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HUMANS AND YOUNGER DRYAS: DEAD END, SHORT DETOUR, OR OPEN ROAD TO THE HOLOCENE?

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Paleoindians and the Younger Dryas in the New England-Maritimes Region

Jonathan C. Lothrop [a,*], Paige E. Newby [b], Arthur E. Spiess [c], James W. Bradley [d]

[a] New York State Museum, Anthropology Collections, CEC Room 3049, Albany, NY 12230, USA
[b] Brown University, Box 1846, 324 Brook St., Providence, RI 02912, USA
[c] Maine Historic Preservation Commission, State House Station 65, Augusta, ME 04333, USA
[d] Archlink, 55 Park Street, Charlestown, MA 02129, USA

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ABSTRACT

This paper examines environmental and archaeological data for the Younger Dryas (YD) (12,900–11,600 calibrated years before present) (cal BP) and early Holocene (11,600–10,000 cal BP) in the New England-Maritimes (NEM) to model environmental changes and possible human responses. For some other regions of North America, researchers argue for negligible environmental changes and human responses, while others suggest that ecological changes associated with cold conditions at the YD onset disrupted regional biota, causing subsistence stress for Paleoindian populations and the end of the Clovis cultural adaptation (circa 13,200–12,900 cal BP). The NEM shows abrupt cooling at the YD onset, which fostered more open habitats favorable to both long-distance migrating and local herds of caribou, and may have encouraged early Paleoindian colonization and settlement of this unoccupied deglacial region. Comparison of the Paleoindian point sequence with calibrated radiocarbon dates indicates fluted point groups probably occupied the NEM during, but not after, the YD. Abrupt warming at the YD terminus (circa 11,600 cal BP) caused a rapid reorganization of the region's vegetation and prey species populations, coinciding in the archaeological record with a decline in Paleoindian biface fluting technology and altered regional site distributions. In the closed forests of the succeeding early Holocene NEM, late Paleoindian groups (11,600–10,000 cal BP) used unfluted, lanceolate points that may signal post-YD immigration to the NEM.

1. Introduction and background

Marking the end of the last major climate reorganization, the Younger Dryas (YD), 12,900–11,600 calendar years before present (cal BP), was the most significant rapid climate change event during the last deglaciation of the North Atlantic region (Dansgaard, 1993; Alley, 2000; Broecker et al., 2010; Carlson, 2010). In the North Atlantic region, Greenland ice core data show a centennial-scale climate reversal from warm to cold at the onset of the YD, and an extremely rapid change back to warm conditions at the end of the YD (Taylor et al., 1997; Alley, 2000; Stuiver and Grootes, 2000; Rasmussen et al., 2006; Steffensen et al., 2008). This paper examines the potential impacts of YD climatic and ecological changes on human populations, and possible human responses in New England and the Canadian Maritimes region (NEM) (Fig. 1).

Over the past 20 years, recognition has grown for potential impacts on vegetation, animal, and human populations associated with the YD in NEM. Clear 'reversals' in vegetation sequences were first recognized in fossil pollen and plant macrofossil studies in the Canadian Maritimes (Mott et al., 1986; Mayle and Cwynar, 1995). Peteet et al.'s (1990, 1993) work in southern New England and the northeastern Middle Atlantic region showed a YD-associated sequence of vegetation changes, with spruce (*Picea*), alder (*Alnus*), and birch (*Betula*) pollen abundances. Recent studies using multiple lines of evidence from single sites and regional syntheses have underscored the regional heterogeneity of changes across North America during the YD (e.g., Maenza-Gmelch, 1997; Kirby et al., 2002; Shuman et al., 2002, 2004, 2009; Toney et al., 2003; Newby et al., 2005, 2009; Hou et al., 2006; Miller, 2008a, b; Gill et al., 2009; Gonzales and Grimm, 2009; Jones et al, 2009; Marlon et al., 2009).

In the last two decades, North American archaeologists have begun to explicitly consider the potential effects of YD climatic and ecological changes on human populations, and possible human responses. In the North American Plains and Southwest, uncalibrated age estimates for Clovis vary (Huckell and Judge, 2007; Beck

* Corresponding author. Fax: +1 518 486 2034.
E-mail addresses: jlothrop@mail.nysed.gov (J.C. Lothrop), paige_newby@brown.edu (P.E. Newby), arthur.spiess@maine.gov (A.E. Spiess), jbradley@archlink.org (J.W. Bradley).

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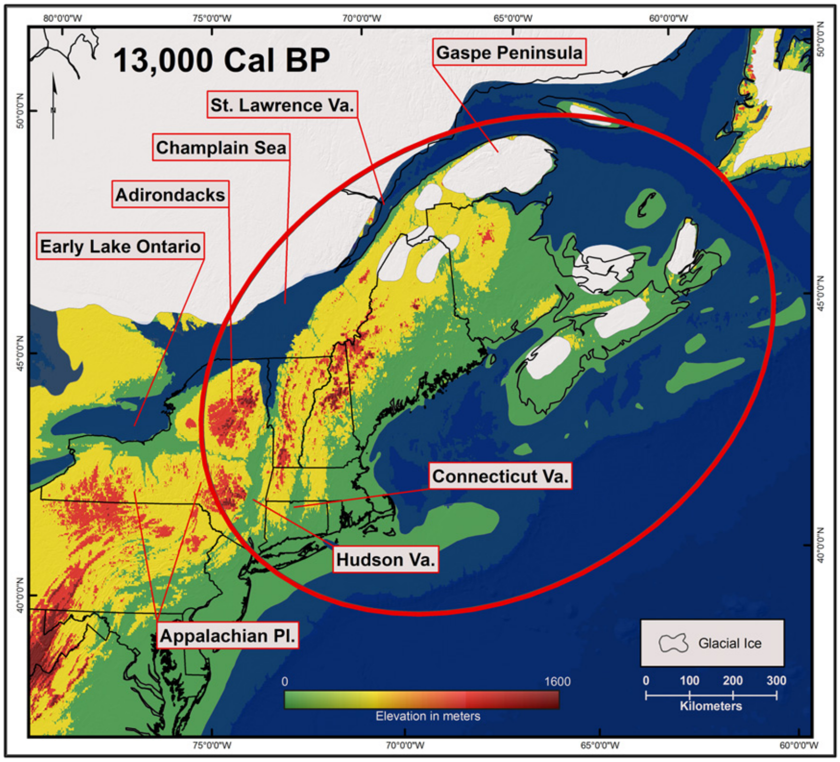

Fig. 1. Overview of northeastern North America, showing boundary of the NEM study area and major physical features of the late Pleistocene landscape at circa 13,000 cal BP. (modified from Dyke 2004).

and Jones, 2010), but even by the most restricted estimate (11,050–10,800 yr BP, or 13,125–12,925 cal BP) (Waters and Stafford, 2007), Clovis Paleoindian populations were resident for about two calendar centuries by the onset of the YD at 12,900 cal BP. The coincident timing for the "end" of Clovis and the onset of the YD has prompted some archaeologists to propose that YD impacts contributed to both the demise of Clovis Paleoindian lifeways and to the subsequent emergence of Folsom and other regional Paleoindian adaptations (e.g., Anderson and Faught, 2000; Anderson, 2001; Goodyear, 2006). In the Canadian Maritimes of the northern NEM, Ellis (2004) suggests YD environmental changes may have led to regional abandonment by Paleoindians. Others argue that over most of North America, YD climatic changes were generally not pronounced, and varied significantly between regions (Meltzer and Holliday 2010).

Unlike the situation further south, it appears that Paleoindians colonized the NEM at, or shortly after, the YD onset (Bradley et al., 2008). Accelerator mass spectrometry (AMS) radiocarbon dates from the Shawnee-Minisink site, located in eastern Pennsylvania just north of the terminal moraine, provide evidence for a seasonal presence of Native American populations in the upper Delaware Valley close to the YD onset (Gingerich, 2007, 2011; Gingerich and Waters, 2007). Newby et al. (2005) and Newby and Bradley (2007) have raised the possibility that the impact of cooler-than-previous YD conditions set in motion regional changes in vegetation and faunal populations that may have been advantageous to early Paleoindian colonizers. Furthermore, environmental changes at the end of the YD, coinciding with shifts in technology and site distribution at ca. 11,600 cal BP, suggest effects from, and possible human responses to, climate change (Spiess et al., 1998; Newby et al., 2005; Newby and Bradley, 2007; Bradley et al., 2008).

A key component of this research addresses the ages-old archaeological conundrum of how, if at all, climate change impacted human groups in prehistory. For early sites in the Americas, Dillehay (2009) suggests that "Even if…past climate changes strongly influenced human behavior…dating of geological events and archaeological occupations are too imprecise to fit a specific behavioral change…to specific regional climatic conditions" (Dillehay, 2009, p. 972).

Systematic examinations of regional datasets at comparable scales, as pursued in the NEM, are critical for gauging if climatic changes associated with the YD "…measurably added to the challenges routinely faced by Paleoindian groups" (Meltzer and Holliday, 2010: 1). Where attempted, examinations of paleoenvironmental change and potential responses by human populations are best addressed using comparisons of archaeological and paleoenvironmental data at regional and sub-regional levels (Newby et al., 2005, pp. 142–143).

Expanded archaeological and paleoenvironmental datasets and refined deglacial chronologies in the NEM are approaching thresholds of data resolution allowing exploration of possible relations between dynamic environmental changes and cultural behaviors of Paleoindian populations in the region. This work is facilitated by recent advances in the region's early cultural systematics (Bradley et al., 2008), enabling examination of Paleoindian technology and colonization/settlement during and after the YD.

As in Newby et al. (2005), the NEM is used as the study area (Fig. 1). From west to east, the NEM is bordered by rugged uplands along the eastern flanks of the Adirondacks and Appalachian Plateau in eastern New York and by the Atlantic and Gulf of Maine coastlines along New England and the Maritimes provinces. The terminal glacial moraine of Long Island forms the southern boundary of the NEM region, and the St. Lawrence drainage is the northern boundary. These physical boundaries define a 1200-km-long peninsula extending from the Hudson-Champlain lowlands of eastern New York, through New England, and into the Canadian Maritimes (Bradley et al., 2008). Unlike most other regions of North

America, current evidence indicates that Paleoindians likely did not colonize the NEM until the YD onset (ca. 12,900 cal BP) or shortly thereafter, making the region well-suited for studying human colonization and settlement of a physically bounded region during and after the YD.

As background, this paper first summarizes the physical parameters and deglacial chronology of the NEM and vicinity across the late Pleistocene/early Holocene boundary. Next, it provides an overview of climatic and ecological changes before, during, and after the YD in the NEM. Archaeological evidence for human occupation of the NEM during and after the YD is discussed, and these cultural developments compared to synchronous environmental changes at regional and sub-regional scales. Two basic types of archaeological data are considered through time: (1) relative and radiocarbon chronologies for changes in fluted and unfluted Paleoindian biface technology as partial evidence of hunting behaviors, and (2) Paleoindian site locations through time as evidence of colonization and settlement behaviors. The observed patterns yield a set of working hypotheses about effects from, and possible human responses to, YD environmental change in the NEM that can be evaluated by future research.

2. Background: NEM physical setting

2.1. Physiography, drainage, toolstone

Extending from eastern New York to southeastern Québec, Nova Scotia and New Brunswick, the NEM study area is dominated by alternating mountain and lowland sections. On the west, major barriers to movement include the eastern slopes of the Adirondacks and the Appalachian Plateau, with peak elevations exceeding 1400 and 1200 m respectively in eastern New York. Moving east, the Hudson-Champlain and Connecticut lowlands, drained largely by the south-flowing Hudson and Connecticut rivers, mark major north-south corridors through the western NEM (Thornbury, 1965).

West of the Connecticut Lowland, the Green/Notre Dame Mountains extend northward from western Massachusetts through Vermont and into southern Québec. East of the Connecticut River, the White Mountains reach maximum elevations of 1800 m, running north from central Massachusetts through New Hampshire and northwestern Maine to southern Québec. On the northern margin of the NEM, oriented northeast-southwest, the St. Lawrence Lowland is today drained by the St. Lawrence River, but 13,000 years ago, this lowland was occupied by the Champlain Sea (Fig. 1). The overall grain of the NEM landscape – generally trending south-to-north or southwest-to-northeast, likely channeled Paleoindian colonization of the region and subsequent seasonal movements (Fig. 1).

Human colonization of the NEM was made possible in part by the distribution of discrete toolstone sources across the region. In the broader Northeast, Paleoindians made flaked stone tools using mostly higher grade stone, usually acquired from primary geologic outcrops (rather than as cobbles from secondary streambed or glacial sources) (Ellis, 2008; Robinson et al., 2009). Fig. 4 illustrates locations of major lithic sources exploited by Paleoindians in and adjacent to the NEM. From southwest-to-northeast, these include: Hardyston formation jasper, Pennsylvania (Hatch, 1993); Onondaga and other Devonian cherts, New York (Lothrop and Bradley, in press); Normanskill group/Mount Merino formation chert, New York (Lothrop and Bradley, in press); Cheshire quartzite, Vermont (Crock and Robinson, in press); Spherulitic rhyolite, New Hampshire (Pollock et al., 2008a); Munsungun formation chert, Maine (Pollock et al., 1999); Minas Basin chert, Nova Scotia (Robinson et al., 2009); and Gaspé Peninsula Ordovician chert, Québec (Chalifoux 1999; Dumais 2000; Burke, 2010). Of these, the projected geologic source of Minas Basin chert in Nova Scotia (exploited by early Paleoindians), is now likely submerged by postglacial sea level rise (MacDonald 1968; A. Burke, personal communication, 2010), while Ordovician chert

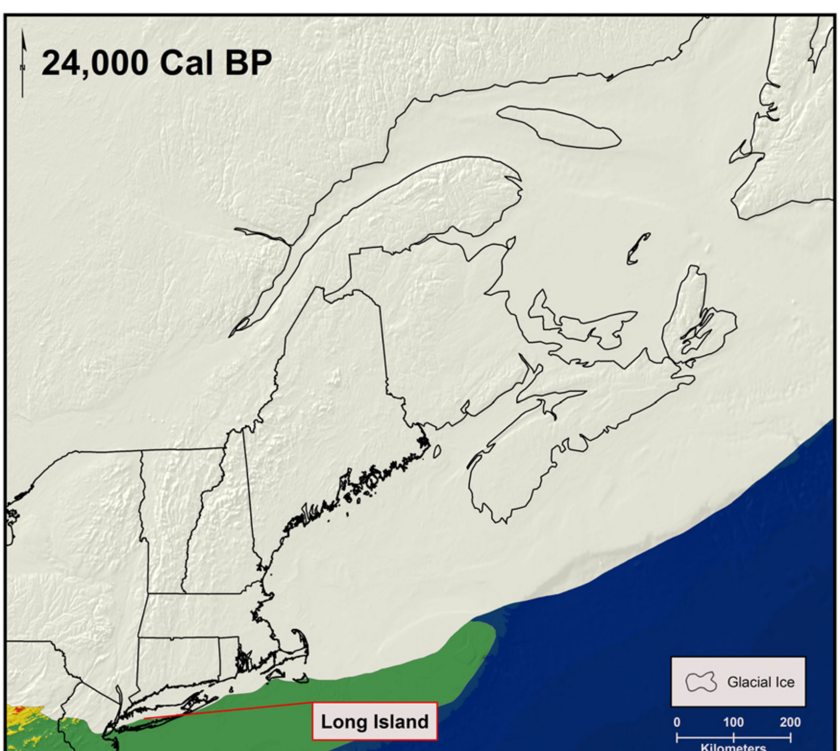

Fig. 2. Maximum extent of the Laurentide Ice Sheet across the NEM at circa 24,000 cal BP.

outcrops on the Gaspé Peninsula, Québec (exploited in late Paleoindian times), were covered by glacial ice caps until the mid-late YD. Chronological trends in source use include (1) early Paleoindian import of Pennsylvania Jasper to the NEM during and after colonization, (2) frequent long-distance transport of toolstone within the NEM from most major sources during early and middle Paleoindian times, and (3) increasingly local source use and more limited movement of toolstone from terminal middle Paleoindian into late Paleoindian sub-periods (Burke, 2006; Bradley et al., 2008; Robinson et al., 2009).

2.2. Deglacial sequence

Prior to the YD onset, the NEM was dramatically reshaped by glacial retreat, marine transgression, isostatic rebound, massive drainage diversions, and the formation and draining of proglacial freshwater and inland marine water bodies (Ridge, 2003; Teller, 2004; Donnelly et al., 2005; Rayburn et al., 2005; Richard and Occhietti, 2005; Bloom, 2008; Cronin et al., 2008; Stanford, 2009). The Late Wisconsin advance of the Laurentide Ice Sheet (LIS) reached its maximum extent before 24,000 years ago, forming the terminal moraine at Long Island (Fig. 2). Thereafter, the retreat of the LIS was periodically interrupted by glacial readvances, forming smaller end moraines further north (Ridge, 2003; Stanford, 2009). By circa 14,700 cal BP, glacial ice had withdrawn northward up the Hudson and Connecticut valleys to northern portions of New England and western Nova Scotia (Fig. 3). Thereafter, the pace of ice retreat accelerated, with final retreat across the St. Lawrence Valley by circa 13,100–13,000 cal BP (Fig. 4) (Ridge, 2003; Donnelly et al., 2005; Richard and Occhietti, 2005).

During deglaciation, meltwater pooled behind the retreating ice front in the Hudson and Connecticut valleys. Large and small proglacial lakes formed and drained, their shoreline footprints fluctuating in response to changes in meltwater input, outlet elevations, and isostatic rebound. Formed at different times, the largest proglacial lakes included Lake Connecticut in Long Island Sound, Lake Albany in the Hudson Valley, Lake Hitchcock in the Connecticut Valley, and Lake Vermont in the Champlain Lowland (Fig. 3). After final draining of these proglacial lakes, streams dissected the lakebed sediments, and winds eroded deltaic sediments, forming dune fields in the Hudson and Connecticut valleys (Donahue, 1977; Dineen, 1982; Thorson and Schile, 1995; Bloom, 2008; Stanford, 2009).

Northwest of the Hudson Valley, ice retreat from the Ontario basin after 16,200 cal BP created proglacial Lake Iroquois. With meltwater input from proglacial lakes in Great Lakes basins to the west, Lake Iroquois continued to expand, eventually exceeding the footprint of modern Lake Ontario. Between 14,600 and 13,800 cal BP, final ice retreat from the Mohawk Valley opened an outlet for proglacial Lake Iroquois near Rome, New York, routing meltwater via the ancestral IroMohawk River into later, lower stages of Lake Albany in the Hudson Valley (Ridge, 2003; Wall, 2008; Stanford, 2009, p. 12).

Beginning about 15,500 cal BP, as glacial ice retreated north of the Maine coast, the Atlantic Ocean flooded isostatically depressed coastal areas, depositing marine sediments (Fig. 3). After isostatic rebound and marine regression, winds reworked some of these glaciomarine sediments, forming dune fields (Thompson and Borns, 1985; Ridge, 2003).

At about 13,400 cal BP, ice retreat from the northern margin of the Adirondacks opened a series of lower outlets for proglacial Lake Iroquois, shifting outflow from the Mohawk Valley to the St. Lawrence Valley. Waters discharging from Lake Iroquois were rerouted east-northeast around the Adirondacks, then south into proglacial Lake Vermont in the Champlain basin, and finally down the Hudson Valley to the Atlantic. Waters in the Ontario basin dropped 90–100 m below modern levels to Early Lake Ontario, (Fig. 1) (Anderson and Lewis, 1985). Rayburn et al. (2005) and Theiler et al.

