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Archaeobotanical evidence of prehistoric maize (*Zea mays*) consumption at the northern edge of the Great Plains

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Abstract

Analysis of starch granules, phytoliths, and plant macrofossils from archaeological features and carbonized food residue provides important new insight into the extent of prehistoric maize (*Zea mays*) consumption on the North American Great Plains. These data suggest that consumption of maize, and probably other cultigens, was widespread on the eastern Canadian Prairies between approximately AD 1000 and 1600. Domesticated plants may have been grown locally, acquired through trade, or transported into the region following dispersal of family groups from horticultural villages located elsewhere. However, the lack of strong artifactual evidence of gardening, and the small-scale nature of sites on the eastern Canadian Prairies indicate that local horticulture, if practiced, was non-intensive.

Keywords: Archaeobotany; Phytoliths; Starch granules; Plant macrofossils; Maize (*Zea mays*); Bean (*Phaseolus*); Northern Great Plains

1. Introduction

In the last millennium before European contact, large, semi-sedentary village societies flourished in some regions of the North American Great Plains. Economically, these societies depended to a considerable extent on the cultivation of maize (*Zea mays*), beans (*Phaseolus*), squash (*Cucurbita*), and other domesticated plants. On the Northern Plains, the shift to large-scale horticultural production is well documented by village sites along the Missouri River in the Dakotas [1,27], and in neighbouring Minnesota [2]. North of these regions, in southern Manitoba, many sites dating to the same time period show strong cultural connections to these larger settlements. However, the sites on the Canadian Prairies lack many of the characteristics of horticultural villages, and artifactual evidence of gardening (e.g., scapula hoes, storage pits) is rare. Because systematic archaeobotanical research has not been undertaken across this region, the role of domesticated plants in the diet of prehistoric societies is largely unknown. This information, however, is crucial for understanding the larger, dynamic, system of social and economic relations across the Northern Plains, and in small-scale horticultural societies more generally.

In this study, prehistoric consumption of domesticated plants on the eastern Canadian Prairies is identified through the analysis of phytoliths, starch granules, and plant macrofossils from archaeological features and carbonized food residue recovered from multiple sites dating to the period between AD 1000 and 1600. This multiproxy approach is designed to maximize the total amount of information available on the plant component of paleodiet, while enabling some independent confirmation of results. In other parts of the New World, maize phytoliths and starch granules have been successfully extracted from carbonized food residue and soils, and have provided important insight into the history of early agricultural economies [23,37,38,40,43,53]. From previous studies, it is apparent that these microscopic remains preserved under a variety of depositional conditions are often abundant and, for

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some plants at least, possess distinctive morphologies which can be identified to the source plant. Plant macrofossils, although they are less likely to preserve in comparison to phytoliths and starch granules, have the advantage of being more readily identifiable to the genus- or species-level for a wider range of plants, as well as being less prone to long distance transport prior to deposition in the sedimentary record [4]. In combination, these proxies yield important insight into the subtleties of plant use at the site level, as well as regional economic patterns and processes. On the fringe of the Northern Plains, furthermore, where sites tend to be small and artifactual evidence of local horticulture is sparse, this approach provides a means of tracking the consumption of domesticated plants with surprising sensitivity.

2. Study areas

Plains Woodland sites are generally abundant in southern Manitoba, and appear especially well-represented in certain discrete locales. Two of these locales – the Tiger Hills and Oak Lake Sandhills (Fig. 1) – are particularly important because they have been subject to intensive archaeological research over the last decade; this work has revealed several sites with clear cultural affinities to farming populations in the Dakotas and Minnesota [32,33].

Despite similarities in the archaeological record, however, the physiography of these regions is different. The surficial geology of the Tiger Hills (TH) is composed of Cretaceous shale which is covered by thick, kettled to hummocky, calcareous glacial till and glaciofluvial deposits [51]. The strongly undulating and rolling to hummocky topography that characterizes the area is associated with a large number of small lakes, ponds and sloughs occupying shallow depressions. Vegetation in the Tiger Hills today is dominated by a cover of trembling aspen (*Populus tremuloides*) with secondary quantities of balsam poplar (*Populus balsamifera*) and bur oak (*Quercus macrocarpa*), and an understory of mixed herbs and tall shrubs. Warmer and drier south and west facing slopes typically have grassland vegetation, while the cooler and more humid valley bottoms, and north and east facing slopes have woodland vegetation. Soil surveys indicate that the mix of woodland and prairie seen today has likely persisted for centuries in this region [51]. Water-filled depressions and poorly drained sites are usually covered with sedges (Cyperaceae) and willow (*Salix* spp.) [51].

The modern landscape of the Oak Lake Sandhills (OLS), in contrast, is dominated by a series of discrete eolian dune fields which migrated into the glacial Lake Hind basin during the mid- to late Holocene [9,48]. The dominant eolian landforms in the OLS are large parabolic dunes (up to 10 m high) with arms that are oriented WNW–ENE. Other eolian landforms include low conical, irregular, or sinuous mound dunes (1–3 m high, 4–10 m in diameter with no slipfaces), and eolian sand sheets (1–3 m in thickness). Interdunal swales are commonly occupied by shallow wetlands. Much of the eolian landscape of the OLS was emplaced well before the Plains Woodland period [7,48], and archaeological sites tend to be located in interdunal contexts adjacent to small lakes [22].

The contemporary OLS is associated with relatively high habitat diversity compared to the surrounding drift prairie [7]. This diversity is due, at least in part, to the combination of high rugosity and an extensive groundwater system; thus, the region supports at any given time the close association and multiplication of wetland, mesic and xeric plant assemblages [7]. Oak savanna, mixed grass prairie, and aspen woodland/forest are the dominant vegetation types in the area today. High resolution paleovegetation data are not available for southern Manitoba for the period between AD 1000 and 1600, but recent paleoecological data from the OLS [7–9] broadly suggest that these habitats were established in the region by at least the late Holocene.

Both locales are within the subhumid climate zone, characterized by short, warm, summers and cold winters [51]. Yearly precipitation ranges from 340 mm (OLS) to 540 mm (TH) [19], and the average growing season is about 2800 degree days [62].

