

Digital Soil Mapping



Ronald Vargas Rojas

01 April 2012



**GLOBAL SOIL
PARTNERSHIP**

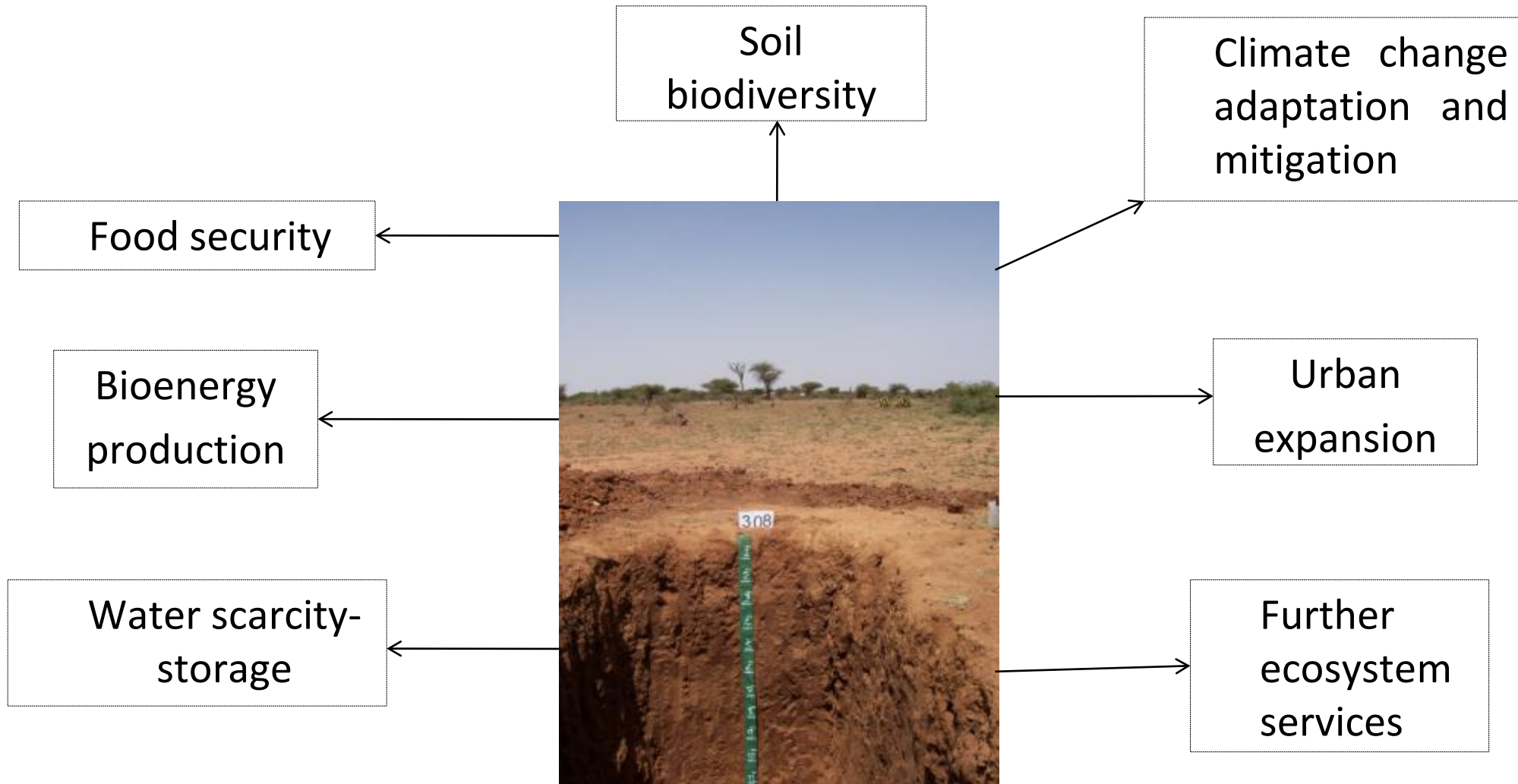
Outline

- **Conventional soil mapping**
- **Technological developments in soil mapping**
- **Case studies**



Conventional Soil Mapping

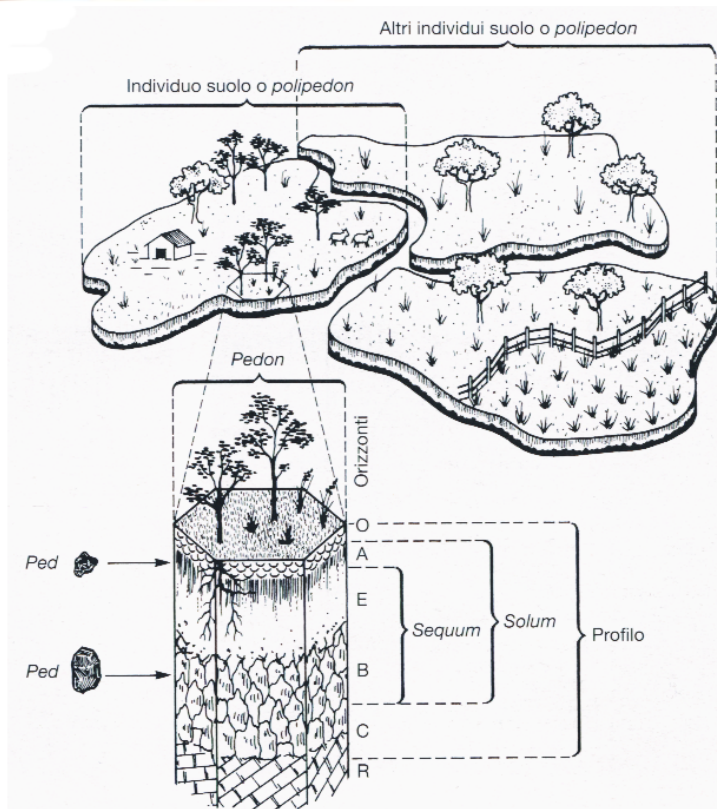
SOIL INFORMATION IS REQUIRED FOR



Who are/could be the users of soil information?

- Decision takers
 - International organizations
 - National governments
 - Extensionists/Farmers
- Researchers/scientists
 - Modellers from other disciplines requiring soil data
 - Researchers working in the food production field
 - Soil scientists working purely in new approaches
- Agronomists and extensionists
 - Extensionists that use the data to take decisions and provide advise. At field level.
- Farmers/Agrodealers
 - In the absence of extension services, farmers require guidance. They could be potential users of soil information.
 - Already happening in precision farming
- Lecturers and students, etc.

Soil as body vs. soil as continuum



- Soil as soil body (pedon).
- Soil unit (mappable) polipedon.
- **Discrete Model of Spatial Variation** (based on polygons). (Heuvelink, 2005).

- Soil is continuous in the geographic space.
- **Continuous Model of Spatial Variation** (grid-pixel)

Considerations of conventional soil mapping

- Soil information represented by choroplethic (polygon) maps (discrete units).
- Discrete model of spatial variation
- Maps are static and qualitative (subjectivity when using interpretation).
- Soil classes (Typic Ustorthents), difficult to integrate with other themes or sciences (specially with modeling).
- Pedology = pure science? Other sciences have made use of the Geo-information tools and methods.
- Approach: qualitative or quantitative?

FIVE SOIL FORMING FACTORS

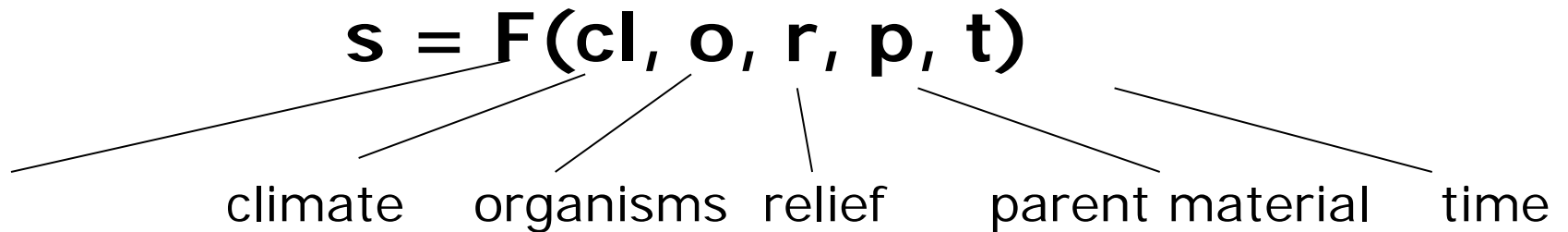
(V.V. Dokuchaev, Rusia, 1883)

- Soil as a natural body having its own genesis and history of development.
- Conceptual model: the soil genesis and geographic variation of soils could be explained by a combined activity of the 5 factors.
- **Five soil forming factors:**
 - 1. climate
 - 2. organisms
 - 3. parent material
 - 4. relief
 - 5. time

SOIL FORMING FACTORS

(Hans Jenny, Switzerland/USA, 1941)

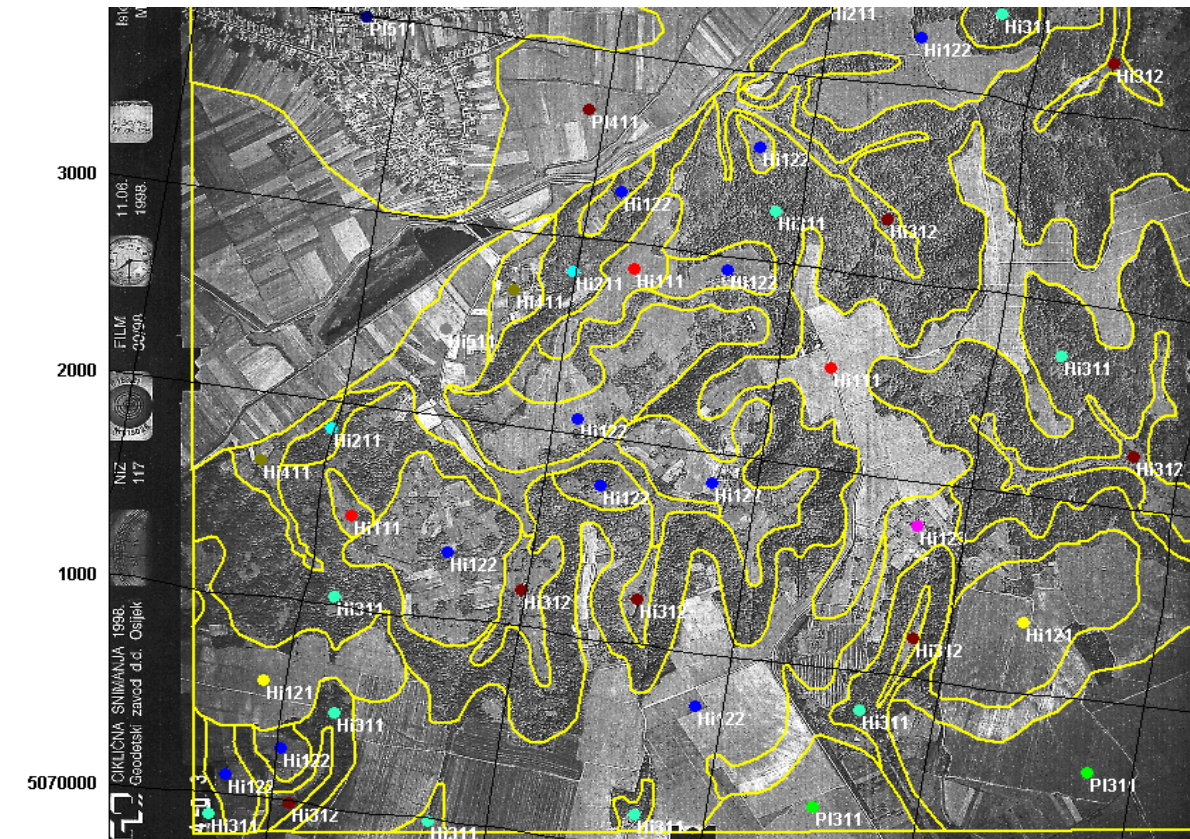
- Jenny equation, soil forming factors:



- Generic relation connecting observed soil properties with independent factors that determines the process of soil formation.
- A concept, not an equation to be solved

CONVENTIONAL SOIL MAPPING

- DMSV, polygon based mapping.
- Soil classes.
- Soil survey:
 - + finding soil-landscape units (photointerpretación).
 - + soil profile description
 - + soil classification
 - + modal profiles and composition of units.

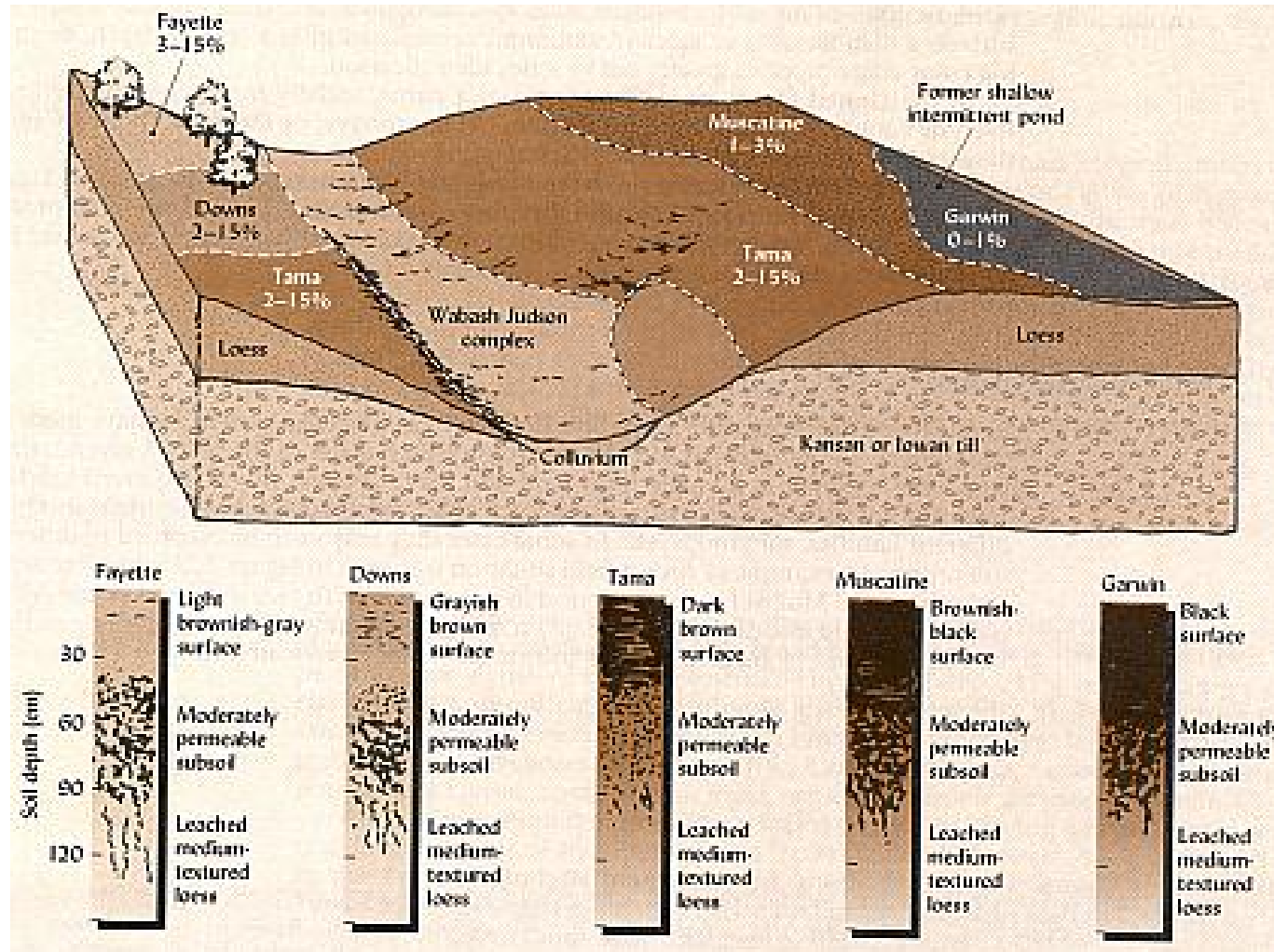


Baranja, Croatia (source: Tomislav Hengl, Msc thesis, ITC)

