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The Mascoma Headwaters Project:
A Study of Soil Morphology and Temperature in New Hampshire for Documenting Hydric Soil Indicators and Wetland Boundary Criteria

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Cover
Soil moisture soil temperature site at the 417 catena located at the Mascoma Headwaters Project.

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Contents

Issued 2006

List of Figures

List of Tables

Abstract

The Mascoma Headwaters Project (MHP) was established in 1995 in order to document defensible criteria for identifying and delineating wetland boundaries in frigid soils of northern New England and to test and refine both the National and the New England Regional Field Indicators of hydric soils. Many ideas, techniques, and theories were applied at the Mascoma site for studies which include: the comparison of soil temperature and growing season to bud score data in hydric soil sites, the comparison of soil temperature and piezometric head to soil morphology and hydric conditions in Spodosols, the comparison of site-specific maps made from both Regional and National Hydric Soils Indicator manuals, and the study of three drainage catenas to differentiate between folistic and histic epipedons. The first 5 years of data are examined.

There are five major key results/discoveries of the study:

1) Vegetative growth began well before the start of the “regulated” growing season requirements (5 degrees C at a depth of 50 cm); and yellow birch *(Betula lutea)* may prove to be a good indicator of growing season for hydric soil sites.
2) The moderately well drained Spodosol in the 417 catena had no water in a piezometer at a depth of 18 cm and no observable redoximorphic features (the ortstein layer at this site may reflect long-term climate-controlled wet and dry cycles of the soil).
3) The marginally hydric Spodosol in the 417 catena had water in enough amounts in the profile and of sufficient duration to qualify as hydric but not during the growing season, and the Spodosol “morphologically” keyed out as hydric by Regional Indicators only.
4) Site-specific maps based upon Regional Indicators (1996) showed a significantly higher amount of hydric soils (60 percent) than was determined by applying the National Indicators (28 percent); recommendations made to both committees resulted in much closer agreement in percent area designated as hydric soils (25 percent vs. 24 percent).
5) The term “muck” needs further testing (a simple field test of pH in water may differentiate folistic and histic epipedons in the field).

The MHP plans to collect at least 10 years of data to further test and refine hydric indicators and requirements for hydric soils in northern New England.

Introduction

The Mascoma Headwaters Project (MHP) is a comparative field study of regional and national wetland boundary indicators on a 40-acre site within a watershed typical of northern New England (fig. 1). The project design intent in 1995 was to evaluate hydric soils morphology, wetland hydrology, hydrophytic plant communities and growing season criteria. Specific objectives were: 1) to systematically identify and describe hydric soils; 2) to test and refine the National Hydric Soils Indicators *(USDA—NRCS, 1996b)* and the New England Regional Field Indicators *(New England Hydric Soils Technical Committee, 1995)* of hydric soils and; 3) to document defensible criteria for identifying and delineating wetland boundaries in frigid soils of northern New Hampshire.

Specific monitoring and assessment procedures include: 1) installation of six soil temperature and vegetation plots, 2) installation of three Soil Moisture/Soil Temperature (SMST) sites, 3) installation of a Soil Climate Analysis Network (SCAN) site, and 4) various soil mapping procedures and data collection by USDA—NRCS and private soil consultants within the 40-acre parcel.

Site and Soil Descriptions

The MHP is a 40-acre parcel of land about 9 miles east of the Connecticut River in the town of Dorchester, New Hampshire. Elevation is roughly 1,400 feet above mean sea level, and the soil temperature regime is frigid *(USDA—NRCS, 1999).* The site is

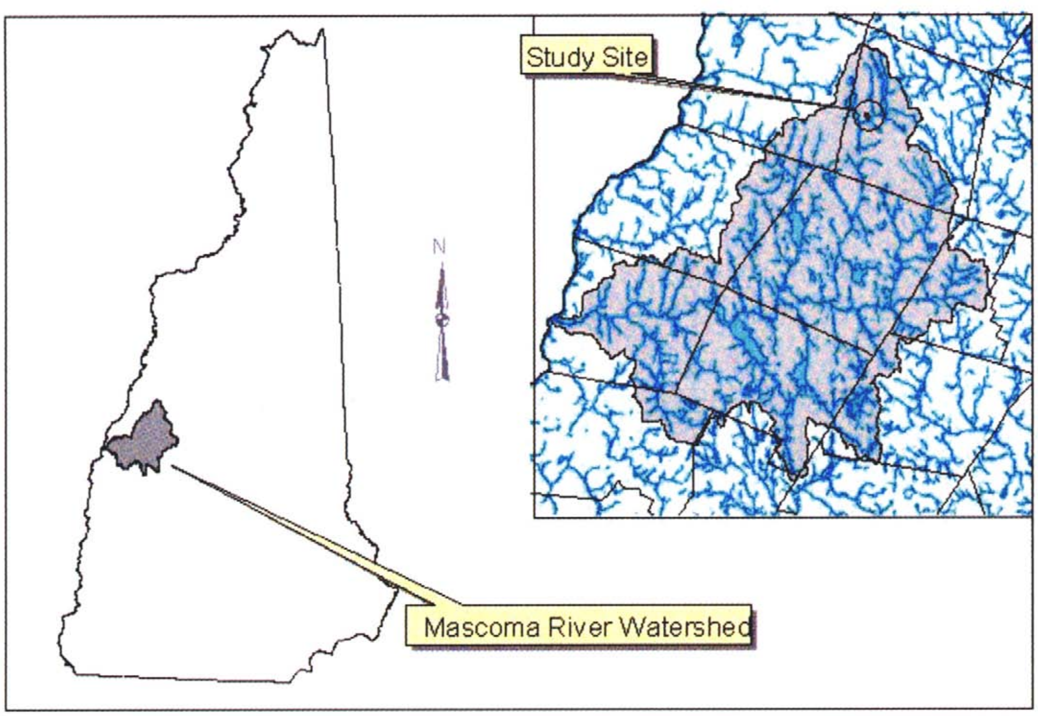


Figure 1.—Location of Mascoma Headwaters Project (MHP) in Dorchester, New Hampshire. Branching lines indicate surficial drainage network of the area.

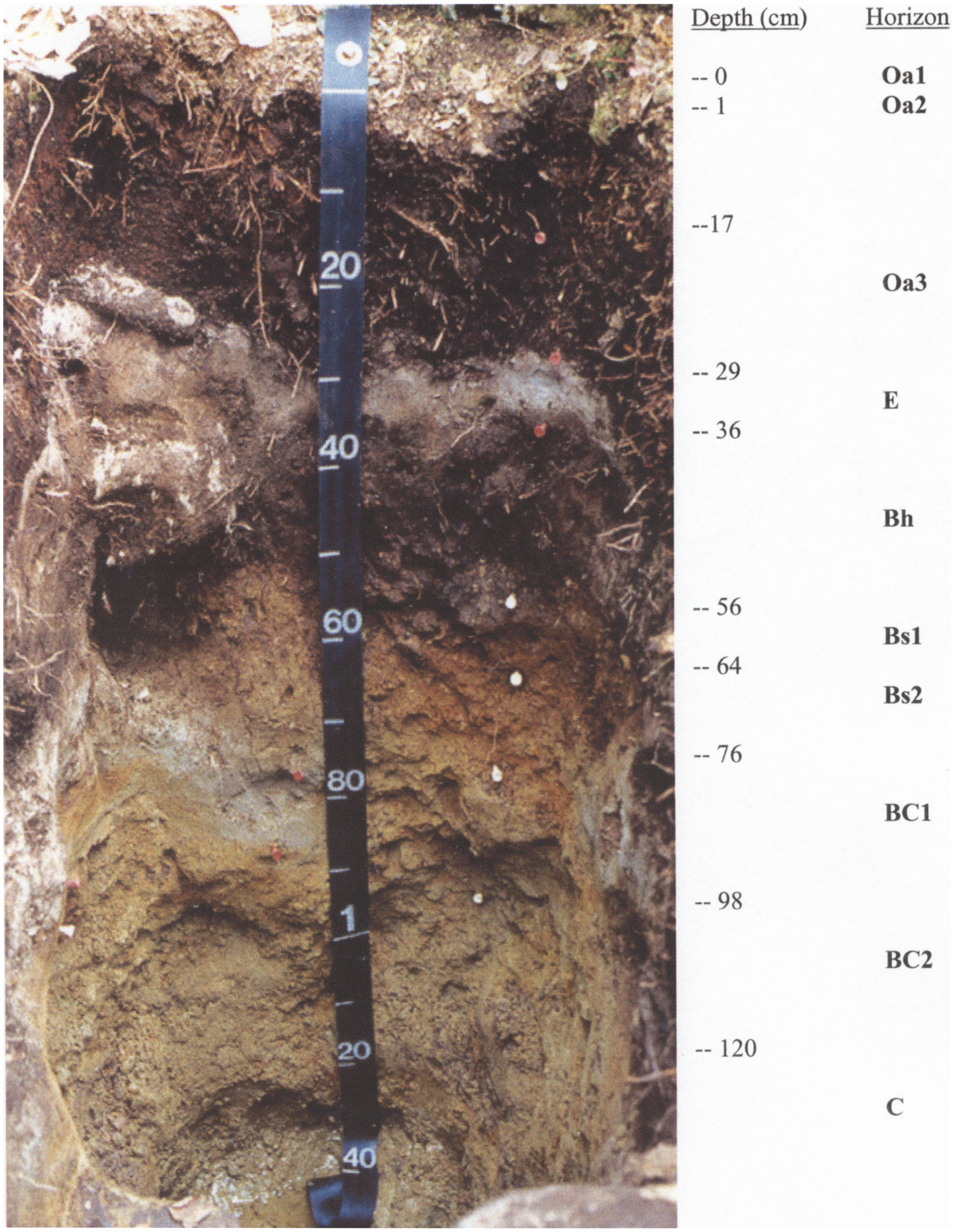


Figure 2.—A typical Spodosol profile at the Mascoma Headwaters Project (grid 418D).

100 percent forested. It is dominated by softwood stands of eastern hemlock (*Tsuga Canadensis*), black spruce (*Picea mariana*), and balsam fir (*Abies balsamea*) with a hardwood component of red maple (*Acer rubrum*), white ash (*Fraxinus Americana*), yellow birch (*Betula lutea*), and white birch (*Betula papyifera*). The age of the forest stand ranges from 45 to 160 years.

The soils at the MHP are very deep, range from somewhat excessively drained to very poorly drained, and formed in loamy to sandy, loose to firm glacial till. Most soils are Spodosols (fig. 2) with complex morphologies that are typical throughout northern New England.

Upland podzolization combined with seasonal water tables creates color patterns that are challenging in the determination of hydric soils in northern New England. The Spodosol forming processes (eluviation and illuviation of iron, aluminum, and organic matter) may mask redoximorphic indicators which formed during periodic saturation. Alternatively, Evans and Mokma (1996) suggest that the effects of podzolization processes simply exceed the effects of saturation and reduction on iron chemistry.

Procedures

Soil Sampling

Standard soil characterization methods *(USDA–NRCS, 1996c)* were used to sample and analyze soils from Pedon 417B (Appendix C) and the SCAN site. Selected methods were used to describe histic/folistic horizon transects (Appendices H and I). All soil analyses were performed by the National Soil Survey Laboratory, Lincoln, Nebraska (Appendices C and I).

Growing Season, Soil Temperature, and Bud Score Studies

The commonly applied concept of “growing season” is an agricultural interpretation established for cropland and is directly related to the timing of farming practices (such as tilling and planting) in spring and fall. The concept was not designed for natural ecosystems and does not reflect well the growing season of wetland plants or organisms. Consequently, an alternative approach was sought that could better capture natural ecosystem behavior.

One procedure that is more applicable to wetlands is the collection of bud scores. This procedure was designed to identify the onset of the growing season in spring in an attempt to test requirements as defined by the U.S. Army Corps of Engineers (1987) manual for identifying wetlands. Onset of vegetative growth occurred several weeks before the soil temperature reached theoretical biological zero of 5 degrees C at a depth of 50 cm. This discovery effectively lengthens the conventionally recognized onset of the growing season and extends it into the time that the soil is saturated in the upper part. This growing season extension effects mapping wetlands by soil hydrology criteria during growing season and greatly increases the extent of a mapped wetland.

Six stand-alone soil temperature monitoring stations were established adjacent to 1-meter-square vegetative plots (fig. 3). Two of these stations had Taylor indoor/outdoor thermometers, and four had automated Hobo temperature sensors (Onset Computer Corporation). Three were located in poorly drained soils and three in moderately well drained soils. Two additional vegetation plots were monitored in association with the automated SCAN site; one in a moderately well drained area and another in a poorly drained area. The standard SCAN site establishment protocol required the clearing of overstory. Consequently, the two SCAN vegetation plots had less canopy cover compared to the vegetative plots located in native forest.

In order to provide accurate identification of initial vegetation growth the following spring, herbaceous plants within the vegetation plots were identified in fall and a number-coded golf tee was inserted at the base of each plant. A 25-foot radius around the vegetation plot was established, and plants that represented the shrub layer were identified, flagged, numbered, and monitored during vegetative emergence. Appendix A has an example of the bud score worksheet used at the MHP.

Vegetation plots were monitored as spring temperatures rose and snow melt began at the MHP. Data were collected at the eight sites. Soil temperatures were recorded at depths of 15 cm and 50 cm, plus additional depths (30 cm and 38 cm) at the SCAN and SMST (Soil Moisture/Soil Temperature) sites. Vegetative emergence and growth were monitored by observing and quantifying the expansion, burst, and elongation of terminal buds. A qualitative ranking, called a bud score *(Coultais, 1997; Murray et al.,*

Figure 3.—Vegetation site 4. The stand-alone soil temperature monitoring station (the white half-tube on central tree with duct tape) is adjacent to the 1-meter-square vegetation plot (orange flags in foreground).

1989; Myking and Heide, 1995) was determined for each plant on a given date. Table 1 shows the scale by which bud scores were measured. In all, 27 species in the herb layer and 11 species in the shrub layer were monitored throughout the sites.

Bud scoring is rather subjective, and there is not enough precision to use intervals finer than 0.5 bud score. Up to five different people recorded the data. Results from each individual were rounded down to the nearest 0.5 bud score, for example, 0.678 became 0.5. If the bud score data did not keep increasing with time, the previous and following values were used to interpolate a value which would replace the aberrant data point. Bud score averages per site were calculated for each day that data were recorded. Because the main focus of the study was on wetlands and hydric soils, the budscore/growing season calculations were based only on the wetter sites.

Soil Moisture/Soil Temperature Monitoring Methods

SCAN Instrumentation

The SCAN station was equipped with the following above-ground sensors: RM Young windspeed/direction sensor, Texas Instrument Te535 tipping bucket rain gauge, Licor Li200 pyronometer solar radiation sensor, and Hmp45c air temperature and humidity sensor. To measure ground-water levels, there were two Keller pressure transducer sensors enclosed in well casings. Two sets of Five Vitel Hydra soil moisture sensors were used to monitor soil water content and temperature at depths of 15, 30, 38, 50, and 100 cm. An MCC 545b radio was used to transmit data through

Table 1.—Scale for bud score development (Murray et al., 1989; Myking and Heide, 1995).

Bud Score	Stage of Development
0	No observable growth
1	Bud swollen
2	Green foliage showing
3	Leaf elongation (>1 cm)

a meteor burst communication system to the NRCS National Water and Climate Center in Portland, Oregon. A Campbell CR10X datalogger was used to control the measurements and store data until it was transferred to the radio. A 10-W solar panel and 7.5 AH gel-cell battery provided power to the CR10X. Appendix B presents the SCAN site schematic.

SMST Instrumentation

Campbell CR10X dataloggers were used to control the measurements and store the data automatically collected at these sites. A Campbell AM 416 multiplexer was used at each of the five stations to expand the dataloggers capability, allowing them to monitor more sensors. A 10-W solar panel and a 7.5 AH gel-cell battery provided power to each station. Five Campbell 107 sensors (thermisters) were used to monitor soil temperature. Keller pressure transducer sensors enclosed in well casings were strategically placed to measure ground-water levels. Redoximorphic potentials were measured using protocol and electrodes constructed by Dr. Wayne Hudnall, Louisiana State University. Data from each datalogger were manually downloaded quarterly and processed. The data were organized, and raw sensor output voltages were converted to the appropriate parameters. Data were evaluated graphically for quality control. Appendix D shows an example of raw soil temperature data from the 417A and 417B sub-sites.

Precipitation Data

Precipitation data obtained from the USDA—NRCS National Water and Climate Center, Portland, Oregon, were examined for the years 1997 through 2000 (2001 was not available) from Benton, Bethlehem, Grafton, Hanover, and Plymouth, New Hampshire. These stations are in close proximity to or at a similar elevation as the MHP, or both.

Site Information—417 Catena Site

The complex soil morphologies of the 417 catena of the MHP, particularly pedon 417B, created substantial difficulty in the extrapolation of hydric soils determination to the 40-acre parcel. Soils at the MHP are Spodosols and Inceptisols that formed in glacial ablation till (superglacial melt-out and flow tills) over basal melt-out till. The 417 catena was considered to be an excellent representative area to install automated Soil Moisture/Soil Temperature (SMST) monitoring stations. Five SMST stations (A to E) run from A, at the top (summit) of the small hill, to E, which is situated in a very poorly drained area at the bottom (toeslope) of the hill, about 21 meters downslope and roughly 3 meters lower. The five stations simultaneously collected hourly readings of soil temperature (degrees C), soil moisture (via tension, bars), piezometric head levels (cm), and redox potentials (mV). Unfortunately, 417E's electronics malfunctioned and the data was lost. Figure 4 shows the relation of soil morphology to position along the catena. Pedon descriptions for 417A and 417B are in Appendix C. Data from pedons 417A and 417B (see Appendix C) were examined in order to relate soil morphology, hydrology, and growing season.

Site-Specific Maps

In order to compare competing criteria for hydric soil indicators and to address other aforementioned objectives, various maps were independently made for a variety of purposes.

A universal grid of the MHP study site was initially surveyed to establish control points for subsequent work. Control points were marked on the land to form a 100-by-100-foot grid on the 40-acre parcel. The elevations at each grid point and other pertinent areas were surveyed relative to a locally established benchmark datum. A 2-foot contour map (1:1,200) was created using standard survey techniques. The control grid and subsequent maps were digitized into a Geographic Information System (GIS) for comparative analysis. Scientists then delineated areas on the grid map according to criteria for each of the three components used to identify wetlands: hydric soils, hydrophytic plants, and hydrology with excellent ground control. Appendix E shows the maps of the MHP that have been produced. These maps include a contour map, a soil drainage map (created from an order-one site-specific map), two hydric soils maps using the Regional Indicators, two hydric soils maps using the National Indicators, and one map with the boundary of wetland hydrology based on the ACOE 1987 manual. Maps were not amended by professional judgment so that literal definitions could be compared. When mapping with the National Indicators, the scientists were instructed to ignore indicator A10 completely (the requirement of 2 cm of muck within 15 cm of the soil surface). The MHP has organic horizons that are more than 2 cm thick throughout the site; if this indicator was applied, almost the entire 40-acre site would key out as hydric.

Folistic and Histic Epipedon Transects

Field observations at the MHP indicate that surface organic layers commonly are saturated in low areas but not in adjacent uplands and that a folistic/histic boundary might be based on topographic position. Transects were marked out along three drainage catenas to evaluate the physical and chemical differences between folistic and histic epipedons. By definition in "Soil Taxonomy" *(USDA–NRCS, 1999),* folistic epipedons are never saturated, except for a few days after heavy rains or snow melt. Histic epipedons are saturated most of the time. Landscape position may be key in separating folistic epipedons from histic epipedons. Topographic sketches for each transect plus a soil description of each test point and the associated analytical data are tallied in Appendices H and I. The three transects were sampled to a depth of about 30 inches unless sampling was limited by a shallow water table or lithic contact. Five holes were sampled in transect #1 and two holes were sampled in transects #2 and #3. Soil samples were analyzed by the USDA—NRCS National Soil Survey Laboratory for carbon, pH, extractable bases, CEC-7, extractable aluminum, fiber content, pyrophosphate color, total N, total C, C/N, 15-bar water, and iron and aluminum extracted by dithionite-citrate extract, acid oxalate, and pyrophosphate.

