NORTHERNMOST PRECONTACT MAIZE IN NORTH AMERICA

Matthew Boyd and Clarence Surette

*Corn (*Zea mays *ssp.* mays*) was a key economic plant in the Americas, yet little information exists on the northern limit of maize consumption before European contact. Based on the analysis of carbonized food residue on pottery for plant microfossils (phytoliths and starch granules) from 58 precontact archaeological sites, we report the first evidence of maize consumption in the subarctic boreal forest. Recovery of maize microfossils from several widely distributed Laurel phase (Middle Woodland/Initial Shield Woodland) vessels indicates that the diffusion of corn into this region was surprisingly early (ca. A.D. 500) and may have initially spread through long-distance exchange networks linking temperate and boreal North America during the Woodland period. After A.D. 1000 maize was a widespread component of diet and was consumed by every major Late Woodland culture in the region. These results have profound implications both for the history of this cultigen and for small-scale human societies in northern North America.*

*El maíz (*Zea mays *ssp* mays*) fue la una de las plantas económicas más importantes de las Américas. Sin embargo, existe muy poca documentación sobre el limitado consumo de esta planta en el norte antes del primer contacto con Europa. En este artículo presentamos las primeras evidencias del consumo de este gramíneo en el bosque boreal subártico. Estos resultados están basados en el análisis de residuos de alimentos carbonizados en vasijas de barro durante la búsqueda de microfósiles de plantas (fitólitos y gránulos de fécula) en 58 sitios arqueológicos precolombinos. La recuperación de microfósiles de maíz de varias vasijas de la Fase de Laurel (Woodland Medianero/ Escudo Inicial de Woodland) y que están ampliamente distribuidas indican que la difusión del maíz en esta región ocurrió sorprendentemente antes del primer contacto (N.E. 500), y puede que haya sido a través de redes de intercambio a larga distancia uniendo así América tropical y boreal durante el periodo de Woodland. Después del año 1000 (N.E.) el maíz ya era un fuerte componente de la dieta y cada grupo cultural grande de los Woodland lo consumía. Por consiguiente, estos resultados tienen profundas implicaciones tanta para la historia de este cultivo como para sociedades pequeñas en el norte de Norteamérica.*

As the dietary staple of most sedentary societies in the New World, maize (*Zea mays* ssp. *mays*) has long been regarded as a key economic species in this region. Despite its importance, however, considerable uncertainty remains regarding both the timing and nature of its dispersal in the Americas. This is particularly true outside of the known centers of maize production; that is, in the hunter-gatherer "periphery," where maize may have been acquired through trade or nonintensive horticulture, and consumed at low levels. Although virtually invisible to the archaeologist, in these subtleties lie clues for understanding the transition to food production and patterns of exchange between hunter-gatherer and village societies (Boyd et al. 2006; Boyd et al. 2008).

We propose that maize consumption in these peripheral areas of North America was probably much more extensive than previously suspected. Recently, for example, a previously unknown pattern of maize consumption was reported from multiple sites on the Canadian prairies (Boyd et al. 2006; Boyd et al. 2008; Zarrillo and Kooyman 2006) and southern boreal forest (Boyd et al. 2008). In this paper we present an expanded dataset that covers a much larger geographic area (Boyd et al. 2006; Boyd et al. 2008). Specifically, our total analyzed sample consists of 128 food residue samples from 58 archaeological sites and 11 locales. These span the edge of the Canadian Prairies to the subarctic boreal/Shield region of central Canada for a total distance of about 500 km north-south and

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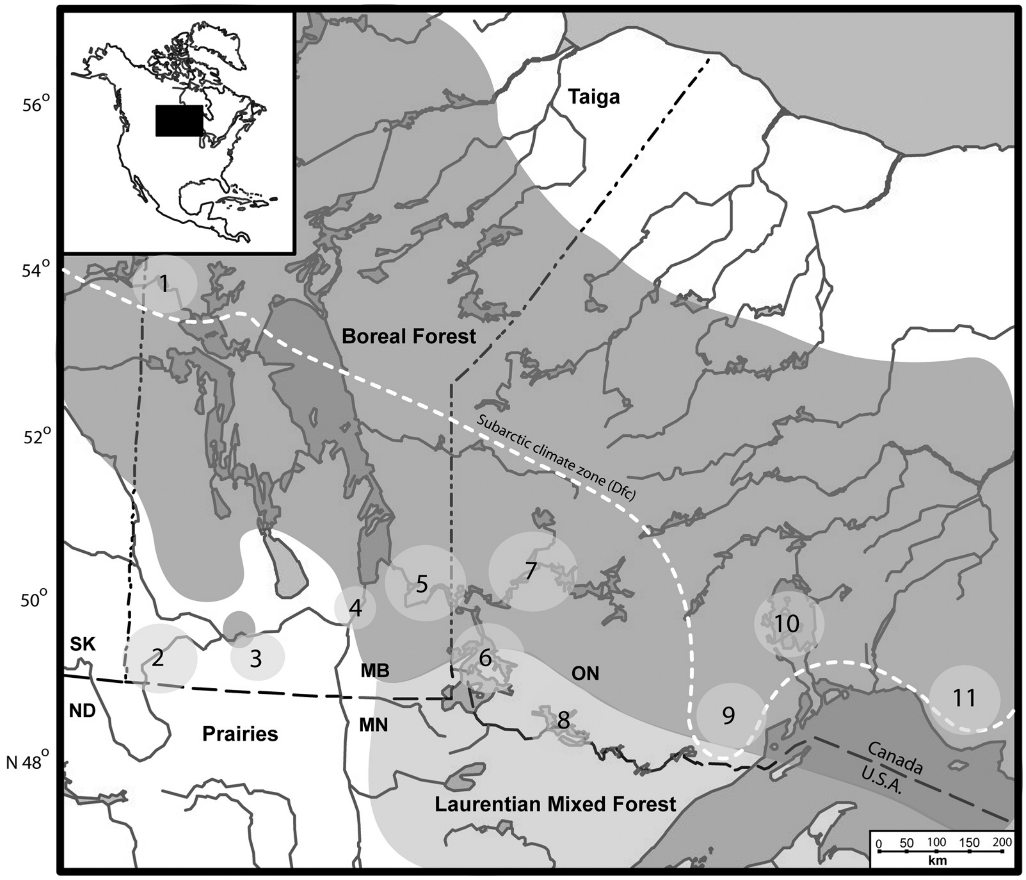


Figure 1. Map of the study area showing sample locales, vegetation, and southern limit of the subarctic climate zone.

1,200 km east-west (Figure 1). This large collection includes multiple samples from all known ceramic-producing cultures in the region, beginning with the Middle Woodland (Initial Shield Woodland) Laurel phase (ca. 300 B.C.–A.D. 1100). The bulk of these samples are derived from sites located in the boreal forest of Ontario and Manitoba, as far north as the subarctic climate zone and well above the modern limit of commercial maize production.

Without exception, prehistoric peoples living in boreal/subarctic North America have been characterized as broad-spectrum foragers who subsisted exclusively on wild resources (Mason 2001; Meyer and Hamilton 1994; Wright 1999, 2004). As a result, the subsistence strategies of boreal populations have been portrayed as relatively static, undifferentiated from previous Archaic times, and unaffected by the major transformation in diet that occurred in the midwest in the last millennium before contact. In some regions during the early historic period, however, maize and other domesticated foods were acquired periodically through long-distance trade (Henry 1901; Ray 1998) or local gardening (James 1830; La Vérendrye 1927). These few historic accounts, although complicated by the economic and social changes associated with the fur trade period, offer the possibility that maize was a component of diet in boreal North America prior to European contact. Proof of this practice, however, has not previously been reported from precontact sites in this vast region despite over 50 years of scientific excavation (Boyd et al. 2008).

Our ongoing research focuses on identifying the northern limit, and dynamics, of maize consumption in North America through the analysis of carbonized food residue for plant microfossils (starch granules and phytoliths) and other paleodietary proxies (Boyd et al. 2006; Boyd et al. 2008). Carbonized food residue is an important archive of information on diet because it provides an opportunity to study subtle, and sometimes short-term, subsistence choices. Preserved on the interior portion of some ceramic vessels, this inert carbonaceous material represents the remains (including lipids, proteins, and carbohydrates) of foods cooked when the pot was in use. These remains may potentially be analyzed for a variety of botanical and chemical indicators, directly dated, and linked to specific cultural groups based on stylistic characteristics of the associated ceramic sherd. Several recent studies have shown that phytoliths and starch granules may be successfully extracted from ancient food residue; diagnostic morphotypes for maize have also been established for both proxies (Pearsall, Chandler-Ezell, and Chandler-Ezell 2004; Pearsall, Chandler-Ezell, and Zeidler 2003, 2004; Staller and Thompson 2002). Application of this technique has enabled key insight into the history of early agriculture in the Americas and, more recently, on the use of maize by peripheral hunter-gatherer populations (Boyd et al. 2006; Boyd et al. 2008). Carbonized food residue can also be analyzed for C and N stable isotope content (Boyd et al. 2008; Hart et al. 2007; Morton and Schwarcz 2004) and trace elements (Boyd et al. 2008; Fie et al. 1990), although it appears that plant microfossil analyses provide the only unequivocal evidence of maize consumption (see discussions in Boyd et al. 2008 and Hart et al. 2007). This is the methodological approach that we take in this paper.