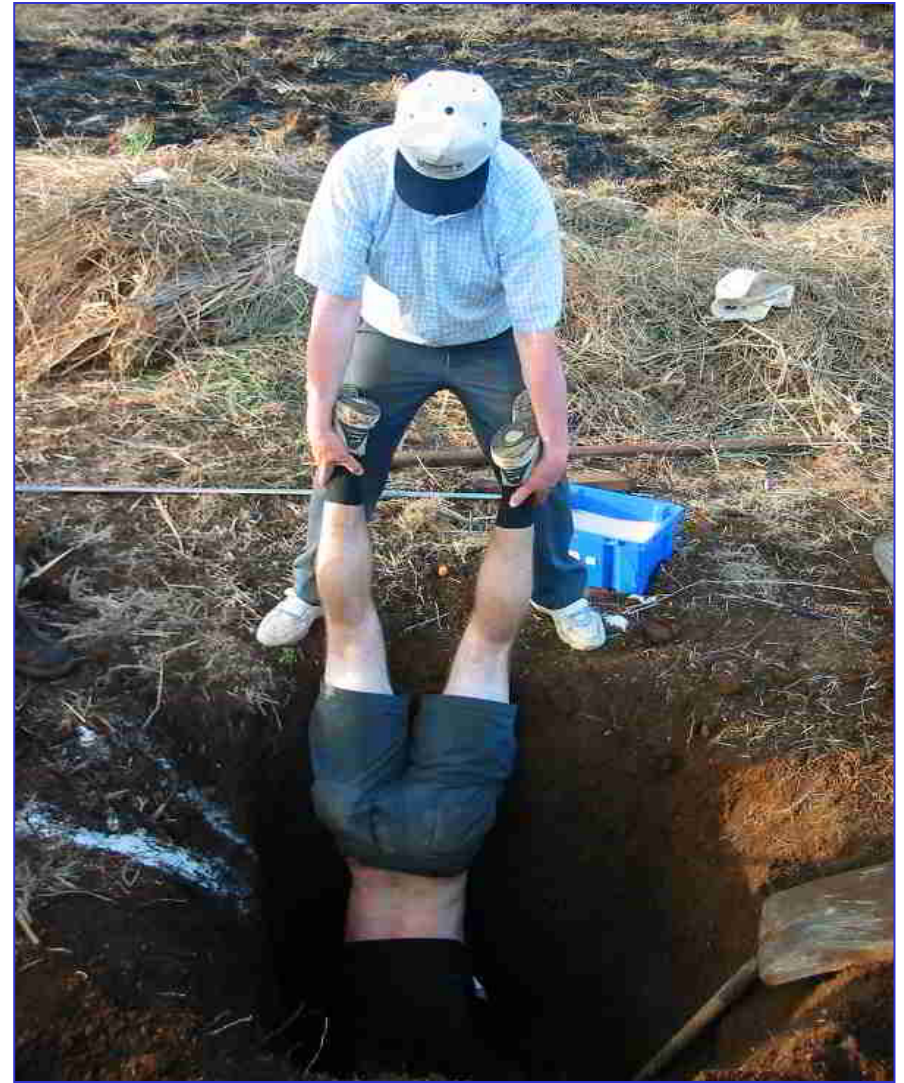
UNDERSTANDING SOILS



SOIL-LANDSCAPES



STUDYING SOILS IN AUSTRALIA



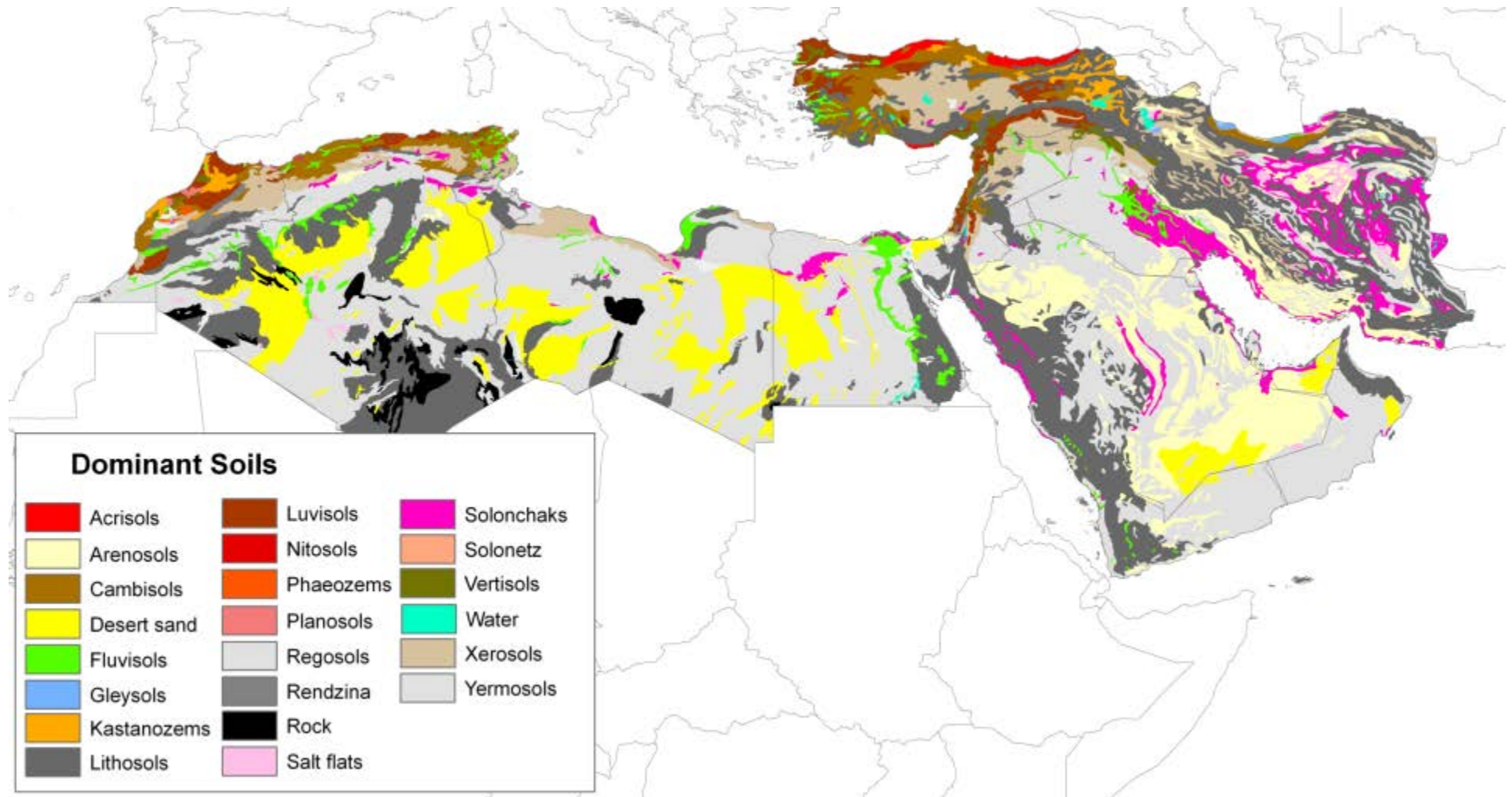
DID SOIL SURVEY CHANGED ON TIME?



Available Global and Regional Soil Information



Harmonized World Soil Database for the region: based on FAO World Soil Map produced on 1978



Limitations of conventional soil mapping

- Pedologist generate a soil-landscape model. The model and knowledge is implicit, not documented and intuitive. Difficult to re-build and reproduce.
- Soil class/type choroplethic map. The name comes from a modal profile (most representative of the unit).
- Assumptions, limitations and unknown accuracy.
- Soils varies along the landscape but still soil. Gradual changes are represented by sharp boundaries.
- Variability inside a class is considered non spatially correlated.
- Qualitative: there is no quantitative expression of the spatial variability of the soil body and its properties.
- Two main types of errors: commission and omission.

Limitations of conventional soil mapping

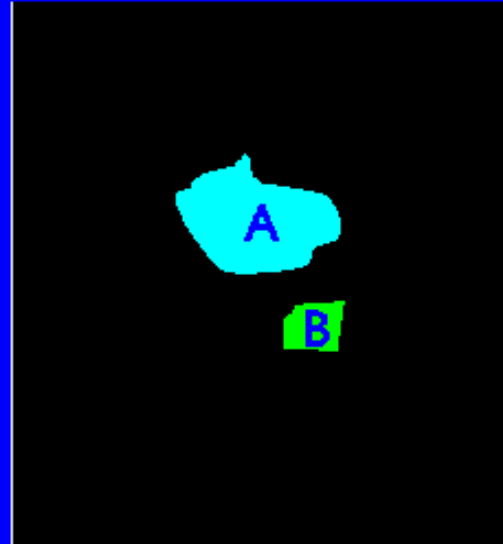
- Comission errors: when a MLA is established, smaller areas are eliminated.
- Omission errors: spatial variability of soil properties inside a polygon is eliminated in the GIS context.

Commission Errors

At Large Scales



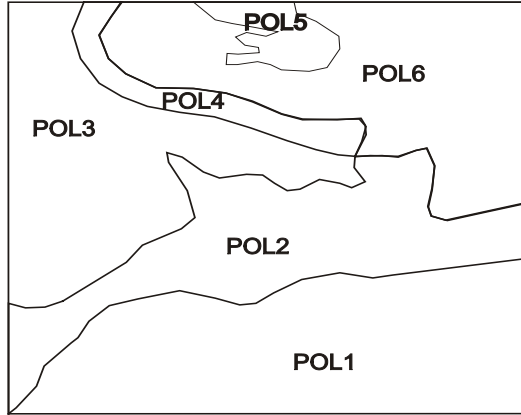
At Small Scales



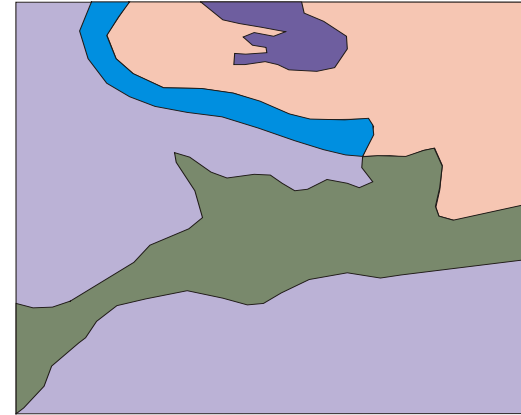
Omission Errors

CHLOROPLET MAP

POLYGON MAP

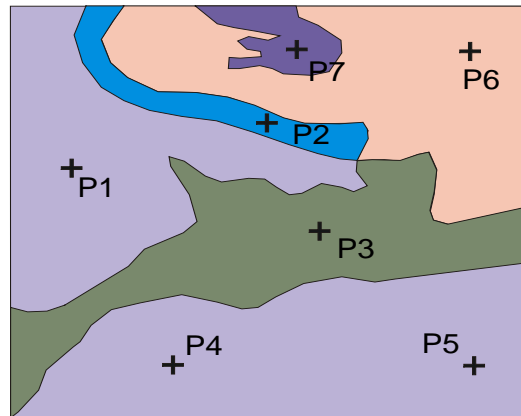


SOIL TYPES

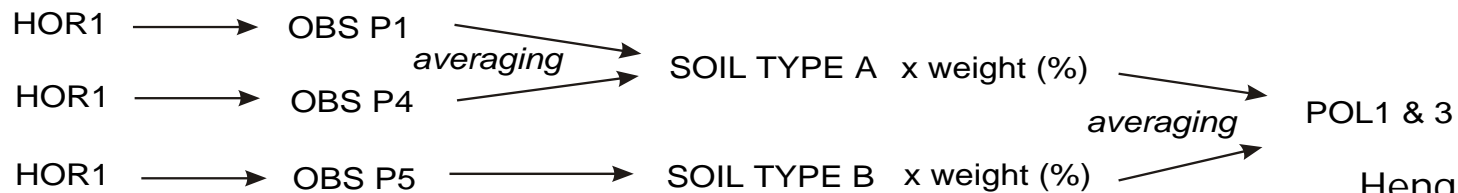
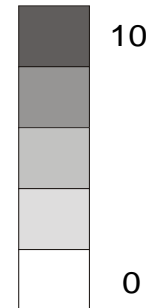


ATTRIBUTE MAP

SMU + SDB



OM CONTENT IN HOR1

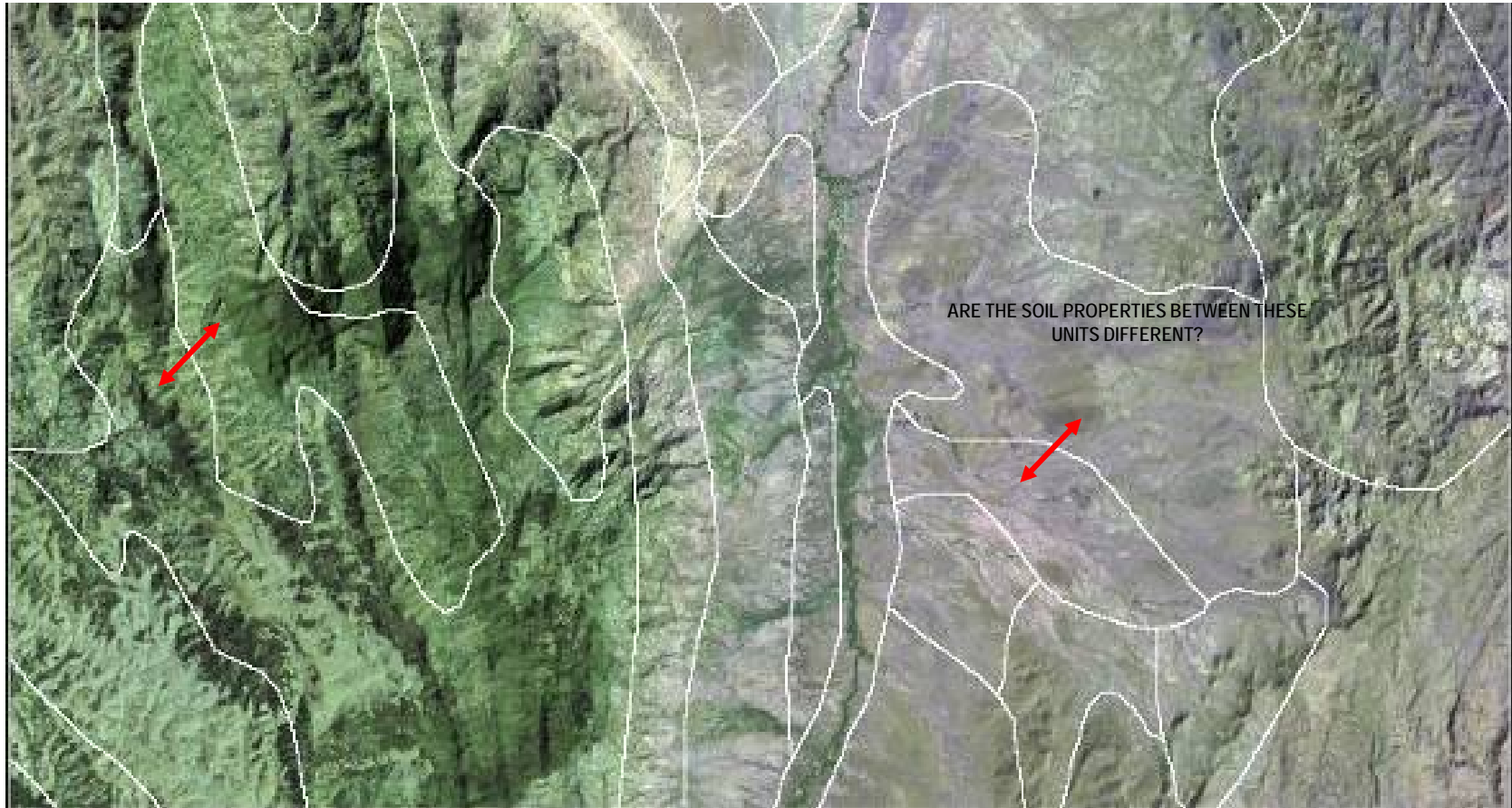


Example

SRTM, Landsat ETM composite & SEA, Tugen Hills, Kenya.

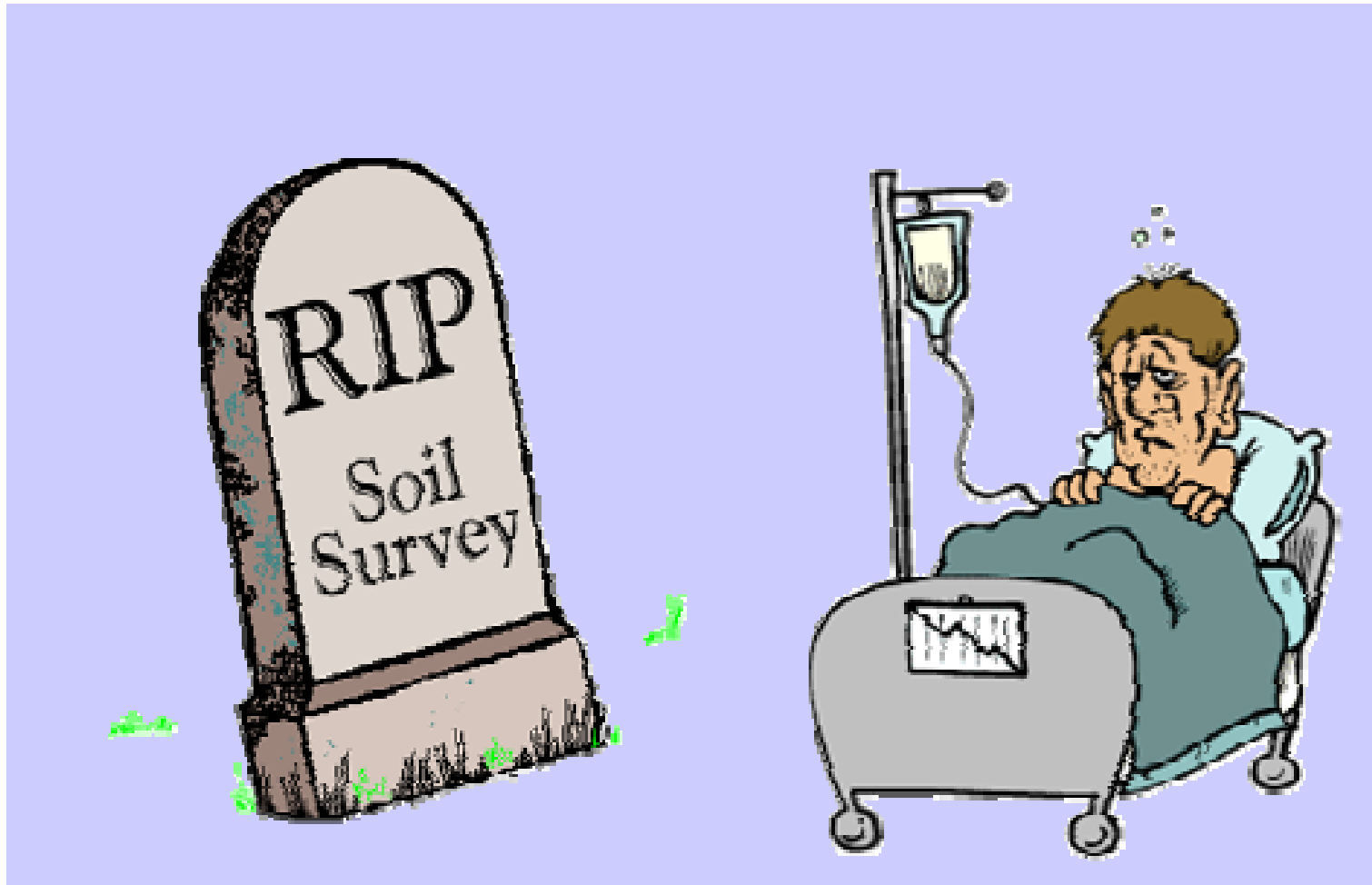


Example



SOTER map from the Tugen Hills in Kenya overlaid over SRTM DEM and Landsat ETM image (slide credit: Walsh, M., 2009). The boundaries of the polygons representing soil units do not show consistency considering the soil factors.

Soil Survey diminished significantly



Type of data and information required

The different type of users require different type of soil data and information. Usually, soil scientists are used to provide standard type of Soil Survey Report and Data, even if clients are not asking for it . Below some current requisites for soil information as requested by some users of FAO databases:

- Soil properties datasets should be available
- Data should be quantitative, nor qualitative
- Data should be represented in a continuous format (raster)
- Accuracy of the products should be included
- Apart from global products, more detailed data and information is required.
- Global and regional data should be updated
- Monitoring of the data is necessary

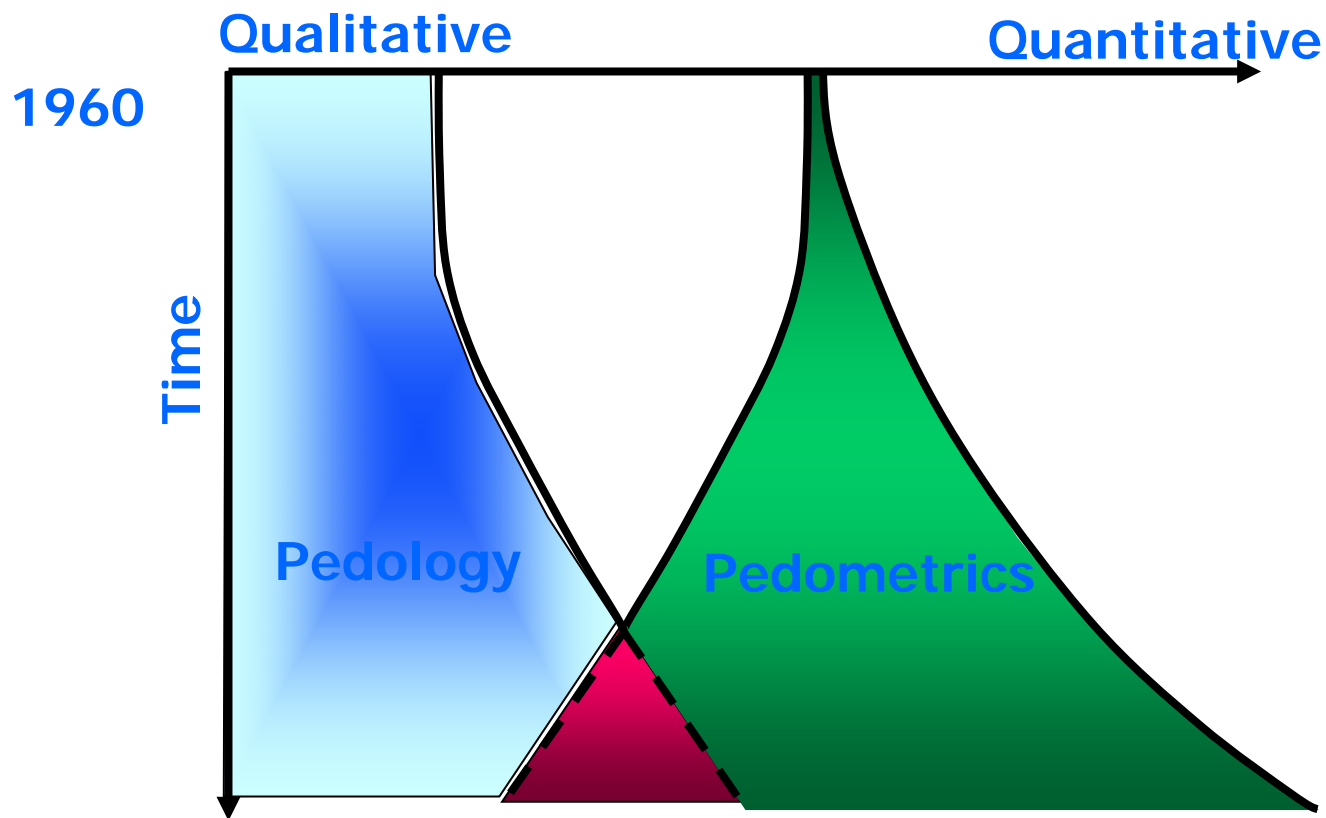


Technological Developments in Soil Mapping

An alternative approach: digital soil mapping

- Based on the Continuous Model of Spatial Variation (CMSV).
- Challenge: new methods that represent the spatial variability of soils at known accuracy and that are cheaper and faster. They should take advantage of the available technology. Pedometrics, Digital Soil Mapping, Predictive Soil Mapping.

