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

March 2007

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 anastamosing 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 transeverse profile e.g the Canaan Dry Valley suggest their origin by groundwater sapping (Aharonson et al., 2002), (Dunne, 1980).
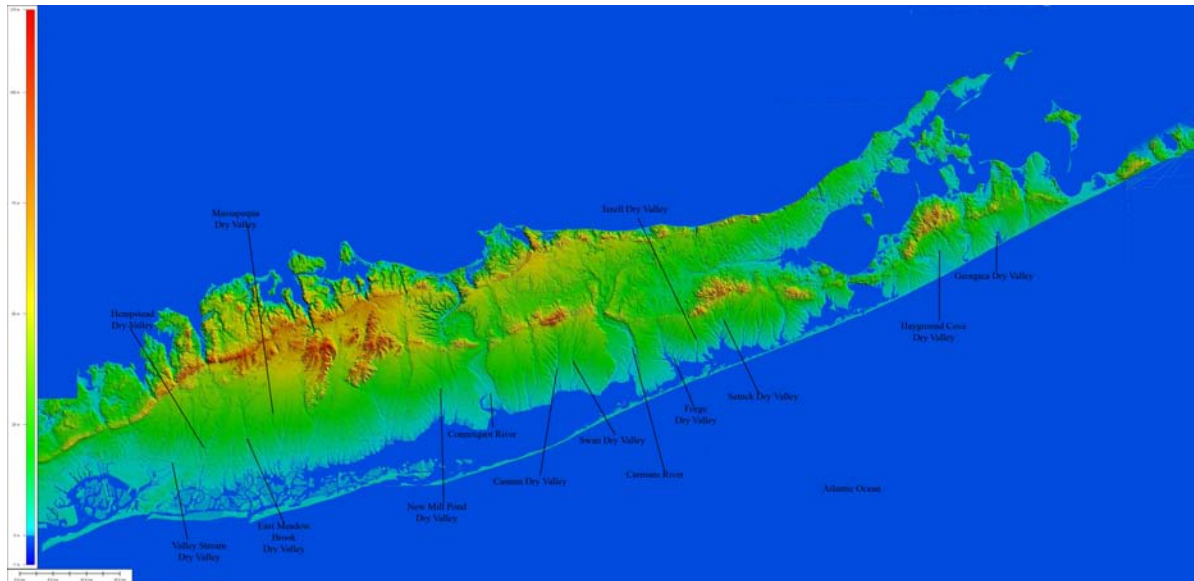
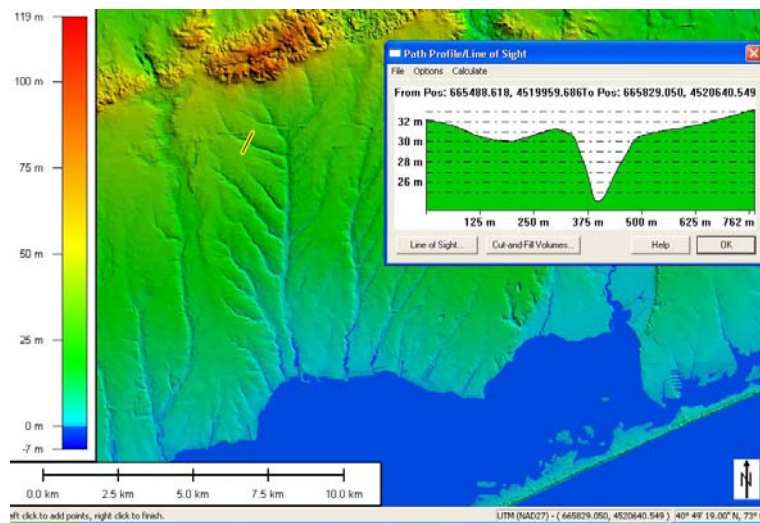Figure 1: *DEM of Long Island, from eastern Nassau in the left to East Hampton in the right.*

