

Prediction of soil organic carbon concentration and soil bulk density of mineral soils for soil organic carbon stock estimation

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Motivation:

- legacy soil data,
- soil pedotransfer functions,
- soil organic carbon stock

Soil bulk density

Soil organic carbon concentration

HYPOTHESIS AND AIMS

The hierarchical structure in the National Soil Monitoring network data requires a **multi-level mixed model approach** to achieve good prediction accuracy of soil properties.

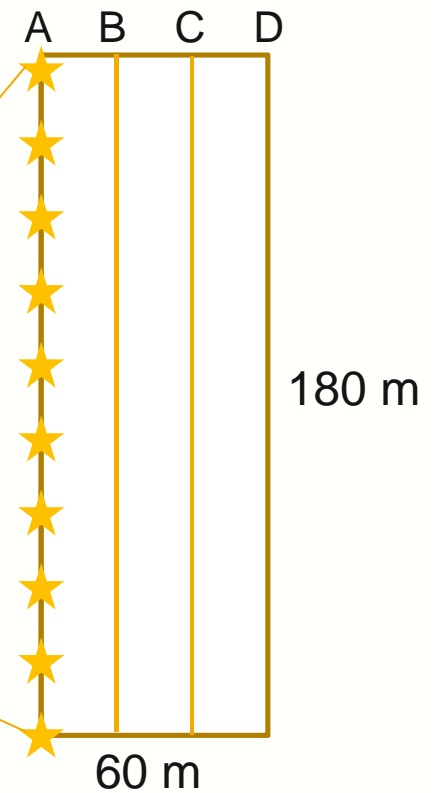
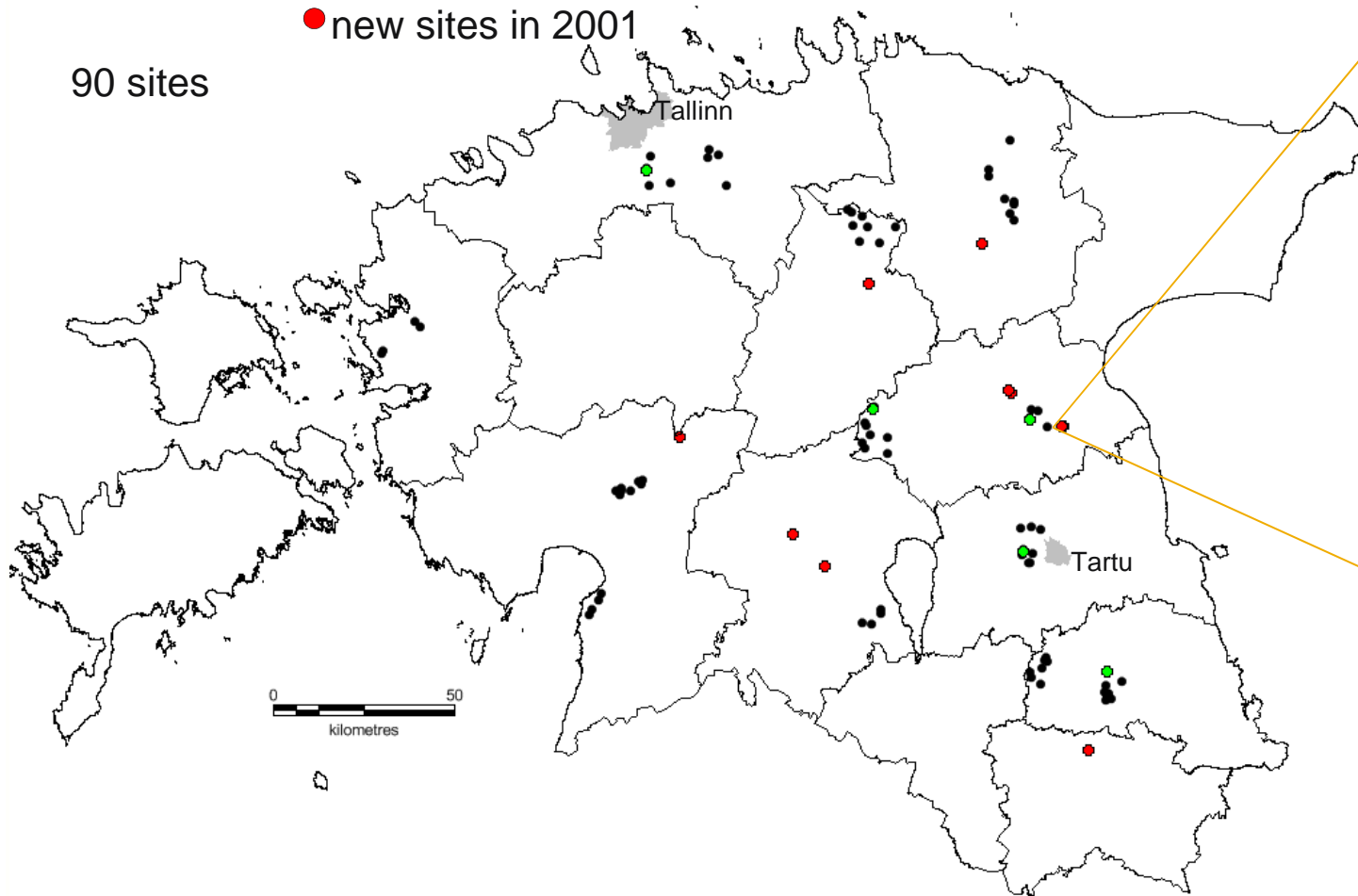
- Develop a prediction model for soil bulk density (D_b) and soil organic carbon concentration (SOC, %) in Estonian arable soils with the compatibility of Estonian large-scale soil map.
- Combine and compare predictions of separate SOC (%) and D_b models to calculate SOC stock and implement the results into large-scale Estonian Soil Map.