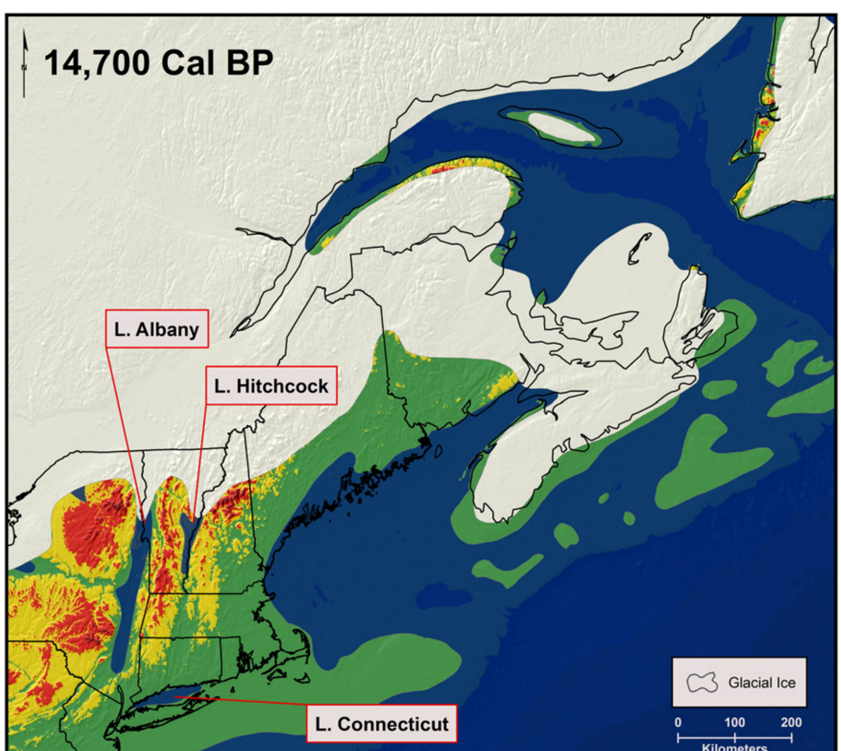

Fig. 3. Position of retreating Laurentide Ice Sheet and major proglacial lakes in the NEM at circa 14,700 cal BP.

(2007) propose that ice retreat from Covey Hill, New York released two successive flood pulses of meltwater (700 km^3 and 2500 km^3) through the Champlain Lowlands and Hudson Valley, likely around 13,100 cal BP. These outflow pulses are associated with catastrophic flooding down the Hudson Valley (Donnelly et al., 2005).

Around ca. 13,100–13,000 cal BP, with final ice withdrawal to the north side of the St. Lawrence Valley, the Atlantic Ocean flooded this isostatically depressed region, forming the Goldthwait Sea in the St. Lawrence estuary and the Champlain Sea in the St. Lawrence and Champlain lowlands (Fig. 4) (Rayburn et al., 2005; Richard and Occhietti, 2005; Rodrigues, 2006; Cronin et al., 2008; Rayburn, personal communication, 2008). At its maximum extent, this inland Champlain Sea stretched 500 km east-west between Ontario and Québec, and 300 km south from Québec into the Champlain Basin of eastern New York and western Vermont (Figs. 1 and 4). With continued isostatic rebound, the footprint of the Champlain Sea shrank, forming a freshwater body (Lake Lampsilis) separate from the Atlantic Ocean at about 9800–9700 cal BP (Cronin et al., 2008). Formation of the Champlain Sea rendered the NEM a geographic peninsula, open to human colonization, and simultaneously created a potential inland marine subsistence base for immigrant Paleoindian populations (Loring, 1980; Newby and Bradley, 2007; Crock and Robinson, in press; Lothrop and Bradley, in press; Robinson, in press).

3. The Younger Dryas in the New England-Maritimes

During the Paleoindian occupation of the NEM, dramatic environmental changes influenced the surroundings in which these people lived. Pollen records from Maritime Canada (Mott et al., 1986; Levesque et al., 1993; Mayle et al., 1993; Mayle and Cwynar, 1995) and New England (Peteet et al., 1990, 1993; Shuman et al., 2002, 2004) record the impact of the colder-than-previous conditions at the onset and throughout the YD. Warming at the end of the YD was substantial (4–20 °C) and rapid (Levesque et al., 1997; Hou et al., 2006), and corresponds with a shift to drier-than-previous regional conditions recorded in lake-level data (Newby et al., 2000; Shuman et al., 2001).

In Newby et al. (2005), evidence for paleoenvironmental change was linked with the archeological record to explore the potential impact that climate change may have had on human resource use and technology. These data indicate that human resource use in the NEM may have been profoundly altered by rapid environmental changes, associated with abrupt changes in climatic patterns.

At the broad scale of the entire NEM, changes in the dominant regional vegetation include a shift from spruce and sedge (*Cyperaceae)* to pine (*Pinus*) and oak (*Quercus*) populations between ca. 14,000 and 10,000 cal BP, as the regions of highest abundances of these taxa shifted northward. Spatially-refined maps of pollen data that show sub-regional variations within these broader patterns are most relevant for inferences about human adaptations within the region.

By 13,000 cal BP, spruce populations had extended into Maine, New Brunswick, and Nova Scotia, but by 12,000 cal BP, spruce abundance had declined throughout the same area (Fig. 5). Concurrent with the onset of the YD, a change to cooler-than-previous conditions caused spruce populations to shift southward, and expanded the extent of open vegetation types (sedge, willow [*Salix*],

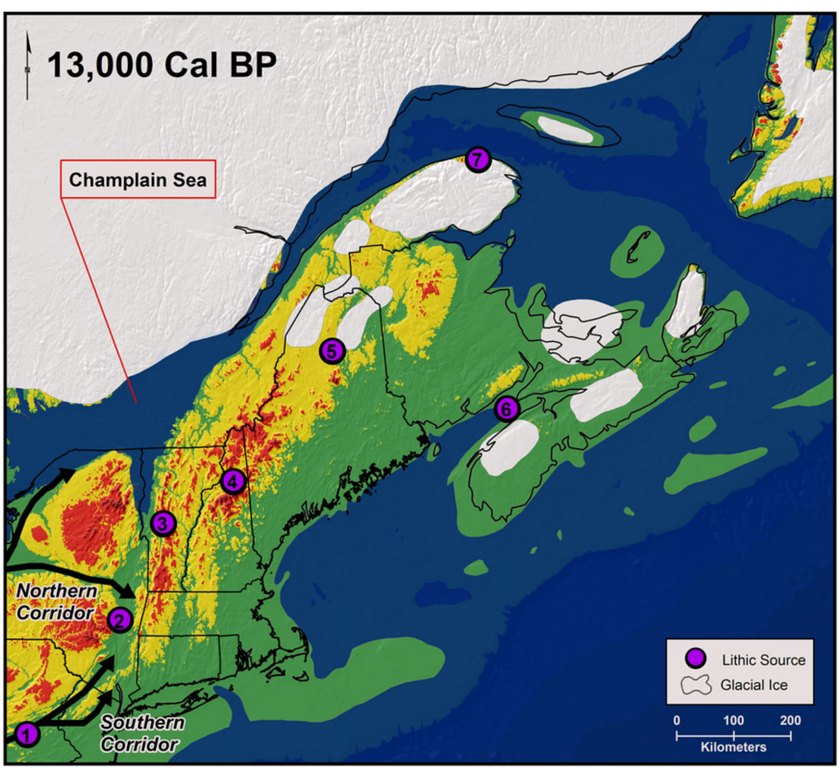

Fig. 4. Position of retreating Laurentide Ice Sheet and footprint of newly formed Champlain Sea in the NEM at circa 13,000 cal BP, probable Paleoindian migration routes, and schematic locations of key Paleoindian lithic sources. Probable routes of Paleoindian migration into the NEM may have included a northern corridor, following the Erie-Ontario lowlands into eastern New York, or a southern corridor, leading northeasterly via the upper Susquehanna or Delaware/Wallkill valleys to the Hudson Valley (after Newby and Bradley, 2007, Fig. 1B). Lithic sources: (1) Pennsylvania Jasper; (2) Normanskill chert, Hudson Valley, New York; (3) Cheshire quartzite, Vermont; (4) New Hampshire spherulitic rhyolite; (5) Munsungun chert, Maine; (6) Minas Basin chert, Nova Scotia; (7) Gaspé Peninsula Ordovician chert, Québec. (Not shown: Onondaga and other Devonian cherts that outcrop extensively along the northern and eastern fronts of the Appalachian plateau in New York [Fig. 1]).

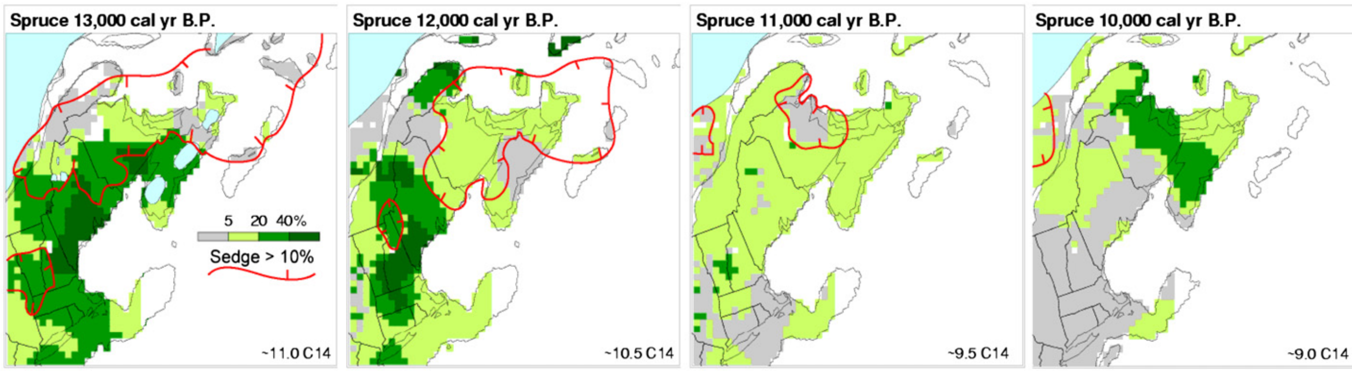

Fig. 5. Changes in vegetation in the NEM from 13,000 to 10,000 cal BP, showing spruce and sedge pollen abundance. At 13,000 cal BP, spruce was abundant throughout NEM. During the YD, spruce abundance shifted southward and sedge abundance increased. After 11,000 cal BP, spruce abundance diminished region-wide, then increased in the north by 10,000 cal BP.

grass [*Poaceae*] and sage [*Artemisia*] pollen) in portions of Maritime Canada where glaciers reactivated (Stea and Mott, 2005). Along the southwestern edge of the Gulf of Maine, and in New Hampshire and Massachusetts, abundant spruce populations increased even further, while in southern New England, spruce populations rebounded. These spruce woodlands and open tundra-like vegetation remained regionally important, and represent an environment that is similar to long-range migratory and local caribou herd habitats found in northern regions today (Newby et al., 2005).

After ca. 11,600 cal BP, dramatic warming 1) reduced the extent of both open and spruce-dominated vegetation, 2) increased the extent of temperate deciduous populations, and thus, 3) substantially reduced the habitat for long-range migratory caribou. This rapid warming is associated with regionally lower water levels as white pine (*Pinus strobus*: Newby et al., 2005, Fig. 2) became abundant in regional forests (Davis, 1969; Webb et al., 1993, 2004; Shuman et al., 2002, 2004; Oswald et al., 2007). This rapid climate shift at the end of the YD changed the resource base for humans, and may have also triggered changes in lithic technology and settlement in the region.

The mapped changes in pollen taxa indicate a shift in the landscape from late-glacial open woodlands and parklands to early Holocene closed canopy forests that began in portions of the NEM during the YD. These changes included increased abundances of spruce, alder, birch and pine and decreased abundances of sedge, willow, grass and sage (Newby et al., 2005, Fig. 1). Regionally, a general gradient from the northeastern to the southwestern portions of NEM sets the 'reversal' nature of the long-term changes in vegetation in the north apart from those in the south.

The focus on the rapid changes associated with the abrupt onset and even more rapid termination of the YD (Steffensen et al., 2008) now includes highly-resolved (sub-annual-to-multi-centennial) ocean and terrestrial records from the North Atlantic region that show other intervals of variable conditions during the YD, including glacial readvances, changes in sediment composition and transport rates, and variations in sea-surface temperatures and sea-ice (Kroon et al., 2000; Ebbesen and Hold, 2004; Bakke et al., 2009). The possibility exists that these variations in the North Atlantic region may have also impacted proximal areas like the NEM intermittently throughout the YD.

Lake-level studies across southern New England have shown significant variation in moisture levels over the past 15,000 years, including during the YD, indicating that drier (as well as colder) conditions may have accompanied the earliest human migrations into the NEM region.

In southeastern Massachusetts, lake-level analyses from Rocky Pond and New Long Pond, now provide the highest resolution hydroclimatic records currently available for the late-glacial to early Holocene NEM, and document evidence for previously unrecognized water level fluctuations in southeastern Massachusetts from 14,500 to 7000 cal BP (Newby et al., 2009). At Rocky Pond, a brief lowstand accompanied the onset of the YD, with two additional draw downs before ca. 12,200 cal BP, after which, water levels were higher until ca. 11,000 cal BP. The initial low stand at New Long Pond peaks around 12,600 cal BP, after which, three additional rises and falls in lake-levels are recorded between ca. 12,100 and 11,600 cal BP.

In southwestern Massachusetts, the sedimentary record from Davis Pond shows prolonged dry conditions throughout the YD (Newby et al., 2011). North of Davis Pond in the Taconic Uplands, North Pond has a well-represented pollen sequence during the YD, yet little is recorded at Berry Pond, only 50 km away (Whitehead and Crisman, 1985) and slightly further west, Burden Lake does not begin deposition until the early Holocene (Gaudreau, 1986).

Southwest of Davis Pond, in New York's Hudson Highlands at Spruce and Sutherland Ponds, Maenza-Gmelch (1996, 1997) showed the expansion of boreal taxa, such as spruce and fir, the decline in temperate taxa, such oak, ash (*Fraxinus*) and hop/hornbeam (*Ostrya*/*Carpinus*) and maximum abundances for alder and birch, consistent with regional vegetation changes associated with the YD (Peteet et al., 1993; Shuman et al., 2002). Low water conditions during portions of the YD may be evidenced at Spruce Pond from changing abundances of aquatic macrofossils.

Finally, in the Hudson Lowlands, late-glacial pollen stratigraphies from three wetland sites have little or non-constant deposition for the YD, and at Binnewater Pond, a pine-, fir-, alder- and birch-dominated pollen assemblage is abruptly replaced by an oak-dominated, Holocene-age (10,100 cal BP) pollen assemblage (Robinson et al., 2005). These wetland sites each became dry shortly after 12,000–11,000 cal BP, likely due to both local topography and climate (Robinson et al., 2005).

This review shows that changes in regional moisture balance in the NEM, as inferred from lake-level reconstructions, represent another critical aspect of climate variability during and after the YD that has received relatively little consideration. Coupled with information about past changes in vegetation, these insights provide a richer, more detailed environmental context for ongoing and future research on possible links between ecological changes and shifts in Paleoindian cultural behaviors.

Table 1
Chronology of modal point forms for New England-Maritimes and eastern Great Lakes regions (modified after Bradley et al., 2008).

Chronology	New England-Maritimes	Eastern Great Lakes
Early Paleoindian ~12,900–12,200 cal BP (~11,000–10,300 BP)	Kings Road-Whipple (12,900–12,700 cal BP)	Gainey
	Vail-Debert (12,700–12,200 cal BP)	Not present
	Bull Brook-West Athens Hill (12,700–12,200 cal BP)	Butler
Middle Paleoindian ~12,200–11,600 cal BP (~10,300–10,100 BP)	Michaud-Neponset (12,200–11,800 cal BP)	Barnes
	Crowfield-related (Age indeterminate)	Crowfield
	Cormier-Nicholas (11,800–11,600 cal BP)	Holcombe
	Not present	Hi-Lo
Late Paleoindian ~11,600–10,000 cal BP (~10,100–9000 BP)	Agate Basin-related (11,600–10,800 cal BP)	Agate Basin/Plano
	Ste. Anne-Varney (10,800–10,000 cal BP)	Eden/Plano

4. Human occupations in the NEM during and after the Younger Dryas

4.1. Paleoindian Biface sequence and chronology

Newby et al. (2005, pp. 148–150) and Spiess et al. (1998, pp. 235–238) proposed the first comprehensive sequence of Paleoindian bifaces for the NEM, consisting of early (Bull Brook, Debert/Vail); middle (Michaud/Neponset); and late Paleoindian (Nicholas, Agate Basin-related, Dalton-related and Ste. Anne/Varney) biface forms. These seven "types" were defined using morphological and technological criteria (Newby et al., 2005, pp. 149–150). Newby et al. (2005) compared this proposed sequence to then-available NEM Paleoindian radiocarbon ages, which were ranked based on quality of archaeological context and size of standard deviation (Newby et al., 2005, p. 148, Table 1). This comparison provided partial support for the proposed sequence of earlier fluted and later unfluted NEM Paleoindian point forms. Additionally, this analysis showed that NEM fluted point forms overlapped the YD, and that the transition from fluted to unfluted bifaces roughly coincided with the YD terminus (Newby et al., 2005, p. 150). The radiocarbon ages associated with fluted point forms, however, contained several crucial, yet low-rank determinations, highlighting the need to augment the regional radiocarbon database.

Bradley et al. (2008) proposed a revised Paleoindian biface sequence for the NEM (Table 1) using morphological and technological attributes to identify "modal, or common, forms recognizable across the region," noting that these categories each display a range of internal variability (Bradley et al., 2008: 123). Key technological and stylistic attributes defining these modal forms include overall dimensions, face angle, basal treatment, and fluting characteristics (Bradley et al., 2008: 123–124). Importantly, most of the resulting eight biface categories in this revised NEM sequence have analogs in the Paleoindian point series developed for the eastern or lower Great Lakes (e.g., Ellis and Deller, 1997; Ellis et al., 2003; Ellis, 2004) (Table 1) (Fig. 6).

Bradley et al. (2008: 124–125) also considered the applicability of the Clovis point type to the NEM. Recent morphological and technological definitions of Clovis biface technology describe finished points as lanceolate bifaces with shallow basal cavities, parallel to slightly divergent lateral margins, and single or multiple flutes extending less than half the length of the point (e.g., Morrow and Morrow, 2002, pp. 148–149). Gainey and Kings Road-Whipple points, the earliest biface forms proposed for the eastern Great Lakes and NEM sequences respectively (Ellis and Deller, 1997; Ellis et al., 2003; Bradley et al., 2008), display generally similar morphology and metrics to Clovis points (Table 2). In terms of morphology, the most pronounced difference is in shallower basal depth for the Clovis form.

