Multinomial Logistic Regression with soil diagnostic features and land surface parameters for soil mapping of Latium (Central Italy)

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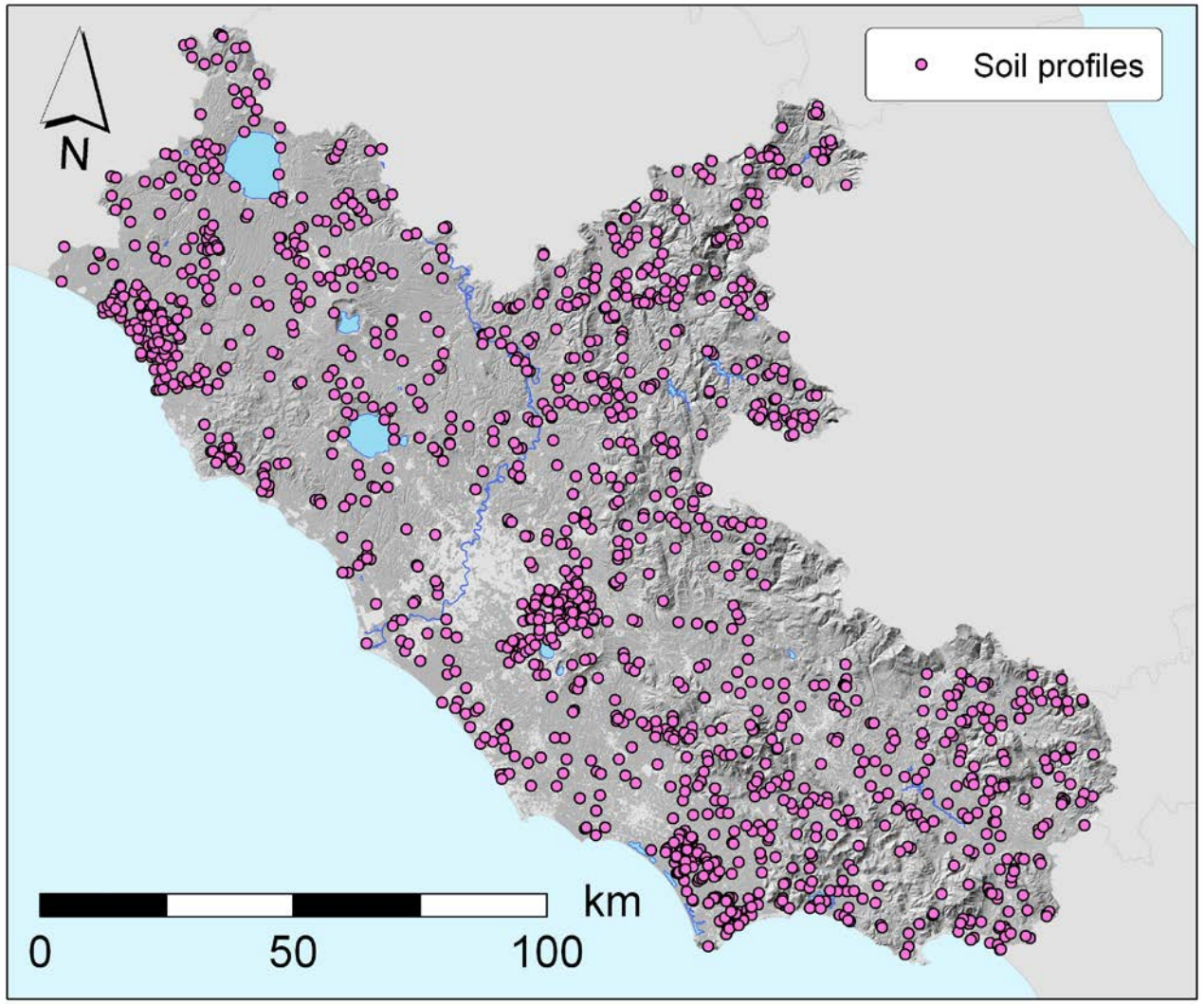
AIMS AND SCOPE

A semi-automatic procedure to define homogeneous land components using available data on soil features and territorial auxiliary information

Supporting the definition of Soil Typological Units to realize the 1:250,000 Soil map of Latium Region (Central Italy)