PEDOLOGY vs. PEDOMETRICS



McBratney et al., (2000) - Geoderma, 97 : 293-327

Digital Soil Mapping

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 (Lagachiere and McBratney, 2007).

Digital Soil Mapping

NEWS ABOUT WORKSHOPS CONTACT



IUSS Working Group on Digital Soil Mapping



MS or PhD position in Digital Soil Mapping

12
07 2009

The **Division of Plant & Soil Sciences at West Virginia University** has an opening for an M.S. or a Ph.D. student starting in August 2009 or January 2010. The student will collaborate on efforts to develop digital soil property maps at regional and continental scales. Efforts will include regionalizing and disaggregating existing vector soil survey information, incorporating existing and new point data, and investigating the use of raster data sources to improve the spatial prediction of soil classes and soil properties. The specific project, funded by the US Forest Service, is to develop spatial prediction models of soil organic carbon across the Northeast and North Central United States based on detailed soil map information and soil point data. We seek an individual with an interest in studying soil variability and spatial modeling, as well as an understanding of geographic information science and statistical modeling techniques.

Visit <http://www.caf.wvu.edu/plsc/soilscience/Thompson/Research/pedometrics/assistantships.htm> for more information.

<http://www.digitalsoilmapping.org/>

Links

AfricaSoils.net

GlobalSoilMap.net

ICSU.org

ISRIC.org

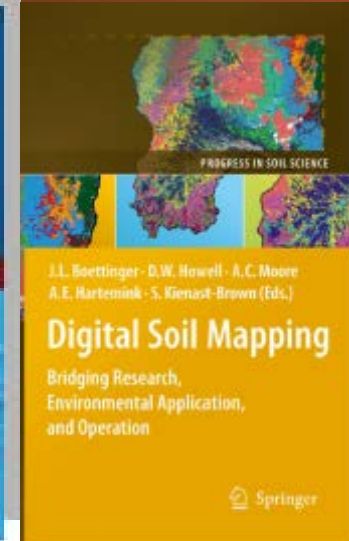
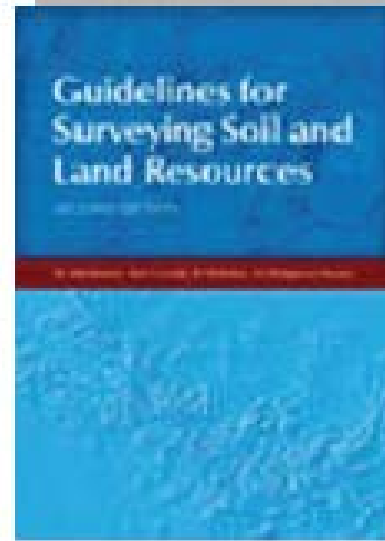
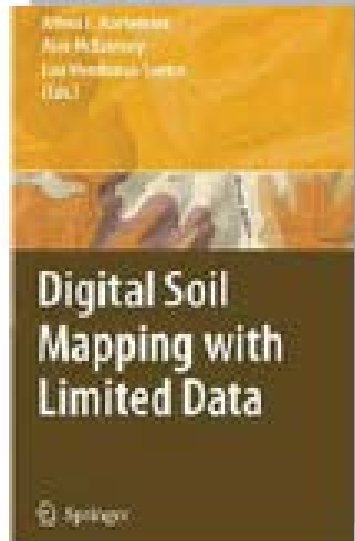
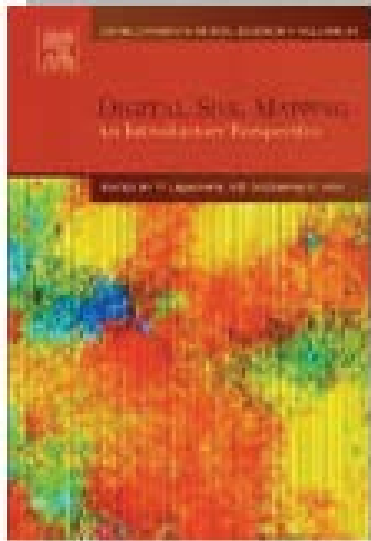
IUSS.org

Pedometrics.org

Next Workshop

2010.digitalsoilmapping.org

Digital Soil Mapping



Available online at www.sciencedirect.com



Geoderma 117 (2003) 3–52

GEODERMA

www.elsevier.com/locate/geoderma

On digital soil mapping

A.B. McBratney^{a,*}, M.L. Mendonça Santos^b, B. Minasny^a

^aAustralian Centre for Precision Agriculture, Faculty of Agriculture, Food and Natural Resources, 163 Miles Building 403, The University of Sydney, Sydney, New South Wales 2006, Australia

^bEMBRAPA Centro Nacional de Pesquisa de Solos, Rua Jardim Botânico 1024, 22-460-460 Rio de Janeiro, RJ, Brazil

Received 19 November 2002; received in revised form 14 May 2003; accepted 5 June 2003

Digital Soil Mapping

<http://www.pedometrics.org/pm/>

The image shows a screenshot of the Pedometrics website. The header features the site name 'Pedometrics' on the left and navigation links: 'about', 'what is pedometrics?', 'history', 'pedometron', 'contacts', 'search', and 'skip content'. Below the header is a main navigation bar with links for 'Home', 'Artides', 'Best paper', 'Books', 'Conferences Report', 'Datasets', 'Digital Soil Mapping', 'Jobs & Scholarships', and 'News'. An 'rss' icon is located on the right side of this bar. A secondary navigation bar includes 'Obituary', 'Papers', 'Past Conferences/ Workshops', 'Past jobs', 'Pedometrics meetings', 'Uncategorized', and 'Upcoming Conferences & Events'. The main content area is divided into two columns. The left column has an 'About' section with the following text: 'This is the website of the Pedometrics commission of the International Union of Soil Sciences. Pedometrics is a branch of soil science, and our Commission brings together soil and environmental scientists, who are primarily interested in the use of statistical and mathematical tools to analyze and interpret soil data. You can now access important information, look for or post new jobs, submit your articles & opinion about various issues and announce conferences, events and activities in this website. Register for Pedometrics 2009.' The right column has a 'G'day Welcome to the Pedometrics website' section with the text: 'Thanks for dropping by! Feel free to join the discussion by leaving comments, and stay updated by subscribing to the RSS feed. See ya around!' Below this is a 'Recent Posts' section with a list of three items: 'Digital Soil Map of the World', 'The Elements of Statistical Learning', and 'MICRO SOIL WORKSHOP 2009'.

Pedometrics

about what is pedometrics? history pedometron contacts search skip content

Home Artides Best paper Books Conferences Report Datasets Digital Soil Mapping Jobs & Scholarships News **rss**

Obituary

Papers Past Conferences/ Workshops Past jobs Pedometrics meetings Uncategorized Upcoming Conferences & Events

About

This is the website of the Pedometrics commission of the International Union of Soil Sciences.

Pedometrics is a branch of soil science, and our Commission brings together soil and environmental scientists, who are primarily interested in the use of statistical and mathematical tools to analyze and interpret soil data.

You can now access important information, look for or post new jobs, submit your articles & opinion about various issues and announce conferences, events and activities in this website.

Register for Pedometrics 2009.

G'day Welcome to the Pedometrics website

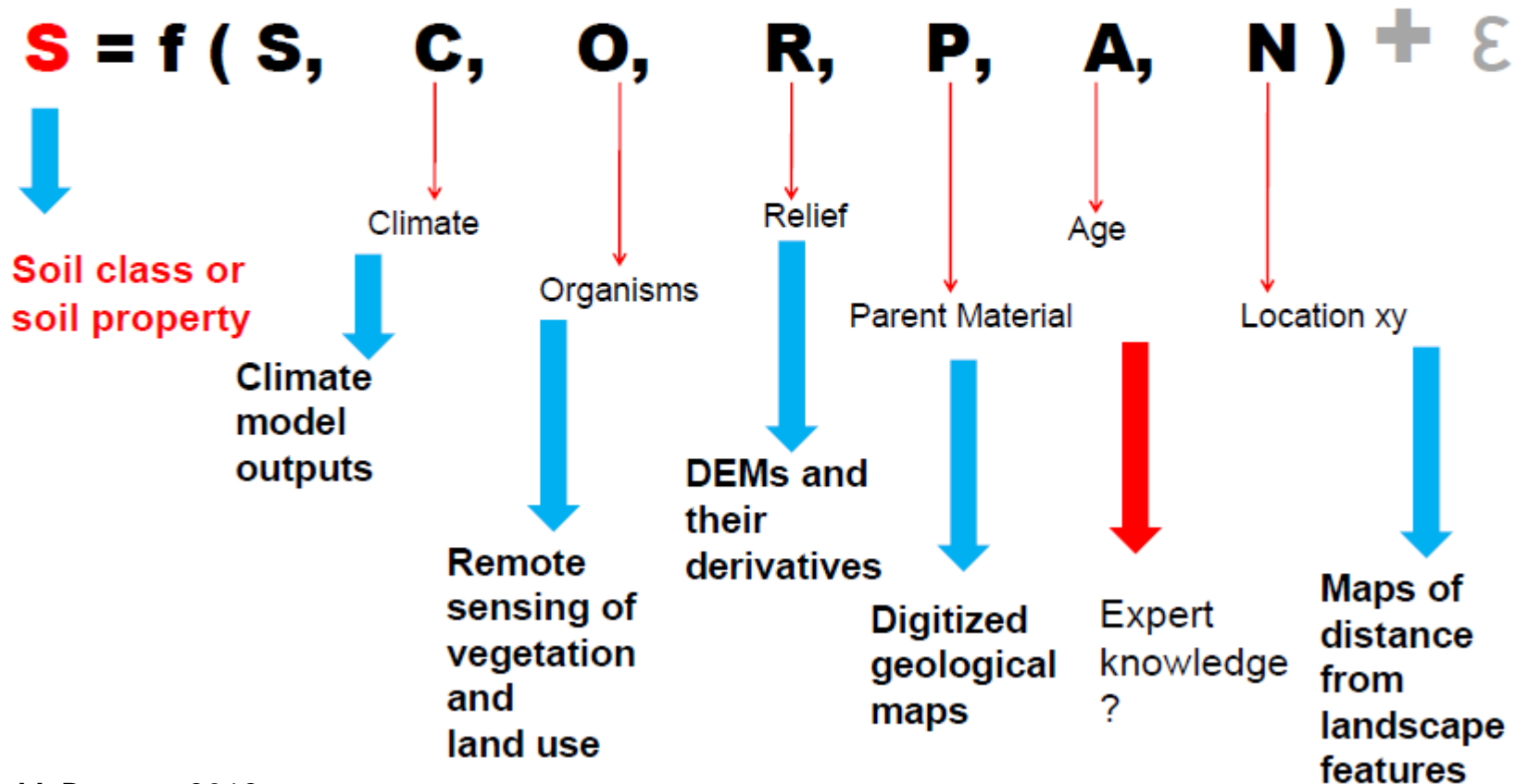
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Recent Posts

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Digital Soil Mapping

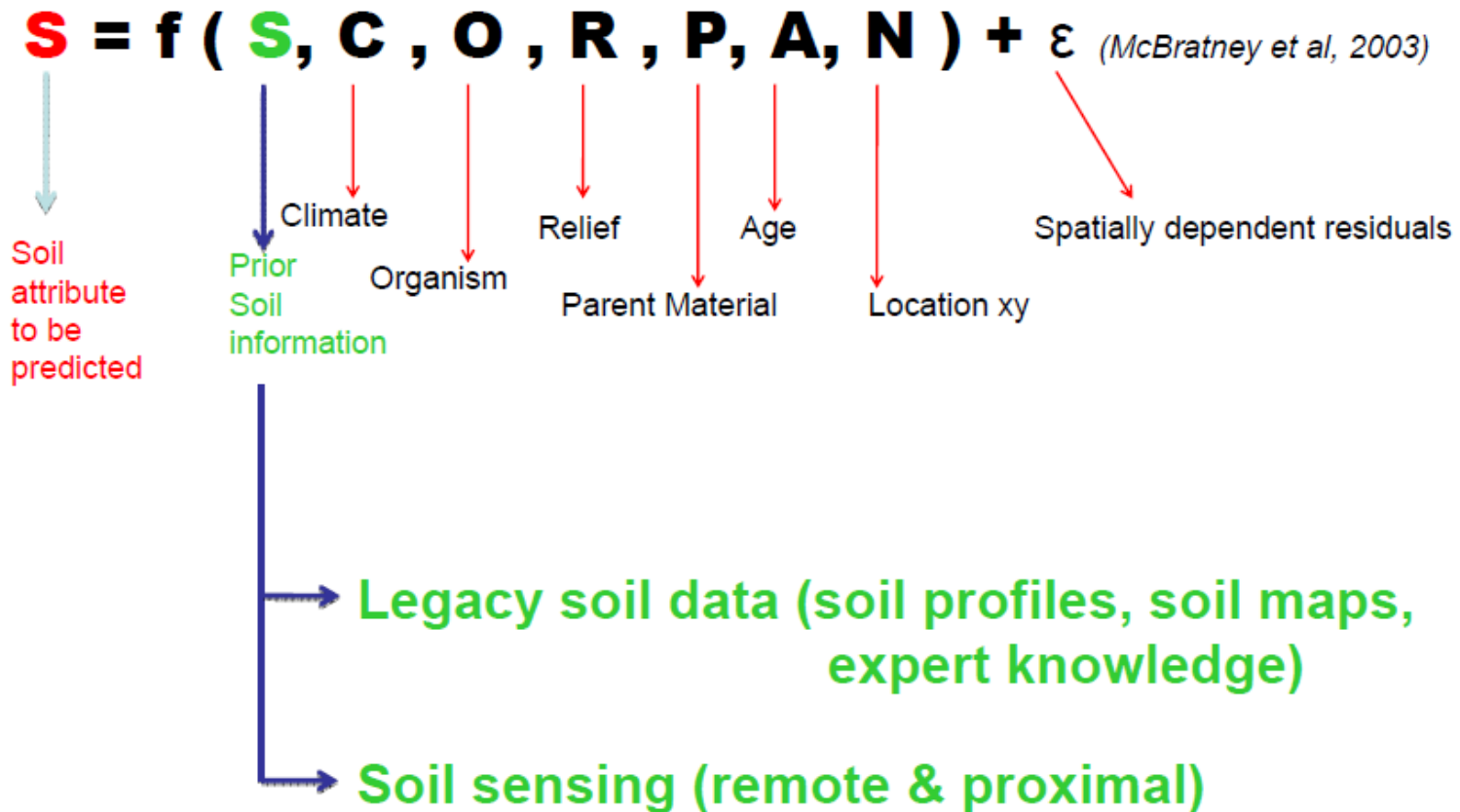
Spatial data on soil-forming factors



Digital Soil Mapping



Prior soil information



Digital Soil Mapping

Spatial inference models



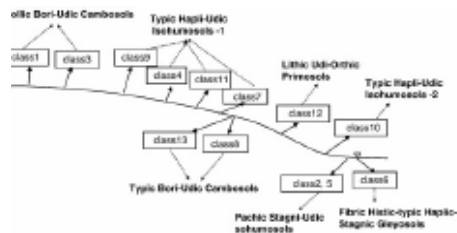
Interpolation/extrapolation function calibrated (validated) over limited sets of soil observations (profile, maps, ...).

Quantitative soil surveyor approaches

(largely knowledge driven)

- Human and artificial intelligence model e.g. SoLIM (Zhu et al. 2009)

$$\bullet s(x,y) = f(s,r)$$



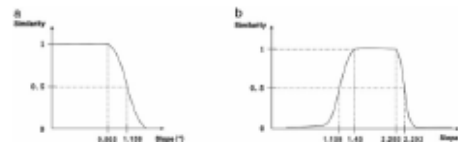
Pedometric approaches
(largely data-driven)

Non-linear environmental correlation models

- $$s(x,y) = f(\{c,o,r,p,a,n\}(x,y))$$
- Regression, classification trees, neural networks, random forests etc.

Pedo-Geostatistical models

- $$s(x,y) = f(s(x+u, y+v), \{c,o,r,p,a,n\}(x,y))$$
- Co-kriging, regression kriging, conditional simulation etc.

