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REVIEW ARTICLE

Early Human Settlement of Northeastern North America

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This paper summarizes current evidence for earliest human occupation of northeastern North America during the late Pleistocene and early Holocene. We review evolution of the region's landscapes and evidence of archaeological chronologies as context for understanding human settlement of the region. Current data support limited evidence for pre-Clovis occupation south of the Laurentide glacial margin, followed by a significant temporal gap prior to early Paleoindian settlement of the region. Despite differences in sub-regional data sets, mapping of site distributions and assemblage data do support the notion of variation in lifeways between Paleoindian populations occupying formerly glaciated parts of the Northeast in the late Pleistocene, versus contemporary groups in lands south of the Laurentide glacial margin. Through time, the greatest differences in Paleoindian land use and technology occur between the Younger Dryas and early Holocene.

Keywords northeastern North America, colonization, pre-Clovis, Clovis, Paleoindian, Younger Dryas, early Holocene

1. Introduction and background

This paper examines archaeological evidence for the human colonization and settlement of northeastern North America, from the late Pleistocene into the early Holocene. Our goal is to build on earlier synthetic studies (e.g., Anderson 1990, 1996; Carr and Adovasio 2002, 2012; Ellis and Deller 1997; Ellis and Lothrop 1989; Ellis et al. 2011; Lepper 2005; Lothrop et al. 2011; Meltzer 1988; Newby et al. 2005; Spiess et al. 1998; Tankersley and Isaac 1990), incorporating recent data and findings to provide an updated archaeological synthesis of the earliest human occupations in the Northeast.

As defined for this paper, the Northeast extends from the Potomac and Ohio valleys north into the provinces of Ontario, Québec, New Brunswick and Nova Scotia, and from the Atlantic coast west to Lake Michigan and mid-reach of the Ohio Valley (Figure 1). As defined, these boundaries encompass diverse physiographic regions, from coastal plains and lowlands to highlands. Formerly glaciated terrain occupies the northern two-thirds of this study area (Figure 2).

We distinguish four sub-regions in this Northeast study area, each the focus of ongoing archaeological research into early peopling and settlement, and which may comprise culture regions for early through late Paleoindian peoples (see Figure 2). Formerly glaciated sections of this Northeast study area include the eastern Great Lakes (EGL), including southern Ontario, Michigan, northern Indiana and Ohio, northwestern Pennsylvania and central

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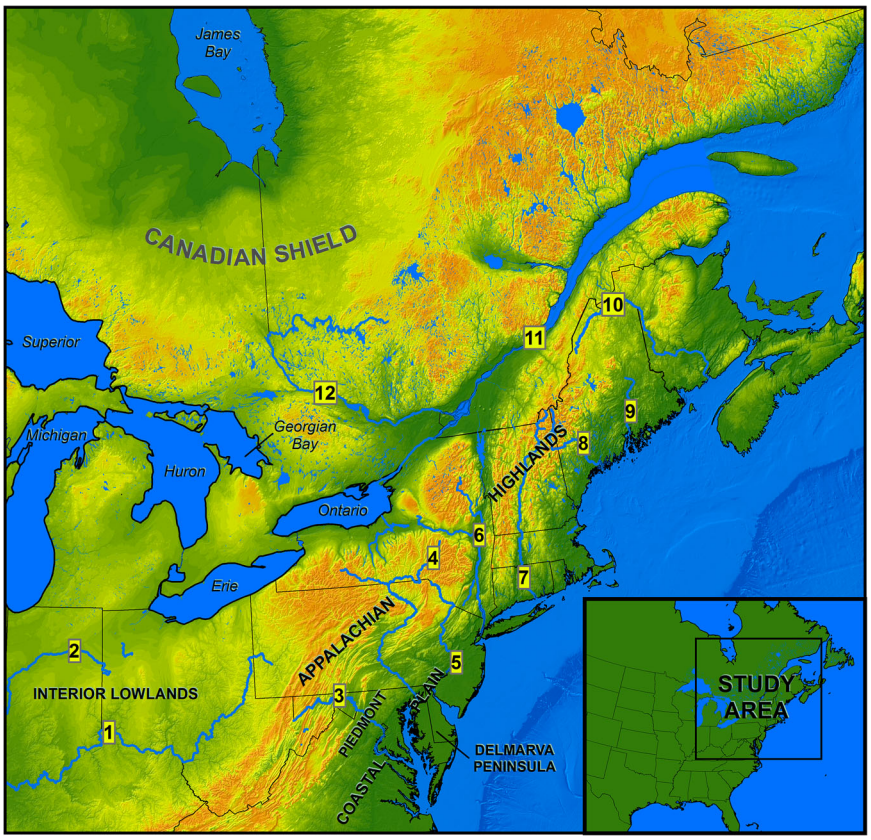

Figure 1 Map of the Northeast study area, showing physiographic regions, Great Lakes basins, and numbered river drainages: 1 = Ohio; 2 = Wabash; 3 = Potomac; 4 = Susquehanna; 5 = Delaware; 6 = Hudson; 7 = Connecticut; 8 = Androscoggin; 9 = Penobscot; 10 = St. John; 11 = St. Lawrence; 12 = Ottawa.

New York (Ellis et al. 2011). Also glaciated, the New England-Maritimes (NEM) region includes eastern New York, the New England states, and Québec, New Brunswick and Nova Scotia (Bradley et al. 2008; Spiess et al. 1998). The mid-Atlantic sub-region encompasses central and eastern Pennsylvania, Delaware, Maryland, Virginia, and eastern West Virginia. Finally, for this study, the middle-upper Ohio Valley includes southwestern Pennsylvania, western West Virginia, eastern Kentucky, and southern portions of Ohio and Indiana. As shown in Figure 2, these mid-Atlantic and Ohio Valley sub-regions lie largely south of the Laurentide ice sheet's southern limit at the Last Glacial Maximum (LGM), and archaeological data sets in these areas suggest closer connections to the Southeast (Anderson et al. 2015).

To organize data and interpretive models for this review, we employ the following chronological subdivisions: pre-Clovis (>13,400 cal yr BP), early Paleoindian (13,000–12,200 cal yr BP), middle Paleoindian (12,200–11,600 cal yr BP), and late Paleoindian (11,600–10,000 cal yr BP). In the chronological scheme used here, early and middle Paleoindian occupations are represented by fluted biface technology. Early Paleoindian subsumes Clovis biface forms recognized in southern portions of the study area, as well as "Clovis-like," parallel-sided biface forms in the EGL and NEM that may date to as late as circe 12,200 cal yr BP. Middle Paleoindian occupations are represented by biface types with expanding lateral margins and variable fluting. Late Paleoindian bifaces encompass stylistic and technological diversity across the Northeast, and include basally thinned Dalton points in the middle Ohio Valley, Hi-Lo points in the Great Lakes, and a northern focus for unfluted, parallel flaked ("Plano") forms (Bradley et al. 2008; Carr and Adovasio 2002; Deller and Ellis 1992a; Ellis et al. 2011). During the early Holocene, late Paleoindian occupations in the Northeast appear to overlap chronologically with early Archaic components further south represented by notched weapons tips (e.g., Ellis and Deller 1990; Petersen et al. 2000).

We emphasize two key points that underlie this chronological scheme. First, fluted point-affiliated occupations in the Northeast appear to roughly span the Younger Dryas (YD), while late Paleoindian sites, with unfluted point forms, mainly postdate that climatic event. Consequently, in contrast to some other regions (e.g., Anderson et al. 2015), Paleoindian occupation of the Northeast (particularly

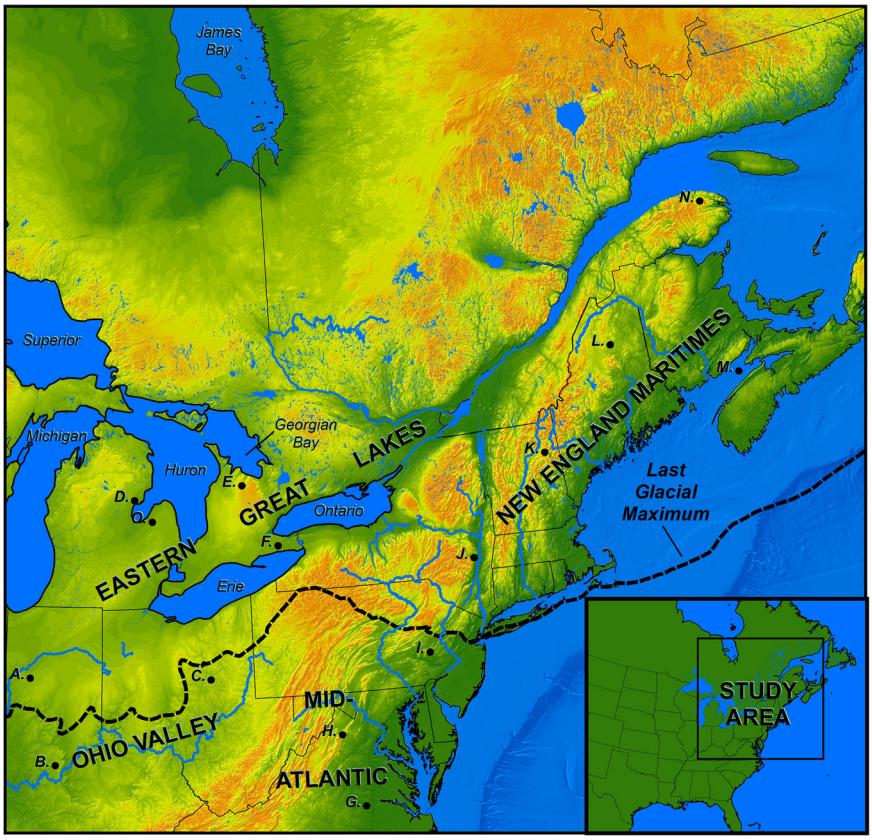

Figure 2 Map of the Northeast study area, illustrating designated sub-regions, Laurentide ice margin at LGM and major bedrock sources of chert and other toolstone for Paleoindian populations: A = Attica; B = Wyandotte; C = Vanport and Upper Mercer; D = Bayport; E = Fossil Hill; F = Onondaga and Haldimand; G = Williamson chalcedony; H = Flint Run jasper; I = Hardyston ("Pennsylvania.") jasper; J = Normanskill; K = northern New Hampshire rhyolites; L = Munsungun Lake; M = Minas Basin; N = Gaspé (not depicted: major secondary lithic sources located on the Mid-Atlantic Coastal Plain & Delmarva Peninsula).

in its northern glaciated sections) displays greater time depth and extends into the early Holocene (see Section 3). Second, a handful of archaeological sites in the Northeast provide tentative evidence for early occupations that precede Clovis, apparently with significant time gaps in between (see Section 4). Our "pre-Clovis" designation for these early occupations highlights these temporal differences, and at present, discourages notions of cultural or genetic linkages between pre-Clovis and Clovis as well as later occupations in the Northeast.

Several factors distinguish the Northeast as a unique physical stage in the peopling of North America. From the late Pleistocene into the early Holocene, this study area was accompanied by dramatic changes in geomorphic landscapes and water bodies as a result of final deglaciation, isostatic rebound, and eustatic sea level fluctuation. The Northeast is also notable because of significant latitudinal differences in late Pleistocene and early Holocene paleoenvironments, as well as sub-regional variation in expressions of rapid climate change events such as the onset and terminus of the YD, and potential effects on plant, animal, and human populations (Ellis et al. 2011; Meltzer and Holliday 2010; Newby et al. 2005).

Natural and modern cultural factors pose distinct challenges to researching early human settlement in the Northeast. Perhaps most notably, archaeological visibility and preservation of early Native American sites in the Northeast is subject to a wide range of factors. For example, across the Delmarva Peninsula, pre-Clovis and early Paleoindian sites are differentially subject to burial by late Pleistocene loess deposits (Lowery 2002; Lowery et al. 2010). Along the Atlantic coast, rising sea levels have submerged both late Pleistocene and Holocene archaeological sites in former coastal settings (Lowery and Martin 2009), while fluctuating water levels in the Great Lakes basins have both submerged (Sonnenburg et al. 2015), and in some cases drowned and then re-exposed terminal Pleistocene and early Holocene sites (e.g., Ellis and Deller 1986). More rarely, post-glacial isostatic rebound and shoreline regression, such as along the former Champlain Sea, have effectively preserved sites associated with formerly high levels of this inland marine water body (e.g., F. Robinson 2012).

How archaeological research has been conducted in these different parts of the Northeast has led to undeniable biases in site discovery. In some areas, such as portions of southern Ontario, decades of grant-supported systematic survey have identified large and small Paleoindian sites in a variety of physical settings (Ellis and Deller 1997). In some New England states, recognition of locational trends and low archaeological visibility for Paleoindian sites has led historic preservation offices and archaeological practitioners to develop field methodologies better tailored to identify these early sites during mandated cultural resource management (CRM) and grant-supported surveys (e.g., Boisvert 2012; Crock and Robinson 2012; Singer and Jones in press; Spiess et al. 2012). Nevertheless, many late Pleistocene and early Holocene sites in the Northeast represent fortuitous discoveries, not found through targeted research.

Other sources of bias in the archaeological record of early sites in the Northeast likely include over-representation of more easily detected near-surface sites in agricultural settings and under-representation of sites in forested (often upland) landscapes and buried geomorphic settings. These same modern agricultural practices that led to discovery of many near-surface sites have likely also damaged or destroyed ephemeral cultural features that may have been associated with these sites. Across the Northeast, acidic soils ensure that preservation of faunal remains on Paleoindian sites is unlikely and typically restricted to calcined bone.

In remaining portions of this paper, Section 2 summarizes the evolution of late Pleistocene and early Holocene landscapes for early human occupation of the Northeast, including deglacial sequences and proglacial lakes, sea level rise, and paleoenvironments. In Section 3, we discuss relative chronologies based on biface sequences, followed by a new look at absolute chronologies, based on a review and calibration of the region's small corpus of radiocarbon dates. Section 4 summarizes currently available evidence for pre-Clovis occupations in the Northeast, and includes a brief overview of the recently discovered Parson's Island site. Sections 5, 6, and 7 present information on early, middle, and late Paleoindian occupations in the region, and focus on archaeological evidence for settlement, technology, and subsistence. In Section 8, we conclude with brief comments on key issues for future research.

2. Landscapes of the late Pleistocene and early Holocene Northeast

The landscapes for human colonization of northeastern North America were diverse across space and through time. The study area today encompasses a range of physiographic regions. Beginning at the Atlantic coast, these include Coastal Plain, Piedmont, Appalachian Highlands (Ridge-and-Valley, Appalachian plateaus), Interior Lowlands, and Canadian Shield provinces (Thornbury 1965). The Michigan, Huron, Erie, and Ontario basins of the Great Lakes are dominant features of the interior Northeast (Larson and Schaetzl 2001).

Physical features of these Northeast landscapes that may have influenced exploratory movements of colonizing populations include mountain ranges in the Appalachian Highlands and Canadian Shield, fluctuations in the Atlantic coastline and proglacial and post-glacial lake footprints, and axes of major river valleys. Post-colonization, seasonal movements of early human groups would have also been governed by distributions of toolstone sources and mobile and fixed subsistence resources. Below we summarize the late Pleistocene to early Holocene evolution of these landscapes and paleoenvironments, which set the stage for human colonization of the Northeast.

2.1 *Deglacial sequences and proglacial lakes*

Retreat of the Laurentide ice sheet from its LGM position was underway across the Northeast by circa 18,300 cal yr BP (Dyke 2004; Ridge 2003) (see Figure 2). In the Great Lakes, proglacial lakes first appeared in the southern basins, circa 18,800 cal yr BP, formed by melt waters impounded along the retreating ice front (Kincare and Larson 2009; Lewis et al. 2008). The complex deglacial lake histories that followed in these lakes were driven by progressive retreat and intermittent readvance of the Laurentide ice sheet. During this process, proglacial lake footprints were dictated by shifting ice margins, differential isostatic rebound and changing elevations of proglacial lake outlets, and topography south of ice sheet margins (Teller 2004).

Most of the early proglacial lakes were centered in the Erie basin, constrained to the north by the ice front and draining southwesterly to the Ohio and Mississippi valleys. At about 13,000 ^{14}C yr BP (15,340 cal yr BP), with the Port Huron ice advance, while the Huron and Ontario basins were still largely ice covered, Lake Glenwood occupied the southern portion of the Michigan basin and Lake Whittlesey encompassed most of the Erie basin (Figure 3). Subsequent ice retreat exposed the Huron basin, forming early Lake Algonquin, with drainage southeasterly through the Kirkfield outlet to the Ontario basin. After isostatic uplift closed the Kirkfield outlet, Lake Algonquin expanded to its Main stage (11,300–10,500 ^{14}C yr BP [13,100–12,500 cal yr BP]), exceeding the footprint of modern Lake Huron and stretching westward from Georgian Bay into the Michigan basin (Lewis et al. 2008, 129) (Figures 4 and 5).

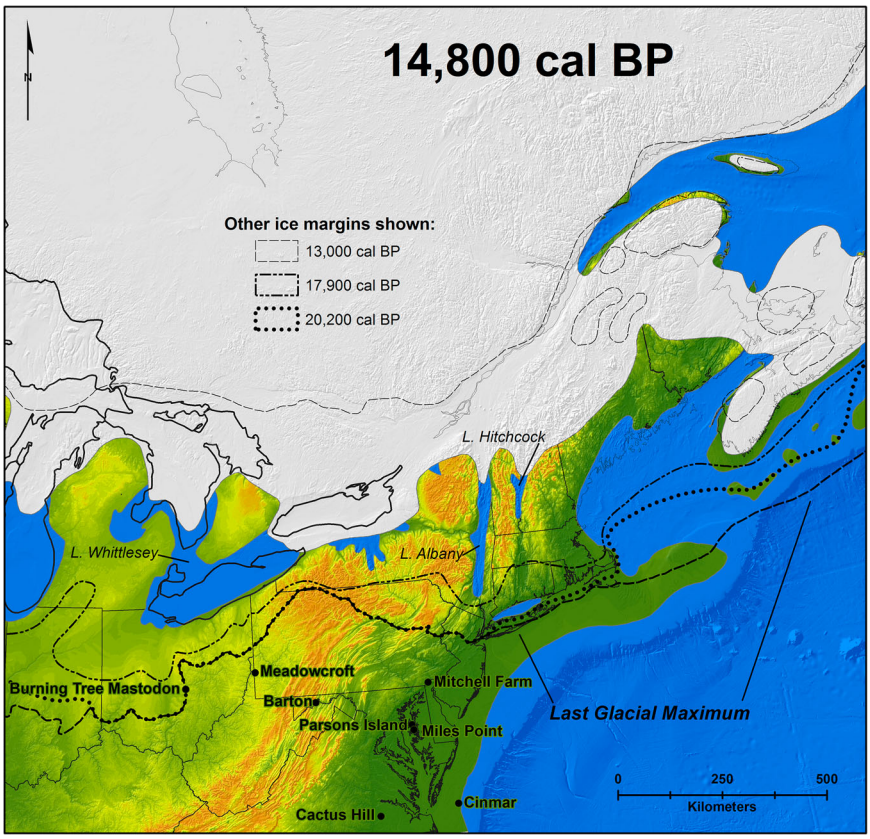

Figure 3 Map showing (1) Laurentide ice sheet margin, proglacial lakes, and Atlantic coast at circa 14,800 cal yr BP, (2) outlines of earlier and later ice margins, and (3) possible pre-Clovis sites in the Northeast.

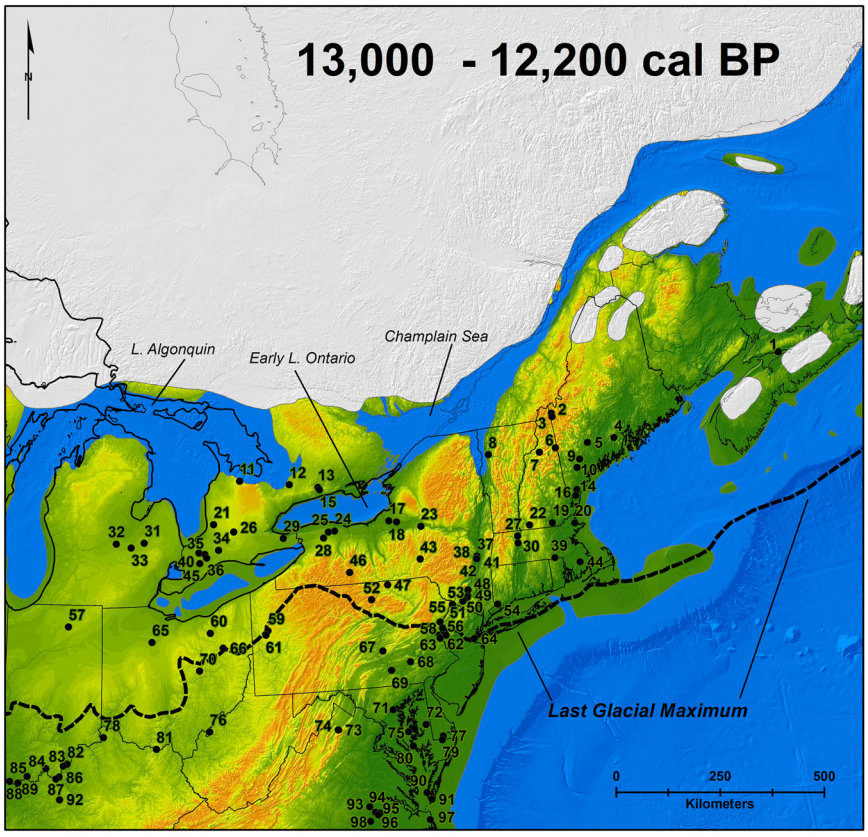

Figure 4 Late Pleistocene landscapes and early Paleoindian site locations in the Northeast, circa 13,000–12,200 cal yr BP (see Table 5 for site names corresponding to numbers).

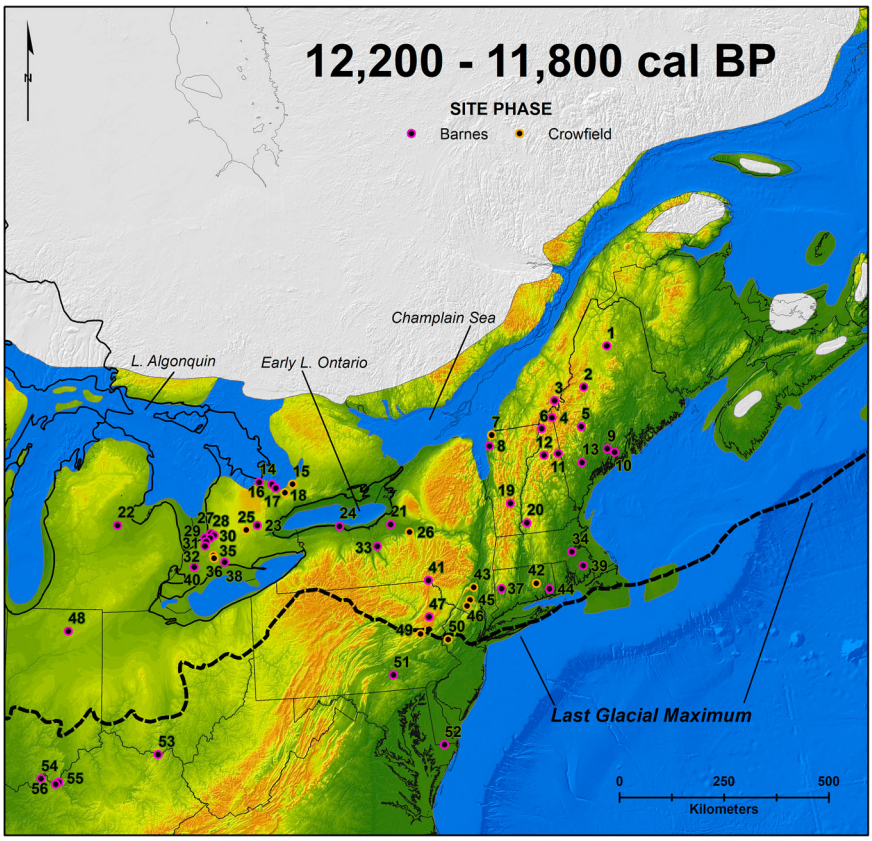

Figure 5 Late Pleistocene landscapes and middle Paleoindian site locations in the Northeast, restricted to Barnes/Cumberland/Michaud–Neponset point sites and Crowfield point sites, circa 12,200–11,800 cal yr BP (see Table 8 for site names corresponding to numbers).

Sometime after 10,400/10,300 ^{14}C yr BP, ice retreat opened the lower North Bay outlet, via the Ottawa River to the St. Lawrence drainage, causing levels in the Huron basin to drop. The resulting low-stand Lakes Stanley and Hough in the Huron and Georgian Bay basins persisted from about between circa 9900 and 7500 ^{14}C yr BP (circa 11,300–8400 cal yr BP) (Figure 6), followed by rising water levels during the Nipissing transgression (Jackson et al. 2000; Lewis et al. 2008, 130–131). During this early Holocene low stand, the now-drowned Alpena-Amberley Ridge stood as an isthmus, separating Lake Stanley and a smaller water body to the southwest within the Huron basin. Ongoing underwater research on the Alpena-Amberley Ridge documents boulder-constructed drive lanes and hunting blinds, likely for intercept hunting of caribou herds, sometime during its low-stand exposure, 11,500–8200 cal yr BP (O'Shea et al. 2013; Sonnenburg et al. 2015).

In the Erie basin, between 17,500 and 14,600 cal yr BP, a succession of early proglacial lakes formed along ice front with footprints extending southwest of modern Lake Erie. With final ice retreat from the basin 12,500 ^{14}C yr BP (14,600 cal yr BP), three small lakes comprising early Lake Erie formed circa 30–45 m below the level of modern Lake Erie (see Figure 3) (Herdendorf 2013; Kincare and Larson 2009; Lewis et al. 2012). Circa 10,400 ^{14}C yr BP (12,270 cal yr BP), water supply from the Huron basin ceased, and for nearly 6000 cal yr thereafter, the Erie basin remained at a low-stand stage, dependent on local precipitation and runoff (see Figures 5 and 6) (Lewis et al. 2012, 505–506). This low-water stage, collectively referred to as early Lake Erie, meant that perhaps as much as one-third to one-half of the modern footprint of Lake Erie was available for human occupation during Paleoindian times (Jackson et al. 2000, 429).

In the Ontario basin, as summarized by Anderson and Lewis (2012), after ice retreat from the Mapleton Moraine (Port Huron readvance), proglacial Lake Iroquois began forming circa 14,500 cal yr BP. By 13,500 cal yr BP, Lake Iroquois reached its maximum footprint, exceeding the limits of modern Lake Ontario (Kozlowski and Graham 2014). After 13,400 cal yr BP, northward retreat of the Laurentide ice sheet along the Adirondacks in northern New York rerouted Lake Iroquois drainage from the Mohawk Valley around the Adirondacks. With outflow via a series of lower outlets, water levels in the Ontario basin dropped 110 m in stepwise fashion. Rayburn et al. (2005) propose that opening of these new outlets resulted in catastrophic flood pulses down the Hudson Valley. Occupying a smaller

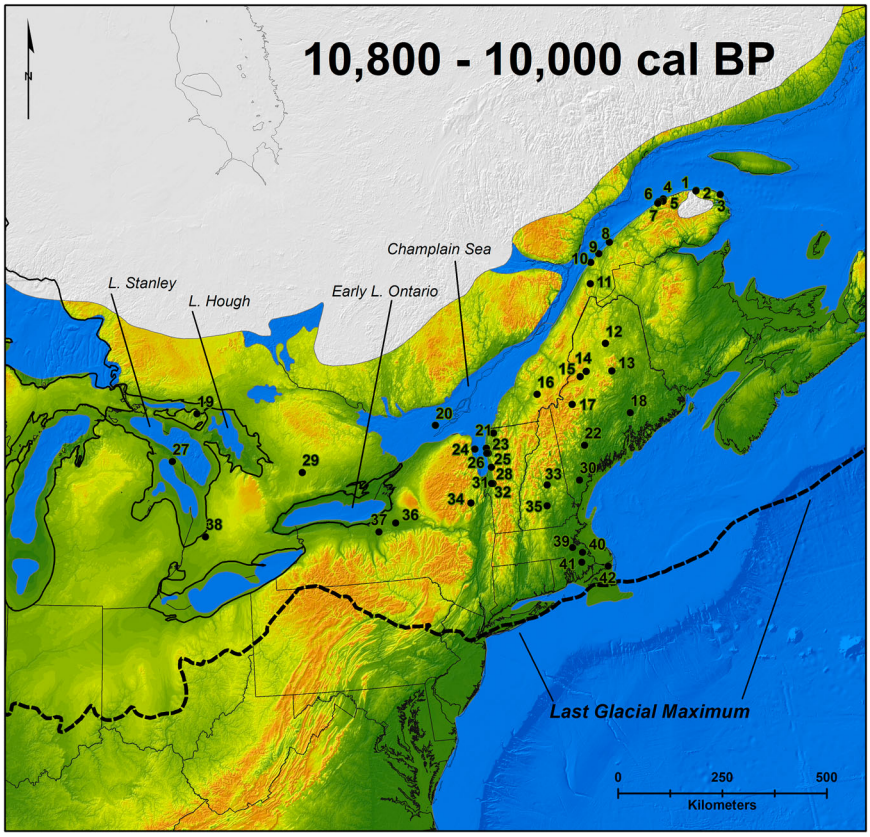

Figure 6 Early Holocene landscapes and late Paleoindian site locations in the Northeast, restricted to Eden/Ste. Anne–Varney point sites, circa 10,800–10,000 cal yr BP (see Table 9 for site names corresponding to numbers).

footprint than modern Lake Ontario, Early Lake Ontario persisted from 12,900 to 12,300 cal yr BP, and was confluent with the Champlain Sea to the east (see Figure 4). Thereafter, isostatic rebound of St. Lawrence Valley outlet sills, and later, reduced precipitation from warmer, drier early Holocene climates, resulted in a closed-basin low-stand in the Ontario basin between 12,300 and 8300 cal yr BP (see Figures 5 and 6) (Anderson and Lewis 2012). Thus, in both the Erie and Ontario basins, former landscapes open to Paleoindian populations are now submerged by the higher water levels of modern Lakes Erie and Ontario (Jackson et al. 2000; Lothrop et al. 2014, 2016).