From a technological standpoint, comparison of lithic reduction sequences for Clovis, Gainey, and Kings Road-Whipple reveal several differences (Table 3). Preform thinning techniques perhaps offer the clearest distinction: Clovis preforms were reduced by transverse percussion and controlled overshot flaking, versus

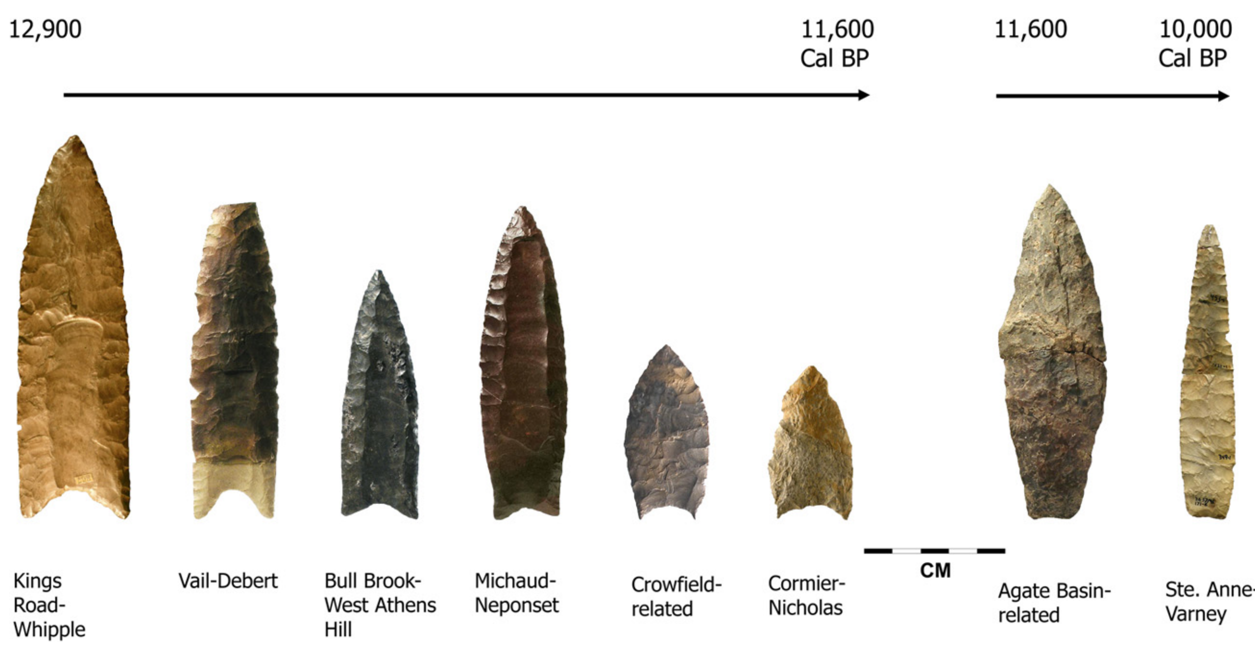

Fig. 6. Sequence of NEM Paleoindian biface forms, including fluted points during the YD (12,900–11,600 cal BP) and unfluted points, post-YD (11,600–10,000 cal BP).

Table 2
Comparison of attributes for Clovis, Gainey, and NEM Paleoindian point forms (derived from Bradley et al., 2008: 125 and Tables 3–11).

Attribute[a]	Clovis		Gainey		NEM Early Paleoindian						NEM Mid. Paleoindian				NEM Late Paleoindian			
					KR-W		V-D		BB-WAH		M-N		C-N		AB-r		Ste. A-V	
	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N	Mean	N
Length	71	28	59.4	9	65.6	8	79.6	17	63.0	20	66.0	9	45.0	6	81.4	8	118.0	9
Medial width	27		26.0	13	29.4	19	30.0	41	26.4	53	23.8	20	26.0	29	28.2	26	21.8	27
Basal width	25		25.3	(14)	28.6	19	29.5	45	25.5	54	24.0	19	17.0	32	14.5	21	18.0	25
Thickness	7		7.0	(13)	5.8	(6)	7.9	(41)	7.0	(35)	5.3	(12)	4.8	(28)	6.3	(19)	6.4	(17)
Face angle (°)	>90		90.5	(18)	91.9	(18)	90.3	(61)	91	(50)	92	(18)	98	(28)	101.8	(21)	92.7	(27)
Basal ears[b]	P					–		–		1		6		–		–		–
	D					–		3		4		7		–		–		–
	S					10		16		26		2		–		–		–
	N					12		44		23		–		32		21		26
Basal depth[c]	2.4		5.3	(14)	5.9	(21)	10.6	(16)	5.3	(55)	4.8	(16)	2.3	(30)	NA		NA	

Notes:
[a] Attributes defined in Bradley et al., 2008, pp. 123-124 (unless noted, mean attribute values in mm).
[b] Basal ears: P = Prominent (>2 mm); D = Distinct (1-2 mm); S = Slight (<1 mm); N = None.
[c] Basal shape on AB-r and Ste. A-V points ranges from convex to concave (see Bradley et al., 2008, Tables 10 and 11).
[d] NEM Point forms: KR-W = Kings Road-Whipple; V-D = Vail-Debert; BB-WAH = Bull Brook-West Athens Hill; M-N = Michaud-Neponset; C-N = Cormier-Nicholas; AB-r = Agate Basin-related; Ste. A-V = Ste. Anne-Varney.

primarily medial percussion flaking for Gainey and Kings Road-Whipple preforms. (Controlled overshot flaking is now commonly viewed as a diagnostic trait of Clovis biface technology [e.g., Collins and Hemmings, 2005, p. 10; Graves et al., 2006; Huckell, 2007, pp. 192–193; Smallwood, 2010; Bradley et al., 2010]). Other differences include striking platform position relative to biface centerplane before fluting, and post-fluting biface reduction (Table 3). Bradley et al. (2008) conclude that the Clovis fluted biface type is not present in the NEM, although all three biface forms appear to be related: "…it appears to us that Clovis is the earlier, antecedent form, while Gainey and Kings Road-Whipple points…are later and Clovis-derived" (Bradley et al., 2008: 29).

The Bradley et al. (2008) Paleoindian biface sequence differs in certain key areas from earlier NEM typology in Newby et al. (2005) and Spiess et al. (1998). First, the Bull Brook "type" is now superseded by the Kings Road-Whipple form as the presumed oldest fluted point form in the region; further, this Bull Brook "type" has been redefined as the Bull Brook-West Athens Hill form (Bradley et al., 2008, pp. 127–130, 136–141). Second, the cultural status of regionally rare Dalton-like bifaces remains uncertain for the NEM, and this form is not included in the revised sequence (Bradley et al., 2008, p. 161). Based on Bradley et al. (2008, pp. 126–161), these NEM point forms are summarized below, with additional data presented in Tables 2 and 3.

Kings Road-Whipple (KR-W) points resemble Gainey points of the eastern Great Lakes region. These fluted bifaces are usually medium-to-large, robust forms with a moderately deep basal concavity and single flutes on each face usually measuring 1/4 to 1/3 of the point length. Lateral margins are nearly parallel (face angle mean = 91.9°).

Vail-Debert (V-D) points are generally large and robust, nearly parallel-sided, with a distinctive deep U-shaped basal concavity. Channel flake scars typically extend roughly one-third of the total point length.

Bull Brook-West Athens Hill (BB-WAH) points are smaller and more gracile, with nearly parallel sides and a moderately deep basal concavity, and often, weakly flaring basal "ears." Flutes measure one half or more of the total length of the biface.

Table 3
Comparison of reduction sequences proposed for Early Paleoindian Clovis, Gainey, and Kings Road-Whipple fluted point forms (revised from Bradley et al., 2008, Table 4).

	Reduction Sequences for Early Fluted Point Forms			
	Clovis	Clovis	Gainey	Kings Road-Whipple
Manufacturing task	Multiple researchers	Morrow and Morrow (2002)	Morrow and Morrow (2002)	Bradley et al. (2008)
Preform thinning	Transverse percussion flaking and overshot flaking.[a]	Transverse percussion flaking from isolated, centered striking platforms.	Primarily medial percussion flaking.	Primarily medial percussion flaking.
Positioning Striking Platform for Fluting	Platform placed at or near biface centerplane ("diagonal fluting").[b]	Platform placed at or near biface centerplane.	Platform set low to the face to be fluted.	Platform set below biface centerplane.
Fluting Procedure	Probably fluted by direct, soft hammer percussion.[c]	Probably fluted by direct, soft hammer percussion.	Probably fluted by indirect percussion, with tipsupported.	Probably fluted by direct, soft hammer percussion (no tip-supported fluting).
Post-Fluting Reduction	Variable, ranging from percussion thinning and shaping to percussion or pressure retouch.[b]	Additional thinning by soft hammer percussion after fluting.	No additional thinning after fluting, only pressure flake to finish.	Variable

Notes:
[a] Bradley et al., 2010, pp. 68–77; Collins and Hemmings, 2005, p. 10; Huckell, 2007, pp. 191–193; Smallwood, 2010.
[b] Bradley et al., 2010, pp.100–101.
[c] Collins et al., 2007, p. 103.

Michaud-Neponset (M-N) points are medium-to-long bifaces with slightly divergent sides, moderately deep basal concavities, prominent basal ears, and long channel flake scars that often extend the full length of the point. These forms are analogous to Barnes points in the eastern Great Lakes.

Crowfield-related points are comparable to the Crowfield point form in the eastern Great Lakes. In the NEM, they are exceedingly rare, having only been recorded at the Reagen site (Robinson, 2009), and as a few isolated finds. Crowfield-related points are moderate to large in size and thin, with a shallow basal concavity, and lateral edges that expand markedly from the base. Basal ears are absent.

Cormier-Nicholas (C-N) points are comparable to Holcombe points in the eastern Great Lakes. C-N points are small and thin, with a shallow basal concavity, and expanding lateral margins (face angle mean = 98°). Again, basal ears are absent. Compared to earlier biface forms, the most striking aspect of C-N points is the lack of consistent fluting: points may be fluted on both faces, on one face only, or sometimes are only basally thinned.

Agate Basin-related (AB-r) points, similar to the Agate Basin form in the High Plains of North America (Frison and Stanford, 1982; Stanford, 2005; Huckell and Judge, 2007), likely represent the earliest late Paleoindian form in the NEM. These large points are unfluted, display sub-parallel to collateral flaking, and possess lateral margins that expand markedly from a narrow base that is slightly concave, flat, or slightly convex.

Ste. Anne-Varney (Ste. A-V) points are long, thin, narrow bifaces that are unfluted, with either a slightly contracting or squared-off base. Bases may be slightly concave or convex, but are most commonly flat. Like AB-r points, they usually exhibit parallel or collateral flaking, but are more gracile in form. As with AB-r points, these forms have often been referred to as "Plano" points in the Great Lakes.

This point sequence was compared with a revised selection of radiocarbon ages from 13 archaeological sites, including some ages newly available since the original synthesis in Newby et al. (2005, p. 145, Table 1) (Fig. 7; Appendix). As before, radiocarbon dates were ranked for precision, accuracy, and archaeological association, excluding lower scoring determinations. Problematic suites of older radiocarbon dates from the Whipple and Bull Brook sites that displayed very large aggregate time spreads were discarded. To avoid over representation from the Debert site, its 13 radiocarbon ages were calibrated, and then the average of the median probabilities was used from this suite of ages for this site. The revised chronology shows that 16 of 26 calibrated radiocarbon ages fit the criteria for the highest rank (1), indicating good archaeological provenience and a STD ≤150 yrs (Appendix).

Review of these calibrated determinations indicates three probable outliers. The youngest and oldest dates for Vail (10,040 ± 395, 11,120 ± 180) have a lower rank because of broad standard deviations. These two ages are considered here to be unacceptable outliers (Haynes et al. 1984, p. 185). (Note: Gramly and Puryear [2009] consider the radiocarbon date of 10,710 ± 50 yr BP [12,577–12,660 cal BP or median probability age of 12,626 cal BP] to be the most accurate determination for the age of the Vail occupations). In addition, the youngest date for Michaud (9010 ± 210 yr BP or median probability age of 10,109 cal BP) falls in the latter portion of the early Holocene, and this outlier is therefore likely too young to be associated with the site's middle Paleoindian occupation.

Excluding outliers, this suite of calibrated radiocarbon ages further supports the basic conclusions of Newby et al. (2005, p. 150) on chronological changes in NEM Paleoindian bifaces: (1) the biface sequence is marked by a shift from fluted to non-fluted forms, and (2) radiocarbon determinations indicate fluted bifaces are likely confined to the YD (12,900–11,600 cal BP), after which unfluted late Paleoindian lanceolate points prevail (Fig. 7). From these results, the approximate calendar time ranges for individual NEM point forms were generated (Table 1). These represent minor revisions of some of the time ranges proposed in Bradley et al. (2008).

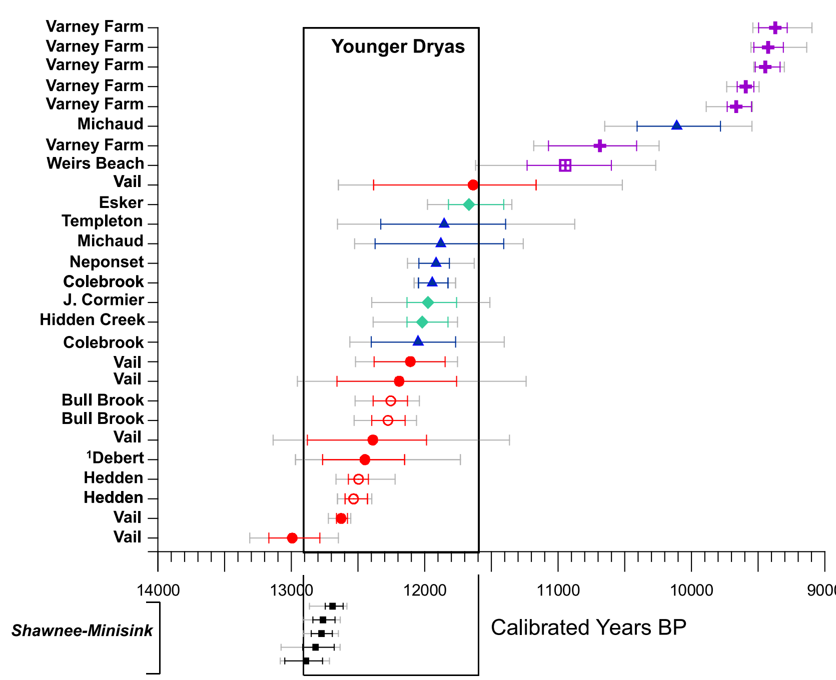

Fig. 7. Calibrated radiocarbon ages for NEM Paleoindian sites. Symbols indicate median age with the highest probability, and horizontal lines show 1-sigma and 2-sigma confidence intervals for each determination. Key for NEM modal point forms associated with these dates: solid circles = V-D points; open circles = BB-WAH points; triangles = M-N points; diamonds = C-N points; grid square = AB-r points; cross = Ste. A-V points. (Note: radiocarbon ages from the Shawnee-Minisink site, located immediately south of the NEM region, discussed text.)

Additional observations arise from this updated comparison of radiocarbon ages versus the revised point sequence of Bradley et al. (2008) (Fig. 7). For the early Paleoindian portion of this biface sequence, overlap between dates for V-D and BB-WAH points suggests either contemporaneity or partial chronological overlap of these biface forms between about 12,700 and 12,200 cal BP.

With outliers excluded, the remaining eight calibrated Middle Paleoindian ages all fall in the latter portion of the YD (Fig. 7). Bradley et al. (2008, pp. 141–152) hold that, like the Barnes and Holcombe point analogs in the eastern Great Lakes, C-N bifaces follow M-N points in the NEM. Plotted M-N and C-N dates indicate a possible chronological overlap for these point forms (Fig. 7). This could reflect persistent difficulties in accurate calibration of Younger Dryas-age dates due to past fluctuations in atmospheric carbon (Fiedel 2006; Muscheler et al., 2008). Pending additional age determinations, M-N point sites fall in a projected timeframe of circa 12,200–11,800, and C-N sites in a span of circa 11,800–11,600.

Finally, for late Paleoindian determinations, the available dates provide limited evidence for the temporal primacy of AB-r points over Ste. A-V forms. Other NEM sites (Rimouski, Lower Saranac, Ste. Anne des Monts) have also produced young dates that have been questioned by some researchers (Bradley et al., 2008, pp. 161; Petersen et al., 2000, pp. 127–128), while others see a later end-date for late Paleoindian parallel-flaked points in the northern NEM (e.g., Burke, 2010). For the region as a whole, the terminal age of Ste. A-V points remains uncertain.

4.2. Paleoindian colonization and settlement

Before the mid-1970s, archaeologists had investigated less than 10 Paleoindian sites in the NEM. Since then, over 90 additional sites have been documented in the region, a handful with radiocarbon ages and most with diagnostic bifaces that now permit relative dating (Spiess et al., 1998; Bradley et al., 2008). Using relative and radiocarbon chronological data on these sites allows comprehensive examination of the late Pleistocene colonization of the NEM, building on previous models of human migration into the region (e.g., Bradley, 1998; Spiess et al., 1998; Curran, 1999; Newby and Bradley, 2007).

This study relies primarily on chronology and diagnostic point form associations of archaeological sites to track Paleoindian colonization and settlement in the NEM. Non-site point finds comprise important data that also bear on these issues (Anderson et al., 2010), but due to currently variable coverage and data quality for point isolates across the region (e.g., Lothrop, 2009; Lothrop and Bradley, in press), the focus is on site-level data here. In the future, standardization and expansion of the information on provenience, form, and relative age of NEM Paleoindian point isolates will provide a valuable companion data set for studying Paleoindian settlement in the region.

In this study, Paleoindian sites are defined as one or more horizontal artifact concentrations on a single landform, reflecting residential or other activity areas. The data set is drawn from Bradley et al. (2008), with the addition of a handful of sites identified or reported in the last three years. The resulting group of 82 NEM Paleoindian sites consists mostly of residential encampments, but also includes other types of activity loci such as toolstone quarries and reduction stations (e.g., Funk et al., 1969; Funk, 2004; Burke, 2010), caches (Bradley et al., 2008, p. 159), residential sites with caches (Gramly, 1998), and a probable kill site (Gramly, 1984).

As part of this settlement analysis, local concentrations of Paleoindian sites were also distinguished as *site clusters*. These consist of three or more sites in an area measuring 10 km or less in diameter, and typically associated with a single geomorphic

Table 4
Locational data on NEM Paleoindian Site Clusters.

Cluster	Sites	Footprint Diameter	Landscape(s)	Other Locational Factors	References
Mid-Hudson Valley	Kings Road/ Swale, West Athens Hill, Railroad #1	7 km	Valley bottom/Proglacial lakebed, Ridge tops	Ordovician toolstone outcrops; major valley corridor	Funk (1973, 1976, 2004); Funk et al. (1969), Weinman and Weinman (1978), Lothrop and Bradley (in press)
Israel River	Jefferson I, II, III, IV, and V	1 km	Glacial ablation till plain	Proximal rhyolite sources, bed of proglacial Lake Israel, topographic funnel to White Mountains	Boisvert (1998, 2004, in press); Bunker and Potter (1999)
Magalloway Valley	Vail, Vail kill #1, Wheeler Dam, Adkins, Vail kill #2, Morss	10 km	Glacial outwash plain	Valley constriction	Gramly (1982, 1984, 2005); Gramly and Puryear (2009), Spiess et al. (in press)
Auburn Airport	Lamontagne, Michaud, Lamoreau, Taxiway, Beacon Hill, Keogh, Cormier	3 km	Late Pleistocene Dune field	Low-order stream drainages	Spiess and Wilson (1987, 1989), Spiess et al. (1998, in press)
Debert-Belmont	Debert, Belmont I & II, Hunter Rd.	4 km	Proglacial lakebed with reworked sands	Proximal to glaciers (& "ice patches") during occupation	MacDonald (1968), Brewster et al. (1996), Rosenmeier et al. (in press)
La Martre	Reduction/residential sites: La Martre (DhDm1), Stations 12, 13, 15, 16; Quarry sites: Suroit Quarry (DhDn-8); Montagne Bleue (DhDn-9, DhDn-10)	3 km	Reduction/residential sites on marine terraces; Quarry sites at outcrops	Proximal to Goldthwait Sea/St. Lawrence estuary; Quarry sites at toolstone outcrops; late deglacial landscape	Burke (2010), Chalifoux (1999), Dumais (2000)
Rimouski	DcEd-1, DcEd-5, DcEd-6	1 km	Marine terraces	Proximal to Goldthwait Sea/St. Lawrence estuary &, toolstone sources; late deglacial landscape	Chapdelaine and Bourget (1992), Chapdelaine (1996)

Table 5
Chronology of NEM Paleoindian Site Clusters.