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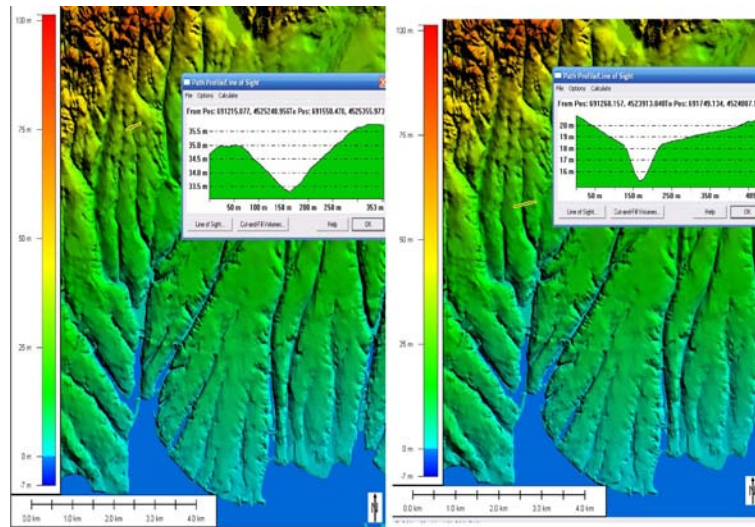
Figure 3: *(a)The profile of the tributary valley of Setuck Dry Valley in East Moriches with relatively gentle sloping walls, DEM,(b)Steep V-shaped transverse profile of tributary valley of Setuck Dry Valley, East Moriches,Eastern Long Island. The yellow line shows the cross section path.*

