

# Origin and Evolution of Dry Valleys South of Ronkonkoma Moraine

Soma Sen and Gilbert N. Hanson

Department of Geosciences, Stony Brook University, Stony Brook, NY - 11794

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South of the Ronkonkoma Moraine, Long Island hosts a network of straight, parallel Dry Valleys with few tributaries. The north-south valleys are clearly visible on a digital elevation model (DEM) of Long Island (Figure 1). These valleys are dry upstream. However further downstream water is present where the bottom of the valleys intersect the water table. We have named the Dry Valleys based on the ponds and lakes associated with the valleys. For example, Swan Dry Valley includes Swan Lake in Medford. According to Schmitthenner (1925-1926), small and shallow dry valleys are also known as 'dells'. Katasonova (1963) refers to dry, straight and parallel valleys as 'delly'. They both suggest that these are runoff valleys developed on a permafrost terrain.

There are two kinds of Dry Valleys south of the Ronkonkoma Moraine. One has straight, parallel drainage networks with few tributary valleys, low sinuosity (less than 1.5), low slope of the main trunk channel (0.0016-0.004), rectangular watershed, and an angulated transverse profile, which is V-shaped with steep walls (Figure 2). Typical examples are the Canaan Dry Valley and the Swan Dry Valley.

Further east is the other kind of Dry Valleys which have dendritic drainage patterns with both gentle and steep slopes such as the Setuck Dry Valley at East Moriches (Figure 3).

An interesting feature occurs at the Scuttlehole Ponds which are immediately south of the interlobate zone of the Ronkonkoma Moraine (Figure 4). Here the tributaries of the Hayground Cove Dry Valley system appear to cross the Scuttlehole Ponds. Presence of till south of Ronkonkoma Moraine suggests that the glacier that formed the Ronkonkoma Moraine advanced south beyond Ronkonkoma Moraine (King et al., 2003). Our suggestion is that the Scuttlehole Ponds are water filled kettle holes that were filled with glacial ice from the glacier that advanced south of the Ronkonkoma Moraine. These kettles appear to have been filled with ice and covered with sediment at the time the Hayground Cove Dry Valley system developed over them.

The patterns of the Dry Valleys south of the Ronkonkoma Moraine do not resemble the braided pattern of outwash plain valleys with their source of water at the moraine. Instead the headwaters of these headward eroding valleys are near the moraine, ruling out their formation from glacial meltwater. Their features are also not similar to those of tunnel valleys formed by subglacial meltwater, which include anastomosing valleys, paucity of tributaries and watersheds, and obliquity to the general drainage pattern (Cofaigh, 1996).

However, certain distinguishing characteristics of these Dry Valleys such as the dendritic drainage network, circular to elliptical watershed and gently sloping transverse profiles resemble those of surface runoff valleys developed on permafrost, (Marsh and Ming-ko, 1981), (Bogaart et al., 2003), (Aharonson et al., 2002). The other features of some Dry Valleys like the straight pattern, low order of tributaries, steep walls and V-shaped angulated transverse profile e.g the Canaan Dry Valley suggest their origin by groundwater sapping (Aharonson et al., 2002), (Dunne, 1980).