Site Cluster & sites	NEM sub-periods and point form associations						
	Early Paleoindian			Middle Paleoindian		Late Paleoindian	
	KR-W	V-D	BB-WAH	M-N	C-N	AB-r	Ste. A-V
Mid-Hudson Valley Cluster							
Kings Road/Swale	X						
West Athens Hill	X		X				
Railroad #1	?	?	?				
Israel River Cluster							
Jefferson III	X	X		X			
Jefferson II		X		X			
Jefferson IV			X		X		
Jefferson I				X			
Jefferson V				X			
Magalloway Valley Cluster							
Vail		X					
Vail K1		X					
Wheeler Dam		X					
Adkins			X				
Vail K2				X			
Morss				X			
Auburn Airport Cluster							
Lamontagne			X				
Michaud				X			
Lamoreau				X			
Taxiway				X			
Beacon Hill				X			
Keogh				X			
Cormier					X		
Debert-Belmont Cluster							
Debert		X					
Belmont I		?					
Belmont II		?					
Hunter Rd.		?					
La Martre Cluster							
La Martre-16						X	
La Martre-12							X
La Martre-15							X
La Martre-13						?	?
Suroit Quarry (DhDn-8);						?	?
Montagne Bleue (DhDn-9, DhDn-10)						?	?
Rimouski Cluster							
DcEd-1							X
DcEd-5							X
DcEd-6							?

Key to NEM point forms: KR-W = Kings Road-Whipple; V-D = Vail-Debert; BB-WAH = Bull Brook-West Athens Hill; M-N = Michaud-Neponset; C-N = Cormier-Nicholas; AB-r = Agate Basin-related; Ste. A-V = St. Anne-Varney.

landscape (potentially comprised of multiple landforms). Additionally, these site clusters may or may not consist of sites represented by the same or different point types, and can include undated sites as well. By this definition, site clusters can offer implications about increased or redundant use of certain NEM landscapes during variable spans of time. Tables 4 and 5 list site clusters in terms of locational factors, and with respect to constituent sites and associated point forms.

Of the 82 Paleoindian sites used in this analysis, nearly two-thirds (51 sites) are situated on discrete landforms with no other associated sites. The remaining 31 sites (38%) are associated with site clusters.

To examine Paleoindian colonization and settlement in the NEM, a sequence of GIS-based maps was generated, plotting locations of sites and site clusters through time as reflected by associated NEM point forms. Collectively, these data offer insights at multiple spatial scales (regional, sub-regional/local) for (1) human colonization of the region, (2) distributions of sites of similar age across the NEM, and (3) local site clusters.

Figs. 8–13 illustrate locations of Paleoindian sites and site clusters in the NEM, sorted by associated point forms, between circa 12,900 and 10,000 cal BP. (Because middle Paleoindian Crowfield-related points in the NEM have only one site association thus far – the Reagen site in northern Vermont [Bradley et al., 2008; Robinson, 2009, in press]), settlement mapping was not generated for this point form.) Using GIS shape files derived primarily from Dyke (2004), and supplemented by Franzi et al. (2010), these maps show site and site cluster locations in relation to the evolving deglacial landscapes and coastlines of the NEM, during and after the YD. (Although the configuration of the

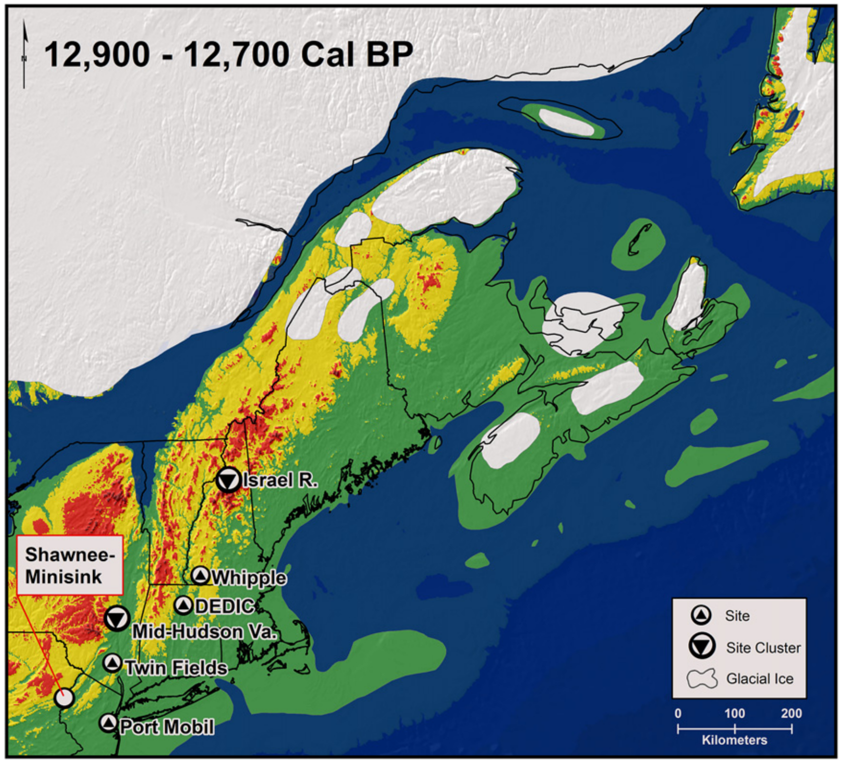

Fig. 8. Locations of NEM early Paleoindian sites and site clusters with Kings Road-Whipple point forms (12,900–12,700 cal BP). (Note: location of Shawnee-Minisink site, illustrated to show proximity to the NEM study region.)

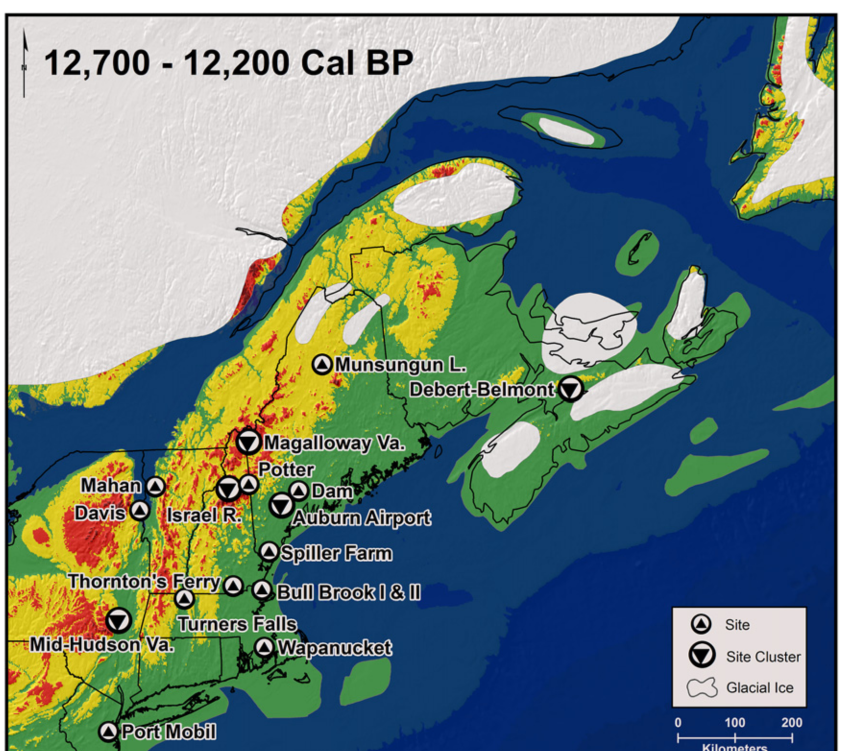

Fig. 9. Locations of NEM early Paleoindian sites and site clusters with Vail-Debert and Bull Brook-West Athens Hill point forms (12,700–12,200 cal BP).

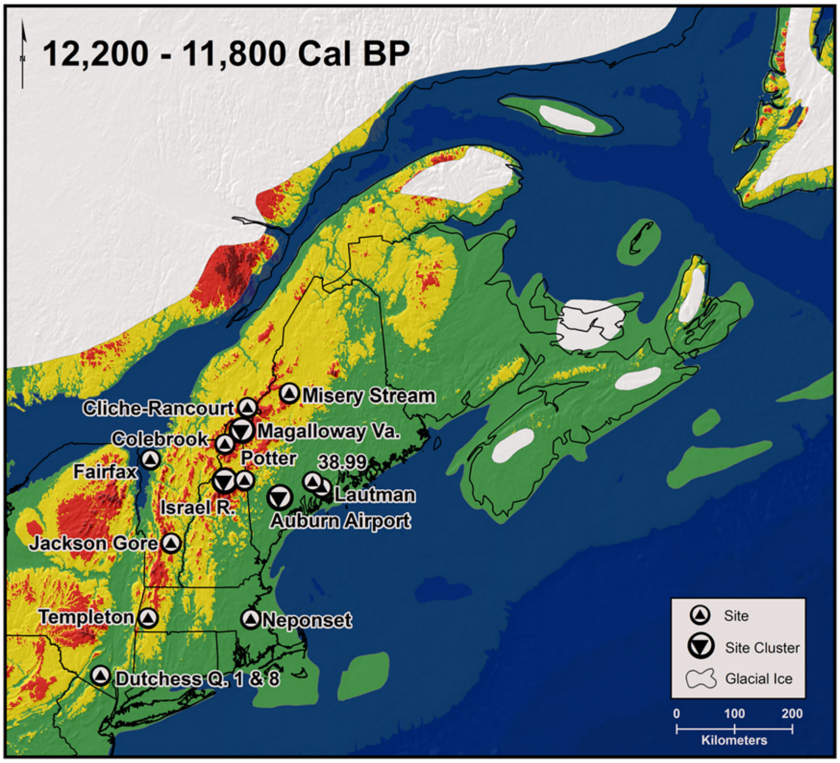

Fig. 10. Locations of NEM middle Paleoindian sites and site clusters with Michaud-Neponset point forms (12,200–11,800 cal BP).

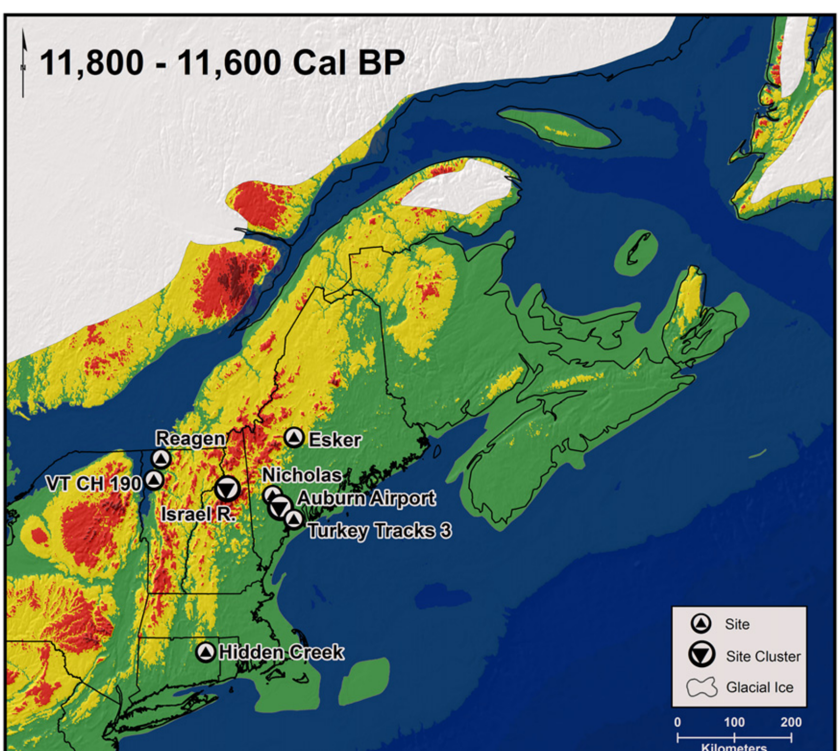

Fig. 11. Locations of NEM middle Paleoindian sites and site clusters with Cormier-Nicholas point forms (circa 11,800–11,600 cal BP).

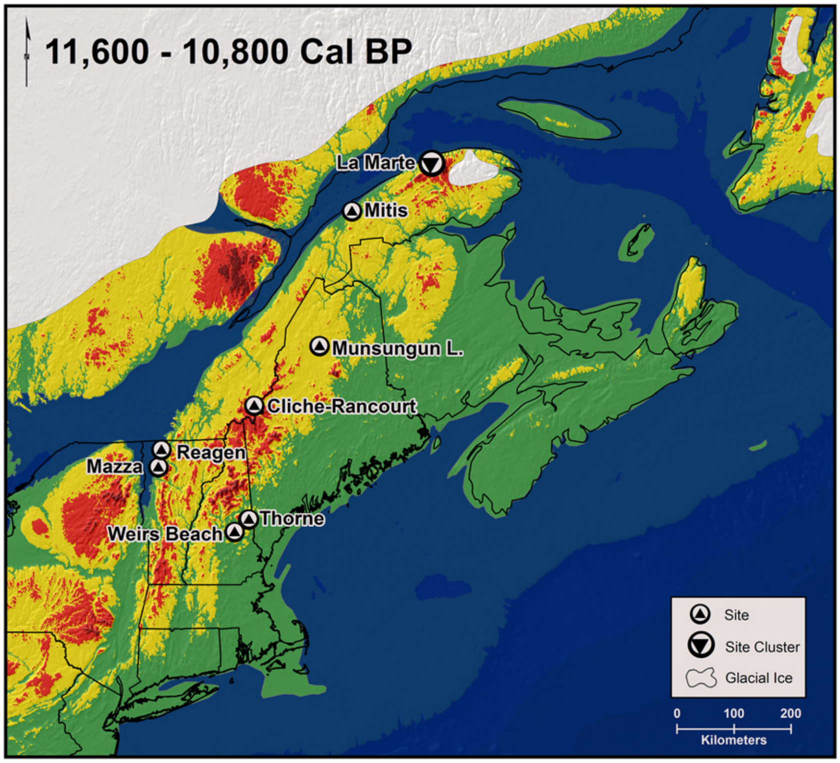

Fig. 12. Locations of NEM late Paleoindian sites and site clusters with Agate Basin-related point forms (circa 11,600–10,800 cal BP).

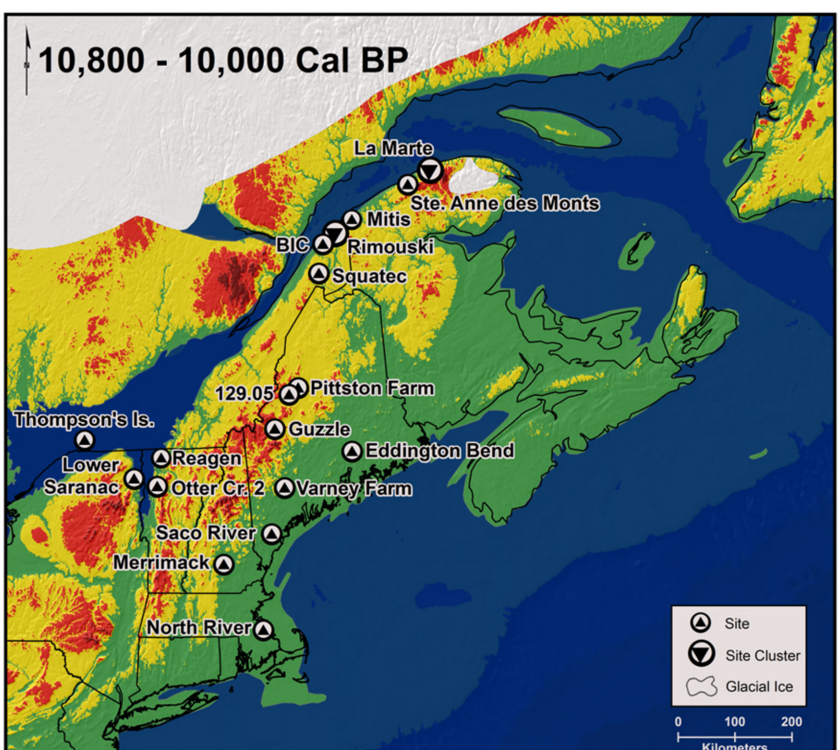

Fig. 13. Locations of NEM late Paleoindian sites and site clusters with Ste. Anne-Varney point forms (10,800–10,000 cal BP).

Champlain sea continuously regressed because of isostatic rebound between 13,100 and 9800/9700 cal BP [Cronin et al., 2008], comprehensive mapping of these changes is not yet available. Hence, for Figs. 1, 4, and 8–13, the approximate maximum footprint of this inland sea when it first formed was held constant.)

Eastern New York occupies the southwestern base of the NEM peninsula, making it the gateway for Paleoindian settlement of the broader NEM. At least two lines of evidence suggest that human colonization of eastern New York did not occur before about 12,900 BP (Newby and Bradley, 2007; Lothrop and Bradley, in press). First, during the span of roughly 13,400 and 13,000 cal BP, dramatic deglacial events periodically impacted landscapes in the Hudson Valley, probably limiting the region's ease of human travel and habitability. Proglacial lakes persisted in the Hudson-Champlain lowlands, including Lake Albany to the south and other meltwater bodies to the north. This timespan was also punctuated by two catastrophic meltwater floods down the Hudson Valley (Donnelly et al., 2005; Rayburn et al., 2005; Stanford, 2009). By about 13,000 cal BP, proglacial Lake Albany appears to have drained from the Hudson Valley, opening up this natural north-south corridor to human transit and habitation (Fig. 4). Second, five AMS ages for the Shawnee-Minisink Paleoindian site in the upper Delaware Valley have yielded a mean age of $10,937 \pm 15$ BP (Gingerich and Waters, 2007; Gingerich, 2011), while the spread of two-sigma calibrated ages extends from 13,070 to 12,780 cal BP (Gingerich 2007, p. 121), indicating a Paleoindian presence in the upper Delaware Valley of Pennsylvania at around 12,900 cal BP. This suggests that probably by no later than 12,800 cal BP, Paleoindian populations had entered the NEM region from the west or south, by valley corridors through eastern New York (Fig. 8).

Likely pathways for colonization through eastern New York could have followed at least two major corridors (Ritchie, 1957; Newby and Bradley, 2007; Lothrop and Bradley, in press) (Fig. 4). To the north, groups moving eastward from the Ohio Valley could have followed the Ontario Lake Plain, skirting the southern margin of early Lake Ontario, and then traveling north around the Adirondacks, or more likely, down the Mohawk Valley. From the south, Paleoindian groups could have entered eastern New York by following the Susquehanna or Delaware valleys upstream, and then traversing drainage divides into the Mohawk or Wallkill/Hudson valleys.

