

Wild Rice (*Zizania* spp.), the Three Sisters, and the Woodland Tradition in Western and Central Canada

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Analysis of carbonized food residue for plant microfossils from 176 archaeological sites distributed across western and central Canada demonstrates that wild rice (*Zizania* spp.) was consumed in combination with maize (*Zea mays* ssp. *mays*) and other cultigens throughout the Middle to Late Woodland periods. Although this pattern is most evident in the boreal forest, *Zizania* was also recovered from some sites on the northern prairies dating to at least A.D. 700. Domesticated bean (*Phaseolus vulgaris*), on the other hand, was less important in places where wild rice was locally available. In general, our data indicate that significant regional variation, and selectivity, existed in the domesticated plant component of diet for northern Woodland populations. We suggest that the traditional emphasis on the wild rice harvest in the southern boreal forest, perhaps in combination with environmental factors, influenced the way in which specific domesticated plants were adopted, or excluded, by local populations.

KEYWORDS wild rice (*Zizania* spp.); maize (*Zea mays* ssp. *mays*); common bean (*Phaseolus vulgaris*); paleodiet reconstruction; Woodland tradition; food residue analysis; plant microfossils

Introduction

The boreal forest of Canada was home to some of the most northerly Woodland populations in North America. Due to extremely poor organic preservation and relatively limited archaeological research in the region, little is known about the subsistence base of subarctic populations prior to European contact. It has generally been assumed, however, that wild rice (*Zizania* spp.) played a strong role in the diet of Woodland populations across the Upper Great Lakes and southern boreal forest. Support for this idea can be found in the apparent overlap in ranges of *Zizania* and Middle and Late Woodland archaeological sites, placement of large habitation sites adjacent to extant stands of wild rice, occasional recoveries of wild rice macrobotanical remains in Woodland and Archaic archaeological sites, as well as the importance of this plant to historic Anishinaabe peoples living in this same region.

Shortly after the initial spread of Woodland cultural influence into the boreal forest, however, domesticated plants—such as maize (*Zea mays* ssp. *mays*), common bean (*Phaseolus vulgaris*), and squash (*Cucurbita* sp.)—became widespread components of diet in the Woodland heartland to the south. These crops, commonly referred to as the “Three Sisters” (Mt. Pleasant 2006), were part of an integrated agricultural system that sustained many late prehistoric complex societies in the New World. Despite their importance, however, considerable uncertainty remains regarding both the timing and nature of cultivated plant dispersal. This is particularly true outside of the known centers of agricultural production, where cultigens may have been acquired through trade or nonintensive horticulture and consumed in small amounts. The recent discovery of maize microbotanical remains at numerous archaeological sites in the Canadian boreal forest and prairies (Boyd and Surette 2010; Boyd *et al.* 2006, 2008) points to the widespread influence of domesticated foods, well beyond the conventional limit of precontact food production, in areas where northern wild rice was a traditional mainstay of diet. This observation leads to a number of interesting questions about the processes of dispersal and adoption of domesticated plants by hunter-gatherer societies. Why, for example, were domesticated foods adopted by subarctic foragers in the first place? Were these foods acquired primarily through trade or local horticulture? How was the procurement of cultivated foods integrated into the existing seasonal round, and what were the long-term impacts of domesticated plant use on traditional economic activities, such as the wild rice harvest?

This paper focuses on the interaction between wild rice and domesticated food procurements systems and on the degree to which selectivity occurred in the adoption of cultivated plants by northern Woodland peoples. It is generally understood that the Three Sisters agricultural system developed as a result of the nutritional, and ecological, complementarity of maize, common bean, and squash (Mt. Pleasant 2006). However, for societies in which domesticated foods played a minor dietary role or were acquired through trade or who lived where locally abundant wild substitutes were available, adoption of the complete system may not have been necessary or even beneficial. Environmental factors may have also played a role in the preferential cultivation of some plants over others: Common bean, for example, is more vulnerable to spring frost than maize is (Mt. Pleasant 2006), so it may have been less viable as a crop in more northerly settings. In either case, selec-

tive use of some domesticated foods, and exclusion of others, may have occurred. Selectivity may have been particularly strong in the boreal forest due to the more marginal growing conditions, the dispersal of domesticated plants via long-distance trade (Boyd and Surette 2010), and the fact that wild rice embodies many of the advantageous characteristics of cultivated plants (it is abundant, predictable, nutritious, and can be stored for winter consumption).

Our ongoing research involves archaeobotanical analysis of food residues from 176 sites scattered across the boreal and prairie zones of western and central Canada, in addition to more comprehensive site-level research employing geophysical survey techniques, excavation, residue analysis, and lake sediment coring in the Whitefish Lake basin of northern Ontario (Figure 1). In recent years, food residues have been increasingly employed in order to address fundamental research questions in archaeology—especially those dealing with food procurement strategies and the forager-farmer transition. Although archaeological residues may be analyzed for a variety of chemical and biological indicators of past diet (e.g., Boyd et al. 2008; Hart et al. 2007; Morton and Schwarcz 2004), the emphasis in this paper is on plant microfossil (phytolith and starch) remains. Previous research has shown that phytoliths and starch granules preserve well in a range of depositional and archaeological contexts and provide subtle knowledge of the plant component of paleodiet (e.g., Boyd and Surette 2010; Hart et al. 2003, 2007; Pearsall et al. 2003, 2004; Piperno and Holst 1998). Recent applications of this technique have led to insight into the development of agriculture in the Americas, long-distance food exchange networks, and the use of wild plants by early and modern humans, among other topics. Furthermore, due to poor preservation of organics in most subarctic archaeological sites, plant microfossils provide one of the few surviving sources of information on past diet, making them essential for understanding past interactions between humans and the environment across the northern reaches of the continent.

Woodland archaeology of the southern boreal forest

Middle (Initial Shield) and Late Woodland periods

Beginning approximately 150 B.C., major changes occurred in the archaeological record of the southern boreal forest due to the spread of Woodland cultural influence into this region—the most obvious of which included the first appearance of pottery technology and, in some cases, burial mounds, larger residence sizes, and a greater emphasis on long-distance trade and regional interaction. Over the next two millennia, a variety of Middle and Late Woodland cultures—distinguished and differentiated almost entirely by pottery style—successively occupied the region. Although a general culture-history framework for the boreal forest has been developed and refined over the last fifty years, major information voids continue to exist because of limited archaeological exploration of the region, a lack of well-dated sites, and generally poor organic preservation and site stratigraphy.

Ceramic production in the Canadian boreal forest began with the Laurel phase (approx. 150 B.C.–A.D. 1100). This widespread Middle Woodland/Initial Shield Woodland culture was distributed from western Quebec to northern Saskatchewan,