In interior New England and New York, glacial melt waters pooled in valleys south of the retreating ice front, forming Lake Albany in the lower Hudson Valley at circa 22,500 cal yr BP, and Lake Hitchcock in the Connecticut Valley at circa 18,000 cal yr BP (see Figure 3) (Ridge et al. 2012; Stanford 2009). Over their life spans, the footprints of these narrow New England proglacial lakes shifted northward, responding to the variable effects of ice retreat, meltwater input, and south-to-north isostatic rebound. Lakes Albany and Hitchcock likely came to a close circa 13,100–13,000 cal yr BP (Ridge et al. 2012). At about the same time, retreat of the Laurentide ice sheet to the north side of the St. Lawrence Valley allowed the Atlantic Ocean to flood the St. Lawrence lowlands, forming the Champlain Sea (Cronin et al. 2008). This inland ocean stretched 600 km east-west between Québec and Ontario, and 300 km south into the Champlain basin of eastern New York and western Vermont (see Figure 4). With isostatic rebound over the next three millennia, the Champlain sea contracted and was finally cut off from the Atlantic circa 9800–9700 cal yr BP. In western Vermont, plotting of older and younger Paleoindian sites and points tracks the receding coast of the Champlain sea from the late Pleistocene into the early Holocene (F. Robinson 2012).

2.2 *Evolving Atlantic shorelines*

Marked sea level changes occurred along the Atlantic coastal margins over the past 24,000 cal yr (Figure 7, see Figures 3 through 6). Coastline positions from the Middle Atlantic northward to the Canadian maritime region over this period were heavily influenced by glacial isostatic adjustments (GIA), as a result of the Laurentide ice sheet. During the maximum low stand, the weight of the Laurentide ice sheet caused glacioisostatic down-warping in areas near the terminal margin and uplifting or a fore bulge occurred in areas located south and east of the ice sheet. At the time of glacial maximum, the offshore islands and peninsulas that are now part of the broad continental

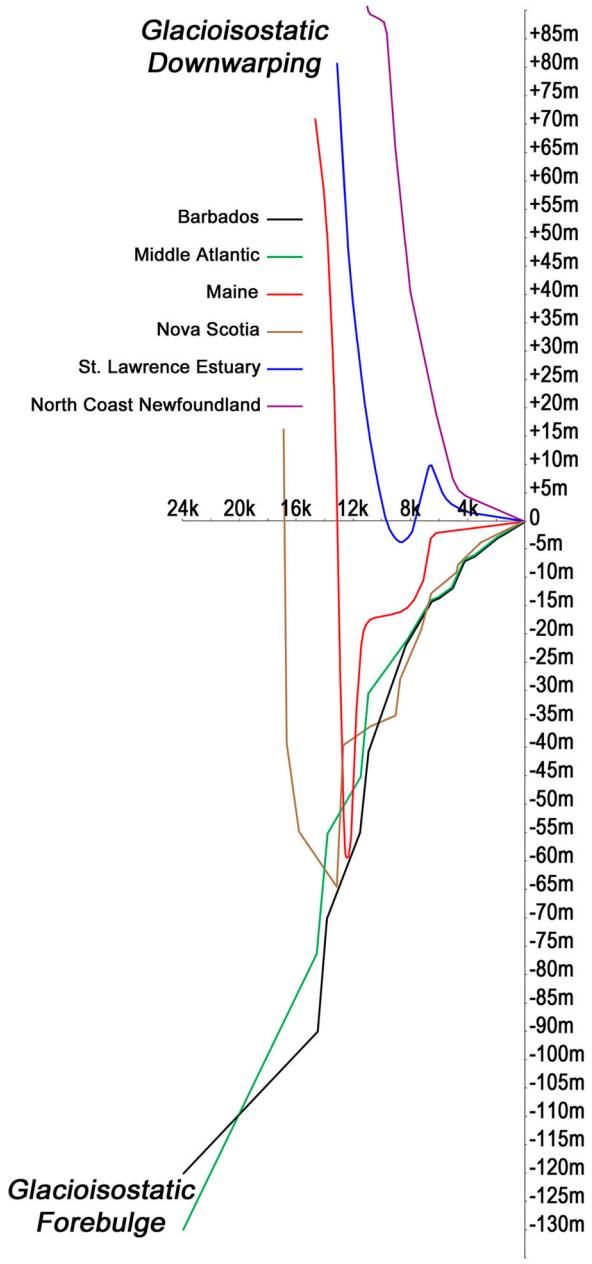

Figure 7 Combined sea level curves, 24,000 cal yr BP (LGM) to present, for the Barbados, the Middle Atlantic, Nova Scotia, Maine, the north coast of the St. Lawrence estuary, and the north coast of Newfoundland.

shelf, including Georges Bank, Stellwagen Bank, Sable Island, and the Grand Banks, were unglaciated. Some of these isolated northeastern coastal margins served as refugia for resilient plant and animal species, including mammoth, mastodon, and walrus (Rhoads 1898; Whitmore et al. 1967). The vegetation for the Georges Bank region consisted of a mixture of tundra grasses with conifers (Emery et al. 1967), both of which would have been attractive to proboscideans. The presence of walrus in these locations would indicate that an established coastal marine ecosystem existed, which would have included bivalve species (Emery et al. 1967). If human populations were present south of the Laurentide glacial margin position at circa 24,000 cal yr BP, these northeastern shelf regions could have been attractive for human settlement.

South of the LGM glacial ice margin, the coastal margins reflect a much milder climate. Both Emery et al. (1967) and Harrison et al. (1965) reported a freshwater peat from a core extracted from the continental shelf near the mouth of the Chesapeake Bay, which was dated to 18,398 ± 316 cal yr BP. Pollen data and macro-organic remains from this peat indicate the Middle Atlantic coastal forests were composed of grasslands and a variety of coniferous and deciduous arboreal species, such as spruce (*Picea*), pine (*Pinus*), fir (*Abies*), birch (*Betula*), alder (*Alnus*), and oak (*Quercus*). The drowned Middle Atlantic continental shelf area would have been attractive to both megafauna (Whitmore et al. 1967), as well as humans (see Stanford et al. 2014), if they were present during this early time period.

Given the marked variations in relative sea level along the North Atlantic coast, sea level fluctuations would have had a profound impact on human populations utilizing the coastal zone during the Paleoindian period. If pre-Clovis populations existed in the Northeast and if these early colonizers were remotely interested in coastal resources, the Middle Atlantic region would have potentially supported a rich coastal biome (see Lowery et al. 2012). Certain coastal margins within the Gulf of Maine and Nova Scotia may have also been productive coastal ecosystems prior to Meltwater Pulse 1A (MWP-1A), which lasted from circa 14,500 to 13,800 cal yr BP. MWP-1A was an extreme marine transgression event, consisting of a circa 20-m rise in global sea level over a short 500- to 600-year period, beginning at either circa 14,600 cal yr BP (Weaver et al. 2003) or around 14,100 cal yr BP (Stanford et al. 2006). Given the duration of this marked event, global coastlines would have endured circa 5-m of sea level rise per century. As such, MWP-1A may have initiated a collapse in established global coastal ecosystems (e.g., Webster et al. 2004). If present, early coastal-adapted human populations could have shifted their subsistence focus away from the coastline towards interior non-coastal resources. Ultimately, MWP-1A may explain the presence of potential ≤ 14,600 cal-yr-BP pre-Clovis sites being reported in the interior portions of both North and South America (e.g., Anderson et al. 2013; Dillehay et al. 2008; Joyce 2013; Waters et al. 2011a, 2011b; Webb 2006).

With respect to the sea level curves shown in Figure 7, Stright (1995) defines criteria that classify these dissimilar sea level curves into her Isostatic Zones A, B, and C. The relative sea level curves for Newfoundland, the St. Lawrence estuary, Nova Scotia, and Maine fit within Isostatic Zone A,

wherein isostatic uplift exceeded eustatic sea level rise throughout most of the post-LGM era. Such regions contain emergent paleo-shorelines of noticeably different ages. Stright (1995) further divides Isostatic Zone A into two groups: those where a late Pleistocene relative high sea level dropped markedly below present and remained low during the Holocene (Nova Scotia and Maine sea level curves would fit this category), and a second group comprised of those regions where isostatic high sea levels endured through most of the late Pleistocene and the Holocene (the north coast of the St. Lawrence estuary and the north coast of Newfoundland, qualifying for this group).

Stright's Isostatic Zone B (1995, 138) would encompass those areas where the net result of deglaciation was submergence of the continental shelf by eustatic sea level rise. Glacioisostatic uplift and depression have impacted those areas. The Middle Atlantic zone is included in this group, and therefore deviates from the Barbados eustatic sea level summary. Finally, the areas along the south Atlantic coast and the Gulf of Mexico qualify for Stright's Isostatic Zone C (1995, 139). These areas have been impacted by sediment loading at relic and active deltas, which has caused extensive down-warping along some areas of the shelf.

Based on the various sea level curves in Figure 7, the marked glacioisostatic rebound-regression events noted along the coasts of Maine, Nova Scotia, Newfoundland, and along the north coast of the St. Lawrence estuary could have had a profound impact on early human populations focused on coastal ecosystems. The rapid aerial exposure of former subaqueous anaerobic sediments along these coastlines would result in an ultra-acid pH nearshore environment, as well as the release of toxic sulfate minerals (Fanning et al. 2010; Sánchez-Marañón et al. 2015). These coastlines may have encapsulated coastal ecological "dead zones" throughout the period of rapid glacioisostatic rebound-related regression. As sea level overcame the isostatic rebound in these areas, however, coastal ecosystems would have quickly recovered.

Glacioisostatic adjustments are extremely important when trying to understand the magnitude and variability in sea level changes over time within northeastern North America (Peltier 2009). Glacioisostatic sea level variability can influence coastal archaeological site visibility, as well as our understanding of human interest in coastal resources. Renouf and Bell (2006) illustrate a prime example of this unique relationship along the coast of Newfoundland. The north coast of Newfoundland is an area where isostatic high sea levels have endured throughout the late Pleistocene and Holocene (Grant 1994). In contrast, the sea level record along the south coast of Newfoundland (Shaw and Forbes 1995) encompasses a late Pleistocene high sea stand, which then dropped well below present and has been slowly rising throughout the duration of the Holocene. Renouf and Bell (2006, figure 4) have recorded 84 Maritime Archaic sites along the north coast of Newfoundland and only five comparable-age sites along Newfoundland's south coast. The assumption is that the south coast of Newfoundland may have once had an equal or greater number of Maritime Archaic sites, but were inundated and/or eroded by sea level rise over the past several thousand years. These observations for the Newfoundland coast offer a cautionary tale for using site data (or the lack of it) for excluding the possibility of coastal-oriented Paleoindian populations with a maritime subsistence focus along the $\geq$ 13,000 cal yr BP coastlines of the northeastern North America.

Rates of marine transgression can influence or impact coastal ecosystems (Webster et al. 2004), and Custer (1988, 121) suggests that the rates of post-Pleistocene sea level rise prevented the establishment of shellfish beds in the Chesapeake and Delaware Bay areas before 5000 cal yr BP. However, Cronin (2000) documents that the rate of post-Pleistocene sea level rise in the Chesapeake and Delaware Bay areas was slower than that witnessed, for example, during the preceding MWP-1A at circa 14,500–13,800 cal yr BP. Also, Cronin (2000) reports a 10,200 cal-yr-BP oyster bed situated 36 m beneath the modern Chesapeake Bay. Many short-term variables (i.e., sedimentation, tidal amplitude, freshwater runoff, temperature, bathymetry, anoxia, sub-aquatic vegetation, and predation) can influence the establishment of sustainable and usable shellfish beds, and that the effects of these variables occur on the sub-decadal level, not the century or millennial level. To illustrate how quickly shellfish reefs can develop, in 2002 Lowery (2004) conducted an informal experiment in Magothy Bay, Virginia (Figure 8), showing that a shellfish reef can form in less than eight years. Excluding the possible impacts of barrier island transgression and/or transgression-related sedimentation, this exercise suggests that oyster reefs could have survived and provided a reliable and predictable food source to potential pre-Clovis and Paleoindian populations, even during periods of late Pleistocene sea level rise (but not including meltwater pulse events). We also note, however, that the visibility of sites illustrating pre-Clovis or Paleoindian coastal adaptations has been greatly reduced as a result of marine transgression.

2.3 Post-glacial climate change: Paleoenvironments

Across much of the Northeast, recent advances in understanding of late Pleistocene and early Holocene

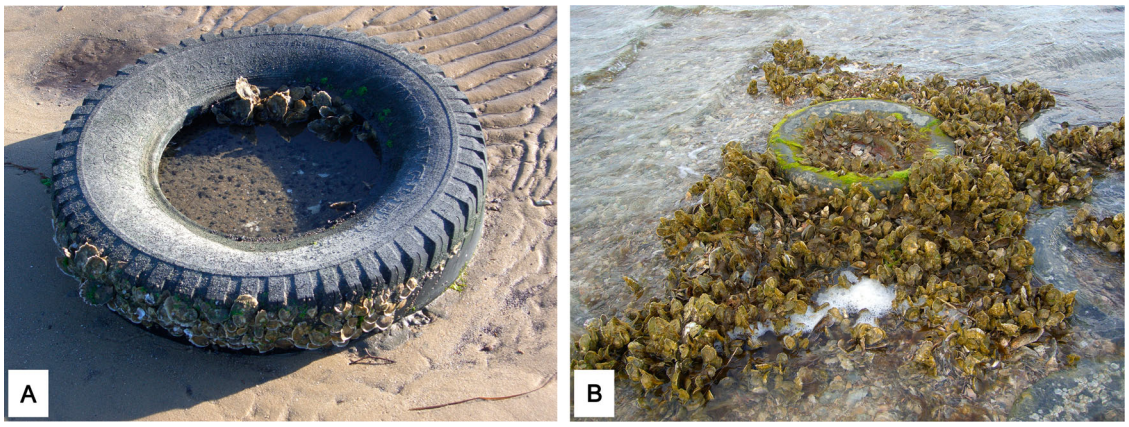

Figure 8 Informal experiment on oyster reef development, illustrating the short-term dynamic nature of coastal ecosystems along Virginia's Atlantic coast. A daily tidal amplitude of circa 1.5 m occurs in Magothy Bay, Virginia. In 2002, an abandoned tire was placed offshore within the inter-tidal zone of Magothy Bay, an Atlantic coast barrier island lagoon system. Photograph A: on February 9, 2003, young eastern oysters (*Crassostrea virginica*) have attached themselves to the tire. Photograph B: On March 13, 2010, an extensive oyster reef has developed after only seven years.

climate and vegetation (and its potential effects on human subsistence resources) provide additional context for inferring how early human populations colonized and adapted to the region. In recent decades, data on climate proxies from Greenland ice sheet cores have shown that in addition to orbitally driven, directional warming after the LGM, there were also abrupt climate oscillations in the North Atlantic region that accompanied the last deglaciation of the Northeast (Alley 2000; Steffenson et al. 2008). These proxies indicate that the warming of the Bolling-Allerod (BOA) (beginning circa 14,600 cal yr BP) was interrupted by temperature reversals of the Older Dryas, Intra-Allerod, and YD climatic reversals. Of these, the YD reversal was the most pronounced and of greatest duration, extending from circa 12,900 to 11,600 cal yr BP (Carlson 2013).

Comparison of climate proxies with radiocarbon-dated pollen cores in the Northeast shows that climate change was a critical factor governing paleoecological changes, and past changes in vegetation represent rapid responses to changing deglacial climates (Shuman et al. 2004). These changes in late Pleistocene and early Holocene vegetation were products of both long-term orbitally driven climate change and abrupt climate oscillations. Especially in New England, these oscillations or rapid climate change events reversed long-term trends in vegetation regimes, or conversely, accelerated paleoecological trends (Shuman et al. 2009). Below, we summarize paleoenvironmental data for the Northeast study area, highlighting differences between sub-regions (Table 1).

2.3.1 New England-Maritimes

Newby et al. (2005, 145–148) summarize vegetation changes for the broader NEM, from the BOA into the early Holocene. From deglaciation to circa 14,600 cal yr BP, earliest pollen assemblages are variably dominated by sedge, spruce, and willow, reflecting largely open environments. Beginning circa 14,600 cal yr BP, warming associated with the BOA was rapid, and by 13,000 cal yr BP, temperatures rose to within 1–2°C of today (Shuman et al. 2004, 1300). During this time, pollen assemblages across the NEM are variably dominated by spruce, pine, birch, oak, and poplar; by the end of BOA warming at 13,000 cal yr BP, spruce extends into northern New England and the Maritimes, with open environments limited to the northernmost NEM. With the onset of the YD at circa 12,900 cal yr BP (11,000 ^{14}C yr BP), multiple climate proxies indicate that regional temperatures declined abruptly by as much as 5°C, making the YD the coldest period since 15,000 cal yr BP in the NEM (Hou et al. 2006).

Table 1
Age and environmental associations of sub-regions in northeastern North America

Climate event	Timescale (Cal BP)	Cultural period	Middle Ohio Valley	Mid-Atlantic	EGL	NEM
Pre-BOA		Pre-Clovis?	Spruce/Oak woodlands	Spruce-Larch parkland		
BOA	14.6–12.9 K	Pre-Clovis?	Deciduous woodlands	Mixed boreal and deciduous forest	Spruce-pine-oak forest	Mixed boreal and deciduous forest
YD	12.9–11.6 K	Early middle Paleoindian	Spruce-pine-oak forest	Mixed boreal and deciduous forest	Spruce parkland to pine forest	Tundra (north) to spruce forest (south)
Early Holocene	11.6–10 K	Late Paleoindian	Pine-oak forest	Oak deciduous forest	Pine-oak forest	Pine-oak forest

Further, AMS-dated stratigraphic sequences record significantly lower lake levels, reflecting decreased precipitation during the YD (Shuman et al. 2004, 1301–1302). The resulting rapid shifts in vegetation patterns across the NEM were often contrasting, reflecting latitudinal variation. The northern range of spruce shifted south to the central NEM, and vegetation of open environments (sedge, willow, grass, sage) expanded in the Canadian Maritimes. Conversely, spruce populations rebounded during the YD onset in southern New England. Newby et al. (2005) observe that these contrasting YD vegetation regimes of open landscapes in the northern NEM and boreal forests in the southern NEM constituted ideal summer and winter habitats for long-distance migratory caribou herds.

At the YD terminus, circa 11,600 cal yr BP (10,100 ^{14}C yr BP), isotopic and chironomid records for the NEM indicate dramatic warming, and lake level proxies point to even drier conditions in the early Holocene that persist until circa 8000 cal yr BP. In response, open vegetation in the Canadian Maritimes contracted, spruce declined in the central and southern NEM, and pine rapidly became the dominant species in closed-canopy forests across most of the region. In the northern NEM, however, the rapid spread of closed pine forests was delayed in the Gaspé region of Québec, where melting ice caps persisted into the early Holocene (see Figure 6).

2.3.2 Eastern Great Lakes and Ohio Valley

Looking west to the EGL, isotopic proxies from shell carbonates signal cooling from the BOA into the YD, and warming with the early Holocene onset (Yu and Wright 2001). Compared to the NEM, however, fossil pollen records across the EGL provide a less consistent record of climatic cooling during the YD. South of Lake Ontario in western New York, fossil pollen records reveal a decline in spruce and sedge, and a rise in pine, from the BOA into the YD. Beginning with the early Holocene, pine becomes dominant, accompanied by oak and birch (Webb et al. 2003). In Ontario and Michigan, some pollen sequences show a short-lived spruce peak at the YD onset, but followed during the YD by declines in spruce, ash, and non-arboreal pollen, and an increase in pine during the YD (Ellis et al. 2011; Karrow 2004). Following its initial dominance in the early Holocene, pine is later accompanied by deciduous taxa. Based on pollen transfer functions, McCarthy and McAndrews (2012, 419–420) link the early dominance of pine to significantly lower precipitation during the early Holocene throughout the Great Lakes region, with peak values between 9900 and 8200 cal yr BP. This extended early Holocene drought contributed to closed-basin low stands in the Great Lakes region.

South of the EGL in southern Ohio and Indiana, with BOA warming, spruce park lands were replaced by deciduous woodlands, with spruce as a minor component. Some pollen profiles do suggest a YD signal, with a secondary peak in spruce, the presence of fir and/or a decline in oak, and the appearance of pine (Gill et al. 2012; Shane 1987, 1994). Post-YD, pine is accompanied by deciduous taxa, signaling closed forests. During the latter part of the early Holocene (circa 10,900–8200 cal yr BP), oak and hickory replaced pine (Gill et al. 2012, 71–72).

2.3.3 Mid-Atlantic

South of the LGM glacial ice margin in the interior middle Atlantic region, paleoenvironmental studies are few in number and mostly limited to fossil pollen sequences in the Ridge and Valley region of Virginia, West Virginia, and southeastern Pennsylvania (Craig 1969; Kneller and Peteet 1993; Litwin et al. 2004; Maxwell and Davis 1972; Watts 1979). Despite often poor age constraints, these studies nevertheless suggest broad vegetation trends from late glacial into early Holocene times. Pre-BOA, there is variable evidence for either tundra or boreal parkland biomes. During the BOA, these studies suggest variable boreal forest communities of spruce, fir, and pine, with some deciduous taxa. YD-age pollen and plant macro botanical assemblages typically show no clear temperature reversals: coniferous taxa are still present, but usually accompanied by oak. Moving into the early Holocene, hardwood forests prevail, typically dominated by oak. In some pollen core profiles, low rates of deposition or unconformities suggest dry early Holocene climates (e.g., Kneller and Peteet 1993; Watts 1979, 440).

Recent studies provide paleoenvironmental insights on the Coastal Plain of the mid-Atlantic from before the LGM until early Paleoindian times. During the period encompassing marine isotope stages (MIS) 3 through MIS 2 (circa 60,000–11,600 cal yr BP), the general trend for the Middle Atlantic coastal plain suggests a switch from mild-cool wet conditions circa 42,000 cal yr BP to cool dry conditions circa 20,000 cal yr BP. Puseman et al. (2014) have provided a detailed summary supporting these observations. Their analysis consisted of the identification of associated plant charcoal, pollen, and phytoliths from five paleosols dated to 42,000, 35,000, 30,000, 24,000, and 20,000 cal yr BP. During this period, the upland interior landscape of the Delmarva Peninsula appears to have been relatively stable. The episode of maximum intense cold in northern hemisphere, which occurred at circa 24,000 cal yr BP (Alley 2004), did not seem to harshly impact the Middle Atlantic coastal plain region. The relatively benign conditions at circa 24,000 cal yr BP are further

reinforced by the contemporaneously dated Columbian mammoth (*Mammuthus columbi*), a mild-adapted southern species, unearthed at the Inglewood site near Largo, Maryland (Haynes, n.d.; Karr 2015).

Floral data for the Middle Atlantic coastal plain region are relatively scant for the period after 20,000 cal yr BP (see Emery et al. 1967; Harrison et al. 1965). Pollen from several locations suggests relatively mild conditions at or slightly before Clovis. A freshwater peat dated to circa 13,500 cal yr BP from a core extracted near the mouth of the Chesapeake Bay (Harrison et al. 1965) revealed pine, fir, birch, alder, spruce, willow, and oak pollen. A similar suite of pollen was noted for a roughly contemporaneous sample extracted at Duck Creek in Delaware (Kellogg and Custer 1994, 69–71). Brush (2001, figure 3.2) also documented birch, alder, oak, pine, spruce, and hop hornbeam pollen in a circa 13,000-cal-yr-BP core sample extracted from the Anacostia River near Washington, DC.

2.4 Windblown surficial deposits of the Northeast

Surficial geology of glaciated portions of the Northeast consists primarily of till deposits, and around the Gulf of Maine, silty near-shore submarine deposits of the Presumpscot transgression (e.g., Smith 1985). South of the LGM ice margin, residual soils prevail. In addition, late glacial landscapes of the Northeast included distinctive aeolian landscapes that reflect sub-regional histories of the late Pleistocene. In the unglaciated middle Ohio Valley, wind erosion of outwash deposits during late Pleistocene formed localized dune fields on the margins of the river valley. Comprising unusual ecological settings, these dune fields sometimes attracted early Paleoindian occupations (e.g., Lothrop and Cremeens 2010; Seeman et al. 1994). Further east, in the Hudson and Connecticut valleys, drainage of proglacial lakes Albany and Hitchcock exposed lake bed sediments to wind erosion. Where rivers had drained into these former proglacial lakes, winds eroded deltaic sediments, creating localized dune fields in their vicinity. As in the Ohio Valley, these dune fields were attractive for early and middle Paleoindian occupations (J. Bradley et al. 2010; Lothrop and Bradley 2012, 24). Around the Gulf of Maine, sandy submarine deltas of the Presumpscot regression, some of which were eroded into dunes (Mckeon 1989), were preferred Paleoindian campsite locations more than 1000 years later (Spiess et al. 1998).

Extensive, true loess deposits are mapped along the Coastal Plain of the southern mid-Atlantic and across the Delmarva Peninsula. The deposition and differential erosion of these deposits have variably buried or exposed late Pleistocene archaeological materials (Lowery et al. 2010). Variation in the aeolian sequence chronology for the Delmarva Peninsula usually reflects factors of localized geology and wind velocity. For example, Markewich et al. (2015, figure 1) provide a broad range of ages affiliated with loess deposits (86,000–55,000, 40,000–30,000, and 13,000–11,000 cal yr BP) and dune fields (35,000–16,000 cal yr BP) on the Delmarva Peninsula. The most carefully studied regional loess deposit on the Delmarva Peninsula can be confined to a very narrow time frame (Wah et al. 2014). Clovis-age (circa 13,000 cal yr BP) artifacts are found as a lag deposit beneath loess (Lowery et al. 2010). Early Holocene (circa 11,000 cal yr BP) diagnostic notched projectile points have been found within the top of this loess deposit. As such, the youngest loess sequence can be confined to the middle and late YD climatic event (circa 12,600–11,600 cal yr BP). As indicated by the "Clovis lag," the YD was an era of marked upland erosion. The timing of this erosion event has also been observed in dated cores extracted from beneath the modern Chesapeake Bay (Cronin 2000).

In the mid-Atlantic, the YD-age Paw Paw loess was formed as the result of several factors, including rapid climate change, sea level change, isostasy, and possibly bio-ecological stress. Because of the collapse of the glacial fore bulge, the region was undergoing a period of marked isostatic depression circa 13,000 cal yr BP, and as a result, relative sea level was circa 50–52 m (164–170 feet) lower at this time. Some researchers (Eisenman et al. 2009) have suggested a period of increased atmospheric precipitation contributed to the YD cooling in the North Atlantic region. If the increased precipitation noted by Eisenman et al. (2009) contributed to Delmarva's upland erosion, the formation of the Clovis lag may have commenced during the terminus of the late Allerød oscillation and persisted into the earliest phase of the YD. The combination of factors may have also initiated biological stress on the vegetation, which may have further destabilized the upland and exacerbated erosion.

During the YD, the lower reaches of the Susquehanna River (i.e., the Chesapeake Bay) accumulated a vast quantity of eroded sediment in the adjacent floodplain (Lowery 2009). Because of the accrued sediment at or near base level, a braided lower Susquehanna River channel may have formed. As the northern hemisphere climate cooled, the intense northwesterly winds reworked the accumulated sediment within the lower Susquehanna Valley, which provided the parent material for the Paw Paw loess (dated circa 12,600–11,600 cal yr BP).

Recent research has shown that the chronological timing of the MIS 4 to MIS 2 aeolian sequences for the Delmarva Peninsula is further complicated by the accumulation of mixed carbon within the

regionally recognized Tilghman paleosol (Lowery et al. 2010). Cooler late Wisconsinan climatic conditions resulted in the long-term preservation of vitrified charcoal. As such, aeolian localities with a single paleosol can produce a gamut of averaged radiometric ages (see Section 4). There are, however, geologic exposures like Elliotts Island, which contain peat buried beneath aeolian deposits (Lowery et al. 2011). The buried peat exposures at Elliotts Island would suggest that aeolian activity also occurred sometime prior to 13,000 cal yr BP and after 24,000 cal yr BP. Like the YD, the period between 15,000 and 20,000 cal yr BP is an era of noticeable dust in the northern hemisphere (Mayewski et al. 1993, figure 1). Further research may ultimately be able to correlate the Delmarva sequence with dust in the northern hemisphere ice core record.

3. Chronologies: Relative and absolute dating

Across the Northeast study area, pre-Clovis and Paleoindian sites with radiocarbon dates in good association are rare and geographically variable in their occurrence. Accordingly, researchers rely heavily on relative dating for site age assessments, most commonly using temporal sequences of diagnostic bifaces developed for different parts of the Northeast. For much of our study area, however, these sub-regional biface sequences are still in a formative stage and subject to revision and refinement as attribute data sets expand and opportunities for radiocarbon and geochronological dating come to light. Below, we describe and discuss biface sequences proposed for relative dating of pre-Clovis and Clovis-and-later Paleoindian occupations (Figure 9 and Table 2). Subsequently, we compare the Paleoindian biface sequences with accepted age determinations for Paleoindian sites in the Northeast.

