CHAPTER 2

GEOLOGICAL HISTORY AND PALEOENVIRONMENT
by Alan V. Morgan, John H. McAndrews and Christopher Ellis

Introduction

In this chapter, we place the Parkhill site into a geological and paleoenvironmental context. In addition to drawing upon the general literature on these topics for the central to eastern Great Lakes, information collected from the site and environs in conjunction with the archaeological studies is synthesized. These paleoenvironmental studies were undertaken by Alan V. Morgan (Pleistocene geology and fossil insects), J. H. McAndrews (palynology) and Andrew J. Cooper (Pleistocene geology and soils). Although much information recovered from the site pertains to time periods post-dating that inferred for the Paleo-Indian occupation, these latter events provide information on disturbance processes active at the site since Paleo-Indian times. Knowledge of these processes is essential to an interpretation of the evidence and is summarized below. Moreover, this information is important because it has been (e.g. Ellis and Deller 1986) or will be useful in providing a context for other studies of later prehistoric occupations in the area.

First, we present an overview of the geological and vegetation history of the southeastern Huron basin and adjacent areas. This overview will provide a framework into which specific project data can be placed and interpreted. Second, the project data itself is summarized and placed into the framework provided by the general overview. Finally, estimates of the age of the Paleo-Indian occupation of the site are presented and the setting of the site at that time is delineated.

General Overview

Geological History

The southern Huron basin region underwent a complex series of geological events during Late Pleistocene and post-Pleistocene times. By about 17,000 B.P. the Late Wisconsin ice sheet had begun to retreat from the Great Lakes area (Dreimanis 1977; Fullerton 1980; Karrow and Warner 1988). This retreat was accompanied by a series of pro-glacial lakes formed at the ice-sheet margins. The retreating ice first exposed the Parkhill area at ca. 13,500 B.P. during the Mackinaw Interstade. However, the region probably remained inundated by pro-glacial Lake Arkona during at least some of this period (see Eschman and Karrow 1985:83). The area was subsequently covered again by the Huron ice lobe during the Port Huron stadial readvance of ca. 13,000 B.P. (Figure 2.1). This readvance blanketed the area with the St. Joseph till (Cooper 1979:19) and obliterated most of the surface evidence of previous geological events. The most visible product of the Port Huron readvance is the Wyoming Terminal Moraine. This feature follows the orientation of the modern Lake Huron shore and occurs about 8 km to the south and east of the Parkhill site (Figure 1.2). The moraine is 4 to 8 km wide and rises to an elevation of over 800' (244 m) a.s.l. or ca. 125-200' (38-61 m) above the
surrounding terrain. After the Port Huron advance, the ice began its final retreat from the area. The Warren series of pro-glacial lakes formed between the ice-sheet and the Wyoming Moraine by ca. 12,500 B.P. and mantled the area with lacustrine deposits. The relatively well-developed Warren strandlines straddle the northwest margin of the Wyoming Moraine (Figure 1.2) at elevations between ca. 710 and 730' (216-222 m; Cooper 1979:29). Continued retreat of the ice-sheet resulted in falling water levels. At least two pro-glacial lakes, Grassmere and Lundy, formed and drained by about 12,400 B.P. These were very short-lived and consequently left little trace in the area. A poorly developed strandline which may relate to either of these lakes is traceable at an elevation of ca. 640' (195 m) to a point 14 km (8.7 miles) west of the Parkhill site (Figure 1.2) but there is no definitive evidence of these lakes near the site (Cooper 1979). All lake levels after Grassmere/Lundy are below the elevation of the

Figure 2.1: Southern Ontario at time of Port Huron Stade, ca. 13,000 B.P. Star shows Parkhill site location.

Figure 2.2: Map of modern eastern Great Lakes showing location of various drainage outlets.
<table>
<thead>
<tr>
<th>AGE (B.P.)</th>
<th>TRADITIONAL VIEW</th>
<th>REVISIONIST VIEW</th>
<th>POLLEN ZONES</th>
<th>BORRHOLSES</th>
<th>AREA F</th>
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<td>ZONE 4 (ZONE 3D) (HEMLOCK DECLINE)</td>
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Figure 2.3: Glacial history sequences comparing traditional and revisionist models of Main Lake Algonquin for southern Huron basin area and correlations with Parkhill site data. For ease of presentation, some events have been omitted such as low water stages and post-Algonquin lakes.

Parkhill site. Thus, the first opportunities for human occupation post-date ca. 12,400 B.P. However, as will be discussed later, penetration of the area by human groups probably did not take place until ca. 11,000 B.P.

The first of the lakes below the elevation of the Parkhill site, and the last of the pro-glacial series to some investigators, was Lake Algonquin. This lake, or actually a series of lakes, formed when the ice margin had retreated to a position about 100 km north of the Parkhill site. Algonquin is usually said to have had two stages but the evidence for a first phase or Early Lake Algonquin is not clear (Eschman and Karrow 1985:87-88). Those favouring its existence infer it was short-lived around 12,000 B.P. after which water levels fell much below that of modern Lake Huron. This low water Kirkfield phase was due to the removal of ice from an outlet to the east at Fenelon Falls which allowed Early Algonquin to drain southeast into pro-glacial Lake Iroquois in the Ontario basin. The Kirkfield phase ended with the closure of the Fenelon Falls outlet (Figure 2.2) due to either a minor ice readvance or isostatic rebound. Water levels subsequently rose to form the Main Algonquin stage (Figures 2.3 and 2.4).
As has been discussed in more detail elsewhere (e.g. Jackson et al. 1995; Storck 1997:248-250), there are at least two conflicting interpretations of the age of this lake stage (Karrow 1986; Karrow et al. 1975; Kaszicki 1985; Larsen 1987).