STUDY AREA



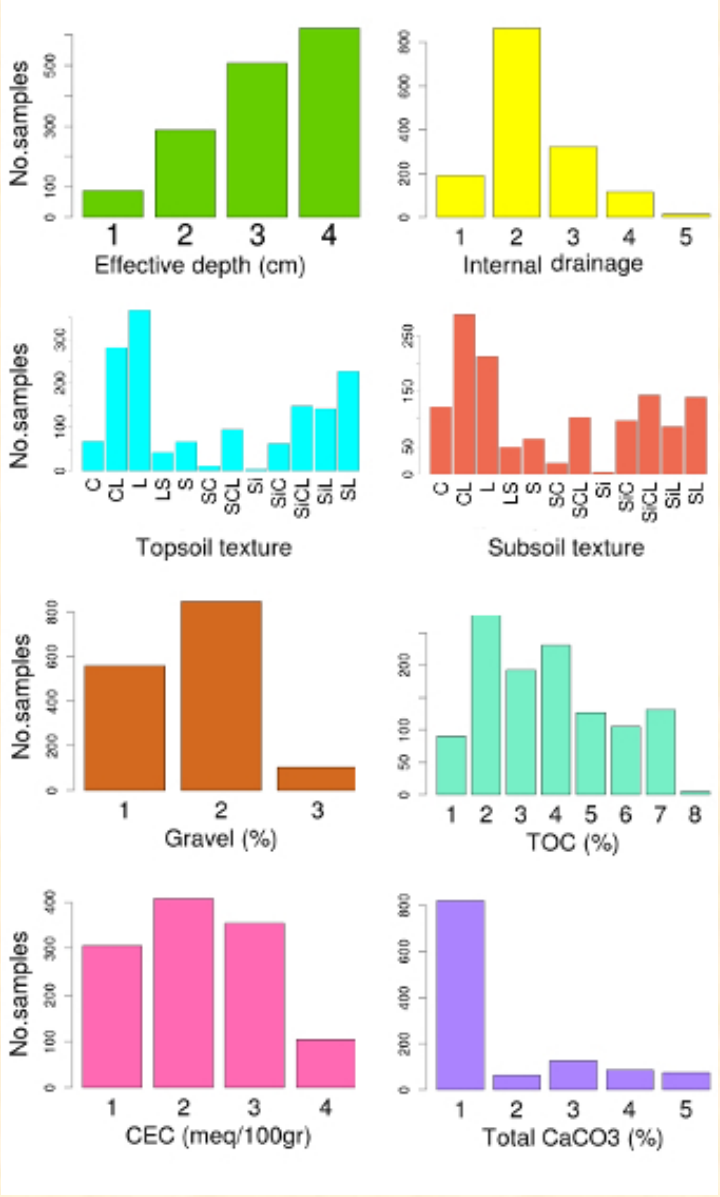
Area ≈ 17,000 km²

Climate: Mediterranean - Continental
Mean annual air temperature: 5° C – 17° C
Mean annual rainfall: 600 mm – 1200 mm
Dry season: summer

1,510 soil profiles

AVAILABLE DATA

Feature	Class	Description
Effective depth for plant growth	1	0 - 25 cm
	2	25 - 50 cm
	3	50 - 100 cm
	4	> 100 cm
Internal drainage	1	Somewhat excessively drained
	2	Well drained
	3	Moderately well drained
	4	Somewhat poorly drained
	5	Poorly drained
Topsoil and subsoil texture (USDA)	S, LS, C, SC, SiC, L, SL, SCL, CL, SiCL, Si, SiL	
Gravel	1	< 1 %
	2	1 - 40 %
	3	> 40 %
Total organic carbon	1	< 0.6 %
	2	0.6 - 1.0 %
	3	1.0 - 1.4 %
	4	1.4 - 2.5 %
	5	2.5 - 4.0 %
	6	4.0 - 6.0 %
	7	6.0 - 20.0 %
	8	> 20 %
Cation exchange capacity	1	0 - 16 meq 100 g^{-1}
	2	16 - 24 meq 100 g^{-1}
	3	24 - 36 meq 100 g^{-1}
	4	> 36 meq 100 g^{-1}
Calcium carbonate	1	0 - 2 %
	2	2 - 5 %
	3	5 - 15 %
	4	15 - 25 %
	5	> 25 %