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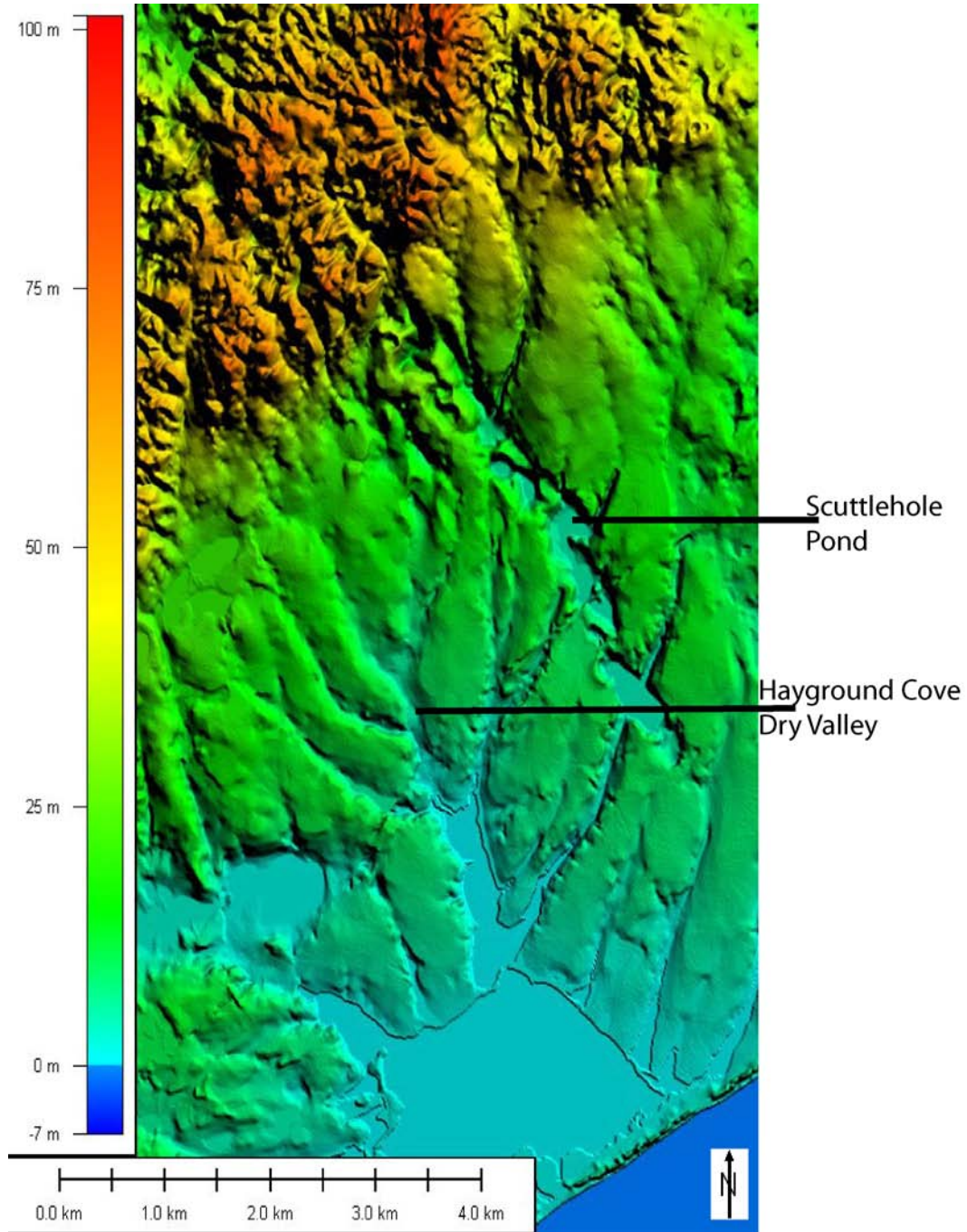
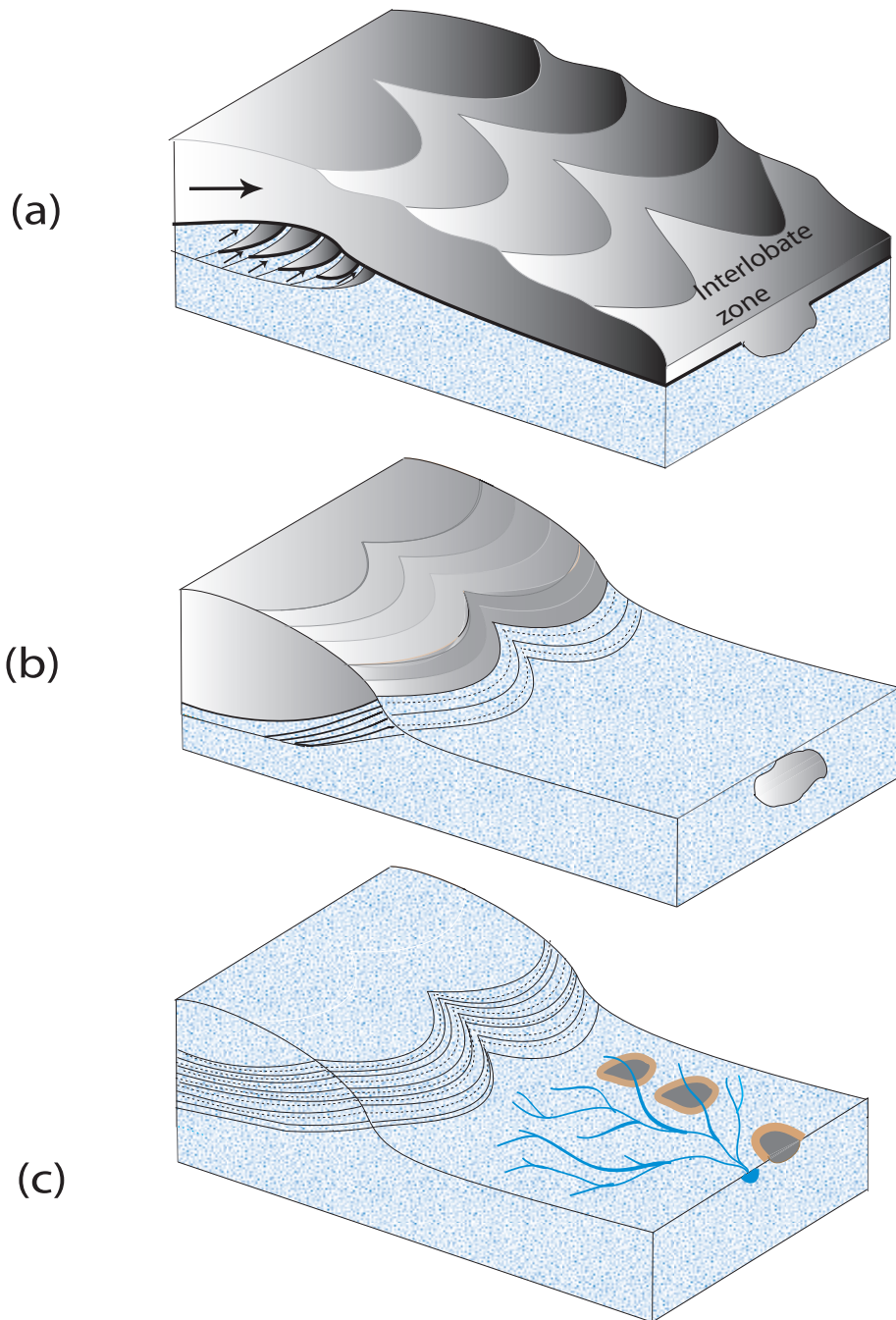Figure 4: *Scuttlehole Ponds, Sag Harbour, Long Island.*

