III. ENVIRONMENTAL SETTING

A. PHYSIOGRAPHY AND GEOLOGY

The Whitby Branch Site (7NC-G-151) is located in the High Coastal Plain physiographic province, an area of rolling topography combining deeply incised stream valleys with intrusive tidal salt marshes (Kraft 1977:44). The High Coastal Plain is underlain by the unconsolidated sands and gravels of the Columbia Formation, water-borne sediments of the Pleistocene epoch dating from approximately 1.6 million years to 10,000 years BP. The depth of these deposits ranges from 10 feet to 80 feet in the site vicinity, and the deposits have been extensively reworked by water and wind erosion during the Holocene, the most recent 10,000-year period of geologic time (Pickett and Spoljaric 1971).

The coastal plain in Delaware can be further divided into a series of environmental zones, basically paralleling the Delaware River and Delaware Bay (Custer 1984:26-28). These zones comprise areas sharing a number of environmental features, such as elevation, direction of drainage flow, vegetation, and degree of saltwater intrusion. Whitby Branch is situated in the Mid-Drainage Zone, an area centered on the inland limits of the modern tides and containing both brackish and freshwater environments, creating a particularly productive ecosystem.

The region is drained by the Appoquinimink River, which discharges into the Delaware River 7 kilometers (4.5 miles) east of the project area. Second-order drainages feeding the Appoquinimink River include Deep Creek to the west, Drawyer Creek to the north, and Hangmans Run to the east, of which the last two are tidally influenced. The Whitby Branch Site is located adjacent to an extensive tidal wetland area along a low-order tributary of the Appoquinimink River. The site occupies the summit and toeslope of a Coastal Plain Upland area, immediately west of U.S. Route 13. The Appoquinimink River tidal wetlands delimit the southern and western margins of the site, with the southern wetland further fed by a first-order drainage. A shallow swale marks the northern boundary of the site locale. Site elevations range from approximately 5 meters (16.5 feet) above mean sea level (amsl) in the eastern part of the site to 1.5 meters (5 feet) amsl along the western and southern shoreline.

At the time of the fieldwork the Whitby Branch Site was wooded, supporting widely spaced mixed stands of tulip poplar, oak, yellow pine, and laurel. Oak and pine, along with hickory, are thought to have figured prominently in the forest composition during Woodland I and Woodland II prehistoric occupations (Kellogg and Custer 1994:24). Understory growth within the site boundaries is minimal, although dense patches of poison ivy, wild rose, and other weedy species are found in moist areas to the north of the site.

B. SOILS

The soils of the Whitby Branch Site are variable. The soil at higher elevations of the site (to the east) is classified as a Rumford series, gravelly phase soil (Wagner 1996a). The soil on the toeslope of the site landform (to the west) is classified as a Sassafras sandy loam. The eastern portion of the site shows evidence of having been plowed to a limited extent. The shallow depth of the plowzone in this area probably reflects non-mechanized plowing undertaken during the nineteenth and early twentieth centuries. The toeslope, or western portion of the site, has never been plowed, and the natural profile is entirely intact. Only minimal slopewash buildup can be detected in the stratigraphic profile of the toeslope. This absence of slopewash adds additional support to the impression that the higher elevation to the east has been subject to only very limited plowing. Profiles from both portions of the site indicate that the site surface has been intact for 15,000 to 20,000 years (Wagner 1996a:5).

A 1-meter-high scarp once existed between the western edge of the site and the wetland/river area below. The existence of that scarp or bank is probably masked by the sedimentation associated with Late Holocene sea rise. Expanses of gravels and cobbles may have been once exposed on the beach below this bank. Sedimentation, induced by historical cultivation in areas upstream from the site, has contributed to the burial of these proposed lithic sources, and has reduced the total landform height in relation to the adjacent drainage floor (Wagner 1996a:5).