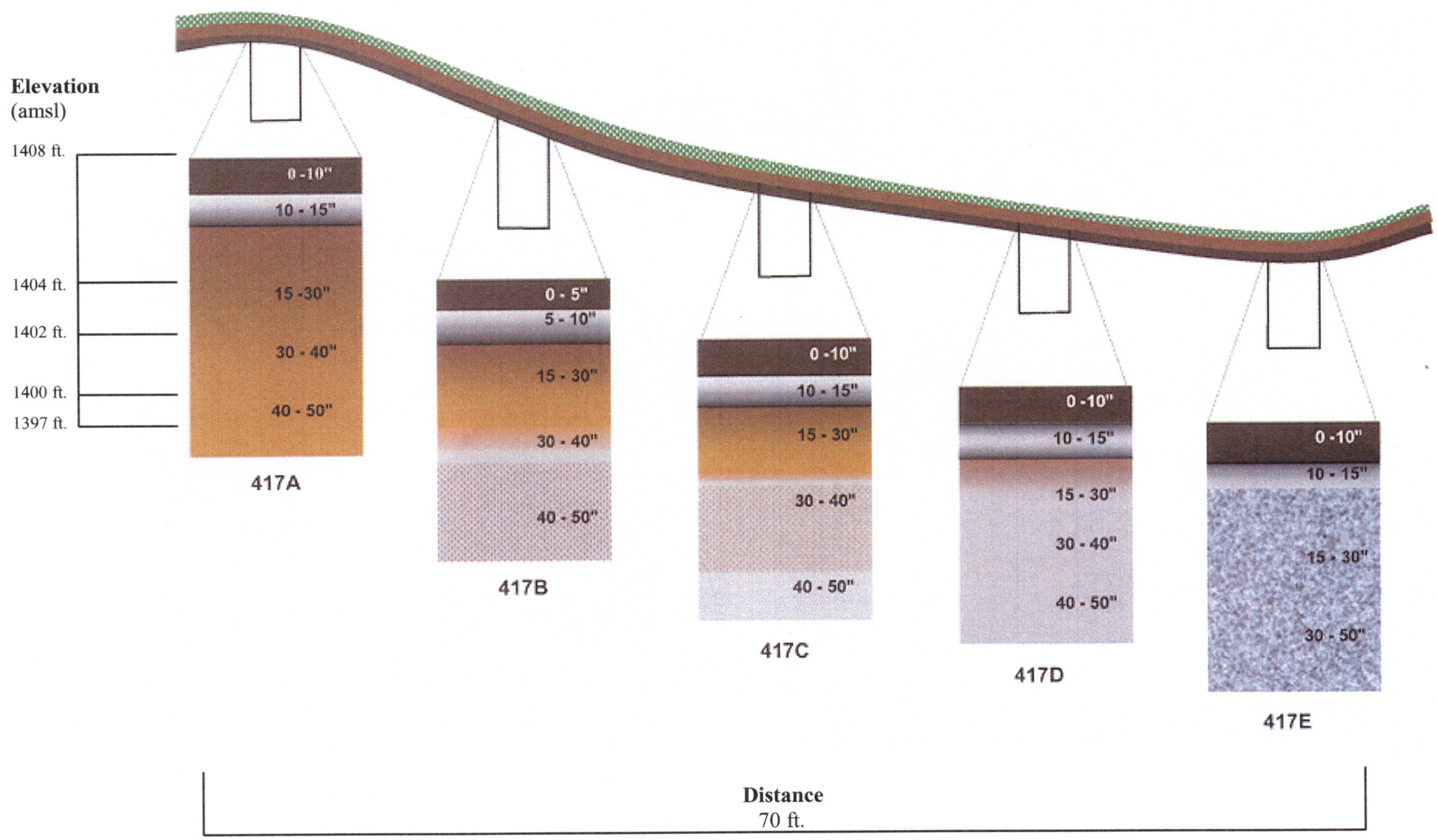


Figure 4.—A representation of the soils along the 417 drainage catena. Pedon 417A strongly expresses spodic development (bright brownish colors underlying a dark O horizon and whitish E horizon). Best expressed at the best drained position, spodic expression weakens along the drainage catena as the profiles become progressively wetter, until it disappears completely at the 417E sub-site. An actual site picture can be seen on the front cover of this document.

Results and Discussion

Growing Season and Bud Score Comparison

The criteria to meet wetland hydrology during the growing season must be met in most years (6 out of 10) *(US–ACOE, 1987)*. There are few, if any, locations in New England where the onset of vegetative growth and length of the growing season have been documented for a period of 10 years. The intent is to extend data collection at the monitoring stations for at least 10 years in order to document the growing season. Results of the first 5 years of data collection at the MHP are presented in table 2.

In the first spring, when soil temperature at 50 cm at the poorly drained site had reached 5 degrees C (biological zero), most of the overstory vegetation had leafed out, ferns were already unfurled, and the Trillium was flowering. The actual start of the growing season had begun several weeks prior to 5 degrees C. Coultais (1997) noted, in his study in Cheshire County, New Hampshire, that the buds of many wetland shrubs showed obvious swelling and growth at least 2 weeks before growing season began.

Researchers in Alaska have also noted that growing season based on 5 degrees C does not fit in subarctic environments. They observed vegetative growth in spring well before biological zero was reached and the seasonal frost was only a few centimeters below the surface *(Ping et al., 2001)*.

The traditional approach to determine the onset of the growing season is to determine the calendar date at which the soil temperature (at a specific depth) reaches a specific temperature.

An alternative approach was applied in this study. Instead of soil temperature, a method for rating the extent of bud swelling was applied.

The objectives of this portion of the study were to: 1) compare a bud score of 1 with the temperature inversion between 15 and 50 cm (i.e., when the temperature at a depth of 15 cm becomes warmer than that at a depth of 50 cm); 2) compare a bud score of 1 with soil temperature at a depth of 23 cm; and 3) test for an indicator plant that would have a bud score of 1 at the beginning of the MHP growing season.

Soil temperature and bud score data from 1997 to 2001 were compiled and analyzed from the hydric soil sites only. Comparison of growing season to bud scores suggests that there is a definite time lag between when the site averages have

Table 2.—Annual calendar day that bud score reached 1, the average calendar day when soil temperature at 50 cm reached 5 degrees C, and the time span between biological zero and a bud score of 1 (at the hydric soil sites).

YEAR	DAY WHEN AVERAGE BUD SCORE REACHED 1	DAY WHEN SOIL TEMPERATURE REACHED BIOLOGICAL ZERO AT 50 cm	TIME SPAN BETWEEN BIOLOGICAL ZERO AND BUD SCORE (DAYS)
1997	120	144	24
1998	106	123	17
1999	108	130	22
2000	116	127	11
2001	123	128	5

Figure 5.—Examples of bud scores for hobblebush. In the upper illustration the bud score is 2, and in the lower one the bud score is 3. Note that the data were collected on the same day.

reached a bud score of 1 (vegetation is starting to emerge and expand) and when the soil temperature at a depth of 50 cm has reached biological zero (5 degrees C). Table 2 represents the average dates when soil temperature at a depth of 50 cm reached 5 degrees and the dates that the average bud scores of the hydric soil sites reached 1. Figure 5 shows examples of bud scores measured in the field.

Table 3 presents bud scores and additional soil temperatures taken from various poorly drained and somewhat poorly drained sites (SCAN and SMST) and snow melt data. Additional temperature data include dates when biological zero was met at the site at depths of 15, 30, and 23 cm.

Temperature inversion (between shallow and deeper depths—the soil temperature at a depth of 15 cm becomes warmer than the soil temperature at a depth of 50 cm)

Table 3.—Annual calendar day when bud score = 1, annual calendar day when biological zero (5 °C) occurred at varying depths, and annual calendar day of temperature inversion. Soil temperature data were taken from hydric soil sites and automated sites with hydric soils (SCAN and SMST).

Hydric sites only	Bud score = 1	5 °C at 15 cm	5 °C at 30 cm	5 °C at 23 cm	5 °C at 50 cm	Temperature inversion at 15 cm and at 50 cm	Approx. date of snow melt
1997	120	136	----	----	144	114	-----
1998	106	109	120	121	122	100	106
		106	121	121	113	105	
		106			121	101	
		120			124	104	
1999	108	120			123	98	109
		112	114	115	121	100	
				113	115		
2000	116	124	127	128	140	120	109
		126		128			
2001	123	126	128	128	120	122	122
				122	135		
Average	114.6	118.5	122	122	125.3	107.1	111.5

was thought to be an indicator for bud scores. By comparing the average date of a bud score of 1 and the average temperature inversion date (table 3), a trend between the two (day 114.6 vs. day 107.1) does not exist. Another objective was to test a bud score of 1 and the 23 cm depth temperatures and dates. There is also not a correlation between the two, although in 1999, the days that the depth reached biological zero came very close to the days that the bud score (over 5 years average) was at 1. Further evaluation of table 3 shows that the closest field indicators that may predict a bud score of 1 (the beginning of the growing season) are the soil temperature at a depth of 15 cm and the date of snow removal (averages: day 114.6 vs. days 118.5 and 111.5). One objective of this study was to observe the bud score data for a total of 10 years. Additional data may provide a strong indicator for the onset of the growing season.

Another challenge of this growing season study was to identify a plant that would indicate when a site has reached biological zero (bud score of 1). All the plants at or near bud score of 1 when the site average had reached a bud score of 1 were further examined.

Yellow birch shows promise as an indicator plant. It emerges consistently as reaching a bud score of 1, either on, immediately before, or directly after hydric soil sites have reached an average bud score of 1 (Appendix G). Yellow birch occurs in the shrub layer at the MHP and can be easily found in the forest. Future research at the MHP should look closely at the yellow birch shrub.

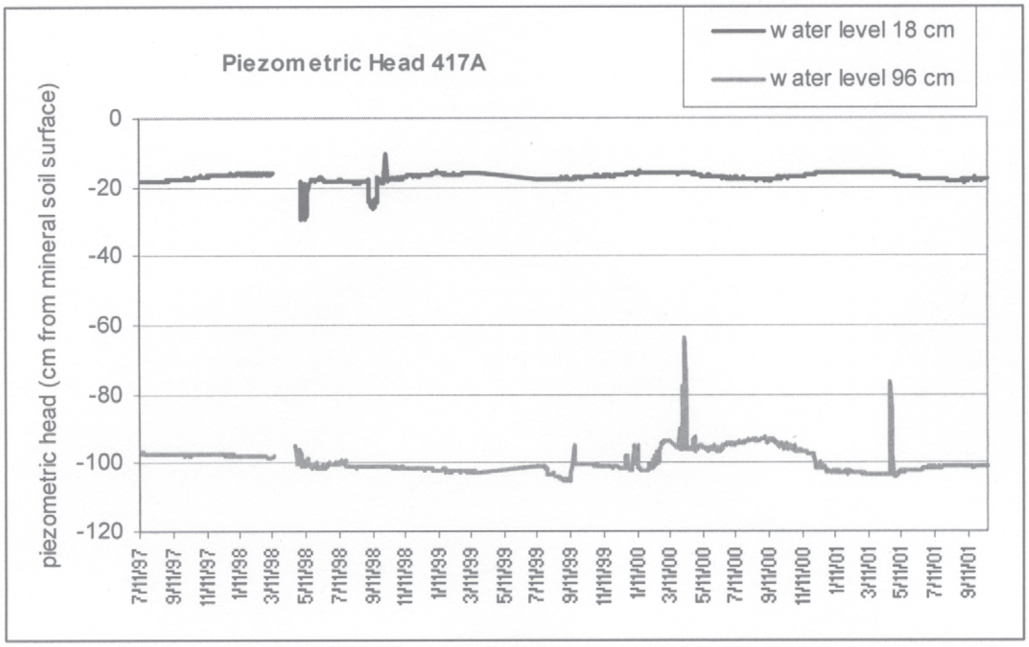


Figure 6.—Piezometric heads at NH3A (417A sub-site). The water level at a depth of 18 cm represents the top of ortstein. Flat lines in the data represent dry pipes.

Precipitation Data

Precipitation data were examined for the years 1997 through 2000 (2001 was not available). It was determined that the average of all the years were within about 10 percent of the 25- or 30-year average annual rainfall for each site. All sites had precipitation amounts that exceeded the 25- or 30-year average in some years.

Soil Moisture/Soil Temperature Catena 417

Data from the catena of 417A and 417B were examined to relate soil morphology, hydrology, and growing season. Water levels measured via piezometric head, soil temperature data, and soil moisture data were used for pedons 417A (top of hill, moderately well drained) and 417B (about 50 cm lower) (see figure 4) and were compared with US—ACOE wetland regulations and growing season requirements. Pedon 417A is not considered a hydric soil, and pedon 417B is considered a marginally hydric soil or a hydric soil. In fact, the catena study was placed at this site due to the inability of high-level soil scientists to agree about the hydric status of pedon 417B.

Pedon 417A.—The piezometric head data (fig. 6) and the soil moisture tension data (fig. 7) suggest that there is minimal free water at or near the surface. It should be noted that the soil moisture probes (Campbell 253L soil moisture probes) are considered to be not very accurate or precise at the wet end of the soil moisture spectrum *(W. Lynn, personal correspondence)*. Therefore, the readings that are shown to be saturated by the sensors are considered to be “approaching saturation” by the authors. The lack of water at pedon 417A is further defended by the lack of redoximorphic features described.

Ortstein has been considered a type of redoximorphic feature, and it has been suggested that the existence of an ortstein layer might be an indicator of a water table

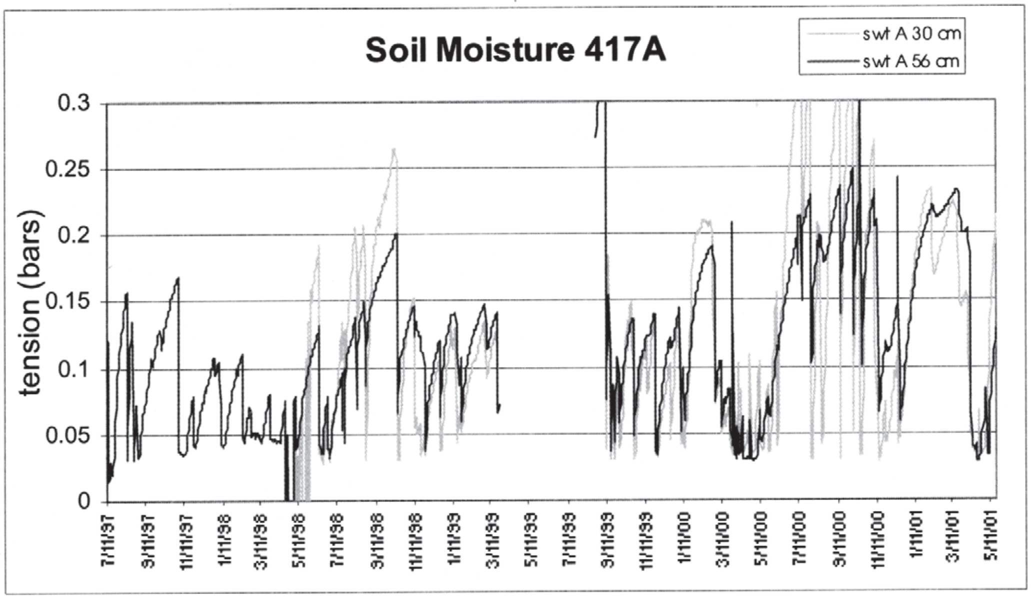


Figure 7.—Soil moisture tension at sub-site 417A. Sensors are at 30 cm and 56 cm below the mineral soil surface. Saturation occurs between 0 and 0.1 *(Campbell Scientific, Inc., 1993)*. The soil becomes drier as the tension increases.

(Pilgrim, 2000). The ortstein layer found at pedon 417A may coincide more with wetting and drying cycles (particularly if the soil periodically reaches very dry conditions that promote internal packing of iron oxide) rather than water in the soil (swt A 30 cm; fig. 7). The wetting and drying cycles occur during the growing season/warmer months of the year due to the coexistence of rainfall and evapotranspiration. The proximity of the 30-cm-deep moisture block to the soil surface is the reason that the fluctuations occur more often and stronger in the shallower moisture block as compared to the 56-cm-deep block. During spring melt, the 56-cm-deep probe remains wetter longer and is less affected by the evaporation and transpiration processes (fig. 7).

The U.S. Army Corps of Engineers *(US–ACOE, 1987)* state that although hydrology is the least exact parameter for wetland determination, it is essential that a wetland is periodically inundated or has saturated soils (pressure greater than that of the atmosphere) during the growing season. According to the US–ACOE (1987), an area has wetland hydrology if it is inundated or saturated to the surface (mineral soil surface was considered in this paper) continually for at least 5 percent of the growing season in most years (a 50 percent probability of recurrence). The soil moisture readings at pedon 417A do not approach zero (bar) value for tension, thus it is not saturated (fig. 7). It is obvious that there is not free water at or near the mineral surface at this sub-site (figs. 6 and 7), and it can be concluded that this sub-site is not hydric. It is unfortunate that the depth moisture block placed at the top of the mineral soil surface is not currently working at this sub-site since these data are essential in studying the soil morphology, particularly the ortstein layer at pedon 417A in terms of soil moisture amounts and seasonal cycles.

Pedon 417B.—This pedon is considered a marginally hydric soil or a hydric soil. The piezometric head and the growing season become very important tools in the determination of hydric soils for this pedon. Figure 8 shows piezometric head and soil temperature at a depth of 50 cm. The water levels at pedon 417B reflect relatively short, widely spaced, sporadic spurts of piezometric head above a depth of 23 cm (light blue, fig. 8) and common occurrence of piezometric head above a depth of

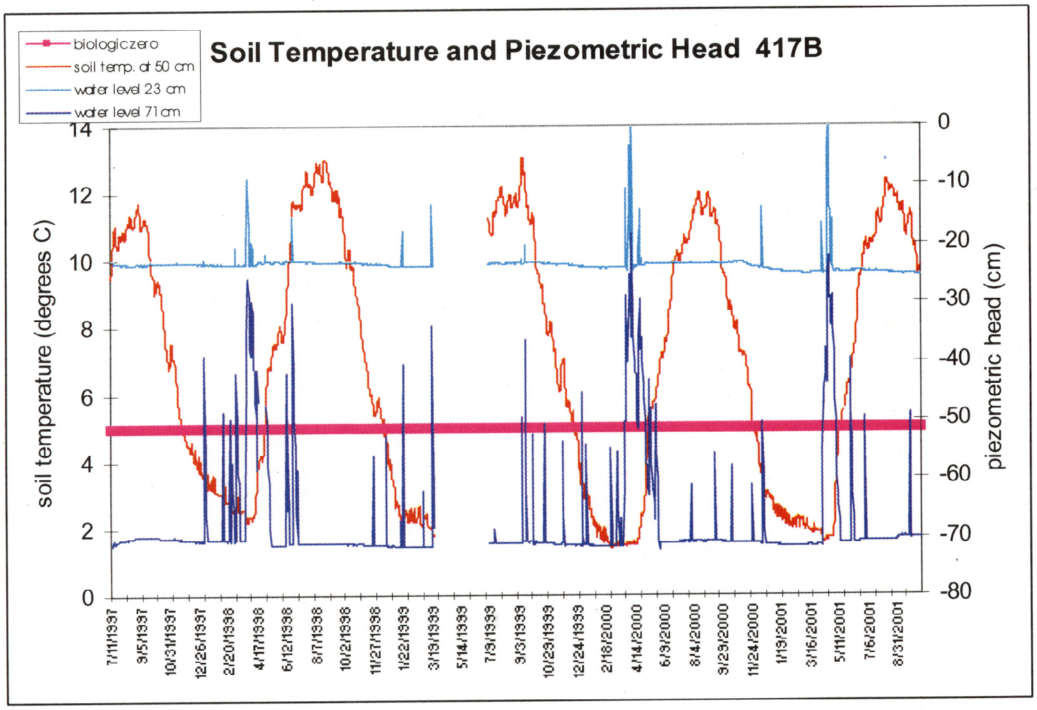


Figure 8.—Soil temperature at a depth of 50 cm, and piezometric head at pedon 417B. Piezometric head measurement at a depth of 23 cm reflects the top of the ortstein. Flat lines represent dry pipes in the piezometric head data.

71 cm (dark blue, fig. 8). The occurrence of water in the 23 cm pipe may result from the pipe being placed on top of an ortstein layer/horizon (Bhsm, 23–41 cm). The reason for this pipe placement was to check for a perching effect due to the ortstein horizon. Figure 8 suggests that there is perching on the ortstein as the water levels in the deeper pipe do not commonly rise above the ortstein layer.

Piezometric head is within 30 cm of the mineral soil surface quite commonly in the 23 cm pipe: 8 days in 1998; 3 days in 1999 (equipment damage); 11 days in 2000; and 10 days in 2001 (only twice temperature was more than 5 degrees C). The recorded piezometric head exists primarily during spring snow melt. The 71 cm pipe also has piezometric head recorded in the pipe within 30 cm of the mineral soil surface primarily during spring snow melt: 7 days in 1998; 7 days in 2000; and 8 days in 2001 (both water level and soil temperature data were lost at this pipe in 1999). With these data, it seems that determining pedon 417B as hydric due to the piezometric head in the pipes would be easy. However, according to the US–ACOE, the growing season must be taken into account. The piezometric head is not perching on frozen soils as the soil temperatures do not go below 0 degrees C for more than a couple of days in the coldest months at the depths monitored.

Growing season and water levels at pedons 417A and 417B.—The growing season at the MHP has been determined to be May 4th through October 10th *(US–ACOE, 1987)* (USDA–NRCS NWCC, Appendix F). The actual growing season data (via soil temperature measured at pedon 417B) show that the season runs much longer than expected for the area (May 9th through December 6th). The actual growing season is two months longer than the calculated growing season (28 degrees F thresholds at a frequency of 5 years in 10) with the extended time occurring in fall.

To be hydric, according to the national criteria, a soil must have the water table within the upper part (i.e., in the upper 30 cm) during 5 percent of the growing season,

Table 4.—Comparison of growing seasons and water levels (measured from the mineral soil surface).

