Floodplains and Agricultural Origins: A Case Study in South-Central Ontario, Canada

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Human interaction with riverine ecology is an important component of recent modelling of agricultural origins in eastern North America. Recent research on the ancestral Ontario Iroquoian Princess Point Complex (A.C. 500–900) in south-central Ontario, Canada, demonstrates that the floodplain of the Grand River was an important setting for initial maize production in this region. This paper presents a case study of an archaeological occupation in relation to its floodplain setting during the transition from hunting and gathering to agriculture. Previous interpretation of the Princess Point occupation of the lower Grand River Valley suggested that maize cultivation was grafted onto a Middle Woodland pattern of seasonally scheduled foraging. In particular, the old model proposed that floodplain disruption by substantial annual flooding and ice rafting limited use of the floodplain; exploitation of floodplain habitats was limited to the late spring, summer, and early autumn when maize cultivation could be conducted. Between 1993 and 1995, the Grand Banks site (AfGx-3), situated on a lateral bar in the floodplain of the Grand River, was the subject of archaeological and geomorphological investigation of stratigraphy and site formation. The stratigraphy of the bar shows that its development was characterized by variable sedimentation rates throughout the Holocene. The rates were affected by changes in Lake Erie water levels and possibly by climate shifts, both of which broadly coincide with events interpreted from the Grand Banks site stratigraphy. The bar surface was, contrary to earlier interpretations, relatively stable during two periods, one being the crucial period from A.C. 500–900 when maize cultivation was introduced. Explanations of agricultural origins in eastern North America need to take the complexity of floodplain histories into account.

Introduction

Floodplains and riverine ecology are significant components of models of agricultural origins in eastern North America (Struever and Vickery 1973; Smith 1987, 1992, 1995). In the Midwest riverine area (Missouri, southern Illinois and Ohio, Kentucky, and Tennessee), agricultural origins are primary, that is, the shift to agricultural behavior took place along with plant domestication (Smith 1987, 1992, 1995). Where plant husbandry became important in NE North America, however, crops were not locally domesticated so it is a region of secondary agricultural origins. Settlements on floodplains figure prominently during the initial phase of the shift in the Northeast, as they do in the Midwest (e.g., Stewart 1994; Ritchie and Funk 1973). In Ontario, Canada, fertile floodplains provided favored locations for Princess Point peoples who formed the first agricultural communities (Stothers 1977; Stothers and Yarnell 1977). Despite the apparent importance of floodplain settings for the first agricultural communities in both primary and secondary origins models in eastern North America, the nature of archaeological occupations in relation to their floodplain settings during this crucial period in eastern North American prehistory is in need of detailed examination. A few studies have examined this topic (e.g., Delcourt et al. 1986; Marquardt and Watson 1983; Stein 1982).

Additionally, Bruce Smith (1992) provides the first analysis of the floodplain ecology of wild relatives of eastern complex crops and examines briefly the floodplain settings of related archaeological sites.

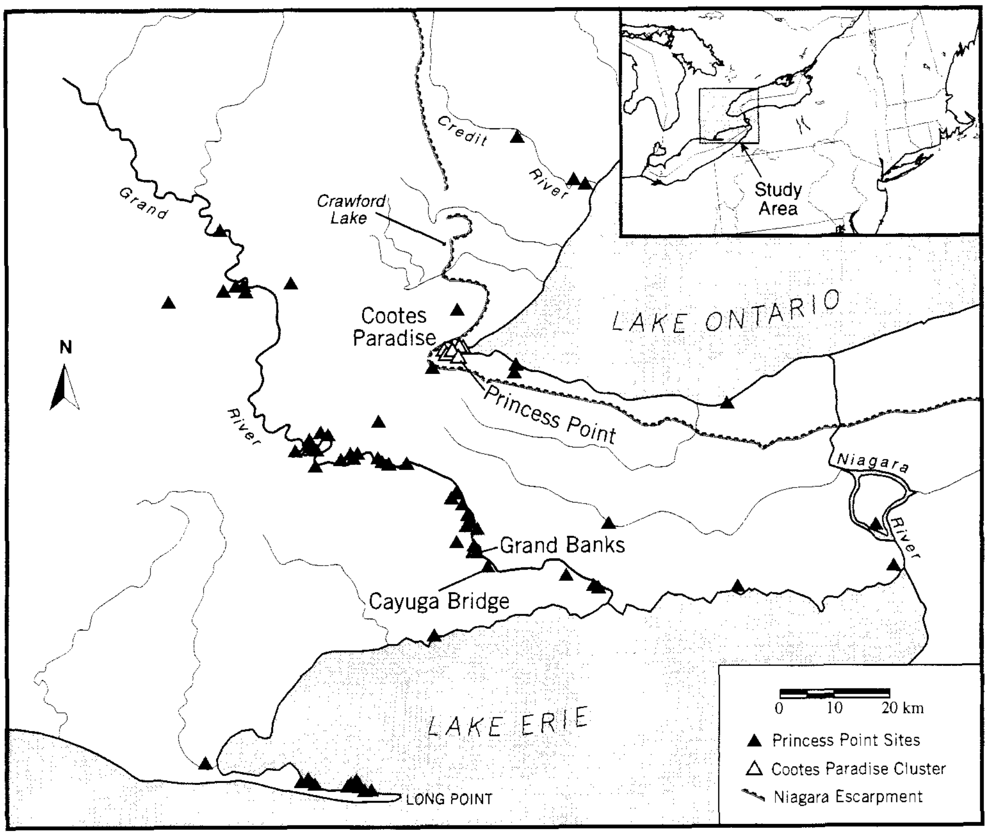
In this contribution to the understanding of floodplain archaeology during the shift to horticulture in eastern North America, we explore a case study of human interaction within a floodplain setting in southern Ontario, Canada. We detail the results of our stratigraphic and site formation research at the Grand Banks site (AfGx-3) in the context of a program designed to reevaluate the early Late Woodland of southern Ontario (FIG. 1) and show that floodplain use in prehistory must be evaluated in the context of documentable local fluvial geomorphological dynamics. Specific details on the nature of preservation, disturbance, and burial of the Grand Banks site are assessed in Walker et al. (1997). There we evaluate the evidence for relatively stable floodplain surfaces in the lower Grand River Valley during two periods in the Holocene. The latter period of stability dates from at least A.C. 500 to possibly A.C. 1700 and was an important factor facilitating early corn horticulture along the lower Grand River.