Archaeological and Historical Background

Middle Woodland (ca. 300 B.C.–A.D. 1100)

Ceramic production in the Canadian boreal forest begins with the Laurel phase (ca. 300 B.C.–A.D. 1100). This widespread Middle Woodland/Initial Shield Woodland culture is distributed from Quebec to Saskatchewan and, in addition to its distinctive conoidal pottery, is associated with the first appearance of burial mounds (and associated mortuary ceremonialism) and effigy mounds on the Canadian Shield (Budak and Reid 1995). Although unclear, the burial mound ceremonialism of the Laurel phase seems to have been derived indirectly from the distinctive mortuary complex of the Hopewell culture, perhaps via the Malmo culture of central Minnesota (Wilford 1955; Wright 1999). Indeed, occasional Hopewell mortuary artifacts have been recovered from Laurel mounds in northwestern Ontario (Kenyon 1986), although, as Wright (1999:773) points out, there is little evidence that Laurel participated in the Hopewell Interaction Sphere in any significant way. Furthermore, broad similarities in pottery form and decoration between Laurel and the Saugeen and Point Peninsula (Middle Woodland) complexes of the Lower Great Lakes suggest diffusion of some cultural elements across an east-west axis (Wright 1999:727). In any case, this aspect of the Laurel phase—its connection to the wider Middle Woodland "world"—is important in light of the evidence of maize consumption presented in this study.

After several decades of research into the Laurel phase, we have only a general understanding of subsistence practices. In part, this stems from poor bone preservation in sites on the Canadian Shield (Wright 2004:1490). However, archaeologists working in this region rarely process archaeological sediments for plant remains; here, as in many other parts of North America dominated by small-scale prehistoric societies, the plant component of paleodiet has tended to remain invisible. In those Laurel sites where food remains have been sufficiently well-preserved and studied, a broad-based foraging economy has been inferred. Although the specific foods included in diet varied according to season of site occupation and geographic region, many species of medium- to large-sized ungulates (e.g., moose, elk, caribou, deer), other mammals (e.g., beavers, hare, dog, muskrat), birds (e.g., common loon, mallard), reptiles (turtles), shellfish, and fish have been recovered from Laurel components. Site locations and, in some cases, abundant fish remains and bone harpoon heads, indicate that fishing was a central subsistence activity from the spring to fall (Dawson 1981; Mayer-Oakes 1970; Wright 1999). Fall fishing camps probably record the importance of dried fish during the winter, when large mammals were hard to find (James 1830:228–229). Furthermore, in the Laurel component at the Lockport site (MacNeish 1958), fish and shellfish were apparently exploited more intensively over time. In contrast, Laurel sites in the Saskatchewan and Manitoba parklands—the transitional zone between the grasslands and boreal forest—indicate a shift toward bison exploitation in these regions (Buchner 1979:113; MacNeish 1958).

Importantly, the westward and northward spread of Laurel phase sites has been linked to the dispersal of wild rice (Buchner 1979:124; Wright 1999). This idea is based largely on correlation—the distribution of Laurel/Woodland sites and modern wild rice overlap spatially at a variety of scales (Rajnovich 1984), and both may first appear around the same time (McAndrews 1969)—but the small number of dated Laurel components, persistent confusion concerning its geographic origin (Reid and Rajnovich 1991:228; Wright 1999:726), and the absence of palynological studies of northern wild rice in Canada, mean that this correlation is not firmly grounded. As well, Laurel is generally regarded as a direct descendant of the preceding Archaic tradition (Wright 1999:726), implying that the spread of Laurel material culture was not necessarily accompanied by the spread of a new *people* into the Canadian Shield. Likewise, virtually no Laurel components in Canada have been associated with wild rice macroremains or processing features (Dawson 1980; Reid and Rajnovich 1991). In addition, the dispersal of *Zizania* (wild rice) in northern Minnesota has been linked to late Holocene climate cooling (McAndrews 1969) rather than anthropogenic factors. Huber (2000) has also recently suggested that wild rice may have been widespread in northern Minnesota by the early Holocene. Despite these complications, the idea of a cause-and-effect linkage between the appearance of Laurel and wild rice has stuck in the literature (Wright 1999), and provides a convenient means of explaining the evidence of increased sedentism (e.g., multifamily dwellings, high frequency of pottery vessels) seen in some Laurel sites (Reid and Rajnovich 1985, 1991).

Late Woodland (ca. A.D. 1000–1600)

Following the Laurel phase, a series of new complexes emerged in the study area that are mostly distinguished from one another based on differences in ceramic surface treatment and form, namely: Blackduck (ca. A.D. 700–1200), Sandy Lake and Selkirk (A.D. 1000–1600), and a variety of other cultures subsumed by the Rainy River composite (ca. A.D. 1100–1350).

In general, the Late Woodland period in the boreal forest is associated with greater site densities compared to preceding Laurel times, suggesting that population numbers were larger at any given time (Reid and Rajnovich 1985, 1991). This apparent trend has been explained by intensification of the wild rice harvest—a practice that would have sustained larger regional populations as seen during the historic period. However, unequivocal evidence of prehistoric wild rice consumption is rare in the boreal forest. Other than a possible increase in the importance of wild rice, archaeologists have not identified any significant, widespread differences in subsistence between the Middle and Late Woodland periods in the boreal forest. As with Laurel, Late Woodland populations in the study area have been portrayed as broad-spectrum foragers who lived exclusively on wild food resources. A recent study by Boyd et al. (2008), however, identified evidence of maize (preserved in carbonized food residue) in several Late Woodland sites located near the boreal-prairie margin. Although surprising, both Sandy Lake and Blackduck sites, for example, have been identified on the prairies of Minnesota and Manitoba, a short distance from horticultural villages where maize could have been obtained through trade. In one of these prairie sites (Michlovic and Schneider 1993), the makers of Sandy Lake ceramics appear to have adopted a full-fledged Plains Village lifeway, including habitation in a large fortified village and a mixed horticulture-hunting economy. It is also clear that both Middle and Late Woodland societies in the study area participated in long-distance trade networks that extended across North America, based on the occasional recovery of exotic lithic materials, marine shell ornaments, and so on (Wright 2004). There were opportunities, therefore, for the movement of maize into boreal North America before European contact. In general, however, Sandy Lake and Blackduck habitation sites in the boreal forest are small and ephemeral, and no archaeological evidence of horticulture or domesticated plants has previously been reported in this region.

The Rainy River composite (ca. A.D. 1100–1350) consists of a group of temporally and regionally defined complexes that share common ceramic traits, as well as perhaps a shared hunter-gatherer economy, social structure, and ideology (Lenius and Olinyk 1990). Samples belonging to two of these complexes (Bird Lake and Winnipeg River) are included in our study. In general, Rainy River ceramics possess traits from both Blackduck and Laurel wares, leading to the suggestion (Lenius and Olinyk 1990:82–83) that it was formed from a "coalescence" of these two earlier cultures. Rainy River composite ceramics are distributed from the Mississippi headwaters in central Minnesota to Lake Superior and west of the Rainy River through the Parklands to central Manitoba (Lenius and Olinyk 1990). In this study, Bird Lake and Winnipeg River vessels are restricted to the region near the southern border of Manitoba and Ontario (these types have not been identified elsewhere in the study area). A recent food residue study (Boyd et al. 2008) failed to show any unequivocal evidence of maize in Rainy River composite sherds.

Selkirk composite (ca. A.D. 1000–1600) ceramics are widely distributed across the boreal forest in western 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 and excurvate rims. Smoothed fabric impressed exteriors are highly characteristic and diagnostic, and the nonceramic portion of Selkirk assemblages is very similar to Blackduck materials (Meyer and Hamilton 1994:119). Between ca. 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, these materials appear to show influences from cultural groups in the parklands and grasslands—mainly in the form of angular rims and shoulders, decorated shoulders, and occasional 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). In general, however, the makers of Selkirk wares are assumed to have been boreal-adapted foragers, and no evidence of domesticated plant use has previously been associated with this culture.

Accounts of Maize in the Boreal Forest during the Early Historic Period

Penetration of Europeans and their material goods into the study area began in the early 1600s in the Lake Superior basin, although it was not until the 1700s that fur trade posts were established across the region. The gradual westward movement by, first, the French and, later, the English allowed direct control over fur trade routes. This period of direct contact and trade had major consequences for Native societies and their traditional lifeways, and the scant historical documents that pertain to this time must be viewed in light of these changes.

Although evidence of maize and wild rice is scarce in the archaeological record, these plants played an important role in sustaining the historic fur trade across the Upper Great Lakes and westward. Both foods are portable, highly nutritious, and able to be stored for long periods of time when dried; for these reasons, it is unsurprising that they were considered ideal for long voyages through the fur trade country. In the Lake Superior region, for example, European traders were often provided with corn for their journey to the northwest, and established gardens of maize (and other indigenous and introduced cultigens) in the vicinity of fur trade posts (Harmon 1820:161; Henry 1901; Keating 1825:183; Mackenzie 1970).

Although less apparent, there is some historical evidence that maize was also obtained through trade, and grown locally in some cases, by Aboriginal populations living north of the Great Plains. In 1737, for example, La Vérendrye reports that a group of Assiniboin living near Ft. Maurepas (located at the mouth of the Winnipeg River, locale #5 on Figure 1) were planning to "go to the country of the Kouathéattes [Mandan] to buy Indian corn and beans" (Ray 1998:34). This lengthy (500 km) expedition to the villages on the Missouri River was undertaken annually, usually in the summer but occasionally in late fall to early winter, and took two to three months for the return trip (Ray 1998). In general, trade between the Assiniboin-Cree (hunter-gathers) and Mandan-Hidatsa (villagers) thrived from at least the 1730s until the early nineteenth century. At least in part, this relationship was based on the exchange of bison meat for maize, which provided a way of optimizing diet and expanding social and military alliances (Boyd 1998); as middlemen, the Assiniboin-Cree were also responsible for bringing European goods to the Middle Missouri villages during this period. The existence of food-exchange networks may also explain the recovery of a single carbonized maize kernel from the protohistoric/early historic Nyman site on the northeastern shore of Lake Superior (Dawson 1976).