C. PALEOENVIRONMENT

As there is evidence of continuous human occupation of the Middle Atlantic Coastal Plain from the Late Pleistocene onward, a reconstruction of the regional environmental history should consider at least the last 11,000 years. For the Whitby Branch Site, the primary factors to be considered in a local paleoenvironmental reconstruction are changing climatic conditions and sea levels which, in turn, influenced the local distribution of floral and faunal resources. Analysis of fossil pollen provides the most direct method for reconstructing past environmental conditions, as pollen assemblages reflect vegetational communities. Paleoclimatic conditions can be inferred from fossil pollen because of the ecological relationship that exists between biotic communities and their environment. Using known relationships between temperature and moisture for certain plant species, past climatic conditions may be inferred. The concept of plant succession is the principal technique for determining past changes in vegetation and, by inference, climate (Ogden 1965).

During the Pleistocene epoch, a series of massive continental glaciers advanced and retreated over much of North America. Because vast amounts of water were incorporated into these ice sheets, the sea levels were 300 to 500 feet lower than at present. The late Pleistocene was not only slightly cooler than the present, but was also characterized by higher levels of precipitation (Carbone 1976). The generally accepted marker for the end of the Pleistocene is the beginning of the glacial retreat immediately following the Valders substage maximum, which has been dated to about 10,500 years BP (radiocarbon ages are expressed in years before the present, which by convention is the year AD 1950).

The clustering of a large, world-wide sample of radiocarbon dates indicated that an abrupt climatic shift occurred over a period of a few decades, marking the beginning of the present Holocene epoch (Bryson et al. 1970). As the sea levels rose with the release of the glacial meltwater, the ancestral

Susquehanna River Valley and the Delaware River Valley were drowned, and the rising water eventually formed the estuarine environments of the Chesapeake Bay and the Lower Delaware River Valley.

While data indicate that the sea level has been rising continuously during the past 12,000 to 14,000 years, the rate of marine transgression over the Coastal Plain has varied considerably. In the first few thousand years after the close of the Pleistocene, sea levels rose relatively rapidly, but more recently, sea levels have been rising at a rate of less than 1 foot per century (Edwards and Merrill 1977).

Abatement of the glacial climatic conditions at the end of the Pleistocene allowed modern environmental conditions to become established. The first pollen studies in North America defined a sequence of five climatic episodes, based on temperature and moisture. The climatic sequence from postglacial to modern times includes five relatively distinct periods: (1) a moist, cool postglacial period represented by a maximum of spruce and fir pollen; (2) a dry, warmer period represented by a maximum of pine; (3) a more humid and warm period represented by beech and deciduous trees such as oak and hemlock; (4) a warm, dry period represented by a maximum of oak and hickory; and (5) the modern period, moister and cooler than the preceding period, represented by a mixed deciduous forest dominated by oak and chestnut (Deevey 1943; Sears 1942).

The environments of the Middle Atlantic Coastal Plain for the late Pleistocene have not yet been definitively reconstructed, and each new pollen core seems to add more complexity to an already complex picture. Detailed paleoenvironmental studies have been completed for the Shenandoah Valley (Carbone 1976) and the Upper Delaware River Valley (Dent 1979). These studies are useful for understanding regional paleoenvironmental conditions; however, a reconstruction of local conditions should also consider applicable pollen cores. For Delaware, Custer (1984, 1986) relies heavily on Carbone's (1976) work, and discusses paleoclimatic history in terms of an episodic model wherein abrupt, rather than gradual, changes in climate influenced the regional biogeography.

There are no available pollen profiles that would be wholly suitable in reconstructing the environmental history of the Whitby Branch Site area. The environmental character of the site area must be inferred from a consideration of regional conditions such as overall trends in climate, together with the local variations in altitude, soils, exposure, and drainage. Dent and Kauffman (1985) have demonstrated that many distinct plant communities may exist within a small area, depending on variations in altitude, exposure to sunlight, and availability of water.

Although the marsh area adjacent to the Whitby Branch Site initially appeared to offer the right conditions for pollen preservation, samples taken from this area contained relatively modern material, not suitable for use in interpreting the conditions that existed when the site was occupied by Native American groups. Paleoenvironmental data for the SR 1 corridor have been synthesized in a recent study prepared for DelDOT by the University of Delaware Center for Archaeological Research (Kellogg and Custer 1994). Along with a summary of regional information, this study involved geological and pollen studies of four localities in New Castle and Kent counties, and provided local data regarding paleoenvironmental conditions in the area. In general these studies showed a long dry period in the early Holocene, followed by more moist conditions.