DATA

National Soil Monitoring of arable soils

- 1983 – 1994; ● resumed in 2001
- new sites in 2001

90 sites



SOIL PROPERTIES

- Humus horizon thickness: 12-100 cm
- SOC (%): 0.6-6%, Tjurin method
- Oven-dry bulk density (D_b) and water content (Wc) at sampling time in four depths: 3, 15, 25, 40 cm
- Soil texture classified after Katchinski
 - Physical clay – particles smaller than 0.01 mm
- Soil type – Estonian Soil Classification

Estonian large-scale soil map (1:10 000)

STATISTICAL METHODS

- Median value based on soil type and texture
- Linear regression
- Mixed model – fixed and random effects

SOIL BULK DENSITY PREDICTION MODEL

- Mixed model

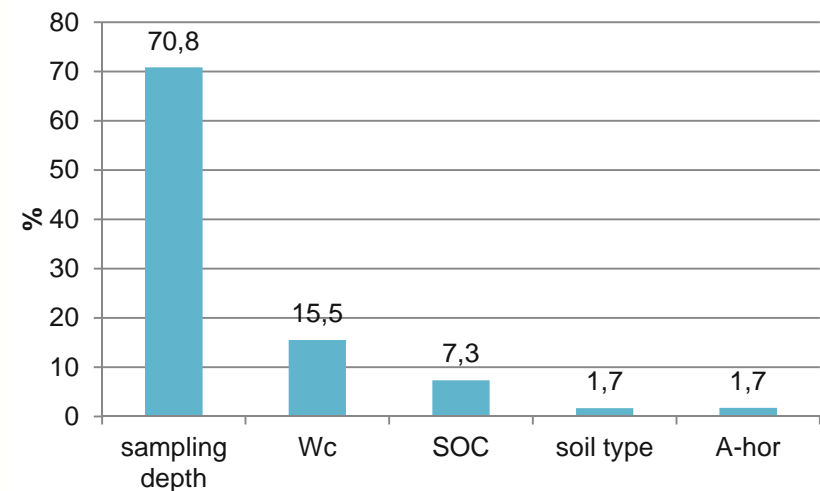
$D_b \sim$ SOC, water content, clay, A-hor, texture, sampling depth, and soil type; site, transect, plot, year, and the site-year interaction

RMSE – 0.07 g cm⁻³

- Multiple linear regression

$D_b = \beta_0 - 0.45/Wc - 0,004*A-hor - 0.08*SOC + 0.00004*Cf^2 + 0.01*Cf - 0.0002*Wc:Cf$