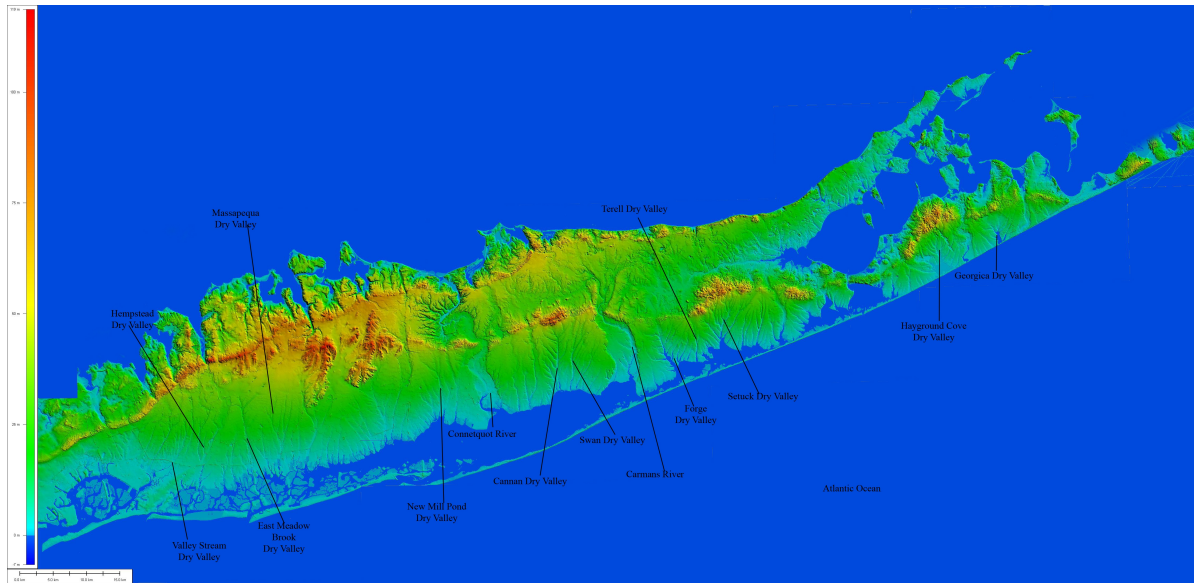


Figure 1: DEM of Long Island, from eastern Nassau in the left to East Hampton in the right.

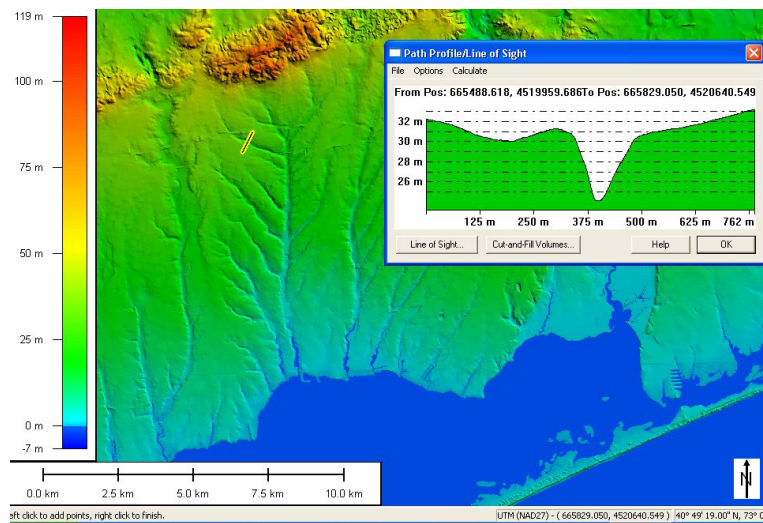


Figure 2: Angulated Drainage of Cannan Dry Valley, Patchogue. The tributary valleys meet the trunk valley at certain angles, hence the name. The yellow line is the line of cross-section of the tributary valley. The profile indicates a V-shaped, steep walled valley, DEM.

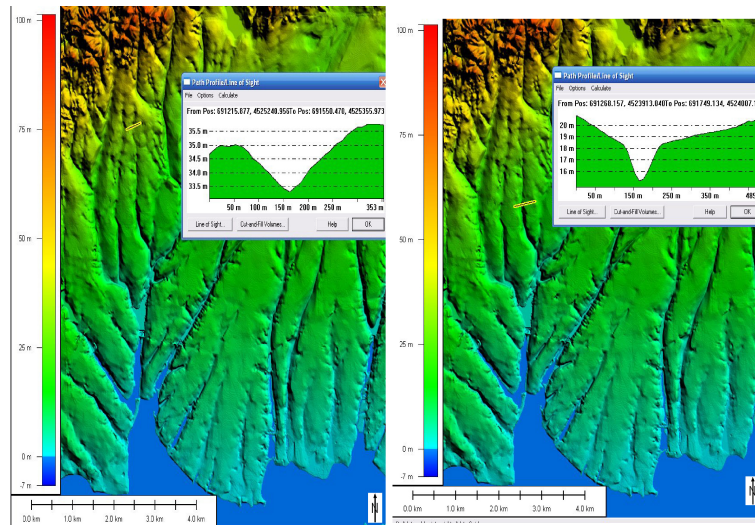


Figure 3: (a) The profile of the tributary valley of Setuck Dry Valley in East Moriches with relatively gentle sloping walls, DEM, (b) Steep V-shaped transverse profile of tributary valley of Setuck Dry Valley, East Moriches, Eastern Long Island. The yellow line shows the cross section path.