The SR 1 study locality nearest to the Whitby Branch Site is a bay/basin feature named Walter's Puddle, near Townsend. The Walter's Puddle study provides only general information about Holocene climate and vegetation. Conditions were so dry in the 12,000-6,000 BP interval that the bay/basin feature dried up completely, leaving no sedimentary record. After 6,000 BP, local conditions were wetter, and a mixed forest of oak, pine, and hickory grew in the region, with buttonbush, alder, sedges, and other wetland plants around the margin of the bay/basin feature. Only six pollen samples were taken for this period, so that it was not possible to discern climatic changes within the past 6,000 years (Kellogg and Custer 1984; Newby et al. 1994; Webb et al. 1989).

Custer's (1984, 1986) discussion of the Lower Coastal Plain paleoenvironmental sequence would be generally applicable to the Mid-Drainage Zone and the Whitby Branch Site. Two pollen samples were taken from the Dill Farm Site, located in southern Kent County and within the interior Drainage Divide Zone. These would also generally apply to the Whitby Branch Site. One of the samples dated to the Late Glacial/Pre-Boreal transition and the other to the Sub-Atlantic episode. The Late Glacial/Preboreal sample was dominated by pine, with associated hemlock, birch, and oak. The more recent Dill Farm Site sample reflected an oak-dominated forest, with beech, maple, alder, aspen, and aquatic species (Custer 1984, 1986).

A pollen core from an abandoned stream channel near the Indian Creek Site (18PR94) in Prince Georges County, Maryland, has also provided important new information for reconstruction of regional prehistoric environments in the Middle Atlantic Coastal Plain (LeeDecker et al. 1991). The DB-6 pollen core from Indian Creek contains a virtually complete record of the local vegetational succession from the Late Glacial to the historic period. Seven pollen zones were defined in the DB-6 core, and the chronology of the pollen zones was accomplished by a series of radiocarbon dates and the calculation of sedimentation rates between dated horizons (Brush 1990).

A summary of the regional paleoenvironmental history is presented in Table 1. During the Late Glacial period, the regional climate was controlled to a large extent by the presence of the Laurentide ice sheet. The ice sheet would have prevented northern Arctic air from reaching the lower continental region, thereby allowing somewhat warmer winter temperatures in that area. Strong westerly winds would have prevailed. There was a zone of intense frontal activity in the northern unglaciated areas of the Middle Atlantic region.

Pollen evidence from the Late Glacial episode indicates that the dominant forest elements were spruce and pine and that non-arboreal flora, such as grasses, shrubs, and herbs, were also present. This suggests a mosaic of vegetational habitats, including open grasslands, coniferous forests, and deciduous floodplain forests. At the Indian Creek Site, the Late Glacial forest was dominated by pine and spruce, with alder becoming more abundant toward the end of the episode. Madder, milkwort, and composites were the dominant non-arboreal plants. The Full Glacial and Late Glacial fauna would have included a variety of extinct and currently existing animals. Some of the larger

Table 1. Paleoenvironmental Episodes, Delaware Lower Coastal Plain

EPISODE	DATES	GENERAL CHARACTERISTICS
Late Glacial	10,000-8000 BC	Mosaic of different vegetational communities; open grasslands within coniferous forests dominated by spruce and fir; deciduous elements present in wetland areas, etc.; bay/basin features open and active; animals include cold-adapted megafauna (musk ox, mammoth, mastodon), peccaries, white-tailed deer, caribou, elk, beaver, etc.
Pre-Boreal/Boreal	8000-6500 BC	Reduction of open grasslands and spread of forests dominated by pine and northern hardwoods; extinction of Pleistocene megafauna and reduction of habitat for grazing and browsing species
Atlantic	6500-3100 BC	Full appearance of modern environment with warm, moist conditions; continental climate with marked seasonal differences; widespread dominance of mesic oak-hemlock forests; modern faunal communities
Sub-Boreal	3100-800 BC	Warm, dry climate (mid-postglacial xerothermic) at the beginning of the episode, followed by gradually increasing moisture and cooling temperatures; spread of grasslands and reduction of oak-dominated forests
Sub-Atlantic	800 BC-recent	Cooling reduced the moisture stress of the Sub-Boreal, leading to essentially modern conditions; upland forests include a mix of coniferous and deciduous species; reduction of sea level rise permits florescence of estuarine environments in coastal areas

Sources: Custer (1984, 1986); Kellogg and Custer (1994).

animals included browsing mastodon, mammoth, horse, camel, caribou, and white-tailed deer, while the smaller animals included wolf, skunk, otter, weasel, fox, moles, shrews, squirrels, lemmings, and mice (Carbone 1976; Custer 1984, 1986).