AUXILIARY DATA

Auxiliary data were derived from

- **ASTER GDEM (30 m) → elevation, slope, aspect, mean curvature, curvature profile and plan, vertical distance from the drainage network, depth of valleys, flow accumulation, Convergence Index, Topographic Wetness Index, Stream Power Index, Topographic Position Index**

- **1:25,000 Regional Geological Map of Latium**

- **1:25,000 Land Use Map of Latium**

- **1:250,000 Pedoclimate → temperature and soil moisture regimes**

PROCEDURE (1)

- **ANOVA on all the covariates for each soil feature – used if significant at $p<0.001$**

- **Principal Component Analysis → orthogonal and independent components**

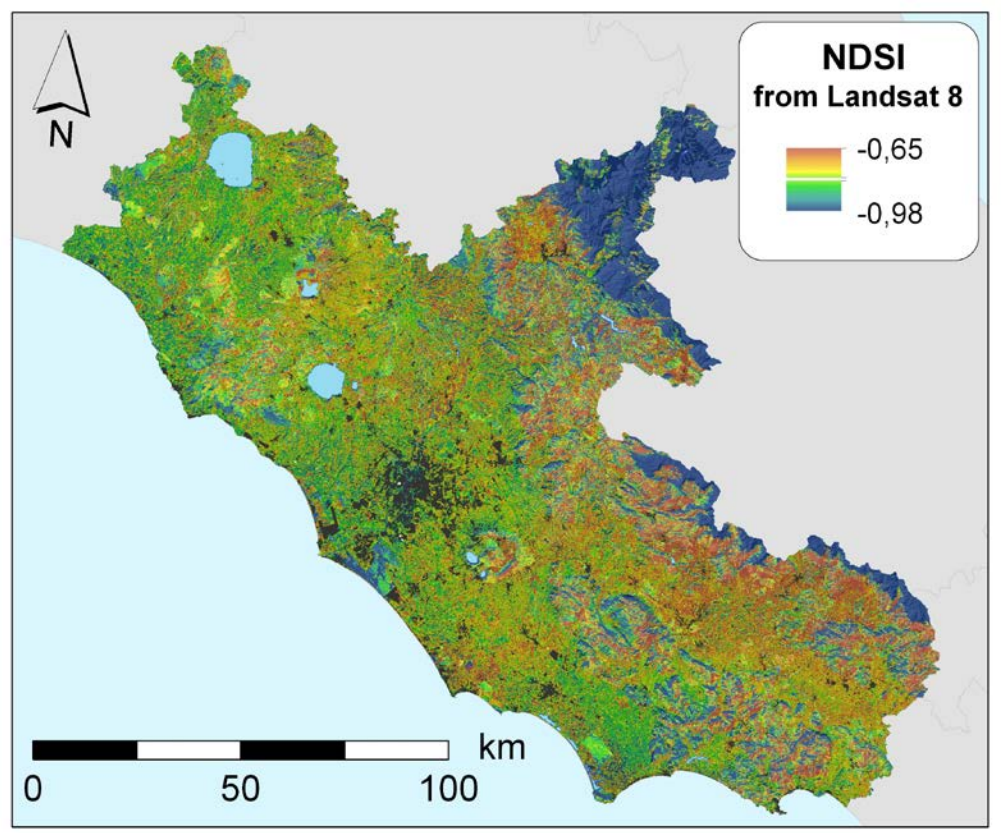
- **Multinomial Logistic Regression - establishing the relationships among the PC and each soil feature**

- **Accuracy assessment → map purity and kappa statistics**

ADDITIONAL INFORMATION

To improve the estimate in areas with uniform land characteristics, from Landsat 8 OLI images (18th and 25th January 2016, cloud cover <5%) the following indexes were derived:

1. **NDSI Normalized Difference Soil Index (Deng et al., 2015)**
2. **GSI Grain Size Index (Xiao et al., 2006)**
3. **CI Clay Index (Hengl, 2009)**
4. **NDVI Normalized Difference Vegetation Index (Colwell, 1974)**