3. Materials and methods

If maize and other domesticated plants were consumed on the eastern Canadian Prairies, then evidence of this practice will most likely be found in sites demonstrating cultural affinities to farming populations in the Dakotas and Minnesota. In this study, sherds containing carbonized food residue, and soil samples from features, were analyzed from six key archaeological sites (Lovstrom, Lowton, Duthie, Vera, Schuddemat, and Hollow B) in the TH and OLS that met this criterion. Sites in this first group contain components attributed to the Vickers focus, Mortlach phase, and Northeastern Plains Village complex. One other site (Twin Fawns) was chosen randomly and analyzed using identical methods. This other site contains ceramics with general ‘Late Woodland’ attributes, no artifactual evidence of gardening and, in short, no clear archaeological connections to the Plains Village tradition.

The Vickers focus (AD 1350–1650) is isolated to southwestern Manitoba, and is characterized by a diverse ceramic assemblage, abundance of Knife River Flint (sourced to west-central North Dakota) debitage and finished tools, and generally small sites.[1] Predominance of bison bone in these sites attests to the economic importance of this species at the time of occupation. Artifactual evidence of local gardening is rare to absent, although recoveries from Vickers focus sites in the TH include some grinding stones and a possible bison scapula hoe [32]. One of us [32,33,35] has argued for the practice of small-scale horticulture as support for a foraging subsistence strategy in the TH. In contrast, Vickers sites in the OLS – where no gardening implements have been found – are interpreted as short-term, seasonal, occupations by hunter-gatherers [22]. Vickers focus ceramics are similar to vessels

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[1] The Lovstrom site, located in south-central Manitoba (TH region), is a notable exception [32]. The known area of this site is over 400 × 200 m, although the Vickers component does not extend across this entire area.

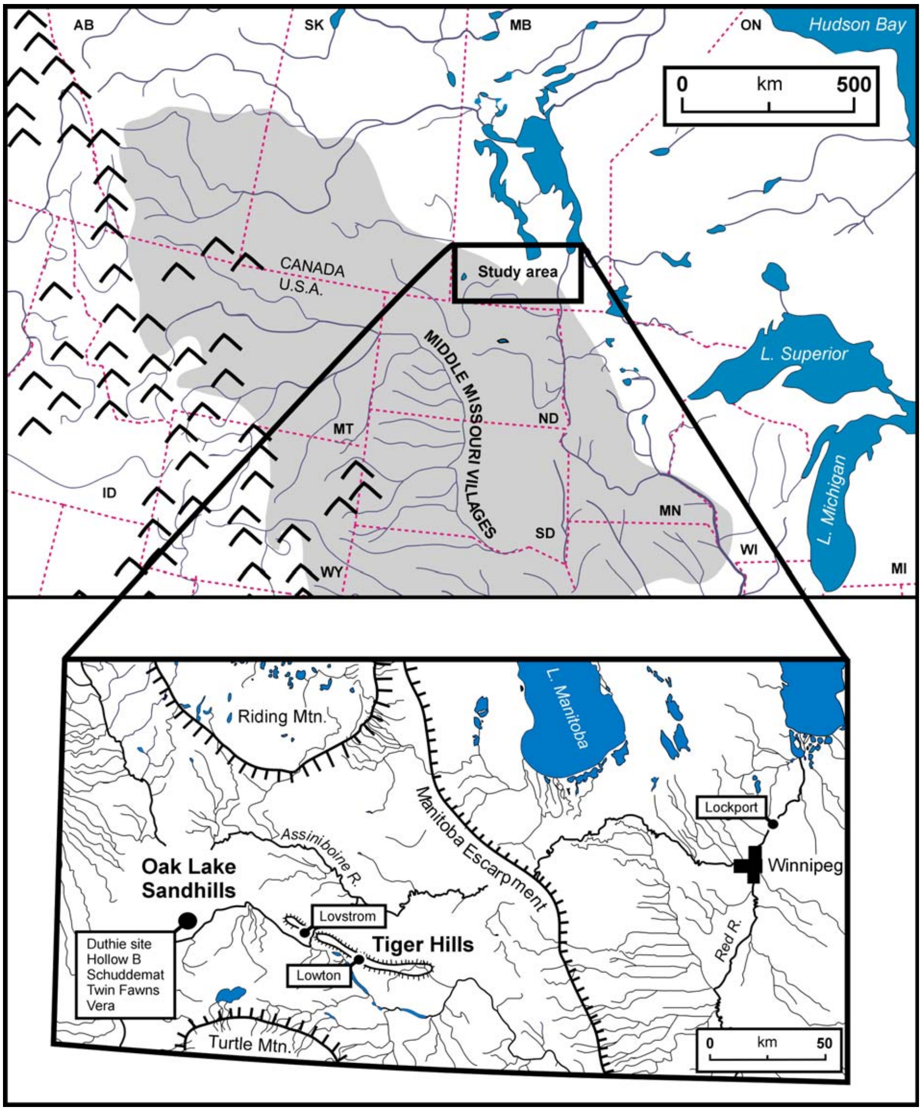

Fig. 1. Location of Oak Lake Sandhills (OLS) and Tiger Hills (TH) locales, study sites, and Middle Missouri region within the Great Plains (shaded in gray). Base maps courtesy of Scott Hamilton.

from Scattered Village complex sites in the Knife River area (North Dakota), and Coalescent tradition wares identified elsewhere as Campbell Creek Pinched, Campbell Creek Indented, and Talking Crow [32]. Although it is possible that some of this ceramic diversity may represent multiple occupations of the same site, individual rim sherds from Vickers focus sites also display a mixture of both Woodland and Plains Village ceramic traits (e.g., cordwrapped-object impressions, incipient ‘‘S’’ profiles, vertical trailed lines) [32]. In this study, the Vickers focus is represented by the Lovstrom, Lowton, and Vera sites.

