2009 National Cooperative Soil Survey National Conference

Las`Cruces NM May 11

Methodologies for Digital Soil Mapping & Monitoring

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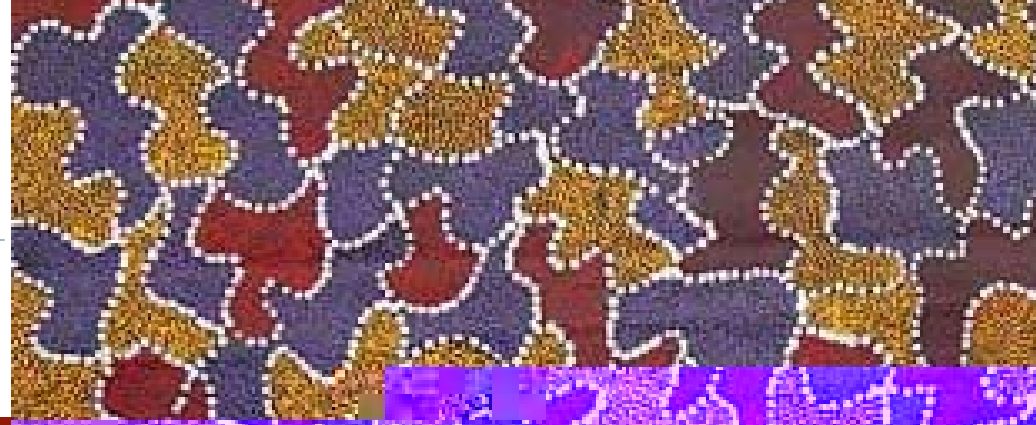
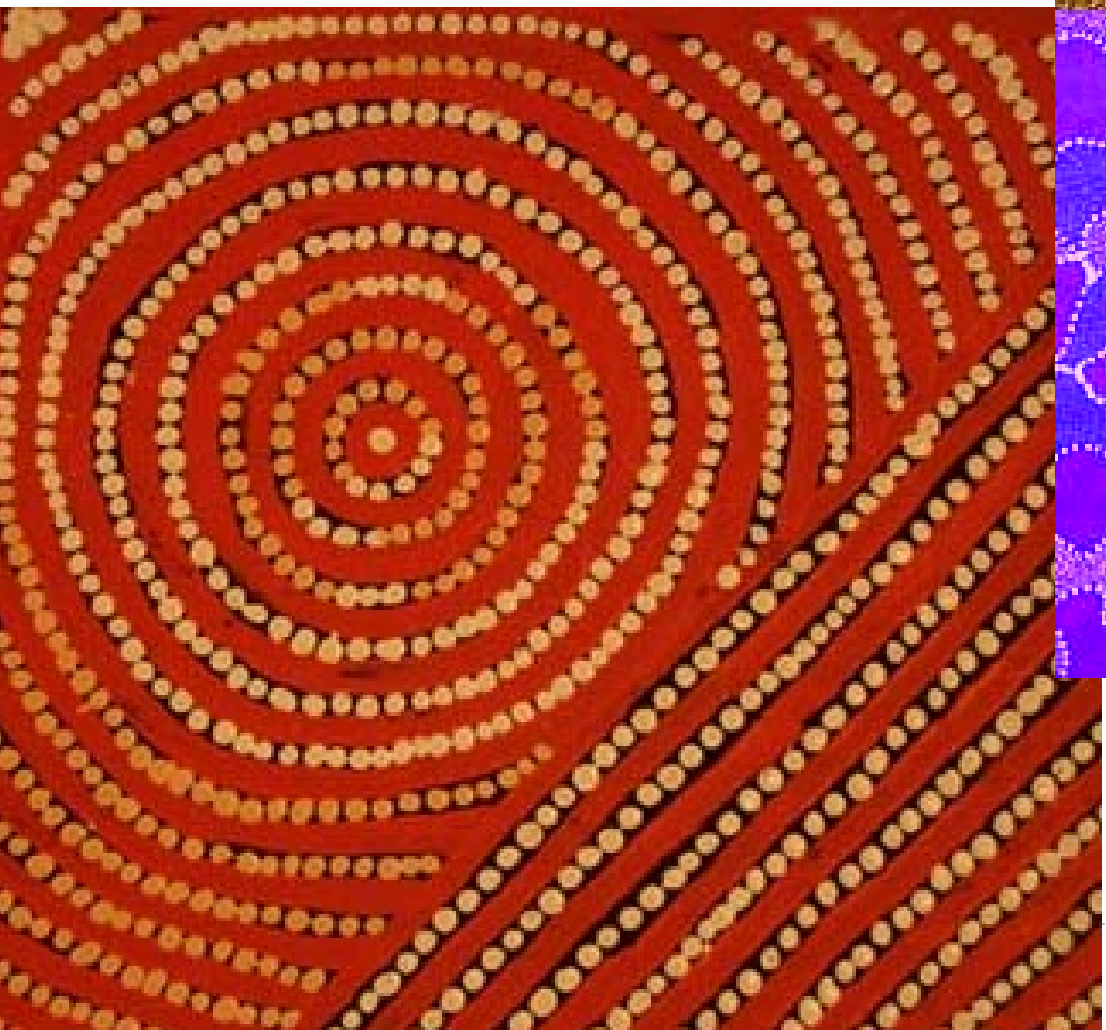
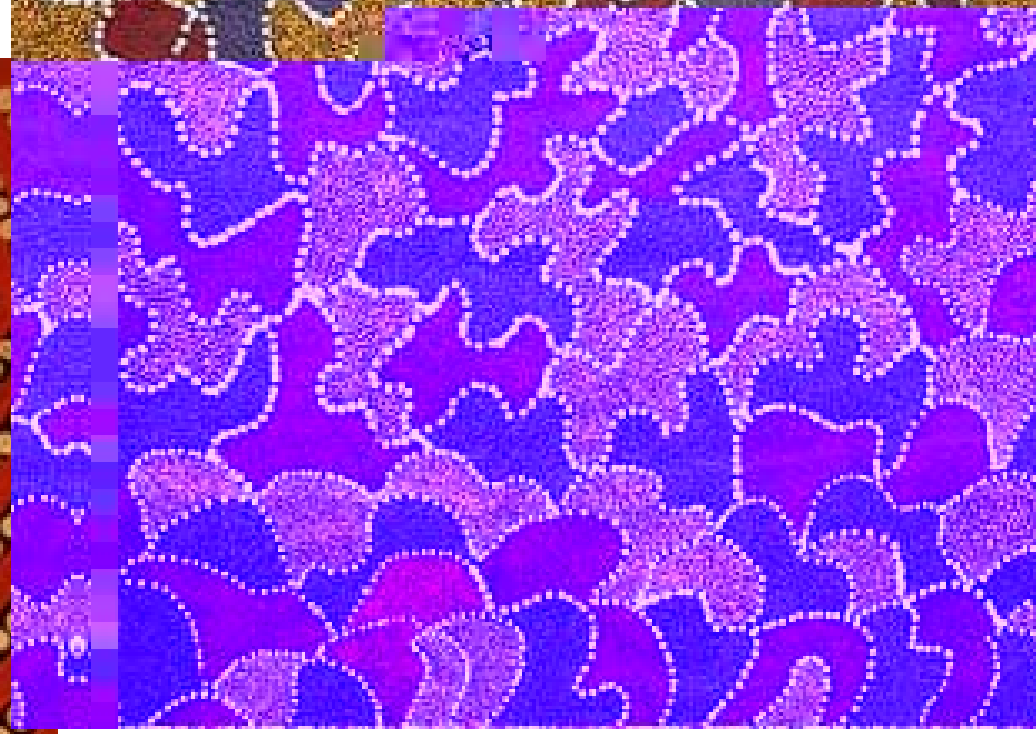
AUSTRALIA

"We know more about the movement of celestial bodies than about the soil underfoot."

- Leonardo da Vinci







- Digital soil mapping
- *globalsoilmap.net* project
- Digital soil assessment
- Digital soil monitoring
- (My thoughts on) opportunities for National Cooperative Soil Survey

DSM definition

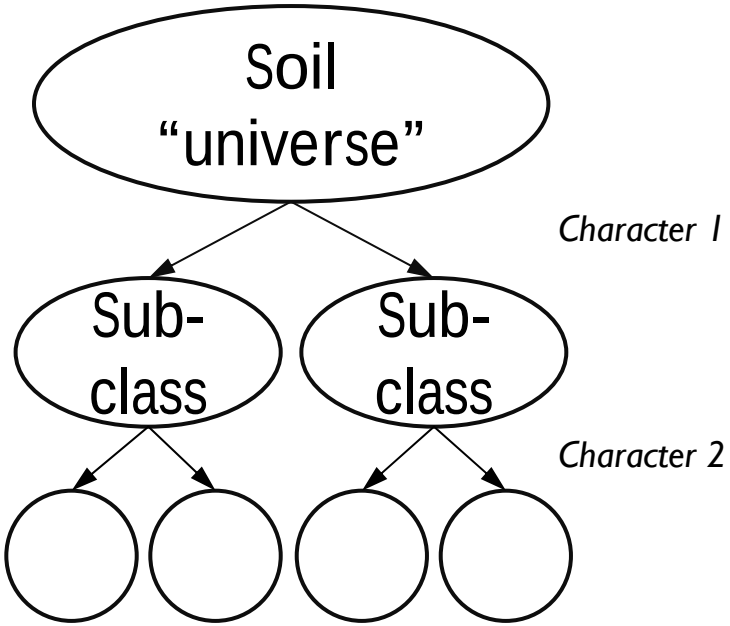
- The creation and population of spatial soil information systems by numerical models inferring the spatial and temporal variations of soil types and soil properties from soil observation and knowledge and from related environmental variables

