PRECERAMIC SETTLEMENT-SUBSISTENCE STRATEGIES IN THE LAKE ONTARIO BASIN

by

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Preceramic Setttlement-subsistence Strategies in the Lake Ontario Basin

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ABSTRACT

The archaeological sites used in this research are located in four study areas along the north shore of Lake Ontario and span over 6,000 years from the late Pleistocene to the middle Holocene. During this relatively short period the climate improved and the environment evolved from an open "tundra-parkland" to an essentially modern mixed deciduous forest. Palaeo-Indian and Archaic cultures must have adapted their settlement-subsistence patterns to suit the different conditions. According to widely accepted theory, the late Pleistocene Palaeo-Indians of northeastern North America had a focal economy based on caribou and other large game, and were only opportunistic foragers where other food resources were concerned. Because of their presumed focus on caribou predation, Palaeo-Indians have been compared to subarctic Athapaskan, Algonkian, and Inuit groups. Thus, it has often been assumed, implicitly and explicitly, that the environment of Palaeo-Indians in the Northeast was similar to the subarctic tundra and boreal forest. The palaeo-geography of the Northeast, and of the Ontario Basin in particular, indicates, however, that this may be a misleading analogy, for there was considerably more environmental diversity in the early post-glacial period than now exists in the subarctic. As a more modern biome developed, the subsequent Archaic cultures practised "primary forest efficiency" and became hunters, fishers and collectors of a variety of plant foods, shellfish, and other game.

This research investigated the focal-diffuse theory by comparing the terrain of Palaeo-Indian and Archaic sites (and their settings and vicinities) with each other and with a control sample of randomly chosen locations. It was assumed that as the environment changed, the adaptive strategies and related cultural site selection processes must have changed as well. Thus, some terrain variables of archaeological sites should differ from control locations and should also change over time, as new adaptive strategies were adopted.

The results supported these assumptions and also revealed some consistent terrain patterns that are thought to have been related to adaptive strategies.

The maximum relief of archaeological sites decreased with time and their soil was coarser and better drained than control locations. Small stream density and marsh density were higher in archaeological site areas and increased with time. These data generally support the focal-diffuse theory; but, there are some suggestions that the Palaeo-Indians of the Ontario Basin may not have been entirely oriented to caribou predation. Small and large stream densities and marsh density were often significantly high suggesting a more diffuse strategy based principally upon a littoral adaptation. This suggests that fishing and the exploitation of other littoral species, both plant and animal, was probably developed at an early date.

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DEDICATION

To Donald G. MacLeod, who encouraged me; and, my mother, who helped make it possible.

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CHAPTER 1

INTRODUCTION

This terrain analysis of archaeological sites and their environs provides geographic information about human environmental adaptation and the evolution of settlement-subsistence behavior in northeastern North America during the late Pleistocene and early Holocene. In turn this information sheds light on several current theories of cultural distribution, subsistence economy, and adaptation to a dynamic environment.

Following deglaciation *circa* 12,000 BP, southern Ontario was continously occupied by Amerindian cultures from *circa* 11,000 years BP (Dumont, 1981; Roberts, 1985). Over time these cultures have been hypothesized to have adapted to environmental change by shifting their subsistence strategy from focal big-game hunting (Funk *et al*, 1970) and opportunistic foraging, to a diffuse pattern involving a variety of mammals, plants and fish (Cleland, 1976; Funk, 1978). Subsequent late Holocene cultures became increasingly dependent upon horticultural crops. Few prehistorians would dispute this general hypothesis, but empirical archaeological evidence leading to tests of the focal-diffuse model is rare, especially in the Northeast where Archaic and Palaeo-Indian sites are seldom preserved, due to acidic soil conditions, a generally moist climate, and extensive agricultural disturbance (Savage, 1981; qtd. in Peers, 1985). Furthermore, few of the thin scatters of lithic debris, which seem to characterize early Holocene sites, have been excavated (Roberts, 1985). However, if these societies selected sites to minimize the cost of aquiring resources (Jochim, 1976), as modern hunter-gatherers do (Lee, 1969), then some of this behavior should be reflected by terrain analysis and the environmental aspects of site locations. If their decisions are based on rational law-like principles, then at least some of the physical characteristics of their site area were intrinsically important. Considered in the light of the focal diffuse theory mentioned earlier, it is unlikely that a single variable would always be crucial to the decision making process, and certainly prehistoric hunter-gatherers did not recognize site terrain, as such, in the same terms or units as the writer. However, they must have assesed the merits of different sites and and different site areas for specific purposes at certain times, and this must have been ultimately related to some combination of physical factors which produced favorable conditions for a subsistence strategy. Thus, the settlement-subsistence data produced by this analysis are an important contribution to to our understanding of human environmental adaptation in the Northeast.

Regional settlement studies, using northeastern North American archaeological data, are still concerned primarily with site distribution patterns rather than the physical terrain of the actual site areas. Due to the pragmatic requirements of cultural resource management legislation many are directed at predictive modelling for site discovery purposes or regional sampling problems. Consequently, few prehistorians, working with these data, have been directly concerned with site area as an entity that can be measured and compared to those of other periods, or "average" places characteristic of the sub-region.But the technique of terrain analysis from aerial photographs and maps has already been developed for site discovery purposes and some cultural analyses. Vita-Finzi (1978:14) has noted:

> "Now and then we may come across a topographic change which is in itself an adequate explanation of a hiatus or drastic change in the pattern of settlement... morphological studies often form the basis of analyses that go beyond mere topography...the aim should be to isolate and exploit the full range of information that can be derived from the physical record, while holding in reserve evidence from other sources until the time is ripe for corroboration."

In view of the scanty and incomplete nature of archaeological remains from the Northeast,this statement illustrates the value and necssity of empirical data relating to early settlement-subsistence change. For, unhappily, there are not, as yet, sufficient archaeological data to test adaptive models in a wholly deductive context. It is not the intent of this study to "let the facts speak for themselves", or to observe phenomena in the absence of theory. However, it is necessary to gather empirical data which, when interpreted in the light of these theories, can provide an inductive test.

CHAPTER 2

THEORETICAL CONTEXT

2.1 The Development of Spatial Analysis in Archaeology

Prehistoric settlement pattern analysis is one of a number of inter-related studies including: territorial ethology, regional ecology, locational economics and architectural theory (Clarke, 1977). Many prehistorians concerned with site distributions have noted that a geographical approach is fundamental to spatial analysis (Redman, 1973; Clarke, 1977 ; Trigger, 1978). Some of the earliest spatial analyses of prehistoric sites were by the Austro-German school of "anthropo-geographers" (1880-1900) who used formal mapping techniques to study the distribution of artifact attributes in light of a "Social-Darwinist" and "environmental determinist" paradigm in which diffusion was a central concept employed to explain cultural change (Clarke, 1977; Moran, 1979). These were deductive studies which constrained the available data to fit a favored theory.

In the 1950s British prehistorians developed an economic and ecological approach (Clark, 1952;1954) that was later influenced by the spatial theories of geographers (Haggett, 1965; Chorley and Haggett, 1967; Chorley, 1969). As a result a new, more empirical, interest in spatial variables such as: density, agglomeration, scatter, extent, shape and topography emerged (Hodder and Orton, 1976; Higgs and Vita-Finzi, 1972; Clarke, 1977). This was a more productive approach and resulted in an improved understanding of subsistence economies and permitted the development of hypotheses of human adaptation. The success of this approach illustrates the importance of an inductive approach and empirical data when a paucity of data precludes more deductive studies (Beveridge, 1957).

In North America the geographical influence was not as strong and the emphasis of prehistorians was on taxonomy and classification (Taylor, 1948). But, from its early stages interpretation of cultural adaptation used an ethnographic paradigm (eg. Morgan, 1877). Some of the first attempts at summarizing indigenous settlement patterns employed informal, or unstated, theory and implicit assumptions derived from anthropological analogy (Willey, 1956; Ritchie and Funk, 1973; *cf* Williams *et al*, 1973). In the Northeast, for instance, Ritchie (1932) virtually defined the "Archaic" period on the basis of ground stone tools from Lamoka Lake and other large sites with deep deposits. At that time, without the benefit of radiocarbon dating, he tacitly assumed that such sites were single occupation villages, inhabited year-round by a relatively large population. Unstated here was the assumed analogy with Late Woodland Iroquoian groups whose history was better known as a result of the written records of the *Jesuit Relations*. Now, however, these "large village" sites are recognized as a palimpsest of seasonal multi-component occupations spanning many centuries. Similarly, because Ontario Palaeo-Indians lived in relative proximity to the retreating continental glaciers and are believed to have been dependent on caribou, their environment and settlement-subsistence pattern has been widely interpreted in light of ethnohistoric Athapaskan and Inuit analogues. This analogy is still widely held (tacitly or explicitly) despite the fact that the southern Ontario environment of their day must have been much more similar to today' environment than to any subarctic or arctic environment, past or present. As well, the direct evidence of caribou predation is still rare and inconclusive.

One of the first North American studies to produce a regional ecological interpretation was accomplished by Steward (1938) who based his reconstruction of the Shoshonean seasonal economy on ethnographic reports. More recently, Thomas (1972) built on this foundation and extrapolated the analogy into prehistory to produce one of the first predictive settlement-subsistence models. This direct historical approach has had some success with relatively shallow time depths. For instance, cultural and adaptive studies of the Huron and other proto-historic groups have been able to blend archaeological data with historical data to produce insights into settlement-subsistence changes.However, there are many inherent pitfalls in attempting to study similar changes in the earlier Archaic and Palaeo-Indian period through ethnological analogy, the direct historical approach, and the tacit assumptions of previous archaeological theory.

In a study based on Thomas (1972), Williams *et al* (1973) point out that most settlement-subsistence research has mainly been at a "gut" level (*eg*. Streuver, 1968), and they emphasize the neccessity of operationalizing intuitive concepts by objectively framing them as testable hypotheses. They point out that there is real value in quantifying terrain features to test implicit "gut" assumptions of settlement-subsistence strategies which have often implicitly been held for generations.

Geographers such as Von Thunen, Christaller and Weber (Haggett, 1979) developed models and theories to explain the distribution of population centers in terms of distance to resources, markets and neighboring centers. These models assume that a modern market economy, often based on nested heirarchical settlements, characterizes the culture under study. As well, they assume that rational economic decisions seek to maximize income while minimizing cost (Zipf, 1965). Hunter-gatherer economies on the other hand, do not seek to maximize income, but to satisfy pre-determined aspirations of security and seasonal aggregation (Jochim, 1976). Thus, the application of these models to the Archaic and Palaeo-Indian period would likely produce misleading results. Furthermore, "cost" in a hunter-gatherer society is a term relative to cultural values. Traditional geographical models also assume the landscape is occupied contemporaneously, while prehistorians must be satisfied with a cultural site distribution current to a particular, and often relatively broad, period (*circa* 1000 years or more). Consequently, the only direct application of traditional geographical models to archaeological distributions are in an historical, proto-historical, or Iron Age context (eg. Hodder and Orton, 1976).

However, geographical theories of spatial organization have influenced some prehistoric applications, primarily through the concept that the environment presents economic choices to a society and that the society must respond with rational planning. The concentric zones of landuse and activity described by Von Thunen, and elaborated by Weber and Christaller, assume an increase in energy expenditure with distance from a center (Haggett, 1965). This principle is recognized, at least implicitly, as a factor in the economic strategies of modern hunter-gatherers (Binford, 1983; Lee and Devore, 1969).In conjunction with later geographic theory (Chorley, 1969), this inspired "site catchment" analysis (Vita-Finzi and Higgs, 1970; Higgs and Vita-Finzi, 1972). Thus, as a result of geographical theory, prehistorians recognized the concept of "optimal site location" and realized that rational economic planning created a regular pattern of landuse centered on a residence (Clarke, 1977).

2.2 Hunter-Gatherer Settlement-Subsistence Theory

As stated earlier, there is very little direct archaeological evidence relating to the settlement-subsistence pattern of Palaeo-Indian and Archaic cultures of the Northeast, and Ontario in particular. However, general models of hunter-gatherer behavior and motivation have been developed, and hypothetically these can be extended back to the late Pleistocene and early Holocene.

Two types of theory are discussed in the following sections: a) models of the economic behavior of hunter-gatherers; and, b) frameworks for terrain analyses.

2.3 Models Of Hunter-Gatherer Behavior

Recently, ecological anthropology and ethnoarchaeology have provided theories that pertain directly to prehistoric hunter-gatherer settlement-subsistence and spatial organization. These are general models and, although they use specific societies as illustrations, they are attempts at a universal synthesis. They were inspired by ethnological studies of the !Kung Bushmen (Lee, 1969; Vayda, 1969) and the desire to develop nomothetic models of hunter-gatherer behavior that could be used to interpret Hominid fossils and artifacts.

Jochim (1976) has summarized the factors affecting hunter-gatherer behavior. These principles are grounded in the assumption that all economic decisions result from carefully considered rational planning, and are not normally due to spontaneous or random action. Also, hunter-gatherers seek not to maximize resources, but only to aquire enough to satisfy predetermined goals and aspirations. Furthermore, the desire to keep activity to a minimum and to exploit resources at the most efficient time are motivating forces that require hunter-gatherers to schedule their activities in accordance with seasonal availability and collection and processing efficiency. To maintain a safe subsistence resource level these societies used mixed collecting strategies and contingency plans which considered alternate sources that may have been more costly to collect or process but were more reliable.

Two goals to which hunter-gatherers aspired were (*ibid*):

1. Security: a safe level of food and manufacturing resources that could be reliably and cheaply acquired.
2. Aggregation: concerns the cultural neccessity to aggregate , at least seasonally, to fulfill social and religious ceremonies.

The principles of hunter-gatherer economic behavior can be summarized as follows (*ibid*):

* People aspire to live well while maintaining energy costs to a comfortable level.
* If two options are available hunter-gatherers will exploit both, emphasizing the more efficient or reliable, even if more costly in terms of processing (security goal).
* Hunter-gatherers will use two or more resources if available, but only if they are at their most efficient stage for collection (security goal).
* Distance is a determining factor in economic decisions.
* Big game hunting is a high risk activity, but has high returns and is capable of satisfying the "aggregation goal". Big game hunting was also a high status activity and was especially important for social reasons.

2.3.1 The Spatial Organization of Collectors and Foragers

Binford (1980) has made a significant contribution to the theoretical understanding of hunter-gatherer societies. Based on ethnographic studies, his model is essentially nomothetic and is specifically intended for archaeological studies of place. According to his theory the adaptive strategies of hunter-gatherers are either "foraging" or "collecting" patterns depending on environmental conditions. The former are exemplified by the !Kung Bushmen, the latter by the Nunamiut Eskimo. "Foragers move consumers to goods, with frequent residential moves, while collectors move goods to consumers with generally fewer residential moves." (Binford, 1983:349)

Foragers store very little food and gather food daily on an encounter basis. Their foraging pattern resembles a "daisy" with a residence at the center and daily expeditions, limited in extent to approximately 10 km, forming the petals. When the resources around the residence were exhausted the base camp was moved to another resource "patch". Alternatively, specialized work parties would go further afield on an overnight excursion. The foraging strategy was only possible because resources were ubiquitous and their subsistence strategy did not require major seasonal adjustments. If these characteristics are essential to the definition, it seems unlikely that either Palaeo-Indians or Archaic people were "foragers" , for resources capable of satisfying hunter-gatherer goals and aspirations could not have been ubiquitous, and seasonal adjustments certainly must have been necessary. Of importance to archaeologists is the fact that foragers create only two types of sites: base camps and "locations". Both of these had low archaeological visibility due to short-term occupation and the limited tool-kit required. This is accentuated by the fact that the sites were rarely used in subsequent rounds (Binford, 1980).

Collectors like the Nunamiut did not occupy environments with ubiquitous resources and could not rely on chance encounters to aquire food. Instead, they established a residential base near the resource with the greatest bulk demand and used logistical task groups to access other locations. Seasonal variety was an important consideration and food had to be stored at least part of the year. Significant to archaeologists are the many types of sites generated by specific activities: base camps, locations, field camps, work stations and caches. Since these sites were likely to have been occupied or used seasonally, year after year, they have greater archaeological visibility.

Assuming the aspirations and behavior summarized by Jochim (*ibid*) are largely true, and in view of the archaeological data we do have (summarized in following chapters), it would seem that both Palaeo-Indian and Archaic cultures could be classified as "collectors". But, is it necessary that these two settlement-subsistence strategies be lumped together? There may be other (sub)categories that would better suit them, because, as the following chapters show, the climate, environment, and essential food/manufacturing resources all changed markedly in the relatively short time (*circa* 6,000 years) spanning the two periods.

Using data on hunter-gatherer mobility derived from Murdock (1967), Binford (1980) has estimated that full mobility and a nomadic foraging strategy characterizes 75% of tropical hunter-gatherers and 64% of those in semi-tropical environments. However, full mobility is only characteristic of 9.3% of those in warm temperate environments and 7.5% in cool temperate. Clearly, this quality attenuates rapidly as latitude increases and it is difficult to imagine any prehistoric society in northeastern North America with full mobility and a true foraging strategy - except briefly, perhaps in the summer months.

2.3.2 Primary Forest Efficiency

"Primary forest efficiency" is an economic model designed to explain cultural evolution within the Archaic tradition. The essential premise is that as climate and environment changed new resources and procurement strategies were developed resulting in an increasingly successful adaptation. The new strategies involved a gradual shift from a narrow range of resources at the beginning of the Archaic to a wide range at the end (Caldwell, 1958).

2.3.3 Focal Diffuse Model

The focal diffuse model is an attempt to explain cultural adaptation as a continuous gradation from a highly specialized economy to a generalized pattern of resource exploitation (Cleland, 1976). This model is a logical extension of primary forest efficiency, and was similarly developed from palaeo-environmental models. Palaeo-Indian and Early Archaic are usually considered to be focal adaptations. Thus, their economy is believed to have been centered on a few species of large game which were abundant, consistent and of high nutritional quality. Storage, by means of freezing or drying, is essential to a focal economy (this was certainly an option open to these people). Diffuse adaptations, on the other hand, select from scattered and varied resources because there is no single consistently available, high quality resource to provide an economic focus. Archaic cultures are believed to have developed an increasingly diffuse economy as a result of the ecological diversity of their environment. The key to a diffuse subsistence pattern is a flexible annual schedule allowing alternative collection strategies. Tool inventories are larger than those of focal societies and although base camps may be quite stable, mobility between resource sites is required. Diffuse adaptations promote territorialism and group variability and lead to the development of exchange systems which allow ideas and material to diffuse rapidly (*ibid*).

As stated earlier, the focal economy of the Palaeo-Indians of the Northeast is believed to have been based on caribou, and other large game animals such as wapiti, moose and possibly extinct mega-fauna (Funk *et al*, 1970). According to the "primary forrest efficiency" theory, the settlement-subsistence pattern of the Archaic groups are believed to have been diffuse strategies: dependent upon big-game such as deer, moose, wapiti and bear; but also, increasingly, upon fish, nuts, small game, and numerous edible plants.

In the absence of an adequate body of archaeological artifact data to test the focal-diffuse model, it is possible to use archaeological site location data instead; for surely if the two strategies were undertaken in different environmental contexts, they would have required the conscious selection of a different suite of terrain features. The following section describes two studies which have attempted this type of analysis and two additional studies which were based on similar assumptions and method.

2.4 Frameworks For Terrain Analyses

A recent approach to site catchment analysis has been reported by Tiffany and Abbot (1982). An underlying assumption of this method was that the occurrence of a site on any given portion of land was a function of the diversity of the local environment. In other words, the greater the potential diversity of an area the more extensive and complex was its use by prehistoric groups. The procedure involved first preparing a reconstuction of the prehistoric vegetation based on current soil maps. Secondly, an overlay of concentric circles of fixed radii, representing 50 m to 500 m, was superimposed over the vegetation map at selected locations and the numbers of different floral species known to be present in each circle were totalled. Later, those areas with "high" scores were surveyed for archaeological resources, apparently with encouraging results (Tiffany and Abbot, 1982). This study used no control sample for comparison, and the radii of the catchments were too small to effectively investigate site setting or vicinity.

This technique was refined by Schermer and Tiffany (1985) using a more rigorous and controlled procedure. In this study "diversity" was evaluated statistically to see if it was greater than would be expected if the sites were located randomly. Woodland sites (n=108) and random controls (n=100) were used and the comparisons were tested by CHI-X and t-tests. Schermer and Tiffany (1985) also quantified the terrain from a vegetation reconstruction based on soil maps.As well, they used an overlay of concentric circles with fixed radii to tally potential reources, however the radii were larger in this case: 100 m, 500 m and 1000 m. The results of their tests suggesed that: a) the mean environmental diversity of archaeological sites was greater than random control locations; b) sites are disproportionately located on certain landforms (*eg*. river terraces); and, c) on the whole, sites are closer to a water source. This study was an improvement over the former because of the use of a control sample and the larger catchment areas which better represented site "setting" and "vicinity". However, there was no attempt to explain why sites were located on specific landforms, and the restriction of the archaeological sample to a single, narrow, time period (Late Woodland) precluded any study of adaptive change. A weakness common to both techniques however was the initial decision to attempt a reconstruction of the palaeo-vegetation on the basis of soil maps. This must result in a very generalized thematic map because it is based on a thematic map which has already simplified the data.

An alternative to quantifying terrain from a vegetation reconstruction was the "topographic" approach which was essentially an attempt to measure the relation between topographical features and regional site density. The advantage of this technique was that real, tangible, variables were measured instead of estimated from a hypothetical reconstruction. Recently a topographic predictive model developed by the Public Archaeology Facility of the State University of New York (SUNY) was tested by Curtin (1981). Although inspired by "traditional, intuitive and internalized understanding of site locations" (Curtin, 1981:89; *cf.* Williams *et al*, 1973) this approach used a pragmatic technique of measuring, scoring and stratifying a region according to its potential to contain prehistoric sites. The underlying assumption of the SUNY model was similar to the forementioned methods: as the heterogeneity of topographical features increased, so did the potential for prehistoric subsistence activity (Curtin, 1981).

The SUNY method superimposed a grid of hexagons, each one square kilometer, over a drainage basin and scored each hexagon by the presence or absence of specific surficial features. (Hexagonal units were used because they pack evenly and have more neighbors because they have more sides.) The unit scores were weighted by the presence of a known site within a unit or a neighboring unit. These ordinal scale scores were transformed to nominal values (high or low potential) and used to stratify the region. To test the accuracy of his predictions Curtin (1981) selected 20 units. Of these units, 10 were selected probabilistically, 7 judgmentally, and 3 because sites were reported from them. The results confirmed the expectations of the model. All of the probabilistically chosen units with high scores produced sites, while only 2 of 5 low probability units did. In general, there was a strong tendency for the "highs" to have a high site density, and the "lows" to have a low site density. Statistical tests on the whole sample, and the probabilistic sub-sample, indicated that the results were not due to chance.

Roberts (1980) too has employed a "topographic" approach to study the relation between site location and topographic variables in Halton County, Ontario. His procedures, which were developed in over a period from 1974 to 1980 (Roberts, 1977; 1982) involve the measurement of distance from the centre of an artifact cluster to a terrain feature (*eg*. a stream). Archaeological sites (n = 157) spanning the period from Palaeo-Indian to Late Woodland were compared to random locations (n = 50). From a slate of many variables, three were statistically significant: a) soil drainage; b) distance to nearest stream; and, c) the order of the nearest stream. Site catchments were not used in this study, a site was considered to be a "point" where artifacts were recovered.

The approach used in this study is a combination of that of Schermer and Tiffany (1985) and Roberts (1980) because their research addresses the same essential question: what landforms or terrain features did prehistoric cultures select to carry out site-creating activities? Roberts' study is the most relevant because it is specifically aimed at cultural adaptation to a changing environment. Furthermore, it was undertaken in the same study area and some of the same site locations are used in this research.

Schermer and Tiffany (1985) were ultimately concerned with site discovery, for cultural resource management purposes, so their study was not explicitly of cultural adaptation nor was it a "topographic" approach. However, like this research, it did use a random control sample and concentric catchment areas to condsider the "site" in the context of its setting.

The studies of Curtin (1981) and Tiffany and Abbot (1982) are less relevant because they were not concerned with cultural adaptation, but one of the pragmatic concerns of cultural resource management: site discovery. However, both use similar methods and the SUNY technique is "topographic". More importantly, both explicitly state a fundamental assumption shared here: terrain with higher levels of environmental diversity or heterogeneity, was preferred by prehistoric societies.

Although the purposes of these four studies varied, they were all successful in providing information to advance more elaborate hypotheses, and they underscore the value of empirical data and, at least initially, some form of inductive approach.

2.5 Terrain Analysis Method

The method used in this study was inspired by the topographical approach of the SUNY technique but, instead of relying solely on topographical maps, it also used aerial photographs, soil maps, and land capability maps as data sources. Like Schermer and Tiffany (1985) a series of concentric catchments were employed, but their radii were increased to better approximate areas of "site" "setting" and "vicinity" in order to investigate the relative importance of terrain variables in a spatial context. Furthermore, by using a sample of archaeological sites from different cultural periods it was possible to consider adaptive changes over time. The terrain variables selected for measurement were also different from previous studies (or were defined differently). For instance, instead of "distance to nearest water" this method measured the density of each stream order for each concentric catchment. Other variables included: average slope, maximum relief, soil texture and drainage and the density of marsh, swamp and cliff. In addition to these improvements the objectives of this method differed from many previous studies because the intent was not site discovery, but interpretation of environmental adaptation and change.

2.5.1 Summary

Contemporary spatial theory in prehistory stems from British and American schools of thought: the former concerned with site distribution; the latter with ethno-anthropology and archaeological taxonomy and classification. Geographical theories of spatial order can be applied to archaeological distributions only if one has precise chronological control and sound evidence of prehistoric economies. Some, for instance may be applicable with proto-historic Huron site distributions in southern Ontario. Since these criteria are seldom met, this approach precludes most prehistoric distributions - on both continents. The British economic approach to prehistory (for example Clark's [1954] work at Star Carr) and the environmental approach of Steward and Willey were, however, complementary, and contemporary spatial theory is a blend of these histories and a more inter-disciplinary approach. Ethno-anthropology gave insight into the motivations and economic strategies of modern hunter-gatherers, and recently ethno-archaeology (e.g.Binford, 1980; Jochim, 1976) has produced universal theories of settlement-subsistence behavior that can be tested with a Mesolithic or Archaic site sample.

CHAPTER 3

PALAEO-ENVIRONMENTAL CONTEXT

It has been noted that cultural change through time cannot be explained without a paradigm that includes climatic change (Butzer, 1978) because climate directly affects the environment, and floral and faunal communities must adapt and evolve as well. In turn, this causes a change in cultural settlement-subsistence strategies. Consequently, it is necessary in this chapter to "set the environmental stage" which provides the context of this research. Although archaeological data from early sites in southern Ontario are rare and incomplete, there are other sources of data suitable for a hypothetical environmental reconstruction: astronomical theory, surficial geology, palynology, and palaeontology (coleoptera studies).

3.1 Palaeoclimate

In the last decades astronomical theory of climatic change has become the operational and conceptual paradigm of Quaternary palaeoecology (Davis, 1984), because the original hypothesis of Milankovitch, once thought untestable, has been substantiated by new research and techniques (Covey, 1980; Davis, 1984; Ruddiman and McIntyre, 1981). An important finding, relevant to this study, is that the end of the last ice-age came quickly, because glaciers take much longer to build up than to melt (Kerr, 1983; Covey, 1984). The rapid deglaciation produced the dynamic environments inhabited by Palaeo-Indian and Archaic people. According to oxygen isotope data from the Bay of Biscay, one third of the continental ice had melted between 16,000 to 13,000 years ago, and solar insolation is believed to have been similar to or greater than today (Kerr, 1984). Between 13,000 to 11,000 years ago (the period when Ontario first became occupied) the retreating ice sheets paused due to surging and ice-plasticity, but continued to thin because the solar insolation rate was higher than today (Kerr, 1983; Kutzbach, 1983).

Another implication of the data supporting Milankovitch's theory is the concept of multiple thermal maxima rather than a single "hypsithermal" event (Davis, 1984). The idea of a single event developed because pollen analyses indicated a warming environment for several milenia after *circa* 8,000 BP (Sears, 1948; Deevey and Flint, 1957). However, because the pollen analyses used were particularly sensitive to increased insolation in the late summer, warmer conditions at other seasons were not indicated. As a result pollen data have often been seemingly incongruent with the dated remains of thermally sensitive insects found in earlier sediments (Schwert and Morgan, 1980). Maximum solar insolation advanced through the seasons with late spring insolation at its maximum approximately 17,000 BP, early summer at approximately 13,000 BP and late summer about 5,000 BP (Davis, 1984; Kerr, 1983).

3.2 Palaeoecology

3.2.1 Forest Reconstruction

Palaeo-ecological interpretations have relied mainly on pollen analyses. This technique was first developed to explain the evolution of the European forest, and was then applied directly to North America (Sears, 1948; Deevey and Flint, 1957). This European or "Blytt-Sernander" model, consisted of the "Pre-Boreal", "Boreal", "Atlantic" and "Sub-Atlantic" periods (Salwen, 1975).

Since this model was introduced, a significant body of palaeoecological data for the Northeast has been sampled and analysed (Davis, 1969; McAndrews, 1981; Schwert and Morgan, 1980; Bernabo and Webb, 1977). The sequence of forest evolution for Ontario, developed by McAndrews (1981) from studies of fossil pollen and modern analogues, is widely accepted today.

* Zone 1 is the earliest, appearing immediately after deglaciation (*circa* 13,000 BP), and is characterized by *Picea* (spruce) pollen and that of herbs such as Cyperaceae (sedge), Gramineae (grass) and *Artemisia* (sage). These assemblages are contained in a mineral-rich sediment and suggest a "tundra" environment. However, spruce needles are frequently

found as well which indicates that open forest conditions existed. It is important to this study to realize there was some latitudinal variation and some *Quercus* (oak) and *Pinus* (pine) and small quantities of other arboreal deciduous pollen are present in sediments from southern Ontario. Palaeo-Indians occupied southern Ontario during Zone 1.

* Zone 2 began approximately 10,000 BP and coincided with the advent of the Early Archaic culture. The demise of *Picea*(spruce) and the abrupt ascension of *Pinus* (pine) was the essential characteristic of this stage. Although herb pollen in the core samples is minimal there was more latitudinal variation and *Quercus* (oak) was well represented in samples from southern Ontario, as well as some pollen of *Acer* (maple), *Betula* (birch), *Carya* (hickory) and other arboreal species.

* Zone 3 begins about 7600 BP and is the period when Ontario was occupied by Middle and Late Archaic as well as the Early Woodland people. This period sees the addition of many more deciduous arboreal species and the establishment of *Acer* (maple) and *Fagus* (beech) as principal forest components. For the first half of this zone *Tsuga* (hemlock) was also a principal component. The rapid decline of *Tsuga* fossil pollen has been interpreted as the result of an epidemic.

* Zone 4 begins about 3000 years BP and continues to the present day. In this period southern Ontario was occupied by people of the Woodland tradition. Forest composition was essentially similar to Zone 3 except for prominent peaks of *Ambrosia* (ragweed) and Graminaeae starting about 200 BP which represent the development of agriculture on a large scale by European colonists. The smaller scale horticulture of the preceding Late Woodland culture was marked by small peaks of maize (*Zea*) pollen in some core samples.

Many archaeologists have misconceptions about the prehistoric environment (Dumont, 1981), and the fact that deglaciation was swifter and earlier than first thought has not always been appreciated. New insect and vertebrate finds (Schwert and Morgan, 1980; Churcher and Peterson, 1982) lead to the conclusion that although dominated by spruce and birch, the environment of the Palaeo-Indians exhibited greater species diversity than palynological evidence alone suggested. Thus, southern Ontario during the "Spruce" (Zone 1) and "Pine" (Zone 2) periods may not have been as species deficient as the contemporary tundra and boreal forest. For, as Davis (1969) has pointed out, the modern boreal forest has no clear southern antecedent; and some ancient environments have no modern analogy (Gutherie, 1985). Some misconceptions about palaeo-habitat has been caused by over-simplification and the uncritical use of analogy to modern environments (Fitting, 1968; Starbuck, 1977).

3.3 The Late Pleistocene and Holocene Environment of the Lake Ontario Basin

The following section provides an outline of a number of dramatic changes that took place in the Ontario Basin, over a relatively short period of time. These had considerable effect upon the settlement-subsistence strategies of the "pioneer" cultures, as well as the extant archaeological record. These changes effected the climate and weather, river drainages and lake levels as well as the character and evolution of the floral and faunal communities.

The palynological sequence of the Holocene established for Ontario can be explained within a tri-partite division: late Pleistocene/early Holocene (11,000 to 9,000 BP), middle Holocene (9,000 to 4,000 BP) and Late Holocene (4,000 BP to present) (Wright, 1983). The first division corresponds to the Palaeo-Indian and Early Archaic periods; the second to the Middle Archaic, and the third to the Late Archaic and Woodland periods.

3.3.1 Early Lake Ontario

The level of Lake Ontario fluctuated many times during the late Pleistocene and Early Holocene. Southern Ontario became habitable about 13,300 BP during the Mackinaw Interstadial but in the Ontario Basin the Port Huron readvance about 13,000 BP precluded potential occupation. By 12,600 BP the Port Huron ice withdrew but still blocked the St. Lawrence to create glacial

Lake Iroquois which was forced to empty through the Rome outlet in New York State. Sometime between 12,000 and 11,800 BP the ice receded and the low-water Duck-Galloo phase of Lake Ontario ensued (Johnston, 1978). Subsequently, the Greatlakean Stadial caused a readvance (or halt) of the ice blocking the Covey Hill Gap on the St. Lawrence and led to a second high-water phase known as the Frontenac, Sydney, Belleville and Trenton sequence (Johnston, 1978; Sutton *et al*, 1972). After Covey Hill deglaciated, the ice withdrew to the northeast and eventually, about 10,500 BP, the Upper Great Lakes began to drain into the Champlain Sea through the North Bay outlet and the Mattawa/Ottawa system (Karrow *et al*, 1975; Terasmae, 1980; Dreimanis, 1977). Thus the low-water Admiralty phase in the Lake Ontario basin (15 m amsl) began sometime before 10,150 BP (Karrow *et al*, 1961).

The Dune phase of Lake Ontario characterized most of the middle Holocene until about 5,000 BP when modern levels were achieved (Roberts, 1985). After about 10,150 BP isostatic uplift in the St. Lawrence trough caused the level of Lake Ontario to rise slowly creating the Dune phase. Sutton, (*et al*, 1972) and Karrow (*et al*, 1961) have documented a number of shallow water features relating to this period approximately 20 m below the present lake datum, in the vicinity of Toronto, and have calculated an average age of 5,025 BP for the termination of the Dune phase. These features represent an early stage of Lake Ontario prior to isostatic uplift closing the North Bay outlet and the Upper Great Lakes draining through the St. Clair River (Sly and Prior, 1984). This caused many early and middle Holocene (littoral) archaeological sites to be inundated. This effect was more predominant in the western end of the basin because the uplift was more pronounced in the northeastern end of the basin (Roberts, 1985). This creates a serious skew in the archaeological site data prior to *circa* 5,000 BP which is uncorrectable and must be considered when interpreting the results of terrain analysis.

3.3.2 Climate and Temperature

According to a model of atmospheric circulation based on astronomical theory, Kutzbach (1983) estimates the mean global July temperature at 10,000 BP to have been 7% greater than today. By 9,000 BP he estimates that the northern hemisphere had a summer temperature 7 degrees Celsius warmer than today and experienced 7% more precipitation (see also Kerr, 1983; Davis, 1984). However, Kutzbach's model does not include the peri-glacial influence of the continental ice sheet which lingered until about 6,000 BP in northern Quebec occupied parts of the Canadian Shield in Ontario during the Palaeo-Indian and Early Archaic periods. Although inland areas of North America experienced a higher rate of summer insolation , the extensive ice sheets may have negated higher temperatures. In summer the high albedo of the ice sheet probably led to the formation of a cool air mass which deflected the warm maritime tropical air mass that is now dominant in the summer months (Kutzbach, 1983). Thus a cool moist climate may have prevailed, especially in the first half of the early Holocene, despite the increased rate of summer solar insolation. In winter, the ice sheets which covered most of the Canadian Shield would have trapped frigid arctic air in the polar regions and inhibited storms and blizzards, because any air that did flow southwards would be warmed adiabatically as it descended the ice cap (Kutzbach, 1983; Knox, 1983). As well the pressure differences created continent-wide between the reflective surface to the north and the bare surface south of the ice sheets may have resulted in strong "March-like" winds throughout the year (Knox, 1983). There are reliable well-dated data however from southern Ontario and the Northeast that suggest that the periglacial effect of the waning ice was of short duration, probably preceding human occupation. This includes the consistent presence of small amounts of pollen from temperate deciduous species in core samples dating to 12,000 BP, and the climatic implications of thermophilous Coleoptera fossils and plant macrofossils from sediments deposited in periglacial times.

At first the periglacial effects of the waning ice sheet would still have influenced the climate of southern Ontario (Knox, 1983) but the remaining ice attenuated rapidly and disappeared by about 6,000 BP. However, the influence on the climate during the Palaeo-Indian and Early Archaic periods was apparently not great. The summer and late summer temperatures were greater than today due to an increased rate of solar insolation (Kutzbach, 1983) and this resulted in increasingly warmer and drier conditions in the growing season, which caused a shift of the general character of the forest from pine/oak to a coniferous-hardwood phase and probably contributed to the increase in the hickory (*Carya*) component of many habitats.

3.3.3 Early Vegetation

Palynological evidence has consistently indicated that plant species now known only from arctic or alpine regions were present in southern Ontario in the late Pleistocene and early Holocene (McAndrews, 1981). This, in conjunction with the paucity of pollen from temperate arboreal species has led to the conclusion that tundra and tundra-parkland characterized the environment (Davis, 1983). Although there is certainly a similarity, the use of the word "tundra" is perhaps misleading: for late Pleistocene and early Holocene environments in general have no modern analogy (Davis, 1969; Gutherie, 1985). As insect fossils are often a better indication of rapid climate change than pollen, in southern Ontario and the Northeast in general, they suggest that conditions favorable to temperate arboreal species existed before they were able to migrate into the area (Schwert and Morgan, 1980). Although the predominance of spruce (*Picea*) and non-arboreal plants such as sedges (Cyperaceae), sage (*Artemisia*), avens (*Dryas integrafolia*) and grasses (Gramineae) in the early Holocene are evident throughout the study area, there was a variety of other species as well. Although the evidence is not abundant, the presence of these plants indicate that a variety of micro-habitats existed, and therefore the potential resource base available to late Pleistocene and early Holocene cultures was more variable than that of tundra or boreal forest. The pollen record of the early Holocene often includes small amounts of pine (*Pinus*), oak (*Quercus*), elm (*Ulmus*), ash (*Fraxinus*), birch (*Betula*), ironwood and sugar maple (*Acer saccharum*) (Davis, 1983). Mott (1977) reports that maple (*Acer*) and beech (*Fagus*) were present in southern Quebec between 8,000 and 9,000 BP but their presence was masked by the predominance of pine (*Pinus*), hemlock (*Tsuga*), and birch (*Betula*) pollen. According to Bernabo and Webb's data (1977) a deciduous Carolinian forest was established in southwestern Ontario by 9,000 BP, and in south-central Ontario and northern New York State by 7,000 BP. The presnt boundary (or ecotone) between the Canadian and Carolinian forest zones is along the north shore of Lake Ontario and it seems likely that an ecotone existed there prehistorically as well. Although hickory (*Carya*) was late in colonizing most areas of the Northeast, it was present in the Great Lakes region as early as 10,000 BP (Davis, 1983). More recently, Churcher and Peterson (1982) report small quantities of pollen representative of temperate deciduous trees in association with a new genus of fossil deer. The fragmentary cranium and antlers of this animal (*Torontoceros hypogaeus*) were found in Toronto in sandy deposits laid on the newly exposed bench post-dating Lake Iroquois and were dated to 11,315 ≤ 325 C-14 years BP. Although the pollen associated with this specimen was predominantly spruce (*Piceae*), pine (*Pinus*), and sedge (Cyperaceae) there was also representation of oak (*Quercus*), hazel (*Corylus*), birch (*Betula*), poplar (*Populus*), elm (*Ulmus*), alder (*Alnus*), hickory (*Carya*), willow (*Salix*) and larch (*Larix*). Linden (*Tilia*) and dogwood (*Cornus*) also were sparsely represented, even though these are species which are now at their northernmost range in the Toronto area. Churcher and Peterson (1982) conclude that this early Holocene deer lived in a mixed hardwood-coniferous environment. This evidence agrees with a proposal that the newly exposed lake bed created by the initial low-water phase of Lake Ontario provided an avenue for pioneer deciduous forests (Roberts, 1985; Dreimanis, 1977).

Based on these well-dated data it is clear that the Ontario Basin littoral, even when the waning ice-front was a few hundred kilometers distant, was anything but "periglacial" in the modern sense: arctic and alpine tundra. Palaeo-Indian caribou hunters in southern Ontario during the "spruce" period did not face the environment that faces modern subarctic and arctic caribou hunters, and they had many more options open to them in terms of alternate resources and strategies. Similarly, the Archaic cultures in the "pine" period did not operate in a boreal environment, as we know it today.

In addition to arboreal species there was also a diversity of herbaceous and aquatic plants in the potential resource base. Because recovery of pollen of these plants was not the object of most palynological studies (and many do not preserve well), the implications of their presence is often overlooked (cf. Gutherie, 1985). These species have been best represented by their macro-fossils. At bogs such as the Winter Gulf site and the Nichol's Brook site elderberry (*Sambucus*) was the most abundant macro-fossil in all zones, and many species of aquatic plants were abundant even in the lowest levels. Evidently marsh conditions began at these sites (on the south shore of Lake Ontario) immediately after deglaciation when the ice-front may have been less than 100 km to the north (Calkin and McAndrews, 1980). The presence of aquatic plants soon after deglaciation is relevant to this study because many species are edible (*eg* wild rice, cattail, water lily, and arrowroot). As well, they provide manufacturing material (for wattle, mats and baskets *etc.*) and create an environment attractive to a variety of mammals and birds. They are reliable resources, often available in quantity throughout the growing year. For these reasons aquatic marsh resources were important both ethnohistorically (Fernald and Kinsey, 1943) and prehistorically.