The contemporaneous Mortlach phase (AD 1400–historic) is widely distributed across the Northern Plains north of the Missouri River, and is represented in this study by the Schuddemat, Hollow B, and Vera sites. Small sites, and abundant bison remains in the faunal assemblage have led to the assumption that Mortlach assemblages were produced by highly mobile, and specialized, hunter-gatherers [61]. However, Mortlach ceramics are highly reminiscent of wares derived from horticultural villages in the Middle Missouri region, and this ceramic evidence is complemented by the recovery of typical Plains Village artifacts such as pitted handstones, grinding slabs, scapula knives, and ice gliders [34,60]. Although speculative, Mortlach sites may have been produced by Plains Village ‘splinter groups’ that abandoned village life in favour of full-time bison hunting [18].

The Northeastern Plains Village (NEPV) complex [57], represented in this study by the Duthie site, is also associated with a diverse ceramic assemblage. The Duthie site is significant because it appears to be the earliest (ca. AD 1010–1270) such site on the Canadian Prairies. Non-local lithic (e.g., Knife River Flint, catlinite) sources dominate, and the ceramic assemblage includes vessels similar to Sandy Lake [15,28,29], Red River [28], and Lisbon Wares [57]. The large loop-handled vessels examined in this study are very similar to NEPV vessels described by Toom [57] from North Dakota (Fig. 2). In Minnesota and North Dakota, sites containing ceramics similar to those found at the Duthie site have yielded evidence of

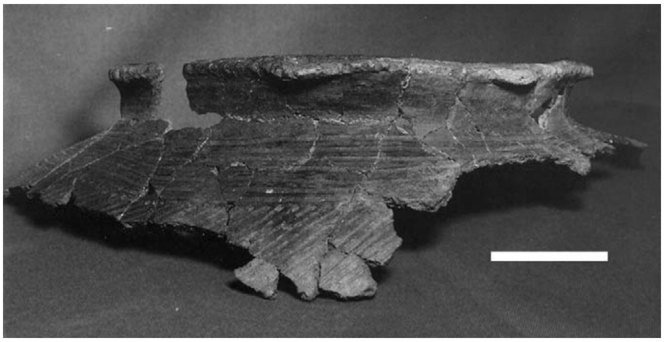

Fig. 2. Photo of reconstructed loop-handled vessel (Northeastern Plains Village complex) from the Duthie site. *Zea mays* phytoliths and starch granules extracted from this vessel provide the earliest (ca. AD 1010–1270) evidence of maize consumption on the Canadian Prairies. Scale bar is 5 cm long. Image courtesy of Jill Taylor-Hollings.

gardening [49,57]. However, no artifacts associated with gardening have been recovered from Duthie, the site is relatively small, and storage pits are likewise absent [56]. As with Vickers and Mortlach components, the faunal assemblage at this site is dominated by bison, and consumption of cultivated plants cannot be inferred from artifactual evidence alone.

3.1. Phytoliths and starch granules

The identification of maize phytoliths in soil has a relatively long history which has been punctuated, at times, by uncertainty and controversy [e.g., 39,47]. In contrast to pollen, plants commonly produce diverse assemblages of phytoliths, and individual forms within these assemblages may or may not be restricted to a particular species, genus, or family. As a result, the search for diagnostic forms requires extensive morphological comparison from one plant to another; such comprehensive studies are very time-consuming and have rarely been undertaken on the Great Plains [10,31]. Because of the economic importance of corn in the Americas, however, phytolith assemblages produced by this plant have probably 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 only those samples that contain ‘wavy-top’ rondels with entire bases (Fig. 3) [38,39,45]. This form has only been found in *Z. mays*, is produced 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 [11,23,26,38–40,53].

Other grass phytoliths were identified following Brown [12] and Twiss et al. [59]. In general, although many grass phytoliths may be identified to the subfamily level (e.g., Panicoideae, Chloridoideae, and Festucoideae), other forms such as elongate plates and trichomes are less diagnostic. These less diagnostic types are less useful indicators of past environmental conditions. As well, because it is known that at least one festucoid genus (*Danthonia*) produces bilobate phytoliths [12], only well-lobed forms can be confidently identified as panicoid [16]. Panicoid phytoliths occur mostly in C_4 grasses (including maize) that flourish in warm, tropical to subtropical regions with a moderate amount of soil moisture, while chloridoid types are found mostly in C_4 grasses that grow in warm, arid to semiarid regions [58]. Festucoid forms are associated mostly with C_3 grasses, which are concentrated in high latitudes or high elevations [58]. For a taxonomic review of grass phytoliths for the Northern Great Plains (mixed grass prairie), the reader is referred to Mulholland [31].

Phytoliths from deciduous trees were also sought in this study. These forms currently lack sufficient criteria for identification to even the family level, but some morphological generalizations are available in several sources [e.g., 10,21,46,63].

Starch granules are a crucial source of paleodietary information because they allow independent confirmation of phytolith data and, in some cases, enable plants that do not produce distinctive phytoliths to be identified in the archaeological record. Furthermore, because many economic plants (including maize) are rich sources of starch, these remains are usually abundant in archaeological sites [44]. Indeed, one study indicated that analysis of maize phytoliths alone would have seriously reduced the number of sites where evidence of this plant was found [40]. Based on previous studies, it has been shown that maize starch may be successfully extracted and identified from archaeological sites [e.g., 24,40,41]. As with phytoliths, identification of starch is based on size and morphological characteristics. Starch from *Z. 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 centre of the granule, and displays a 90° ‘extinction cross’ when viewed under cross-polarized light (XPL) (Fig. 4 (4.1)) [3,40]. Starch with these morphological characteristics that are less than 20 μm in diameter are identified in this study as ‘probably’ belonging to maize (“cf. *Z. mays*”), while those that are larger than 20 μm are considered positively identified. We also use starch evidence to identify the consumption of beans (*Phaseolus vulgaris*) on the Northern Plains. *Phaseolus* starch granules are generally large (16–38 μm long), thick, elliptical to oval and, under XPL, show an obtuse extinction cross [25,54] (Fig. 4 (4.2)).