In the 1850s, maize ("Indian corn") was seen

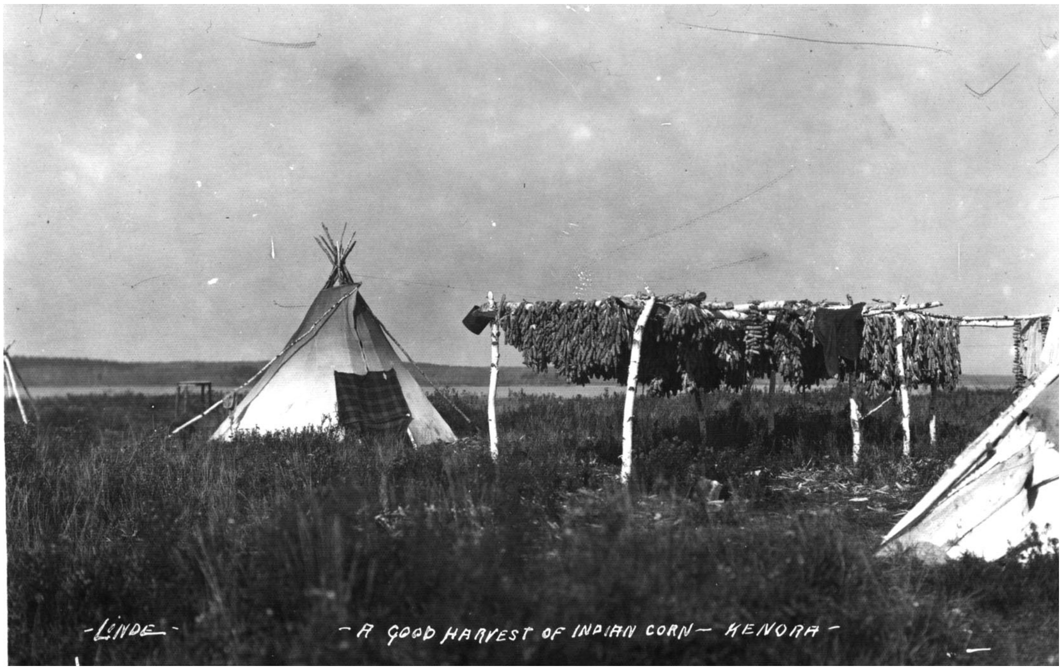


Figure 2. Photo of traditional maize drying racks in the boreal forest, northern Lake of the Woods, Ontario. Taken by Carl G. Linde in 1913. Reproduced with permission of the Lake of the Woods Museum.

growing on the lower Assiniboine and Red rivers (Figure 1, near locale #4) in addition to the mouth of the Winnipeg River (locale #5) and on islands in Lake of the Woods (locale #6; Canada Provincial Secretary's Office 1858:390; Moodie and Kaye 1969). In these areas, furthermore, native maize varieties (e.g., "Mandan corn") could be grown reliably in most years (Canada Provincial Secretary's Office 1858:390). Evidence that at least some of these gardens were established by Aboriginal groups is most clearly seen on Garden Island, located in southwestern Lake of the Woods. Here, La Vérendrye claims to have taught the local residents how to grow corn in 1734: "I have induced two families of Indians, by earnest solicitations, to sow maize. I trust that the benefits they will derive therefrom will induce others to follow their example" (La Vérendrye 1927). Almost 125 years later, five acres of Indian corn were seen to be growing on the eastern (cleared) portion of Garden Island, in addition to "several small patches of potatoes, pumpkins, and squashes" (Canada Provincial Secretary's Office 1858:242; Harmon 1820:333). As John Tanner recalled, in addition to maize cultivation in the early 1800s the Ojibwa residents of Garden Island (*Menauzhetaunaung*) also engaged in wild rice harvesting, hunting, and fishing (James 1830:217). According to Lovisek et al. (1997:138), economic diversity was a major aspect of the Ojibwa subsistence dynamic throughout the nineteenth century, and the extensive cultivation of corn and potatoes on garden islands was needed in order to offset rapid increases in regional populations during this time. Traditional, small-scale gardening of maize and other cultigens appears to have continued until at least the early twentieth century in the Lake of the Woods area (Figure 2), as seen elsewhere in Northwestern Ontario (e.g., Berkes and Davidson-Hunt 2006). In the Lake Superior basin, historic or ethnographic accounts record maize farming in several locales, including Garden River, near Sault Ste. Marie (James 1830:17); La Pointe, Wisconsin (American Board of Commissioners for Foreign Missions 1836:183; Warren 1984); and in sheltered locations near Fort William, Ontario (Thwaites 1907:338).

Clearly, corn figured prominently in the diet of at least some boreal-adapted populations during the fur trade period. It is not known, however, if this aspect of subsistence behavior emerged as a consequence of the fur trade, or whether it has deeper roots in the boreal forest. Indeed, the regional archaeological record—with its small habitation sites and lack of evidence of permanent settlement, food storage, gardening, or the cultigens themselves—lends little support to the latter perspective. We argue, however, that low levels of maize consumption or cultivation are almost invisible to conventional archaeological methods (Boyd et al. 2006; Boyd et al. 2008); in these situations, new analytic techniques are required in order to identify the more subtle use of plants in prehistoric sites.

Materials and Methods

Our total analyzed sample consists of 128 pottery sherds from 58 archaeological sites spanning the northern edge of the Canadian prairies to the boreal region of central Canada. In all cases, these materials were obtained from government- or university-held archaeological collections, representing material obtained through controlled excavations over the last 40 or more years.

Using a clean dental probe and knife under a dissecting microscope, approximately 5–40 mg of carbonized food residue was removed from the interior portion of each sherd. Special care was taken to ensure that no adhering soil particles (though rarely encountered) were included in the material analyzed. All sherds were washed in water following excavation and were considered clean upon inspection under a microscope. Residue samples were digested in heated 50 percent nitric acid for 12 to 24 hours, and the acid was subsequently removed by repeated dilution with water followed by centrifugation for 15 minutes at 3,000 rpm (Boyd et al. 2006; Hart et al. 2003; Staller and Thompson 2002). The remaining residue was mounted and examined using a compound light microscope (with differential interference contrast), petrographic microscope, and Scanning Electron Microscope (SEM). Comparative starch and phytolith samples from commercial corn (*Zea mays*), "Mandan" corn, squash (*Cucurbita*), wild rice (*Zizania palustris*), common bean (*Phaseolus vulgaris*), and other plants were digested using the same method (Boyd et al. 2006; Boyd et al. 2008). For purposes of this paper, however, only maize microfossil evidence will be discussed. We aimed for minimum phytolith and starch counts of 250 specimens each, although a few samples were virtually barren of microfossils. In total, our microfossil counts ranged from 5 to 8,551 specimens per sample (mean = 449, n = 128). Only starch granules identified to genus or species are presented, and discussed, in this paper. Although acid treatment may have caused some loss of starch during processing, our average starch count was high (105 grains per sample). Furthermore, starch preservation in processed samples was generally good (i.e., features required for identification such as the hilum or lamellae were usually present). For these reasons, it is unlikely that the treatment method significantly affected our results. Other possible sources of starch attrition include physical damage due to prehistoric flour milling, cooking method and temperature, and postdepositional processes (Haslam 2004).

Due to the economic importance of corn in the Americas, phytolith assemblages produced by this plant have received more attention than any other species, and several diagnostic forms have previously been described. In this study, we take a cautious approach and restrict the positive identification of maize from archaeological materials to those samples that contain "wavy-top" rondels with entire bases (Figure 3; Pearsall, Chandler-Ezell, and Chandler-Ezell 2004; Pearsall, Chandler-Ezell, and Ziedler 2003, 2004). This form has only been found in *Zea mays*, is produced under genetic control (Dorweiler and Doebley 1997; Piperno 2006) in the cob portion of the plant, and has been successfully used to identify maize in archaeological sites from South America to the Great Plains and Eastern Woodlands (Boyd et al. 2006; Boyd et al. 2008; Bozarth 1993; Hart et al. 2003; Iriarte et al. 2004; Pearsall, Chandler-Ezell, and Chandler-Ezell 2004; Pearsall, Chandler-Ezell, and Zeidler 2003, 2004; Piperno 2006; Staller and Thompson 2002). We also sought phytolith evidence of wild rice (Hart et al. 2003; Surette 2008), which we will discuss in a subsequent paper.

Maize also produces distinctive starch granules, which have been shown to preserve in carbonized food residue, other types of archaeological residue, and soil (e.g., Haslam 2004; Pearsall, Chandler-Ezell, and Zeidler 2004; Perry 2004). Starch from *Zea mays* tends to be larger (4–24 μm) than granules from wild grasses, has a polygonal shape (produced by grain packing), a linear X or Y fissure in the center of the granule, and displays a 90° extinction cross when viewed under cross-polarized light