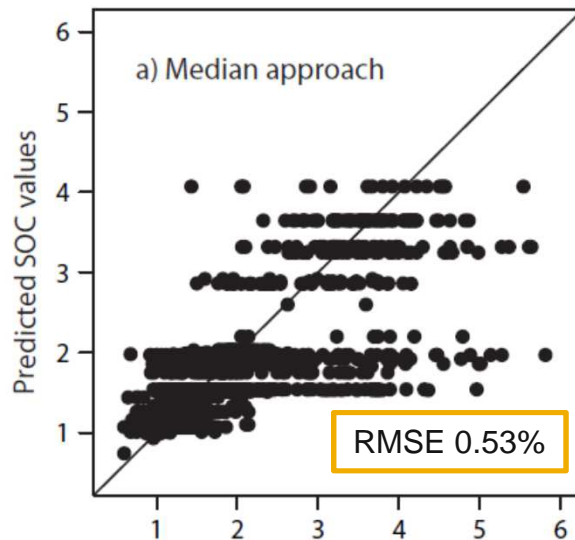
RMSE – 0.10 g cm⁻³



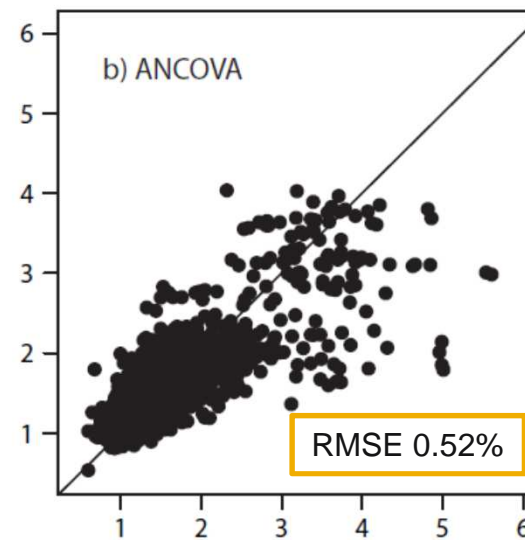
RMSE – root mean square error: the square root of the mean of the squared differences between predicted and observed values; the smaller, the better

SOC (%) PREDICTION

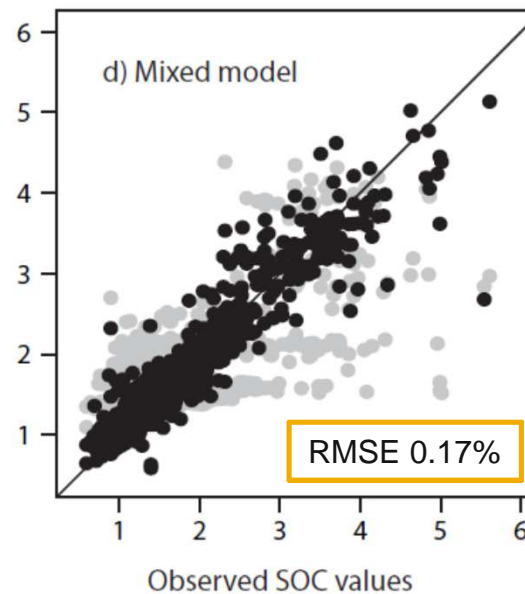
Soil type,
texture



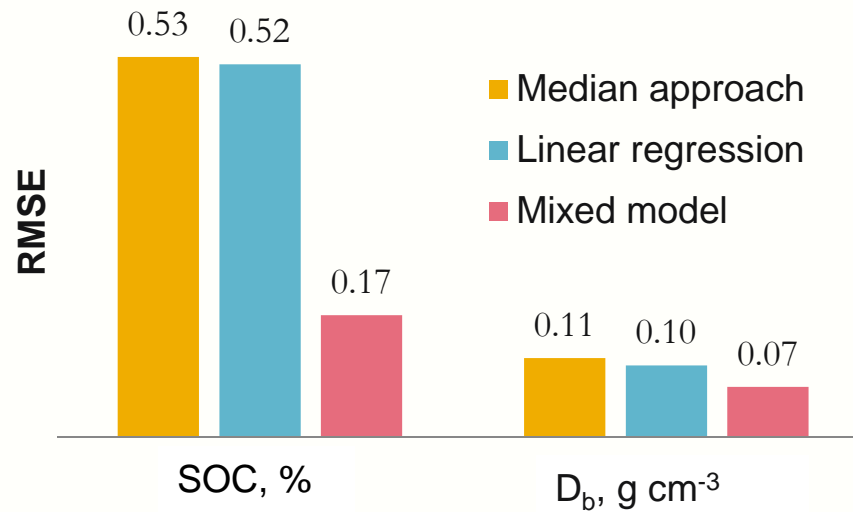
Soil type,
Cf content, A-hor



Soil type, Cf
content, A-hor
site, clay*site,
plot, year,
transect,
transect*year