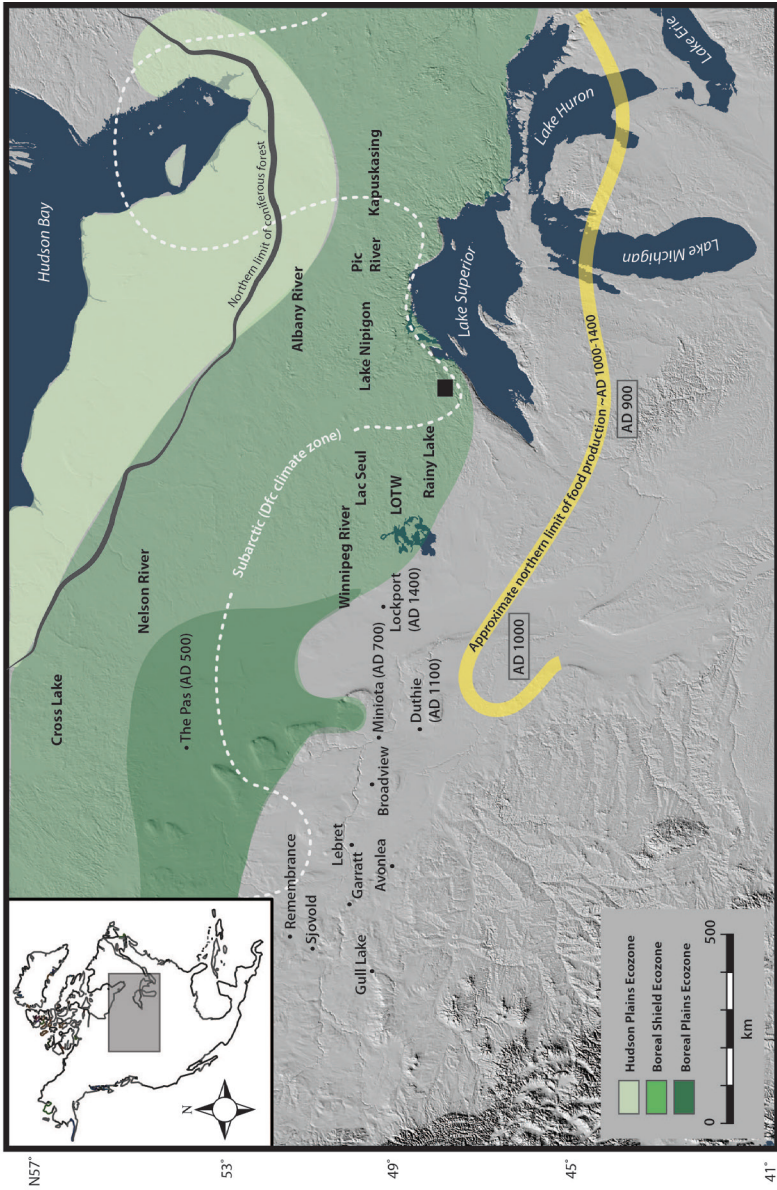


FIGURE 1 Map showing location of study sites and locales in relation to the conventional northern limit of precontact food production, major boreal–subarctic environmental zones, and Whitefish Lake region (solid black box). Dates in boxes are conventional estimates for the first appearance of maize horticulture in the Midwest. Dates in parentheses are estimates for maize consumption based on the recovery of *Zea mays* microfossils or macroremains. *Sources:* Boyd and Surette (2010); Boyd *et al.* (2006, 2008); Lints (2012).

in addition to northern Minnesota and adjacent regions of the U.S. upper Midwest. As a whole, Laurel components are associated with distinctive conoidal, smoothed, grit-tempered pottery types; perforated antler harpoons; occasional copper tools; burial and effigy mounds; and stemmed/notched projectile points, grinding stones, and a range of other lithic and organic artifacts (Anfinson 1979; Arzigian 2008; Budak and Reid 1995). Burial mound ceremonialism, which is only evident in the southern portion of the Laurel range (especially the boundary waters area between Minnesota and Ontario), may have been derived indirectly from the mortuary complex of the Hopewell culture (Wilford 1955; Wright 1999). However, as Wright (1999:773) observes, there is little evidence that the Laurel participated in the Hopewell Interaction Sphere in any significant way. Broad similarities in pottery form and decoration between Laurel and the Saugeen and Point Peninsula (Middle Woodland) complexes of the Lower Great Lakes also suggest diffusion of some cultural elements across an east–west axis (Wright 1999:727). We also note that Middle Woodland pottery-producing groups are strongly represented in the upper Midwest (specifically the Mississippi River headwaters) and may also be an important source for the northward diffusion of pottery into the boreal forest via the boundary waters region (Anfinson 1979; Lugenbeal 1976; Stoltman 1973). Although its origin is unclear, Laurel is generally regarded as a direct “descendant” of the preceding Archaic tradition (Wright 1999:726), rather than a result of the spread of a new people into the boreal forest.

The Late Woodland period in the boreal forest is associated with a variety of archaeological complexes that are largely defined by differences in pottery style and form. The major complexes—Blackduck-Kathio, Rainy River Late Woodland, Psinomanani (Sandy Lake), and Selkirk—generally date to the period after A.D. 1000, although some variants of Blackduck in northern Minnesota and southern Manitoba appear between about A.D. 600 and 800 (Arzigian 2008; Hamilton et al. 2007; Rapp et al. 1995).

The Blackduck-Kathio/Rainy River and Sandy Lake complexes are found mostly in the mixed forest and boreal forest zones of northern Minnesota, Manitoba, and Ontario, although some sites have also been recorded on the northeastern prairies. Blackduck-Kathio and Rainy River ceramics are stylistically complex and typically include cord-wrapped object impressions, deep circular punctates, cord-marked or textile-impressed bodies, and globular vessel forms with constricted necks (Arzigian 2008; Lenius and Olinyk 1990). Sandy Lake pottery, while similar in many ways to Blackduck/Rainy River, is rarely decorated; exterior surfaces are usually either smoothed, cordmarked, or stamped with grooved paddles. Lithic and non-lithic components of Late Woodland artifact assemblages are broadly similar to the Laurel tool kit, with some exceptions (e.g., projectile point form, decreased use of hard-hammer percussion through time, production of unilaterally barbed harpoon heads) (see Arzigian 2008). Construction and reuse of burial mounds continued into the Late Woodland period, particularly in association with Blackduck-Kathio and Rainy River Late Woodland complexes. Burials were usually flexed, and associated mortuary artifacts included pottery, projectile points, red ochre, bone tools, and birch bark (Arzigian 2008).

Selkirk composite (approx. A.D. 1000–protohistoric) ceramics are widely distributed across the boreal forest in northwestern Ontario, northern Manitoba, and

Saskatchewan and have been linked to the Algonquian ancestors of the Cree (Meyer and Russell 1987:25–26). These vessels are generally globular with constricted necks, excurvate rims, and smoothed, fabric-impressed exteriors. The nonceramic portion of Selkirk assemblages, however, is very similar to Blackduck materials (Meyer and Hamilton 1994:119). Between approximately A.D. 1250 and 1500, Selkirk peoples may have expanded out of northern Manitoba and into adjacent regions to the south, east, and west (Meyer and Hamilton 1994:122–123). In Saskatchewan, some sites show influences from cultural groups in the parklands and grasslands—mainly in the form of ceramics with angular rims and shoulders, decorated shoulders, and occasionally S-shaped rims (Meyer 1981). Possible contact between Selkirk peoples and Plains-adapted societies has also been identified in southern Manitoba (Syms 1977:140, 1979).

Diet and subsistence

Many aspects of the northern Woodland subsistence base and seasonal round are unclear due in large part to poor bone preservation on the Canadian Shield (Wright 2004:1409), as well as the lack of attention given to plant remains by archaeologists working in this region. However, it is generally assumed that Laurel and Late Woodland peoples were broad-based, mobile foragers who were primarily adapted to the resources of the boreal and Great Lakes–St. Lawrence forests. Although specific foods varied according to season of site occupation and geographic region, many species of medium- to large-size ungulates (e.g., moose, elk, caribou, deer), other mammals (e.g., beaver, hare, dog, muskrat), birds (e.g., common loon, goose, duck), reptiles (turtles), shellfish, and fish have been recovered from these sites. Site locations and, in some cases, abundant fish remains and bone harpoon heads indicate that fishing was a central subsistence activity from spring to fall (Dawson 1981; Mayer-Oakes 1970; Wright 1999). Fall fishing camps were likely established because of the importance of dried fish during the winter, when large mammals were scarce (James 1830:228–229). In the Laurel component at the Lockport site (Manitoba) (MacNeish 1958), fish and shellfish may have been exploited more intensively through time. In contrast, Middle and Late Woodland sites in the aspen parkland (the transitional zone between grassland and boreal forest) indicate a heavy emphasis on bison exploitation (Buchner 1979:113; Hamilton *et al.* 1982, 2007; MacNeish 1958). The presence of multifamily dwellings and relatively high artifact densities in some locales may also suggest more sedentary habitation and/or increased populations beginning during the Laurel phase and continuing into the Late Woodland period (Reid and Rajnovich 1985, 1991). This trend has been explained by intensification of wild rice exploitation through time (Dobs and Anfinson 1990), although there is little direct evidence to support this idea.

