**2008 and 2009 Soil Description and Sampling Protocols** ***Updated 04.27.10***

**Overview:**

Soil pit descriptions and soil samples were collected once at all LEMP plots established in 2008 and 2009. Three soil pits per LEMP plot were dug, described, and sampled using the protocols described herein. Soil samples were air dried, then sent to the Northern Research Station for analysis and archiving***.*** LEMP plots were designed to accommodate the digging of three soil pits at each re-sampling entry. Soils should be re-sampled every 10 years.

Protocols for pit digging, soil descriptions, and soil sampling are the same as those developed in 2007 by the Vermont Monitoring Cooperative (VMC), for the 5th year sampling at the Cooperatives’ Long-term Soil Monitoring plots at Mount Mansfield and Lye Brook Wilderness.

All protocols and activities described should be followed as closely as possible during future sampling occasions, unless otherwise noted.

**Topics:**

1. Pre-field and field determination of pit locations
2. Soil pit digging
3. Soil description protocols
4. Soil sampling protocols for long-term study
5. Refilling excavated soil pits
6. Soil sample transport
7. Future need for additional soil rectangles
8. **Pre-field and field determination of pit locations**

Three pits were dug per LEMP plot. Each of the three soil pits sampled per entry was located within a randomly selected 5x5 meter “soil square”, with one pit being located in each “soil rectangle”. The soil rectangles were situated outside and between annular plots (see Figure A: Location of soil rectangles and 5x5 meter soil squares). All field measurements were done using a metal, cloth, or fiberglass tape. Azimuths were measured with a good quality hand-held compass set to a declination of 15 degrees west. No other resource sampling was done within the soil rectangles.

Each soil pit was normally located at the center of each 5x5 m square. However, the pit was moved slightly toward an edge of the square when the center was not representative or when soils were too wet or rocky to dig a pit. On rare occasions, entire squares were eliminated due to unusually high soil wetness or extreme surface stoniness. The summer of 2009 was one of the wettest on record in Vermont.

Figure A. Location of soil rectangles and 5x5 meter soil squares.

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# Soil Pit Digging

A soil pit at least 24 inches wide by 36 inches long and 0.7-0.9 mdeep (27 inches or more) was dug at the approximate center of each 5x5 m square. The exact pit location was moved to avoid obstacles such as large boulders. All excavated material from the soil pit was placed on plastic tarps to avoid contamination of surrounding surface soil. Since the north wall of each pit was to be described by the soil scientist, this side of the pit was dug straight and smoothed over. In addition, the surface above the north wall remained undisturbed. The surface organic matter was stockpiled separately from the remainder of the soil. When the pit was filled back in, the organic matter was put back last.

An experienced Soil Scientist described all soil pit profiles. This assured consistency in horizon delineation and designation.

1. **Soil Description Protocols**

Thom Villars, an experienced Soil Scientist with the NRCS, described all the soil pit profiles. Thom also did many soil pit descriptions at the VMC Long-term Soil Monitoring plots at the initial and 5th year sampling periods. There should, therefore, be good consistency between pits described for the LEMP and the VMC project.

There were no criteria for minimum horizon thickness (and extent, for discontinuous horizons like E horizons) in describing the soil profiles. However, not all horizons that were described were sampled. It was too difficult to collect enough soil material for lab analysis if a soil horizon was only a centimeter or two thick.

Soils were described using NRCS procedures referenced in the Field Book for Describing and Sampling Soils, version 2.0, September, 2002 (or newer versions). The Soil Profile Description Form was provided by Villars, based on the form in the Field Book, page 2-75.

The following soil physical properties were described. The numbers in parentheses refer to page numbers in the Field Book referencing that property. There are also tabs on the sides of the Field Book pages for quick access to different sections.

* Horizon Designation and lower Boundary (pgs 2-2 to 2-6).
* Depth of horizon (upper and lower) in centimeters
* Matrix color, moist, Munsell notation
* Texture (pgs 2-29 to 2-31)
* Percent rock fragments by volume (shape- pg 2-40, note basic Percent Chart on page 2-9 – some Munsell color books also have a Percent Chart)
* Structure; grade, size, and type (pgs 2-41 to 2-48)
* Consistence, moist (also referred to as Rupture Resistance, pgs 2-49 to 2-50)
* Redoximorphic features; quantity, size, contrast – and Munsell color (pgs 2-14 to 2-17; see also quantity, size and contrast charts under Mottles on pgs 2-9 to 2-12)
* Roots (pgs 2-56 to 2-58)
* Other features such as: organic streaks and stains, type of organic material, moisture status
* Slope percent and Aspect
* Horizons that are sampled should also be noted

Soil chemical properties (such as pH) were not recorded in the field since they will be analyzed more accurately in the lab at a later date.

Horizon designation protocols:

O vs. A horizon designations – designation of these horizons was the decision of the soil describer at each pit. In the future, some sort of protocol might be necessary due to the difficulty of consistently separating Oi, Oe and Oa horizons from each other and in separating Oa from A horizons and in setting depths for these horizons.No transitional or mixed horizon designations, such as AE, EB or E/Bs, were used.