The whole estimation procedure was repeated including these indexes
Resulting maps have a better quality

PROCEDURE (2)

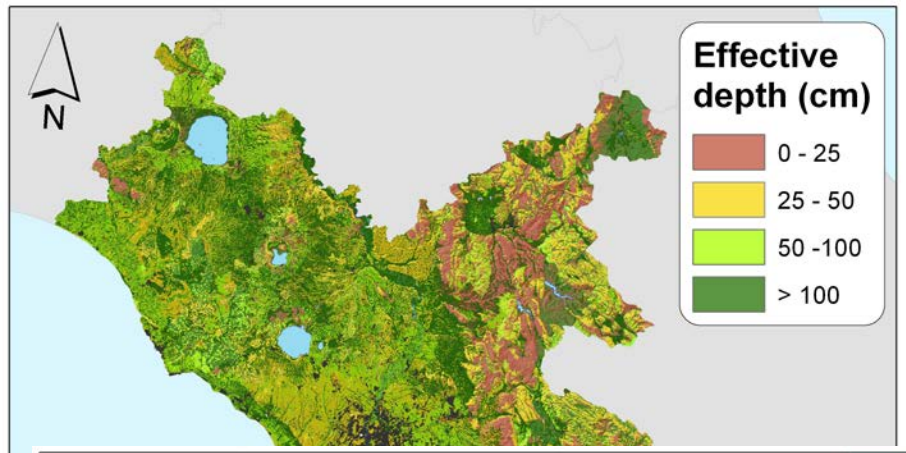
Maps of soil internal features

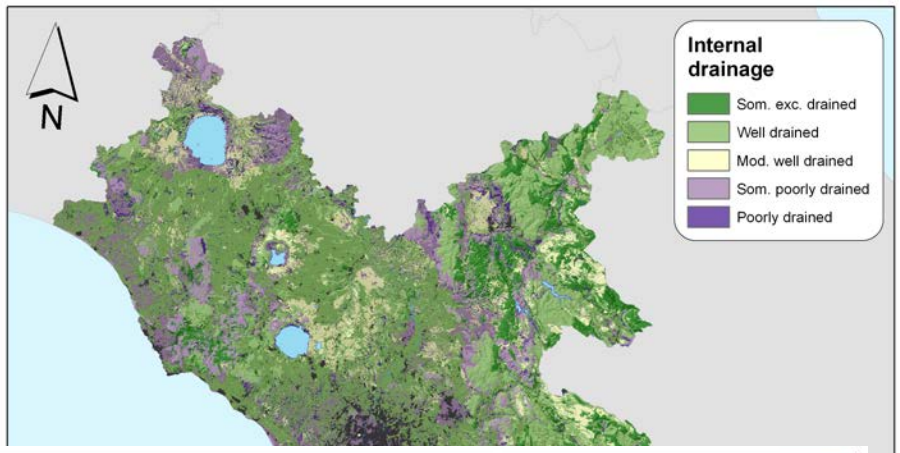
cluster analysis
(Hill-Climbing - Rubin, 1967)