3.1.1. Carbonized food residue

Approximately 5–40 mg of carbonized food residue was removed from the interior portion of each of the sherds examined in this study (Fig. 5). This procedure was done using a clean dental probe and knife under a dissecting microscope. Although rarely encountered, special care was taken to ensure that no adhering soil particles were included in the material analyzed. All sherds were washed in water following excavation (in the course of cataloguing), were quite clean upon inspection under a microscope, and so further washing was deemed unnecessary. Residue samples were digested in heated 50% nitric acid for 12–24 h, and the acid was subsequently removed by repeated dilution with water followed by centrifugation for 15 min at 3000 rpm [23,53]. The remaining residue was mounted and examined using a compound light microscope (with differential interference contrast), petrographic

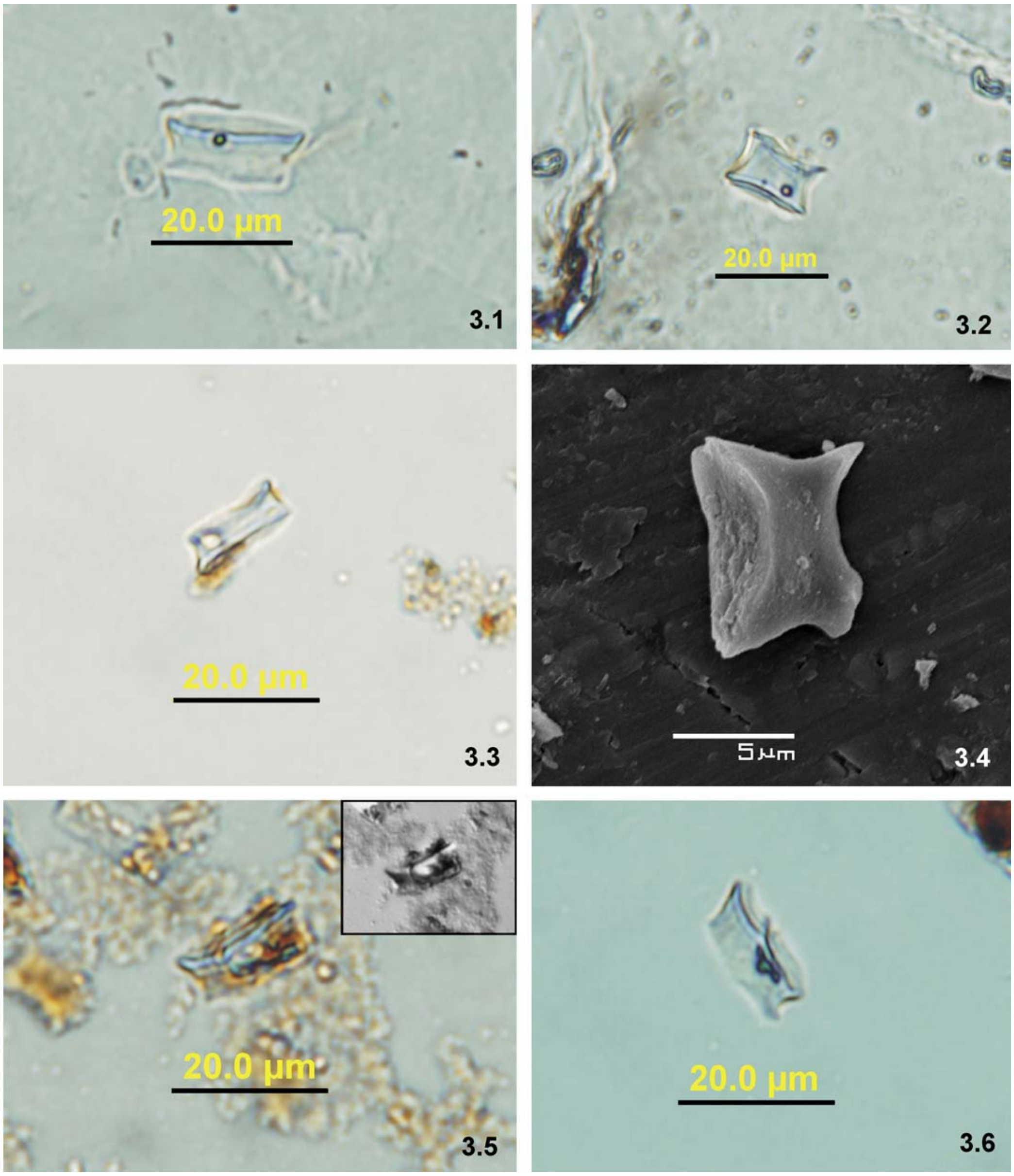

Fig. 3. Microscopic images of wavy-top rondel phytoliths from comparative and archaeological samples. 3.1 = *Zea mays*, comparative sample (Mandan corn); 3.2 = *Zea mays*, comparative sample (Mandan corn); 3.3 = *Zea mays*, Twin Fawns site, carbonized food residue; 3.4 = SEM of *Zea mays* rondel, Lowton site, food residue; 3.5 = *Zea mays*, Duthie site, food residue (inset shows same phytolith with differential interference contrast); 3.6 = *Zea mays*, Vera site, food residue.

microscope, and scanning electron microscope (SEM). Comparative starch and phytolith samples from commercial corn (*Z. mays*), 'Mandan' corn, squash (*Cucurbita*), common bean (*P. vulgaris*), and other plants were digested using the same method. For the food residue samples, phytolith counts were approximately 250 specimens per sample, and a minimum of 300 starch granules were counted for each. Only starch granules identified to the genus level or better are presented, and discussed, in this paper.

