# RELATING SOIL ORGANIC CARBON TO ELEVATION FOR SEPARATION OF HUMODS AND ORTHODS IN VERMONT AND MAINE

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## INTRODUCTION

The objective of this study was to analyze the relationships between discernable landscape features and the identification of Humods and Orthods in Essex County, Vermont. Humods and Orthods are separated based on the amount of soil organic carbon (SOC) occurring in a layer 10 cm thick in the spodic horizon (Keys to Soil Taxonomy, 10th edition). The spodic diagnostic horizon may include a combination of Bhs, Bh, and Bs horizons.

In Essex County, Vermont, the suborders were initially separated based on elevation and/or landform breaks near 2000 ft (608 m). Previous investigation has indicated that Humods and Orthods can be closely intermingled. For instance, satellite samples taken near the Hogback typical pedon (Loamy, isotic, frigid Lithic Haplohumods) had SOC contents that classified in both the Humods and Orthods suborders. This distinction is important as the average SOC assigned to map units will be used in land management decisions, modeling, and planning. The primary hypothesis of this study was that SOC content would be closely related to elevation. The relationship between other landscape variables, the thickness of the Bhs horizon, and the type of horizon designation in the spodic diagnostic horizon were also considered.

## MATERIALS AND METHODS

Three sets of data were analyzed for this study: Essex County, VT (N=66), Camels Hump, VT (N=35), and sites throughout Maine (N=78). Samples were collected randomly from transects described as a part of soil survey activities. A sample was collected from each pedon's spodic diagnostic horizon. Samples were analyzed for total carbon using the dry combustion method with a CNS elemental analyzer by the National Soil Survey Laboratory (Soil Survey Staff, 2004). These soils have low pH and no carbonates present so total carbon is assumed to equal organic carbon. Particle size determination was run on a subset of those samples.

Data recorded for each pedon included genetic horizon designations in the spodic horizon, the soil series assigned at the time of sample collection ("sampled as" groups), aspect, soil depth class, and parent material. SOC did not have a normal distribution so transformed data (logSOC) and non-parametric tests were used. Statistical analysis included linear regression, analysis of variance (ANOVA), Wilcoxon rank sums, and contingency tables with chi-square tests. All statistical analysis was done with JMP (SAS, Cary, NC).

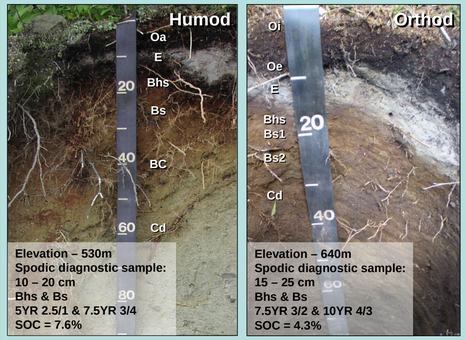





Figure 1. Two pedons sampled as Dixfield (Coarse-loamy, isotic, frigid Aquic Haplorthods) from similar landscape positions. Dixfield soils are formed in dense glacial till on drumlin and till ridges.

Figure 2. Typical pedon landscapes for the Essex County, Vermont dataset.

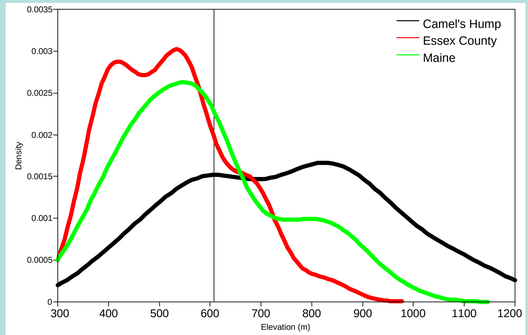


Figure 3. Density distributions of elevation for the three datasets used in this study. Reference line is at 608 m (2,000 ft).

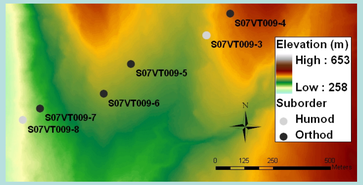


Figure 4. Example of Essex County, Vermont, pedons sampled for soil organic carbon in the spodic diagnostic horizon. Elevation, slope, and aspect were extracted from a LIDAR-derived DEM.

| Pedon | Sampled as (all Orthods) | SOC % | Elev. (m) | Slope % | Aspect | Horizon nom. | Depth sampled (cm) |
|---|---|---|---|---|---|---|---|
| 3 | Lyman | 9.4 | 574 | 24 | W | Bhs | 13 - 23 |
| 4 | Tunbridge | 5.3 | 599 | 21 | W | Bhs | 15 - 25 |
| 5 | Dixfield | 5.1 | 564 | 14 | SE | Bhs | 23 - 33 |
| 6 | Tunbridge | 5.2 | 558 | 9 | S | Bhs | 23 - 33 |
| 7 | Tunbridge | 5.9 | 504 | 35 | W | Bhs | 3 - 13 |
| 8 | Tunbridge | 6.3 | 482 | 29 | W | Bhs | 5 - 15 |

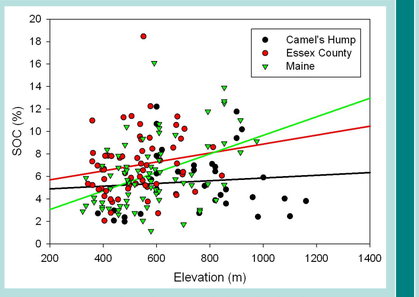


Figure 5. Regression of SOC and elevation by dataset. Transforming SOC to achieve a more normal distribution did not improve the relationship, so original values are shown.

