitization protocol, hydrogen reduction method (organic samples). Electronic document, http://www.ess.uci.edu/group/ams/files/organic_graphitization_protocol.pdf. Department of Earth System Science, University of California.

Wagner GE (1982) Testing flotation recovery rates. Am Antiquity 47:127–132

Wallace BL (2006) Westward vikings: The saga of L'Anse aux Meadows. Historic Sites Association of Newfoundland and Labrador, St. John's

Wilmshurst JM, Higham TFG (2004) Using rat-gnawed seeds to independently date the arrival of Pacific rats and humans in New Zealand. The Holocene 14(6):801–806

Table captions

Table 1 Dated non-charcoal archaeobotanical specimens from Newfoundland archaeological sites. 'Unid.' = unidentified

Site name	Borden no.	Lab no.	Sample material	^{14}C age BP	Calibrated range (BP)
L'Anse aux Meadows	EjAv-1	S-1167	cut unid. wood	260±110	500–modern
L'Anse aux Meadows	EjAv-1	T-905	unid. plant remains	460±80	640–310
L'Anse aux Meadows	EjAv-1	S-1361	*Picea* sp. wood	470±60	640–320
L'Anse aux Meadows	EjAv-1	QU-352	cut unid. wood	530±80	670–330
L'Anse aux Meadows	EjAv-1	GSC-2051	*Larix* sp. wood	640±50	670–550
L'Anse aux Meadows	EjAv-1	S-1364	*Picea* sp. stump	655±95	760–510
L'Anse aux Meadows	EjAv-1	S-1166	cut unid. wood	615±115	790–330
L'Anse aux Meadows	EjAv-1	QU-349	cut unid. wood	740±80	900–550
L'Anse aux Meadows	EjAv-1	S-1091	unid. *Larix* sp. artefact	865±65	920–690
L'Anse aux Meadows	EjAv-1	T-531	unid. plant remains	950±50	950–750
L'Anse aux Meadows	EjAv-1	TO-118	unid. twigs	990±30	960–800
L'Anse aux Meadows	EjAv-1	T-530	unid. plant remains	950±90	1050–690
L'Anse aux Meadows	EjAv-1	TO-119	Abies sp. stump	1040±30	1050–920
L'Anse aux Meadows	EjAv-1	S-1355	Larix sp. twigs	955±100	1060–690
L'Anse aux Meadows	EjAv-1	TO-117	unid. twigs	1030±50	1060–800
L'Anse aux Meadows	EjAv-1	S-1113	cut Abies sp. wood	1040±50	1060–800
L'Anse aux Meadows	EjAv-1	S-1111	cut Abies sp. wood	960±105	1170–680
L'Anse aux Meadows	EjAv-1	S-1340	cut *Abies* sp. twig	1050±65	1170–800
L'Anse aux Meadows	EjAv-1	S-1093	*Abies* sp. stake	1070±65	1180–800
L'Anse aux Meadows	EjAv-1	S-1101	burned unid. log	1075±60	1180–830
L'Anse aux Meadows	EjAv-1	S-1110	cut unid. wood	1090±60	1180–920
L'Anse aux Meadows	EjAv-1	S-1120	*Larix* sp. wood	1095±100	1260–800
L'Anse aux Meadows	EjAv-1	S-1357	*Picea* sp. wood	1160±60	1260–1000