Pedon	MHP growing season (from NWCC air temperature data)	Growing season at pedon (50 cm depth)	Average number of days water is within a depth of 30 cm 1998-2001	Average number of days water is within a depth of 30 cm during Grafton Co. GS* 1998-2001	Average number of days water is within a depth of 30 cm during site GS* 1998-2001
417A	May 4 – Oct. 10	May 9 – Dec. 11	0	0	0
417B	May 4 – Oct. 10	May 9 – Dec. 6	23 cm pipe: 8 71 cm pipe: 7	23 cm pipe: <1 71 cm pipe: <1	23 cm pipe: <1 71 cm pipe: <1

* GS = growing season

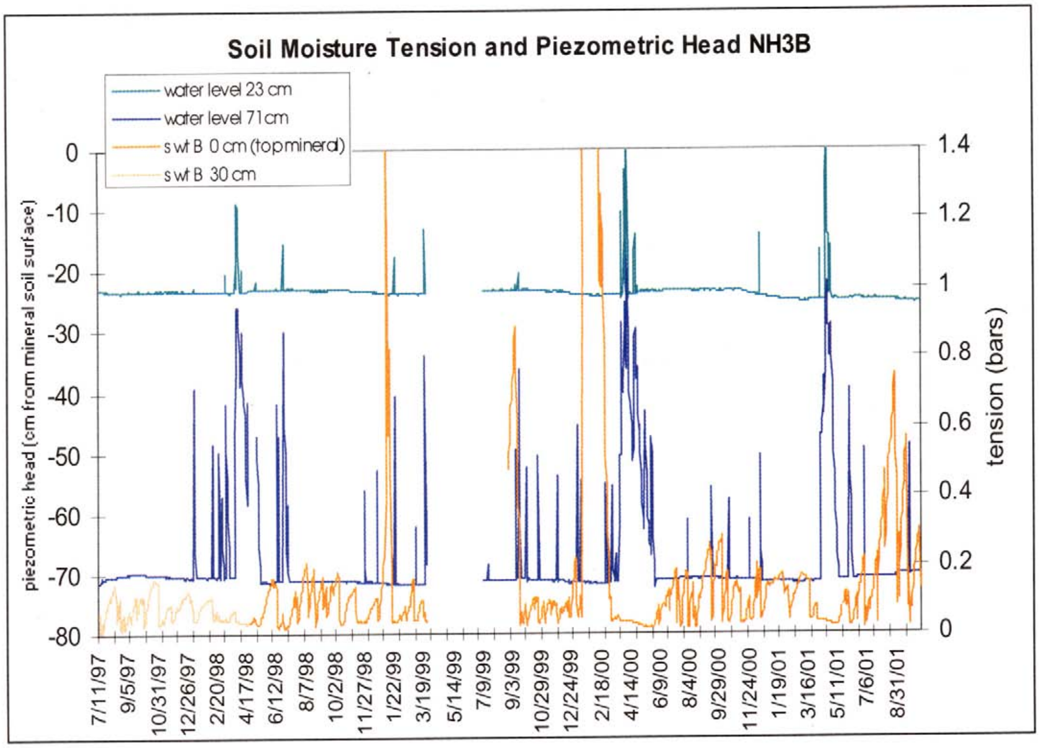


Figure 9.—Soil water tension and piezometric head at NH3, sub-site B. Saturation approached between 0.0 and 0.1 bar, and the soil is adequately wet from 0.1 to 0.2 bar.

or 8 days in Grafton County. There are a few instances in the data set of pedon 417B where there are 8 days of piezometric head within a depth of 30 cm from the mineral soil surface, but not after May 4th (the start of the growing season). Table 4 presents a comparison of growing season data and piezometric head for both pedons 417A and 417B. In addition, the occurrence of the water table within the upper part of pedon 417B during the actual pedon growing season based on the soil temperature readings at the site (at 50 cm depth — the red sinuous line in figure 8) are very minimal. The 71 cm pipe had water within 50 cm of the mineral soil surface in it for 1 day, and the 23 cm pipe had it for 2 days.

Figure 9 shows both the 30-cm and the 0-cm depth soil moisture readings at pedon 417B that coincide primarily with the top and bottom of an ortstein layer—the Bhsm and Bsm horizons. These readings often oscillate between (approaching) saturated soils to adequately wet soils *(Campbell Scientific, Inc., 1993)*. Partial readings (due to animal damage) at both depths prevented examination of a complete data set.

Generally, the soil moisture readings approach zero (saturation) and remain near zero during the spring melt season. Additionally, soil moisture readings also show a trend toward saturation during times when the piezometers are dry. The moisture block readings may indicate water during spring but also suggest soil moisture from precipitation during the dry seasons. Evapotranspiration may be the main cause of moisture loss during the dry season as opposed to percolation. It is unfortunate that the deeper moisture blocks that are in place (30 cm and 71 cm depths) are not working; additional moisture data at these deeper depths may increase the ability to interpret soil morphology. The deeper (71 cm) block may show that saturation occurs due to capillary rise or percolation or that a stronger wetting and drying cycle may be the cause of an ortstein layer. Data from the deeper portion of the pedon may show that ortstein is an indicator of a water table.

To better understand the wetness conditions of the soils, water table data interpretation for pedon 417C (the next pedon down in the catena) is warranted. These data would be very helpful in determining if this pedon also has its water table within 30 cm of the mineral soil surface during the growing season or just previous to the growing season (as in pedon 417B).

Growing season criterion based on 5 degrees C used for wetland delineation (hydric soils and hydrology) requires further investigation. The US–ACOE (1987) states, "areas of evident characteristics of wetland hydrology are those where the presence of water has an overriding influence on characteristics of vegetation and soils due to anaerobic and reducing conditions, respectively." The resulting evidence is the formation of redoximorphic features. The line of thought is that redoximorphic features only form during the growing season. Yet researchers have noted that redoximorphic features are characteristic of most of the soils affected by ice-cemented permafrost *(Ping et al., 2001)*. Furthermore, the history of the concept of biological zero stems from the U.S. Fish and Wildlife Service *(Cowardin et al., 1979)* and this concept was used specifically for disturbed sites. Disturbed sites would not have typical redoximorphic features or hydric plants available for determining whether a soil is hydric or not. Many sites do have redoximorphic features as a result of saturation, and the US–ACOE (1987) requirements work well. But many others areas, such as the MHP, do not. The pedon 417B monitoring station has a seasonal water table near the surface prior to the "official" growing season (fig. 8). Additionally, redoximorphic features in the E and Bs or Bhs/Bsh horizons are similar to and commonly coincide with features of podzolization. Table 5 presents a summary of information from pedons 417A and 417B stations and their hydric determinations.

Site-Specific Maps

In 1996, the first set of site-specific maps was developed with version 1 of the Regional Indicators *(New England HSTC, 1995)* and version 2.1 of the National Indicators *(USDA–NRCS, 1996b)* (fig. 10a and 10b). The goal was to compare these maps with local hydrology and resolve the issues that caused the differences.

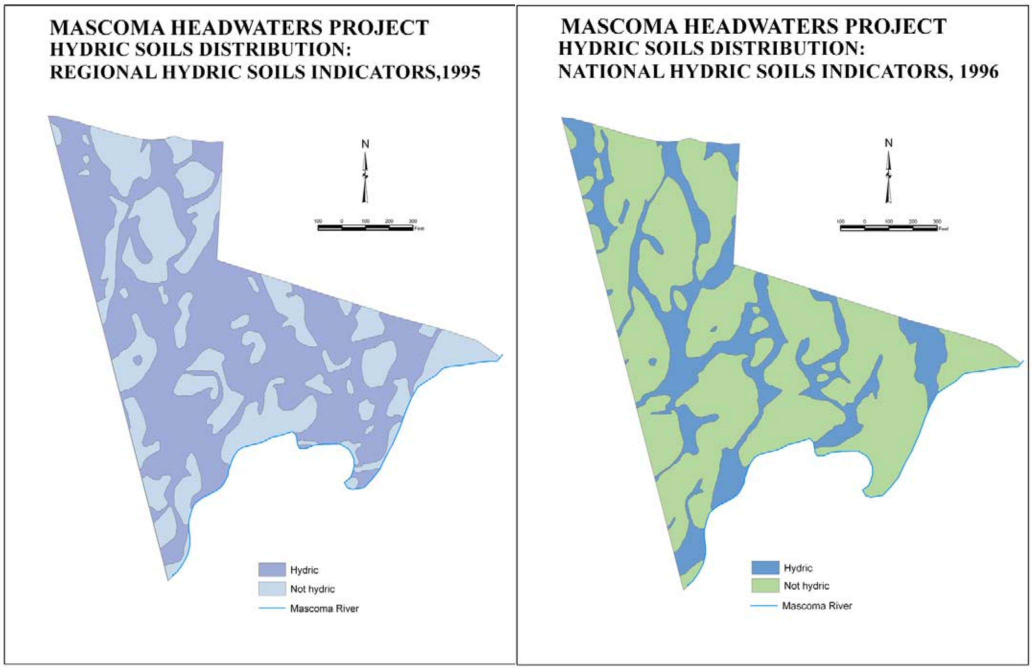
The acreage of hydric soils was independently determined using two different sets of criteria at the MHP: 1) the 1996 National Indicators and 2) the 1995 Regional Indicators (60 percent vs. 28 percent; see table 6). This substantial disparity resulted in recommendations for the revision of both manuals. A key recommendation to the Regional Indicators was to change the depth requirement for redoximorphic features below the spodic horizon. The 1995 version keyed out a Spodosol as hydric if a spodic horizon was directly underlain by a horizon with 5 percent or more redoximorphic features. This situation proved to be a problem because 5 percent redoximorphic features could be located in the bottom of the horizon directly below the spodic horizon. Even though the soil is not hydric, it keys out as being hydric. Requirements were changed *(New England HSTC, 1998)* so that if the spodic horizon is directly underlain by a horizon with 5 percent or more redoximorphic features, the features must be in the upper part. Another problem in this situation is that, because oxidized iron colors (Bs horizon) are normal in podzolization, only gray colors from reduction are clear evidence of redoximorphic features in these Spodosols but both reduced and oxidized features are considered. The observer must pay close attention to the oxidized features in these Spodosols when determining redoximorphic features.

Another important recommendation to the 1998 Regional Indicators was that a gleyed matrix (due to iron reduction) or redoximorphic features directly below a histic

Table 5.—Summary: Pedons 417A and 417B and hydric determinations

Pedon	Water table within 30 cm of mineral soil surface	Growing season (NWCC data)	Growing season (sub-site)	Redoximorphic features	Soil moisture	Hydric indicators – New England	Hydric indicators – National	ACOE wetland hydrology
417A	Minimal free water	May 4 – Oct 10 5% = 8 days	May 9 – Dec 11 5% = 11 days	None	Soil saturation approached at A30 and A56 often (30 cm and 256 cm below mineral soil surface)	Not hydric	Not hydric*	Not hydric (0 days during growing season)
417B	23 cm pipe: 8 days (avg.) 71 cm pipe: 7 days (avg.)	May 4 – Oct 10 5% = 8 days	May 9 – Dec 6 5% = 11 days	Described in Bsm starting at 48 cm (33 cm from mineral surface)	B 0 (mineral soil surface) shows high oscillation of approached saturation and adequately wet soils during dry times; saturation during spring snow melt	Hydric	Not hydric*	Not hydric (23 cm pipe: <1 day average during growing season) (71 cm pipe: <1 day average during growing season)

* Assumption: The A10 muck indicator is ignored due to Oa (folistic epipedon) recognition throughout the Mascoma site



10a 10b.

Figure 10a and 10b.—Hydric and not hydric soils mapped according to the Regional (version 1) and National (version 2.1) Indicators. (Enlargements of these maps are in Appendix E.)

epipedon should be required. This revision provided new differentia between folistic and histic epipedons. (Note: These organic layer subtypes had previously been treated the same.) In addition, the National Indicators addressed the same histic/folistic epipedon problem by requiring 2 cm of structureless muck present (Oa horizon) and noting landscape position. Figure 11 shows the key changes made to the National and Regional Indicators after testing the earlier manuals at the MHP. These recommendations are a very good step in the right direction for testing the differences between histic and folistic epipedons, but an easier field indicator is needed at the MHP because of the Spodosol morphologies.

Another site-specific map was created using the hydrology requirements in the US–ACOE 1987 manual and then compared to the maps made with the National and Regional manuals (Appendix E). Hydrology was determined at the MHP by observing free water at 30 cm below the mineral soil surface (unless in a Histosol) 14 days after the soil temperature reached 5 degrees C at a depth of 50 cm. The four assessment techniques suggest a remarkable disparity in the estimate of wetlands at the MHP (table 6). When comparing the four methods (table 6), the National and the ACOE maps were similar (28 percent vs. 23 percent) yet different from the Regional (60 percent hydric soils) and hydrophytic plant communities (94 percent). The hydrophytic

Table 6.—Percent of wetland in MHP by each of the listed assessment procedures.

Regional Indicators 1995	National Indicators 1996	ACOE manual Wetland Hydrology (1987)	Hydrophytic plant community
60	28	23	94

Regional Indicators of Hydric Soils Revised

Version 1 - 1995	Version 2.0 - 1998
III.E.2:	**III. F.2:**
Within 12 inches of the top of the mineral soil material, the Spodic horizon has a dark Bh or Bhs horizon 2 inches or greater in thickness, and is directly underlain by a horizon with 5 percent or more redoximorphic features; or	Beginning within 10 inches of the top of the mineral soil surface and directly underlying a dark A horizon and/or a shallow E horizon, (if neither is present, an O horizon), there is a dark Bh and/or Bhs horizon that is greater than 2 inches thick that is directly underlain by a horizon with 5 percent or more redoximorphic features **in the upper part**; or

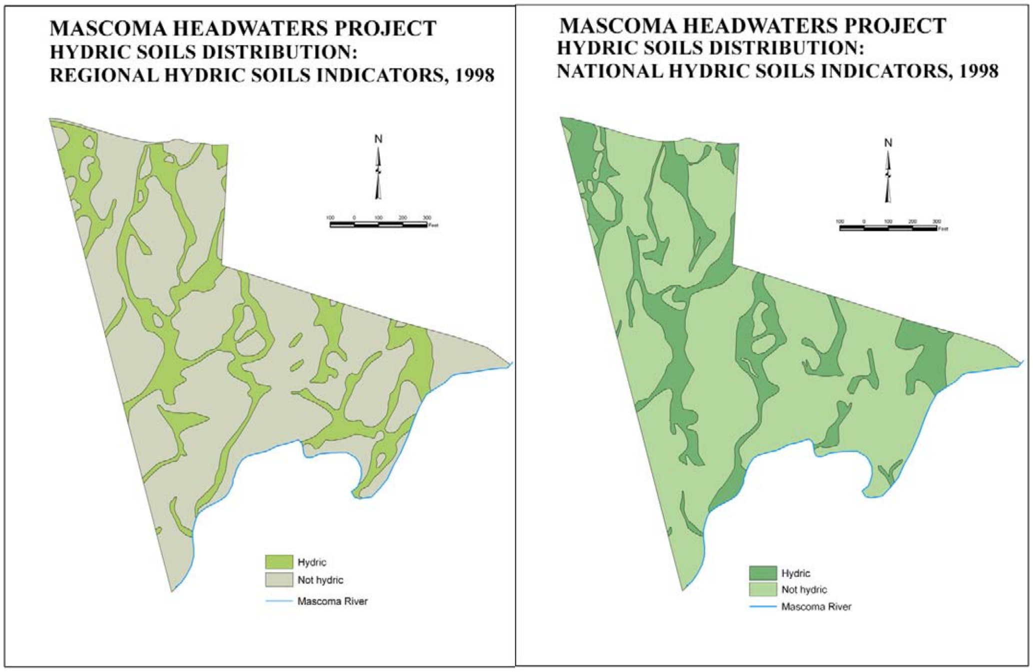
Regional Indicators of Hydric Soils Revised

Version 1 - 1995	Version 2.0 - 1998
III.B:	**III. B:**
Have organic soil materials at or near the soil surface that are 8 to 16 inches thick (i.e., histic epipedon); or	Have a layer of organic soil materials at or near the soil surface that is 8 to 16 inches thick (I. e., histic epipedon); and directly underlying the O horizon or, if present, the A horizon, **have a depleted or gleyed matrix and/or other redoximorphic features; or**

National Indicators of Hydric Soils Revised

Version 2.1 - 1996	Version 4.0 - 1998
A10. 2 cm Muck	TA2. Structureless Muck
(For testing in Region R)	(For testing in MLRAs 141, 143, 144b, 145 and 146 of Region R)
A layer of muck 2 cm (0.75 in) or more thick with a value of 3 or less and chroma 1 or less starting within 15 cm (5 in.) of the soil surface.	Starting within 15 cm (6 in.) of the soil surface on concave positions or in depressions, a layer of muck 2 cm (0.75 in.) or more thick that has no soil structure.
(Not used during 1996 Mascoma mapping due to false positive in NH)	

Figure 11.—Changes made to the Regional and National Indicators after 1996 field testing at the MHP.



12a. 12 b.

Figure 12a and 12b.—Hydric and not hydric soils mapped according to the Regional (version 2.0) and National (version 4.0) Indicators (both 1998). (Enlargements of these maps are in Appendix E.)

plant communities map includes the tree black spruce as a wetland indicator and may require further investigation (Appendix E).

A second set of site-specific hydric soil maps were made after the recommendations were accepted by both the Regional Committee *(New England HSTC, 1998)* and the National Committee *(USDA–NRCS, 1998)*. The resulting maps (fig. 12a and 12b) appear to have a similar percentage of hydric soils (table 7), and are close to the US–ACOE estimate (table 6). Also, the resulting acreage amounts are similar to the US–ACOE hydrology (23 acres). The large disparity between these results and the estimate by hydrophytic plant community remain to be resolved. Currently in the Northeast, the Regional Indicators are used as an appendage to the National Indicators, especially for the challenging Spodosols in the frigid temperature regime of northern New Hampshire.

Table 7.—Percent of site having hydric soils as a result of indicator manual revisions.

Hydric Indicator Manual	1995 and 1996 manuals	1998 manual
Regional	60	25
National	28	24

Table 8.— pH of histic and folistic horizons in H_2O

Histic	Folistic
5.6	3.2
5.8	3.3
6.4	3.1
4.4	3.3
4.6	3.8
5.1	2.9
6.1	
4.3	
4.6	

Transects for Folistic and Histic Epipedons

The organic horizon morphologies at the MHP are very problematic. Almost all pedons at the MHP site have an Oe horizon as much as 8 cm thick underlain by an Oa horizon of varying thickness. This layered organic feature (an Oe horizon over an Oa horizon) is consistent in upland as well as wetland settings and its total thickness may range from 3 to 20 cm or, in some areas, can exceed 25 cm. Usually, any soil with 20 to 25 cm of “muck” (an Oa horizon) over it is automatically considered hydric. The National Hydric Soil Committee considers “muck” to be synonymous with the term “sapric material.” At the MHP, sapric material is found in both upland and wetland areas throughout the 40-acre parcel. This situation creates a challenge for soil scientists using the A10 muck indicator for hydric soil determinations. This challenge especially occurs when examining the complex Spodosol morphologies.

A better field indicator of “muck” needs to be developed due to the substantial extent and intermingling of folistic and histic epipedons in northern New England and other parts of the country, such as Alaska. D’Amore and Lynn (2002) noted that Saprists and Hemists were difficult to distinguish in the field. A rationale that may separate them in stagnant water situations does not work in the steeply sloping terrain of southeast Alaska. The boundary between folistic and histic epipedons is difficult to find on the gently sloping terrain of the MHP.

The intention of this portion of the study was to find a field indicator that could differentiate histic and folistic epipedons. The results of the three transects were analyzed. Appendices H and I contains the field and laboratory results. One field test that may differentiate histic from folistic epipedons is the simple test of pH in water *(USDA–NRCS, 1996b)*. Table 8 presents the pH data from the three transects. F test results show a significant difference between folistic and histic epipedons (F test; $p \leq .05$, $n = 16$). These tests will be applied on additional transects in the future.

Summary

The Mascoma Headwaters Project was established in order to document defensible, practical criteria for identifying and delineating wetland boundaries in frigid soils of northern New Hampshire and to test and refine both the National and the New England Regional Field Indicators of hydric soils. Many theories and techniques were and are being applied for various hydric soil-related studies.

Growing Season and Bud Score Comparison

Growing season is an important variable in the determination of soil hydrology and hydric soils. At the MHP, a time lag between vegetative emergence and biological zero was noted. This time lag was examined and compared in terms of soil temperatures and bud scores. The soil temperature at a depth of 15 cm and the date of snow melt appeared to be good indicators for the onset of growing season, based on a bud score of 1 at the hydric soil sites, and will be examined further as data are collected to finish the 10-year study. The initial assumption about bud score and growing season was that the day when soil temperatures between depths of 15 and 51 cm or between depths of 15 and 23 cm became inverted would indicate the start of the growing season. These two hypotheses were proven to be incorrect.

An indicator plant may be used to indicate the start of the growing season, based on a bud score of 1, at the MHP. Pin cherry seemed to be the best foliage indicator for start of the growing season but was proved not to be. Yellow birch emerged consistently to reach a bud score close to the time that all the vegetative plots averaged a bud score of 1. Yellow birch occurs in the shrub layer at the MHP and can be easily found in the forest. After a few more years of this study, the use of yellow birch as an indicator of the beginning of the growing season in areas of hydric soils may prove applicable throughout northern New Hampshire. Southeast Alaska certainly has a different climate and vegetation than New Hampshire. It would be a good venue to test the validity of the bud score technique.

Soil Moisture/Soil Temperature and Soil Morphology—Catena 417

Data from pedons 417A and 417B of the 417 catena were used to relate soil morphology, hydrology, and growing season. Pedon 417A had characteristic spodic morphology (Oe-Oa-E-Bh-Bsm-Bs1-Bs2) without any affect from a water table. The piezometers were predominantly dry (fig. 6). Soil moisture readings show that the ortstein layer coincides with a strong wetting and drying cycle. Pedon 417B conditions challenged the inference of water table depth from soil morphological features because the pedon also had characteristic spodic morphology (Oa-E-Bh-Bhsm-Bsm-BS-C1-C2-C3) in combination with a water table. Redoximorphic features may be masked or overridden by podzolization processes. Free water occurred sporadically in the shallow piezometer, placed on the ortstein and commonly in the deeper piezometer. The free water increased primarily during snow melt, prior to the “regulated” growing season. The combined soil moisture readings approached saturation near the surface during the spring snow melt. They also suggested higher moisture amounts from precipitation during drier seasons; this moisture may be lost through evapotranspiration as opposed to percolation.