One model, which we call the "traditional" model (Jackson et al. 1995) is best expressed in Karrow et al. (1975). They propose that Main Algonquin lasted from ca. 11,200 to 10,400 B.P. (Figure 2.3). Their model has profoundly influenced past interpretations of the age and setting of Paleo-Indian sites because this time interval corresponds to the probable time of the Early Paleo-Indian occupation of Ontario (e.g. Deller 1980b; Deller and Ellis 1992a, 1992b; Roosa 1977a, 1977b; Storck 1982, 1984a, 1984b). It is argued Main Algonquin was at such an elevation that it drained for at least part of its existence through the Port Huron outlet south into the Lake Erie basin (see Figure 2.2) and that it reached an elevation of 605' (184 m) in the southern Huron basin area where the Parkhill site is located (Figure 2.4). However, with continuing ice retreat to the north, a series of outlets were uncovered at progressively lower elevations. Beginning ca. 10,400 B.P. lake levels dropped stepwise through a series of lakes (called the "Post-Algonquin group") as outlet flow switched from Port Huron to the outlets near North Bay, Ontario, and hence, down the modern Ottawa River valley. These Post-Algonquin lakes are named and include Lake Ardrea, Lake Orillia and several others.

From 10,000 to around 5500 B.P., lakes in the Huron and Georgian Bay basins (Lakes Stanley and Houch; see Eschman and Karrow 1985; Hough 1963) were much below the modern level of Lake Huron (Figure 2.5). However, by 5500 B.P. a major rise in water levels in the Huron basin called the Nipissing Phase occurred. Isostatic rebound closed the North Bay outlet and water levels rose to a level of 605' (184 m; Figure 2.6). As noted above, Karrow (1980) infers this to have been the same level occupied by the much earlier Main Lake Algonquin. Nipissing waters began to drain south through outlets such as at Port Huron. Nipissing strandlines are well-developed in the Thedford embayment area and are locally
Figure 2.5: Lake levels at time of Stanley/Hough Low Stage, ca. 10,000 to 5500 B.P.

backed by an up to 10 metre (33') high shorecliff. The lake had several major inlets at the point where major modern streams entered the embayment such as at the Ausable River and Parkhill Creek. Eventually, downcutting at the Port Huron outlet led to the lowering of water from the maximum Nipissing elevation after ca. 4500 to 4000 B.P. (Larsen 1984) until levels finally reached those of modern Lake Huron (ca. 580'; 177 m).

Although this model proposes Main Algonquin reached the 605' level near the Parkhill site, the exact local placement of the strandline is not clear. To the north of Parkhill, what this model regards as a Main Algonquin strandline can be traced. This feature is separate from, and at a higher elevation than, the later Nipissing Phase feature due to differences in their age and thus, differential exposure to the effects of isostatic rebound. In the southernmost part of the Huron basin, the Algonquin strandline cannot be easily located. It is argued that this strandline was shared here with the Nipissing Phase because there was no isostatic rebound. Rather, isostatic activity had affected only that area north of the "hinge-line" located near the modern town of Grand Bend (Figure 1.2). Therefore, the strandline is sometimes referred to as "Nipissing-Algonquin" (e.g. Cooper 1979). Yet, Karro (1980) summarized available data from the southern Huron basin and concluded that the directly dated Nipissing-Algonquin strandline in that region consisted solely of Nipissing age sediments. He stated that Main Algonquin had achieved the same elevation as Nipissing in the area at ca. 605' (184 m) but that the later Nipissing transgression had extensively reworked the Algonquin beach sediments.

In contrast to the traditional model of Main Algonquin sketched in above there is a "Revisionist" (Jackson et al. 1995) model of the age and extent of that lake and which is best expressed by Kaszycki (1985) and Larsen (1987). The reasons for these conflicting interpretations are beyond the scope of this study except to note that it is based on work which predicts different elevations in more southern areas for Main Algonquin based on southward projections from known elevations of that lake in more northern areas of the province.
Suffice to say, this model proposes that Main Algonquin drained through the Kirkfield outlet (Figure 2.7) throughout its history and never reached an elevation for drainage at Port Huron into Lake Erie. The projection also indicates that the actual southern margin of Main Algonquin did not reach the Parkhill site vicinity but instead, was located about 100 km to the north (Figure 2.7). Finally, the revisionist model argues the lake ended much earlier than in the traditional model; that is, that Main Algonquin had ended by around 11,500 B.P. (Figure 2.3) or dates to a time older than any of the large number of radiocarbon determinations now available for fluted point producing peoples throughout North America (see for example, Curran 1996; Ellis et al. 1998; Fiedel 1999; Haynes 1992; Levine 1990).

Taken at face value, this revisionist model undermines the long-standing idea of an association between Main Algonquin or any southern Huron basin lake level for
that matter, and the Early Paleo-Indian occupation of the province. However, it is worth noting that this newer model also suggests some subsequent developments which may be germane to understanding the Parkhill site geological setting. In particular, workers such as Kaszycki (1985) have also provided projections of the elevations of the subsequent Post-Algonquin lakes in the southern Huron basin. These projections suggest that due to the continuing effects of isostatic rebound, during the period of ca. 11,000 to 10,400 B.P. the levels of at least some of these Post-Algonquin lakes were above the elevations projected in this model for the earlier Main Algonquin. In particular, they suggest that the earliest Post-Algonquin lake called Ardtrrea was above Algonquin and imply that dates used by Karrow et al. (1975) to mark the end of Main Algonquin actually date Ardtrrea. They also imply Ardtrrea may have reached elevations at least as high or higher than the levels of modern lake Huron in the southern Huron basin where the Parkhill site is located. In other words, there is a distinct possibility that there were water levels in the southern Huron basin above those of the modern levels of that lake which were contemporary with the Early Paleo-Indian occupations. However, this lake was not Main Algonquin as previously thought, but instead was Lake Ardtrrea. Further, there is a possibility that the lake shoreline with which Early Paleo-Indian sites in more northern parts of southcentral Ontario are definitely associated in the ca. 11,000 to 10,500 B.P. period is also Ardtrrea (Storck 1997:248-250).

Regardless of whether the higher water levels in the Huron basin related to the Paleo-Indian occupation was Main Algonquin or Ardtrrea, it is important to note that there is evidence of higher water levels in the southern Huron basin during the period from ca. 11,000 to 10,500 B.P. One good source of evidence is the wealth of data now appearing for the Lake Erie basin to the south (e.g. Pengelly 1990; Pengelly et al. 1997; Tinkler 1993; Tinkler et al. 1992, 1994). These data strongly indicate that water had to be flowing into Erie from the Upper Great Lakes. In short, water levels were high enough in the southern Huron basin such that water was draining through the Port Huron outlet (Figure 2.2) into the Lake Erie basin. Another major source of evidence is the geological data recovered by the Parkhill project from the southern Huron basin area as will be discussed below.