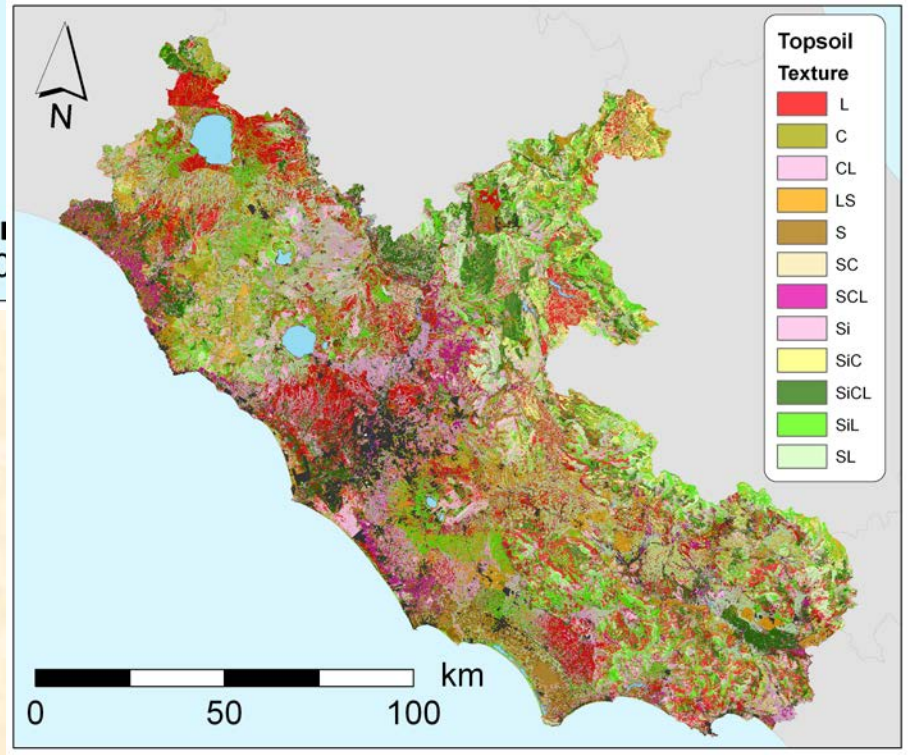
53 different clusters

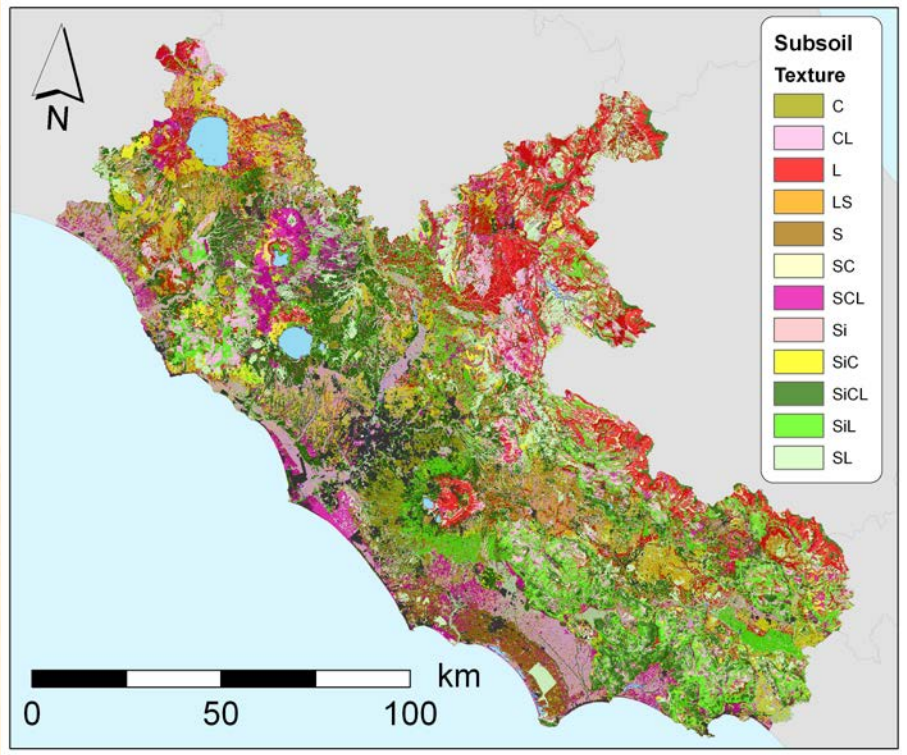
Zonal statistics allowed to associate a set of values to each cluster.

MAPS OF SOIL FEATURES (1)