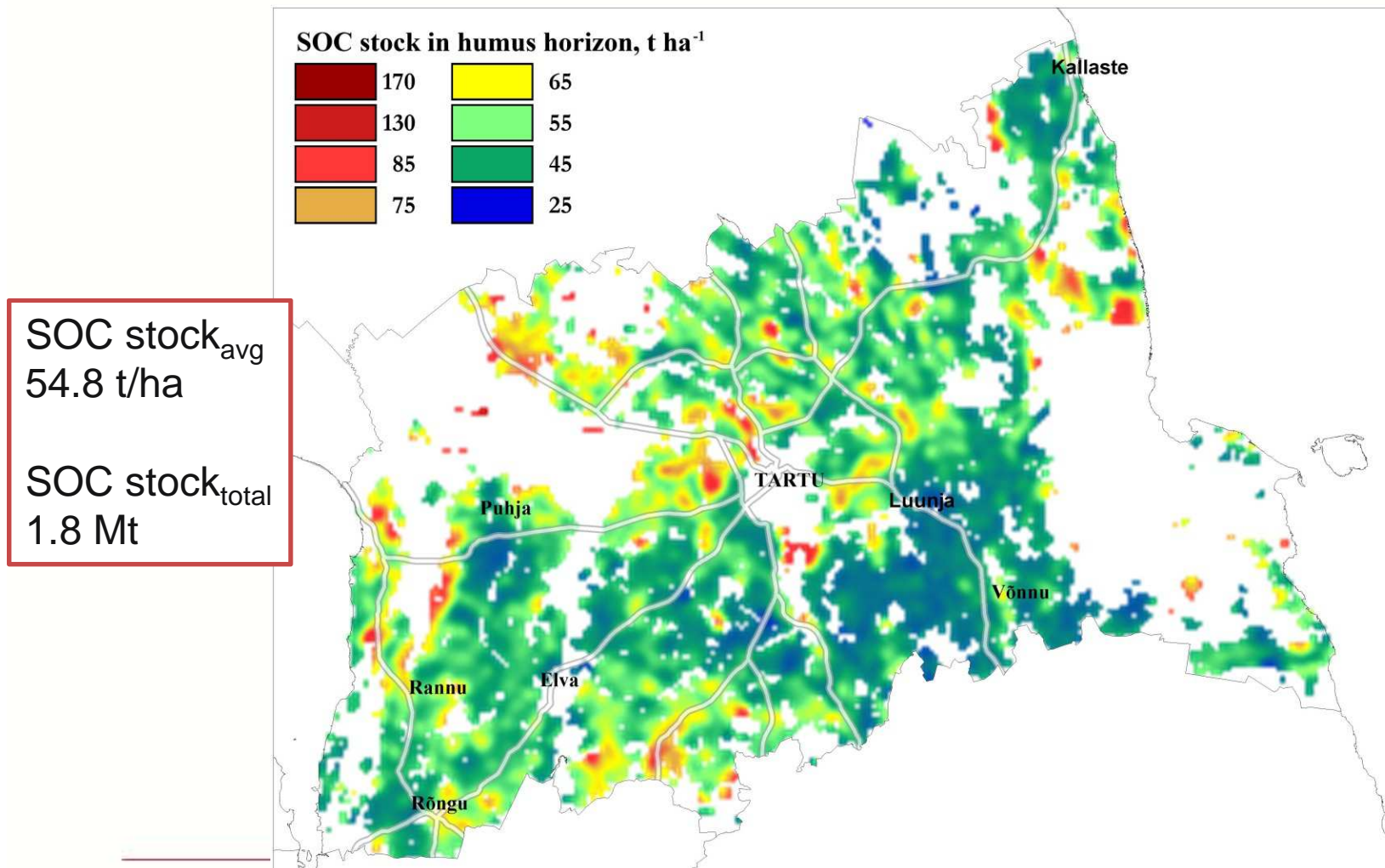
SOC STOCK



$$\text{SOC (t C ha}^{-1}\text{)} = (\text{A(m)} * \text{area} - \text{coarse fraction}) * \text{D}_b \text{ (t m}^{-3}\text{)} * \text{SOC (\%)}$$