L'Anse aux Meadows	EjAv-1	S-1098	partly burned unid. shrub	1115±90	1270–800
L'Anse aux Meadows	EjAv-1	S-1115	burned unid. wood	1210±45	1270–1010
L'Anse aux Meadows	EjAv-1	S-1114	burned unid. wood	1120±120	1280–800
L'Anse aux Meadows	EjAv-1	S-1090	unid. *Abies* sp. artefact	1230±70	1290–990
L'Anse aux Meadows	EjAv-1	S-1118	cut Abies sp. branch	1210±100	1300–940
L'Anse aux Meadows	EjAv-1	S-1343	cut *Abies* sp. wood	1250±70	1300-1000
L'Anse aux Meadows	EjAv-1	S-1109	cut *Abies* sp. wood	1305±60	1310–1070
L'Anse aux Meadows	EjAv-1	S-1126	partly burned unid. log	1240±100	1320–1000
L'Anse aux Meadows	EjAv-1	T-817	unid. plant remains	1300±70	1330–1060
L'Anse aux Meadows	EjAv-1	T-818	unid. plant remains	1320±80	1370–1060
L'Anse aux Meadows	EjAv-1	S-1346	*Picea* sp. wood	1330±80	1380–1060
L'Anse aux Meadows	EjAv-1	S-1358	cut and burned unid. wood	1345±65	1380–1090
L'Anse aux Meadows	EjAv-1	WAT-436	unid. *Abies* sp. artefact	1350±80	1400–1070
L'Anse aux Meadows	EjAv-1	TO-116	partly charred unid. stick	1440±50	1510–1280
L'Anse aux Meadows	EjAv-1	QU-350	cut unid. wood	1400±80	1520–1180
L'Anse aux Meadows	EjAv-1	GSC-2088	*Picea* sp. wood	1470±60	1520–1290
L'Anse aux Meadows	EjAv-1	S-1119	burned unid. wood	1375±115	1530–1010
L'Anse aux Meadows	EjAv-1	S-1092	*Picea* sp. plank	1410±90	1530–1100
L'Anse aux Meadows	EjAv-1	GSC-2069	*Larix* sp. wood	1600±60	1620–1350
L'Anse aux Meadows	EjAv-1	S-1104	unid. plant remains	1665±45	1700–1420
L'Anse aux Meadows	EjAv-1	GSC-2076	*Abies* sp. wood	2150±60	2310–2000
L'Anse aux Meadows	EjAv-1	GSC-2071	unid. wood	1780±280	2350–1090
L'Anse aux Meadows	EjAv-1	S-1345	unid. cut wood	1800±350	2700–990
L'Anse aux Meadows	EjAv-1	S-1360	*Abies* sp. wood	2350±70	2700–2160
L'Anse aux Meadows	EjAv-1	S-1344	cut *Abies* sp. wood	2365±65	2710–2180
L'Anse aux Meadows	EjAv-1	S-1363	*Picea* sp. wood	2375±65	2710–2210
L'Anse aux Meadows	EjAv-1	S-1362	*Picea* sp. wood	2475±75	2730–2360

L'Anse aux Meadows	EjAv-1	GSC-1987	*Abies* sp., rod-shaped artefact	2500±60	2740–2380
L'Anse aux Meadows	EjAv-1	S-1359	Picea sp. wood	2425±105	2750–2180
L'Anse aux Meadows	EjAv-1	S-1117	unid. bark	2490±105	2770–2340
L'Anse aux Meadows	EjAv-1	S-1356	*Picea* sp. wood	2675±70	2960–2540
L'Anse aux Meadows	EjAv-1	S-1094	*Larix* sp., harpoon mainshaft	2795±100	3170–2750
L'Anse aux Meadows	EjAv-1	S-1116	cut unid. wood	2840±115	3320–2750
L'Anse aux Meadows	EjAv-1	S-1103	unid. plant remains	3045±55	3380–3080
L'Anse aux Meadows	EjAv-1	S-1105	unid. plant remains	3455±75	3910–3510
L'Anse aux Meadows	EjAv-1	S-1107	unid. plant remains	3845±130	4780–3870
L'Anse aux Meadows	EjAv-1	QU-351	*Abies* sp. wood	6550±90	7580–7280
Gould site	EeBi-42	Beta-134154	unid. wood	70±40	modern
Gould site	EeBi-42	Beta-121859	unid. wood	144.6±1.3	modern
Gould site	EeBi-42	Beta-120795	cut *Picea* sp. log	3450±70	3900–3490
Port au Choix-3	EeBi-2	I-4380	*Betula* sp. bark	3230±220	3980–2880
Port au Choix-3	EeBi-2	Y-2609	unid. wood inside bog iron	5120±120	6180–5610
Phillip's Garden	EeBi-1	P-729	charred unid. wood	1538±55	1540–1330
Fleur de Lys-1	EaBa-1	Beta-129941	*Picea* sp. logs in platform	1520±50	1530–1320
Fleur de Lys-1	EaBa-1	Beta-116637	*Picea* sp. logs in platform	1610±60	1690–1370
Back Harbour-3	DjAq-5	GSC-1411	unid. wood	100±130	modern

Table 2 Volume and weight of samples from dwelling Feature 64

Sample	**Volume (mL)**	**Weight (mg)**
N-135 E-15	1875	1236
N-136 E-14	250	200
N-131 E-13	325	270
Total	2450	1706

Table 3 Archaeobotanical remains from sediment sample N–135 E–15. ‘c’ = carbonized