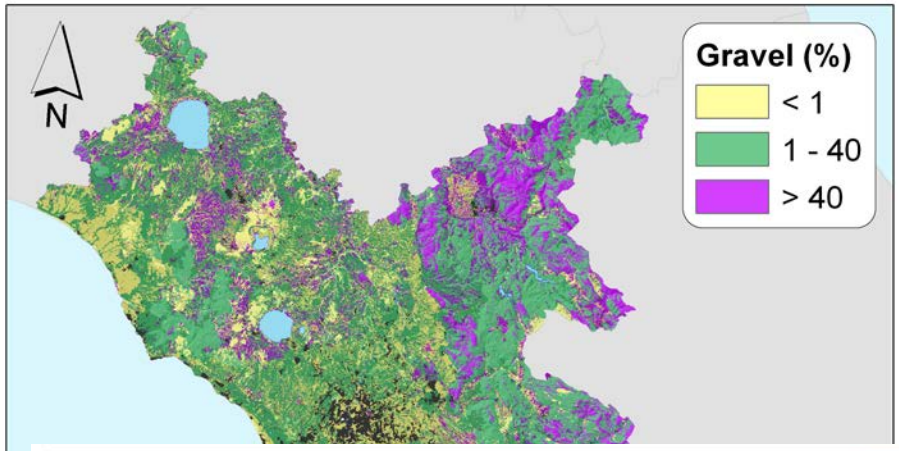


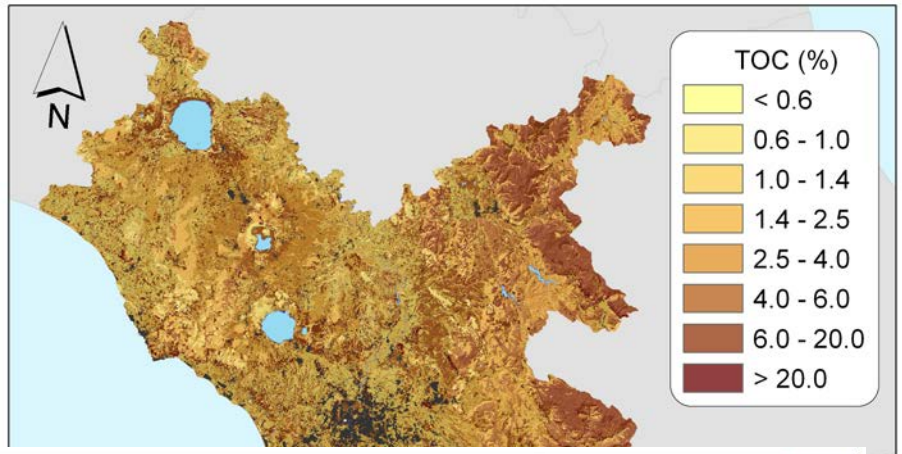