3.3.4 Faunal Resources

From the discussion above it is clear that there was considerable floral richness in the region in the late Pleistocene and early Holocene. The Ontario landscape in the centuries immediately after deglaciation was evidently an open or park-like environment characterized by spruce (*Picea*), sedges (Cyperaceae), sage (*Artemisia*), avens (*Dryas integrifolia*), and grasses (Gramineae) with thickets of willow (*Salix*), alder (*Alnus*) and poplar (*Populus*) (Davis, 1983; Bernabo and Webb, 1977; Terasmae, 1980). But, there were developed marsh environments and micro-habitats where temperate deciduous species flourished (including nut trees). Also the newly exposed bed of Lake Iroquois was colonized at an early date by a deciduous hardwood forest.

This environment supported a variety of big game animals: mammoth (*Mammuthus columbi*), mastodon (*Mammut americanus*), musk-oxen (*Ovibos*), caribou (*Rangifer tarandus*), grizzly bear (*Ursus arctos*), moose (*Alces alces*), wapiti (*Cervus elaphus*), deer (*Odocoileus virginianus* and *Torontocerus hypogaeus*) and (probably) black bear (*Ursus americanus*) (Stoltman and Baerreis, 1983). Mammoth and mastodon however were likely extinct, or rare, by 11,000 BP when the Ontario basin first became occupied by humans (Semken, 1983), and are therefore not considered part of the potential resource base in this study. Because faunal remains are rare in Northeastern sites the subsistence economy of late Pleistocene and early Holocene cultures is hypothetical and largely based on indirect evidence (Peers, 1985). In view of available climatic and environmental data (Kutzbach, 1983; Schwert and Morgan, 1980; Churcher and Peterson, 1985) it seems unlikely that barren ground caribou (*Rangifer tarandus*) would be prevalent along the north shore of Lake Ontario in Late Palaeo-Indian times. Noble (1972) concurs with this view arguing that Woodland Caribou would be a more likely resource. Thus, the Palaeo-Indian people of the Ontario Basin probably depended upon a combination of woodland caribou (*Rangifer caribou*), moose (*Alces alces*), wapiti (*Cervus elaphus*), bear (*Ursus americanus*), and deer (*Odocoileus virginianus* and *Torontocerus hypogaeus*) as well as a variety of smaller mammals such as beaver. Significantly, the (small game) mammalian fauna of Hosterman's Pit in Pennsylvania (9,290 BP) is modern in every sense, while the faunal assemblage at the New Paris Sinkhole #4, only 80 km to the north and dated at 11,300 BP, has a strong "boreal" character (Semken, 1983).

No late Pleistocene or early Holocene fish assemblages are known from the Northeast, but due to cold water temperatures and turbidity resulting from river down-cutting it seems likely that many river-spawning species, at least, were not present (Stoltman and Baerreis, 1983; Muller, 1977). Ironically, the earliest fish remains are from the Palaeo-Indian Shawnee-Minisink site in Pennsylvania, but there are only a few elements represented and the species have not been identified.

The mammalian fauna of this period were essentially modern although species such as woodland caribou (*Rangifer caribou*), moose (*Alces alces*), and wapiti (*Cervus elaphus*) may have been more common than now or during the Late Holocene.

With the rising lake level and the resultant infilling of river valleys (Knox, 1983) fish resources became well established and some economically important species were abundant (Cleland, 1982).

3.3.5 Summary

Flora and fauna of a tundra nature first colonized the study area immediately after deglaciation and persisted, in a parkland form, until about 11,500 BP when human occupation was possible. The early Lake Ontario shoreline was much lower when "pioneer" Palaeo-Indian and Early Archaic groups arrived (in the late Pleistocene and early Holocene) and the lake littoral was probably already colonized by hardwood deciduous trees, although spruce, and later pine, dominated within a few kilometers of the present shoreline. In the subsequent Middle Archaic and Late Archaic (middle Holocene) lake levels rose and inundated previous littoral archaeological sites, at least until about 5,000 BP. Since that time lake levels remained essentially modern through the Woodland period (late Holocene).

Although Palaeo-Indians and Early Archaic cultures lived in a "periglacial" context, and the waning ice sheet influenced weather patterns and geological processes, the environment was not arctic tundra or subarctic boreal forest. The solar insolation rate was then higher than now, especially in the late spring and early summer. Temperature was more similar to modern conditions than any high latitude environment. As a result of good, well-dated, data from palynological studies (including plant macro-fossils) and research into thermophilous coleoptera, it is clear that many modern plant communities had been established even when the ice was only a few hundred kilometers away. Thus, the earliest Palaeo-Indian economic strategies could have chosen between a wide variety of seasonal resources: including nuts, deer, and aquatic species usually associated with later Archaic economies.

CHAPTER 4

PRECERAMIC CULTURAL CONTEXT

This general reconstruction of the cultural context is based on archaeological data from Southeastern and Northeastern North America as well as from southern Ontario. Southern Ontario (indeed both North and South America) was a *tabula rasa* after deglaciation. If there were any previous human occupations their impact upon the environment has not been preserved in any archaeological site. Consequently, Palaeo-Indians may be considered as North America's first "pioneers", and the uniformity of the technolgical remains of the first widespread "Clovis" horizon is remarkable and attests to the exploring aspect of their culture. Faunal remains from sites on the Great Plains and elsewhere indicate an adaptation focused on extinct mega-fauna such as mammoth and giant bison. In the Northeast however, they are believed to have been primarily caribou hunters.

4.1 Palaeo-Indian

The preservation of organic remains is rare in Northeastern Palaeo-Indian sites due to the scant nature of the deposits and acidic soil conditions. As a result there are only a few radiocarbon dates (Haynes *et al*, 1984) and little direct evidence of subsistence. In southern Ontario there are no direct C-14 dates and the evidence of their subsistence economy is entirely hypothetical (Peers, 1985). Although most prehistorians accept a "generalist" interpretation of northeastern Palaeo-Indians as occasional foragers (Ritchie and Funk, 1984), most also believe their economy was focused on caribou (Jackson, 1982; Speiss *et al*, 1983;Peers, 1985).

The direct evidence for the northeast as a whole consists of: a calcined distal caribou phalanx (*Rangifer tarandus*) from the Holcombe Beach site in Michigan (Fitting *et al*, 1966); uncalcined caribou teeth, phalanges and long bones from the Dutchess Quarry Cave site (Funk *et al*, 1970); and calcined caribou bone fragments from the Whipple site in New Hampshire and the Bull Brook site in Massachusetts (Speiss *et al*, 1985). (see Fig. 4.1 on page 35 for a map of the sites mentioned in the text. Holcombe Beach is undated but is considered to be a late Palaeo-Indian or Early Archaic site (Storck, 1982). The Dutchess Quarry Cave specimens have been dated to 12,580 BP but are only weakly associated with Palaeo-Indian artifacts (Funk *et al*, 1970) and the bone from the Whipple site has been dated to 10,680 BP (Speiss *et al*, 1985). Caribou remains from non-archaeological contexts have been reported from deposits of Lake Iroquois age by Coleman (1899) and Savage (1981; qtd. in Peers, 1985).

The Shawnee-Minisink site in Pennsylvania has produced calcined beaver and fish bones and charred hawthorn and plum pits from a hearth associated with Palaeo-Indian lithics (Kauffman and Dent, 1982). The only other direct evidence of the exploitation of species other than caribou is reported by Ogden (1977) who recovered a wapiti rib perforated by a Palaeo-Indian point from Silver Lake in Ohio; and beaver bone from the Bull Brook II site (Speiss *et al*, 1985). Haynes (1980) has noted that many Clovis sites of the southern plains (remarkable for the remains of extinct mega-fauna) also included elements of many smaller species such as hare and antelope.

4.1.1 Palaeo-Indian Site Location

The indirect evidence of a focal adaptation on big-game hunting in the Northeast is based on two general criteria: the nature of the lithic tool-kit, and the implications of site location. The lithic tools of Palaeo-Indians are functionally limited and are consistent with such primary activities as hunting, butchering, hide processing and working bone and wood (Stoltman and Baerreis, 1983; Peers, 1985). Sites tend to be small, with a low density of artifacts, suggestive of the focal requirements of small highly mobile bands (*ibid*).

Funk (1978) has noted that Palaeo-Indian sites in the Northeast are associated with good vantage points on well-drained hills and rises, often close to sources of lithic material. Similarly, Dumont (1981) remarks that they are found in highlands near large bodies of water on well defined knolls, terraces and ridges. These observations are seen as indirect confirmation that the sites are small hunting camps and look-outs and are examples of tacit assumptions held for generations (see page 5).

The interpretation from southern Ontario data, however, is somewhat different because most surveys here have been oriented to relict shorelines with little systematic survey in other areas. As a result, the data appear to confirm an adaptation to ancient shorelines. This type of bias illustrates the potential danger of a rigid deductive approach when there is a small (empirical) data base.

Deller (1976) has located a number of Palaeo-Indian sites along relict shorelines of pro-glacial lakes Algonquin, Whittlesley and Warren above modern Lake Huron. Although these sites were not necessarily contemporaneous with the lakes, he believes they were situated there to take advantage of caribou who browsed and migrated along these shorelines . Storck (1982; 1984) concurs, although he suggests that by Late Palaeo-Indian times the quarry inhabiting the re-vegetated lake beds may have been moose, wapiti and deer. Storck (1984) notes that most sites have an uninterrupted view of both the strand and the hinterland beyond, presumably to observe game movements. However, he qualifies these observations by noting that most Palaeo-Indian surveys in Ontario are oriented to post-glacial beaches, and thus the regional distribution may be biased. Jackson (1979; 1982) has studied the location of a large number of Palaeo-Indian sites and find-spots (many with only township provenience) and concludes that a typical site is in a low-lying plain with modest relief in a major river valley, in areas of pro-glacial lake sediments, usually on sand or till plains with sandy soil. He notes that palynological reconstructions indicate these were spruce, and spruce-parkland environments at the time and may have been favorable habitat for caribou. Actually many of the southwestern Ontario Palaeo-Indian sites would have been well north of the spruce/pine transition line *circa* 10,500 BP (see Berbabo and Webb, 1977) when they are believed to have been occupied. Therefore, a transitional type of environment was more likely in southern Ontario. Certainly the littoral (probably ecotonal) environment of early Lake Ontario, with walnut and palaeo-deer dated *circa* 11,000 BP, was much differet than Jackson suggests.

Loring (1980) has mapped a series of Palaeo-Indian sites in Vermont along the fossil beaches of the Champlain Sea and after summarizing the evidence for abundant marine mammals, he suggests that Palaeo-Indians may have adapted to a marine-based economy (seals and beached whales) for at least part of the year. To date however there are no archaeological data to support this contention; indeed, no Palaeo-Indian sites have been located on Champlain Sea beaches in Ontario or Quebec.

4.2 Archaic Subsistence

Although archaeological data from southern Ontario relating to Archaic settlement and subsistence are more abundant than that for the Palaeo-Indian period, it is still necessary to build the interpretation from Southeastern and Northeastern information.

The Archaic was initially identified on the basis of "traits": variety and abundance of lithics, bone tools, and burials; as well as the presence of copper tools and the absence of pipes (Ritchie, 1932). The hallmark of the Archaic however has always been the appearance and abundance of ground stone tools (Willey and Phillips, 1958). As dating methods improved, archaeologists realized that the "Archaic" was a tradition of continous development which spanned over 6,000 years.As a result the adjectives "early", "middle", and "late" were used to categorize the stages of development. The Early Archaic was marked by a shift from lanceolate to stemmed, notched, or barbed projectile point types, as well as the introduction of awls, adzes, gouges, and grinding stones (Ritchie and Funk, 1973). The Middle Archaic was characterized by a rise in the number of ground stone tools, and the introduction of atlatl weights, grooved axes, pendants and pestles (Chapman, 1975). Late Archaic innovations included improved methods of hafting, borers, stone boiling, the use of wild cereals, effective methods of fishing (by line, weir, and net) and trapping small mammals, acorn processing, and the use of sleds, watercraft, and dogs (Hayden, 1982).

Only recently have prehistorians accepted that an Early Archaic phase existed in the Northeast although it was well established in deep stratified sites in the Southeast (Fowler, 1959; MacDonald, 1971) There had appeared to be a "hiatus" between the Late Palaeo-Indian period and the flouresence of the Late Archaic. Fitting (1968) attributed this to the species-impoverished pine forest that characterized the Northeast until "the thermal maximum" created conditions suitable for a deciduous forest with a much higher carrying capacity (*cf.* Davis, 1984). By the late 1970s however Early Archaic projectile points were recognized in many private collections and the inventory of sites increased steadily. In Ontario, the phase was apparently confined to the Carolinian biotic zone, which includes the present study areas along the north shore of Lake Ontario (Wright, 1978; Roberts, 1980; 1985). The low site visibility, which spawned the hiatus theory, resulted from an incomplete point typology (Funk and Wellman, 1984), and a site survey bias, in part due to the inundation of the coasts (including Lake Ontario) since Early Archaic times (Speiss *et al*, 1983).

According to primary forest efficiency and the focal-diffuse model, the archaeological record of the Northeast should show a shift (beginning in the Early Archaic) away from big-game hunting to a wider variety of plants and animals, in particular fish, nuts and seeds; however, there is little direct evidence to test this model because of poor organic preservation and a lack of detailed settlement data (McBride, 1978). Consequently, the archaeological data from deep stratified sites in the Southeast and the lower Illinois Valley, in conjunction with the palaeo-ecological evidence discussed earlier, are important in inferring Archaic subsistence in the Northeast.

4.2.1 Settlement-Subsistence Of The Southeastern Archaic

At the Rose Island site (Chapman, 1975) and the Koster site (Asch *et al*, 1972) hickory shells account for approximately 80% to 90% of the plant macro-fossil remains and acorn for most of the remaining 10% to 20%. Asch *et al* (1972) refer to hickory as a "first line" food because it is high in oil and protein and is easy to procure and process. For these reasons, and because it has three times the caloric energy of acorn per 100 gm, he speculates that it is the most reliable of the two resources. However, Chapman (1975) notes that the relative gram weights of the shells are misleading: acorn shells are less dense and lighter and there is more meat per nut. One hundred lbs of shag-bark hickory (husk removed) produces 15 to 20 lbs of meat and a similar amount of shell-bark hickory produces 25 to 35 lbs. One hundred lbs of acorns, on the other hand, yields from 60 to 90 lbs of meat. Thus, the weight of acorn shells recovered from archaeological sites should be multiplied by two or three to provide an estimate in line with hickory . Furthermore, the high carbohydrate content of acorns is complimentary to the protein and oil of the hickory. Chapman (1975) concluded that acorn was as important a resource as hickory, despite the extra processing required because of the bitter tannin content.

Reliability is another factor increasing the value of acorns because oak trees are ubiquitous and have less frequent crop failures than hickory. A primary forest efficiency model was not strongly supported by the Koster data since only a narrow range of foods were reported (Asch *et al*, 1972). However, at the Rose Island site (and others in Tennessee) a wider variety of plants were utilized in the Early and Middle Archaic (Chapman, 1975; Chapman and Shea, 1981), although acorn was the most important. Walnut, hazel, and beech were rare in Early Archaic deposits but increased in importance by Late Archaic times as did weed seeds such as goosefoot, knotweed and pokeweed.

Conaty (1983) points out that there is a correlation between the number of seeds recovered and the amount of fill screened and/or "floated". Since this is seldom considered in analysis most results are surely biased.

4.2.2 Archaic Settlement-Subsistence In The Northeast

In the Northeast, one of the few archaeological sites to produce plant remains is the Late Archaic Woodchuck Knoll site in Connecticut (McBride, 1978). Here remains of several species have been recovered and they indicate that the three micro-environments surrounding the site were exploited. American lotus (*Nelumbo lutea*) were represented from the immediate littoral zone, and goosefoot (*Chenopodium*) and walnut (*Juglans* sp.) came from the floodplain. Hickory shells probably originated from the better-drained uplands. McBride (1978) noted that *Chenopodium* can be included in cultural deposits accidently, but he discounts the possibility at Woodchuck Knoll because they were associated with the charred remains of a weevil (*Sitophilous*) which is known to subsist solely on stored grain.

In the Southeast Early Archaic faunal assemblages indicate that deer continued to be a primary resource (Fowler, 1959), but in the Northeast only indirect evidence supports this contention. Luchterland (1970) for instance reports that distributions of Early Archaic points correlate strongly with areas where deer now tend to congregate in the winter: sunny sheltered valleys. A similar situation may have existed along the northern shore of early Lake Ontario. By Middle Archaic times deposits like the Lund site (in Maine state) produced a wide variety of faunal remains including: beaver, muskrat, deer, bear, gull, loon, lake trout, sucker and turtle. These data tend to support primary forest efficiency and the focal diffuse model in the Northeast (Speiss *et al*, 1983).

The evidence for fishing in the Northeast, during the Early and Middle Archaic, is also largely indirect, but there is a consensus among prehistorians that this would have been a logical adaptation (Cleland, 1982; Speiss *et al*, 1983; Dumont, 1981). Dumont (1981) notes that net sinkers have been recovered from several New England sites (Rocklein, Harry's Farm and the Russ site) and Speiss *et al* (1983) point out that inlet and outlet locations on lakes (ideal fishing locations) characterize Early and Middle Archaic habitats in Maine.

4.2.3 Settlement-Subsistence Of The Archaic In Ontario

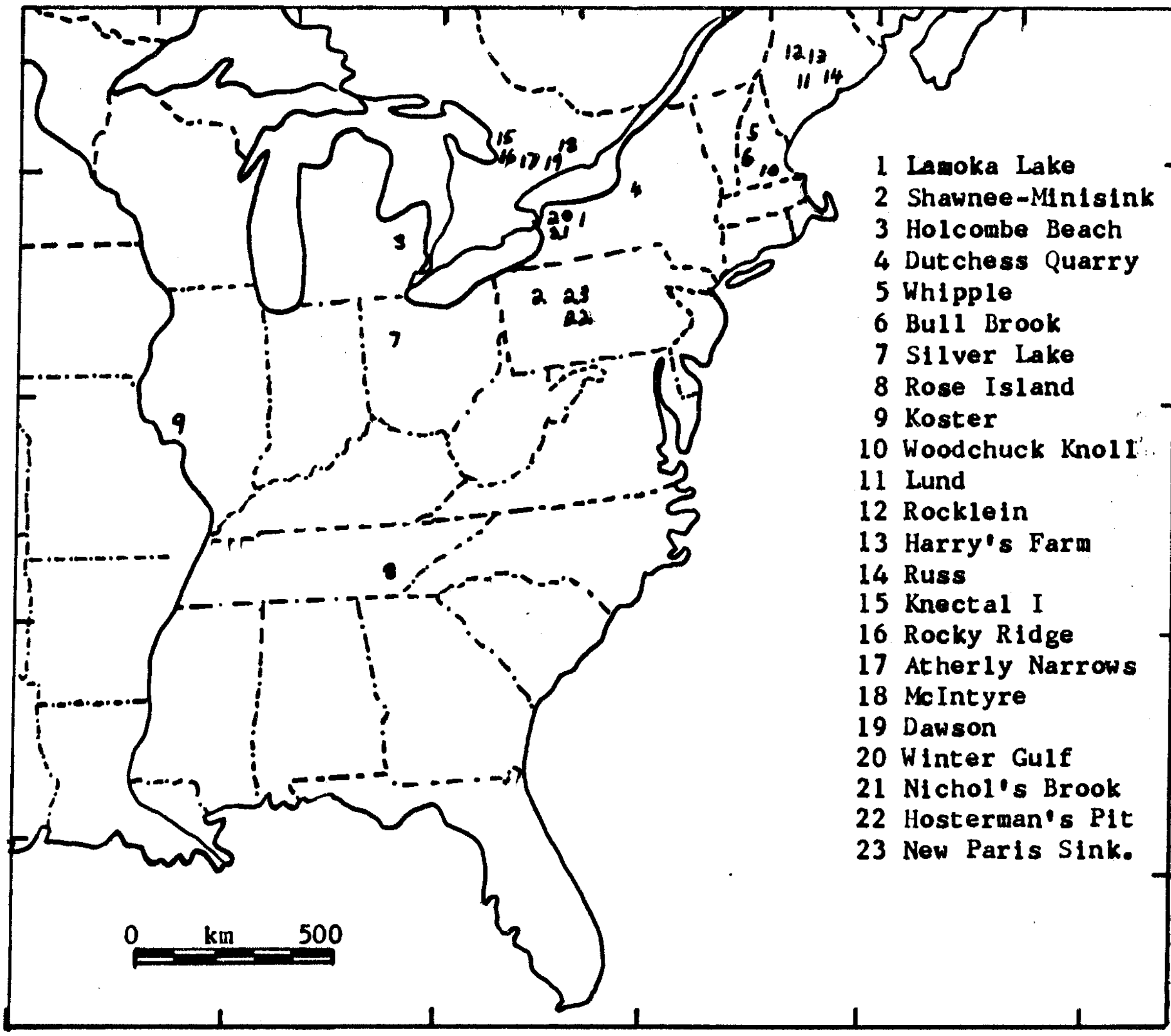
Although Archaic period sites are widespread and common throughout Southern Ontario, only a dozen or so have been the focus of extended excavations and even fewer have produced enough organic remains to construct valid hypotheses about settlement-subsistence (Wright, 1972a).Few large undisturbed or stratified Archaic sites have been found and to date archaeologists have been reluctant to analyse the thin flake scatters from ploughed fields and other disturbed environments (Roberts, 1985).

Until this decade the evidence available suggested that the Archaic people of Ontario relied almost solely on large and small game, fish and shellfish with plant foods playing only a supplementary role (Wright, 1972b) This view was based primarily on the results of two excavations, both of sites on Lake Huron: Knectal I (Wright, 1972a) and Rocky Ridge(Inverhuron) (Ramsden, 1976). F. Stewart, who analysed the faunal remains from Knectal I, identified deer , beaver and fish as the principal food resources. Fish bone was 2/3 of the sample by weight in the lower levels but was superceded by mammalian remains in the upper levels (Wright, 1972a). Rocky Ridge produced similar results but fish were not as abundant and birds assumed more importance, especially aquatic species (Savage, 1971).

At Atherley Narrows on Lake Simcoe, Johnston and Cassavoy (1978) discovered a complex of fish weirs, some of which were carbon dated to the Late Archaic period. These were constructed of closely spaced poles driven into the soft mud and between which were woven smaller branches to create a "fence" across the narrows to "funnel" fish into basket traps. This remarkable site demonstrates that fish could have been caught in considerable numbers at an early date.

In the late 1970s the McIntyre site, located on Rice Lake, added substantially to our knowledge of Archaic subsistence (Johnston, 1985). This large site contained numerous pit features intact below the plough zone which were apparently used for roasting meat and fish and parching plant food. Because all of the pit fill from these features was screened and subjected to a flotation process, large volumes of organic remains from the Late Archaic period (4715 BP to 3650 BP) in Ontario became available for the first time. From this it is deduced that the population relied on mammalian resources (deer, bear, beaver, dog *etc.*) for 71% of their diet and fish (many small shallow water species) for 28%. Bird and reptiles made up the remainder. These results elaborate on, but do not challenge the interpretations provided by Knectal I and Rocky Ridge. Analysis of the

Figure 4.1 Location Of Sites Mentioned In The Text



plant remains however added a new dimension to our interpretation of the period, for there were large quantities of carbonized plant foods preserved in the deposits. Clearly, the Ontario Archaic people (like those of the SoutheastZ) were "collectors" - not solely hunters. These included butternut, acorn, hickory, hazel, beechnut, tuber and fruit pulp. Although butternut predominates, acorn probably represents a greater food bulk, but perhaps not as many calories (Yarnell, 1984; cf. Chapman, 1975). Seeds of the following species were also recovered in some quantity: grape, raspberry, hawthorn, plum, cherry, blueberry, sumac, goosefoot (*Amaranthus*), cleavers, lambs quarters (*Chenopodium album*) and knotweed (*Polygonum cuspidatum*). Yarnell (1984) estimates that all plant species were under-represented, due to site occupation activities, differential attrition, and damage incurred during collection. This was especially true for tubers, rhizomes, corms and bulbs as well as stems, greens, flowers, and lower plants. Also plants with very small seeds (blueberry and strawberry) would be seriously under-represented. The excavators expected to recover wild rice seeds (*Zizania aquatica*) from the site and were surprized by its virtual absence. However, McAndrews (1984) reports that he has evidence that an aquatic grass (which could be *Zizania aquatica*) became established in the shallows of the lake about 4,000 BP and persisted to the present. McAndrews believes that wild rice grains were indeed present but were destroyed in the collection process. According to his colleague, R.D.Fecteau, charred wild rice crumbles with 5 grams pressure while charred sunflower seeds resist crumbling with 100 grams pressure (Johnston, 1981).

Jackson (1986) has excavated an Early Woodland site also located on Rice Lake a few kilometers from the McIntyre site. The Dawson site, which has been carbon dated to between 2,940 BP and 2,230 BP, has produced organic remains which indicate a primary reliance on deer and a complimentary reliance on nuts and fleshy fruits. Although the charred plant food remains primarily acorn and a few other species such as hawthorn and raspberry, wood charcoal analysis indicated that red and white oak, beech, hickory, walnut and butternut were available in the immediate vicinity (Jackson, 1986).

4.2.4 Summary

A tri-partite division is also appropriate to the cultural sequence because the first two divisions and their boundaries compare closely to cultural divisions. The Palaeo-Indian and Early Archaic are late Pleistocene and early Holocene cultures; Middle and Late Archaic are middle Holocene events and the transition to the Woodland period largely coincides with the advent of the Late Holocene. It is evident from this review that there is very little direct evidence to interpret the subsistence economy of Palaeo-Indian or Early Archaic people and test the focal-diffuse model. The preserved organics that do remain, however, suggest that Palaeo-Indians were probably opportunistic foragers, who nevertheless depended on caribou and other cervids for their sustenance and clothing requirements. Although there is no doubt that a broad base of diffuse resources were exploited in the Late Archaic, the early development of "primary forest efficiency" is not strongly supported by the meager data: apparently the economy was still largely focused on deer, acorns and perhaps fish.

CHAPTER 5

METHOD AND PROCEDURE

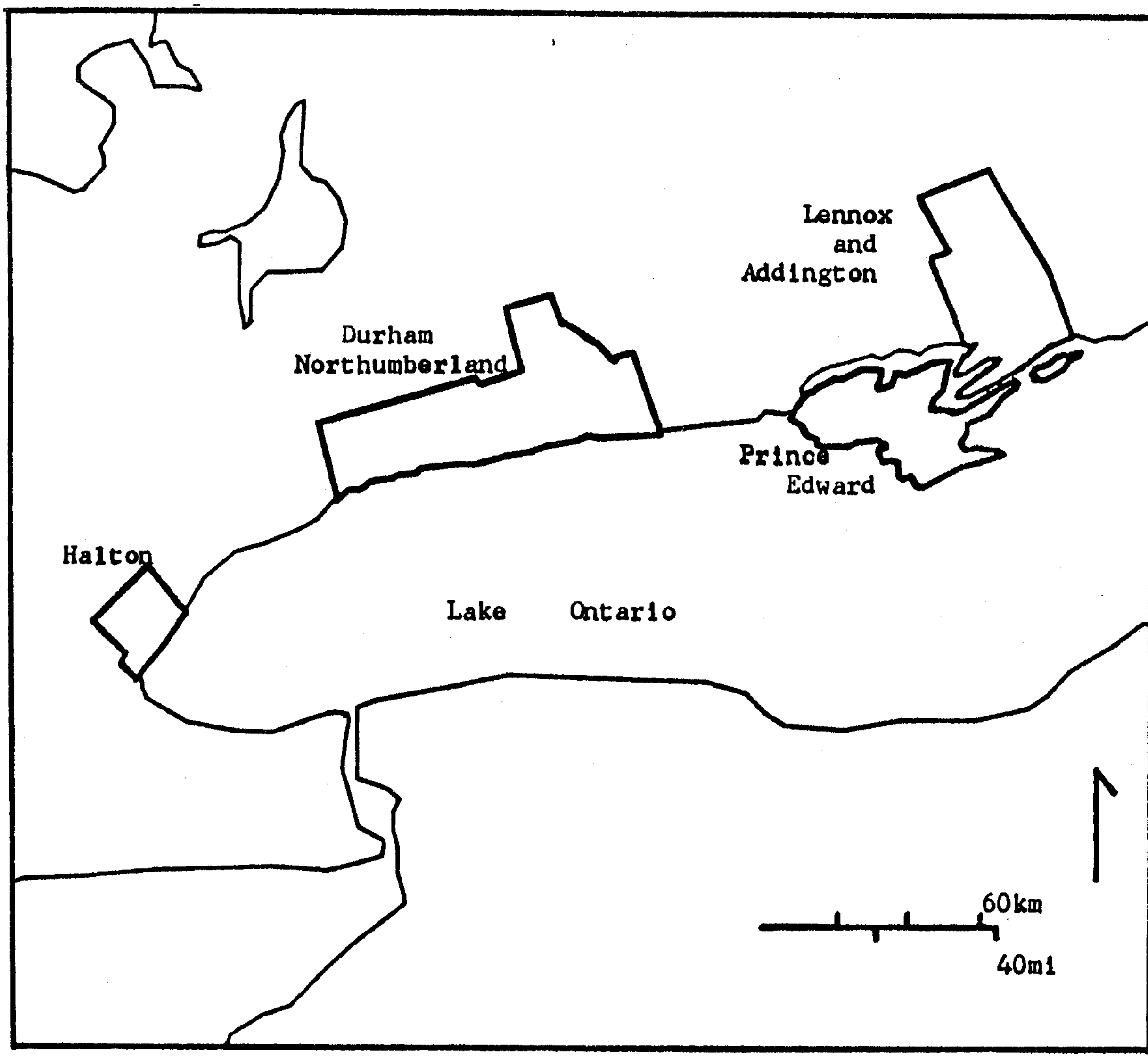
The aim of this research was to study the site selection process of prehistoric hunter-gatherers of the Ontario Basin by comparing the terrain of archaeological sites to a control sample of locations chosen at random. The controls describe the physical terrain of any "average" location within specific physiographical zones of the four study areas (see Fig. 5.1). The archaeological sample describes the terrain of sites occupied by prehistoric hunter-gatherers. Thus, one may assume that any statistically significant differences between the two samples probably relates to settlement-subsistence requirements (see chapter 2.3).

The climate and environment of the Ontario basin changed rapidly during the late Pleistocene and early Holocene and archaeological evidence from Ontario, and elsewhere in eastern North America (sparse as it is), suggest there was a resultant change in the subsistence economy of early cultures. The method of terrain analysis employed here permits comparison of specific cultural periods (Palaeo-Indian and Early Archaic for instance), to the random sample, or the entire archaeological sample, to identify trends in the site selection process that can be related to environmental change.

5.1 Sample Selection

This method also permits the investigation of the relative importance of the setting and vicinity around an archaeological site. A "site" is usually considered to be the immediate area where artifacts have been discovered. In this study, "site area" was operationally defined as three concentric rings expanding from the point, or center, of the artifact cluster. The smallest was the **"site area"** with a radius of 300 m; followed by **"setting"** and **"vicinity"** with radii of 1 km and 2 km respectively. The terrain variables (measured cumulatively for each ring) were average slope, relief,

Figure 5.1 Map Showing the Study Areas and Lake Ontario

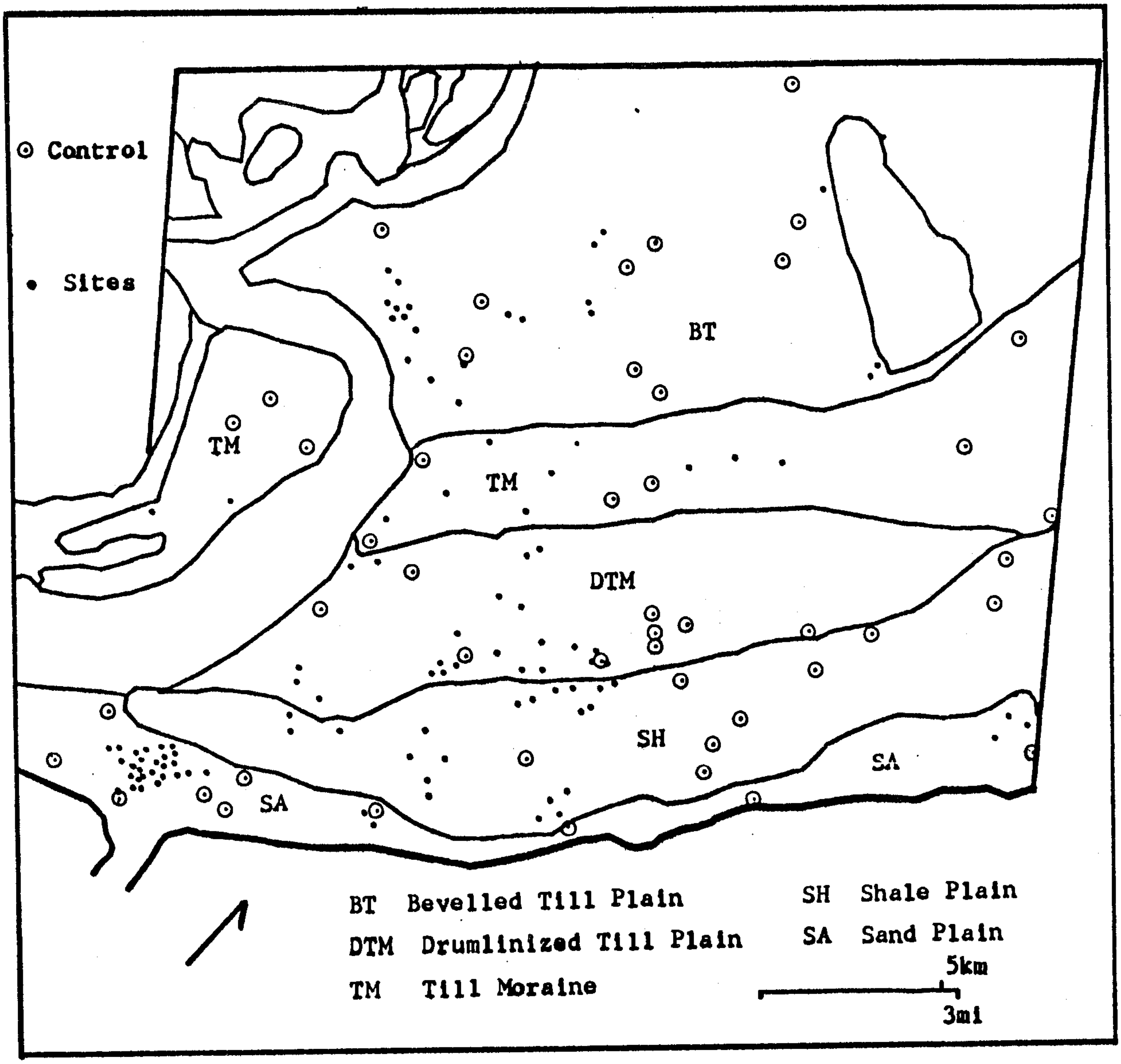


soil texture, soil drainage, stream densities (for orders one to four), marsh and swamp area cliff density, and land use capability for nut trees and deer. The last two variables were measured on an interval scale and the remainder on a ratio scale.Data sources for these measurements were: 1) National Topographic Series maps (1:25,000); 2) Ontario Soil Series maps (1:63,360) compiled for the Department of Agriculture; 3) Canada Land Inventory maps (1:250,000) (used to estimate capability for deer and nut trees) and; 4) stream order densities,marsh and swamp density and shoreline and cliff density ere measured using 1953 panchromatic aerial photography (1:16,000).

TABLE 5.1:Terrain Variables - sources, measurement, and theoretical importance
(see text for definition of measurements)

Variable	Data Source	Quantification Method	Theoretical Importance
Average Slope	NTS maps 1:25,000	Use mylar template of site areas Slope=CIxM/3361 (CI is contour interval; M is number of contours per mile of cardinal or quadrantal transect)	Environmental diversity increases with average slope
Maximum relief	NTS maps 1:25,000	The difference in feet between highest and lowest elevation in each area	Camping amenity and lookout
Stream Order Density	Aerial Photographs 1:16,000>	Length each order summed and divided by area. Total density is distance of all orders divided by area	Higher density corresponds with higher environmental diversity. Also camping amenity, fishing, and transportation
Soil Drainage	Soil maps 1:63,360	Measure area of each soil class. Weighted and expressed as index value	Well drained soil is camping amenity, range of drainage increases environmental diversity.
Soil Texture	Soil maps 1:63,360	Similar to drainage but series are weighted by particle size	Loose texture is camping amenity;range of values increases diversity
Cliff Density	Aerial Photography 1:16,000	Cliff distance summed and divided by area	High density increases environmental diversity, can facilitate hunting
Marsh Area	Aerial Photography 1:16,000	marsh area as a percentage of site area	Environmental diversity increases with marsh area
Swamp Area	Aerial Photography 1:16,000	Similar to marsh	Increased environmental diversity
Nut Potential	CLI maps 1:250,000	Percentage of each class per area is weighted and presented as an index	Historically and prehistorically an important food
Deer Potential	CLI maps 1:250,000	Percentage of each class per area weighted and presented as an index	Historically and prehistorically an important resource

Figure 5.2 Map of Halton Region



5.1.1 Objectives

The objectives of this method were to test three broad hypotheses:

* The physical attributes of archaeological sites differ significantly from a representative sample of random control locations.

* Over time hunter-gatherer societies selected areas with different compositions of physical attributes. (This should be most apparent between Palaeo-Indian and Early Archaic, and Early Archaic and Late Archaic.Such changes in terrain composition should be a result of adaptive

changes to dynamic environments and changes in subsistence strategies.)

* Some aspects of the terrain are more important at the immediate **site** area, while others are more important at the **setting** and **vicinity** areas.

The first hypothesis was based on the assumption that the economic decisions of hunter-gatherers result from rational planning and are not normally due to random or spontaneous action (Jochim, 1976). The second hypothesis was based directly on the focal-diffuse model (Cleland, 1976) for if prehistoric hunter-gatherers did adapt to new environments by switching from a focal economy to a diffuse strategy, the change should be reflected in their site selection process. The relatively short period from Palaeo-Indian to Early Archaic was a time of rapid environmental change and presumably a change of settlement-subsistence strategy. If so one would expect the site selection process to change as well. The third hypothesis assumed that the importance of certain terrain features varies over area. Cliff density, for instance, was expected to be most important in the vicinity (2km) area, while others, such as small stream density, were expected to be most important at the site (300m) level.

5.1.2 Study Areas and Control Samples

Four study areas (see Figs. 5.2; 5.3; 5.4; 5.5) were selected from the north shore of Lake Ontario: Halton, Durham, Lennox and Addington, and Prince Edward. Each study area is part of of a political unit, either a county or an administrative region, and has been named accordingly. The first three were chosen because they have been intensively surveyed and were known to contain sites from the Palaeo-Indian to the Early Woodland periods. Prince Edward has been less intensively surveyed but, as with the three other areas, it is familiar to the author. With the exception of Prince Edward these areas, and many of the same sites, have been used in a previous terrain analysis. Thus, there is an appropriate body of data to which the results of this study may be compared. Furthermore, because the last ice sheet retreated from the Lake Ontario Basin in a northeasterly direction there is a climatic and biotic gradation from the temperate Niagara peninsula ("Carolinian" forest) to the Canadian Shield ("Canadian" forest zone) in Lennox and Addington (see page 23). According to Bernabo and Webb's data (1977), this zonation also existed during the late Pleistocene and early Holocene. The four study areas, therefore, are representative of different environmental regions along the north shore of Lake Ontario.

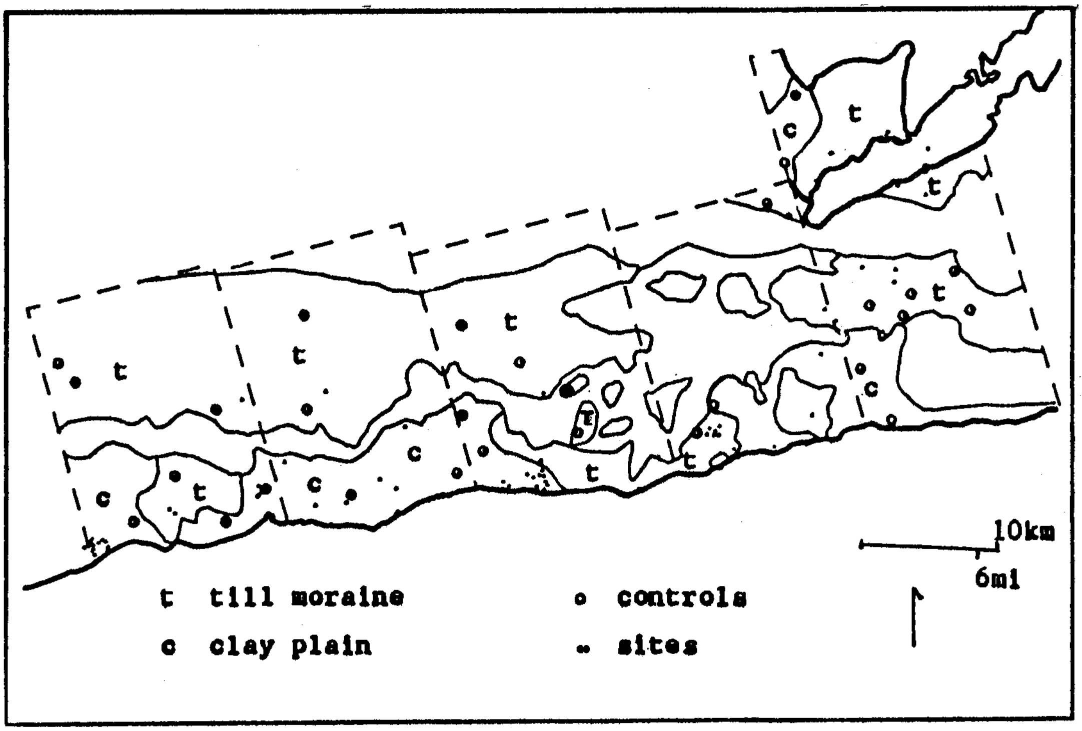
The four study areas were divided into zones on the basis of surficial deposits, using the physiographic maps accompanying Chapman and Putnam (1972), and a control sample of random locations was selected for each zone which had an adequate archaeological site sample. The size was roughly proportional to the archaeological sample.