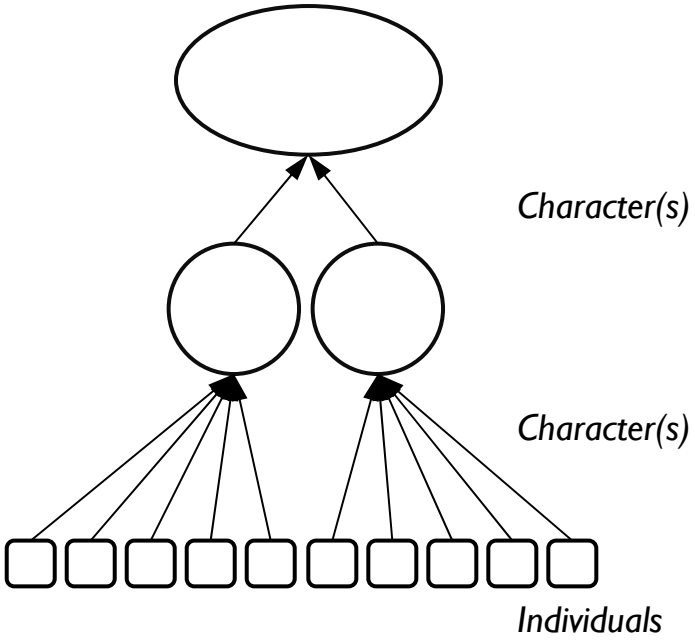
- Lagacherie & McBratney 2007

DSM resolution

- High <20 m
- **Medium 20-200 m**
- Low > 200 m

Top-down and bottom-up approaches



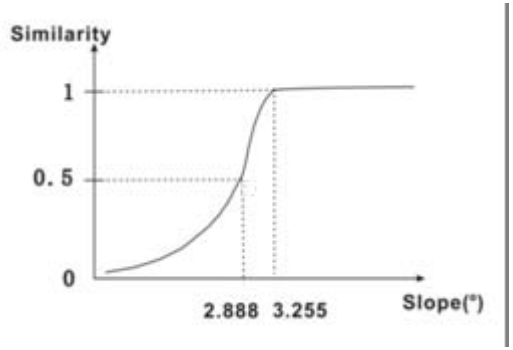


Top-down approaches

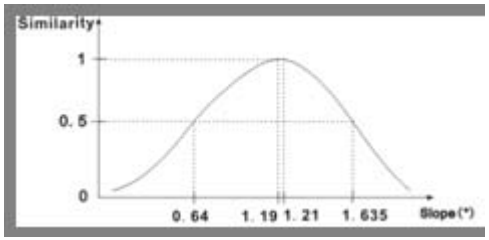
- Expert - SOLIM
- Data-based scorpan

SOLIM

- a personal construct-based approach to extract the knowledge on soil-environment relationships from local soil experts and represent the knowledge as membership curves



Fuzzy membership curves with respect to slope for a toposequence: a. Mollic Bori-Udic Cambosols, b. Typic Hapli-Udic Isohumosols -1, c. Typic Bori-Udic Cambosols, d. Lithic Udi-Orthic Primosols (Zhu et al, 2009)


Similarity
1
0. 5
0
0. 64
1. 19
1. 21
1. 635
Slope(°)

scorpan

$$S_{c,p} = f\,(s,c,o,r,p,a,n) + e$$

s: soil, other properties or prior knowledge of the soil at a point;

c: climate, climatic properties of the environment at a point;

o: organisms, vegetation or fauna or human activity;

r: topography, landscape attributes;

p: parent material, lithology;

a: age, the time factor;

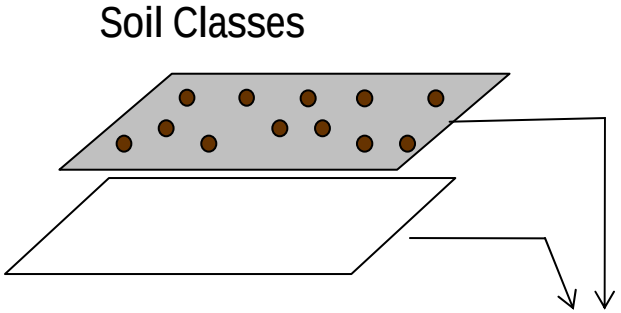
n: space, relative spatial position.

e: autocorrelated random spatial variation

scorpan

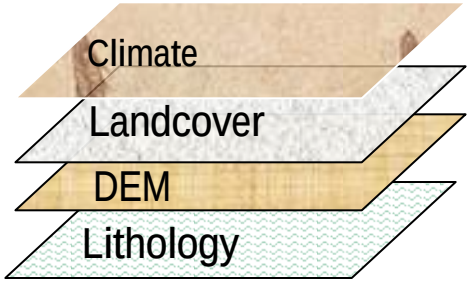
$$S_{c,p} = f\,(s,c,o,r,p,h,a,n) + e$$

scorpan -classes



$S_c = f\,(s,c,o,r,p,a,n)$ ⟶

scorpan layers

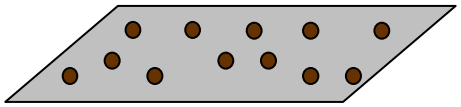


f - *Decision trees,*
Random forests,
Neural networks,
Etc..

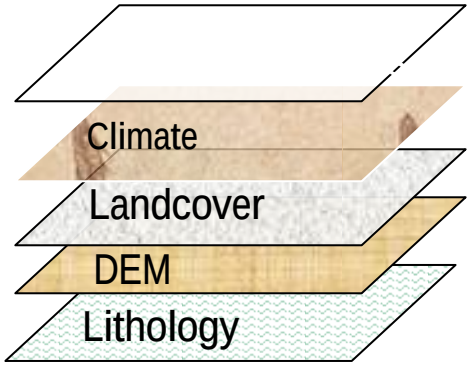
Krige the residuals

scorpan - properties

Soil observations



scorpan layers



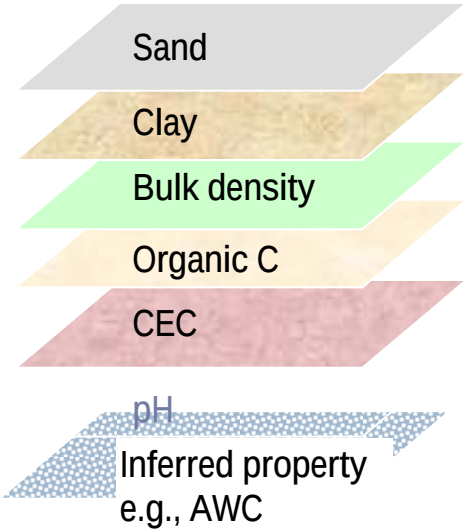
$S_p = f\,(s,c,o,r,p,a,n) + e$

f - Linear regression,
Regression trees,
Random forests,
Neural networks,

Etc..

Krige residuals (e)

Master variables



scorpan properties - the continous layer model

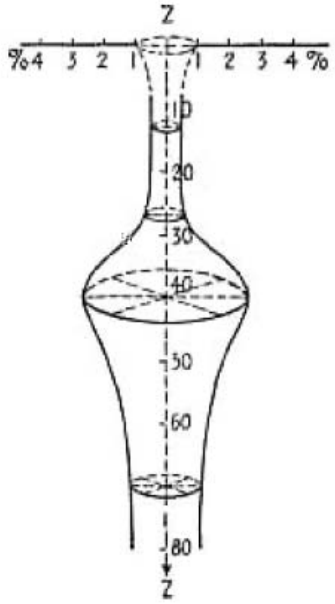


FIG. 6.—Illustration of a soil indicatrix. Colloidal Al_2O_3 of a podsol profile on level topography.

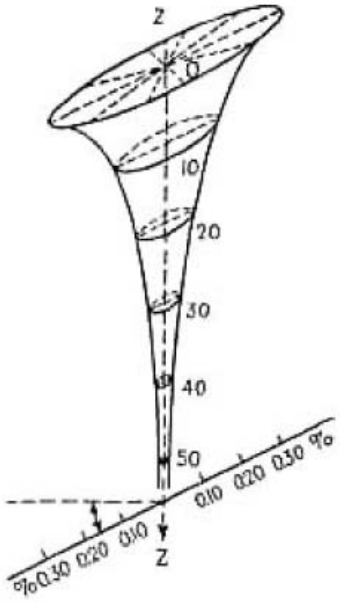
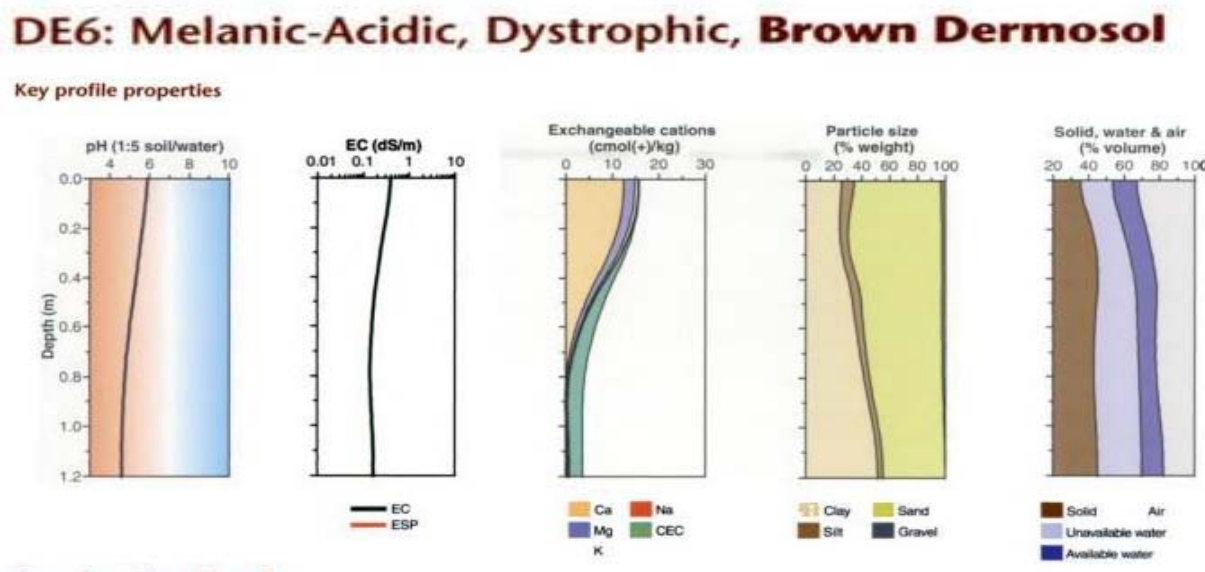
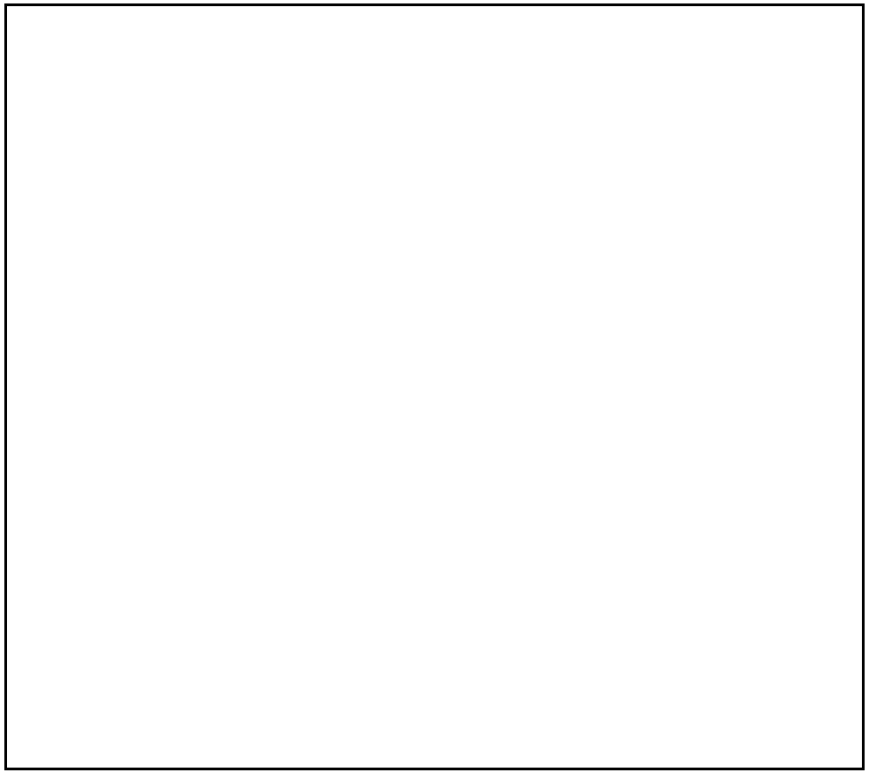