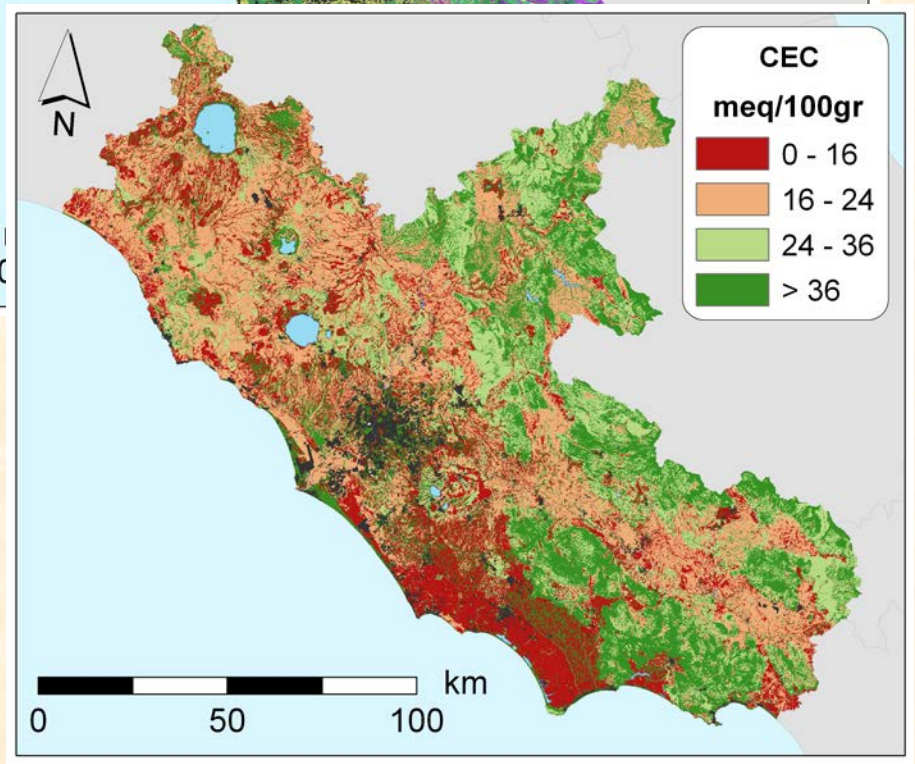


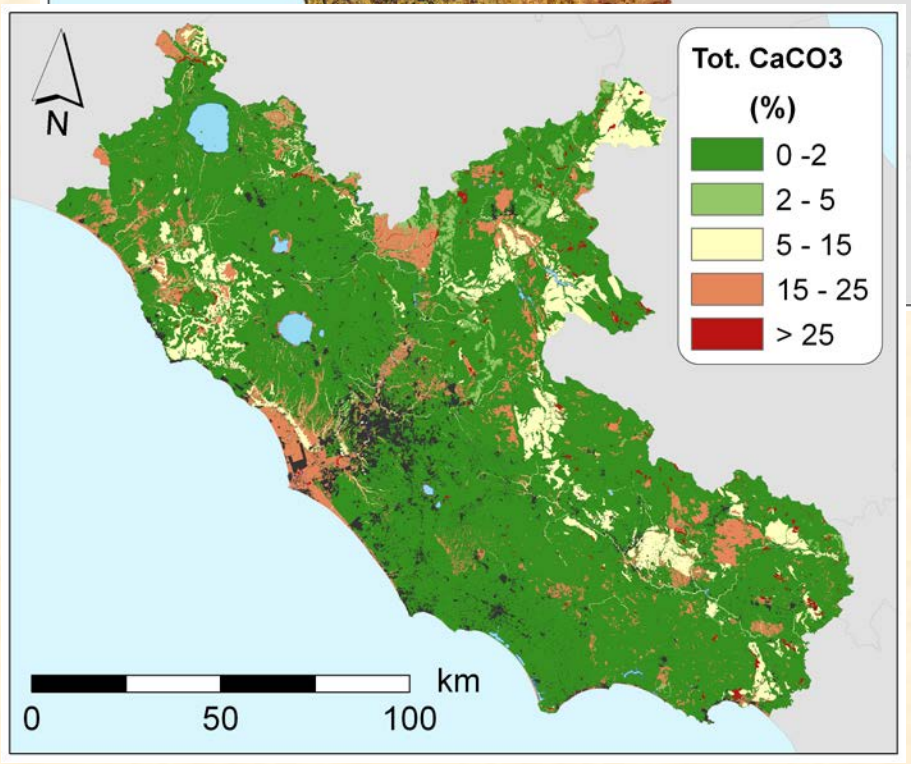


MAPS OF SOIL FEATURES (2)