The scenario we are suggesting for the development of these Dry Valleys is that after the glacier that formed the Ronkonkoma Moraine retreated the landscape was a desert tundra, dominated by sedges and grasses. The mean annual temperature is estimated to be  $-6$  to  $-8^{\circ}\text{C}$  (Table 1)

Based on this mean annual temperature the permafrost on Long Island was probably a few hundred meters thick (Judge, 1973). The impervious frozen ground led to the development of the surface runoff stream valleys during the spring and summer when the snow would melt. During this time the tributary streams of Hayground Cove Dry Valley, near the Scuttlehole depressions developed on the frozen sediments on top of the buried ice in the depressions (Figure 5).

The climate started warming at the onset of Bolling Allerod around 14,600 cal years (Table 1). This rise in temperature led to the melting of the permafrost (Figure 6). Geothermal heat is responsible for the upward thawing of permafrost and the climatic warming is responsible for the downward thawing of permafrost (Szewczyk, 2005).

With the melting of the permafrost snowmelt water and rain could now infiltrate and runoff stopped. A perched water table developed on the melting permafrost. Downstream where the bottom of the Dry Valleys were at the same level as the perched water table the valleys were affected by groundwater sapping. The upstream ends of the runoff tributaries were above the water table and became dry. The ice in the depressions of the Scuttleholes also melted (Figure 6). At some point the perched water table dropped beneath the level of the stream valleys and the Scuttlehole ponds leaving them dry (Figure 6). Associated with the more recent sea level rise the bottoms of the downstream parts of the Dry Valleys are now intersecting the regional water table.