Princess Point: Background

The earliest evidence of crop production in Canada is from the early Late Woodland Princess Point Complex of south-central Ontario (Crawford, Smith, and Bowyer 1997; Smith and Crawford 1997). A significant characteristic of Princess Point settlement is a choice of location for many sites immediately adjacent to water. Of approximately 80 recorded Princess Point sites, 22 are located on the floodplain of the lower Grand River. The remaining sites include numerous occupations on shores of lakes or embayments (e.g., Cootes Paradise), as well as a few upland locations. Few Princess Point sites have been systematically investigated.

Little is known about how the transition to the mixed economy of the Iroquoians took place here. Unlike the neighboring Midwest riverine area where indigenous domestication of crops—e.g., sumpweed (*Iva annua* var. *macrocarpa*), sunflower (*Helianthus annuus* var. *macrocarpa*), chenopod (*Chenopodium berlandieri*), cucurbit (*Cucurbita pepo*)—is evidenced as early as the Middle Holocene (Fritz 1990; Smith 1989, 1992; Yarnell 1978), south-cen-

Figure 1. The location of Princess Point sites. Inset shows the location of the study area.



tral Ontario is a secondary center of agricultural origins. The crops involved are maize (*Zea mays*), bean (*Phaseolus vulgaris*), cucurbit, sunflower, and tobacco (*Nicotiana rustica*), none of which are native to Ontario. For Ontario, the role of migration in the introduction of cultigens and, ultimately, the beginning of Iroquoian society is being actively debated. To date, this important debate, involving two very different processes, has not been resolved. Thus diffusion, apart from migration, may have been the primary mechanism responsible for the transition to horticulture much as it was in central and northern Europe as well as in Japan (Crawford 1992; D'Andrea 1995; Price, Gebauer, and Keeley 1995). On the one hand, researchers such as Fox (1990) contend that maize diffused into southern Ontario and was incorporated into the subsistence regime of indigenous Middle Woodland societies. On the other hand, Snow (1995) argues that a northward migration of Iroquoian peoples who already had taken on maize production brought horticulture with them to southern Ontario. Snow initially hypothesized that this migration occurred after ca. A.C. 900 but, in light of recent evidence from Ontario (Crawford and Smith 1996; Crawford, Smith, and Bowyer 1997), he has revised this date to some 300–400 years earlier (Snow 1996; see also Bursey 1995).

The Princess Point Complex is one of a number of transitional Middle to Late Woodland cultures in the Northeast dating to between 1000 and 1500 years ago. It is seen as ancestral to later Iroquoian societies in this region (Crawford and Smith 1996; Fox 1990; Smith and Crawford 1995; Stothers 1977). Stothers (1977) initially defined the Princess Point Complex as a cultural-historical construct bridging the Middle and Late Woodland periods in SW and south-central Ontario. This "complex" incorporated three regional foci, all dating from A.C. 600–900 (Stothers 1977: 113). More recently, Fox (1990: 174) restricted the term Princess Point to a region of south-central Ontario at the west end of Lake Ontario and the east end of Lake Erie (see also Crawford and Smith 1996). An initial date of A.C. 700–750, rather than A.C. 600 seemed warranted by the more recently available radiocarbon dates (Fox 1990: 182). Although Fox's proposal is now generally accepted, and the rationale for using the term "complex" for Princess Point would appear to have been eliminated, this terminology remains in common use.

Stothers (1977) argued that Princess Point people had an incipient form of maize cultivation. Their overall subsistence regime, however, was dominated by a seasonal round of scheduled activities that encompassed macroband concentration during the late spring, summer, and early fall in lacustrine and riverine environments where a limited form of horticulture could most easily be practiced, and micro-band dispersal into upland environments in the late fall, winter, and early spring. In other words, the settlement-subsistence system was a continuation of Middle Woodland seasonal foraging (see Spence, Pihl, and Murphy 1990) with some maize cultivation grafted onto it (Stothers 1977: 123). Stothers' interpretation went unchallenged by Fox (1990: 179), and has been the standard interpretation until the present.

Stothers based his model primarily on evidence he gathered from sites that he interpreted as late spring to early fall macro-band encampments located in the lower Grand River Valley and on Cootes Paradise (FIG. 1). Fall/winter upland camps were poorly represented and largely hypothetical. The Princess Point type site, located on a low-lying peninsula in Cootes Paradise at the western end of Lake Ontario, borders a marsh. The site is also stratified although the Princess Point component appears to be limited to a single stratum occurring below later artifact-bearing strata. At the Cayuga Bridge and Grand Banks sites (FIG. 2), both located on lateral bars of the Grand River, Stothers excavated profiles in the river bank. At each site he distinguished nearly identical stratigraphy, consisting of three distinct layers containing artifacts, each separated by layers of silt with no artifacts. He interpreted the artifact-rich strata as sequential, seasonal Princess Point occupations. He argued that people would have been unable to occupy these locales in the early spring due to flooding and ice rafting, so the sites were late spring through early fall encampments (Stothers 1977: 122–123).

A number of issues arise concerning Stothers' interpretation of seasonal settlement-subsistence for Princess Point. First, it is unclear whether the three distinct strata recorded by Stothers at both sites represent single or multiple seasonal Princess Point occupations separated by alluvium left by the floods that caused the sites to be temporarily abandoned. Second, accretion rates due to the hypothesized regular flooding need to be examined; annual accretion of sediment would likely result in much deeper profiles at the Grand River floodplain sites than was reported. Third, the type of settlement at Princess Point on Cootes Paradise cannot be ascertained due to the limited data available.

Finally, the stability of Princess Point settlement-subsistence patterns and social organization can be questioned. The riverine bars, as well as marshland sites such as the Princess Point type site, may have been exploited seasonally by Princess Point communities at an early date, along the lines of Stothers' proposed model, but more intensively as time went on. Such a scenario poses a set of even more complex questions pertaining to stratigraphic evidence that would support such a model of developmental change, whether the floodplains were stable to the extent that year-

Figure 2. Aerial view of the Grand Banks Site. View is to the NW.

round occupations were feasible, and whether evidence could be obtained to support a view for rapid settlement-subsistence and social change at about A.C. 900. These questions could only be pursued through a detailed and intensive examination of natural and cultural stratigraphy in the lower Grand River Valley, something that had not been done until now.