Control samples were chosen by superimposing a 100mm by 100mm grid over a 1:250,000 map of each region. A random number table was used to select co-ordinates until the desired sample size for each zone was attained.

5.1.3 Archaeological Sample

The site sample was drawn from reports submitted to historical agencies of the Ontario Government. The writer conducted much of the original field research in Prince Edward County (Swayze, 1973; 1977) and contributed to a small part of the Halton inventory (Swayze and Emerson, 1972). Roberts (1976; 1978; pers. comm.) provided most of the site location data for Durham Region and Northumberland County and Lennox and Addington County. The site sample from Halton County on the other hand, was the result of many separate surveys (sites from Halton County have been registered by M. Ambrose; D. Poulton; R. Pihl; K. Ryan; J. Chisholm; S. Jamieson; T. Hutchinson and others. The site information is available from the Historical Sites Branch, of the Ontario Ministry of Culture and Recreation.) Table 5.2 presents the total sample size by county and cultural period.

Figure 5.3 Map of Durham Region



5.1.4 Method of Selection

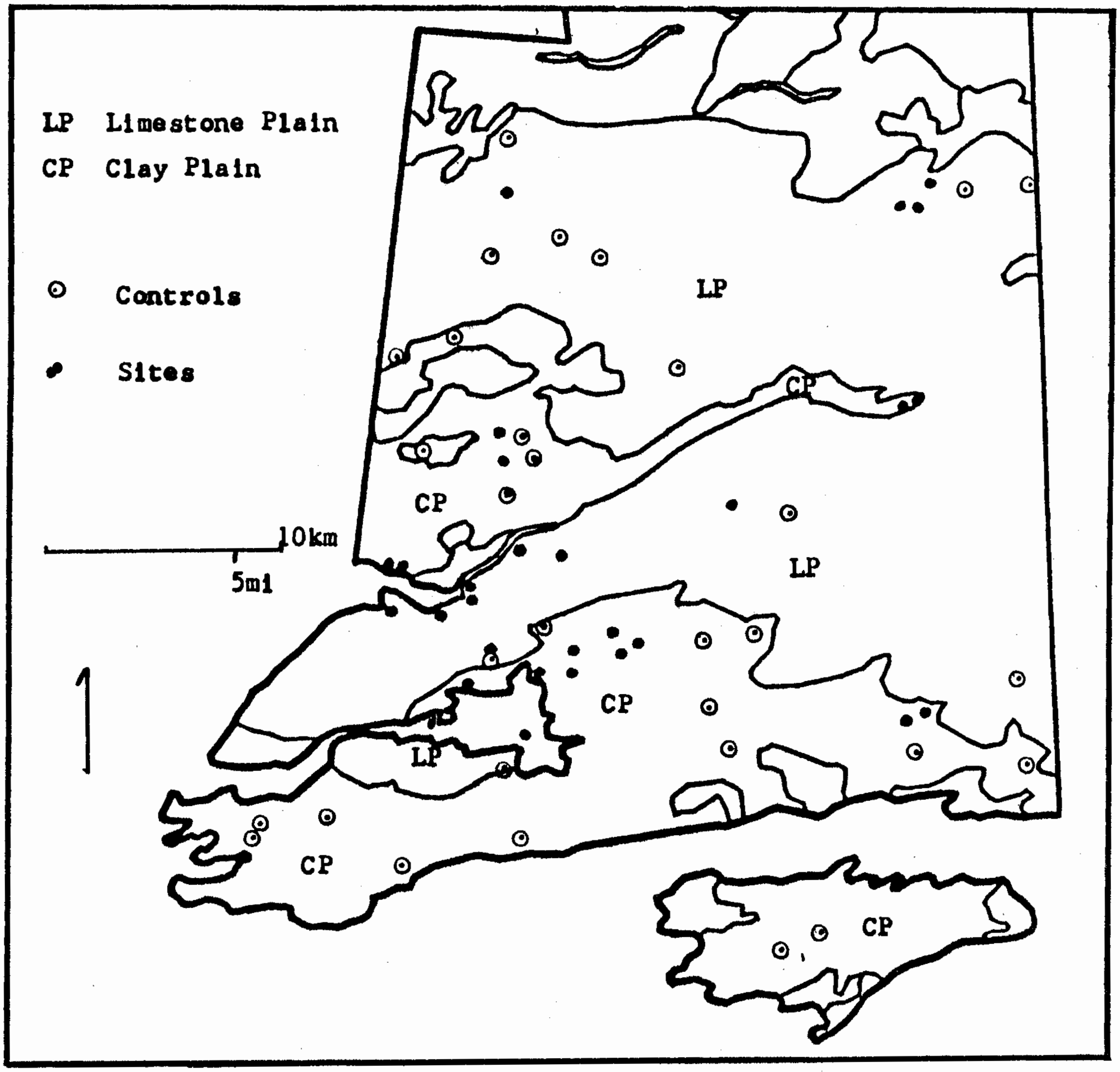
A site was eligible for selection if it met two criteria: accurate provenience, and cultural affiliation. Provenience was important because of the concentric site areas used in the terrain analysis procedure. It was often difficult to "pin-point" the precise location(s) of the artifact discoveries unless one was familiar with a site from field work, or the written description in the archival record was explicit. Although every registered site had UTM grid co-ordinates, the method was often inaccurate and one could not always be sure that the area designated actually contained the site. Not all sites were discovered in the course of systematic sampling. Many were reported by local inhabitants, whose memory and reliability varied. Sites reported to an archaeologist, in the course of a regional inventory, were not always surface collected or tested by the archaeologist. These were, therefore, not considered for analysis. Provenience was judged acceptable if the informant or investigator could convincingly identify a precise location of artifact discovery: the corner of a certain field; or beside a barn, or pond. Sites reported in vague terms ("arrowheads from the Old Mulholland Farm") were excluded.

The cultural affiliation of a location was based upon the association of diagnostic artifacts; thus,"Brewerton" points indicate that, probably, Late Archaic people occupied the site at least once. Of course, many Late Archaic sites, with "Brewerton" points, may also have been occupied previously and/or subsequently but if there are no diagnostic artifacts to prove it, the site remained classified as single component. Many sites, however, have two or more cultural components as shown by the presence of earlier or later period artifacts. Most sites have been assigned to one or more cultural periods on the basis of reported or observed diagnostic artifact associations. There was no attempt at estimating duration of site occupation or perimeter measurement of the artifact scatter in this study.

A small number of sites were "unclassified". These had no diagnostic artifacts reported but, based on the absence of ceramics, they did not suggest a Woodland occupation and were tentatively labelled "probably Archaic" on the site survey forms. Although only a small proportion fall into this category they were included to see if their terrain characteristics grouped with any other period.

All sites satisfying the criteria of provenience and cultural affiliation were chosen for measurement; however, the overall sample remained small. In general, the sample size increased with time, although for Prince Edward County no Palaeo-Indian or Early Archaic sites were represented.

Figure 5.4 Map of Lennox and Addington Region



5.1.5 Sampling Problems

The primary problem with most of the archaeological sample was that it was not randomly selected, and was therefore unlikely to be completely representative of the true regional distribution of sites through time. This problem stemmed from the fact that archaeological sites were usually discovered by accident, by non-archaeologists, during the course of some activity which disturbs the soil such as agriculture, highway construction and maintainance, or excavation. Thus, the distribution of known prehistoric sites could correspond to the density of farming and roadways.

The degree of representativeness was impossible to determine in this case; but even if regional samples were biased, the site area was known to have been selected by a prehistoric population. There is some evidence however which suggests that the sample from Halton and Durham Regions are reliable regional distributions (with, of course, the exception of the littoral sites pre-dating 5,000 BP which would have been flooded by rising lake levels). Roberts (1977; 1982) located many sites by systematic methods and compared these regional distributions to that of a stratified "random", or probabilistic, survey. He concluded that the regional site distribution (from which this sample was selected) was relatively unbiased.

The comparative sample, on the other hand, was selected at random by the writer and in general will be representative of an average location for the zone.

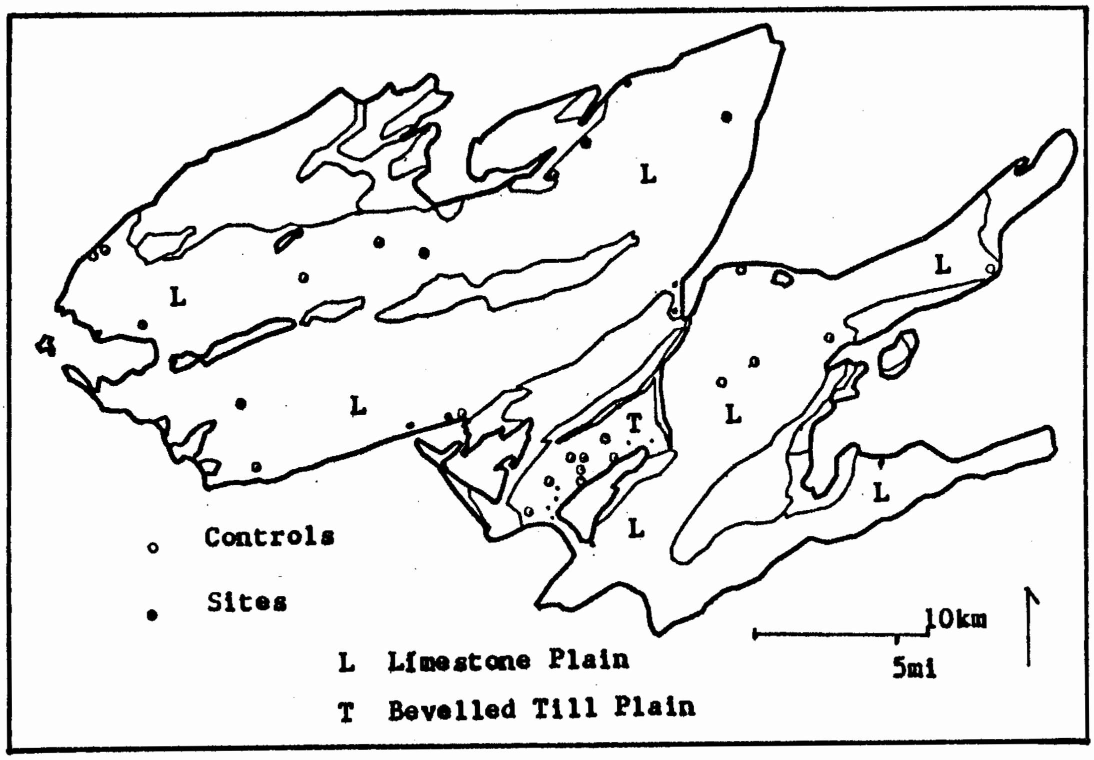
Another problem was the clustered nature of the archaeological sample, in some zones, as compared to the scattered nature of the control sample. Clustering was most noticeable in the sand plain of the Halton region and the clay plain of the Durham region. Undoubtedly, this condition resulted in reduced variances in some archaeological samples and perhaps inflated the number of statistically significant results. However, the same variables were often statistically significant in other zones, where clustering was not pronounced, which suggests that clustering has not created misleading results.

In any event, all scientists using palaeo-environmental data have problems with small and generally less than adequate samples; but, all must, and do, construct and test hypotheses using the best data available for the purpose.

5.1.6 Statistical Tests

Student's t test was used to test the hypothesis that the mean of the terrain variables of archaeological areas (300m, 1km, 2km) was significantly different from the mean of the random control sample. In this case the sample included site areas from all cultural periods (Palaeo-Indian to

Figure 5.5 Map of Prince Edward Region



Early Woodland inclusive). The null hypothesis was that there is no difference between the terrain values of archaeological sites and the random sample.

Mann Whitney U tests were used to determine if there were statistically significant differences between the mean terrain values of each area of each cultural period and the site areas of the random control sample. This non-parametric test has the same function and 95% of the "strength" as the Student's t test but it is more effective with small samples (Siegal 1958). Thus, this test is appropriate because the archaeological site sample in this study was, unfortunately, small.

All statistical tests, and calculations of mean and standard deviation, were performed by the main-frame computer at Simon Fraser University, using the SPSSx statistical package.

Statistical significance was determined by rejecting the Null hypothesis at alpha levels of $p \leq 0.05$ (for Student's t) and $p \leq 0.05$ and $p \leq 0.10$ (for Mann Whitney U). Although the maximum level of rejection is commonly set at $p \leq 0.05$ there is no methodological lapse in using lower levels of statistical significance. The level of statistical significance is in effect a statement of one's willingness to permit a "type 1 error" (the null hypothesis is rejected but is actually true). However if the alpha level is made smaller to reduce type 1 errors the probability of a "type 2 error" increases (the null hypothesis is accepted but is actually false). Only an increase in sample size will reduce the probability of committing these errors. Thus, the level of statistical significance is determined by the researcher's discretion and, since one of the purposes of statistical tests is to reveal patterns not readily apparent, and because a larger sample size is not feasible, the author used two significance levels (cf. Thomas 1976, pp.213-216).

TABLE 5.2 Archaeological Components and Control Locations By Region And Zone

	CO	PI	HL	EA	MA	LA	EW	Un	Tot
Halton									
Till Moraine	8	1	0	4	6	4	2	0	17
Drumlinized Till	10	0	0	4	20	1	0	0	25
Bevelled Till	8	4	1	2	13	8	5	0	33
Shale Plain	8	1	0	2	16	6	2	0	27
Sand Plain	9	7	0	9	29	14	12	0	71
subtotals	43	13	1	21	84	33	21	0	173
Durham and Northumberland									
Drumlinized Till	14	1	5	1	6	10	3	8	34
Clay Plain	14	2	5	4	24	16	2	4	57
subtotals	28	3	10	5	30	26	5	12	91
Lennox and Addington									
Limestone Plain	14	0	0	2	2	3	4	5	16
Clay Plain	18	3	0	2	8	4	6	6	29
subtotals	32	3	0	4	10	7	10	11	45
Prince Edward									
Bevelled Till	8	0	0	0	0	6	0	0	6
Limestone Plain	18	0	0	0	7	6	0	1	14
subtotals	20	0	0	0	7	12	0	1	20
grandtotals	123	19	11	30	131	78	36	23	329

CO=Control, PI=Palaeo-Indian, HL=Hi-Lo, EA=Early Archaic, MA=Middle Archaic, LA=Late Archaic, EW=Early Woodland, Un=Unclassified

5.2 Description of Variables and Expected Results

5.2.1 Average Slope

Average slope in this study was a measure of "hilliness" or "roughness" rather than gradient (Mitchell, 1973:82) and, in general, it was expected that site slope would be less ("flatter") than control values. Secondly, it was expected that the site (300m) and setting (1km) areas would be "flatter" than vicinities (2km). Thirdly, if there was any apparent change with time, it would be for increasing "flatness".The assumption here was that level ground was preferred for a living or working area, and as population and village size increased,this factor became more important in the site selection process .

There are many ways of measuring slope, the most common being the rise divided by the run. The method used here however (Mitchell 1973:82) can be thought of as an index of the "hilliness" or "roughness" of terrain.

slope tangent = contour interval x number of contours per mile of transect / 3361

A 1:25,000 NTS map and a mylar template, with the concentric rings and four diametric transects drawn upon it, was used to make this measurement. For each area,the number of contour lines crossed along all transect lines were summed and used in the formula to measure average slope. Only the miles of transect over dry land were used for the formula, otherwise a site located on a lakeshore would yield a deceptively low index.

5.2.2 Maximum Relief

It was expected that relief would be less for the general archaeological sample than for controls. But, if Palaeo-Indians were primarily caribou and big game hunters and the subsequent Archaic cultures increasingly relied on deer, small game, fish, and plants, then one could expect the overall relief of site areas to decrease with time.Furthermore, since some Palaeo-Indian sites are assumed to be lookouts and kill sites, there will be a tendency for values of this period to exceed controls especially in the setting (1km) and vicinity (2km) areas .

Relief was calculated as the difference between the lowest and highest elevation in a site area. This figure was measured in conjunction with the average slope using the same mylar template.

5.2.3 Soil Drainage

The index value of soil drainage on archaeological sites was expected to be above the control mean for any particular zone of a region. This was attributed to the greater comfort a drier surface creates for camping; as well as the fact that the more important species of nut trees and other terrestrial herbaceous plants prefer well-drained conditions. If there was to be any temporal trend, it would be for a decrease in time, reflecting the increasing economic diversity that could be expected to have resulted from a broader range of soil conditions. Also, drainage values were expected to be higher in the site (300m) area because of the amenity a well drained location provides.

The index number of this variable was measured from the Ontario Soil Series maps (1:63,360), using a mylar template with the concentric rings superimposed on a dot planimeter. The procedure was to calculate the percentage of each soil series in an area and score that measurement, by an arbitrary value, to arrive at an index.

For instance, if an area has 50% well drained series, 25% imperfectly drained and 25% poorly drained series; and, the arbitrary values are well drained = 1; imperfectly drained = .5

;and poorly drained = .25 ; then the index may be calculated: (50% x 1 = 50) + (25% x .5 = 12.5) + (25% x .25 = 6.25) = 68.75. Soil drainage scores may range from 25 (all poorly drained) to 100 (all well drained).

5.2.4 Soil Texture

In general the index value of soil texture of archaeological sites should exceed that of random spot locations. Texture will increase with time if Late Archaic and Early Woodland were becoming more dependant upon seeds and nuts and other terrestrial plants. *Amaranthus* and *Chenopodium*, for example, prefer well-drained medium to coarse textured soils which are easily disturbed by fire or activities in and around a camp. Texture values would be highest in the site (300m) and setting (1km) areas because there is more convenience with loose textured soil in the immediate environs of a camp.

The soil series percentages derived above were also used in this calculation. The series were ranked on a scale from 0.5 to 5.0 according to texture or particle size (very fine to coarse) and this score was multiplied by the percentage in each area.

For example, a vicinity area has 50% loam (3 medium), and 25% gravelly loam (4.5 medium coarse), and 25% clay (1 fine). Thus the index can be calculated: (50% x 3 = 75) + (25% x 5.5 = 105) + (25% x 1 = 25) = 205. These measurements may range from 50 (all very fine) to 500 (all very coarse).

5.2.5 Total Stream Density

In most cases, the writer expected the total stream order density of archaeological sites to be higher than the strata norm. This assumed that a higher ratio of stream littoral to area would produce more biomass and species variation. For instance the "edge effect" (Odum, 1959) of these streams would produce more browse for deer and create a gradation of biotic communities. According to the principles and assumptions about hunter-gatherer behavior discussed earlier, this factor should have intrinsic economic value. Total stream order density was expected to be higher in the site (300m) and setting (1km) areas than vicinity (2km) and will tend to increase with time.

5.2.6 Small Stream Density

First and second order densities should in general be higher near archaeological sites than random control locations and should have a higher mean value in the site (300m) and setting (1km) area than the vicinity (2km) area. This variable reflects the convenience and practicality of a small clean stream close to camp. Also winter hunting of deer should be more effective in areas with good shelter and browse (ie. areas with a high density of first order streams). It is also possible that a high density of small streams would increase the potential of an area to support beaver. These animals were not only an important, and predictable, source of winter food but their ponds increased environmental diversity and provided dead standing timber ideal for winter fuel. If there is any change over time it was expected to be an increase in small stream density in concordance with the expected increase in total stream density.

5.2.7 Large Stream Density

The Focal-diffuse theory of environmental adaptation in the Northeast (Cleland, 1976) holds that fishing became a major economic activity by Late Archaic and Early Woodland times. If so, it was expected that large order densities (third, fourth and higher) would increase with time especially in the site (300m) and setting (1km) areas.

The density for each order of stream was calculated by summing all stream lengths and dividing this by the area. Stream lengths were measured with a wheeled "charto-meter" on acetate maps made from stereo-pairs of 1:16,000 panchromatic aerial photography. These were used for this step (rather than the NTS maps) because maps do not consistantly show first order streams whereas photographs clearly show ephemeral, or intermittant, stream channels. First order streams are defined as the smallest discernable streams; and, since Strahler's method of stream ordering is used, the identification of each subsequent order depends ultimately upon the accuracy of the first order identification.

Using several hundred stereo-models (1:16,000), a drainage and landform map of each site and control point was traced onto acetate. These maps showed all streams, water bodies, cliffs, marshes, swamps, eskers, drumlins, flutes, kame and till deposits as well as some relict beach ridges

5.2.8 Nut Capability

Also according to the focal-diffuse theory , nuts would be increasingly important as Archaic cultures adopted "primary forest efficiency" (Caldwell, 1958). So, it was expected that the archaeological sites would have a higher mean score than the representative control locations. Secondly, vicinity (2km) areas would have a higher mean score than site (300m) areas. Thirdly, mean values should increase with time if settlement-subsistence strategies were becoming more diffuse.

This information was taken from the Canada Land Inventory maps (1:250,000) using the same technique as for the soil data. However, in order that a high index value indicates a high capability, the CLI classifications were inverted. In other words, the highest class (class 1) became class 7 in this study and the lowest CLI class (class 7) became class 1.

Nut trees, as such, are not specified in the CLI classification. Rather this classification is concerned with the potential for commercially valuable species. In this part of Southern Ontario the focus is on lumber-producing species like hard maple, red maple, red oak, and white and red pine. The writer assumes that decidous nut-producing species such as hickory, walnut, white oak, and chestnut share many of the same optimal growth requirements. The CLI maps were based on soil series maps and consider not only beneficial environmental traits (eg. deep, moist, well-drained, neutral loam) for these species but also limiting factors (eg. excessive soil moisture, fertility, or restrictions of the rooting zone).

5.2.9 Deer Capability

The only species of ungulates considered in the Canadian Land Inventory (CLI maps of southern Ontario were white-tailed deer and moose. These species were almost certainly common throughout the area in Archaic times, and may have been present locally in Palaeo-Indian times, along with caribou, wapiti and *Torontocerus hypogaeus*. These other species have very different dietary requirements than the contemporary white-tailed deer and moose and the CLI maps are, therefore, not as reliable as indicators of the potential for these ungulates. Archaeological remains from the Eastern Woodlands suggests that by Archaic times white-tail deer was economically the most important game species (Ritchie and Funk, 1973).

It was predicted that, in most cases, the deer capability of archaeological sites would score higher than the control sample. This would be more apparent in the vicinity (2km) areas and if there was a chronological pattern, it would be a decrease with time as a diffuse adaptation was adopted.

5.2.10 Cliff Density

In some regions,like Halton County which has been deeply incised, the writer expected that the mean cliff density for all site areas would be higher than the control means, especially at the vicinity level. It was assumed that cliff density would decrease with time as reliance upon ungulates was augmented by more diversity in fishing and gathering. Historic accounts indicate that a common method of hunting deer, sheep and bison was to drive the herd into a trap or an ambush where they could be dispatched conveniently (Anell, 1969; qtd. in Frison *et al*, 1986). These drives were more efficient if aspects of the local terrain, such as cliffs and streams were incorporated into the plan (Teit, 1930). Archaeological evidence clearly indicates that the drive and ambush technique was well established during the Late Palaeo-Indian period on the Plains (Frison *et al*, 1986; Wheat, 1972). Early in the fifteenth century Samuel de Champlain witnessed a deer drive by the Huron Indians in an area close to or in the Lennox and Addington study area. In all likelihood this method had a long history of use in the Ontario basin. By de Champlain's estimate, the drive employed a two mile long brush fence as a funnel and over one hundred deer were captured within a week. Certainly fences such as these would be located to take advantage of any natural features, such as cliffs, which would improve its effectiveness (Champlain, 1970:57-58).

This variable was measured using acetate maps made from aerial photographs, and a wheeled "charto-meter". Cliff refers not only to large escarpments, but also to less dramatic features such as steep stream banks. Any continous or abrupt break in the terrain which conceivably could have hidden hunters from view, or provided them with a trap was called a "cliff" in this study, although there was no threshold slope criterion established. The vertical exaggeration of the aerial photographs was an advantage in identifying and mapping these features.

5.2.11 Marsh and Swamp Area

The writer assumed that marshy areas today were also marshy in the Early Holocene. Marshes, and some other wetlands, have a high biomass and species variety and for this reason they must have been a part of hunters and gatherer settlement-subsistence strategy. Swamps may not have been as important, for few swampland species provided staple food or essential raw materials. However, many of these swamps have formed from in-filled kettle lakes and have probably evolved to their present form from one that may have had features more like a bog or a marsh.

Because of the economic importance of aquatic resources throughout the year, and the convenience of their proximity, the writer expected that marsh density, especially in the smaller areas, would be considerably higher for sites than random spot locations. If there was any chronological trend, adaptive theory suggests that it would be for increasing values. These hypotheses were applied for swamp density as well, although there may have been a decrease over time due to in-filling.

The area of marsh and swamp was measured on acetate maps prepared from aerial photographs and was presented as a percentage of the area. In the Durham Region and Northumberland County this was accomplished with a dot planimeter;but for Lennox and Addington County and Prince Edward County the areas were measured analytically using a microcomputer-controlled stereoplotter.

5.2.12 Summary

The terrain variables selected indirectly evaluate the (palaeo) environment, for in concert with climate, they determine the presence and distribution of the plant and animal species that sustained prehistoric hunter-gatherers.

If Palaeo-Indians were primarily caribou hunters, and not concerned with a diffuse variety of other plant, fish and mammal resources, then one would expect, generally, low values of terrain variables (except for maximum relief, which many expect would be high in order to spot game - see Funk *et al*, 1970 and Dumont, 1981). Palaeo-environmental data suggests that there were many other resources available in the late Pleistocene and early Holocene. Thus, if Palaeo-Indian sites had high values of these variables, it may indicate they had an adaptive strategy based on a more diffuse resource base. In any case, if there was a change in settlement-subsistence strategy between the Palaeo-Indian and Archaic periods, as the focal-diffuse model contends, then there should be a difference between the index values of the terrain variables of sites from these different periods.

CHAPTER 6

RESULTS

6.1 Introduction

Although the results initially appeared diverse, there were many terrain features of archaeological sites which were significantly different from random locations. In fact all variables measured were statistically significant at sometime and some were consistently significant. In general the results clearly indicated that the composition of the terrain within 2 km, or less, of an archaeological site differed significantly from random locations. It was evident that the proportions of the index values of terrain variables differed from one physiographic zone to another. This reflected different adaptations to micro-habitats and different regional physiographic adaptations. As such, it illustrated how sensitive hunter-gatherers may have been to local physical factors. This adaptive flexibility perhaps represented different activities for each zone or perhaps seasonal use.

Furthermore, the pattern of terrain variables was not consistent within the same surficial unit from one region to another. Thus, the pattern of sites on a till plain in Halton was different from the pattern on till plains from the Durham or Prince Edward regions. Similar behavior was noted by Roberts (1977; 1982) in his terrain studies. This pattern is probably related to the proximity of the zone to the Lake Ontario shore. In Halton for instance, the till plains are removed from the lake, while in parts of Durham and Prince Edward regions till plains border the shore.

The bar graphs in the following pages have hachured bars to show statistically significant values of the combined cultural sample (Palaeo-Indian to Early Woodland inclusive) according to the results of a one-tailed t test. The three bar clusters represent site areas with radii of 300 m, 1 km, and 2 km respectively. Statistically significant values, as assessed by a one-tailed Mann Whitney U test, of areas associated with individual cultures are indicated on the bars by solid circles ($p \leq 0.05$) or open circles ($p \leq 0.10$).

TABLE 6.1 Significant Archaeological Site Variables and Control Locations

The most significant site areas are indicated, and areas of secondary significance are bracketed

Variable	Direction of Significance	Most Significant Areas	Significantly Above Controls	Significantly Below Controls
Marsh	all above random	1km(2km)	1km(2km)	
Large Stream	above and below random	1km(2km)	1km(300m)	2km(1km)
Relief	most lower than random	300m & 2km	2km	300m(1km)
Texture	most above random	1km(300m)	1km(300m)	
Cliff	above and below random	2km(1km)	2km	1km(2km)
Small Stream	most above random	1km(300m)	300m	1km
Deer	above and below random	2km	2km	1km
Average Slope	above and below random	300m(1km)	300m(1km)	300m
Soil Drainage	most above random	1km	1km	1km
Nuts	mostly lower than random	300m & 2km	2km	300m

*Note:Nut capability and soil drainage/texture were small samples from one and two regions respectively. Therefore results were not as conclusive relative to other variables.

6.1.1 General Terrain Characteristics of Archaeological Sites

Table 6.1 shows the significant site values aggregated for all cultural periods and physiographic zones. It is intended to show some of the general characteristics of hunter-gatherer sites along the north shore of Lake Ontario. This, however, is not a description of a "typical site" for it averages the particular patterns that developed in each physiographic zone for each region, for each cultural period.

In general, archaeological sites had higher than average marsh area within 1 or 2 kilometers, although the density within 300 meters was usually very high as well. Large streams played an important role, even in the Palaeo-Indian period, so sites usually had higher than random value of large stream density within 1 kilometer and a lower than random density between 1 and 2 kilometers. Relief values were usually lower than random within the first 300 meters, but within 2 kilometers relief was often higher than average. Soil texture was most often coarser than average within 1 kilometer. Many sites had higher than average cliff densities within 1 to 2 kilometers, often within 300 meters; but, depending upon the local physiographic zone, cliff density was often lower than average. Most sites had high densities of small streams within 300 meters but this density sometimes dropped off sharply within 1 kilometer. Higher than average swamp area was present between 1 and 2 kilometers. "Flatter" terrain (low average slope) often occurred within 300 meters and "hillier" more rugged terrain occurred within 1 kilometer. In many cases, however, rugged terrain may also occur within 300 meters. Soil was generally well-drained within 1 kilometer but poorly-drained soil ocurred in some site areas.

The terrain features of site areas selected by prehistoric hunter-gatherers reflect their concern for environmental diversity, probably because it increased their resource options, thus making it easier to satisfy their pre-determined goals and aspirations (Jochim, 1976). The high incidence of marsh, swamp, cliff and streams in their site areas would have increased the availability and variety of aquatic and terrestrial plants and animals through the "edge effect" (Odum, 1959). Other terrain features such as low slope values, and loose textured well drained soil may be related to comfort and convenience rather than environmental diversity.

6.2 Terrain Characteristics of Archaeological Sites

6.2.1 Halton Region

The terrain variable characteristics in the Halton region indicated that two types of landscape were selected, probably for different economic reasons. The physical character of archaeological sites (regardless of period) changed with distance from Lake Ontario: sites on the lacustrine shale and sand plains were very different from those on the upland till plains (see Fig. 5.2). A pivotal zone appears to have been the bevelled till plain which overlies a bedrock change from the (dolostone) Amabel Formation to the (red shale) Queenston Formation. Also, archaeological sites of the Palaeo-Indian, (transitional) Hi-Lo and Early Archaic period often exhibited site characteristics which were contrary to the general trend.

In the sand zone, sites of all periods were characterized by lower than average values of all variables except small stream density, which was significantly ($p \leq 0.05$) high (Fig.6.1). Exceptions in terms of relief were Palaeo-Indian, Early Archaic and Middle Archaic sites which had significantly ($p \leq 0.05$) high relief values within the **vicinity (2km)** area (Fig.6.2). This was an important quality because the sand plain is quite uniform and may indicate that there was selection of strategic vantage points for big-game hunting; or these hills may have had more varied communities of herbaceous plants. The general proximity of a small stream was a strong result and indicated that fresh water in proximity to a camp was important. Because of the porous nature of the sand deposits, this physiographic zone had the lowest small stream density of all zones in the Halton region. The small stream density of archaeological sites however was significantly ($p \leq 0.05$) high, especially in the **site (300m)** and **setting (1km)** areas (Fig.6.1). In the Halton region the sand plain had the highest concentration of archaeologcal sites, while in Durham region it was the clay plain

Figure 6.1 Halton Sand Plain Small Stream Density
All areas had significantly high values

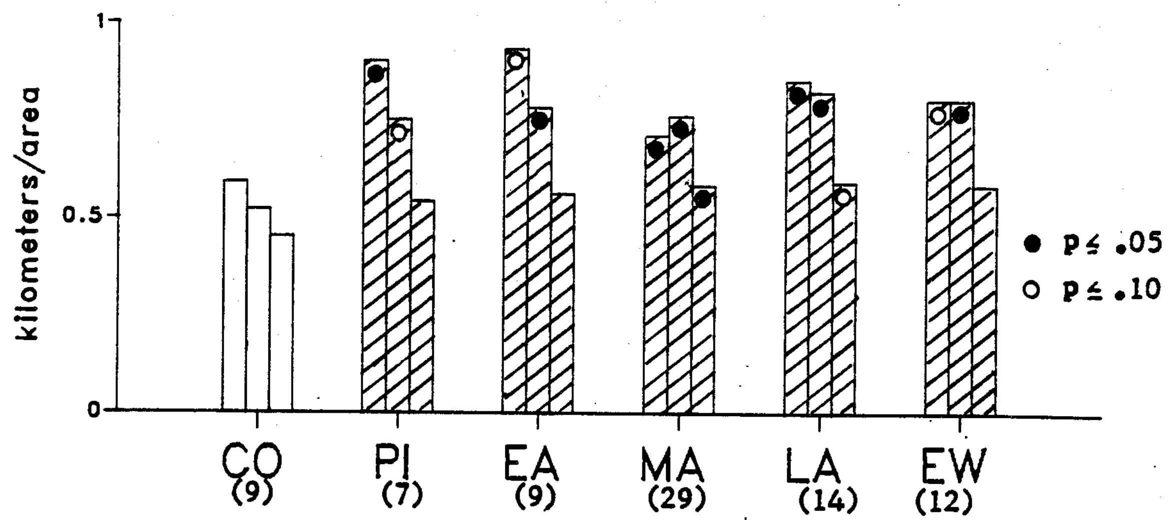
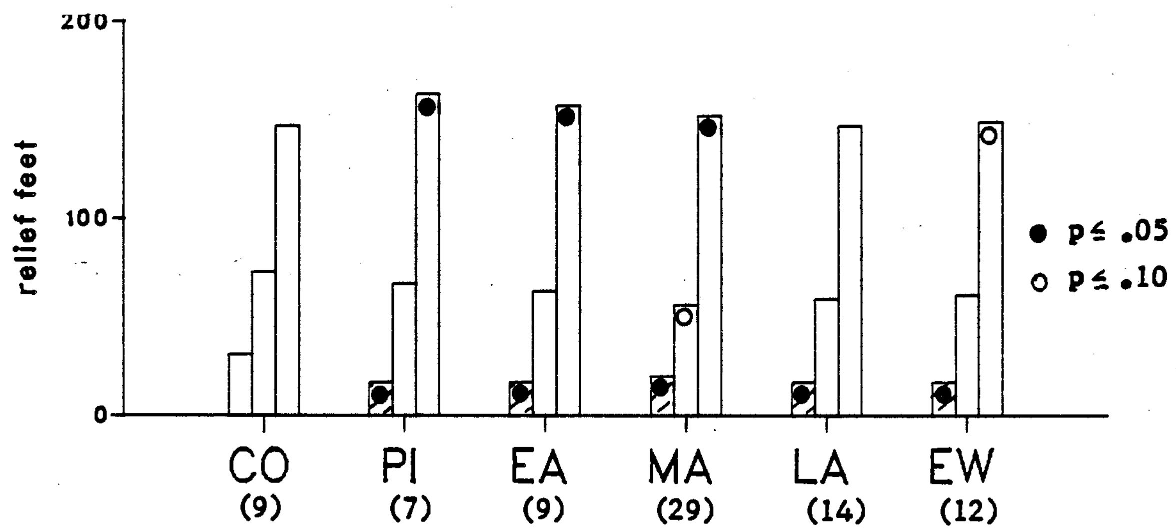


Figure 6.2 Halton Sand Plain Maximum Relief
Site (300m) values were significantly low, but vicinities (2km) were high



(see Table 5.2) This of course was mainly a function of proximity to Lake Ontario. There were of course other benefits from being close to a large body of water (even though the shoreline was further away in early Holocene times): cooler in summer, wind a relief from insects, driftwood for fuel, transportation and, of course, fishing.

The loose-textured gentle terrain of the sand plain may have provided conditions suitable for the many shrubs, bushes and weeds which prefer sunny clearings and easily disturbed soil. In turn this plant community would have supported a variety of game birds, rodents and perhaps bear.

The character of sites in the shale plain was similar to that of the sand plain in terms of topography (level and gentle) but, because of the impervious nature of shale, it had the highest drainage density of the five zones. With such a small and large stream density it is not surprizing that prehistoric cultures selected locations where the stream density was significantly ($p \leq 0.05$) low, perhaps because the ground was drier and better drained, thus more amenable to camping (Figs.6.3; 6.4). Large streams in proximity to a camp did not seem to have been a requirement in the site selection process in this zone, for the density was very low except in the immediate **site (300m)** area of Middle and Late Archaic and Early Woodland sites. This suggested that fishing in this area could have been more important to these later sites. Cliff density in the shale plain was about average, except for later sites for which it was significantly ($p \leq 0.05$) high. In this zone cliff density may have been related to the density of large streams.