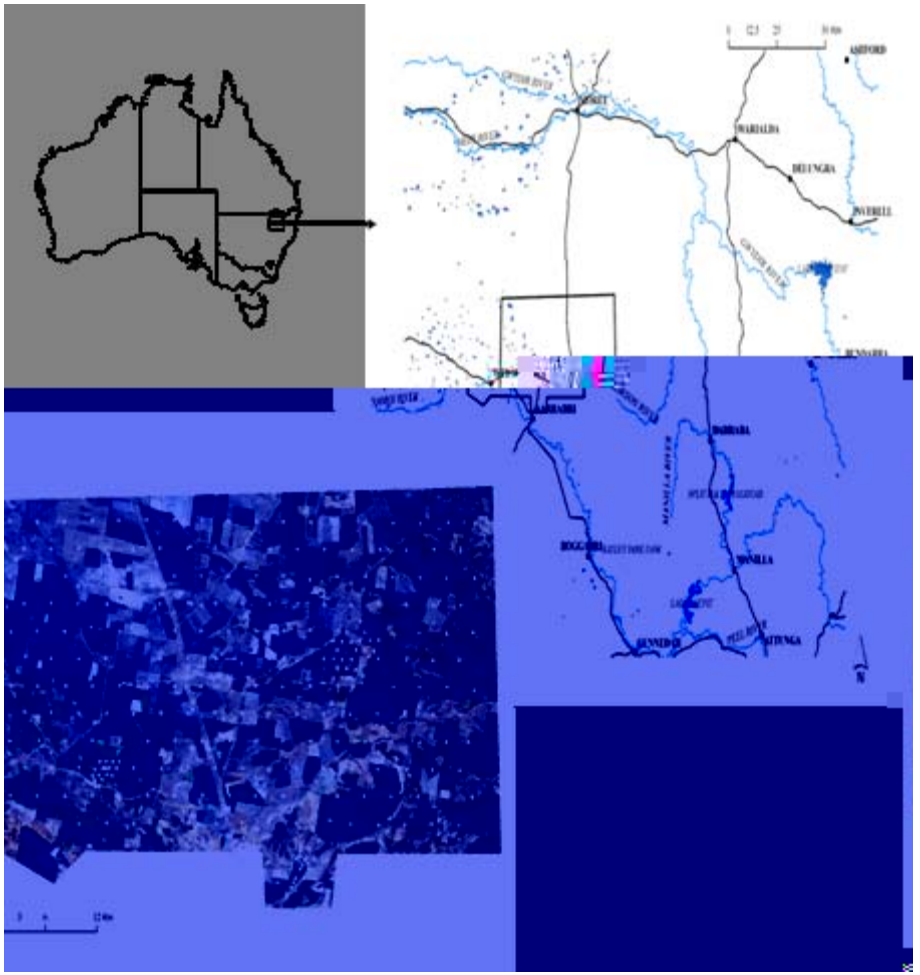
FIG. 7.—Illustration of a soil indicatrix. Total nitrogen of a prairie soil profile on a slope of 26°34' or 50 per cent.