Physical Geography of the Grand River Valley

The lower Grand River is an entrenched river valley that developed following deglaciation of southern Ontario about 12,000 years ago. It flows onto a low-lying plain along the north shore of Lake Erie. During ice retreat much of the southern Niagara Peninsula was inundated by several phases of ice-marginal lakes resulting in widespread deposition of glaciolacustrine clays. Rapid lowering of the Great Lakes base level during final ice withdrawal produced river entrenchment of between 10 and 25 m. The absence of terraces suggests rapid and continuous downcutting that was probably complete within a few millennia.

Within the entrenched valley, the Grand River exhibits a sinuous to straight single-thread channel. Lateral and vertical movement of the channel is severely restricted in places by bedrock or resistant glacial materials. Elsewhere, the river has constructed a floodplain composed mainly of accreted lateral bars and point bars built from river transported silts and sands. Prior to European settlement no large lakes in the upper basin prevented the flow of water and sediment to the lower reaches of the river.

The lower Grand River Valley is in one of the warmer parts of southern Ontario, located in the ecotone between the Carolinian and the mixed conifer-hardwood forest zones. Plants and animals with southern affinities range into the lower Grand River Valley. The mean daily temperature is 47° F (8.3° C) and there are about 3700 Growing Degree Days (a GDD is the amount of effective growth heat accumulated during the day, obtained by subtracting a base temperature, in this case 42° F, from the mean temperature for the day)(Webber and Hoffman 1969: 13, 17).

Grand Banks Site Reevaluation

Until recently, Stothers' preliminary investigations at the Grand Banks site over twenty years ago had not been reevaluated in detail, particularly from an interdisciplinary perspective. We have been testing Stothers' suggestions regarding settlement system, subsistence, site formation processes, and environmental context of the Grand River Princess Point manifestation, of which the Grand Banks site is one example (Smith and Crawford 1997). The following discussion outlines results to date.

Methods

Initial inspection of the Grand Banks floodplain documented a scattering of artifacts for over 1000 m of the river edge. Alluvial deposits are deepest and artifact densities are highest toward the middle of the floodplain bank. For these reasons, this area, which was also the portion of the site examined by Stothers, was chosen for test excavation. Excavation units were placed about 10 m from the river bank in order to comply with conservation authority regulations designed to maintain stability of the river banks. This was of particular concern at Grand Banks, where significant erosion of the river bank has been taking place.

Initially, 1 m square units were excavated in 5 cm and 10 cm levels in order to retain a relatively fine-scale resolution of the site structure which, based on Stothers' earlier observations, was expected to be stratigraphically complex. We were also concerned that if cultigen remains were recovered their context would need to be properly documented (Crawford, Smith, and Bowyer 1997: 116). Once a better understanding of the site structure was developed methods were modified accordingly; with the basic stratigraphic and occupational strata identified, the most detailed excavations were reserved for the occupational deposits found in two paleosols.

Flotation samples were taken from all strata that were sometimes further divided into 2 cm levels and from nearly all 1 m square excavation units. All the soil from pits and features and about 20 percent of the remaining soil fill was collected for flotation. The 1993 samples, from which the plant remains reported here were recovered, totaled about 2000 liters of soil.

Floodplain development was investigated using standard geomorphological techniques. Topographic and stratigraphic data were collected on a systematic grid covering the entire Grand Banks lateral bar (1000 m × 200 m). At this scale, processes of floodplain erosion and deposition could be evaluated to provide an environmental context for the detailed lithostratigraphies at the main site. Narrow-gauge auger holes were drilled at more than 150 grid intersections to define overall thickness of the alluvial fill. Sediment samples were taken from all major stratigraphic units at each borehole site and analyzed for grain size, carbonate content, organic matter concentration, and mineralogy. In addition, exposed cut banks, remnants of those initially investigated by Stothers, were logged and surveyed. The sediment database was tied into the topographic survey to illustrate horizontal and vertical variations in alluvial sediment properties across the bar.

Overview of Results

Eighty square meters have been excavated at Grand Banks, all to a minimum of about 0.6–0.8 m below the surface (FIGS. 3, 4). Three square meters were excavated to depths of about 2.0 m to clarify the floodplain stratigraphy. The excavations were divided into three areas designated A, B, and C (FIG. 3). One large pit and a few posts have been discerned in Area B, while Area C, the northernmost area tested to date, has the highest concentration of posts, pits, and other features. Three features were found in the east third of Area C. All three areas have high concentrations of artifacts. We are not yet able to offer a definitive interpretation of the settlement pattern revealed in the three areas (Smith and Crawford 1997: 17). Clarification of stratigraphy was a higher priority than was an examination of settlement pattern during this phase of testing at Grand Banks.

Stratigraphy

The broader context of the Grand Banks site stratigraphy is the valley, which here is about 400 m wide (FIG. 2). Half the valley is occupied by the active river channel. The other half is filled by floodplain alluvium, 95 percent of which is deposited on the west side of the valley bottom. Morphologically the floodplain resembles a large single lateral bar, or a complex of smaller side-channel bars, formed by the accumulation of silt and sand in a depositional zone that persisted adjacent to a laterally stable active channel. The bar surface is slightly hummocky and slopes gently from a high point along the outer downstream bar edge (where the excavation site is located) toward the west valley wall. Higher concentrations of clay in the sediments occur closer to the valley wall where slope wash has contributed fine material from the surrounding uplands.

Fine-grained alluvial sediments are on average 2.2 m thick and vary from a minimum of 0.5 m adjacent to the valley wall to a maximum of 3.5 m near the excavation site. Bottom (auger refusal depth) materials are mainly coarse clastic sediments, possibly alluvial in origin, and occasionally the weathered bedrock surface. The latter suggests that basement materials are thin. Median grain size of the mineral sediment fraction is predominantly silt (0.038 mm) and shows a consistent trend towards reduced silt and increased fine sand from bottom to top of each borehole.