3.1 Pre-Clovis

Collins et al. (2013) have proposed two pre-Clovis biface forms for North America that have examples from or adjacent to the Northeast. The first of these is a laurel leaf-shaped bipoint that may display overface or overshot percussion flaking and variable marginal pressure flaking (Collins et al. 2013, 526–527). This form was defined based on recent recognition of a 1970s discovery of one bipoint in possible association with mastodon remains at the Cinmar locality, on the mid-Atlantic continental shelf (see Figures 3 and 9) (Stanford et al. 2014). A radiocarbon date on

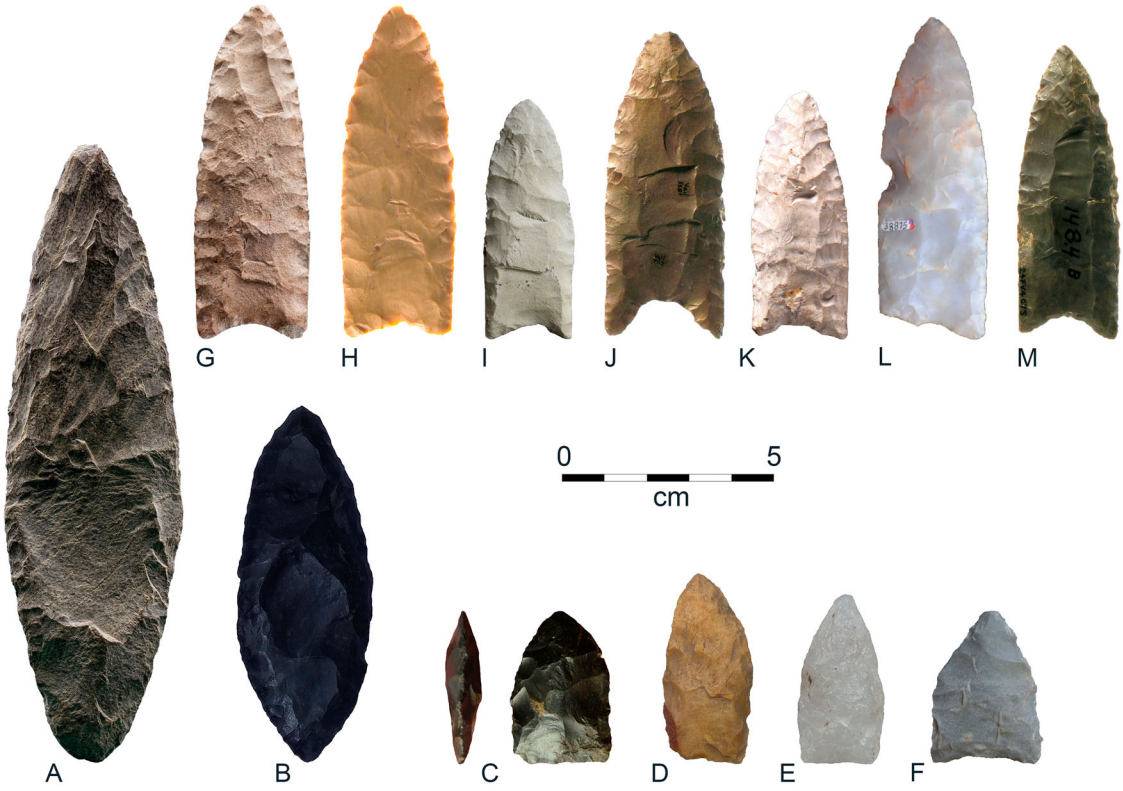

Figure 9 Pre-Clovis (bottom row) and early Paleoindian biface forms (top row) in the Northeast. A: Bipoint, rhyolite, Cinmar locality; B: Bipoint, chert, Parson's Island site, MD; C: Basally thinned, lanceolate point, chert (profile and plan), Miles Point site, MD; D: Lanceolate point, chalcedony, Parson's Island site, MD; E: Lanceolate point, quartz, Parson's Island site, MD; F: Lanceolate or triangular point, chert, Cactus Hill site, VA; G: Clovis point, Shawnee-Minisink site, PA; H: Clovis point, Site 33Ms391, OH; I: Clovis point, Williamson site, VA; J: Vail-Debert point, Vail site, ME; K: Gainey point, Gainey site, MI; L: Gainey point, Nobles Pond site, OH; M: Fluted point, Bull Brook site, MA (points G through M, all chert) (Image credits: G-Joe Gingerich; I–J. and L. McAvoy; J & M-Jeff Boudreau; K-Don Simons; L-Mark Seeman).

Table 2
Comparison of Paleoindian point sequences for sub-regions of the Northeast

Chronology	Northeast sub-regions				Climatic event
	Middle Ohio Valley	Mid-Atlantic	EGL	NEM	
Early Paleoindian	Clovis Gainey	Clovis Gainey?	Clovis? Gainey	Clovis? Kings Road-Whipple Vail-Debert Bull Brook-West Athens Hill	Late BOA
Middle Paleoindian	Cumberland	Cumberland/Barnes Crowfield Holcombe?	Barnes Crowfield Holcombe	Michaud–Neponset Crowfield Cormier–Nicholas	YD
Late Paleoindian	Agate Basin Quad/Beaver Lake/Dalton	Agate Basin Dalton/Carson Lanceolate?	Agate Basin/Hell Gap Hi-Lo Eden-like	Agate Basin-like Ste. Anne–Varney	Early Holocene
Key references	Anderson et al. 1996, 2015; Jefferies 2008; Maggard and Stackelback 2008; Smith 1990; Tankersley 1990, 1996; White 2013	Carr and Adovasio 2002, 2012; Fogelman and Lantz 2006; Gingerich 2013a, 2013b; Lowery 2002; Lowery and Stanford 2013; McAvoy and McAvoy 2015	Deller and Ellis 1992a, 2011; Ellis 2004b; Ellis and Deller 1990; Jackson 2004; White 2006, 2013	Bradley et al. 2008; Chapelaine 2012; Ellis 2004a; Lothrop et al. 2011; Newby et al. 2005; Petersen et al. 2000; Spiess et al. 1998	

the mastodon tusk yielded an AMS age of 22,760 ± 90 ^{14}C yr BP (27,440 ± 394 cal yr BP), while sea level data indicate the find spot was most recently exposed from roughly the LGM onset until circa 14,500 cal yr BP. Stanford et al. (2014) report other possible examples of bipoints from the Chesapeake and New England regions. Between 2013 and 2016, field investigations at the Parson's Island site in coastal Maryland (see Figure 3) recovered six bipoints along with other stone tools from an eroded bank shoreline, with one of the bifaces found embedded in an exposed buried A horizon, 1.5 m below a YD-age Clovis-lag surface at this location (see below). Boulanger and Eren (2015) argue that similar biface forms that taper at the distal and proximal ends are found at Native American sites in the Northeast dating to the middle and late Holocene, an observation that we agree with. These apparent Pleistocene-age bipoint biface forms, however, with multiple examples found at the Parson's Island site (see below), may be the *oldest* examples of this particular artifact type in the Northeast.

Collins et al. (2013) also propose a second pre-Clovis biface type, consisting of unfluted, small lanceolate points "of thin triangular form that lack fluting and marginal grinding" (2013, 526) (see Figure 9). Reported examples from or near the Northeast include Meadowcroft Rockshelter, Pennsylvania, Cactus Hill, Virginia, and Miles Point, Maryland (Collins et al. 2013, 526; McAvoy and McAvoy 2015). In 2013–2016, two possible examples were found at the Parson's Island site, in the same buried A horizon that yielded bipoint bifaces. With so few possible examples recognized to date, however, this short lanceolate biface type remains poorly defined in terms of its manufacturing technology and formal and metric variation. Collins et al. (2013, 528) suggest these unfluted lanceolate points fall within a time range of 21–14,000 ^{14}C yr BP. McAvoy and McAvoy (2015) report radiocarbon dates of 14,180, 15,070, and 16,670 ^{14}C yr BP attributed to the pre-Clovis component at Cactus Hill that has yielded these unfluted lanceolate points (see below).

3.2 Early Paleoindian (circa 13,000–12,200 cal yr BP)

Table 2 compares Clovis-and-later Paleoindian biface sequences for sub-regions of the Northeast. Deller and Ellis (1992a) and Ellis and Deller (1990) define a biface sequence for the EGL, while Bradley et al. (2008) present a biface chronology for the NEM. Anderson et al. (1996, 2015) present biface sequences for the Southeast that apply to the Ohio Valley and to the southern mid-Atlantic, while Carr and Adovasio (2002, 2012) summarize Paleoindian point forms for Pennsylvania in the northern mid-Atlantic.

In the Ohio Valley and mid-Atlantic, researchers have recorded presumed Clovis biface forms that tend to be large, with parallel to near-parallel hafting margins, and single flute scars on each face that terminate below midpoint (see Figure 9). The age of Clovis points in North America continues to be debated. Some researchers favor a "short" Clovis interval of circa 13,000–12,800 cal yr BP (Waters and Stafford 2007) or 13,000–12,615 cal yr BP (Waters and Stafford 2013, 544), while older dates at the sites of Aubrey, Wilson-Leonard, and El Fin del Mundo

may document a "long" chronology, with a possible start date of circa 13,400 cal yr BP (Madsen 2015, 218–219).

In the EGL, researchers have defined the early Paleoindian Gainey point type (Deller and Ellis 1992a; Ellis and Deller 1990; Roosa and Deller 1982), while Bradley et al. (2008, 126–141) propose related early Paleoindian forms for the NEM that include Kings Road-Whipple, Vail-Debert, and Bull Brook-West Athens Hill bifaces. All these early Paleoindian point forms bear some resemblance to Clovis bifaces, but usually display longer (and sometimes multiple) flutes and often deeper basal concavities, and are viewed by most researchers as probably Clovis-derived and therefore slightly younger (see Figure 9).

Along with Clovis, the Gainey form has also been identified in the Ohio Valley, mid-Atlantic and Midwest regions, and Morrow (2015) and Morrow and Morrow (2002) argue that these two early fluted point types can be discriminated by differences in manufacturing technology. For example, Clovis is distinguished in part by overshot flaking as a component of lateral preform thinning (with residual overshot scars sometimes present on unfinished points), and end-thinning/fluting by direct percussion from isolated striking platforms set at or close to the biface center plane (B. Bradley et al. 2010, 68–77, 100–101). By contrast, Gainey point manufacture reflects mostly medial lateral flaking and end-thinning/fluting from platforms set below the center plane, toward the face to be fluted, and residual overshot flake scars are likely absent (Morrow 2015; Morrow and Morrow 2002; Seeman in press). Further, Morrow (2015, 96–98) notes the presence of ground tips on Gainey preforms suggesting that "they were immobilized during the fluting process by having their tips held against a supporting medium," suggesting indirect percussion for fluting Gainey preforms. For small assemblages and isolated point finds, however, these distinctions may not be evident, and overlap between Clovis and Gainey in continuous variables can make discrimination difficult (Morrow 2015, 100–101).

Using these technological criteria, there are hints of a possible Clovis presence in the EGL and NEM. Preliminary analysis of the Arc site, situated on the south shore of Lake Ontario, reveals fluted preforms and points with possible overshot flake scars (Eren et al. 2011), suggesting Clovis-era as well as perhaps Gainey point occupations (Morrow 2015, 86). At West Athens Hill, a Paleoindian quarry and habitation site situated in the mid-Hudson Valley of New York (Funk 2004), preliminary analysis of the biface assemblage reveals some late-stage fluted preforms variably display flat bases and a "rowboat" shape in plan view, overshot thinning scars, and/or fluting/end-thinning removals originating from striking platforms that were positioned close to the center plane, similar to Clovis manufacturing rejects.

Although initially defined in one sub-region, some of the early Paleoindian and later point forms in these biface sequences are also recognized in other portions of the Northeast. For example, Vail-Debert points with distinctive deep basal concavities (Bradley et al. 2008, 130–135) are best known from northern portions of the NEM, including the Debert site in Nova Scotia and the Vail site in northwestern Maine. However, similar deeply indented points have also been recorded south of Lake Ontario at the Lamb site in western New York, and as isolates across southern New York and the mid-Atlantic region. Goodyear (2010) proposes that similarities in parallel to sub-parallel hafting margins and deeply indented basal concavities suggest a possible link to presumed post-Clovis Redstone fluted points in the Southeast. Based on inter-site comparisons, Ellis (2004a) documents a range of variation in what most researchers would designate as Vail-Debert biface forms, reinforcing the need to view the types or modal forms in these biface sequences as arbitrary constructs.

Four sites in the Northeast — Shawnee-Minisink (PA), Paleo Crossing (OH), Sheriden Cave (OH), and Cactus Hill (VA) — have produced points assigned by the investigators to the Clovis type and have been radiocarbon dated. Of these, Shawnee-Minisink has yielded the most robust set of radiocarbon determinations, making it the most securely dated early Paleoindian site in the Northeast. A series of six recently obtained AMS determinations on charred botanical materials from two features, yielding an average age of $10{,}937 \pm 15$ ^{14}C yr BP, suggest an occupation at or immediately prior to the YD onset (Gingerich 2013a, 238–240). Investigators of the Paleo Crossing site in Medina County, Ohio, report six AMS determinations on charcoal from a presumed post mold; these samples yielded two statistically distinct groups of radiocarbon ages, respectively averaging $12{,}150 \pm 75$ and $10{,}980 \pm 75$ ^{14}C yr BP (Brose 1994, 65). The investigator favors the second average determination, but the range of dates produced suggests at least two populations of charcoal from the post-mold feature. At Sheriden Cave in Wyandot County, Ohio, Waters et al. (2009, 109) report an AMS date of $10{,}915 \pm 30$ ^{14}C yr BP on collagen from one of two bone points (with a two-sigma calibration of 13,025–12,925 cal yr BP). A small, reworked fluted point from the same stratum, originally identified as a possible Gainey point (Redmond and Tankersley 2005, 518), was reclassified as a Clovis point after the AMS dating result (Waters

et al. 2009, 107). At Cactus Hill, McAvoy and McAvoy (2015) report three dates from features attributed to the Clovis occupation (see below).

Lothrop et al. (2011, 554–555, figure 7, appendix) report calibrated radiocarbon ages from 13 NEM Paleoindian sites. For fluted point sites, the associated dates extend from before to after the YD. Based on recent reinvestigations at the DEDIC/Sugarloaf site, Gramly (2014, 38) reports an AMS determination on calcined bone of 10,350 ± 50 14C yr BP (one sigma, 12,410–12,030 cal yr BP) that compares well with two AMS determinations for Bull Brook (Robinson et al. 2009, 425–426), suggesting a late duration for early Paleoindian point forms in the NEM.

3.3 *Middle Paleoindian (circa 12,200–11,600 cal yr BP)*

In the middle portion of the Northeast Paleoindian biface sequence, Cumberland, Barnes, and Michaud–Neponset forms (of the Southeast, EGL, and NEM sub-regions, respectively), all display single flutes often extending to the tip, and bases that may appear waisted or fishtailed, with delicate ears (Figure 10). As a fluted point type, Cumberland was originally defined in the Mid-South (Lewis 1954). Gramly (2008, 2009a, 2012) argues that the Cumberland form predates Clovis, although most researchers in the Southeast view this as a post-Clovis form, with a distinctive mid-South/Carolinas distribution (Anderson et al. 2015, 29, figure 6; Tune 2015). Although no radiocarbon dates exist for Cumberland, in the NEM middle Paleoindian-era AMS dates on the Michaud–Neponset form (see below) support a late YD antiquity that we believe also applies to comparable Barnes and Cumberland forms.

Crowfield points comprise the last middle Paleoindian biface form with typically longer flutes in the Northeast (see Figure 10). These shouldered bifaces expand markedly from the base, are typically thin, and often display multiple flutes on each face. Holcombe points show some similarity to Crowfield bifaces, but are more narrow, expand less markedly from the base, display shallowly concave bases with inwardly rounded basal corners, and exhibit basal thinning rather than true fluting (Ellis and Deller 1990, 57). Importantly, in Ontario, archaeologists have recovered Holcombe, Hi-Lo, and "Plano" points (but not earlier fluted points) on the bed of Lake Algonquin, demonstrating that these biface forms *must postdate* the draining of Lake Algonquin (Ellis and Deller 1986). Following Karrow et al. (1975), this draining of Lake Algonquin is often glossed as occurring at circa 10,400 ^{14}C yr BP. However, this event is projected from a single conventional date on a drained lakebed location of 10,290 ± 150 ^{14}C yr BP (GSC-1111) so the lake could easily have drained later or closer to 10,000 ^{14}C yr BP (11,500 cal yr BP). An interpretation of a later draining would be more consistent with a later ending dating for fluted point use as suggested by radiocarbon dates from the west (e.g., Folsom; Holliday 2000, 266–267) and with middle Paleoindian sites in the NEM (see below). In the NEM, Cormier–Nicholas points are similar to Holcombe forms, but show a somewhat greater variation in basal treatment, ranging from fluting to basal thinning (Bradley et al. 2008, 148–152) (see Figure 10).

Reviewing calibrated radiocarbon determinations in the NEM for Middle Paleoindian forms (Lothrop et al. 2011, 554–555, figure 7, appendix), the dates for sites with Michaud–Neponset points (Michaud, Neponset, Colebrook, Templeton) and Cormier–Nicholas points (Cormier, Esker) extend from the YD into the early Holocene. However, if one very late outlier from Michaud is excluded, at one sigma, these calibrated Middle Paleoindian age determinations fall within the latter portion of the YD, with the Michaud and Esker determinations extending two calendar centuries into the early Holocene.

In the Northeast, radiocarbon dating of Crowfield points remains elusive. Of note is a recent series of radiocarbon dates obtained at the Nesquehoning Creek site, in Carbon County, eastern Pennsylvania (Stewart et al. in press). Excavation of this stratified site has recovered the base of a probable Crowfield point and characteristic Paleoindian artifacts that concentrate in a buried ABw2b6 soil horizon designated Stratum 17. Three uncalibrated AMS dates on charred wood samples encountered in this stratum (but not associated with a cultural feature) include: 9940 ± 50 BP, 10,340 ± 40 BP, and 10,480 ± 30 ^{14}C yr BP. The second of these determinations (10,340 ± 40 ^{14}C yr BP) derived from a charcoal sample at the same depth and proximal to the Crowfield point base. The investigators interpret these age determinations as evidence "that Paleoindian occupations first began during the YD and reoccurred into the early Holocene" (Stewart et al. in press). Minimally, these determinations provide a geologic age estimate for the Paleoindian artifact-bearing deposits, although not necessarily the antiquity of the cultural occupation that produced the Crowfield point. Anticipated additional AMS determinations for the site may shed light on this issue.

Finally, we note two other fluted biface forms in the Northeast with uncertain age affiliations, and which are not part of the biface sequences defined here.

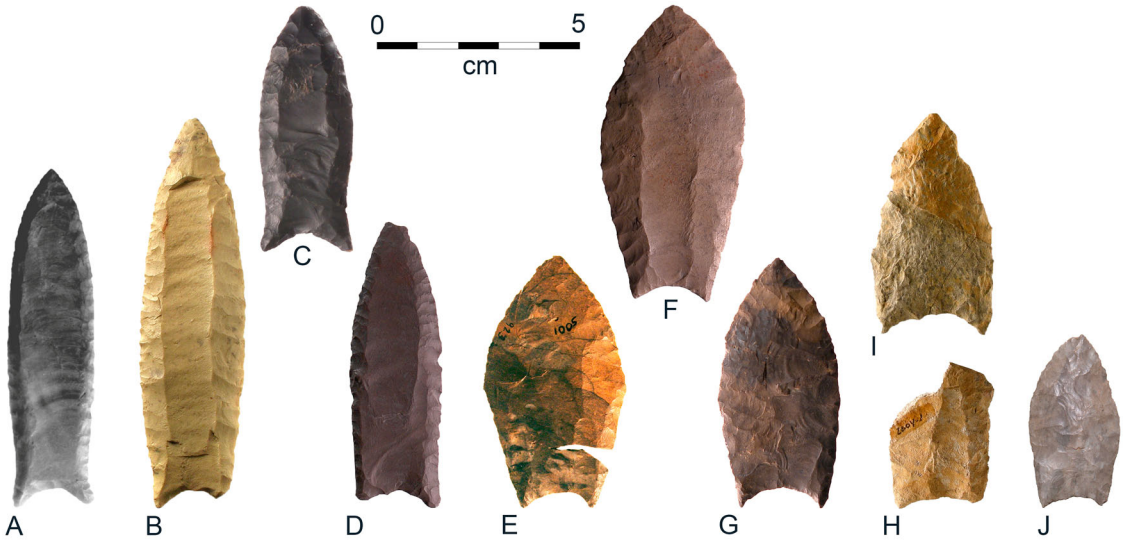

Figure 10 Middle Paleoindian biface forms in the Northeast. A: Cumberland point, Sandy Springs site, OH; B: Barnes point, Thedford II site, Ontario; C: Michaud–Neponset point, Dutchess Quarry Cave #8 site, NY; D: Barnes point, western NY; E: Crowfield point, Crowfield site, Ontario; F: Crowfield point, western NY; G: Crowfield point, central NY; H: Cormier–Nicholas point base, Cormier site, ME; I: Cormier–Nicholas point, Cormier site, ME; J: Holcombe point, Fowler site, Ontario (A–G and J: chert; H and I: NH rhyolite) (Image credits: A-Mark Seeman; I & H-Jeff Boudreau; J-Phil Woodley).

Witthoft (1950) first recognized Northumberland points as an unusual fluted biface form, and were later so designated by Fogelman and Lantz (2006, 33–34). In outline and overall flaking, these bifaces resemble Agate Basin points, but also display a single flute on one face that often extends to the tip. These forms may be most common in the mid-Atlantic region (Fogelman and Lantz 2006), but have also been recorded in the southern EGL of New York. More recently, the reported 2013 discovery of the McManus cache in Lehigh County, eastern Pennsylvania, revealed several ovate bifaces that are fluted singly or multiply on both faces, and also bear shallow lateral notches at the base (Cresson 2015; Fogelman 2013). Lothrop et al. (in press) report a comparable example from the Wallkill Valley of southeastern New York. The geographic distribution and age of this form are unknown, although the presence of notching raises the possibility that it may date to the latter portion of the Northeast fluted point sequence.

3.4 Late Paleoindian (11,600–10,000 cal yr BP)

As for Late Paleoindian sequences in the Northeast, the middle Ohio Valley shows the closest affinity to the Southeast (Anderson et al. 2015, 8; Justice 1987), with Dalton cluster bifaces, including unfluted, fish-tailed Quad and Beaver Lake bifaces, and Dalton points with basal thinning and serrated/beveled blades appearing occasionally in the middle Ohio Valley (Figure 11). Dalton points are rare across most of this Northeast study area, being found far more commonly further west in the lower Ohio Valley, closer to the Dalton "heartland" (Jefferies 2008, 79–85; Koldehoff and Walthall 2009).

Lanceolate Agate Basin-like points — with lateral edges that usually contract toward the base and occasional parallel flaking — display the broadest distribution, having been reported in the lower Ohio Valley, mid-Atlantic, EGL, and NEM regions (Bradley et al. 2008; Ellis and Deller 1990; Tankersley 1990) (see Figure 11). Other "Plano" forms such as contracting stemmed Hell Gap-like points also occur but are spatially restricted to more northern parts of the EGL (e.g., Dibb 2004; Ellis and Deller 1986; Stewart 1983, 1984). Narrow, parallel-sided or leaf-shaped Eden-like and Ste. Anne–Varney points, with collateral/comedial flaking, appear to be present only in the easternmost EGL and NEM (Bradley et al. 2008; Jackson 2004) (see Figure 11). Given their distinctive forms and flaking technologies, most researchers believe that the widely recognized "Plano" biface varieties, including Agate Basin and Eden/Ste. Anne–Varney forms, are intrusive from the High Plains and reflect either stylistic diffusion or in-migration (e.g., Chapdelaine 1996; Dumais 2000; Petersen et al. 2000).

In the Northeast, radiocarbon ages for "Plano" late Paleoindian diagnostics are very poorly constrained. In the High Plains, Agate Basin forms date to circa 10,500–10,000 ^{14}C yr BP (circa 12,500–11,500 cal yr BP) and Hell Gap forms to around 10,000 ^{14}C yr BP (Kornfeld et al. 2010, 84–86). In the NEM, a single determination of 9615 ± 225 ^{14}C yr BP (circa 10,950 cal yr BP) is associated with a large parallel-flaked biface fragment at the Weirs Beach site in New Hampshire. In the Mississippi Valley, Agate

Basin has been recovered stratigraphically below Dalton points (Jefferies 2008, 83). In the NEM, Bradley et al. (2008, 152) propose a date range of 11,600–10,800 cal yr BP for Agate Basin-like forms.

In both the EGL and NEM, Eden-like and Ste. Anne–Varney forms very likely postdate Agate Basin bifaces. Holliday (2000) dates transitional Alberta–Cody point forms on the High Plains to 10,200–9400 ^{14}C yr BP, and "classic" Eden and Scottsbluff points of the Cody complex to 9400–8800 ^{14}C yr BP. The Varney Farm site, located in Androscoggin County, Maine, produced a large assemblage of Ste. Anne–Varney points. Petersen et al. (2000) report a conventional radiometric age of 9410 ± 190 ^{14}C yr BP from a hearth feature at Varney Farm that also yielded a series of five AMS ages ranging from 8700 to 8380 ^{14}C yr BP. The sites of Rimouski and Ste. Anne-des-Monts (Québec), and Lower Saranac (New York), have produced even younger determinations (Bradley et al. 2008, 161; Chapdelaine 1994). Based partly on geochronology for Ste. Anne–Varney sites on marine terraces of the Gaspé Peninsula, Dumais (2000, 103–105) proposes a date range of 9500–9000 ^{14}C yr BP (circa 10,800–10,100 cal yr BP).

In the EGL, Hi-Lo points with basal thinning, sometimes side-notching and frequent blade beveling, constitute a proposed regional analog for Dalton (Ellis 2004b; Koldehoff and Walthall 2009) (see Figure 11). The traditional time frame proposed for Dalton extends from 10,500 to 10,000 ^{14}C yr BP (circa 12,500–11,500 cal yr BP) (Goodyear 1982; Koldehoff and Walthall 2009, 142–143). Ellis (2004b, 70–72) argues for an approximate age of 10,000 ^{14}C yr BP for Hi-Lo points, perhaps rendering them contemporaneous with Plano forms. Based on their research in the Nottaway River Valley of the southern mid-Atlantic, McAvoy and McAvoy (2015, 58–60) define the Carson Lanceolate as a Late Paleoindian point type. This biface form is unfluted, basally thinned, wide at the base, with a deep basal concavity and sub triangular shape (see Figure 11). Excavations recovered this point form stratigraphically beneath Palmer and Kirk points at the Gray site, and McAvoy and McAvoy (2015, 60) project Carson Lanceolate points to be roughly contemporaneous with Dalton (see Table 2).

3.5 Dating analysis of Northeast Paleoindian point forms

The basis for radiometric dating of Paleoindian occupations in the Northeast is limited to a handful of Clovis point-affiliated sites, and a small number of early, middle, and late Paleoindian point occupations in the NEM. Previous researchers have compared calibrated ages for Paleoindian sites in the NEM, with that region's proposed biface sequence (Lothrop et al. 2011, 554–555; Newby et al. 2005, 150). Both studies suggested that fluted bifaces in the NEM roughly overlapped the YD, with early and middle Paleoindian point forms largely attributed to the first half and second half of the YD, respectively. In the NEM, fluting technology appears to fall off around or shortly after the YD terminus. A handful of dates suggested that Late Paleoindian parallel flaked bifaces in the NEM are associated with the early Holocene.

For the present study, we reviewed available radiometric dates for Paleoindian sites across the Northeast, using a chronometric hygiene approach to factor out dates of suspect association or poor precision. To this end, we used many of the criteria listed by others (Goebel and Keene 2014; Graf 2009; Pettitt et al. 2003) as guides to help eliminate suspect dates, resulting in a more high-graded suite of dates for the NEM, compared to Lothrop et al. (2011). In particular, we favored:

- Age determinations derived from cultural features that could be associated with a single point type, and excluded dates on nonspecific distributions of charcoal or other datable material that might reflect a geologic age of a site surface, rather than an age for a cultural occupation (sites eliminated: Hedden, Hidden Creek);
- Age determinations generated by AMS, and excluded standard counting assays with sigmas of more than 300 years (sites eliminated: Michaud);
- Most precise age determinations in cases where multiple dates were derived from a single feature (e.g., Vail), and excluded all dates from a single site feature that strongly suggested multiple populations of charcoal or other dated material (sites eliminated: Paleo Crossing, Rimouski, Whipple).

Finally, as with Lothrop et al. (2011, 554), we chose to employ the average determination for the suite of 12 radiocarbon dates from Debert site in Nova Scotia (10,600 ± 47 ^{14}C yr BP; MacDonald 1968, 53), so as not to obscure dating trends reflected by other sites in the sample.

As listed in Table 3, we calibrated 29 radiocarbon determinations using the IntCal13 calibration (OxCal 4.2) (Bronk Ramsey 2009; Reimer et al. 2013), and plotted these dates at one and two sigma, sorting by site and associated point forms (Figure 12). Based on these calibrations, we offer summary assessments below, relative to dated biface forms.