Scientific name (common name)	**Complete**	**Fragment**
Lathyrus palustris (marsh vetchling)	2	0
Polygonum sp. (knotweed)	20	1
Potentilla sp. (cinquefoil)	1	0
Prunus pensylvanica (pin cherry)	0	4
Rubus chamaemorus (bakeapple)	2(c)	0
Rumex sp. 1 (sorrel)	6	0
Rumex sp. 2 (sorrel)	5	0
Stellaria graminea (lesser stitchwort)	3	0
Viola sp. (violet)	12	1
Compositae (flowering plants)	1	0
Gramineae (grasses)	12	6
Other Macroremains		
Abies balsamea needle (balsam fir)	0	1(c)
Contaminants		
Trifolium sp. (clover)	15	0
Unidentifiable specimens	0	1
Total seeds	79	14

Table 4 Radiocarbon dates on sample of seeds from Feature 75. 'Fraction modern' is a measurement of the deviation of the $^{14}C/^{12}C$ ratio of a sample from the Modern radiocarbon dating standard (Stuiver and Polach 1977). '$D^{14}C$' is the normalized value of '$d^{14}C$' which represents the per mile depletion in a sample prior to isotopic fractionation correction (Stuiver and Polach 1977)

UCIAMS no.	**Sample**	**Fraction Modern**	**$D^{14}C$**	**^{14}C age BP**	**Calibrated range (AD)**
134367	*Rubus chamaemorus* (bakeapple)	.9918 ± .0017	-8.2 ± 1.7	65 ± 15	1670–1960
134368	Prunus pensylvanica (pin cherry)	1.2904 ± .0022	290.4 ± 2.2	-2045 ± 15	1960–1980
134369	*Viola* sp. (violet)	1.3739 ± .0027	373.9 ± 2.7	-2545 ± 20	1960–1980

Figure captions

Fig 1 Location of places mentioned in text. Map: Port au Choix Archaeology Project

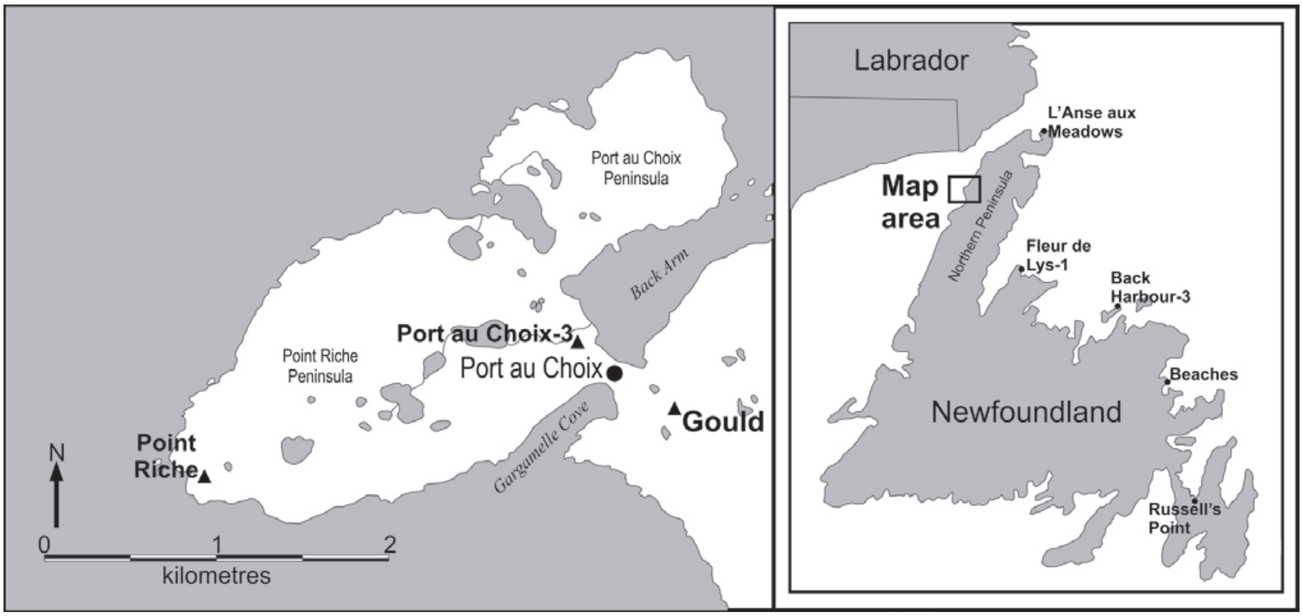

Fig 2 Plan map of the Feature 64 excavation area at Point Riche showing locations of sediment samples used for the present study. The extent of midden Feature 75 is highlighted in transparent grey. Map: Port au Choix Archaeology Project