The terrain of archaeological sites in the upland till moraine and drumlinized till deposits (underlaid by Amabel limestone) were quite different from the pattern in the lacustrine deposits. Average slope, (Figs.6.5; 6.6) maximum relief (figs.6.7; 6.8) and small stream density (Fig. 6.9) were significantly ($p \leq 0.05$) higher than average control values for each zone, especially in the immediate **site (300m)** area. Large stream density (Figs.6.10; 6.11), on the other hand, was very low in all site areas, except the **setting (1km)** of Early Archaic sites. Cliff density (Figs.6.12; 6.13) too was significantly ($p \leq 0.05$) higher than average in all areas for these "upland" physiographic units, so in this case it is not closely associated with large stream density. For these till plain units, prehistoric hunter-gatherers seem to have preferred "rougher and hillier" terrain near small streams and which offered a range of elevations close to their camp. Aerial photographs of this area showed a network of low glacial flutes and drumlins which were below the resolution of even the 1:25,000 NTS maps. Hunter-gatherers seem to have selected camps on and around these flutes (close to small streams), perhaps because they provided good conditions for oak, hickory and other nut trees, which in turn provided browse and mast for ungulates, bear and wild turkey. The unusual and significantly ($p \leq 0.05$) high density of large streams in the **setting (1km)** of Early Archaic

Figure 6.3 Halton Shale Plain Small Stream Density
Settings (1km) and vicinities (2km) have low densities

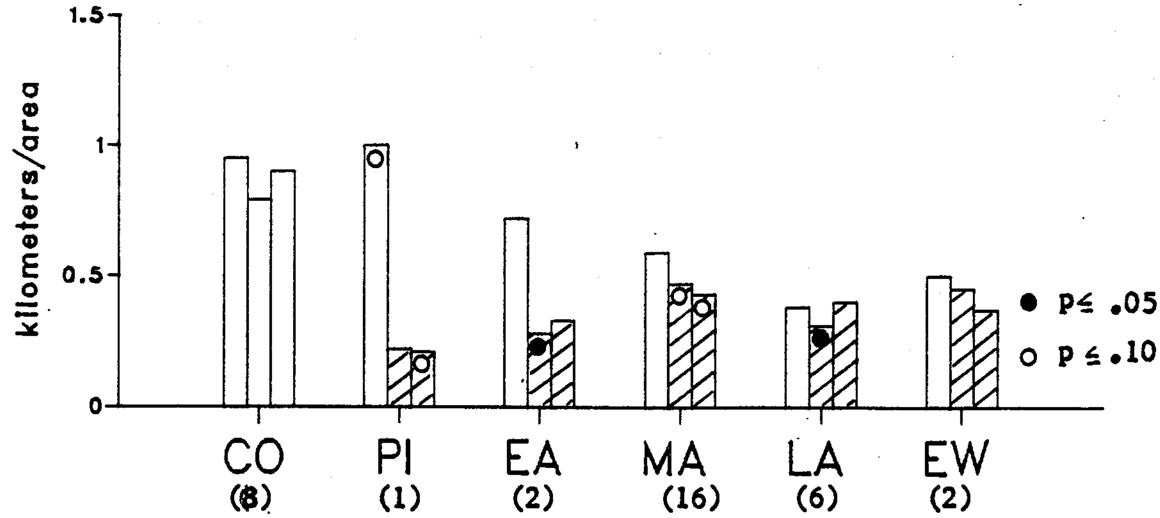


Figure 6.4 Halton Shale Plain Large Stream Density
Large streams were not selected for the setting (1km) area

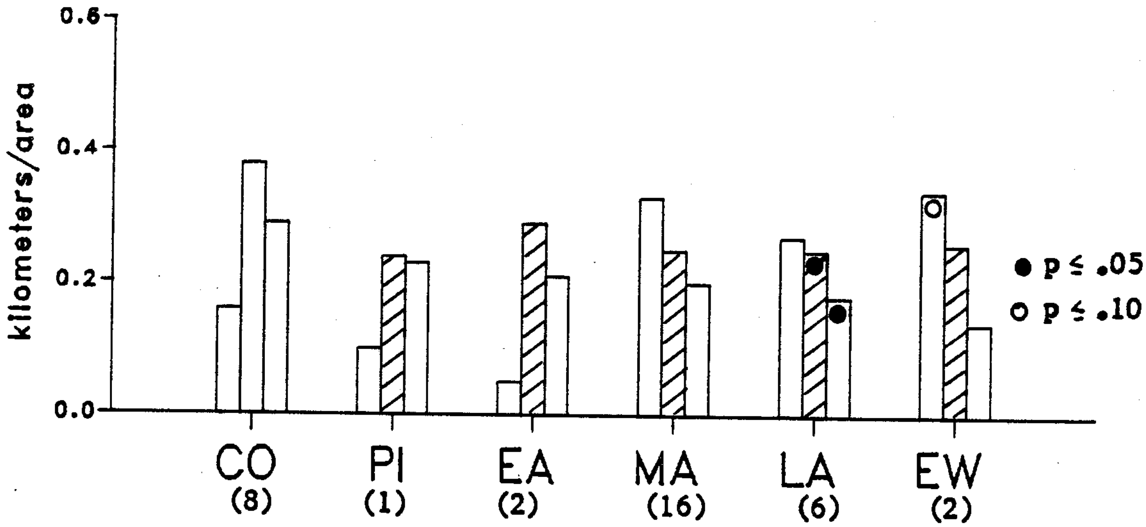


Figure 6.5 Halton Till Moraine Average Slope
Site (300m) areas are significantly high

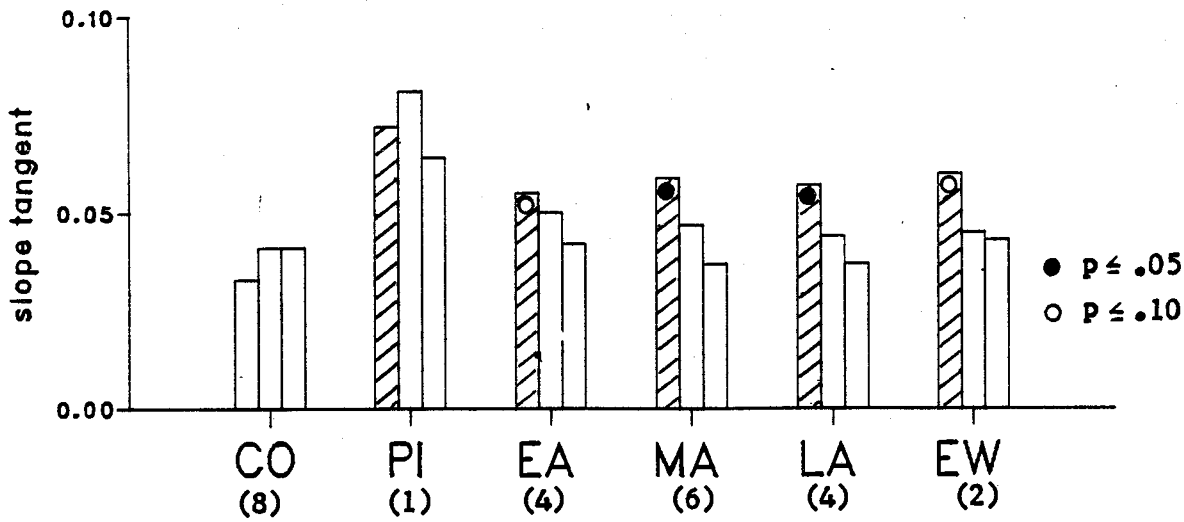


Figure 6.6 Halton Drumlinized Till Average Slope
"Rougher" or "hillier" terrain was preferred in the setting (1km)

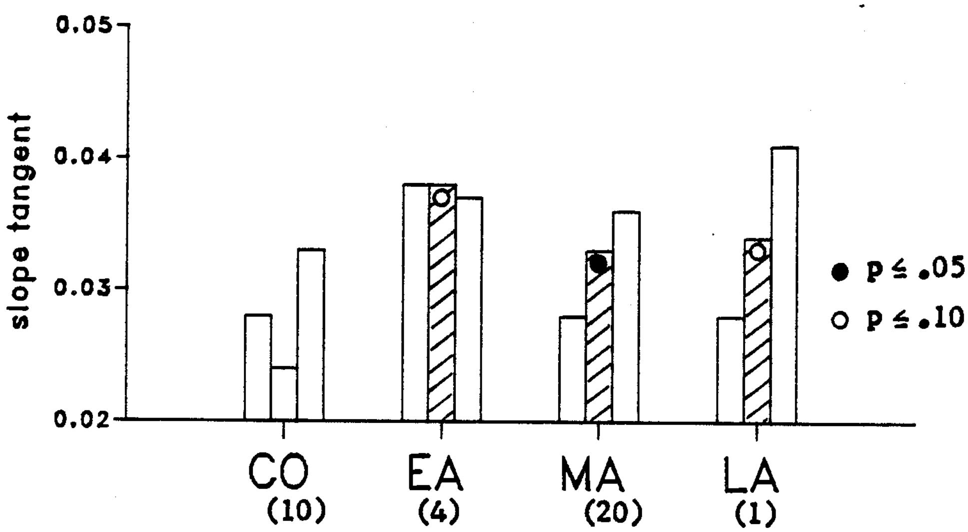


Figure 6.7 Halton Till Moraine Maximum Relief
Values were significantly high in site (300m) area

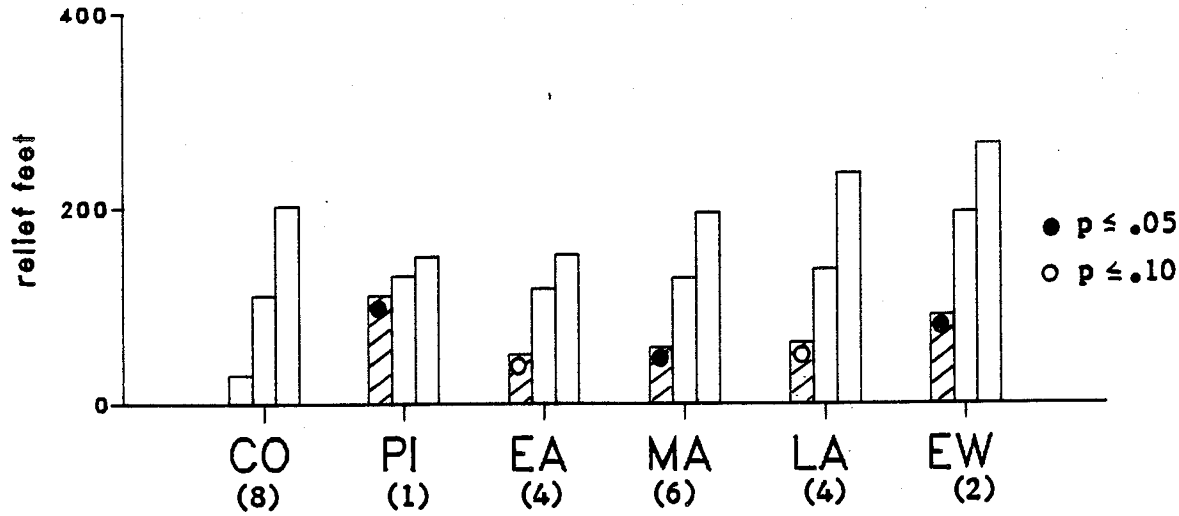


Figure 6.8 Halton Drumlinized Till Maximum Relief
High relief was selected for the setting (1km)

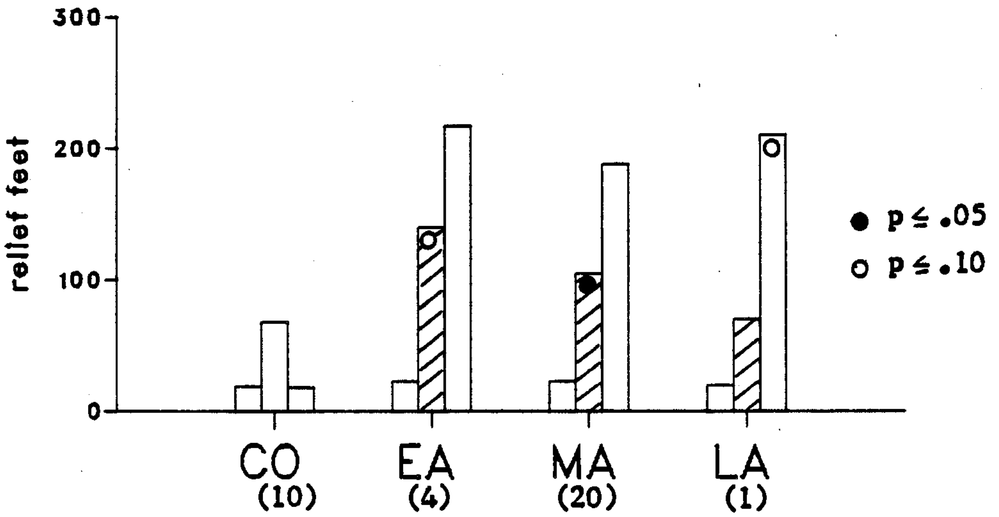


Figure 6.9 Halton Drumlinized Till Small Stream Density
Small streams in proximity to camp were selected

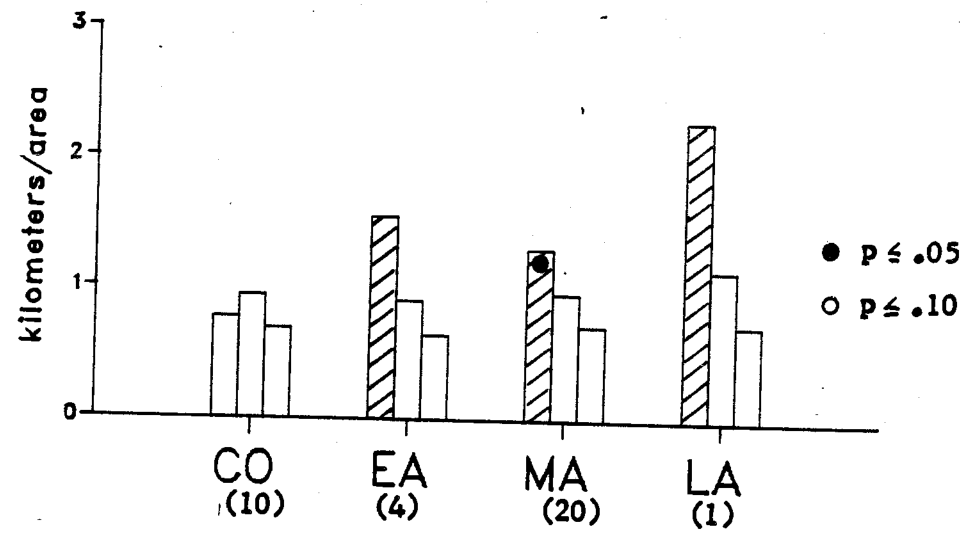


Figure 6.10 Halton Till Moraine Large Stream Density
Values are absent at site (300m) level, but significantly high in the settings (1km) of early sites

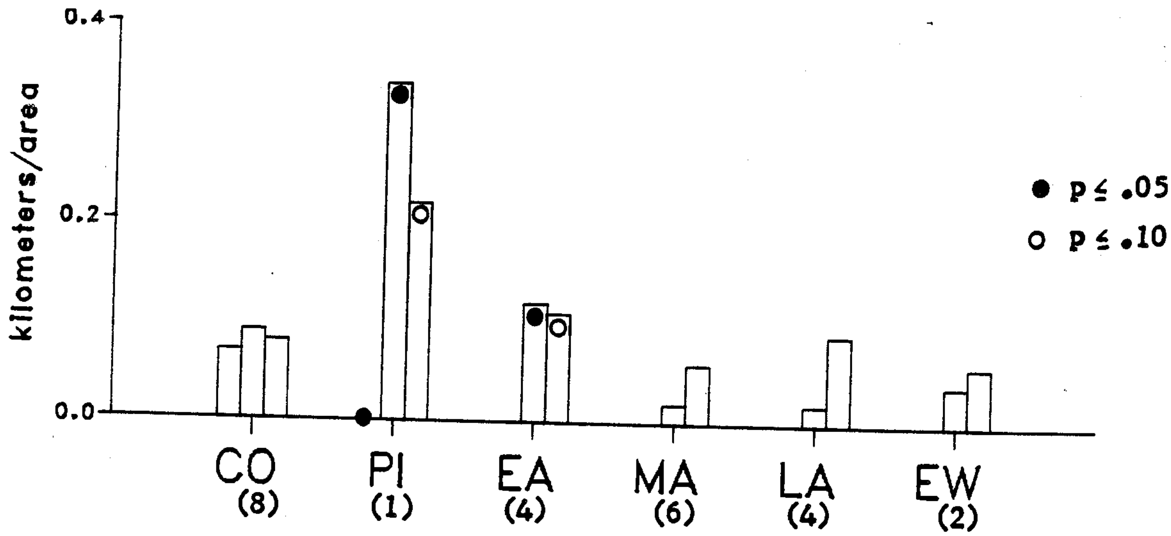


Figure 6.11 Halton Drumlinized Till Large Stream Density
Site (300m) values were significantly low or absent

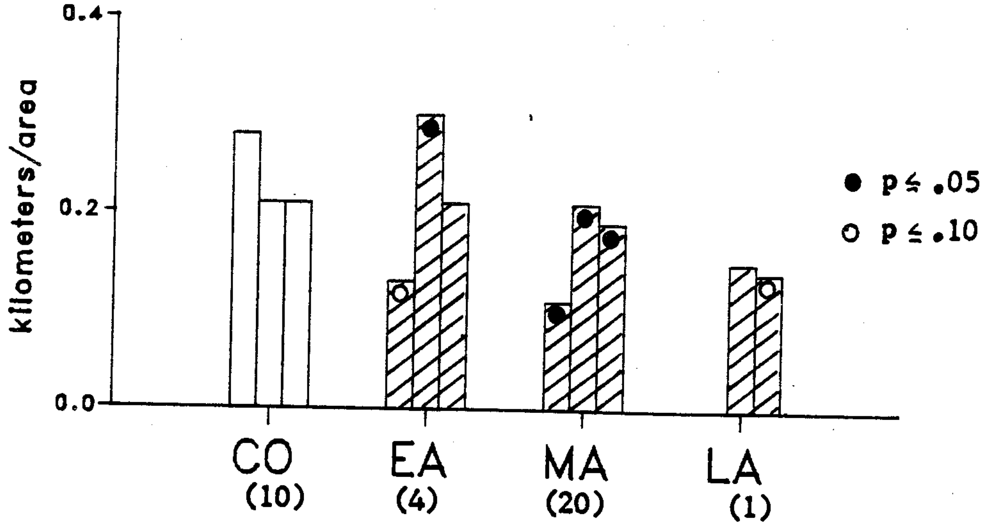


Figure 6.12 Halton Till Moraine Cliff Density
Values are significantly high in all areas

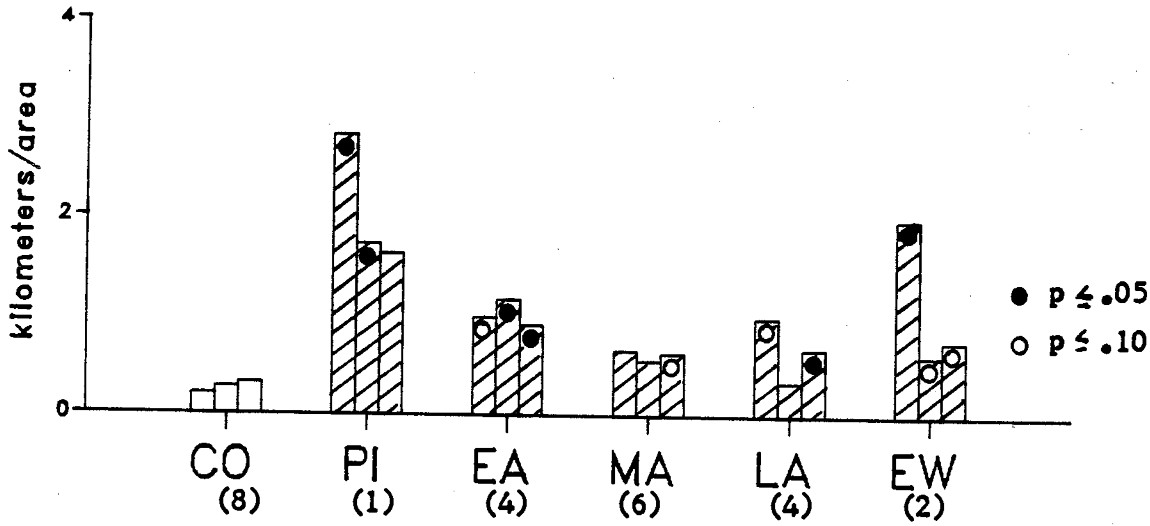
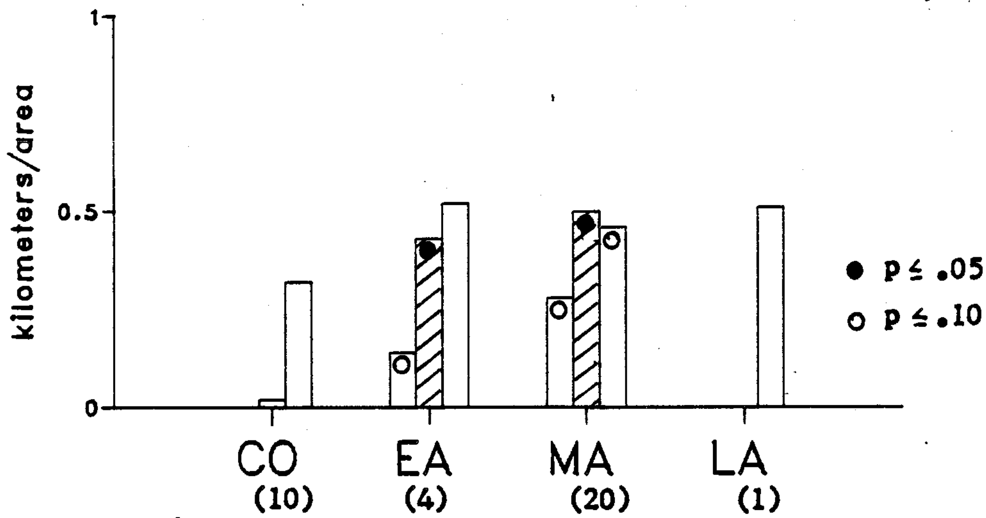


Figure 6.13 Halton Drumlinized Till Cliff Density
Values were significantly high in the setting (1km)



sites (Figs. 6.10; 6.11) suggested that a different activity (fishing?) was undertaken here at that time, or that a different quarry or hunting strategy was pursued.

In the bevelled till zone the terrain characteristics of archaeological sites were often intermediate between the upland tills and the lacustrine deposits. Average slope (Fig. 6.14) and maximum relief (fig. 6.15) values were higher than average, but only in the **vicinity (2km)** area of earlier sites (Palaeo-Indian and Early Archaic). The drainage pattern however was more like that of the shale plain: selecting for a lower small stream density (Fig. 6.16) and a generally higher large stream density (Fig. 6.17). This suggested that the bevelled till zone was used for fishing as well as the kind of activities carried out on the till plains (gathering nuts and deer hunting?).

These results indicate that the site selection process of prehistoric hunter-gatherers varied with distance to Lake Admiralty. In the "upland" till zones sites were located in areas of low drumlins and glacial flutes and had higher than average slope and relief, but were close to small streams. In the zones which were closer to the lake, stream densities were a major factor in the site selection process: proximity to a small stream was preferred in the sand zone (where overall stream density is low) and proximity to a large stream was preferred in the shale zone (where stream density is high). Early sites (Palaeo-Indian and Early Archaic) often varied from the general cultural pattern. In the sand plain, these sites had higher than average maximum relief in site

Figure 6.14 Halton Bevelled Till Average Slope
The earlier cultures selected "rougher", "hillier" terrain

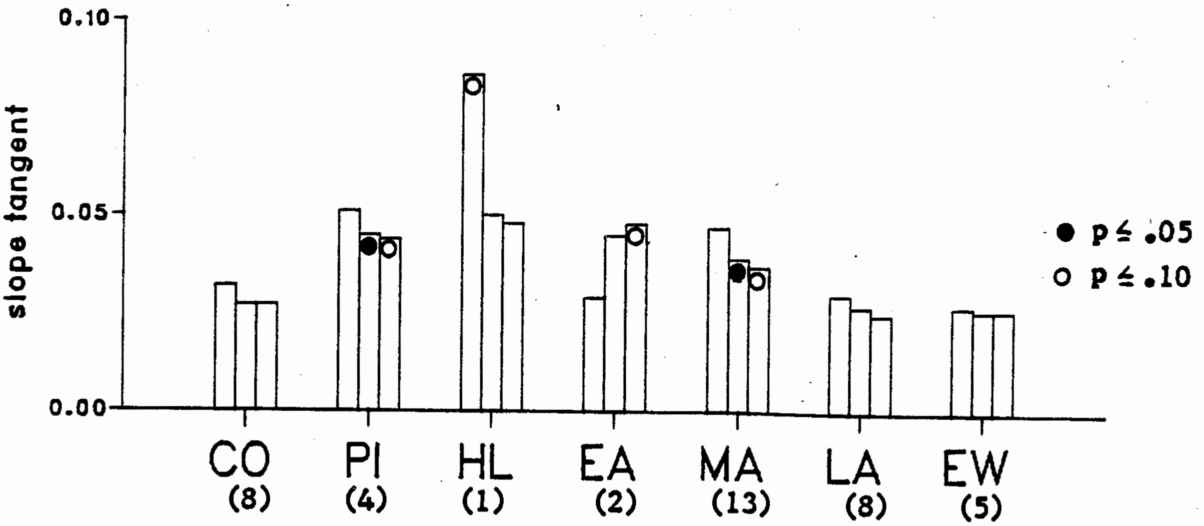


Figure 6.15 Halton Bevelled Till Maximum Relief
Vicinity (2km) values were especially high in the earlier sites

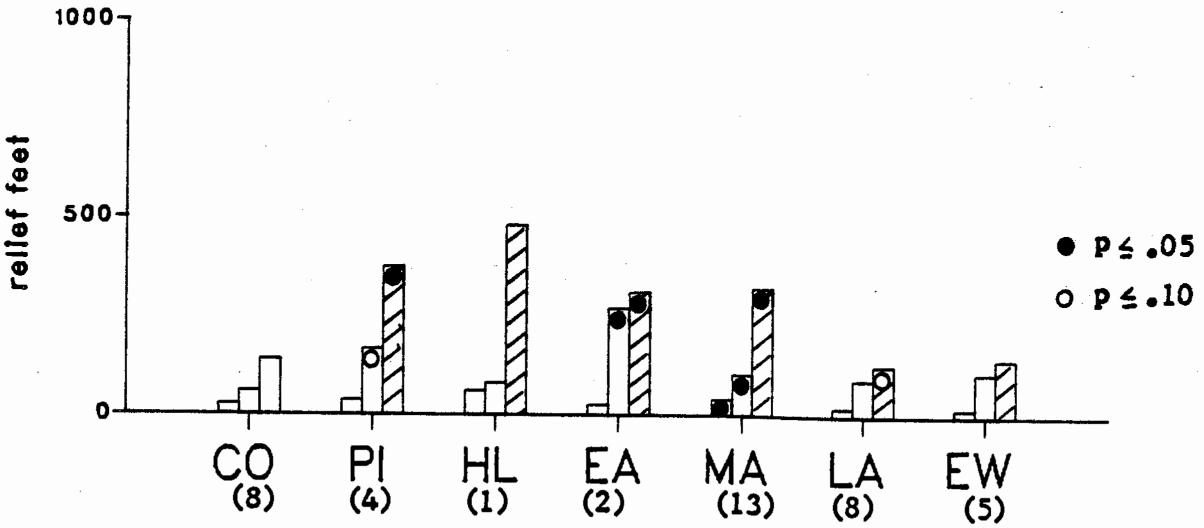


Figure 6.16 Halton Bevelled Till Small Stream Density
Note the trend for higher values in the vicinity

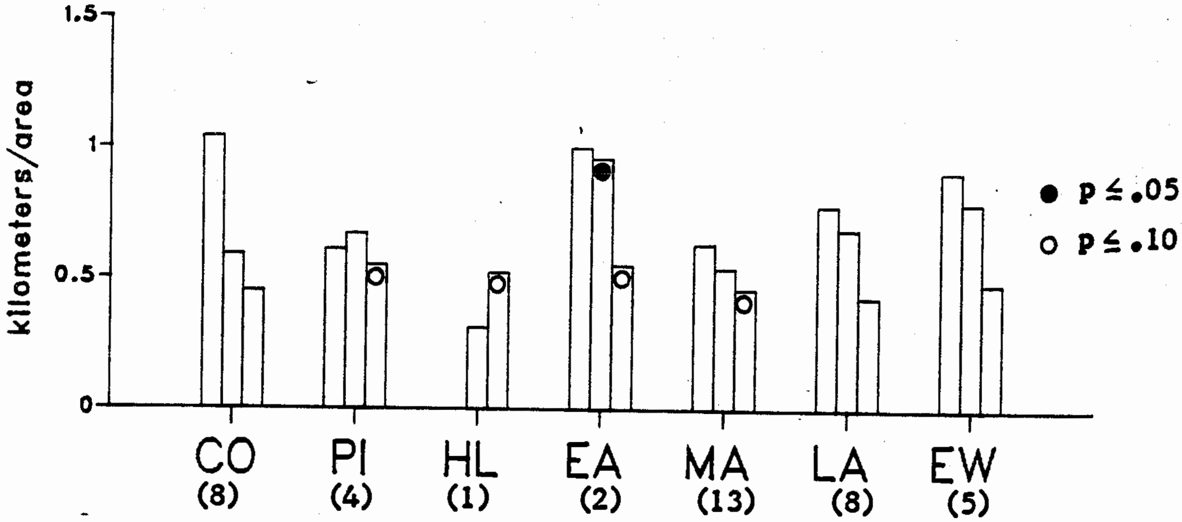
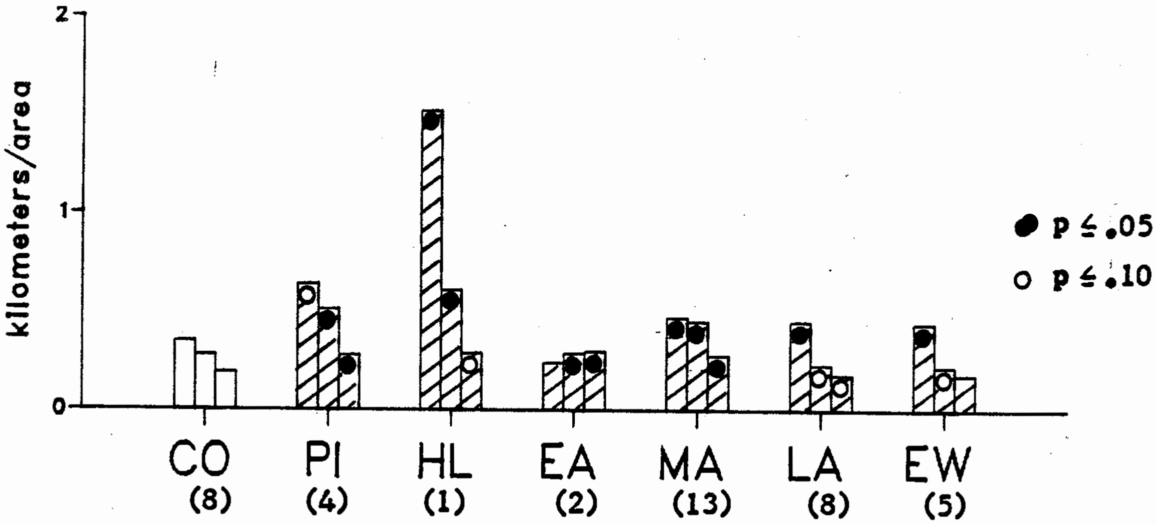


Figure 6.17 Halton Bevelled Till Large Stream Density
High values suggest fishing was important, even in the early periods



vicinity; in the shale plain, they had lower large stream densities in the site (.3 km) area. In the bevelled till zone, their vicinity (2 km) values of slope and relief were higher; and, in the till zones, Early Archaic settings (1 km) had higher large stream densities than other periods.

6.2.2 Durham Region

The two physiographic zones in the Durham region have close parallels with zones in Halton. Most obvious is the till plains found in both regions. However, the Durham clay plain is similar in character to the Halton shale plain, the latter being rather shallow clay loam over shale bedrock. In

Halton the zones are more or less parallel bands extending back from the lake, but in Durham both zones border the lake, although the till tends to be more "upland" than the clay plain. Also Durham is a more elongated region than Halton and the sites tend to be located closer to the present shore.

In both the till and clay plain zones of the Durham-Northumberland Region (see Fig. 5.3) the archaeological sites shared similar characteristics in terms of relief, and densities of small streams, cliff and marsh; but they differed in terms of slope and densities of large order streams and swamp. As in Halton Region, Palaeo-Indian, Hi-Lo and Early Archaic sites often had different terrain characteristics from later sites.

In both the till and the clay plain maximum relief was generally lower than average, especially in the **setting (1km)** and **vicinity (2km)** areas (Figs 6.18; 6.19). Archaeological slope values in the till zone were average (Fig. 6.20), but in the clay zone values were significantly ($p \leq 0.05$) less than average in all catchment areas except for the Palaeo-Indian sites which trended ($p \leq 0.10$) higher in the **setting (1km)** area (Fig. 6.21). This was not unexpected since most sites in this zone were clustered near the lakeshore in areas of flatter terrain. Still, the divergence of Palaeo-Indian terrain from the overall pattern suggested that this was related to the site selection process. In the clay zone Palaeo-Indian relief values trended ($p \leq 0.10$) higher than average in the **vicinity (2km)** area, perhaps reflecting their concern for elevated vantage points for big-game hunting.

Small stream densities in both zones were significantly ($p \leq 0.05$) high for the early sites, but trended ($p \leq 0.10$) lower than average with the later sites (Figs. 6.22; 6.23). In the till plain the large stream density trended ($p \leq 0.10$) lower than average in the **site (300m)** and **setting (1km)** areas (Fig. 6.24), but Palaeo-Indian and Early Archaic values were often high. In the clay zone the trend ($p \leq 0.10$) was for higher large stream densities in all areas (Fig. 6.25), but Palaeo-Indian and Early Archaic values often had the lowest values. The transitional Late Palaeo-Indian/Early Archaic Hi-Lo sites however did have a high large stream density. Thus in the till zone only the early cultures seem to have selected for a high density of all streams while in the clay zone the

Figure 6.18 Durham Region Drumlinized Till Maximum Relief

Early and Late Archaic showed a trend for lower values

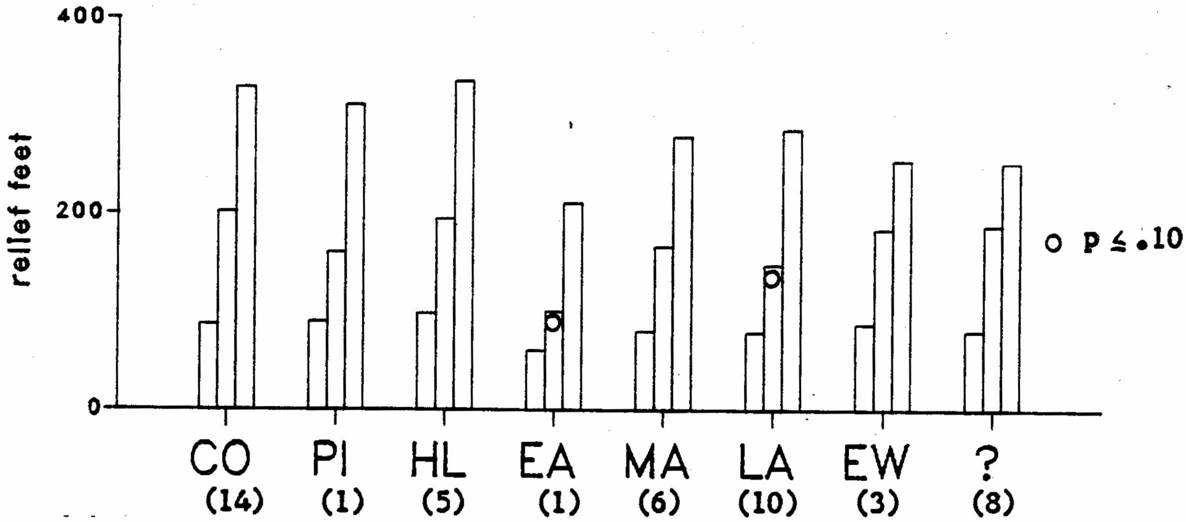


Figure 6.19 Durham Region Clay Plain Maximum Relief

Except for Palaeo-Indian setting (1km) and vicinity (2km), values were significantly low

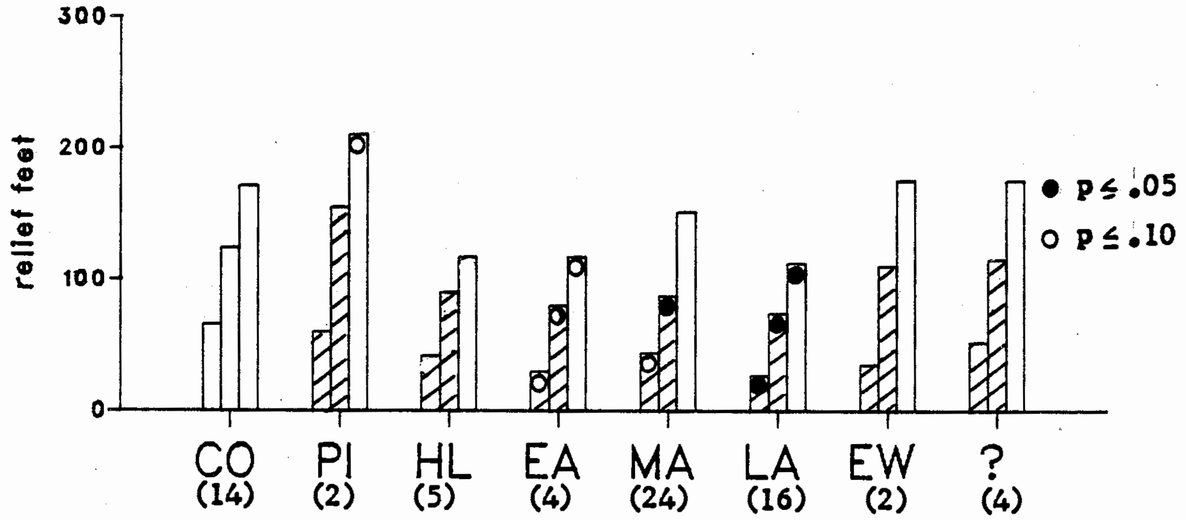


Figure 6.20 Durham Region Drumlinized Till Average Slope

There were no significant values in this zone

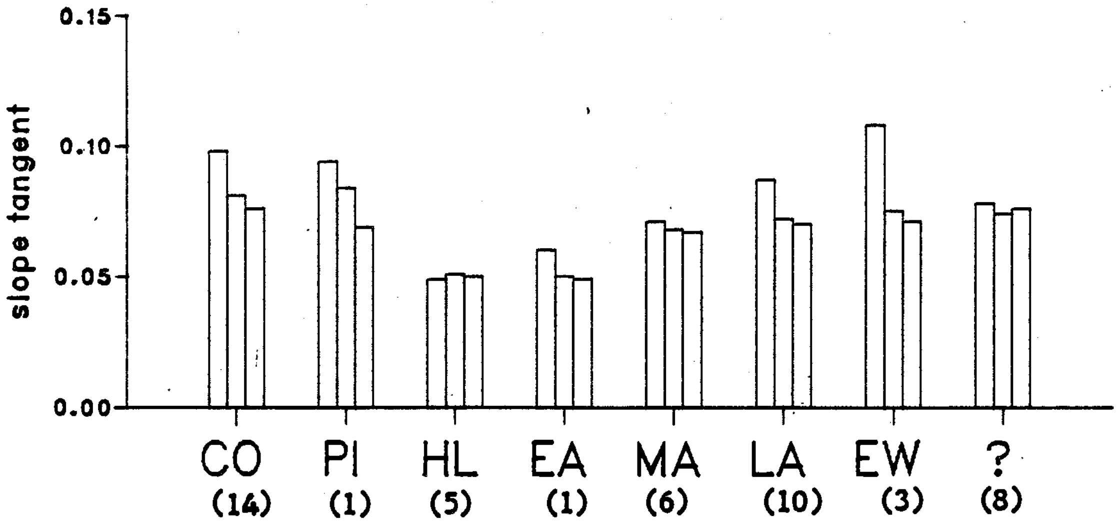


Figure 6.21 Durham Region Clay Plain Average Slope

Except for Palaeo-Indian setting (1km) and vicinity (2km), values were significantly low

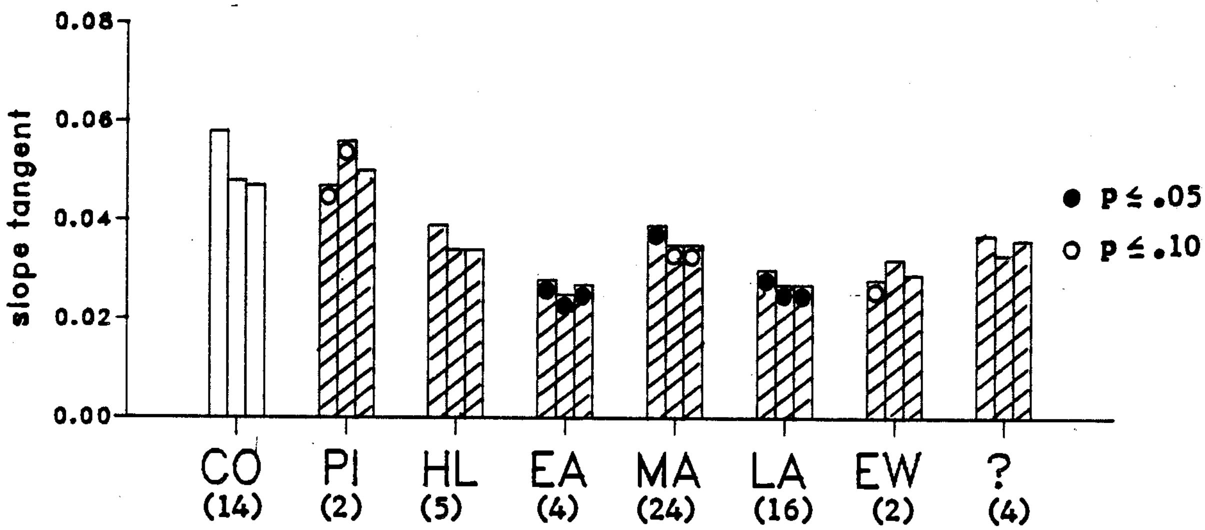


Figure 6.22 Durham Region Drumlinized Till Small Stream Density
Except for Early Archaic, values were higher in earlier periods

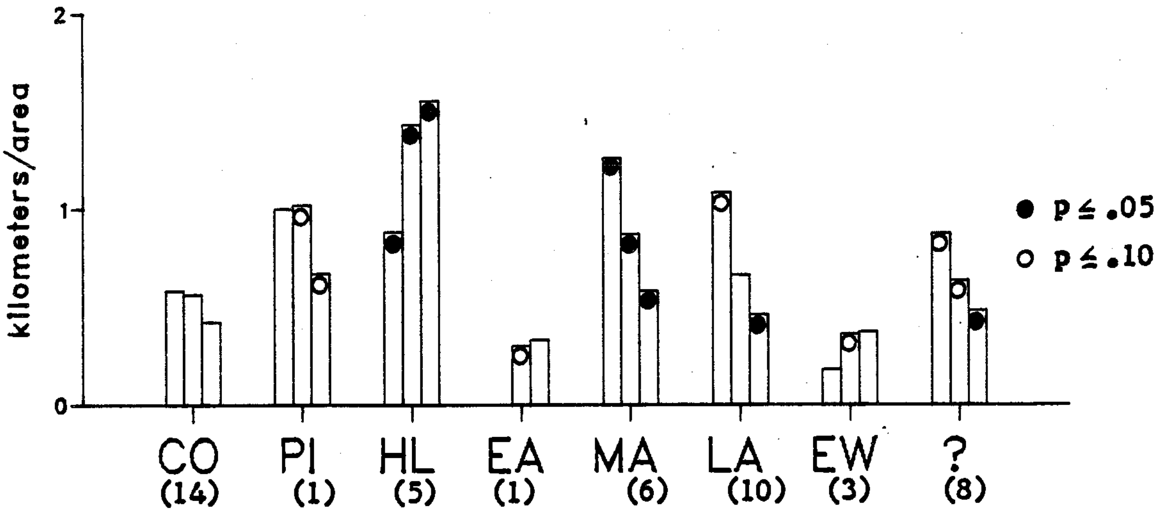


Figure 6.23 Durham Region Clay Plain Small Stream Density
Note the strong signal from the Palaeo-Indian sample

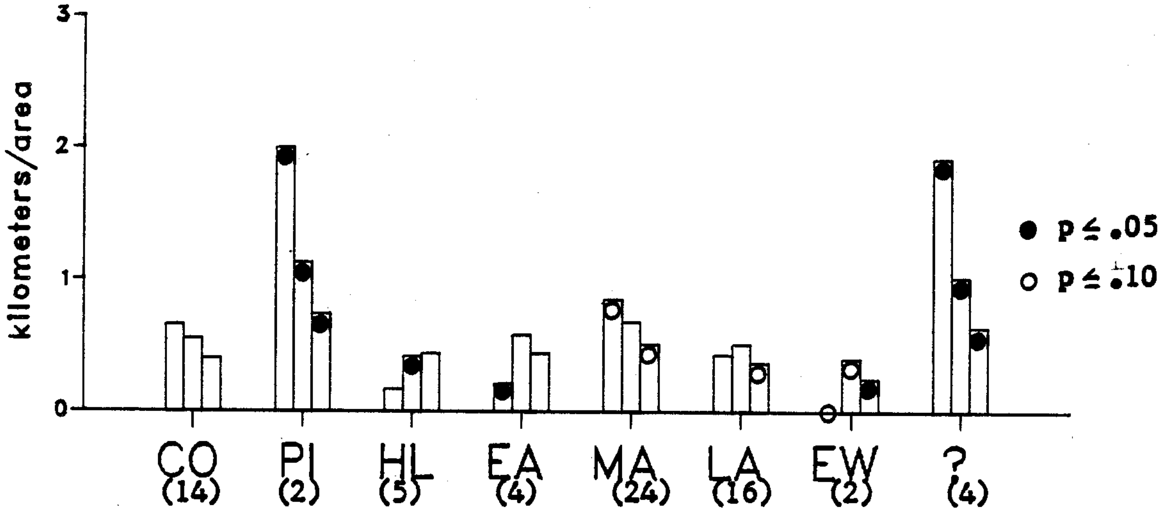


Figure 6.24 Durham Region Drumlinized Till Large Stream Density
Except for Palaeo-Indian site (300m) area, large streams were more important in later periods

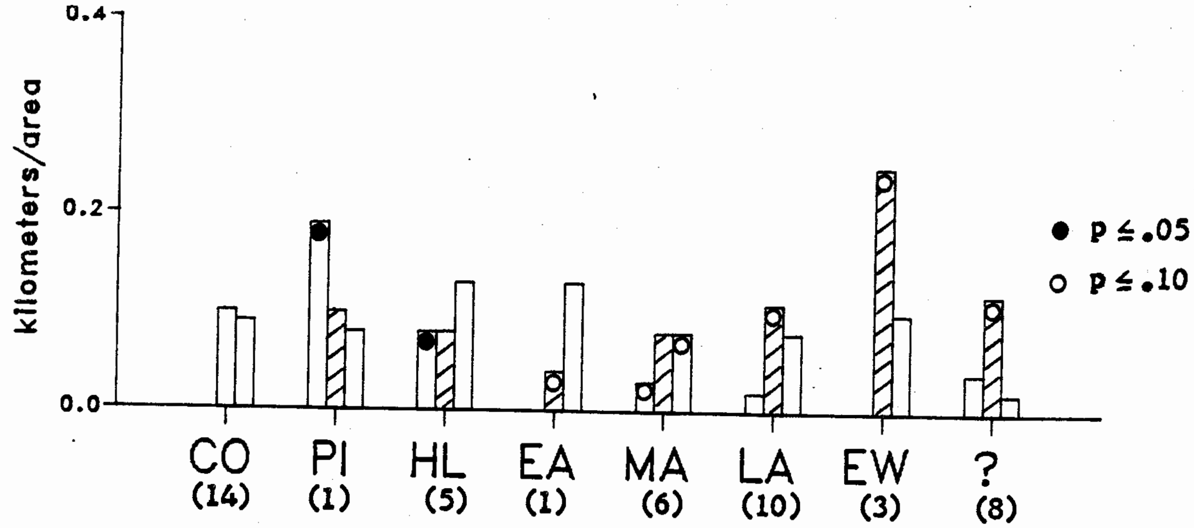
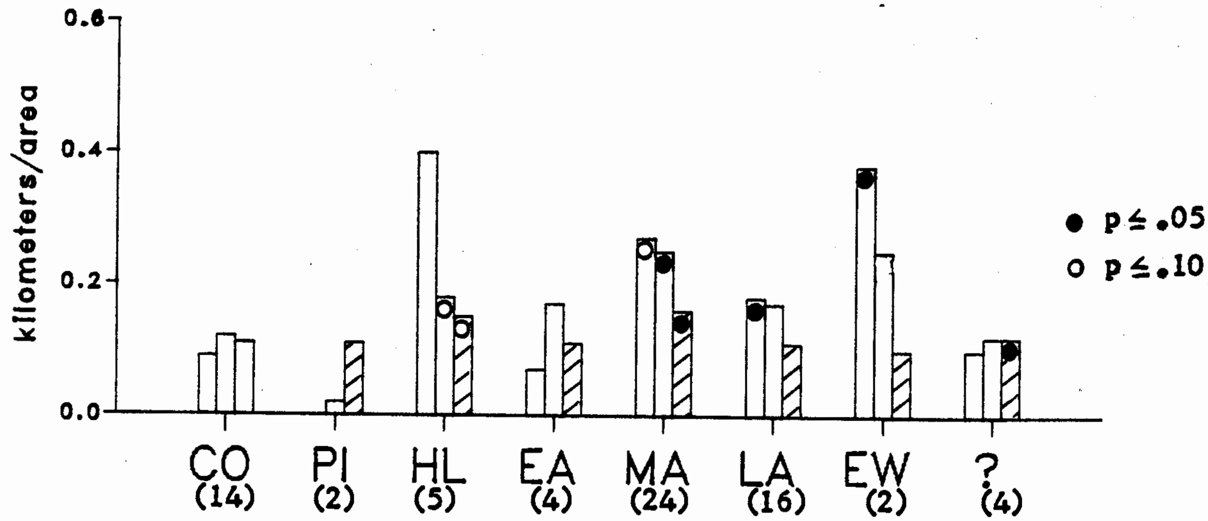


Figure 6.25 Durham Region Clay Plain Large Stream Density
Large orders were more important in the later periods



larger orders were less important in the selection process than they were to later cultures. In contrast the early cultures in the clay plain seem to have selected higher small stream densities than later cultures.