The recent recovery of maize in multiple Laurel and Late Woodland sites as far north (54° N) as The Pas, Manitoba, indicates that domesticated plants were incorporated into the diet of some subarctic peoples by at least A.D. 500 (Boyd and Surette 2010). As summarized in Boyd and Surette (2010) and Boyd and colleagues (2006, 2008), maize may have been available at these sites through long-distance trade or local horticulture; however, because some of the sites reported in Boyd and Surette (2010) are located at latitudes where native corn was frequently un-

able to ripen during the fur-trade period, domesticated foods likely flowed through long-distance exchange networks (Boyd and Surette 2010). In other locations in the boreal forest, however, small-scale horticulture may have been practiced. The dietary importance of domesticated plants to subarctic foragers is unknown, but greater evidence of maize in Late Woodland sites in the boreal forest may suggest that cultivated foods became more important and/or widespread through time in this region (Boyd and Surette 2010; Boyd et al. 2008).

Wild rice (*Zizania* spp.) and the archaeological record

Direct evidence of wild rice in subarctic archaeological sites is extremely scarce, despite the prevalence of this plant in boreal aquatic ecosystems, as well as its cultural importance during the historic period. Nevertheless, archaeologists have generally believed that a close connection existed between wild rice and precontact human societies across the southern boreal forest and Upper Great Lakes. For example, the westward and northward spread of the Laurel phase over time has been linked to the dispersal of northern wild rice (*Zizania palustris*) across the Canadian Shield (Buchner 1979:124; Wright 1999). This idea is based largely on the apparent overlap in the distribution of Laurel and Late Woodland sites and of modern wild rice (Rajnovich 1984). However, it is not exactly known when wild rice appeared across this region. Estimates from lakes in northern Minnesota, for example, vary from 12,600 cal B.P. (Birks 1976; Huber 2000) to 1960 cal B.P. (McAndrews 1969). Due to the sensitivity of *Zizania* to water depth and temperature, hydrological fluctuations driven by climate change likely had a major influence on the history of wild rice at the watershed level (Boyd et al. 2013; McAndrews 1969). In any case, the lack of research on the history of northern wild rice makes identifying a dominant cause for its dispersal—whether anthropogenic or environmental—highly speculative.

The occasional recovery of wild rice processing areas and *Zizania* macrofossils in Middle and Late Woodland sites (e.g., Valppu 2000), as well as the proximity of some of these sites to extant wild rice fields (Rajnovich 1984), supports the idea that Aboriginal people exploited this food source in the Great Lakes region during the Holocene. In total, direct or indirect evidence of wild rice has been reported from more than 65 sites in eastern North America (see Surette 2008:Table 1); usually, however, this evidence is limited to the recovery of a few seeds or the presence of features interpreted as “ricing jigs” (Surette 2008). Although the majority of these sites date to the Woodland period, *Zizania* remains have occasionally been associated with Archaic materials (Chapman and Shea 1981; Crawford 1982; Hart et al. 2003, 2007; Johnston 1984), suggesting widespread use of this food resource both before and after the introduction of the Three Sisters agricultural system.

Whitefish Lake

The archaeological record of Whitefish Lake, northern Ontario, Canada, provides an excellent opportunity to study the connection between maize and wild rice in northern Woodland societies. This region, which is located near the northwestern shore of Lake Superior (see Figures 1 and 2), is significant because it marks the

northern limit of burial mound ceremonialism in North America, and is associated with a relatively high concentration of Woodland habitation sites. Although Whitefish Lake is located well north of the accepted limit of prehistoric food production (see Figure 1), initial testing of carbonized food residue from several Woodland sites in this region yielded strong evidence of maize, in addition to wild rice (*Zizania palustris*) (Boyd and Surette 2010). Beginning in 2009, a multidisciplinary research program—involving lake sediment coring (Boyd *et al.* 2013), geophysical survey, archaeological excavation, and residue analysis—was initiated in order to situate the domesticated plant component of diet at these sites against the backdrop of late Holocene environmental change at Whitefish Lake and the emergence of the traditional wild rice economy.

Due to the shallow (approx. 2 m deep) and uniformly flat-bottom shape of its basin, Whitefish Lake supports very large communities of aquatic macrophytes. The largest of these wetlands, located at the western end of the lake (see Figure 2), is 120 ha and dominated by northern wild rice (*Zizania palustris*) (Lee and McNaughton 2004). Other common macrophytes associated with wild rice in the lake include *Nymphaea odorata*, *Nuphar variegatum*, *Sagittaria latifolia*, and *Potamogeton gramineus*. The vegetation surrounding Whitefish Lake is dominated by conifer and deciduous species typical of the boreal and Great Lakes–St. Lawrence forests. Paleoecological (pollen, phytolith) analysis of lake sediment cores indicates that wild rice had colonized the western basin by approximately 6100 cal B.P., in response to a climate-driven rise in lake level (Boyd *et al.* 2013).

The archaeological record of the Whitefish Lake area is extremely sparse until the Middle Woodland period; the importance of the lake after this time can be seen in the concentration of habitation sites located along the modern shore or on islands within the lake (see Figure 2). Two of these sites (Martin-Bird and MacGillivray) were the focus of archaeological research by Kenneth C. A. Dawson between 1966 and 1970 (Dawson 1980, 1987), as well as by us in 2009 and 2010. Both sites are located on an island at the western end of the lake and contain low burial mounds and extensive habitation zones adjacent to each mound. At the Martin-Bird site, the burial mound is situated on a low, N–S trending, ridge overlooking the western end of the lake. Excavation of the central portion of the mound by Dawson (1987) revealed a 1.4 m-deep pit containing a secondary (bundle) burial enclosed by a birch-bark container, a miniature Blackduck ceramic vessel, a clam shell “spoon,” red ochre, a copper pendant, and a variety of precontact lithic and ceramic artifacts. Cultural deposits to the west and the east of the mound are extensive and interpreted as domestic spaces based on the recovery of numerous hearths, pit features, and a wide variety of artifactual debris (Dawson 1987). In 2009 and 2010, survey test pits and excavation units revealed a heavy concentration of fire-cracked rock (FCR) which, based on magnetic and ground penetrating radar (GPR) data, appears to form localized (but quite dense) “pavements” in various places across the southeastern portion of the site (Terry Gibson, personal communication 2010). Ceramics recovered indicate that the Martin-Bird site was repeatedly occupied by a variety of Middle and Late Woodland complexes, including Laurel, Duck Bay, Blackduck, Sandy Lake, and Selkirk. Based on minimum vessel counts, however, Blackduck pottery accounts for roughly 50 percent of the total assemblage, suggesting that the site