1. Clovis point-affiliated dates: At two standard deviations, determinations for Shawnee-Minisink, Cactus Hill, and Sheriden Cave straddle the YD onset, and therefore fall in generally accepted time ranges for Clovis chronologies (Madsen 2015).
2. NEM early Paleoindian dates: Modes for Vail and Debert dates precede DEDIC/Sugarloaf and Bull

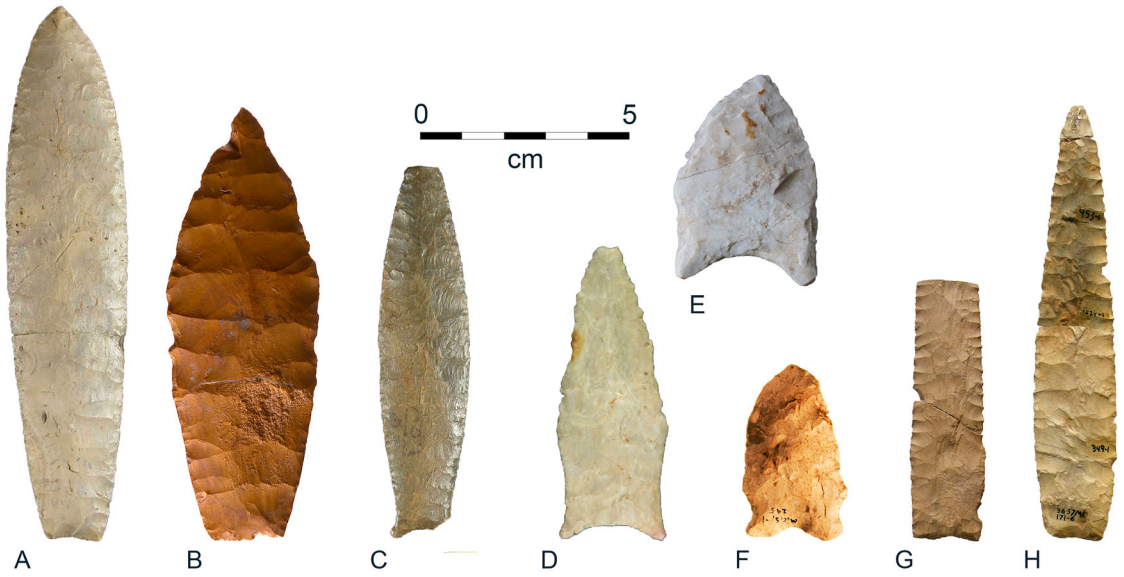

Figure 11 Late Paleoindian biface forms in the Northeast (all chert). A: Agate Basin-like point, southern OH; B: Agate Basin-like point, central NY; C: Beaver Lake point, OH; D: Dalton point, OH; E: Carson Lanceolate point, China Doll site, eastern VA; F: Hi-Lo point, Stewart site, Ontario; G: Ste. Anne–Varney point, Varney Farm site, ME; H: Ste. Anne–Varney point, Varney Farm site, ME (Image credits: A, C, D-Ohio History Connection; E–J. and L. McAvoy; G and H-Jeff Boudreau).

Brook, suggesting that Vail-Debert points *may* predate the less deeply indented bifaces from DEDIC/Sugarloaf and Bull Brook. For the NEM, these dates suggest manufacture of Early Paleoindian points until circa 12,200–12,100 Cal yr BP. Finally, the single date from Tenant Swamp is associated with a fluted point base of uncertain affiliation.

3. NEM middle Paleoindian dates: Of the four determinations associated with Michaud–Neponset points, two dates — Colebrook #1 and Templeton — display extremely broad calibrated sigmas and are not useful. Modes for the two remaining dates (Colebrook #2 and Neponset) provide stronger support for the notion that Michaud–Neponset points date to circa 12,000 Cal yr BP. Bradley et al. (2008) propose that Cormier–Nicholas points signal a devolution of fluting technology at the end of the YD. Calibrated modes for the two determinations from the Cormier and Esker sites only generally suggest a late YD age for this biface type.
4. NEM late Paleoindian dates: Based on available determinations, the chronology for "Plano" occupations in the NEM is extremely weak. Standard counting determinations for Weirs Beach (undifferentiated parallel flaked point) and Varney Farm #1 (Ste. Anne–Varney points) are all extremely broad. At Varney Farm, the same feature yielded a series of five much later AMS dates, raising the possibility of two populations of dated charcoal. Assuming that Ste. Anne–Varney point forms are indeed restricted to the early Holocene (perhaps circa 10,800–10,000 cal yr BP), the tendency for a northern distribution of this point form in the Northeast (see below) suggests a greater time depth for Paleoindian occupations in higher latitudes of the Northeast. Further south, in the broader Southeast (and including the middle Ohio Valley and southern mid-Atlantic), early Archaic notched forms appear after Dalton, near the YD terminus (Anderson et al. 2015).

4. Site-based evidence for pre-Clovis in the Northeast

Eight investigated sites in the Northeast are potential candidates for a pre-Clovis human presence: Meadowcroft, Burning Tree Mastodon, Mitchell Farm, Barton, Cinmar, Cactus Hill, Miles Point, and Parson's Island (Table 4). Figure 3 depicts the locations of these sites relative to Laurentide ice sheet margin positions at the LGM, and at 20,200, 17,900, 14,800, and 13,000 cal yr BP. Except for Parson's Island, these sites have been reported at varying levels of detail, and we refer readers to the site-specific published literature as well as recent detailed examinations of these sites by Fiedel (2013), Haynes (2015), and Madsen (2015). With new discoveries, pre-Clovis research continues to evolve rapidly, and we therefore include a preliminary overview of the recently recorded Parson's Island site on the Delmarva Peninsula. Below, we briefly summarize these eight sites, highlighting issues of context and chronology, and close by noting broader implications from some of these sites for older-than-Clovis occupations of the Northeast.

4.1 Meadowcroft Rockshelter

Meadowcroft Rockshelter, located in western Pennsylvania, remains central to the evolving debate on pre-Clovis occupations in North America.

Table 3
Accepted age determinations on Paleoindian sites in northeastern North America

Site	Feature	Age	Point form assoc.	Material	Assay #	Date	Converted age	Calibrated Cal BP Age 1-Sigma ±	Calibrated Cal BP Age 2-Sigma ±	Reference
Shawnee-Minisink 1	Hearth #1	EP	Clovis	Charred seed	UCIAMS-24866	AMS	11020 ± 30	12924 ± 99	12995 ± 117	Gingerich 2013b
Shawnee-Minisink 2	Hearth #2	EP	Clovis	Charred seed	OxA-1731	AMS	10970 ± 50	12894 ± 97	12918 ± 130	Gingerich 2013b
Shawnee-Minisink 3	Kline hearth	EP	Clovis	Charred seeds	Beta-101935	AMS	10940 ± 90	12887 ± 105	12926 ± 159	Gingerich 2013b
Shawnee-Minisink 4	Kline hearth	EP	Clovis	Charred seeds	Beta-127162	AMS	10900 ± 40	12850 ± 79	12831 ± 64	Gingerich 2013b
Shawnee-Minisink 5	Hearth #1	EP	Clovis	Charred seed	UCIAMS-24865	AMS	10915 ± 25	12855 ± 77	12830 ± 53	Gingerich 2013b
Shawnee-Minisink 6	Hearth #1	EP	Clovis	Charred seeds	Beta-203865	AMS	10820 ± 50	12792 ± 71	12800 ± 62	Gingerich 2013b
Cactus Hill	5F1	EP	Clovis	Charcoal	Beta-81589	SRC	10920 ± 250	12855 ± 247	12813 ± 576	McAvoy and McAvoy 2015
Cactus Hill 1	12F1	EP	Clovis	Charcoal	Beta-210651	AMS	10910 ± 40	12855 ± 79	12838 ± 70	McAvoy and McAvoy 2015
Cactus Hill 2	5F1	EP	Early fluted	Charcoal	Beta-206060	AMS	10840 ± 40	12805 ± 71	12802 ± 50	McAvoy and McAvoy 2015
Sheriden Cave	Stratum 5A	EP	Clovis	Bone	UCIAMS-38249	AMS	10915 ± 30	12855 ± 78	12832 ± 57	Tankersley et al. 2009
Vail	Feature #1	EP	Vail-Debert	Charcoal	Beta-207579	AMS	10710 ± 50	12697 ± 46	12718 ± 75	Gramly 2009b
Debert	Average	EP	Vail-Debert	Charcoal	MacDonald 1968, 53	SRC	10600 ± 47	12575 ± 113	12630 ± 135	MacDonald 1968
Tenant Swamp	Locus #2	MP	M-N	Calcined Bone	Beta-326991	AMS	10700 ± 50	12690 ± 50	12714 ± 75	Goodby et al. 2014
Sugarloaf	Ulrich Locus	EP	BB-WAH	Calcined Bone	Beta-360436	AMS	10350 ± 50	12273 ± 187	12270 ± 200	Gramly 2014
Bull Brook 1	None	EP	BB-WAH	Calcined Bone	Beta-240629	AMS	10410 ± 60	12338 ± 180	12363 ± 235	Robinson et al. 2009
Bull Brook 2	Locus #22	EP	BB-WAH	Calcined Bone	Beta-240630	AMS	10380 ± 60	12308 ± 186	12335 ± 253	Robinson et al. 2009
Colebrook 1	Feature	MP	M-N	Charcoal	Beta-107429	AMS	10290 ± 170	12070 ± 364	12053 ± 590	Kitchel and Boisvert 2011
Colebrook 2	Feature	MP	M-N	Charcoal	Beta 258579	AMS	10220 ± 40	11932 ± 128	12000 ± 165	Kitchel and Boisvert 2011
Neponset	Feature	MP	M-N	Charcoal	Beta-75527	AMS	10210 ± 60	11911 ± 156	11959 ± 252	Ritchie 1994
Templeton	Feature	MP	M-N	Charcoal	W-3931	SRC	10190 ± 300	11895 ± 497	11970 ± 811	Moeller 1980
Cormier	Feature	MP	C-N	Charcoal	Beta-126645	AMS	10210 ± 90	11911 ± 228	11963 ± 486	Bradley et al. 2008
Esker	Feature	MP	C-N	Charcoal	Beta-103284	AMS	10110 ± 70	11704 ± 215	11760 ± 327	Bradley et al. 2008
Weirs Beach	Feature	LP	Plano	Charcoal	GX-4569	SRC	9615 ± 225	10943 ± 298	11056 ± 710	Bradley et al. 2008
Varney Farm	Feature #3	LP	Ste. A-V	Charcoal	Beta-79658	SRC	9410 ± 190	10717 ± 293	10780 ± 469	Petersen et al. 2000
Varney Farm	Feature #3	LP	Ste. A-V	Charcoal	Beta-88673	AMS	8700 ± 60	9686 ± 95	9783 ± 173	Petersen et al. 2000
Varney Farm	Feature #3	LP	Ste. A-V	Charcoal	Beta-93001	AMS	8620 ± 60	9607 ± 58	9681 ± 122	Petersen et al. 2000
Varney Farm	Feature #3	LP	Ste. A-V	Charcoal	Beta-81250	AMS	8430 ± 100	9408 ± 99	9412 ± 211	Petersen et al. 2000
Varney Farm	Feature #3	LP	Ste. A-V	Charcoal	Beta-88674	AMS	8420 ± 60	9426 ± 70	9484 ± 114	Petersen et al. 2000
Varney Farm	Feature #3	LP	Ste. A-V	Charcoal	Beta-81251	AMS	8310 ± 100	9289 ± 133	9329 ± 230	Petersen et al. 2000

Note: EP, MP, LP = early, middle, and Late Paleoindian; BB-WAH = Bull Brook-West Athens Hill; M-N = Michaud–Neponset; Ste. A-V = Ste. Anne–Varney; SRC = standard radiometric counting; AMS = accelerator mass spectrometry

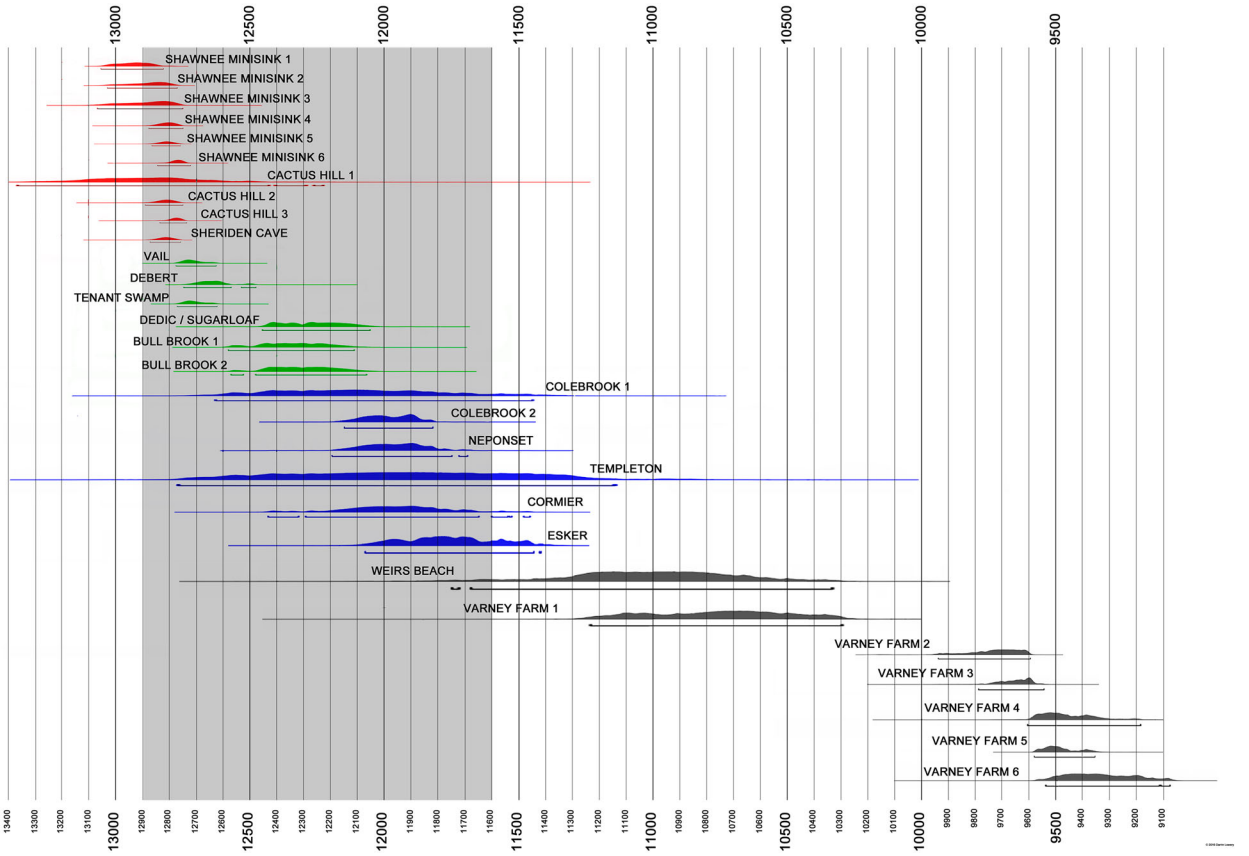

Figure 12 Plot of 29 accepted age determinations on Paleoindian sites in northeastern North America, calibrated using IntCal13 (OxCal 4.2), and plotted at one and two sigma, with shaded area approximating duration of YD. Red: Clovis point-affiliated dates; Green: Post-Clovis, Early Paleoindian point dates; Blue: Middle Paleoindian dates (Michaud–Neponset point sites: Colebrook, Neponset, and Templeton. Cormier–Nicholas point sites: Cormier and Esker); Black: Late Paleoindian dates ("Plano" point site: Weirs Beach. Ste. Anne–Varney point site: Varney Farm). Horizontal axis is in cal yr BP.

Summarized in many publications (e.g., Adovasio and Pedler 2004, 2014; Adovasio et al. 1979, 1980, 1990; Carlisle and Adovasio 1982), questions persist as to the chronology of human occupation, and the nature of faunal, botanical, and artifact assemblages attributed to the late Pleistocene occupations at the site. Regarding chronology, researchers have raised questions about the radiocarbon date suite and the potential for groundwater coal contamination (Haynes 1980; Tankersley and Munson 1992). Adovasio and colleagues dismiss this notion (Adovasio and Pedler 2014), and soil micromorphology analysis indicates no evidence for groundwater effects (Goldberg and Arpin 1999), suggesting the original sequence of radiocarbon dates is valid. Adovasio and Pedler (2014) provide for the first time calibrated determinations of the radiocarbon sequence at Meadowcroft (Adovasio and Pedler 2014, table 1, figure 5). The original radiocarbon determinations, obtained using standard radiometric counting in the late 1970s and early 1980s, range from $11,300 \pm 700$ ^{14}C yr BP for middle Stratum IIa to $21,070 \pm 475$ ^{14}C yr BP for the base of lower Stratum IIa. Calibrated at one sigma, these youngest and oldest dates extend from 13,606–9311 cal yr BC, to 24,690–22,098 cal yr BC. The single diagnostic biface reported for the early occupations — the Miller lanceolate point — "was found in situ on the uppermost living floor of lower stratum IIa […] This floor is dated by bracketing radiocarbon assays above and below it of $11,300 \pm 700$ ^{14}C yr BP (circa 13,350 cal yr BP) and $12,800 \pm 870$ ^{14}C yr BP (circa 15,250 cal yr BP)" (Adovasio and Pedler 2004, 149). As Fiedel (2013, 336–337) notes, however, if the Miller point is most closely associated with the youngest determination, then at two standard deviations this biface could actually date as late as circa 10,000 ^{14}C yr BP.

First advocated by Haynes (1991), the broad spans of several calibrated ages for Stratum IIa provide a compelling rationale to re-date Meadowcroft (Fiedel 2013, 340; Lothrop 2015, 254; Madsen 2015, 235). AMS assays would greatly increase the precision of the rockshelter's radiocarbon chronology, thereby clarifying the ages and periodicity of the earliest occupations, and would help address questions on the potential effects of intrusive later cultural features and rodent burrows on the rockshelter's chronology (Fiedel 2013, 340; Haynes 2015, 139; Kelly 1987).

Table 4
Pre-Clovis site candidates in northeastern North America

Site and location	Physiographic setting/ host landform	Cultural evidence	^{14}C dates (^{14}C yr BP)	Issues	Key references
Meadowcroft Washington Co., PA	Appalachian plateaus/ rockshelter	Mid-Lower IIA assemblage: Chert tools, blades and debitage	Range: 11,300 ± 700 to 21,070 ± 475	– Precision of radiocarbon dates; – Carolinian floral and faunal assemblages; – Age associations and variance of artifacts between levels	Adovasio and Pedler 2004, 2014; Adovasio et al. 1990; Carlisle and Adovasio 1982
Burning Tree Mastodon Licking County, OH	Appalachian plateaus/ kettle pond	Cut and gouge marks on post-cranial elements; Nonlocal sediment on bones	"Gut contents": 11,450 ± 70 11,660 ± 120 Bone: 11,390 ± 80	– Age: Early Paleoindian or pre-Clovis? – Absence of stone tools; – Taphonomy of cut/gouge marks on bone	Fisher et al. 1994; Lepper et al. 1991
Mitchell Farm New Castle Co., DE	Appalachian plateaus/ sinkhole	Quartz debitage	11,530 ± 400	– Age: Early Paleoindian or pre-Clovis?	Custer 1989
Barton Allegheny Co., MD	Appalachian plateaus/ terrace	Biface, overshot and other flakes, scraper, near basin Fea.136	14,250 ± 70 and 4040 ± 40 (Feature 136)	– Age of deeply buried, AMS-dated feature and associated artifacts	Wall 2008
Cinmar, VA	Coastal plain (Continental shelf)/ Terrace of LGM Susquehanna Va.	Bipoint biface, mastodon elements	Tusk: 22,760 ± 90	– Association of biface and mastodon	Stanford et al. 2014
Cactus Hill Sussex County, VA	Coastal Plain/terrace	Lanceolate points, blades, blade cores, debitage, calcined bone	Feature 6F1: 15,070 ± 70 Feature 9F1: 14,180 ± 80 Feature 10 F1: 16,670 ± 730	– Shallow vertical separation of pre-Clovis and Early Paleoindian components	McAvoy and McAvoy 2015
Miles Point Talbot County, MD	Coastal plain/uplands	Lanceolate point, polyhedral blade core, blades bipolar core/wedge, anvil, top of 2Btxb horizon	Date range, overlying 2ABtxb horizon: 21,490 ± 140 to 27,240 ± 230	– Dates likely reflect environmental organic-carbon from multiple sources	Lowery et al. 2010
Parson's Island Talbot County, MD	Coastal plain/uplands	Lanceolate points, bipoint bifaces, utilized flakes and blades, unifacial shouldered blades, hammerstones	Associated 4ab1 horizon: 17,133 ± 88	– Date likely reflects environmental organic-carbon from multiple sources	This paper

Re-dating of Meadowcroft would also address other outstanding issues, including: (1) the Holocene (Carolinian) character of the faunal and botanical assemblages in mid-lower Stratum IIA (Fiedel 2013, 340–342; Mead 1980), as well as (2) a more precise age determination for the Miller point (noted by Ellis (2004b, 71) to be similar to late Paleoindian Hi-Lo points of the EGL) and prismatic blades reported to be stratigraphically associated with the Miller point (blades also co-occur with Hi-Lo points in the Great Lakes [Ellis 2004b, 64–67]). Re-dating, along with issuance of a final report remain keys to clarifying the role of Meadowcroft in the early peopling of the Northeast (Fiedel 2013, 342; Madsen 2015, 235–236).

4.2 Burning Tree Mastodon

The Burning Tree mastodon was discovered in 1989 during dragline excavation of a peat bog (a former post-glacial pond) in Newark, Ohio (Fisher et al. 1994; Lepper et al. 1991). Subsequent excavations revealed a nearly complete skeleton, lacking long bones of the right hind limb and distributed in three spatial clusters. Non-coniferous twigs and organic matter were interpreted as gut contents, yielding AMS radiocarbon dates of $11{,}660 \pm 120$ ^{14}C yr BP (Beta-38241/ETH-6758) and $11{,}450 \pm 70$ ^{14}C yr BP (Pitt-0832), while bone collagen produced a determination of $11{,}390 \pm 80$ ^{14}C yr BP (NSRL-283/AA-6980). Excavations did not recover any stone tools, flakes or other artifacts. The investigators report the presence of: (1) cut and gouge marks on several elements (indicated as not "fresh," i.e., resulting from excavation), (2) coarse nonlocal sediment on some of the elements, and (3) striations on some elements. The investigators propose that humans dismembered the Burning Tree mastodon at a nearby kill site, carried or dragged carcass units to the pond margin, and deposited these as a winter meat cache (Fisher et al. 1994). Additional taphonomic analysis of elements could shed further light on this interpretation, while the apparent absence of stone tools or other artifacts remains a concern (Haynes 2015, 148).

4.3 Mitchell Farm site (7NC-A-2)

The Mitchell Farm site, situated in a Piedmont setting near Hockessin, Delaware, consists of a surface artifact scatter in a plowed field, as well as artifacts found in a sinkhole (Custer 1989, 104). Surface finds of three fluted points on a tilled field adjacent to the sinkhole prompted test excavations. Although most of the archaeological artifacts were confined to the plow zone, testing in the sinkhole recovered quartz flakes in a buried stratum. Charcoal in the soil horizon overlying the excavated assemblage of quartz flakes produced an AMS age of $11{,}530 \pm 400$ ^{14}C yr BP or $13{,}529 \pm 461$ cal yr BP (UGa-2343). The use of quartz as a toolstone at Mitchell Farm contrasts with the more common early Paleoindian emphasis on cherts and jaspers (e.g., Carr and Adovasio 2002; Lowery 2002). The Mitchell Farm data are noteworthy because they suggest either a very early Clovis component or a pre-Clovis presence in this northern portion of the Delmarva Peninsula.

4.4 Barton

The Barton site is situated on a terrace of the Potomac River in the Ridge and Valley region of western Maryland. Ongoing archaeological excavations since 1993 have included deep testing (Wall 2008; Robert D. Wall, personal communication to Jonathan C. Lothrop, 2015). This work has recovered a probable early Archaic serrated point fragment in Level 11, and in the deepest cultural layers (levels 16–18), evidence of possible Pleistocene occupations in argillic horizons at 1.4 m below surface. Artifacts from this early component include debitage of local chert (soft hammer and overshot flakes), a large scraper, and a distal biface fragment. At the same stratigraphic position, charcoal from an adjacent hearth (Feature 136) yielded two AMS radiocarbon dates of 4040 ± 40 ^{14}C yr BP (Beta-201186) and $14{,}250 \pm 70$ ^{14}C yr BP (Beta-201187). Hopefully, future excavations will clarify the age and cultural affiliation of this deep component.

4.5 Cinmar

The Cinmar locality is a submarine find spot on the edge of the outer continental shelf, south of the ancestral Susquehanna paleo river valley (Stanford et al. 2014). In 1974, while dragging for scallops, the trawler *Cinmar* recovered a mastodon skull and biface together in spoil dredged from a single run. Based on regional sea level curves, this find spot was last exposed from approximately 25,000 to 14,500 cal yr BP. The biface and portions of the tusks and teeth were retained, and some of these items were later curated on display at a small regional museum. Collagen from tusk fragments has yielded an AMS date of $22{,}760 \pm 90$ ^{14}C yr BP (UCIAMS-53545). The biface displays a laurel leaf or bipoint shape in plan view, and use wear analysis points to possible use as a hafted knife for butchering. The biface was manufactured of meta-rhyolite, and XRF sourcing analysis indicates a likely source to the northwest in the middle Susquehanna drainage, in or near south-central Pennsylvania. Based on the circumstances of recovery, the investigators suggest a likely association of the mastodon skull and biface. Although details of this discovery have been questioned (Eren et al. 2015), the basic elements of this find, as outlined here, are accurate.

4.6 Cactus Hill

The Cactus Hill site is located in southeastern Virginia's Inner Coastal Plain. The host landform for the site is a relic sand dune, resting on an abandoned terrace of the Nottaway River. Excavations of the earliest components at the site sampled stratified deposits containing Clovis and apparent pre-Clovis components beneath Archaic and Woodland occupations (McAvoy and McAvoy 1997, 2015, 211–420).

Pedological studies of the site report that the pre-Clovis and Clovis component materials lie in the lower and upper portions of the 2BAb horizon of the second soil sequence at the site that formed in aeolian sands (Wagner and McAvoy 2004). Artifacts of these respective components are variously described as separated by 7-to-20 cm of sterile sands (Wagner and McAvoy 2004, 313), or separated by 7-to-15 cm (Feathers et al. 2006, 167). Wagner and McAvoy's (2004) site formation model concludes that the vertical separation of the pre-Clovis and Clovis components resulted from burial of the former by aeolian deposition, although they cannot exclude the possibility "that pedoturbation processes accomplished the shallow burial of the blade artifacts before the arrival of the Clovis inhabitants" (Wagner and McAvoy 2004, 313–314). They conclude that the vertical relationship of the cultural components in the soil sequences "demonstrate a high degree of deposit integrity in which coherent layers have been preserved in stable, buried contexts" (Wagner and McAvoy 2004, 320).

As reported in McAvoy and McAvoy (2015, 355–371), identified cultural features in Area B at Cactus Hill produced radiocarbon dates on the Clovis/early Paleoindian component of 10,920 ± 250 ^{14}C yr BP, 10,910 ± 40 ^{14}C yr BP, and 10,840 ± 40 ^{14}C yr BP. In the pre-Clovis component, two hearth-like features yielded accepted dates of 15,070 ± 70 ^{14}C yr BP (18,680–18,050 cal yr BP), and 14,180 ± 80 ^{14}C yr BP (17,350–16,510 cal yr BP) (McAvoy and McAvoy 2015, 600–601, table 5.8). OSL determinations at Cactus Hill "are broadly in agreement with the radiocarbon ages," and seem "to confirm the overall integrity of the strata" (Feathers et al. 2006, 167). Others have expressed concerns, particularly with the shallow separation of early Paleoindian and pre-Clovis components, and indicators of downward drift of artifacts and/or botanical materials (Fiedel 2013, 343–344; Haynes 2015, 237), but the investigators of Cactus Hill are to be commended for assembling multiple lines of evidence to assess stratigraphic integrity.

The pre-Clovis component lithic assemblage at Cactus Hill is represented by stone tools and debris manufactured mostly of river cobble quartzite, rhyolite, and meta-rhyolite — a marked contrast to the emphasis on cherts and jaspers for Clovis components in Virginia. The artifact assemblage is reported to include small lanceolate bifaces with basal thinning, and evidence for a blade industry that includes polyhedral blade cores and tools (unifacial end and side scrapers, "snapped-blade" burins) and abrading and grinding tools (McAvoy and McAvoy 2015, 392). Based on the limited radiocarbon dates obtained, McAvoy and McAvoy suggest two possible periods of pre-Clovis occupation at Cactus Hill, dating to circa 14,500–15,500 and 16,500–18,700 cal yr BP (McAvoy and McAvoy 2015, 600–601).

4.7 Miles Point and Parson's Island

The Miles Point site, located on the western shore of the Delmarva Peninsula (see Figure 3) was identified during Phase I archaeological survey of the surrounding property (Lowery 2007). The eroded bank profile associated with this property consisted of two distinct loess deposits and a paleosol (see Lowery 2009; Wah et al. 2014). Artifacts, consisting of an anvil, two hammerstones, several utilized flakes, a core, and a bifacial lanceolate projectile point, were found at the base of the paleosol. Charcoal from the paleosol produced four AMS dates, ranging from 21,490 ± 140 to 27,240 ± 230 ^{14}C yr BP (with calibrated estimates from circa 25,000 to 32,000 cal yr BP) (Lowery et al. 2010). The AMS results would imply that charcoal from this 19-cm-thick paleosol encompassed a time frame spanning circa 7000 cal yr. The large range of dates associated with this paleosol and the associated archaeological remains were perplexing, but subsequent discoveries at Parson's Island (located circa 13 km to the northwest) have shed light on this issue.

Unlike Miles Point, Parson's Island encompasses over 1300 m of an exposed shoreline bank profile. A single paleosol, similar to the example noted at Miles Point, also occurs along portions of the eroding shoreline at Parson's Island (Figure 13B). Charcoal from this single paleosol produced an AMS age of 27,897 ± 171 ^{14}C yr BP (32,411 ± 298 cal yr BP). Another bank profile section of Parson's Island includes four stratified paleosols (see Figures 13A and 14C). These stratified paleosols were sampled along a vertical column and yielded radiocarbon dates at the following gaps:

- 298 cm — 4Ab1 paleosol: 23,403 ± 114 ^{14}C yr BP (28,175 ± 177 cal yr BP);
- 310 cm — 4Ab2 paleosol: 25,125 ± 141 ^{14}C yr BP (30,054 ± 248 cal yr BP);
- 342 cm — 5Ab paleosol: 30,689 ± 202 ^{14}C yr BP (34,850 ± 348 cal yr BP);
- 370 cm — 6Ab paleosol: 36,308 ± 258 ^{14}C yr BP (41,519 ± 285 cal yr BP).