Both the clay and till plains had lower values of archaeological cliff density (Figs. 6.26; 6.27) although in the till zone the Palaeo-Indian and Hi-Lo sites had the highest values of any period.

Marsh values were significantly ($p \leq 0.05$) high in all areas (Figs. 6.28; 6.29) although in the clay plain Palaeo-Indian values were quite low. The lake level was lower in Palaeo-Indian times

Figure 6.26 Durham Region Drumlinized Till Cliff Density
Setting (1 km) values were often significantly low

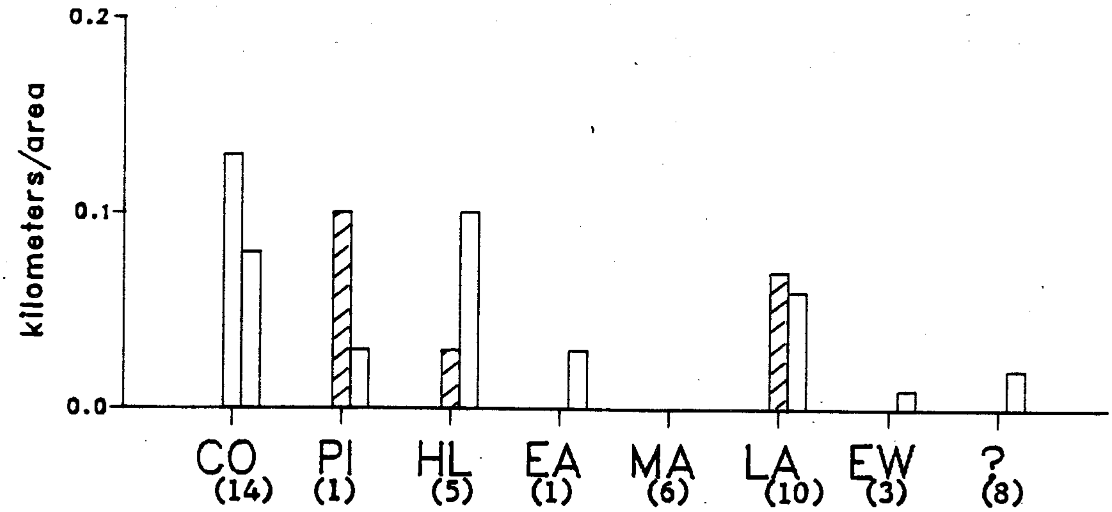


Figure 6.27 Durham Region Clay Plain Cliff Density
Values for all periods and areas were significantly low

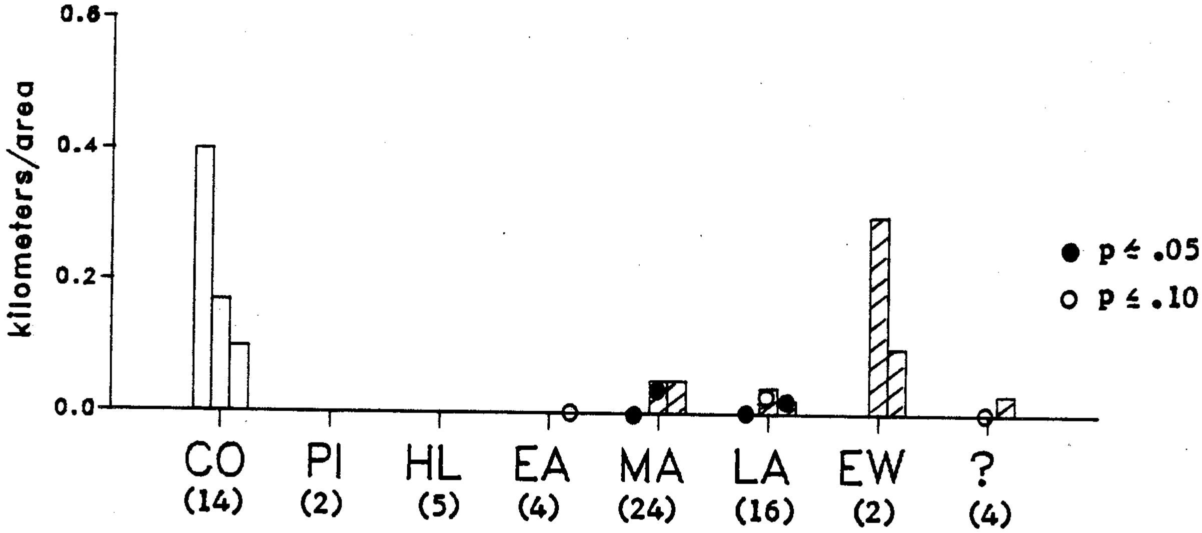


Figure 6.28 Durham Region Drumlinized Till Marsh Area
Early values were low, but still significantly higher than controls

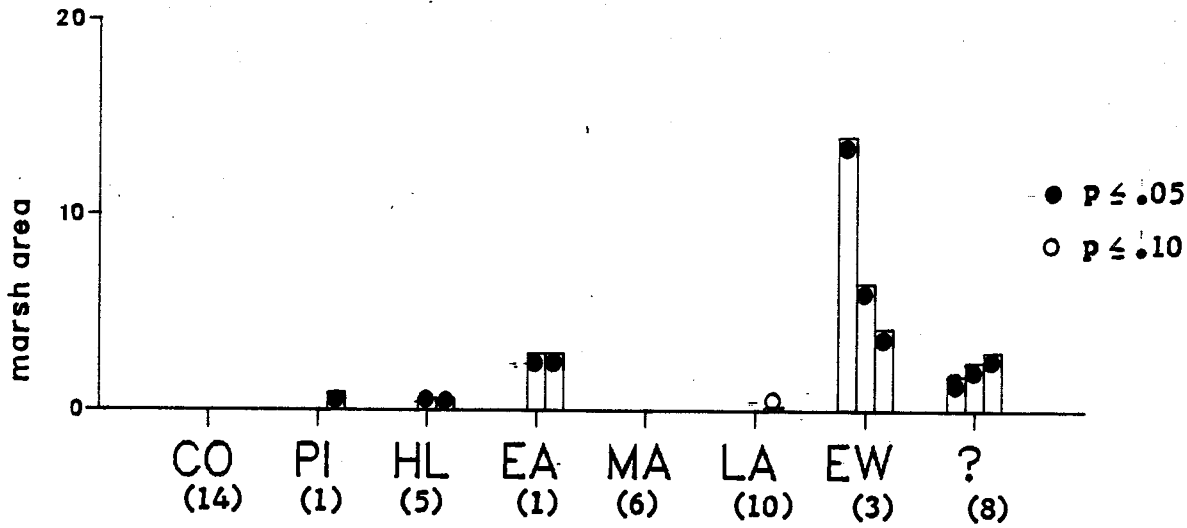
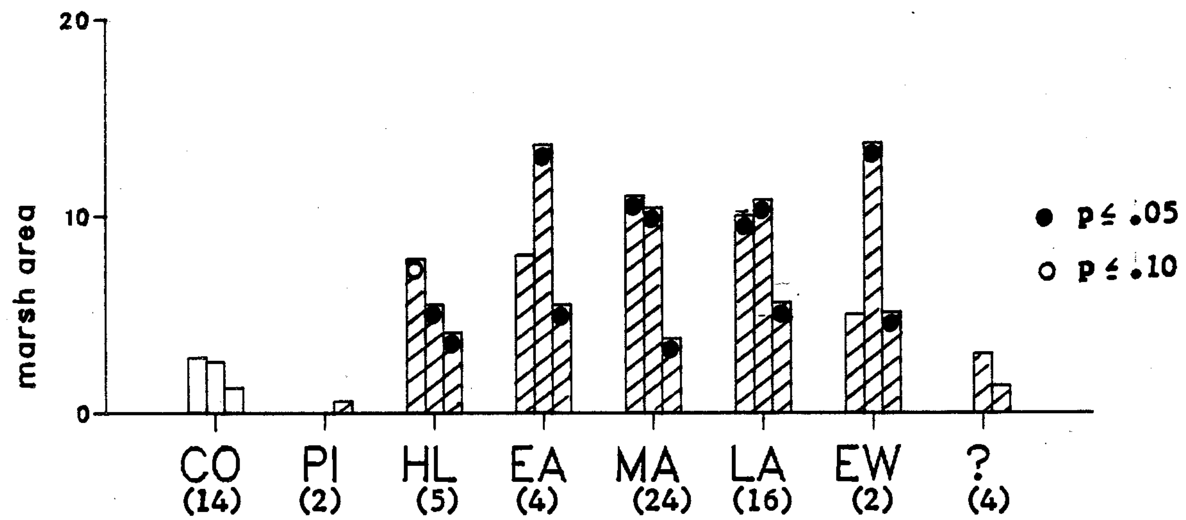


Figure 6.29 Durham Region Clay Plain Marsh Area
Except for Palaeo-Indian, all periods and areas had a strong signal



(Admiralty Phase) and it is possible that now-modern marshes had not as yet begun to form; however, the subsequent Hi-Lo and Early Archaic sites did have high values for these marshes, despite low lake levels at this time, so perhaps marshes were present in Palaeo-Indian times in this zone but were not as important in the site selection process.

In the till plain, swamp area values trended ($p \leq 0.10$) low in **site (300m)** areas but were about average elsewhere (Fig. 6.30). In the clay plain however swamp area was significantly ($p \leq 0.05$) high for Hi-Lo **sites (300m)** and Early Archaic **settings (1km)** and **vicinities (2km)** while the later Archaic periods had average values (Fig. 6.31). Thus, in both the till and the clay

Figure 6.30 Durham Region Drumlinized Till Swamp Area
Except for Late Archaic site (300m) area, values were low or absent

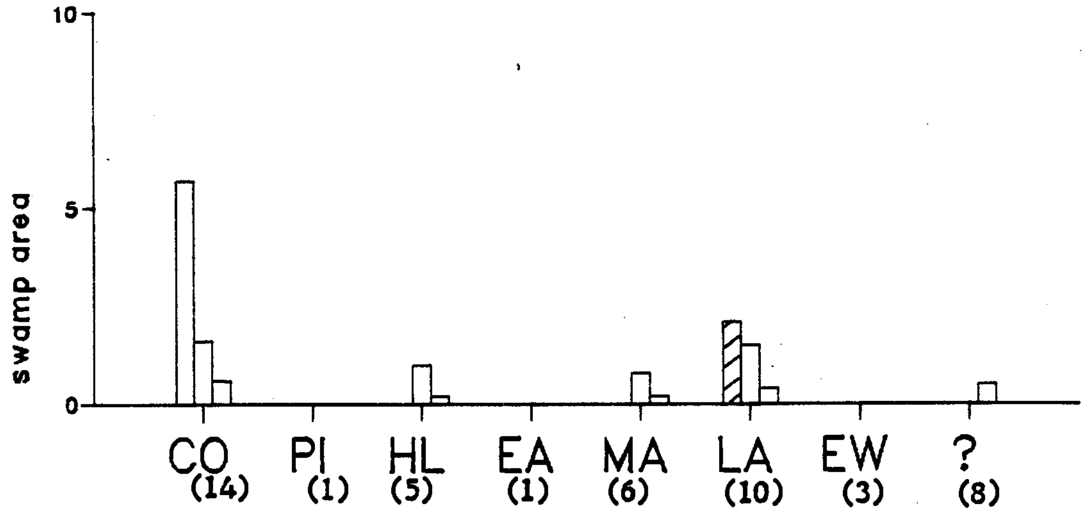
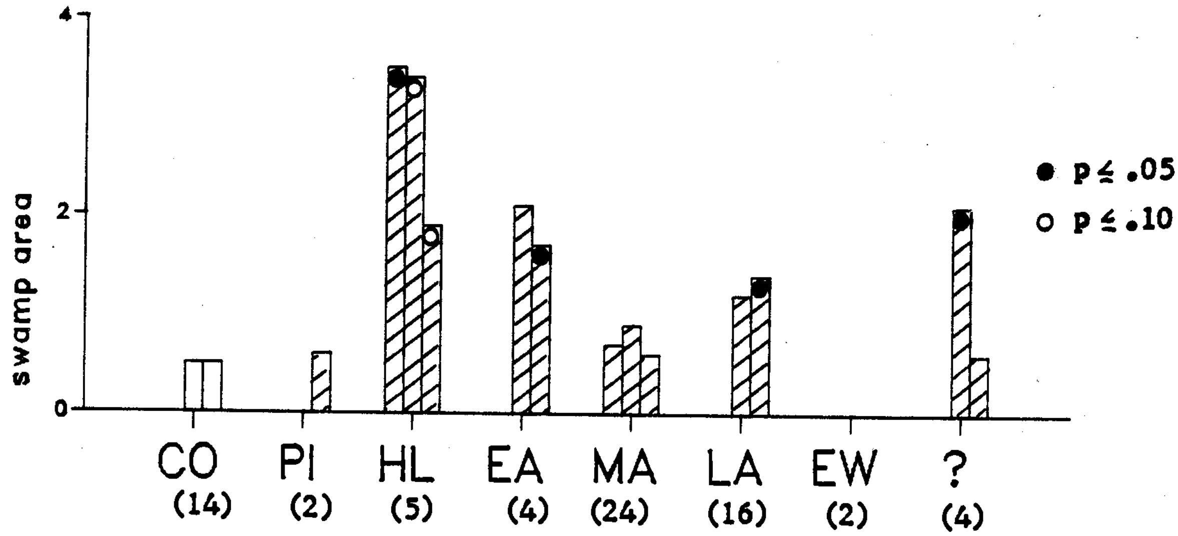


Figure 6.31 Durham Region Clay Plain Swamp Area
Except for Palaeo-Indian, early periods had high values



plains, earlier cultures seem to have selected for higher densities of cliff and swamp and less of marsh. Later cultures selected only for marsh and were apparently not concerned with cliff density and swamp area.

Archaeological sites in both the clay and till plain had similar patterns of relief and small stream, cliff, and marsh areas. Relief and cliff density were lower than control locations, and small stream and marsh areas were higher. Slope was average on the till plain but lower on the clay plain. Large stream density was lower on the till plain and higher on the clay plain. The early sites often differed from the later Archaic pattern. In the clay plain Palaeo-Indian marsh area was low and the transiti onal Hi-Lo and Early Archaic had high swamp areas. Also on the clay plain, Palaeo-Indian and Early Archaic often had the lowest large stream density and Palaeo-Indian had high slope values (setting) and relief (vicinity). On the till plain, Palaeo-Indian and Early Archaic often had the highest large stream densities and Palaeo-Indian and Hi-Lo cliff densities were high.

6.2.3 Lennox and Addington Region

Lennox and Addington is quite different from the previous regions because it is contiguous to the Canadian Shield and is at the opposite end of an environmental continuum from Halton. There is a clay zone which borders the lake, as it does in Durham, but also a regosolithic limestone plain which has no parallel in either Halton or Durham regions.

In the limestone zone (see Fig. 5.4) the topographic features, slope and relief, appear to have had a negligible effect on site selection. In the clay zone however there was a significant trend ($p \leq 0.10$) for high slope values in the **site (300m)** area and high relief values in the **vicinity (1km)** area (Figs. 6.32; 6.33). This may indicate that, like Halton Region, there was a preference for glacial flutes and low drumlins in this area also. Perhaps this topography was preferred because it was elevated above swamps and marshes.

Large stream density in general was fairly high in both zones in the **site (300m)** area in the early periods as well as the later periods (Figs. 6.34; 6.35). This may indicate that fishing or other aspects of these large stream environments were important in all periods. In the limestone zone where small stream density (of control locations) was relatively low the cultural tendency was to seek out site areas with high densities, perhaps to compensate for the generally low density, caused by intermittent first order streams - a characteristics typical of karst topography (Fig. 6.36). In the clay plain where small stream density was relatively high, the opposite was the case: a low incidence of small streams was preferred (Fig.6.37) Once again this may have been related to the selection of drumlin-marsh interfaces.

Figure 6.32 Lennox and Addington Clay Plain Average Slope

High site (300m) and setting (1km) values may indicate selection of low drumlins and glacial flutes

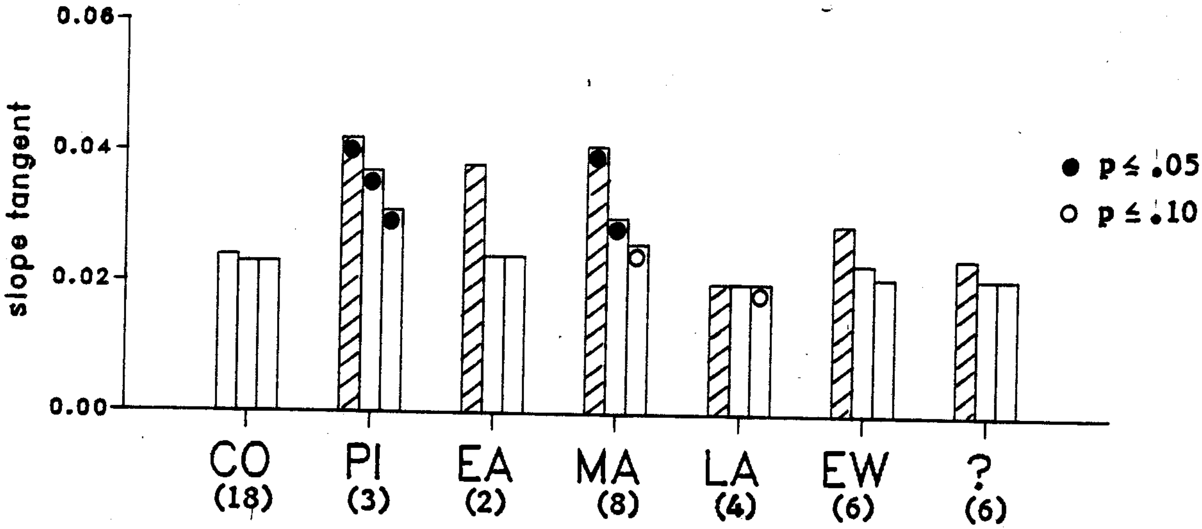


Figure 6.33 Lennox and Addington Clay Plain Maximum Relief

All Palaeo-Indian areas were significantly high

Only vicinities (2km) were significantly high in other periods

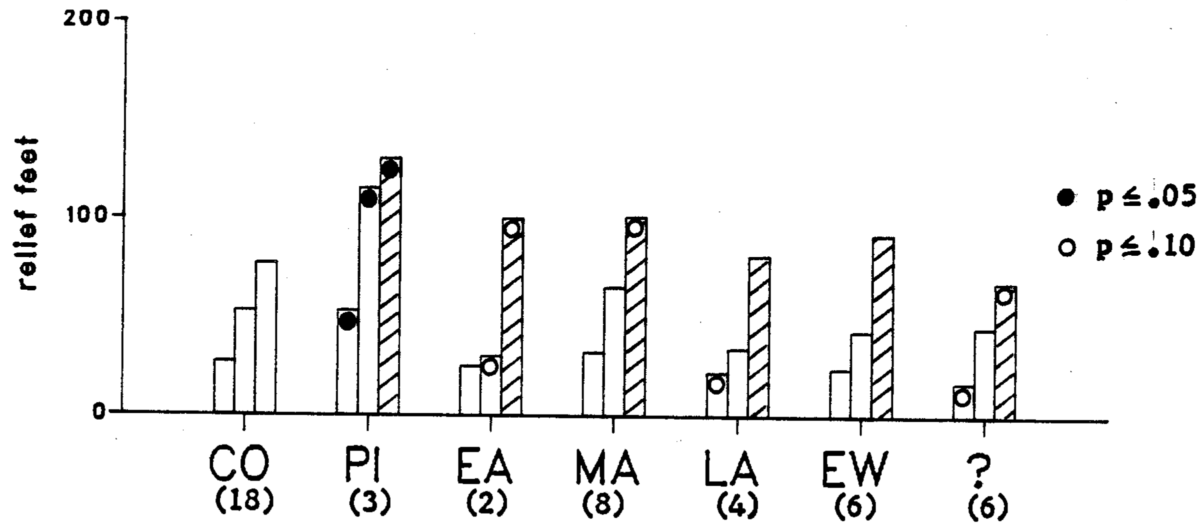


Figure 6.34 Lennox and Addington Limestone Plain Large Stream Density
Except for Late Archaic, values were significantly low in the vicinity (2km) area

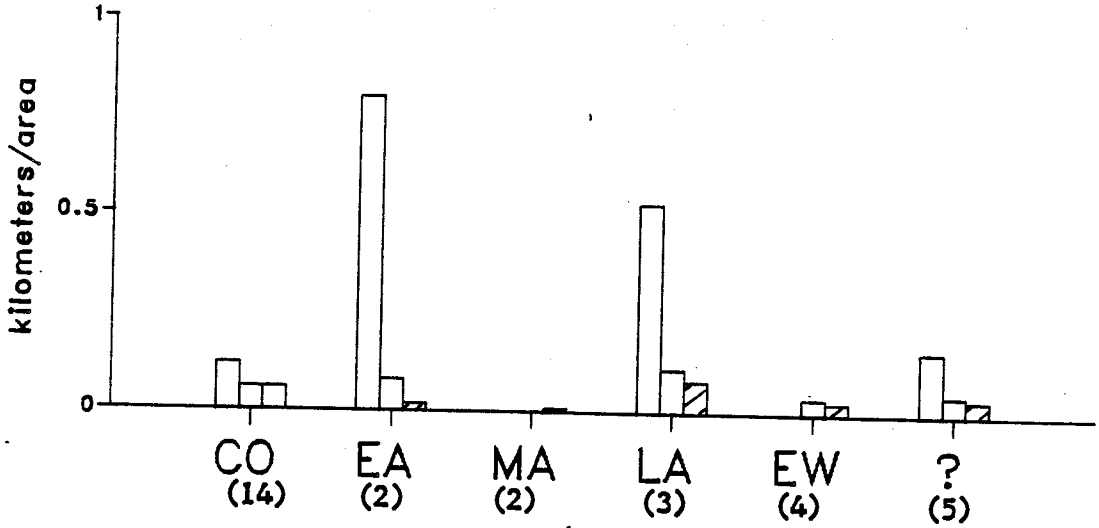


Figure 6.35 Lennox and Addington Clay Plain Large Stream Density
Significantly high values in site (300m) and setting (1km) may indicate fishing

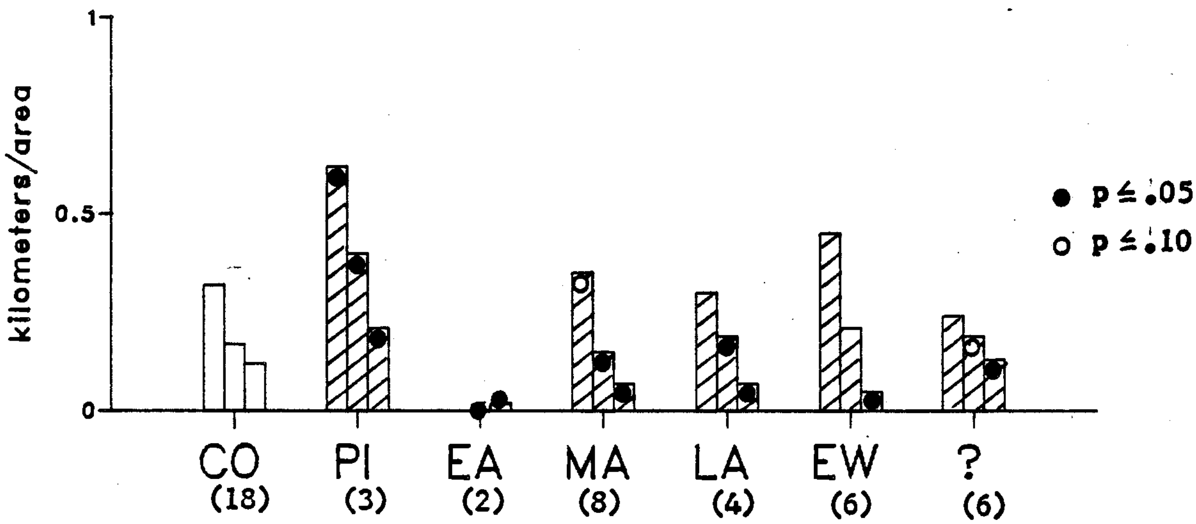


Figure 6.36 Lennox and Addington Limestone Plain Small Stream Density
Setting (1km) and vicinity (2km) values were significantly high
Many first order streams are intermittant

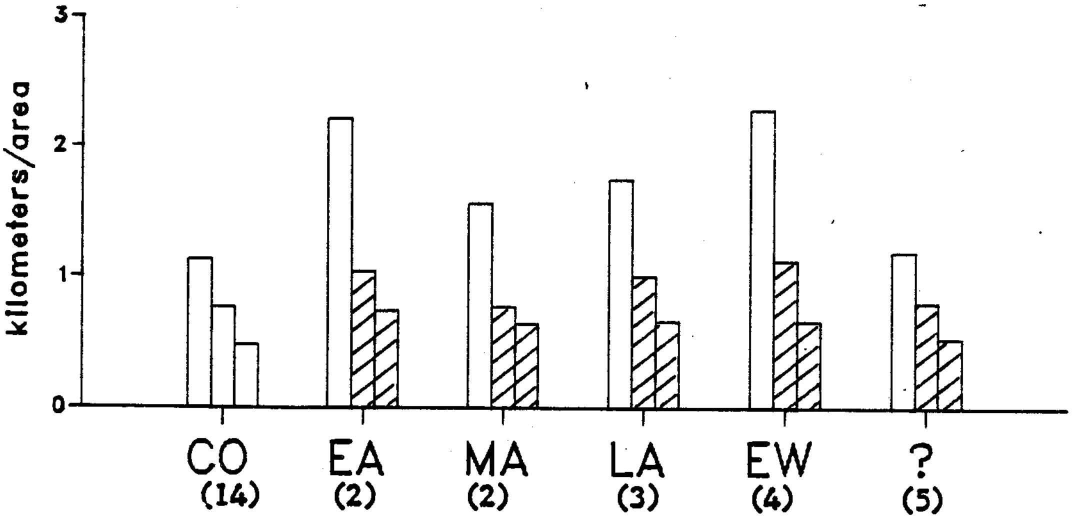
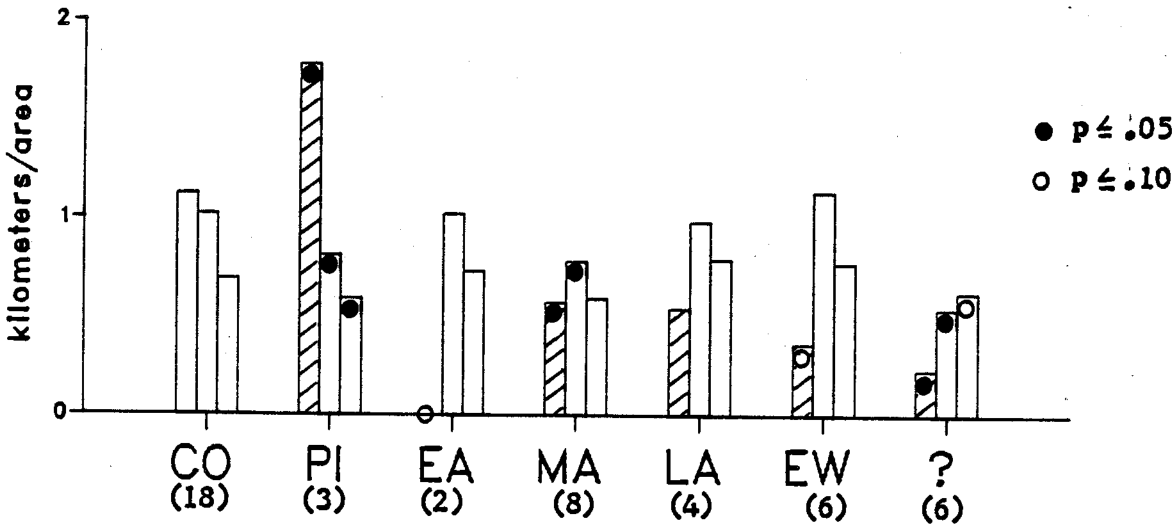


Figure 6.37 Lennox and Addington Clay Plain Small Stream Density
Except for Palaeo-Indian, site (300m) and setting (1km) areas were significantly low



Both zones had significantly ($p \leq 0.05$) higher values of soil texture, indicating that there was a preference for coarser soils, but in the clay zone all site areas were important while in the limestone zone coarse texture in the **setting (1km)** area appeared more important (Figs. 6.38; 6.39). Soil drainage was also significantly ($p \leq 0.05$) low in the limestone **settings (1km)**(Fig. 6.41) and was high in the clay zone (Fig. 6.40). Once again, this may be related to a preference for low drumlins and glacial flutes. Because the regosolithic limestone plain is prone to drought, it seems that prehistoric hunter-gatherers sought areas of low relief and slope near marshes where soil conditions were moister.

Figure 6.38 Lennox and Addington Limestone Plain Soil Texture
Setting (1km) appears to have been the most important area

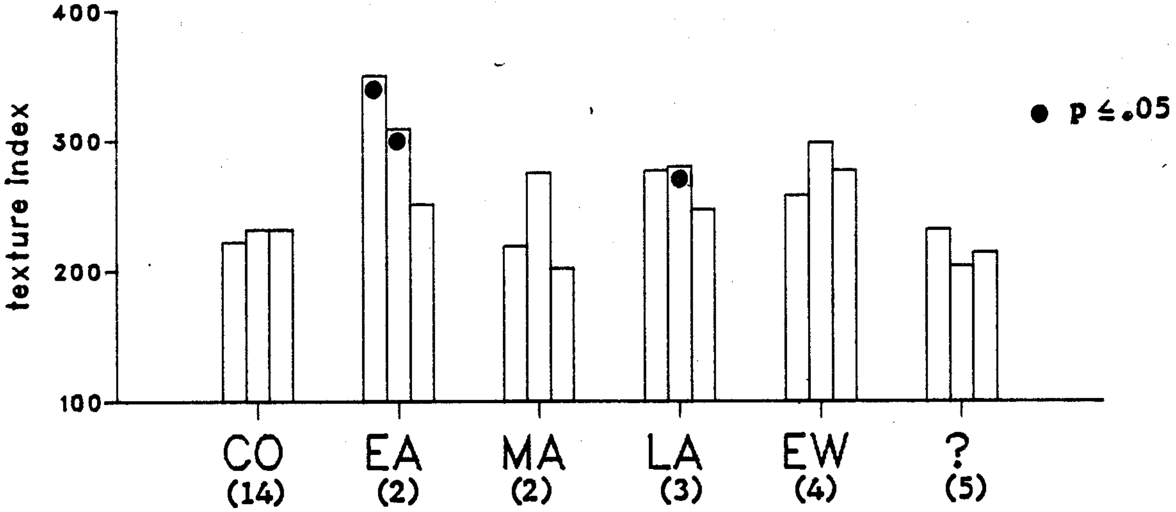


Figure 6.39 Lennox and Addington Clay Plain Soil Texture
A strong preference for coarser textured soils is indicated

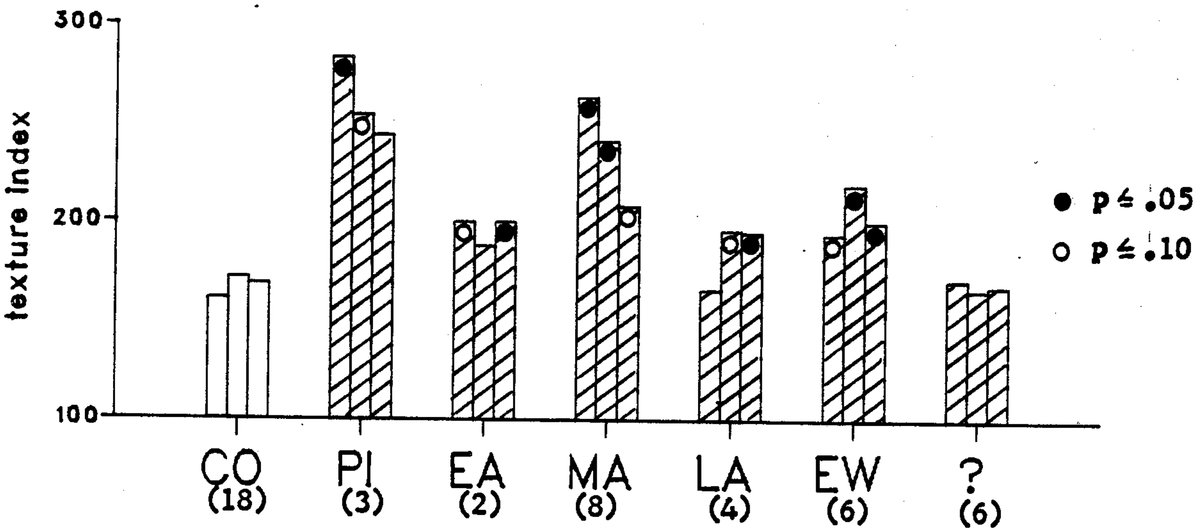


Figure 6.40 Lennox and Addington Limestone Plain Soil Drainage
Significantly low values occurred in the settings (1km)

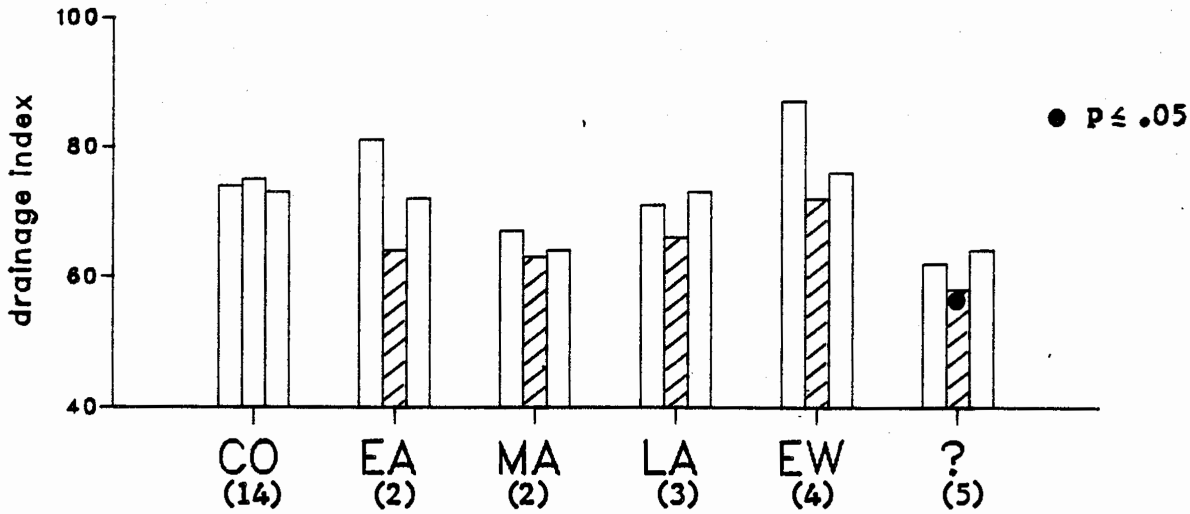
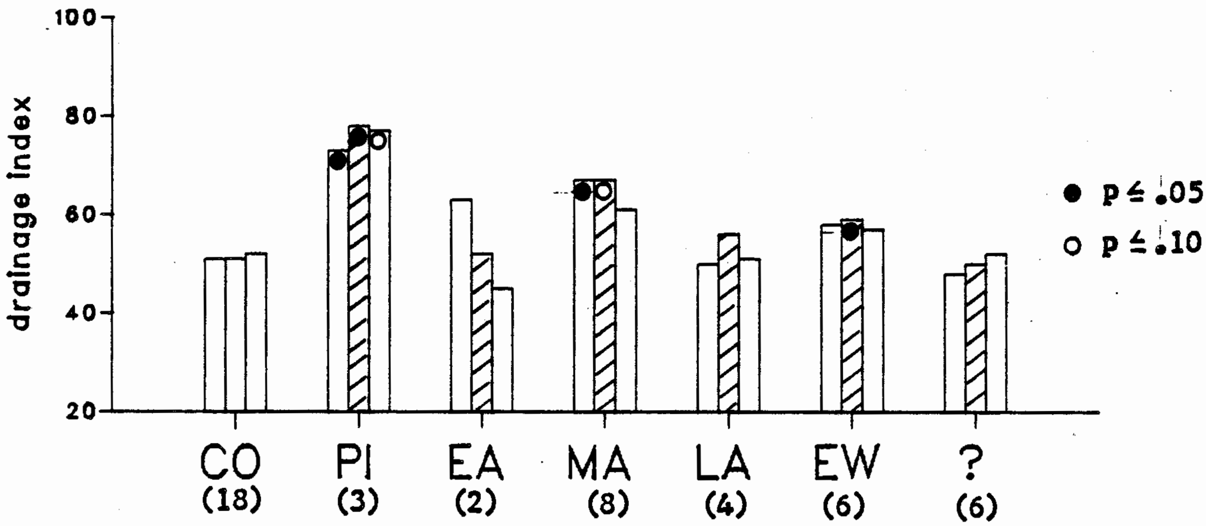


Figure 6.41 Lennox and Addington Clay Plain Soil Drainage
Note the significantly high values



Significantly high values of marsh characterized the archaeological sites of both zones especially in the **setting (1km)** and **vicinity (2km)** areas, although there was no marsh within the areas of Palaeo-Indian sites in the clay zone (Figs. 6.42; 6.43). This clearly indicates that marshes were attractive to prehistoric hunters and gatherers. Like Durham Region, the absence of marsh in the Palaeo-Indian site areas may have been because the marshes in the clay zone had not yet formed in these areas due to lower water tables as a result of lower levels in the Ontario basin. On the other hand, perhaps marshes were not then important in their site selection process. Swamp incidence was low in the limestone zone, due to droughty regosolithic conditions and bedrock