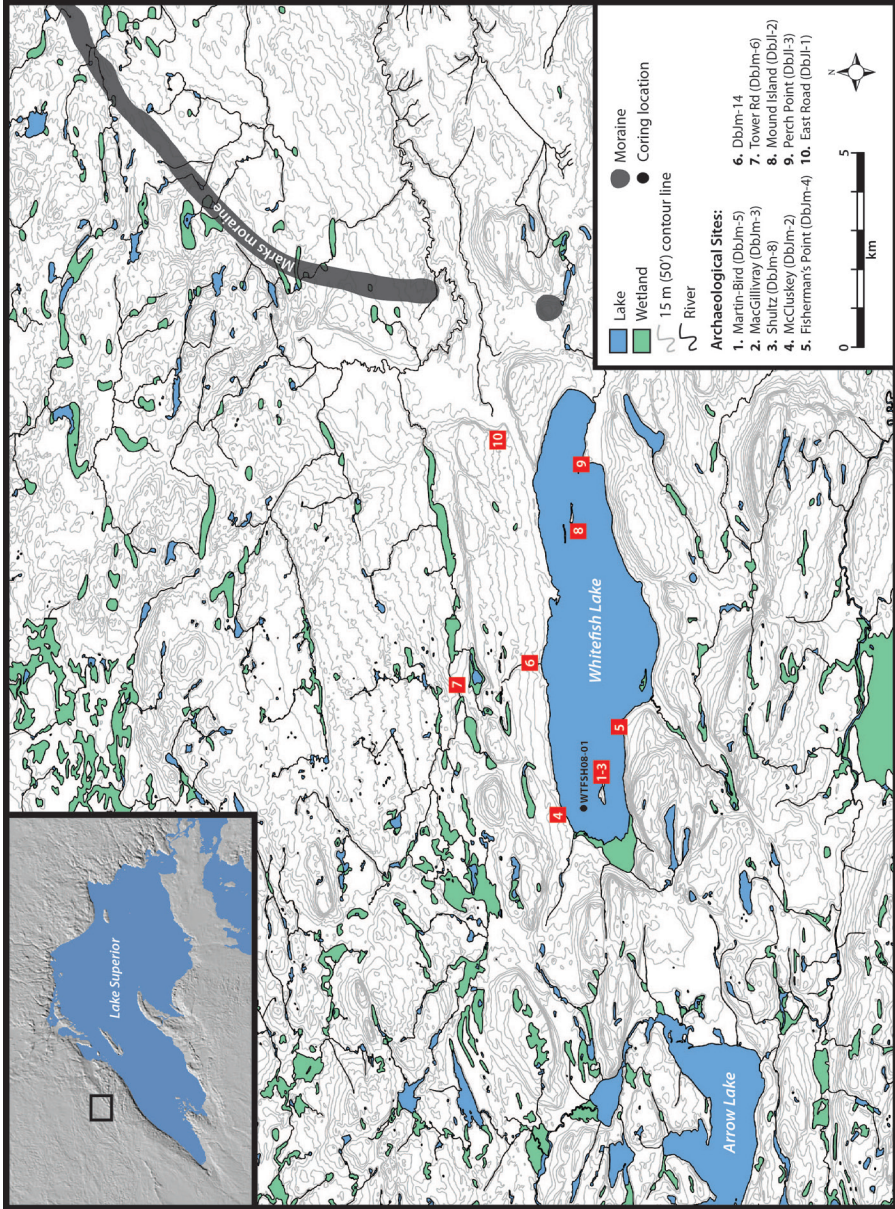


FIGURE 2 Map of the Whitefish Lake, Ontario, region showing locations of major Woodland archaeological sites.

was predominantly occupied by the makers of this and related pottery types (Duck Bay and Kathio). Other ceramic types identified at Martin-Bird and other sites on Whitefish Lake, and analyzed in this study, include Laurel, Brainerd, Sandy Lake, and Selkirk (Table 1).

Methods

The total collection analyzed for this study consists of 379 samples of pottery (and associated food encrustations) from 176 archaeological sites scattered across the southern boreal forest and northern prairies of Canada (see Figure 1), representing nearly all Middle and Late Woodland and Plains Woodland cultures that occupied the region between approximately A.D. 500 and 1500. Most pottery samples were stored in provincial, museum, or university repositories and private collections following excavation at various times after the 1940s. Within the total collection, 63 samples originate from Woodland components on Whitefish Lake and were either found in the field by us or by Kenneth Dawson in the 1960s and 1970s. Presence/absence data from the Whitefish Lake samples are presented in Table 1 (domesticated plants and *Zizania* only), and select results from the larger collection are presented in Figures 3, 4, and 5.

Archaeological sites are categorized in this paper as either being from the “boreal forest” (boreal shield/plains) or the “prairies” based on their location with respect to modern ecozone boundaries. This division, and our macroscale/multisite comparative approach, is justified because (1) the location of vegetation zones has generally remained stable over the last two thousand years in this region (Liu 1990); (2) significant differences in diet, dietary breadth, and other aspects of subsistence are recorded between these two regions (Boyd *et al.* 2008; Hamilton 1982; Wright 2004); and (3) clear cultural differences often existed between contemporaneous boreal and prairie sites. This is seen, for example, in the restricted distribution of many ceramic wares. Thus, despite their proximity, the boreal forest and the northern prairies engendered distinctive cultural traditions, adaptations, and archaeological records. As discussed below, neighboring boreal- and plains-adapted societies may also have differed in the extent to which domesticated plants were incorporated into diet.

Some limitations exist in the use of plant microfossils (extracted from food residues) for paleodietary reconstructions. In particular, due to the nature of plant microfossil identification, differences in starch/phytolith abundance, and other factors, some domesticated and wild plants will be better represented than others in food residues or other archaeological contexts. For example, maize and, to a lesser extent, common bean are expected to be well represented in our samples because of their high starch content. Squash (*Cucurbita pepo*), on the other hand, does not appear to produce distinctive starch granules (Lints 2012), and phytoliths are only found in the inedible (rind) portion of the fruit. As a result, squash microfossils should be rare in carbonized food residue. Wild rice is also expected to be underrepresented in food residues due to its low starch content, lack of identifiable starch morphotypes, and production of diagnostic phytoliths in the “chaff” (glumes) only

TABLE 1

CARBONIZED FOOD RESIDUE SAMPLES FROM ARCHAEOLOGICAL SITES^a NEAR WHITEFISH LAKE
NORTHWESTERN ONTARIO, AND SELECT PLANT MICROFOSSIL RECOVERIES^b

#	Site Number	Site Name	Cultural Affiliation	<i>Zea mays</i> rondel	<i>Zizania</i> sp. rondel	cf. <i>Cucurbita</i> phytolith	<i>Zea mays</i> starch	<i>Phaseolus vulgaris</i> type starch
1	DbJl-1	East Road	Selkirk	—	—	—	—	X
2	DbJl-2	Mound Island	Woodland	X	X	—	X	X
3	DbJl-2	Mound Island	Laurel	—	—	—	—	—
4	DbJl-2	Mound Island	Sandy Lake Plain	—	—	—	—	—
5	DbJl-2	Mound Island	Late Woodland	—	—	—	—	X
6	DbJl-2	Mound Island	Blackduck	—	—	—	—	—
7	DbJl-3	Perch Point	Blackduck	—	—	—	—	—
8	DbJm-2	McCluskey	Blackduck	—	X	—	—	—
9	DbJm-2	McCluskey	Blackduck	—	X	—	—	—
10	DbJm-2	McCluskey	Blackduck	X	X	—	X	—
11	DbJm-2	McCluskey	Blackduck	—	—	—	—	—
12	DbJm-2	McCluskey	Late Woodland	—	—	—	—	—
13	DbJm-2	McCluskey	Late Woodland	—	—	—	—	—
14	DbJm-2	McCluskey	Late Woodland	X	—	—	—	—
15	DbJm-2	McCluskey	Late Woodland	—	X	—	—	—
16	DbJm-2	McCluskey	Blackduck	—	X	—	—	—
17	DbJm-2	McCluskey	Late Woodland	—	—	—	—	—
18	DbJm-2	McCluskey	Laurel	—	—	—	—	—
19	DbJm-3	MacGillivray	Laurel	X	X	—	—	—
20	DbJm-3	MacGillivray	Laurel	—	—	—	—	—
21	DbJm-4	Fisherman's Point	Blackduck	X	X	—	—	X
22	DbJm-5	Martin-Bird	Blackduck Mortuary Vessel	X	X	—	X	X
23	DbJm-5	Martin-Bird	Blackduck (rim)	X	X	—	—	X
24	DbJm-5	Martin-Bird	Blackduck (rim)	X	X	—	X	—
25	DbJm-5	Martin-Bird	Blackduck (rim)		X	—	X	—
26	DbJm-5	Martin-Bird	Blackduck complete vessel (FCR feature), rim	X	—	—	X	—
27	DbJm-5	Martin-Bird	Blackduck complete vessel (FCR feature), body	—	—	—	X	—
28	DbJm-5	Martin-Bird	Blackduck (rim)	X	—	—	X	—
29	DbJm-5	Martin-Bird	Blackduck (rim)	X	X	—	—	—
30	DbJm-5	Martin-Bird	Blackduck/Laurel transitional	—	—	—	—	—
31	DbJm-5	Martin-Bird	Brainerd Parallel Grooved	—	—	—	—	—
32	DbJm-5	Martin-Bird	Kathio Series (rim)	X	X	—	—	—
33	DbJm-5	Martin-Bird	Late Woodland	X	—	X	X	X
34	DbJm-5	Martin-Bird	Late Woodland	—	—	—	X	—
35	DbJm-5	Martin-Bird	Late Woodland (body)	X	—	—	—	—
36	DbJm-5	Martin-Bird	Late Woodland (body)	X	X	—	X	—
37	DbJm-5	Martin-Bird	Late Woodland (body)	—	—	—	X	—
38	DbJm-5	Martin-Bird	Late Woodland (body)	X	—	—	X	—
39	DbJm-5	Martin-Bird	Late Woodland (body)	—	—	—	X	—