Hydrology and Growing Season—Pedons 417A and 417B

Pedons 417A and 417B do not exhibit wetland hydrology according to US–ACOE (1987) requirements. Pedon 417A lacks piezometric head in its piezometers. Pedon 417B does exhibit piezometric head near the surface for an average of 8 days in the shallow pipe and 7 days in the deeper pipe during the snow melt season but not during the growing season designated by the US–ACOE.

Site-Specific Maps

Site-specific maps for the MHP 40-acre parcel were made first with the 1995 Regional Indicators and the 1996 National Indicators of hydric soils for onsite testing purposes. The large disparity in hydric soils between the two, 60 percent National and 28 percent Regional, led to the recommendation that both manuals be revised. As a result, the manuals of 1998 Regional and National Indicators have site-specific maps with similar amounts of hydric soils (25 percent vs. 24 percent), which are close to the US–ACOE hydrology (1987) estimate of 23 percent. This study provided sound factual data which assisted the compromise between Regional and National Hydric Soil Indicators and their respective manuals. Key recommendations were to change the depth of redoximorphic features to just below the spodic horizon and to require a gleyed matrix or redoximorphic features directly below a histic epipedon in the Regional Indicators. The National Indicators committee took the A10 muck indicator into consideration. The National Indicators now require “structureless” muck and the record of a landscape position (concave positions or depressions).

The study showed that the vegetative map was highly dependent on one softwood tree. The tree black spruce (a hydric indicator) needs further investigation because it may have hybridized with red spruce (a non-hydric indicator). An investigation may bring the hydrophytic plant community more in line with other site-specific maps.

Folistic and Histic Epipedons

Muck has created a challenge for soil scientists as an indicator of hydric soils at the MHP. The National Indicator A10 (muck) had to be ignored when the site-specific maps were made because the whole 40-acre parcel would have keyed out as hydric. Muck is present at both dry and wet sites as a folistic epipedon and a histic epipedon, respectively. Three transects were analyzed to find a field indicator to differentiate a histic epipedon from a folistic epipedon. The simple test of pH in water between an extremely acid folistic epipedon and a slightly acid to strongly acid histic epipedon is both intuitively and statistically different and should be used more widely. The National Indicator A10 needs further study, and the term “structureless muck” requires a better field definition in northern New Hampshire and other areas of Region R. Muck is a mineral soil with elevated organic matter but does not qualify for organic soil materials or histic/folistic epipedons. Muck is common in wet environments in thermic or hyperthermic soil temperature regimes but not in frigid soil temperature regimes.

Suggested Further Study

Many questions that require further investigations arose during this study. A few of the most important needed investigations are listed below (but not necessarily in order of importance).

1) Study the acreage difference between the hydrology maps based on the US–ACOE (1987) growing season and a growing season based on a bud score of 1.

2) Test both the hydric and upland areas used in the bud score method separately and compare results.
3) Focus on a few selected herbs and shrubs (especially yellow birch) as indicators of growing season on upland and wetland (hydric) sites and extend this study to southern New Hampshire in order to test its validity.
4) Include redoximorphic potential data trends in the 417 site soil morphology portion of the study. This additional data will back up the existing data and may help to decipher the overriding processes of spodic development in Spodosols. Problems with instruments freezing during the spring melt need to be overcome.
5) Include water table levels of pedon 417C in order to study the soil morphologies and water table influence in the 417 catena. This study will help to decipher soil morphologies due to podzolization as opposed to the effects of water tables along the drainage catena.
6) Because podzolization is further complicated by water tables, examine ortstein layers at the 417 catena in terms of iron chemistry, piezometric head, and redoximorphic potentials.
7) Further investigate the tree black spruce (a hydric indicator) because it may have hybridized with red spruce (a non-hydric indicator). This investigation may bring the hydrophytic plant community more in line with the other site-specific maps.
8) Test pH throughout the 40-acre MHP on folistic and histic epipedons. An increase in the number of samples/transects will increase the validity of the simple field test. In addition, run analyses for other chemical properties that separated histic and folistic epipedons in the pilot study (Appendices H and I).
9) Produce cross sections of organic matter thickness across the folistic/histic epipedon transects using a 2-meter interval. An aluminum rod of sufficient diameter that would readily penetrate the organic layer but not the mineral horizons should be used.
10) At the end of 10 years of data gathering, compare soil temperatures at the same depths to determine if soil temperature has significantly changed through the years.

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Appendix A

Vegetation Plot Data Sheet Examples

USDA-NRCS WETLAND EVALUATION PROJECT
MASCOMA VEGETATIVE PLOTS

Updated 10/21/02

DATE: **OBSERVATIONS BY:**

VEGETATIVE PLOT – SITE 1H – SPRING 2003
75' South of #519, 20' West of N/S line between #519 & #520
Herbaceous Layer

1)	Hay Scented Fern – *Dennstaedtia punctilobula* (new fiddleheads from ground)	Bud Score = 0 1 2 3
2)	Stiff Clubmoss – *Lycopodium annotinum* (growth on end of runners)	Bud Score = 0 1 2 3
3)	Goldthread – *Coptis groenlandica* (new leaves at base of plant)	Bud Score = 0 1 2 3
4)	Sessile Bellwort – *Uvularia sessilfolia* (new shoots from ground)	Bud Score = 0 1 2 3
5)	Pin Cherry – *Prunus pensylvanica* (bud swelling and splitting)	Bud Score = 0 1 2 3
6)	Blue Bead Lily – *Clintonia borealis* (new shoots from ground)	Bud Score = 0 1 2 3
7)	Wild Sasparallia – *Aralia nudicaulis* (new shoots from ground)	Bud Score = 0 1 2 3
22)	Red Maple – *Acer rubrum* (red flowers swelling and splitting)	Bud Score = 0 1 2 3

NOTES:

BUD SCORE
0 = No Observable Growth
1 = Bud Swollen
2 = Green Foliage Showing
3 = Leaf Elongation

VEGETATIVE PLOT – SITE 1S – SPRING 2003
75' South of #519, 20' West of N/S line between #519 & #520
Shrub Layer – 70% Canopy

1)	Red Maple – *Acer rubrum* (red flowers swelling and splitting)	Bud Score = 0 1 2 3
2)	Balsam Fir – *Abies balsamea* (bud swelling and splitting)	Bud Score = 0 1 2 3
3)	White Ash – *Fraxinus anadensi* (bud swelling and splitting)	Bud Score = 0 1 2 3
4)	Pin Cherry – *Prunus pensylvanica* (bud swelling and splitting)	Bud Score = 0 1 2 3
5)	Yellow Birch – *Betula alleghaniensis* (bud swelling and splitting)	Bud Score = 0 1 2 3
9)	Striped Maple – *Acer pensylvanicum* (bud swelling and splitting)	Bud Score = 0 1 2 3
13)	Sugar Maple – *Acer saccharum* (bud splitting and swelling)	Bud Score = 0 1 2 3

NOTES:

USDA-NRCS WETLAND EVALUATION PROJECT
MASCOMA VEGETATIVE PLOTS

VEGETATION MASTER LIST – SPRING 2003
Herbaceous Layer

1)	Hay Scented Fern – *Dennstaedtia punctilobula* (new fiddleheads from ground)	Bud Score = 0 1 2 3
2)	Stiff Clubmoss –*Lycopodium annotinum* (growth on end of runners)	Bud Score = 0 1 2 3
3)	Goldthread – *optis groenlandica* (new leaves at base of plant)	Bud Score = 0 1 2 3
4)	Sessile Bellwort – *Uvularia sessilfolia* (new shoots from ground)	Bud Score = 0 1 2 3
5)	Pin Cherry – *Prunus pensylvanica* (buds swelling and splitting)	Bud Score = 0 1 2 3
6)	Blue Bead Lily – *Clintonia borealis* (new shoots from ground)	Bud Score = 0 1 2 3
7)	Wild Sasparallia – *Aralia nudicaulis* (new shoots from ground)	Bud Score = 0 1 2 3
8)	Shinleaf Pyrola – *Pyrola elliptica* (new leaves at base of plant)	Bud Score = 0 1 2 3
9)	Indian Cucumber Root – *Medeola virginiana* (new shoots from ground)	Bud Score = 0 1 2 3
10)	Wood Sorrel – *Oxalis anaden* (new leaves at base of plant)	Bud Score = 0 1 2 3
11)	Dewdrop – *Dalibarda repens* (new leaves at base of plant)	Bud Score = 0 1 2 3
12)	Star Flower – *Trientalis borealis* (new shoots from ground)	Bud Score = 0 1 2 3
13)	Bunchberry – *Cornus anadensis* (new shoots & leaves at base of plant)	Bud Score = 0 1 2 3
14)	Spinulose Woodfern – *Dryopteris spinulosa* (fiddleheads split membrane & unfurl)	Bud Score = 0 1 2 3
15)	Painted Trillium – *Trillium undulatum* (new shoots from ground)	Bud Score = 0 1 2 3
16)	Balsam Fir – *bies balsamea* (buds swelling and splitting)	Bud Score = 0 1 2 3
17)	Hobblebush – *Viburnam lantanoides* (naked buds, no splitting to observe)	Bud Score = 0 1 2 3
18)	Striped Maple – *Acer pensylvanicum* (buds swelling and splitting)	Bud Score = 0 1 2 3
19)	Tree clubmoss – *Lycopodium obscurum* (new growth on end of runners)	Bud Score = 0 1 2 3
20)	Twin flower – *Linneae borealis* (new growth and leaves from end of runners)	Bud Score = 0 1 2 3
21)	Low bush blueberry – *Vaccinium angustifolium* (buds swelling and splitting)	Bud Score = 0 1 2 3
22)	Red Maple – *Acer rubrum* (red flowers swelling and splitting)	Bud Score = 0 1 2 3
23)	Lady Slipper – *Cypripedium acaule* (new shoots from ground)	Bud Score = 0 1 2 3
24)	Bracken Fern – *Pteridium aquilinum* (new shoots from ground)	Bud Score = 0 1 2 3
25)	Current – *Ribes* (buds splitting and swelling)	Bud Score = 0 1 2 3
26)	Mountain Ash – *Sorbus Americana* (buds splitting and swelling)	Bud Score = 0 1 2 3
27)	Mountain Holly – *Nemopanthis* (buds splitting and swelling)	Bud Score = 0 1 2 3
28)	Cinnamon Fern – *Osmunda cinnamomea* (new fiddleheads from ground)	Bud Score = 0 1 2 3
29)	Sedge – *Carex (pensylvanica?)* (new shoots & leaves at base of plant)	Bud Score = 0 1 2 3
30)	New York Fern – *Osmunda cinnamomea* (new fiddleheads from ground)	Bud Score = 0 1 2 3

USDA-NRCS WETLAND EVALUATION PROJECT
MASCOMA VEGETATIVE PLOTS

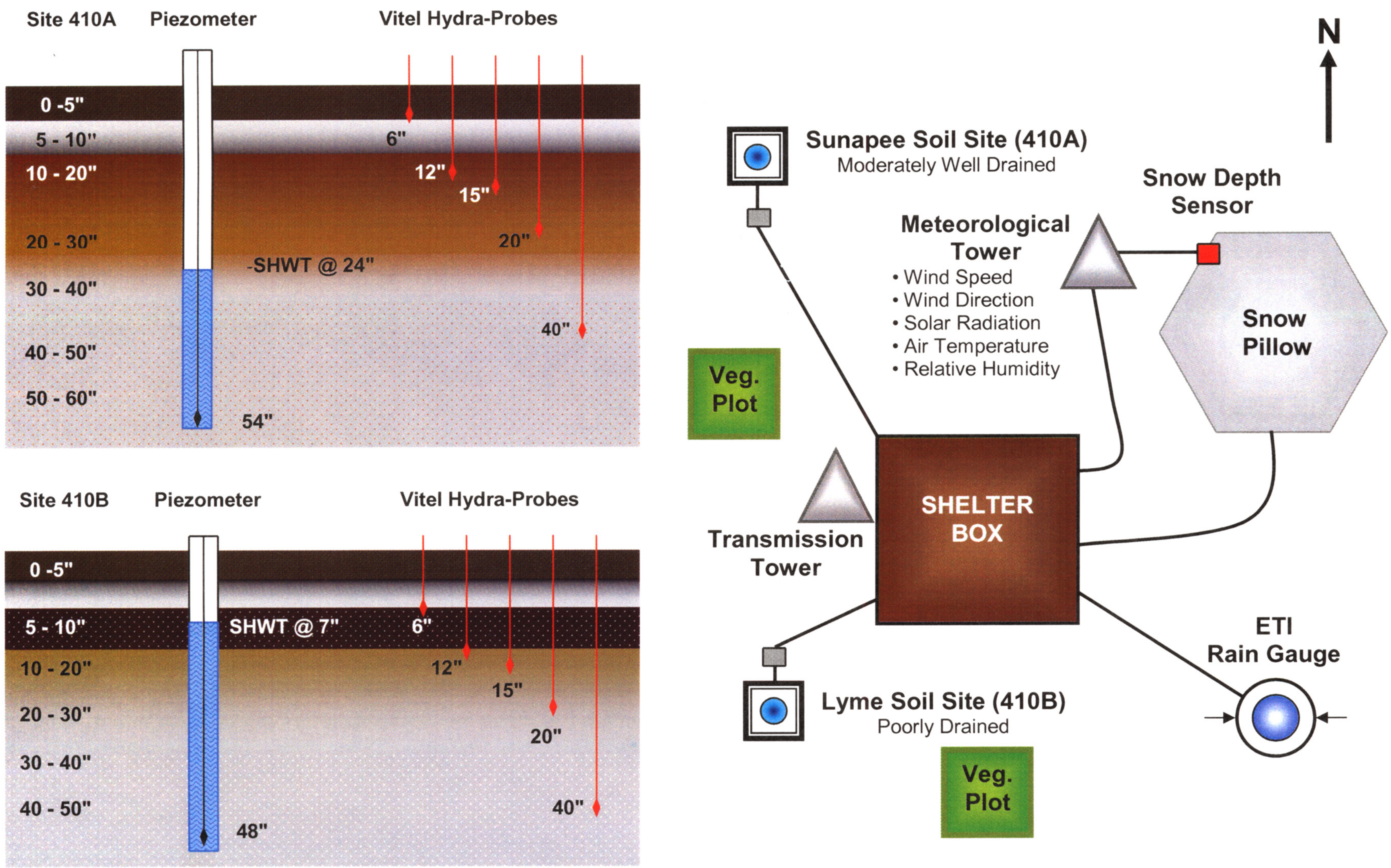
VEGETATION MASTER LIST – SPRING 2003
Shrub Layer

1)	Red Maple – *Acer rubrum* (red flowers swelling and splitting)	Bud Score = 0 1 2 3
2)	Balsam Fir – *Abies balsamea* (buds swelling and splitting)	Bud Score = 0 1 2 3
3)	White Ash – *Fraxinus anadensi* (buds swelling and splitting)	Bud Score = 0 1 2 3
4)	Pin Cherry – *Prunus pensylvanica* (buds swelling and splitting)	Bud Score = 0 1 2 3
5)	Yellow Birch – *Betula alleghaniensis* (buds swelling and splitting)	Bud Score = 0 1 2 3
6)	Black Spruce – *Picea mariana* (buds swelling and splitting)	Bud Score = 0 1 2 3
7)	Hobblebush – *Viburnam lantanoides* (naked buds, no splitting to observe)	Bud Score = 0 1 2 3
8)	Hemlock – *Tsuga anadensis* (buds swelling and splitting)	Bud Score = 0 1 2 3
9)	Striped Maple – *Acer pensylvanicum* (buds swelling and splitting)	Bud Score = 0 1 2 3
10)	Mountain Maple – *Acer spicatum* (buds splitting and swelling)	Bud Score = 0 1 2 3
11)	Mountain Holly – *Nemopanthis mucronata* (buds splitting and swelling)	Bud Score = 0 1 2 3
12)	American Beech – *Fagus grandifolia* (buds splitting and swelling)	Bud Score = 0 1 2 3
13)	Sugar Maple – *Acer saccharum* (buds splitting and swelling)	Bud Score = 0 1 2 3
14)	Common Poplar – *Populus tremulodies* (buds splitting and swelling)	Bud Score = 0 1 2 3

NOTES:

Appendix B

SCAN Site Schematic



Site 410A
Piezometer
Vitel Hydra-Probes
0 -5"
5 - 10"
10 - 20"
20 - 30"
30 - 40"
40 - 50"
50 - 60"
-SHWT @ 24"
54"
6"
12"
15"
20"
40"
Site 410B
Piezometer
Vitel Hydra-Probes
0 -5"
5 - 10"
10 - 20"
20 - 30"
30 - 40"
40 - 50"
SHWT @ 7"
48"
6"
12"
15"
20"
40"
N
Sunapee Soil Site (410A)
Moderately Well Drained
Snow Depth Sensor
Meteorological Tower
• Wind Speed
• Wind Direction
• Solar Radiation
• Air Temperature
• Relative Humidity
Snow Pillow
Veg. Plot
Transmission Tower
SHELTER BOX
ETI Rain Gauge
Lyme Soil Site (410B)
Poorly Drained
Veg. Plot

Appendix C

Pedon Description 417A and 417B

Instrument Placement in Pedon 417A Through 417E Transect

Pedon 417B Characterization Data

SOIL DESCRIPTION – Pedon 417A

Soil type:
Area: Mascoma Headwaters Project, Dorchester, Grafton, Co., NH
Classification: Typic Haplorthod, Coarse-loamy, mixed, frigid, ortstein.
Location: Grid Point 417, Piezometer A, 43° , 46', 40.16" - 72° , 01', 36.29"
N. Veg: B. Fir, R. Maple, Y. Birch, W. Birch, B. Spruce, Aspen, Blueberry, Beadlily
Parent Material: Glacial Till, Ablation
Physiography: Glaciated Upland, Hillslope
Relief:
Elevation: 1405'

Drainage: Well
Slope:

File No.
Date: 07/2/97 Stop# 1

Gr. water: None
Aspect: West

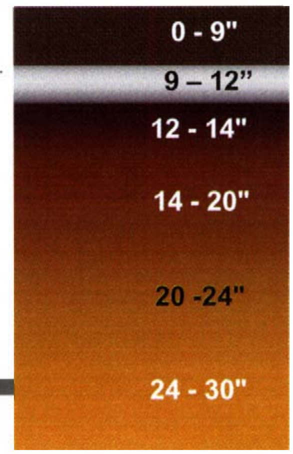
Additional notes:

① Bsm - Discontinous ortstein, 5YR 3/4 matrix with 5YR 3/1, 7.5YR 4/6, and 10YR 6/3.

② Bs1 - 10% cemented at 50 cm.

③ Stopped by stone or boulder at 30".

Described and sampled for characterization by Joe Homer, Karen Dudley, and Warren Lynn.



Hori-zon	Depth (inches)	Redox color	Soil color (moist)	Texture	Structure	Consistence	pH	Boun-dary	Frags (pct)	Roots
Oe	0 - 2			Hemic		vfr		as	0	2 f & m
Oa	2 - 9		7.5YR 2.5/1	Sapric		vfr		as	0	2 f & m
E	9 - 12		7.5YR 6/2	LS	2 m sbk	fr		as	5 gr	2 f
Bh	12 - 14		5YR 2.5/1	FSL	3 m sbk	fr		as	5 gr	2 f & m
Bsm	14 - 20		5YR 3/4 ①	FSL	3 m sbk	fi		aw	5 gr	1 f
Bs1	20 - 24		10YR 5/6	FSL	2 m sbk	fr ②		cw	5 gr	-
Bs2	24 - 30 ③		10YR 5/6	SL	1 f sbk	fr			5 gr	-

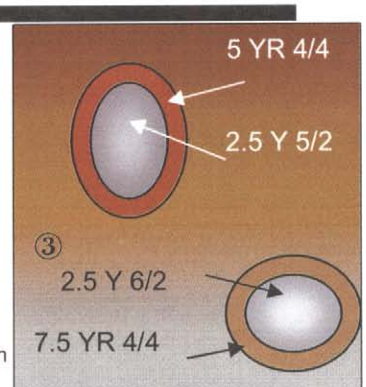
Note: Soil description abbreviations are explained in the "Field Book for Describing and Sampling Soils," version 1.0 *(Schoeneberger et al., 1998)*.

SOIL DESCRIPTION - Pedon 417B

Soil type:
Area: Mascoma Headwaters Project, Dorchester, Grafton, Co., NH
File No. S97-NH-9-2
Date: 07/15/97 Stop# 1
Classification: Typic Endoaquod, Coarse-loamy over sandy or sandy-skeletal, mixed, frigid, ortstein.
Location: Grid Point 417, Soil Pit, 43° , 46', 40.16" - 72° , 01', 36.29"
N. Veg: B. Fir, R. Maple, Y. Birch, W. Birch, B. Spruce, Aspen, Blueberry, Beadlily
Parent Material: Glacial Till, Ablation
Physiography: Glaciated Upland
Relief:
Drainage: Poor
Gr. water:
Elevation: 1405'
Slope:
Aspect: West

Additional notes:

① 5% woody fragments, 5YR 3/3.
② Scattered clean sand grains (7.5YR 8/1) on ped faces.
③ Some redox features occur as low chroma spheres with a high chroma rind.
④ On ped faces.
⑤ Firm, weakly cemented (not as firm as Bhsm).
⑥ Horizon is discontinuous.
⑦ 7.5YR 3/3 color in root channels and pores.
⑧ Layering (stratification?) in this horizon suggests water-worked till material.
⑨ Texture of 2.5Y 6/2 material is loamy sand.