4.2.1. Kings Road-Whipple Point Sites (~12,900–12,700 cal BP)

Dating to the YD onset or shortly thereafter, the presumed earliest sites in the NEM are relatively rare, and largely restricted to the southern portion of the region (Fig. 8). In the Hudson Valley, Paleoindian occupations with KR-W points are recorded at the Port Mobil and Twin Fields sites, and at the Mid-Hudson site cluster (where the Kings Road/Swale and West Athens Hill sites are associated with Normanskill chert outcrops) (Tables 4 and 5). There is good evidence in these Hudson Valley sites for the import of Pennsylvania Jasper, perhaps related to colonizing movements from eastern Pennsylvania (Lothrop and Bradley, in press). To the northeast, KR-W point sites are also recorded in the middle and upper Connecticut Valley, including the DEDIC (Sugarloaf) and Whipple sites, and the Jefferson III site in the Israel River cluster (likely situated within 5 km of a major source of spherulitic rhyolite) (Pollock et al. 2008a, b). In general, these sites are restricted to the southwestern and central sectors of the NEM, while more recently deglaciated northerly areas contain no recorded sites.

4.2.2. Bull Brook-West Athens Hill and Vail-Debert Point Sites (12,700–12,200 cal BP)

BB-WAH and V-D point sites are depicted jointly, reflecting presumed temporal overlap (Fig. 7, Appendix). Viewed collectively, the broad distribution of sites with V-D or BB-WAH points shows how, after initial entry to the NEM, Paleoindian populations expanded further north and east from the Hudson and Connecticut valleys. For the first time, sites are found in what were near-coastal Atlantic settings (e.g., Bull Brook and Spiller Farm), and fronting the southern arm of the Champlain Sea (e.g., Davis and Mahan) (Fig. 9). Pelletier and Robinson (2005) and Robinson et al. (2009) propose that the Bull Brook I and II sites may have been linked to seasonal caribou use of offshore emergent island settings exposed by low sea levels during the YD. By their interpretation, the Bull Brook site locations were strategically chosen near a topographic valley setting to intercept caribou migrating to winter ranges. Along the western margin of the NEM, the Davis and Mahan sites each lie within one kilometer of the early Champlain Sea coastline, perhaps reflecting Paleoindian use of marine or estuarine resources (Ritchie, 1969, pp. 19–22; Robinson, in press).

Sites with V-D points display a more northern focus, and include the Jefferson II site in the Israel River cluster, three sites in the Magalloway Valley cluster, and tentatively, most or all sites of the Debert-Belmont cluster (Table 5). By contrast, almost all remaining sites have yielded BB-WAH points, and occupy a more southerly distribution. Bradley et al. (2008, pp. 135) suggest that these northern and southern site distributions may reflect separate Paleoindian populations in the NEM. Interestingly, the Israel River and Magalloway Valley site clusters each include two or more sites with V-D points and also one site each with BB-WAH bifaces (Table 5), perhaps signaling geographic overlap in groups represented by these point forms.

Exploitation of the Munsungun Lake chert source in north-central Maine begins at this time, evidenced by Paleoindian workshops confined to a small site area associated with outcrops (Bonnichsen et al., 1991; Bradley et al., 2008). Artifacts at BB-WAH sites often reflect long-distance movement of toolstone by Paleoindians from primary geologic sources. In southern Maine, for example, the Spiller Farm site assemblage consists almost exclusively of Munsungun chert, even though the site is located 340 km south of the geologic source (Burke, 2006; Pollock et al., 2008b). At the Mahan site in western Vermont, Paleoindians discarded stone tools manufactured of Cheshire quartzite and Munsungun chert (Crock and Robinson, in press). Extensive transport of toolstone from several sources is indicated at the Bull Brook site, including Munsungun chert, New Hampshire rhyolites, Pennsylvania Jasper, and Normanskill chert (Robinson et al., 2009). The last of these appears to be the most common raw material, pointing to a strategic role for this Hudson Valley source during early Paleoindian times. For V-D point sites, lithic source use is more variable. At the Debert-Belmont site cluster, Minas Basin cherts predominate, with little evidence of toolstone from southern locations (MacDonald, 1968; Burke, personal communication, 2010). To the southwest, Munsungun cherts appear to be present at the Vail site (Pollock et al., 1999), although Hudson Valley cherts may also be present (Lothrop and Bradley, in press).

Remnant glaciers in northern Maine and Nova Scotia reactivated and expanded during the YD, and were thus prominent features of the northern NEM landscape (Fig. 9) (Borns et al., 2004; Stea and Mott, 2005). Recent research on modern melting glaciers and "ice patches" (smaller, stratified accumulations of snow and ice) in northern arctic/subarctic regions highlights the potential importance in prehistory of these local landscape features for both caribou and humans – a relationship that perhaps also applied to the late Pleistocene northern NEM (Farnell et al., 2004; Hare et al., 2004; Dixon et al., 2005). Radiocarbon dating of ice-stratified dung of *Rangifer tarandus* in Yukon ice patches testifies to the long-term attractiveness of these features for caribou, presumably during warm seasons when herds would have sought relief from insect pests (Farnell et al., 2004). Recent discoveries of prehistoric hunting weaponry (including dart shaft and arrow components) on melting ice patches and glaciers support the notion that prehistoric hunters preyed on caribou in these settings (Hare et al., 2004; Dixon et al., 2005). In the northern NEM, ice patches could have been common on YD-age landscapes near reactivated glaciers, and both types of ice features may have figured prominently in Paleoindian exploitation of caribou.

Pelletier and Robinson (2005) and Robinson et al. (2009) use this "ice patch model" to partially explain the proximity of early Paleoindian occupations at Munsungun Lake to YD-age glaciers (noting also the obvious additional draw of Ordovician chert outcrops for toolstone at the Munsungun Lake vicinity). Rosenmeier et al. (in press) propose a similar hypothesis for the position of the Debert-Belmont site cluster near footprints of YD-age glaciers in Nova Scotia.

4.2.3. Michaud-Neponset Point Sites (12,200–11,800 cal BP)

Mapping of M-N point sites shows a relatively broad scale distribution across most of the NEM (Fig. 10). For the first time, there is an apparent scarcity of Paleoindian occupation in the Hudson Valley, limited to M-N point occupations at the Dutchess Quarry Caves 1 and 8 in the tributary Wallkill Valley (Funk and Steadman, 1994; Lothrop and Bradley, in press). It is unclear whether Paleoindian groups at this time had abandoned the Debert-Belmont site cluster in the Minas Basin of Nova Scotia. The Cliche-Rancourt site in the Megantic Lake region offers the first evidence for fluted point groups moving north of the Boundary Mountains to occupy southern Québec (Chapdelaine, 2007, 2009, in press).

At the sub-regional level, there are three site clusters with M-N point occupations (Magalloway Valley, Israel River, and Auburn Airport; Table 5). The large numbers of sites listed for two of these clusters are especially striking: four of the five sites of the Israel River cluster contain M-N point occupations, as do five of seven sites in the Auburn Airport cluster. The Israel River cluster occupies a glacial ablation till plain dotted with kettle ponds, proximal to the footprint of former proglacial Lake Israel and a topographic "funnel" leading towards the central White Mountains (Boisvert, in press). By contrast, the Auburn Airport cluster straddles an entirely different landscape: a late Pleistocene dune field drained by low- and mid-order streams (Spiess et al., in press).

Lithic source use at middle Paleoindian M-N point sites continues to indicate extensive Paleoindian transport of toolstone in different directions. For example, at the Neponset site in eastern Massachusetts, Munsungun chert from northern Maine and spherulitic rhyolite from northern New Hampshire are common in the assemblage (Pollock et al., 2008b). At Cliche-Rancourt in southern Québec, Paleoindians brought the same raw materials north from New Hampshire and southwest from Maine (Chapdelaine, in press).

4.2.4. Cormier-Nicholas point sites (11,800–11,600 cal BP)

Mapping of sites with C-N points reveals a distinctly different distribution. With the exception of Hidden Creek in eastern Connecticut (Jones, 1997), C-N point sites concentrate in the NEM midsection. To the west, the Reagen and VTCh190 sites show continuing association with the southern arm of the Champlain Sea (Robinson, in press). In the upper Connecticut valley, Jefferson IV comprises the only C-N point site in the Israel River cluster footprint, as is the Cormier site in the Auburn airport cluster (Table 5). Further east, a handful of sites are found in central and southern Maine, in interior upland and near-coastal Atlantic settings (Fig. 11).

Lithic source use at terminal middle Paleoindian C-N point sites appears to follow some previous trends. By example, at the Cormier and Nicholas sites in southern Maine, spherulitic rhyolite from northern New Hampshire is a common raw material, and Munsungun chert is also present (Pollock et al., 2008b). At these and other late middle Paleoindian sites, however, use of previously important toolstone sources such as Normanskill chert in the southern NEM appears to be on the decline (Lothrop and Bradley, in press, Table 5).

The geographically restricted distribution of C-N point sites, together with evidence for decreased use of some regional toolstone sources, indicates a settlement contraction into the NEM midsection (Fig. 11). It does not, however, appear to be accompanied by an increase in site size that could indicate larger groups occupying fewer sites. This contracted site distribution suggests reduced or more limited use of the NEM region, perhaps due to population decline or outmigration.

4.2.5. Agate basin-related point sites (11,600–10,800 cal BP)

The distribution of AB-r sites appears to be relatively diffuse across the region, extending from northern Vermont and central New Hampshire northward to the Gaspé Peninsula (Fig. 12). Although the LIS retreated north of the St. Lawrence by 13,000 cal BP, extensive glacial ice persisted on the Gaspé Peninsula through the YD terminus, and then dissipated rapidly to local ice caps (Richard et al. 1997). After 11,600 cal BP, the AB-r point sites of La Martre and Mitis mark the earliest known human occupation of the Gaspé, at this northern edge of the NEM. While there is continuing evidence for occupations fronting the Champlain Sea in Vermont (Mazza and Reagen sites [Robinson, in press]) and at Munsungun Lake in north-central Maine, locations of earlier site clusters (Israel River, Auburn Airport) appear to be abandoned (compare Figs. 10–12). More broadly, there are no AB-r sites recorded in the southern NEM.

The pattern of site clusters in the NEM does continue into late Paleoindian times, but only along the northern margin of the region on the Gaspé Peninsula. This is evident at La Martre, a cluster of four sites on marine terraces that includes an AB-r point occupation (La Martre, station 16), succeeded by two St. A-V point sites and one indeterminate late Paleoindian occupation, plus associated late Paleoindian quarry sites three km away (Tables 4 and 5).

4.2.6. Ste. Anne-Varney point sites (10,800–10,000 cal BP)

The overall distribution of Ste. A-V point sites stretches from the central NEM north to the Gaspé Peninsula (Fig. 13); within this larger pattern, there are two sub-regional site distributions. One grouping straddles the middle NEM, from near-coastal Atlantic settings northwestward to the Champlain Sea's southern arm in Vermont and New York with sites in interior New England most often situated at stream-side and lake shore settings (Petersen et al., 2000, p. 132). A second site grouping lies roughly 150 km to the north on the Gaspé Peninsula, with most Ste. A-V point sites located on marine terraces fronting the south shore of the St. Lawrence valley and proximal to major Ordovician chert sources. These dual site distributions may represent separate late Paleoindian populations focused in northern and central sectors of the NEM. Unlike further south in the NEM, late Paleoindian occupation of the Gaspé is accompanied by site clusters, including La Martre and Rimouski, and other examples may be present as well (Tables 4 and 5). Similar to AB-r point sites, the southern portion of NEM contains only a single site in eastern Massachusetts (Fig. 13).

During late Paleoindian times in the NEM, there is a trend towards more sub-regional or local toolstone use (Bradley et al., 2008, pp. 155, 159). This is perhaps best exemplified on the Gaspé Peninsula, where extensive chert outcrops were freed of glacial ice towards the end of the YD. These toolstone sources were intensively exploited, perhaps most heavily during occupations associated with Ste. A-V point sites (Chalifoux, 1999; Dumais, 2000;

Burke, 2010), and must have been a major factor in the location of sites and site clusters there.

5. Discussion

5.1. Paleoindian subsistence and NEM habitat change

The rare physical evidence for subsistence at NEM Paleoindian sites suggests a subarctic, seasonal terrestrial hunting and gathering component. Thus far, evidence for Paleoindian adaptation to the marine or estuarine environments of the Champlain Sea is limited to site location data, especially near estuaries (Robinson, 2009, in press). The Late Pleistocene Gulf of Maine/Atlantic coast is now deeply submerged (approximately 60–70 m) and consequently has not yet yielded any evidence of Paleoindian use. Hence, rare recoveries of carbonized plant remains and calcined faunal bone from Paleoindian sites are biased toward “interior” locations.

Carbonized berry fruit or seed fragments are known from Paleoindian features or contexts that suggest contemporaneity with the Paleoindian occupants from the Michaud (Spiess and Wilson, 1987) and Hedden sites (Spiess et al., 1995; see also Asch Sidell, 1999). Use of late summer, fall or perhaps over-wintered (desiccated) berry fruits from various species is indicated.

Similarly, calcined animal bone has been recovered from Paleoindian features or contexts at several sites. Calcined bone is produced by exposure of bone to a hot fire, over 600 °C (Shipman et al., 1984), indicating deliberate discard into a fire hearth. (Wildfire rarely reaches temperatures high enough to calcine bone lying on the surface or shallowly buried.) Calcined bone is resistant to soil acids, is often shrunken 10 to 20% in dimension from fresh bone, and is structurally weak, resulting in small fragments (Knight, 1985; Spiess et al., 1985). However, study has frequently been able to differentiate calcined mammal, bird, fish, and turtle “shell” in Archaic and later sites in the NEM (Spiess and Mosher, 2006). Further, it is relatively easy to differentiate fragments of caribou hoof bones from those of other deer family (Cervidae) species because of various morphological specializations in the caribou hoof.

The Whipple and Bull Brook sites have yielded definitively identified caribou bone, including confirmed specimens from multiple Paleoindian loci at Bull Brook (Spiess et al., 1985, 1998; Robinson and Spiess, in prep). There is also a medium-size mammal identification (porcupine or beaver), and an antler fragment and probable cervid tooth fragments of Paleoindian age from Bull Brook (Robinson and Spiess in prep). Less precisely identified calcined large mammal bone comes from other NEM Paleoindian sites as well. Antler (deer family) fragments are reported from the Michaud (Spiess and Wilson, 1987) and Neal Garrison (Kellogg, 2003) sites in Maine, and large mammal bone fragments were found at the DEDIC (Sugarloaf) site in Massachusetts. All of these less precisely identified bone/antler pieces could be caribou. This faunal assemblage of caribou and large/medium mammals is duplicated at the Udora Gainey phase Paleoindian site, located in Ontario in what was an analogous environment to the YD NEM YD (Storck and Spiess, 1994). The absence of fish and bird identifications in calcined bone assemblages from NEM Paleoindian sites contrasts with similarly sized and preserved samples from regional Archaic period sites, and thus may be significant.

To date, no terminal fluted (C-N) point or Late Paleoindian sites in the NEM have yielded calcined bone. Therefore, the combination of carbonized berry fragments and caribou and small mammal bone fragments from what were inland locations allows characterization of what may be only a seasonal, geographic focus of the early and middle fluted point Paleoindian groups. A seasonal caribou hunting adaptation, during which berries were also available, is envisioned. None of the caribou bone identifications from the Bull Brook or Whipple site are demonstrably from very young animals (the only age group that would indicate season of hunting), so seasonality is solely derived from the presence of berry remains.

Newby et al. (2005, pp. 150–152) explored the potential effects of YD and post-YD habitat change on large herd species such as caribou in the NEM. Although YD ecosystems have no direct modern analogs, the reconstructed vegetation conditions in the NEM during the YD are similar to the mixture of open forest habitats in the modern North American subarctic used by caribou. Today, these landscapes consist of relatively open tundra, open coniferous woodland, and closed boreal forest, supporting seasonal herd movement across these environments. These modern environments yield pollen assemblages with ≥10% sedge pollen in open areas and 20% to >40% spruce pollen in closed environments (Newby et al., 2005, Fig. 5a).

In the NEM, cold conditions during the YD caused spruce populations to shift southward, expanding open conditions in parts of Maritime Canada and relocating the tree line south of 45°. During this time, prevailing vegetation consisted of (1) open tundra-like vegetation in northern Maine and the Maritimes; (2) open coniferous woodland across Vermont, New Hampshire, and central and southern Maine; and (3) more closed coniferous forest in southern New England. Mapping of reconstructed YD vegetation for the NEM reveals habitats similar to those on the Québec-Labrador Peninsula today, and therefore favorable to long-range migratory and multiple, geographically peripheral shorter-range (mountains/woodland) caribou herds. Newby et al. (2005, p. 151) estimated the northern and southern limits of long-distance migrating caribou herds in the NEM during the YD as extending south from the 45th parallel in the Canadian Maritimes to Massachusetts and eastern New York (Fig. 1).

With rapid warming at the YD terminus (11,600 cal BP), habitat for large long-distance caribou herds diminished and shifted northward, as more closed oak and pine forests prevailed across much of the central and southern NEM. In the succeeding early Holocene, large mammal prey species for human populations likely consisted largely of solitary cervids, such as moose and deer.

5.2. Technological change

In comparing Paleoindian biface forms for the NEM, Bradley et al. (2008) note design evidence that some forms (KR-W, V-D, and BB-WAH points) probably were multipurpose tools, while others (M-N, AB-r, Ste. A-V bifaces) likely functioned exclusively as weaponry components. For all of these biface forms, however, the body of evidence suggests a primary function as hafted weapons tips for hunting.

In the NEM, abrupt climate change at the YD onset yielded more open habitats favorable for caribou, perhaps providing incentive for Paleoindian groups to colonize the region (Newby and Bradley, 2007). Limited faunal data from archaeological sites support the notion that caribou were a seasonally important prey species for early and middle Paleoindians in the NEM during the YD. Parts of this adaptation may have resembled the historic Innu on the Labrador Peninsula, for whom caribou seasonally comprised a key component of their subsistence base (Loring, 1997).

This comparison of the NEM Paleoindian biface sequence with additional radiocarbon determinations appears to support the original thesis (Newby et al., 2005; Bradley et al., 2008) that the appearance of C-N points – embodying the collapse of a 1000-year-old fluting tradition in the NEM – roughly coincided with the YD terminus at 11,700–11,600 cal BP. One possible interpretation is that the change from hunting of herd animals in more open landscapes to pursuit of solitary prey such as moose and deer in more closed forests perhaps contributed to this abandonment of fluting technology. After the YD, Late Paleoindian lanceolate biface forms appear in the NEM (Bradley et al., 2008, pp. 152–161) that are similar to biface types that appear several calendar centuries earlier in the High Plains (Holliday, 2000; Stanford, 2005; Huckell and Judge, 2007). The prevailing interpretation holds that this represents migrations of Paleoindians from a northern High Plains ancestral homeland to the NEM, bringing with them this unfluted biface technology (e.g., Chapdelaine, 1996; Dumais, 2000).

In the eastern Great Lakes, Ellis and Deller (1997, pp. 15–20) and Shott (1989) both suggest that changes in habitat and prey species in the eastern Great Lakes region may have led to modifications in fluted biface technology to enhance functional efficiency. These important analyses focus on possible changes in subsistence resources and fluted biface technology *during* the YD. By contrast, analogous habitat transformations in the NEM took place much more rapidly at the end of YD, perhaps within 1–2 centuries. Extirpation of caribou from most of the NEM, with subsequent replacement by solitary cervids and adoption of new hunting techniques likely took place at this time. The evidence suggests that this rapid change coincided with, and may have contributed to, the regional collapse in fluting technology.