In summary, based upon our reading, the major events which could possibly have affected the site area or are important from the perspective of the Paleo-Indian occupation of the site are (Figure 2.3): the Port Huron ice advance (13,500 B.P.), flooding of the area by Lake(s) Warren (12,500 B.P.); the Main stage of Lake Algonquin or Post-Algonquin Lake Ardtrrea (11,000 to 10,400 B.P.); the subsequent drop in water levels to the Stanley low stage (10,000 to 5500 B.P.) and finally, the Nipissing transgression (5500 to 4000 B.P.). Lakes Grassmere, Lundy and Early Algonquin, as well as events prior to the Port Huron advance and perhaps even Main Algonquin, either had little effect on the area, have been obliterated by subsequent events or are unimportant to the Paleo-Indian occupation of the site.

Vegetation History

As in the rest of the Northeast, inferences on the past environment of southern Ontario have been based primarily on the nature and composition of sediments, analyses of invertebrate assemblages such as molluscs and
insects and especially, pollen analysis. The dated pollen record at several sites provides an excellent means of cross-dating deposits and at the same time, yields a convenient framework with which to organize other paleoenvironmental information.

Several time-sequential pollen zones can be recognized. McAndrews (1981, 1994) scheme of four major zones is followed here. Some subzones can be delineated. Generally, these will be noted only where they are relevant to the specific data collected from Parkhill. Prior to ca. 13,000 B.P., some of the deglaciated parts of the landscape supported a short-lived, treeless (or nearly so), tundra (subzone 1a) dominated by the pollen of sedges (Cyperaceae) (McAndrews and Jackson 1988; Mott and Farley-Gill 1978). The presence of polygonal ground features (Morgan 1972) and fossil insect assemblages (Edwards et al. 1985:1724; Morgan et al. 1983:358) indicate a periglacial environment at that time with mean annual temperatures below freezing. This landscape was invaded by trees due to climatic warming (subzone 1b). The main diagnostic indicator of subzone 1b is abundant spruce (Picea) pollen. High percentages of spruce pollen (over 30%) and C-14 dated macro-fossils (Terasmae and Matthews 1980) show these trees were present by 13,000 B.P. in at least the most southerly areas of Ontario (Karrow and Warner 1988:46).

Initially, this was an open landscape spruce woodland similar to the boreal forest/tundra transition of the modern sub-arctic. The open nature of the landscape is indicated by a high percentage of herb and shrub pollen such as Cyperaceae, Gramineae and Artemisia, mineral-rich sediments (McAndrews 1981:323), and a low rate of pollen influx per unit time (Mott and Farley-Gill 1978; cf. Davis 1969:411). Comparison with modern spruce woodlands should not be taken to indicate complete similarity. For example, thermophilous deciduous tree pollen such as that of oak (Quercus) is consistently recovered. This pollen does not occur in the pollen rain of modern forest/tundra transition areas but can consist of up to 10% of the Zone 1 pollen assemblage (see Mott and Farley-Gill 1978; Watts 1983:308). Some interpret this to indicate that these trees were present as a minor component in well-drained upland localities (Karrow et al. 1975:57) while McAndrews (e.g. 1981:329) and Morgan suggest the grains were simply blown in from the south.

Although the spruce pollen zone indicates initially a widespread open landscape, through time there are decreases in shrub pollen and increases in the pollen influx which indicate a more closed vegetation cover developed at certain sites. An example is the Gage Street site in Kitchener where as early as 12,000 to 12,500 B.P., a more dense spruce cover is present (Schwert et al. 1985) although this was not a closed boreal forest. In any case, a more open spruce woodland seems to have persisted in many areas for some time. In fact, Muller (1999) recently has considered the spread of various kinds of vegetation into and across southern Ontario by compiling and interpolating data from dated pollen profiles reported at 100+ sites in the area. Using critical percentages of pollen of various species as indicators of certain kinds of tree cover (following Gaudreau 1988), he has mapped the spread of these various covers. Of note here is the mapping of the 5% Non-Arboreal (herb) Pollen (NAP) as an indicator of an open environment, as well as the mapping of spruce pollen. He found that by around 11,000 years ago, all of southern Ontario was covered by an open spruce woodland.
(sometimes called "parkland") environment. By 10,500 B.P., declines in the NAP indicate this woodland had been replaced by a closed spruce forest throughout southwestern-most Ontario from around the Parkhill area southward. However, an open spruce woodland persisted in areas to the northeast (e.g. southcentral Ontario including the location of well-known fluted point sites such as Udora [Storck and Spiess 1994] and Fisher [Storck 1997]) until 10,000 B.P. or later.

Pollen Zone 2 is marked by a decrease in spruce pollen and a peak in pine (*Pinus*). Spruce probably persisted in lower, more poorly drained areas. The change from Zone 1 to Zone 2 is abrupt on standard pollen diagrams. This transition is generally stated to have occurred around 10,600 to 10,500 B.P. This estimate is based on an average of six C-14 dated pollen profiles from northern Ohio, eastern Michigan and southern Ontario reported some time ago by Karrow et al. (1975:53) although, as we will return to later, this dating can be questioned on several grounds (Jackson et al. 1995).

Analogies are often drawn between Zone 2 pollen assemblages and southern areas of modern boreal forests. However, the high percentage of trees such as oak and other hardwoods inferred from pollen diagrams (Mott and Farley-Gill 1978:1109) suggest deviations from the modern boreal situation. Although Muller (1999) tracked individual species rather than several as is used in the zonal approach, his mapping is a useful adjunct and the mapping of the arrival of 20% pine as a significant percentage indicates a pine-rich forest had extended into the southwestern-most area of the province by 10,500 B.P. and then spread northeast into the Parkhill area and beyond after that date.

Zone 3 represents a mixed evergreen/deciduous forest of a more modern aspect. Pine pollen decreases and elm (*Ulmus*), maple (*Acer*), beech (*Fagus*), hemlock (*Tsuga*), hickory (*Carya*) and ash (*Fraxinus*), among others, increase. The transition from Zone 2 to this Zone 3 assemblage dates to around 8,000 B.P. (McAndrews 1981, 1994). Zone 3 continued until about 130 years ago. The pollen assemblages varied throughout zone 3 and four subzones can be recognized. The latest (3d) is notable for our purposes. It consists of a decline in hemlock and beech pollen and increases in pine, maple and oak around roughly 1000 B.P. (McAndrews 1994).