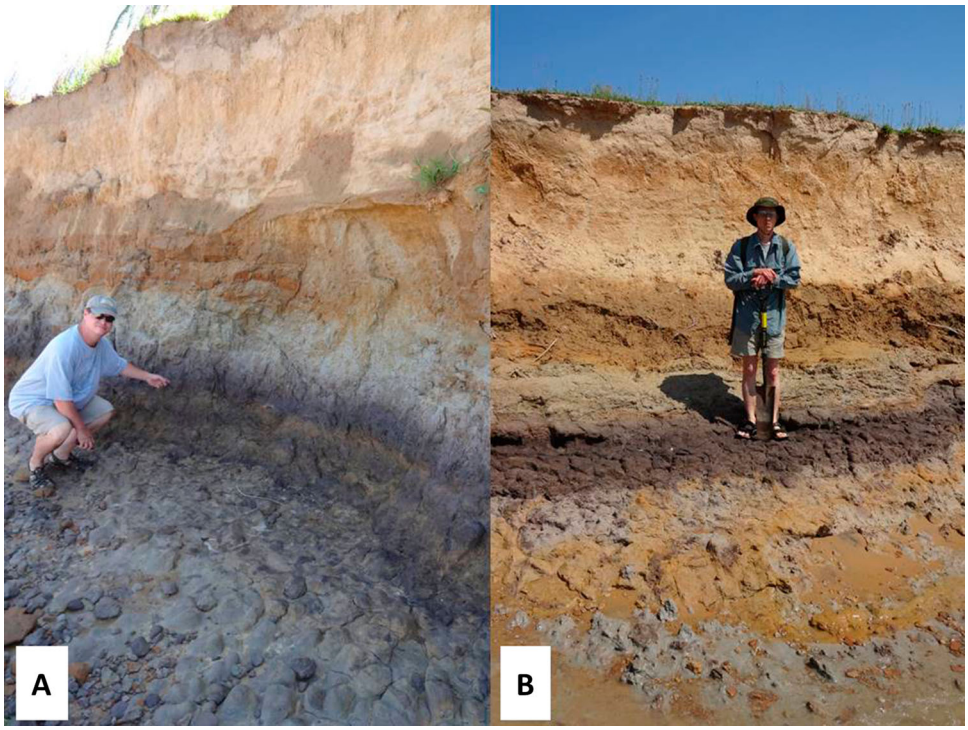

Figure 13 Views of two bank profiles along the eroded shoreline at Parson's Island, Maryland. Some sections show evidence of multiple stratified paleosols (A). At approximately 50 m to the south, the multiple paleosols merge and become what seems to be a single paleosol (B).

The average of all the above dated stratified paleosols shown in Figure 13A is 28,881 ± 178 ^{14}C yr BP (33,398 ± 352 cal yr BP). Just 50 m south of the section shown in Figures 13A and 14C, the four paleosols merge and become what seems to be a single paleosol (see Figure 13B). (As noted, an AMS age estimate of 27,897 ± 171 ^{14}C yr BP (32,411 ± 298 cal yr BP) was generated for a sample from this single or merged paleosol).

Approximately 180 m north of this sampling location, and at a depth of 225 cm, four lithic artifacts were in the exposed bank profile, firmly embedded in the 4Ab1 paleosol (Figure 15). The four artifacts include two bipoint bifaces and two utilized blades. A sample containing charcoal collected above the in situ biface illustrated in Figure 16C produced an age estimate of 17,133 ± 88 ^{14}C yr BP (20,525 ± 341 cal yr BP) (see Figure 14B). Note that the calibrated ages for this 4Ab1 paleosol along the extended bank profile at Parson's Island span circa 8000 years (see Figure 14B and C).

Although eroded out of context, over 40 additional lithic artifacts have been found since 2013 along a circa 20-m section of the shoreline that coincides with the embedded or in situ assemblage. The displaced assemblage includes five additional bipoint bifaces (Figure 16A–D), five small basally thinned lanceolate bifaces (Figure 16E and F), three small lanceolate biface basal fragments, one late-stage lanceolate preform, one late-stage bipoint preform, three biface distal fragments, four additional utilized blades (Figure 12M), eight utilized flakes (Figure 16H–J), one small end scraper on a prismatic blade (Figure 16G), two unifacial "shouldered" blades (Figure 16K and L), two hammerstones, one anvil, and over 20 small flakes. One of the displaced artifacts (Figure 16L) was associated with a dislodged columnar ped and found firmly embedded within the 4Ab1 paleosol. Notably, the lanceolate points found at Parson's Island are similar in size and shape to the single specimen found at Miles Point (see Figure 9C–E). Aside from the previously mentioned artifact cluster, multiple re-examinations of the shoreline at Parson's Island since 2013 have revealed no additional prehistoric sites or any evidence for a later prehistoric occupation. As such, both the in situ and the displaced assemblages can be viewed as a single archaeological site or component.

Analysis of the Parson's Island data provides some insights into the age differences noted for the paleosol at Miles Point (see Figure 14). The data from Parson's Island would imply that locations on the Delmarva Peninsula containing a single paleosol (like Miles Point), actually represent merged or welded paleosols that contain accumulated mixtures of charcoal spanning MIS 3 through MIS 2. It would seem that the northern hemisphere climate during this era may have hindered the decay of organic-carbon. As such, the circa 7000-year age discrepancy noted at Miles Point seems to be a byproduct of charcoal-age averaging. As such, the true age of the archaeological

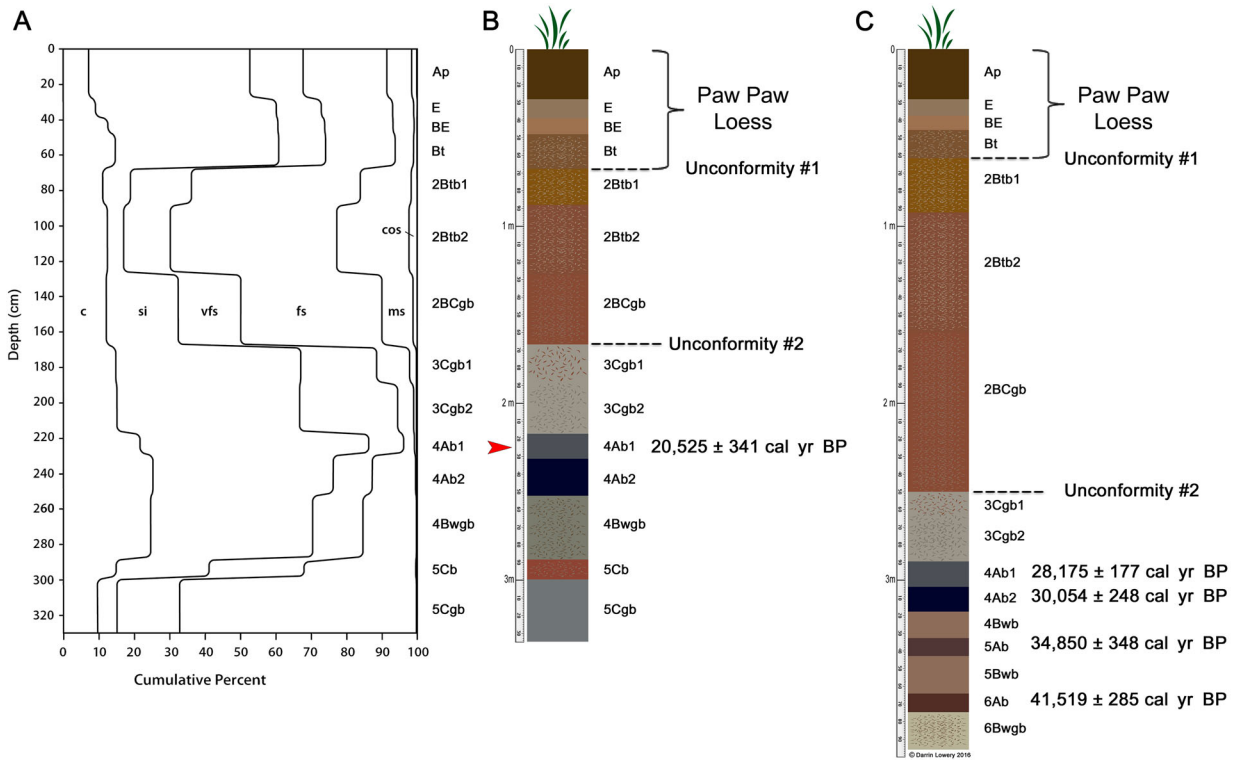

Figure 14 Particle size analysis (A) conducted at Parson's Island site for the area associated with the in situ artifact assemblage. Bank profile (B) graphically illustrates the soil horizons associated with the in situ artifact cluster. YD-age loess or Paw Paw loess (0–68 cm) brackets a regionally recognized unconformity (Unconformity #1) or "Clovis-lag" surface. Within the various aeolian strata, a marked wind velocity change is recorded by yet another unconformity (Unconformity #2). The in situ assemblage at Parson's Island, associated with the 4Ab1 paleosol, was AMS-dated to 20,525 ± 341 cal yr BP; these archaeological remains are buried circa 1.5 m below the Clovis-lag surface. Approximately 180 m south of the archaeological cluster, the bank profile (C) contains multiple stratified paleosols that have been dated between 41,519 and 28,175 cal yr BP.

assemblage found at Miles Point is unlikely to be rectified unless an associated cultural feature containing charcoal (i.e., hearth) is discovered.

Determining the true age of the assemblage found at Parson's Island may also be hindered by the averaging of accumulated environmental organic-carbon within the 4Ab1 paleosol. The AMS radiocarbon date generated on charcoal collected above the bipoint biface (see Figure 16C) within the 4Ab1 paleosol was 17,133 ± 88 ^{14}C yr BP or 20,525 ± 341 cal yr BP. However, 180 m south of the archaeological site, the same 4Ab1 paleosol provided an AMS age estimate of 23,403 ± 114 ^{14}C

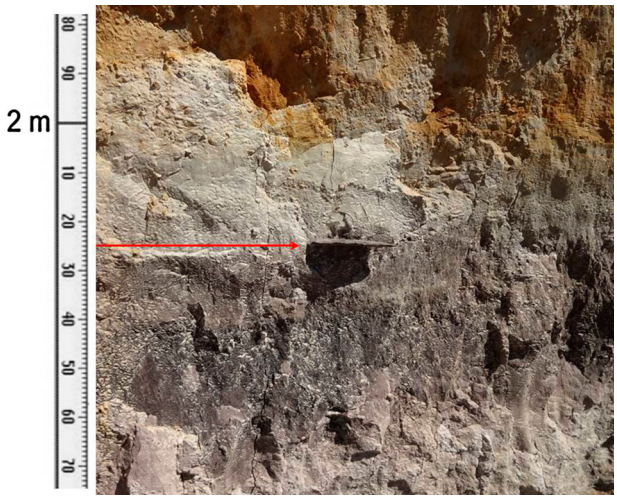

Figure 15 Side view of a bipoint biface, firmly embedded within the 4Ab1 paleosol at Parson's Island site. Since 2013, several additional artifacts have been found embedded within the 4Ab1 paleosol along a circa 20-m section of the eroded shoreline. Established benchmarks and monitoring indicate that the shoreline at Parson's Island is eroding at a rate of circa 270 cm per year.

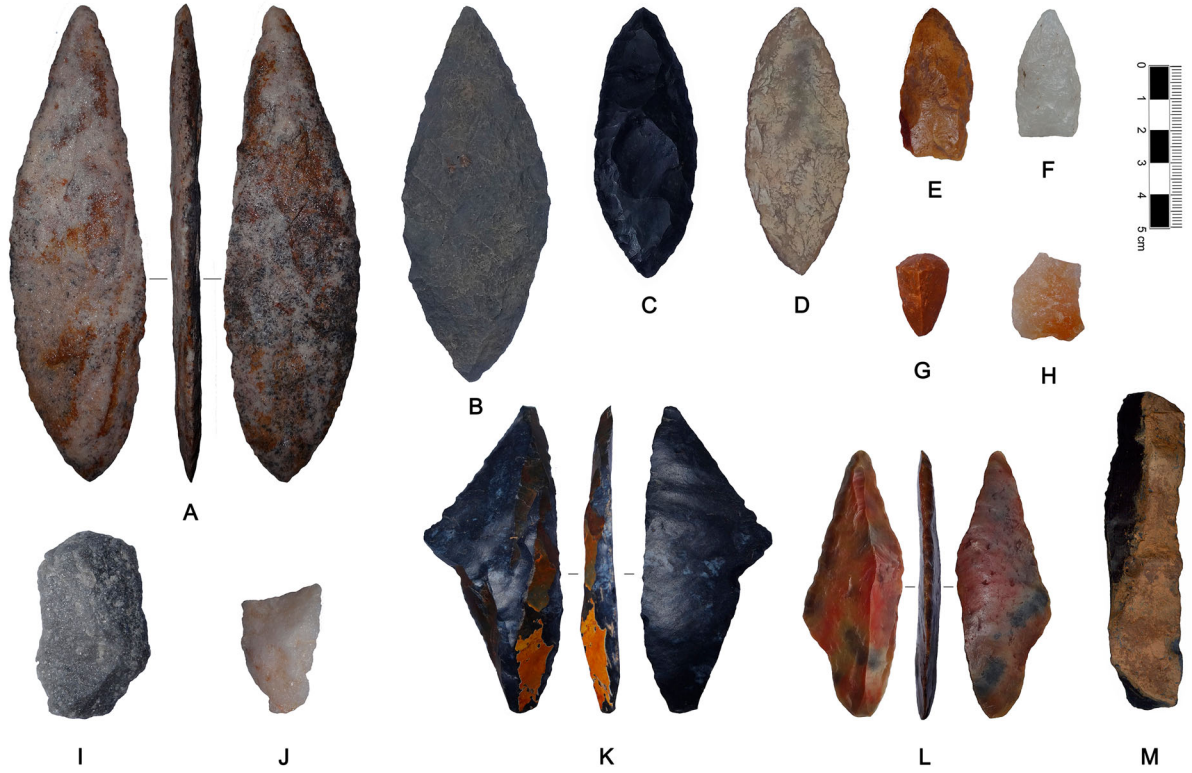

Figure 16 Examples of artifacts found at the Parson's Island site: A: Bipoint biface, Cretaceous Magothy Formation quartzite; B: Bipoint biface, quartzite; C: Bipoint biface, chert (found in situ); D: Bipoint biface, meta-rhyolite (patinated); E: Small lanceolate, chalcedony (with rounded cobble cortex); F: Small lanceolate, quartz; G: Small End scraper, jasper (made on a true blade); H: Utilized Flake, quartz; I: Utilized Flake, quartzite; J: Utilized Flake quartz; K: Shouldered Uniface, chert; L: Shouldered Uniface, chalcedony; M: Utilized Blade, cobble chert (note cortex). Note: Specimen C was found in situ within the 4Ab1 paleosol (see Figure 14B). Charcoal collected above this in-situ biface produced an age estimate of 17,133 ± 88 ^{14}C yr BP or 20,525 ± 341 cal yr BP.

yr BP or 28,175 ± 177 cal yr BP. Similar to the Miles Point situation, it would seem that the 4Ab1 paleosol at Parson's Island contains an amalgamation of environmental organic-carbon spanning at least 8000 years.

In contrast to Miles Point, however, the in situ Parson's Island archaeological assemblage is positioned circa 1.5 m beneath the regionally recognized Clovis-lag surface or unconformity and the region's YD-age Paw Paw loess (Lowery et al. 2010). We note that the pedogenically developed strata above the in situ archaeological material and beneath the YD-age Paw Paw loess at Parson's Island contain some pop-down tension wedges, which are the result of isostatic transpression or squeezing (see van Vliet-Lanoe et al. 2004). Folded fabric and faulted strata (Lowery 2009, figure 5.3) have occasionally been observed within these pre-YD deposits. These distinct isostatic features provide a rough chronological control for the age of the underlying in situ archaeological remains.

Isostasy does provide a means to determine the approximate age of the archaeological assemblage at Parson's Island (Figure 17). The Chesapeake region was impacted by the effects of an isostatic fore bulge as a result of the weight of the Laurentide ice sheet to the north. The pre-YD strata at Parson's Island were all deposited during a protracted period of isostatic uplift when the Laurentide ice sheet was advancing south, reaching its LGM aerial extent 250 km to the north, and during its initial phase of retreat. These fore bulge deposited sediments were ultimately impacted by the isostatic transpression or down-warp squeezing (see van Vliet-Lanoe et al. 2004). The sea level record (see Lowery et al. 2012) suggests that the Delmarva/Middle Atlantic region was impacted by the effects of fore bulge or crustal uplift prior to circa 18,000 cal yr BP and isostatic depression or crustal down-warping began circa 18,000 cal yr BP and persisted until circa 8500 cal yr BP (see Figure 17). River bedrock incision data for the lower stretches of both the Susquehanna and Potomac rivers (see Reusser et al. 2004) suggest that isostatic depression or down-warping began prior to 14,500 cal yr BP. With these rough chronological controls, we can say that the in situ archaeological remains at Parson's Island likely date to circa 14,500 cal yr BP or older. Based on this review, the research at Parson's Island and Miles Point provides a cautionary tale about the use of environmental organic-carbon as a means to determine the true antiquity of pre-YD archaeological remains.

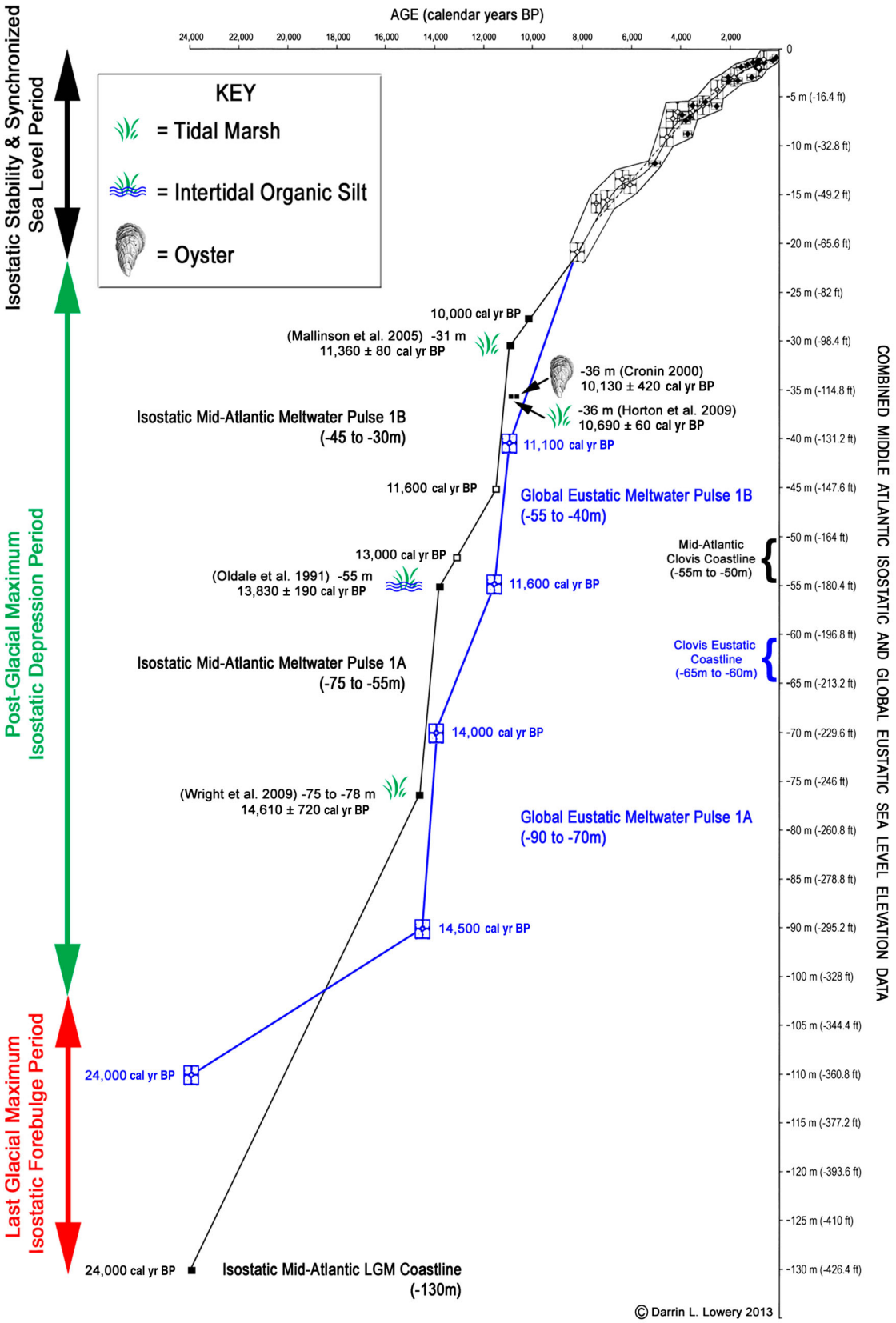

Figure 17 Comparison of Middle Atlantic sea level curve (blue) and the eustatic sea level curve (black), from LGM (24,000 cal yr BP) to present. The Delmarva/Middle Atlantic region was impacted by the effects of forebulge or crustal uplift prior to circa 18,000 cal yr BP. Isostatic depression or crustal down-warping began circa 18,000 cal yr BP and persisted until 8500 cal yr BP. Using near-shore benchmarks, such as dated tidal marsh peat and shellfish (Cronin 2000; Horton et al. 2009; Mallinson et al. 2005; Oldale et al. 1991; Wright et al. 2009), the region was subjected to $\geq$ 15 m of crustal down-warping during the post-glacial maximum isostatic depression period.

4.8 Discussion

As with pre-Clovis candidate sites reported elsewhere, a common concern for the eight sites in the Northeast is absolute dating and age associations. In the case of Burning Tree mastodon, human agency also remains a question. Cactus Hill, Miles Point, and Parson's Island currently present the strongest cases for a pre-Clovis occupation in the Northeast. All three sites are located on the mid-Atlantic coastal plain and have yielded stone tool assemblages that include small lanceolate points with basal thinning and evidence of blade core-based technologies. In the case of Parson's Island, laurel leaf-shaped bipoints also appear to constitute an element of the toolkit represented there. Dating of the pre-Clovis components at these three sites remains a concern, although radiocarbon assays from apparent cultural features at Cactus Hill suggest occupations between 18,680–18,050 and 17,350–16,510 cal yr BP, while geological context at Parson's Island suggests the pre-Clovis component dates to 14,500 cal yr BP or older. Hopefully, future investigations at Parson's Island will identify cultural features that can support radiometric dating of its pre-Clovis occupation.

The respective age assessments for the pre-Clovis components at Parson's Island and Cactus Hill suggest occupations in the mid-Atlantic region at or before circa 14,500 cal yr BP for Parson's Island, and circa 18,680–18,050 and 17,350–16,510 cal yr BP for Cactus Hill. If these tentative age estimations are fundamentally correct, this would indicate a human presence at one or more times on the southern mid-Atlantic Coastal Plain, predating Clovis by over 1000 calendar years. Current evidence does not show whether these early colonizing episodes(s) were successful (i.e., resulting in long-term occupations extending into the YD), or instead represent one or more failed peopling events.

5. Early Paleoindian in the Northeast

Current views on the geographic origin and age span of Clovis bear on scenarios for human colonization of northeastern North America. Most researchers currently favor an in situ model for the origins of Clovis technology, after which late Pleistocene populations with this technology colonized North America (rather than Clovis technology diffusing to extant populations) (Haynes 2013, 364). For example, Broster et al. (2013, 303–304) argue for a locus of Clovis origins in the Tennessee Valley, while Haynes (2013, 364) advocates a cultural hearthstone along the Texas-Mexico border.

As noted above, the small suite of acceptable radiocarbon dates on early fluted point sites in the Northeast suggests that Paleoindian groups likely colonized parts of the Northeast circa 13,000 cal yr BP. If the Northeast was settled by immigrant Clovis-era populations, then ice margin positions at circa 13,000 cal yr BP and early Paleoindian site distributions (see Figure 4) suggest that Clovis-affiliated populations likely entered from the west, southwest or south, occupying the southern unglaciated Ohio Valley and mid-Atlantic regions first, followed by migration northward into the deglaciated EGL and NEM.

By this scenario, we assume that exploring or in-migrating Clovis groups encountered either uninhabited landscapes or landscapes occupied by human populations at such low densities that they left little-to-no discernible archaeological signature. The human strategies of wayfinding and landscape learning are relevant to narratives for Paleoindian settlement of the Northeast (Meltzer 2002, 2004; Rockman and Steele 2003). In colonizing situations, Anderson (2012, 242) argues that prehistoric foragers likely used risk-averse strategies as they explored unknown landscapes. Based on ethnography, Kelly (2003, 54) suggests that foragers wayfinding through unfamiliar terrain likely would have relied on easily traceable geographic features such as rivers and mountain ranges. For the Northeast, such features could also have included the shorelines of the late Pleistocene Great Lakes, the Champlain Sea and the Atlantic Ocean.

Anderson's place-oriented staging area model for Paleoindian colonization east of the Mississippi projects the Ohio Valley as the primary conduit for dispersal into the Great Lakes and broader Northeast (Anderson 1990, 1996) (see Figure 1). Alternatively, Anderson and Gillam's (2000) least cost path analysis suggests other colonization routes to the Northeast, including (1) eastward into the Great Lakes from the Mississippi Valley, via the Illinois River Valley, and (2) northward into the mid-Atlantic via the Susquehanna Valley and along the Atlantic coast. The Potomac Valley could have provided westward access from the coast to the interior mid-Atlantic, while valleys of the south-flowing Susquehanna, Delaware, Hudson, Connecticut, Androscoggin, Penobscot, and St. John Rivers all offered potential routes north from the Atlantic coast into the mid-Atlantic and NEM regions (see Figure 1). Formation of the Champlain Sea had rendered the NEM a peninsula, with likely corridors for human entry leading through eastern New York (Lothrop and Bradley 2012). Newby and Bradley (2007) suggest a "northern corridor" along the southern shore of early Lake Ontario, or a "southern corridor," following the Susquehanna or Delaware drainages upstream to the Hudson Valley.

As to factors making the broader Northeast attractive for human colonization, toolstone was an obvious requirement, and major source outcrops exploited by

Early Paleoindian groups are distributed across the region, as are secondary deposits of cobble toolstone on the Coastal Plain (see Figure 2). As for subsistence resources, paleoenvironmental data and limited faunal recoveries (see Section 5.3) suggest early YD conditions that were attractive for migratory herd caribou in the EGL (Storck and Spiess 1994) and in the NEM (Newby et al. 2005).

Early Paleoindian sites in the Northeast include examples in the Ohio Valley and mid-Atlantic that have yielded fluted points identified as "Clovis," as well as sites in the EGL and NEM that have produced similar forms, some of which clearly postdate Clovis. The most recent age determinations from Bull Brook and DEDIC/Sugarloaf strongly suggest a significant time depth for early Paleoindian occupation in northern, glaciated portions of the Northeast, likely extending till about 12,200 cal yr BP.

5.1 Early Paleoindian settlement

Plotting of early Paleoindian sites (see Figure 4 and Table 5) shows a broad distribution across the Northeast, extending from the Debert-Belmont site cluster in the Minas Basin of Nova Scotia to the middle Ohio Valley of Indiana and Kentucky. However, site locations are clearly not uniform across the region. Higher densities of sites are shown, for example, in southern Ontario (Ellis and Deller 1990, 1997; Storck 1984, 2004) and portions of New England (Bradley et al. 2008; Spiess et al. 1998). By contrast, other parts of the glaciated Northeast appear to be site-poor, a situation that likely reflects discovery bias due to limited research, or natural or cultural factors. For example, the dearth of sites in northern Maine, New Brunswick, and Nova Scotia may reflect low archaeological visibility due to recent dense forest cover.

South of the LGM ice margin, in the western part of the study area, sites appear more common along the Ohio River, and conversely there are few sites recorded in higher elevations of the Appalachian Highlands of Pennsylvania, West Virginia, western Virginia, eastern Kentucky, and southeastern Ohio. This distribution is also reflected in recent PIDBA data plots of early Paleoindian points across the same area (Anderson et al. 2010, figure 2). Seeman and Prufer (1982) suggest that the scarcity of fluted points in southern Ohio reflects Paleoindian land-use patterns that included avoidance of these unglaciated uplands outside the Ohio Valley proper. Further south, Lane and Anderson (2001) and Maggard and Stackelback (2008) propose that the scarcity of fluted point sites on the Appalachian Highlands and Cumberland Plateau is real, perhaps because early Paleoindian groups avoided these higher elevation settings during initial colonization. Miller and Carmody (2016, 93) suggest that Native Americans only established a permanent presence in these Highlands when hardwoods replaced high elevation boreal forests during the early Holocene, "thereby increasing the abundance and diversity of resources available for hunting and gathering."

We also note that in areas of highest elevation on the unglaciated Appalachian Highlands (eastern Kentucky, southern West Virginia, southwestern Virginia), extreme relief and deeply dissected terrain is common. Hence, the lack of recorded early and middle Paleoindian sites in these settings could also reflect taphonomic factors, with suboptimal conditions for early site preservation due to often thin residual soils, and Holocene storm-induced erosional and debris-flow events in upland valleys that alternately could have destroyed or buried early sites (Cremeens and Lothrop 2001). Finally, this patterning may reflect archaeological visibility as well. Ray (2003) records collections from a series of early, middle, and late Paleoindian localities in central Kentucky. Most of these finds appear to consist of point isolates, and at least some could be signals of small, low-visibility occupation sites.