On the whole, the primarily massive, structureless silts that characterize the Grand Banks site demonstrate transport and deposition of suspended sediments in overbank flows during flooding of the Grand River. During the last

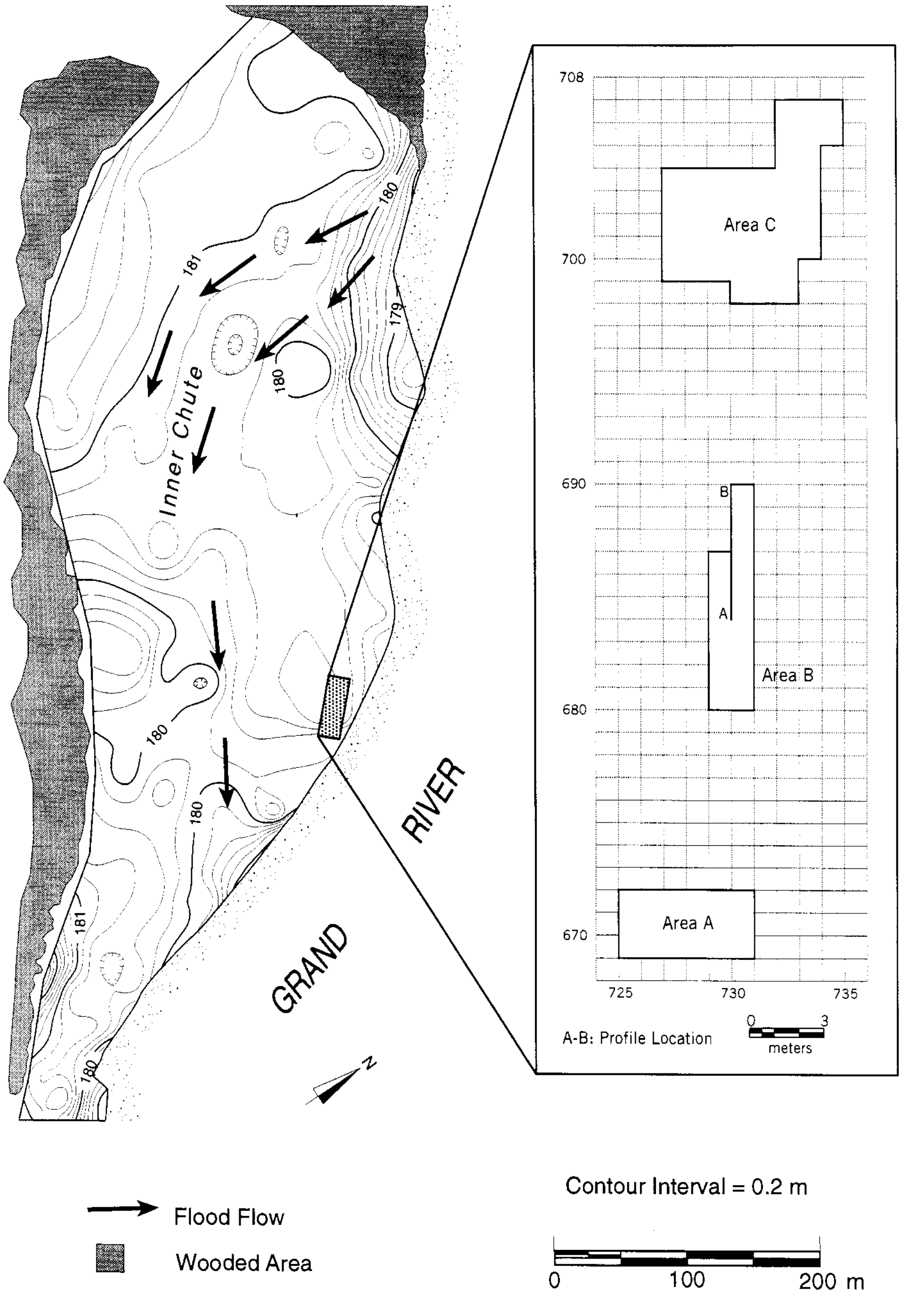


Figure 3. Schematic digital contour map of the Grand Banks Site floodplain. Inset shows excavated areas (1993–1995) and profile location.

large flood (May 1974) 1.0–1.5 m of water covered most of the floodplain (John Riley, personal communication, 1993). Suspended sediment is diffused across the bar surface resulting in a wedge of sediment that thickens outward from the west valley wall. Standing or quiet water during the waning phase of each flood produces local pockets of fine silt. Large floods lead to channelized overbank flows that enter the bar at the upstream end and extend across the middle and inner bar as a series of small bifurcating chute channels (FIG. 3). Within each chute, water velocities are sufficient to erode the underlying materials and then small amounts of silt and fine sand are infilled immediately following peak flows. Floods of low to moderate magnitude produce vertical accretion of sediment over most of the bar surface, whereas high magnitude floods erode locally. The most stable and least affected section of the bar is the

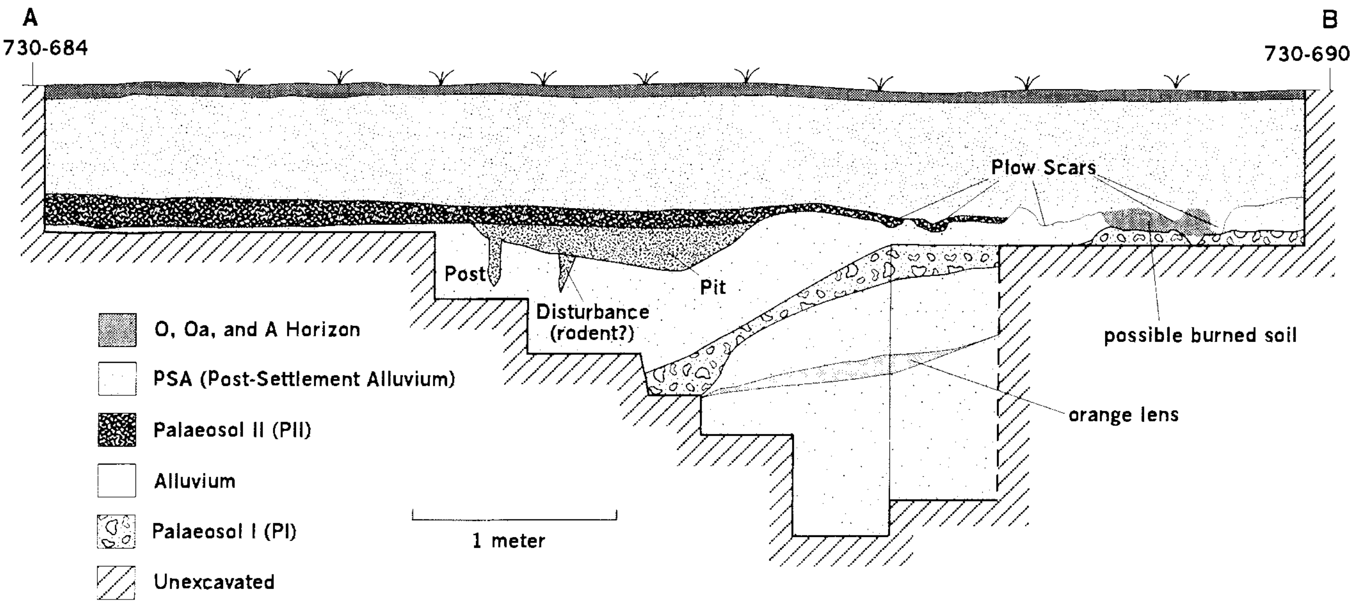


Figure 4. Grand Banks Site stratigraphic profile (Area B).

downstream outer zone which lies between the main channel and inner chute (FIG. 3). Continual vertical accretion has built this section to the highest elevation anywhere on the bar surface. With few exceptions (see below), erosion here only occurs as the result of low flow bank undercutting.