Figure 6.42 Lennox and Addington Limestone Plain Marsh Area

A strong preference for marsh environment was indicated

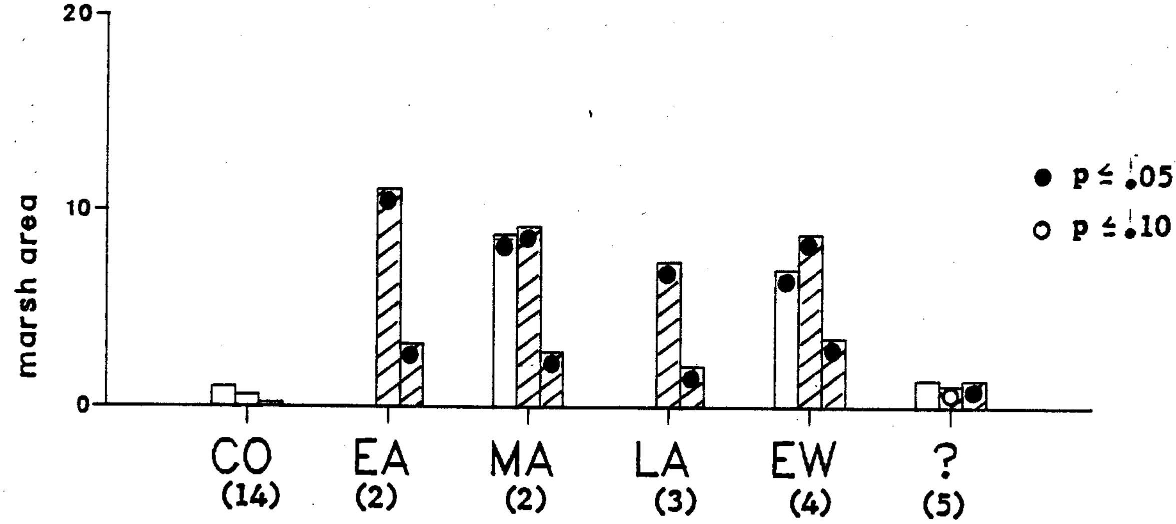


Figure 6.43 Lennox and Addington Clay Plain Marsh Area

Except for Palaeo-Indian, values were significantly high in setting (1km) and vicinity (2km)

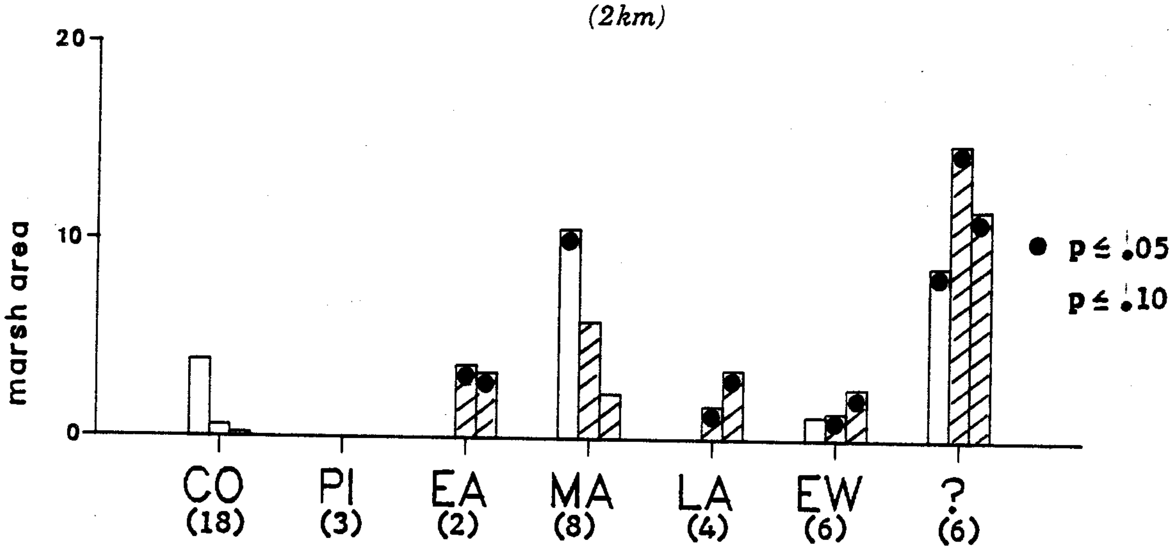
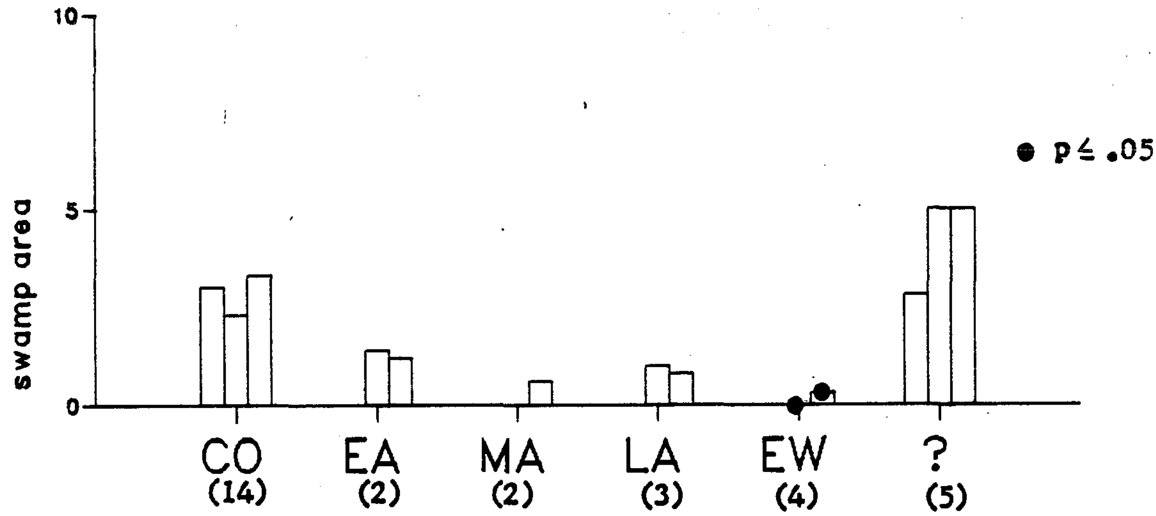


Figure 6.44 Lennox and Addington Limestone Plain Swamp Area
Archaeological values were low, but rarly significant



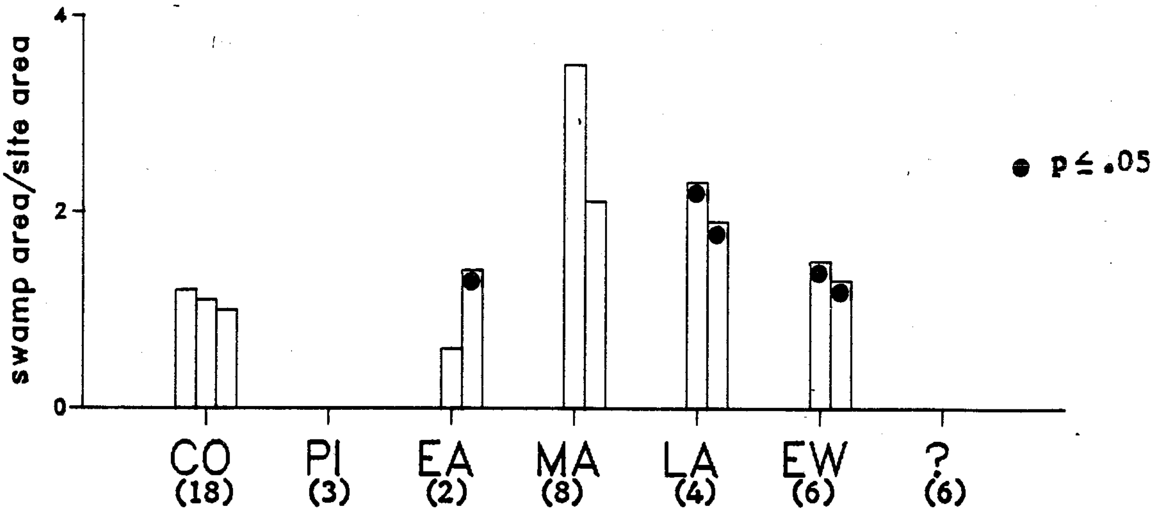
porosity, but was relatively high in the site areas by the later periods in the clay zone (Figs. 6.44; 6.45). The swamp areas in the clay zone were often contigous to the marshes, so in the Middle and Late Archaic period they may have been more marsh-like , although there is no evidence to support this at present.

Values of slope and relief on the limestone plain were seldom significant, but on the clay plain high slope (site) and relief values (vicinity) were observed. Both zones had high soil texture values, in all areas. Where control stream densities and soil drainage were low, archaeological values tended to be high, and where control values of these same variables were high, cultural sites tended to have low values. On the clay plain, Palaeo-Indian sites differed from the Archaic pattern by their absence of marsh area.

6.2.4 Prince Edward Region

Prince Edward most resembles Lennox and Addington because of the predominant limestone plain, and location near the eastern end of an environmental continuum along the north shore of Lake Ontario. However, Prince Edward is almost insular, and its character has been shaped by over 300 miles of coastline and steep cliffs along the northern and eastern shores.

Figure 6.45 Lennox and Addington Clay Plain Swamp Area
Note the significantly high values in settings (1km)and vicinities (2km)



Slope and relief had average values in the bevelled till zone (see Fig. 5.5) but were significantly ($p \leq 0.05$) higher in the in the Middle Archaic sites of the limestone plain (Figs. 6.46; 6.47). Topographic variation was quite limited on the limestone plain but what there was (with the exception of the cliff faces) was sought out by prehistoric groups. Since the limestone plain is regosolithic even slight increases in slope and relief may have indicated that there was a thicker till deposit and the potential for more vegetation.

Both ~~the~~ bevelled till and the limestone plains tended to have some significantly ($p \leq 0.05$) high values for large (third order) stream density (Figs. 6.48; 6.49), but small stream density was low to average. In the limestone zone, this low density of small streams and high density of third order streams may have been due to the intermittent nature of many small streams.

Soil drainage values were average in both zones and soil texture was average to low in the bevelled till zone. In the limestone zone however texture trended ($p \leq 0.10$) to above average, probably because more elevated areas with deeper till were sought out (Fig. 6.50).

There was no incidence of swamp in the bevelled till zone but it was significantly ($p \leq 0.05$) lower than the control mean in the limestone plain, probably because higher areas with deeper till were preferred (Fig. 6.51). Marsh area however, was high in both zones indicating the importance

Figure 6.46 Prince Edward Limestone Plain Average Slope
Middle Archaic values were significantly high in the site (300m) and setting (1km) areas

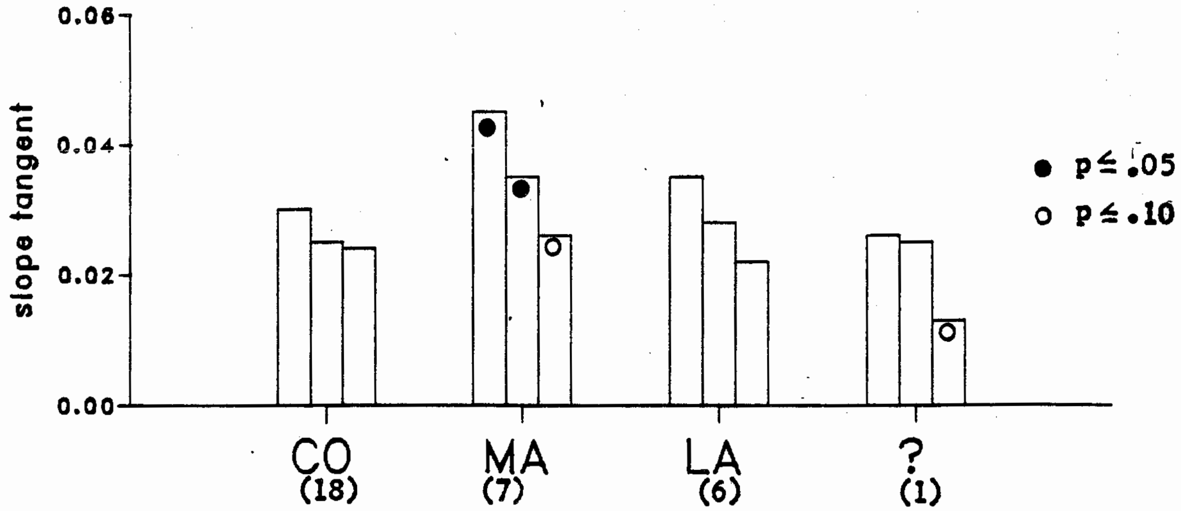


Figure 6.47 Prince Edward Limestone Plain Maximum Relief
The significant Middle Archaic value may indicate areas of deeper till

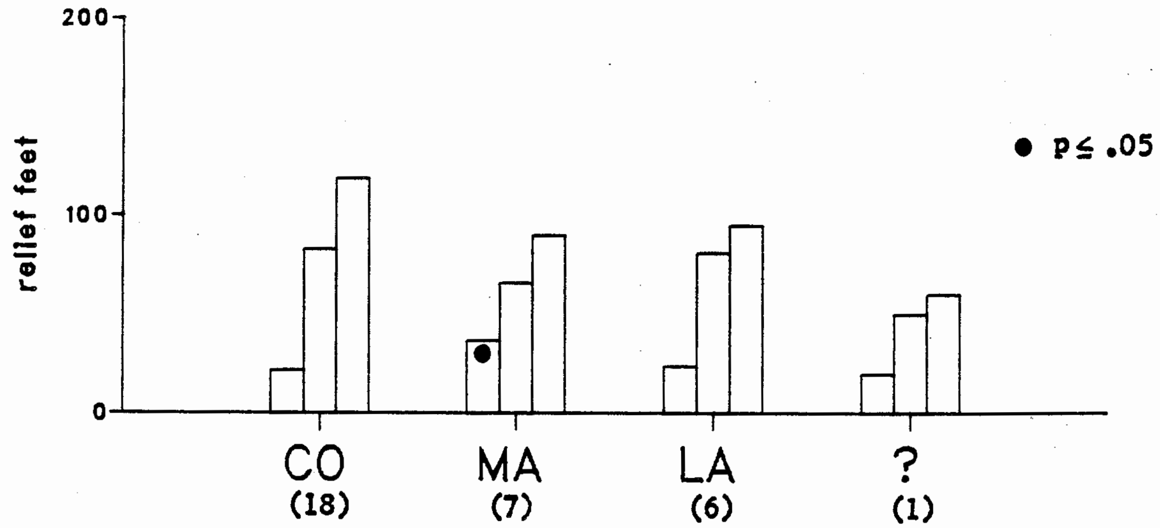


Figure 6.48 Prince Edward Bevelled Till Large Stream Density
A preference for stream littorals is indicated

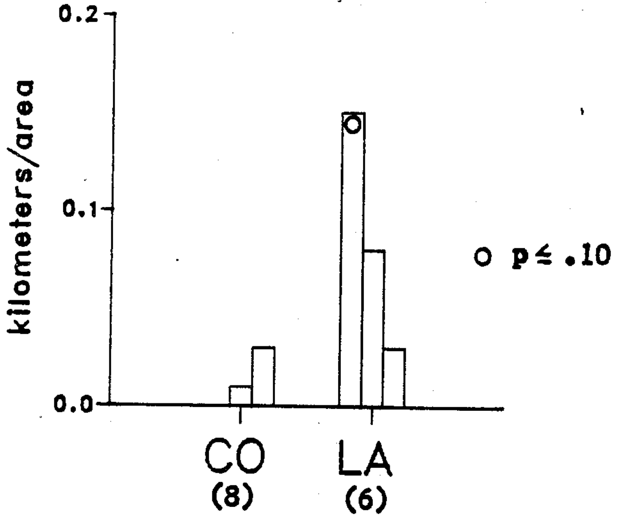


Figure 6.49 Prince Edward Limestone Plain Large Stream Density
Vicinity (2km) was important in the Middle Archaic
Site (300m) area was important in the Late Archaic

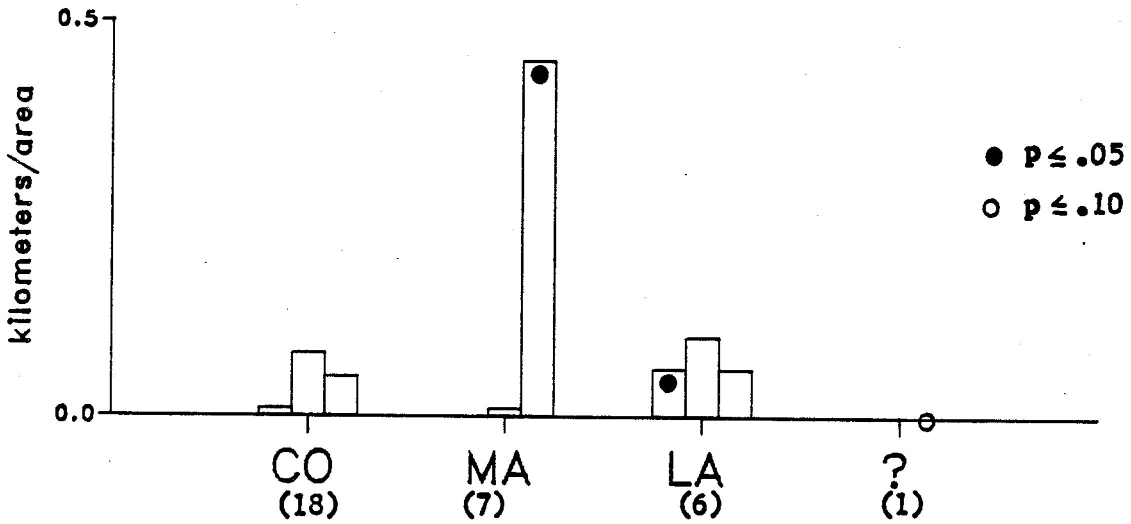


Figure 6.50 Prince Edward Limestone Plain Soil Texture
High values may indicate selection of deeper till

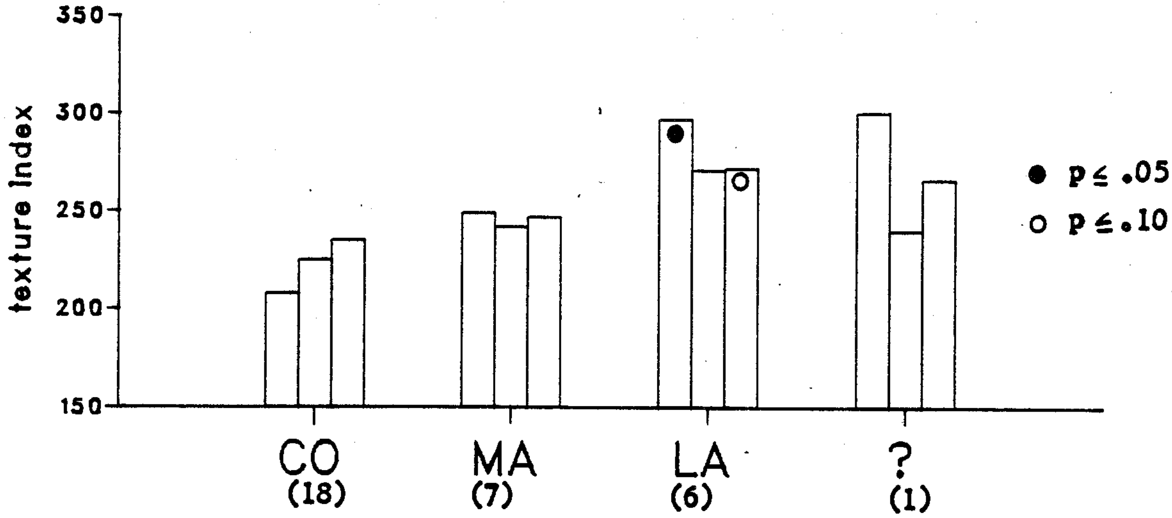


Figure 6.51 Prince Edward Limestone Plain Swamp Area
In general, swamp was avoided in this zone

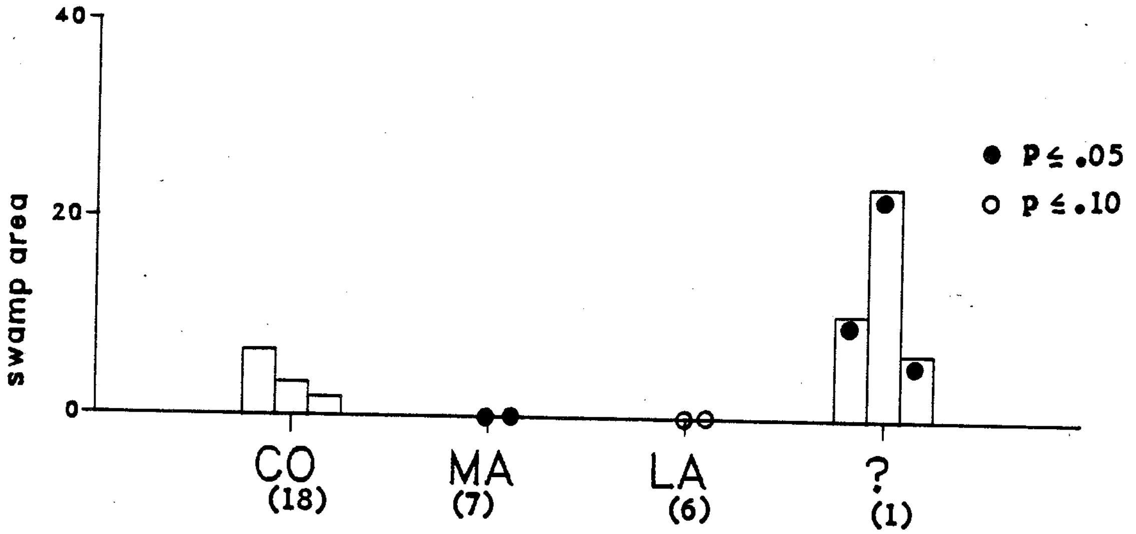


Figure 6.52 Prince Edward Bevelled Till Marsh Area
Marsh was important in the site selection process

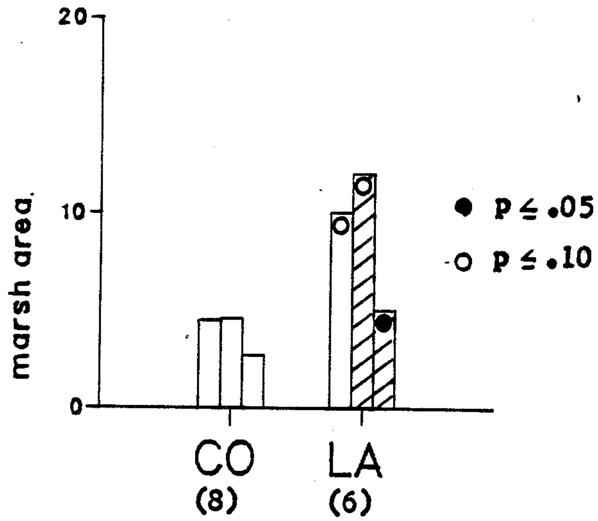
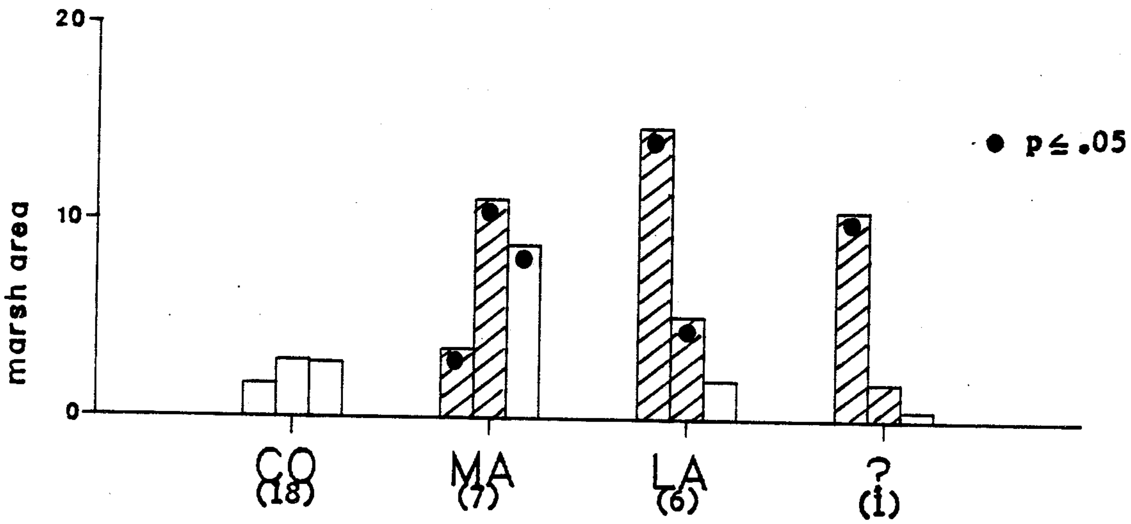


Figure 6.53 Prince Edward Limestone Plain Marsh Area
A strong preference for marsh environment is indicated



of this biotic community (Figs. 6.52; 6.53).

On the limestone plain slope, relief, soil texture, and large stream density were above average and thus important in the archaeological site selection process. This was probably due to droughty regosolithic conditions. Marsh area was high in both zones and large stream density was important on the bevelled till plain.

6.2.5 Summary Of Results

With a few exceptions the pattern of the terrain variables of the archaeological sample was not consistent in any study area but varied from one physiographic zone to another. In fact the *a priori* hypotheses were true for about 50% of the zones. The following hypotheses however were generally true and were supported with some consistency across all the regions:

* **Relief** values decreased with time, from Palaeo-Indian to Early Woodland.
* **Soil drainage and soil texture** were usually higher in archaeological areas than random control locations.
* **Small stream density** was usually higher in the archaeological sample than the control values, and the density increased over time from Palaeo-Indian to Early Woodland.
* **Marsh area** values were generally consistently higher in the archaeological sample, and the density also increased over time.

There were two other general observations which are important in terms of cultural interpretation: First, in many physiographic zones, the mean terrain values of Palaeo-Indian, Hi-Lo and Early Archaic sites diverged from the pattern or trend of subsequent periods. Second, there was usually a decrease in terrain variable scores over the relatively short time period from Palaeo-Indian to Early Archaic. Even though the absolute difference was sometimes slight it was consistent and suggests changes in the adaptations that must have acompanied the rapid climatic and environmental changes of that period. Only **marsh area** increased consistently in all zones over this period.

CHAPTER 7

DISCUSSION

7.1 Terrain Characteristics of Palaeo-Indian Sites

Although the results were diverse and archaeological site terrain varied over physiographical zones, there are consistent patterns which have important theoretical implications. Relief values for instance during the Palaeo-Indian and the transitional Hi-Lo period tended to be higher than their "average" control locations, within 2 km of the site centre. Also, relief showed a tendency to consistently decrease in value from this period to the Early Woodland. It has been widely believed that Palaeo-Indians of the northeast relied upon caribou as a major source of food and clothing. The high relief values observed for these Palaeo-Indian sites support this theory (*eg.* Funk *et al,* 1970) because they could have provided a vantage point or look-out.

Cliff density was also high in Palaeo-Indian times especially in the till plains of Halton and Durham Regions and this too may be indirect evidence of caribou hunting. The low water level of the Admiralty phase of Lake Ontario created rapid and extensive river down-cutting which resulted in cliff formation and probably swift river currents at least seasonally. These conditions could have been exploited by Palaeo-Indian hunters by ambushing the caribou at river crossings. Furthermore, the steep cliff-like river banks could have served as a barrier along which the caribou could have been driven or contained.

It is interesting to note that although marsh area was remarkably high in the Archaic and Hi-Lo periods, it was insignificant in most zones during Palaeo-Indian times. This could be because marshes had not yet formed along the lower reaches of streams flowing into Lake Admiralty. Because of the low-water Admiralty phase it is certain that many early sites (pre-dating *circa* 5,000 BP) have been submerged and the settlement pattern for this period is biased for upland areas, and does not include the presently submerged Lake Admiralty littoral. On the other hand, perhaps marsh resources were not as important to Palaeo-Indians along the north shore of the Ontario basin, because their subsistence economy was focussed on caribou rather than more diffuse resources including aquatic species.

It has been suggested (Roberts, 1984) that the Palaeo-Indians of south-central Ontario migrated annually from wintering grounds in the lower Grand River valley north-easterly along the shore of Lake Admiralty to a summer locale in the open "tundra-parkland" of eastern Ontario. The motive for this presumed seasonal migration was to hunt caribou in their summer grounds, and to intercept them in the fall (when hides and flesh are at their best) on their return to the shelter of the forest. The low incidence of marsh in the Palaeo-Indian site areas supports this hypothesis, because marsh resources would have been less important to a group following a caribou migration.

However, some aspects of the physical terrain of Palaeo-Indian sites suggest that activities other than caribou hunting were carried out:

* Large and small stream densities, in general, were significantly higher than in random or "average" locations. Even though this preference for high small stream density areas (and often large stream density) increased through time, it indicates a conscious selection by Palaeo-Indians for these features and, by implication, an adaptive strategy to some degree similar to the more diffuse Archaic.
* In the Durham Region, Palaeo-Indian sites had significantly higher marsh areas than random locations, even though they were much less than the Archaic densities.
* Swamp densities were low for Palaeo-Indian sites but increased abruptly for the Early Archaic.

The high stream density of Palaeo-Indian sites may be an indication that there was environmental diversity created by the "edge effect" (cf. Odum, 1959) of stream and lake littorals. Small streams may have provided a better habitat for beaver, which historically provided a reliable winter food resource and attracted a variety of species to their ponds. Beaver activity may also have provided dead standing trees, ideal for winter fuel.

Small streams could have contributed to the availability of fish when food resources were scarce, especially during the early spring "bottleneck". Several species spawn in small streams from late March through to May and Walleye (*Stizostedian vitreum vitreum*), Smelt (*Osmerus mondex*), and Mooneye (*Hioden tergisus*) spawn in small streams soon after the ice goes out. Sucker (*Catostomius*) spawns later in the spring using the same spawning grounds as Walleye. Atlantic salmon (*Salmo salar*) spawns in the same drainages in the autumn. Fish resources were probably important because they were predictable, could be harvested efficiently and were insurance against the spring "bottleneck".

Although the observations concerning swamp densities were derived from a small sample and from only three physiographic zones, they suggested these areas may have been marshes in the early Holocene and support the suggestion of an early attraction to marsh environments. Previously, in Palaeo-Indian times, these environments may have been either immature marshes, or of minor importance to a hunter-gatherer adaptive strategy. The importance of these environments beginning with the Hi-Lo and Early Archaic provides evidence of a new settlement-subsistence strategy in the early Holocene, perhaps with the first year-round resident population of the Ontario basin.

Proximity to marsh environments was important to hunter-gatherers of the northeast because they provided a wide variety of food resources and manufacturing materials. The most important plant foods were wild rice (*Zizania aquatica*), cattails (*Typha latifolia*), and waterlilys (*Nuphar advena* and *Nymphaea tuberosa*) although many more were also edible: Arrowhead (*Sagittaria latifolia*), Bulrush (*Scirpus validus*) Chuffa (*Cyperus esculantes*) . Many reeds and rushes provided manufacturing materials for mats, baskets, nets and many other items. Marsh habitat also provides a wide variety of animal resources: fish, fowl, and mammal. Some species of fish and waterfowl were probably predictable and abundant seasonally. The marsh littoral, especially if partly cleared (*cf.* Yarnell, 1984), would have offered a diversity of herbaceous plants providing greens, seeds, tubers and fruits, as well as manufacturing materials and medicinal plants. Bottomlands and marsh littorals may also have been good habitats for nut trees such as walnut, butternut, hickory and hazel. If the littoral was well drained, with light textured soil it would also have provided an attractive camping ground.

7.2 Terrain Characteristics of Archaic Sites

By the Middle Archaic period the environment of the Ontario basin was marked by an essentially modern climate. Modern lake levels had also been achieved, so the present distribution of sites was not truncated by Lake Ontario as with earlier groups. Until *circa* 4700 BP the forest environment of southern Ontario had a significant proportion of Hemlock (*Tsuga)* and its abrupt decline after that has been attributed to a forest pathogen (Davis, 1983). This could have been catastrophic to deer populations because they often seek winter shelter and browse in hemlock stands. If so, it would have been stressful on a society anticipating deer for food, clothing and manufacturing material. On the other hand, by opening up new areas for maple and beech, and other superior browse, this epidemic would have contributed eventually to an improved deer habitat. This, and more mature marsh environments could have been important factors in the Late Archaic transition to a more sedentary society adapted to stream and lake littorals.

The Late Archaic in the northeast has widely been believed to to be marked by an adaptive shift to a more sedentary pattern using a wider range of resources. Large Late Archaic sites such as Lamoka Lake, Oberlander and Robinson have been seen as evidence of this shift (Ritchie, 1965). The settlement pattern along the north shore of Lake Ontario however suggests that subsistence on an annual basis still required mobility within a large band territory. The Archaic sites in the Ontario basin, although numerous, are small and have thin deposits of artifacts. The only apparent exceptions are the McIntyre, Morrison Island and Allumette Island sites. These sites however are not directly comparable to the New York State sites such as Robinson, Oberlander or Lamoka Lake. Morrison Island and Allumette Island for instance are not typical habitation sites, but were primarily cemetaries and, perhaps, trading centres.

7.3 Theoretical Implications

It is possible to speculate on the results of this study within the context of the economic and spatial theories of Caldwell (1958), Cleland (1976), Jochim (1976) and Binford (1980).

Caldwell (1958) explained the transition to the Archaic period as a shift from a narrow to a wide range of resources as new resources and procurement strategies led to an increasingly successful adaptation known as "primary forest efficiency". Cleland (1976) expanded on this theme with his " focal-diffuse" theory: focal subsistence strategies are dependent on a few, abundant, high quality resources that can be stored for a period of time; while diffuse adaptations rely on scattered and varied resources. Palaeo-Indians in the northeast are usually considered to have had a focal adaptation based upon caribou, deer, moose and wapiti. As a result, they have been considered to be only "opportunistic foragers" with little concern for plant foods, fish, or small-game (Ritchie and Funk, 1984; Peers, 1985). The results of this study are largely in agreement with this theory at least during the initial Palaeo-Indian occupation, however, a more diffuse collector strategy had begun by Late Palaeo-Indian times (Hi-Lo) and was established by the Early Archaic period.

Archaic groups, with their larger more varied tool kit and regional variations, are usually seen as a diffuse collector adaptation practising "primary forest efficiency". The results of this study agree with this concept and indicate that stream and marsh littorals were preferred Archaic habitats.

Binford (1980) has divided hunter-gatherers into two groups: "foragers", who store no food and move consumers to resources in a series of short residential moves, and "collectors", who store food and move resources to consumers and prefer more sedentary residences close to bulkier resources. In view of the archaeological record and ethnographic analogy it seems logical to link Binfords "collector" strategy with the "diffuse" adaptations of the Archaic of the Northeast. However, an analogy between "foraging" and the "focal" economy of Palaeo-Indians is not as logical because foraging groups, according to Binford's (1980) definition, store no food and require ubiquitous resources and no major seasonal climatic changes. Since it seems likely that Palaeo-Indians did store food, (for meat is easily dried, smoked or frozen and is compact and nutritious) and seasonal climatic changes were certainly a factor, Palaeo-Indians may have been in fact primarily "collectors" with some "foraging" strategies , perhaps on a seasonal basis. Thus Palaeo-Indians may be considered "focal-collectors", and the Archaic a "diffuse-collector" strategy.

However, during both the Palaeo-Indian and Archaic periods, people must have aspired to the "security" and "aggregation" goals identified by Jochim (1976). The first concerns a safe level of food and manufacturing resources, the second the need to aggregate, at least seasonally, to conduct social and religious ceremonies. Satisfaction of the aggregation goal requires that food and other resources be acquired or stored in sufficient abundance. However, it is doubtful that a big-game oriented adaptation would have satisfied the "security" goal, for, as Jochim (1976) points out, big-game hunting is a high-risk venture. The returns of big-game hunting, on the other hand, are rewarding and, at least seasonally, a large number of animals may be taken to satisfy the "aggregation" goal. Palaeo-Indians probably focused on caribou, especially in the fall, to satisfy this goal but other large mammals were probably supplementary resources. Spawning fish and nuts, however, may also have contributed to satisfying the aggregation goal, perhaps on a contingency basis, for both are reliable and can provide a storable surplus.

Palaeo-Indians probably satisfied the security goal by following the caribou to their summer range, foraging on their route for a wide variety of small and large animals and fortuitously for fruits and other plant foods. By Late Palaeo-Indian times, however, the security goal was increasingly satisfied by systematically collecting along stream and lake littorals. The Archaic strategy clearly was centred around these environments because the wide variety, reliability and efficiency of the resource base satisfied security requirements. During the Archaic period, the aggregation goal was probably satisfied by a strategy of collecting diverse resources that were abundant, nutritious and predictable to varying degrees. These certainly included deer and other large cervids but fish, nuts and wild rice were probably important too.

CONCLUSIONS

Terrain analysis has shed light on the subject of human adaptation during the late Pleistocene and early Holocene in the Ontario basin. Adaptive information is relatively rare in Archaic and Palaeo-Indian archaeological studies in northeastern North America because organic remains have not usually been preserved, and because few sites of this period have been excavated, especially in Ontario.

Only recently have prehistorians begun systematic quantification of the terrain variables of archaeological sites, usually for cultural resource management purposes such as site prediction and discovery. This study differed because it was concerned primarily with the record of environmental adaptation. Also, it employed a random control sample for comparison and considered various site areas over a continuum of 6,000 years. The terrain analysis technique employed here was also an improvement over previous studies because it emphasized the quantity of a variable rather than distance from a "site" to a variable. For instance, in many previous analyses (*eg*. Roberts 1980) distance to various terrain features, such as "nearest water source" was measured, whereas in this study the density of each stream order was calculated. Another improvement was the "real" or "tangible" nature of the features quantified in this study. Many earlier studies (*eg*. Schermer and Tiffany 1985) analysed sites from their location on a reconstructed map of the palaeo-vegetation, which was based on soil maps. The author believes that thematic reconstructions such as these are too abstract and over-simplify the terrain data available and preclude more detailed physical studies. In contrast, the data used in this research were primarily derived from a primary source: aerial photographs. Furthermore, the presence and nature of features such as streams, cliffs, slopes and elevations may be extrapolated into a prehistoric context with confidence, while the presence of specific vegetation communities, based on abstract environmental reconstructions, is more tenuous.

In essence, the site areas (and settings and vicinities) were considered as "pseudo-artifacts" in this study: not manufactured or modified, but deliberately selected activity areas that reflect human adaptation to local environments. Thus, inferences and hypotheses about settlement-subsistence strategies can be made on both a regional and site specific scale.

This study has tested and accepted three hypotheses:

* The physical attributes of archaeological sites differed significantly from representative control locations.
* Over time, hunter-gatherer societies selected sites with different compositions of terrain attributes.
* Some aspects of terrain were selected for close proximity, others were significant within one or two kilometers radii of the artifact deposits.

This terrain analysis has lead to several other important, if tentative, conclusions about settlement-subsistence strategies in the Ontario basin during the late Pleistocene and early Holocene.

* The terrain characteristics of Palaeo-Indian sites were largely in agreement with an adaptive model of subsistence focused on caribou and settlement structured around migration between summer and winter ranges.
* Except for late Pleistocene Palaeo-Indian sites, there were also indications that an orientation to marsh, stream, and lake littorals was established by Late Palaeo-Indian times.
* The structural organization of the late Pleistocene/ early Holocene adaptations was probably "focal-collector" rather than "forager", although Palaeo-Indians may have practiced foraging more frequently.
* The terrain characteristics of the Archaic site sequence conform with a model of adaptation to increasingly diffuse resources; however, they emphasize an early and increasing orientation to marshy lake shores and streams.
* The Late Palaeo-Indian (Hi-Lo) and Early Archaic was a transitional period in the evolution of adaptive strategies.

There is no doubt that more work must be done before this type of analysis can produce more specific conclusions and further hypothesis testing. A larger site sample and field survey of both archaeological and control samples would be an obvious refinement of this research. However the development of adaptive models through terrain analysis is directly related to the need for more excavated data: particularly organic remains, functional analyses, and intra/infra site distribution analyses. As environmental studies at the McIntyre Site have shown, the immediate environment of a site can be inferred in some detail using palynological macro fossil data.

Although beyond the scope of the present study, it would be useful to know which of the "significant" terrain variables are more important than others. This is an important aspect of the theory of locational analysis and affects the way empirical results are interpreted (Limp and Carr, 1985). Because the fundamental underlying assumption of this research is that archaeological sites were chosen by means of rational planning, within a site selection process the terrain variables should, ideally, be priorized to construct a model of the prehistoric settlement-subsistence strategies (*ibid*). However, this priorization is beyond the scope of the present study and awaits better data and further analytical refinements.

Lastly, more sophisticated geographic models of adaptation could be constructed with better control over site age. It is now possible, through tandem accelerator (AMS) carbon dating, to obtain a better control of the time factors involved, since minute amounts of excavated organic material can be dated. Finally, as our theories and hypotheses are advanced and elaborated regarding these early cultures, these types of analyses will develop more power.

APPENDIX A

Tables Of Results By Variable

The following tables present the mean values of the terrain variables measured and the standard deviations. In cases where there was a sample size of one, mean and standard deviation do not apply. The values marked by asterix indicate statistically significant results, accordng to a Mann-Whtney U test.