The final pollen zone (4) represents simply the extensive land clearance by Europeans and is marked by increases in ragweed (*Ambrosia*) and grasses reflecting more open weedy vegetation.

**Project Data**

Geological and paleoenvironmental data were collected from three main locations in the Parkhill site vicinity. First, such data were collected from Area F (Brophy Ditch), the small, linear marshy area adjacent to Paleo-Indian activity area D (Figure 1.3). Second, bore holes were made on a tributary of Parkhill Creek south of the site by A. V. Morgan to produce continuous core samples (Figure 1.2). Finally, data were collected from excavated Paleo-Indian concentrations, particularly Areas B, C and D (Figure 1.3). These separate localities and the information provided by each are discussed below. Correlations are drawn between the localities and with the general geological and vegetation history framework outlined previously.
Area F

This area was investigated in 1975. Because it was not cultivated and was surrounded by evidence of Paleo-Indian activity, it was hoped that undisturbed cultural deposits would be encountered. Moreover, the low marshy nature of the area (ca. 605-610'; 184-185m) raised the possibility that preservation of organics would provide material to allow dating of the site and to directly infer the nature of the environmental setting and Paleo-Indian subsistence practices.

The initial investigation consisted of the hand excavation of three five foot squares to varying depths. The maximum depth was achieved in the easternmost of these squares (75/270) which was taken down to ca. 4 ft. (120 cm). At 2.5 ft. (75 cm), the water table was encountered. Excavation below that level was difficult because water had to be continually pumped out. Moreover, the small size of the area made it difficult to maneuver and observe the deposits and there was a constant danger of slumping of the square walls. These difficulties, as well as the fact that even the deepest exposed deposits much post-dated the Paleo-Indian occupation necessitated a change in strategy. In order to gain a better understanding of the deposits, it was necessary to expose a wider and deeper area. A backhoe was used to expose a 19.5 ft. long by 5 ft. wide trench down to a depth of ca. 10 ft. This cut was placed just to the west of the deepest five foot square (Figure 1.3). It was reasoned that this trench would provide a quick evaluation of the potential of the area for containing Paleo-Indian deposits and if located, their stratigraphic position could be readily determined and more careful excavation could be carried out to expose those deposits.

Continuous slumping of the lower parts of the trench meant that only the upper 6 ft. could be examined in detail. However, this was sufficient to indicate that no deposits of roughly Paleo-Indian age were present. The backhoe cut showed that the deposits represent a semi-circular depression cut down into and surrounded by older deposits (Figure 2.8). This depression represented an old stream channel. In the depression itself were two main stratigraphic units. These units had been exposed to varying degrees in the five foot test squares. The uppermost unit (Unit 4) consisted of a peaty sand which extended from the surface down to depths ranging from 40 to 60 cm. In general, this unit and others to be described below thinned eastwards. This upper unit was formed in historic times by soil eroded from the surrounding cultivated fields. The dating of this unit to the historic period is confirmed by its Zone 4 pollen assemblage (Figure 2.9) as well as the fact that it contained historic artifacts ranging from a clay inkwell to fence wire.

Below the peaty sand was a peaty silt containing gastropods and tree trunk sections. This unit (Unit 3) averaged about 90 cm thick and extended down to 130 to 150 cm below the ground surface. The pollen assemblage, although somewhat poorly preserved, is Zone 3 (Figure 2.9). The uppermost 20 cm or so is Subzone 3d and should span 1,000 to 150 B.P. The lower sediments of these units are assigned to earlier Zone 3 pollen subzones. Two C-14 dates were obtained on this part of the unit. A hemlock log in the westernmost five foot square was dated at 4570+/1-95 B.P. (I-9355) and a twig sample from the bottom of the unit in the backhoe trench was dated at 5080+/6-250 B.P. (WAT-245). Thus, the earliest part and bulk of the Unit 3 deposit clearly correlates with the Nipissing transgression of ca. 5500 to 4500 B.P.
10,000 to 5500 B.P.) in the Huron basin. Below this erosional surface and the bottom of the former stream channel was a red, water-laid clay (Unit 2) which correlates with the clay encountered in excavated areas such as Area B (see below). Pollen from this clay is Zone 1 (Figure 2.9). Underlying the red clay below ca. 160-200 cm was a grey clay till (Unit 1). The clay is most likely a product of the covering of the area by glacial Lake(s) Warren around 12,500 B.P. while the till was deposited by the Port Huron ice advance (St. Joseph Till) of 13,000 B.P. Thus, these sediments much pre-date estimates of the age of the Paleo-Indian occupation of the site (see below).

In summary, Area F represents an old stream channel incised into Lake Warren sediments. The stream may have been formed in Main Algonquin or Ardtrea times. If Algonquin/Ardtrea reached a similar level as the later Nipissing transgression, then the low gradient and slow rate of flow would have eroded only a shallow stream channel. The modern peat-filled channel was eroded during the Stanley low stage which began around 10,000 B.P. The lowered levels in the Huron basin at that time increased the gradient of the

(see Figure 2.3). Since the sediment is peat and not lake sediment Nipissing itself did not enter the depression. Rather it would appear that the transgression caused the water-table to rise. The stream in the depression became sluggish so that plants falling into it formed peat. The lake itself only invaded up to a point just to the west where the gully opens up onto the Nipissing plain. From this area was recovered a waterworn end scraper with the distinctive brown patina indicating submergence in Nipissing waters (see Ellis and Deller 1986).
Figure 2.9: Lithology, radiocarbon ages and the most common fossil pollen and spores from the Area F (Brophy section; upper) and Parkhill Creek borehole #234-75 (lower). The lithology component was determined by loss-on-ignition following Dean (1974). The pollen sum was usually over 100 tree pollen; shrub and herb pollen and spores were individually added to the tree pollen counts before their percentages were calculated. The complete pollen and spores counts have been deposited in the North American Pollen Database.
stream which eroded a channel down into older deposits of Warren and possibly, Algonquin/Ardtre, age. This erosion would have removed any Algonquin/Ardtre deposits or their correlatives. Following the Stanley low stage, the rise to Nipissing levels led to a lowered gradient in the stream channel and the Unit 3 peats accumulated. During or as Nipissing drained, the stream was sluggish and deposits slowly accumulated through the time of the Zone 3 pollen assemblage. Finally, farming by Europeans caused soil eroded from adjacent fields to fill the top of the depression (Unit 4).