As Figure 4 also shows, there are extensive areas of the Northeast with no recorded sites because they represent former terrestrial landscapes now submerged by the modern Great Lakes (Huron, Erie, and Ontario basins), and extensive areas of the now-submerged Atlantic Continental shelf, from the Chesapeake Bay to the Canadian Maritimes. For example, the locations of the Udora (Figure 4, #12) and Kolapore (#11) sites, situated along the former south shore of Lake Algonquin, suggest that comparable sites could also be present along the now-drowned margins of early lakes Erie and Ontario. Likewise, the location of the early Paleoindian Mahan site (#8) along the southern arm of the Champlain sea in western Vermont (Crock and Robinson 2012; F. Robinson 2012) highlights what we may be missing along the former coast of the late Pleistocene Atlantic.

Differences in site settings and assemblages suggest a range of early Paleoindian site types in the Northeast, including residential encampments, quarry-related sites, caches, and kill/scavenging sites. By far the most common, open-air *residential encampments* generally consist of one or more, small artifact concentrations, yielding a range of exhausted and broken biface and uniface artifact forms. In the glaciated Northeast, most sites measure less than 200 m^2, and in undisturbed contexts, within-site artifact concentrations are small, often measuring no more than 25–50 m^2, and may represent single-family dwelling areas (e.g., Vail [Gramly 1982]). In the EGL, small Gainey point sites are noted in Ontario

Table 5
Early Paleoindian sites in the Northeast (illustrated on Figure 4)

1. Debert-Belmont cluster (Rosenmeier et al. 2012)
2. Upper Wheeler Dam (Gramly 2005)
3. Vail and Adkins (Gramly 1982, 1988)
4. 39.1 (Spiess et al. 1998)
5. Dam (Spiess et al. 1998)
6. Potter (Boisvert 2012)
7. Israel R. cluster (Boisvert 2012)
8. Mahan (Crock and Robinson 2012)
9. Auburn Airport cluster (Spiess et al. 2012)
10. Sebago Point (Spiess et al. 1998)
11. Kolapore (Ellis and Deller 1990)
12. Udora (Storck and Spiess 1994)
13. Sandy Ridge (Jackson 1998)
14. Hedden (Spiess et al. 1998)
15. Halstead (Jackson 1998)
16. Spiller Farm (Spiess et al. 1998)
17. Potts (Lothrop 1989)
18. Toad Harbor (Lothrop et al. 2016)
19. Thornton's Ferry (Boisvert 2012)
20. Bull Brook (Robinson et al. 2009)
21. Haunted Hill (Ellis and Deller 1990)
22. Whipple (Curran 1984)
23. Cordtaipe (Funk and Wellman 1984)
24. Hiscock (Laub 2003)
25. Arc (Tankersley et al. 1997)
26. Uniondale (Ellis and Deller 1990)
27. Turners Falls (Spiess et al. 1998)
28. Lamb (Gramly 1999)
29. Ward (Ellis and Deller 1990)
30. DEDIC/Sugarloaf (Gramly 2014)
31. Hatt (This paper)
32. Leavitt (Shott 1993)
33. Gainey and Butler (Simons 1997)
34. Culloden Acres (Ellis and Deller 1990)
35. Weed (Ellis and Deller 1990)
36. Murphy (Ellis and Deller 1990)
37. Swale (Lothrop and Bradley 2012)
38. Kings Road (Lothrop and Bradley 2012)
39. Sands of Blackstone (Leveilee and Cox 2012)
40. Ferguson (Ellis and Deller 1990)
41. Rail Road #1 (Lothrop and Bradley 2012)
42. West Athens Hill (Funk 2004)
43. Green-Pauler (This paper)
44. Wapanucket #8 (Bradley and Boudreau 2008)
45. Snary (Ellis and Deller 1990)
46. Kilmer (Tankersley et al. 1996)
47. 36Br151 (Lothrop and Bradley 2012)
48. Twin Fields (Lothrop et al. in press)
49. James Decker (Lothrop et al. in press)
50. Zappavigna (Lothrop et al. in press)
51. Hutt Farm (Lothrop et al. in press)
52. Warrior Spring (Fogelman and Lantz 2006)
53. Soon's Orchard (Lothrop et al. in press)
54. Allen's Meadows (Spiess et al. 1998)
55. Zierdt (Werner 1964)
56. Shawnee-Minisink (Gingerich 2013b)
57. Valentine (White 2006)
58. Poirier (Lothrop et al. in press)
59. Kellogg (Kellogg 2003)
60. Paleo Crossing (Eren et al. in press)
61. Kellogg Farm (Carr and Adovasio 2002)
62. Plenge (Gingerich 2013b)
63. Snyder (Stewart and Rankin in press)
64. Port Mobil (Bradley et al. 2008)
65. Sheriden Cave (Waters et al. 2009)
66. Nobles Pond (Seeman in press)
67. Shoop (Carr et al. 2013a)
68. 36La336 (Carr and Adovasio 2002)
69. Saginaw (Fogelman and Lantz 2006)
70. Welling (Prufer and Wright 1970)
71. Higgins (Blong 2013)
72. Potter's Landing (Lowery and Stanford 2013)
73. Thunderbird (Carr et al. 2013b)
74. Fifty (Carr et al. 2013b)
75. Paw Paw Cove (Lowery and Stanford 2013)
76. 33MS391 (Lothrop and Cremeens 2010)
77. Gumboro (Lowery and Stanford 2013)
78. Big Bone Lick (Tankersley et al. 2009)
79. Twilley (Lowery and Stanford 2013)
80. Long Marshes (Lowery and Stanford 2013)
81. Sandy Springs (Seeman et al. 1994)
82. Schafer (Tankersley et al. 1990)
83. Randall (Tankersley et al. 1990)
84. Mary Ann Cole (Tankersley et al. 1990)
85. Raaf (Tankersley et al. 1990)
86. Little Mosquito Creek (Tankersley et al. 1990)
87. Zimmerman (Tankersley et al. 1990)
88. Newburgh (Tankersley et al. 1990)
89. Rockport (Tankersley et al. 1990)
90. Savage Neck (This paper)
91. 44NH233 (Stanford et al. in press)
92. Joe Priddy (Haag et al. 2014)
93. Williamson (McAvoy and McAvoy 2015)
94. Conover (McAvoy and McAvoy 2015)
95. Cactus Hill (McAvoy and McAvoy 2015)
96. Slade Farm (McAvoy and McAvoy 2015)
97. Quail Springs (McAvoy 1992)
98. Greensville Co. (McAvoy 1992)

and New York (Ellis and Deller 1997, 10; Lothrop 1989). Rare large sites such as Gainey, Butler, Udora, and Nobles Pond consist of from 5 to 12 occupation areas (Seeman 1994; Simons 1997; Storck and Spiess 1994). The NEM sites of Bull Brook, Debert, DEDIC/Sugarloaf and Vail all consist of multi-loci encampments (Gramly 1982, 2014; Robinson et al. 2009; Spiess et al. 1998, 228–230). In the mid-Atlantic, Shoop constitutes another example of a large multi-locus residential site (Carr et al. 2013b). In addition to discrete occupation areas, sectors of some of these sites exhibit extensive artifact distributions that suggest palimpsests of reoccupation, such as at Vail and perhaps Nobles Pond.

Spiess (1984) notes that some large, multi-locus sites may represent single occupation events, perhaps of aggregated bands rather than reoccupations by smaller residential groups. With its 36 non-overlapping artifact loci, Bull Brook comprises the best candidate for this interpretive scenario (Robinson and Ort 2013; Robinson et al. 2009). A notable characteristic of these residential sites, large and small, is the rarity of cultural features such as hearths, highlighting the ephemeral nature of these encampments and their low archaeological visibility.

In the Northeast, *quarry-related sites* are most often associated with the mining and/or reduction of toolstone at source outcrops. Notably, early Paleoindian occupation sites seem to be found more often in

close association with toolstone outcrops compared to later Paleoindian sites (Ellis 2011, 395), a situation which also holds in the Southeast (Anderson et al. 2011, 574). West Athens Hill in eastern New York (Funk 2004) documents reduction of Ordovician cherts in the NEM. In the Ohio Valley, the Welling site in Ohio includes a Paleoindian workshop for the reduction of Upper Mercer chert (Prufer and Wright 1970), and in Kentucky, the Adams, Easel and Reeder sites make up the Little River Clovis workshop complex, associated with St. Genevieve Mississippian cherts (Freeman et al. 1996; Gramly and Yahnig 1991; Sanders 1990). The mid-Atlantic sites of Thunderbird and Fifty record early Paleoindian reduction of Flint Run jasper associated with the Beekmantown formation in the Shenandoah Valley of northern Virginia (Carr et al. 2013b), while the Williamson site is associated with a primary source of chalcedony along the Fall Line in eastern Virginia (Hill 1997; McAvoy and McAvoy 2015, 559–594) (see Figure 2). The West Athens Hill assemblage documents both mining extraction and reduction of toolstone associated with the outcrop of Normanskill chert at this mid-Hudson Valley locality (Funk 2004), and Williamson may record this as well (McAvoy and McAvoy 2015).

In recent years, the Northeast has witnessed discovery of *caches* dating to early and later Paleoindian occupations (Deller et al. 2009). Among historically documented, high-latitude hunter-gatherers, caching of food and equipment is a well-documented practice (Binford 1979; Damas 1984; Helm 1981; Jarvenpa and Brumbach 2006). In these arctic and subarctic environments, the highly seasonal nature of subsistence resources makes caching a risk-reducing adaptive strategy (Stopp 2002). Thus, utilitarian caching by early Paleoindian groups might be expected, especially in northern latitudes of northeastern North America.

Gramly (1988) documents a possible boulder food cache structure at the early Paleoindian Adkins site in northwestern Maine. In addition, researchers have recorded six early Paleoindian stone tool caches at five locations in the glaciated EGL and NEM regions, including Hatt, Udora, Lamb, Green-Pauler (two caches), and DEDIC/Sugarloaf (Table 6). The Udora, Lamb, and DEDIC/Sugarloaf caches appear to be associated with encampments, while the Hatt and Green-Pauler caches are isolated occurrences. The content of these caches ranges from only bifaces (points, preforms) at Lamb, to unifacial tools and tool blanks at Udora, to combinations of forms at Hatt, DEDIC/Sugarloaf, and Green-Pauler. In this respect, these caches show a range of compositional variation similar to Clovis caches west of the Mississippi (Huckell and Kilby 2014; Kilby and Huckell 2013). These Clovis caches are generally viewed as having utilitarian functions, either as evidence of (1) stockpiling imported toolstone during exploratory colonization (Meltzer 2002), versus (2) cyclical/seasonal traverses of known landscapes, including strategic placement of caches (Collins 1999; Kilby and Huckell 2013). Based largely on artifact condition and content, we view these six early Paleoindian caches in the Northeast as likely utilitarian, and depending on raw material suites, could relate to exploratory colonization or post-colonization strategic land-use. That being said, we recognize evidence for Clovis caches with sacred or ritual functions elsewhere in North America (Deller et al. 2009; Kilby and Huckell 2013), and observe that early Paleoindian ritual caches could also be present in the Northeast.

Finally, there are rare examples in the Northeast that likely reflect *kill or scavenging sites*. The Vail site in northwestern Maine consists of a residential area with multiple occupation areas on the east side of the relic channel of the Magalloway River. Upwind, and 250 m west of the site, field investigations in 1980 recovered 12 fluted points and fluted point tip sections in lag deposits on the eroded surface of the Aziscohos Lake impoundment (Gramly 1982). During laboratory analysis, refitting conjoined five of the fluted point tips to bases recovered at the habitation site. Subsequent field investigations located two additional distal fragments of fluted points at a second location, 750 m west of the habitation site. These findings are most easily explained as evidence for ambush hunting of herd animals — most likely caribou — during residential encampments at the Vail site (Gramly 1984).

On the Delmarva Peninsula, the Potters Landing site in Caroline County, Maryland, represents a possible analog to the Vail kill site (Lowery and Stanford 2013, 41). Surface collection at this terrace setting along the Choptank River yielded three fluted points, two with obvious distal impact damage. Although no bone was found, the modified points and absence of flaking debris or other stone tools strongly suggest a kill site.

While multiple Paleoindian sites in the glaciated portions of the Northeast have yielded faunal remains of caribou, cervid, and large mammal (see below), the degree to which early Native Americans may have interacted with, and exploited, mastodon and mammoth remains an open question (Lothrop and Bradley 2012, 36–37). Investigations at the paleontological and archaeological Hiscock site in western New York have recovered the remains of mastodon, stag moose, caribou, and giant beaver from late Pleistocene deposits, with evidence that, minimally, mastodon were attracted to this locality because of salt spring vents (Laub 2003). Excavations also recovered Gainey-like fluted points, a biface fragment, a

Table 6
Comparison of Paleoindian caches in the Northeast

Cache (location)	Point form	Site or isolate	Artifact categories	Cache type	Reference
Early Paleoindian					
Hatt (MI)	(Indet.)	Isolate	Point Bifaces Blanks	Utilitarian	Donald B. Simons, personal communication to Jonathan C. Lothrop (2008)
Udora (ON)	Clovis-like	Site	Unifaces Blanks	Utilitarian	Storck and Tomenchuck (1990)
Lamb (NY)	Clovis-like	Site	Points Preforms	Utilitarian	Gramly (1999)
DEDIC/Sugarloaf (MA)	Clovis-like	Site	Blanks Preforms	Utilitarian	Gramly (1998)
Green-Pauler #1 (NY)	Fluted	Isolate	Point Bifaces Unifaces Blanks	Utilitarian	This paper
Green-Pauler #2 (NY)		Isolate	Bifaces Blanks	Utilitarian	This paper
Middle Paleoindian					
Thedford II (ON)	Barnes	Site	Points Preforms	Utilitarian	Deller and Ellis (1992a)
Crowfield (ON)	Crowfield	Site?	Points Bifaces Unifaces Blanks	Ritual	Deller and Ellis (2011)
Late Paleoindian					
Caradoc (ON)	Hi-Lo	Isolate	Point Bifaces Unifaces Blanks	Ritual	Ellis and Deller (2002)
Thurman Station (NY)	Ste. Anne–Varney-related	Isolate	Large Biface Narrow Bifaces	Ritual	Robinson (2011)
Bass River (MA)	Ste. Anne–Varney	Isolate	Points	Utilitarian?	Bradley et al. (2008)
Meredith (NH)	Ste. Anne–Varney	Isolate	Points	Utilitarian?	Bradley et al. (2008)

probable end scraper haft element, a graver, and a sandstone bead, all discarded into the wetland deposits (Ellis et al. 2003). Especially notable is the presence of notches on the upper blade margins of four of the fluted points. Microwear analysis indicates these modified points may have been used for slicing soft tissue, suggesting that perhaps early Paleoindians visited Hiscock to scavenge dead or dying mastodons or other animals (Ellis et al. 2003). Other resource processing activities may have taken place here as well (Laub and Spiess 2003), but there is no evidence of a nearby associated Paleoindian habitation area at Hiscock.

Looking south to the Delmarva Peninsula, the Gumboro site in Sussex County, Delaware, bears a possible parallel to the Hiscock site (Lowery and Stanford 2013, 38–40). Discovered in a basin that was part of a bald cypress swamp in historic times, surface collection recovered three fluted points, all exhibiting distal impact damage. Two of the points show obvious asymmetric resharpening, perhaps for knife use, superimposed on the distal impact fractures. Reminiscent of Hiscock, one of these points displays an obvious notch flaked onto the opposite blade margin, above the haft area. The landowner reported discovery of a mammoth tooth at this location several decades earlier, and examination of the find confirms a *Mammuthus columbi* identification.

Turning from site types to aspects of land use and interaction, we note how the frequent presence of nonlocal toolstones in Paleoindian assemblages has long prompted researchers to consider such data as potential evidence for the extent and directionality of seasonal mobility, and alternatively as possible indicators for band interaction. Across the glaciated EGL and NEM regions, residual cortical surfaces (i.e., bedding and joint surfaces) on flaked stone artifacts found at early Paleoindian sites suggest these peoples were routinely mining mostly good to high quality toolstone at primary sources of bedded or nodular toolstone (rather than secondary cobble) sources (Burke 2006; Ellis 1989, 2011; Lothrop and Bradley 2012). South of Lake Erie, and in the unglaciated Ohio Valley, toolstone from primary sources dominates early Paleoindian assemblages (e.g., Boulanger et al. 2015; Gramly and Yahnig 1991; Sanders 1990; Seeman 1994; Tankersley 1989, 261–262).

In the unglaciated mid-Atlantic uplands, primary source toolstone appears to dominate most assemblages (e.g., Carr and Adovasio 2002; Carr et al. 2013a, 2013b; Gingerich 2013a, 2013b; Hill 1997).

However, early Paleoindian sites on the Coastal Plain of Virginia and the Delmarva Peninsula represent an entirely different pattern of lithic procurement. In these areas, although primary toolstone sources are available in the nearby Ridge and Valley, Piedmont, Fall Line, and on the Delmarva Peninsula, early Paleoindian groups of the Coastal Plain relied primarily on that region's ubiquitous secondary cobble toolstone (Lowery 2002; McAvoy and McAvoy 1997, 2015). In addition, there is some use of primary sources, including Williamson chalcedony at the Fall Line of Virginia (McAvoy and McAvoy 2015, 559–594), and Eocene orthoquartzite from the Nanjemoy formation on the Coastal Plain (Lowery and Wagner in press).

Most researchers believe that the evidence for Paleoindian lithic procurement in the glaciated Northeast largely entailed direct acquisition during residential occupations at or near lithic sources (Ellis 2011), although direct procurement by logistical task groups has also been proposed (Spiess 2002; Spiess and Wilson 1989). Importantly, excavations at the quarry-related sites of West Athens Hill in the Hudson Valley and Welling in northern Ohio recovered a range of tool forms along with toolstone reduction and manufacturing debris (Funk 2004; Prufer and Wright 1970), suggesting that at these sites, early Paleoindian occupation at these localities consisted of residential encampments rather than visits by logistical task groups.

As others have noted, Paleoindians could have acquired toolstone indirectly, via fluid band memberships or exchange (e.g., Bamforth 2002; Custer and Stewart 1990, 318; Lothrop 1989, 119–123; Lothrop and Bradley 2012, 28; Speth et al. 2013). Meltzer (1989) observes that where toolstone from a distant source occurs on only one tool class in an assemblage (and at low frequencies), this increases the likelihood of indirect acquisition. While caution is warranted, it is nevertheless reasonable to infer that the dominant toolstone in a Paleoindian site assemblage likely reflects direct procurement during seasonal movements (Ellis 2011, 390). Conversely, raw materials present in small, trace-level percentages in assemblages could well represent indirect acquisition.

Based on a sample of 55 early Paleoindian sites, derived primarily from the glaciated Great Lakes and NEM regions, Ellis (2011, figure 3) reports an average straight-line distance of 167 km from site to geologic source of the most common toolstone in an assemblage (with an equally broad standard deviation), and multiple cases of sites situated over 250 km from the dominant toolstone source. In the ethnographic record, the Chipewyan are the only high-latitude group on record to have routinely traveled straight-line distances of over 250 km, without using watercraft (Ellis 2011, 393). While some might suggest that early Paleoindian sites located at distances over 250 km from a toolstone source could represent colonizing rather than seasonal movements (e.g., Eren et al. in press), this seems unlikely because of the extremely low probability of discovering one or more sites that actually represent a colonizing event (Bamforth 2014, 40; Ellis 2011, 389; Snow 1980, 129, 147).

These levels of range mobility for early Paleoindian groups in the glaciated Northeast contrast markedly with evidence for contemporary populations to the south in unglaciated terrain. For northwest Virginia, patterns of toolstone procurement suggest seasonal moves of no more than 75 km in one direction (Custer and Stewart 1990, 316). At early Paleoindian sites found on the Fall Line and Coastal Plain of eastern Virginia, site locations relative to toolstone sources suggest linear seasonal movements measuring circa 80–100 km across (McAvoy 1992, 149; McAvoy and McAvoy 2015, 606). For the mid-Atlantic and Southeast, Gardner (1989, 30–32) and Meltzer (1988, 27–28) link these dominantly local/subregional patterns of early Paleoindian toolstone procurement and low levels of seasonal mobility to closed forest landscapes lacking migratory prey species. Other studies suggest these trends of low mobility for early Paleoindian populations prevail across much of the Southeast (e.g., Smallwood et al. 2015).

Traditionally, archaeologists have assumed that evidence for high mobility by early Paleoindian groups in the glaciated Northeast reflected both a highly seasonal, subarctic resource base, and a life way that may have included caribou herd following strategies (e.g., Snow 1980, 136, 150–152). Others suggest that high mobility for early Paleoindians in the glaciated Northeast and Midwest reflects strategic practices of routinely targeting widely spaced resource patches, while largely ignoring or only minimally exploiting resources on intervening terrain (Koldehoff 1999, 2013, 24–26; Koldehoff and Loebel 2009, 282–283). Additionally, under conditions of low population density that likely prevailed during early Paleoindian times in the glacial Northeast, social concerns such as mate exchange and information sharing could also have been an important driver of high residential mobility (Anderson 1996; Anderson and Gillam 2000; Ellis 2008, 308–310; MacDonald 1998, 1999). Intriguingly, the directionality of straight-line distances between early Paleoindian sites and primary toolstone sources is dominantly north-south, perhaps reflecting dominant seasonal movements north in the summers and south in the cold seasons (Ellis 2011, figure 6).

5.2 *Early Paleoindian technology*

B. Bradley et al. (2010, 177–178) present a synthetic model of Clovis lithic and organic technology that they define as a "techno-complex," distributed across unglaciated portions of North America. By their

model, Clovis stone tool technology was produced by two manufacturing sequences, the first involving large, portable biface cores that generated blanks for flake tools, and which could also be further reduced into Clovis fluted points using controlled overshot flaking. In addition, conical- and wedge-shaped cores were used to produce blades for use as hand-held implements, or for manufacture of hafted end scrapers and other unifacial tools. They also note certain distinctive tool forms associated with Clovis stone technology, such as flaked adzes that likely functioned as woodworking implements.

Given the variable evidence for Clovis-related occupations in the Northeast, the B. Bradley et al. (2010) model of Clovis technological organization provides a useful foil for reviewing evidence of early Paleoindian stone tool technology in our study area. Site assemblages in the middle Ohio Valley with presumed Clovis fluted bifaces do display elements of this Clovis technology model, including evidence for (1) points manufactured from biface cores or flake blanks, (2) the manufacture of other tools on blanks from blade and flake cores, and (3) the occasional presence of flaked adzes (e.g., Freeman et al. 1996, 386–389; Gramly and Yahnig 1991; Haag et al. 2014; Sanders 1990; Tankersley 1990).

To the east, in the interior mid-Atlantic, Carr et al. (2013a, 93) describe the fluted bifaces from Shoop, noting that the "most common fluted point type would be classified as Clovis (or the eastern equivalent)." Toolstone at Shoop appears to be dominated by Clarence member chert from the Onondaga formation of western New York ("western Onondaga"). Carr et al. (2013a, 85–89) propose that this toolstone was reduced into biface and angular polyhedral cores, the latter to generate blanks for flake tools (Carr et al. 2013a, 85–89). Two flaked adzes are noted in the site collections and may be associated with the early Paleoindian occupation (Carr et al. 2013a, 91–92). In the Delaware Valley, Gingerich (2013a) views Shawnee-Minisink as Clovis-affiliated based on its two fluted points and suite of radiocarbon dates. Local toolstone dominates the site assemblage, and cortical surfaces on cores point to exploitation of both primary in-situ and secondary cobble sources, reduced using both biface and "amorphous" cores (Gingerich 2013a, 242–244). Iceland (2013, 263) reports refitting of Shawnee-Minisink cores and broken end scrapers in the assemblage, concluding that "many or most [end scrapers] were produced on blades or blade-like flakes." However, Gingerich notes that "while some blade-like flakes are present, debris of standard blade production has not been recognized" (Gingerich 2013a, 246).

Continuing east, on the Virginia Fall Line and Coastal Plain, McAvoy and McAvoy (2015) indicate that Clovis point sites such as Cactus Hill and Williamson include some evidence for blade production. On the Delmarva Peninsula, early Paleoindian sites bear several parallels to the Clovis technology model. Lowery (2002, 162–174) observes that site assemblages are based largely on secondary cobble materials, and suggest two reduction technologies, including (1) overshot flaking on rare biface cores and fluted bifaces, and (2) blades and tools made on blades. Possible reduction of bipolar cores on small cobbles is also indicated.

Assemblage analysis of early and middle Paleoindian sites in the EGL led to a comprehensive model of technological organization for the northern portions of the Northeast (Deller and Ellis 1992a, 87–92; Ellis 2008). They note that fluted point sites not directly associated with quarries typically yield assemblages consisting of broken and resharpened tools, and small debris from late-stage biface reduction and edge maintenance of unifaces. These assemblage characteristics suggest that early and middle Paleoindian groups employed a highly segmented reduction sequence, producing standardized tool blanks and preforms for specific morphological tool types. Tool blanks were largely generated from polyhedral (but not necessarily morphological blade-producing) cores using primary source toolstone, and unlike the Clovis technology model, biface cores appear to have played a minor role in this technology. At quarry-related sites, Paleoindians performed early stage through late-stage reduction, carrying away stocks of finished tools, standardized tool blanks and biface preforms. In the context of high mobility, this practice served to reduce weight of the transported tool kit, enhancing portability. Equally important, however, this conferred toolkit flexibility, such that blanks could be converted to different morphological tool types at use locations, as needed.

The Potts site in central New York exemplifies this model of Paleoindian technological organization (Lothrop 1989). Cortical surfaces on stone tools and raw material analysis indicate the early Paleoindian assemblage was manufactured from a bedded Devonian chert, now tentatively identified as Esopus formation chert that outcrops as close as 125 km to the southeast along the Onondaga escarpment in eastern New York (Lothrop et al. 2016). Consistent with the Ellis and Deller model, analysis of residual blank attributes show that most formal tools were manufactured on blanks from systematically reduced polyhedral block cores, and that tools on flakes or blanks from bifaces or biface cores were restricted to expedient implements such as utilized flakes and flake gravers. The assemblage discarded at Potts was dominated by small numbers of fluted points, failed fluted point preforms, and broken and resharpened unifacial tools. Debris at the site, consisting of biface

thinning, fluting, and retouch flakes, and small uniface resharpening flakes from end and side scrapers, support the notion that early- and middle-stage reduction took place prior to the occupation, likely at the toolstone source.

Adovasio and Carr (2009, 518) propose that Paleoindian technologies in the Great Lakes and New England were based on "a staged biface reduction sequence," but as described above, only a minority of the transported tool kit was produced on flakes or blanks from bifaces. We note that the basic elements of this northern Paleoindian technology model is reflected in detailed studies of fluted point assemblages in the EGL (Deller and Ellis 1992a, 2011; Ellis and Deller 2000; Jackson 1998; Lothrop 1989; Shott 1993; Storck 1997) and also the NEM (Gramly 1982, 1988; Jones 1997; Singer and Jones in press; Spiess and Mosher 1992; Spiess and Wilson 1987; Wilson et al. 1995). Perhaps consistent with this scenario, preliminary analysis of the Shoop site suggests that occupants produced tools on blanks more commonly produced from polyhedral as opposed to biface cores (Carr et al. 2013a, 86–87).

From a morphological standpoint, early Paleoindian tool assemblages across the Northeast share some basic similarities, particularly in more common unifacial tool classes such as hafted end scrapers and hand-held side scrapers. However, there is significant variability in the region in the presence of other formal tool types. For example, fluted twist drills appear to be restricted to early Paleoindian sites in the NEM (e.g., Gramly 1982; MacDonald 1968; Robinson et al. 2009). Narrow uniface forms designated *limaces* (Gramly 1982) or flake shavers (Grimes and Grimes 1985) are recorded at EGL and NEM sites, but appear to be absent at sites in unglaciated terrain. Morphological and microscopic analysis indicates these tools were hafted for "whittling or shaving […] hard materials such as bone, ivory, wood or antler" (Grimes and Grimes 1985, 40).

Bipolar artifacts, variously referred to as *pieces esquillees*, or wedges, are present but rare on Gainey, Barnes, and even Holcombe phase sites in the EGL (Ellis and Poulton 2014; Fitting et al. 1966; Woodley 2004) and common on many sites in the NEM (Lothrop and Bradley 2012, 33). These bipolar forms are present on Fall Line/Coastal Plain sites in eastern Virginia (McAvoy and McAvoy 1997; McAvoy and McAvoy 2015, 56), and on some Delmarva sites (Lowery 2002), but are not reported for interior mid-Atlantic and Ohio Valley sites. Originally interpreted as wedging tools for splitting bone and wood (MacDonald 1968), microscopic analysis of bipolar pieces at the Mockhorn Island site on the Delmarva Peninsula (Stanford et al. in press) provisionally links these artifacts to woodworking for boat construction. McAvoy and McAvoy (2015, 56, 591–592) report results of microwear analysis conducted by L. Kimball on bipolar pieces from the Williamson site, indicating bone or antler as a contact material, supporting a hypothesized use for splitting bone, antler, or tusk.

From a compositional standpoint, Paleoindian site assemblages in the NEM reveal significant changes through time in the proportions of general tool classes. Based on single-component assemblages, early Paleoindian sites show the highest proportional frequencies of unifacial tools versus bifacial elements in these assemblages, at a uniface:biface ratio of approximately 5:1. Variation appears to be driven primarily by the frequency of formal unifaces, including end scrapers and side scrapers. Based on use wear analyses (Loebel 2013; Miller 2014), frequency of end scrapers in assemblages may be one partial barometer of the importance of hide processing activities during site occupations. (As Miller (2014), notes, however, use wear analysis of end scrapers from the Paleo Crossing site shows that, along with hide processing, these tools were also used less commonly to work other materials such as plants, bone/antler, wood, and meat.)