TABLE A-1 Average Slope

ZONE	SITE	SETTING	VICINITY
H-Till-Moraine			
Control(8)	.033 ±.032	.041 ±.027	.041 ±.015
Palaeo-Indian(1)	.072	.081	.064
Early Archaic(4)	.055 ±.040*	.050 ±.020	.042 ±.010
Middle Archaic(6)	.059 ±.032**	.047 ±.020	.037 ±.010
Late Archaic(4)	.057 ±.022**	.044 ±.020	.037 ±.010
Early Woodland(2)	.060 ±.025*	.045 ±.031	.043 ±.020
H-Drumlinized Till			
Control(10)	.028 ±.017	.024 ±.008	.033 ±.007
Early Archaic(4)	.038 ±.025	.038 ±.016*	.037 ±.009
Middle Archaic(20)	.028 ±.030	.033 ±.013**	.036 ±.010
Late Archaic(1)	.028	.034*	.041
H-Bevelled Till			
Control(8)	.032 ±.018	.027 ±.015	.027 ±.012
Palaeo-Indian(4)	.051 ±.027	.045 ±.016**	.044 ±.018*
Hi-Lo(1)	.086*	.050	.048
Early Archaic(2)	.029 ±.016	.045 ±.025	.048 ±.018*
Middle Archaic(13)	.047 ±.030	.039 ±.016**	.037 ±.015*
Late Archaic(8)	.030 ±.017	.027 ±.018	.025 ±.016
Early Woodland(5)	.027	.026	.026
H-Shale Plain			
Control(8)	.100 ±.234	.076 ±.155	.079 ±.142
Palaeo-Indian(1)	.018	.016	.020
Early Archaic(2)	.015 ±.004	.020 ±.006	.023 ±.004*
Middle Archaic(16)	.032 ±.025	.029 ±.014	.027 ±.011
Late Archaic(8)	.031 ±.021	.029 ±.008*	.029 ±.006
Early Woodland(2)	.044 ±.037	.027 ±.016	.026 ±.008
H-Sand Plain			
Control(9)	.030 ±.017	.027 ±.015	.028 ±.015
Palaeo-Indian(7)	.018 ±.005*	.019 ±.002	.020 ±.005
Early Archaic(9)	.019 ±.005*	.019 ±.002*	.020 ±.004
Middle Archaic(29)	.021 ±.004	.019 ±.002**	.022 ±.003
Late Archaic(14)	.020 ±.006*	.020 ±.002*	.021 ±.004
Early Woodland(12)	.019 ±.005*	.019 ±.002*	.020 ±.004
DN-Drumlinized Till			
Control(14)	.098 ±.063	.081 ±.037	.076 ±.008
Palaeo-Indian(1)	.094	.084	.069
Hi-Lo(5)	.049 ±.019	.051 ±.018	.050 ±.017
Early Archaic(1)	.060	.050	.049
Middle Archaic(6)	.071 ±.033	.068 ±.036	.067 ±.031
Late Archaic(10)	.087 ±.041	.072 ±.033	.070 ±.025
Early Woodland(3)	.108 ±.056	.075 ±.024	.071 ±.021
Unclassified(8)	.078 ±.022	.074 ±.027	.076 ±.025

DN-Clay Plain			
Control(14)	.058 ±.036	.048 ±.034	.047 ±.026
Palaeo-Indian(2)	.047 ±.018*	.056 ±.013*	.050 ±.009
Hi-Lo(5)	.039 ±.022	.034 ±.020	.034 .018
Early Archaic(4)	.028 ±.010**	.025 ±.011**	.027 ±.012**
Middle Archaic(24)	.039 ±.016**	.035 ±.012*	.035 ±.010*
Late Archaic(16)	.030 ±.016**	.027 ±.013**	.027 ±.011**
Early Woodland(2)	.028 ±.005*	.032 ±.015	.029 ±.013
Unclassified(4)	.037 ±.010	.033 ±.003	.036 ±.004
L&A-Limestone Plain			
Control(14)	.031 ±.020	.028 ±.013	.026 ±.008
Early Archaic(2)	.021 ±.016	.021 ±.008	.024 ±.000
Middle Archaic(2)	.038 ±.008	.029 ±.004	.029 ±.008
Late Archaic(4)	.024 ±.013	.023 ±.005	.025 ±.002
Early Woodland(4)	.029 ±.003	.024 ±.002	.025 ±.001
Unclassified(5)	.024 ±.010	.030 ±.005	.027 ±.003
L&A-Clay Plain			
Control(18)	.024 ±.013	.023 ±.022	.023 ±.006
Palaeo-Indian(3)	.042 ±.015**	.037 ±.002**	.031 ±.002**
Early Archaic(2)	.038 ±.017	.024 ±.007	.024 ±.006
Middle Archaic(8)	.041 ±.014**	.030 ±.007**	.026 ±.004*
Late Archaic(4)	.020 ±.010	.020 ±.004	.020 ±.001*
Early Woodland(6)	.029 ±.019	.023 ±.010	.021 ±.006
Unclassified(6)	.024 ±.020	.021 ±.009	.021 ±.005
PE-Bevelled Till			
Control(8)	.025 ±.009	.022 ±.007	.023 ±.007
Late Archaic(6)	.023 ±.011	.022 ±.009	.020 ±.006
PE-Limestone Plain			
Control(18)	.030 ±.016	.025 ±.016	.024 ±.013
Middle Archaic(7)	.045 ±.020**	.035 ±.015**	.026 ±.007*
Late Archaic(6)	.035 ±.024	.028 ±.018	.022 ±.012
Unclassified(1)	.026	.025	.013*

** $p \leq 0.05$
* $p \leq 0.10$

TABLE A-2 Maximum Relief

ZONE	SITE	SETTING	VICINITY
H-Till Moraine			
Control	29 ±30	110 ±91	202 ±95
Palaeo-Indian(1)	110**	130	150
Early Archaic(4)	50 ±42*	117 ±44	152 ±37
Middle Archaic(6)	57 ±36**	128 ±67	195 ±92
Late Archaic(4)	62 ±50*	137 ±130	235 ±132
Early Woodland(2)	90 ±57**	195 ±191	265 ±219
H-Drumlinized Till			
Control(10)	19 ±11	68 ±23	185 ±33
Early Archaic(4)	23 ±15	140 ±108*	217 ±101
Middle Archaic(20)	23 ±26	105 ±38**	188 ±32
Late Archaic(1)	20	70	210*
H-Bevelled Till			
Control(8)	26 ±19	59 ±33	139 ±103
Palaeo-Indian(4)	37 ±22	167 ±190*	375 ±197**
Hi-Lo(1)	60	80	480
Early Archaic(2)	25 ±70	270 ±255**	310 ±212**
Middle Archaic(13)	41 ±19**	103 ±108*	321 ±174**
Late Archaic(8)	21 ±14	91 ±146	127 ±134*
Early Woodland(5)	18 ±13	108 ±168	143 ±155
H-Shale Plain			
Control(8)	114 ±237	114 ±40	200 ±52
Palaeo-Indian(1)	10*	60*	150*
Early Archaic(2)	10 ±00**	55 ±07**	120 ±42**
Middle Archaic(16)	31 ±29**	88 ±32**	157 ±40**
Late Archaic(6)	30 ±21	73 ±19**	148 ±35**
Early Woodland(2)	35 ±35	65 ±07**	145 ±07**
H-Sand Plain			
Control(9)	31 ±20	73 ±43	147 ±89
Palaeo-Indian(7)	17 ±05**	67 ±31	163 ±36**
Early Archaic(9)	17 ±05**	63 ±28	157 ±34**
Middle Archaic(29)	20 ±04**	56 ±17*	152 ±27**
Late Archaic(14)	17 ±05**	59 ±23	147 ±35
Early Woodland(12)	17 ±05**	61 ±24	149 ±37*
DN-Drumlinized Till			
Control(14)	87 ±50	202 ±76	328 ±128
Palaeo-Indian(1)	90	160	310
Hi-Lo(5)	98 ±114	194 ±119	334 ±158
Early Archaic(1)	60	100*	210
Middle Archaic(6)	80 ±61	166 ±38	278 ±99
Late Archaic(10)	79 ±58	147 ±73*	285 ±113
Early Woodland(3)	87 ±55	183 ±104	253 ±84
Unclassified(8)	80 ±41	187 ±89	251 ±80

DN-Clay Plain			
Control(14)	66 ±55	124 ±58	171 ±64
Palaeo-Indian(2)	60 ±14	155 ±50	210 ±14*
Hi-Lo(5)	42 ±46	90 ±68	117 ±76
Early Archaic(4)	30 ±22*	80 ±80*	117 ±79*
Middle Archaic(24)	44 ±32*	87 ±59**	151 ±66
Late Archaic(16)	27 ±16**	74 ±56**	112 ±68**
Early Woodland(2)	35 ±07	110 ±99	175 ±28
Unclassified(4)	52 ±21	115 ±41	175 ±64
L&A-Limestone Plain			
Control(14)	25 ±16	72 ±37	104 ±45
Early Archaic(1)	10	20**	60
Middle Archaic(2)	30 ±28	65 ±64	90 ±42
Late Archaic(3)	15 ±07*	22 ±04	67 ±11
Early Woodland(4)	17 ±05	41 ±22	69 ±06
Unclassified(5)	24 ±08	77 ±31	98 ±32
L&A-Clay Plain			
Control(18)	27 ±19	53 ±26	77 ±24
Palaeo-Indian(3)	53 ±26**	115 ±41**	130 ±35**
Early Archaic(2)	25 ±07	30 ±00*	100 ±00*
Middle Archaic(8)	32 ±21	65 ±49	101 ±34*
Late Archaic(4)	22 ±10	34 ±11*	81 ±31
Early Woodland(6)	24 ±12	43 ±10	92 ±21
Unclassified(6)	17 ±14*	45 ±15	68 ±08*
PE-Bevelled Till			
Control(8)	16 ±09	51 ±29	81 ±16
Late Archaic(6)	16 ±09	47 ±32	83 ±47
PE-Limestone Plain			
Control(18)	22 ±15	83 ±50	119 ±58
Middle Archaic(7)	37 ±10**	66 ±47	90 ±40
Late Archaic(6)	24 ±16	81 ±87	95 ±82
Unclassified(1)	20	50	60

** $p \leq 0.05$
* $p \leq 0.10$

TABLE A-3 Total Drainage Density

ZONE	SITE	SETTING	VICINITY
H-Till Moraine			
Control(8)	1.50 ±1.57	1.71 ±88	1.50 ±71
Palaeo-Indian(1)	2.29	2.38	1.92
Early Archaic(4)	1.24 ±.60	1.63 ±.34	1.24 ±.39
Middle Archaic(6)	3.29 ±1.08**	2.38 ±.51*	1.77 ±.70
Late Archaic(4)	2.00 ±.99*	1.93 ±.50	1.66 ±.71
Early Woodland(2)	1.71 ±.00*	1.58 ±.14	1.17 ±.37
H-Drumlinized Till			
Control(10)	2.37 ±1.90	2.50 ±.79	2.09 ±.61
Early Archaic(4)	3.47 ±.77*	2.67 ±.71	1.90 ±36
Middle Archaic(20)	2.73 ±1.57	2.50 ±.44	2.02 ±31
Late Archaic(1)	4.57	2.75	1.87
H-Bevelled Till			
Control(8)	3.11 ±1.42	2.02 ±.68	1.46 ±.36
Palaeo-Indian(4)	3.14 ±2.12	2.84 ±.79**	1.93 ±.50**
Hi-Lo(1)	4.57*	2.44	1.92
Early Archaic(2)	2.71 ±2.22	2.77 ±1.56	1.97 ±.32**
Middle Archaic(13)	2.67 ±1.85	2.42 ±.59*	1.74 ±.36**
Late Archaic(8)	2.90 ±.81	2.07 ±.94	1.39 ±.42
Early Woodland(5)	3.14 ±.75	2.24 ±1.05	1.50 ±.50
H-Shale Plain			
Control(8)	1.12 ±.89	2.70 ±2.52	1.42 ±.22
Palaeo-Indian(1)	2.29	1.14	1.11*
Early Archaic(2)	1.57 ±1.01	1.42 ±.40	1.26 ±.21
Middle Archaic(16)	2.19 ±1.44**	1.69 ±.60	1.43 ±.36
Late Archaic(6)	1.57 ±1.73	1.38 ±.70*	1.33 ±.26
Early Woodland(2)	2.00 ±.41	1.64 ±.71	1.25 ±.20
H-Sand Plain			
Control(9)	1.72 ±1.68	1.41 ±.55	1.23 ±.38
Palaeo-Indian(7)	1.80 ±.61	1.49 ±.21	1.14 ±.24
Early Archaic(9)	1.86 ±.71	1.53 ±.20	1.19 ±.23
Middle Archaic(29)	1.43 ±.84	1.54 ±.26	1.26 ±.24
Late Archaic(14)	1.67 ±.92	1.59 ±.19	1.23 ±.19
Early Woodland(12)	1.59 ±.83	1.57 ±.20	1.22 ±.21
DN-Drumlinized Till			
Control(13)	1.16 ±1.51	1.42 ±.54	1.09 ±.25
Palaeo-Indian(1)	2.57	2.35**	1.58**
Hi-Lo(5)	1.77 ±1.19	3.16 ±2.47**	1.50 ±.47**
Early Archaic(1)	0.00	.71*	1.04
Middle Archaic(6)	2.72 ±1.86**	2.00 ±.58**	1.38 ±.37**
Late Archaic(10)	2.20 ±2.09*	1.65 ±.78	1.13 ±.37
Early Woodland(3)	.36 ±.41	.88 ±.38**	1.04 ±.04
Unclassified(7)	1.85 ±1.47	1.31 ±.55	1.02 ±.43

DN-Clay Plain			
Control(14)	1.61 ±1.60	1.46 ±.58	1.12 ±.33
Palaeo-Indian(2)	4.00 ±2.42*	2.31 ±.18**	1.78 ±.54**
Hi-Lo(5)	1.54 ±2.06	1.38 ±.49	1.32 ±.60
Early Archaic(4)	.63 ±.81	1.65 ±.60	1.17 ±.52
Middle Archaic(24)	2.50 ±2.56	2.11 ±.89**	1.48 ±.39**
Late Archaic(16)	1.40 ±1.41	1.51 ±.68	1.08 ±.50
Early Woodland(2)	1.14 ±1.62	1.54 ±1.55	.78 ±.48
Unclassified(4)	4.14 ±3.14**	2.40 ±1.01**	1.63 ±.54**
L&A-Limestone			
Control(14)	2.64 ±1.55	1.72 ±.70	1.15 ±.48
Early Archaic(2)	6.64 ±4.73	2.34 ±.33	1.50 ±.02
Middle Archaic(2)	3.13 ±.24	1.56 ±.78	1.34 ±.24
Late Archaic(3)	4.95 ±4.45	2.35 ±.24	1.46 ±.06
Early Woodland(4)	4.57 ±2.56	2.38 ±.20	1.44 ±.05
Unclassified(5)	2.87 ±2.02	1.77 ±.80	1.20 ±.72
L&A-Clay Plain			
Control(18)	2.62 ±2.09	2.59 ±.82	1.60 ±.48
Palaeo-Indian(3)	5.10 ±2.20*	2.82 ±.32	1.82 ±.48
Early Archaic(2)	0.00**	2.05 ±.27	1.50 ±.08
Middle Archaic(8)	2.06 ±2.97	2.00 ±1.12	1.38 ±.55
Late Archaic(4)	1.98 ±2.29	2.53 ±.64	1.81 ±.29
Early Woodland(6)	2.08 ±1.83	2.90 ±.70	1.71 ±.27
Unclassified(6)	1.19 ±1.47*	1.66 ±1.17*	1.63 ±.36
PE-Bevelled Till			
Control(8)	1.14 ±1.64	1.06 ±1.63	.85 ±.97
Late Archaic(6)	1.76 ±1.60	1.63 ±.70*	.98 ±.97
PE-Limestone			
Control(18)	1.47 ±1.36	1.27 ±.41	.83 ±.18
Middle Archaic(7)	.10 ±.25**	.97 ±.37*	.71 ±.16**
Late Archaic(6)	.96 ±1.04	1.22 ±.65	.92 ±.19
Unclassified(1)	2.00	2.16**	1.15**

** p≤0.05
* p≤0.10

TABLE A-4 **Soil Texture Index**

ZONE	SITE	SETTING	VICINITY
L&A-Limestone			
Controls (14)	222 ±76	232 ±50	232 ±45
Early Archaic (2)	350 ±71**	309 ±06**	251 ±71
Middle Archaic (2)	219 ±114	275 ±42	202 ±01
Late Archaic (3)	277 ±135	280 ±50**	247 ±50
Early Woodland (4)	258 ±84	298 ±52	277 ±67
Unclassified (5)	232 ±60	204 ±55	214 ±46
L&A-Clay Plain			
Control (18)	161 ±66	172 ±24	169 ±30
Palaeo-Indian (3)	283 ±72**	254 ±90*	244 ±101
Early Archaic (2)	200 ±00*	188 ±26	200 ±16**
Middle Archaic (8)	263 ±86**	241 ±73**	208 ±64*
Late Archaic (4)	166 ±47	196 ±32	195 ±23
Early Woodland (6)	194 ±34	219 ±41	200 ±32
Unclassified (6)	171 ±88	166 ±23	168 ±51
PE-Bevelled Till			
Control (8)	247 ±62	276 ±37	283 ±34
Late Archaic (6)	251 ±58	265 ±48	273 ±17*
PE-Limestone			
Control (18)	208 ±88	225 ±60	235 ±43
Middle Archaic (7)	249 ±84	242 ±65	247 ±51
Late Archaic (6)	297 ±71**	271 ±54	272 ±45*
Unclassified (1)	300	240	266

** $p \leq 0.05$
* $p \leq 0.10$

TABLE A-5 Soil Drainage Index

ZONE	SITE	SETTING	VICINITY
L&A-Limestone			
Control (14)	74 ±27	75 ±18	73 ±14
Early Archaic (2)	81 ±26	64 ±11	72 ±02
Middle Archaic (2)	67 ±46	63 ±12	64 ±14
Late Archaic (3)	71 ±26	66 ±09	73 ±02
Early Woodland (4)	87 ±25	72 ±0.5	76 ±03
Unclassified (5)	62 ±17	58 ±14**	64 ±08
L&A-Clay Plain			
Control (18)	51 ±18	51 ±05	52 ±09
Palaeo-Indian (3)	73 ±04**	78 ±20**	77 ±29*
Early Archaic (2)	63 ±00	52 ±04	45 ±01
Middle Archaic (8)	67 ±16**	67 ±23*	61 ±21
Late Archaic (4)	50 ±18	56 ±10	51 ±08
Early Woodland (6)	58 ±08	59 ±12**	57 ±11
Unclassified (6)	48 ±32	50 ±10	52 ±16
PE-Bevelled Till			
Control (8)	93 ±10	92 ±10	92 ±06
Late Archaic (6)	97 ±08	95 ±06	94 ±06
PE-Limestone			
Control (18)	82 ±22	84 ±10	85 ±07
Middle Archaic (7)	85 ±20	88 ±13	88 ±10
Late Archaic (6)	93 ±10	87 ±08	87 ±07
Unclassified (1)	100	100*	100**

** $p \leq 0.05$
* $p \leq 0.10$

TABLE A-6 Deer Capability Index

ZONE	SITE	SETTING	VICINITY
H-Till Moraine			
Control (8)	262 ±52	262 ±52	262 ±46
Palaeo-Indian (1)	300	300	300
Early Archaic (4)	275 ±50	276 ±48	280 ±40
Middle Archaic (6)	267 ±52	267 ±50	270 ±41
Late Archaic (4)	250 ±57	251 ±56	251 ±49
Early Woodland (2)	200 ±00*	202 ±04	210 ±14*
H-Drumlinized Till			
Control (10)	275 ±43	275 ±43	276 ±41
Early Archaic (4)	256 ±52	260 ±50	260 ±32*
Middle Archaic (20)	261 ±43	262 ±36*	256 ±27**
Late Archaic (1)	300	300	295
H-Bevelled Till			
Control (8)	298 ±07	291 ±27	290 ±30
Palaeo-Indian (4)	300 ±00	286 ±14**	280 ±14**
Hi-Lo (1)	300	280**	270**
Early Archaic (2)	300 ±00	285 ±21	282 ±18**
Middle Archaic (13)	277 ±44	276 ±21**	276 ±18**
Late Archaic (8)	300 ±00	296 ±11	296 ±11
Early Woodland (5)	300 ±00	295 ±12	295 ±12
H-Shale Plain			
Control (8)	175 ±70	175 ±70	181 ±70
Palaeo-Indian (1)	200	200	215**
Early Archaic (2)	200 ±00	200 ±00	207 ±11**
Middle Archaic (16)	212 ±28**	211 ±23**	217 ±17**
Late Archaic (6)	200 ±00	200 ±00	202 ±06*
Early Woodland (2)	200 ±00	200 ±00	207 ±11**
H-Sand Plain			
Control (9)	200 ±00	200 ±00	203 ±08
Palaeo-Indian (7)	200 ±00	200 ±00	202 ±03
Early Archaic (9)	200 ±00	200 ±00	202 ±03
Middle Archaic (29)	200 ±00	200 ±00	204 ±03**
Late Archaic (14)	200 ±00	200 ±00	203 ±04
Early Woodland (12)	200 ±00	200 ±00	204 ±04
L&A-Limestone			
Control (14)	492 ±71	490 ±66	483 ±61
Early Archaic (2)	500 ±00	500 ±00	507 ±11*
Middle Archaic (2)	550 ±71	535 ±50	537 ±32
Late Archaic (3)	500 ±00	498 ±03	472 ±63
Early Woodland (4)	510 ±20	511 ±17	490 ±60
Unclassified (5)	550 ±87*	548 ±87*	535 ±77*
L&A-Clay Plain			
Control (18)	544 ±51	545 ±51	538 ±57

Palaeo-Indian (3)	467 ±115*	467 ±115*	472 ±111*
Early Archaic (2)	500 ±00	500 ±00*	500 ±00
Middle Archaic (7)	486 ±69**	486 ±69**	488 ±66*
Late Archaic (4)	525 ±50	524 ±48	516 ±47
Early Woodland (6)	550 ±55	544 ±58	540 ±54
Unclassified (6)	600 ±00**	598 ±04**	594 ±14**

** $p \leq 0.05$
* $p \leq 0.10$

TABLE A-7 Cliff Density

ZONE	SITE	SETTING	VICINITY
H-Till Morraine			
Control (8)	.21 ±60	.28 ±59	.32 ±32
Palaeo-Indian (1)	2.83**	1.73**	1.63
Early Archaic (4)	.99 ±1.35*	1.17 ±.53**	.91 ±.40**
Middle Archaic (6)	.66 ±1.17	.56 ±.56	.63 ±32**
Late Archaic (4)	.99 ±1.35*	.34 ±.32	.68 ±.33**
Early Woodland (2)	1.98 ±1.21**	.61 ±.14*	.76 ±.55*
H-Drumlinized Till			
Control (10)	.00	.02 ±.05	.32 ±.27
Early Archaic (4)	.14 ±.29*	.43 ±.65**	.52 ±.10
Middle Archaic (20)	.28 ±.92*	.50 ±.59**	.46 ±.27*
Late Archaic (1)	.00	.00	.51
H-Bevelled Till			
Control (8)	.63 ±1.25	.63 ±1.04	.36 ±.50
Palaeo-Indian (4)	1.13 ±1.40	.85 ±.65	.72 ±.52*
Hi-Lo (1)	.00	.76	.73
Early Archaic (2)	1.41 ±2.03	.82 ±.43	.97 ±.03**
Middle Archaic (13)	.78 ±1.21	.76 ±.53	.66 ±43**
Late Archaic (8)	.35 ±1.00	.14 ±.39*	.22 ±.35
Early Woodland (5)	.46 ±1.14	.19 ±.14	.30 ±.38
H-Shale Plain			
Control (8)	.00	.18 ±.36	.31 ±.28
Palaeo-Indian (1)	.00	.00	.00
Early Archaic (2)	.00	.41 ±.59	.20 ±.29
Middle Archaic (16)	.49 ±1.07*	.32 ±.32	.31 ±.37
Late Archaic (6)	1.13 ±1.82**	.85 ±.47**	.45 ±.23
Early Woodland (2)	1.98 ±.82**	.66 ±.94	.30 ±.42
H-Sand Plain			
Control (9)	.40 ±1.25	.25 ±.36	.12 ±.17
Palaeo-Indian (7)	.00	.00**	.00**
Early Archaic (9)	.00	.00**	.00**
Middle Archaic (29)	.00**	.00**	.00**
Late Archaic (14)	.00	.00**	.00**
Early Woodland (12)	.00	.00**	.00**
DN-Drumlinized Till			
Control (16)	.00	.13 ±.25	.08 ±.13
Palaeo-Indian (1)	.00	.10	.03
Hi-Lo (5)	.00	.03 ±.04	.10 ±.12
Early Archaic (1)	.00	.00	.03
Middle Archaic (6)	.00	.00	.00
Late Archaic (10)	.00	.07 ±.16	.06 ±.10
Early Woodland (3)	.00	.00	.01 ±.01
Unclassified (8)	.00	.00	.02 ±.05

DN-Clay Plain			
Control (14)	.40 ±.82	.17 ±.29	.10 ±.11
Palaeo-Indian (2)	.00	.00	.00
Hi-Lo (5)	.00	.00	.00
Early Archaic (4)	.00	.00	.00*
Middle Archaic (24)	.00**	.05 ±.17**	.05 ±.09
Late Archaic (16)	.00**	.04 ±.17*	.02 ±.06**
Early Woodland (2)	.00	.30 ±.47	.10 ±.18
Unclassified (4)	.00	.00*	.03 ±.06
L&A-Limestone			
Control (14)	.35 ±.74	.29 ±.41	.19 ±.24
Early Archaic (2)	.00	.64 ±.18*	.61 ±.06**
Middle Archaic (2)	.00	.40 ±.54	.32 ±.40
Late Archaic (3)	.75 ±1.24	.62 ±.13**	.50 ±.13**
Early Woodland (4)	.51 ±1.07	.34 ±.40	.41 ±.12**
Unclassified (5)	.00	.09 ±.14	.09 ±.14
L&A-Clay Plain			
Control (18)	.12 ±.50	.04 ±.13	.02 ±.04
Palaeo-Indian (3)	.00	.00	.03 ±.05
Early Archaic (2)	.00	.00	.00
Middle Archaic (7)	.00	.00	.00*
Late Archaic (4)	.00	.00	.01 ±.02
Early Woodland (6)	.00	.10 ±.25	.04 ±.03
Unclassified (6)	.00	.00	.00
PE-Bevelled Till			
Control (8)	.00	.00	.00
Late Archaic (5)	.00	.03 ±.08	.01 ±.04
PE-Limestone			
Control (16)	.43 ±.99	.35 ±.44	.18 ±.19
Middle Archaic (7)	.00	.01 ±.02**	.05 ±.06**
Late Archaic (5)	.38 ±.93	.15 ±.35	.10 ±.13*
Unclassified (1)	2.30**	.86*	.34

** $p \leq 0.05$
* $p \leq 0.10$

TABLE A-8 Nut Capability Index

ZONE	SITE	SETTING	VICINITY
L&A-Limestone			
Control (14)	45 ±08	44 ±08	43 ±08
Early Archaic (2)	46 ±00	46 ±00	47 ±01
Middle Archaic (2)	52 ±08	51 ±07	51 ±05*
Late Archaic (3)	48 ±03	48 ±03	47 ±01
Early Woodland (4)	47 ±03	48 ±02	49 ±01*
Unclassified (5)	45 ±13	45 ±13	45 ±12
L&A-Clay Plain			
Control (18)	55 ±07	54 ±07	52 ±14
Palaeo-Indian (3)	45 ±11*	45 ±11*	46 ±11*
Early Archaic (2)	51 ±00*	51 ±00	53 ±00
Middle Archaic (7)	49 ±07**	49 ±07**	49 ±07*
Late Archaic (4)	54 ±04	54 ±04	54 ±02
Early Woodland (6)	55 ±03	54 ±04	53 ±04
Unclassified (6)	58 ±00	58 ±.40	57 ±02

** $p \leq 0.05$
* $p \leq 0.10$

TABLE A-9 Marsh Area

ZONE	SITE	SETTING	VICINITY
DN-Drumlinized Till			
Control (16)	.00	.00	.00
Palaeo-Indian (1)	.00	.00	.90 **
Hi-Lo (5)	.00	.60 ±1.27**	.60 ±1.27**
Early Archaic (1)	.00	2.90**	2.90**
Middle Archaic (6)	.00	.00	.00
Late Archaic (10)	.00	.00	.20 ±.67*
Early Woodland (3)	14.00 ±25.00**	6.50 ±8.85**	4.20 ±5.06**
Unclassified (8)	1.80 ±3.82**	2.50 ±4.64**	3.00 ±5.63**
DN-Clay Plain			
Control (14)	2.80 ±9.54	2.60 ±6.45	1.30 ±2.48
Palaeo-Indian (2)	.00	.00	.60 ±.79
Hi-Lo (5)	7.80 ±17.58*	5.50 ±8.04**	4.10 ±3.14**
Early Archaic (4)	8.00 ±10.25	13.60 ±11.94**	5.50 ±2.90**
Middle Archaic (24)	11.00 ±15.25**	10.40 ±12.05**	3.80 ±3.20**
Late Archaic (16)	10.00 ±12.14**	10.80 ±9.33**	5.60 ±2.78**
Early Woodland (2)	5.00 ±7.57	13.70 ±16.21**	5.10 ±2.81**
Unclassified (4)	.00	3.00 ±3.64	1.40 ±1.56
L&A-Limestone			
Control (14)	1.00 ±3.82	.60 ±2.13	.20 ±.62
Early Archaic (2)	.00	11.10 ±5.85**	3.20 ±1.30**
Middle Archaic (2)	8.80 ±12.64**	9.20 ±8.56**	2.80 ±1.85**
Late Archaic (3)	.00	7.40 ±7.65**	2.10 ±2.07**
Early Woodland (4)	7.00 ±8.25**	8.80 ±6.34**	3.50 ±2.36**
Unclassified (5)	1.40 ±3.18	1.10 ±1.57*	1.40 ±2.11**
L&A-Clay Plain			
Control (18)	3.90 ±11.82	.59 ±1.14	.20 ±.30
Palaeo-Indian (3)	.00	.00	.00
Early Archaic (2)	.00	3.70 ±1.13**	3.30 ±2.58**
Middle Archaic (7)	10.60 ±30.32	5.90 ±13.92**	2.30 ±4.29
Late Archaic (4)	.00	1.70 ±1.43**	3.50 ±2.43**
Early Woodland (6)	1.20 ±2.92	1.40 ±130**	2.60 ±2.36**
Unclassified (6)	8.80 ±13.50**	15.00 ±18.50**	11.70 ±10.45**
PE-Bevelled Till			
Control (8)	4.50 ±11.25	4.60 ±7.09	2.70 ±3.01
Late Archaic (5)	10.00 ±16.36*	12.00 ±10.18*	5.00 ±2.79**
PE-Limestone			
Control (16)	1.70 ±5.54	2.90 ±6.06	2.80 ±5.52
Middle Archaic (7)	3.50 ±5.04**	11.10 ±12.04**	8.80 ±10.72**
Late Archaic (5)	14.80 ±13.68**	5.20 ±6.03**	2.00 ±2.50
Unclassified (1)	10.60**	1.90	.50

** $p \le 0.05$
* $p \le 0.10$

TABLE A-10 Swamp Area

ZONE	SITE	SETTING	VICINITY
DN-Drumlinized Till			
Control (16)	5.70 ±17.14	1.60 ±5.66	.60 ±1.88
Palaeo-Indian (1)	.00	.00	.00
Hi-Lo (5)	.00	1.00 ±2.14	.20 ±.53
Early Archaic (1)	.00	.00	.00
Middle Archaic (6)	.00	.80 ±1.95	.20 ±.49
Late Archaic (10)	2.10 ±6.78	1.50 ±4.73	.40 ±1.41
Early Woodland (3)	.00	.00	.00
Unclassified (8)	.00	.00	.50 ±1.40
DN-Clay Plain			
Control (14)	.00	.50 ±1.28	.50 ±1.38
Palaeo-Indian (2)	.00	.00	.60 ±.84
Hi-Lo (5)	3.50 ±8.00**	3.40 ±4.72*	1.90 ±2.64*
Early Archaic (4)	.00	2.10 ±4.14	1.70 ±197**
Middle Archaic (24)	.70 ±3.64	.90 ±2.06	.60 ±1.22
Late Archaic (16)	.00	1.20 ±2.25	1.40 ±1.67**
Early Woodland (2)	.00	.00	.00
Unclassified (4)	.00	2.10 ±2.45**	.60 ±.69
L&A-Limestone			
Control (14)	3.00 ±6.25	2.30 ±3.22	3.30 ±4.12
Early Archaic (2)	.00	1.40 ±2.03	1.20 ±.11
Middle Archaic (2)	.00	.00	.60 ±.79
Late Archaic (3)	.00	1.00 ±1.66	.80 ±.69
Early Woodland (4)	.00	.00**	.30 ±.56**
Unclassified (5)	2.80 ±6.39	5.00 ±7.04	5.00 ±5.32
L&A-Clay Plain			
Control (18)	1.17 ±1.35	1.11 ±2.10	1.00 ±2.58
Palaeo-Indian (3)	.00	.00	.00
Early Archaic (2)	.00	.60 ±.90	1.40 ±00**
Middle Archaic (7)	.00	3.50 ±9.40	2.10 ±4.91
Late Archaic (4)	.00	2.30 ±2.98**	1.90 ±2.11**
Early Woodland (6)	.00	1.50 ±2.60**	1.30 ±1.91**
Unclassified (6)	.00	.00	.00
PE-Bevelled Till			
Control (8)	.00	.00	.00
Late Archaic (5)	.00	.00	.00
PE-Limestone			
Control (16)	6.60 ±19.89	3.40 ±6.08	1.90 ±2.58
Middle Archaic (7)	.00	.00**	.00**
Late Archaic (5)	.00	.00*	.00*
Unclassified (1)	10.60**	23.60**	6.70**

** p≤0.05

* $p \leq 0.10$

TABLE A-11 Stream Density Values

By Region, Zone and Period

Halton Till Moraine

Site (300m)

	first	second	third	fourth	> fourth
CO 8	0.43 ±0.66	0.86 ±1.80	0.07 ±0.20	0.00	0.14 ±0.40
PI 1	2.29	.00			
EA 4	.57 ± .57	.67 ± .91			
MA 6	2.14 ±1.89	1.14 ±1.40			
LA 4	1.29 ±1.64	.71 ± .86			
EW 2	.86 ±1.21	.86 ±1.21			

Setting (1km)

	first	second	third	fourth	> fourth
CO 8	.79 ± .43	.64 ± .80	.11 ± .16		.17 ± .32
PI 1	.66	.71	.25		.76
EA 4	.58 ± .21	.70 ± .40	.10 ± .13	.25 ± .25	
MA 6	1.35 ± .70	1.10 ± .15	.06 ± .13		
LA 4	.98 ± .48	.88 ± .57	.06 ± .13		.01 ±.03
EW 2	.92 ±.72	.54 ± .69	.13 ± .18		

Vicinity (2km)

	first	second	third	fourth	> fourth
CO 8	.78 ± .32	.48 ± .45	.08 ± .09	.05 ± .09	.10 ± .15
PI 1	.76	.51	.13	.19	.33
EA 4	.50 ± .12	.41 ± .16	.08 ± .06	.16 ± .14	.09 ± .16
MA 6	.90 ± .36	.69 ± .28	.10 ± .03	.02 ± .02	.06 ± .13
LA 4	.79 ± .35	.60 ± .34	.11 ± .05	.03 ± .07	.13 ± .14
EW 2	.65 ± .40	.37 ± .06	.10 ± .06	.07 ± .10	

Halton Drumlinized Till

Site (300m)

	first	second	third	fourth	> fourth
CO 10	.29 ± .33	1.26 ±2.23	.71 ±1.00	.12 ± .28	
EA 4	1.50 ±1.64	1.57 ±1.95	.18 ± .27	.07 ± .15	.14 ± .29
MA 20	1.73 ±1.35	.86 ±1.27	.19 ± .53	.03 ± .13	.11 ± .51
LA 1	.57	4.00			

Setting (1km)

	first	second	third	fourth	> fourth

		first	second	third	fourth	> fourth
CO	10	1.01 ± .42	.86 ± .53	.56 ± .27	.08 ± .18	
EA	4	1.06 ± .36	.73 ± .53	.42 ± .40	.22 ± .26	.26 ± .38
MA	20	1.13 ± .39	.77 ± .45	.31 ± .26	.12 ± .21	.21 ±± .28
LA	1	1.27	1.02	.46		

Vicinity (2km)

		first	second	third	fourth	> fourth
CO	10	.75 ± .16	.63 ± .28	.43 ± .12	.08 ± .10	.11 ± .12
EA	4	.68 ± .15	.59 ± .14	.34 ± .20	.10 ± .11	.20 ± .14
MA	20	.78 ± .16	.65 ± .33	.32 ± .13	.08 ± .09	.18 ± .13
LA	1	.71	.74	.23		.19

Halton Bevelled Till

Site (300m)

		first	second	third	fourth	> fourth
CO	8	1.04 ± .97	1.04 ± .94	.71 ±1.05	.21 ± .60	.11 ± .30
PI	4	.50 ± .82	.71 ± .86		1.50 ±1.18	.43 ± .86
HL	1				2.86	1.71
EA	2	1.42 ± .40	.57 ± .81		.72 ±1.01	
MA	13	.61 ± .94	.64 ± .78	.01 ± .04	1.05 ± .95	.35 ± .68
LA	8	.94 ±1.22	.61 ± .78		1.35 ±1.35	
EW	2	1.31 ±1.27	.51 ± .71		1.31 ±1.30	

Setting (1km)

		first	second	third	fourth	> fourth
CO	8	.73 ± .31	.45 ± .31	.55 ± .62	.11 ± .20	.18 ± .26
PI	4	.95 ± .71	.38 ± .09	.24 ± .17	.69 ± .06	.59 ± .06
HL	1	.36	.25	.41	.76	.66
EA	2	1.58 ± .51	.33 ± .11	.13 ± .18	.46 ± .36	.28 ± .40
MA	13	.68 ± .49	.39 ± .16	.38 ± .28	.53 ± .34	.45 ± .22
LA	8	.80 ± .65	.57 ± .47	.17 ± .19	.38 ± .37	.14 ± .20
EW	2	.96 ± .72	.62 ± .48	.14 ± .16	.39 ± .37	.13 ± .24

Halton Shale Plain

Site (300m)

		first	second	third	fourth	> fourth
CO	8	1.18 ±3.00	.72 ±1.04	.43 ±1.01	.04 ± .10	.001 ±.004
PI	1	2.00		.29		
EA	2	1.00 ±1.41	.43 ± .61	.15 ± .21		
MA	16	.25 ± .53	.93 ±1.23	.57 ± .81	.11 ± .44	.32 ± .87
LA	6	.33 ± .82	.43 ± .72	.24 ± .46		.57 ± .88
EW	2	1.00 ±1.41		.15 ± .21		.86 ±1.21

Setting (1km)

		first	second	third	fourth	> fourth
CO	8	.80 ± .84	.78 ± .61	.89 ±1.33	.12 ± .24	.12 ± .21
PI	1	.23	.20	.71		
EA	2	.12 ± .16	.44 ± .33	.42 ± .42	.15 ± .21	.31 ± .43
MA	16	.42 ± .36	.52 ± .35	.43 ± .30	.12 ± .24	.20 ± .30
LA	6	.26 ± .34	.36 ± .34	.17 ± .27	.12 ± .15	.48 ± .27
EW	2	.53 ± .42	.36 ± .22	.41 ± .43		.36 1 .50

Vicinity (2km)

		first	second	third	fourth	> fourth
CO	8	1.18 ±2.20	.62 ± .49	.61 ± .93	.12 ± .13	.15 ± .17
PI	1	.17	.25	.49	.20	
EA	2	.27 ± .13	.39 ± .19	.27 ± .32	.20 ± .01	.15 ± .21
MA	16	.48 ± .21	.38 ± .17	.29 ± .24	.15 ± .10	.15 ± .15
LA	6	.41 ± .15	.38 ± .20	.14 ± .18	.16 ± .10	.24 ± .12
EW	2	.35 ± .25	.38 ± .18	.29 ± .29	.10 ± .14	.14 ± .20

Halton Sand Plain

Site (300m)

		first	second	third	fourth	> fourth
CO	9	.93 ±1.57	.25 ± .38	.22 ± .45		.32 ± .95
PI	7	1.46 ±1.03	.34 ± .42			
EA	9	1.28 ± .97	.57 ± .67			
MA	29	.62 ± .67	.81 ± .61			
LA	14	.99 ± .90	.70 ± .72			
EW	12	1.03 ± .96	.56 ± .60			

Setting (1km)

		first	second	third	fourth	> fourth
CO	9	.57 ± .55	.46 ± .38	.32 ± .22		.08 ± .25
PI	7	.78 ± .28	.72 ± .40	.04 ± .05		
EA	9	.75 ± .25	.80 ± .38	.04 ± .05		
MA	29	.64 ± .24	.87 ± .35	.12 ± .20		
LA	14	.73 ± .22	.90 ± .34	.05 ± .05		
EW	12	.71 ± .22	.89 ± .37	.05 ± .05		

Vicinity (2km)

		first	second	third	fourth	> fourth
CO	9	.46 ± .29	.44 ± .23	.24 ± .19	.04 ± .07	.05 ± .12
PI	7	.57 ± .06	.51 ± .20	.06 ± .07		
EA	9	.57 ± .06	.55 ± .19	.07 ± .07		
MA	29	.55 ± .14	.61 ± .22	.10 ± .12		
LA	14	.57 ± .07	.60 ± .17	.06 ± .06		

EW	12	.56 ± .05	.60 ± .18	.06 ± .06

Durham Drumlinized Till

Site (300m)

		first	second	third	fourth	> fourth
CO	13	.81 ±1.38	.35 ± .68			
PI	1	1.71	.29	.57		
HL	5	1.76 ±1.18				.002 ±.005
EA	1					
MA	6	1.76 ±1.12	.76 ±1.18	.10 ± .23		
LA	10	1.46 ±1.24	.69 ±1.00	.06 ± .18		
EW	3	.36 ± .41				
UN	7	.98 ±1.27	.75 ± .83	.13 ± .33		

Setting (1km)

		first	second	third	fourth	> fourth
CO	13	.72 ± .44	.40 ± .36	.22 ± .26	.09 ± .21	
PI	1	1.02	1.02	.31		
HL	5	3.08 ±3.75	1.83 ±2.69	.23 ±.43	.02 ±.05	
EA	1	.59			.12	
MA	6	1.22 ± .62	.53 ± .21	.25 ± .27		
LA	10	.84 ± .42	.48 ± .39	.33 ± .28		
EW	3	.57 ± .06	.15 ± .27	.08 ± .14	.07 ± .06	
UN	7	.96 ± .23	.30 ± .25	.05 ± .14		

Vicinity (2km)

		first	second	third	fourth	> fourth
CO	13	.52 ± .18	.29 ± .23	.19 ± .12	.09 ± .16	
PI	1	.89	.46	.23		
HL	5	2.04 ±3.11	1.06 ±1.33	.30 ± .34	.10 ± .15	
EA	1	.39	.26	.21	.18	
MA	6	.72 ± .13	.44 ± .20	.14 ± .08	.06 ± .13	.03 ± .07
LA	10	.61 ± .25	.30 ± .15	.17 ± .11	.05 ± .10	.01 ± .03