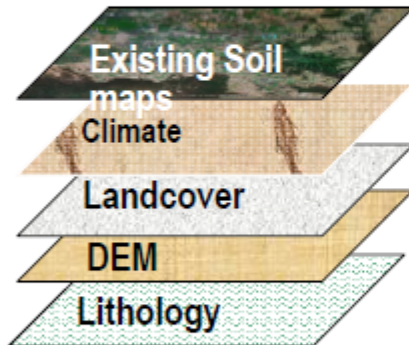


Many soil points: the easiest approach

Soil observations or maps with legends



scorpan layers

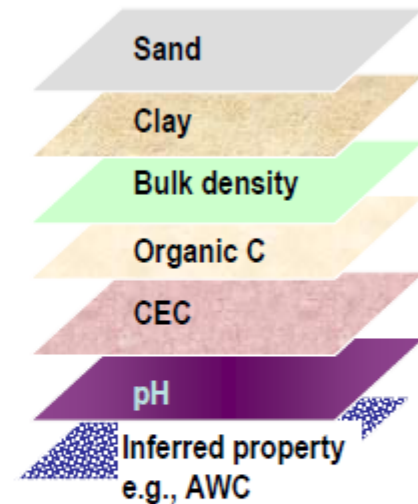


$$S = f(s, c, o, r, p, a, n) + e$$

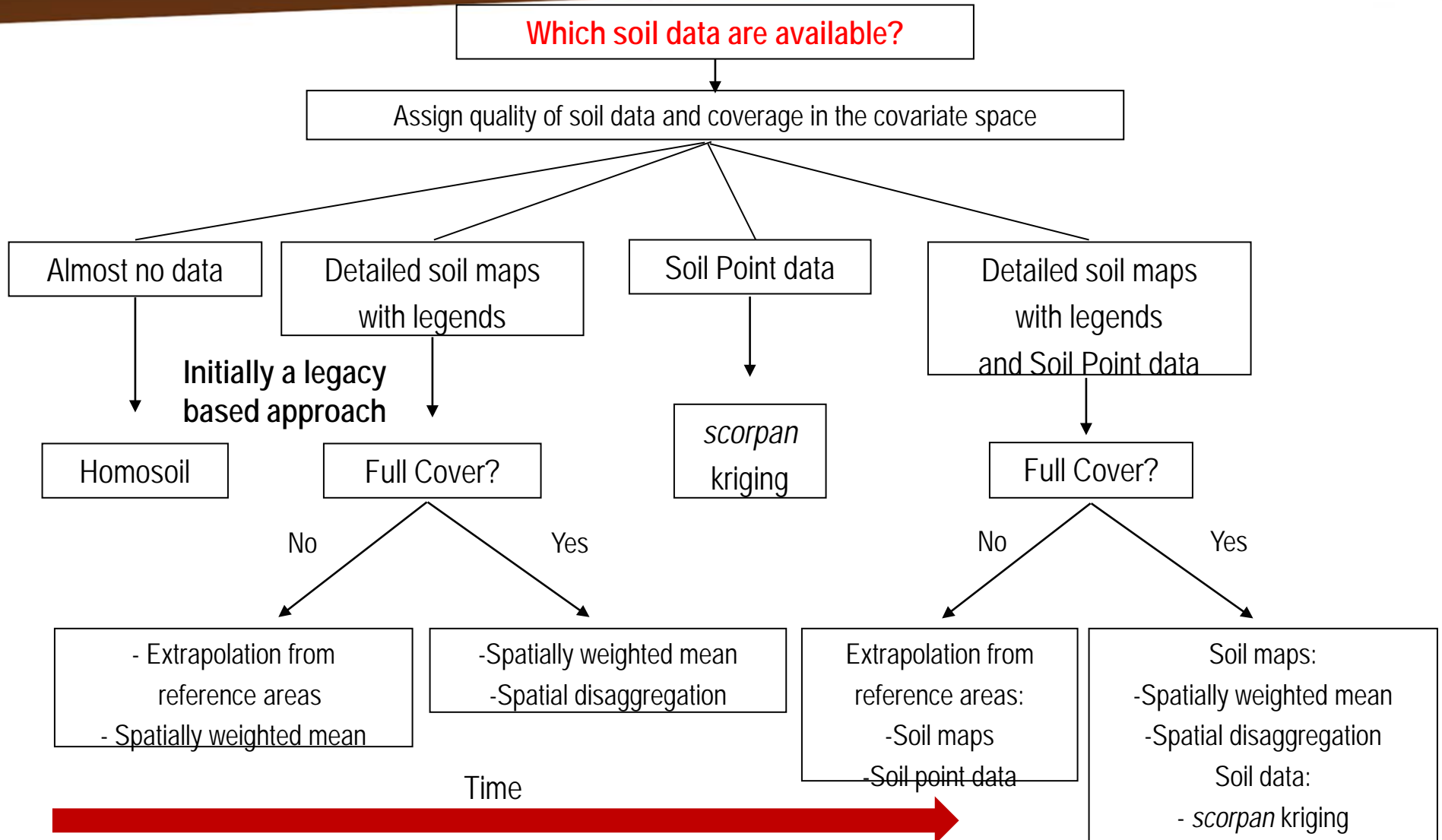
f - Linear regression,
Regression trees,
Random forests,
Neural networks,
Expert system
Etc..

Krige residuals (*e*)

Or generalised mixed
model by REML or
MCMC



Prediction Methods



Slide credit: Bob McMillan



**Digital Soil Mapping in Somalia: mapping soil
classes (Vargas and Omutu, 2009)**

Case in Somalia: soil data needs



Status of legacy data and challenges

- Some data were available

- Soil map
- Climate data

• Available datasets have huge gaps

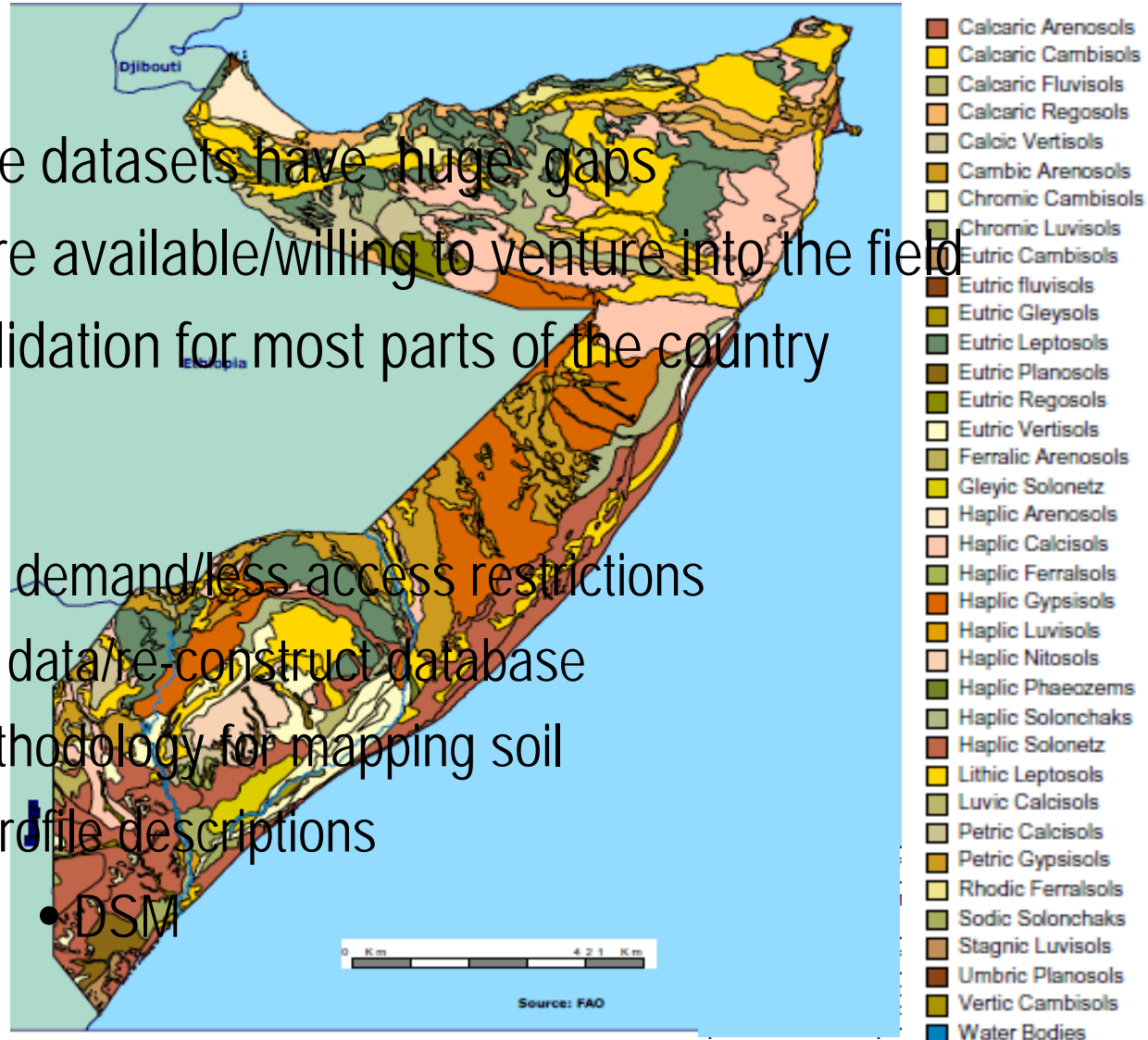
- Few soil scientists are available/willing to venture into the field
 - Limited field validation for most parts of the country

Strategy

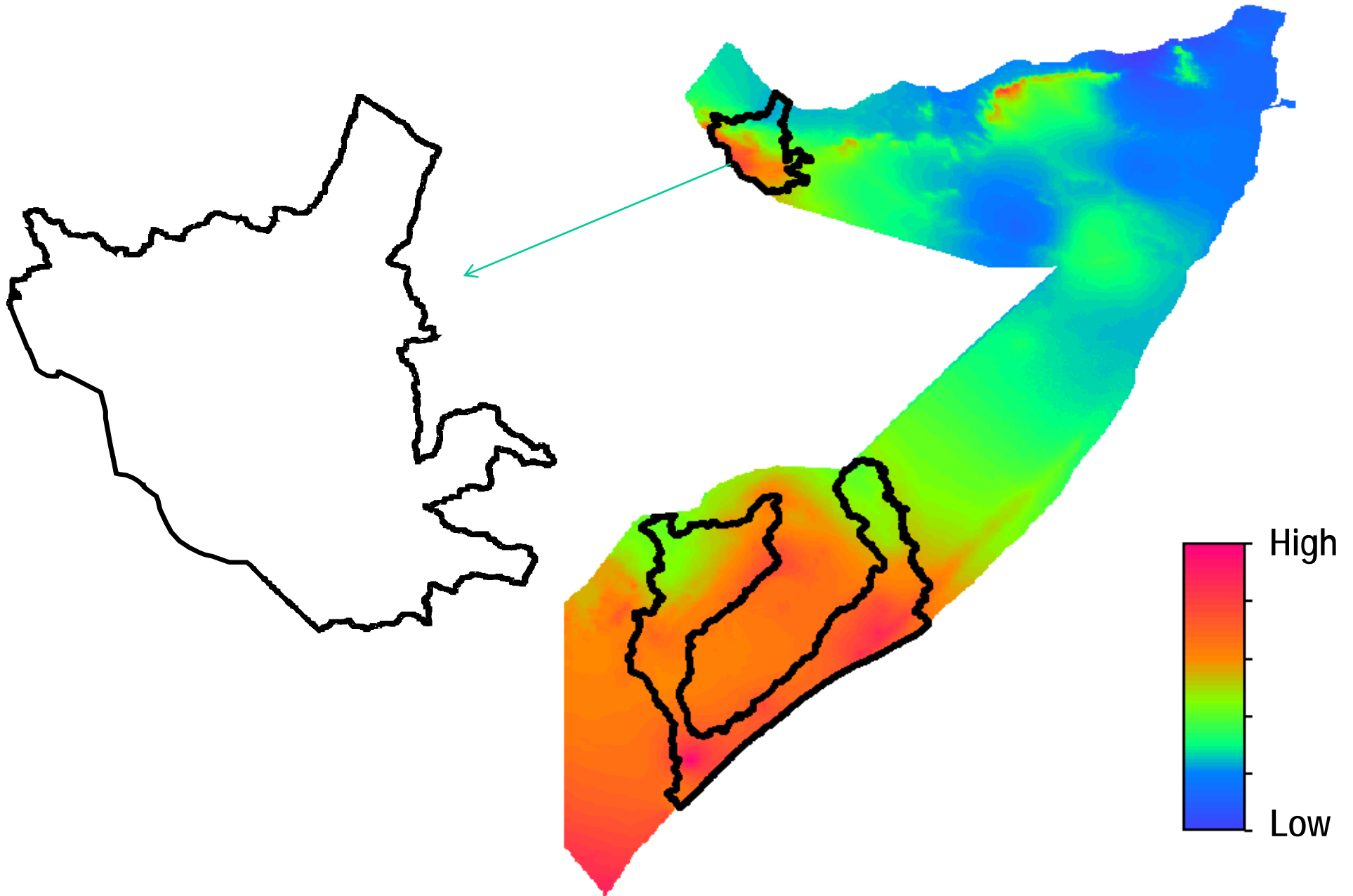
- Choose area(s) with high demand/less access restrictions
- Develop necessary data/re-construct database
- Combine tools/methodology for mapping soil
 - Soil profile descriptions
 - DSM

1: 1, 000, 000

FAO Soil map



Focus on high-rainfall areas



Carry out data reconstruction/generation



A few soil profiles data were found

Reclassifying the profiles
using WRB method

Locate areas for new samples

At each location

Surface description

Pit excavation

Profile characterization &
soil sampling

Laboratory analysis

- wet chemistry
- Spectral reflectance



Digital soil mapping

- Soil profile classification - WRB

- Input data layers

- Landform
- Geology
- Land cover/use
- Climate
- Soil attributes



Field data
Available data
Remote sensing
Software
Existing algorithms

- Digital Soil Mapping –

- use parametric models : combine regression kriging and

Mixed-effects = Fixed and random models – account for variations within and between soil classes

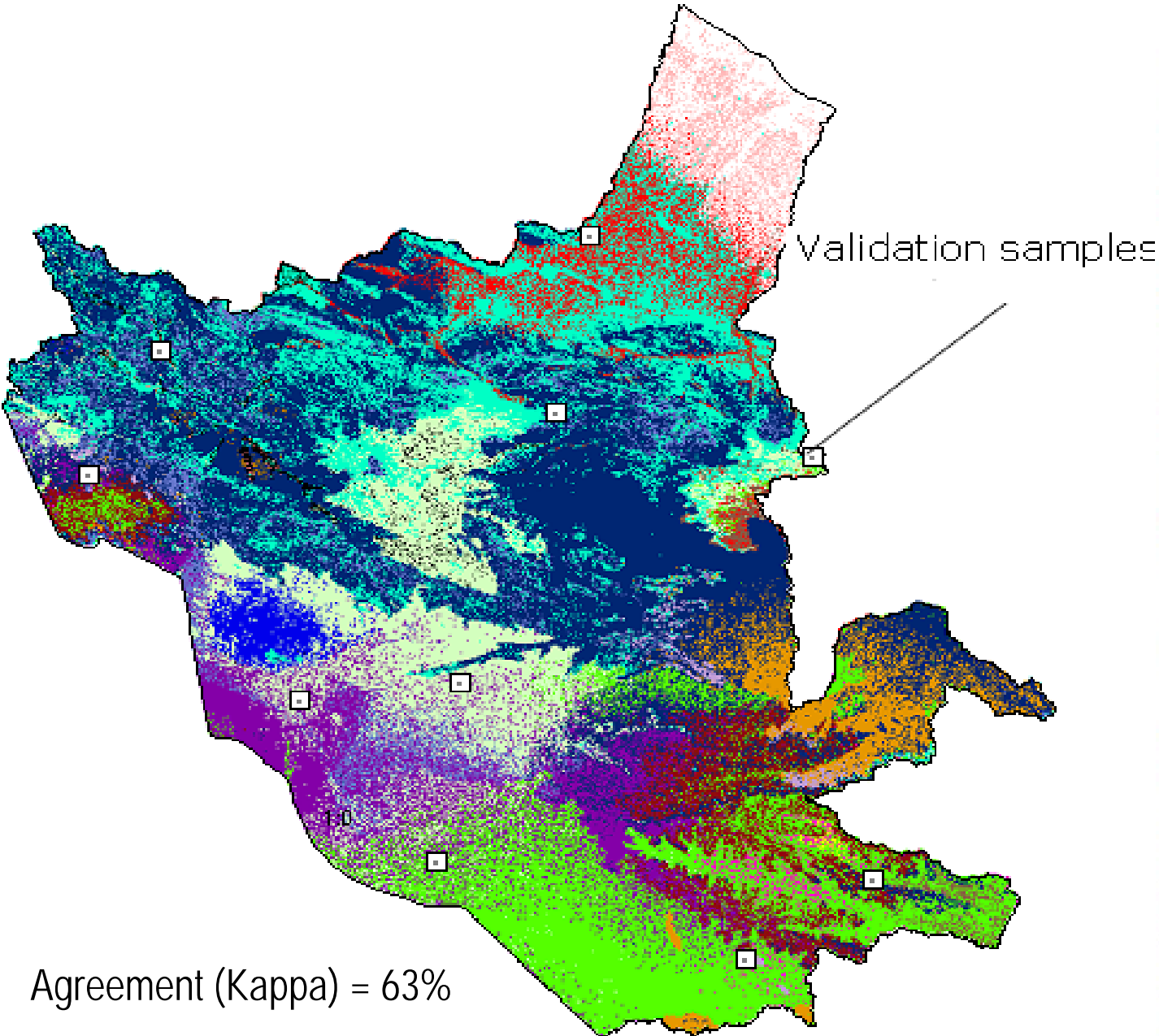
Fixed-effects ← $Y = a + b_1x_1 + \dots + b_nx_n + \eta + \epsilon$ → Random-effects

Residuals

- R Computer codes developed

- Validation (holdout) and final adjustments

Digital soil map of northwest Somalia



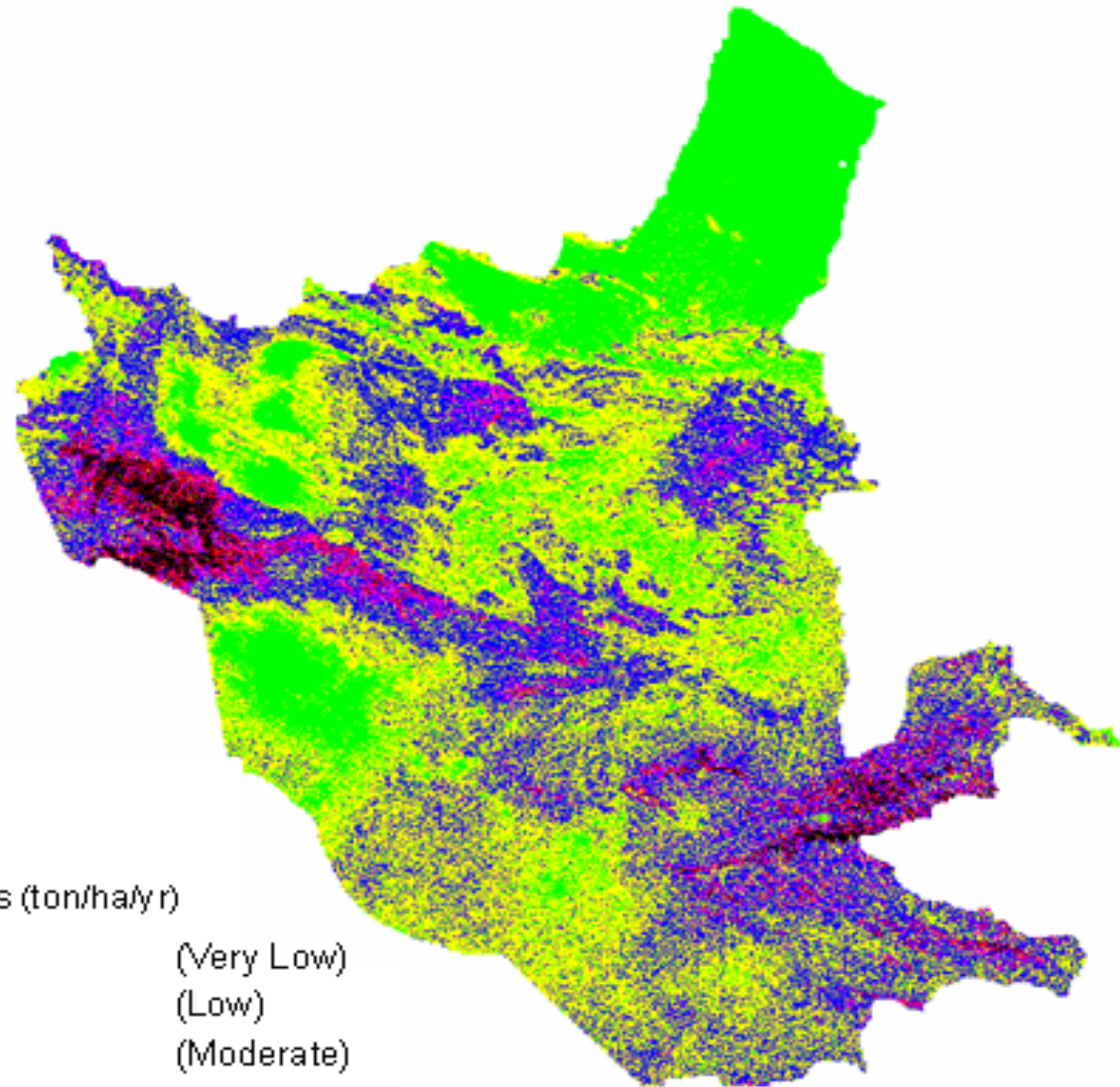
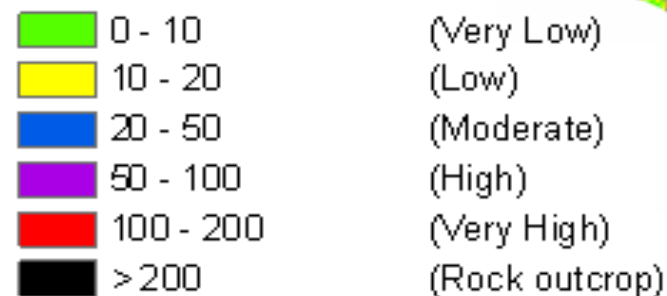
- Haplic Arenosol
- Hyperskeletal Leptosol
- Calcic Endosalic Fluvisol
- Calcic Fluvisol
- Haplic Fluvisol
- Haplic Regosol
- Fluvisol Cambisol
- Vertic Petric Calcisol
- Haplic Leptosol
- Haplic Calcisol
- Luvic Calcisol
- Endosalic Calcisol
- Hypercalcic Calcisol
- Vertic Calcisol
- Calcic Vertisol
- Haplic Vertisol
- Calcic Grumic Vertisol
- Calcic Mazic Vertisol
- Hyperskeletal Lithic Leptosol
- Lithic Leptosol