Following Newby et al. (2005, p. 152), other factors may also have contributed to the observed variation in NEM fluted point forms. These include, for example, stylistic drift (Morrow and Morrow, 1999), more recently articulated by Hamilton and Buchanan (2008) as changes through time in point morphology due to stochastic copying errors during social learning. Viewed more broadly, interaction between Paleoindian groups on the contiguous margins between the eastern Great Lakes and NEM could have contributed to the analogous sequences of fluted point forms in these two regions. The similar changes in YD-age biface forms in both regions are believed to be roughly synchronous, but most accompanying environmental changes in the YD are not (Ellis et al., 2011). In this regard, Haynes' (2002, pp. 251–252) discussion of synchronous metapopulations could be relevant. This model holds that colonizing dispersals of different groups of individuals into adjoining regions, even those with dissimilar ecological conditions, may lead to in-phase demographic or cultural responses.

5.3. Colonization and settlement variation

This section summarizes archaeological evidence and possible interpretations for Paleoindian colonization and settlement trends in the NEM. Beginning with KR-W point sites (12,900–12,700 cal BP), the initial pattern of sites restricted to the Hudson and Connecticut valleys likely reflects colonization via entry routes from the west or south, first entering the NEM through eastern New York (Fig. 8) (Newby and Bradley, 2007; Lothrop and Bradley, in press). This site distribution could reflect hypothesized wayfinding strategies of colonizing groups, for example, using linear physical features like river valleys for piloting into unknown terrain (Kelly, 2003, p. 54).

V-D and BB-WAH point sites in the NEM (12,700–12,200 cal BP) appear to illustrate a process of settling in to nearly all of the region's landscapes, stretching northward to Nova Scotia and from the Champlain sea on the west to near-coastal Atlantic settings (Fig. 9). The northern distribution of V-D point sites and southern predominance of BB-WAH point sites may indicate sub-regional Paleoindian populations that were roughly contemporaneous (Bradley et al., 2008, p. 135). Sites with V-D points could represent Paleoindians favoring ecological niches in the northern NEM (including ice patch caribou predation strategies). BB-WAH sites may reflect groups largely focused in southern parts of the region. Here, perhaps for the first time, Paleoindians may be exploiting marine or estuarine resources of Champlain Sea (Crock and Robinson, in press; Robinson, in press). Further east, sites such as Bull Brook may mark the appearance of exceptionally large seasonal Paleoindian aggregation sites (Robinson et al., 2009).

M-N point sites (12,200–11,800 cal BP) include multiple occupations within individual site cluster footprints, perhaps signifying intensified seasonal reuse of targeted landscapes (Fig. 10). This pattern is best exemplified by multiple M-N point sites at the Israel River and Auburn Airport clusters. The distinctive landscapes associated with these two site clusters (Israel River = glacial ablation till plain with kettle ponds and nearby proglacial lakebed; Auburn Airport = late Pleistocene dune field) could reflect sub-regional differences in seasonal resource procurement. Beginning with this time interval, the paucity of sites in eastern New York could signal declining use of the Hudson Valley region.

The geographically restricted distribution of C-N point sites (circa 11,800–11,600 cal BP) marks a major departure from earlier near-region-wide site locations (Fig. 11). With one exception, these terminal fluted point sites are limited to the NEM midsection (northwestern Vermont, northern New Hampshire, and south-central Maine). At the same time, there is a decline in Paleoindian use of Normanskill chert sources located in the Hudson Valley. This contracted site distribution roughly coincides with rapid ecological changes at the end of the YD, raising the possibility of demographic developments such as a population bottleneck or outmigration from the NEM.

Late Paleoindian sites in the NEM with AB-r (11,600–10,800 cal BP) or Ste. A-V points (10,800–10,000 cal BP) reflect post-YD occupations of early Holocene environments dominated by closed oak and pine forests (Figs. 12, 13). The appearance of unfluted lanceolate biface forms after the YD marks a striking contrast with the preceding fluted point forms. This change in biface design could represent in-situ development of new stone tool weaponry by peoples descendent from middle Paleoindian groups, diffusion of this technology to the NEM, or its import by Paleoindian immigrants from western homelands in the High Plains. The latest NEM Paleoindian occupations, reflected by Ste. A-V point sites, show two geographic distributions, with sites in the central NEM and further north on the Gaspé Peninsula (Fig. 13). During this time, it appears that Paleoindians largely avoided the southern NEM.

In a marked contrast to earlier times, late Paleoindian site clusters are evident on the Gaspé Peninsula but not further south. Unlike the central and southern NEM, much of the Gaspé was covered by glacial ice through the late YD (Figs. 8–13). With glacial wasting, relatively open vegetation likely persisted into the early Holocene, and the Peninsula may have provided a late refuge for northward shifting caribou populations (Dumais, 2000, pp. 83–86). These features, together with extensive Ordovician chert outcrops and proximity to potential marine resources, help explain the presence of late Paleoindian site clusters on the Gaspé along the northern rim of the NEM, and their absence in more closed forests further south.

This proposed sequence of early Paleoindian colonization of the NEM differs from some other assessments of early human occupation in the Canadian Maritimes. Bonnichsen and Will (2005, p. 407) argue for more favorable pre-YD environmental conditions, and thus a human presence in the Maritimes before the YD onset. Ellis (2004) also raises the possibility that Paleoindians first entered the Maritimes shortly before the YD, and occupied the Debert and Belmont sites in Nova Scotia at the YD onset. Citing a YD vegetation shift from spruce/poplar woodland back to shrub tundra, he suggests “this rapid change must have increased greatly the unpredictability of resource locales and also have had sweeping effects on environmental productivity” (Ellis, 2004, pp. 243–244), ultimately forcing Paleoindians to abandon the Maritimes for several centuries. The alternative scenario proposed here holds instead that habitat changes at the YD onset may have made the Maritimes a more (rather than less) attractive area for Paleoindians as evidenced by occupations at the Debert-Belmont site cluster. Abandonment or avoidance of the Maritimes may have occurred, but likely later in the YD (perhaps as Ellis suggests, with Paleoindians leaving the area or possibly favoring other landscapes, such as now-drowned parts of the Maritimes coast) (Ellis, 2004, p. 244).

Conceptual models of human colonization (Anthony, 1990), especially for late Pleistocene North America (e.g., Beaton, 1991; Anderson and Gillam, 2000; Haynes, 2002; Kelly and Todd, 1988; Meltzer, 2003, 2004; Rockman and Steele, 2003; Barton et al., 2004; MacDonald, 2004), provide a framework to evaluate evidence for human immigration to regions like the NEM. Among these models, Haynes (2002, pp. 239–262) views forager migration as a stepwise process in which individuals from a central homeland first disperse beyond a “mother” population boundary into a new range (“dispersal”), and then may (or may not) colonize or settle in more broadly to this new region’s local landscapes (“colonization”) (Haynes 2002, pp. 246–248).

In the NEM, the restricted distribution of KR-W point sites to the Hudson and Connecticut valleys may represent Haynes’ (2002) concept of initial human dispersal. Subsequent expansion of early Paleoindian occupations (V-D and BB-WAH point sites), distributed across most of the region, could reflect Haynes’ (2002) post-dispersal colonization phase. This colonizing or settling-in phase could even be extended to middle Paleoindian sites with M-N points that in some cases reflect intensive reuse of local landscapes. Other researchers have also proposed models for staged Paleoindian colonization of the NEM (e.g., Dincauze, 1993), but this two-stage scenario better fits the currently available site-level data. In the future, new site discoveries, along with information on Paleoindian point isolates, will permit researchers to refine or revise this interpretation.

6. Conclusions

The interpretive model presented here holds that cooling at the YD onset (circa 12,900 cal BP) fostered more open habitats in the NEM favorable to both long-distance migrating and local herds of caribou, and may have encouraged early and middle Paleoindian settlement of this unoccupied region. Conversely, warming at the YD terminus (circa 11,700–11,600 cal BP) caused a rapid reorganization of regional vegetation and prey species populations, accompanied in the archaeological record by a decline in Paleoindian biface fluting technology and a geographic contraction in regional settlement at C-N point sites. In the mostly closed forests of the succeeding early Holocene NEM, Late Paleoindian groups used “foreign” lanceolate points that may signal post-YD immigration to the NEM.

In other parts of North America, some researchers suggest that ecological changes associated with the YD onset were a source of stress for early Paleoindian populations that may have led to local or regional abandonment, or even the end of Clovis lifeways. In the NEM, the reverse may have occurred: ecological changes at the YD onset that perhaps encouraged early Paleoindian colonization, with other habitat shifts at the YD terminus coinciding with, and perhaps contributing to, altered technology and settlement for terminal middle Paleoindian groups.

The apparent correlation between ecological changes at the YD terminus and the decline of fluting technology in the NEM does not demonstrate a causal relationship, and could be fortuitous (Newby et al., 2005, p. 152). Evidence from the distribution of C-N point sites for a coincident settlement contraction, however, strengthens the notion that these Paleoindian populations were, at some level, reacting to regional ecological changes.

These interpretations are working hypotheses that warrant continued exploration and evaluation. Ongoing paleoenvironmental studies will likely refine emerging evidence for internal environmental variability during the YD in the NEM. To more fully address possible links of environmental and technological change in the NEM, both during and after the YD, inquiry should be broadened to other elements of Paleoindian material culture across the region (Meltzer and Holliday, 2010, p. 30). The preliminary sense is that changes in other aspects of NEM Paleoindian technology during and after the YD were, at least in some respects, incremental rather than punctuated. Future studies should thus be explicitly designed to detect variability in Paleoindian material culture across space and time (Ellis, 2004, p. 245). The obvious platform for this work will be continued refinement (and revision where necessary) of relative and radiocarbon chronologies for the region (Bradley et al., 2008, p. 162).

Increasingly fine-grained assessments of sub-regional environmental change during the late Pleistocene and early Holocene will be one key for evaluating shifts in Paleoindian land use and settlement behavior. Taking site clusters as one example, what are the local environmental and ecological factors that led Paleoindians to reuse, sometimes intensively, certain landscapes in the NEM? Conversely, why were certain areas (e.g., New York’s Hudson Valley) seemingly avoided by middle and late Paleoindians, or is this an artifact of site discovery bias? For these questions, systematic recording and analysis of isolated Paleoindian point finds will complement study of site distributions. Ultimately, comparisons with neighboring regions in eastern North America will bring into focus the lifeway strategies that NEM Paleoindians shared with other groups during and after the YD, and what made their human story unique.

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Appendix

Calibrated Radiocarbon Determinations for NEM Point Forms and Sites. Calibrated age spans for 26 radiocarbon ages from 13 NEM Paleoindian sites (INCAL09.14C; Reimer et al., 2004, 2009; Stuiver et al., 2005). The median calibrated age, with 1σ and 2σ age ranges and probabilities are displayed. Ranks for radiocarbon ages: Rank 1 = good archaeological provenience and STD ≤150 yrs; Rank 2 = good archaeological provenience and STD ≥ 150 yrs. (Note: Point forms: KR-W = Kings Road-Whipple; V-D = Vail-Debert; BB-WAH = Bull Brook-West Athens Hill; M-N = Michaud-Neponset; C-N = Cormier-Nicholas; AB-r = Agate Basin-related; Ste. A-V = Ste. Anne-Varney).

Site & Date #	Lab. No.	^{14}C Age	1-Sigma	1 or 2-Sigma	Lower Age	Median Probability Age	Upper Age	Relative Probability	Assoc. Point Form	Rank
Bull Brook 1	Beta- 240630	10,380	60	1	12,130	12,254	12,232	0.416	BB-WAH	1
					12,245		12,387	0.584		
				2	12,038		12,429	0.961		
					12,470		12,522	0.039		
Bull Brook 2	Beta-240629	10,410	60	1	12,145	12,275	12,198	0.212	BB-WAH	1
					12,203		12,396	0.788		
				2	12,059		12,437	0.927		
					12,460		12,527	0.073		
					12,970		11,731			
Colebrook 1	Beta-258579	10,220	40	1	11,826	11,943	11,893	0.39	M-N	1
					11,904		11,915	0.042		
					11,954		12,046	0.568		
				2	11,768		12,079	1		
Colebrook 2	Beta-107429	10,290	170	1	11,768	12,049	12,400	1	M-N	2
				2	11,403		11,583	0.073		
					11,590		12,561	0.927		
Cormier	Beta-126695	10,240	90	1	11,762	11,976	12,131	1		1
				2	11,509		11,515	0.002		
					11,611		12,395	0.998		
Debert AVG					12,764	12,448	12,150		V-D	n/a
Esker	Beta-103384	10,090	70	1	11,406	11,667	11,454	0.109	C-N	1
					11,470		11,560	0.216		
					11,594		11,823	0.675		
				2	11,345		11,379	0.022		
					11,383		11,980	0.978		
Hedden 1	Beta-68806	10,500	60	1	12,423	12,495	12,497	0.549	BB-WAH	1
					12,514		12,573	0.451		
				2	12,221		12,270	0.027		
					12,327		12,337	0.003		
					12,379		12,644	0.97		
Hedden 2	Beta-70668	10,580	60	1	12,428	12,533	12,477	0.358	BB-WAH	1
					12,521		12,598	0.642		
				2	12,397		12,653	1		
Hidden Creek	Beta-126817	10,260	70	1	11,824	12,019	11,933	0.292		1
					11,950		12,133	0.708		
				2	11,753		12,228	0.899		
					12,248		12,384	0.101		
Michaud 1	Beta-13833	9010	210	1	9781	10,109	9850	0.089	M-N	2
					9861		9878	0.021		
					9884		10,406	0.891		
				2	9547		10,597	0.992		
					10,624		10,650	0.008		
Michaud 2	Beta-15660	10,200	200	1	11,407	11,879	11,451	0.048	M-N	2
					11,472		11,558	0.093		
					11,596		12,155	0.789		
					12,185		12,215	0.031		
					12,293		12,311	0.018		
					12,354		12,373	0.02		
				2	11,259		12,434	0.0976		
					12,465		12,525	0.024		
Neponset	Beta-75527	10,210	60	1	11,816	11,914	12,044	1	M-N	1
				2	11,630		11,636	0.003		
					11,640		11,672	0.016		
					11,698		12,129	0.982		
Templeton	W-3931	10,190	300	1	11,393	11,853	12,223	0.898	M-N	2
					12,266		12,328	0.059		
					12,334		12,379	0.043		
				2	10,874		10,945	0.01		
					11,075		12,655	0.99		
Vail 1	AA-116	10,040	395	1	11,163	11,637	12,226	0.919	V-D	2
					12,255		12,382	0.081		
				2	10,516		12,648	1		
Vail 2	SI-4617	10,300	90	1	11,846	12,107	11,856	0.021	V-D	1
					11,973		12,223	0.716		
					12,264		12,380	0.263		
				2	11,753		12,426	0.986		

(continued on next page)

Appendix (*continued*)

Site & Date #	Lab. No.	^{14}C Age	1-Sigma	1 or 2-Sigma	Lower Age	Median Probability Age	Upper Age	Relative Probability	Assoc. Point Form	Rank
					12,480		12,518	0.014		
Vail 3	AA-117	10,460	325	1	11,759	12,191	12,658	1	V-D	2
				1	11,240		12,954	1		
Vail 4	AA-114	10,610	330	1	11,986	12,388	12,877	1		2
				1	11,362		11,373	0.002		
					11,392		13,136	0.998		
Vail 5	Beta-207579	10,710	50	1	12,577	12,626	12,660	1	V-D	1
				1	12,552		12,723	1		
Vail 6	Beta-1833	11,120	180	1	12,786	12,992	13,168	1	V-D	2
				1	12,648		12,954	1		
Varney Farm 1	Beta-81251	8380	100	1	9281	9369	9497	1	Ste. A-V	1
				2	9094		9098	0.002		
					9123		9540	0.998		
Varney Farm 2	Beta-88674	8420	60	1	9334	9446	9336	0.006	Ste. A-V	1
					9406		9519	0.994		
				2	9302		9530	1		
Varney Farm 3	Beta-81250	8430	100	1	9309	9426	9360	0.209	Ste. A-V	1
					9397		9532	0.791		
				2	9135		9552	1		
Varney Farm 4	Beta-93001	8620	60	1	9531	9592	9631	0.935	Ste. A-V	1
					9646		9656	0.065		
				2	9491		9708	0.984		
					9717		9735	0.016		
Varney Farm 5	Beta-88673	8700	60	1	9551	9664	9705	0.948	Ste. A-V	1
					9720		9732	0.052		
				2	9542		9835	0.939		
					9840		9888	0.061		
Varney Farm 6	Beta-79658	9410	190	1	10,411	10,684	10,868	0.814	Ste. A-V	2
					10,951		11,070	0.186		
				2	10,242		11,180	1		
Weirs Beach	GX-4569	9615	225	1	10,601	10,944	10,622	0.025	AB-r	2
					10,652		11,233	0.975		
					10,268		11,619	1		

References

Alley, R.B., 2000. Ice-core evidence of abrupt climate changes. Proceedings of the National Academy of Sciences 97, 1331–1334.

Anderson, D.G., 2001. Climate and culture change in prehistoric and early historic eastern North America. Archaeology of Eastern North America 29, 143–186.

Anderson, D.G., Faught, M., 2000. Paleoindian artifact distributions: evidence and implications. Antiquity 74, 507–513.

Anderson, D., Gillam, J.C., 2000. Paleoindian colonization of the Americas: implications from an examination of physiography, demography, and artifact distribution. American Antiquity 65, 43–66.

Anderson, D.G., Miller, D., Yerka, S., Gillam, J.C., Johansen, E., Anderson, D.T., Goodyear, A.C., Smallwood, A.M., 2010. PIDBA (Paleoindian Database of the Americas) 2010: current status and findings. Archaeology of Eastern North America 38, 91–100.

Anderson, T.W., Lewis, C.F.M., 1985. Postglacial water-level history of the Lake Ontario Basin. In: Karrow, P.F., Calkin, P.E. (Eds.), Quaternary Evolution of the Great Lakes. Geological Association of Canada, pp. 231–253. Special Paper 30.

Anthony, D., 1990. Migration in archaeology: the baby and the bathwater. American Anthropologist 92, 95–914.

Asch Sidell, N. 1999 Prehistoric plant use in Maine: Paleoindian to the contact period. In: Hart, J. (Ed.). Current Northeast Paleoethnobotany, edited by John P. Hart. New York State Museum Bulletin vol. 494, Albany, pp. 191-223

Bakke, J., Lie, Ø., Heegard, E., Dokken, T., Haug, G.H., Briks, H.H., Dulski, P., Nilsen, T., 2009. Rapid oceanic and atmospheric changes during the Younger Dryas cold period. Nature Geoscience 2, 202–205.

Barton, C., Clark, G., Yessner, D., Pearson, G. (Eds.), The Settlement of the American Continents, University of Arizona Press, Tucson, pp. 123–137.

Beaton, J.M., 1991. Colonizing continents: some problems from Australia and the Americas. In: Dillehay, T.D., Meltzer, D.J. (Eds.), The First Americans: Search and Research. CRC Press, Boca Raton, Florida, pp. 209–230.

Beck, C., Jones, G.T., 2010. Clovis and western stemmed: population migration and the meeting of two technologies in the intermountain west. American Antiquity 75 (1), 81–116.

Bloom, A.L., 2008. The Late Pleistocene glacial history and environment of New York State Mastodons. In: Allmon, W.D., Nestor, P.L. (Eds.), Mastodon Paleobiology, Taphonomy and Paleoenvironmental in the Late Pleistocene of New York State: Studies on the Hyde Park, Chemung, and North Java Sites. Paleontographica Americana, vol. 1, pp. 13–23.

Boisvert, R., Paleoindian in New Hampshire. In: Chapdelaine, C. (Ed.), Late Pleistocene Archaeology and Ecology in the Far Northeast. Center for the Study of the First Americans and Texas A&M University Press, College Station, in press.

