Protocol Problems in Building the Alaska Soil-Carbon Database

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ABSTRACT

There is increased demand for soil carbon data in Alaska. Carbon data from various sources are constantly cited or used as estimates. Based on our examination of data from 292 pedons (in Boreal Alaska sites only) the following problems were encountered: (1) 83% of the pedons lack some horizon bulk density (Db) measurements. (2) 47% of the pedons have OC measured by dichromate oxidation which produced results 21% higher than that from TOC by ignition. (3) 20% of the pedons are missing OC and Db data on the surface organic horizons. (4) In about 12% of the pedons the rock fragment contents were missing even though the texture modifiers were gravelly or very gravelly. (5) 3% of the pedons with missing depth increment. (6). Some Gelisol pedons lack ice content estimation. Except item 4, 5 and 6, regression equations were developed to extrapolate the missing data. To avoid larger variability other soil and site characteristics such as soil classification, horizon sequence and vegetation community must be considered when selecting data for estimating either Db or %OC for surface organic layers.

INTRODUCTION

Alaska is over 147 million ha (570,000 sq. mi) of land that covers the treeless arctic tundra in the north to boreal forests of the central and south-central areas and temperate rainforests of the southeastern coast.

The USDA soils data base is the largest available for Alaska soils. It contains data on over 500 pedons collected from 1956 to present. Combined with the UAF-soils data base this amounts to over 600 pedons across Alaska. This data base has the greatest potential for use in estimating soil OC stores in soils across Alaska as it contains data for soil properties necessary to calculate OC stores in soils across Alaska (**Figure 1**).
(*http://ssldata.nrcs.usda.gov/querypage.asp?chksa=1&ac=244&as=3946#sitevar*)
These data however were collected over a 50 year period and by numerous individuals working on projects with different goals. *Ping et al*. (2008) summarized soil OC stores for the treeless Arctic Region of N. America using data for the arctic Alaska region and most of which is available through the USDA-NRCS data base. However special techniques were necessary to calculate soil horizon thicknesses for cryoturbated soils and bulk densities for the ice rich horizons of Gelisols using data for the pedons that were not available in the data base but collected in the field.

Soil horizon properties that are essential to calculation of soil organic-C storage in a pedon are: soil horizon Organic C (%OC), bulk density (Db – g cm^3) and horizon thickness (cm).
Pedon OC (kg OC m^2) = sum of OC in horizons to depth = $\sum$ horizon OC in kgOC m^2 = (OC%/100)*(Db in g cm^3) *horizon cm thickness*10.
The question remains how complete and useful is the large USDA-NRCS data base with respect to calculating OC stores for Alaska soils in the Boreal regions of Alaska.

OBJECTIVE

To evaluate the available pedon data for use in the calculation of soil OC stores in the Boreal Alaska region of interior and south-central Alaska by examining soil data available in the USDA- NRCS soils and the UAF Soils Program data bases.

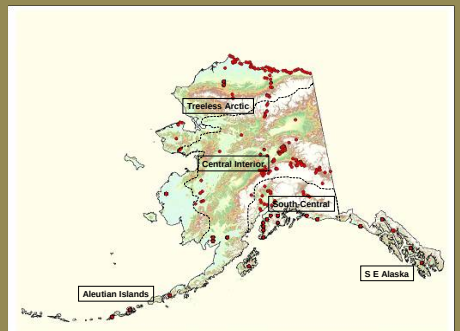

Figure 1. Map of Alaska with regions and locations with pedon points data

Table 1. Number of pedons in data bases by region.

Region	NRCS&UAF Alaska Data-Bases Number of Pedons with OC data	General Ecosystem
Arctic	108	Treeless Tundra
Central Interior	**169**	**Boreal**
S. Central	**123**	**Boreal**
Aleutian Is.	7	Maritime Tundra
SE Alaska	200	Temperate Rainforest
total	607	

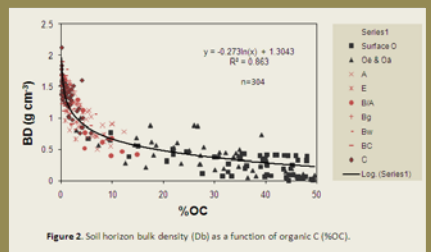

Figure 2. Soil horizon bulk density (Db) as a function of organic C (%OC).

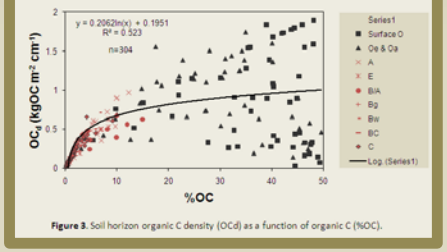

Figure 3. Soil horizon organic C density (OCd) as a function of organic C (%OC).