Agreement (Kappa) = 63%

Topsoil loss assessment

- Combined RUSLE and field benchmarks for validation
- Use soil properties maps

Risk of soil loss (ton/ha/yr)



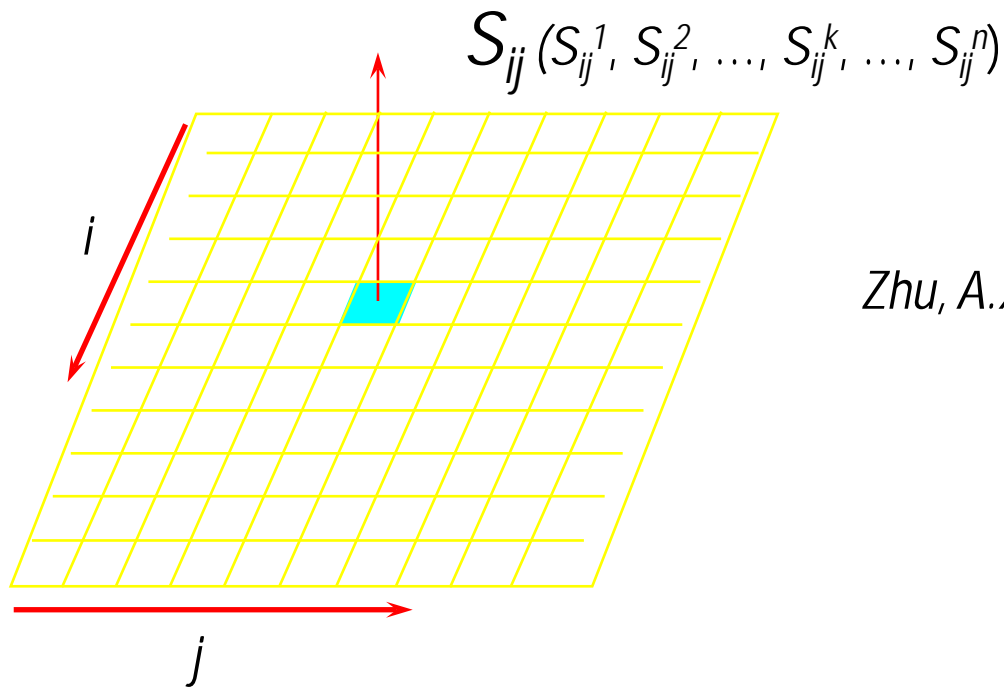


**Soil Mapping with the Soil Inference Model:
SoLIM (Axing Xhu, 2012)**

Overview of SoLIM

Components

The similarity model - overcoming the limitations of “polygon-soil type” model

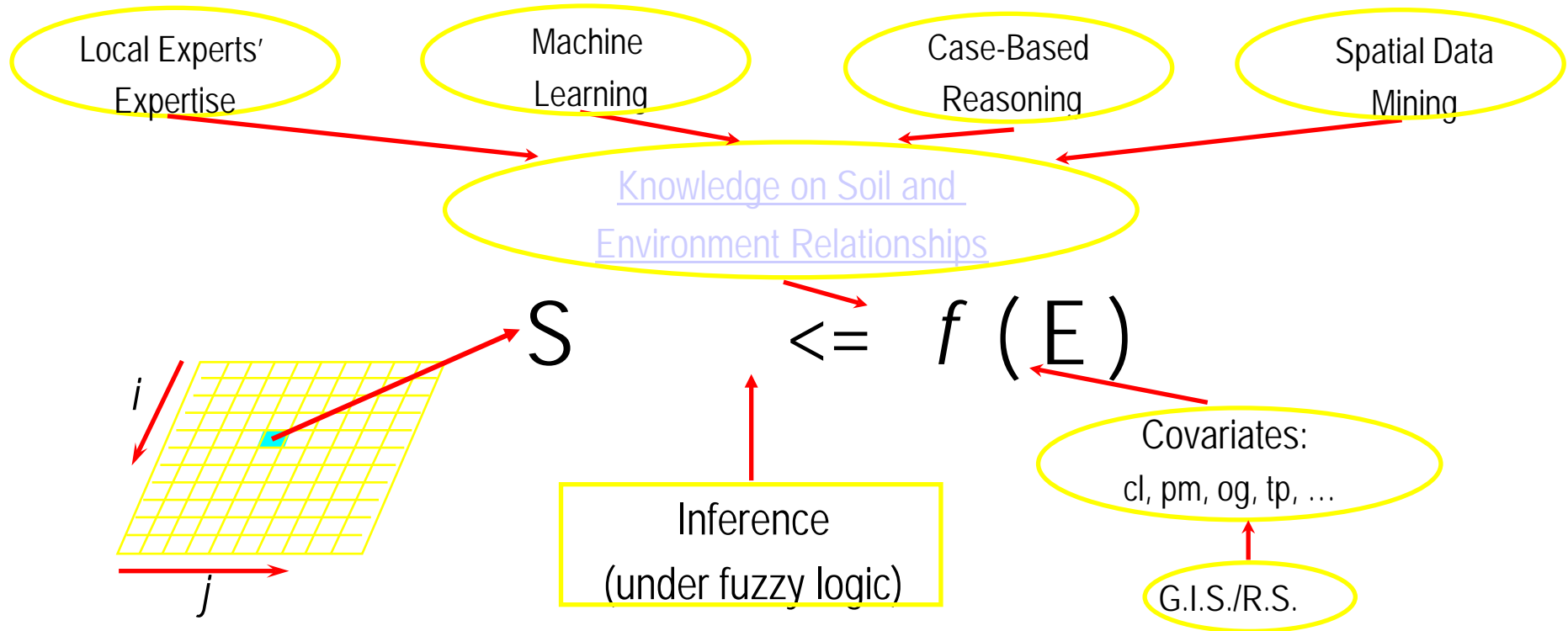


Zhu, A.X. 1997. *Geoderma*, Vol. 77, pp. 217-242.

Overview

Components

Inference - overcoming the limitations of manual delineation and the like



Zhu, A.X. 1999, *IJGIS*; Zhu et al., 2001, *SSSAJ*; Qi and Zhu, 2003, *IJGIS*;
Shi et al., 2004, *SSSAJ*; Qi et al., 2008, *Cartography and GIS*;

[More at solim.geography.wisc.edu](http://solim.geography.wisc.edu)

Overview

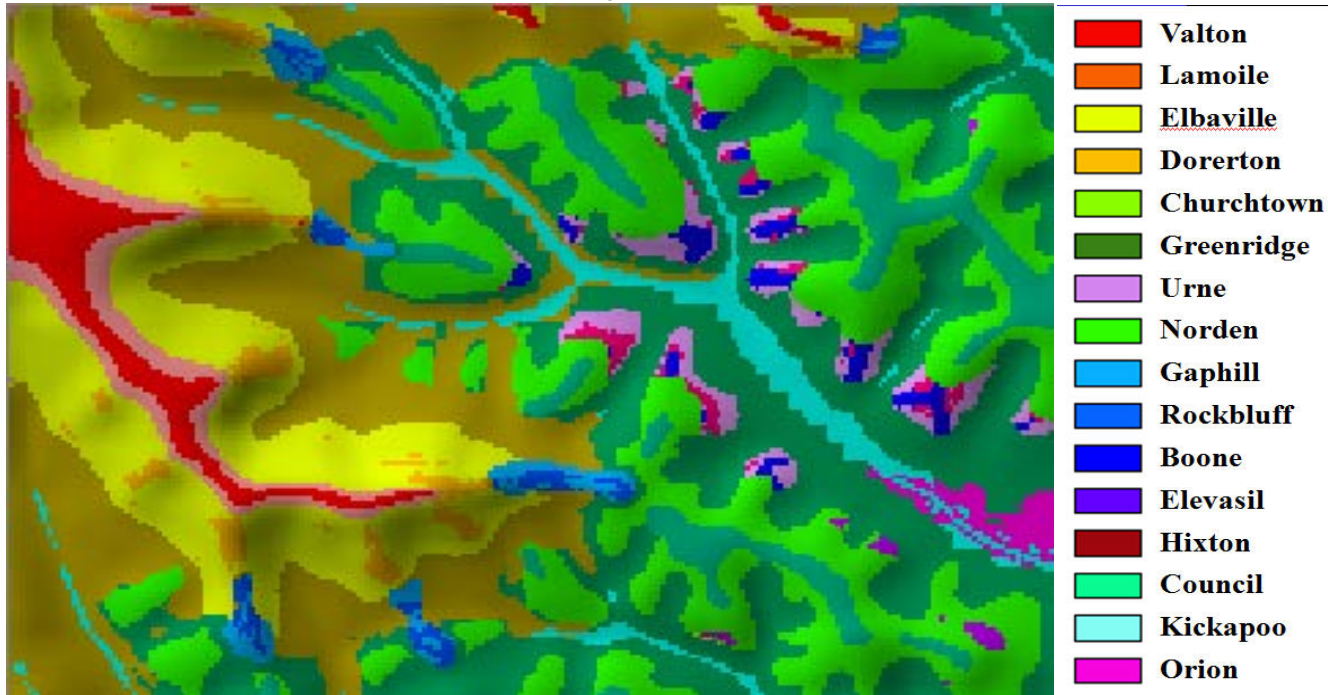
Applications and Assessment

Products - Basic output: Fuzzy membership maps

Derived products and accuracy:

Raster soil type maps

Raster Soil Type (Series) Map



Accuracy of the Raster Soil Map

Comparison between SoLIM and Soil Map against field data (Raffelson)

	Sample Size = 99		
	Overall	In Complexes	In Single
SoLIM	83.8%	89%	81%
Soil Map	66.7%	73%	61%
	Mismatches		
	Correct	Total Mismatches	Percentage
SoLIM	24	30	80%
Soil Map	4	30	13%



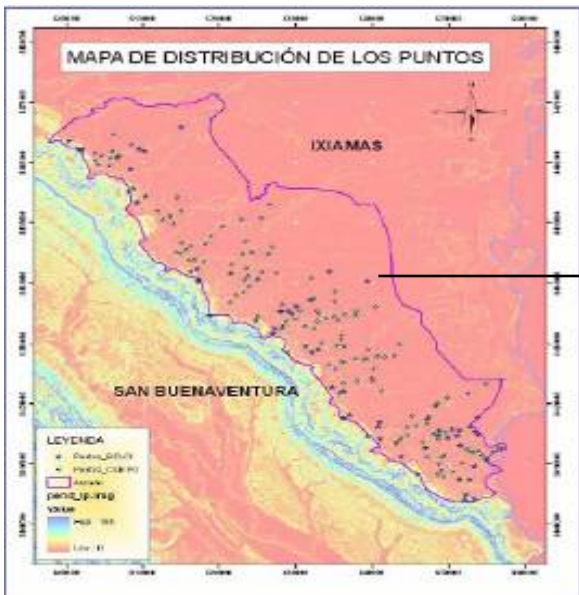
**Digital Soil Mapping in Bolivia for sugarcane
suitability assessment (Vargas, 2010)**

CO-KRIGING AND MIXED EFFECTS MODELS

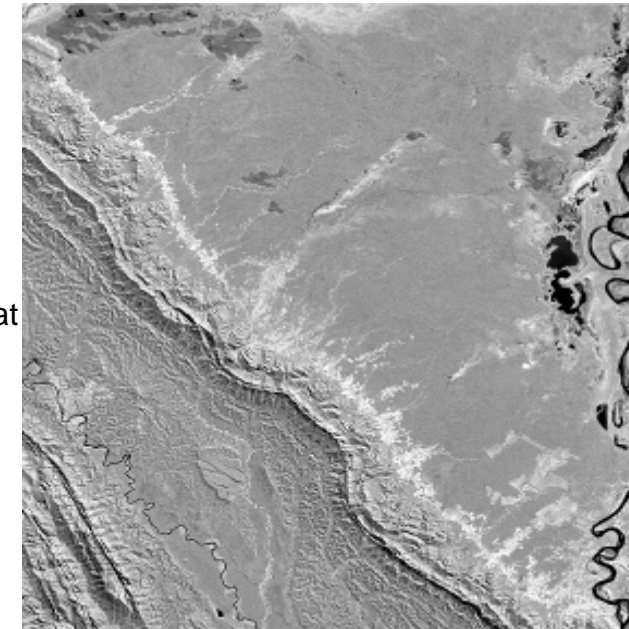
200 soil samples (points) were collected in the field for the topsoil only (30cm) and analyzed at the soil lab. Using Co-Kriging and mixed effect models, properties were predicted and suitability assesment was performed (Omuto and Vargas, 2010).

$$\sqrt{\theta_{s_{ij}}} = (\beta_o + b_{oi}) + (\beta_1 + b_{1i}) * DEM_{ij} + (\beta_2 + b_{2i}) * Y_{ij} + e_{ij}$$

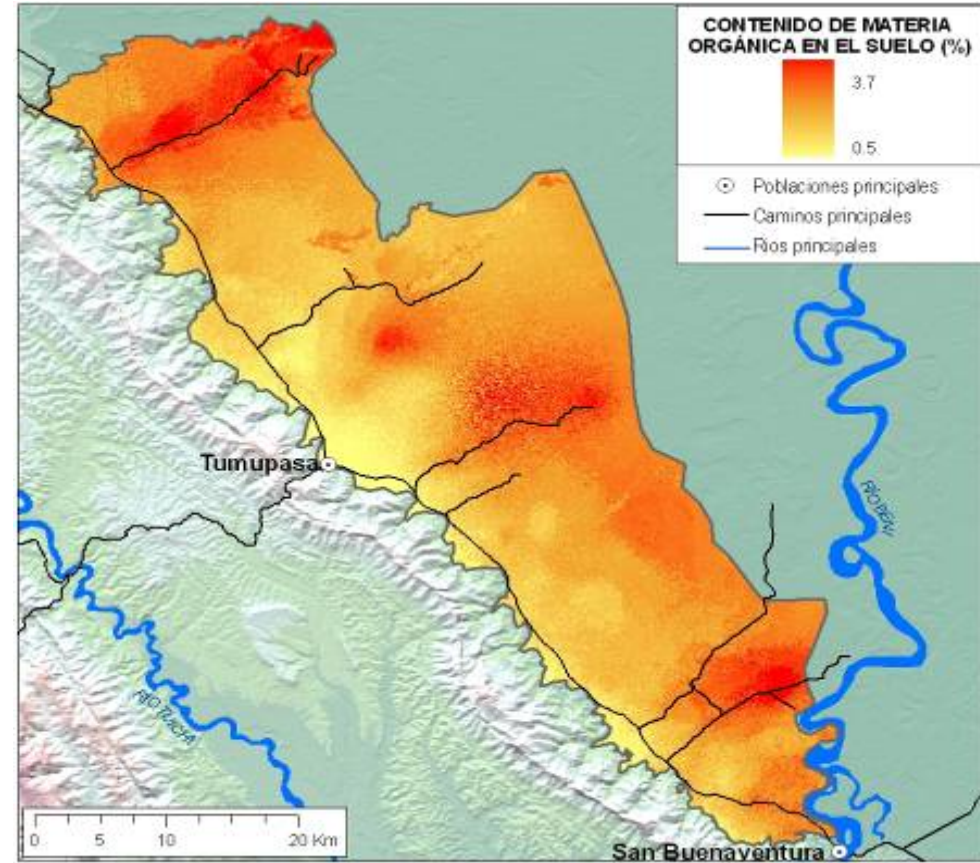
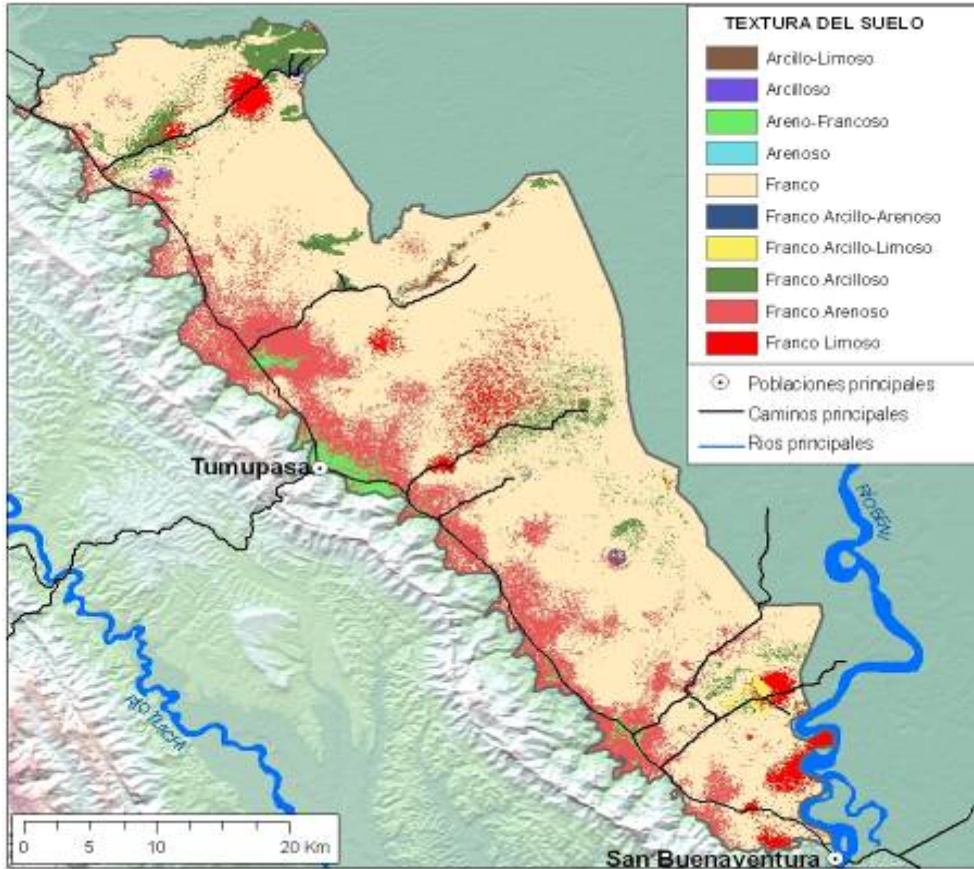
$$\mathbf{b}_i = \begin{bmatrix} b_{oi} \\ b_{1i} \\ b_{2i} \end{bmatrix} \sim N(\mathbf{0}, \psi), \quad e_{ij} \sim N(0, \sigma^2), \quad i = 1, 2, \dots, 5 \quad j = 1, 2, \dots, 180$$