Continued

TABLE 1
CONTINUED

#	Site Number	Site Name	Cultural Affiliation	<i>Zea mays</i> rondel	<i>Zizania</i> sp. rondel	cf. <i>Cucurbita</i> phytolith	<i>Zea mays</i> starch	<i>Phaseolus vulgaris</i> type starch
40	DbJm-5	Martin-Bird	Late Woodland (body)	—	—	—	—	—
41	DbJm-5	Martin-Bird	Late Woodland (body)	X	X	—	—	X
42	DbJm-5	Martin-Bird	Late Woodland (body)	X	X	—	X	—
43	DbJm-5	Martin-Bird	Late Woodland (body)	—	—	—	—	—
44	DbJm-5	Martin-Bird	Late Woodland (body)	X	—	—	—	—
45	DbJm-5	Martin-Bird	Late Woodland fabric impressed (body)	X	X	—	X	—
46	DbJm-5	Martin-Bird	Late Woodland refit (body, n=4)	X	X	—	X	—
47	DbJm-5	Martin-Bird	Laurel (body), wide CWT impressions	X	X	—	X	—
48	DbJm-5	Martin-Bird	Middle Woodland? net-impressed sherd	X	—	—	—	—
49	DbJm-5	Martin-Bird	Selkirk (Clearwater Lake Punctate) rim/neck	X	X	—	X	X
50	DbJm-5	Martin-Bird	Selkirk (neck)	—	—	—	—	—
51	DbJm-5	Martin-Bird	Selkirk (neck)	X	—	—	X	—
52	DbJm-5	Martin-Bird	Selkirk (rim)	X	X	—	X	—
53	DbJm-5	Martin-Bird	Duck Bay (rim)	X	X	—	X	—
54	DbJm-5	Martin-Bird	Selkirk/Rainy River	X	X	—	X	—
55	DbJm-5	Martin-Bird	Indet. fabric impressed (surface find)	—	—	—	—	—
56	DbJm-5	Martin-Bird	Late Woodland (rim/neck), trailed	X	—	—	X	—
57	DbJm-5	Martin-Bird	Blackduck	—	—	—	—	—
58	DbJm-5	Martin-Bird	Blackduck?	X	—	—	—	—
59	DbJm-5	Martin-Bird	Late Woodland	—	—	—	—	—
60	DbJm-5	Martin-Bird	Late Woodland	—	X	—	—	—
61	DbJm-5	Martin-Bird	Laurel	—	—	—	—	—
62	DbJm-5	Martin-Bird	Laurel?	—	X	—	—	—
63	DbJm-5	Martin-Bird	Sandy Lake	—	—	—	—	—

^aSite locations are shown on Figure 2.

^bX = presence

(Surette 2008). Secondly, plant remains recovered from carbonized food encrustations represent only one component of the total dietary range of a past population. Obviously, only plant foods that were cooked through extensive boiling in ceramic vessels will be recorded in carbonized residues; plants exclusively eaten raw or cooked in other ways (e.g., roasted) will be invisible. However, in the case of starchy food—such as maize, beans, and squash, as well as wild rice—boiling was commonly required to make it edible or was a preferred cooking method employed by historic Aboriginal societies living in the region (e.g., Wilson 1987).

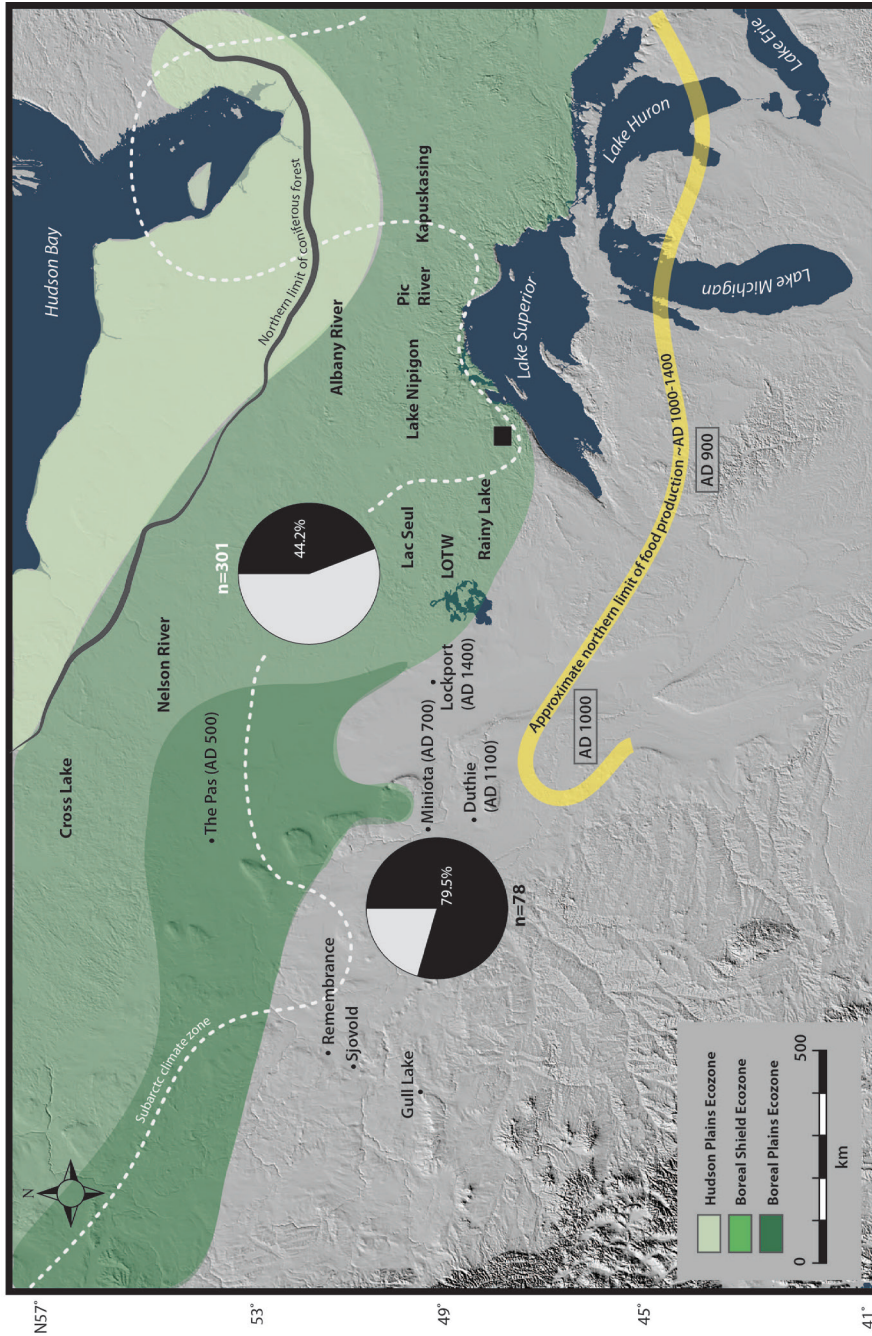


FIGURE 3 Map showing proportion of food residue samples with maize starch and/or phytoliths from the Canadian prairies (lower pie chart, $n = 78$ samples) and boreal forest (upper pie chart, $n = 301$).