5.3 Early Paleoindian subsistence

The reconstruction of Paleoindian subsistence patterns in the Northeast is complicated by uncommon preservation of food animal bone (often as calcined fragments) and possible plant food remains (charred). When preserved, faunal bone identifications are limited to caribou and small mammal species, and the database of bone identifications is smaller than we would wish. A number of other topics and data sources have been used and debated to gain perspective on the issue of Paleoindian subsistence. These include (1) the question of mammoth and mastodon hunting, for which there is often good bone preservation but difficulty in interpretation of taphonomy and determining human association; (2) paleoenvironment, settlement patterns, and landscape use (site location, site clusters, "kill" sites); (3) the question of marine and coastal adaptations and foodways; and (4) blood residue analyses that may be subject to over-interpretation. Each of these topics is relevant to one, two, or all three of the early/middle/late Paleoindian temporal divisions used in this paper, because the data sets are uneven. The primary discussion of Paleoindian subsistence is presented in this section, with topics or data relevant to middle and late Paleoindian provided in Sections 6.3 and 7.3.

Despite the direct evidence of mammoth and mastodon hunting by Paleoindians elsewhere in North

America (Ballenger 2015; Haynes and Hutson 2013), and perhaps by pre-Clovis people (e.g., Joyce 2013), direct evidence such as associated flaked stone tools and unequivocal human butchery is so far absent in the Northeast. Mammoth and mastodon teeth recovered from the now-inundated late Pleistocene land offshore (Claesson 2015; Whitmore et al. 1967), and the Cinmar recovery (Stanford et al. 2014) prove the presence of viable elephant habitat on what is now the continental shelf. The Scarborough mammoth in Maine (Bourque 2001, 17–18), dated 12,200 ± 55 and 12,160 ± 50 ^{14}C yr BP, proves the presence of elephants and suitable habitat shortly (centuries) after an inundation event ended along the Maine coast, but seemingly before early Paleoindian immigration into the New England region (Lothrop et al. 2011).

Radiocarbon dating at Hiscock and other localities in the Northeast indicates chronological overlap of mastodon and early Paleoindian populations for several centuries after 13,000 cal yr BP (Boulanger and Lyman 2014; Feranec and Kozlowski 2016; Lothrop and Bradley 2012). Primarily at Midwestern localities, researchers report various lines of evidence for possible pre-Clovis or Clovis-era butchery of mastodon and mammoth (Brush and Smith 1994; Brush et al. 1994; Fisher 1984; Fisher et al. 1994; Joyce 2013). In this regard, Haynes and Krasinski (2010) highlight the need for caution in interpreting possible cut marks and other potential evidence of bone butchery patterns. They and others are doubtful of the proposed cultural associations (see also Grayson and Meltzer 2015; Haynes and Hutson 2013). Mastodon bone and ivory at the Hiscock site (Laub 2003; Laub et al. 1988; Tomenchuk 2003) may have been scavenged and used as raw material to make bone-based tools, but again, Haynes (2003) advocates caution. Like Hiscock, analogous recoveries at the Gumboro site in Delaware may also indicate butchery/scavenging behavior, here perhaps associated with a Colombian mammoth (see Section 5.1).

Importantly, Feranec and Kozlowski (2016) report Bayesian analysis of AMS dates on paleontological specimens from New York, providing regional indicators of species colonization and extirpation. This analysis shows that mastodon were probably extirpated from the region during the YD (circa 12,460–11,930 cal yr BP), while optimal spruce habitats for this species were still present. Because of the chronological overlap of several centuries for mastodon and early Native American populations, this study implicates humans and not habitat change in the extirpation of mastodon from New York — a working hypothesis for which we as yet have no clear archaeological evidence. In sum, we consider the hunting of mammoth and mastodon in the Northeast by the earliest inhabitants and fluted point-using Paleoindians to be possible but not proven.

Settlement patterns, site locations, and landscape use provide some guidance for Paleoindian subsistence reconstruction. The clearest case so far is the presence of stone caribou drive line complexes, hunting blinds, and related stone features on the Alpena-Amberley Ridge (now inundated) between Michigan and Ontario (O'Shea et al. 2013; Sonnenburg et al. 2015). A cervid (deer/caribou family) tooth fragment was recovered from one of these sites (Lemke 2015). As noted, the Vail habitation site in northwestern Maine is associated (by refitting fluted point fragments) with a probable kill-site concentration of fluted points 250 m to the west (Gramly 1982, 1984). No faunal remains were present. In the NEM region and New York, and in southern Ontario where sites are often associated with proglacial lake beach ridges, early and middle Paleoindian site locations have been interpreted as logical for "caribou hunting" (Funk 1972; Jackson 1997; Simons 1997). Discovery of eight Paleoindian sites in roughly a one-km radius near the Auburn, Maine airport, including an "outlook" hilltop site and several sites along a small river channel, clearly seem to reflect hunting focused on migratory herd animals (Spiess et al. 2012).

Two cave sites in the Northeast have yielded bone and faunal remains that may be culturally associated: Sheriden Cave, Ohio, including flat headed peccary and bear, as well as bone points that may be made of mammoth bone (Redmond and Tankersley 2005), and Dutchess Quarry Caves 1 and 8, New York, where caribou bone was recovered (Funk and Steadman 1994). However, at Dutchess Quarry Caves, the direct association of the faunal remains with Paleoindian artifacts is not established (Funk and Steadman 1994; Steadman et al. 1997). Multiple terminal Pleistocene and early Holocene paleontological specimens of caribou are known from the Great Lakes (Lemke 2015), many contemporary with Paleoindian occupation of the region based on radiocarbon dating, as are caribou antlers from the Hiscock site (Laub 2003, 74–75). There are no Paleoindian-contemporary paleontological (or archaeological) specimens of bison or elk (*Cervus*) from the Northeast.

Notably, unburned bone does not survive for long in acid soils that characterize the Northeast. Consequently, Paleoindian "open air" sites in the EGL and NEM yield only fragments of calcined bone, if any bone at all. Bone calcination occurs at temperatures over 600°C, resulting in shrinkage and loss of tensile strength (leading to small fragment size), but increasing resistance to acid (Shipman et al. 1984). Thus, the calcined bone samples recovered

thus far from Paleoindian sites must have resulted from direct discard into a fire hearth which reaches the appropriate temperature. The effects of small fragment size on bone identification mean that larger mammal long bones are rarely identifiable to genus or species. Specific identifications tend to be on the smaller bones, such as carpals, tarsals, and phalanges (Spiess et al. 1985). For a large animal, such as a caribou, most calcined bone fragments would be identifiable (primarily based on cortex thickness and curvature) as "large mammal." Some bones would be identifiable as "cervid" (deer/caribou family, but not differentiable to species). A few bones, mostly including the specially adapted bones in the caribou hoof, would be identifiable by morphology and/or size as caribou specifically. In samples of calcined bone from the Bull Brook and Whipple sites in the Peabody Essex Museum collection, we identified four caribou bones and 24 bones as "cervid" (either caribou or deer) (Spiess et al. 1985).

Finding calcined bone fragments in context on Paleoindian sites is relatively common (contra Levine 1997), judging by the data from New England (with which we are most familiar, and much of which is unpublished). Table 7 assembles data on Paleoindian sites in New England that have produced calcined bones (either analyzed by Spiess, or reported to him). In addition to the listed sites, hearths at the Debert site in Nova Scotia yielded "a few calcined bone fragments […] judged to be the size and structure of caribou" (i.e., large mammal) (MacDonald 2011, 8).

These data, and faunal finds at several other Northeast Paleoindian sites in particular, deserve comment. All identifications so far are mammal bone, limited to large mammal/cervid/caribou, and several species of small mammals. Although bird hunting has been hypothesized (Dincauze and Jacobson 2001), there are no bird faunal remains found at Paleoindian sites, nor are there confirmed recoveries of fish bone (the original report of fish bone at the Shawnee-Minisink site in Pennsylvania could not be confirmed [Gingerich 2013a, 248–249]). We note that calcined bird and fish bones as small as eel vertebrae (1 mm diameter) preserve perfectly well in early and middle Archaic sites in the region (e.g., Spiess and Mosher 2006), so the lack of fish and bird bones in regional Paleoindian sites is seemingly significant.

Bull Brook was the first site to yield calcined cervid bones ("deer-like bones" [Byers 1955]). In addition to the faunal sample in the Bull Brook collection at the Peabody Essex Museum (one identified caribou bone) (Spiess et al. 1985), Spiess examined and identified the Bull Brook faunal materials from Locus 18, curated at the R.S. Peabody Museum (Spiess et al. 1998, 210, table 4). The R.S. Peabody faunal sample is exclusively mammal bone, of which three were definitively identified as caribou and two as either caribou or deer (family Cervidae). Spiess also identified calcined beaver bone in the Peabody Essex Bull Brook site collection (Spiess et al. 1985). Spiess and Brian Robinson reexamined the Peabody Essex Bull Brook calcined bone sample in 2010, resulting in a second small mammal bone identification (unpublished).

Analysis of the Feature 1 faunal sample from the Udora site, Ontario, identified three caribou bone, hare (*Lepus* sp.) and arctic fox (*Alopex lagopus*), specifically differentiable from red fox (Storck and Spiess 1994). The Tenant Swamp site, New Hampshire, has yielded one cervid bone (probably caribou) and several small mammal bones, including one identified as otter (Goodby et al. 2014). Thus, the bone sample from Great Lakes and NEM region fluted point using Paleoindian sites can be characterized as caribou, plus various small mammal species. Finally, we also note that two sites (Bull Brook [Spiess et al. 1985] and Neal Garrison, ME [Kellogg 2003]) have yielded identifiable pieces of worked antler (artifact fragments). Antler in Paleoindian contexts in the region is, again, most likely caribou.

Summarizing the subsistence of early Paleoindian occupations in the Northeast, faunal remains from the Udora and Bull Brook sites record use of caribou and small mammals in the Great Lakes and New England. Bull Brook is reconstructed as an organized, multi-dwelling camp of almost 40 loci, with internal activity differentiation, and hence an occupation needing a large food supply, perhaps implying caribou drive hunting (B. Robinson 2012; B. Robinson et al. 2009). The Debert-Belmont complex Paleoindian sites, Nova Scotia, are reconstructed with a caribou-hunting focus (Rosenmeier et al. 2012), with early Paleoindians perhaps accessing summer snow fields where caribou would have congregated. At Vail's kill-site locus in northwestern Maine, situated 250 m upwind and west of the habitation site, is most likely a caribou-hunting location.

The few sites in the Northeast that contain evidence of plant foods are limited to the carbonized berry fruit or seed fragments from the Michaud and Hedden sites in Maine (Lothrop et al. 2011, 562), the Colebrook site in New Hampshire (Kitchel and Boisvert 2011) and the Shawnee-Minisink site in Pennsylvania (Gingerich 2013a). These meager finds suggest exploitation in the late summer or fall, or of over-wintered (desiccated) berry fruits. As Gingerich and Kitchel (2015) note, these foods have low acquisition and processing costs, and thus can be seen as compatible with a mobile life way.

In the NEM region, we realize that all of these Paleoindian sites that appear to be caribou-focused could represent a *seasonal interior* adaptation. *Was*

Table 7
Paleoindian sites with calcined bone, NEM region

Site/location	Age	Excavator and/or reference	Calcined faunal remains (*n*)	Faunal analyst
Whipple, NH	Early Paleo	Spiess et al. 1985	Caribou (3), cervid (15)	Spiess
Bull Brook, MA	Early Paleo	Byers; Spiess et al. 1985	Caribou, cervid, beaver, other small mammal	Spiess and B. Robinson
DEDIC/ Sugarloaf, MA	Early Paleo	Gramly 2014, in press	Large mammal, cervid (antler)	Spiess
Colebrook, NH	Mid Paleo	Boisvert and Kitchel in press	Large or medium mammal	Spiess
Neal Garrison, ME	Mid Paleo	Kellogg 2003	Large mammal, cervid (antler)	Spiess
Michaud, ME	Mid Paleo	Spiess and Wilson 1987	Large mammal (2), possible antler (4)	Spiess
Neponset, ME	Mid Paleo	Carty and Spiess 1992	Large mammal, cervid	Spiess
Tenant Swamp, NH	Mid Paleo	Goodby et al. 2014	Large mammal, cervid, otter	Largy, Spiess
Lamontagne, ME	Mid Paleo	NEA 2015 fieldwork	Mammal	Spiess (in field)
Cormier, ME	Terminal fluted point	Moore and Will 1998	Mammal	Spiess
Nicholas, ME	Terminal fluted point	Wilson et al. 1995	Mammal (41)	Will
Varney Farm, ME	Late Paleo	Cox and Petersen 1995	Mammal (3) (Fea. 3)	Spiess

there a contemporary coastal adaptation? Unfortunately, as with the mid-Atlantic coast, the Paleoindian marine shoreline of the NEM has been inundated by relative sea level rise of 30–70 m (Kelley et al. 2010). Only around the Champlain Sea, a biologically productive marine incursion into what is now the Lake Champlain basin, are Paleoindian shorelines preserved and available for study above current water levels. As Robinson (2012) illustrates, in western Vermont, sequentially younger groups of Paleoindian sites appear to be associated with appropriate shorelines as the Champlain Sea level fell, with sites especially concentrated around what may have been estuaries. Although no archaeological faunal remains have been recovered from the Paleoindian sites in Vermont, Robinson makes a good case that estuarine salt water environments, possibly hunting seals and beluga whales, might have been a Paleoindian focus from early through late Paleoindian times (F. Robinson 2012). There is relatively clear evidence for coastal adaptation along the Gulf of Maine by the late Paleoindian period (see Section 7.3).

6. Middle Paleoindian in the Northeast

For this study, middle Paleoindian occupations date to the latter part of the YD, circa 12,200–11,600 cal yr BP (circa 10,400–10,100 ^{14}C yr BP). In the NEM, the initial transition from spruce to pine tree taxa may begin during this time span; further west and south, where the YD signal is less pronounced, landscapes were likely trending towards closed pine and/or oak forests. The Laurentide ice sheet had retreated circa 50–75 km further north, leaving the Champlain sea bounded on all sides by deglaciated terrain. In the Great Lakes, early lakes Erie and Ontario were in low-stand phases, while Lake Algonquin dropped from its main stand level at some point during this period.

6.1 Middle Paleoindian settlement

Figure 5 depicts middle Paleoindian sites in the Northeast that have yielded (1) Barnes points (including Barnes, Cumberland, and Michaud–Neponset forms, all of which are viewed as equivalent regional variations on the same basic form) and (2) Crowfield points (estimated to encompass a time span of circa 12,200–11,800 cal yr BP). Holcombe and Cormier–Nicholas point sites are discussed, but not illustrated in this map figure. Overall, these middle Paleoindian sites are far more common north of the LGM ice margin in the midsection of the Northeast study region; the few sites found south of the glacial margin are associated with the lower Ohio, Susquehanna, and Delaware drainages (see Figure 5 and Table 8). This discrepancy may well reflect differences between these northern and southern sectors in documentation and investigation of individual sites. For example, on the Delmarva Peninsula, Lowery has documented 45 Barnes points that show a relatively broad distribution. However, Barnes point components have only been recognized at two sites — Paw Paw Cove and Twilley (Lowery and Stanford 2013). Some of these Barnes point isolates may represent residential encampments that could be confirmed with additional investigation.

A similar situation likely occurs in the middle to lower Ohio Valley, where Cumberland points are fairly common, but few sites have been identified and investigated (Jefferies 2008, 78; Smith 1990; Tankersley et al. 1990) (see Figure 5). North of the LGM ice margin, the paucity of Barnes point sites in Michigan, Ohio,

Table 8
Middle Paleoindian sites in the Northeast (illustrated on Figure 5)

1. 154.14 (Bonnichsen et al. 1981)	29. Thedford II (Deller and Ellis 1992a)
2. Misery Stream (Bradley et al. 2008)	30. McLeod (Ellis and Deller 1990)
3. Cliche-Rancourt (Chapelaine 2012)	31. Wight (Ellis and Deller 1990)
4. Morss (Spiess et al. 2012)	32. Stott Glen (Ellis and Deller 1990)
5. Avon (Spiess and Hedden 2000)	33. Canoga (Lothrop et al. 2016)
6. Colebrook (Boisvert 2012)	34. Neponset (Spiess et al. 1998)
7. Reagen (J. Robinson 2009)	35. Crowfield (Deller and Ellis 2011)
8. Fairfax (Crock and Robinson 2012)	36. Bolton (Deller and Ellis 1996)
9. 38.88 (Bradley et al. 2008)	37. Templeton (Moeller 1980)
10. Lautman (Spiess et al. 1998)	38. Mullin (Ellis and Deller 1990)
11. Potter (Boisvert 2012)	39. Wapanucket #8 (Bradley and Boudreau 2008)
12. Israel R. (Boisvert 2012)	40. Babula (Ellis and Deller 1990)
13. Auburn Airport Cluster (Spiess et al. 2012)	41. Beaver Lodge (Lothrop and Bradley 2012)
14. Fisher (Storck 1997)	42. Liebmann (Spiess et al. 1998)
15. Watpool (Ellis and Deller 1990)	43. Rural Cemetery (Lothrop et al. in press)
16. Bear Creek/Stapleton (Archaeologix 2004)	44. Ohomowauke (Singer and Jones in press)
17. Hussey (Ellis and Deller 1990)	45. James Decker (Lothrop et al. in press)
18. Zander (Ellis and Deller 1990)	46. Dutchess Q. 1 and 8 (Lothrop et al. in press)
19. Jackson Gore (Crock and Robinson 2012)	47. Pocono Lake (Fogelman and Lantz 2006)
20. Tenant Swamp (Goodby et al. 2014)	48. Valentine (White 2006)
21. Potts (Lothrop 1989)	49. Nesquehoning (Stewart et al. in press)
22. Barnes (Voss 1977)	50. Plenge (Gingerich 2013a)
23. Gosling (Ellis and Poulton 2014)	51. Saginaw (Fogelman and Lantz 2006)
24. Devil's Nose (Tankersley 1994)	52. Twilley (Lowery and Stanford 2013)
25. Alder Creek (Timmins 1994)	53. Sandy Springs (Seeman et al. 1994)
26. Owlville Cluster (Lothrop et al. 2016)	54. Magnet (Smith 1995)
27. Parkhill (Ellis and Deller 2000)	55. Little Mosquito Creek (Smith 1990)
28. Dixon (Ellis and Deller 1990)	56. Zimmerman (Smith 1990)

and Indiana, may reflect the same phenomenon. In northern New England and the Canadian Maritimes, however, the complete absence of Barnes point sites could well be due to low site visibility in these wooded landscapes, intentional avoidance of this region, or a combination of these factors.

In Ontario, there is a marked drop in the total number of Barnes point sites/finds versus earlier Gainey or Clovis-like point locations (e.g., Hanson 2010). Rather than reflecting population decline, however, this is more likely a product of greater time depth represented by early Paleoindian sites with Clovis-like points (Ellis and Deller 1997; Ellis et al. 2011, 539–540). In the EGL, most Barnes point sites are small, averaging less than 200 m^2. Large, multi-locus sites do exist, exemplified by Fisher (Storck 1997) and Parkhill (Ellis and Deller 2000), consisting of 19 and 9 occupation areas respectively. At these two sites, assemblage variation between occupation areas, as well as the large size of some of the loci at Parkhill, suggest they may represent aggregation locales. Further, the situation of both sites on Lake Algonquin strandlines suggests strategic positioning to intercept migrating or local caribou herds (Ellis and Deller 1997, 13, 2000; Storck 1984, 1997).

Thedford II, situated in the same concentration of Barnes point sites south of Lake Huron (including Parkhill and seven other sites) constitutes a site of intermediate size (Deller and Ellis 1992a). Field investigations identified six artifact concentrations, four of which were excavated. Spatial analysis indicates variations in artifact content between clusters, and it is suggested the site represents an occupation by several family groups, organized around a central communal work area (Deller and Ellis 1992a, 101–121).

The Wight site is also included in the Parkhill site complex and may represent a kill/butchery locality. This interpretation is based on the small (25 m^2) size of the site area, the absence of flaking debris, and the recovery of a small collection limited to a tip-impacted distal point section, along with possible butchering implements, consisting of two backed bifaces and a beveled biface (Deller and Ellis 1992b, 31).

Large middle Paleoindian sites are also present in the NEM. The Potter site, located in northern New Hampshire, is a large multi-locus site with both early and middle Paleoindian occupation areas, some with significant variation in assemblage composition that may reflect a repeatedly used aggregation site (Boisvert 2012; Boisvert et al. in press). Middle Paleoindian occupations in the NEM include clusters of sites, such as Israel River in northern New Hampshire and Auburn Airport in south-central Maine. These clusters consist of multiple sites located on different landforms within specific geomorphic landscapes, and likely represent reuse of these locales to target seasonal subsistence resources (Boisvert 2012; Lothrop et al. 2011, 561; Spiess et al. 2012).

Large multi-locus residential sites and clusters of sites associated with distinctive landforms or geomorphic settings may represent the most visible parts of the middle Paleoindian record in the Northeast. However, recent discoveries reveal that very small sites can also be found in contrasting landscape settings, and likely represent other types of seasonal settlement. The Gosling site in Wellington County, Ontario, is located on an "interior" setting, far removed from the strandline settings of proglacial Lake Algonquin (Ellis and Poulton 2014). Discovered unexpectedly during a CRM survey, this small, low-density site yielded 12 stone tools and 12 waste flakes. The diverse suite of unifacial and bifacial tools highlights how such small sites are not necessarily "simple," and can witness a wide range of site activities. Because of low archaeological visibility, such sites are surely underrepresented in the current record of the Northeast.

Crowfield points are the rarest well-fluted point forms in the Northeast; they are recorded in low numbers as isolates from Michigan and Ohio eastward to central New England, and southward into the mid-Atlantic (Bradley et al. 2008; Carr and Adovasio 2002; Ellis and Deller 1997; Lowery 2002, 127–129; Prufer and Baby 1963). They do not appear to be present in the middle Ohio Valley (Jefferies 2008; Smith 1990). Prior to 2000, the handful of known Crowfield component sites was restricted to southern Ontario and the Reagen site in northwestern Vermont (Deller and Ellis 1984; Ellis and Deller 1997; Robinson 2009). In recent years, additional sites have been identified in the upper Delaware, Lehigh, and lower Hudson/Wallkill valleys, on the Ontario plain of New York, and in western New England (see Figure 5) (Gingerich 2013b; Lothrop et al. 2014, 2016, in press; Stewart et al. in press).

Crowfield sites include the type locality, a remarkable subsurface concentration of heat-shattered artifacts, interpreted as the intentional destruction by fire of one individual's stone toolkit (Deller and Ellis 2011). The larger significance of the Crowfield site is that it provides the earliest evidence for Paleoindian ritual behavior in northeastern North America. From a settlement standpoint, this ritual deposit is viewed as a sacred, rather than secular utilitarian cache (Ellis 2009). The few investigated Crowfield occupation sites in Ontario have yielded assemblages with few unifacial tools that may reflect hunting-related camps (Deller and Ellis 1996; Timmins 1994). The Crowfield component at the Alder Creek site measures only 80 m^2 (Timmins 1994), suggesting the scarcity of these sites is due in part to their small size and, hence, low archaeological visibility.

Holcombe points in the EGL and Cormier–Nicholas points in the NEM lack consistent attempts at fluting, and are typically basally thinned. Sites and isolates of the Holcombe form are found in northern Indiana (White 2005), Michigan and southern Ontario (Ellis and Deller 1990; Fitting et al. 1966; Jackson 2004; Woodley 2004), and western New York (Smith et al. 2010). In the NEM, sites with Cormier–Nicholas bifaces concentrate in a restricted section of central New England (Bradley et al. 2008; Lothrop et al. 2011, 559).

In the EGL, most sites with Holcombe points are multicomponent, making specific assessments of settlement and delineating activities difficult. A key change, however, is that sites are no longer necessarily associated with the strandline of proglacial Lake Algonquin, as lake levels had dropped below that strandline (Ellis and Deller 1990; Jackson 2004). In the NEM, the few excavated Cormier–Nicholas point sites suggest a pattern of small residential occupation areas, measuring 150 m^2 or less (Wilson et al. 1995).

For both middle and late Paleoindian sites in glaciated sections of the Northeast, there is evidence for decreased range mobility, compared to early Paleoindian sites. Ellis (2011, figure 4) reveals that later Paleoindian sites are located at a mean straight-line distance from site to primary toolstone source of 123 km, or 43 km less than the average value for early Paleoindian sites. One explanation for this trend could be that through time, Paleoindian populations were increasing, with the landscapes becoming more densely populated. Thus, compared to early Paleoindian groups who had recently colonized the empty landscapes of the glacial Northeast (and were able to practice "unbounded" mobility strategies [Koldehoff and Loebel 2009]), later Paleoindian groups simply had access to smaller total ranges. Alternatively, this trend could also be due to (1) environmental changes (i.e., increasing forest closure during the late YD and early Holocene militating against extensive mobility), or (2) changes in prey species with the onset of the early Holocene.

6.2 *Middle Paleoindian technology*

In the glaciated Northeast, analysis of Barnes component sites such as Thedford II and Parkhill provide examples of the systematic approach taken to toolstone reduction and implement manufacture (Deller and Ellis 1992a; Ellis and Deller 2000). At both of these sites, Collingwood chert of the Silurian Fossil Hill formation was acquired at outcrops in the Georgian Bay region, roughly 180 km to the Northeast. This bedded chert can be extracted in blocks, and analysis of blank attributes on tools reveals that these block cores were systematically reduced using block geometry to drive off tool

blanks for reduction (Deller and Ellis 1992a, 11–24; Ellis and Deller 2000, 40–66). As at early Paleoindian sites, the evidence at both sites suggests that initial- to mid-stage toolstone reduction was carried out elsewhere (presumably close to the chert source), and that toolstone was imported to the sites as finished tools, point preforms, and tool blanks. Excavations at the Fisher site, located about 25 km from the presumed Fossil Hill chert source (see Figures 2 and 6), recovered a small number of cores and may indicate the maximum distance from source that middle Paleoindian groups carried cores to perform early- and middle-stage reduction (Storck 1997).

Compared to early Paleoindian sites, EGL middle Paleoindian stone tool kits appear to consist of a larger number of morphological tool types (Ellis and Deller 1988). This is especially true with Barnes point sites (associated with the Parkhill phase); these assemblages include formal tool types that do not appear to be present at early Paleoindian sites or at later middle Paleoindian Crowfield sites. Examples include points manufactured on channel flakes, large parallel-sided end scrapers, offset end scrapers, and proximal end-and-side scrapers. Other morphological tool types, also absent in early Paleoindian assemblages, are present in both Barnes point and Crowfield point sites, such as backed bifaces, alternately beveled bifaces, and narrow end scrapers (Ellis and Deller 1997, table 5). The distinctive design and methods of manufacture for many of these tool classes strongly suggest they are use-specific from a functional perspective (Ellis and Deller 1988) and provide potential windows into variation in activity sets between sites. From a chronological perspective, recognition of variation in these formal tool classes through time provides another means of assessing the relative age of many Paleoindian sites.

Notably, recent excavations at Cliché-Rancourt in Québec and Potter in New Hampshire recovered alternately beveled bifaces, marking the first evidence of this tool class at Middle Paleoindian sites in the NEM (Boisvert in press; Chapdelaine 2012). Beyond technological insights, the broader significance of these finds is the implication of cultural links during middle Paleoindian times between the EGL and NEM.

Returning to the issue of chronological variation in Paleoindian tool kits, comparison of single-component middle Paleoindian site assemblages in the NEM shows that unifacial tools are typically more common than bifacial artifacts, as is the case for early Paleoindian assemblages in the NEM. However, the ratio of unifacial to bifacial tools is generally lower for middle Paleoindian sites, with an average ratio of 3:1.

Beyond these broader trends, in the EGL, there is evidence of inter-site variation in artifact class frequency for middle Paleoindian sites. By graphing ratios of fluted bifaces and trianguloid end scrapers versus all tools for a series of site assemblages (some of which are early Paleoindian in age), Ellis and Poulton (2014, figure 12) demonstrate contrasting emphases between sites in these two tool classes. These contrasting ratios strongly suggest intersite "differences in site activities or function" (Ellis and Poulton 2014, 97–98). Importantly, these frequency differences are not products of site assemblage size or occupation span.

6.3 Middle Paleoindian subsistence

Large Paleoindian sites of middle Paleoindian age in the EGL, such as Parkhill and Fisher, show associations with Algonquin strandlines, suggesting intercept hunting of caribou herds may have played a role in site location. Consistent with this scenario, paleoenvironmental reconstructions at both sites suggest open or semi-open landscapes at the time of Barnes point occupations (McAndrews 1997; Morgan et al. 2000). In the NEM region, middle Paleoindian Michaud–Neponset and later fluted point sites are the most common, with at least one large multi-site concentration in Maine, known as the Auburn Airport site cluster (Spiess et al. 2012), and the Israel River site cluster in New Hampshire (Boisvert 2012). Environmental reconstruction (Newby et al. 2005) indicates nearly 1000 cal yr of stability in the YD, with the NEM characterized by a sedge tundra, parkland, conifer woodland trend from north to south, across a scale of 400–600 km. Modern environments of this scale (e.g., Labrador and northern Quebec) support long-distance large-herd migratory caribou populations (Newby et al. 2005, 156). Faunal remains from sites of this age indicate continued caribou plus small mammal hunting/trapping (e.g., Tenant Swamp [Goodby et al. 2014]). In the EGL, the Holcombe Beach site, Michigan, dating to late middle Paleoindian times, was the first Paleoindian site in the Great Lakes area with a reported identification of caribou bone (Cleland 1965; Fitting et al. 1966). In this case, the bone was reported as a "barren ground" caribou because of its small size. Although definitely caribou, identification as either "barren ground" or "woodland" caribou behavioral type based on this bone is not supportable, however (Spiess et al. 1985, 153–154).