Predictor: Landsat
ETM+ band



SOIL PROPERTIES MAPS



SOIL SUITABILITY ASSESSMENT

Características de la Tierra



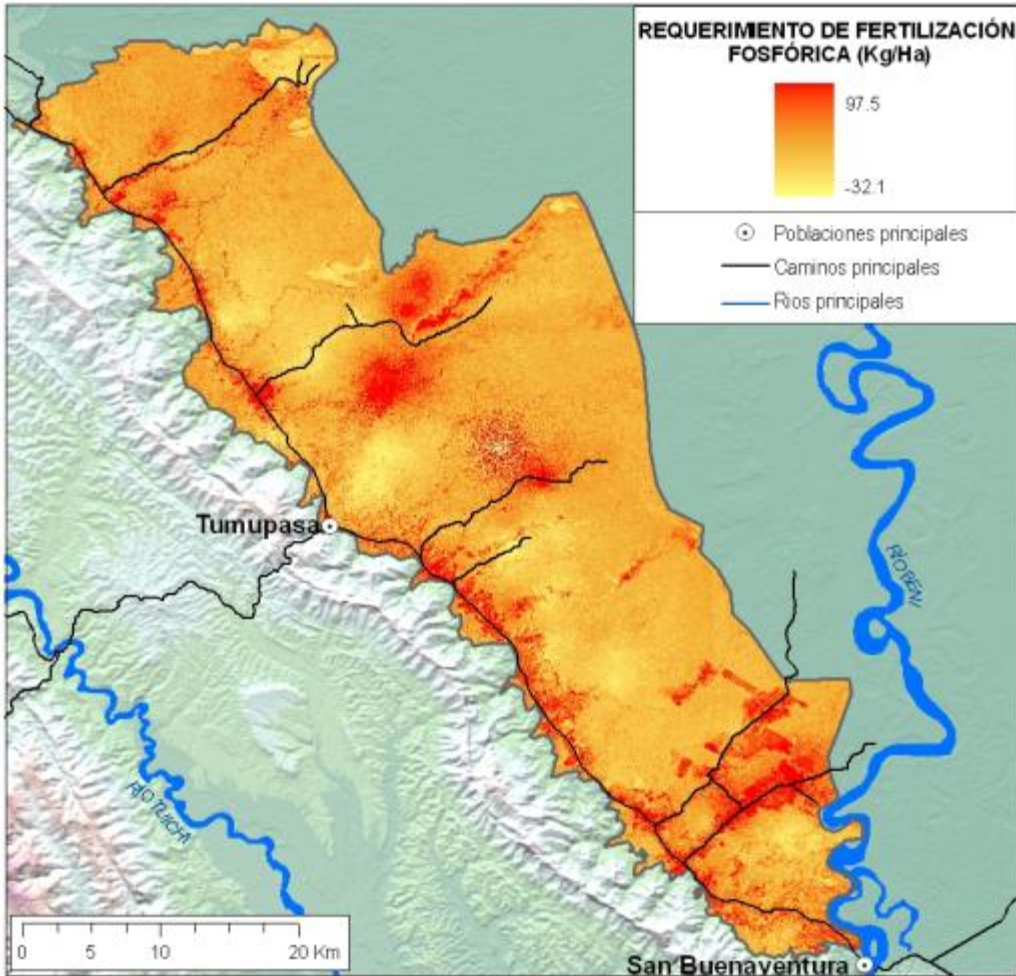
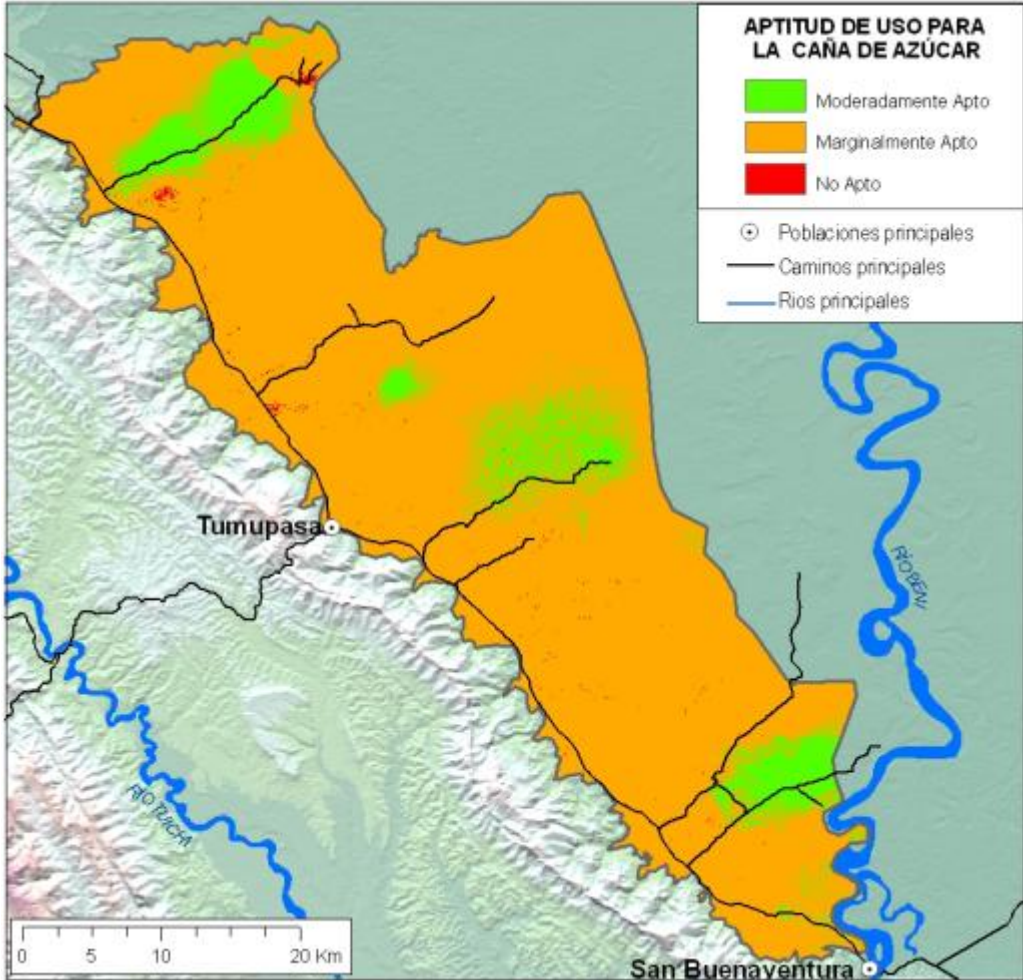
Requerimientos del TUT

Características de la Tierra	Rangos de Aptitud			
	Apto	Mod. Apto	Marg. Apto	No Apto
Clima	Rangos de Aptitud			
Temperatura media anual (°C)	>23<32	>22<35	>21<38	<21>38
Temperatura máx. media anual (°C)	>28<30	>30		
Temperatura mín. media anual (°C)	15-20	13-15	13-10	<10
Precipitación media anual (mm)	1600-2500	1400-1600	1200-1400	<1200
Meses secos	<2	2-3	3-4	>4
Topografía				
Pendiente (%)	0-8	8-16	16-30	>30
Drenaje externo	bueno-moderado	imperfecto-moderado	pobre	pobre-inundable
Características edáficas				
Textura	FVL-FY-FL-FVA	FVA	FA-AF	AF-A-Y
Drenaje interno	Bien drenado-Mod. drenado	Imperfectamente drenado	Pobremente drenado Algo ex. Dren.	Muy Pobre drenado
Profundidad (cm)	>150	>100	>50	<30
pH	6.0-7.0	5.5-6.0	5.0-5.5	<5.0
CEC (meq/100g)	>16	7.0-7.6	7.6-8.0	>8.0
Materia orgánica	>16	12-16	6-12	<6
N (%)	>4.00	2.5-4	1.3-2.5	<1.3
P (ppm)	>0.35	0.2-0.35	0.08-0.2	<0.08
K (meq/100g)	>10	5-10	3-5	<3
Calcio (meq/100g)	>0.5	0.3-0.5	0.1-0.3	<0.1
Magnesio (meq/100g)	>10	6-10	2-6	<2
CaCO3(%)	>3	2-3	1-2	<1
C/N	0	0-1	1-5	5-10
	11.5	9.5	7.5	<7.5

Comparación Algebra de Mapas



SOIL PROPERTY MAPS



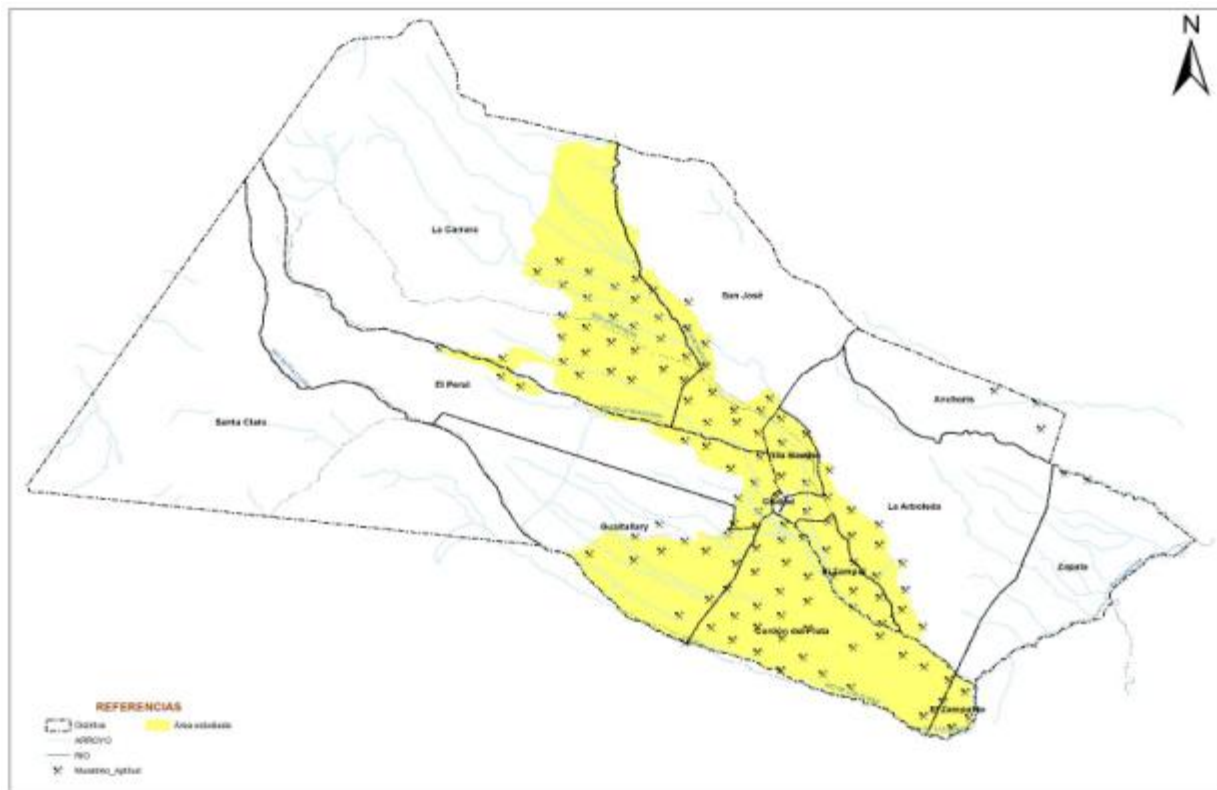


Digital Soil Mapping in Argentina: disaggregating polygons (Angelini, 2012)

Materials

710 Km².

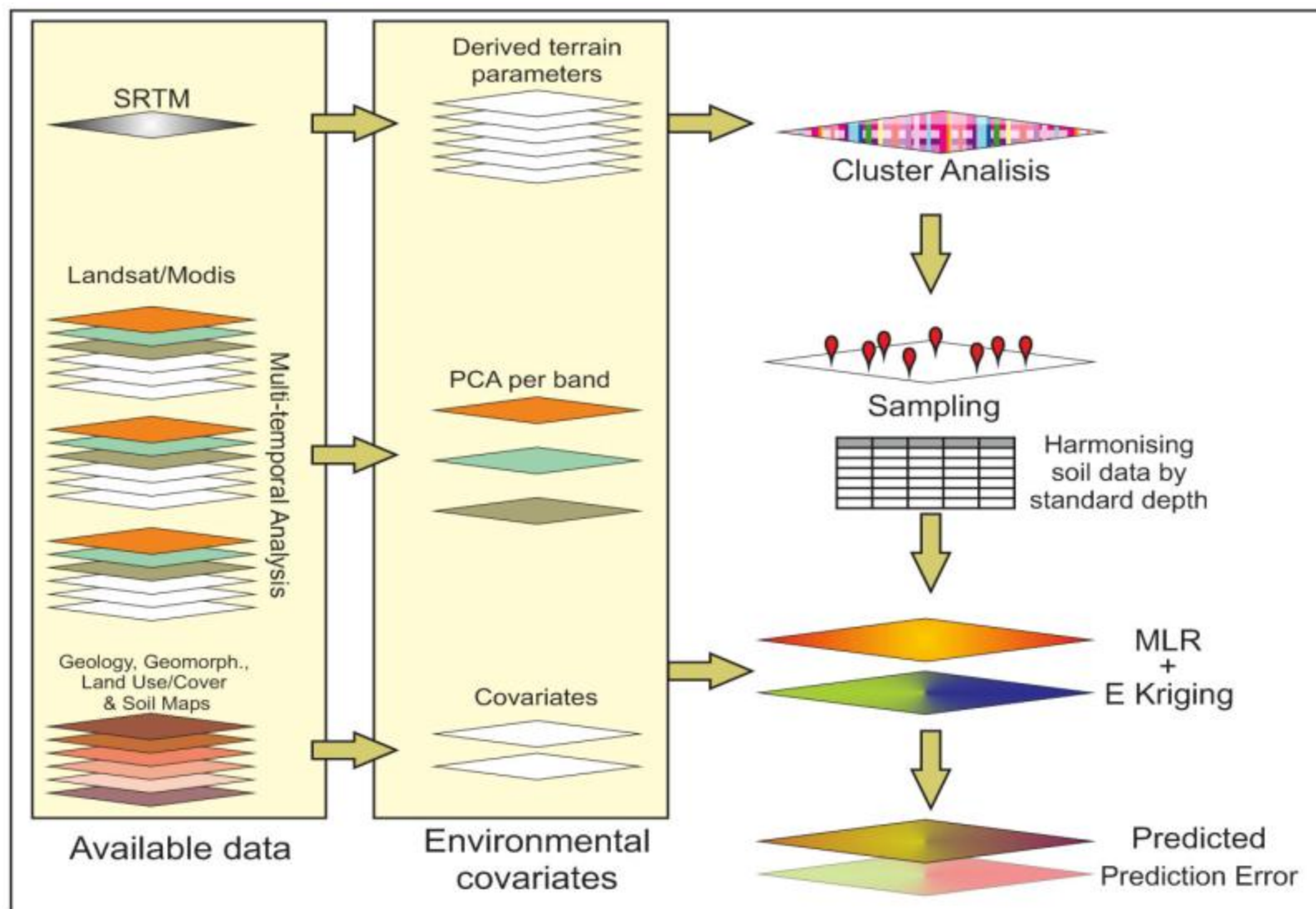
121 Soil Profiles sampled



PROF	CE.0	PH.0	ARC.0	LIM.0	ARE.0
Min. : 25.0	Min. : 0.180	Min. : 4.920	Min. : 0.0000	Min. : 2.554	Min. : 11.33
1st Qu.: 85.0	1st Qu.: 0.545	1st Qu.: 7.558	1st Qu.: 4.8010	1st Qu.: 15.501	1st Qu.: 60.40
Median : 170.0	Median : 1.030	Median : 7.865	Median : 7.6685	Median : 22.694	Median : 69.71
Mean : 144.6	Mean : 1.869	Mean : 7.689	Mean : 8.2569	Mean : 24.169	Mean : 67.64
3rd Qu.: 200.0	3rd Qu.: 2.507	3rd Qu.: 8.012	3rd Qu.: 10.3209	3rd Qu.: 29.347	3rd Qu.: 79.78
Max. : 200.0	Max. : 19.620	Max. : 9.220	Max. : 24.3000	Max. : 64.410	Max. : 97.89

CE.30	PH.30	ARC.30	LIM.30	ARE.30
Min. : 0.230	Min. : 6.190	Min. : 0.0000	Min. : 3.274	Min. : 24.42
1st Qu.: 0.607	1st Qu.: 7.625	1st Qu.: 4.8010	1st Qu.: 15.501	1st Qu.: 64.43
Median : 1.140	Median : 7.885	Median : 7.0950	Median : 21.255	Median : 71.72
Mean : 1.950	Mean : 7.783	Mean : 7.6435	Mean : 22.631	Mean : 69.80
3rd Qu.: 2.447	3rd Qu.: 8.050	3rd Qu.: 9.1739	3rd Qu.: 26.470	3rd Qu.: 79.78
Max. : 22.660	Max. : 9.210	Max. : 20.5722	Max. : 55.060	Max. : 96.89