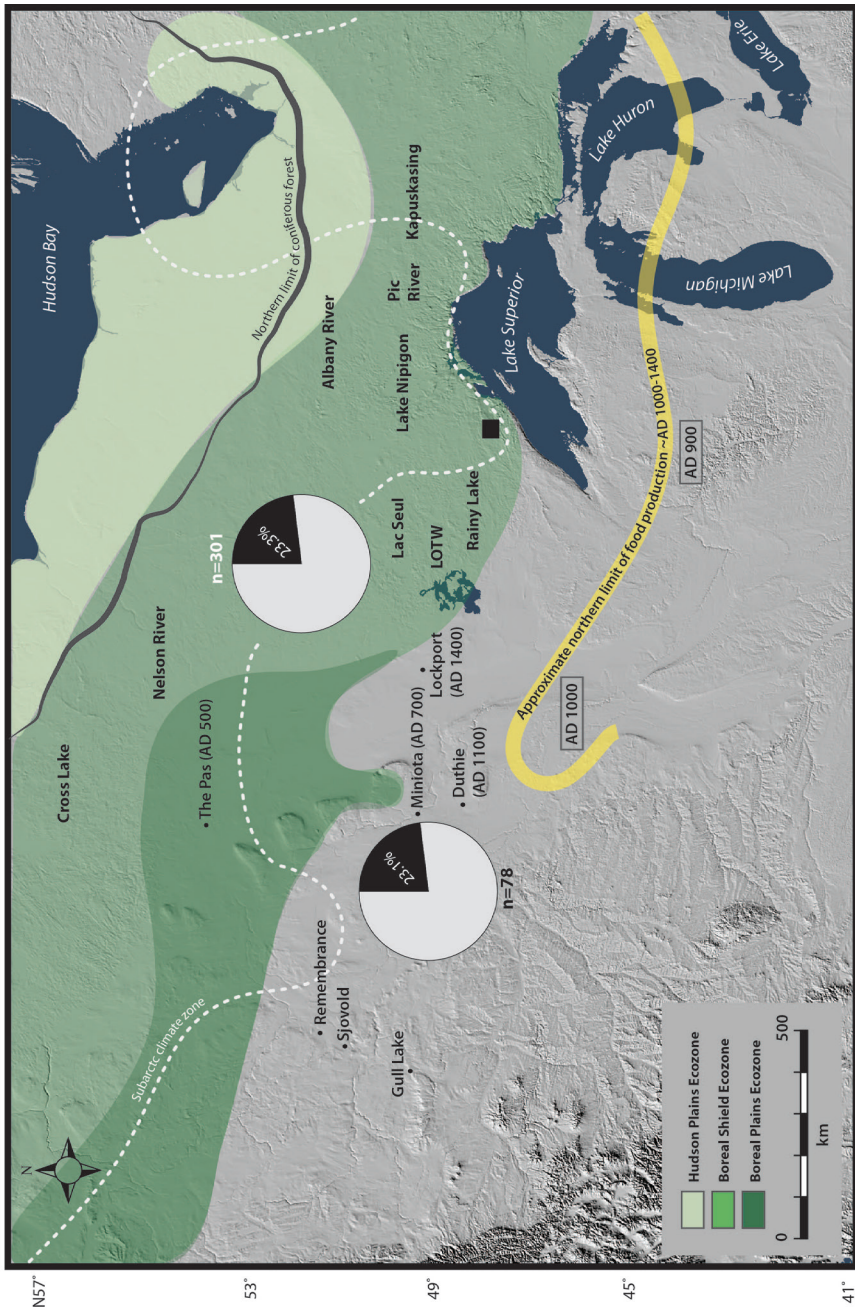


FIGURE 4 Map showing proportion of food residue samples with wild rice (*Zizania sp.*) phytoliths from sites located on the Canadian prairies (lower pie chart) and boreal forest (upper chart).

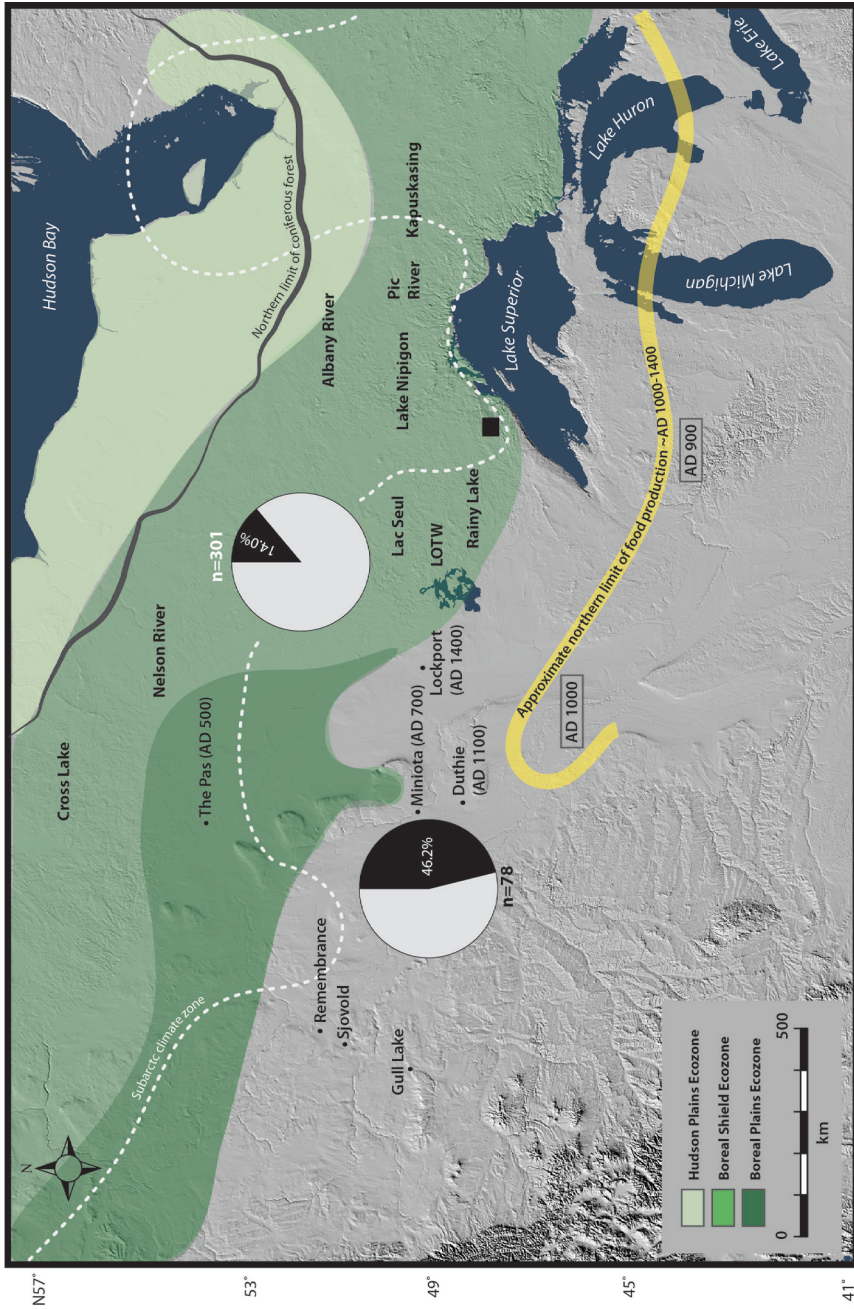


FIGURE 5 Map showing proportion of food residue samples with common bean (*Phaseolus vulgaris*) starch from sites located on the Canadian prairies (lower pie chart) and boreal forest (upper chart).