Settlement pattern evidence from the Champlain Sea shore in Vermont hints at a seasonal maritime/estuarine hunting focus, as mentioned in Section 5.3,

although supporting data from the Gulf of Maine coast is now well underwater.

Identifications of blood residue on stone tools have been applied more to middle and late Paleoindian assemblages than to early Paleoindian assemblages. Blood residue identifications that are specific to Paleoindian prey species can be problematic, possible but not yet confirmed. The problem appears to be one of false positives and interpretations of weak cross-reactions in the laboratory with anti-sera. There is a poor understanding of the survival of hemoglobin protein in generally wet, acid soils of varying temperatures over long time spans (Downs and Lowenstein 1995). Cervid (deer family), human, and bovine (family includes bison) hemoglobin has been identified at the Sheguiandah site (Newman and Julig 1989). Bear hemoglobin has been identified at three sites (Nobles Pond, Ohio; La Marte, Gaspe, Quebec; and Jefferson VI, New Hampshire) (Boisvert and Milligan 2014; Dumais 2000; Seeman et al. 2008). The bear anti-sera reaction from Jefferson VI is reported as a "probable positive" (Boisvert and Milligan 2014, 7–8). There were, however, no (fully) positive reactions to antisera for the Jefferson VI tools that were tested, raising some question as to the results.

7. Late Paleoindian

As defined in this study, late Paleoindian occupations in the Northeast are associated with post-YD early Holocene environments and landscapes, between circa 11,600 and 10,000 cal yr BP (10,100–9000 ^{14}C yr BP) (in northernmost portions of the NEM, late Paleoindian occupations may extend after 10,000 cal yr BP). During this late Paleoindian timeframe, water bodies in the EGL basins were uniformly in low-stand phases, due to isostatic closure of inlets and/or outlets of individual lakes, as well as prolonged early Holocene droughts (see Figure 6). With continued retreat, the southern edge of the Laurentide ice sheet lay between 100 and 250 km north of EGL basins. Although smaller in size, the Champlain Sea persisted in the St. Lawrence and Champlain basins, with its northern shores situated 50–100 km south of the glacial margin. A single remnant ice cap persisted on the Gaspé Peninsula. On the continental shelf, the retreating Atlantic shoreline now lay within 10–50 km of most modern day positions. The Chesapeake and Delaware basins were still dry land, drained by the ancestral lower Susquehanna and Delaware rivers. Save for the Gaspé Peninsula, closed pine and oak forests prevailed across the early Holocene Northeast. Mastodon had been extirpated, and the spread of closed pine and oak forests suggests that caribou were likely absent from the lower and perhaps middle latitudes of the Northeast, likely replaced by white tailed deer, and other Holocene fauna.

7.1 Late Paleoindian settlement

Late Paleoindian occupations are marked by a diversity of stone projectile point morphologies and hafting modes. Often attributed to a "filling up" of the landscapes in eastern North America and increasing populations, late Paleoindian projectile point forms variably show broad scale or more restricted distributions that in some cases may reflect sub-regional populations.

Largely undated, but perhaps present during several calendar centuries before and after the YD terminus, "Plano" Agate Basin-like points show the broadest distribution of any late Paleoindian form. Sites and isolated finds are found in the middle and lower Ohio Valley, sometimes in association with Beaver Lake and Quad forms (Jefferies 2008, 85–86; Smith 1990, 1995), and across the EGL and NEM (Bradley et al. 2008; Jackson 2004; Prufer and Baby 1963; White 2005, 2006). Although present, Agate Basin-like points are generally uncommon in the mid-Atlantic (e.g., Carr and Adovasio 2002; Gingerich 2013b; Kraft 1973).

In the middle Ohio Valley, late Paleoindian occupations often co-occur with early and middle Paleoindian components as palimpsests on near-surface sites (Smith 1990). Overlooking the Ohio River in Perry County, southern Indiana, the Magnet site (also referred to as the Alton site [Tomak 1994]) represents a partial exception to this trend (Smith 1995). Although Cumberland points are present, bifaces at this site are dominated by late Paleoindian forms, especially Agate Basin, suggesting repetitive use of this locality in the early Holocene. In southern Ontario and the NEM, sites yielding Agate Basin and Hell Gap-like points appear to have a more northerly distribution (e.g., Dibb 2004; Jackson 2004; Lothrop et al. 2011), and these appear to generally represent residential occupations.

Reflecting proximity to the central Mississippi Valley "heartland" (Koldehoff and Walthall 2009), basally thinned Dalton bifaces are more common in the lower Ohio Valley, west of the Northeast study area (Jefferies 2008; Tankersley 1990, 1996), but are rare across the rest of the Northeast. In the central Mississippi Valley, Dalton is dated to circa 10,500–10,000 ^{14}C yr BP, but its temporal parameters remain poorly understood in peripheral regions (Koldehoff and Walthall 2009, 142–143); in the lower Ohio Valley, Dalton components likely postdate Agate Basin point occupations (Jefferies 2008). Broadly associated with the northward spread of temperate deciduous forest habitats and Holocene resources, Dalton occupations to the west in the

central Mississippi Valley suggest sub-regional settlement adaptations associated with warm season floodplain camps, aggregations at fall encampments, and dispersed, upland settlements during cold weather, including the first widespread use of rockshelters. Formalized cemeteries and the ritualized exchange of large Sloan-style bifaces also characterize Dalton adaptations in the Mississippi Valley (Koldehoff and Walthall 2009). West of the study area, Jefferies (2008, 81–85) notes the presence of seasonal Dalton sites in upland settings of the lower Ohio Valley.

Stemmed and side notched Hi-Lo bifaces appear to have a sub-regional, southern EGL distribution, with the greatest concentration of sites extending from northwest Ohio north to Lake Erie as well as in areas farther west (Browne 2016; Ellis 2004b; Ellis et al. 2009; Jackson 2004; White 2012). Sites with Hi-Lo components are occasionally recognized south of Lake Ontario (e.g., Smith et al. 2010) and on the "Southern Tier" Appalachian Highlands of New York (Tankersley et al. 1996). Because of shared biface features such as alternate beveling of blade margins on points, Hi-Lo occupations are viewed as having a possible chronological and historical relationship with Dalton (Koldehoff and Walthall 2009, 139). Indeed, White's (2012, 245, 259) study of Hi-Lo and Dalton distributions shows that they are found in adjacent areas but they are largely mutually exclusive in space with little overlap, a pattern supporting contemporaneity. As a result, although Hi-Lo sites have not been dated radiometrically, they likely overlap in age with Dalton: Ellis (2004b) projects an age of circa 10,000 ^{14}C yr BP, while Jackson (2004, table 2.2) suggests a time span of circa 10,000–9500 ^{14}C yr BP (11,500–10,800 cal yr BP).

Investigated sites with substantive Hi-Lo components are limited to southern Ontario, and the great majority appears to consist of residential encampments. Most sites are small, measuring under 200 m^2, but Welke-Tonkonoh comprises a large site occupation, consisting of five artifact concentrations (Ellis 2004b, 68–69). The presence of other Hi-Lo components sites near Welke-Tonkonoh suggests a settlement trend of repetitive use of the least certain landscapes. In addition to residential encampments, the Allan site in southern Ontario represents an apparent Hi-Lo quarry site, associated with outcrops of Haldimand chert (Parker 1986).

The Caradoc Hi-Lo site provides additional evidence for late Paleoindian ritual activity (Deller and Ellis 2001). Investigations at this site revealed a concentration of purposefully broken ("killed") stone tools that is interpreted as an offering or ritual cache of grave goods (although no evidence of human remains was encountered at this locus).

Despite some similarities between Dalton and Hi-Lo bifaces, evidence from Hi-Lo sites and assemblages suggest fundamental differences in lifeways. Regarding evidence for mobility based on distance to source for assemblage toolstone, Dalton sites of the midcontinent are viewed as evidence for "bounded" settlement systems, in which sites are rarely situated more than 50 km from geologic sources of toolstone in the assemblages (Koldehoff and Loebel 2009). By contrast, Hi-Lo sites in southern Ontario can be found at distances of over 120 km from a particular chert source, despite the fact that over 80 per cent of the assemblage may be made of that toolstone (Ellis 2004b, 60–61). In addition, Hi-Lo tool kits apparently lack certain classic Dalton artifacts such as the flaked woodworking adze (Koldehoff and Walthall 2004).

Eden-like and Ste. Anne–Varney point forms, distinguished by narrow, leaf-shaped, or parallel-sided forms with precise collateral flaking and diamond-shaped cross-sections, are projected to date to circa 9500–9000 ^{14}C yr BP (circa 10,800–10,000 cal yr BP), and their temporal duration could easily extend later. Sites with these distinctive late Paleoindian point forms (Figure 6 and Table 9) are recorded north and south of Lake Ontario (Jackson 2004; Lothrop et al. 2014), in the Champlain and St. Lawrence valleys (associated with the Champlain sea) (e.g., F. Robinson 2012), and in riverine settings east of the Appalachian Highlands in Massachusetts, New Hampshire and Maine (Lothrop et al. 2011; Petersen et al. 2000; Spiess et al. 1998).

Most Eden/Ste. Anne–Varney point sites appear to represent small residential occupations represented by one to three artifact concentrations. Excavations of single-component sites reveal artifact clusters interpreted as occupation areas, measuring as little as 50–100 m^2 each (e.g., Chapelaine and Bourget 1992; Graillon et al. 2012). Excavations at the Varney Farm site in Androscoggin County, Maine, revealed a larger occupation area measuring circa 250 m^2 (although this near-surface lithic scatter was likely enlarged by plow dispersion) (Petersen et al. 2000).

In addition to residential sites, there is provisional evidence for utilitarian caching by late Paleoindian Eden/Ste. Anne–Varney point groups. The Meredith cache in the upper Connecticut Valley of New Hampshire apparently consisted of 40 Eden-like points, while the Bass River cache on Cape Cod produced 12 points of this form. In both cases, points in these caches were made of felsite, perhaps deriving from northern New England (Bradley et al. 2008, 159). Based on the minimal information available, these are likely utilitarian caches. Unlike early Paleoindian caches, however, these two late Paleoindian examples appear to consist solely of

Table 9
Late Paleoindian Eden-like/Ste. Anne–Varney point sites in the Northeast (illustrated on Figure 6)

1. Ayotte (Benmouyal 1987)	22. Varney Farm (Petersen et al. 2000)
2. Minville (Benmouyal 1987)	23. Arbor Gardens (Crock and Robinson 2012)
3. Plourde (Benmouyal 1987)	24. Lower Saranac (Bradley et al. 2008)
4. Cap-au-Renard (Benmouyal 1987)	25. VT-CH-1124 (Mandel and Crock 2014)
5. La Martre (Dumais 2000)	26. Winookski Redevelopment (Crock and Robinson 2012)
6. St. Joachim (Benmouyal 1987)	27. Alpena-Amberley Ridge (O'Shea et al. 2013)
7. Ste. Anne-des-Monts (Benmouyal 1987)	28. Bristol Pond (Crock and Robinson 2012)
8. Mitis (Dumais 2000)	29. Coboconk (Crock and Robinson 2012)
9. Rimouski (Chapdelaine 1994)	30. Saco River (Bradley et al. 2008)
10. BIC (Bradley et al. 2008)	31. Arnold Brook (Crock and Robinson 2012)
11. Squatec (Bradley et al. 2008)	32. Otter Creek #2 (Crock and Robinson 2012)
12. 154.7 (Bonnichsen et al. 1981)	33. Meredith cache (Bradley et al. 2008)
13. Sandy Stream (Will and Moore 2002)	34. Thurman Station (Robinson 2011)
14. 129.05 (Will and Moore 2002)	35. 27-HB-1 (Boisvert and Bennett 2004)
15. Pittston Farm (Doyle et al. 1985)	36. Oberlander #1 (Lothrop et al. 2016)
16. Gaudreau (Graillon et al. 2012)	37. Salt Creek (Lothrop et al. 2016)
17. Guzzle (Will and Moore 2002)	38. Heaman (Deller et al. 1985)
18. Eddington Bend (Bradley et al. 2008)	39. Ponkapoag (Bradley and Boudreau 2008)
19. Sheguiandah (Julig 2002)	40. North River (Bradley and Boudreau 2008)
20. Thompson Island (Bradley et al. 2008)	41. Wapanucket #8 (Bradley and Boudreau 2008)
21. Reagan (J. Robinson 2009)	42. Bass River cache (Bradley et al. 2008)

Note: Stanley/Hough low stands in the Huron basin exposed Alpena-Amberley Ridge between circa 11,300 and 8400 Cal BP; human use of this landscape may date to the Late Paleoindian, Early Archaic, or both.

projectile points, with no evidence for other finished tools, preforms, or tool blanks (Table 6).

Finally, the Thurman Station site in Warren County, New York, provides evidence of late Paleoindian ceremonial or ritual caching in the upper Hudson Valley of the NEM (Robinson 2011). Accounts of this site's discovery in the early 1930s indicate a large pit was found during a road construction project that contained a large quantity of stone tools covered with ocher. Most of the artifacts were lost shortly after discovery, but a surviving subsample includes a large platter-like biface and a series of five needle-like lanceolate bifaces of astounding craftsmanship, measuring between 11 and 19.1 mm in width, with precise collateral pressure flaking and diamond-shaped cross-sections (Robinson 2011, 71–79). Taken together, the elongated form of these narrow bifaces, as well as their collateral flaking and diamond cross-sections, indicate a late Paleoindian age, and more specifically, a probable Eden/Ste. Anne–Varney affiliation. Further, the dimensions and form of these narrow bifaces strongly suggest they were not utilitarian, and consistent with the associated presence of ocher, implies a ceremonial or ritual function to the original feature and its contents. West of Lake Michigan, in northern Illinois, Wisconsin and the upper Peninsula of Michigan, archaeologists in recent years have recorded a series of six late Paleoindian sites or features with "killed" and/or heat-shattered artifact assemblages, now designated as the Renier Ceremonial Complex (Loebel and Hill 2012). Viewed in this light, the Caradoc and Thurman Station sites appear to be reflective of a broader trend of variable ritual or ceremonial behaviors, extending from the late Paleoindian Midwest into the EGL and NEM.

Late Paleoindian sites associated with Eden/Ste. Anne–Varney points and presumed earlier Agate Basin forms collectively suggest an increased regionalization in lithic procurement patterns. Although sites such as Varney Farm (Munsungun Lake formation chert) and the possible northern New England felsites in Meredith and Bass River caches suggest some long-distance transport of toolstone still took place, most Plano sites in the Northeast indicate more local, sub-regional procurement patterns and declining mobility (Bradley et al. 2008), consistent with the evidence for reduced range mobility for later Paleoindian groups across the glaciated Northeast (Ellis 2011).

Although others dispute the claim, Ellis (2004b) argues that the Hi-Lo point type reflects sub-regional evolution from earlier Crowfield and Holcombe points, while the "Plano" Agate Basin and Eden/Ste. Anne–Varney forms are widely viewed as intrusive to the Northeast. While stylistic and technological diffusion remain a possibility, most researchers view the similarities between Agate Basin and Eden forms of the High Plains to analogs in the Northeast as evidence of an eastward migration in early Holocene times. For example, Dumais (2000, 100–103) proposes in migration of late Paleoindian populations from the northern High Plains along southern margins of the Laurentide ice sheet circa 9500 ^{14}C yr BP.

Agate Basin forms are documented across the High Plains (Justice 1987, 33–34), and similar forms display a broad north-south distribution in the east, being found as far south as Alabama. By contrast, the distribution of Eden style points on the High Plains shows a

more northern focus (Justice 1987, 49–50), as do Eden-like/Ste. Anne–Varney bifaces in the Northeast (see Figure 6), perhaps consistent with an eastward migration scenario along a northern latitude. As mapped, the variable associations of Eden-like/Ste. Anne–Varney point sites with early Lake Ontario, the Champlain Sea, and eastern New England suggest a potential diversity of subsistence adaptations. In particular, sites along the Champlain Sea and Gaspé Peninsula could have exploited cold-water marine fauna as well as the last large caribou herds perhaps present in the open environments that persisted on the Gaspé until about 7800 ^{14}C yr BP (circa 8800 cal yr BP) (Dumais 2000, 85).

Finally, although not specifically dated and lacking cultural affiliation, the submerged Alpena-Amberley Ridge site provides unequivocal evidence for early Holocene caribou hunting in the Huron basin (O'Shea et al. 2013; Sonnenburg et al. 2015). The Alpena-Amberley Ridge landform is a bedrock ridge, measuring 125 km in length and 5–15 km wide, that subdivides the Huron basin; its exposure during Lake Stanley/Hough low stands between circa 9900 and 7500 ^{14}C yr BP (circa 11,300–8400 cal yr BP) formed a northwest-southeast trending isthmus that separated Lake Stanley from a smaller unnamed water body to the west (see Figure 7) (Lewis et al. 2008; McCarthy and McAndrews 2012; O'Shea et al. 2013, 37). Underwater survey of this ridge, using remote submersibles and scuba divers, has identified boulder-constructed drive lane and V-shaped hunting blind features that are identical to those used historically in the arctic and subarctic for terrestrial intercept hunting of migrating caribou. Beyond its importance as a unique site discovery, the larger significance of the AAR site is the implication that similar, now-submerged Paleoindian drive lane hunting sites may be preserved elsewhere in the EGL (Jackson et al. 2000).

7.2 Late Paleoindian technology

Late Paleoindian stone technologies are most strongly documented in glaciated sectors of the Northeast where single-component sites have been excavated. Despite possible cultural or chronological connections to Dalton, Hi-Lo lithic industries show significant continuity with earlier fluted point occupations (Ellis 2004b). Lithic procurement continues to be based primarily on mining and systematic core reduction of bedded cherts, with a particular focus on Haldimand chert outcrops in southwestern Ontario. This preference for Haldimand toolstone is intriguing, because Hi-Lo groups seemingly ignored other higher-quality toolstone outcrops in southern Ontario, such as Onondaga cherts, that were exploited by early and middle Paleoindian groups. Ellis (1989, 2004b, 61) argues that this differential toolstone presence may have reflected nonutilitarian criterion for these Hi-Lo groups.

Hi-Lo stone tool kits include elements such as backed knives that are found in middle Paleoindian assemblages, but also include stemmed drills that are not represented at middle Paleoindian sites. The greatest similarities with earlier middle Paleoindian tool kits are in unifacial tool classes, including hafted triangular and narrow end scrapers and side scrapers. Notably, a few Hi-Lo (and Holcombe [see Fitting et al. 1966]) sites provide evidence that some unifacial tools were made on small morphological blades as opposed to flakes (Ellis 2004b, 64–68). In sum, while there are distinctive differences, most elements of the Hi-Lo toolkit suggest continuity with middle Paleoindian artifact assemblages.

In the EGL, late Paleoindian lanceolate point assemblages are typically found in multicomponent palimpsests with earlier and later occupations, making assessments of stone technology difficult. Across the NEM, researchers have uncovered late Paleoindian sites that contain both Agate Basin and Ste. Anne–Varney components, as well as fewer sites where only one point form is represented. For both Agate Basin and Ste. Anne–Varney point occupations, stone tool kits mark fundamental differences with earlier fluted point occupations (e.g., Benmouyal 1987; Chapdelaine 1994; Dumais 2000; Graillon et al. 2012; Petersen et al. 2000; Pintal 2006). In addition to points and preforms, biface tools include expanded base drills (although Trihedral flaked stone adzes, common in late Paleoindian sites west of Lake Michigan (Lambert and Loebel 2015) appear to be absent in the Northeast).

In almost all cases, however, formal unifaces are rare or absent at NEM Agate Basin and Ste. Anne–Varney point sites. This trend is particularly true for end scrapers which, in a striking contrast to fluted point tool kits, represent the *least common* tool type in NEM late Paleoindian assemblages. Even where present, late Paleoindian end scrapers lack the standardization of size and shape that is typical of those found in fluted point component sites. Side scrapers — a presumed hand-held cutting and scraping tool — are infrequent in these assemblages also. We are aware of only one case in the NEM — the Agate Basin component Price site in the Gaspé region (Pintal 2006) — where side scrapers comprise more than 15 per cent of the tool assemblage. In a striking contrast to early and middle Paleoindian tool kits, biface tool categories significantly outweigh formal uniface tool classes at Agate Basin and Ste. Anne–Varney point sites in the NEM, at ratios of circa 2:1 up to 9:1. This paucity of formal unifaces, and especially end scrapers, at these late Paleoindian sites

appears to be a regional phenomenon restricted to the NEM. End scrapers are relatively common in late Paleoindian site assemblages west of Lake Michigan (Lambert and Loebel 2015, 286) and in Cody complex sites in the central and northern Plains (Knell and Muniz 2013).

The major difference in NEM late Paleoindian stone tool assemblages is not the role of biface technology, but rather the decline of formal uniface tools. Assuming site discovery bias is not a factor, this could reflect (1) adoption of organic tools for activities traditionally conducted with formal stone unifaces, or (2) functional replacement of formal unifaces by expedient stone technologies. The Gaudreau site in southern Québec provides possible support for this latter scenario (Graillon et al. 2012). At Gaudreau, biface tools included seven broken Ste. Anne–Varney points and two drills, while formal unifaces consisted of a single broken scraper fragment. There are 14 utilized flakes in this assemblage, however, and these may represent expedient tools employed for task applications previously fulfilled by formal unifaces. Lacking organic preservation, however, we cannot exclude the possibility that organic tools were filling this role during late Paleoindian occupations in the NEM. Reductions in range mobility, suggested for late Paleoindian sites in the Northeast, may be one factor in these toolkit changes.

7.3 *Late Paleoindian subsistence*

There are very few identified faunal bones from late Paleoindian age sites in the NEM, or elsewhere in the Northeast. The late Paleoindian Rimouski site (Quebec) had at least one unidentifiable calcined mammal bone from probable Paleoindian context (Chapdelaine and Bourget 1992, 173). West of the Northeast study area, in the Superior basin, a calcined caribou bone has been recovered from the Cummins site, Ontario, and there is a concentration of late Paleoindian sites in the Thunder Bay region (Newman and Julig 1989, 129). As noted above, the stone caribou drive lane and hunting blind features on the Alpena-Amberley Ridge (O'Shea et al. 2013; Sonnenburg et al. 2015) must date to sometime during the Stanley/Hough low stands of circa 9900 and 7500 ^{14}C yr BP (circa 11,300–8400 cal yr BP), suggesting to us a probable association with late Paleoindian occupations.

In terms of settlement pattern, the paucity of Agate Basin point sites across the Northeast makes it difficult to project associated subsistence behaviors. Later Eden/Ste. Anne–Varney point sites are more common, making some generalizations possible. First, as noted, late Paleoindian sites in New England show a tendency to be located near river banks and lake shorelines — a contrast with fluted point Paleoindian occupations on glacial outwash landforms, and more like contemporary or later early Archaic and middle Archaic settlement patterns. Kuehn (1998) argues from limited faunal remains that contemporary late Paleoindian groups west of Lake Michigan employed a generalized foraging strategy, exploiting a range of faunal resources. In Maine, if we identified faunal remains in late Paleoindian sites, we would not be surprised to see moose (*Alces*), fish and birds, and possibly (locally migratory, "woodland") caribou. Second, the aforementioned concentration of Ste. Anne–Varney point sites on the Gaspé Peninsula of Quebec coincides with what was likely the last remaining sedge/open woodland environment south of the St. Lawrence (Dumais 2000; Newby et al. 2005, 144, 146). We suspect, again with no hard faunal evidence, that the Gaspe harbored a larger caribou herd that would have been supported in the contemporary dense early Holocene woodlands of northern Maine and the Maritimes. Considering the late Paleoindian Sheguiandah site, Ontario, Julig (2002, 307–310) postulates a Paleoindian "littoral" adaptation for the Great Lakes.

These late Paleoindian Gaspé sites and contemporary occupations in adjacent areas of the Canadian Maritimes (Keenlyside 1985) may also show a transition to maritime hunting (seals, walrus), an adaptation possibly foreshadowed by middle Paleoindian use of the Champlain Sea shoreline, and one that surely characterized early Archaic and later cultures around the Gulf of St. Lawrence.

Submerged late Paleoindian sites point to a possible boat-based coastal adaptation on the central Maine coast (Price and Spiess 2013). Two probable late Paleoindian bipoint knife find spots (recovered by scallop dragging) near Mount Desert Island, Maine, are interpreted as probable beach locations reminiscent of later Archaic- and Woodland-era boat-based coastal settlement patterns (Price and Spiess 2013). These are the earliest now-drowned terrestrial site locations so far discovered on the shore of the Gulf of Maine.

8. Future research and directions

This overview of evidence for early human occupations of Northeast North America provides contexts for ongoing and future research endeavors on this topic. It also points to areas that warrant continued awareness by the research community, including aspects of the pre-Clovis debate, chronology, bias in the archaeological record and how we approach it, and collaboration.

We begin by noting that much of the debate on pre-Clovis occupations in the Americas involves researchers using select sites or data sets to support a narrative of cultural source areas and migration routes for the ancestral peopling of North America (e.g., Stanford

and Bradley 2012), followed by critiques of that narrative (e.g., Boulanger and Eren 2015; O'Brien et al. 2014). This linking of potential pre-Clovis sites with prospective origin stories has had the unfortunate effect of diverting attention away from potential insights that these early archaeological finds might yield. For Northeast North America, the corpus of viable pre-Clovis site candidates is miniscule, and we would argue that for now it is insufficient to evaluate alternative colonization models for populations that preceded Clovis. As Holly (2011) notes, *foragers can fail*, and this was perhaps especially true of small-scale human migrations to empty landscapes in the context of harsh and variable Pleistocene environments (e.g., Riede 2014). Hence, archaeological evidence for early or earliest colonization of a region does not guarantee that those peoples were ancestral to later populations, or that they left a legacy of cultural signatures in archaeology of subsequent populations or genetic signatures in modern populations. In this light, the tentative evidence for the Northeast of one or more early occupations that predate Clovis by a thousand or more years could be seen instead as evidence of one or more failed migrations. Moving forward, we might be best served by focusing less on origin stories from such limited evidence, and instead, evaluating the merits of individual archaeological discoveries as they come to light, and their potential to yield more basic insights on earliest occupations of the Northeast and elsewhere. To do so, of course, obligates investigators to timely and detailed publication of findings.

Looking more broadly at archaeological data sets for early human settlement of the Northeast, chronology remains our single greatest weakness. Even in the NEM, where most of the radiocarbon dates on Paleoindian sites have been generated in recent years, ages of sites and age spans of diagnostic artifacts remain poorly constrained, especially for early Holocene occupations. Viewed positively, with these recently obtained radiocarbon determinations, the situation is much improved compared to where we stood, say in 1980, but still highlights how little we know. Future site investigations in the Northeast, either through dedicated long-term research projects, or as a result of CRM studies, will likely yield additional dates. But for whatever reason, however, experience to date suggests some parts of the Northeast, such as the EGL, may *never* yield any reliable radiometric dates on Paleoindian components. In this context, geochronology remains a key tool for constraining ages of some sites (Jackson et al. 2000), as are continued efforts to revise and refine relative chronologies using both biface sequences (e.g., Bradley et al. 2008; Deller and Ellis 1992a) and other time-sensitive tool types (Ellis and Deller 1988).

A second stumbling block to future insights on the earliest peoples of the Northeast involves multiple inherent biases that condition the region's current data sets of sites and isolated finds. Some of these are expected for the region, such as now-drowned landscapes associated with late Pleistocene and early Holocene low stands in Great Lakes basins, as well as submerged, former terrestrial settings on the continental shelf. The spectacular discovery of the Alpena-Amberley Ridge site in the Huron basin (O'Shea et al. 2013; Sonnenburg et al. 2015) and fortuitous finds off the modern Atlantic coast provide glimpses of what we are missing. Accessing these underwater landscapes will always be challenging and usually problematic, but we nevertheless need to more explicitly take into account what we "cannot see" as we attempt to model the lifeways of these early peoples. Indeed, given the physical diversity of the Northeast, landscape geoarchaeology approaches are key to future progress. In this view, paleoenvironmental data are more than just evidence of environments to which early populations had to adapt; they are also key to inferring regional impacts of climate change on these ancient landscapes and the resulting effects on early site preservation and archaeological visibility (e.g., Araujo 2014; Lowery et al. 2010).

The notion of discovery bias also extends to the recognition that while certain geomorphic landscapes (e.g., abandoned proglacial lake strandlines, Pleistocene dune fields) may have elevated Paleoindian site potential, other settings also harbor early sites, sometimes with lower archaeological visibility. Researchers in Ontario long ago saw this problem and made concerted efforts to survey for sites in "interior" locations — away from proglacial lake strandlines — and discovered sites there as well (e.g., Ellis et al. 1991). This extends to the applied realm of CRM, where the recent identification and investigation of the small, middle Paleoindian Gosling site (Ellis and Poulton 2014) remains an object lesson.

In the larger view, our prospects for understanding these earliest peoples of the Northeast will be enhanced by explicit attempts to seek out variability in the archaeological record that they left behind. For example, given the greater time depth for early Paleoindian occupations in the Northeast (circa 13,000–12,200 cal yr BP) versus other regions, we might expect more evidence of change through time and across space in the form and manufacturing technology of diagnostic stone weapons tips and other realms of their stone technology.

We close by echoing Anderson et al. (2015, 35), noting that continued insights into earliest peoples of the Northeast depends in part on our collaborative efforts with avocational archaeologists. Although

some sites are found by long-term research programs and by CRM surveys, avocational archaeologists have and will continue to discover many of the sites comprising the known early archaeological record of the Northeast. Although not without its challenges (Shott and Pitblado 2015), the extent to which we can successfully partner with the avocational community will determine in large measure future accomplishments in researching the first peoples of the Northeast and elsewhere.

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