Parkhill Creek Boreholes

Three 5 cm diameter continuous core samples were extracted at a location on a tributary of Parkhill Creek. These core sites were located 1300 metres south of and inland from the Thedford embayment/main Nipissing lake plane and the Parkhill site itself. The boreholes were situated adjacent to a highway at an elevation of ca. 605' (184 m) a.s.l. In general, the same nine unit stratigraphic sequence was encountered in each core, a schematic version of which is included here (Figure 2.10).

The lowest unit (1) generally occurred below a 9 m depth and up to 1.5 metres of it was cored. It consisted of a clay containing abundant pebbles and granules of granite and gneiss, frequently striated carbonate pebbles and numerous sub-angular clasts. This unit is St. Joseph till deposited in the Port Huron ice advance of ca. 13,000 B.P. The associated pollen Zone 1 assemblage (Figure 2.9) is consistent with this interpretation. In some cores, the upper part of this unit (1b) had been reworked by subsequent events. Unit 2 was up to 30 cm thick and was a coarse sand and gravel with clasts up to 5 cm in diameter. This represents a fluvial deposit associated with the formation of the ancient Parkhill Creek system; it post-dates and cuts down into Warren sediments which mantle the surrounding area. During a low water stage post-dating Warren, the creek eroded the Warren sediments. Unit 2 is separated from the overlying Unit 3 by an abrupt lithological contact.

Unit 3 is a ca. 30 cm thick calcareous clay including twigs and spruce needles as well as fossil coleoptera (beetles); it is dated to 10,870 +/- 90 B.P. (WAT-376). The pollen assemblage continues to be Zone 1 (Figure 2.9). The overlying Unit 4 ranges from 3 to 4.2 m thick. It is a lacustrine deposit of a primarily grey clay except for a more silty clay near the top in some cores. Small amounts of organic detritus and a few molluscs are scattered throughout this unit. Consistent with the C-14 dates, the molluscs suggest a post-Warren age, as such fauna have rarely, if ever, been reported in Warren contexts (P. F. Karrow: personal communication). Throughout the unit, pollen indicates a continuation of the spruce zone. NAP pollen in significant percentages exceeding 10% suggest this layer was deposited in a time of relatively open tree cover (e.g. a more woodland environment). Near the top of the unit, there is an increase in pine pollen (to above 20%) at the expense of spruce, so as a whole the unit seems to approach the time of the pollen Zone 1 to Zone 2 transition.

As noted earlier, that pollen transition is dated by Karrow et al. (1975) to around 10,600 B.P. based on the average of six radiocarbon dates. There are problems in using that estimate as the date of the transition. The dates used by Karrow et al. (1975) are selective and several come from areas to the south such as Ohio where the transition would have occurred earlier.
Figure 2.10: Schematic diagram of borehole deposits on Parkhill Creek.

certainly occurred in the Parkhill area between 10,500 and 10,000 B.P.

The radiocarbon date as well as the pollen data strongly suggest that Units 3 and 4 date from around 11,000 to at least, and probably more recent than, ca. 10,600 B.P. The thickness and composition of the deposits as well as their thickness indicates they correlate to the rise to (Unit 3), or actually represent (Unit 4), a high-water level in the southern Huron basin. The age estimates agree very well with the traditional estimates for the beginning and end of Main Lake Algonquin or in the revisionist view, Lake Ardtrea (see Figure 2.3). In fact, an initiation of this level around 11,000 B.P. is consistent with recent dates on the beginning of that lake level in areas farther northward in the modern southern Georgian Bay region (Karrow et al. 1995).

Unfortunately, the top of the Unit 4 lake deposit has been eroded so the exact elevation this lake reached and how long it really lasted cannot be determined from these data alone. Given that the top of these lake bottom deposits in the cores is 180 m (590.6 ft.), this level was certainly above the level of modern Lake Huron (177 m or 580.7 ft.). We argue the placement is consistent with a strandline elevation comparable to that of the later Nipissing phase in this area of ca. 184 m. The organic deposit, Unit 3, represents a depositional event around 11,000 years ago, probably as a result of a slowing down of the creek flow associated with the rise of waters to the Algonquin level while Unit 4 represents the actual influx of Algonquin waters as far up the
old creek valley as the borehole locations. The continuing Zone 1 pollen indicates this influx occurred only a short time after the Unit 3 event. We reconstruct that a large estuary-like elongation of this lake existed adjacent to Parkhill and the other Paleo-Indian sites in the area and that it extended over a kilometre inland from the actual shore of the pro-glacial lake along the existing creek valleys in the area.

The top of the Unit 4 lake clay is disconformably terminated by an erosional episode (Figure 2.10). The fall of lake levels to the Stanley level increased the stream gradient and led to the erosion of the upper part of the Unit 4 deposits. The sediments overlying this episode represent a sequence similar to that of the Algonquin/Ardtrea incursion. The lower unit (5) is a pronounced horizon of organic materials and consists of a ca. 30 cm thick non-calcareous peaty sand and clay pond mud and dates to 5410 +/- 100 years B.P. (WAT-392). Consistent with this age is a Zone 3 pollen assemblage dominated by beech (Fagus), elm (Ulmus) and oak (Quercus; Figure 2.9). This pollen assemblage continues into an overlying mollusc-rich clayey marl (Unit 6) which was 1.6 to 1.8 m thick. The age of Units 5 and 6 is consistent with a post-glacial Lake Nipissing placement although there are indications of a Subzone 3d pollen assemblage of much later age near the top of Unit 6. The lithology contact between Units 6 and 7 is abrupt. Unit 7, up to one metre thick, is a non-calcareous peaty clay containing wood fragments. The discontinuity between this level and the underlying unit may be due to the drop in water levels associated with the Nipissing draining and hence, an erosional event due to an increased stream gradient. However, Nipissing probably deposited a beach bar across the valley where the cores were taken to form a pond. The pond persisted to Zone 3d when it filled up to form a button bush (Cephalanthus) swamp. Thus, Unit 7 represents a floodplain deposit.