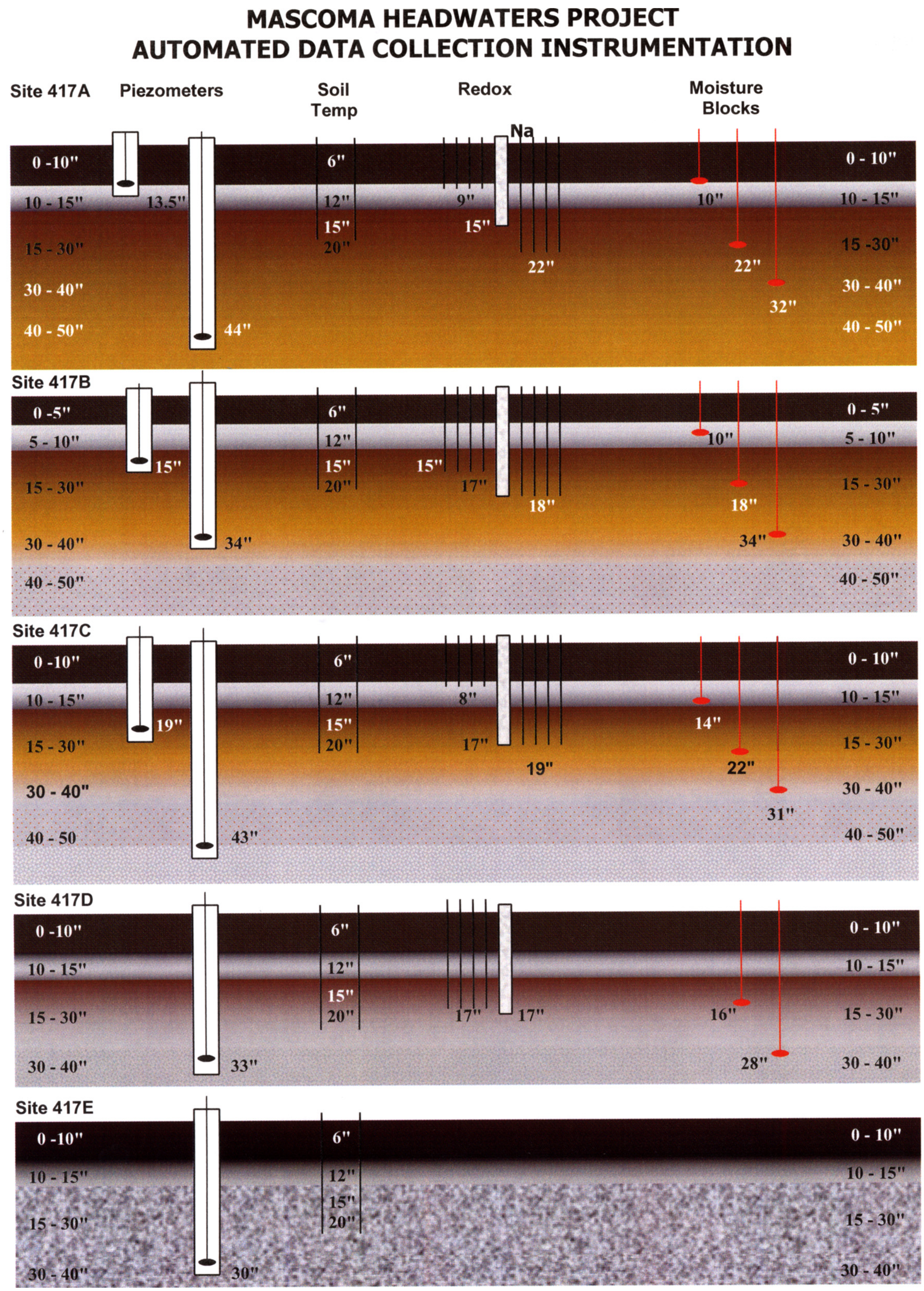


Described and sampled for characterization by Joe Homer, Karen Dudley, and Warren Lynn

Hori-zon	Depth (in)	Redox color	Soil color (moist)	Tex-ture	Structure	Consis-tence	pH	Boun-dary	Frags (pct)	Roots
Oa	0 - 6		5YR 2.5/1	Sap-ric		fr	3.9	aw	5 ①	2 f & m
E	6 – 7.5		5YR 4/1 60% 7.5YR 5/2 40% 7.5YR 8/1 ②	LS	1 m sbk	fr	3.7	aw	1 gr	2 f
Bh	7.5 - 9		N 2.5/0	FSL	2 m&c sbk	fr	3.7	cw	0	2 f & m
Bhsm	9 - 19		5YR 3/2 50% 7.5YR 3/4 30% 5YR 3/3 20%	FSL	2 m&c sbk	fi	4.6	aw	3 gr	1 f
Bsm	19 - 26	2.5Y 5/2 5% 5YR 4/4 5% ③	75YR 3/4 40% 10YR 4/4 40% 5YR 3/2 20% ④	LFS	1 m&c sbk	fi ⑤	4.9	cw	20 gr 1 cb	-
Bs ⑥	26 - 30	2.5Y 5/2 10% 7.5YR 4/2 10% 2.5Y 7/1 5%	2.5Y 4/3 7.5YR 3/3 ⑦	LFS	1 m&c sbk	fr	4.9	cw	2 gr	-
C1	30 - 37	2.5Y 6/2 15% 7.5YR 4/4 5% ③	5Y 4/2	LFS ⑨	M ⑧	fr	5.0	cs	5 gr 10 cb	-
C2	37 - 44	2.5Y 6/2 15% 10YR 5/4 5%	5Y 4/1	LFS ⑨	M ⑧	fr	5.0	cs	20 gr 20 cb	-
C3	44 - 50	2.5Y 6/2 5% 5YR 6/2 5%	5Y 4/1	LFS ⑨	M ⑧	fr	5.0		20 gr 20 cb	-

Note: Soil description abbreviations are explained in the "Field Book for Describing and Sampling Soils," version 1.0 *(Schoeneberger et al., 1998).*

Instrument Placement
417 Catena
(417A – 417E)



Catena Site 417B Soil Laboratory Data

*** Primary Characterization Data ***
(Grafton County, New Hampshire)

Pedon ID: 97NH009002

Print Date: Apr 8 2004 11:26AM

Sampled as : Snd (Mascoma 417) ; Coarse-loamy, mixed, frigid Aquic Haplorthod
Revised to SSL: (unnamed); Sandy, isotic, frigid Aquic Haplorthod

SSL - Project CP97NH124 NEW HAMPSHIRE-MASCOMA
- Site ID 97NH009002 Lat: 43° 46' 40.60" north Long: 72° 1' 36.00" west
- Pedon No. 97P0512
- General Methods 1B1A, 2A1, 2B

United States Department of Agriculture
Natural Resources Conservation Service
National Soil Survey Center
Soil Survey Laboratory
Lincoln, Nebraska 68508-3866

Layer	Horizon	Orig Hzn	Depth (cm)	Field Label 1	Field Label 2	Field Label 3	Field Texture	Lab Texture
97P03029	Oa	Oa	0-15					LS
97P03030	E	E	15-19				LS	LS
97P03031	Bh	Bh	19-23				FSL	LS
97P03032	Bhs	Bhs	23-47				FSL	LS
97P03033	Bs	Bs	47-66				LFS	LS
97P03034	Bw	Bw	66-76				LFS	LS
97P03035	C1	C1	76-93				LFS	LS
97P03036	C2	C2	93-113				LFS	S
97P03037	C3	C3	113-123				LFS	LS

Pedon Calculations

Calculation Name	Result	Units of Measure
CEC Activity, CEC7/Clay, Weighted Average	32.03	(NA)
Clay, Carbonate Free, Weighted Average	0	% wt
Weighted Particles, 0.1-75mm, 75 mm Base	77	% wt
Volume, >2mm, Weighted Average	23	% vol
Clay, Total, Weighted Average	0	% wt
LE, Whole Soil, Summed to 1m	0	cm/m

Weighted averages based on control section: 25-100 cm

*** Primary Characterization Data ***

(Grafton County, New Hampshire)

Pedon ID 97NH009002
Sampled As
USDA-NRCS-NSSC-National Soil Survey Laboratory

Pedon No. 97P0512

Print Date Apr 8 2004 11:26AM

PSDA & Rock Fragments

Layer	Depth (cm)	Horz	Prep	-1- Total Clay < .002	-2- Total Silt .002 -.05	-3- Total Sand .05 -2	-4- Clay Fine < .0002	-5- Clay CO3 < .002	-6- Silt Fine .002 -.02	-7- Silt Coarse .02 -.05	-8- Sand VF .05 -.10	-9- Sand F .10 -.25	-10- Sand M .25 -.50	-11- Sand C .5 -1	-12- Sand VC 1 -2	-13- Rock Fragments Weight 2 -5	-14- Rock Fragments Weight 5 -20	-15- Rock Fragments Weight 20 -75	-16- Rock Fragments 1- 75	-17- >2 mm wt % whole soil
				(- - - % of <2 mm Mineral Soil											- - -)	(- - % of <75 mm		- - -)		
				3A1	3A1	3A1			3A1	3A1	3A1	3A1	3A1	3A1	3A1	3B1	3B1	3B1		
97P03029	0-15	Oa	S	0.4	23.1	76.5			13.1	10.0	10.1	22.7	24.3	16.5	2.9	1	2	--	67	3
97P03030	15-19	E	S	0.8	19.9	79.3			9.0	10.9	10.6	22.7	23.6	16.1	6.3	2	tr	2	70	4
97P03031	19-23	Bh	S	1.9	20.7	77.4			9.7	11.0	9.8	21.9	26.3	15.0	4.4	2	1	5	70	8
97P03032	23-47	Bhs	S	0.5	22.3	77.2			7.7	14.6	12.7	22.9	24.5	14.4	2.7	6	11	6	73	23
97P03033	47-66	Bs	S	0.3	15.6	84.1			6.4	9.2	10.8	23.2	29.6	17.5	3.0	4	10	27	84	42
97P03034	66-76	Bw	S	--	17.7	82.3			5.3	12.4	16.1	26.0	22.4	14.0	3.8	4	10	3	72	17
97P03035	76-93	C1	S	--	16.6	83.4			4.2	12.4	16.6	25.8	22.3	13.9	4.8	2	10	8	73	30
97P03036	93-113	C2	S	--	13.9	86.1			3.8	10.1	13.0	24.1	26.1	17.4	5.5	4	9	30	85	56
97P03037	113-123	C3	S	0.1	15.7	84.2			4.1	11.6	17.1	30.0	22.4	11.9	2.8	2	6	39	83	60

Bulk Density & Moisture

Layer	Depth (cm)	Horz	Prep	-1- Bulk Density 33 kPa (g cm-3)	-2- Bulk Density Oven Dry (g cm-3)	-3- Cole Whole Soil	-4- Water Content 6 kPa	-5- Water Content 10 kPa	-6- Water Content 33 kPa	-7- Water Content 1500 kPa	-8- Water Content 1500 kPa Moist	-9- Ratio AD/OD	-10- WRD Whole Soil cm3 cm-3	-11- Aggst Stabl 2-0.5 mm %	-12- Ratio/Clay CEC7	-13- Ratio/Clay 1500 kPa
							(- - % of < 2mm				- - -)					
				4A1d	4A1h				4B1c	4B2a	4B2b	4B5	4C1		8D1	8D1
97P03029	0-15	Oa	S	0.31	0.39	0.079			113.2	55.2		1.018	--			
97P03029	0-15	Oa	M								134.2					
97P03030	15-19	E	S	1.52	1.52	--			3.9	1.5		1.004	0.04			
97P03031	19-23	Bh	S	0.91	0.95	0.014			30.1	13.7		1.007	0.15		22.63	7.21
97P03032	23-47	Bhs	S	1.11	1.16	0.013			27.9	11.9		1.006	0.16			
97P03033	47-66	Bs	S	1.69	1.70	0.001			7.2	2.9		1.002	0.05			
97P03034	66-76	Bw	S	1.87	1.89	0.003			3.0	1.2		1.001	0.03			
97P03035	76-93	C1	S	1.80	1.82	0.003			4.5	0.4		1.001	0.06			
97P03036	93-113	C2	S	1.98	2.02	0.003			2.7	0.2		1.000	0.03			
97P03037	113-123	C3	S	1.83	1.86	0.003			3.2	0.2		1.001	0.03			

*** Primary Characterization Data ***

(Grafton County, New Hampshire)

Pedon ID: 97NH009002
Sampled As
USDA-NRCS-NSSC-National Soil Survey Laboratory

Pedon No. 97P0512

Print Date. Apr 8 2004 11:26AM

Water Content

Layer	Depth (cm)	Horz	Prep	-1- Atterberg Limits LL	-2- Atterberg Limits PI	-3- Bulk Density Field	-4- Bulk Density Recon 33 kPa	-5- Bulk Density Recon Oven Dry	-6- Water Content Field	-7- Water Content Recon 33 kPa	-8- Sieved Samples 6 kPa	-9- Sieved Samples 10 kPa	-10- Sieved Samples 33 kPa	-11- Sieved Samples 100 kPa	-12- Sieved Samples 200 kPa
				pct <0.4 mm		g cm⁻³			% of < 2 mm						
															4B1a
97P03029	0-15	Oa	S												65.8
97P03030	15-19	E	S												2.1
97P03031	19-23	Bh	S												18.8
97P03032	23-47	Bhs	S												18.0
97P03033	47-66	Bs	S												5.8
97P03034	66-76	Bw	S												2.3
97P03035	76-93	C1	S												1.4
97P03036	93-113	C2	S												0.9
97P03037	113-123	C3	S												0.8

Carbon & Extractions

Layer	Depth (cm)	Horz	Prep	-1- Total C	-2- Total N	-3- Total S	-4- Org C	-5- C/N Ratio	-6- Dith-Cit Ext Fe	-7- Dith-Cit Ext Al	-8- Dith-Cit Ext Mn	-9- Acid Oxalate Extraction Al+½Fe	-10- Acid Oxalate Extraction ODOE	-11- Acid Oxalate Extraction Fe	-12- Acid Oxalate Extraction Al	-13- Acid Oxalate Extraction Mn	-14- Acid Oxalate Extraction Si	-15- Na Pyro-Phosphate C	-16- Na Pyro-Phosphate Fe	-17- Na Pyro-Phosphate Al	-18- Na Pyro-Phosphate Mn
				% of <2 mm					% of < 2 mm							mg kg⁻¹	% of < 2 mm				
				6A2e	6B4a				6C2b	6G7a	6D2a		8J	6C9b	6G12b	6D5b	6V2b				
97P03029	0-15	Oa	S	38.25	1.647			23	0.7	0.4	0.1	0.53	0.30	0.25	0.41	30.0	0.05				
97P03030	15-19	E	S	0.72	0.038				0.7	0.2	0.1	0.03	0.03	0.01	0.03	--	tr				
97P03031	19-23	Bh	S	8.48	0.338			25	1.8	0.9	0.1	1.37	2.88	1.11	0.82	--	0.03				
97P03032	23-47	Bhs	S	5.19	0.158			33	1.0	1.6	0.1	2.51	1.16	0.50	2.26	--	0.45				
97P03033	47-66	Bs	S	1.41	0.060				0.5	0.5	0.1	0.84	0.25	0.13	0.77	--	0.21				
97P03034	66-76	Bw	S	0.39	0.022				0.5	0.2	0.1	0.28	0.08	0.05	0.26	--	0.07				
97P03035	76-93	C1	S	0.16	0.013				0.5	0.2	0.1	0.16	0.02	0.05	0.14	30.0	0.04				
97P03036	93-113	C2	S	0.08					0.5	0.2	0.1	0.09	0.01	0.03	0.08	40.0	0.03				
97P03037	113-123	C3	S	0.08					0.5	0.2	0.1	0.10	0.01	0.03	0.09	30.0	0.03				

*** Primary Characterization Data ***
(Grafton County, New Hampshire)

Pedon ID 97NH009002
Sampled As
USDA-NRCS-NSSC-National Soil Survey Laboratory

Pedon No. 97P0512

Print Date. Apr 8 2004 11:26AM

CEC & Bases

Layer	Depth (cm)	Horz	Prep	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-	-11-	-12-	-13-	-14-
				(- - - - - NH$_4$OAC Extractable Bases - - - - -)								CEC8	CEC7	ECEC		(- - - - Base - - - -)	
								Sum	Acid-	Extr	KCl	Sum	NH$_4$	Bases	Al	(- Saturation -)	
				Ca	Mg	Na	K	Bases	ity	Al	Mn	Cats	OAC	+Al	Sat	Sum	NH$_4$OAC
				(- - - - - - - - cmol(+) kg^{-1} - - - - - - - -						- - - -)	mg kg^{-1}	(- - - - cmol(+) kg^{-1} - - -)			(- - - - - - - - % - - - - - - - -)		
				6N2e	6O2d	6P2b	6Q2b		6H5a	6G9c	6D3b	5A3a	5A8b	5A3b	5G1	5C3	5C1
97P03029	0-15	Oa	S	15.6	2.3	1.2	1.2	20.3	113.9	15.1	13.4	134.2	93.3	35.4	43	15	22
97P03030	15-19	E	S	3.1	0.3	0.7	0.3	4.4	9.2	5.7	--	13.6	6.9	10.1	56	32	64
97P03031	19-23	Bh	S	2.2	0.2	0.4	0.2	3.0	67.9	27.3	--	70.9	43.0	30.3	90	4	7
97P03032	23-47	Bhs	S	0.6	--	0.5	0.3	1.4	54.8	12.1	--	56.2	30.5	13.5	90	2	5
97P03033	47-66	Bs	S	0.4	0.2	0.4	0.2	1.2	14.0	3.1	--	15.2	6.0	4.3	72	8	20
97P03034	66-76	Bw	S	0.4	0.2	0.3	0.4	1.3	5.0	1.3	--	6.3	2.3	2.6	50	21	57
97P03035	76-93	C1	S	2.1	0.2	0.3	0.3	2.9	2.2	0.6	--	5.1	0.9	3.5	17	57	100
97P03036	93-113	C2	S	0.5	0.2	0.4	0.6	1.7	1.2	0.3	--	2.9	0.5	2.0	15	59	100
97P03037	113-123	C3	S	1.8	0.2	0.4	0.4	2.8	1.2	0.4	--	4.0	0.5	3.2	13	70	100

Extractable Ca may contain Ca from calcium carbonate or gypsum.. CEC7 base saturation set to 100.

pH & Carbonates

Layer	Depth (cm)	Horz	Prep	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-	-11-
				(- - - - - - - - - - - - - - - - pH					- - - - - - - - -)	(- - Carbonate - -)		(- - Gypsum - - -)		
					CaCl$_2$					As CaCO$_3$		As CaSO$_4$*2H$_2$O		Resist
					0.01M	H$_2$O	Sat			<2 mm	<20 mm	<2 mm	<20 mm	ohms
				KCl	1:2	1:1	Paste	Sulf	NaF	(- - - - - - - - - - - - %			- - - - - - - - - -)	cm^{-1}
					8C1f	8C1f			8C1d					
97P03029	0-15	Oa	S		3.3	3.9			6.1					
97P03030	15-19	E	S		3.2	3.7			7.4					
97P03031	19-23	Bh	S		3.4	3.7			8.7					
97P03032	23-47	Bhs	S		4.2	4.6			11.5					
97P03033	47-66	Bs	S		4.5	4.9			11.2					
97P03034	66-76	Bw	S		4.6	4.9			10.8					
97P03035	76-93	C1	S		4.7	5.0			10.5					
97P03036	93-113	C2	S		4.8	5.0			10.1					

Pedon ID: 97NH009002

Sampled As

USDA-NRCS-NSSC-National Soil Survey Laboratory

*** Primary Characterization Data ***

(Grafton County, New Hampshire)

: Pedon No. 97P0512

Print Date: Apr 8 2004 11:26AM

Phosphorous

				-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-
					(- - - Phosphorous							- - -)	
				Melanic	NZ	Acid	Bray	Bray	Olsen	H_2O	Citric	Mehlich	Extr
	Depth			Index		Oxal	1	2			Acid	III	NO_3
Layer	(cm)	Horz	Prep		%	(- - - mg kg^{-1}						- - -)	mg kg^{-1}
						6S8a							
97P03029	0-15	Oa	S			190.0							
97P03030	15-19	F	S			91.0							
97P03031	19-23	Bh	S			171.0							
97P03032	23-47	Bhs	S			182.0							
97P03033	47-66	Bs	S			100.0							
97P03034	66-76	Bw	S			120.0							
97P03035	76-93	C1	S			111.0							
97P03036	93-113	C2	S			49.0							
97P03037	113-123	C3	S			158.0							

*** Primary Characterization Data ***

(Grafton County, New Hampshire)

Pedon ID: 97NH009002
Sampled As
USDA-NRCS-NSSC-National Soil Survey Laboratory

Pedon No. 97P0512

Print Date: Apr 8 2004 11:26AM

Sand - Silt Mineralogy (2.0-0.002 mm)

Layer	Depth (cm)	Horz	Fraction	-1-	-2-	-3-	-4-	-5-	-6-	-7-	-8-	-9-	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-17-	-18-
				X-Ray					Thermal				Tot Re	Optical Grain Count 7B1a						EGME Retn	Interpretation
				<- - - peak size - - ->					<- - - % - - ->				<- - -	- - -	- - - %	- - -	- - -	- - ->	mg g^{-1}	
97P03030	15-19	E	fs										65	QZ 65	FK 19	FP 14	PR 1	HN tr	MS tr		
														OP tr	RA tr	GN tr					
97P03031	19-23	Bh	fs										41	QZ 40	OT 31	FK 16	FP 11	PR 1	NX 1		
														OP 1	HN tr	MS tr	CD tr	GN tr	GS tr		
97P03033	47-66	Bs	fs										71	QZ 71	FK 20	FP 4	PR 2	AR 1	BT 1		
														GN tr	HN tr	OP tr	OW tr				
97P03036	93-113	C2	fs										73	QZ 72	FK 20	BT 4	FP 2	OP 1	PR 1		
														AR tr	HN tr	FE tr	MS tr	GN tr			