Although the contribution of a given plant to the overall diet is difficult to ascertain from food residue alone, it should be possible to say if a particular plant species was more important in one group of sites versus another by comparing the proportion of sites yielding microremains of this plant in each group. For example, if wild rice was consumed more frequently at sites located in the boreal forest (vs. the northern plains), then a higher percentage of carbonized residue samples from this region should contain wild rice plant remains. Conversely, a plant that was cooked (and consumed) less often, or in smaller amounts, in one group of sites should be found in relatively fewer carbonized residue samples regardless of overall starch/phytolith production levels for that plant. Through large multisite comparisons and the use of presence/absence data, the problem of differential plant microfossil visibility is alleviated while, at the same time, providing insight into the relative importance of key economic plants through time and space.

Starch and phytolith extraction

Carbonized food encrustations were removed from the interior surface of each ceramic sherd using a dissecting probe, weighed, and placed in sealed centrifuge tubes. Next, 5 ml of 6 percent hydrogen peroxide was added to the residue and oscillated at 1400 rpm in an orbital shaker for 10 minutes. After washing in pure water, the residue sample was divided into two equal fractions: one for phytoliths and the other for starch. The starch fraction was sieved using 118 μm disposable Nitex nylon cloth in order to remove larger debris; the material that passed through the sieve was then centrifuged, the supernatant was removed, and the remaining residue was placed in a sterile microcentrifuge tube for later mounting and analysis. The phytolith sample was air dried and placed in a warm (55°C) bath with 5 ml of 50 percent nitric acid for 12 to 24 hours. When digestion was complete, the sample was washed several times in order to remove the acid solution, and the remaining material was mounted on slides (in Entellen and thiodiethanol) and analyzed under a compound light microscope equipped with differential interference contrast/cross-polarization.

Contamination controls

By virtue of their small size and abundance, modern microfossils from economic plants such as maize may potentially contaminate archaeological materials at any stage following excavation. We eliminate the risk of modern contamination in the lab by (1) using a clean facility dedicated to plant microfossil extraction; (2) processing comparative plant materials in a separate lab using separate equipment; (3) running sample “blanks” at the start of a new batch and analyzing any resultant residue for microremains; (4) regularly analyzing airborne particle traps (microscope slides with silicone oil and no cover slips) placed throughout the lab; (5) thoroughly cleaning all processing equipment using an ultrasonic bath and frequently using disposable lab equipment, such as pipette tips, sample trays, and filtration cloths; (6) using only pure water in all lab procedures; and (7) eliminating all known modern starch-containing materials from the lab environment at all times (e.g., food, makeup, powdered examination gloves, some powdered detergents). Based on our experience, the risk of introducing modern starch during lab processing is virtually nil with these

controls in place. When dealing with archaeological collections from museums, of course, it is impossible to completely assess the risk of modern starch/phytolith contamination during, and following, excavation. However, we note that starch from common Old World economic plants, such as *Triticum* (wheat), are always rare to absent in archaeological residues in our study area, indicating that microfossil contamination is probably not a significant concern when dealing with older collections. Further confidence in results is obtained through the use of multiple lines of evidence for domesticated plants; maize, for example, produces identifiable phytoliths, starch granules, and pollen, all of which may potentially be found in residue (Boyd and Surette 2010; Boyd et al. 2006, 2008). Lastly, many of the artifacts from Whitefish Lake were collected by us in the field during test excavations and were carefully handled to ensure that no contamination occurred.

Identification of plant taxa using starch and phytoliths followed several sources: Bozarth (1993) and Pearsall and colleagues (2003) for *Zea mays*; Boyd and colleagues (2008), Boyd and Surette (2010), and Lints (2012) for *Phaseolus vulgaris*; Bozarth (1987) and Lints (2012) for *Cucurbita* sp.; and Surette (2008) and Yost and Blinnikov (2011) for *Zizania palustris*. Positive identifications were only made for rondel phytoliths if both the base and top were clearly visible; starch identifications were based on observation under both plane- and cross-polarized light. A modern starch and phytolith reference collection, comprising over 154 domesticated and wild species, was used to confirm identifications. An average of roughly 250 phytoliths and 250 starch granules were counted and identified for each archaeological sample. However, only a select portion of the complete data set is presented in this paper. Microfossil data from some of the sites discussed were previously presented in Boyd and Surette (2010), Boyd and colleagues (2006, 2008), and in two master's theses (Lints 2012; Surette 2008). The phytolith/starch results from Whitefish Lake, furthermore, are part of a larger data set from this region that will be reported elsewhere.

Results

Plant microfossils from maize, common bean, squash, and wild rice were recovered from food residue samples obtained from sites in the boreal forest and on the prairies, although in varying proportions depending on the region. These proportions are shown in Figures 3, 4, and 5. In general, maize starch and/or phytoliths were recovered from approximately 44 percent of the food-residue samples from the boreal forest and 80 percent of the samples from the prairie sites (see Figure 3). Starch from domesticated bean, on the other hand, was recorded in only 14 percent of the boreal samples while being found in nearly half (46 percent) of the residue samples from the prairies (see Figure 5). Wild rice phytoliths were less common in food residue from both regions and were recovered in nearly equal proportions (23 percent) (see Figure 4). Squash (*Cucurbita pepo*) phytoliths were generally rare across the study area; in fact, only four samples (1 percent) from the boreal forest and one sample (1 percent) from the prairie (Lints 2012) yielded squash remains.

Microfossils produced by domesticated plants were recovered from 57 percent ($n = 36$) of the carbonized food residue samples from Whitefish Lake, representing six of

the total seven archaeological sites studied (see Table 1). A slightly higher proportion (69 percent, $n = 29$) of the samples from the Martin-Bird site, which dominated our ceramic collection, yielded domesticated food remains. Evidence of maize, furthermore, was frequently found in more than one form: Only nine carbonized food residue samples (14 percent) yielded only *Zea mays* phytoliths, and only four samples (6 percent) yielded only maize-type starch. We also observed that wild rice phytoliths were recovered from most (57 percent) of the food-residue samples which produced maize microfossils. Starch from common bean (*Phaseolus* sp.) was recovered from nine (14 percent) of the samples, and only one squash phytolith was found in the food residue samples from Whitefish Lake. In general, domesticated plant remains were recovered from both Middle (e.g., Laurel) and Late Woodland ceramic vessels.

Interpretations and discussion

Our results show that differences exist in the degree to which cultivated plants are represented in food residues from contemporaneous sites on the northern prairies and in the boreal forest. This, in turn, may imply differences in the relative importance of these plants in the diets of plains- and boreal-adapted Woodland societies. These broad regional trends are also mirrored to some extent at the site level—in our case, by a subset of Middle and Late Woodland samples from Whitefish Lake.

In general, we note that a smaller proportion of samples from sites in the boreal forest (vs. the Canadian prairies) yielded domesticated plant remains. This is particularly true for common bean, which is found in only one of every seven samples examined from this region, in contrast to its being found in nearly half the samples from the northern prairies (see Figure 5). Relatively fewer boreal sites were also associated with maize; although in some locales, such as Whitefish Lake (see below) and Lake of the Woods (Boyd and Surette 2008), the majority of our samples tested positive for *Zea mays* starch and/or phytoliths (see Table 1). With these regional variations aside, it is not surprising that archaeological evidence of domesticated plants generally declines in a northward direction. This would be expected if these plant foods were acquired by trade or local horticulture; in the latter scenario, the short growing season and thin, acidic soil, among other characteristics of the subarctic Canadian Shield, would have imposed constraints on horticulture that increased in severity with latitude. Similarly, a drop-off in the availability of domesticated plants would occur with increased distance from the source of these foods. Significantly, however, we note that maize microfossils have been recovered from ceramic vessels as far north as Cross Lake and the Nelson River in Manitoba, and the Albany River in northern Ontario (see Figure 1). These sites are located near the limit of coniferous forests in North America, indicating that domesticated plant foods were a component of diet at the very northern edge of Woodland cultural influence.