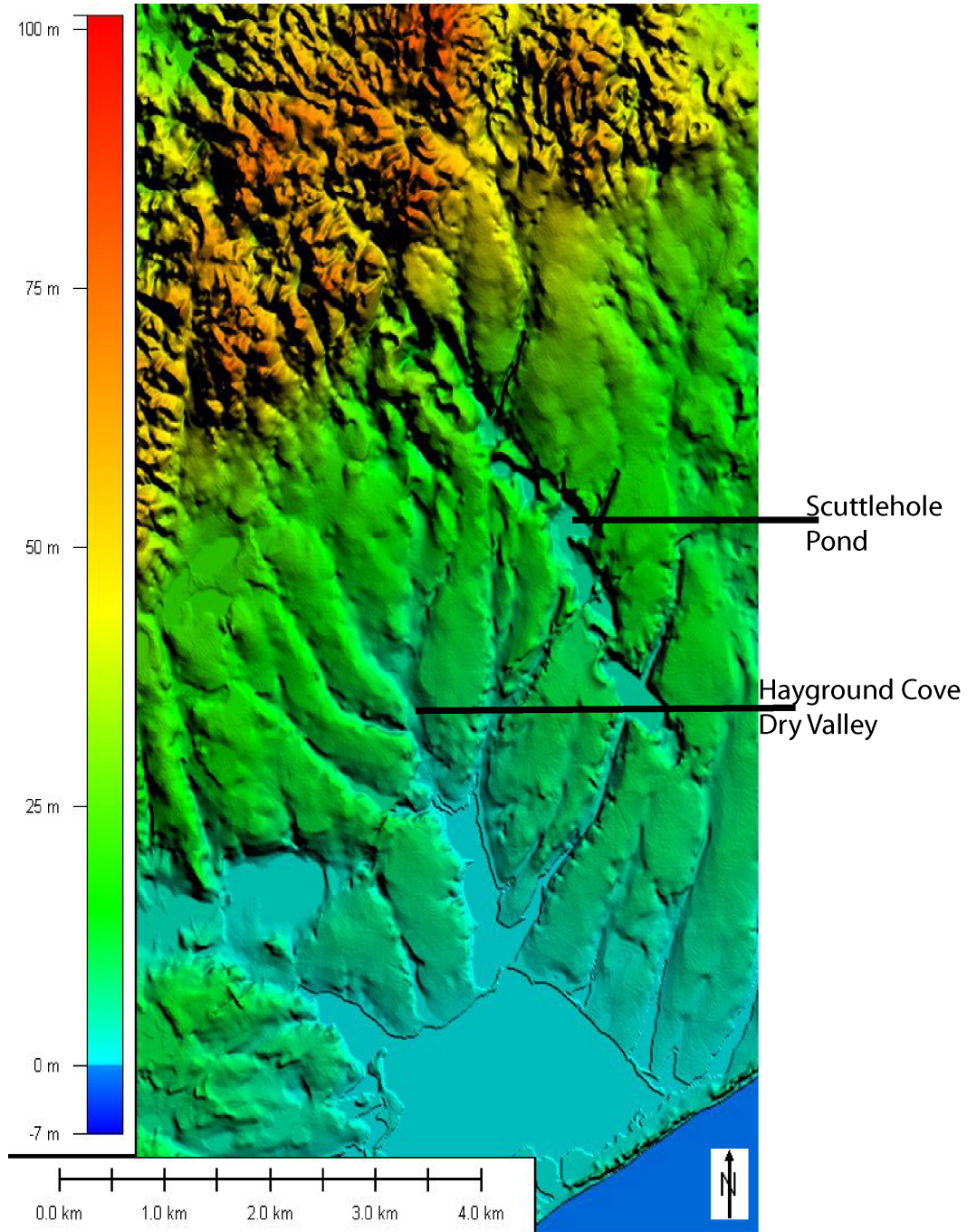


Figure 4: *Scuttlehole Ponds, Sag Harbour, Long Island.*

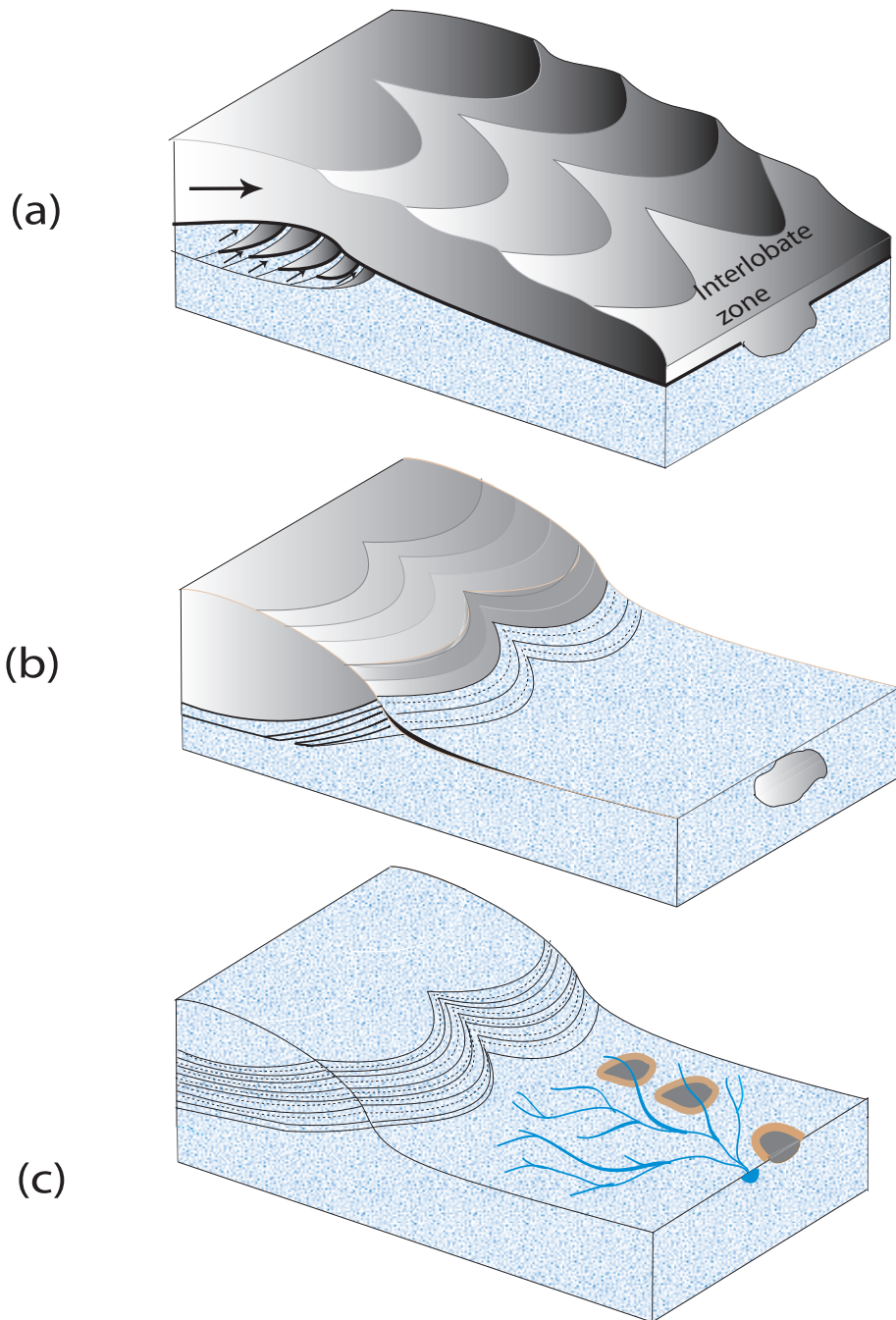


Figure 5: Models describing formation of Dry Valleys in Long Island: (a) At the time of Ronkonkoma Glacier advance(60-20 kyr), (b)Ronkonkoma Glacier retreat(20-18 kyr), (c)During time when of permafrost until about 15kyr