Unit 8 is 1 to 1.4 metres of historic stream alluvium containing a Zone 4 pollen assemblage. The uppermost unit (9) represents a ca. 0.75 metre thick fill deposited during the construction of the nearby highway.

In summation, the boreholes revealed a long and relatively complete sequence spanning the period since Port Huron ice retreat from the area. Although there is a hiatus during the time of the Stanley low stage beginning just before 10,000 B.P., sediments are present of, or correlated to, every major high water stage except Lake Warren(s).

Excavated Areas

Some information on paleoenvironmental and geological matters was derived from the main excavated site Areas B, C and D. All of these areas had been cultivated. The plowzone averaged 20-25 cm thick. Most cultural material was recovered from this zone and it seems evident that the actual Paleo-Indian occupation levels were at some point close to the modern surface in this level. Pollen was recovered from the excavated areas at Area B near Paleo-Indian Feature 9. This pollen was sparse and poorly preserved but the analyst (McAndrews) is confident of his interpretation. A sample from the plowzone surface (Table 2.1) is assigned, not surprisingly, to the modern Zone 4. The subsurface plowzone is Zone 3 as there is no corn pollen or pollen characteristic of the more open vegetation cover associated with land clearing. This assemblage represents the nature of the vegetation cover just prior to Euro-American agricultural activities and
Table 2.1: Pollen Frequencies, Area B, Parkhill Site.

<table>
<thead>
<tr>
<th>Genera/Species</th>
<th>Ground Surface, 960/65</th>
<th>Ploughzone, North Wall 1015/60</th>
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</tr>
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</table>
represents Zone 3d.

Subsoil Paleo-Indian cultural materials were restricted to two contexts. The first included cultural features which had penetrated into the underlying sediments and will be discussed in a later section. The remaining subsoil cultural materials were in contexts reflecting post-occupational disturbances at the site. This largely included numerous root disturbances, rodent burrows and features resulting from historic period activities. An exception was some material encountered at Area D. As will be discussed in later chapters, the Area D excavations encountered concentrated Paleo-Indian materials in a southeast to northwest trending feature (assigned feature #30). This feature represents an erosional event. Plotting of the depth of the Paleo-Indian material relative to that of later prehistoric occupations in the feature shows that the Paleo-Indian materials primarily occur deeper in the sediments. There is some mixing with later materials due to the construction of features by later occupants and other disturbance processes intruding material into the sediments. Thus, most Paleo-Indian material was eroded into and concentrated in the feature before later occupations. This erosional feature trends toward Area F. The later prehistoric materials in it, and the cultural features cutting into it, are post-Nipissing in age (Late Archaic "Smallpoint"; Early Woodland). Also, the C-14 dates on cultural pits intruding into the erosional feature are on the order of 3000 to 2500 B.P. (Ellis 1994c, 1998). Therefore, this erosional episode is probably associated with the Nipissing transgression in the area and perhaps, with the fall to lower lake levels just post-dating this event around 4500 to 4000 B.P.

The unit immediately underlying the cultivated layer, and presumably at least some of the plowzone itself prior to cultivation and soil formation, represent a complex mixture of sediments. Grain size analyses and microscopic analyses of these sediments were done on samples obtained from Area B by A. J. Cooper (1975). The sediments were derived from glacial deposits and consisted primarily of a sandy loam intermixed with pockets of a silt loam. Also, in some areas, pockets of sand had intruded from underlying levels (see below) and there were some areas of laminated sands. Apparently, the "soft" nature of the sediments, combined with exposure to high loading action, led to much deformation. Although analyses were not conclusive, the loams appear to be derived from lacustrine sediment. However, some samples appear to be of aeolian origin. A sample from the sandy loam just under Paleo-Indian Feature 9 (Table 2.1) contains pollen of Zone 1 (Roosa and Deller 1982:4-5) not Zone 2 as was earlier reported (Roosa 1977a:349, 1977b:90).

Underlying the loams and sand was a red, probably water-laid, clay which correlates with the clay underlying the stream channel at Area F. At Area F, this clay overlies till. At other exposures around the site (see Cooper 1979), this till is the St. Joseph Till of the Port Huron ice advance. Thus, the red clay must post-date 13,000 B.P. Since the Algonquin, Post-Algonquin and Nipissing lakes did not flood the excavated site areas, the clay as well as the complex overlying sands and loams were probably deposited by pro-glacial Lake(s) Warren. However, it is possible that some sediments may be deposits of the short-lived Lakes Grassmere/Lundy at ca. 12,400 B.P. In either case, this means the Zone 1 pollen from under Feature 9 at Area B could be a product of events much before the occupation of the site by
Paleo-Indians. This evidence does not mean that the Paleo-Indian occupation of the site was not during the time represented by pollen Zone 1 because this zone spanned much later time. It only means the pollen sample itself is probably earlier.

In summary, the excavated areas are underlain by lacustrine clays and other sediments of a probable Lake Warren or Lakes Lundy/Grassmere age. After the draining of these lakes and before the invasion of vegetation onto their old lakebeds, the surface was probably subjected to aeolian processes including perhaps dune formation. This interpretation is suggested by the sediments of possible aeolian origin examined by Cooper (1975) and the presence of extant dunes developed on Warren deposits elsewhere in the region (Cooper 1979:35). At a subsequent time, probably after vegetation was established on the site, it was occupied by the Paleo-Indian groups.

Summary

Figure 2.3 correlates the data from Area F, the boreholes and the excavated areas with each other and presents the two general frameworks outlined earlier. Our data provides new information which documents and refines the geological and paleoenvironmental history of the area. Especially notable is the documenting of Lake Algonquin or Ardtrea sediments and the nature of the environments during at least part of the tenure of that lake in the area. Unfortunately, other than providing gross maximum and minimum age estimates, these data do not allow a firm placement of the Paleo-Indian occupations in time and by extension, into an environmental context. This age must be inferred using other lines of evidence given in the next section.