3.1.2. Soil/sediment samples

All microfossils were extracted from approximately 2–4 g sub-samples of soil following a standard procedure [42]. For all sub-samples, phytoliths were concentrated from the clay, sand, and silt fractions. Samples were initially washed through a 250 μm geological sieve in order to remove larger debris. Oxidation of the remaining material was unnecessary due to low organic content. Following centrifugation (5 min at 2500 rpm) to remove any excess water, carbonates were dissolved by immersing each sample in 1 M hydrochloric acid (HCl) until the reaction stopped (<5 h). The HCl was removed by a water wash followed by centrifugation (5 min at 2500 rpm), and the samples were then treated with a warm Na-pyrophosphate solution (25 g/L) for deflocculation. Gravity separation of the phytoliths from heavier minerals was performed using sodium polytungstate (specific gravity = 2.3). Residues were then dehydrated using 98% ethanol, mounted, and observed under 400–1000× magnification. Phytolith

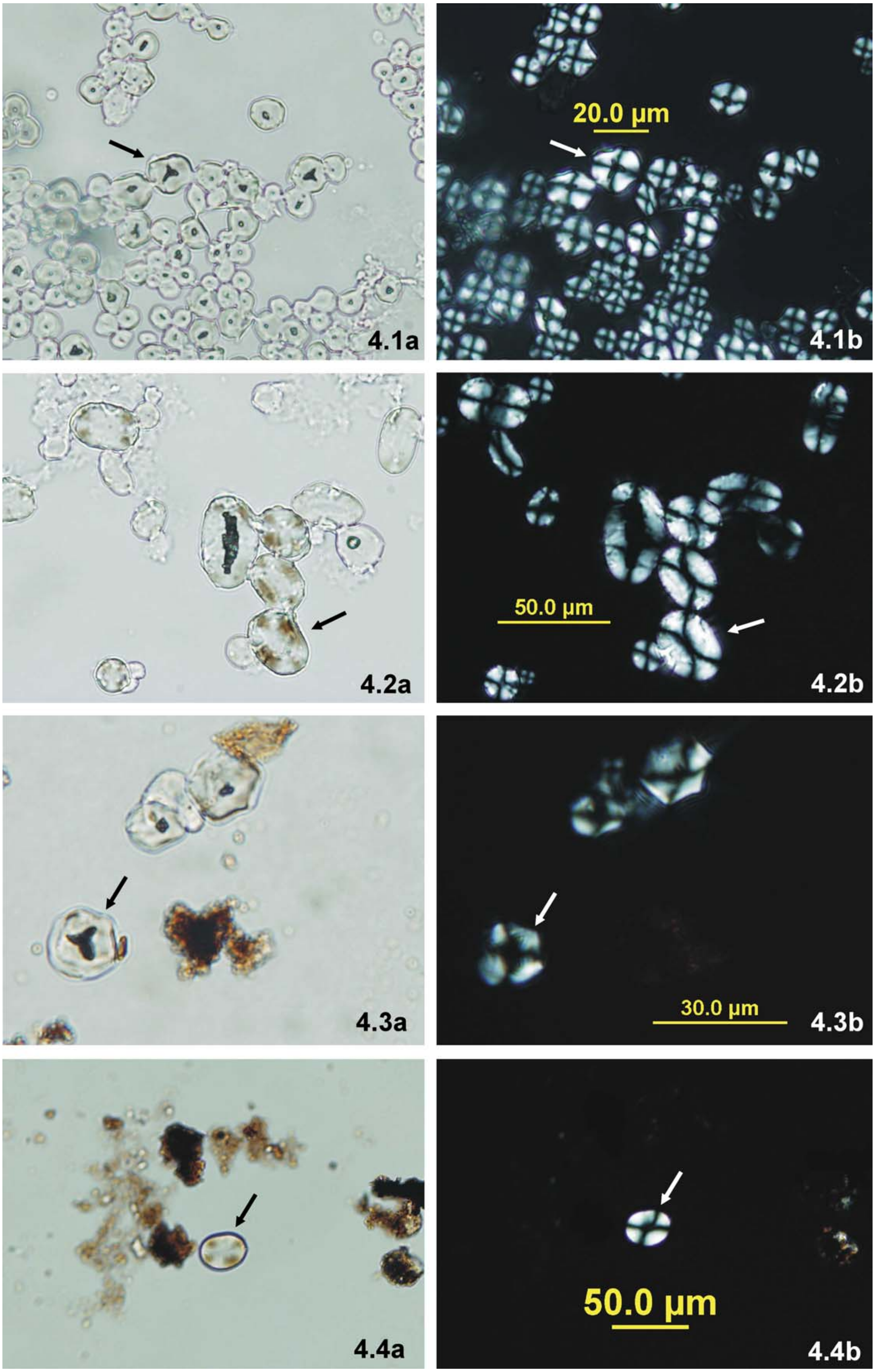

Fig. 4. Starch granules from comparative samples and carbonized food residue, viewed under plane polarized (PPL) and cross-polarized (XPL) light. 4.1a = *Zea mays*, comparative sample (PPL); 4.1b = same sample under XPL; 4.2a = *Phaseolus vulgaris*, comparative sample (PPL); 4.2b = same sample under XPL; 4.3a = *Zea mays*, Lowton site, food residue (PPL); 4.3b = same sample under XPL; 4.4a = cf. *Phaseolus vulgaris*, Duthie site, food residue (PPL); 4.4b = same sample under XPL. Arrows point to same granule in paired images.

Fig. 5. Photo showing carbonized food residue deposited on the inner wall of one of the vessels examined in this study. Scale bar is approximately 1 mm long.

counts ranged from approximately 250 to 500 specimens per sample.

3.2. Plant macrofossils

A total of 167 soil/sediment samples were examined for plant macrofossils from four sites in the TH and OLS (not all sites containing sherds with carbonized food residue were associated with archaeological features, and vice versa). These samples were obtained from hearths, occupation layers, and, at one site (Lowton), a possible pit feature. For each sample, seeds and other macrofossils were extracted by wet-screening a measured volume (100–300 cc) of sediment following deflocculation in a solution of sodium pyrophosphate powder mixed with water (25 g/L). The samples were then rinsed of fine debris through a column of sieves (1 mm and 250 μm), and the remaining organic material was air-dried for subsequent analysis under a dissecting microscope. All macrofossil counts were recalculated to a fixed volume (1000 ml). Seed identifications were aided using comparative materials housed at the University of Manitoba Herbarium, in addition to published keys [30].