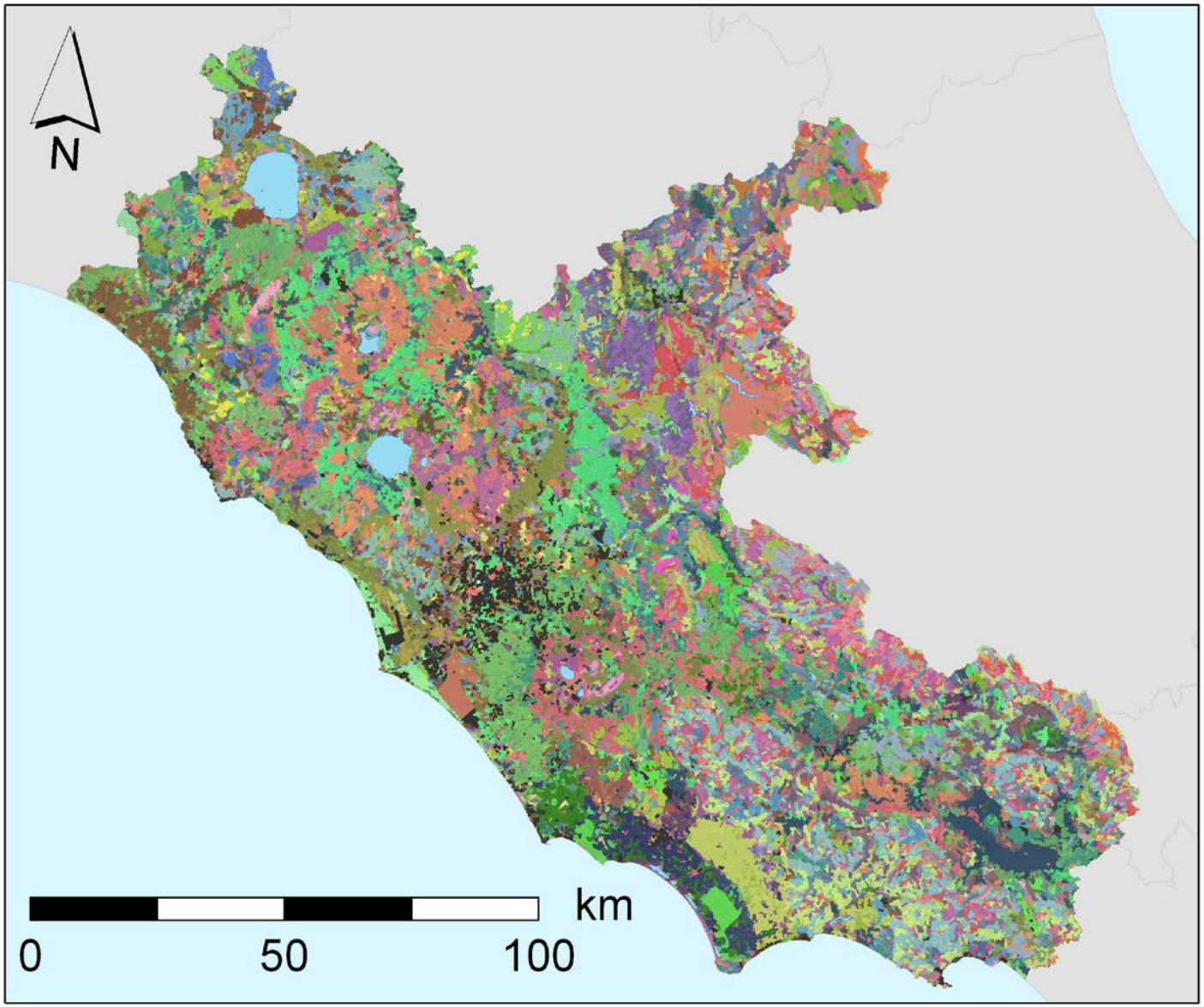




MAPS ACCURACY

	COHEN'S KAPPA		MAP PURITY %	
	No Landsat	With Landsat	No Landsat	With Landsat
Effective depth	0.78	0.83	76	80
Internal drainage	0.75	0.77	77	77
Topsoil texture	0.81	0.90	80	81
Subsoil texture	0.77	-	84	-
Gravel	0.77	0.88	72	79
Total organic carbon	0.80	0.98	77	94
Cation exchange capacity	0.80	0.83	72	82
Calcium carbonate	0.58	-	77	-

MAP OF LAND COMPONENTS



LAND COMPONENTS

53 different clusters were defined

Cl.	Majority parent material	Majority effective depth	Majority internal drainage	Majority topsoil texture	Majority subsoil texture	Majority gravel	Majority TOC	Majority CEC	Majority $CaCO_3$
1	Lacustrine sediments	4	3	L	CL	2	7	1	1
2	Limestones	2	1	SL	L	4	7	4	1
3	Limestones	2	2	LS	SiCL	6	7	4	1
4	Sandy sediments	4	2	S	SL	2	4	1	1
...	...	...	...	...	...	...	...	...	...
24	Tuffs	3	2	LS	SiC	2	3	2	1
...	...	...	...	...	...	...	...	...	...
53	Lacustrine sediments	4	5	L	CL	4	7	4	1

A field validation of the land components map with an independent dataset is in progress

CONCLUSIONS

Soil features relevant in distinguishing soil types, and their relationships with land characteristics were represented in a single map using DSM techniques.

Such approach allowed to solve several problems:

a) **spatialization of different soil features in soilscapes with non-homogeneous relationships among soils and covariates**
b) **considering simultaneously several variables with different categories**
c) **building a solid spatial base for mapping soil typological units distribution inside the soilscapes**

The estimation procedure adopted in this area might be applied in other regions, in consideration of the amount of pedological information available, and at a wider scale (i.e. at the national level)


Thank You