Site Age and Setting

Age of Fluted Points

Radiocarbon dates are scarce for fluted point associated occupations in the Great Lakes area. In the Western United States, dates indicate these occupations began as early as 11,500 B.P. with assemblages including Clovis points (Taylor et al. 1996). Dates on assemblages with Folsom points and the succeeding unfluted forms suggest fluted points fell out of use by ca. 10,400-10,200 B.P. (Frison 1983, 1991; Frison and Stanford 1982; Haynes et al. 1984). Acceptable dates from east of the Great Lakes place the beginning of Early Paleo-Indian occupations around 11,000 B.P. or later (Haynes et al. 1984; Levine 1990). Dates elsewhere, including some recently reported ones from sites like Arc in western New York state, also indicate the use of fluted points was abandoned shortly after 10,500 B.P. to be replaced by Late Paleo-Indian point forms (Ellis et al. 1998; Goodyear 1982).

Geochronological estimates of the age of fluted points in the Great Lakes area have proven useful and popular (e.g. Farrand 1977; Jackson 1978, 1983; Mason 1958, 1962; Meltzer 1984; Roberts 1984). The position of finds relative to landforms such as glacial till plains, moraines and pro-glacial lake strandlines has been used to suggest the maximum age of the sites. These data suggest some of these finds could be as old as 14,500 B.P. Other sites and findspots are in areas covered by ice or pro-glacial lakes until ca. 12,000 to 11,500 B.P. (Jackson 1983). At the Fisher Paleo-Indian site in southcentral Ontario a strandline crosses the centre of the site below which Paleo-Indian artifacts occur (Storck 1997). If that strandline is Main Algonquin, and if Main Algonquin
dates to only as late as 11,500 B.P. (Kaszycki 1985; Larsen 1987), then an age for fluted points more recent than 11,500 B.P. is indicated. Overall, when compared to the C-14 dates noted above, the geochronological estimates in the 14,500 to 11,500 B.P. range seem inflated.

A better estimate of a maximum possible age of these occupations is the data from Parkhill and vicinity where no fluted point sites or findspots have been found in areas which were apparently flooded by Main Algonquin/Ardtrear but at least 17 sites occur just above and lining the apparent margin of that lake (Deller at al. 1986; see Figure 1.2). The data from Parkhill indicate water levels did not rise to a level comparable to the Parkhill site until around 11,000 B.P., so the area below that level was available for human occupation prior to that time. The absence of evidence for such an occupation on the available lakebed of prior to 11,000 B.P. indicates the sites date after that time although it is possible that the rise to that lake level destroyed earlier sites. In any case, because C-14 dates indicate older fluted points in the west than in the east by as much as 500 radiocarbon years, the use of these tools overall can be interpreted as a west to east progression. Thus, given the intermediate position of the Great Lakes area between these extremes, a maximum age estimate of just before ca. 11,000 B.P. seems the most reasonable with present data.

As for a minimum age, the C-14 dates and geochronological data are complementary. In both east and west, the radiometric dates suggest fluted points fell out of use between ca. 10,500 and 10,000 B.P. Geochronological estimates are consistent with this estimate. In areas of Ontario such as the southcentral region where the strandline of Algonquin/Ardtrea can be traced, fluted points sites are unknown on its lakebed but numerous sites line the landward side of the beach (e.g. Storck 1982). The same relationship holds in other areas such as around the Parkhill site even though this distribution is related to an inferred level of Lake Algonquin or Ardtrear. Moreover, it is worth emphasizing that in the Parkhill area there is definitive evidence of Late Paleo-Indian occupation characterized by unfluted Holcombe and Plano points well within the inferred lakebed of Algonquin/Ardtrea (Ellis and Deller 1986). Because this lake drained around 10,400 B.P., fluted points pre-date that draining and a shift to the use of unfluted point forms probably occurred shortly thereafter as was the case in the west. Therefore, as a whole, an age range of 11,000 to 10,400 B.P. is viewed as a very good estimate of the antiquity of fluted points in the Great Lakes area.

Age of the Parkhill Site

With the above age estimates, it is possible to provide more specific suggestions as to the environmental setting at Parkhill during the Paleo-Indian occupation. As noted earlier, the pollen from Unit 4 in the boreholes strongly suggests the lake persisted to at least, and most likely more recently than, 10,600 B.P. in the Parkhill area. On this basis alone, the area predominantly had a spruce zone cover during the time span suggested above for the occupations. Further, other lines of evidence suggest an occupation in the spruce zone.

First, as suggested earlier, the spruce zone seems to have persisted beyond the 10,600 B.P. estimate long attributed to it by Karrow et al. (1975) and in some areas certainly extended beyond even 10,000 B.P. (e.g. McAndrews
1984:170; Miller and Morgan 1982; Pilny et al. 1987:618). The variation in dates of that transition can be most easily seen to be due to the time-transgressive nature of the event. That is, the replacement of spruce by pine occurred roughly first in the southwest of the southern Ontario peninsula and then spread northeast (see Bernabo and Webb 1977; Jackson 1978; Muller 1999; Roberts 1984). Therefore, it is most likely that the spruce vegetation persisted to 10,500 B.P. in more northerly areas such as at Parkhill and as noted earlier, Muller's (1999) mapping of the rise of pine pollen above 20% strongly suggests the transition had to occur after 10,500 B.P. in that area.

Second, some of the variation in the dating of the spruce/pine zone transition seems to be due to specific locational factors beyond latitude. For instance, there is evidence that spruce vegetation and its associated insect fauna persisted longer in areas such as along pro-glacial lake shorelines including Algonquin/Ardtrea perhaps due to the cool winds blowing off the pro-glacial lakes. It is evident for example, in the consistent appearance of arctic-alpine insect species at lake marginal sites (Ashworth 1977:1633; Morgan et al. 1983:358). Again, Parkhill's location on a strandline make it likely the spruce zone persisted to at least if not beyond ca. 10,500 B.P. in the site vicinity.

