Quantitative Color and Soil C - A Simple Low Cost Approach to Estimate C in Forest Soils

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Today’s Talk

• ‘Quantifying’ Color
• ‘Darkness’ to predict C
• Soil Redness
• Predictive Accuracy
Why Soil C?

Significance

• ‘Bank of C’ – < ½ of terrestrial C stored in soils

• Supports critical function and ‘ecosystem services’

• Indicator of soil quality

• Poorly constrained across scales local → global
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Limitations

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- Time and Cost intensive – collection, processing and analysis
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Need

• A simple low cost tool to quantify soil C - plot → landscape
Soil color supported the development of civilization through the linkage between dark soils (SOM proxy) and productivity.
Color – Primary Interface with Soils

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Pigments -
- Primary Minerals
- Oxides
- Salts
- SOM
‘Quantifying’ Color

Spectral Measures

- Chromameters
- Optical and Objective
- Standardized light/collection conditions
- Rapid, reproducible, quantitative
- Reduces visible EM spectrum to ‘Master’ color space (CIE xyz)
- Data easily transformed to color spaces (LAB, RGB, Munsell)
Robust and Quantitative

CIE LAB (1976) - complete color space (numeric and visualization) & stimulus align with dominant soil pigments

- L – Black (0) → White (100)
- A⁺ – Gray to Red
- B⁺ – Gray to Yellow

Region of the color space occupied by soil samples
Simple is Better – Color is Best!

Objective –
Develop quantitative relationships between soil color and C to support accurate estimation across a broad range of forest soils.
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**Mode –**
- Group based models
- Explore ‘additional colors’ to support prediction
- Generalized prediction - Simple \( \rightarrow \) ‘complex’
Representative Forest Soils

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<th>Soil</th>
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<td>Mixed Conifer</td>
<td>Mixed Sedimentary</td>
<td>Haplohumults</td>
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Extensive Properties

- Major Conifer ecosystems
- Broad soil and Parent Material properties
- Altitude, Climatic and productivity gradients
- Site and landscape based sample collection
Linear Relationship

![Graph showing a linear relationship between % Carbon and Darkness (L) with data points for Ash, Basalt, Granodiorite, Intermediate Lahar, Mafic Lahar, and Mixed Sedimentary. The graph includes a total of 1884 data points.](image)
Darkness to Predict C

![Graph showing the relationship between Darkness (L) and % Carbon for Inceptisol, Andisol, Alfisol, and Ultisol.]

- Inceptisol: $r = -0.91$, $n = 431$
- Andisol: $r = -0.78$, $n = 101$
- Alfisol: $r = -0.19$, $n = 547$
- Ultisol: $r = -0.6$, $n = 805$

The graph illustrates the negative correlation between Darkness (L) and % Carbon for different soil types.
Darkness to Predict C

![Graph showing the relationship between darkness and carbon content for different rock types.](image)
Additional Color Info??

Redness (A) - categorize soils/groups
- help constrain predictions
An ‘Ordinary’ Framework

Ordinary Least Squares Framework
• $\ln(\text{Carbon}) \sim L+A$ (*group)
• Aligns Model Slopes
• Support prediction at multiple scales
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‘Granitic’ Soils

- ‘Granitic’ Entisols, Inceptisols and Mollisols cover ~ 12% (5.2 million ha) of California
- This model provides modest accuracy to estimate soil C with a simple point and click measurements
Most general model (C ~ L+A) provides suitable predictive power from ~ 0.5 – 4 % C (75% of the population)
Conclusions

• Color is the primary interface with soil – let's quantify it!

• Colorimetry – simple, easy to use & powerful for quantifying C

• Predictive accuracy varies but strong across scales

• Using redness (A) is important to classify soils and align models

• As always MORE data is needed with abundant opportunity to utilize existing samples and capture new ones as they are generated
Cleaning Out the Office?

or lost opportunity?
Questions?
Site or Soil Specific

- Initial application at site or soil scale – ‘small’ landowners
- ‘Customized’ models developed at low sample density (~ 100)