In contrast, and unexpectedly, wild rice phytoliths were found in nearly equal proportions across the boreal forest and the northern prairies (see Figure 4). Once again, however, regional and/or temporal variation is likely masked by this trend. Specifically, nearly all (63 percent) our prairie samples with wild rice were obtained from Avonlea complex (A.D. 300–1100) sites, including Gull Lake, Sjøvold, Lebrt,

Avonlea, Broadview, and Miniota (Lints 2012) (see Figure 1). Based on radiocarbon dates from the Avonlea component at the Miniota site, wild rice was evidently consumed by this plains-adapted culture by at least A.D. 700 (Lints 2012). These results are surprising because wild rice is scarce to absent south of the Canadian Shield/boreal forest (Lahring 2003), implying either that *Zizania* had a larger distribution in the past or that this food was acquired through trade with contemporaneous boreal Woodland cultures such as Laurel (Lints 2012). In any case, despite no previous archaeological evidence of this practice, it seems that wild rice was occasionally consumed by some Plains Woodland societies living outside the modern range of this plant. In many regions of the southern boreal forest, of course, wild rice was deeply embedded in the spiritual and social institutions and subsistence behaviors of historical populations. In our study, less than one-quarter of the residue samples from this region yielded *Zizania* phytoliths; however, due to the underrepresentation of wild rice microfossils in food encrustations and the uneven availability of this food resource across the region, it would be incorrect to assume that this food was generally less important to the Woodland ancestors of postcontact subarctic peoples. Indeed, in some regions, such as Whitefish Lake, where wild rice is locally plentiful, *Zizania* plant remains are found in a majority of food samples (see Table 1).

Close-up: Whitefish Lake

Because Whitefish Lake has probably supported large populations of wild rice since at least 6100 cal B.P. (Boyd et al. 2013), it is not surprising that the remains of this plant are present in most of the food residue samples that we analyzed from this locale. However, our data clearly show that wild rice was only one of several plants consumed by local Woodland peoples. In particular, a close association can be seen between *Zizania* and maize; in most vessels, the remains of both plants were recovered, indicating that these foods were regularly cooked and consumed together. This pattern is not restricted to Whitefish Lake; it is also evident in residue samples from a broad region of the south-central boreal forest (Boyd and Surette 2010:Table 1), in addition to Avonlea complex sites on the prairies of southern Manitoba and Saskatchewan (Lints 2012). Maize, therefore, appears to have been systematically linked to wild rice in the subsistence behaviors of Woodland peoples across a considerable portion of central and western Canada. This pattern may have also extended eastward into the Lower Great Lakes; Hart and colleagues (2003), for example, report recovering maize and wild rice phytoliths (along with *Cucurbita* sp. and sedge remains) from multiple carbonized food residue samples in the Finger Lakes region of New York (see also Raviele 2010).

The low recovery of *Cucurbita* phytoliths and *Phaseolus vulgaris*-type starch granules from sites in the Whitefish Lake region mirrors the overall paucity of these plant remains across the central boreal forest. As discussed above, squash will be strongly underrepresented in microfossil assemblages due to its apparent lack of distinctive starch grains and production of phytoliths in only the inedible (rind) portion of the fruit. Domesticated beans, on the other hand, are starch rich, so the sporadic recovery of these starch granules in our food-residue samples cannot be explained by differential microfossil production alone. In other regions—such as the Canadian prairies, for example—*Phaseolus*-type starch is found in nearly half the samples analyzed (see

Figure 5). We argue, therefore, that common bean was a relatively unimportant dietary component in subarctic locales such as Whitefish Lake, where the remains of wild rice and maize dominate the plant microfossil component of food residue.

One explanation for this trend is that domesticated beans were nutritionally unnecessary in areas where wild rice was locally available (Hart *et al.* 2003) and where hunting provided the bulk of dietary protein. In the Three Sisters agricultural system, common bean is important as a nutritional complement to maize due to its higher protein content and contribution of the amino acids lysine and tryptophan, which are missing in maize (Hart *et al.* 2003). Wild rice is nutritionally similar to *Phaseolus*, although its complementarity with maize appears to weaken with cooking because of the reduction of its amino acid and protein content with added heat (Hart and Lovis 2013). A regular supply of animal-derived protein, of course, would also fill the dietary space occupied by common bean in agricultural societies. In the boreal forest, there is no indication that domesticated plants were anything more than a minor addition to a diet largely focused on hunting and gathering (Boyd and Surette 2010). For these reasons, there may have been no advantages to adopting a new source of protein—especially given the long history of use (Chapman and Shea 1981; Crawford 1982; Hart *et al.* 2003, 2007; Johnston 1984), local abundance, and ceremonial and social significance of wild rice in the region. In contrast, maize may have been more readily adopted by subarctic peoples due to the paucity of starch-rich wild foods in this region. In general, the idea that the availability of wild rice helped discourage the widespread adoption of *Phaseolus* is supported by the higher incidence of this food outside the boreal forest and natural range of wild rice (see Figure 5). However, one important exception to this trend seems to be found in the Avonlea complex (A.D. 300–1100), which, as summarized above, is associated with *both* *Phaseolus* and *Zizania* remains (along with maize) in cooking residues and accounts for nearly all our evidence of wild rice on the northern prairies. This may suggest that nutritional considerations alone do not fully account for the presence or the absence of specific cultivated plants in the archaeological record (Hart and Lovis 2013).

Environmental constraints may also explain the more selective use of domesticated plants in the boreal forest. Specifically, because common bean is more vulnerable to spring frost than maize (Mt. Pleasant 2006), it may have been more prone to failure in the short growing season of the subarctic. Significantly, in early nineteenth-century descriptions of crops grown by the Ojibway at one of the largest and most productive garden islands in the southern boreal forest (*Menauzbetaunaung*, Lake of the Woods), common bean is not mentioned, although corn, potatoes, and squash routinely are (Canada Provincial Secretary's Office 1858; Harmon 1820; James 1830). This suggests that the near exclusion of *Phaseolus* from boreal gardens—whether due to climate or choice—was a pattern that was established during the Woodland period and continued into historic times.

Conclusions

Domesticated plants and wild rice were widely consumed across the central boreal forest and the northern prairies during the Woodland tradition, although the economic importance of particular taxa appears to have varied geographically at the

local and regional levels. In particular, we discern (1) a general northward decline in the evidence of domesticated plants across the prairie/boreal border, suggesting comparatively lower importance of cultigens in the diet of boreal-adapted Woodland populations due to decreased availability of these foods (if acquired through trade) and/or decreased viability of horticulture at higher latitudes; (2) the widespread use of wild rice in combination with maize across the boreal forest and adjacent northern prairies, suggesting that these two foods were closely intertwined components of diet in many northern Woodland societies; and (3) a pronounced drop in the proportion of residue samples with evidence of *Phaseolus* in the boreal forest, which we attribute in part to its nutritional overlap with wild rice and/or its decreased viability in subarctic gardens. In general, these results highlight the spatial variability of domesticated plant use during the Woodland period, as well as the importance of applying new techniques—such as food residue analysis—to the study of old archaeological problems.

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Scott Hamilton specializes in historical and pre-contact archaeology of north-eastern Plains and eastern Subarctic, and also ethno-history of these regions. Recent work has focused upon community-based research with northern Ontario First Nations.

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