Equal-area spline

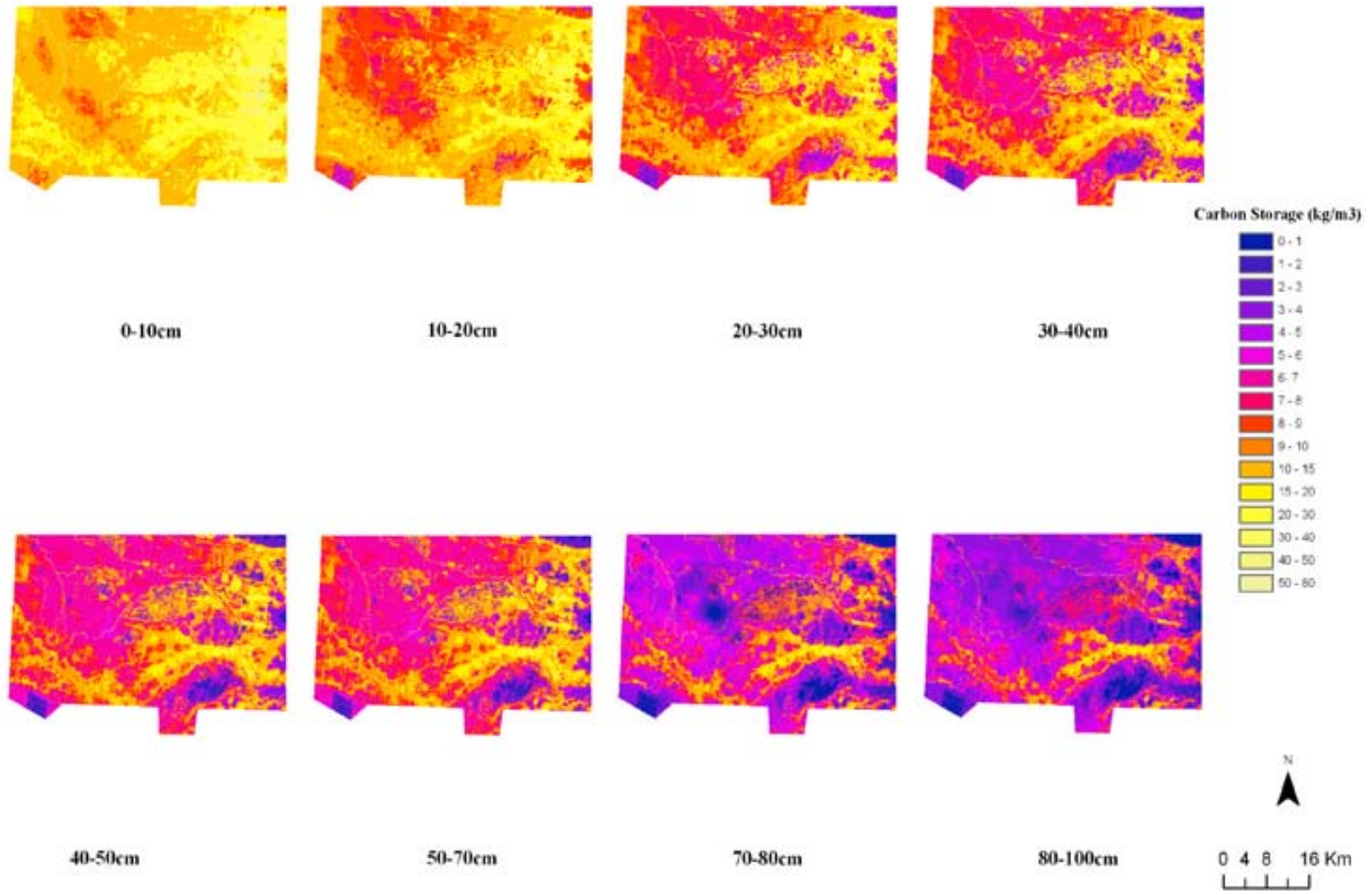


Whole profile mapping

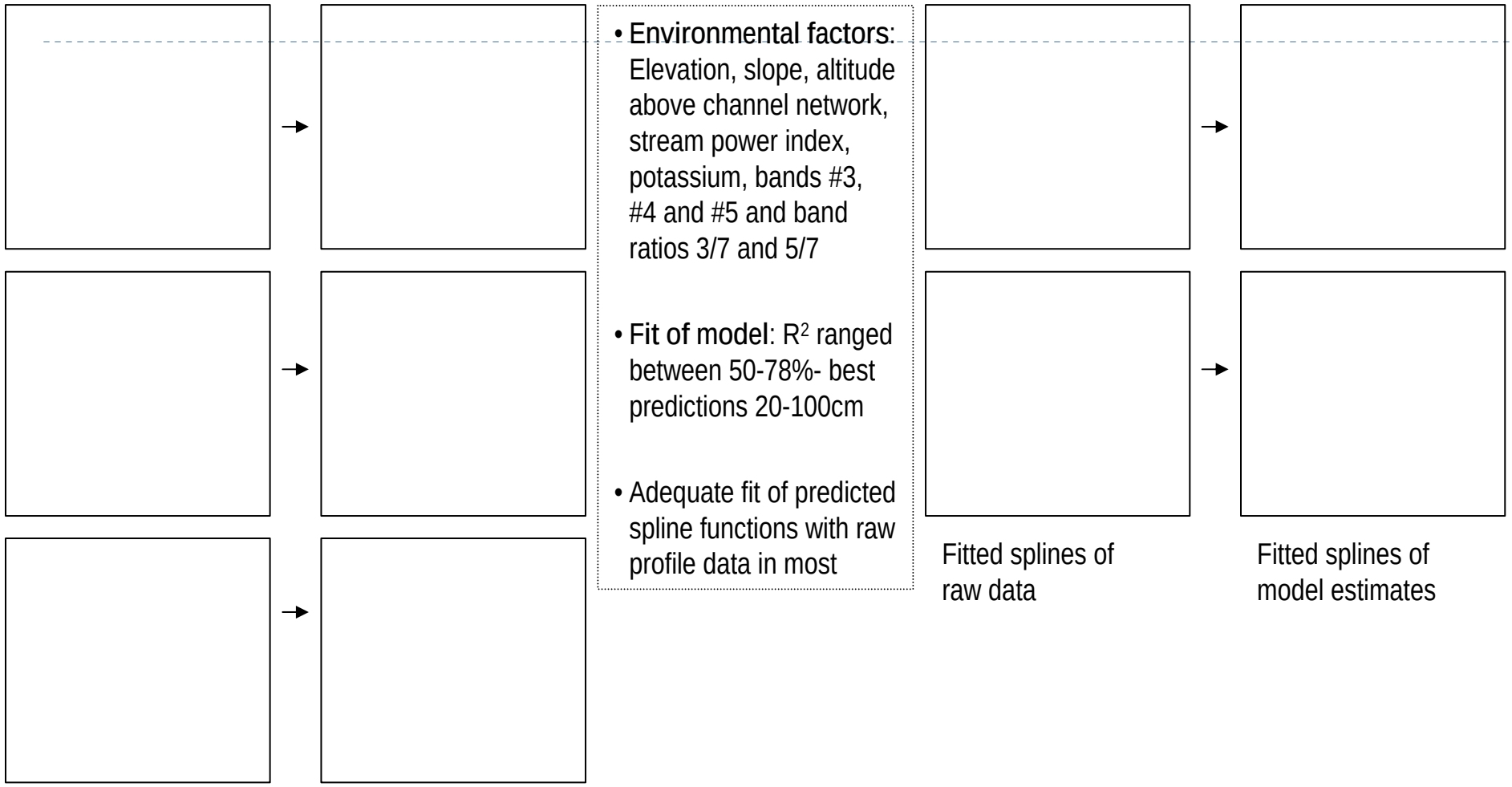


Clay content

Profile Soil C prediction



Carbon Storage



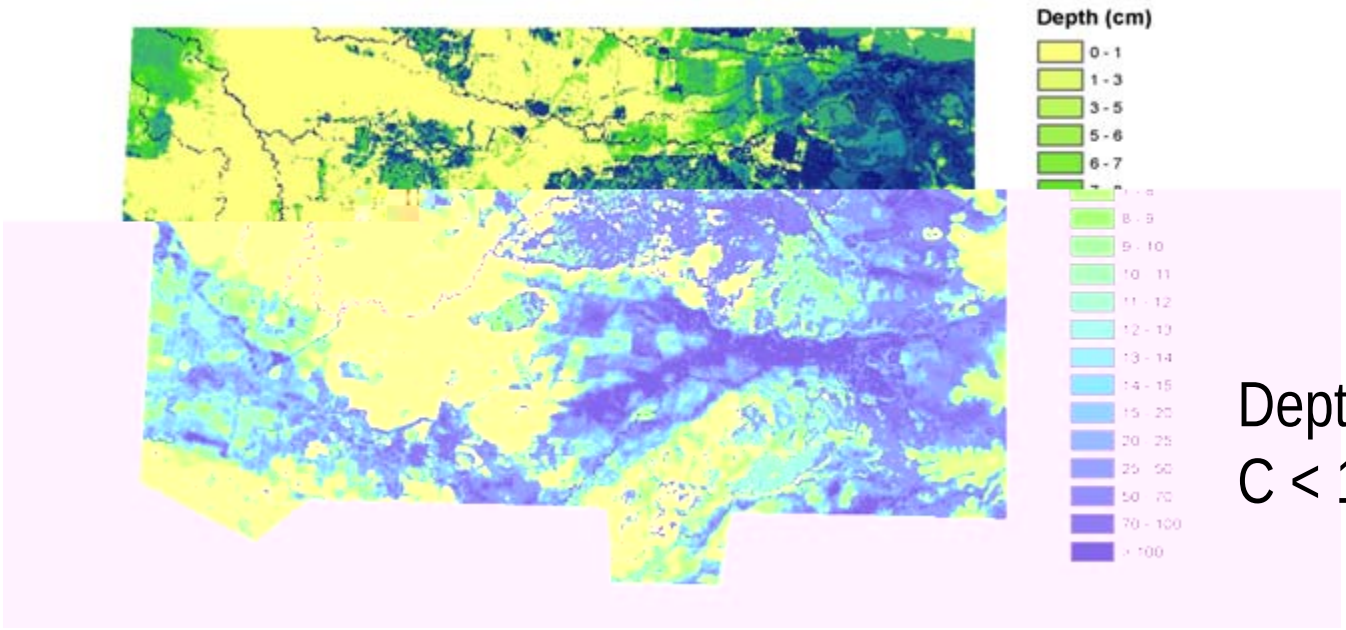
- **Environmental factors**: Elevation, slope, altitude above channel network, stream power index, potassium, bands #3, #4 and #5 and band ratios 3/7 and 5/7
- **Fit of model**: R^2 ranged between 50-78%- best predictions 20-100cm
- Adequate fit of predicted spline functions with raw profile data in most

Fitted splines of raw data

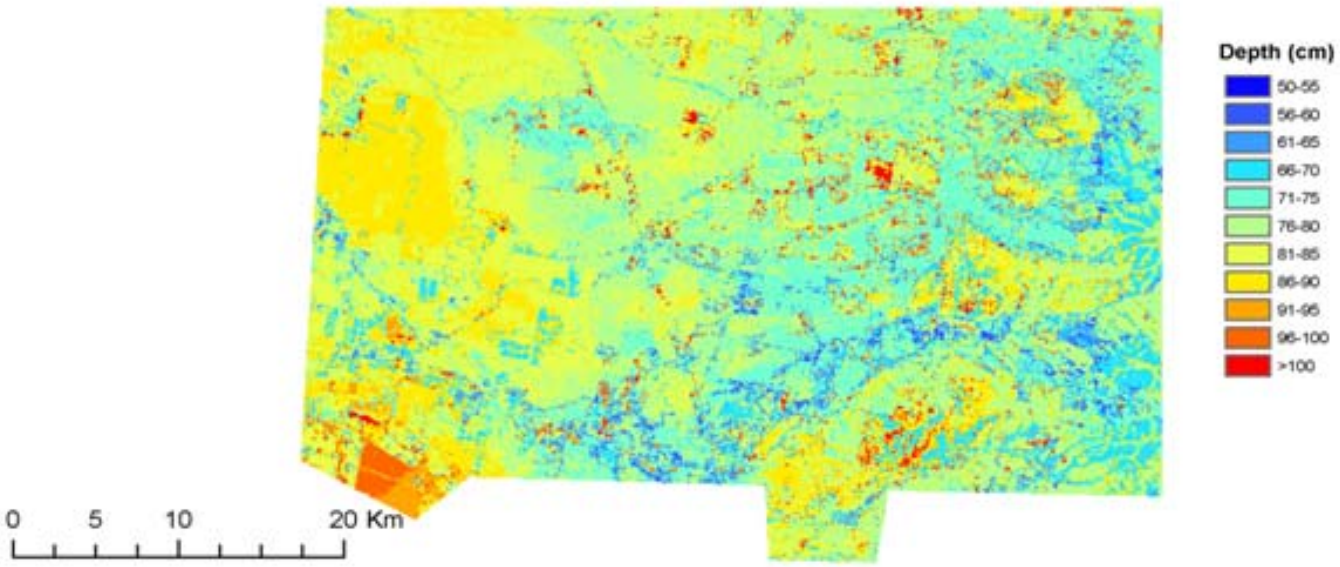
Fitted splines of model estimates

Fitted splines of raw data

Fitted splines of model estimates



Depth at which soil C < 1%



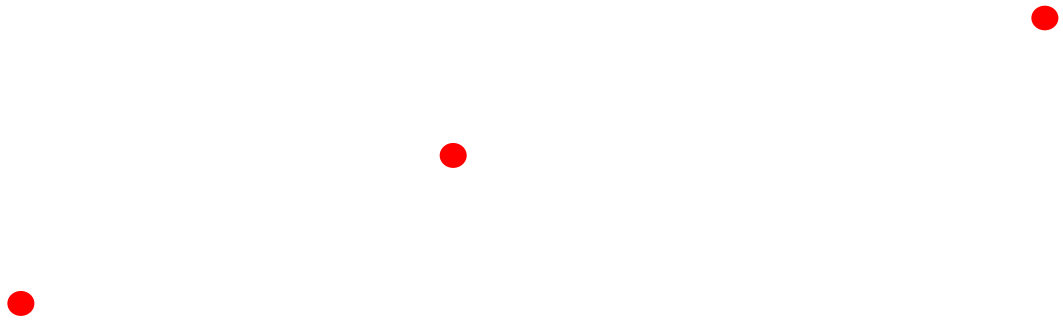
Depth at which AWC = 100 mm

A wee bit on sampling

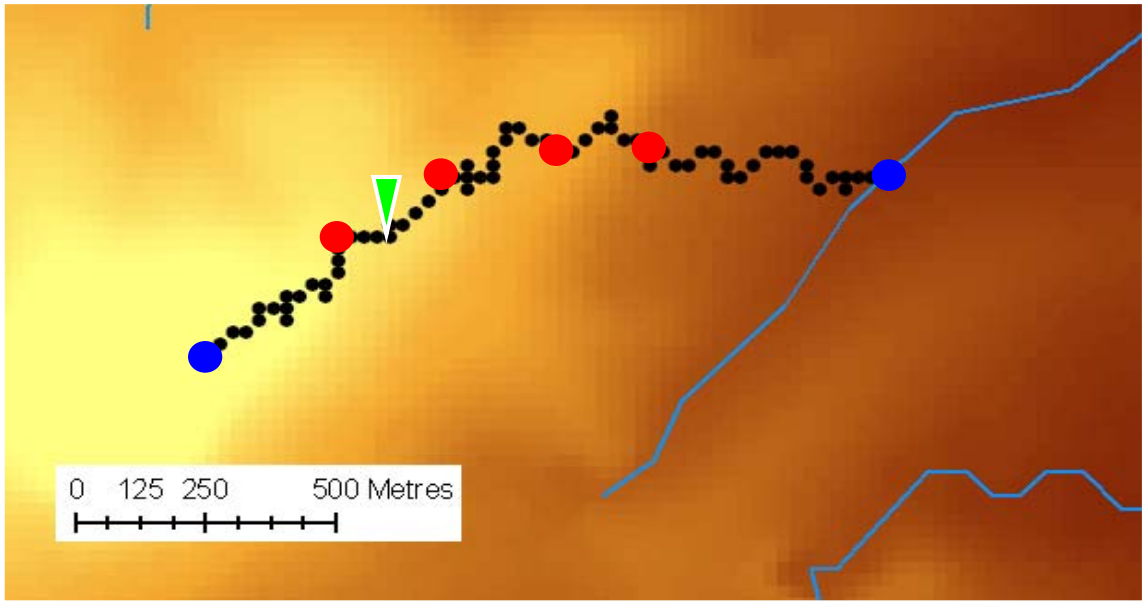
- 1/3 of the samples used for corroboration/validation/certainty estimation