	Mean, t C ha ⁻¹	RMSE, t C ha ⁻¹
Median approach	65.7	19
Linear regression	64.3	22
Mixed model	70.8	7

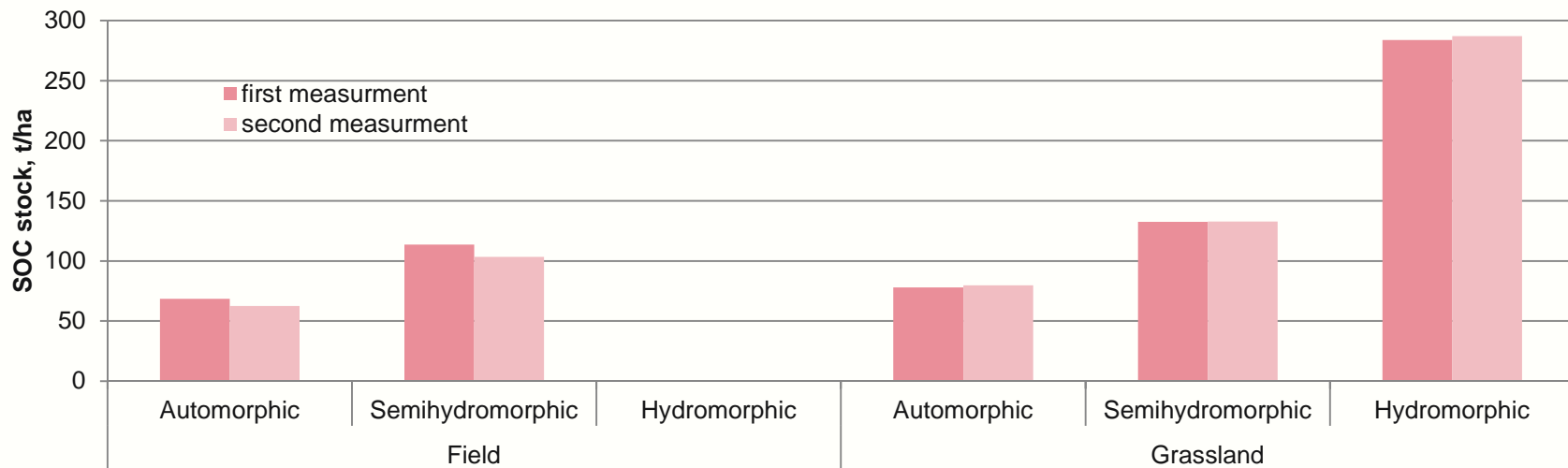
SOC STOCK IN TARTU COUNTY



CONCLUSIONS

- Sampling depth, water content and soil organic carbon concentration had the dominant effects in D_b prediction model and soil type in SOC models.
- Mixed model-predicted SOC (%) and D_b values were with the highest prediction accuracy.
- SOC stock was estimated with mixed model-based predictions and implemented into Estonian Soil Map.
 - First estimation of Tartu County SOC stock in mineral arable fields – 1.8 Mt in humus horizon.

SOC stock and land use



BG2.15/SSS6.14 (N24) *Wed, 20 Apr, 17:30–19:00 / Foyer N*
Kauer et al. Dynamics of organic carbon stock of Estonian arable and grassland peat soils

Thank You for your attention!

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Soil Monitoring Bureau, Agricultural Research Centre