Finally, there are excellent data which indicate the specific fluted point phase represented at Parkhill is not the latest in the Great Lakes area (see Deller and Ellis 1992b; Ellis 1994b; Ellis and Deller 1997). Rather, Crowfield points (see Deller and Ellis 1984) seem a better candidate for a terminal fluted point status, given their close resemblances to unfluted, demonstrably post-Algonquin/Ardtrea (Ellis and Deller 1986), Late Paleo-Indian, Holcombe forms. In short, the industrial complex represented at Parkhill, pre-dates the suggested ca. 10,400 B.P. terminal date for fluted point use in the region. Elsewhere, it has been speculated that the Parkhill Paleo-Indian industry dates to 10,800 to 10,500 B.P. (Deller and Ellis 1988) although we should stress these are radiocarbon years – there is growing evidence that much more than 300 sidereal years is represented in these radiocarbon time periods (e.g. Curran 1996; Ellis et al. 1998). In any case, granted these estimates of the age of the site, again, this evidence increases the probability that Parkhill was occupied during a vegetation cover contemporaneous with Units 3 and 4 identified in the Parkhill Creek boreholes and as such, this information has a direct bearing on the setting of the site when it was occupied.

Setting of the Parkhill Site

Turning to the physiographic setting of the site, and of major importance, the Parkhill Creek boreholes revealed deposits representing a high water level in the southern Huron basin during the ca. 11,000 to beyond 10,500 B.P. period. Although such a high water level has long been expected based on work farther to the north (Karrow et al. 1975), the Parkhill cores provide the first directly dated evidence of this high water level in the southernmost part of the basin. Regardless of whether they represent Main Algonquin or a Post-Algonquin Lake Ardtrea, these deposits indicate an inlet to the lake was present at the mouth of Parkhill Creek adjacent to the Parkhill site and that the strandline of this lake approached or was identical to that of the later Nipissing transgression.
The physical setting of the site, and specifically, the elevation reached by the waters of this lake, is not easily discerned because of the erosion of the top of the Parkhill core deposits and the fact they are lake bottom sediments -- we only know it went above modern Huron levels and reached at least 180 m a.s.l. However, we believe that the lake of the 11,000 to post-10,500 B.P. period did reach the level of 184 m long attributed to it and thus, it is possible to use modern topography to sketch in the lake near the site area (see Figure 2.11). The nature of the modern Parkhill Creek valley where the bore holes with the lake deposits were found would have constricted the waters. Therefore, a large estuary did form extending up that valley from adjacent to the site on the southwest to a considerable distance inland. At the very least, the presence of lake deposits 1.3 km inland from the Thedford embayment up the Parkhill Creek valley south of the site indicate there is no doubt the Parkhill site was adjacent to a lake, and a lake estuary at that, at the time it was occupied; this evidence refutes claims to the contrary (e.g. Storck 1997:250). As will be discussed in a later section, the setting of the site beside a major water crossing is very similar to those seen amongst modern northern hunters as they intercept groups of caribou impeded and slowed by crossing the waters (e.g. Loring 1997).

The paleoenvironment of the lake itself is poorly known. Studies of lake deposits of this age have revealed that life was present in the lake. Several species of molluscs and ostracodes are reported, including species indicating boreal and cold-water near shore conditions (Karrow et al. 1975, 1995) which is expected in a proglacial lake. Indirect evidence indicates fish were present in the lake (Karrow et al. 1975:65) and were undoubtedly pursued by Paleo-Indians but it is unknown just how common these were and how important they may have been in Paleo-Indian diets.

Turning to the vegetation cover of the time, as previously noted, the pollen identified in the boreholes includes substantial percentages (over 10%) of non-arboreal pollen such as sedges (Cyperaceae), grass (Gramineae) and other herbs (Figure 2.9) throughout both units 3 and 4 suggesting the site was occupied by an open vegetation cover throughout that time span. This interpretation is consistent with Muller's (1999) mapping of critical percentages of non-arboreal (NAP) pollen alluded to earlier which also indicates that the area remained quite open until around 10,500 B.P. However, the relatively high percentages of spruce pollen in the units (ca. 40 to 60%) indicates trees were present in the area (e.g. it was by no means a tundra), probably restricted to more sheltered areas. The presence of spruce needles in Unit 3, which represents the slowing of the creek as water levels rose to the Algonquin/Ardtrea level, indicates these trees were present from the beginnings of this high water stage and corroborate the pollen evidence.

The fossil coleoptera remains from at least Unit 3, some implications of which were reported elsewhere (Morgan 1988; Morgan and Morgan 1980; Morgan et al. 1982, 1983), also corroborate the pollen and plant macro-fossil remains from that layer. Species in this small micro-fauna include: a ground beetle of the family Carabidae (Bembidion mutatum G & H), an aquatic beetle of the family Gyrinidae (Gyrinus bifarius Fall), a rove beetle (Acidota quadrata Zett.), and bark beetles of the family Scolytidae (Ips borealis Sw. and Phloetritius piceae Sw.). These species characteristically inhabit a diversity of habitats in tree-line and
than in modern areas and especially to find asynchronies between the plant and insect species probably because the insect species are able to colonize newly available areas faster than the plant species and may be more accurate indicators of climatic conditions (Morgan et al. 1983:357-358; Schwert et al. 1985:223).

In any case, at least initially around 11,000 to 10,800 B.P. the coleoptera species suggest an open spruce woodland with many available micro-habitats although we do not know how long in time this persisted into the subsequent Unit 4 time when actual lake waters invaded the prehistoric Parkhill Creek area beside the site. For what it is worth, the Eighteen Mile Creek site located about 35 km due north of Parkhill has a similar insect assemblage indicating comparable conditions to Parkhill persisted there until at least ca. 10,600 B.P. (Ashworth 1977). Regardless, the Parkhill data indicates such open environments were present in the area at the time of fluted point users of ca. 11,000 to 10,400 B.P. regardless of whether or not the Parkhill site perhaps was occupied precisely at the time of the preserved lake deposits. There have been some who have argued that Early Paleo-Indians inhabited only boreal forests in the Northeast/Great Lakes (Custer and Stewart 1989) but the Parkhill borehole data and several other recent studies (e.g. Karrow et al. 1995; Muller 1999) refute such a polemic. A diversity of environments seem to have been lived in by Early Paleo-Indians in southern Ontario ranging from open woodlands earlier on which persisted longer in more northeasterly areas, to boreal forests later in time and in the southwesternmost areas (Deller and Ellis 1988; Ellis and Deller 1997).
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