Stratigraphic boundaries are weakly defined and involve mostly minor changes in grain size. Sedimentary structures, which are generally absent, include thin horizontal laminae of fine sand within a mostly massive silt matrix. Silt beds vary from 3–100 cm in thickness. Throughout the floodplain, two buried dark brown, organic rich units are prominent. We interpret these to be buried pedogenic Ah horizons (paleosols). The upper paleosol (PII) (10–20 cm thick) can be found throughout most of the floodplain at depths of around 40 cm buried below a massive light brown to gray silt (FIG. 4). The lower or earlier paleosol (PI) is less than 15 cm thick and occurs at depths of 1.2–1.7 m. PI is absent throughout most of the upstream and inner sectors of the bar.

Detailed excavations reveal two lithostratigraphies, rather than the single one described above. One is in Areas A and B while the other is in Area C and partially represented in Area B. PI and PII are evident in the profiles in Areas A and B. Area C, however, has no clearly discernible paleosols, although one diffuse artifact-rich stratum is evident.

In Area A, artifact-bearing deposits extend to approximately 1.4 m below the surface. The artifacts are concentrated in PI and PII. The chronology of PI is evidenced by a radiocarbon assay on charcoal from an associated hearth dated to ca. 1400 B.C. (TABLE 1). Stothers rejected a date of ca. 1250 B.C. (TABLE 1: DIC-257) that he obtained in the 1970s from a test pit at the inland margin of the floodplain, but it probably relates to PI, although its stratigraphic context is unclear. This occupation is most likely Late Archaic or Early Woodland.

PII yielded only Princess Point material. Three AMS radiocarbon dates on maize ranging from A.C. 540–780 have been obtained from PII in Area A (TABLE 1: TO-4585, TO-5308, TO-5307). Two dates of about A.C. 1000 are from pits in Areas B and C (TABLE 1: TO-4584 and TO-5875). The significance of these dates has been discussed elsewhere (Crawford and Smith 1996; Crawford, Smith, and Bowyer 1997); they indicate a chronology from at least A.C. 500–1000 for PII. Most of the artifacts in Areas A and B are from PII (FIG. 5), including high densities of artifacts immediately below the paleosol. Very few of the artifacts are from PI. The sediments separating the two paleosols contain a few artifacts; the alluvial sediments between PI and PII, however, were excavated as a unit, so the precise context of the artifacts remains unclear. They are likely from the sediment immediately underlying the stratum with high densities of artifacts below PII and from the sediments immediately overlying PI.

Overlying PII is a unit of massive silt about 40 cm thick. The top of this unit is the modern surface which exhibits only minimal pedogenic development of a thin (< 3 cm) O horizon. The thickness and uniformity of the unit, the lack of a pedogenic A horizon and modern radiocarbon dates (TABLE 1: Beta 75094, TO-4558) all suggest recent deposition following European settlement and forest clearance in

Table 1. Radiocarbon dates from the Grand Banks Site.

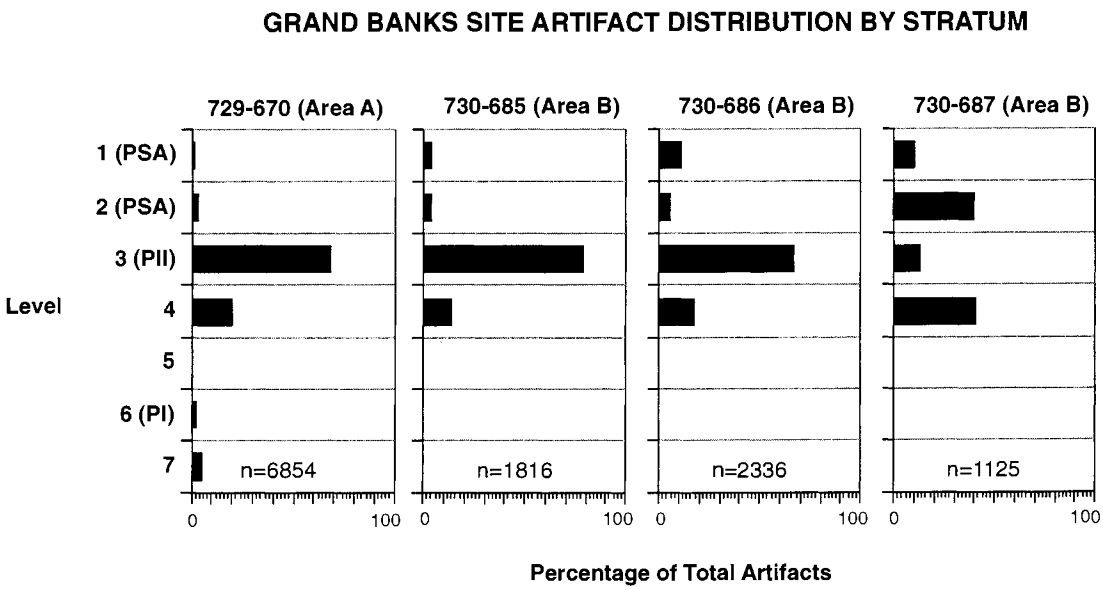
Radiocarbon lab. no.	*Context*	*Sample*	*Years b.p.*	*Calibrated date**
Beta 75094	Post	Charcoal	140 ± 70‡	A.C. 1670 (1690, 1730, 1810, 1930) 1950
TO-4558	PSA	Bean	210 ± 60†	A.C. 1740 (1660, 1780) 1810
TO-5875	Pit	Maize	970 ± 50†	A.C. 990 (1030) 1210
TO-4584	Pit	Maize	1060 ± 60†	A.C. 880 (1000) 1150
TO-4585	PII	Maize	1250 ± 80†	A.C. 650 (780) 980
TO-5308	PII	Maize	1500 ± 150†	A.C. 415 (570, 595) 670
TO-5307	PII	Maize	1570 ± 90†	A.C. 410 (535) 605
DIC-257	PI?	Charcoal	3010 ± 65‡	1379 (1259, 1232, 1227) 1126 B.C.
Beta-75096	PI	Charcoal	3120 ± 80‡	1520 (1400) 1150 B.C.

