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Quantifying the Distribution and Landscape Controls of Peatlands and Organic Layer Thickness within Alaska

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Introduction

The northern circumpolar region is estimated to contain 50% of the global belowground carbon pool and is experiencing climate change at rates higher than anywhere else globally. Surface organic horizons associated with these immense carbon pools are important to ecosystem functioning in terms of soil moisture and temperature regulations, permafrost degradation, successional trajectories, and soil respiration levels. However, fire-induced changes to surface organics and their distribution are poorly understood, especially at landscape scales. These ambiguities make future predictions uncertain for these significant carbon pools, which have the potential for substantial feedbacks to global warming. Moreover, given the significant impacts and increasing severity and amount of fires in boreal systems, the spatial quantification of post-fire surface organic thickness is important for ecosystem model calibrations and comparisons, and can improve future projections of vegetation types, carbon stocks and fluxes, and future thaw depths.

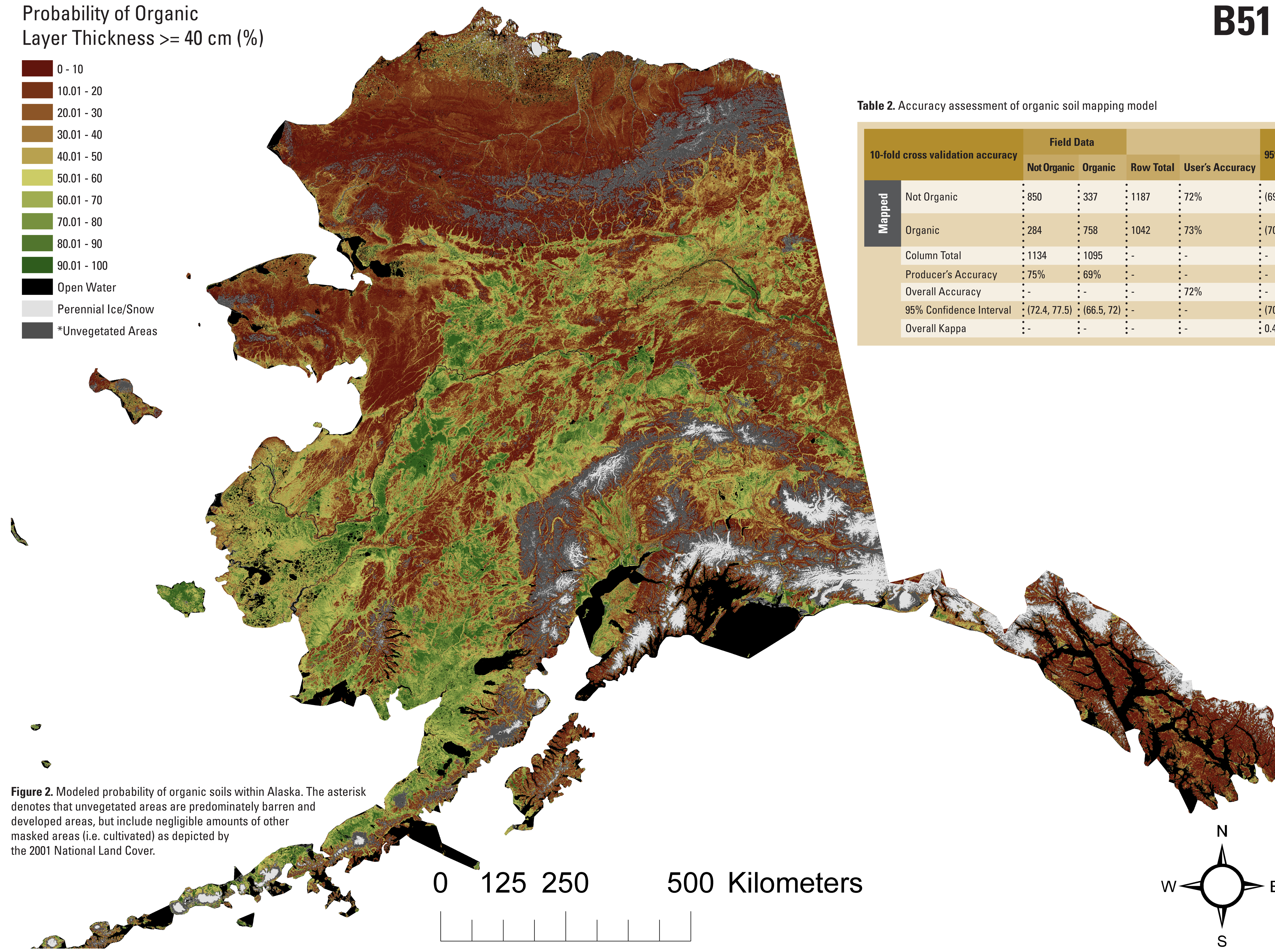

Figure 2. Modeled probability of organic soils within Alaska. The asterisk denotes that unvegetated areas are predominately barren and developed areas, but include negligible amounts of other masked areas (i.e. cultivated) as depicted by the 2001 National Land Cover.

Table 2. Accuracy assessment of organic soil mapping model