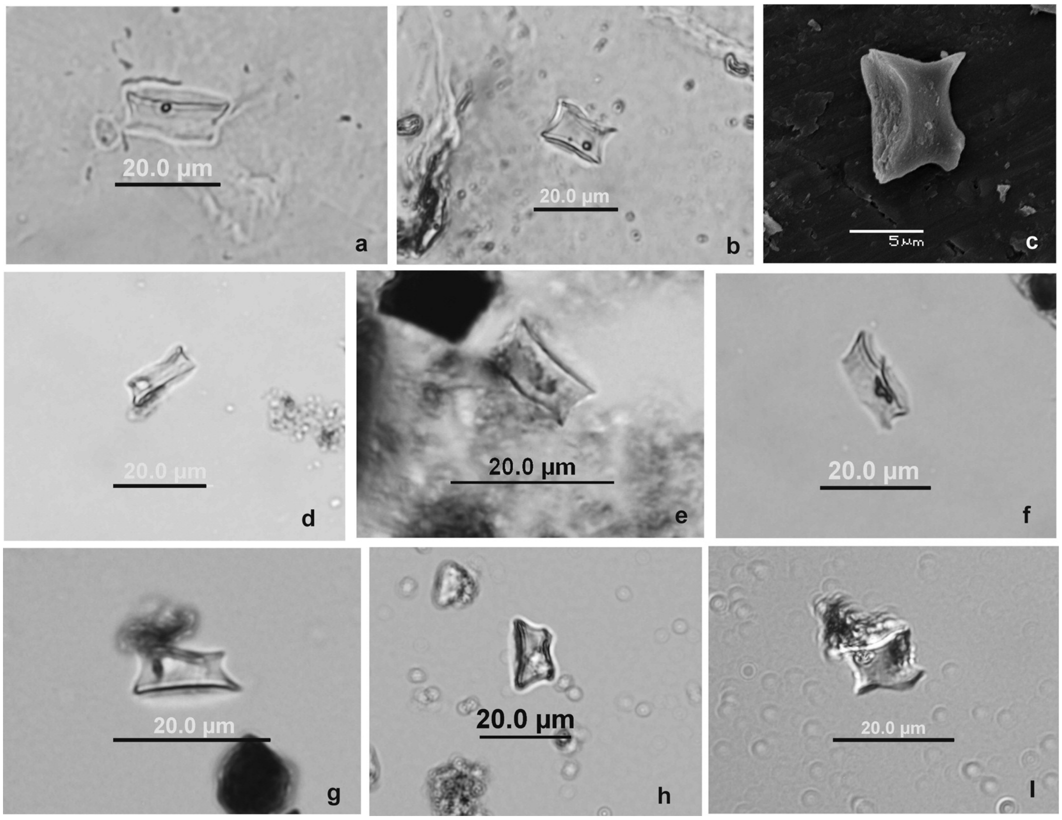


Figure 3. Microscopic images of wavy-top (*Zea mays*) rondel phytoliths from comparative and archaeological samples. (a and b) comparative samples (Mandan corn); (c) Lowton site (SEM); (d) Twin Fawns site; (e) Meek site (Laurel); (f) Vera site; (g) Arklow site (Selkirk); (h) Healing site; (i) Meek site (Selkirk).

(Figure 4; Babot and Apella 2003; Pearsall, Chandler-Ezell, and Zeidler 2004; Piperno and Holst 1998).

Results

Maize phytoliths and/or starch granules were recovered from a total of 77 sherds (60 percent of the total) from 45 archaeological sites scattered across the entire study area (Table 1; Figure 5). Thirteen samples contained only maize-type starch, and the remaining 64 samples yielded either *Zea mays* rondel phytoliths or both phytolith and starch evidence of maize. The bulk of samples that we analyzed date to the Late Woodland period (i.e., post A.D. 1000). However, maize microfossils were recovered from 10 Laurel (Middle Woodland) sherds and represent 10 separate archaeological sites distributed from the Saskatchewan border to Northern Ontario (Figure 5). One of these samples (The Pas Reserve), furthermore, was recovered from a Laurel component closely associated with two radiocarbon dates: 1590 ± 50 B.P. (A-1368), obtained on charcoal immediately beneath a Laurel vessel; and 1820 ± 150 B.P. (A-1424), obtained on charcoal from a hearth deposited in the same Middle Woodland occupation layer as A-1368 (Morlan 2000:179; Tamplin 1977:143). These dates overlap at the 2σ level, with means ranging from ca. A.D. 200 to 500 (Reimer et al. 2004). The remaining Late Woodland samples (with evidence of maize) are distributed as follows: 13 Blackduck; 8 Sandy Lake; 8 Selkirk/Clearwater Lake; 5 Rainy River composite; 24 unidentified Late Woodland; and 9 sherds with other cultural affiliations.

In general, those sites located south of the boreal forest margin in areas covered historically by prairie vegetation yielded stronger evidence of maize in the food residue. Every sample ($n = 23$) examined from the Oak Lake Sandhills and Tiger Hills locales

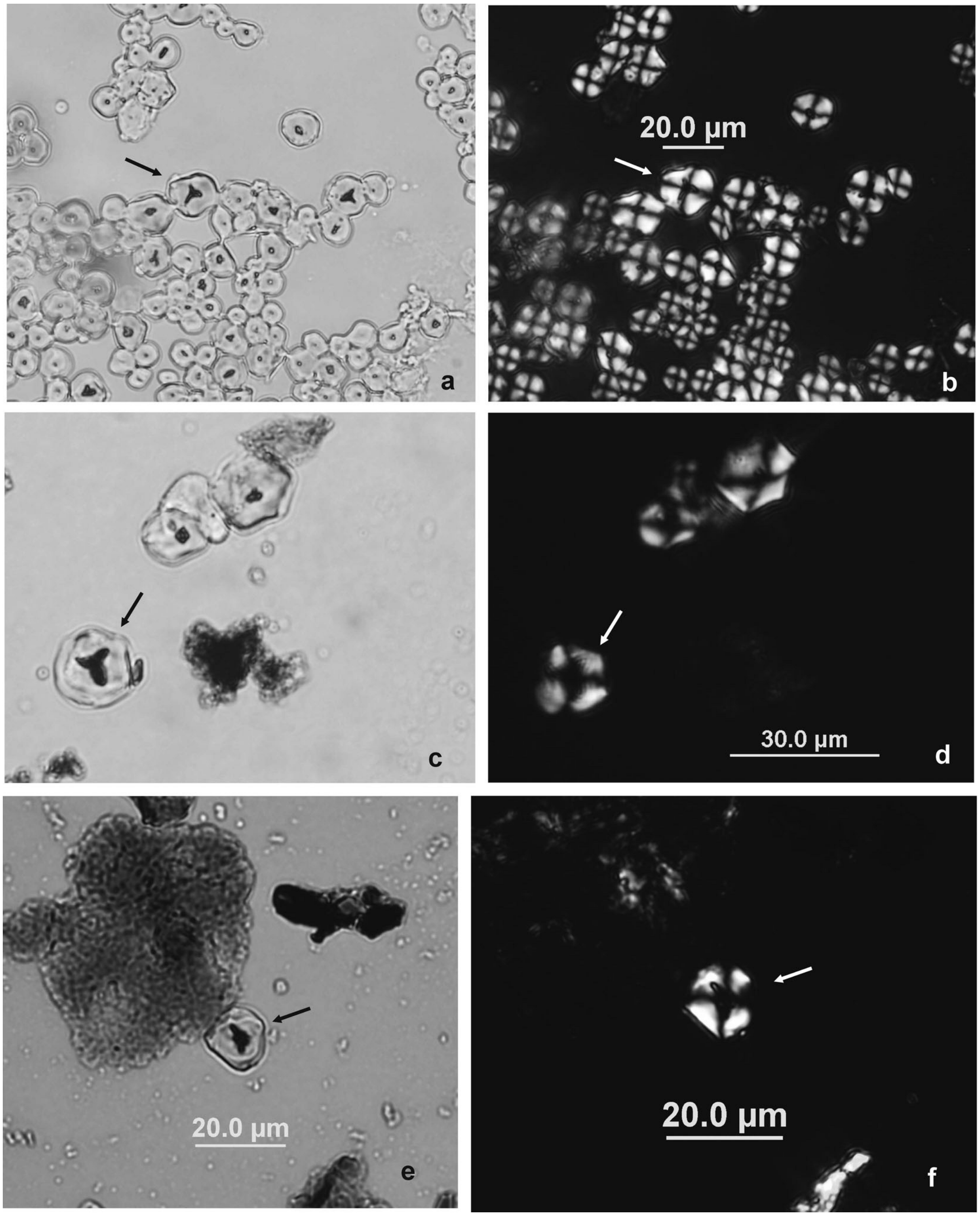


Figure 4. Maize type starch granules from comparative samples (a and b) and carbonized food residue, viewed under plane polarized (PPL) and cross polarized (XPL) light; (c) maize granule from Lowton site under PPL; (d) same specimen (Lowton site) under XPL; (e) Spruce Point site (PPL); (f) same specimen (Spruce Point site) under XPL. Arrows point to same granule in paired images.

(Figure 1), for example, tested positive and 78 percent of these samples provided multiproxy (starch and phytolith) evidence of maize, as reported elsewhere (Boyd et al. 2006; Boyd et al. 2008). In contrast, 55 percent of the 97 samples from sites located within the boreal forest yielded maize, and only 11 (11 percent) of these are associated with multiproxy evidence of this plant.

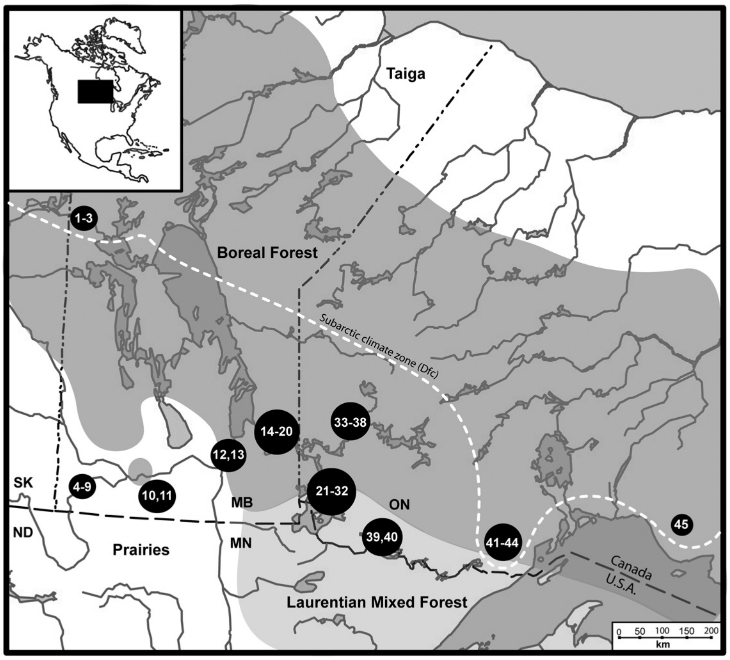
Table 1. Plant Microfossil Content of Carbonized Food Residue Samples.