FRACTION INTERPRETATION
fs - Fine Sand, 0.1-0.25 mm

MINERAL INTERPRETATION:

AR - Weatherable Aggregates	BT - Biotite	CD - Chert (Chalcedony)	FE - Iron Oxides (Goethite)	FK - Potassium Feldspar
FP - Plagioclase Feldspar	GN - Garnet	GS - Glass	HN - Hornblende	MS - Muscovite
NX - Non-Crystalline	OP - Opaques	OT - Other	OW - Other Weatherable Minerals	PR - Pyroxene
QZ - Quartz	RA - Resistant Aggregates			

RELATIVE PEAK SIZE 5=Very Large 4=Large 3=Medium 2=Small 1=Very Small 6=No Peaks

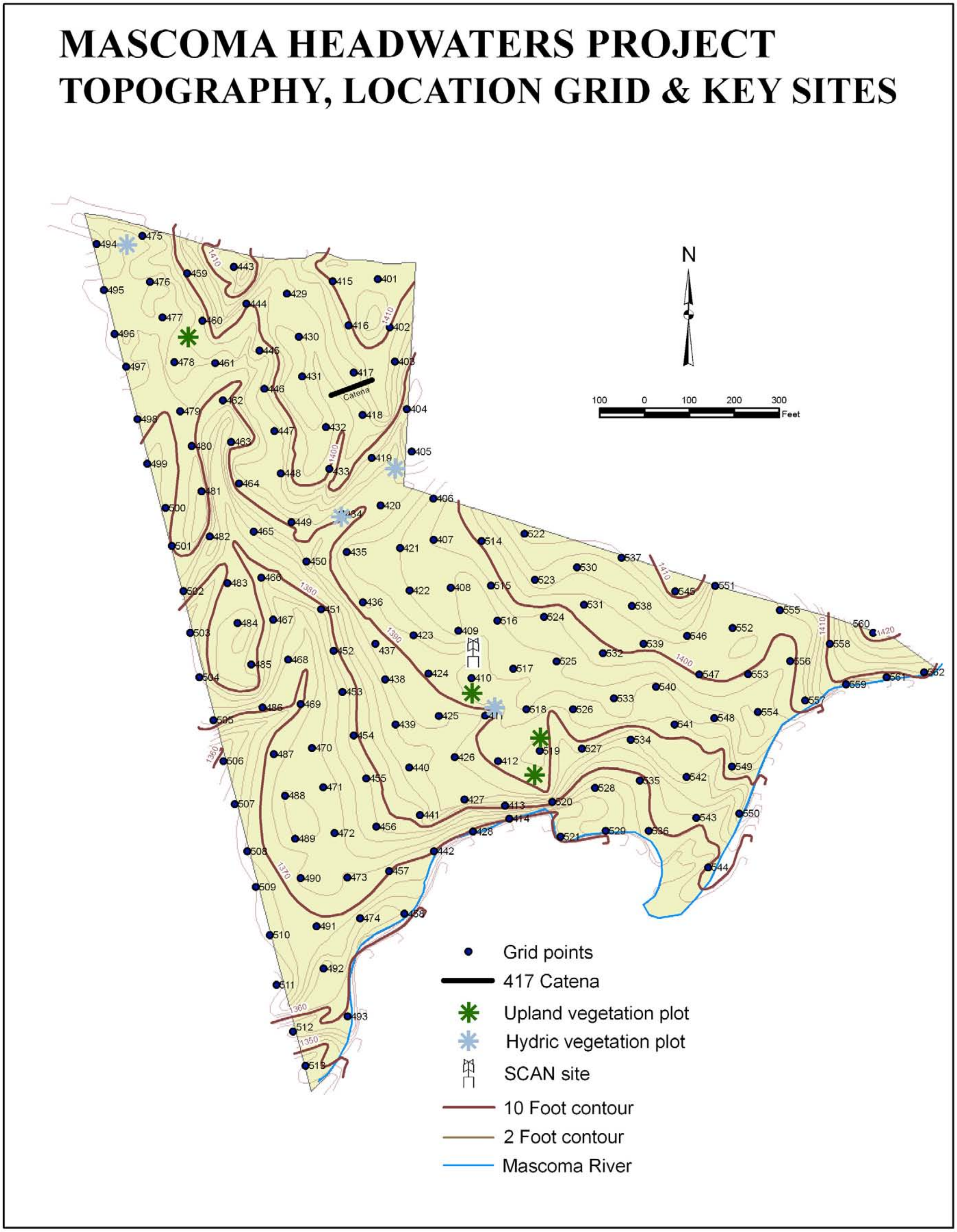
Appendix D

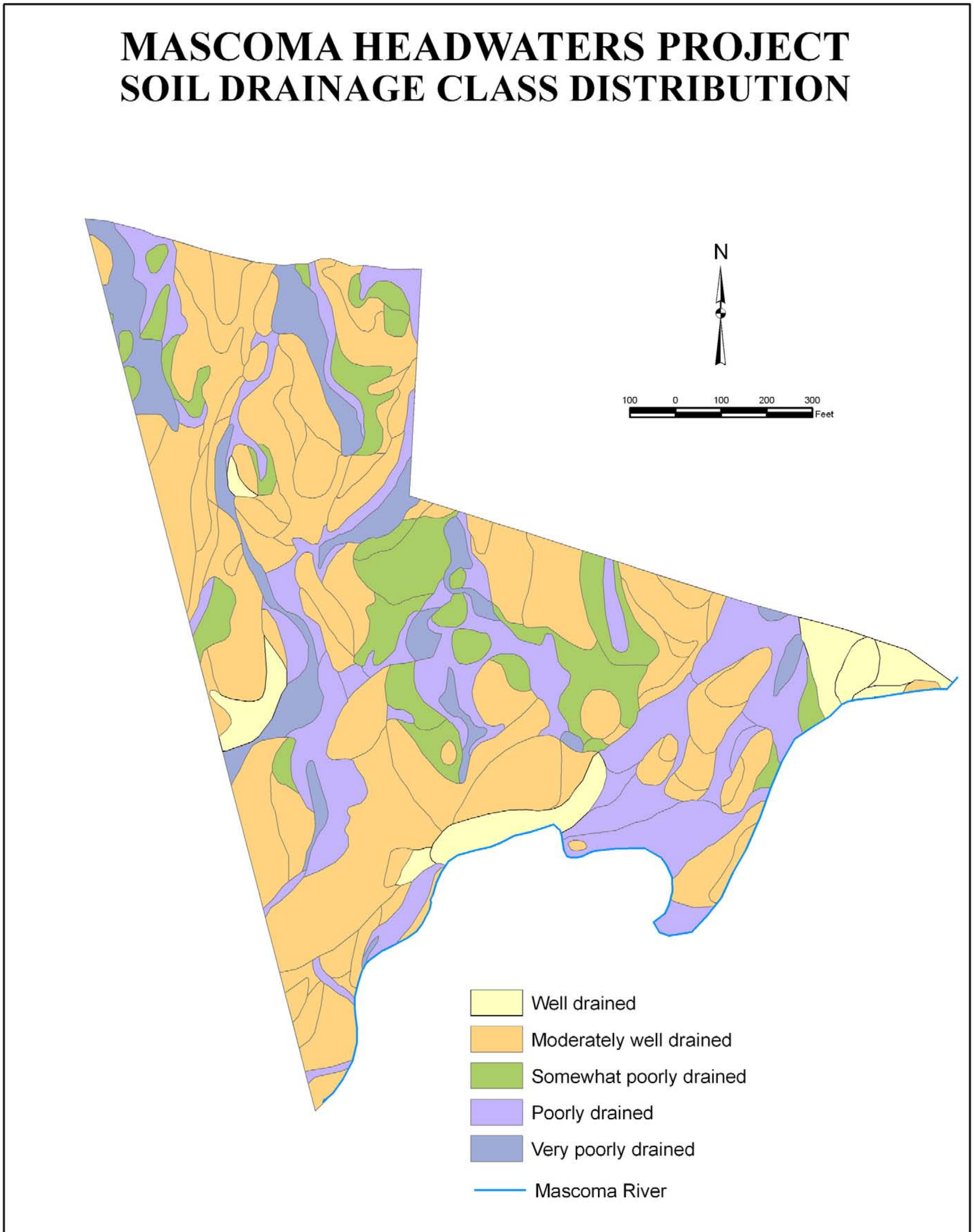
Example of Raw Data From 417A and 417B Sub-Sites
Temperature Data (^{o}C) at Depths of 6 Through 20 Inches
January 12-13, 2001

417 - NH3 YEAR	DAY	hour	417a soil temp at 6" st site A6	417a soil temp at 12" st site A12	417a soil temp at 15" st site A15	417a soil temp at 20" st site A20	417b soil temp at 6" st site B6	417b soil temp at 12" st site B12	417b soil temp at 15" st site B15	417b soil temp at 20" st site B20
2001	12	1100	-	1.459	1.733	2.279	-0.148	1.297	2.011	2.638
2001	12	1200	-	1.458	1.739	2.282	-0.149	1.3	2.007	2.678
2001	12	1300	-	1.46	1.741	2.287	-0.147	1.289	2.009	2.714
2001	12	1400	-	1.464	1.741	2.278	-0.147	1.295	2.006	2.724
2001	12	1500	-	1.462	1.733	2.285	-0.152	1.3	2.001	2.725
2001	12	1600	-	1.462	1.733	2.276	-0.152	1.294	2.001	2.728
2001	12	1700	-	1.459	1.733	2.279	-0.149	1.294	1.998	2.722
2001	12	1800	-	1.457	1.731	2.287	-0.15	1.292	2	2.68
2001	12	1900	-	1.462	1.73	2.273	-0.155	1.284	2.008	2.65
2001	12	2000	-	1.45	1.731	2.27	-0.163	1.282	1.999	2.616
2001	12	2100	-	1.463	1.721	2.277	-0.151	1.285	2.002	2.592
2001	12	2200	-	1.462	1.718	2.276	-0.161	1.284	2.001	2.569
2001	12	2300	-	1.462	1.727	2.288	-0.164	1.287	2.001	2.547
2001	13	0	-	1.46	1.718	2.289	-0.157	1.285	1.996	2.536
2001	13	100	-	1.455	1.72	2.288	-0.158	1.284	1.998	2.528
2001	13	200	-	1.46	1.721	2.289	-0.164	1.285	1.999	2.523
2001	13	300	-	1.457	1.719	2.293	-0.157	1.282	2.002	2.511
2001	13	400	-	1.457	1.712	2.292	-0.163	1.288	1.999	2.514
2001	13	500	-	1.46	1.715	2.289	-0.167	1.276	1.999	2.511
2001	13	600	-	1.457	1.716	2.289	-0.169	1.282	2.002	2.511
2001	13	700	-	1.454	1.709	2.289	-0.179	1.279	1.996	2.517
2001	13	800	-	1.456	1.709	2.289	-0.176	1.278	1.995	2.507
2001	13	900	-	1.45	1.719	2.277	-0.179	1.282	1.999	2.517
2001	13	1000	-	1.444	1.706	2.28	-0.188	1.282	2.002	2.536
2001	13	1100	-	1.444	1.715	2.277	-0.198	1.276	1.996	2.557
2001	13	1200	-	1.436	1.71	2.259	-0.199	1.274	1.991	2.615
2001	13	1300	-	1.441	1.718	2.258	-0.201	1.279	1.989	2.679
2001	13	1400	-	1.446	1.708	2.247	-0.205	1.281	1.979	2.687
2001	13	1500	-	1.438	1.706	2.249	-0.213	1.27	1.983	2.617
2001	13	1600	-	1.432	1.703	2.249	-0.213	1.273	1.977	2.561
2001	13	1700	-	1.429	1.703	2.245	-0.216	1.267	1.968	2.573
2001	13	1800	-	1.438	1.706	2.245	-0.21	1.273	1.974	2.617
2001	13	1900	-	1.438	1.706	2.245	-0.207	1.272	1.971	2.654
2001	13	2000	-	1.438	1.703	2.239	-0.21	1.269	1.974	2.698
2001	13	2100	-	1.428	1.708	2.241	-0.202	1.269	1.986	2.697
2001	13	2200	-	1.429	1.71	2.253	-0.203	1.277	1.984	2.665
2001	13	2300	-	1.431	1.702	2.245	-0.202	1.269	1.979	2.641

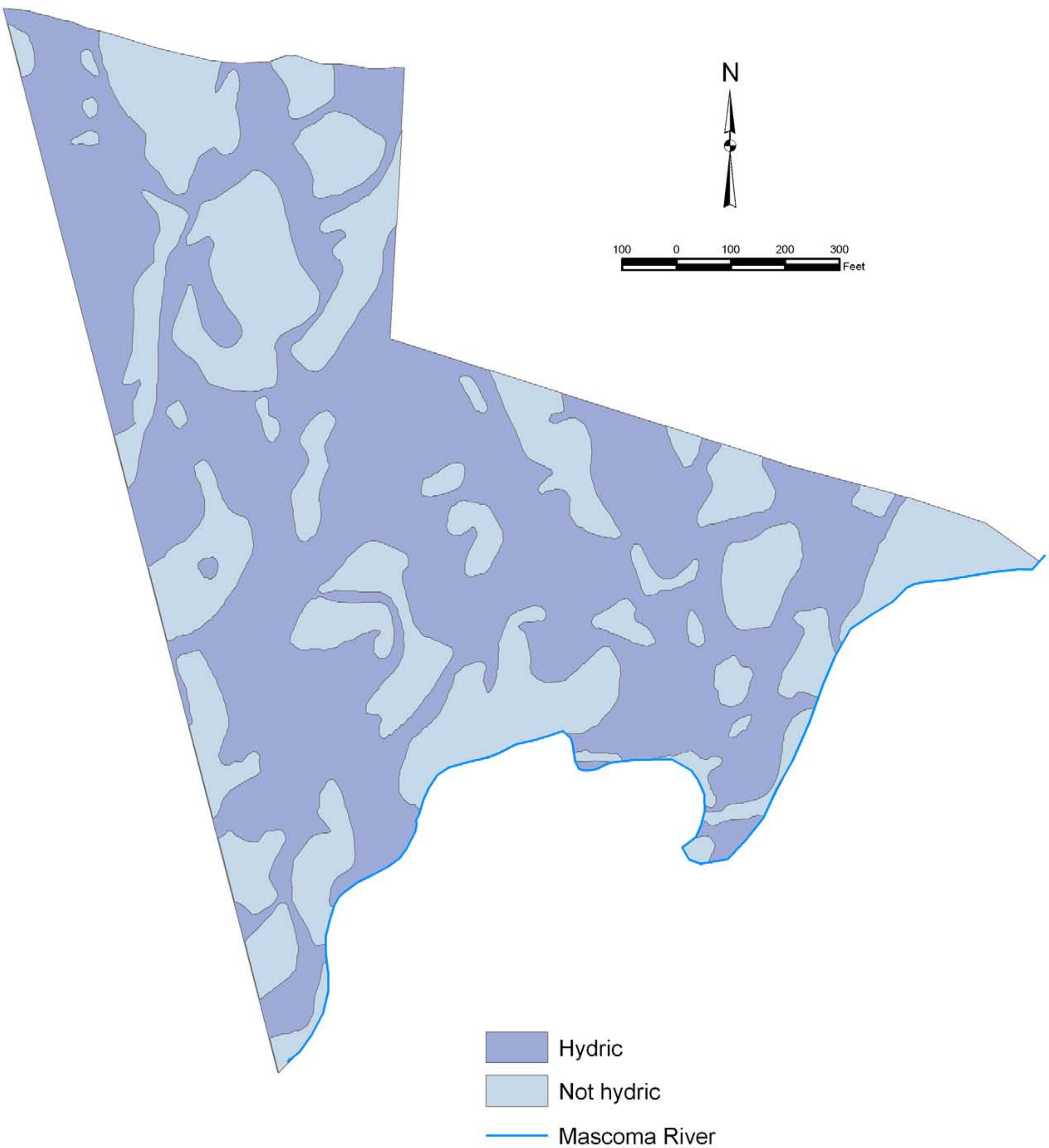
Appendix E

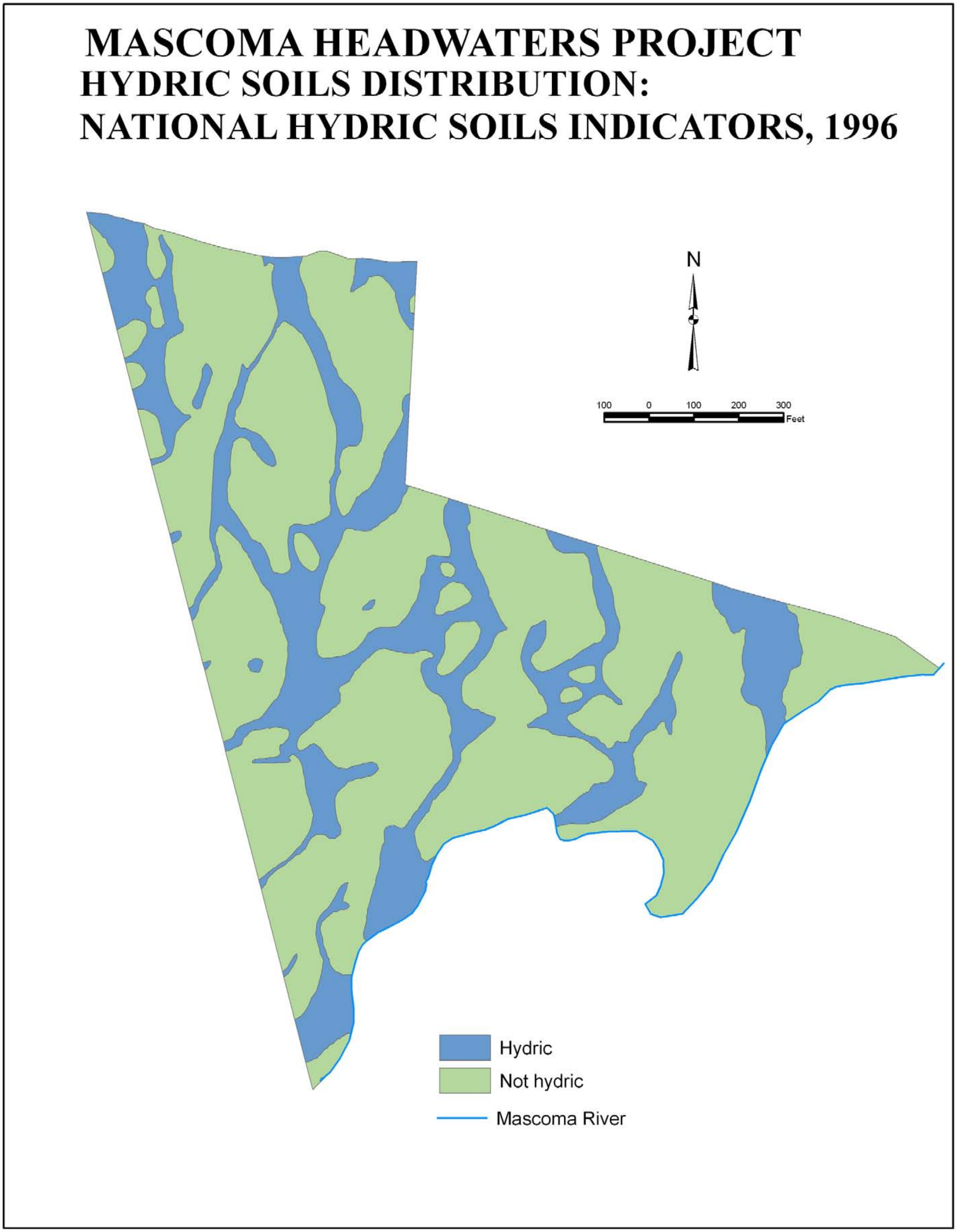
Site Maps

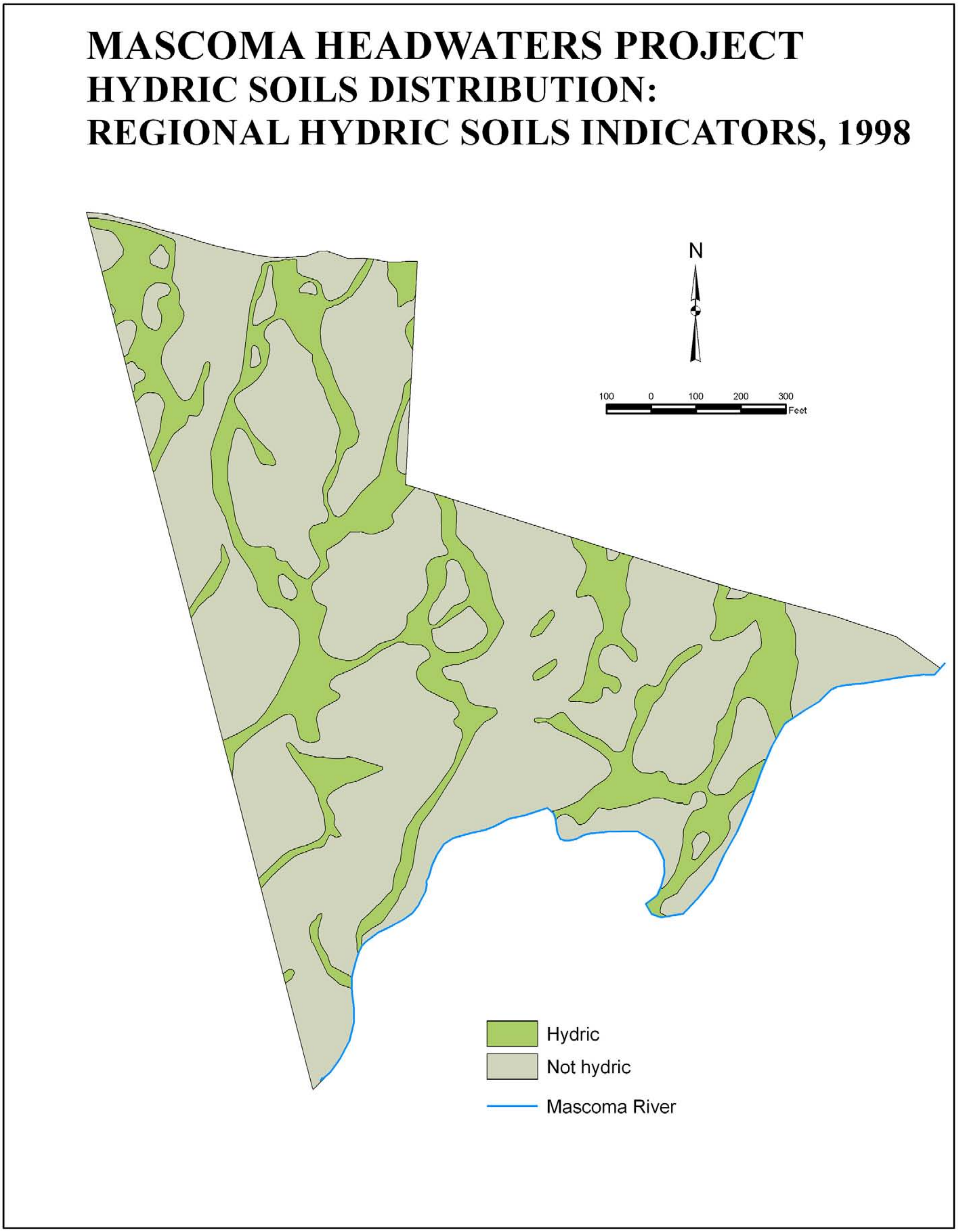

MASCOMA HEADWATERS PROJECT
TOPOGRAPHY, LOCATION GRID & KEY SITES
N
100 0 100 200 300
Feet
Grid points
417 Catena
Upland vegetation plot
Hydric vegetation plot
SCAN site
10 Foot contour
2 Foot contour
Mascoma River