Methodological Scheme



Modeling

70% of data for make models

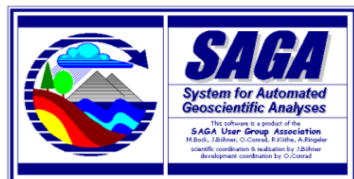
30% of data for validation

Multi-linear Regression

Covariates selected
by stepway

Exclusion of
outliers

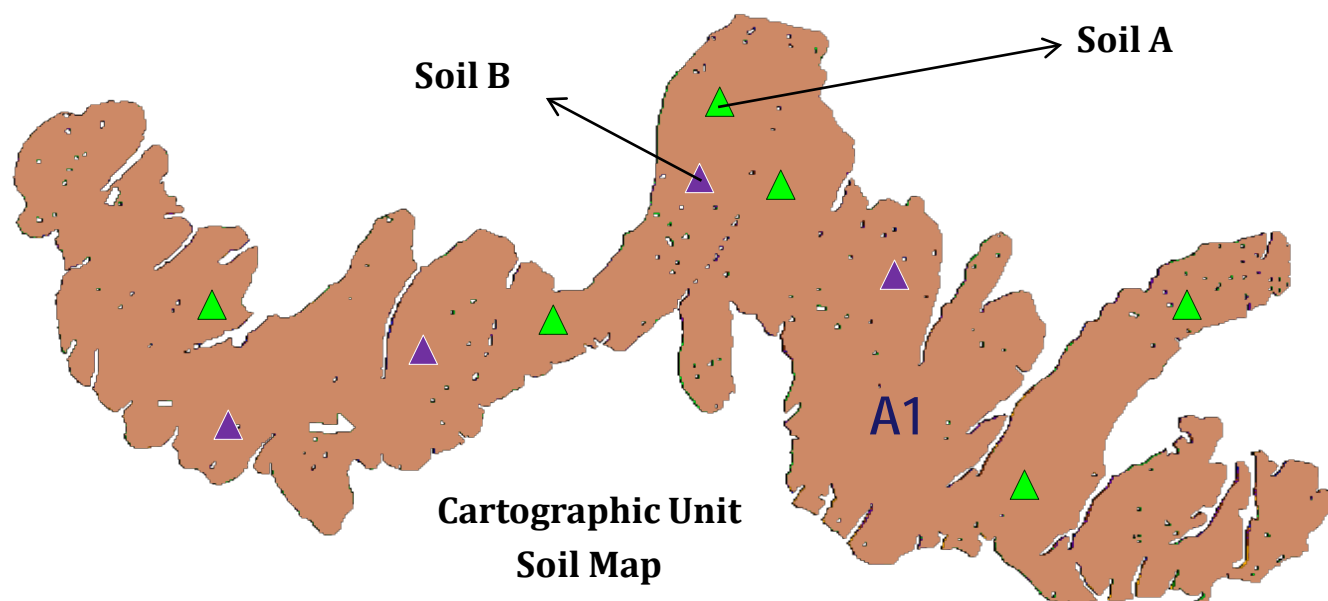
Properties to predict	Environmental Covariate
EC 0-30 cm	ASPECT, CN_BL, LS, MRRTF, MRVBF, WTI
EC 30-60 cm	SLOPE, ASPECT, CN_BL, MBI
pH 0-30 cm	DEM, SLOPE, ASPECT, CN_BL, CI, MRRTF, WTI
pH 30-60 cm	ASPECT, CN_BL, LS, MRRTF
Clay 0-30 cm	SLOPE, ASPECT, Curv1KK, MRVBF, MBI
Silt 0-30 cm	SLOPE, ASPECT, Curv1KK, MRVBF, MBI
Sand 0-30 cm	SLOPE, ASPECT, Curv1KK, MRVBF, MBI
Clay 30-60 cm	CI, MRVBF, MBI
Silt 30-60 cm	CI, MRVBF, MBI
Sand 30-60 cm	CI, MRVBF, MBI
Depth Prof.	SLOPE, CN_BL, MRRTF, MRVBF



RStudio

Sampling of taxonomic soil classes

- Random sampling



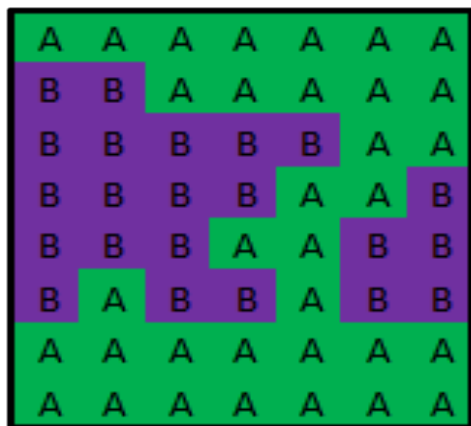
A1 = Soil A: 60%
Soil B: 40%

Sampling of taxonomic soil classes

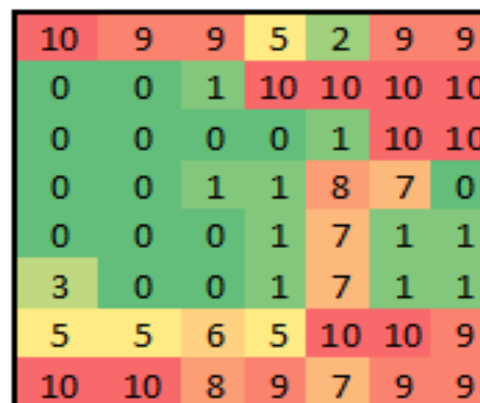
X	Y	DEM	AAChN	Slope	VOFD	OFD	Environment	Classif	NDVI01	NDVI09	K_c	SOIL CLASS
5473989	6271843	50.002	1.297	0.008	1.002	299.022	1	3	121	7	2076	A
5469939	6269233	63.006	13.546	0.005	17.782	4406.518	3	4	70	58	2154	A
5512329	6269143	34.004	5.607	0.005	4.095	1865.187	2	0	67	36	1924	B
5446809	6261493	80.006	7.677	0.006	10.990	3143.538	5	6	92	16	2012	B
5505489	6261133	47.009	7.511	0.032	13.010	3728.312	8	3	53	27	2193	A
5523579	6223603	41.000	8.945	0.020	7.999	1026.766	8	5	57	35	1649	A
5476779	6220993	55.008	2.441	0.016	0.117	474.430	8	3	62	4	1989	A
5497929	6199573	56.057	1.951	0.008	2.363	743.952	6	5	31	9	2436	A
5499639	6185173	51.051	0.000	0.008	0.007	615.368	1	2	62	32	2692	B

Merge environmental covariates and soil classes

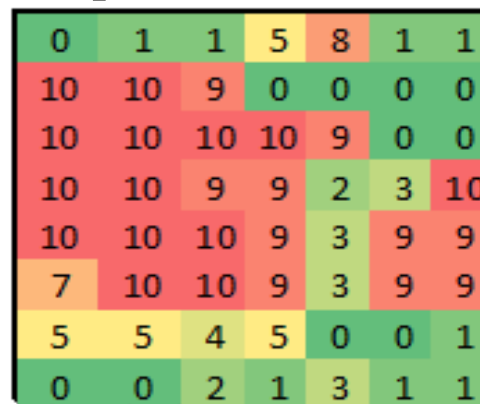
Applying model



Map of A Soil Class

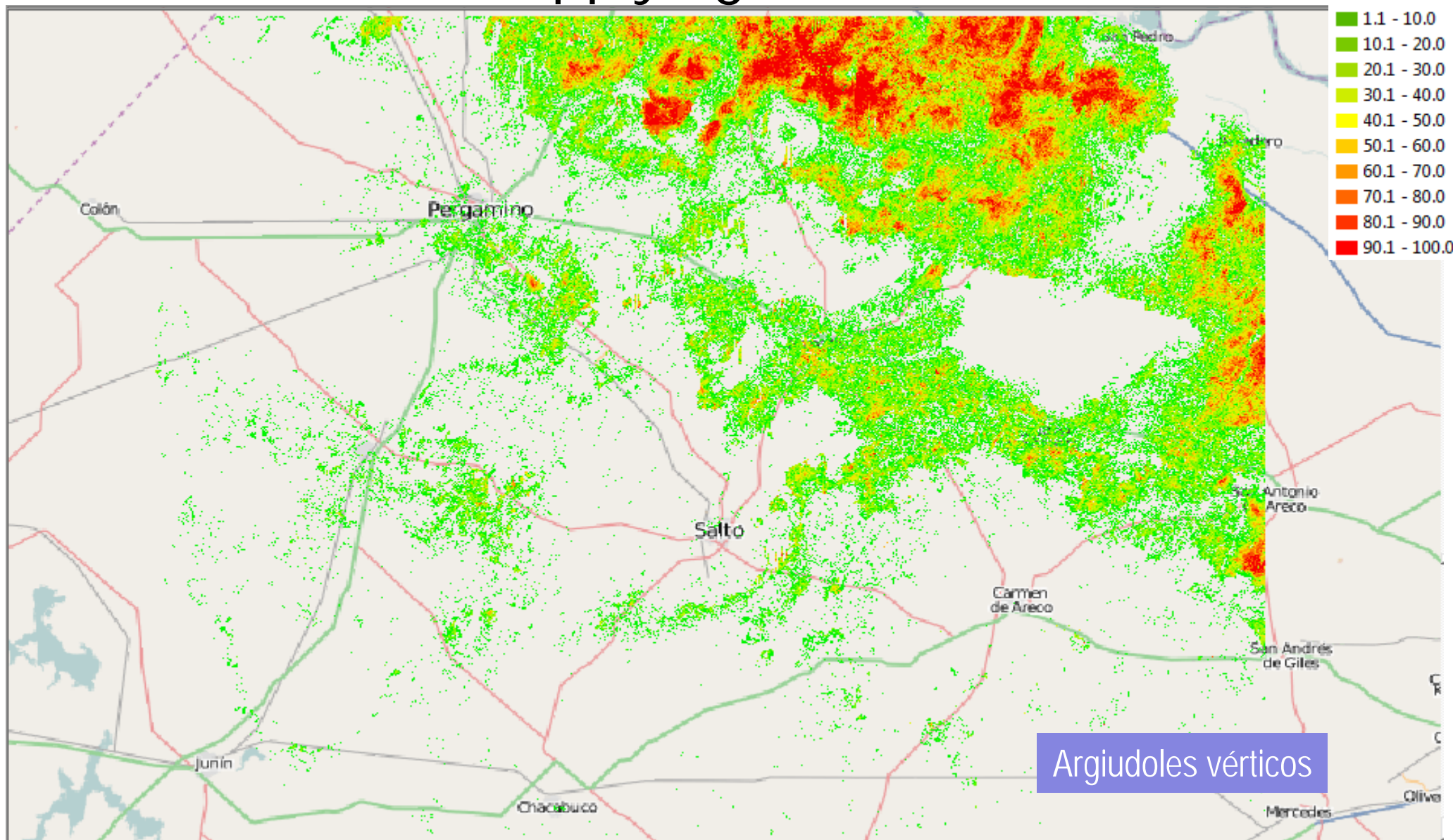


Map of B soil Class

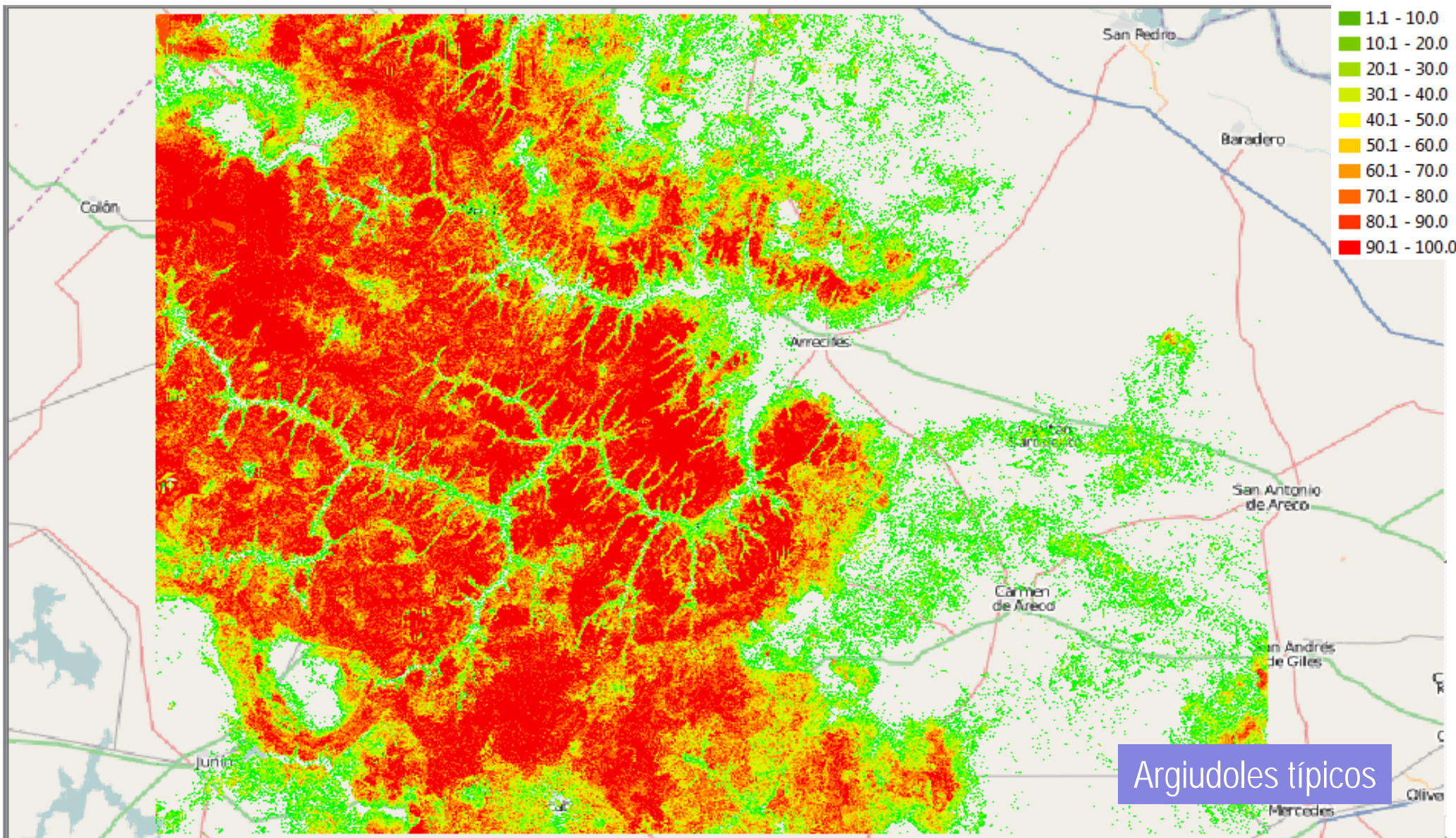


x100 loops

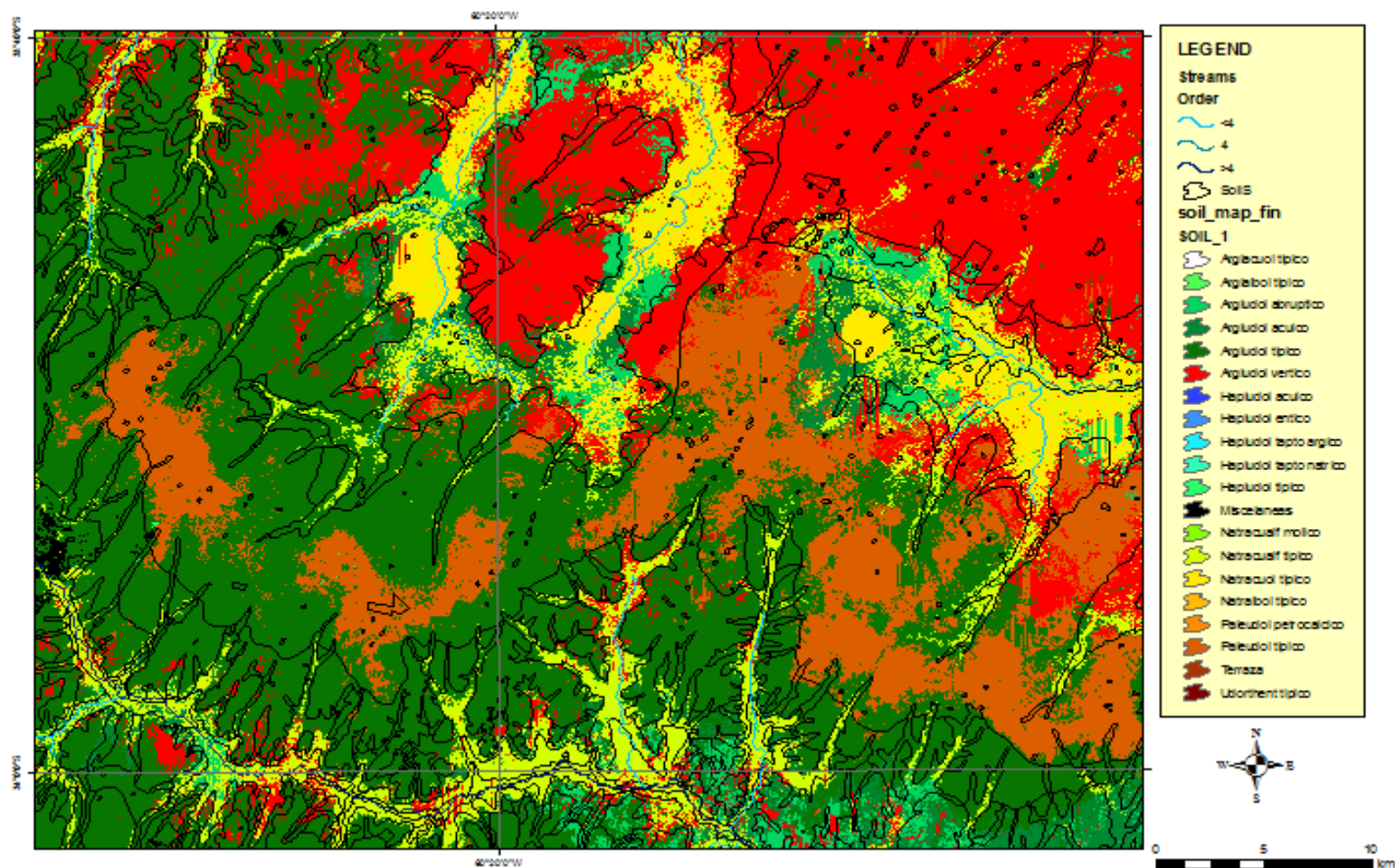
Applying model



Applying model



Applying model



Validation

		MAPA							Total general	
		ARGIALBOL ARGIACUICO	ARGIUDOL ACUICO	ARGIUDOL TIPICO	ARGIUDOL VERTICO	HAPLUDOL ENTICO	HAPLUDOL TIPICO	NATRACUALF TIPICO		NATRACUOL TIPICO
PERFILES	ARGIACUOL TIPICO	1	1	6						8
	ARGIALBOL AERICO	1		4						5
	ARGIALBOL ARGIACUICO		3	2				3	1	9
	ARGIUDOL ACUICO		15	24			3			42
	ARGIUDOL TIPICO	1	17	89	7	1	3	2		120
	ARGIUDOL VERTICO			5	9		1		1	16
	HAPLUDOL ACUICO			4		1	1			6
	HAPLUDOL ENTICO						1			1
	HAPLUDOL TIPICO			1			6			7
	NATRACUALF TIPICO	2	12	8			1	3	2	28
	NATRACUOL TIPICO		1	5				3	2	11
	NATRALBOL TIPICO	1		12						13
	UDORTENT TIPICO					2				2
	Total general		6	49	160	16	4	16	11	6

124	46.27%
185	69.03%



Soil Mapping using Area Weighted (USDA, 2012)



Soil Maps: Weighted mean

Deriving soil properties from a soil polygon map

- Approach 1: Straight areal weighted mean from polygon maps

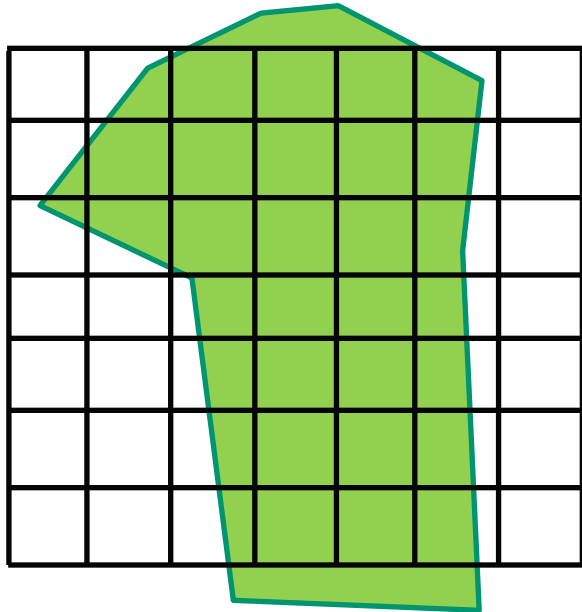
Pre-processing

- Approach 2: Harmonising/updating soil polygon maps using environmental covariates
- Approach 3: Disaggregating soil polygons -> soil series