Boisvert, R., 1998. The Israel River complex: a Paleoindian manifestation in Jefferson, New Hampshire. Archaeology of Eastern North America 26, 97–106.

Boisvert, R., 2004. Clovis era archaeology in northern New Hampshire: the Israel River complex. In: Lepper, B.T., Bonnichsen, R. (Eds.), New Perspectives on First Americans Studies. Texas A & M Press, pp. 49–54.

Bonnichsen, R., Keenlyside, D.L., Turnmire, K.L., 1991. Paleoindian patterns in Maine and the Maritimes. In: Deal, M., Blair, S. (Eds.), Prehistoric Archaeology in the Maritime Provinces: Past and Present Research. Reports in Archaeology, vol. 8. Council of Maritime Premiers, Fredericton, New Brunswick, pp. 1–36.

Bonnichsen, R., Will, R., 2005. Radiocarbon chronology of northeastern paleo-American sites: discriminating natural and human burn features. In: Bonnichsen, R., Turnmire, K.L. (Eds.), Ice Age Peoples of North America: Environments, Origins, and Adaptations. Texas A&M University Press, College Station, pp. 395–415.

Borns, H.W., Doner, L., Dorion, C., Jacobson, G., Kaplan, M., Kreutz, K., Lowell, T., Thompson, W., Weddle, T., 2004. The Deglaciation of Maine, U.S.A. In: Ehlers, J., Gibbard, P.L. (Eds.), Quaternary Glaciations – Extent and Chronology, Part II: North America Developments in Quaternary Science, vol. 2. Elsevier, Amsterdam, pp. 89–109.

Bradley, B., Collins, M.B., Hemmings, A., 2010. Clovis Technology. Archaeological Series, vol. 17 International Monographs in Prehistory, Ann Arbor.

Bradley, James W, 1998. Origins and Ancestors: Investigating New England's Paleoindians. Robert S. Peabody Museum of Archaeology, Andover.

Bradley, J.W., Spiess, A., Boisvert, R., Boudreau, J., 2008. What's the point?: Modal forms and attributes of Paleoindian Bifaces and the New England-Maritimes Region. Archaeology of Eastern North America 36, 119–172.

Brewster, G., Davis, S.A., Frappier, M., Mott, R.J., Stea, R., 1996. Preliminary report on the Debert/Belmont Paleoindian project. In: Powell, S. (Ed.), Archaeology in Nova Scotia 1991. Nova Scotia Museum, Halifax, pp. 81–88.

Broecker, W.S., Denton, G.H., Edwards, R.L., Cheng, H., Alley, R.B., Putnam, A.E., 2010. Putting the Younger Dryas cold event into context. Quaternary Science Reviews 29, 1078–1081.

Bunker, V., Potter, J., 1999. Early occupation in the far upper Connecticut river valley. The New Hampshire Archeologist 39 (1), 70–81.

Burke, A., 2006. Paleoindian ranges in Northeastern North America based on lithic raw materials sourcing. In: Bressy, C., C., Burke, A., Chalard, P., Martin, H. (Eds.), Notions De Territoire Et De Mobilité: Exemples De L'Europe Et Des Premières Nations En Amérique Du Nord Avant Le Contact Européen. Études et Recherches Archéologiques de l'Université de Liège, Liège, pp. 77–89.

Burke, A., 2010. Extraction, reduction, and production at a late Paleoindian chert quarry in Eastern Québec. In: Brewer-Laporta, M., Burke, A., Field, D. (Eds.), Ancient Mines and Quarries: A Trans-Atlantic Perspective. Oxbow Books, Oxford, pp. 85–96.

Carlson, A.E., 2010. What caused the Younger Dryas cold event? Geology 38, 383–384.

Chalifoux, E., 1999. Late Paleoindian occupation in a coastal environment: a perspective from La Martre, Gaspe Peninsula, Quebec. Northeast Anthropology 57, 69–79.

Chapdelaine, C., 1996. Reflexion sur L'Anciennette du peuplement initial du Québec a partir de nouveaux indices materiels du Paleoindien recent de la region de Rimouski, Québec. Geographie Physique et Quaternaire 50 (3), 271–286.

Chapdelaine, C., 2007. Cliche-Rancourt, un site du Paleoindien ancien. In: Chapdelaine, C. (Ed.), Entre Lacs et Montagnes au Meganticois, 12,000 ans d'histoire amerindienne. Recherches Amerindiennes au Quebec, Montreal, pp. 47–120. Paleo-Quebec 32.

Chapdelaine, C., 2009. A 12,000-year archaeological sequence for the megantic lake area. In: Keenlyside, D.L., Pilon, J.-L. (Eds.), Painting the Past with a Broad Brush. Papers in honor of James Valliere Wright. Mercury Series, Archaeology Paper, vol. 170. Canadian Museum of Civilization, Gatineau, Québec, pp. 143–174.

Chapdelaine, C., The early Paleoindian occupation at the Cliché-Rancourt Site, Southeastern Québec. In: Chapdelaine, C. (Ed.), Late Pleistocene Archaeology and Ecology in the Far Northeast. Center for the Study of the First Americans and Texas A&M University Press, College Station, in press.

Chapdelaine, C., Bourget, S., 1992. Premiere regard sur un site Paleoindien recent a Rimouski (DcEd-1). Recherches Amerindiennes au Quebec 12 (1), 17–32.

Collins, M.B., Hemmings, C.A., 2005. Lesser-known Clovis diagnostic artifacts I: the Bifaces. La Tierra 32 (2), 9–20.

Collins, M.B., Lohse, J.C., Shoburg, M.B., 2007. The de Graffenried Collection: a Clovis Biface Cache from the Gault Site, Central Texas. Bulletin of the Texas Archaeological Society 78, 101–123.

Crock, J.G., Robinson, F.W., IV. Maritime mountaineers: Paleoindian settlement patterns on the west coast of New England. In: Chapdelaine, C. (Ed.), Late Pleistocene Archaeology and Ecology in the Far Northeast. Center for the Study of the First Americans and Texas A&M University Press, College Station, in press.

Cronin, T.M., Manley, P.L., Brachfeld, S., Manley, T.O., Willard, D.A., Guibault, J.-P., Rayburn, J.A., Thunell, R., Berke, M., 2008. Impacts of Post-Glacial Lake Drainage Events and Revised Chronology of the Champlain Sea Episode 13-9 KA. Palaeogeography, Palaeoclimatology, Palaeoecology 262, 46–60.

Curran, M.L., 1999. Exploration, colonization, and settling in: the Bull Brook phase, antecedents, and descendants. In: Levine, M.A., Sassaman, K.E., Nassaney, M.S. (Eds.), The Archaeological Northeast. Bergin & Garvey, Westport, Connecticut, pp. 3–24.

Dansgaard, W., Greenland Ice-core Project (GRIP) Members, 1993. Climate instability during the last interglacial period recorded in the GRIP ice core. Nature 364, 203–207.

Davis, M.E., 1969. Climatic changes in southern Connecticut recorded by pollen deposition at Rogers Lake. Ecology 50, 409–422.

Dincauze, D.F., 1993. Pioneering in the Pleistocene: large Paleoindian sites in the Northeast. Archaeological Report No. 25. In: Stoltman, J.B. (Ed.), Archaeology of Eastern North America: Papers in Honor of Stephen Williams. Mississippi Department of Archives and History, Jackson, pp. 43–60.

Dillehay, T., 2009. Probing deeper into first American studies. PNAS 106, 971–978.

Dineen, R.J., 1982. The Geology of the Pine Bush Aquifer, North-Central Albany County, New York. In: New York State Museum Bulletin, vol. 449.

Dixon, E.J., Manley, W., Lee, C., 2005. The emerging archaeology of glaciers and ice patches: examples from Alaska's Wrangell-St. Elias national park and preserve. American Antiquity 70 (1), 129–143.

Donahue, J.J., 1977. Late Wisconsinan Aeolian activity near Albany, New York. Geological Society of America Bulletin 88, 1756–1762.

Donnelly, J.P., Driscoll, N., Uchupi, E., Kegwin, L., Schwab, W., Theiler, E.R., Swift, S., 2005. Catastrophic meltwater discharge down the Hudson Valley: a potential trigger for the intra-allerod cold period. Geology 33 (2), 89–92.

Dumais, P., 2000. The La Martre and Mitis Late Paleoindian Sites: A Reflection on the Peopling of Southeastern Québec. Archaeology of Eastern North America 28, 81–112.

Dyke, A.S., 2004. An outline of North American deglaciation with emphasis on central and northern Canada. In: Ehlers, J., Gibbard, P.L. (Eds.), Quaternary Glaciations – Extent and Chronology, Part II: North America. Developments in Quaternary Science, vol. 2. Elsevier, Amsterdam, pp. 201–207.

Ebbesen, H., Hold, M., 2004. Unstable Younger Dryas climate in the northeast North Atlantic. Geology 32, 673–676.

Ellis, C., 2004. Understanding "Clovis" fluted point variability in the Northeast: a perspective from the Debert Site, Nova Scotia. Canadian Journal of Archaeology 28, 205–253.

Ellis, C., 2008. The fluted point tradition and the arctic small tool tradition: what's the connection? Journal of Anthropological Archaeology 27, 298–314.

Ellis, C., Deller, D.B., 1997. Variability in the archaeological record of northeastern early Paleoindians: a view from Southern Ontario. Archaeology of Eastern North America 25, 1–30.

Ellis, C.J., Tomenchuck, J., Holland, J.D., 2003. Typology, use and sourcing of the Late Pleistocene lithic artifacts from the Hiscock site. In: Laub, R.S. (Ed.), The Hiscock Site: Late Pleistocene and Holocene Paleoecology and Archaeology of Western New York State. Bulletin of the Buffalo Society of Natural Sciences, vol. 37, pp. 221–237.

Ellis, C.J., Carr, D.H., Loebel, T.J., 2011. The Younger Dryas and late Pleistocene peoples of the Great Lakes region. Quaternary International 242 (2), 534–545.

Farnell, R., Hare, P.G., Blake, E., Bowyer, V., Schweger, C., Strand, D., 2004. Multidisciplinary investigations of alpine ice patches in southwest Yukon, Canada: paleoenvironmental and paleobiological investigations. Arctic 57, 247–259.

Fiedel, S., 2006. Points in time: establishing a precise hemispheric chronology for Paleoindian migrations. In: Morrow, J.E., Cristobal, G. (Eds.), Paleoindian Archaeology: A Hemispheric Perspective. University Press of Florida, Gainesville, pp. 21–43.

Franzi, D., Feranec, R. Rayburn, J., 2010. A Champlain Sea Phocid Seal Fossil from the Champlain Lowlands at Plattsburgh, New York. Poster Presentation for Northeastern and Southeastern Sections, Geological Society of America Meetings, Baltimore, MD, March 13–16, 2010.

Frison, G.C., Stanford, D.J., 1982. The Agate Basin site: a record of the Paleoindian occupation of the northwestern High Plains. Academic Press, New York, NY.

Funk, R.E., 1973. The West Athens Hill site (Cox 7). In: Ritchie, William A., Funk, Robert E. (Eds.), Aboriginal Settlement Patterns in the Northeast. New York State Museum and Service Memoir, vol. 20, pp. 9–36.

Funk, R.E., 1976. Recent contributions to Hudson Valley prehistory. New York State Museum Memoir 22.

Funk, R.E., 2004. An ice age quarry-workshop: the West Athens Hill site revisited. New York State Museum Bulletin 504.

Funk, R.E., Steadman, D.W., 1994. Archaeological and Paleoenvironmental Investigations in the Dutchess Quarry Caves, Orange County, New York. Persimmon Press, Buffalo.

Funk, R.E., Weinman, P.L., Weinman, T.P., 1969. The Kings Road site: a recently discovered Paleoindian manifestation in Greene County, New York. New York State Archaeological Association Bulletin 45, 1–23.

Gaudreau, D.C., 1986. Late-Quaternary vegetational history of the Northeast: paleoecological implications of topographic patterns in pollen distributions. Unpublished Ph.D. Thesis, Yale University.

Gill, J.L., Williams, J.W., Jackson, S.T., Lininger, K.B., Robinson, G.S., 2009. Pleistocene megafaunal collapse, novel plant communities, and enhanced fire regimes in North America. Science 326, 1100–1103.

Gingerich, J.A.M., 2007. Picking up the pieces: new Paleoindian research in the upper Delaware Valley. Archaeology of Eastern North America 35, 117–124.

Gingerich, J.A.M., 2011. Down to seeds and stones: a new look at the subsistence remains from Shawnee-Minisink. American Antiquity, 127–144.

Gingerich, J.A.M., Waters, M.R., 2007. New dates from the Shawnee-Minisink Site, Pennsylvania. Current Research in the Pleistocene 24, 90–92.

Gonzales, L.M., Grimm, E.C., 2009. Synchronization of late-glacial vegetation changes at Crystal Lake, Illinois, USA with the North Atlantic Event Stratigraphy. Quaternary Research 72, 234–245.

Goodyear, A.C., 2006. Recognizing the Redstone fluted point in the South Carolina Paleoindian Point Database. Current Research in the Pleistocene 23, 100–103.

Gramly, R.M., 1982. The Vail Site: a Paleoindian encampment in Maine. Bulletin of the Buffalo Society of Natural Sciences 30.

Gramly, R.M., 1984. Kill sites, killing ground and fluted points at the Vail site. Archaeology of the Eastern North America 12, 110–121.

Gramly, R.M., 1998. The Sugarloaf Site: Paleo-Americans on the Connecticut River. Persimmon Press, Buffalo.

Gramly, R.M., 2005. The upper/lower Wheeler Dam sites: Clovis in the upper Magalloway river valley, NW Maine. The Amateur Archaeologist 11, 25–46.

Gramly, R.M., Puryear, K., 2009. Paleo-Americans and Paleo-Environment at the Vail Site, Maine. Persimmon Press, North Andover, Massachusetts.

Graves, A.C., Bement, L.C., Carter, B.J., 2006. The JS Cache: an early-Paleoindian tool cache from the Oklahoma panhandle. Current Research in the Pleistocene 23, 103–105.

Hamilton, M.J., Buchanan, B., 2008. The accumulation of stochastic copying errors causes drift and culturally transmitted technologies: quantifying Clovis evolutionary dynamics. Journal of Anthropological Archaeology 28 (1), 55–69.

Hare, P.G., Greer, S., Gotthardt, R., Farnell, R., Bowyer, V., Schweger, C., Strand, D., 2004. Ethnographic and archaeological investigations of alpine ice patches in Southwest Yukon, Canada. Arctic 57, 260–272.

Hatch, J.W., 1993. Research into the Prehistoric Jasper Quarries of Bucks, Lehigh and Berks Counties, Pennsylvania. Report Submitted to the Pennsylvania Historical and Museum Commission, Harrisburg.

Haynes, G., 2002. The Early Settlement of North America: The Clovis Era. Cambridge University Press, Cambridge.

Haynes, V., Donohue, D.J., Jull, A.J.T., Zabel, T.H., 1984. Application of accelerator dating to fluted point paleoindian sites. Archaeology of Eastern North America 12, 184–191.

Holliday, V., 2000. The evolution of Paleoindian geochronology and typology on the Great Plains. Geoarchaeology 15, 227–290.

Hou, J., Huang, Y., Wang, Y., Shuman, B., Oswald, W.W., Faison, E., Foster, D.R., 2006. Postglacial climate reconstruction based on compound-specific D/H ratios of fatty acids from Blood Pond, New England. Geochemistry Geophysics Geosystems 7, 1–7.

Huckell, B.B., Judge, W.J., 2007. Paleo-Indian: Plains and Southwest. In: Stanford, D., Smith, B., Ubelaker, D., Szathmary, E. (Eds.), Environment, Origins, and Population. Handbook of the American Indian. Smithsonian Institution, Washington, pp. 148–170.

Huckell, B.B., 2007. Clovis lithic technology: a view from the upper San Pedro Valley. In: Vance Haynes Jr., C., Huckle, Bruce B. (Eds.), Murray Springs: a Clovis Site with Multiple Activity Areas in the San Pedro Valley, Arizona. The University of Arizona Press, Tucson, pp. 170–213.

Jones, B., 1997. The Late Paleoindian Hidden Creek site in southeastern Connecticut. Archaeology of Eastern North America 25, 45–80.

Jones, M.C., Peteet, D.M., Kurdyla, D., Guilderson, T., 2009. Climate and vegetation history from a 14,000-year peatland record, Kenai Peninsula, Alaska. Quaternary Research 72, 207–217.

Kellogg, D.C., 2003. The Neal Garrison Paleoindian site, York County, Maine. Archaeology of Eastern North America 31, 73–131.

Kelly, R.L., 2003. Colonization of new land by Hunter-Gatherers. In: Rockman, Marcy, Steele, James (Eds.), Colonization of Unfamiliar Landscapes. Routledge, London/New York, pp. 44–58.

Kelly, R., Todd, L., 1988. Coming into the country: early Paleoindian hunting and mobility. American Antiquity 53 (2), 231–244.

Kirby, M.E., Mullins, H.T., Patterson, W.P., Burnett, A.W., 2002. Late glacial-Holocene atmospheric circulation and precipitation in the northeast United States inferred from modern calibrated stable oxygen and carbon isotopes. GSA Bulletin 114, 1326–1340.

Kitchell, N.R., Boisvert, R., 2011. New radiocarbon date from the Colebrook Paleoindian site. Hampshire Archaeological Society Newsletter 27 (1), 3.

Knight, J., 1985. Differential Preservation of Calcined Bone at the Hirundo Site, Alton, Maine. Master of Science dissertation, Quaternary Studies, University of Maine at Orono.

Kroon, D., Shimmield, G., Austin, W.E.N., Derrick, S., Knutz, P., Shimmield, T., 2000. Century-to millennial-scale sedimentological-geochemical records of glacial-Holocene sediment variations from the Barra Fan (NE Atlantic). Journal of the Geological Society 157, 643–653.

Levesque, A., Mayle, F., Walker, I., Cwynar, L., 1993. A previously unrecognized late glacial cold event in eastern North America. Nature 361, 623–626.

Levesque, A., Cwynar, L., Walker, I., 1997. Exceptionally steep north-south gradients in lake temperatures during the last deglaciation. Nature 385, 423–426.

Loring, S., 1980. Paleo-Indian hunters and the Champlain Sea: a presumed association. Man in the Northeast 19, 15–42.

Loring, S., 1997. On the trail to the Caribou House: some reflections on Innu Caribou hunters in Northern Ntessinan (Labrador). In: Jackson, L.J., Thacker, P.T. (Eds.), Caribou and Reindeer Hunters of the Northern Hemisphere, Worldwide Archaeology Series. Avebury, Aldershot, England, pp. 185–220.

Lothrop, J.C., 2009. The New York Paleoindian database project: a call for data. NYSAA Newsletter 5 (3), 9.

Lothrop, J.C., Bradley, J.W. Paleoindian occupations in the Hudson Valley, New York. In: Chapdelaine, C. (Ed.), Late Pleistocene archaeology and ecology in the far Northeast. Center for the Study of the First Americans and Texas A&M University Press, College Station, in press.

MacDonald, D.H., 2004. Early Paleoindians as estate settlers: archaeological, ethnographic, and evolutionary insights into peopling of the New World. In: Barton, C., Clark, G., Yessner, D., Pearson, G. (Eds.), The Settlement of the American Continents. University of Arizona Press, Tucson, pp. 173–174.

MacDonald, G., 1968. Debert: a Paleoindian site in central Nova Scotia. National Museum of Man Anthropology Papers 16.