Durham Clay Plain

Site (300m)

		first	second	third	fourth	> fourth
CO	14	.92 ±1.11	.39 ± .79		.16 ± .61	.12 ± .33
PI	2	2.57 ±3.63	1.43 ±1.22			
HL	5	.20 ± .31	.14 ± .31		.57 ±1.28	.63 ±1.40
EA	4		.43 ± .86			.20 ± .40
MA	24	.99 ±1.75	.69 ±1.12	.26 ± .63	.19 ± .67	.37 ± .81
LA	16	.47 ± .63	.39 ± .78	.23 ± .62		.30 ± .87
EW	2			1.15 ±1.62		
UN	4	2.57 ±3.00	1.29 ± .98			.29 ± .57

Setting (1km)

		first	second	third	fourth	> fourth
CO	14	.67 ± .36	.44 ± .35	.19 ± .26	.05 ± .20	.12 ± .25
PI	2	1.00 ± .04	1.27 ± .13	.06 ± .08		
HL	5	.34 ± .20	.47 ± .49	.21 ± .32	.15 ± .29	.19 ± .38
EA	4	.59 ± .16	.57 ± .56	.16 ± .18		.34 ± .53
MA	24	.72 ± .55	.63 ± .60	.22 ± .29	.13 ± .25	.41 ± .52
LA	16	.63 ± .39	.39 ± .35	.28 ± .38		.21 ± .41
EW	2	.26 ± .36	.55 ± .06	.74 ±1.05		
UN	4	1.04 ± .95	1.00 ± .48	.08 ± .16		

Vicinity (2km)

		first	second	third	fourth	> fourth
CO	14	.48 ± .6	.32 ± .20	.20 ± .16	.02 ± .07	.10 ± .14
PI	2	.76 ± .17	.71 ± .28	.08 ± .02	.15 ± .21	.10 ± .13
HL	5	.49 ± .15	.38 ± .41	.21 ± .09	.09 ± .12	.15 ± .22
EA	4	.48 ± .19	.39 ± .41	.13 ± .05	.01 ± .03	.19 ± .22
MA	24	.58 ± .18	.43 ± .31	.18 ± .15	.09 ± .13	.21 ± .22
LA	16	.44 ± .23	.29 ± .20	.17 ± .12	.04 ± .08	.14 ± .09
EW	2	.26 ± .04	.24 ± .04	.27 ± .37	.02 ± .03	
UN	4	.60 ± .31	.67 ± .32	.05 ± .02	.22 ± .02	.09 ± .11

Lennox and Addington Limestone Plain

Site (300m)

		first	second	third	fourth	> fourth
CO	14	1.28 ±1.43	.99 ±1.34	.17 ± .64	.	.20 ±.75
EA	2	2.00 ±2.84	2.44 ±1.22	2.40 ±3.40		
MA	2	.64 ± .90	2.50 ±1.14			
LA	3	1.86 ±2.02	1.62 ±1.65	1.60 ±2.77		
EW	4	3.74 ±3.47	.83 ±1.65			
UN	5	1.84 ±1.20	.55 ± .77	.48 ±1.06		

Setting (1km)

		first	second	third	fourth	> fourth
CO	14	.95 ± .57	.59 ± .29	.07 ± .15	.05 ± .20	.06 ± .22
EA	2	.93 ± .15	1.17 ± .17	.25 ± .36		
MA	2	.80 ± .04	.77 ± .74			
LA	3	.98 ± .15	1.02 ± .28	.34 ± .30		
EW	4	1.25 ± .35	1.01 ± .22	.13 ± .27		
UN	5	1.10 ± .77	.51 ± .24	.16 ± .26		

Vicinity (2km)

		first	second	third	fourth	> fourth

		first	second	third	fourth	> fourth
CO	14	.63 ± .27	.33 ± .20	.10 ± .13	.02 ± .08	.06 ± .13
EA	2	1.02 ± .15	.48 ± .17	.06 ± .11		
MA	2	.84 ± .11	.47 ± .20	.04 ± .06		
LA	3	.86 ± .28	.47 ± .12	.25 ± .31		
EW	4	.77 ± .15	.57 ± .08	.10 ± .20		
UN	5	.60 ± .40	.46 ± .23	.13 ± .15		

Lennox and Addington Clay Plain

Site (300m)

		first	second	third	fourth	> fourth
CO	18	.57 ± .86	1.10 ±1.33	.64 ±1.20	.30 ± .73	
PI	3	3.31 ± .99	.26 ± .23			
EA	2					
MA	8	.99 ±1.75	.15 ± .30		.34 ± .98	.70 ±1.29
LA	4	.80 ± .92	.30 ± .60	.30 ± .60	.60 ± .19	
EW	4	.40 ± .62	.33 ± .52	.49 ±1.20	.86 ±1.34	
UN	6	.46 ±1.13			.73 ±1.29	

Setting (1km)

		first	second	third	fourth	> fourth
CO	18	1.20 ± .75	.87 ± .40	.37 ± .31	.16 ± .34	
PI	3	1.30 ± .51	.33 ± .21	.17 ± .29	.24 ± .41	.79 ± .69
EA	2	.90 ± .15	1.15 ± .12			
MA	8	1.00 ± .55	.56 ± .48	.02 ± .06	.12 ± .34	.30 ± .55
LA	4	1.01 ± .35	.95 ± .34	.16 ± .32	.34 ± .67	.08 ± .16
EW	4	1.26 ± .29	1.01 ± .30	.25 ± .47	.38 ± .61	
UN	6	.56 ± .51	.54 ± .72	.13 ± .20	.44 ± .38	

Vicinity (2km)

		first	second	third	fourth	> fourth
CO	18	.95 ± .47	.43 ± .17	.25 ± .20	.11 ± .16	
PI	3	.92 ± .07	.26 ± .15	.34 ± .30	.14 ± .24	.16 ± .28
EA	2	1.07 ± .04	.41 ± .01	.05 ± .00		
MA	8	.84 ± .29	.36 ± .28	.09 ± .15	.05 ± .15	.06 ± .17
LA	4	1.08 ± .22	.52 ± .14	.13 ± .18	.01 ± .02	.08 ± .15

Prince Edward Bevelled Till Plain

Site (300m)

		first	second	third	fourth	> fourth
CO	8	.64 ± .94	.50 ± .94			
MA	6	1.01 ± .99	.29 ± .70	.46 ±1.14		

Setting (1km)

		first	second	third	fourth	> fourth
CO	8	.71 ± .31	.32 ± .23	.03 ± .10		
MA	6	.96 ± .52	.41 ± .20	.26 ± .39		

Vicinity (2km)

		first	second	third	fourth	> fourth
CO	8	.52 ± .12	.24 ± .10	.10 ± .22		
MA	6	.65 ± .23	.21 ± .13	.12 ± .16		

Prince Edward Limestone Plain

Site (300m)

		first	second	third	fourth	> fourth
CO	8	1.12 ±1.08	.31 ± .64		.04 ± .18	
MA	7		.10 ± .25			
LA	6	.62 ± .78	.16 ± .38	.19 ± .47		
UN	1	2.00				

Setting (1km)

		first	second	third	fourth	> fourth
CO	8	.60 ± .27	.43 ± .33	.19 ± .20	.06 ± .18	
MA	7	.69 ± .12	.24 ± .25		.04 ± .11	
LA	6	.70 ± .49	.32 ± .27	.18 ± .33	.01 ± .03	
UN	1	1.57	.65			

Vicinity (2km)

		first	second	third	fourth	> fourth
CO	8	.44 ± .13	.26 ± .11	.11 ± .07	.03 ± .07	
MA	7	.46 ± .10	.29 ± .27	1.29 ±3.40	.07 ± .12	
LA	6	.56 ± .19	.19 ± .08	.14 ± .15	.04 ± .10	
UN	1	.78	.37			

CO = Control
PI = Palaeo-Indian
HL = Hi-Lo (late Palaeo-Indian)
EA = Early Archaic
MA = Middle Archaic
LA = Late Archaic
EW = Early Woodland
UN = Unclassified Period

APPENDIX B

Tables Of Results By Region and Zone

The following tables present the mean values of the terrain variables measured and the standard deviations. In cases where there was a sample size of one, mean and standard deviation do not apply. The values marked by asterix indicate statistically significant results, accordng to a Mann-Whtney U test.

TABLE B-1 Halton Till Moraine

ZONE	SITE	SETTING	VICINITY
Average Slope			
Control(8)	.033 ±.032	.041 ±.027	.041 ±.015
Palaeo-Indian(1)	.072	.081	.064
Early Archaic(4)	.055 ±.040*	.050 ±.020	.042 ±.01
Middle Archaic(6)	.059 ±.032**	.047 ±.020	.037 ±.01
Late Archaic(4)	.057 ±.022**	.044 ±.020	.037 ±.01
Early Woodland(2)	.060 ±.025*	.045 ±.031	.043 ±.02
Maximum Relief			
Control	29 ±30	110 ±91	202 ±95
Palaeo-Indian(1)	110**	130	150
Early Archaic(4)	50 ±42*	117 ±44	152 ±37
Middle Archaic(6)	57 ±36**	128 ±67	195 ±92
Late Archaic(4)	62 ±50*	137 ±130	235 ±132
Early Woodland(2)	90 ±57**	195 ±191	265 ±219
Total Stream Density			
Control(8)	1.50 ±1.57	1.71 ±.88	1.50 ±.71
Palaeo-Indian(1)	2.29	2.38	1.92
Early Archaic(4)	1.24 ±.60	1.63 ±.34	1.24 ±.39
Middle Archaic(6)	3.29 ±1.08**	2.38 ±.51*	1.77 ±.70
Late Archaic(4)	2.00 ±.99*	1.93 ±.50	1.66 ±.71
Early Woodland(2)	1.71 ±.00*	1.58 ±.14	1.17 ±.37
Deer Capability			
Control (8)	262 ±52	262 ±52	262 ±46
Palaeo-Indian (1)	300	300	300
Early Archaic (4)	275 ±50	276 ±48	280 ±40
Middle Archaic (6)	267 ±52	267 ±50	270 ±41
Late Archaic (4)	250 ±57	251 ±56	251 ±49
Early Woodland (2)	200 ±00*	202 ±04	210 ±14*
Cliff Density			
Control (8)	.21 ±.60	.28 ±.59	.32 ±.32
Palaeo-Indian (1)	2.83**	1.73**	1.63
Early Archaic (4)	.99 ±1.35*	1.17 ±.53**	.91 ±.40**
Middle Archaic (6)	.66 ±1.17	.56 ±.56	.63 ±.32**
Late Archaic (4)	.99 ±1.35*	.34 ±.32	.68 ±.33**
Early Woodland (2)	1.98 ±1.21**	.61 ±.14*	.76 ±.55*

** $p \leq 0.05$
* $p \leq 0.10$

TABLE B-2 Halton Drumlinized Till

ZONE	SITE	SETTING	VICINITY
Average Slope			
Control(10)	.028 ±.017	.024 ±.008	.033 ±.007
Early Archaic(4)	.038 ±.025	.038 ±.016*	.037 ±.009
Middle Archaic(20)	.028 ±.030	.033 ±.013**	.036 ±.010
Late Archaic(1)	.028	.034*	.041
Maximum Relief			
Control(10)	19 ±11	68 ±23	185 ±33
Early Archaic(4)	23 ±15	140 ±108*	217 ±101
Middle Archaic(20)	23 ±26	105 ±38**	188 ±32
Late Archaic(1)	20	70	210*
Total Stream Density			
Control(10)	2.37 ±1.90	2.50 ±.79	2.09 ±.61
Early Archaic(4)	3.47 ±.77*	2.67 ±.71	1.90 ±.36
Middle Archaic(20)	2.73 ±1.57	2.50 ±.44	2.02 ±.31
Late Archaic(1)	4.57	2.75	1.87
Deer Capability			
Control (10)	275 ±43	275 ±43	276 ±41
Early Archaic (4)	256 ±52	260 ±50	260 ±32*
Middle Archaic (20)	261 ±43	262 ±36*	256 ±27**
Late Archaic (1)	300	300	295
Cliff Density			
Control (10)	.00	.02 ±.05	.32 ±.27
Early Archaic (4)	.14 ±.29*	.43 ±.65**	.52 ±.10
Middle Archaic (20)	.28 ±.92*	.50 ±.59**	.46 ±.27*
Late Archaic (1)	.00	.00	.51

** $p \leq 0.05$
* $p \leq 0.10$

TABLE B-3 Halton Bevelled Till

ZONE	SITE	SETTING	VICINITY
Average Slope			
Control(8)	.032 ±.018	.027 ±.015	.027 ±.012
Palaeo-Indian(4)	.051 ±.027	.045 ±.016**	.044 ±.018*
Hi-Lo(1)	.086*	.050	.048
Early Archaic(2)	.029 ±.016	.045 ±.025	.048 ±.018*
Middle Archaic(13)	.047 ±.030	.039 ±.016**	.037 ±.015*
Late Archaic(8)	.030 ±.017	.027 ±.018	.025 ±.016
Early Woodland(5)	.027 ±.016	.026 ±.020	.026 ±.018
Maximum Relief			
Control(8)	26 ±19	59 ±33	139 ±103
Palaeo-Indian(4)	37 ±22	167 ±190*	375 ±197**
Hi-Lo(1)	60	80	480
Early Archaic(2)	25 ±70	270 ±255**	310 ±212**
Middle Archaic(13)	41 ±19**	103 ±108*	321 ±174**
Late Archaic(8)	21 ±14	91 ±146	127 ±134*
Early Woodland(5)	18 ±13	108 ±168	143 ±155
Total Stream Density			
Control(8)	3.11 ±1.42	2.02 ±.68	1.46 ±.36
Palaeo-Indian(4)	3.14 ±2.12	2.84 ±.79**	1.93 ±.50**
Hi-Lo(1)	4.57*	2.44	1.92
Early Archaic(2)	2.71 ±2.22	2.77 ±1.56	1.97 ±.32**
Middle Archaic(13)	2.67 ±1.85	2.42 ±.59*	1.74 ±.36**
Late Archaic(8)	2.90 ±.81	2.07 ±.94	1.39 ±.42
Early Woodland(5)	3.14 ±.75	2.24 ±1.05	1.50 ±.50
Deer Capability			
Control (8)	298 ±07	291 ±27	290 ±30
Palaeo-Indian (4)	300 ±00	286 ±14**	280 ±14**
Hi-Lo (1)	300	280**	270**
Early Archaic (2)	300 ±00	285 ±21	282 ±18**
Middle Archaic (13)	277 ±44	276 ±21**	276 ±18**
Late Archaic (8)	300 ±00	296 ±11	296 ±11
Early Woodland (5)	300 ±00	295 ±12	295 ±12
Cliff Density			
Control (8)	.63 ±1.25	.63 ±1.04	.36 ±.50
Palaeo-Indian (4)	1.13 ±1.40	.85 ±.65	.72 ±.52*
Hi-Lo (1)	.00	.76	.73
Early Archaic (2)	1.41 ±2.03	.82 ±.43	.97 ±.03**
Middle Archaic (13)	.78 ±1.21	.76 ±.53	.66 ±.43**
Late Archaic (8)	.35 ±1.00	.14 ±.39*	.22 ±.35
Early Woodland (5)	.46 ±1.14	.19 ±.14	.30 ±.38

** $p \leq 0.05$
* $p \leq 0.10$

TABLE B-4 Halton Shale Plain

ZONE	SITE	SETTING	VICINITY
Average Slope			
Control(8)	.100 ±.234	.076 ±.155	.079 ±.142
Palaeo-Indian(1)	.018	.016	.020
Early Archaic(2)	.015 ±.004	.020 ±.006	.023 ±.004*
Middle Archaic(16)	.032 ±.025	.029 ±.014	.027 ±.011
Late Archaic(8)	.031 ±.021	.029 ±.008*	.029 ±.006
Early Woodland(2)	.044 ±.037	.027 ±.016	.026 ±.008
Maximum Relief			
Control(8)	114 ±237	114 ±40	200 ±52
Palaeo-Indian(1)	10*	60*	150*
Early Archaic(2)	10 ±00**	55 ±07**	120 ±42**
Middle Archaic(16)	31 ±29**	88 ±32**	157 ±40**
Late Archaic(6)	30 ±21	73 ±19**	148 ±35**
Early Woodland(2)	35 ±35	65 ±07**	145 ±07**
Total Stream Order Density			
Control(8)	1.12 ±.89	2.70 ±2.52	1.42 ±.22
Palaeo-Indian(1)	2.29	1.14	1.11*
Early Archaic(2)	1.57 ±1.01	1.42 ±.40	1.26 ±.21
Middle Archaic(16)	2.19 ±1.44**	1.69 ±.60	1.43 ±.36
Late Archaic(6)	1.57 ±1.73	1.38 ±.70*	1.33 ±.26
Early Woodland(2)	2.00 ±.41	1.64 ±.71	1.25 ±.20
Deer Capability			
Control (8)	175 ±70	175 ±70	181 ±53
Palaeo-Indian (1)	200	200	215**
Early Archaic (2)	200 ±00	200 ±00	207 ±11**
Middle Archaic (16)	212 ±28**	211 ±23**	217 ±17**
Late Archaic (6)	200 ±00	200 ±00	202 ±06*
Early Woodland (2)	200 ±00	200 ±00	207 ±11**
Cliff Density			
Control (8)	.00	.18 ±.36	.31 ±.28
Palaeo-Indian (1)	.00	.00	.00
Early Archaic (2)	.00	.41 ±.59	.20 ±.29
Middle Archaic (16)	.49 ±1.07*	.32 ±.53	.31 ±.37
Late Archaic (6)	1.13 ±1.82**	.85 ±.47**	.45 ±.23
Early Woodland (2)	1.98 ±2.82**	.66 ±.94	.30 ±.42

** $p \leq 0.05$
* $p \leq 0.10$

TABLE B-5 Halton Sand Plain

ZONE	SITE	SETTING	VICINITY
Average Slope			
Control(9)	.030 ±.017	.027 ±.015	.028 ±.015
Palaeo-Indian(7)	.018 ±.005*	.019 ±.002	.020 ±.005
Early Archaic(9)	.019 ±.005*	.019 ±.002*	.020 ±.004
Middle Archaic(29)	.021 ±.004	.019 ±.002**	.022 ±.003
Late Archaic(14)	.020 ±.006*	.020 ±.002*	.021 ±.040
Early Woodland(12)	.019 ±.005*	.019 ±.002*	.020 ±.004
Maximum Relief			
Control(9)	30 ±20	73 ±43	147 ±89
Palaeo-Indian(7)	17 ±05**	67 ±31	163 ±36**
Early Archaic(9)	17 ±05**	63 ±28	157 ±34**
Middle Archaic(29)	20 ±04**	56 ±17*	152 ±27**
Late Archaic(14)	17 ±05**	59 ±23	147 ±35
Early Woodland(12)	17 ±05**	61 ±24	149 ±37*
Total Stream Density			
Control(9)	1.72 ±1.68	1.41 ±.55	1.23 ±.38
Palaeo-Indian(7)	1.80 ±.61	1.49 ±.21	1.14 ±.24
Early Archaic(9)	1.86 ±.71	1.53 ±.20	1.19 ±.23
Middle Archaic(29)	1.43 ±.84	1.54 ±.26	1.26 ±.24
Late Archaic(14)	1.67 ±.92	1.59 ±.19	1.23 ±.19
Early Woodland(12)	1.59 ±.83	1.57 ±.20	1.22 ±.21
Deer Capability			
Control (9)	200 ±00	200 ±00	203 ±08
Palaeo-Indian (7)	200 ±00	200 ±00	202 ±03
Early Archaic (9)	200 ±00	200 ±00	202 ±03
Middle Archaic (29)	200 ±00	200 ±00	204 ±03**
Late Archaic (14)	200 ±00	200 ±00	203 ±04
Early Woodland (12)	200 ±00	200 ±00	204 ±04
Cliff Density			
Control (9)	.40 ±1.25	.25 ±.36	.12 ±.17
Palaeo-Indian (7)	.00	.00**	.00**
Early Archaic (9)	.00	.00**	.00**
Middle Archaic (29)	.00**	.00**	.00**
Late Archaic (14)	.00	.00**	.00**
Early Woodland (12)	.00	.00**	.00**

** p≤0.05
* p≤0.10

TABLE B-6 Durham Northumberland Drumlinized Till

ZONE	SITE	SETTING	VICINITY
Average Slope			
Control(14)	.098 ±.063	.081 ±.037	.033 ±.008
Palaeo-Indian(1)	.094	.084	.069
Hi-Lo(5)	.049 ±.019	.051 ±.018	.050 ±.017
Early Archaic(1)	.060	.050	.049
Middle Archaic(6)	.071 ±.033	.068 ±.036	.067 ±.031
Late Archaic(10)	.087 ±.041	.072 ±.033	.070 ±.025
Early Woodland(3)	.108 ±.056	.075 ±.024	.071 ±.021
Unclassified(8)	.078 ±.022	.074 ±.027	.076 ±.025
Maximum Relief			
Control(14)	87 ±050	202 ±076	328 ±128
Palaeo-Indian(1)	90	160	310
Hi-Lo(5)	98 ±114	194 ±119	334 ±158
Early Archaic(1)	60	100*	210
Middle Archaic(6)	80 ±061	166 ±038	278 ±099
Late Archaic(10)	79 ±058	147 ±073*	285 ±113
Early Woodland(3)	87 ±055	183 ±104	253 ±084
Unclassified(8)	80 ±041	187 ±089	251 ±080
Total Stream Density			
Control(13)	1.16 ±1.51	1.42 ±.54	1.09 ±.25
Palaeo-Indian(1)	2.57	2.35 **	1.58**
Hi-Lo(5)	1.77 ±1.19	3.16 ±2.47**	1.50 ±.47**
Early Archaic(1)	0.00	.71*	1.04
Middle Archaic(6)	2.72 ±1.86**	2.00 ±.58**	1.38 ±.37**
Late Archaic(10)	2.20 ±209*	1.65 ±.78	1.13 ±.37
Early Woodland(3)	.36 ±.41	.88 ±.38**	1.04 ±.04
Unclassified(7)	1.85 ±1.47	1.31 ±.55	1.02 ±.43
Cliff Density			
Control (16)	.00	.13 ±.25	.08 ±.13
Palaeo-Indian (1)	.00	.10	.03
Hi-Lo (5)	.00	.03 ±.04	.10 ±.12
Early Archaic (1)	.00	.00	.03
Middle Archaic (6)	.00	.00	.00
Late Archaic (10)	.00	.07 ±.16	.06 ±.10
Early Woodland (3)	.00	.00	.01 ±.01
Unclassified (8)	.00	.00	.02 ±.05
Marsh Area			
Control (16)	.00	.00	.00
Palaeo-Indian (1)	.00	.00	.90**
Hi-Lo (5)	.00	.60 ±1.27**	.60 ±1.27**
Early Archaic (1)	.00	2.90**	2.90**
Middle Archaic (6)	.00	.00	.00
Late Archaic (10)	.00	.00	.20 ±.67*
Early Woodland (3)	14.00 ±25.00**	6.50 ±8.85**	4.20 ±5.06**
Unclassified (8)	1.80 ±3.82**	2.50 ±4.64**	3.00 ±5.63**

Swamp Area			
Control (16)	5.70 ±17.14	1.60 ±5.66	.60 ±1.88
Palaeo-Indian (1)	.00	.00	.00
Hi-Lo (5)	.00	1.00 ±2.14	.20 ±.53
Early Archaic (1)	.00	.00	.00
Middle Archaic (6)	.00	.80 ±1.95	.20 ±.49
Late Archaic (10)	2.10 ±6.78	1.50 ±4.73	.40 ±1.41
Early Woodland (3)	.00	.00	.00
Unclassified (8)	.00	.00	.50 ±1.40

** $p \leq 0.05$
* $p \leq 0.10$

TABLE B-7 Durham Northumberland Clay Plain

ZONE	SITE	SETTING	VICINITY
Average Slope			
Control(14)	.058 ±.036	.048 ±.034	.047 ±.026
Palaeo-Indian(2)	.047 ±.018*	.056 ±.013*	.050 ±.009
Hi-Lo(5)	.039 ±.022	.034 ±.020	.034 ±.018
Early Archaic(4)	.028 ±.010**	.025 ±.011**	.027 ±.012**
Middle Archaic(24)	.039 ±.016**	.035 ±.012*	.035 ±.010*
Late Archaic(16)	.030 ±.016**	.027 ±.013**	.027 ±.011**
Early Woodland(2)	.028 ±.005*	.032 ±.015	.029 ±.013
Unclassified(4)	.037 ±.010	.033 ±.003	.036 ±.004
Maximum Relief			
Control(14)	66 ±55	124 ±58	171 ±64
Palaeo-Indian(2)	60 ±14	155 ±50	210 ±14*
Hi-Lo(5)	42 ±46	90 ±68	117 ±76
Early Archaic(4)	30 ±22*	80 ±80*	117 ±79*
Middle Archaic(24)	44 ±32*	87 ±59**	151 ±66
Late Archaic(16)	27 ±16**	74 ±56**	112 ±68**
Early Woodland(2)	35 ±07	110 ±99	175 ±28
Unclassified(4)	52 ±21	115 ±41	175 ±64
Total Stream Density			
Control(14)	1.61 ±1.60	1.46 ±.58	1.12 ±.33
Palaeo-Indian(2)	4.00 ±2.42*	2.31 ±.18**	1.78 ±.54**
Hi-Lo(5)	1.54 ±2.06	1.38 ±.49	1.32 ±.60
Early Archaic(4)	.63 ±.81	1.65 ±.60	1.17 ±.52
Middle Archaic(24)	2.50 ±2.56	2.11 ±.89**	1.48 ±.39**
Late Archaic(16)	1.40 ±1.41	1.51 ±.68	1.08 ±.50
Early Woodland(2)	1.14 ±1.62	1.54 ±1.55	.78 ±.48
Unclassified(4)	4.14 ±3.14**	2.40 ±1.01**	1.63 ±.54**
Cliff Density			
Control (14)	.40 ±.82	.17 ±.29	.10 ±.11
Palaeo-Indian (2)	.00	.00	.00
Hi-Lo (5)	.00	.00	.00
Early Archaic (4)	.00	.00	.00*
Middle Archaic (24)	.00**	.05 ±.17**	.05 ±.09
Late Archaic (16)	.00**	.04 ±.17*	.02 ±.06**
Early Woodland (2)	.00	.30 ±.47	.10 ±.18
Unclassified (4)	.00	.00*	.03 ±.06
Marsh Area			
Control (14)	2.80 ±9.54	2.60 ±6.45	1.30 ±2.48
Palaeo-Indian (2)	.00	.00	.60 ±.79
Hi-Lo (5)	7.80 ±17.58*	5.50 ±8.04**	4.10 ±3.14**
Early Archaic (4)	8.00 ±10.25	13.60 ±11.94**	5.50 ±2.90**
Middle Archaic (24)	11.00 ±15.25**	10.40 ±12.05**	3.80 ±3.20**
Late Archaic (16)	10.00 ±12.14**	10.80 ±9.33**	5.60 ±2.78**
Early Woodland (2)	5.00 ±7.57	13.70 ±16.21**	5.10 ±2.81**
Unclassified (4)	.00	3.00 ±3.64	1.40 ±1.56

Swamp Area			
Control (14)	.00	.50 ±1.28	.50 ±1.38
Palaeo-Indian (2)	.00	.00	.60 ±.84
Hi-Lo (5)	3.50 ±8.00**	3.40 ±4.72*	1.90 ±2.64*
Early Archaic (4)	.00	2.10 ±4.14	1.70 ±1.97**
Middle Archaic (24)	.70 ±3.64	.90 ±2.06	.60 ±1.22
Late Archaic (16)	.00	1.20 ±2.25	1.40 ±1.67**
Early Woodland (2)	.00	.00	.00
Unclassified (4)	.00	2.10 ±2.45**	.60 ±.69

** $p \leq 0.05$
* $p \leq 0.10$

TABLE B-8 Lennox and Addington Limestone Plain

ZONE	SITE	SETTING	VICINITY
Average Slope			
Control(14)	.031 ±.020	.028 ±.013	.026 ±.008
Early Archaic(2)	.021 ±.016	.021 ±.008	.024 ±.000
Middle Archaic(2)	.038 ±.008	.029 ±.004	.029 ±.008
Late Archaic(4)	.024 ±.013	.023 ±.005	.025 ±.002
Early Woodland(4)	.029 ±.003	.024 ±.002	.025 ±.001
Unclassified(5)	.024 ±.010	.030 ±.005	.027 ±.003
Maximum Relief			
Control(14)	25 ±16	72 ±37	104 ±45
Early Archaic(1)	10	20**	60
Middle Archaic(2)	30 ±28	65 ±64	90 ±42
Late Archaic(3)	15 ±07*	22 ±04	67 ±11
Early Woodland(4)	17 ±05	41 ±22	69 ±06
Unclassified(5)	24 ±08	77 ±31	98 ±32
Total Stream Density			
Control(14)	2.64 ±1.55	1.72 ±0.70	1.15 ±0.48
Early Archaic(2)	6.64 ±4.73	2.34 ±0.33	1.50 ±0.02
Middle Archaic(2)	3.13 ±0.24	1.56 ±0.78	1.34 ±0.24
Late Archaic(3)	4.95 ±4.45	2.35 ±0.24	1.46 ±0.06
Early Woodland(4)	4.57 ±2.56	2.38 ±0.20	1.44 ±0.05
Unclassified(5)	2.87 ±2.02	1.77 ±0.80	1.20 ±0.72
Soil Texture			
Controls (14)	222 ±76	232 ±50	232 ±45
Early Archaic (2)	350 ±71**	309 ±06**	251 ±71
Middle Archaic (2)	219 ±114	275 ±42	202 ±01
Late Archaic (3)	277 ±135	280 ±50**	247 ±50
Early Woodland (4)	258 ±84	298 ±52	277 ±67
Unclassified (5)	232 ±60	204 ±55	214 ±46
Soil Drainage			
Control (14)	74 ±27	75 ±18	73 ±14
Early Archaic (2)	81 ±26	64 ±11	72 ±02
Middle Archaic (2)	67 ±46	63 ±12	64 ±14
Late Archaic (3)	71 ±26	66 ±09	73 ±02
Early Woodland (4)	87 ±25	72 ±00.5	76 ±03
Unclassified (5)	62 ±17	58 ±14**	64 ±08
Deer Capability			
Control (14)	492 ±71	490 ±66	483 ±61
Early Archaic (2)	500 ±00	500 ±00	507 ±11*
Middle Archaic (2)	550 ±71	535 ±50	537 ±32
Late Archaic (3)	500 ±00	498 ±03	472 ±63
Early Woodland (4)	510 ±20	511 ±17	490 ±60
Unclassified (5)	550 ±87*	548 ±87*	535 ±77*
Cliff Density			

Control (14)	.35 ±.74	.29 ±.41	.19 ±.24
Early Archaic (2)	.00	.64 ±.18*	.61 ±.06**
Middle Archaic (2)	.00	.40 ±.54	.32 ±.40
Late Archaic (3)	.75 ±1.24	.62 ±.13**	.50 ±.13**
Early Woodland (4)	.51 ±1.07	.34 ±.4	.41 ±.12**
Unclassified (5)	.00	.09 ±.14	.09 ±.14
Nut Capability			
Control (14)	45 ±08	44 ±08	43 ±08
Early Archaic (2)	46 ±00	46 ±00	47 ±01
Middle Archaic (2)	52 ±08	51 ±07	51 ±05*
Late Archaic (3)	48 ±03	48 ±03	47 ±01
Early Woodland (4)	47 ±03	48 ±02	49 ±01*
Unclassified (5)	45 ±13	45 ±13	45 ±12
Marsh Area			
Control (14)	1.00 ±3.82	.60 ±2.13	.20 ±.62
Early Archaic (2)	.00	11.10 ±5.85**	3.20 ±1.30**
Middle Archaic (2)	8.80 ±12.64**	9.20 ±8.56**	2.80 ±1.85**
Late Archaic (3)	.00	7.40 ±7.65**	2.10 ±2.07**
Early Woodland (4)	7.00 ±8.25**	8.80 ±6.34**	3.50 ±2.36**
Unclassified (5)	1.40 ±3.18	1.10 ±1.57*	1.40 ±2.11**
Swamp Area			
Control (14)	3.00 ±6.25	2.30 ±3.22	3.30 ±4.12
Early Archaic (2)	.00	1.40 ±2.03	1.20 ±.11
Middle Archaic (2)	.00	.00	.60 ±.79
Late Archaic (3)	.00	1.00 ±1.66	.80 ±.69
Early Woodland (4)	.00	.00**	.30 ±.56**
Unclassified (5)	2.80 ±6.39	5.00 ±7.04	5.00 ±5.32

** $p \leq 0.05$
* $p \leq 0.10$

TABLE B-9 Lennox and Addington Clay Plain

ZONE	SITE	SETTING	VICINITY
Average Slope			
Control(18)	.024 ±.013	.023 ±.022	.023 ±.006
Palaeo-Indian(3)	.042 ±.015**	.037 ±.002**	.031 ±.002**
Early Archaic(2)	.038 ±.017	.024 ±.007	.024 ±.006
Middle Archaic(8)	.041 ±.014**	.030 ±.007**	.026 ±.004*
Late Archaic(4)	.020 ±.010	.020 ±.004	.020 ±.001*
Early Woodland(6)	.029 ±.019	.023 ±.010	.021 ±.006
Unclassified(6)	.024 ±.020	.021 ±.009	.021 ±.005
Maximum Relief			
Control(18)	27 ±19	53 ±26	77 ±24
Palaeo-Indian(3)	53 ±26**	115 ±41**	130 ±35**
Early Archaic(2)	25 ±07	30 ±00*	100 ± 00*
Mddle Archaic(8)	32 ±21	65 ±49	101 ±34*
Late Archaic(4)	22 ±10	34 ±11*	81 ±31
Early Woodland(6)	24 ±12	43 ±10	92 ±21
Unclassified(6)	17 ±14*	45 ±15	68 ±08*
Total Stream Density			
Control(18)	2.62 ±2.09	2.59 ±.82	1.60 ±.48
Palaeo-Indian(3)	5.10 ±2.20*	2.82 ±.32	1.82 ±.50
Early Archaic(2)	0.00**	2.05 ±.27	1.50 ±.08
Middle Archaic(8)	2.06 ±2.97	2.00 ±1.12	1.38 ±.55
Late Archaic(4)	1.98 ±2.29	2.53 ±.64	1.81 ±.29
Early Woodland(6)	2.08 ±1.83	2.90 ±.70	1.71 ±.27
Unclassified(6)	1.19 ±1.47*	1.66 ±1.17*	1.63 ±.36
Soil Texture			
Control (18)	161 ±66	172 ±24	169 ±30
Palaeo-Indian (3)	283 ±72**	254 ±90*	244 ±101
Early Archaic (2)	200 ±00*	188 ±26	200 ±16**
Middle Archaic (8)	263 ±86**	241 ±73**	208 ±64*
Late Archaic (4)	166 ±47	196 ±32*	195 ±23**
Early Woodland (6)	194 ±34*	219 ±41**	200 ±32**
Unclassified (6)	171 ±88	166 ±23	168 ±51
Soil Drainage			
Control (18)	51 ±18	51 ±05	52 ±09
Palaeo-Indian (3)	73 ±04**	78 ±20**	77 ±29*
Early Archaic (2)	63 ±00	52 ±04	45 ±01
Middle Archaic (8)	67 ±16**	67 ±23*	61 ±21
Late Archaic (4)	50 ±18	56 ±10	51 ±08
Early Woodland (6)	58 ±08	59 ±12**	57 ±11
Unclassified (6)	48 ±32	50 ±10	52 ±16
Deer Capability			
Control (18)	544 ±51	545 ±51	538 ±57
Palaeo-Indian (3)	467 ±115*	467 ±115*	472 ±111*
Early Archaic (2)	500 ±00	500 ±00*	500 ±00

Middle Archaic (7)	486 ±69**	486 ±69**	488 ±66*
Late Archaic (4)	525 ±50	524 ±48	516 ±47
Early Woodland (6)	550 ±55	544 ±58	540 ±54
Unclassified (6)	600 ±00**	598 ±04**	594 ±14**
Cliff Density			
Control (18)	.12 ±.50	.04 ±.13	.02 ±.04
Palaeo-Indian (3)	.00	.00	.03 ±.05
Early Archaic (2)	.00	.00	.00
Middle Archaic (7)	.00	.00	.00*
Late Archaic (4)	.00	.00	.01 ±.02
Early Woodland (6)	.00	.10 ±.25	.04 ±.03
Unclassified (6)	.00	.00	.00
Nut Capability			
Control (18)	55 ±07	54 ±.07	52 ±14
Palaeo-Indian (3)	45 ±11*	45 ±11*	46 ±11*
Early Archaic (2)	51 ±00*	51 ±00	53 ±00
Middle Archaic (7)	49 ±07**	49 ±07**	49 ±07*
Late Archaic (4)	54 ±04	54 ±04	54 ±02
Early Woodland (6)	55 ±03	54 ±04	53 ±04
Unclassified (6)	58 ±00	58 ±0.4	57 ±02
Marsh Area			
Control (18)	3.90 ±11.82	.59 ±1.14	.20 ±0.30
Palaeo-Indian (3)	.00	.00	.00
Early Archaic (2)	.00	3.70 ±1.13**	3.30 ±2.58**
Middle Archaic (7)	10.60 ±30.32	5.90 ±13.92**	2.30 ±4.29
Late Archaic (4)	.00	1.70 ±1.43**	3.50 ±2.43**
Early Woodland (6)	1.20 ±2.92	1.40 ±1.30**	2.60 ±2.36**
Unclassified (6)	8.80 ±13.50**	15.00 ±18.5**	11.70 ±10.45**
Swamp Area			
Control (18)	1.17 ±1.35	1.11 ±2.10	1.00 ±2.58
Palaeo-Indian (3)	.00	.00	.00
Early Archaic (2)	.00	.60 ±.90	1.40 ±.00**
Middle Archaic (7)	.00	3.50 ±9.40	2.10 ±4.91
Late Archaic (4)	.00	2.30 ±2.98**	1.90 ±2.11**
Early Woodland (6)	.00	1.50 ±2.60**	1.30 ±1.91**
Unclassified (6)	.00	.00	.00

** $p \leq 0.05$
* $p \leq 0.10$

TABLE B-10 Prince Edward Bevelled Till

ZONE	SITE	SETTING	VICINITY
Average Slope			
Control(8)	.025 ±.009	.022 ±.007	.023 ±.007
Late Archaic(6)	.023 ±.011	.022 ±.009	.020 ±.006
Maximum Relief			
Control(8)	16 ±09	51 ±29	81 ±16
Late Archaic(6)	16 ±09	47 ±32	83 ±47
Total Stream Density			
Control(8)	1.14 ±1.64	1.06 ±1.63	.85 ±0.97
Late Archaic(6)	1.76 ±1.60	1.63 ±0.70*	.98 ±0.97
Soil Texture			
Control (8)	247 ±62	276 ±37	283 ±34
Late Archaic (6)	251 ±58	265 ±48	273 ±17*
Soil Drainage			
Control (8)	93 ±10	92 ±10	92 ±06
Late Archaic (6)	97 ±08	95 ±06	94 ±06
Cliff Density			
Control (8)	.00	.00	.00
Late Archaic (5)	.00	.03 ±.08	.01 ±.04
Marsh Area			
Control (8)	4.50 ±11.25	4.60 ±7.09	2.70 ±3.01
Late Archaic (5)	10.00 ±16.36*	12.00 ±10.18*	5.00 ±2.79**
Swamp Area			
Control (8)	.00	.00	.00
Late Archaic (5)	.00	.00	.00

** $p \leq 0.05$
* $p \leq 0.10$

TABLE B-11 Prince Edward Limestone Plain

ZONE	SITE	SETTING	VICINITY
Average Slope			
Control(18)	.030 ±.016	.025 ±.016	.024 ±.013
Middle Archaic(7)	.045 ±.020**	.035 ±.015**	.026 ±.007*
Late Archaic(6)	.035 ±.024	.028 ±.018	.022 ±.012
Unclassified(1)	.026	.025	.013*
Maximum Relief			
Control(18)	22 ±15	83 ±50	119 ±58
Middle Archaic(7)	37 ±10**	66 ±47	90 ±40
Late Archaic(6)	24 ±16	81 ±87	95 ±82
Unclassified(1)	20	50	60
Total Stream density			
Control(18)	1.47 ±1.36	1.27 ±0.41	.83 ±0.18
Middle Archaic(7)	.10 ±0.25**	.97 ±0.37*	.71 ±0.16**
Late Archaic(6)	.96 ±1.04	1.22 ±0.65	.92 ±0.19
Unclassified(1)	2.00	2.16**	1.15**
Soil Texture			
Control (18)	208 ±88	225 ±60	235 ±43
Middle Archaic (7)	249 ±84	242 ±65	247 ±51
Late Archaic (6)	297 ±71**	271 ±54	272 ±45*
Unclassified (1)	300	240	266
Soil Drainage			
Control (18)	82 ±22	84 ±10	85 ±07
Middle Archaic (7)	85 ±20	88 ±13	88 ±10
Late Archaic (6)	93 ±10	87 ±08	87 ±07
Unclassified (1)	100	100*	100**
Cliff Density			
Control (16)	.43 ±.99	.35 ±.44	.18 ±.19
Middle Archaic (7)	.00	.01 ±.02**	.05 ±.06**
Late Archaic (5)	.38 ±.93	.15 ±.35	.10 ±.13*
Unclassified (1)	2.30**	.86*	.34
Marsh Area			
Control (16)	1.70 ±5.54	2.90 ±6.06	2.80 ±5.52
Middle Archaic (7)	3.50 ±5.04**	11.10 ±12.04**	8.80 ±10.72**
Late Archaic (5)	14.80 ±13.68**	5.20 ±6.03**	2.00 ±2.50
Unclassified (1)	10.60**	1.90	.50
Swamp Area			
Control (16)	6.60 ±19.89	3.40 ±6.08	1.90 ±2.58
Middle Archaic (7)	.00	.00**	.00**
Late Archaic (5)	.00	.00*	.00*
Unclassified (1)	10.60**	23.60**	6.70**

** $p \leq 0.05$
* $p \leq 0.10$

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