The rapid climatic shift that occurred circa 10,500 BP marked the onset of the Preboreal/Boreal episodes. This was a period of warming, but by 8000 years BP, the continental ice sheet was still large enough to influence air circulation patterns, and strong westerly winds still prevailed. In the region as a whole, there was a reduction and eventual closure of open grassy habitats and a replacement of spruce by pine or deciduous species. Northern hardwood forests became established in the Coastal Plain during the Preboreal episode. At the Indian Creek Site, this was seen by a replacement of pine and spruce by birch and, to a lesser extent, oak. The reduction of grassland had a corresponding effect on the populations of animals adapted to grassland and forest-edge habitats, and there was a generally reduced biological carrying capacity during the Preboreal/Boreal episode. After the disappearance of the Late Glacial vegetational mosaic, remaining wetland areas may have become increasingly important to animals such as deer, elk, and moose (Carbone 1976; Custer 1984, 1986).

The Atlantic episode was marked by an even further reduction in the influence of Arctic air masses, allowing a warming trend that was accompanied by an increase in precipitation. Regional vegetation patterns were characterized by an initial expansion of hemlock and later of oak. At the Indian Creek Site, the onset of the Atlantic episode was marked by the expansion of a forest dominated by oak, hazelnut, and alder, together with maple, black gum, beech, ash, and walnut; there was also a reduction in pine that occurred at this time and a disappearance of spruce and fir. At the regional level, the warm, wet conditions of this episode may have fostered the expansion of wetland areas. Modern fauna were established during this episode, and the principal animals of importance to human populations were turkey and deer (Carbone 1976; Custer 1984, 1986).

The postglacial warming trend climaxed during the Sub-Boreal episode. Regionally, the xerothermic (warm and dry) conditions led to an expansion of grasslands and the dominance of an oak-hickory forest type. Squirrel and turkey populations would have benefited from the dominance of nut-bearing trees (oak and hickory), while species intolerant of dry habitats would have declined. Essentially modern conditions became established at the close of the xerothermic interval. Sea levels began to rise more slowly during the Sub-Boreal, which allowed stable estuarine environments to form in the tidal areas of the Coastal Plain. With the formation of tidal wetland marshes adjacent to the Chesapeake Bay and the Delaware Bay, the Delmarva peninsula reached its peak carrying capacity, replete with waterfowl, shellfish, and marine fish (Carbone 1976; Custer 1984, 1986; Wesler 1985).

Essentially modern environmental conditions continued through the Sub-Atlantic episode, with minor climatic fluctuations. At the time of initial European contact, the vegetative cover in the Middle Atlantic Coastal Plain was primarily a deciduous forest. Sub-Atlantic conditions in the Dill Farm Site pollen sequence are represented by a hardwood forest dominated by oak, with beech, maple, alder, and aspen (Custer 1984, 1986). This hardwood forest and its associated vegetation would have provided a fairly abundant supply of nuts, fruits, bulbs, and leaves. The terrestrial animals that inhabited the region included white-tailed deer, black bear, porcupine, squirrel, chipmunk, woodchuck, turtle, weasel, skunk, fox, wolf, cougar, raccoon, opossum, muskrat, otter, mink, beaver, turkey, shrew, rabbit, and bobcat (Turner 1976, 1978).

At the time of initial European settlement, New Castle County as a whole was dominated by deciduous forests with oak as the primary species, supplemented by tulip poplar, gum, and yellow pine. Poorly drained wetland areas would have included pin oak, willow oak, red maple, sweetgum, blackgum, holly, sweetbay, dogwood, beech, birch, red cedar, and cypress (Custer 1984, 1986; Matthews and Lavoie 1970).