10-fold cross validation accuracy		Field Data				95% Confidence Interval
		Not Organic	Organic	Row Total	User's Accuracy	
Mapped	Not Organic	850	337	1187	72%	(69, 74.2)
	Organic	284	758	1042	73%	(70, 75.4)
	Column Total	1134	1095	-	-	-
	Producer's Accuracy	75%	69%	-	-	-
	Overall Accuracy	-	-	-	72%	-
	95% Confidence Interval	(72.4, 77.5)	(66.5, 72)	-	-	(70.3, 74)
	Overall Kappa	-	-	-	-	0.44

Methods

Field plots across Alaska (Figure 1) were used as reference data to predict the probability of organic soils (soil organic layer with thicknesses greater than 40 cm). A database was prepared that had spatial variable (30 m resolution) attributes (Table 1) corresponding to each field plot location, and the reference field observed presence / absence of peat and soil organic layer thickness. Winnowing (Quinlan, 2003) was used to identify important predictor variables for the classification tree (organic soil) data mining models (http://rulequest.com/) for Alaska-wide mapping (Figure 2). For more method details see Pastick et al. 2014).

Results

Organic soil model usage is quantified by the percent of the model development database record's prediction affected by each spatial input variable (Table 1). All input variables were used heavily and represented vegetation, terrain, and climate effects.

Overall cross validation accuracy of 72% was obtained with a fairly even balance between commission (user accuracy) and omission (producer accuracy) errors (Table 2).

Largest organic soil model uncertainties were related to organic soil distributions in lowlands (Figure 3).