* Stuiver and Reimer (1993)
† AMS
‡ Conventional

the watershed. Post-settlement alluviation (PSA) is a common feature in floodplain sediments of southern Ontario streams (Weninger and McAndrews 1989; Willson 1993) although amounts are less, by more than 2–3 times, than those noted in some streams of the midwestern United States (Magilligan 1992). It is possible that the 40 cm represents continual accretion throughout the last 150–180 years. Gardner (1977), in his study of the 1974 flood, demonstrated that single large floods produced spatially sporadic deposition and that the amount of fine material deposited was directly tied to flood duration. Thus many overbank flows of short duration may have had little effect in terms of erosion or deposition on the outer bar of the Grand Banks site. As the floodplain aggrades, however, this would result in less erosive flows and greater preservation of cultural materials deposited in the upper paleosol. In newly formed chute channels during flooding, entrainment and transport of artifacts would have occurred. The extent of disturbance would decrease away from the chutes and on higher surfaces.

In general, less than 10 percent of the artifacts are from the PSA (FIG. 5). The artifacts are a mixture of historical and Princess Point materials. Plow scars at roughly right angles to the river bank were noted in Area B extending into PII (FIG. 4). Plowing ceased after the 1954 flood caused by Hurricane Hazel. Up to 15 cm of the PSA was probably deposited in 1954 and in subsequent flood events. The extent to which the Princess Point cultural horizon has been

Figure 5. Chart illustrating artifact percentages by depth/stratum.



plowed is unknown but it appears to have been subjected to at least partial disturbance. The small assemblage of Princess Point artifacts from the PSA is likely a result of plow disturbance of the Princess Point horizon, although bioturbation probably also contributed. Charcoal deposits resembling posts about 50 cm below the surface in Area C yielded a radiocarbon assay dating to about 200 years ago (TABLE 1: Beta 75094). These probably relate to a late 18th-century Cayuga Iroquois settlement on the Grand Banks floodplain (Faux 1985). The fact that these features and others are still intact suggests that plowing had limited impact on the cultural horizon.

The apparent absence of PI and II in Area C, along with high concentrations of artifacts, features, and posts, is explained in part by localized events. About 56 percent of the artifacts from Area C and the north end of Area B were recovered from 25–55 cm below the surface (FIG. 5). This is the same depth at which the majority of posts and features first appear. The upper 25 cm of Area C (PSA) has more artifacts (31% of the total from Area C) than the PSA in Area A, apparently because the prehistoric cultural horizon was shallower than in Area A and was affected by plowing to a greater extent. No artifacts have been recovered deeper than 70 cm below the surface in Area C.

The profile from the trench in Area B clarifies the relationship of the paleosols to the cultural horizon in Area C (FIG. 4). In the south four meters of Area B, PII is as clearly defined as it is in Area A, but in the north two meters, PII is not present. In the center of Area B, PI abruptly rises to a depth just below PII. Both paleosols feather out where they have been disturbed by plowing. PI and PII appear to have been present throughout Areas B and C until plowing began. In Area C, PI is probably relatively intact but the artifacts from PI and PII are, for the most part, mixed. Only deeper cultural features such as the pit in Area C contain undisturbed Princess Point material. In Areas B and C, PI is distinguished by the presence of coarse blocks of calcareous shale, whereas the sediments constituting PII are relatively uniformly fine. In Area A, PI contains much less calcareous shale.

Discussion

The natural and human influences on the floodplain since its inception are complex. The Grand Banks floodplain did not develop uniformly over time, and the early phases of the Grand Banks floodplain development are difficult to reconstruct. The confined nature of the Grand River in this reach limits the extent of lateral migration and exposures of resistant carbonate bedrock (Bass Island Formation) in the valley bottom preclude significant degradation. Immediately upstream the river is confined by glacial materials in a broad sweeping bend that probably results in deflection of the channel thalweg (the line following the deepest part of the river channel) towards the east side of the valley. Bedrock exposed in the channel towards the bar head results in flow divergence and the development of slack water along the west side of the valley where primary sediments accumulate. Low sediment yield combined with periodic floods could account for the lack of accumulation or removal of sediments during the early phase of bar development. In contrast, prolonged periods of sediment accumulation or aggradation to form the floodplain are generally related to two factors: 1) lower stream gradients controlled by a rising base level in Lake Erie; and 2) increased sediment supply from upstream sediment sources. The absence of large degradational floods helps preserve the accumulated sediments.

Paleosols undoubtedly represent important stable periods in floodplain development (Waters 1992: 74). The first stable period at Grand Banks began sometime prior to 1400 B.C. (3100 b.p. uncalibrated), the date of the PI hearth. Weninger and McAndrews (1989) found similar basal dates in flood-pond sediments of the lower Humber River in Toronto. Prior to this, by about 10,000 years ago, and coinciding with the onset of early Holocene cooling, the Lake Erie basin filled rapidly to 15 m below its modern level (below datum) of 173.3 m asl after which the rate of level rise decreased dramatically (Coakley and Lewis 1985: 209). Mean summer water elevation at the Grand Banks site is about 179 m asl or about 6 m above datum. By 7000 years ago water levels were 5 m below datum and they remained nearly constant until 5000 years ago (Coakley and Lewis 1985). Between 5000 and 3900 years ago, Coakley and Lewis (1985) and Coakley (1992) argue that Lake Erie rose to as high as 5 m above datum due to the abandonment of the Nippissing II outlet channel and passage of much greater water volumes from the upper to lower Great Lakes. Under such conditions, an embayment of Lake Erie would have extended somewhere between 25–43 km upstream from the current outlet. Our estimate of backwater extent is derived using a direct integration method (Hwang and Houghtalen 1996: 185) for the probable range in channel conditions (slope and bankfull discharge) and rise in Lake Erie water levels. While some uncertainty exists, the Grand Banks site (at 35 km) was very likely directly influenced by backwater effects beginning as early as 4000 years ago. In addition to eustatic changes, models of post-glacial isostatic adjustment for southern Ontario (Andrews 1989; Tushingham 1992; Clark et al. 1994) indicate a differential rate of uplift between the headwater areas (15–20 cm/100 years) and outlet (0–5 cm/100years) of the

Grand River over the interval from 4000 years ago to the present. Thus, the land surface gradient 4000 years ago was lower than at present and this would have influenced the river gradient. The backwater effects, and potentially lower river gradient, would induce aggradation of sediments and account for the incipient development of the Grand Banks lateral bar at 4000–3900 years ago.