Sample	Site code	Site name	Locale	Cultural affiliation	Maize?	Other taxa
1	FkMh-2	Hunter	1	Late Woodland	P	
2	FkMh-5	The Pas Reserve	1	Laurel		
3	FkMh-5	The Pas Reserve	1	Laurel	P	
4	FkMh-5	The Pas Reserve	1	Selkirk		
5	FkMh-5	The Pas Reserve	1	Laurel		
6	FlMh-1	Carrot River	1	Clearwater Lake	S	cf. *Phaseolus vulgaris*
7	FlMh-1	Carrot River	1	Clearwater Lake		
8	FlMh-1	Carrot River	1	Clearwater Lake		
9	FlMi-1	Big Eddy	1	Late Woodland		
10	FlMi-1	Big Eddy	1	Late Woodland		
11	DiMe-16	Duthie	2	Late Woodland	S/P	cf. *Phaseolus vulgaris*
12	DiMe-16	Duthie	2	NEPV	S/P	
13	DiMe-16	Duthie	2	NEPV	S/P	cf. *Phaseolus vulgaris*
14	DiMe-22	Schuddemat	2	Late Woodland	S	
15	DiMe-22	Schuddemat	2	Late Woodland	S/P	cf. *Phaseolus vulgaris*
16	DiMe-22	Schuddemat	2	Late Woodland	S/P	cf. *Phaseolus vulgaris*
17	DiMe-22	Schuddemat	2	Late Woodland	S/P	
18	DiMe-22	Schuddemat	2	Indet	S	
19	DiMe-23	Twin Fawns	2	Late Woodland	S/P	
20	DiMe-23	Twin Fawns	2	Late Woodland	S	
21	DiMe-23	Twin Fawns	2	Late Woodland	S/P	
22	DiMe-23	Twin Fawns	2	Late Woodland	S	
23	DiMe-24	Hollow B	2	Late Woodland	S/P	cf. *Phaseolus vulgaris*
24	DiMe-25	Vera	2	Indet	S/P	
25	DiMe-25	Vera	2	Late Woodland	S/P	
26	DiMe-25	Vera	2	Late Woodland	S/P	cf. *Phaseolus vulgaris*
27	DiMe-27	Atkinson	2	Late Woodland	S	cf. *Phaseolus vulgaris*
28	DiLv-3	Lowton	3	Vickers Focus	S/P	
29	DiLv-3	Lowton	3	Vickers Focus	S/P	cf. *Phaseolus vulgaris*
30	DiLv-3	Lowton	3	Late Woodland	S/P	
31	DiLv-3	Lowton	3	Late Woodland	S/P	cf. *Phaseolus vulgaris*
32	DjLx-1	Lovstrom	3	Late Woodland	S/P	
33	DjLx-1	Lovstrom	3	Late Woodland	S/P	cf. *Phaseolus vulgaris*
34	EaLf-1	Lockport	4	Late Woodland		
35	EaLf-1	Lockport	4	Bird Lake	S/P	
36	EaLf-1	Lockport	4	Winnipeg River	S/P	
37	EbLf-29	Healing Site	4	Woodland	P	cf. *Phaseolus vulgaris*
38	EbLf-29	Healing Site	4	Precontact	S/P	
39	EbLf-29	Healing Site	4	Precontact		
40	EbLf-29	Healing Site	4	Precontact		
41	EbLf-29	Healing Site	4	Blackduck		
42	EaLg-9	Wright	4	Blackduck		
43	EaLn-13	Mason Wedgewood	4	Winnipeg River		
44	EaKx-16	1915	5	Late Woodland	S	
45	EaLa-1	Whitemouth Falls	5	Late Woodland		
46	EaLa-1	Whitemouth Falls	5	Late Woodland	S	Wild rice (*Zizania* sp.)
47	EaLa-2	Porth	5	Sandy Lake		Wild rice (*Zizania* sp.)
48	EaLa-3	Bjorklund	5	Blackduck		
49	EaLa-3	Bjorklund	5	Blackduck	S/P	
50	EaLa-3	Bjorklund	5	Rainy River		
51	EbKw-30	Anderson II	5	Rainy River		Wild rice (*Zizania* sp.)
52	EbKw-30	Anderson II	5	Late Woodland		Wild rice (*Zizania* sp.)
53	EbKw-30	Anderson II	5	Late Woodland	S/P	Wild rice (*Zizania* sp.)
54	EbKw-30	Anderson II	5	Late Woodland	S	
55	EcKx-13	Portage du Bonnet	5	Blackduck		
56	EcKx-37	Rivermouth	5	Blackduck		
57	EfKv-27	C-23	5	Winnipeg River		
58	EfKv-36	LM-5	5	Rainy River		
59	EfKv-37	LM-6	5	Winnipeg River	P	Wild rice (*Zizania* sp.)
60	EfKv-37	LM-6	5	Rainy River	S	
61	EfKv-6	C-5B	5	Winnipeg River	S	
62	DgKl-3	Nestor Falls	6	Blackduck	S/P	Wild rice (*Zizania* sp.)
63	DiKp-3	Big George	6	Laurel	P	
64	DiKp-3	Big George	6	Late Woodland		
65	DiKp-5	Arklow	6	Selkirk	P	
66	DiKp-5	Arklow	6	Laurel	S/P	
67	DjKn-5	Bundoran	6	Selkirk		cf. *Phaseolus vulgaris*

Table 1. Plant Microfossil Content of Carbonized Food Residue Samples (continued).

Sample	Site code	Site name	Locale	Cultural affiliation	Maize?	Other taxa
68	DjKn-5	Bundoran	6	Late Woodland	P	
69	DjKn-5	Bundoran	6	Laurel		Wild rice (*Zizania* sp.)
70	DjKn-5	Bundoran	6	Blackduck	S/P	Wild rice (*Zizania* sp.)
71	DjKp-3	Meek Site	6	Sandy Lake	P	
72	DjKp-3	Meek Site	6	Selkirk	P	
73	DjKp-3	Meek Site	6	Laurel	P	
74	DjKp-3	Meek Site	6	Blackduck	P	Wild rice (*Zizania* sp.)
75	DjKq-1	Spruce Point	6	Sandy Lake	P	
76	DjKq-1	Spruce Point	6	Blackduck	S/P	cf. *Cucurbita*
77	DjKq-1	Spruce Point	6	Selkirk		
78	DjKq-4	Ash Rapids East	6	Blackduck	P	Wild rice (*Zizania* sp.)
79	DjKq-4	Ash Rapids East	6	Selkirk		Wild rice (*Zizania* sp.)
80	DjKq-4A	Ash Rapids East	6	Sandy Lake	P	Wild rice (*Zizania* sp.)
81	DjKq-4A	Ash Rapids East	6	Laurel	S/P	cf. *Phaseolus vulgaris*
82	DkKn-1	Rushing River Park	6	Sandy Lake	S/P	
83	DkKp-8	Ballinacree	6	Blackduck		
84	DkKp-8	Ballinacree	6	Selkirk	P	
85	DkKp-8	Ballinacree	6	Laurel	P	
86	DkKp-9	Ballinamore	6	Laurel		
87	DkKp-9	Ballinamore	6	Selkirk	P	Wild rice (*Zizania* sp.)
88	DkKr-2	Dowse	6	Sandy Lake	P	
89	DkKr-4	Mud Portage Channel	6	Laurel		
90	DlKp-1	Fisk Site	6	Laurel		Wild rice (*Zizania* sp.)
91	DlKp-1	Fisk Site	6	Blackduck	P	
92	EcKc-4	Two Point Sand Bar	7	Sandy Lake		
93	EcKf-6	N/A	7	Late Woodland		
94	EcKf-8	N/A	7	Selkirk		Wild rice (*Zizania* sp.)
95	EcKg-1	N/A	7	Selkirk/Rainy River	P	Wild rice (*Zizania* sp.)
96	EdKb-1	Wapesi River	7	Blackduck	P	
97	EdKg-17	Scoot	7	Sandy Lake	P	cf. *Phaseolus vulgaris*
98	EdKh-1	Wenasaga Rapids	7	Blackduck	P	
99	EdKh-1	Wenasaga Rapids	7	Late Woodland		
100	EdKh-1	Wenasaga Rapids	7	Blackduck	P	
101	EdKh-1	Wenasaga Rapids	7	Selkirk	S	
102	EdKh-1	Wenasaga Rapids	7	Laurel	S/P	
103	EdKo-6	Rowdy Lake	7	Blackduck	P	Wild rice (*Zizania* sp.)
104	EeKi-3	Snake Falls	7	Selkirk	P	
105	EeKi-4	Crescent Site	7	Sandy Lake	S/P	
106	DcKc-1A	Lady Rapids	8	Sandy Lake	P	
107	DcKc-1C	Lady Rapids	8	Laurel	P	
108	DdKm-1	Long Sault	8	Blackduck	P	
109	DbJl-2	Mound Island	9	Woodland	P	Wild rice (*Zizania* sp.)
110	DbJm-2	McCluskey	9	Blackduck		Wild rice (*Zizania* sp.)
111	DbJm-2	McCluskey	9	Blackduck		
112	DbJm-2	McCluskey	9	Blackduck	P	Wild rice (*Zizania* sp.)
113	DbJm-2	McCluskey	9	Blackduck		
114	DbJm-2	McCluskey	9	Blackduck		
115	DbJm-2	McCluskey	9	Blackduck		
116	DbJm-2	McCluskey	9	Blackduck		
117	DbJm-2	McCluskey	9	Blackduck		Wild rice (*Zizania* sp.)
118	DbJm-2	McCluskey	9	Blackduck		Wild rice (*Zizania* sp.)
119	DbJm-2	McCluskey	9	Blackduck		
120	DbJm-3	MacGillivray	9	Laurel	S/P	
121	DbJm-3	MacGillivray	9	Late Woodland		
122	DbJm-5	Martin Bird	9	Blackduck		Wild rice (*Zizania* sp.)
123	DbJm-5	Martin Bird	9	Late Woodland		
124	DbJm-5	Martin Bird	9	Laurel	S	Wild rice (*Zizania* sp.)
125	DbJm-5	Martin Bird	9	Blackduck		Wild rice (*Zizania* sp.)
126	DkJf-1	Nazoteka Point	10	Laurel		
127	DkJf-1	Nazoteka Point	10	Laurel		
128	DeIk-1	N/A	11	Late Woodland	P	