- Random catena sampling
- Latin hypercube sampling

*k*th-order random toposequences

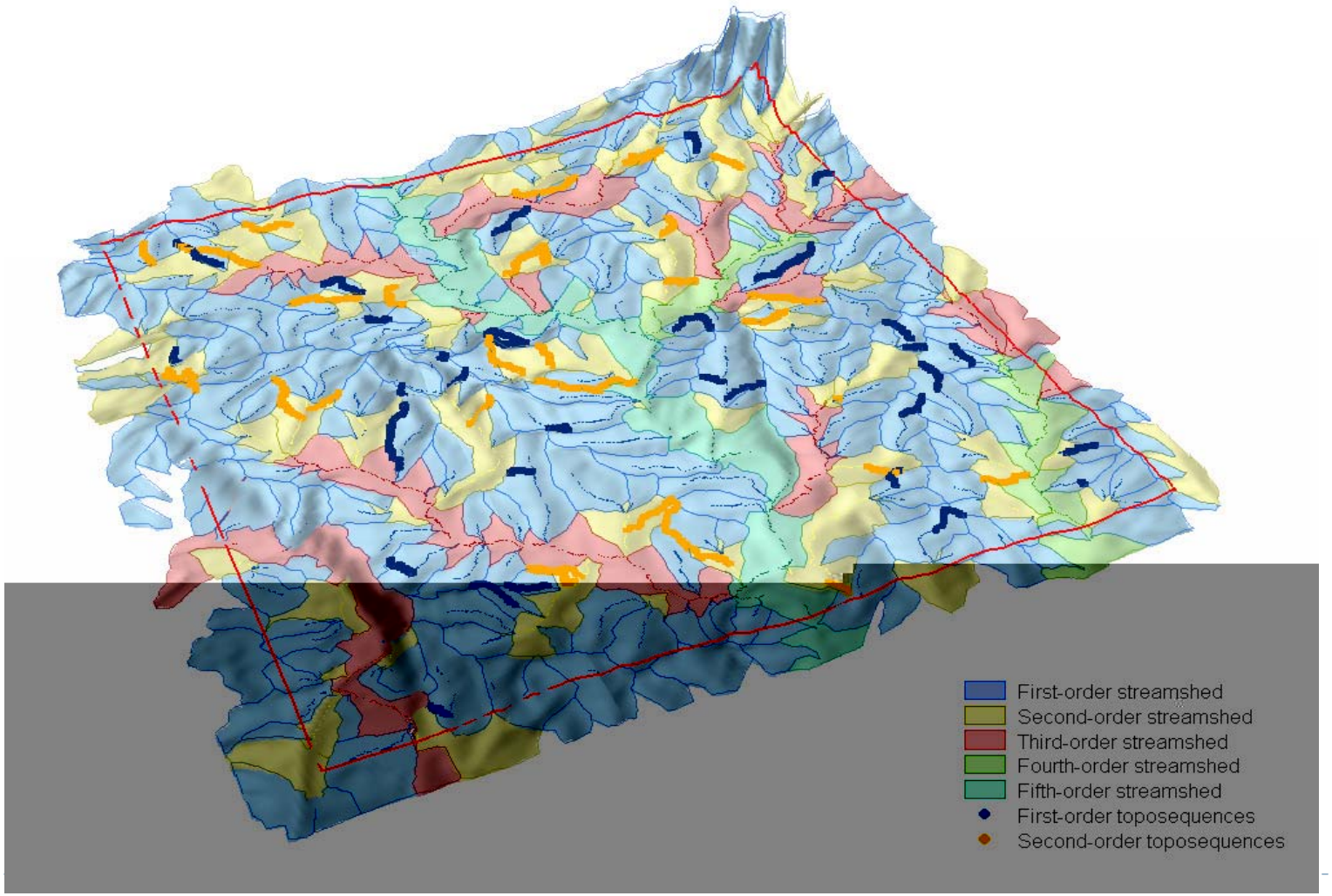


*k*th-order random toposequences



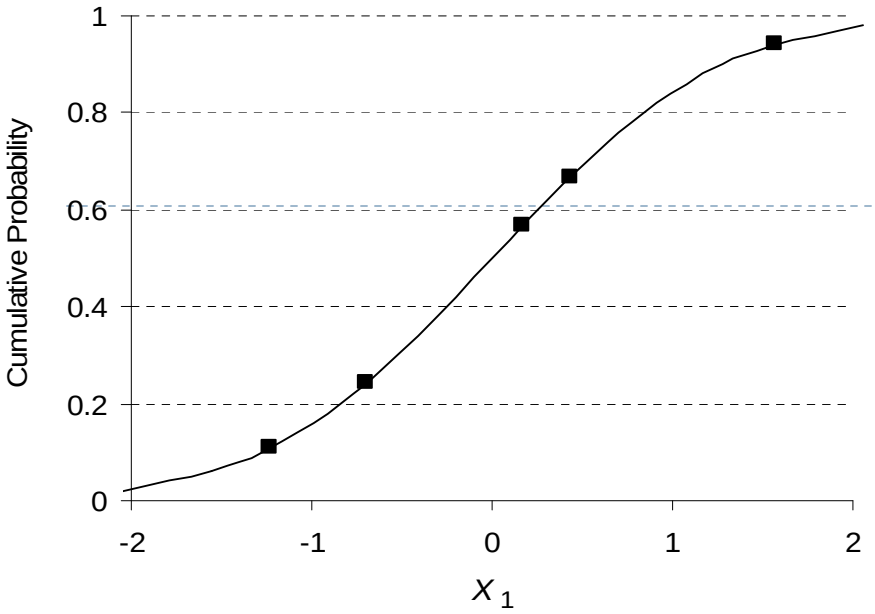
Elevation (m)

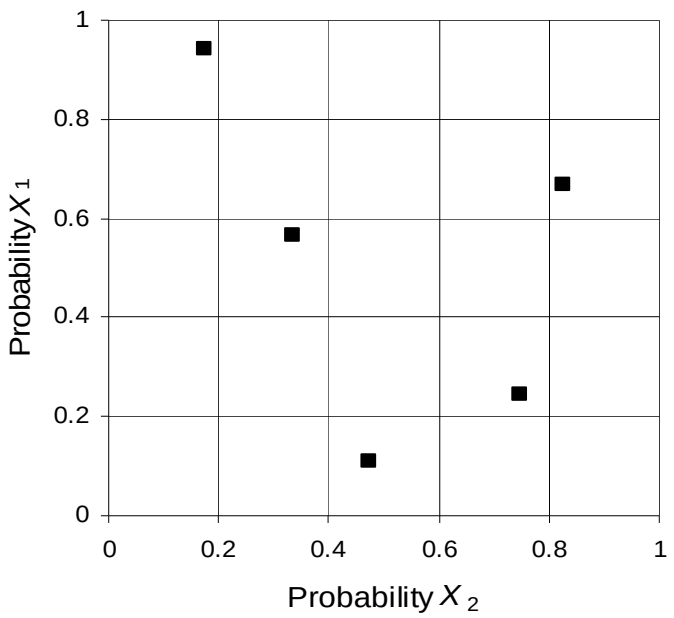
*k*th-order random toposequences



Latin Hypercube Sampling

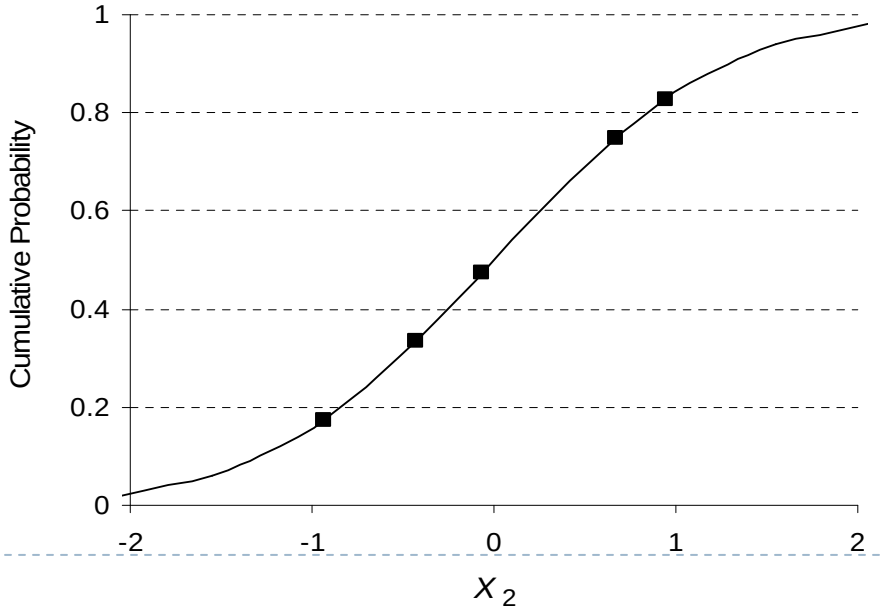
- Designed for the scorpan model

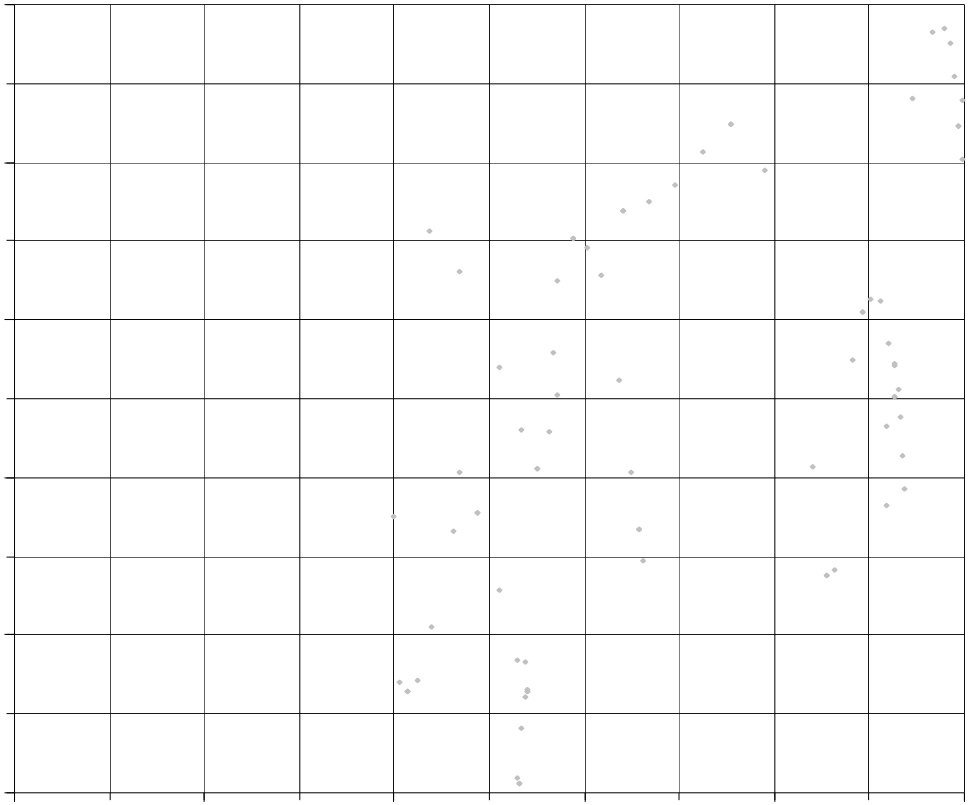




Latin Hypercube Sampling

A random sampling procedure that ensures a full coverage of the range of each variable by maximally stratifying the marginal distribution