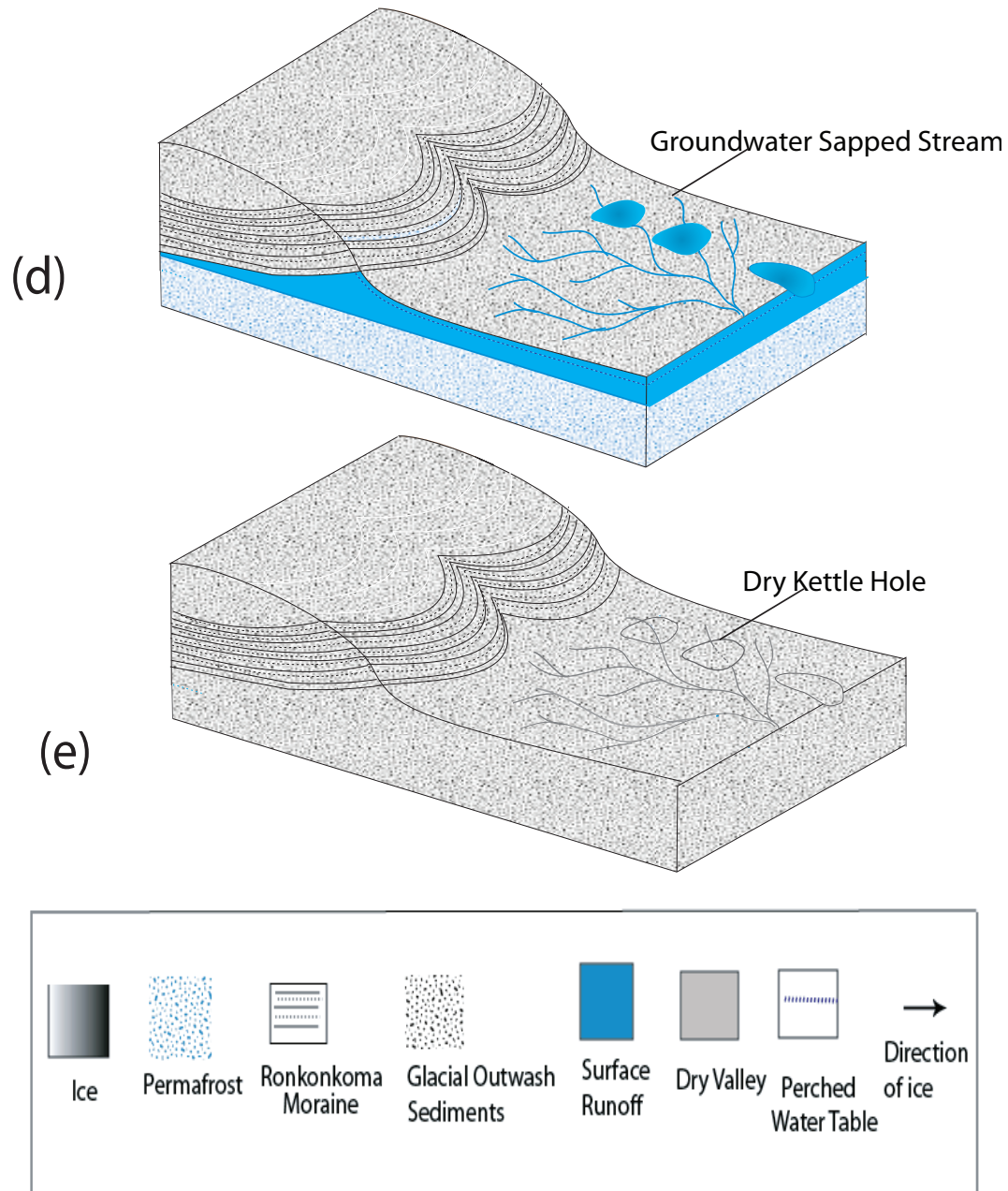


Figure 6: Models describing formation of Dry Valleys in Long Island: (d) During time of perched water table on melting permafrost (15-10kyr), (e) After permafrost melted and before water table rose with post-glacial sea level rise (10kyr to ?)

**Table 1: Paleoclimate after the last deglaciation in Long Island**

Age (kyr)	Climate	Temperatures (°C)	Evidences	Temperature curve: MAT (in °C)
20	Cold, dry, 20-30cm of pptn[1]	Jan: -16 July:14 [1] MAAT: -6 to -8 [2] T <sub>max</sub> :11.5-15 T <sub>min</sub> :-22 [8]	Ice Wedge[3], Sand wedge[4], Thermokarst Involution[5], Ventifacts[3],[4] BeetleAssemblages[8]. DesertTundra Grass, Arctic Alpine pines and Sedges.[6],[7]	<p>The graph plots Long Island MAT (Mean Annual Temperature) in °C against Time (kyr). The x-axis ranges from 20 kyr to 8 kyr, and the y-axis ranges from -20°C to 8°C. The data points are: (20, -18), (18, -17), (15, -15), (13, -14), (12, -14), (11, -13), (10, -11), (8, -11).</p>
18	Cold ,dry, 30-40cm of pptn[1]		Arctic Barren in Upper Delaware and Western Long Island[10] Alder, Pinus, Spruce and Fir [9]	
15	Warm and dry Boiling Allerod	Mean July:12 [6]	Boreal Forest [10] Spruce ,Birch [6][9], Pine, Fir, Hemlock, Oak, Ash, Beech, [11]	
14	Warm, moist& humid,[6]	Mean July: 16-17 [6] [1] Jan: -12°C	Fir, hemlock and Alder.[9] Increase in deciduous trees[9]	
13	Cold, dry climate Younger Dryas.	Mean July: 13 to 14°C[6]	Boreal Forest ., Pine decreases[9] Spruce,Fir, Tamrak, Birch[6]	
	Warm, moist 80cm of pptn [1].	Mean July: 15 to 16°C[6]	Hardwood Forest, Oak, Pine, rise in Beech and Hemlock [6][11]	
12	Warm, moist 80 cm of pptn[1]	Mean July 18 to 19 [6]	Hardwood Forest ,oak, beech, hemlock and alder.[1],[11]	
11	Warm, dry.	Mean July:21 [6]	Increase of hickory pollen. Hemlock (moisture dependant species) decreased[12]	
10	Warm, moist 80to120cm of pptn[1]	Mean July: 22 [6] [1] Jan: -4 to 0	Hardwood Forest Increase of chestnut pollen, hickory pollen	

pptn: average annual precipitation;

[1]Prentice,et al1991, [2] Pewe, 1966, [3]Nieter,1975, [4]Demitroff,2006, [5]Kundic&Hanson,2006,[6]Peteeet,1994, [7]Foster et al,1997, [8]Elias,1996 [9]Kneller et al, 1999, [10] Newman, 1977, [11] Shuman,2004, [12]Allison et al,1986.

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