Note: Locale number as in Figure 1. Other plant identifications based on starch and/or phytolith morphology. Laurel (Middle Woodland) samples with maize microfossils are shaded in grey.
[a] S = presence of maize-type starch; P = presence of *Zea mays* rondel phytolith



Site (Borden #)	# sherds	Type
1. Hunter (FkMh-2)	1	LW
2. The Pas Reserve (FkMh-5)	1	L
3. Carrot River (FlMh-1)	1	S
4. Atkinson (DiMe-27)	1	LW
5. Duthie (DiMe-16)	3	NEPV,LW
6. Hollow B (DiMe-24)	1	LW
7. Schuddemat (DiMe-22)	5	LW
8. Twin Fawns (DiMe-23)	4	LW
9. Vera (DiMe-25)	3	LW
10. Lovstrom (DjLx-1)	2	LW
11. Lowton (DiLv-3)	4	VF,LW
12. Healing (EbLf-29)	2	W
13. Lockport (EaLf-1)	2	WR,BL
14. C5-B (EfKv-6)	1	WR
15. LM-6 (EfKv-37)	2	WR,RR
16. EcKg-1	1	S
17. 1915 (EaKx-16)	1	LW
18. Bjorklund (EaLa-3)	1	B
19. Whitemouth Falls (EaLa-1)	1	LW
20. Anderson II (EbKw-30)	2	LW
21. Fisk (DlKp-1)	1	B
22. Ballinamore (DkKp-9)	1	S
23. Ballinacree (DkKp-8)	2	L,S
24. Dowse (DkKr-2)	1	SL
25. Bundoran (DjKn-5)	2	B,LW
26. Ash Rapids East (DjKq-4)	3	L,B,SL
27. Spruce Point (DjKq-1)	2	B,SL
28. Meek (DjKp-3)	4	L,B,S,SL
29. Nestor Falls (DhKl-3)	1	B
30. Big George (DiKp-3)	1	L
31. Arklow (DiKp-5)	2	L,S
32. Rushing River Park (DkKn-1)	1	SL
33. Wapesi River (EdKb-1)	1	B
34. Scoot (EdKg-17)	1	SL
35. Rowdy (EdKo-6)	1	B
36. Snake Falls (EeKi-3)	1	S
37. Crescent (EeKi-4)	1	SL
38. Wenesaga Rapids (EdKh-1)	4	L,B,S
39. Lady Rapids (DcKc-1)	2	L,SL
40. Long Sault (DdKm-1)	1	B
41. McCluskey (DbJm-2)	1	B
42. Mound Island (DbJl-2)	1	W
43. MacGillivray (DbJm-3)	1	L
44. Martin Bird (DbJm-5)	1	L
45. Delk-1	1	LW

Figure 5. Archaeological sites, and numbers of sherds, producing maize (*Zea mays*) phytoliths and/or starch granules from carbonized food residue. B = Blackduck complex; BL = Bird Lake complex; L = Laurel phase; LW = Late Woodland period; NEPV = Northeastern Plains Village complex; RR = Rainy River composite; S = Selkirk phase; SL = Sandy Lake complex; VF = Vickers focus; W = Woodland tradition; WR = Winnipeg River phase.

Several sites in the Lake of the Woods area of Northwestern Ontario are significant due to the recovery of maize in most, if not all, excavated components. These sites, which include Meek (DjKp-3), Lady Rapids (DcKc-1), Ash Rapids East (DjKq-4), Ballinacree (DkKp-8), and Wenasaga Rapids (EdKh-1) indicate that maize was consumed repeatedly at some sites throughout the Middle to Late Woodland periods. Importantly, in the Lake of the Woods region, these large multicomponent sites may also be associated with increased sedentism—e.g., the presence of multifamily dwellings or a high frequency of pottery vessels (Reid and Rajnovich 1985, 1991).

Interpretations and Discussion

Our research indicates that corn was a component of prehistoric diet well north of the Great Plains and the geographical limit of modern corn agriculture. In effect, we have identified evidence of maize consumption in every major ceramic-producing culture in the central boreal forest, as far north as the subarctic climate zone and as little as 600 km south of the tree line. Although the majority of the archaeological materials in this study date to between ca. A.D. 1000 and 1400 (Late Woodland period), the recovery of maize phytoliths and/or starch granules from 10 Laurel phase vessels indicates that corn penetrated into this region even earlier. Based on radiocarbon assays from The Pas Reserve site (FkMh-5), we conclude that maize was consumed by some subarctic peoples by A.D. 500.

These astonishing results indicate that maize was a component of diet in the subarctic very shortly after its first widespread appearance in the U.S. Midwest and the Northeast. AMS radiocarbon dates from the Holding site (Illinois), for example, suggest that maize was established in the Mississippi Valley between 170 B.C. and A.D. 60 (Riley et al. 1994). By approximately A.D. 600, corn had entered the diets of people living in southern Ontario (Crawford et al. 2006; Katzenberg 2006), although it wasn't until A.D. 1000 that it became an important component of subsistence in this area (Katzenberg 2006). The possibility that maize was consumed earlier in the Northeast, however, is suggested by a date of 2270 ± 35 B.P. (median: 296 B.C.) on a maize phytolith assemblage from the Vinette site, New York State (Hart et al. 2007). How do we explain the almost simultaneous appearance of maize from the Lower Great Lakes to the subarctic?

As noted above, the Laurel phase is significant because it was connected to the wider Middle Woodland "world," with evidence of information exchange and down-the-line trade extending into the U.S. Midwest and Lower Great Lakes. This is most clearly seen in the elaborate mound ceremonialism of the Laurel phase in Northern Ontario, which appears to have been adopted indirectly from the Hopewell culture of the upper Mississippi River valley (Wright 1999), around the time when maize farming first appears in the latter region (Riley et al. 1994). Although little is known about the extent to which Laurel participated in the Hopewell Interaction Sphere, it is clear that both information and goods flowed between boreal and temperate North America during the Middle Woodland period. We suggest that the appearance of maize in Laurel sites reflects the existence of long-distance food exchange networks that accompanied the transfer of ritual knowledge and esoteric and other valuable goods across this region. Although we can't dismiss the possibility that corn was grown locally during the Initial Shield Woodland period, it seems unlikely at our northernmost sites; at least one of our Laurel components is located at a latitude where even the hardiest varieties of corn were considered unable to ripen in most years, according to one early observer (Harmon 1820:382). In contrast, hunter-gatherer/farmer subsistence exchange networks are well documented during the early historic period on the northeastern Plains (Boyd 1998) and elsewhere (e.g., Spielmann 1991). Indeed, as summarized above, boreal-adapted foragers in the Lake Winnipeg region trekked, often annually, over great distances to trade with farming populations in the Dakotas during the early fur trade period (Ray 1998). In all of these historic examples, maize was a key component of these economic transactions, which also included the exchange of other subsistence items (meat, other cultigens) and European trade goods (Boyd 1998). In part, the attraction of maize to mobile foragers may lie in its ability to reduce subsistence risk during the winter months (Spielmann 1991). When converted into flour, maize is a lightweight, easily stored, and carbohydrate-rich food source, and these properties may have made it ideal for mitigating shortfalls in other resources. However, there is no evidence in our data to suggest that maize was anything other than an occasional, and probably minor, supplement to Laurel diet. Furthermore, in the southern boreal forest wild rice (*Zizania* sp.), which seems to have been consumed alongside maize in several of the pots that we examined (Table 1) (Surette 2008), could have provided the same risk-reducing benefits while also being locally available. Like maize, wild rice is harvested in late summer/early fall, provides a relatively large caloric return, and may be stored for long periods of time once parched and dried. For these reasons, the caloric and nutritional value of maize may not, by itself, explain its initial occurrence in our study area. Instead, long-distance exchange of maize across the northern Woodland world may have had a symbolic or social, rather than a strictly dietary, function. In other regions of the Americas such as the Andes, in its early stages, maize may have been primarily a ritual plant with consumption being closely tied to gift giving, reciprocity, ritual feasts and ceremonies (Benz and Staller 2006; Smalley and Blake 2003). It is possible, therefore, that the early, and seemingly rapid, spread of maize into boreal North America was facilitated by its connection to the Middle Woodland ceremonial complex, and through the use of maize-exchange as a way of developing reciprocal social relations over large regions. If maize was not grown in the boreal forest during the Middle Woodland period, as we suspect, then it may have been more valuable than locally available and abundant foods like wild rice, and its greater inherent value may have made it a more effective means of expanding and cementing alliances through gift giving. Certainly, high-quality lithics, copper, ceremonial objects, and many other valuable/exotic materials were widely circulated during the Middle Woodland period, and we suggest that maize (and perhaps other cultivated and wild foods) traveled along these same paths.

The greater evidence of maize consumption during the Late Woodland period in the study area may indicate that corn was a more widespread, and perhaps somewhat more important, component of diet after A.D. 1000 (Boyd et al. 2006; Boyd et al. 2008). This trend, if true, makes sense given the apparent intensification and expansion of maize production in the Lower Great Lakes, Middle Missouri, and Oneota regions after A.D. 900. It was during this period that maize horticulture on the northern Plains reached its maximum geographic extent (Ahler et al. 1991), evidenced in part by the expansion of the Plains Village tradition into neighboring Minnesota (Anfinson 1997) and perhaps the Canadian prairies (Boyd et al. 2006; Forbis 1982; Nicholson 1990; Walde 1994). Indeed, maize was likely universally available by at least A.D. 900 across the Midwestern U.S. (Asch and Asch 1985; Conard et al. 1984). Parallel developments are seen in several other regions of the Eastern Woodlands, where stable isotope values on human bone trace the increased dietary importance of maize around this time (e.g., Ambrose 1987; Katzenberg et al. 1995; Schurr 1992). In general, however, weaker microfossil evidence of maize in the boreal sites (vs. those located on the northern Plains), as well as stable C and N isotope values on carbonized food residue (Boyd et al. 2008), indicate that maize was still only a minor supplement to a broad-based forager diet during the Late Woodland period.