- Land cover
- CTI
- Gamma`K
- 300 soil profiles

Bottom-Up Soil Mapping

- A more radical approach suitable for special purposes
- In this case defining `digital terroir`

Bottom-Up Summary

Create and define soil layer classes

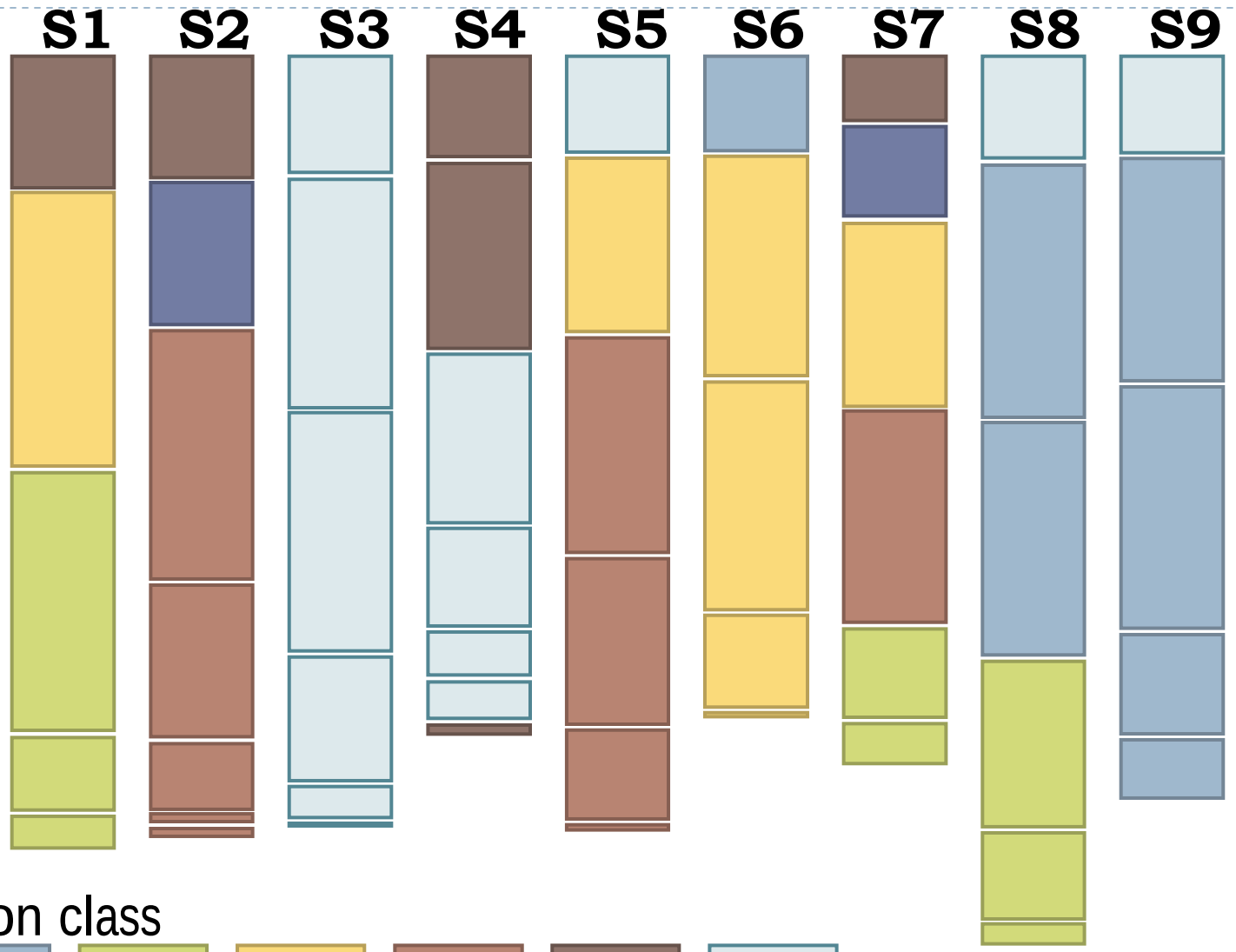
Layer classes

Created and defined soil series classes

Series classes