MASCOMA HEADWATERS PROJECT
SOIL DRAINAGE CLASS DISTRIBUTION
N
100
0
100
200
300
Feet
Well drained
Moderately well drained
Somewhat poorly drained
Poorly drained
Very poorly drained
Mascoma River

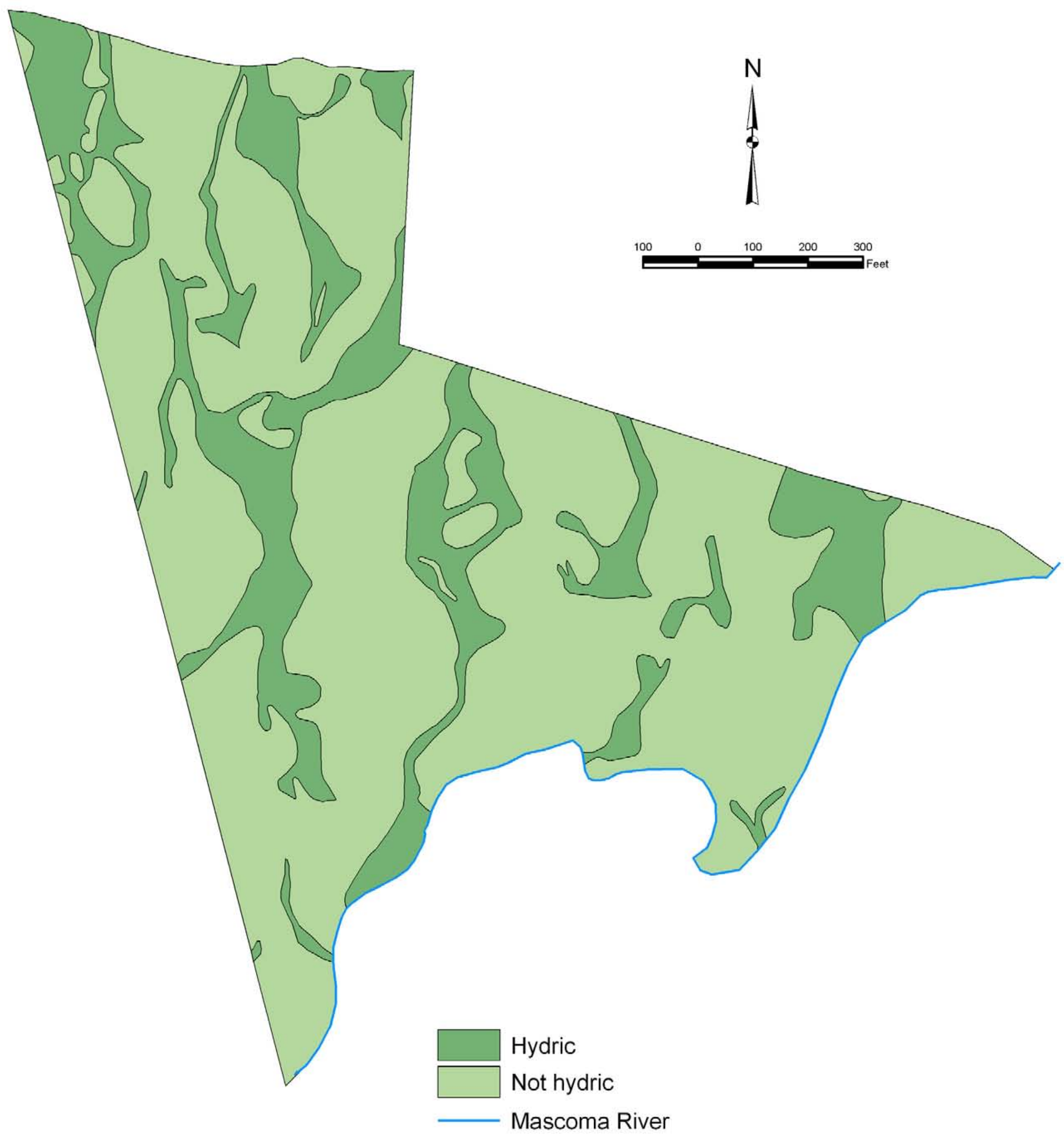
MASCOMA HEADWATERS PROJECT
HYDRIC SOILS DISTRIBUTION: REGIONAL HYDRIC SOILS INDICATORS,1995




MASCOMA HEADWATERS PROJECT
HYDRIC SOILS DISTRIBUTION:
NATIONAL HYDRIC SOILS INDICATORS, 1996
N
100 0 100 200 300
Feet
Hydric
Not hydric
Mascoma River

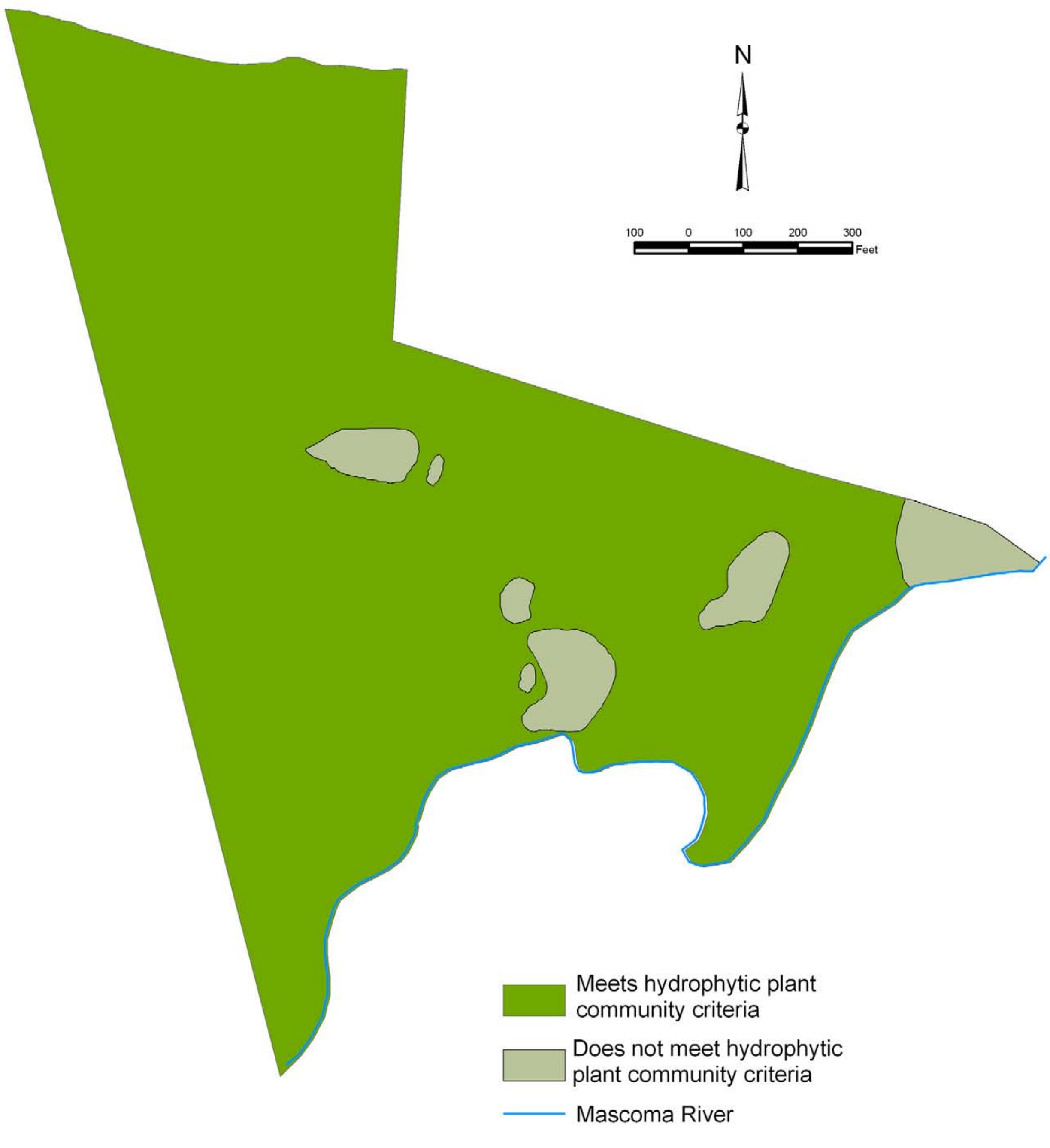

MASCOMA HEADWATERS PROJECT
HYDRIC SOILS DISTRIBUTION:
REGIONAL HYDRIC SOILS INDICATORS, 1998
N
100 0 100 200 300
Feet
Hydric
Not hydric
Mascoma River

MASCOMA HEADWATERS PROJECT
HYDRIC SOILS DISTRIBUTION: NATIONAL HYDRIC SOILS INDICATORS, 1998



MASCOMA HEADWATERS PROJECT

HYDRIC SOILS DISTRIBUTION: HYDROPHYTIC PLANT COMMUNITIES (ACOE, 1987)



Appendix F

Estimated Growing Season Dates for Hanover, NH (1961-1990)

Source: National Water and Climate Center, USDA—NRCS, Portland, OR

Growing Season
USDA NRCS National Water and Climate Center

WETS Station : HANOVER, NH3850 Creation Date: 08/30/1999
Latitude: 4342 Longitude: 07217 Elevation: 600
State FIPS/County(FIPS): 33009 County Name: Grafton
Start yr. - 1961 End yr. - 1990

GROWING SEASON DATES

	Temperature		
Probability	24 F or higher	28 F or higher	32 F or higher
	Beginning and Ending Dates Growing Season Length		
50 percent *	4/21 to 10/23 186 days	5/ 4 to 10/10 159 days	5/16 to 10/1 137 days
70 percent *	4/17 to 10/27 193 days	4/30 to 10/14 167 days	5/13 to 10/4 144 days

* Percent chance of the growing season occurring between the Beginning and Ending dates.

Appendix G

Bud Score Ratings for Possible Indicator Plants (1998-2001)

Possible Bud Score Indicator Plants.

Yellow birch consistently reached a bud score of 1 either on, immediately before, or directly after the hydric sites average reached a bud score of 1.

	SITE / INDICATOR PLANT	BUD SCORE	SITE / INDICATOR PLANT	BUD SCORE	SITE / INDICATOR PLANT	BUD SCORE	SITE / INDICATOR PLANT	BUD SCORE
YEAR 1998								
4/13/1998 CD 103	site 3		site 4		site 6		site 8	
	goldthread	1	goldthread	1	pin cherry	1		
	wood sorrel	1	blue bead lily	1	twin flower	1		
	bunchberry	1	wood sorrel	1	hobblebush	1		
	yellow birch	0	bunchberry	1	striped maple	1		
			S W Fern	1	yellow birch	0		
			dew drop	1				
			yellow birch	0				
4/16/1998 CD 106	site 3		site 4		site 6		site 8	
	balsam fir	1	Balsam fir	1	red maple	1		
	black spruce	1	dew drop	1	balsam fir	1		
	yellow birch	2	black spruce	1	yellow birch	1 to 2		
			yellow birch	2				
YEAR 1999								
4/16/1999 136	site 3		site 4		site 6		site 8	
	goldthread	1	Hay sc fern	1	pin cherry	1	red maple	1
	bunchberry	1	goldthread	1	red maple	1	balsam fir	1
	twin flower	1	blue bead lily	1	twin fl	1	pin cherry	1
	yellow birch	1	wild sarsaparilla	1	yellow birch	1	wood sorrel	1
			bunchberry	1	striped maple	1	striped maple	1
			dew drop	1	mtn maple	1	yellow birch	1
			yellow birch	1			pin cherry	1
			painted trillium	1			mtn ash	1
4/18/1999 CD 138								
4/19/1999 CD 139	site 3		site 4		site 6		site 8	
	goldthread	1.5	goldthread	1	pin cherry	2	goldthread	1
	bunchberry	1	wood sorrel	2	red maple	1	pin cherry	1
	twin fl	1	bunchberry	1	twin flower	1	red maple	0.5
			yellow birch	1	hobblebush	1	balsam fir	1
					yellow birch	1	mtn ash	2
					low bush blue	1.5		
YEAR 2000								
4/20/2000 CD 141	site 3		site 4		site 6		site 8	
	goldthread	1	Hay scented fern	1	pin cherry	1	pin cherry	1
	bunchberry	1	goldthread	1	twin fl	1	wild sarsaparilla	1
	dew drop	1	wood sorrel	1	yellow birch	1	red maple	1
	twin fl	1	bunchberry	1	mtn holly	1	balsam fir	1

			dew drop	1			pin cherry	1
			yellow birch	1			striped maple	1
							mtn ash	1
							mtn holly	1
4/25/2000 CD 146**	site 3		site 4		site 6		site 8	
	wood sorrel	1	blue bead lily	1	red maple	1	pin cherry	1
	bunchberry	1	wood sorrel	1	red maple	1	red maple	1
	S W Fern	1	dew drop	1	yellow birch	1	balsam fir	1
	yellow birch	1	S W Fern	1	low b blue	1	S W Fern	1
			yellow birch	1	mtn holly	1	striped maple	1
							yellow birch	1
4/26/2000 CD 147	site 3		site 4		site 6		site 8	
	goldthread	1	Hay scented fern	1	pin cherry	1	wild sarsaparilla	1
	balsam fir	1	goldthread	2	red maple	1	red maple	1.5
	balsam fir	1	balsam fir	1	red maple	1	balsam fir	1
	wood sorrel	1	wood sorrel	1	balsam fir	1	wood sorrel	1
	bunchberry	1	bunchberry	1	twin fl	1.5	striped maple	1
	dew drop	1	dew drop	2	mtn maple	1	yellow birch	1
	twin fl	1	yellow birch	2	low b blue	1	low b blue	1
	yellow birch	1	star flower	1			mtn holly	1
YEAR 2001	(snow on ground late in season!)							
4/26/2001 CD 116	site 3		site 4		site 6		site 8	
	snow herb		snow herb		snow herb		snow herb	
	hobblebush	1	yellow birch	1	yellow birch	1	yellow birch	1
	yellow birch	1			red maple	1	am beech	1
					hobblebush	1		
					striped maple	1		
					mtn maple	1		
5/2/2001 CD 122	site 3		site 4		site 6		site 8	
	goldthread	1	goldthread	1	red maple	1	goldthread	1
	balsam fir	1	wood sorrel	1	twin fl	1	balsam fir	1
	bunchberry	1	bunchberry	1	hobblebush	1	yellow birch	3
	twin fl	1	dew drop	1	low b blue	1	low b blue	1
							am beech	1
5/3/2001 CD 123*								
5/4/2001 CD 124	site 3		site 4		site 6		site 8	
	goldthread	1	goldthread	2	red maple	2	goldthread	1
	balsam fir	1	balsam fir	1	balsam fir	1	red maple	1
	balsam fir	1	wood sorrel	1	balsam fir	1	balsam fir	1
	wood sorrel	1	bunchberry	1	twin fl	3	balsam fir	1
	bunchberry	2	cinnamon fern	1	low b blue	2	wood sorrel	1
	hobblebush	1					S W Fern	1
							yellow birch	3
							am beech	1

Note: Plants that had a bud score of 1 or more when hydric sites average bud score reached 1 (when growing season began) are indicated by a double asterisk. Calendar day (CD) is included. Not all plants included in the table.

Appendix H

Folistic/Histic Epipedon Transects

Folistic Transects—Field Results

ORGANIC HORIZON NOTECARD

Map Unit / Series - Typic Borosaprist (Mapped as Peacham 549A)	**Date -** 5/31/01
Observer - Joe Homer, Steve Hundley	
Location - Mascoma Wetlands Project, Dorchester, NH, - 10 feet South of grid point 420 - Transect point 1A	
Vegetation - Sphagnum (surface), Black Spruce, Balsam Fir, Yellow Birch	
Slope - 0% **Aspect**	**Elevation -** 1400 ± **Drainage -** VPD

Depth inches (cm)	Horizon	Fiber % Unrubbed	Fiber % Rubbed	Mineral Texture	Color Ped Face	Color Rubbed	Structure	Roots # and Size
0 - 2 (0 - 5)	Oa1	50	< 5	--	7.5YR 2.5/1	7.5YR 2.5/1	none	3 f & m
2 - 19 (5 - 48)	Oa2	10	0	--	10YR 2/1	10YR 2/1	none	1 vf & f
19 - 26 (48-66)	Oa3	50 - 70	0	fine silt 20% Á	5Y 2.5/1 70% 2.5Y5/3 30%Â	10YR 2/1	none	none
26 + (66+)	À							

Additional Notes

À Stone at 26"

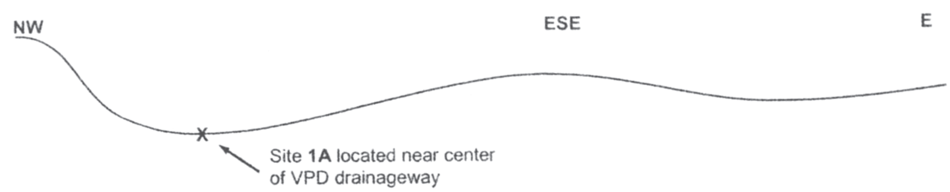
Á Rubbed texture is very smooth and greasy. If any mineral at all it would be fine silt and clay, these textures are not characteristic of the Mascoma site. (Steve says maybe 20% mineral.)

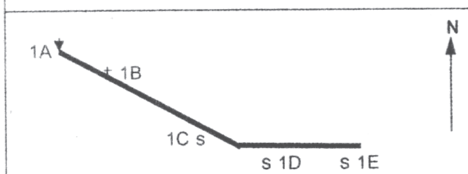
Â 2.5Y5/3 associated with woody fragments and undecomposed leaf material

? Does the Oa3 have a Coprogenous Earth component ?

- Water seeping slowly into hole. There is standing water at the surface about 4 feet from the hole. After 30 mins. water is 18" from the surface.
- Sample #'s - 0 to 5 cm, Oa1, S-01-NH-009-1-1
  - 5 to 48 cm, Oa2, S-01-NH-009-1-2
  - 48 to 66 cm, Oa3, S-01-NH-009-1-3

Landscape Sketch





Approximate location of transect points

ORGANIC HORIZON NOTECARD

Map Unit / Series - 549A Peacham	**Date** - 5/31/01
Observer - Joe Homer, Steve Hundley	
Location - Mascoma Wetlands Project, Dorchester, NH, - 40 feet SE of grid point 420 - Transect point 1B	
Vegetation - Black Spruce, Balsam Fir, Red Maple, Yellow Birch	
Slope - 2% / **Aspect** NNW / **Elevation** - 1402 ±	**Drainage** - VPD

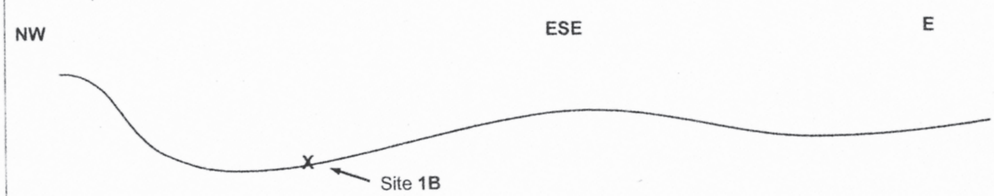
Depth inches (cm)	Horizon	Fiber % Unrubbed	Fiber % Rubbed	Mineral Texture	Color Ped Face	Color Rubbed	Structure	Roots # and Size
0 - 13 (0 - 33)	Oa	5	0	m sand À	7.5YR 2.5/1	7.5YR 2.5/1	2 m abk	2 vf & f
13 - 15 (33-38)	Bg1	10	0	LS	2.5Y 4/2			none
15+ (38+)	Bg2	50 - 70	0	LS	2.5Y 5/2			none

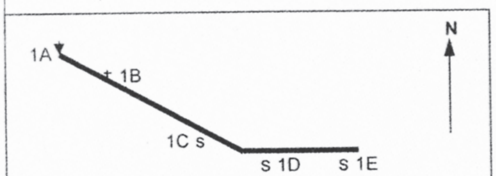
Additional Notes

À ≤ 5% medium sand on ped faces.