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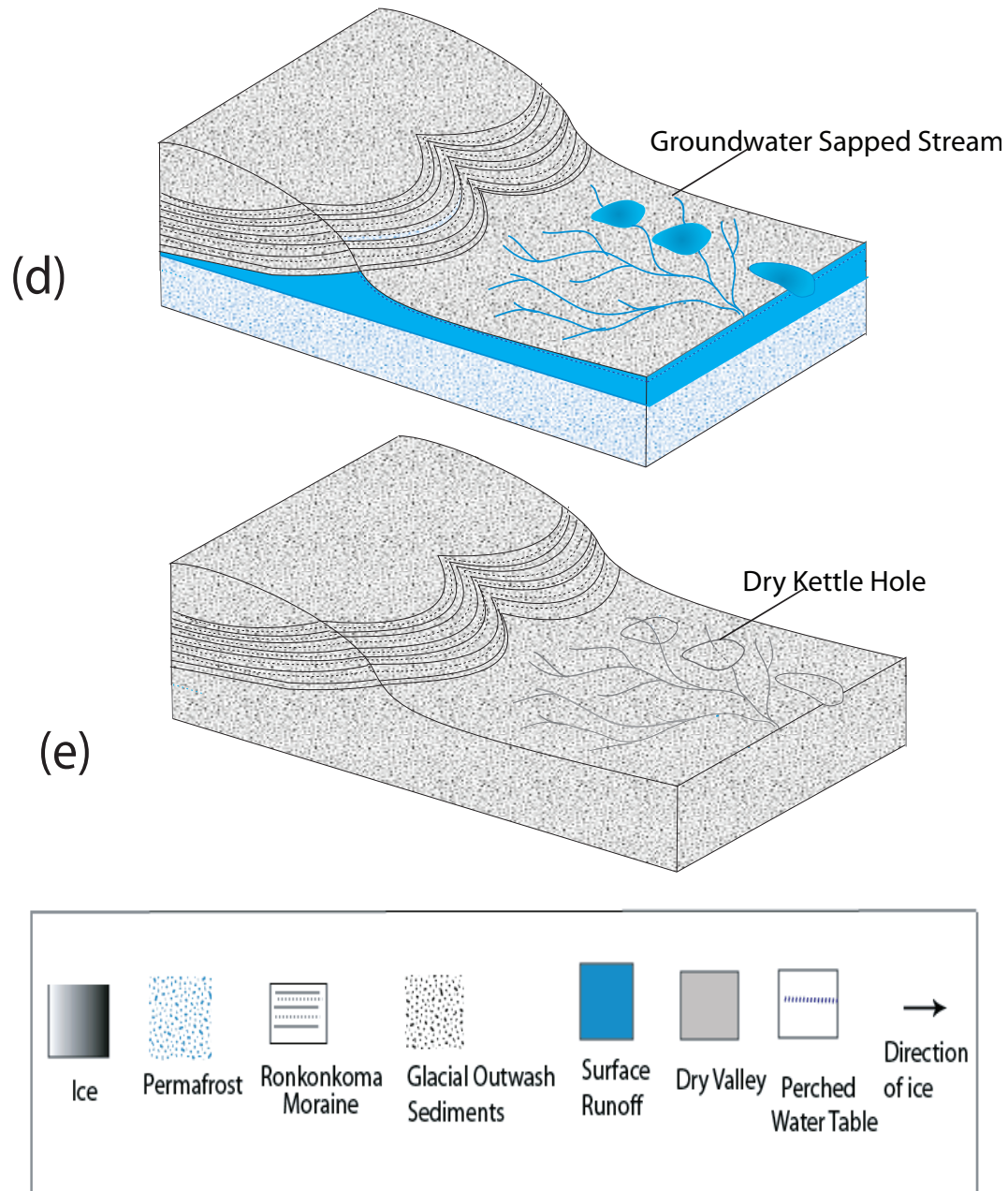
Figure 6: Models describing formation of Dry Valleys in Long Island: **(d)** During time of perchedwater table on melting permafrost (15-10kyr), **(e)**After permafrost melted and before water table rose with post-glacial sea level rise (10kyr to ?)

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_{max}:11.5-15 T_{min} :-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]	
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 Bolling 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][11] 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] [11] 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]Peteet,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.