Conclusions

Forty years after the pioneering Tehuacán Valley project (e.g., Byers 1967), archaeologists are still struggling to understand the history of corn in the Americas. However, with the development of new analytical techniques, domesticated plant foods are becoming a more visible component of small-scale subsistence economies. The surprising discovery of prehistoric maize in the subarctic, 4,000 km north of the Valley of Mexico, suggests a much wider, and perhaps earlier, use of this plant in North America than previously suspected.

We conclude that maize was consumed by as early as A.D. 500 in the subarctic boreal forest, during the Middle Woodland (Initial Shield Woodland) Laurel culture, at about the same time as its first widespread appearance in the Lower Great Lakes. We propose that maize spread rapidly into northern North America, along with the transfer of ritual knowledge and esoteric and other valuable goods across this region; the initial importance of maize, moreover, may have been largely social (rather than dietary) and linked to gift-giving as a means of expanding and maintaining social alliances over large territories. In this sense, long-distance exchange of cultivated foods may be analogous to the exchange of exotic lithic materials, copper, ceremonial objects and other socially valuable goods widely circulated within the Middle Woodland world.

Clearly, maize has a long history in the boreal forest, and its use during the fur trade era was part of a millennium-old pattern. In some locales such as Lake of the Woods (Northern Ontario), the extent of this continuity is truly striking: in several multicomponent sites, maize was recovered from most, if not all, Middle to Late Woodland occupations, indicating repeated and multigenerational use of this plant. Here, as in other areas of North America, the histories of maize and human society are closely entwined. Although much remains to be discovered about the nature of this relationship, it is clear that precontact subarctic economies were more complex and cosmopolitan than archaeologists have previously suspected.

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References Cited

Ahler, Stanley. A., Thomas D. Thiessen, and Michael K. Trimble
1991 *People of the Willows: The Prehistory and Early History of the Hidatsa Indians*. University of North Dakota Press, Grand Forks.

Ambrose, Stanley H.
1987 Chemical and Isotopic Techniques of Diet Reconstruction in Eastern North America. In *Emergent Horticultural Economies of the Eastern Woodlands*, edited by W. F. Keegan, pp. 87–108. Southern Illinois University at Carbondale, Carbondale.

American Board of Commissioners for Foreign Missions
1836 *Report of the American Board of Commissioners for Foreign Missions, Read at the Twenty-Seventh Annual Meeting, Held in the City of Hartford, September 14, 15 and 16, 1836*. Crocker and Brewster, Boston.

Anfinson, Scott F.
1997 *Southwestern Minnesota Archaeology: 12,000 Years*

in the Prairie Lake Region. Minnesota Historical Society Press, St. Paul.

Asch, David L., and Nancy B. Asch
1985 Prehistoric Plant Cultivation in West-Central Illinois. In *Prehistoric Food Production in North America*, edited by R.I. Ford, pp. 149–204. Museum of Anthropology Anthropological Papers 75. University of Michigan, Ann Arbor.

Babot, M. Del Pilar, and Maria C. Apella
2003 Maize and Bone: Residues of Grinding in Northwestern Argentina. *Archaeometry* 45:121–132.

Benz, Bruce F., and John E. Staller
2006 The Antiquity, Biogeography, and Culture History of Maize in the Americas. In *Histories of Maize,* edited by J. Staller, R. Tykot, and B. Benz, pp. 665–673. Elsevier, London.

Berkes, Fikret, and Iain J. Davidson-Hunt
2006 Biodiversity, Traditional Management Systems, and Cultural Landscapes: Examples from the Boreal Forest of Canada. *International Social Science Journal* 58:35–47.

Boyd, Matthew
1998 Interdependence and Power: Complexity in Hunter-Gatherer/Farmer Exchanges. *Plains Anthropologist* 43:311–319.

Boyd, Matthew, Clarence Surette, and Beverly A. Nicholson
2006 Archaeobotanical Evidence of Prehistoric Maize (*Zea mays*) Consumption at the Northern Edge of the Great Plains. *Journal of Archaeological Science* 33:1129–1140.

Boyd, Matthew, Tamara Varney, Clarence Surette, and Jennifer Surette
2008 Reassessing the Northern Limit of Maize Consumption in North America: Stable Isotope, Plant Microfossil, and Trace Element Content of Carbonized Food Residue. *Journal of Archaeological Science* 35:2545–2556.

Bozarth, Steven
1993 Maize (*Zea mays*) Cob Phytoliths from a Central Kansas Great Bend Aspect Archaeological Site. *Plains Anthropologist* 38:279–286.

Byers, Douglas S. (editor)
1967 *The Prehistory of the Tehuacan Valley, Volume 1: Environment and Subsistence*. University of Texas Press, Austin.

Buchner, Anthony P.
1979 The 1978 Caribou Lake Project, Including a Summary of the Prehistory of Southeastern Manitoba. Papers in Manitoba Archaeology Final Report No. 8. Historic Resources Branch, Dept. of Cultural Affairs and Historic Resources, Winnipeg.

Budak, Michael K., and C. S. Reid
1995 Grand Mound and the Serpent. Abstracts of the 22nd Annual Symposium, Ontario Archaeological Society, Thunder Bay.

Canada Provincial Secretary's Office
1858 *Report on the Exploration of the Country Between Lake Superior and the Red River Settlement*. John Lovell, Toronto.

Conard, Nicholas, David L. Asch, Nancy B. Asch, David Elmore, Harry Gove, Meyer Rubin, James A. Brown, Michael D. Wiant, Kenneth B. Farnsworth, and Thomas G. Cook
1984 Accelerator Radiocarbon Dating of Evidence for Prehistoric Horticulture in Illinois. *Nature* 308:443–446.

Crawford, Gary W., Della Saunders, and David G. Smith
2006 Pre-Contact Maize from Ontario, Canada: Context, Chronology, Variation, and Plant Association. In *Histories of Maize,* edited by J. Staller, R. Tykot, and D. Benz, pp. 549–563. Elsevier, London.

Dawson, Kenneth C. A.
1976 The Nyman Site: A Seventeenth Century Algonkian Camp on the North Shore of Lake Superior. *Canadian Archaeological Association Bulletin* 8:1–59.

Dawson, Kenneth C. A.
1980 The MacGillivray Site: A Laurel Tradition Site in Northwestern Ontario. *Ontario Archaeology* 34:45–68.

Dawson, Kenneth C. A.
1981 The Wabinosh River Site and the Laurel Tradition in Northwestern Ontario. *Ontario Archaeology* 36:3–46.

Dorweiler, Jane E., and John Doebley
1997 Developmental Analysis of *teosinte glume architecture1*: A Key Locus in the Evolution of Maize (Poaceae). *American Journal of Botany* 84:1313–1322.

Fie, Shannon M., John Fountain, Eleazer D. Hunt, Ezra Zubrow, Robert Jacobi, Kim Bartalotta, John Brennan, Kathleen Allen, and Peter Bush
1990 Encrustations in Iroquois Ceramic Vessels and Food Resource Areas. In *Organic Contents and Ancient Vessels: Materials Analysis and Archaeological Investigation*, edited by William R. Biers and P. E. McGovern, pp. 11–23. MASCA Research Papers in Science and Archaeology 7. University of Pennsylvania, Philadelphia.

Forbis, Richard G.
1982 *Cluny: An Ancient Fortified Village in Alberta*. University of Calgary, Department of Archaeology, Occasional Paper No. 4. University of Calgary, Calgary.

Harmon, Daniel W.
1820 *A Journal of Voyages and Travels in the Interiour of North America*. Flagg and Gould, Andover.

Hart, John P., Hetty J. Brumbach, and Robert Lusteck
2007 Extending the Phytolith Evidence for Early Maize (*Zea mays* ssp. *mays*) and Squash (*Cucurbita* sp.) in Central New York. *American Antiquity* 72:563–584.

Hart, John P., Ruben G. Thompson, and Hetty J. Brumbach
2003 Phytolith Evidence for Early Maize (*Zea mays*) in the Northern Finger Lakes Region of New York. *American Antiquity* 68:619–640.

Hart, John P., William A. Lovis, Janet K. Schulenberg, and Gerald R. Urquhart
2007 Paleodietary Implications from Stable Carbon Isotope Analysis of Experimental Cooking Residues. *Journal of Archaeological Science* 34:804–813.

Haslam, Michael
2004 The Decomposition of Starch Grains in Soils: Implications for Archaeological Residue Analyses. *Journal of Archaeological Science* 31:1715–1734.

Henry, Alexander
1901 *Travels and Adventures in Canada and the Indian Territories, Between the Years 1760 and 1776*. Edited by J. Bain. George M. Morang, Toronto.

Huber, James K.
2000 Archaeological Implications of Pollen Evidence for Wild Rice (*Zizania aquatica*) During the Paleoindian, Archaic and Woodland Periods in Northeast Minnesota. In *Wild Rice Research and Management, Proceedings of the Wild Rice Research and Management Conference*, edited by L. S. Williamson, L. A. Dlutkowski, and A. P. McCammon Soltis, pp. 40–53. Great Lakes Indian, Fish and Wildlife Commission, Carlton, Pennsylvania.

Iriarte, José, Irene Holst, Oscar Marozzi, Claudia Listopad, Eduardo Alonso, Andrés Rinderknecht, and Juan Montaña.
2004 Evidence for Cultivar Aadoption and Emerging Complexity during the Mid-Holocene in the La Plata Basin. *Nature* 432:614–617.

James, Edwin
1830 *A Narrative of the Captivity and Adventures of John*

Tanner (U.S. Interpreter at the Saut De Ste. Marie) During Thirty Years Residence Among the Indians in the Interior of North America. Baldwin and Cradock, London.

Katzenberg, M. Anne

2006 Prehistoric Maize in Southern Ontario: Contributions from Stable Isotope Studies. In *Histories of Maize,* edited by J. Staller, R. Tykot, and B. Benz, pp. 263–275. London, Elsevier.