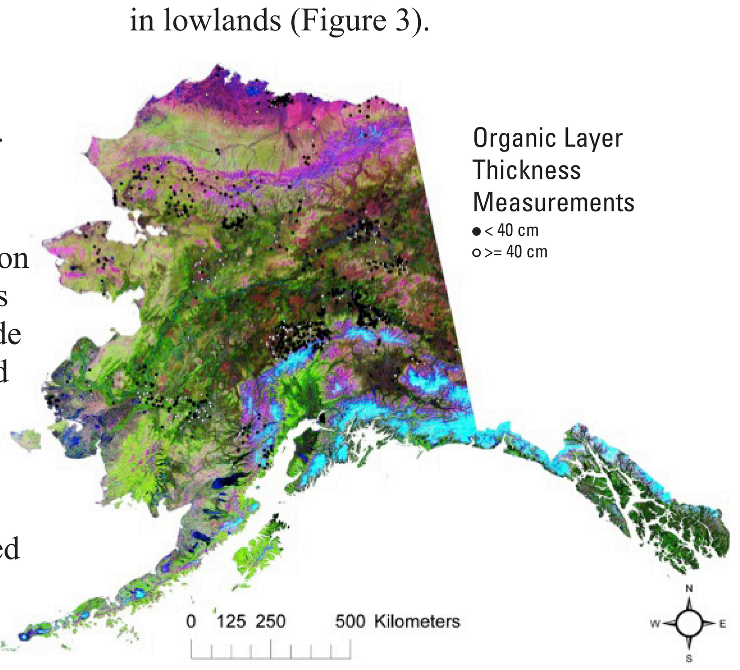

Figure 1. Alaska overlaid with soil organic layer thickness observations and a Landsat WELD 7 Enhanced Thematic Plus mosaic (false color composite [red, green, blue: 5, 4, and 3])

Table 1. Organic soil mapping model inputs

Spatial inputs	Percent usage in the Mapping model
NLCD Land Cover[1]	100
Slope	100
WELD band 3[2]	100
Length of Growing Season	100
Compound Terrain Index[3]	98
Elevation	88
Wetland Classes[4]	84

1. http://www.mrlc.gov/nlcd2011.php
2. http://weld.cr.usgs.gov/
3. http://edna.usgs.gov/Edna/datalayers/cti.asp
4. http://wetlands.jpl.nasa.gov/products/alaska_wetland.html

Planned refinements in SOT mapping

Post fire field plots were limited, so additional post-fire field data were collected in 2014

- Rapid extensive plots (REP; n ~ 90)
  - Soil organic layer thickness, soil stratigraphy, thaw depth, vegetation
- Electrical resistivity tomography plots (ERT; n = 12; Figure 4)
  - More frequent sampling of REP data along ERT transect
  - 1 m spacing of electrodes
  - Continuous mapping to ~ 10 m depths
  - Talik and "soft" permafrost mapped
  - Uniform areas for 30 m map refinement

ERT captures near surface permafrost and SOT associations (Figure 5, Table 3)

- Near surface permafrost favors, or is dependent on, thicker soil organic layers.

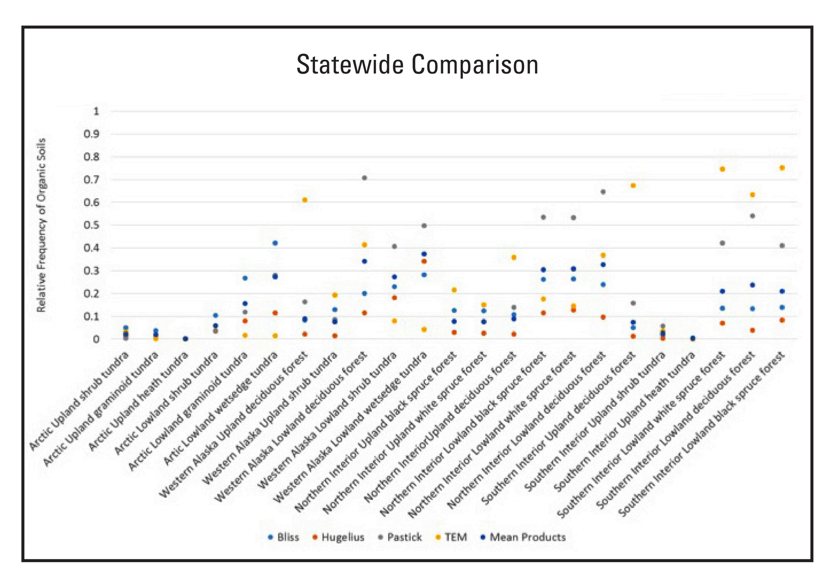

Figure 3. Relative frequency of organic soils by major ecotypes in each Landscape Conservation Cooperatives (LCC). The 'mean products' represent averaged frequencies of empirical estimates made by Bliss and Maursetter, 2010, Hugelius et al., (2013), and Pastick et al., (in-prep). Terrestrial ecosystem model (TEM) estimates are shown in yellow and represent process-based estimates of organic soils from 2000 to 2009 (Wylie et al. in prep).