4. Results

4.1. Plant microfossils

In general, despite the fact that a total of seven archaeological sites were examined from two separate localities, only minor variations were observed in the starch and phytolith content of the residue samples (Fig. 6). In all cases, assemblages were dominated by various types of elongate plates, trapezoids, and rondel phytoliths. Rondels (all types) represented between 17 and 37% of the total biosilicate assemblage. Although constituting <3% of nearly every sample, wavy-top rondels were found in all sites (Figs. 3 and 6). Trace quantities

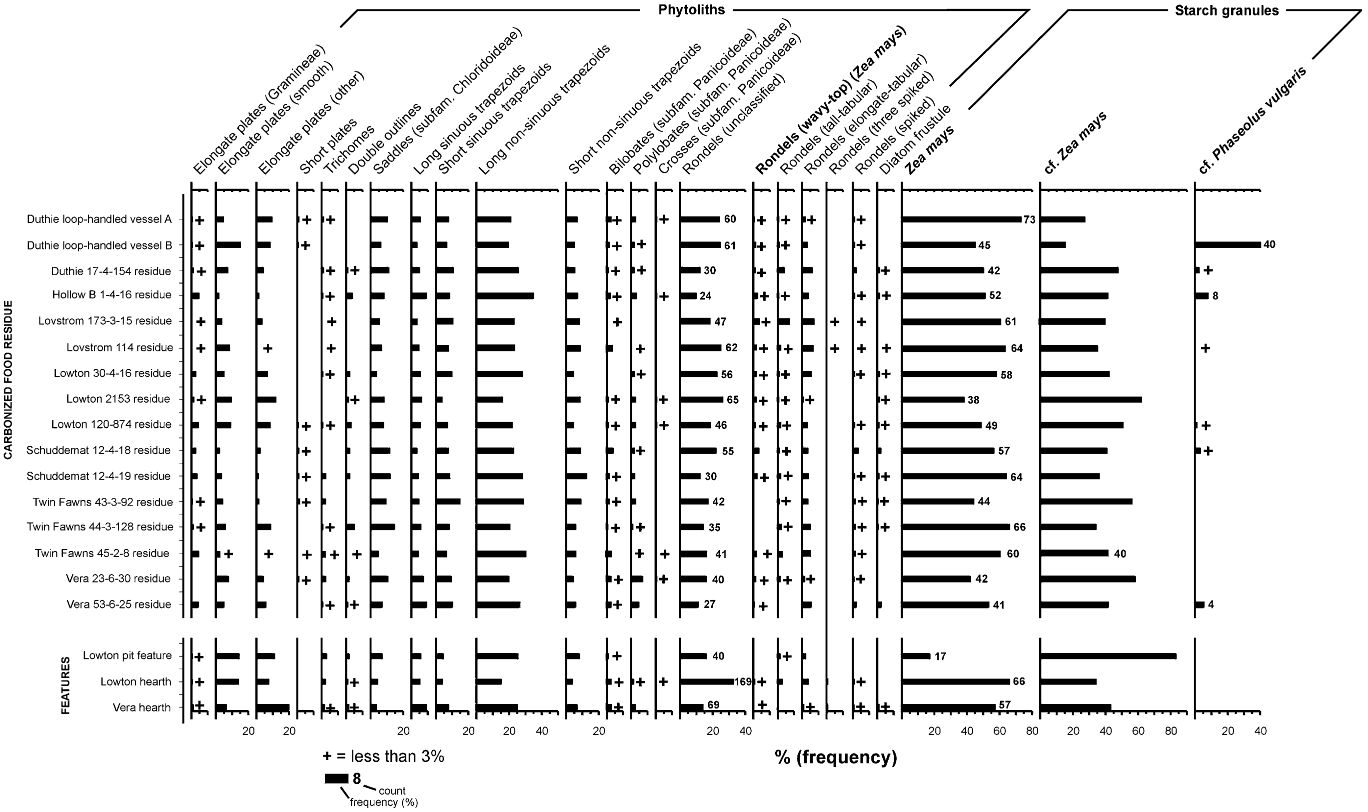

Fig. 6. Starch and phytolith data from food residue samples and features.

of bilobate, polylobate, and cross-shaped phytoliths (produced within the Panicoideae subfamily) were also observed, in addition to saddles (subfam. Chloridoideae), and diatom frustules. Starch granules were abundant in all residue samples and, of the identifiable types, the form produced by *Z. mays* dominated (Figs. 4 (4.3) and 6). Starch identical to that produced by *P. vulgaris* (common bean) was recorded in the residue from all sites except for one (Twin Fawns) (Fig. 4 (4.4)), although not every residue sample contained evidence of this plant. *P. vulgaris*-type starch was particularly abundant on one of the vessels from the Duthie site.

Microfossil assemblages from both hearth features were dominated by many of the same general types found in the food residue, and both hearths contained trace quantities of wavy-top rondels, and abundant maize starch. Rondels diagnostic of maize were not found in the Lowton pit feature, however, and no soil sample contained *P. vulgaris*-type starch.

4.2. Macrofossils

Identifiable macroremains were generally rare in the features examined for this study (Fig. 7). *Chenopodium* (goosefoot) seeds were found in most samples, and were especially abundant in two samples. However, only in one hearth was charred *Chenopodium* found. Other species represented by carbonized seeds include *Rubus idaeus* (raspberry), *Prunus virginiana* (chokecherry), and perhaps *Scirpus* (bulrush). As well, in several samples, seeds from the weeds *Rumex* (dock), *Setaria* (foxtail), *Polygonum* (doorweed), and *Portulaca* (purslane) were found; most, if not all of these remains are probably contaminants from the modern environment. Sclerotia from *Geophilum*, a fungus that thrives in disturbed ground, was also recorded in several of the samples. No identifiable remains of domesticated plants were found in any of the features examined.

5. Interpretations and discussion

If analyzed by themselves, the plant microfossil and macrofossil data would yield a very different understanding of Plains Woodland paleodiet in the study area. Together, however, these different lines of evidence reveal subtle, and surprising, trends in subsistence on the northern edge of the Great Plains. Importantly, despite considerable archaeological ambiguity with regard to the role of domesticated plants, these data show for the first time that consumption of maize, and probably beans, was widespread on the eastern Canadian Prairies after AD 1000.