After 3900 years ago lake level trends are not fully resolved, but the preferred hypothesis is a rapid drop in Lake Erie levels to 5 m below datum due to widening of the Niagara outlet followed by a very gradual rise (10 cm/100 years) to modern datum (Coakley and Lewis 1985). A rapid drop in lake levels sometime after 3900–3700 years ago would make the early phase of the bar accessible only to the largest floods, so PI would begin developing about this time. The radiocarbon date from PI is consistent with this model. An area of further research is to better define the lake level curve after 3900 years ago.

Another potential explanation for the floodplain stability indicated by PI is that it was a consequence of low flow conditions associated with the Hypsithermal climatic episode. Pollen records from eastern North America indicate that this interval, which is usually described as being warm and dry, persisted between 8000 and 4000 b.p. (Andersen, Matthewes, and Schweger 1989; Webb et al. 1993), but was regionally time-transgressive. Baker et al. (1992) claim that the Hypsithermal spanned 8000–5000 b.p. in Minnesota, but was later (5500–3000 b.p.) in southern Wisconsin and southern Michigan. Thus, a late Hypsithermal is likely for southern Ontario, although there is no clear pollen signature for its onset or termination here. The episode may be reflected, however, in lake level changes. Yu (1997) suggests that Crawford Lake was low between 4800 and 2000 b.p. A similar fluctuation occurred at Rice Lake (Yu, McAndrews, and Saddiqi 1996) and at Decoy Lake (Szeicz and MacDonald 1991), although at the former lake levels began rising after 3200 b.p.

PI appears to predate the transition from the Hypsithermal to what is usually considered a wetter, cooler climate. The new climatic regime, with its increased runoff and higher baseflows, would have increased the potential for flooding in the Grand River Valley (Smith and McBean 1995), and may have destabilized the floodplain. When climate became cooler and wetter after ca. 3300 b.p. in the Mississippi Valley, flood behavior changed abruptly with frequent flood events equivalent in size to the contemporary 500 year flood (Knox 1993). The timing of the partial erosion then burial of PI is presently not known, but it is tempting to assume that it was synchronous with the floodplain destabilization in the upper Midwest and, like it, was climatically induced. The assumption of a warm, dry Hypsithermal for southern Ontario has been recently challenged, however. Climatic reconstructions for the area based on oxygen isotope data from fossil wood cellulose and carbonate from lake sediments also indicate a late Hypsithermal, but one that was warm and moist, rather than warm and dry (Duthie et al. 1996; Edwards, Wolfe, and MacDonald 1996).

A second stable floodplain interval subsequently occurred, evidenced by PII which is more widely preserved on the floodplain than PI. This is because as the floodplain aggrades relative to the vertically stable active channel, overbank flows become less energetic. The equilibrium height of the bar was likely achieved by 1500 to 1000 years ago, the period when Lake Erie levels seem to have stabilized near modern levels (Coakley and Lewis 1985: 209). PII then formed. The radiocarbon dates from PII indicate that equilibrium was reached in the early part of the range, perhaps by 1500 years ago or earlier.

Again, climatic change may have contributed to the development of PII. The radiocarbon dates indicate a period of floodplain stability coincident with the Medieval Warm Epoch. This short climatic fluctuation is well documented in Europe, but there is no clear paleoenvironmental evidence for it in eastern North America. Pollen-based reconstructions of summer temperature and annual precipitation for the last 2000 years show few regionally consistent responses (Gajewski 1988). Although the large-scale, long-term climatic changes of the Holocene are well-established, the less pronounced shifts imbedded in these general patterns are not. Local pollen records show no clear climatic signal (Szeicz and MacDonald 1991); neither does a nearly 1400 year tree-ring record from white cedar (*Thuja occidentalis*) on the Niagara Escarpment (Kelly, Cook, and Larson 1994). The resolution of the former might be improved by close-interval sampling. The pollen record, however, may not be sensitive enough to reflect the relatively small and short term climatic shifts of this episode, although the pollen signature of the Little Ice Age which followed is quite strong (Campbell and McAndrews 1991).

Anthropogenesis, or human-induced ecological change, is difficult to assess at the Grand Banks site. Anthropogenesis is a prominent paradigm in discussions of domestication in eastern North America (Crites 1987; Fritz 1990; Fritz and Smith 1988; Smith 1987, 1992, 1995). In recent years, with the analysis of populations of wild relatives of the eastern complex cultigens on floodplains, evidence points to floodplains as important "domestilocalities" (Smith 1992). No evidence for domestication of plants comes from the lower Grand River, but given the floodplain setting of the Grand Banks site and its earliest evidence for crop production in Ontario, the difficulty resolving the extent of anthropogenesis there is instructive. Collection of firewood and construction material, clearance for gardens, and localized disturbance in and around the habitation site all would have influenced local ecology.

Evidence at a regional scale for anthropogenesis at the onset of crop production is limited in eastern North America. Palynology, the standard investigative technique, is frequently inconclusive and ambiguous. The separation of climatic and anthropogenic forcing as agents of environmental change, which has been effected successfully in Europe, has not been possible here. Edwards and MacDonald (1991) attribute this largely to differences in the scale of anthropogenic environmental modification. Agriculture diffused relatively late in eastern North America and forest clearance was on a much smaller scale. Around A.C. 900, southern Ontario may have had a population of only 5000, and prior to A.C. 1600 less than 0.26 percent of the land was being cultivated (Warrick 1990; Campbell and Campbell 1994). The size of North America reduces the chances of finding lakes and mires proximal to areas of human activity (Edwards and MacDonald 1991). Few studies in North America have adopted the close-sampling techniques that feature in many European investigations of human impact (Simmons, Turner, and Innes 1989; Turner and Peglar 1988). One exception is the work of McAndrews and Boyko-Diakonow (1989) at Crawford Lake, Ontario, where the varves of a small meromictic lake provide an absolute chronology for adjacent Iroquoian clearance, settlement, and agriculture.