RESULTS

Pedons in data bases:
►There were some 292 Boreal-region pedons with data (**Table 1).**

Db Data:
►241 of the 292 or 83% of the pedons lack at least some of the essential horizon bulk density (Db) measurements.
Where data were available for total carbon (TC), the missing Db measurements can be estimated reasonably well using the relationships developed from data for Db as a function of TC (R^2=0.863, **Figure 2).**
However, the confidence of the Db estimate will vary according to horizon with mineral horizons having a much better estimate than the organic surface horizons (**Figure 3)**
These estimates can be improved with use of data from selected profiles having similar soil development characteristics (i.e. grouping soils by classification, similar horizon sequences or vegetation communities etc…)

%OC Data:
►The NRCS Data base like many older soils data bases contains soil %OC determined by the both dichromate oxidation method described by *Jackson* (1958) for some pedons and by the more recent high temperature oxidation method (*Soil Survey Laboratory Staff*, 1996).
►47% of data base pedons (137 out of 292) were analyzed by dichromate oxidation only.
► %OC data for 17 pedons (117 horizons) that were analyzed by both methods revealed a strong relationship between the results (R^2=0.991) but the dichromate oxidation over-estimated the high temperature ignition %OC by 21% (**Figure 4).**
►This relatively large difference in resulting %OC depending on analytical method is likely due to the overall lesser degree of SOM decomposition that can be expected for cold region soils. *Ping et al*. (in press) analyzed a subset of soils from the USDA-NRCS for SOM by the loss on ignition (at 400ºC) method and found SOM in Alaska soils to be 49% OC or significantly lower than the average 58% commonly used as an average for all soils (*Jackson*, 1958).

Other Data Problems:
►20% of the pedons in the USDA-NRCS data base lack both %OC and Db data for the surface organic horizons. These pedons will be difficult to use as a large portion (13 - 85%) of the OC stores could be in these horizons (Ping et al., in press)
► In about 12% of the pedons the rock fragment contents were missing even though the gravelly texture modifiers were used.
►3% of the pedons lack horizon depth ranges necessary for OC store calculations.
►Some Gelisol pedons lack ice content estimations that are critical in OC store calculations in frozen or permafrost horizons that could contain from 9% - 39% of OC stores (*Ping et al.*, in press) .

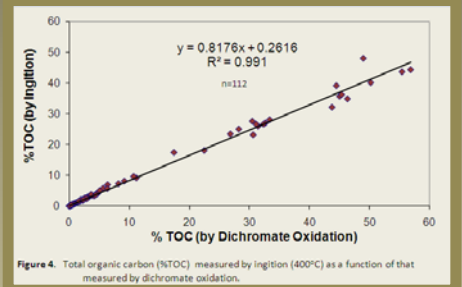

Figure 4. Total organic carbon (%TOC) measured by ingition (400ºC) as a function of that measured by dichromate oxidation.

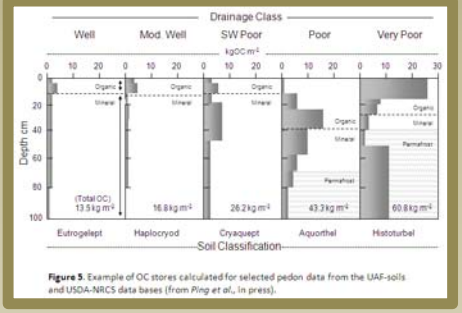

Figure 5. Example of OC stores calculated for selected pedon data from the UAF-soils and USDA-NRCS data bases (from *Ping et al.*, in press).

CONCLUSIONS

1.These data bases are the best available for Alaska soils and contain data that will be very useful in estimating OC stores for Alaska soils (**Figure 5:** from *Ping et al.*, in press**).**
2. Caution and care will have to be used in utilizing the data especially with respect to missing Db, %OC (by ignition) data or both analysis.
3. Strong relationships can be developed to estimate Db from %OC. However, other soil and site characteristics can strongly affect Db and OC-density relationships within horizons and more variability should be expected for the soil surface organic layers than in the mineral soil horizons.

References:
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Ping, C.L., G.J. Michaelson, M.H. Clark, E.S., Kane, E.C. Packee, C.A. Stiles, D.K. Swanson, and N.D. Zaman. 2009., Carbon Stores and Biogeochemical Properties of Soils under Black Spruce Forest, Alaska. ***SSSAJ*** (in press).
Ping, C.L., G.J. Michaelson, T. Jorgenson, J.M. Kimble, H. Epstein, V.E. Romanovsky, and D.A. Walker.2008. High stocks of soil organic carbon in North American Arctic region. ***Nature Geoscience***, 1(9): 615-619.
Soil Survey Laboratory Staff. 1996. Soil Survey Laboratory Manual, Soil Survey Investigations Report No. 42, Version 3.0. United States Department of Agriculture, Natural Resources Conservation Service, National Survey Center, Lincoln, NE