Katzenberg, M. Anne, Henry P. Schwarcz, Martin Knyf, and F. Jerome Melbye

1995 Stable Isotope Evidence for Maize Horticulture and Paleodiet in Southern Ontario, Canada. *American Antiquity* 60:335–350.

Keating, William H.

1825 *Narrative of an Expedition to the Source of the St. Peter's River, Lake Winnepeek, Lake of the Woods, &c, Performed in the Year1823, by Order of the Hon. J.C. Calhoun, Secretary of War, Under the Command of Stephen H. Long, U.S.T.E.* George B. Whittaker, London.

Kenyon, Walter A.

1986 *Mounds of Sacred Earth: Burial Mounds of Ontario*. Royal Ontario Museum, Archaeology Monograph 9.

La Vérendrye , Pierre G. V.

1927 *Journals and letters of Pierre Gaultier de Varennes de La Vérendrye and His Sons, with Correspondence Between the Governors of Canada and the French Court, Touching the Search for the Western Sea*. The Champlain Society, Toronto.

Lenius, Brian J., and David M. Olinyk

1990 The Rainy River Composite: Revisions to Late Woodland taxonomy. In *The Woodland Tradition in the Western Great Lakes: Papers Presented to Elden Johnson*, edited by G. E. Gibbon, pp. 77–112. University of Minnesota Publications in Anthropology Number 4, Minneapolis.

Lovisek, Joan A., Tim E. Holzkamm, and Leo G. Waisberg

1997 Fatal Errors: Ruth Landes and the Creation of the "Atomistic Ojibwa". *Anthropologica* 39:133–145.

McAndrews, John H.

1969 Paleobotany of a Wild Rice Lake in Minnesota. *Canadian Journal of Botany* 47:1671–1679.

Mackenzie, Alexander

1970 *The Journals and Letters of Sir Alexander Mackenzie.* Edited by W. K. Lamb. Cambridge University Press, London.

MacNeish, Richard S.

1958 *An Introduction to the Archaeology of Southeast Manitoba*. National Museum of Canada, Bulletin 157.

Mason, Ronald J.

2001 Initial Shield Woodland. In *Encyclopedia of Prehistory*, Volume 2 (Arctic and Subarctic), edited by P. N. Peregrine and M. Ember, pp. 59–68. Springer, New York.

Mayer-Oakes, William J.

1970 *Archaeological Investigations in the Grand Rapids, Manitoba, Reservoir, 1961–1962*. Occasional Paper 3. Department of Anthropology, University of Manitoba, Winnipeg.

Meyer, David

1981 Late Prehistoric Assemblages from Nipawin: The Pehonan Complex. *Saskatchewan Archaeology* 2:4–38.

Meyer, David, and Scott Hamilton

1994 Neighbors to the North: Peoples of the Boreal Forest. In *Plains Indians A.D. 500 – 1500*, edited by K. H. Schlesier, pp. 96–127. University of Oklahoma Press.

Meyer, David, and Dale Russell

1987 The Selkirk Composite in Central Canada: A Reconsideration. *Arctic Anthropology* 24:1–31.

Michlovic, Michael G., and Fred Schneider

1993 The Shea Site: A Prehistoric Fortified Village on the Northeastern Plains. *Plains Anthropologist* 38:117–137.

Moodie, D. W., and Barry Kaye

1969 The Northern Limit of Indian Agriculture in North America. *The Geographical Review* 59:513–529.

Morlan, Richard E.

2000 *Manitoba Radiocarbon Dates: Archaeological Radiocarbon Dates (Section II)*. Geological Survey of Manitoba Open File Report OF2000-1. Manitoba Industry, Trade and Mines, Winnipeg.

Morton, June D., and Henry P. Schwarcz

2004 Paleodietary Implications from Stable Isotope Analysis of Residues on Prehistoric Ontario Ceramics. *Journal of Archaeological Science* 31:503–517.

Nicholson, Beverly A.

1990 Ceramic Affiliations and the Case for Incipient Horticulture in Southwestern Manitoba. *Canadian Journal of Archaeology* 14:33–59.

Pearsall, Deborah M., Karol Chandler-Ezell, and Alex Chandler-Ezell

2004 Maize Can Still be Identified Using Phytoliths: Response to Rovner. *Journal of Archaeological Science* 31:1029–1038.

Pearsall, Deborah M., Karol Chandler-Ezell, and James A. Zeidler

2003 Identifying Maize in Neotropical Sediments Using Cob Phytoliths. *Journal of Archaeological Science* 30:611–627.

2004 Maize in Ancient Ecuador: Results of Residue Analysis of Stone Tools from the Real Alto Site. *Journal of Archaeological Science* 31:423–442.

Perry, Linda

2004 Starch Analyses Reveal the Relationship between Tool Type and Function: An Example from the Orinoco Valley of Venezuela. *Journal of Archaeological Science* 31:1069–1081.

Piperno, Delores R.

2006 *Phytoliths: A Comprehensive Guide for Archaeologists and Paleoecologists*. AltaMira Press, Oxford.

Piperno, Delores R., and Irene Holst

1998 The Presence of Starch Grains on Prehistoric Stone Tools from the Humid Neotropics: Indications of Early Tuber Use and Agriculture in Panama. *Journal of Archaeological Science* 25:765–776.

Piperno, Delores R., and Deborah M. Pearsall

1993 Phytoliths in the Reproductive Structures of Maize and Teosinte: Implications for the Study of Maize Evolution. *Journal of Archaeological Science* 20:337–362.

Rajnovich, Grace

1984 A Study of Possible Prehistoric Wild Rice Gathering on Lake of the Woods, Ontario. *North American Archaeologist* 5:197–215.

Ray, Arthur J.

1998 *Indians in the Fur Trade: Their Roles as Trappers, Hunters in the Lands Southwest of Hudson Bay, 1660 – 1870*. University of Toronto Press, Toronto.

Reid, C. S., and Grace Rajnovich.

1985 Laurel Architecture: Five Case Studies. *Minnesota Archaeologist* 44:5–30.

1991 Laurel: A Re-evaluation of the Spatial, Social and Temporal Paradigms. *Canadian Journal of Archaeology* 15:193–234.

Reimer, Paula J., Mike G. L. Baillie, Edouard Bard, Alex Bayliss, J. Warren Beck, Chandra J. H. Bertrand, Paul G. Blackwell, Caitlin E. Buck, George S. Burr, Kirsten B. Cutler, Paul E. Damon, R. Lawrence Edwards, Richard G. Fairbanks, Michael Friedrich, Thomas P. Guilderson, Alan G.

Hogg, Konrad A. Hughen, Bernd Kromer, Gerry McCormac, S. Manning, Christopher Bronk Ramsey, Ron W. Reimer, Sabine Remmele, John R. Southon, Minze Stuiver, Sahra Talamo, F. W. Taylor, Johannes van der Plicht, and Constanze E. Weyhenmeyer

2004 IntCal04 Terrestrial Radiocarbon Age Calibration, 0–26 cal kyr B.P. *Radiocarbon* 46:1029–1058.

Riley, Thomas J., Gregory R. Walz, Charles J. Bareis, Andrew C. Fortier, and Kathryn E. Parker

1994 Accelerator Mass Spectrometry (AMS) Dates Confirm Early *Zea mays* in the Mississippi River Valley. *American Antiquity* 59:490–498.

Schurr, Mark R.

1992 Isotopic and Mortuary Variability in a Middle Mississippian Population. *American Antiquity* 57:300–320.

Smalley, John, and Michael Blake

2003 Sweet Beginnings: Stalk Sugar and the Domestication of Maize. *Current Anthropology* 44:675–703.

Spielmann, Katherine

1991 *Interdependence in the Prehistoric Southwest*. Garland, New York.

Staller, John E., and Robert G. Thompson

2002 A Multidisciplinary Approach to Understanding the Initial Introduction of Maize into Coastal Ecuador. *Journal of Archaeological Science* 29:33–50.

Surette, Clarence

2008 The Potential of Microfossil Use in Paleodiet and Paleoenvironmental Analysis in Northwestern Ontario. Unpublished Masters thesis, Department of Geology, Lakehead University, Thunder Bay.

Syms, E. Leigh

1977 Cultural Ecology and Ecological Dynamics of the Ceramic Period in Southwestern Manitoba. *Plains Anthropology 22 (Memoir Series No. 12).*

1979 The Devils Lake-Sourisford Burial Complex on the Northeastern Plains. *Plains Anthropologist* 24:283–308.

Tamplin, Morgan J.

1977 Prehistoric Occupation and Resource Exploitation on the Saskatchewan River at The Pas, Manitoba. Unpublished Doctoral dissertation, The University of Arizona, Tucson.

Thwaites, Reuben G. (editor)

1907 Franchère's Voyage to Northwest Coast, 1811–1814. In *Early Western Travels 1748–1846*. Volume 6. A.H. Clark, Cleveland.

Walde, Dale A.

1994 The Mortlach Phase. Unpublished Doctoral dissertation, Department of Archaeology, University of Calgary, Calgary.

Warren, William W.

1984 *History of the Ojibwa People*. Minnesota Historical Society Press, St. Paul.

Wilford, Lloyd A.

1955 A Revised Classification of the Prehistoric Cultures of Minnesota. *American Antiquity* 21:130–142.

Wright, James V.

1999 A History of the Native People of Canada, Volume 2 (1000 BC – AD 500). Mercury Series Paper No. 152. Canadian Museum of Civilization, Ottawa.

Wright, James V.

2004 A History of the Native People of Canada, Volume 3 Part 1 (AD 500 – European Contact). Mercury Series Paper No. 152. Canadian Museum of Civilization, Ottawa

Zarrillo, Sonia, and Brian P. Kooyman

2006 Evidence for Berry and Maize Processing on the Canadian Plains from Starch Grain Analysis. *American Antiquity* 71:473–499.

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