Archaeological plant remains recovered by flotation provide a better indication of anthropogenesis (Crawford 1997). The carbonized plant remains from the Grand Banks site are dominated by maize and nuts, the latter of which include acorn (*Quercus* sp.), hickory (*Carya cordiformis*), and butternut (*Juglans cinerea*). The next most abundant group is fleshy fruits: American nightshade (*Solanum americanum*), bramble (*Rubus* sp.), ground cherry (*Physalis* sp.), and strawberry (*Fragaria virginiana*). Small numbers of chenopod (*Chenopodium* sp.), grasses (*Poaceae*), and sumac (*Rhus typhina*) have also been recovered (Bowyer 1995). This assemblage is similar to that of the subsequent Glen Meyer period in sw Ontario (G. L. Ounjian, personal communication, 1998), although fleshy fruits and nuts are represented at Archaic and Middle Woodland sites in Ontario. Nightshade, ground cherry, and strawberry are almost exclusively associated with Glen Meyer and later occupations that are substantially horticultural. These plants are likely attracted to the human impacted landscape of the Grand Banks floodplain, largely due to the increasing impact of gardening by A.C. 800–1000. The plant remains generally represent late summer and fall resources that could be stored over the winter. Strawberry is a late spring to early summer resource but could also be dried and stored. Corn would have required late spring through autumn attention and, of course, was also storable. The plant remains give no indication when Grand Banks may not have been occupied and are consistent with remains found from later Iroquoian sites that were year-round habitations.

Although this paper is first and foremost a case study in a region of secondary agricultural origins, it has some relevance to primary agricultural origins in the East. Domestication and the rise of agricultural behavior in the Midwest riverine region between 4500 and 3500 years ago is interactively linked to the evolution of riverine systems from an Early Holocene sediment removal and river incision mode to a more stable and aggrading Middle Holocene mode resulting from the Hypsithermal climatic episode (Smith 1992: 51). Much as we suggest for the Grand Banks locality, more stable floodplain environments appear to have encouraged settlements on and near floodplains and likely for some of the same reasons as they did at Grand Banks (e.g., ease of exploitation of riverine resources). In the Grand Banks case, the specific conditions of the locale can be expected to contrast with conditions in the Midwest riverine area. As in the Midwest, however, the Grand Banks floodplain bar results from processes of aggradation and stability. Our work indicates that aggradation and stability might better be assessed as separate but related processes tied to complex local and regional influences not necessarily limited to climate. Within the Midwest riverine region some variability in floodplain development is already evident. For example, on the banks of the Green River in central Kentucky are Archaic period shellmounds. Shell middens are preserved along the Green River because of restricted movement of the river in its floodplain and the sites were rarely, if ever, flooded (Stein 1982). Anthropogenesis is difficult to recognize in these long-term occupations with no apparent increase of weedy annuals relative to other remains over time (Crawford 1982, 1987). The *Cucurbita* rind recovered there is not clearly identifiable as *C. pepo*, but likely it is. Furthermore, its dismissal as a cultigen because the rind is less than 2 mm thick (Smith 1992: 41, 284) is inappropriate. *Cucurbita* rind from the Late Woodland Dymock site, Ontario, is only 1 mm thick and the only *Cucurbita* in Ontario at the time was the cultigen *C. pepo*. The central Kentucky Green River should not be ruled out as a region where plant domestication occurred. Further extensive geoarchaeological examination of specific locales where people were interacting with floodplain habitats should help to document the conditions of particular floodplain settings over time and the extent to which these settings vary.

Summary and Conclusions

Since 1993 we have been investigating Grand Banks, a Princess Point site located on the floodplain of the lower Grand River, in order to come to a better understanding of the chronology of horticultural origins in Ontario and the context in which this development took place (Crawford and Smith 1996; Crawford, Smith, and Bowyer 1997; Smith and Crawford 1995). Reinterpretation of the Grand Banks site stratigraphy in relation to settlement pattern and land use there, as well as an exploration of the site's floodplain setting, are particular concerns. The entrenched valley of the lower Grand River, and a low-energy river constrained in its lateral movement by bedrock and resistant glacial till, acts to preserve floodplain deposits. Other influences on floodplain genesis here are the Lake Erie water levels and possibly climate through time. We have identified two stable periods at Grand Banks that likely represent regional equilibria. During these periods two paleosols, PI and PII, developed. PI probably began to develop about 3900–3700 years ago and is associated with a Late Archaic/Early Woodland occupation with dates of 3400–3200 B.P. PII, with a Princess Point occupation, dates from at least 1500 years ago to the 19th century A.C. During the intervening period and the 20th century A.C. significant alluvial accumulations occurred.

Stothers (1977) appears to have been mistaken in his indentification of the three distinct Princess Point strata at Grand Banks. In fact, one area of the site has no evidence of paleosols and the Late Archaic/Early Woodland occupations are conflated due to localized variation in the lithostratigraphy and recent plowing. The Princess Point occupation is confined to PII in which no significant sediment accretion due to flooding is recognizable. During the Princess Point period the floodplains of the lower Grand River probably presented suitable locations for occupation with relatively low risk of flooding, at least compared to the period between the Late Archaic/Middle Woodland and the Princess Point occupations. At the moment we have recovered no plant or animal remains that help sort out the seasonality and scheduling issue. Animal remains are scarce at Grand Banks. The plant remains, including corn, are consistent with a year-round occupation, but still do not rule out temporary logistical relocation. Furthermore, disturbance on the floodplain seems to be indicated by weedy herbaceous plants and shrubs more closely associated with later agricultural ecology such as that of the Early Ontario Iroquoians.

The role of floodplains in horticultural origins in NE North America is still poorly understood. In addition to Princess Point, the early Late Woodland Clemson Island culture (A.C. 700–1300), the first agricultural group in Pennsylvania, is associated with the floodplains of the Susquehanna and its tributaries (Stewart 1994: 10, 188). Early Owasco occupations (Carpenter Brook phase and their Hunter's Home predecessors) in New York are situated on floodplains too (Ritchie and Funk 1973). Was there a regional window of opportunity provided by floodplain stability? At the moment, this question is difficult to answer. Regardless of the mechanism of paleosol formation, human occupation at the onset of horticulture in Ontario was facilitated by relatively stable floodplain environments. Paleosols dating to the same period and with Princess Point occupations are also found along the Niagara River. Similarly, sites with the early evidence for corn in Connecticut and SE New York appear to be associated with paleosols (Heckenberger, Petersen, and Sidell 1992) and suggest floodplain habitat stability over a large region. To what extent this is actually the case is in need of further investigation. In particular, the extent to which post A.C. 500 equilibration of water levels and regional climate shifts were factors enabling the shift to crop production in the Northeast will need much more analysis.

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