Strong, multiproxy (starch/phytolith), evidence of maize consumption was identified from carbonized food residue in

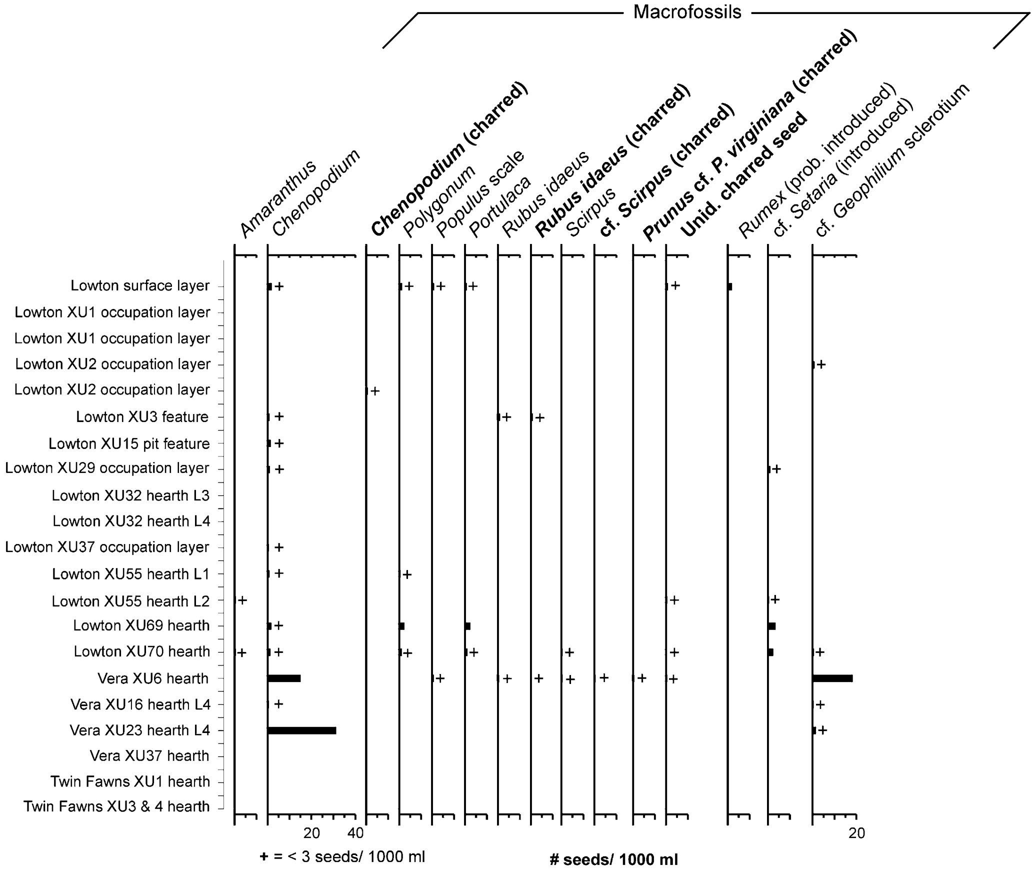

Fig. 7. Macrofossil remains from features and occupation layers in the OLS and TH study areas. Charred plant remains are emphasized (boldface text) because they are more likely to be deposited at the time of occupation versus those that are not carbonized.

all of the sites examined. Furthermore, at least one sherd from nearly all of the sites contained possible evidence of bean (*Phaseolus*). The recovery of maize starch and phytoliths in the hearth features, furthermore, indicates that these plants were probably consumed at the time of occupation. Absence of macroremains from domesticated plants is probably a function of poor organic preservation at these sites (macrofossils of any type are rare), small sample sizes, and perhaps low initial quantities of these plants at the time of occupation. As reviewed above, most of the sites examined are small, and likely represent short-term (seasonal) occupations [22]. If occupations were ephemeral, then middens would be thin, food storage facilities would be nonexistent and, in short, opportunities for preservation of macroremains would be few. Indeed, at the nearby Lockport site (Fig. 1), a small assemblage of maize kernels and cupules was found in two prehistoric bell-shaped pits [13,14]. This site was also associated with gardening implements such as bison scapula hoes, suggesting an extended horticultural occupation. Although macrofossil preservation was extremely poor in the hearths and other features examined in this study, only the remains of wild plant species were identified among the charred remains. All of these wild species are commonly found on the Canadian Prairies, were consumed historically by Aboriginal populations, and would have been locally available during the summer [50].

In large village sites on the Great Plains, including the nearby Middle Missouri region, maize, beans, and squash formed an important aspect of the subsistence economy from at least AD 1000 [1]. From Hidatsa ethnographic accounts, it is known that green corn was prepared in several different ways, including boiled, on the cob; fresh or dried, pounded, shaped into loaves, and cooked in coals; shelled, mixed with beans and fat, and boiled [64]. Recovery of maize and *Phaseolus*-type microfossils from the food residue matches the latter cooking method, and suggests that a similar ‘recipe’ was probably followed at the time of occupation. As well, abundance of smooth elongate plates and trapezoid phytoliths in the residue – commonly produced in the wood of deciduous trees [46,63] – indicates that ash was probably added to the food mixture. *Maxidiwiac*, Wilson’s [64] Hidatsa informant, mentions that ash was traditionally added as a seasoning to corn porridges during the cooking stage – a practice that may have increased the nutritional value of the food [17].

Ultimately, gardening was just one component of the annual subsistence round in the Middle Missouri villages, and wild resources were important supplements. During the historic period, for example, the Mandan and Hidatsa prepared their fields in May in the sandy, fertile, river bottoms of SW North Dakota and harvested their crops in October; bison hunting took place throughout the year, whenever herds approached the villages, but the summer hunt was especially important [65]. Wild plants were also collected, and this activity, along with the summer bison hunt, was probably important for buffering against the inherent delay of the agricultural schedule [36]. The macrofossil evidence presented in this study, although sparse, suggests that local plant species such as *R. idaeus* and *P. virginiana* were consumed along with cultigens. The relative importance of wild resources over domesticated plants is unknown, but this matter is currently being addressed through analysis of stable C and N content of food residue from the study sites.