Maenza-Gmelch, T.E., 1996. Vegetation, climate, and fire during the late glacial-Holocene transition at spruce pond, Hudson highlands, Southeastern New York, USA. Journal of Quaternary Science 12 (1), 15–24.

Maenza-Gmelch, T.E., 1997. Late-glacial – early Holocene vegetation, climate, and fire at Sutherland Pond, Hudson Highlands, southeastern New York, U.S.A. Canadian Journal of Botany 75, 431–439.

Marlon, J.R., Bartlein, P.J., Walsh, M.K., Harrison, S.P., Brown, K.J., Edwards, M.E., Higuera, P.E., Power, M.J., Anderson, R.S., Briles, C., Brunelle, A., Carcaillet, C., Daniels, M., Hu, F.S., Lavoie, M., Long, C., Minckley, T., Richard, P.J.H., Scott, A.C., Shafer, D.S., Tinner, W., Umbanhowar, C.E., Whitlock, C., 2009. Wildfire responses to abrupt climate change in North America. PNAS 106 (8), 2519–2524.

Mayle, F.E., Cwynar, L.C., 1995. Impact of the Younger Dryas cooling event upon lowland vegetation of Maritime Canada. Ecological Monographs 65, 129–154.

Mayle, F.E., Levesque, A.J., Cwynar, L.C., 1993. Alnus as an indicator taxon of the Younger Dryas in eastern North America. Quaternary Science Reviews 12, 295–305.

Meltzer, D., 2003. Lessons in landscape learning. In: Rockman, Marcy, Steele, James (Eds.), Colonization of Unfamiliar Landscapes. Routledge, London and New York, pp. 222–241.

Meltzer, D., 2004. Modeling the initial colonization of the Americas: issues of scale, demography, and landscape learning. In: Barton, C., Clark, G., Yessner, D., Pearson, G. (Eds.), The Settlement of the American Continents. University of Arizona Press, Tucson, pp. 123–137.

Meltzer, D., Holliday, V., 2010. Would North American Paleoindians have noticed Younger Dryas age climate changes? Journal of World Prehistory 23, 1–41.

Miller, N., 2008a. Contemporary and prior environments of the Hyde Park, New York, Mastodon, on the basis of associated plant macro fossils. In: WarrenAllmon, D., Nestor, Peter L. (Eds.), Mastodon Paleobiology, Taphonomy, and Paleoenvironment in the Late Pleistocene of New York State: Studies of the Hyde Park, Chemung, and North Java Sites. Paleontographica Americana, vol. 61, pp. 151–181.

Miller, N., 2008b. The Cohoes Mastodon and Younger Dryas in Eastern New York. In: DeSimone, D., Wall, G., Miller, N., Rayburn, J., Kozlowski, A. (Eds.), Glacial Geology of the Northern Hudson through Southern Champlain Lowlands. Guidebook to Field Trips for the 71st Annual Reunion, Northeastern Friends of the Pleistocene, May 30–31 and June 1, 2008, pp. 19–25.

Morrow, J.E., Morrow, T.A., 1999. Geographic variation in fluted projectile points: a hemisheric perspective. American Antiquity 64 (2), 215–231.

Morrow, J.E., Morrow, T.A., 2002. Exploring the Clovis-Gainey-Folsom Continuum: technological and morphological variation in midwestern fluted points. In: JohnClark, E., Collins, Michael B. (Eds.), Folsom Technology and Lifeways. Lithic Technology, Department of Anthropology, University of Tulsa, Tulsa, pp. 141–157. Special Publication No. 4.

Mott, R.J., Matthews Jr., J.V., Grant, D.R., Beke, G.J., 1986. A late glacial buried organic profile near Brookside, Nova Scotia. Geological Survey of Canada Paper 86–1B, 289–294.

Muscheler, R., Kromer, B., Bojrk, S., Svensson, A., Friedrich, M., Kaiser, K.F., et al., 2008. Tree rings and ice cores reveal 14C calibration uncertainties during the Younger Dryas. Nature Geoscience 1, 263–267.

Newby, P., Bradley, J., 2007. Post-Glacial landscape changes and Paleoamericans in the New England Maritimes Regions. Current Research in the Pleistocene 24, 16–18.

Newby, P.E., Killoran, P., Waldorf, M.R., Shuman, B.N., Webb, R.S., Webb III, T., 2000. 14,000 years of sediment, vegetation and water level changes at the makepeace cedar swamp, southeastern Massachusetts. Quaternary Research 52, 352–368.

Newby, P.E., Bradley, J.B., Spiess, A., Shuman, B., Leduc, P., 2005. A Paleoindian response to Younger Dryas climate change. Quaternary Science Reviews 24, 141–154.

Newby, P.E., Donnelly, J.P., Shuman, B.N., MacDonald, D., 2009. Evidence of centennial-scale drought from southeastern Massachusetts during the Pleistocene/Holocene transition. Quaternary Science Reviews 28, 1675–1682.

Newby, P.E., Shuman, B.N., Donnelly, J.P., MacDonald, D., 2011. Repeated Century-Scale Droughts over the past 13,000 years near the Hudson River watershed. U.S.A. Quaternary Research 75, 523–530.

Oswald, W.W., Faison, E.K., Foster, D.R., Doughty, E.D., Hall, B.R., Hansen, B.C.S., 2007. Post-glacial changes in spatial patterns of vegetation across southern New England. Journal of Biogeography 34, 900–913.

Pelletier, B.G., Robinson, B.S., 2005. Tundra, ice and a Pleistocene cape on the Gulf of Maine: a case of Paleoindian transhumance. Archaeology of Eastern North America 33, 163–176.

Peteet, D.M., Vogel, J.S., Nelson, D.E., Southon, J.R., Nickmann, R.J., Heusser, L.E., 1990. Younger Dryas climatic reversal in northeastern USA? AMS ages for an old problem. Quaternary Research 33, 219–230.

Peteet, D.M., Daniels, R.A., Heusser, L.E., Vogel, J.S., Southon, J.R., Nelson, D.E., 1993. Late-glacial pollen, macrofossils and fish remains in Northeastern U.S.A. The Younger Dryas Oscillation. Quaternary Science Reviews 12, 597–612.

Petersen, J.B., Bartone, R.N., Cox, B.J., 2000. The Varney Farm Site and the Late Paleoindian Period in Northeastern North America. Archaeology of Eastern North America 28, 113–140.

Pollock, S.G., Hamilton, N.D., Bonnichsen, R., 1999. Chert from the Munsungun Lake formation (Maine) and Paleoamerican archaeological sites in northeastern North America: recognition of its occurrence and distribution. Journal of Archaeological Science 26, 269–293.

Pollock, S.G., Hamilton, N.D., Boisvert, R.A., 2008a. Archaeological geology of two flow-banded spherulitic rhyolites in New England, USA: their history, exploitation and criteria for recognition. Journal of Archaeological Science 35 (3), 688–703.

Pollock, S.G., Hamilton, N.D., Boisvert, R.A., 2008a. Prehistoric utilization of spherulitic and flow banded rhyolites from northern New Hampshire. Archaeology of Eastern North America 36, 91–118.

Rasmussen, S.O., Andersen, K.K., Svensson, A.M., Steffensen, J.P., Vinther, B.M., Clausen, H.B., Siggaard-Andersen, M.-L., Johnsen, S.J., Larsen, L.B., Dahl-Jensen, D., Bigler, M., Rotheetberger, R., Fischer, H., Goto-Azuma, K., Hansson, M.E., Ruth, U., 2006. A new Greenland ice core chronology for the last glacial termination. Journal of Geophysical Research 111, 1–16.

Rayburn, J.A., Kneupfer, P.L.K., Franzi, D.A., 2005. A series of large late Wisconsin Meltwater Floods through the Champlain and Hudson Valley's, New York. Quaternary Science Reviews 24, 2410–2419.

Reimer, P.J., Baillie, M.G.L., Bard, E., Baylis, A., Beck, J.W., Bertrand, C.J.H., Blackwell, P.G., Buck, C.E., Burr, G.S., Cutler, K.B., Damon, P.E., Edwards, R.L., Fairbanks, R.G., Friedrich, M., Guilderson, T.P., Hogg, A.G., Hughen, K.A., Kromer, B., 2004. IntCal04 terrestrial radiocarbon age calibration, 0–26 cal kyr BP. Radiocarbon 46, 1029–1058.

Reimer, P.J., Baillie, M.G.L., Bard, E., Bayliss, A., Beck, J.W., Blackwell, P.G., Bronk Ramsey, C., Buck, C.E., Burr, G.S., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Hajdas, I., Heaton, T.J., Hogg, A.G., Hughen, K.A., Kaiser, K.F., Kromer, B., McCormac, F.G., Manning, S.W., Reimer, R.W., Richards, D.A., Southon, J.R., Talamo, S., Turney, C.S.M., van der Plicht, J., Weyhenmeyer, C.E., 2009. IntCal09 and Marine09 Radiocarbon Age Calibration Curves, 0–50,000 cal yr B.P. Radiocarbon 51, 1111–11150.

Richard, P.J.H., Veillette, J.J., Larouche, A.C., Hétu, B., Gray, J.T., Gangloff, P., 1997. Chronologie de la déglaciation en Gaspésie: Nouvelles données et implications. Géographie Physique et Quaternaire 51, 163–184.

Richard, P.J.H., Occhietti, S., 2005. 14C chronology for ice retreat and inception of Champlain Sea in the St. Lawrence Lowlands, Canada. Quaternary Research 63, 353–358.

Ridge, J.C., 2003. The Last Deglaciation of the Northeastern United States: a combined Varve, Paleomagnetic, and Calibrated 14C Chronology. In: David-Cremeens, L., Hart, John P. (Eds.), Geoarchaeology of Landscapes in the Glaciated Northeast. New York State Museum Bulletin, vol. 497, pp. 15–48.

Ritchie, W.A., 1957. Traces of Early Man in the Northeast. New York State Museum and Service, Bulletin 358.

Ritchie, W.A., 1969. The Archaeology of New York State (revised). Natural History Press, Garden City, New York.
Robinson, B. and Spiess, A., Identifying Caribou and Other Calcined Bone from Bull Brook, in preparation.
Robinson, B.S., Ort, J.C., Eldridge, W.A., Burke, A., Pelletier, B.C., 2009. Paleoindian aggregation and social context at Bull Brook. American Antiquity 74 (3), 423–447.
Robinson, G.S., Burney, L.P., Burney, D., 2005. Landscape paleocology and megafaunal extinction in southeastern New York State. Ecological Monographs 75 (3), 295–315.
Robinson IV, F.W., 2009. The Reagen Site Revisited: A Contemporary Analysis of a Formative Northeastern Paleoindian Site. Archaeology of Eastern North America 37, 85–148.
Robinson, F.W. IV. Between the Mountains and the Sea: An Exploration of the Champlain Sea and Paleoindian Land Use in the Champlain Basin. In: Chapdelaine, C. (Ed.), Late Pleistocene Archaeology and Ecology in the Far Northeast. Center for the Study of the First Americans and Texas A&M University Press, College Station, in press.
Rockman, M., Steele, J., 2003. Colonization of Unfamiliar Landscapes: The Archaeology of Adaptation. Routledge, London/New York.
Rodrigues, C.G., 2006. Comments on "The Allerod–Younger Dryas-Holocene Sequence and West-Central Champlain Sea, Eastern Ontario: A Record of Glacial, Oceanographic and Climatic Changes" by U. Brand and F.M.G. McCarthy. Quaternary Science Reviews 25, 2441–2445.
Rosenmeier, L., Buchanan, S., Stea, R., Brewster, G. New Sites and Lingering Questions at the Debert and Belmont Sites. In: Chapdelaine, C. (Ed.), Late Pleistocene Archaeology and Ecology in the Far Northeast. Center for the Study of the First Americans and Texas A&M University Press, College Station, in press.
Shipman, P., Foster, G., Margaret Scheoninger, M., 1984. Burnt bones and teeth: an experimental study of color, morphology, crystal structure, and shrinkage. Journal of Archaeological Science 11, 307–325.
Shott, M.J., 1989. Stone tools and economics: Great Lakes Paleoindian examples. In: Tankersley, K., Isaac, B. (Eds.), Early Paleoindian Economies at the Eastern North America. Research in Economics Anthropology, Supplement, vol. 5, pp. 3–43.
Shuman, B., Bravo, J., Kaye, J., Lynch, J., Newby, P., Webb III, T., 2001. Late-Quaternary water-level variations and vegetation history at Crooked Pond, Southeastern Massachusetts. Quaternary Research 56, 401–410.
Shuman, B., Bartlein, P., Webb III, T., William, J., 2002. The anatomy of a climatic oscillation: vegetation change in eastern North America during the Younger Dryas chronozone. Quaternary Science Reviews 21, 1777–1791.
Shuman, B.N., Newby, P.E., Huang, Y., Webb III, T., 2004. Evidence for the close climatic control of New England vegetation history. Ecology 85, 1297–1310.
Shuman, B.N., Newby, P.E., Donnelly, J.P., 2009. Abrupt climate change as an important agent of ecological change in the Northeast U.S. throughout the past 15,000 years. Quaternary Science Reviews 28, 1693–1709.
Smallwood, A.M., 2010. Clovis Biface technology at the Topper site, South Carolina: evidence for variation in technological flexibility. Journal of Archaeological Science 37, 2413–2425.
Spiess, A., Wilson, D., 1987. Michaud: a Paleoindian site in the New England-Maritimes Region. In: Occasional Publications in Maine Archaeology, vol. 6. The Maine Historic Preservation Commission and the Maine Archaeological Society, Augusta.
Spiess, A., Wilson, D., 1989. Paleoindian Lithic Distribution in the New England-Maritimes Region. In: Ellis, C.J., Lothrop, J.C. (Eds.), Eastern Paleoindian Lithic Resource Use. Westview Press, Boulder, pp. 75–97.
Spiess, A., Mosher, J., 2006. Archaic period hunting and fishing around the Gulf of Maine. In: Sanger, D., Renouf, M.A.P. (Eds.), The Archaic of the Far Northeast. University of Maine Press, pp. 383–408.
Spiess, A., Curran, M.L., Grimes, J.R., 1985. Caribou (Rangifer tarandus L.) Bones from New England Paleoindian Sites. North American Archaeologist 6 (2), 145–159.
Spiess, A., Wilson, D., Bradley, J., 1998. Paleoindian occupation in the New England-Maritimes region: beyond cultural ecology. Archaeology of Eastern North America 26, 201–264.
Spiess, A., Cowie, E., Bartone, R. Geographic clusters of fluted point sites in the New England-Maritimes-Québec Region. In: Chapdelaine, C. (Ed.), Late Pleistocene Archaeology and Ecology in the Far Northeast. Center for the Study of the First Americans and Texas A&M University Press, College Station, in press.
Stanford, S.D., 2009. Onshore Record of the Hudson River drainage to the continental shelf from the Late Miocene through the Late Wisconsinan Deglaciation, USA: synthesis and revision. Boreas 39 (1), 1–17.
Stanford, D., 2005. Paleoindian archaeology and Late Pleistocene environments in the Plains and southwestern United States. In: Bonnichsen, R., Turnmire, K.L. (Eds.), Ice Age Peoples of North America: Environments, Origins, and Adaptations. Texas A&M University Press, College Station, pp. 281–339.
Stea, R.R., Mott, R.J., 2005. Younger Dryas glacial advance in the southern Gulf of St. Lawrence, Canada: analogue for lowland ice inception? Boreas 34, 1–19.
Steffensen, J.P., Andersen, K.K., Bigler, M.H., Clausen, B., Dahl-Jensen, D., Fischer, H., Goto-Azuma, K., Hansson, M.S., Johnsen, J., Jouzel, J., Masson-Delmotte, V., Popp, T., Rasmussen, S.O., Röthlisberger, R., Ruth, U., Stauffer, B., Siggaard-Andersen, M.-L., Sveinbjörnsdóttir, Á.E., Svensson, A., White, J.W.C., 2008. High-resolution Greenland ice core data show abrupt climate change happens in a few years. Science 321, 680–684.
Storck, P.L., Spiess, A.E., 1994. The significance of new faunal identifications attributed to an early Paleoindian (Gainey Complex) occupation at the Udora Site, Ontario, Canada. American Antiquity 59 (1), 121–142.
Stuiver, M., Grootes, P., 2000. GISP2 oxygen isotope ratios. Quaternary Research 53, 277–284.
Stuiver, M., Reimer, P.J., Reimer, R.W., 2005. CALIB 6.0. http://calib.qub.ac.uk/calib/.
Taylor, K.C., Mayewski, P.A., Alley, R.B., Brook, E.J., Gow, A.J., Grootes, P.M., Meese, D.A., Saltzman, E.S., Severinghaus, J.P., Twickler, M.S., White, J.W.C., Whitlow, S., Zielinski, G.A., 1997. The Holocene-Younger Dryas Transition Recorded at Summit, Greenland. Science 278, 825–827.
Teller, J.T., 2004. Controls, history, outbursts, and impact of large late-Quaternary proglacial lakes in North America. In: Gillespie, A.R., Porter, S.C., Atwater, B.F. (Eds.), The Quaternary Period in The United States. Elsevier, Amsterdam, pp. 45–61.
Theiler, E.R., Butman, B., Schwab, W.C., Allison, M.A., Driscoll, N.W., Donnelly, J.P., Uchupi, E., 2007. A catastrophic meltwater flood event in the formation of the Hudson Shelf Valley. Paleogeography, Paleoclimatology, Paleoecology 246, 120–136.
Thompson, W.B., Borns, H.W., 1985. Surficial Geologic Map of Maine. Maine Geological Survey, Department of Conservation, Augusta.
Thornbury, W.D., 1965. Regional Geomorphology of the United States. John Wiley & Sons, Inc., New York.
Thorson, R.M., Schile, C.A., 1995. Deglacial Eolian Regimes in New England. Geological Society of America Bulletin 107, 751–761.
Toney, J.L., Rodbell, D.T., Miller, N.G., 2003. Sedimentologic and palynologic records of the last deglaciation and Holocene from Ballston Lake, New York. Quaternary Research 60, 189–199.
Wall, G., 2008. IroMohawk river discharge and origin of the Cohoes falls. In: DeSimone, David, Wall, Gary, Miller, Norton, Rayburn, John, Kozlowski, Andrew (Eds.), Glacial Geology of the Northern Hudson Through Southern Champlain Lowlands, pp. 17–19. Guidebook to Field Trips for the 71st Annual Reunion, Northeastern Friends of the Pleistocene, May 30–31 and June 1, 2008.
Waters, M.R., Stafford Jr., T.W., 2007. Redefining the age of Clovis: implications for the peopling of the Americas. Science 315, 1122–1126.
Webb III, T., Bartlein, P.J., Harrison, S.P., Anderson, K.H., 1993. Vegetation, lake level, and climate change in eastern North America. In: Wright, H.E., Kutzbach, J.E., Webb III, T., Ruddiman, W.F., Street-Perrott, F.A., Bartlein, P.J. (Eds.), Global Climates since the Last Glacial Maximum. University of Minnesota Press, Minneapolis, pp. 415–467.
Webb III, T., Shuman, B., Williams, J.W., 2004. Climatically forced vegetation dynamics in eastern North America during the late Quaternary Period. Developments in Quaternary Science 1, 459–478.
Weinman, P.L., Weinman, T.P., 1978. Kings Road site: further evidence from this Paleoindian component. Bulletin of the New York State Archaeological Association 72, 1–5.
Whitehead, D.R., Crisman, T., 1985. Paleolimnological studies of small New England (USA) ponds. Part 1. Late glacial and postglacial trophic oscillations. Polskie Archiwum Hydrobiologii 25, 471–481.