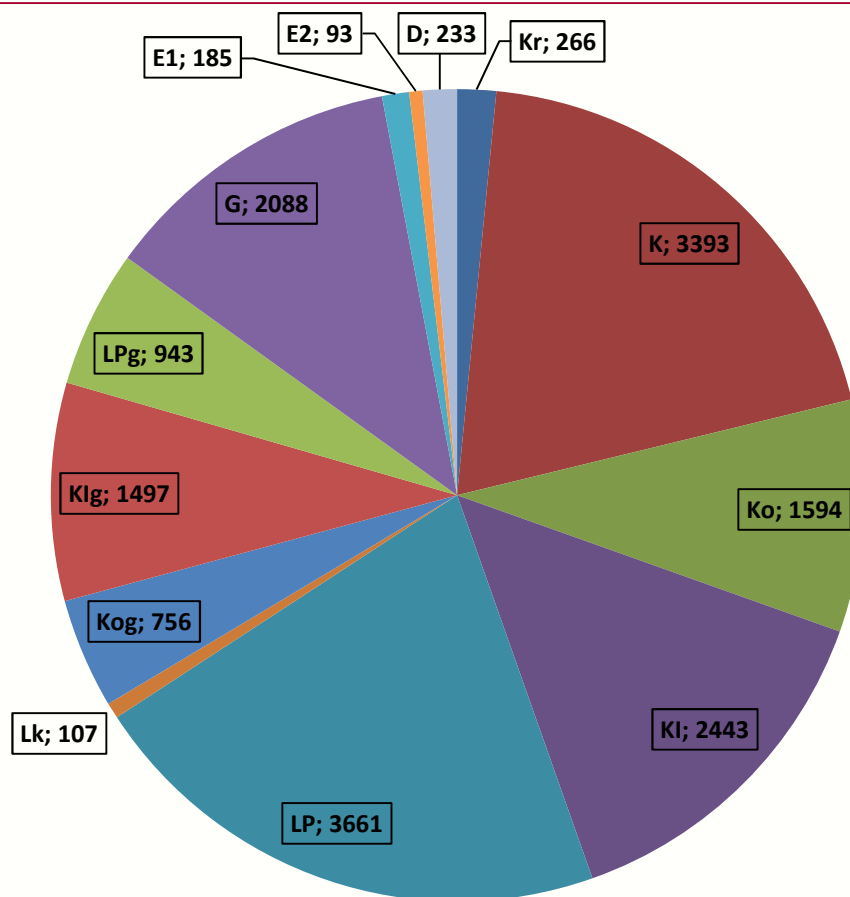
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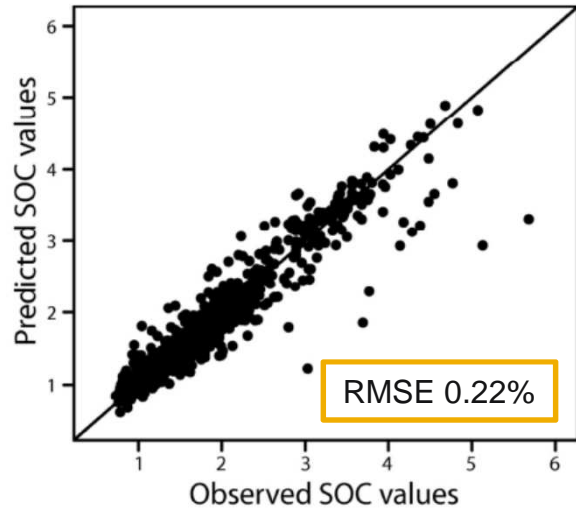
ARCHIMEDES

SOIL GROUPS IN THE DATABASE



Haplic Regosol (Calcaric, Hyperskeletal) – pebble rich rendzinas	Kr
Haplic Cambisol&Regosol (Calcaric, Endoskeletal) – pebble rendzinas	K
Haplic Phaeozem (Calcaric) – typical brown soils	Ko
Cutanic Luvisol (Humic) – eluviated brown soils	KI
Umbric Stagnic Albeluvisol – pseudopodzolic soils	LP
Umbric Carbic Podzol – sod-podzolic soils	Lk
Endogleyic Phaeozem – gleyic typical brown soils	Kog
Endogleyic Cutanic Luvisol (Humic) – gleyic eluvial soils	KlG
Umbric Stagnic Endogleyic Albeluvisol – gleyic pseudopodzolic soils	LPg
Luvic Mollic Spodic Gleysol – gleysols	G
Haplic Cambisol. Cutanic Luvisol. Umbric Albeluvisol slightly eroded	E1
Aric Regosols (Eutric) moderately eroded – moderately eroded soils	E2
Colluvic Regosol (Cumulihumic) – deluvial soils	D

MIXED MODEL-BASED KRIGING



Random effect	Estimated variance	Percentage of total variance
Site (intercept)	0.548	86.8
Site (slope on Cf content)	0.001	0.1
Plot (nested within transects)	0.048	7.7
Transect (nested within sites)	0.004	0.7
Transect-year (nested within year)	0.009	1.4
Year	0.002	0.3
Residual error	0.019	3.0

Exponential correlation structure: nugget 0.23 and range 10.5 km

RMSE 1.06% vs 1.07%