Although it seems that many of the foods which were staples in large villages along the Missouri River were also consumed at the study sites, major archaeological differences are seen between these two regions. In particular, the sites examined in this study lack evidence of semi-sedentary settlement, intensive horticulture, and large populations – the sites are generally small, and gardening implements are rare. In fact, no artifacts associated with gardening (e.g., scapula hoes, squash knives) have been recovered from the OLS site cluster, and therefore sites in this region were previously interpreted as short-term, seasonal, occupations by small groups of foragers [22]. At other sites, such as Lovstrom, Lowton, and Lockport, however, occasional recovery of scapula or stone hoes and grinding stones suggests that gardening may have occurred locally [32,33,35]; the Lowton site is also unusually large (400 × 200 m) in contrast to other Plains Woodland sites on the Canadian Prairies [32]. This diversity in the archaeological record suggests that maize may have entered the region through multiple ‘pathways’, including:

1. *Trade and exchange*: Maize and other domesticated plants may have been obtained by foragers living on the fringe of the Northern Plains through trade with village populations. During the early historic period, for example, Cree and Assiniboin hunter-gatherers were engaged in extensive trade with the Mandan and Hidatsa [6]. To a large extent, this relationship was based on the exchange of bison meat for maize [6]. Similar relationships between hunter-gatherers and villagers have been documented in other parts of North America [e.g., 52]. In part, the corn/bison exchange network may have existed because these foods are complementary (neither is a good source of both calories and protein), and trade may have simply provided a more efficient means of acquiring these items. Alternatively, this system may have functioned as a buffering strategy against localized environmental fluctuations [6,52]. At present, however, it is not known if food exchange networks existed on the Northern Plains before AD 1700. Trace element analysis of carbonized food residue may provide one means of identifying if domesticated plants were grown locally or elsewhere [e.g., 20].
2. *Short-term village dispersal*: Ethnographic accounts indicate that the Mandan and Hidatsa were semi-sedentary; in the summer and fall, these village populations would disperse for extended periods of bison hunting [5,65]. Among the Hidatsa, the largest of these forays occurred during the summer, before their gardens were fully mature [5]. During the historic period at least, these groups (composed of men, women, and older children) traveled far from their villages (up to 200 miles), setting up temporary encampments and subsisting on maize, wild plants, and a variety of game along the way [5]. Although the antiquity of this practice is unknown, if Plains Village

populations engaged in similar behaviour, this pattern would produce small, ephemeral, far-ranging, campsites with an absence of gardening artifacts, evidence of maize consumption and broad-spectrum foraging, and ceramic wares identical to those found in the larger villages. Such repeated, seasonal, northward, incursions into the prairie margin may have produced the Devil's Lake-Sourisford complex (AD 900–1400), a Mississippian-influenced burial complex restricted to southwestern Manitoba and neighbouring portions of Saskatchewan and North Dakota [55]. In any case, in this scenario, maize and other domesticated plants consumed in distant campsites would represent surplus from village gardens, rather than local horticultural activity. Although speculative, the NEPV component at the Duthie site may record this process. As summarized above, the Duthie site is small, gardening artifacts are absent from the assemblage, and ceramics are almost identical to vessels from North Dakota (Lisbon Ware).

3. *Local horticulture*: Maize and other cultigens may also have been grown locally on the eastern Canadian Prairies. Nicholson [32,33] and Nicholson et al. [35] argue, for example, that the Vickers focus (AD 1350–1650) represents an intrusive horticultural manifestation in southern Manitoba, based primarily on similarities in the ceramic assemblage to Plains Village wares, and the recovery of a possible scapula hoe and grinding stones in the TH. Evidence of maize macroremains, scapula hoes, and bell-shaped pits from the Lockport site [13,14] provide somewhat more compelling evidence of horticulture, although this site has received only superficial analysis and remains largely unpublished. Ultimately, the extent of prehistoric horticulture on the eastern Canadian Prairies remains unknown, despite more than two decades of archaeological research on this subject. In general, because archaeological sites in this region are generally small and gardening implements are rare, we suggest that local horticulture, if practiced, was non-intensive and/or irregular. In a recent discussion of the NEPV complex, Toom [57] reports that most sites attributed to this complex in North Dakota are open campsites, and that evidence of gardening has been found in some site clusters and not in others. Although unclear, Plains Woodland economies were probably highly flexible, and the relative importance of horticulture and foraging may have shifted from year to year within these societies in response to a variety of factors. Such a system would produce considerable archaeological diversity and, at times, ambiguity with regard to the role of domesticated plants.

6. Conclusions

Because almost no archaeobotanical research has previously been undertaken on the Canadian Prairies, our understanding of ancient subsistence patterns in this area is largely informed by the more visible components of archaeological sites, such as bison and other large mammal remains. In addition to presenting a skewed image of human diet and subsistence behaviour, this approach may encode a gender bias by over-representing the relative importance of hunting. Plants, of course, are a crucial dietary component in almost all human societies, and the adoption of maize horticulture on the Northern Great Plains undoubtedly played a profound role in shaping human societies living in this region. On the fringe of the Northern Plains, however, where sites are generally small and artifactual evidence of horticulture is sparse, plant microfossils provide sensitive clues to plant use even in contexts where macroremains do not preserve. The sites examined in this paper represent a broad cross-section of Plains Woodland manifestations on the eastern Canadian Prairies; the sample includes material from two separate site clusters, and three different archaeological cultures that date to the period between approximately AD 1000 and 1600. Because multi-proxy evidence of maize was recovered from all of these sites, we suggest that consumption of domesticated plants was widespread in this region shortly before European contact. As reported in this paper, the earliest evidence of maize consumption on the Canadian Prairies comes from the NEPV vessels from the Duthie site (ca. AD 1010–1270). Prior to this study, Lockport was the only site on the Canadian Prairies from which maize remains were recovered. Furthermore, possible evidence of bean (*Phaseolus*) starch in food residue from nearly all of the study sites suggests that maize was just one component of a larger system of domesticated plant use. In order to guide future research on this subject, we suggest three hypothetical pathways through which maize and other cultigens may have entered these sites: (1) trade and exchange, (2) seasonal dispersal of village populations, and (3) local horticulture. Because only one or two sites on the Canadian Prairies have provided artifactual evidence of gardening, we suggest that local horticulture may have occurred only on a small-scale.

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