Patterning between urban soil color and carbon stocks

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Background

URBAN SOILS ARE LESS COMPLEX IN CONTRAST TO NON-URBAN SOILS due to land management, e.g., fill, demolition, etc. For example, urban soils have fewer horizons than non-urban soils, and are also more likely to have lost the "B" horizon [1]. Along similar lines, we hypothesize that urban soils are less complex in color and carbon concentration (Fig. 1). **Here we predict soil carbon based on color and assess how these distributions differ between urban and rural soils.** We use a combination of lab measured total carbon (TC) and estimated total carbon based on color (Munsell Value) obtained as part of the EPA urban soils assessment as well as soils data from the National Cooperative Soil Survey to compare urban and non-urban reference soils up to 150 cm depth to further understand impacts of urbanization.

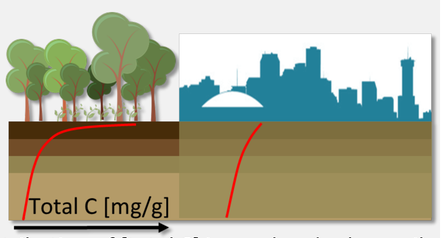

Fig. 1. *Hypothesized distribution of [total C] in rural and urban soil.*

Methods

Field Data. From 2010-2015 we carried out hydropedological assessments in 11 cities (Atlanta, GA; Camden, NJ; Cincinnati, OH; Cleveland, OH; Detroit, MI; New Orleans, LA; Omaha, NE; Phoenix, AZ; Portland, ME; San Juan, PR; Tacoma, WA). Each horizon was described taxonomically and assigned a Munsell color. We measured total carbon for all top and some sub-horizons. In addition, total organic matter was measured in all horizons and converted to TC in Detroit.

Reference Data. NRCS state soil scientists assisted in identifying soil series representative of the assessed areas pre-urbanization. Based on Official Series Descriptions and NSSC lab data of these series we built a database containing Munsell soil color and TC concentrations that was used for analysis.

Analysis. Assuming a linkage between lightness of soil (Munsell Value) and Total Carbon (TC) content we established a relationship that can be used to predict TC distribution in urban and reference soils at 1-cm resolution [2]. To estimate uncertainty between modeled and measured carbon data in urban and non-urban soils of Detroit we applied root mean square error (RMSE) and mean error (ME).

Approach

Previous works suggests a relationship between Munsell Value and SOM [3]. Building on this we built a relationship between Munsell Value and Total Carbon (TC; Fig. 2).

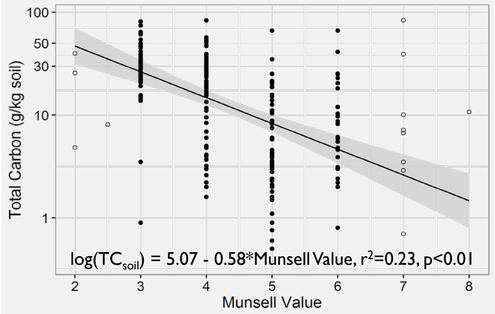

Fig. 2. *The relationship between Munsell value and TC. Solid circles (n=671) represent data used to generate the relationship. Additional open circles complete the dataset but were not modeled due to limited representation at each Munsell Value.*

A comparison between modeled and measured TC based on Munsell Value in Detroit reveals that the relationship generally over-estimates TC in both, urban and non-urban reference soils based on ME.

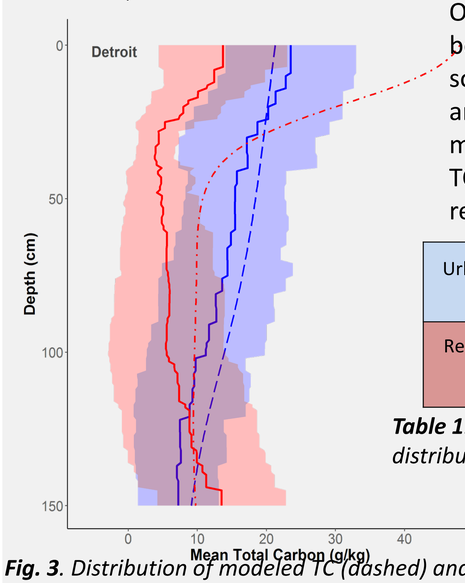

Fig. 3. *Distribution of modeled TC (dashed) and measured TC (solid) in urban soils (blue) and non-urban reference soils (red) in Detroit.*

Overall, Munsell Value is a better predictor of TC in urban soils based on the RMSE (Fig. 3. and Table 1). In this case, the model strongly overestimates TC for the top 30 cm of the reference soil.

Urban Soil	*RMSE 2.66* *ME* 1.98
Reference Soil	*RMSE* 12.61 ME 7.91

Table 1. *RMSE and ME for modeled TC distributions in urban and reference soil.*

Findings

Non-urban soils exhibit different distribution of TC with depth compared to urban soils. We observed the greatest variation in TC concentrations within 30 cm depth in reference soils of Portland, ME; Detroit, MI; Omaha, NE; and Tacoma, WA. In contrast, urban soils showed more homogenized, uniform TC distributions with an overall narrower range of TC concentrations in all cities (Fig. 4) that followed similar patterns except for in New Orleans, LA. Overall, the homogenization may be related to processes of urbanization, such as depletion and fill or mixing of soils as part of (re-) development.

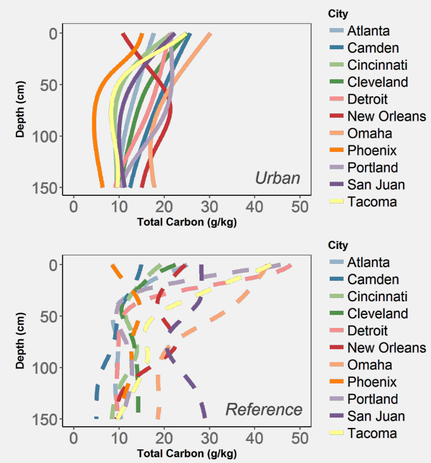

Fig. 4. *Urban soils (top) have a much more simplified profile of predicted TC distribution throughout the soil profile that also encompasses a narrower range of TC concentration compared to non-urban reference soils (bottom).*

Conclusions

- We established a relationship between Munsell Value (lightness of soil color) and TC in soil.
- Comparison between estimated TC distributions in urban and non-urban reference soil profiles exhibit variations in distributions with depth with the most differences occurring in the top 30 cm.
- Further analysis of specific patterns on TC distributions will focus on soil order and its role in C distributions, particularly in non-urban reference soil and how these variations in TC distribution can be explained by urbanization.

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References. [1] Herrmann, Schifman, Shuster. The Urban Soil Profile. (in review *Nature*). [2] Beaudette, D., and P. Roudier. "aqp: Algorithms for Quantitative Pedology." (2012). [3] Wills, S.A., Burras, C.L. and J.A. Sandor. "Prediction of soil organic carbon content using field and laboratory measurements of soil color". (2007).