Essex County – SOC = 4.90 + 0.0012*elevation, $r^2$ = 0.03
Camel's Hump – SOC = 4.65 + 0.0004*elevation, $r^2$ = 0.01
Maine – SOC = 1.40 + 0.0035*elevation, $r^2$ = 0.18*

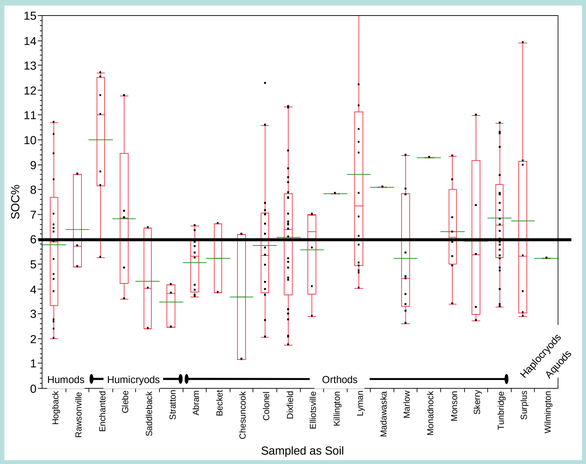


Figure 6. Box plots of SOC concentration in sampled as groups. Green lines are sampled as means. The black line represents the 6.0% SOC break between Humods and Orthods. Sampled as soils are arranged by suborder and great group (Official Soil Series Description): Hogback and Rawsonville are Humods, Enchanted – Stratton are in the Humicryod great group; Abram – Tunbridge are Orthods, Surplus is a Haplocryod, Wilmington is an Aquod. The non-parametric Wilcoxon rank sums test indicated that there was a significant difference (p=0.06) between sampled as soils in SOC content, but 16 of 18 sampled as soils with multiple pedons have values both above and below 6% SOC.

Table 1. Summary of soil organic carbon concentration (%).

| Dataset | N | Mean | Min | Max | Median | 25th pct. | 75th pct. | Coefficient of Variation (%) |
|---|---|---|---|---|---|---|---|---|
| Camel's Hump, VT | 35 | 5.6 | 2.0 | 12.2 | 4.9 | 3.0 | 7.0 | 51 |
| Essex County, VT | 66 | 7.0 | 2.1 | 18.5 | 6.6 | 5.2 | 8.3 | 39 |
| Maine | 78 | 6.2 | 1.2 | 16.1 | 5.7 | 3.9 | 7.9 | 48 |

Table 2. Contingency table of elevation class and suborder (as assigned by SOC content) with counts and total % observed. While a chi-square test is significant (p=0.05), Orthods are only 6% more likely to occur in the < 2000 ft elevation than what would be expected by a proportional assignment: 57 pedons expected (50% of 115 pedons sampled at < 2,000 ft) vs. 64 pedons observed (56% of pedons sampled at < 2,000 ft). However, the assumption of equal probabilities is not reasonable (we would expect more Orthods to be present based on the soils sampled).

| | Suborder by % SOC | | Count / % of Total |
|---|---|---|---|
| **Elevation class** | **Humods, > 6%** | **Orthods, < 6%** | **Row Total** |
| <2,000 ft, 608 m | 51 / 28% | 64 / 35% | 115 / 64% |
| >2,000 ft, 608 m | 38 / 21 % | 26 / 14% | 64 / 36 % |
| Column Total | 89 / 49% | 90 / 50% | 179 / 100% |

Table 3. Contingency table of "sampled as" suborder and great group and suborder as assigned by SOC content. Chi square test is not significant (p=0.97). A pedon sampled as a Humod was equally likely to have SOC content below or above 6%.

| | Sampled as Suborder / Great group | | Count / % of Total |
|---|---|---|---|
| **Suborder using SOC** | **Humods or Humicryods** | **Orthods, Humicryods or Aquods** | **Row Total** |
| Humods, > 6% | 19 / 11% | 70 / 39% | 89 / 50% |
| Orthods, < 6% | 19 / 11% | 71 / 40% | 90 / 50% |
| Column Total | 38 / 21% | 141 / 79% | 179 / 100% |

## CONCLUSIONS

- The relationship between SOC and elevation is very weak. The proposed elevation break of 2000 ft (608 m) does a poor job of predicting the suborder of these pedons.
- While the "sampled as" groups are significantly different from one another in SOC concentration, most sampled soils span the break between Humods and Orthods (at 6% SOC).
- Aspect, slope, soil color, horizon designation, and thickness were not significantly related to SOC content (data not shown).

This information will be used in the design and delineation of soil map units in Essex County, VT.

## REFERENCES

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NRCS Natural Resources Conservation Service