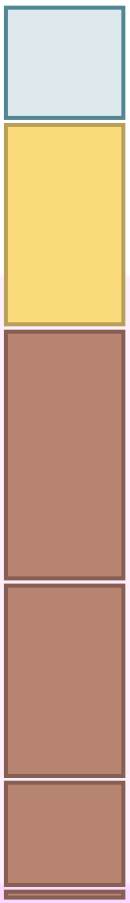
Created and defined soil mapping units

Soil series centroids

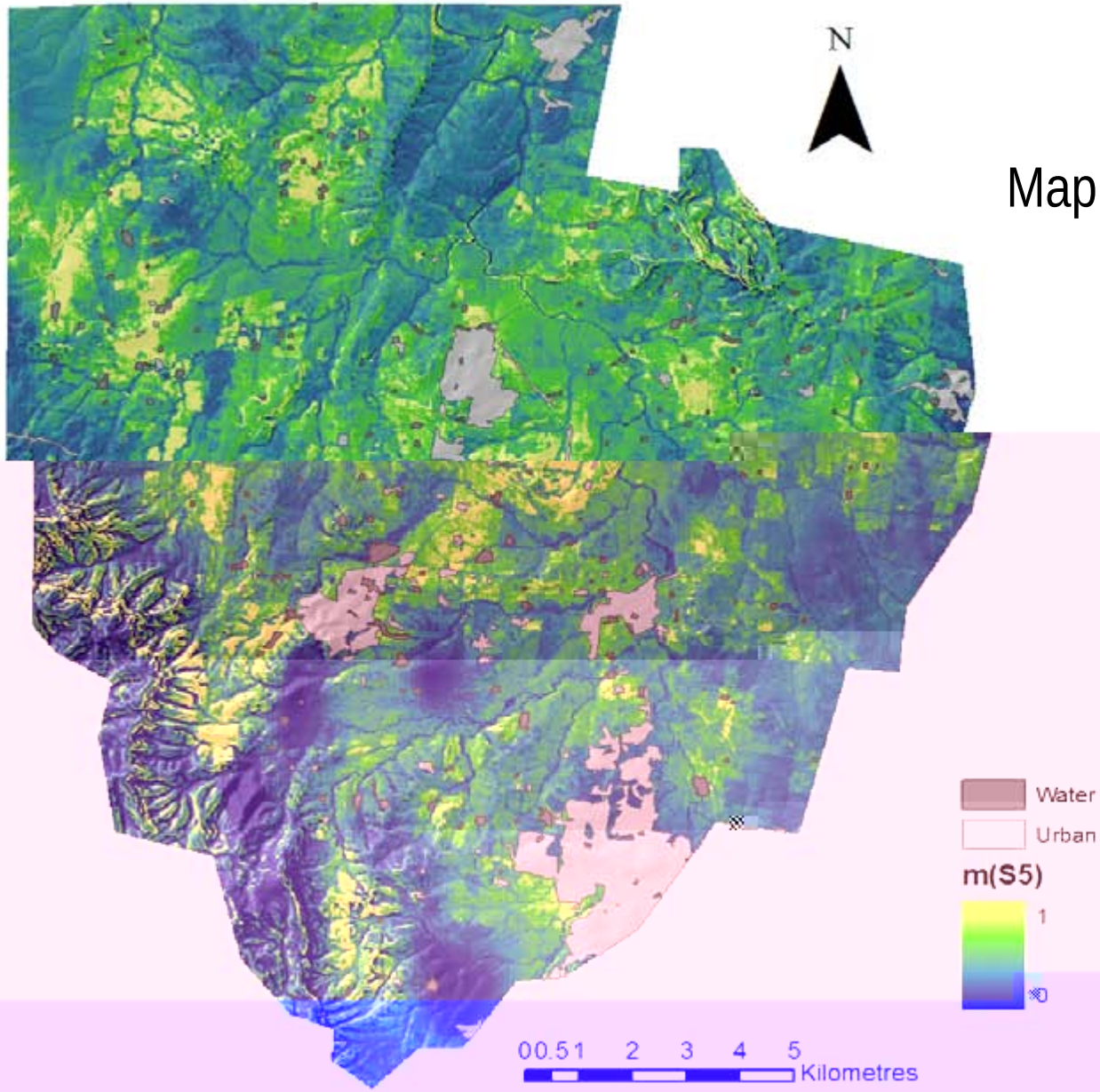


Soil horizon class

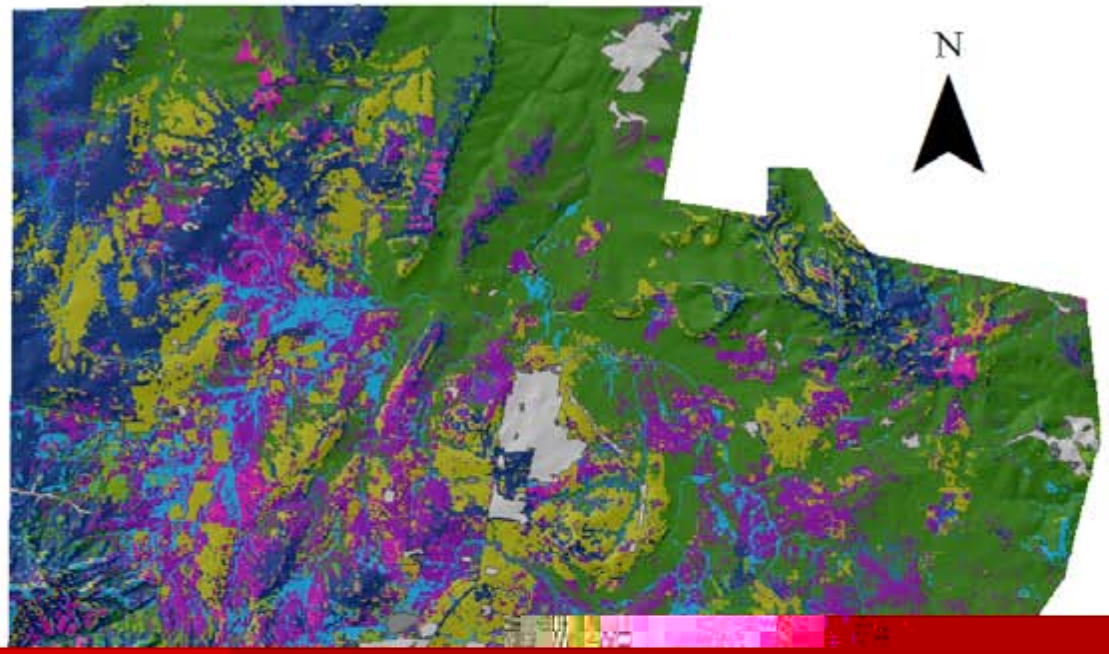
L1 L2 L3 L4 L5 L6 L7



Map

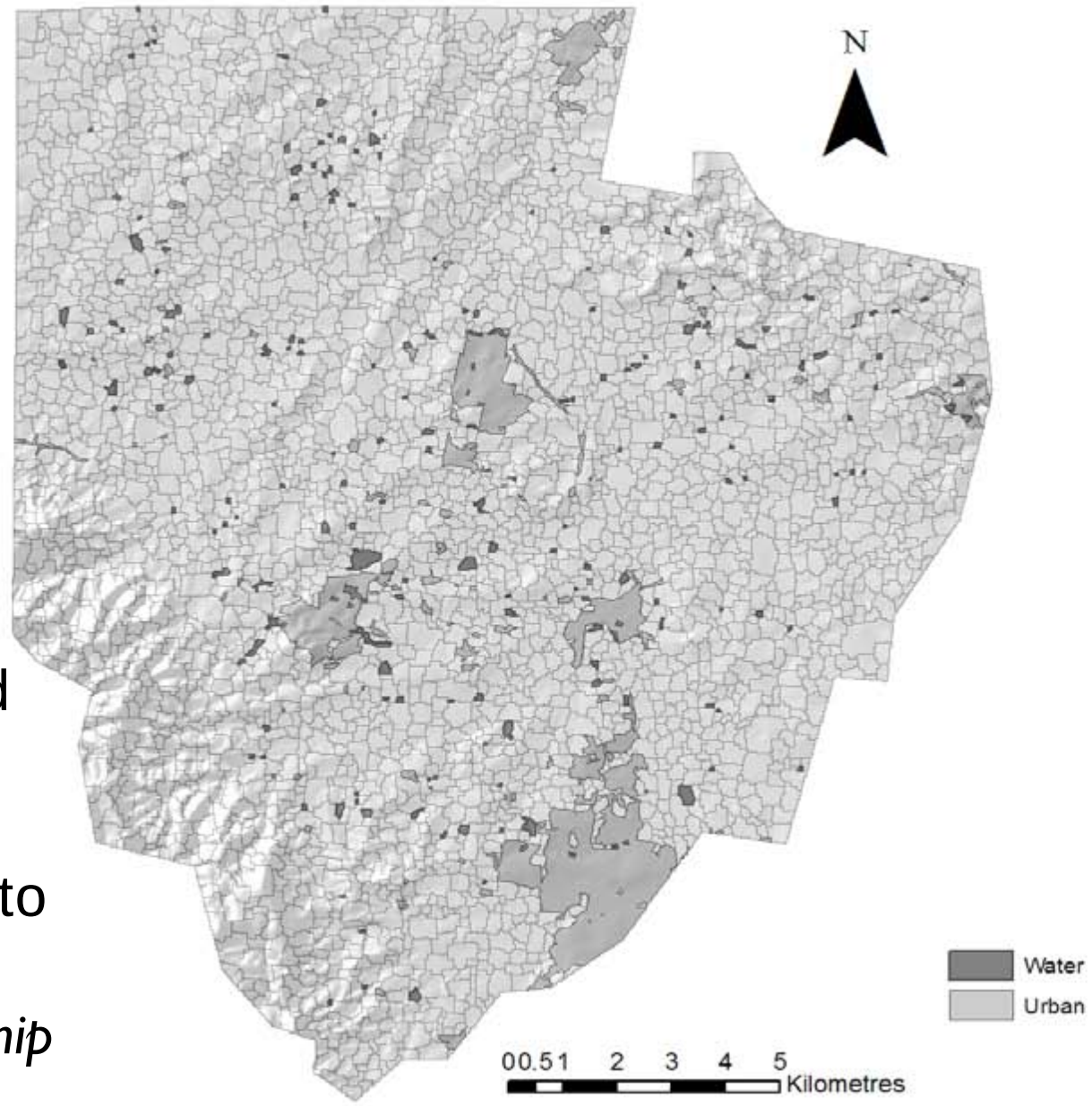


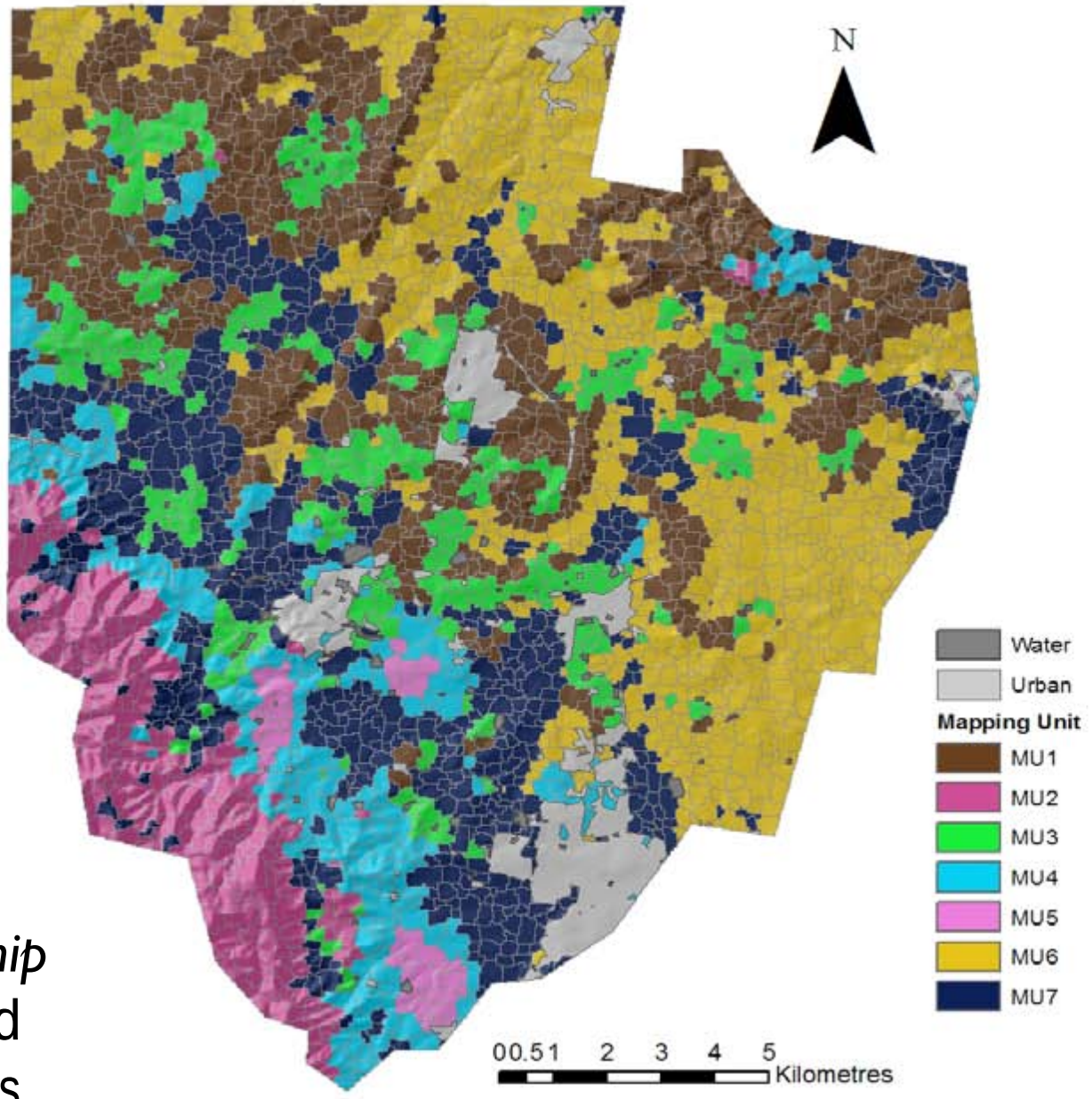
Membership (series 5)