- Sample #'s - 0 to 33 cm, Oa1, S-01-NH-009-2-1.
- Approximately 30 feet between site 1A and 1B.
- Elevation difference between site 1A and 1B, 23 inches.

Landscape Sketch





Approximate location of transect points

ORGANIC HORIZON NOTECARD

Map Unit / Series - 944, SWPD Sunapee w/ortstein	**Date** - 5/31/01
Observer - Joe Homer, Steve Hundley	
Location - Mascoma Wetlands Project, Dorchester, NH, - Transect point 1C	
Vegetation - Yellow Birch, Red Maple, Black Spruce, Balsam Fir	
Slope - / **Aspect** NNW / **Elevation** - 1407 ±	**Drainage** - SWPD

Depth inches (cm)	Horizon	Fiber % Unrubbed	Fiber % Rubbed	Mineral Texture	Color Ped Face	Color Rubbed	Structure	Roots # and Size
0 - 1 (0- 2.5)	Oi	95	80	--	7.5YR 2.5/2	7.5YR 2.5/2	--	3 vf & f, 1 m
1 - 9 (2.5-23)	Oa	5 - 10	0	fine sand À	7.5YR 2.5/1	2.5/N	1 f gr Á	2 vf & f
9 + (23+)	E	0	0					

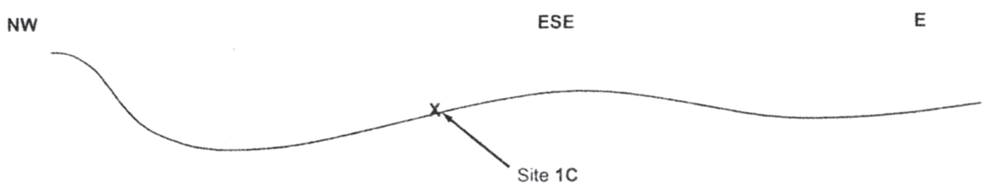
Additional Notes

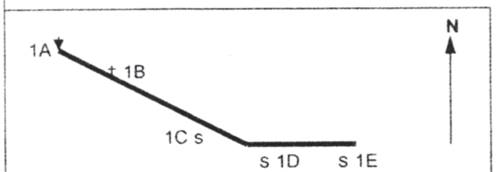
À $\leq$ 5% medium sand on ped faces.

Á Coarse platy structure parting to weak fine granular.

- Sample #'s - 2.5 to 23 cm, Oa1, S-01-NH-009-3-1.
- Approximately 38 feet between site 1B and 1C.
- Elevation difference between site 1B and 1C, 58 inches.

Landscape Sketch





Approximate location of transect points

ORGANIC HORIZON NOTECARD

Map Unit / Series - 944, SWPD Sunapee w/ortstein			**Date -** 5/31/01
Observer - Joe Homer, Steve Hundley			
Location - Mascoma Wetlands Project, Dorchester, NH, - Transect point 1D			
Vegetation - Red Maple, Yellow Birch			
Slope -	**Aspect**	**Elevation -** 1408.5 ±	**Drainage -** SWPD

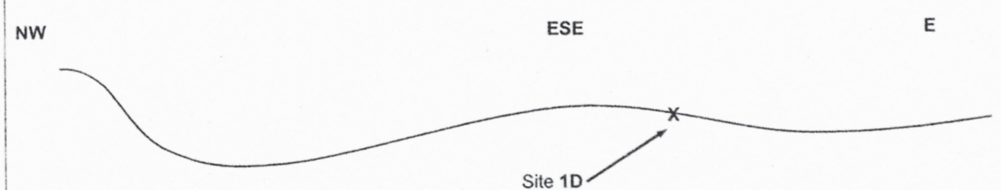
Depth inches (cm)	Horizon	Fiber % Unrubbed	Fiber % Rubbed	Mineral Texture	Color Ped Face	Color Rubbed	Structure	Roots # and Size
0 - 4 (0 - 10)	Oa1	10	0	fine sand À	7.5YR 2.5/1	7.5YR 2.5/1	1 f gr	2 vf, f & m
4 - 9 (10-23)	Oa2	0	0		2.5/N	2.5/N	1 f gr	2 vf & f
9 + (23+)	E	0	0					

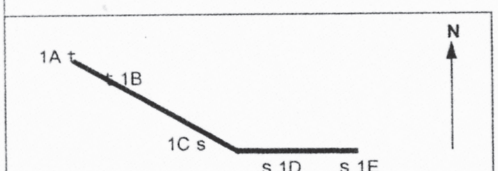
Additional Notes

À ≤ 5% fine sand on ped faces.

- Sample #'s - 0 to 10 cm, Oa1, S-01-NH-009-4-1.
  - 10 to 23 cm, Oa2, S-01-NH-009-4-2.
- Approximately 75 feet between site 1C and 1D.
- Elevation difference between site 1C and 1D, 17 inches.

Landscape Sketch





Approximate location of transect points

ORGANIC HORIZON NOTECARD

Map Unit / Series - 549A, Peacham	**Date** - 5/31/01
Observer - Joe Homer, Steve Hundley	
Location - Mascoma Wetlands Project, Dorchester, NH, - Transect point 1E	
Vegetation - Sphagnum (surface), Black Spruce, Balsam Fir, Yellow Birch	
Slope - 0% / **Aspect** / **Elevation** - 1406.5 ±	**Drainage** - VPD

Depth inches (cm)	Horizon	Fiber % Unrubbed	Fiber % Rubbed	Mineral Texture	Color Ped Face	Color Rubbed	Structure	Roots # and Size
0 - 5.5 (0 - 14)	Oa1	20	0	f sand 5%	7.5YR 2.5/1	7.5YR 2.5/1	none	1 vf & f
5.5 - 13 (14-33)	Oa2	5 -10 À	0	silt 20%	10YR 3/2	10YR 3/2	none	none

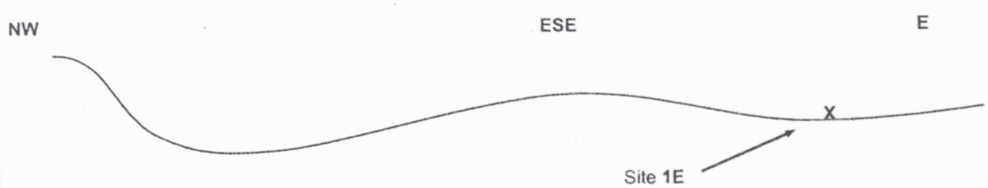
Additional Notes

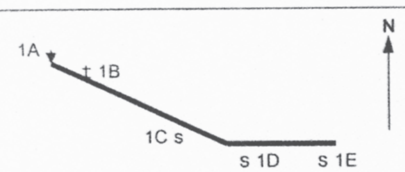
À 2% woody fragments.

? Does the Oa2 have a Coprogenous Earth component ?

- Sample #'s - 0 to 14 cm, Oa1, S-01-NH-009-5-1
  - 14 to 33 cm, Oa2, S-01-NH-009-5-2
- Approximately 15 feet between site 1D and 1E.
- Elevation difference between site 1D and 1E, 26 inches.

Landscape Sketch





Approximate location of transect points

ORGANIC HORIZON NOTECARD

Map Unit / Series - Typic Borosaprist (Mapped as 549A Peacham)			**Date -** 6/1/01
Observer - Steve Hundley, Joe Homer			
Location - Mascoma Wetlands Project, Dorchester, NH, - 50 feet Southeast of grid point 449 - Transect point 2A			
Vegetation - Aspen, Yellow Birch, Red Maple			
Slope - 0%	**Aspect**	**Elevation -** 1400±	**Drainage -** VPD

Depth inches (cm)	Horizon	Fiber % Unrubbed	Fiber % Rubbed	Mineral Texture	Color		Structure	Roots # and Size
					Ped Face	Rubbed		
0 - 20 (0 - 50)	Oa1	30	< 5	--	7.5YR 2.5/1	7.5YR 2.5/1	none	none
20 - 40 (50-100)	Oa2	10	0	sil	10YR 3/2	10YR 2/1	none	none

Additional Notes

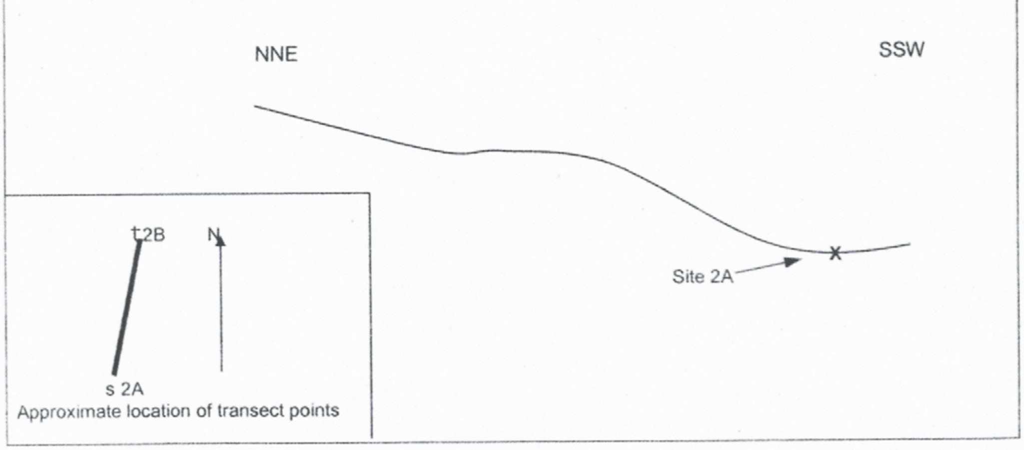
À 2% woody fragments in the Oa2 from 20 to 40".

? Does the Oa2 have a Coprogenous Earth component ?

- Water seeping into hole, after 30 mins. water is 2" from the surface.
- Sample #'s - 0 to 50 cm, Oa1, S-01-NH-009-6-1
  - 50 to 75 cm, Oa2, S-01-NH-009-6-2 (wet, sloppy conditions prevented sampling from 75 to 100 cm).

This is a deep organic soil, didn't reach bottom at 40". Underlying material is presumed to be limnic sediments deposited during open water stage of bog development. The percentage of mineral material in the "limnic" material is being debated. If there is mineral material it would be primarily fine silt and clay. If this area was once open water, it stands to reason the coarse material would settle out near the shore line and the finer suspended material would settle out at the bottom of the water body along with leaf litter (organic component). This might explain the mineral component (if any) being silty, when the general nature of the soils in the region are coarse textured (lfs, ls).

Landscape Sketch



ORGANIC HORIZON NOTECARD

Map Unit / Series - 469 Sunapee w/ortstein	**Date** - 6/1/01
Observer - Steve Hundley, Joe Homer	
Location - Mascoma Wetlands Project, Dorchester, NH, - 50 feet SSW of grid point 433 - Transect point 2B	
Vegetation - Yellow Birch, Red Maple, White Birch	
Slope - / **Aspect** / **Elevation** - 1410±	**Drainage** - MWD

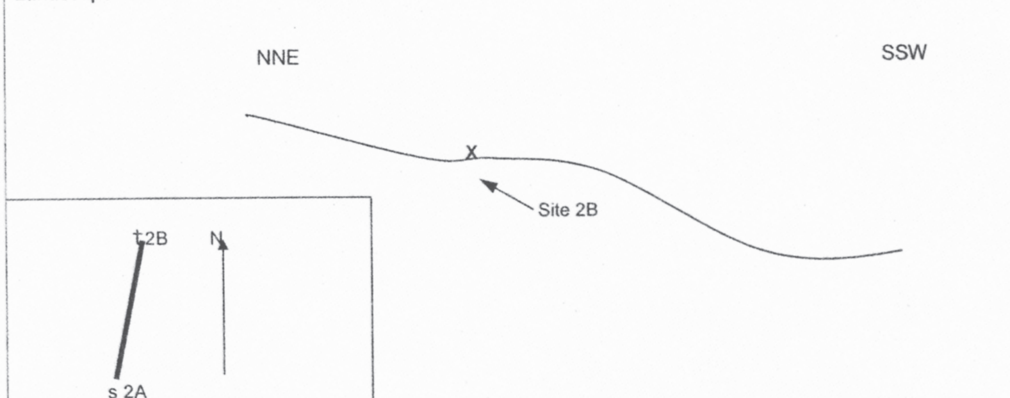
Depth inches	Horizon	Fiber % Unrubbed	Fiber % Rubbed	Mineral Texture	Color Ped Face	Color Rubbed	Structure	Roots # and Size
0 - 11 (0 - 28)	Oa	≤ 5	0	f sand <5%	5YR 2.5/1 À	5YR 2.5/1	1 f gr	2 vf & f, 1 m
11 + (28+)	E							

Additional Notes

À 10% woody fragments in the Oa are 10R 3/3.

- Sample # - 0 to 28 cm, Oa, S-01-NH-009-7-1

Landscape Sketch



Approximate location of transect points

ORGANIC HORIZON NOTECARD

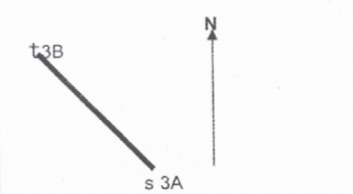
Map Unit / Series - 549A, Peacham	**Date** - 6/1/01
Observer - Steve Hundley, Joe Homer	
Location - Mascoma Wetlands Project, Dorchester, NH, - 40 feet Northwest of grid point 418 - Transect point 3A	
Vegetation - Sphagnum (surface), Black Spruce, Balsam Fir, Yellow Birch, Red Maple	
Slope - 0% **Aspect**	**Elevation** - 1400± **Drainage** - VPD

Depth inches	Horizon	Fiber % Unrubbed	Fiber % Rubbed	Mineral Texture	Color Ped Face	Color Rubbed	Structure	Roots # and Size
0 - 4 (0 - 10)	Oa1	5	0	< 2%	10YR 2/1	10YR 2/2	1 f gr	2 vf & f
4 - 15 (10 - 38)	Oa2	20	0	20% sil	10YR 3/2 2.5Y 3/2	10YR 3/2	none	none

Additional Notes

- Water seeping into hole, after 30 mins. water is 2" from the surface.
- Sample #'s - 0 to 10 cm, Oa1, S-01-NH-009-8-1
  - 10 to 38 cm, Oa2, S-01-NH-009-8-2

Landscape Sketch



Approximate location of transect points

ORGANIC HORIZON NOTECARD

Map Unit / Series - 549A, Peacham	**Date** - 6/1/01
Observer - Steve Hundley, Joe Homer	
Location - Mascoma Wetlands Project, Dorchester, NH, - 30 feet Northwest of grid point 431 - Transect point 3B	
Vegetation - Black Spruce, Balsam Fir, Eastern Hemlock, Red Maple	
Slope - **Aspect** East **Elevation** - 1410±	**Drainage** - MWD

Depth inches	Horizon	Fiber % Unrubbed	Fiber % Rubbed	Mineral Texture	Color Ped Face	Color Rubbed	Structure	Roots # and Size
0 - 2 (0 - 5)	Oe	85	50	--	7.5YR 2.5/2	7.5YR 2.5/2	1 f gr	3 vf & f, 1 m
2 - 13 (5 - 33)	Oa	5	0 –	f sand <2%	7.5YR 2.5/1	7.5YR 2.5/1	1 f gr À	2 vf & f, 1 m
13+ (33+)	E							

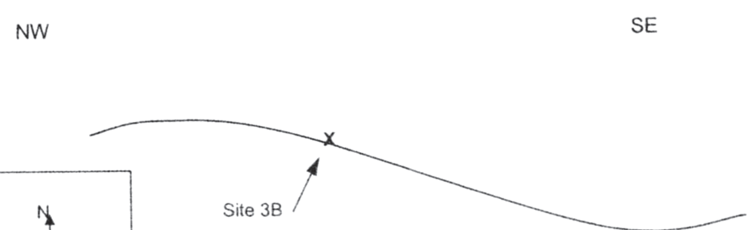
Additional Notes

À Very thick platy structure, parting to weak fine granular.

– 5% woody fragments in the Oa horizon.

- Sample #'s - 0 to 5 cm, Oe, S-01-NH-009-9-1
  - 5 to 33 cm, Oa, S-01-NH-009-9-2

Landscape Sketch



Approximate location of transect points

Appendix I

Folistic Transects—Lab Results

Grafton County, New Hampshire - Mascoma Project

Folic - Histic Epipedon Transects

Pedon	Site	DEPTH					pH		Extractable Bases (NH4oAc)				Ext.			Fiber Content		NaPyro	Decomp.	15-bar Water		
		Top	Base	Horizon		C	CaCl2	H20	Ca	Mg	Na	K	Acidity	CEC-7	Ext. Al	Unrub	Rub	Color	State	Moist	Air-dry	
		cm							meq/100 g soil				me/100g			percent (by vol.)				percent		
S01NH-9-1	1A	0	5	Oa1	histic	44.76	5.0	5.6	17.2	1.9	0.0	0.2	87.0	6.9	3.1	60	44	10YR 6.5/3	hemic	413.5	78.8	histic
		5	48	Oa2		47.57	5.2	5.8	55.7	4.0	0.0	0.0	101.4	24.7		40	20	10YR 6/3	hemic	180.0	56.6	
		48	66	Oa3		35.34	5.8	6.4	53.8	4.1	0.0	0.0	59.4	22.7		20	4	10YR 8/2	sap/copr	116.0	48.7	
S01NH-9-2	1B	0	33	Oa	folistic	45.73	3.7	4.4	3.9	0.0	0.0	0.0	155.4	32.9	21.0	44	20	10YR 6.5/4	hemic	93.1	35.0	?
S01NH-9-3	1C	3	23	Oa1	folistic	53.75	2.7	3.2	7.4	1.7	0.0	0.0	198.2	20.6	9.2	64	16	10YR 7/3.5	hemic	154.9	82.7	folistic
S01NH-9-4	1D	0	10	Oa1	folistic	55.65	2.7	3.3	7.6	1.2	0.0	0.1	156.6	140.8	4.8	80	40	10YR 8/3	fibric	187.0	101.0	
		10	23	Oa2		55.84	2.6	3.1	8.5	0.5	0.0	0.0	184.6	40.5	5.4	56	20	10YR 6/3	hemic	207.0	113.0	
S01NH-9-5	1E	0	14	Oa1	histic	48.85	3.8	4.4	12.6	0.7	0.0	0.0	102.7	17.3	7.0	52	36	10YR 6.5/3	hemic	106.3	87.9	histic
		14	33	Oa2		27.06	4.0	4.6	2.2	0.0	0.0	0.0	80.9	104.2	6.3	18	8	10YR 7/3	hemic	110.9	31.7	
S01NH-9-6	2A	0	50	Oa1	histic	43.16	4.7	5.1	44.3	3.0	0.0	0.0	81.7	38.1	1.4	52	28	10YR 6/3	hemic	150.4	70.7	histic
		50	100	Oa2		38.31	5.9	6.1	82.6	7.5	0.0	0.0	54.6	26.3		44	20	10YR 6/2	hemic	167.8	62.3	
S01NH-9-7	2B	0	27	Oa1	folistic	54.56	2.7	3.3	24.4	0.9	0.0	0.0	152.7	181.8	2.4	64	20	10YR 6/4	hemic	125.5	82.5	folistic
S01NH-9-8	3A	0	10	Oa1	histic	38.83	3.6	4.3	9.4	0.6	0.0	0.0	108.5	28.5	7.7	32	20	10YR 6/3	hemic	108.0	69.2	histic
		10	38	Oa2		33.62	3.9	4.6	4.3	0.0	0.0	0.0	93.6	24.0	6.7	48	20	10YR 6/3	hemic	75.4	29.6	
S01NH-9-9	3B	0	5	Oe	folistic	55.00	3.3	3.8	21.0	3.5	0.0	1.8	135.3	112.1	1.6	92	72	10YR 8/2	fibric	206.8	76.3	folistic
		5	33	Oa		57.50	2.4	2.9	11.9	1.1	0.0	0.0	189.0	9.2	3.1	76	28	10YR 5.5/5		212.7	100.5	

Data trends

1. Total C: folistic - 53-57%; histic - 27-49%
2. Total S: histic > folistic
3. pH (H2O): folistic 2.9-3.8; histic 4.3-6.4
4. pH (CaCl2): folistic 2.4-3.3; histic 3.6-5.9
5. Ext. Acidity: folistic 135-198; histic 59-108 (me/100g)
6. 15-bar (air dry): folistic 76-113; histic 30-88 (%by wt.)
7. 15-bar (moist): folistic 125-212; histic 75-413 (%by wt.)

pH - Ext. CA - Ext. Acidity - CEC-7 and Ext. Al

Ext. Acidity and (total)C seem go togther (see 'exch' sheet)