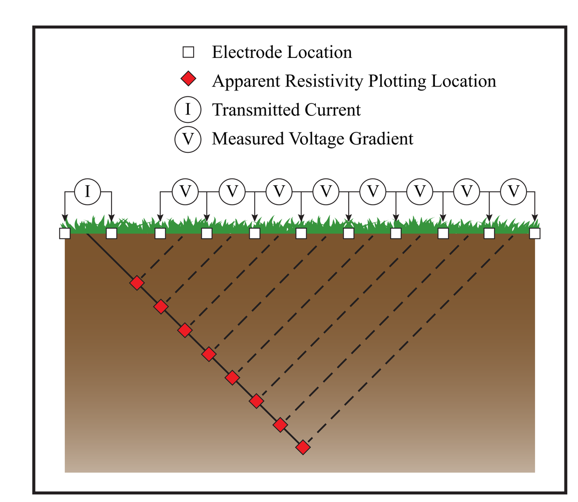

Figure 4. Schematic of ERT transect layout and data collection process.

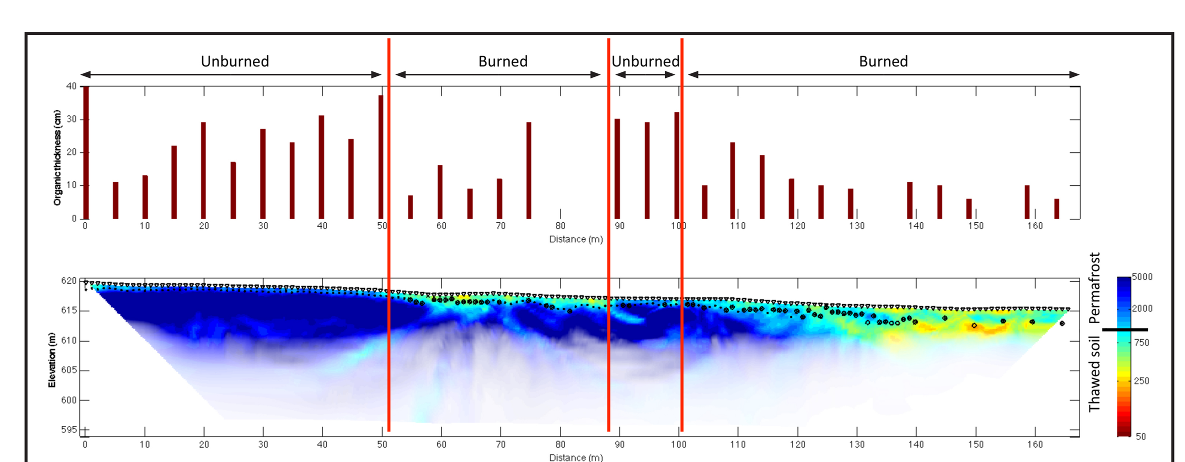

Figure 5. Electrical resistivity tomography and soil organic layer field transect data

Conclusions

SOT map (when planned post-fire improvements are made) to:

- Predict future forest communities
  - A measure of burn severity
- Refine permafrost degradation estimation
- Quantify carbon stocks
- Serve as a baseline for future change

Table 3. Comparison of burn and unburned soil organic thickness

Fire effects	Average Soil Organic Layer Thickness (cm)
burned	10.5_a
unburned	26.1_b
a,b Significant at p < 0.01	

References

Bliss, N.B., Maursetter, J., 2010. Soil organic carbon stocks in Alaska estimated with spatial and pedon data. Soil Science Society of America Journal 74 (2), 565.

Hugelius, G., Tarnocai, C., Broll, G., Canadell, J. G., Kuhry, P., and Swanson, D. K., 2013, The Northern Circumpolar Soil Carbon Database: spatially distributed datasets of soil coverage and soil carbon storage in the northern permafrost regions, Earth Syst. Sci. Data, 5, 3-13.

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