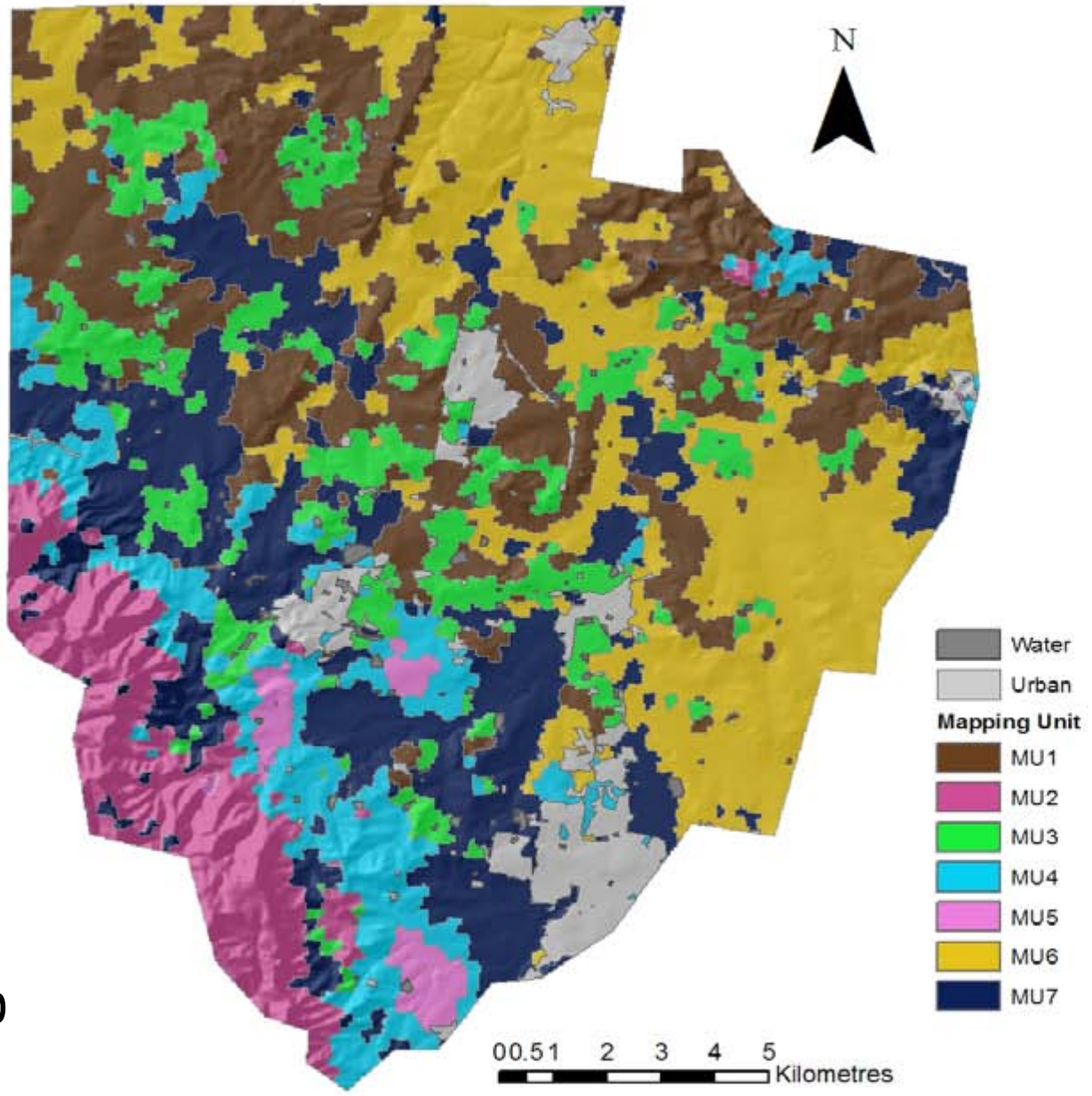
Map of predicted soil series according to *highest membership*

Object-oriented segmentation algorithm to segment map into parcels with *similar membership pattern*





Parcels with *similar membership pattern*, coloured by map unit class



Coalesced map unit polygons

globalsoilmap.net project

Initially a legacy based approach

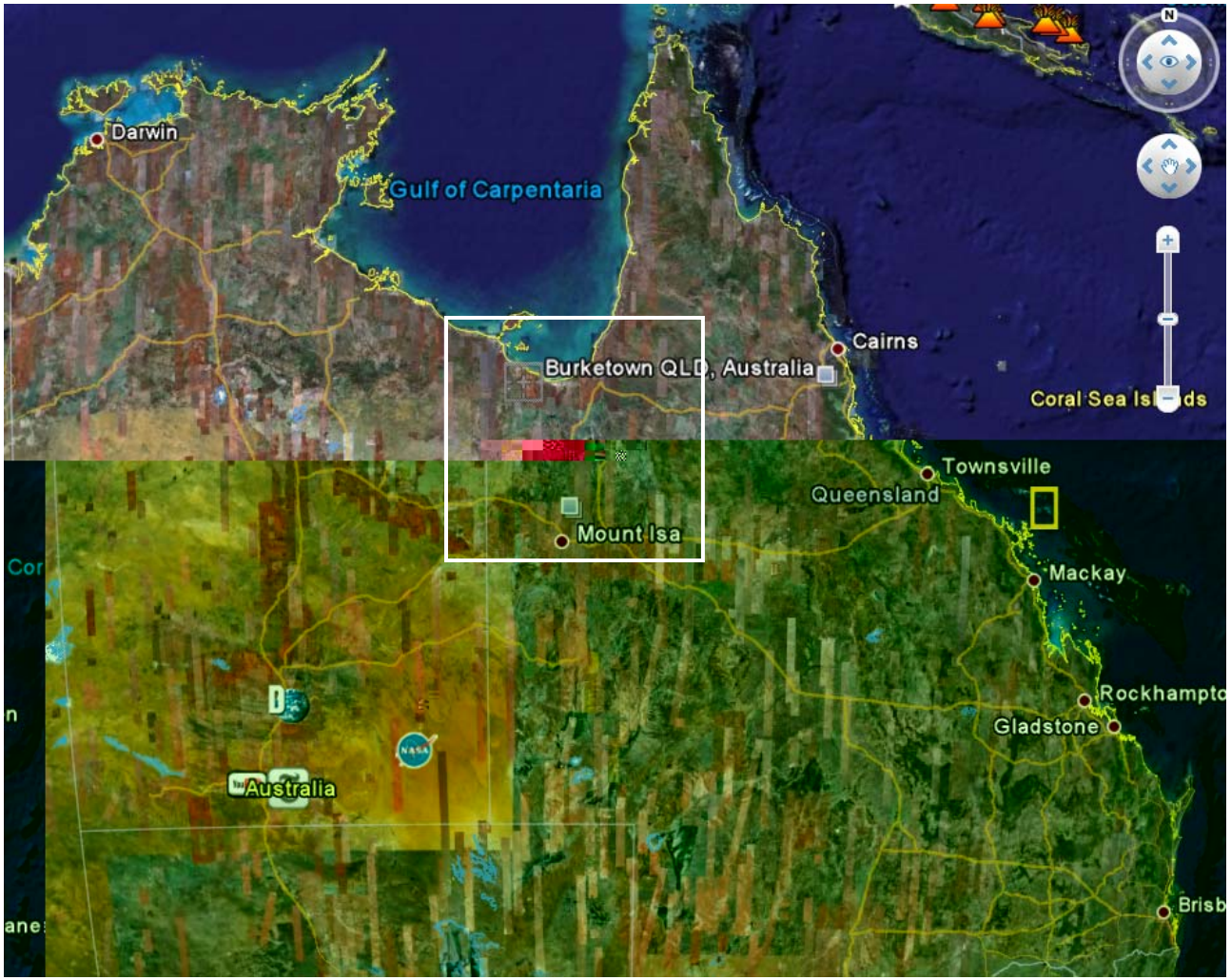
DIGITAL SOIL ASSESSMENT

Soil inference systems

- Linked pedotransfer functions
- SINFERS2 soil inference engine software
- MIR reflectance spectra very useful

DIGITAL SOIL MONITORING

- Stratification using the scorpan covariates suggests appropriate monitoring locations
- Latin hypercube sampling
- Fuzzy k means stratification



Monitoring in the Gulf Country Queensland

- QLD DNR&W

Fuzzy k-means of

The environmental layers

k = 50

Siteses were constrained to be located within 1.5 km from roads

BY WAY OF CONCLUSION

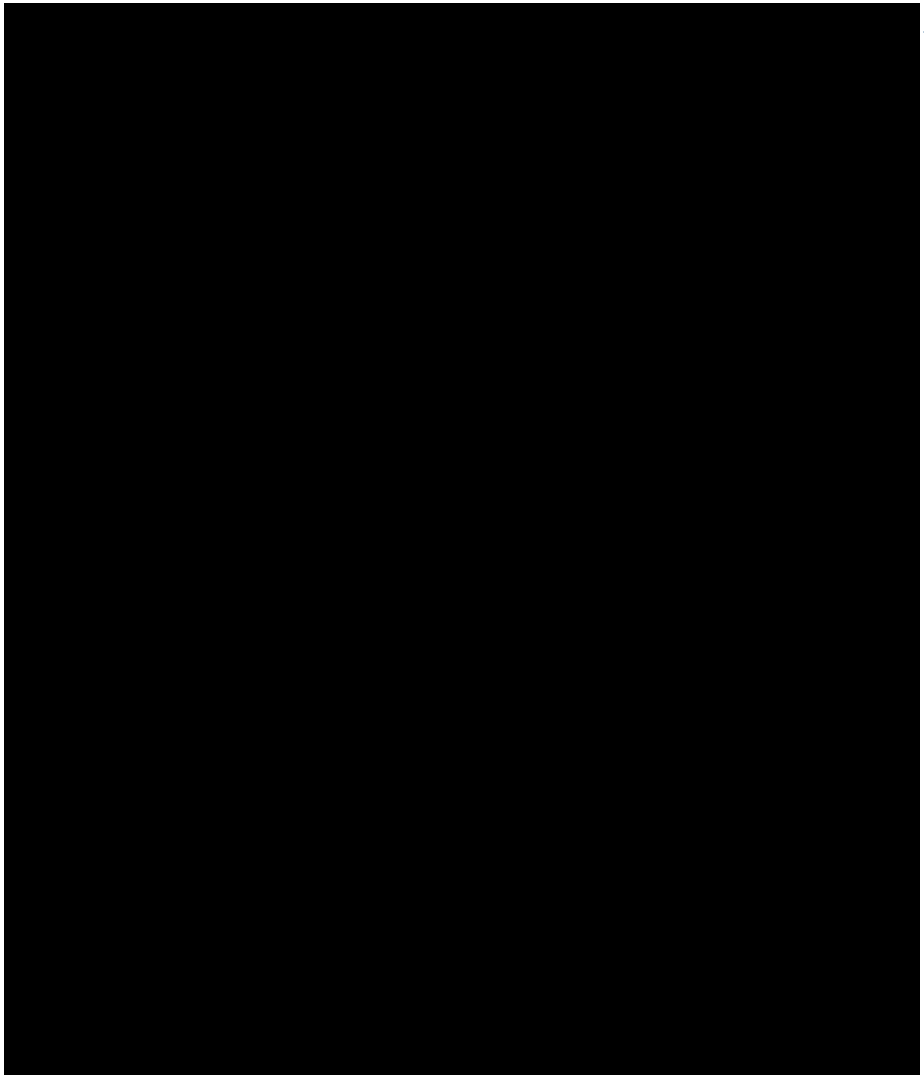
DSMM OPPORTUNITIES FOR National Cooperative Soil Survey

- Remote and Range Lands
- Updating s = *f*(s' corpan)
- Globalsoilmap.net
- Value-adding MLRA soil survey process 20m resolution continuous layer model

Some key points

- Scorpan model
- Latin hypercube sampling
- MIR and gamma radiometrics useful technologies
- All lead to huge value-adding opportunities

Southern Hemisphere pedology



Australia is a cultured country

Cheers!

One soil

There was once

Only one soil

In all our worlds

For me it was

A cryptopodzolic brown earth

In a` Scots pine forest

On the Balmoral estate

Why did we need

To find another

And yet another?

David van der Linden