References

Aharonson, O., Zuber, M.T., Rothman, D.H. and Whipple, N.S.X., 2002, Drainage basins and channel incision on Mars, *Proc Natl Acad Sci U S A*, vol. 99(4), pp. 1780–1783.

Allison, T., Moeller, R. and Davis, M., 1986, Pollen in Laminated Sediments Provides Evidence For a Mid-Holocene Forest Pathogen Outbreak, *Ecology*, vol. 67(4), pp. 1101–1105.

Bogaart, P., Tucker, G. and De Vries, J., 2003, Channel network morphology and sediment dynamics under alternating periglacial and temperate regimes: a numerical simulation study, *Geomorphology*, vol. 54(3), pp. 257–277.

Cofaigh, O.C., 1996, Tunnel valley genesis, *Progress in physical geography*, vol. 20(1), pp. 1–19.

Dunne, T., 1980, Formation and controls of channel networks, *Progress in Physical Geography*, vol. 4, pp. 211–239.

Elias, S., Anderson, K. and Andrews, J., 1996, Late Wisconsin climate in northeastern USA and southeastern Canada, reconstructed from fossil beetle assemblages, *Journal of Quaternary Science*, vol. 11(5), pp. 417–421.

Foster, R., Koski, C. and Johnson, B., 1997, Tundra, Online, URL `http://ths.sps.lane.edu/biomes/tundra5/tundra5.html`.

French, H.M., Demitroff, M., Forman, S.L. and Newell, W.L., 2007, A Chronology of Late-Pleistocene Permafrost Events in southern New Jersey,Eastern USA, *Permafrost and Periglacial Processes*, vol. 18, pp. 49–59.

Judge, A., 1973, The Prediction of Permafrost thickness, *Canadian Geotechnical Journal*, vol. 10.

Katasonova, E.G., 1963, The role of themokarst in the development of delly- Conditions and specialfeaturesofthe formation of frozen horizons in Siberia and in Far-east(in Russian), *Moscow, Isd-vo AN SSSR*, pp. 81–100.

King, C., Mion, L., Pacholik, W. and Hanson, G., 2003, Evidence of Till South of Ronkonkoma Moraine.

Kneller, M. and Peteet, D., 1999, Late-Glacial to Early Holocene Climate Changes from a Central Appalachian Pollen and Macrofossil Record, *Quaternary Research*, vol. 51(2), pp. 133–147.

Kundic, V. and Hanson, N., 2006, Evidence of Permafrost in Long Island, abstracts, Department of Geosciences, Stony Brook University, http://www.geo.sunysb.edu/ lig/ Conferences/ abstracts06/ kundic-06.pdf.

Marsh, P. and Ming-ko, W., 1981, Snowmelt, Glacier Melt, and High Arctic Streamflow Regimes, *Canadian Journal of Earth Sciences*, vol. 18(8).

Newman, S.W., 1977, Late Quaternary Paleoenvironmental Reconstruction:Some contradictions from Northwestern Long Island, New York, *Annals of the New York Academy of Science*, vol. 288, pp. 545–570.

Nieter, W., 1975, *A Late Wisconsin Loess Deposit in SouthEastern Long Island*, 98p, Queens College, New York.

Peteet, D., Daniels, R., Heusser, L., Vogel, J., Southon, J. and Nelson, D., 1994, Wisconsinan Late-glacial environmental change in southern New England: aregionalsynthesis, *JQS. Journal of quaternary science*, vol. 9(2), pp. 151–154.

Péwé, T., 1975, *Quaternary Geology of Alaska*, United States Government Printing Office.

Prentice, I., Bartlein, P. and Web III, T., 1991, Vegetation and Climate Change in Eastern North America Since the Last Glacial Maximum, *Ecology*, vol. 72(6), pp. 2038–2056.

Schmitthenner, H., 1925-1926, The origin of Dellen and their morphological significance, *Zeitschrift fur Geomorphologie, Band 1,Translated from the German by franchescaVincentincollaboration with C.F.Stewart Sharpe*, pp. 3–28.

Shuman, B., Newby, P., Huang, Y. and Webb III, T., 2003, Evidence for the close climatic control of New England Vegetation History, *Ecology*, vol. 85(5), pp. 1297–1310.

Szewczyk, J., 2005, The frozen time, Tech. rep., Polish Geological Institute, http://www.pgi.gov.pl.