The B horizon designation was based on the Munsell moist color:

* Bs (horizon has appearance of having spodic properties)- had hue 7.5YR or redder, with value or chroma greater than 3;
* Bhs (horizon has appearance of having spodic properties) – had hue 7.5YR or redder, with value and chroma of 3 or less, plus hue of 10YR below an E horizon, with value/chroma of 2/1, 2/2, or 3/1.
* Bw (horizon does not have appearance of having spodic properties) - other B horizons with hue of 10YR or yellower shall be identified as Bw horizons.
* The transitional BC horizon designation was not used; instead, the Bw designation was used for lower B horizons.Where there was more than one Bw horizon, they were numbered consecutively.
* For additional information linking horizon designation to soil color, see the following table.

**Typical Munsell Soil Colors for mineral soil horizons for GMNF Long-term Ecosystem Monitoring Project**

|  |  |
| --- | --- |
| **Mineral Soil Horizon** | **Munsell colors (for moist soil)** |
| A | N 2/ , 5YR 2.5/1, 7.5YR 2/2, 7.5YR 2.5/1, 10YR 2/1, 10YR 2/2, 10YR 3/1 ,10YR 3/2 |
| E | 5YR 4/2, 5YR 5/2, 5YR 5/3 (only E color with chroma > 2, but ok) 7.5YR 4/1, 7.5YR 4/2, 7.5YR 5/1, 7.5YR 5/2, 7.5YR 6/2,10YR 4/1, 10YR 4/2, 10YR 5/2, 10YR 6/2, 10YR 7/1, 10YR 7/2 |
| Bhs  | 5YR 2.5/1, 5YR 2.5/2, 5YR 3/1, 5YR 3/2 5YR 3/3,7.5YR 2.5/1, 7.5YR 2.5/2, 7.5YR 2.5/3, 7.5YR 3/2, 7.5YR 3/3 |
|  | Bhs criteria - have hue 7.5YR or redder, with value and chroma of 3 or less, plus hue of 10YR below an E horizon, with value/chroma of 2/1, 2/2, or 3/1. |
| Bs | 7.5YR 3/4, 7.5YR 4/3, 7.5YR 4/4, 7.5YR 4/6, 7.5YR 5/4, 7.5YR 5/6, 7.5YR 5/8 |
|  | Bs criteria - have hue 7.5YR or redder, with value or chroma greater than 3. |
| Bw  | 10YR 3/2, 10YR 3/3, 10YR 3/4, 10YR 3/6, 10YR 4/3, 10YR 4/4, 10YR 4/6, 10YR 5/3, 10YR 5/4, 2.5Y 3/2, 2.5Y 3/3, 2.5Y 4/3, 2.5Y 5/3, 2.5Y 5/4 |
|  | Bw criteria - other B horizons not meeting Bhs or Bs criteria with hue of 10YR or yellower shall be identified as Bw horizons.  |
| Cd | Typical colors range from 10YR to 5Y hue, with value and chroma of 3 or more. |

# Soil Sampling Protocols for Long-term Study

Sampling incorporated genetic horizon sampling and bulk depth increment sampling. The genetic horizon samples will be archived as reference samples and the bulk depth increment samples will be used for all analytical work and will also be archived.

Genetic Horizon Sampling

Genetic horizon samples were taken for all horizons from the side of the pit that was described using a knife, trowel, or other hand tools. All horizon samples were collected in 4-ounce clear polyethylene sterile bags. Bags were labeled with the two-digit LEMP plot name followed by the pit soil rectangle and soil square numbers (for example Z-10). The date, horizon name, and sampling depth are also recorded on the bag using a permanent marker.

Bulk depth increment sampling

Bulk depth increment sampling consisted of collecting one gallon of material from:

1. the Oi and Oe horizons together
2. the Oa and A horizons together
3. the upper 10 cm (4 inches) of uppermost B horizon
4. a depth of 60 to 70 centimeters below the ground surface.

Bulk depth increment samples were taken from the side of the pit that was described and adjacent sides for continuous horizons, if necessary, using a knife, trowel, or other hand tools. All samples were collected to fill 60-ounce clear polyethylene sterile bags. Bags were labeled with the two-digit LEMP plot number (for example 05), followed by a dash (-), then the one-digit subplot number (1, 2, 3 or 4). The date and increment sample type (for example, “Oi + Oe”) was also recorded on the bag with a permanent marker.

1. **Refilling excavated soil pits**

Once all the soil samples were collected, soil from the tarps was replaced into the pits and topped off with the original organic layer. The goal was to not leave any soil material extracted from the pit remaining on the soil surface around the pit.

1. **Soil sample drying and transport**

Soil samples were promptly dried and then transported to the lab at Hubbard Brook Experimental Forest for analysis and archiving.

1. **Future need for *additional* Soil Rectangles**

The current LEMP plot design accommodates future soil re-sampling entries at an interval of 10 years. With 15 squares in each soil rectangle, that means there are only enough squares for re-sampling in years 10, 20, 30 and 40. This is a problem because the study period is at least 50 years. We also know that a few squares will not be usable, due to small inclusions of small rock outcrops or wet soils. To address the need for additional squares for re-sampling in the future, we recommend that another three rectangles be established for soil pits. These rectangles should be located just outside the current soil rectangles (further out from the LEM plot center), and between the annular plots for lichens. Project leaders should consider adding these rectangles at the 10th year re-sampling, then randomly select the soil squares from the total available squares within the six rectangles.