Soil Maps: Weighted mean

Deriving soil properties from a soil polygon map

- Approach 1: Areal weighted average



60% Series A

20% Series B

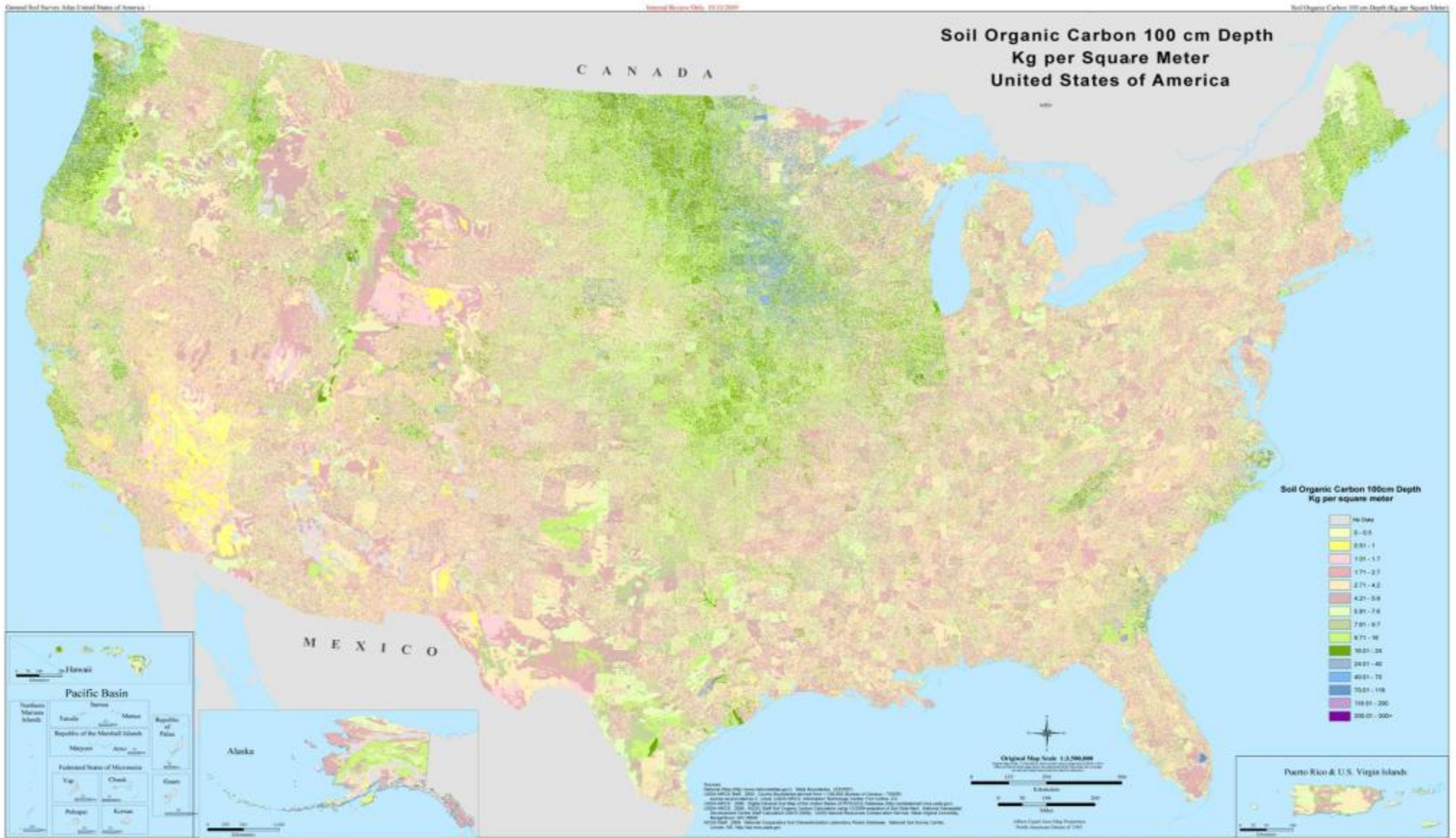
20% Series C

$$\text{Property} = 0.6 A + 0.2 B + 0.2 C$$

OR -> simpler alternative

$$\text{Property} = A \text{ (value of dominant soil)}$$

USDA-NRCS Approach: Deriving area weighted means of soil properties from a soil polygon ma



Calculations and Map prepared by USDA-NRCS Soil Survey Division - National Geospatial Development Center, 3340 University Drive, Suite 3017 West Virginia University, Morgantown, WV 26404



Soil Maps: Weighted mean

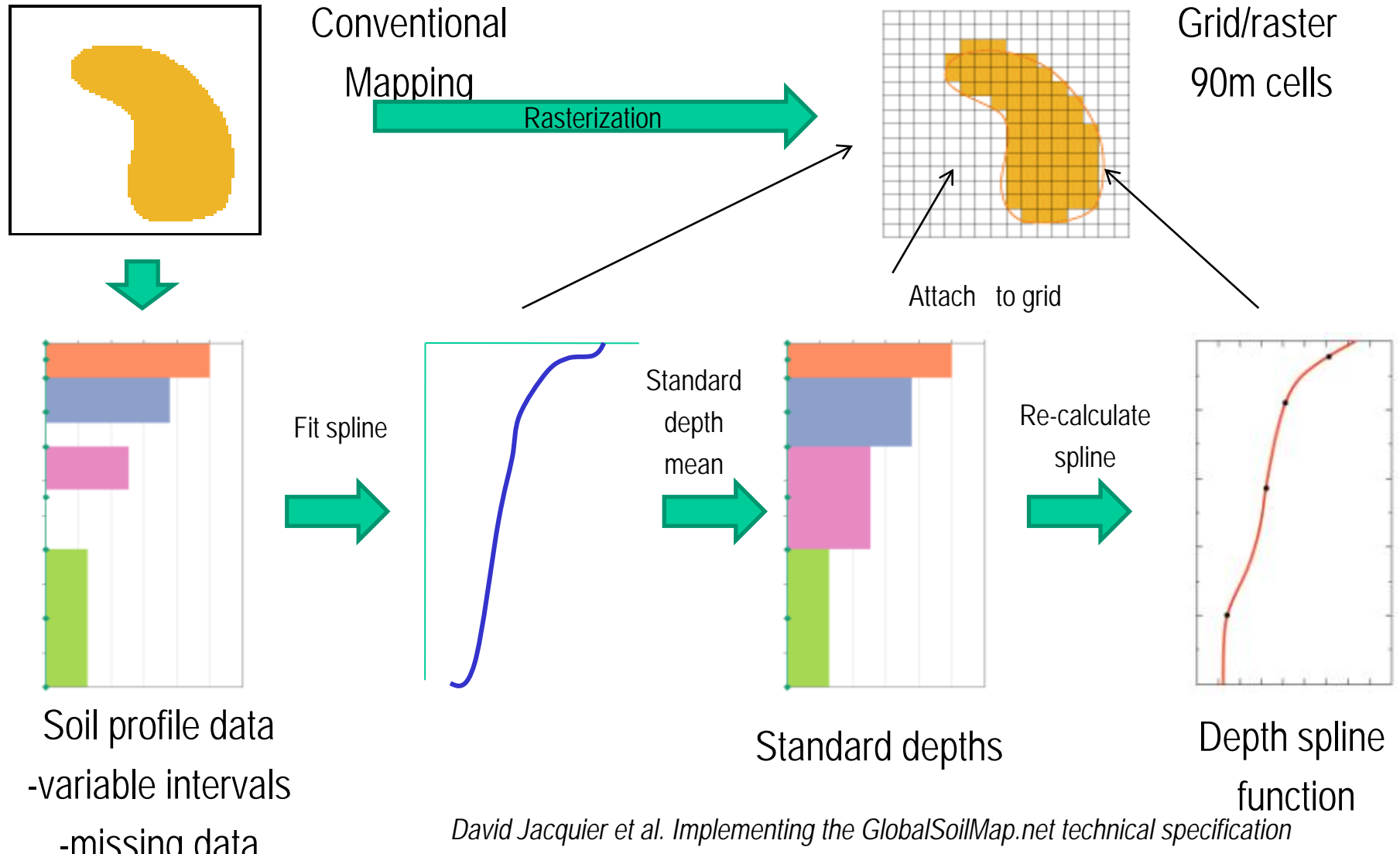
Deriving continuous depth soil properties from a soil polygon map

Depth spline process

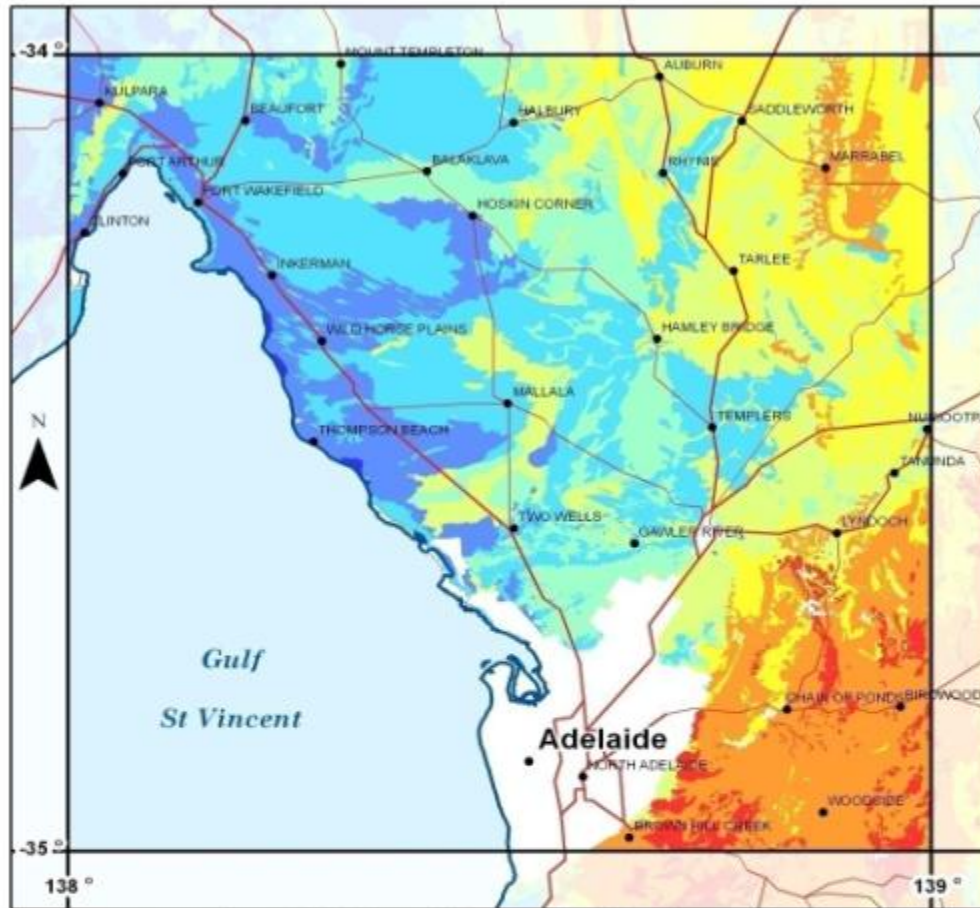
- Soil pH profile data for the test area was extracted from ASRIS. The data contains between 1-5 depth layers of varying thickness and some layers may be missing.
- A spline is fitted to the data and 1cm interval layers of mean pH is returned.
- The mean value of pH is derived for the GSM standard depth intervals (i.e. 0-5, 5-15, 15-30, 30-60, 60-100, 100-200).
- The standard depth mean values are the spline parameters. Only 6 parameters and a smoothing function need to be stored to recreate the spline.
- The outputs of the splining process are attached to the spatial dataset. In this instance the data not attached to the original conventional vector soil map but to a 90m rasterized version.

Soil Maps: Weighted mean

ASRIS Approach: Deriving continuous depth soil properties from a soil polygon map

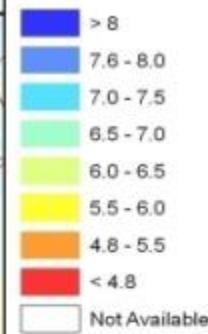


ASRIS Approach: Deriving continuous depth soil properties from a soil polygon map

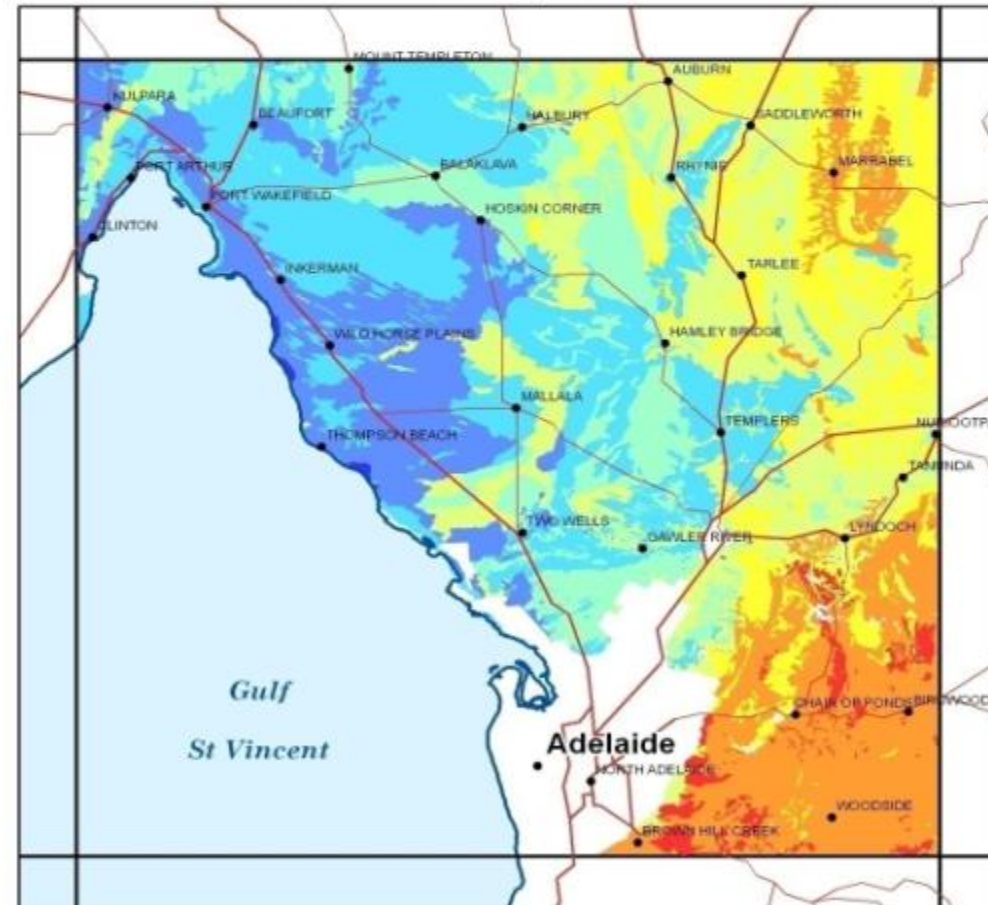


Area Weighted Mean of pH for Layer 1

pH (CaCl₂ 1:5)

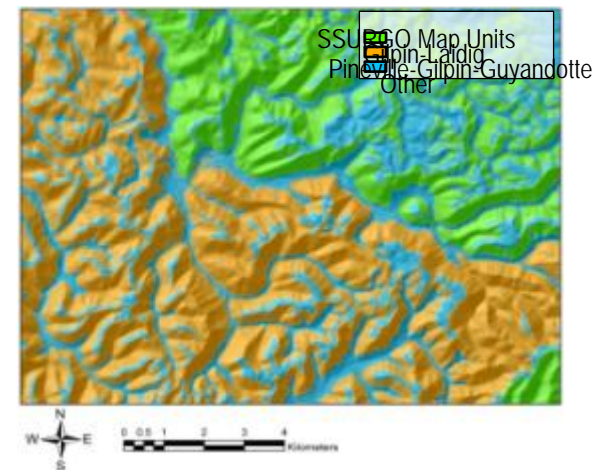
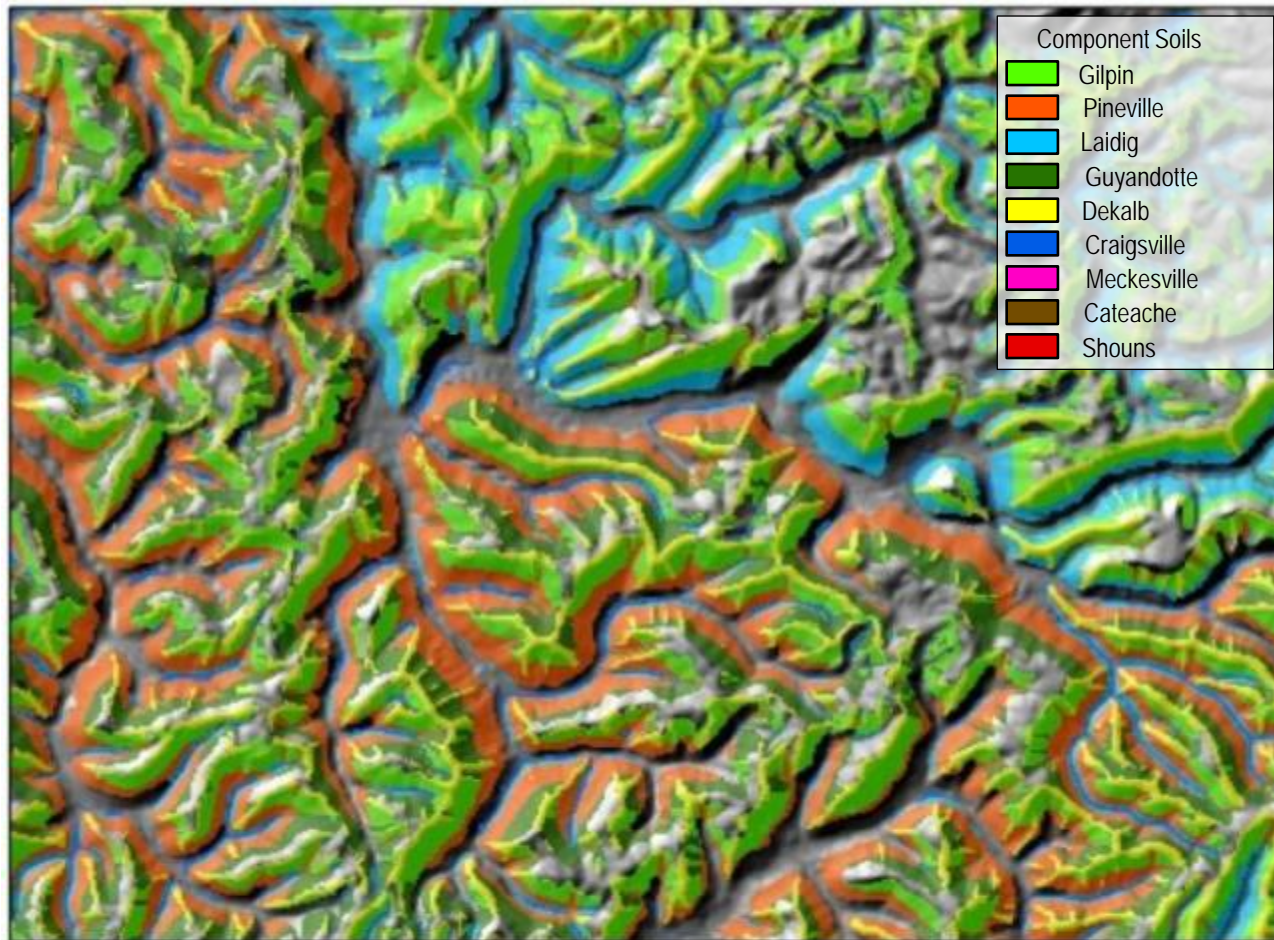


Estimate of mean pH for 0 - 5 cm

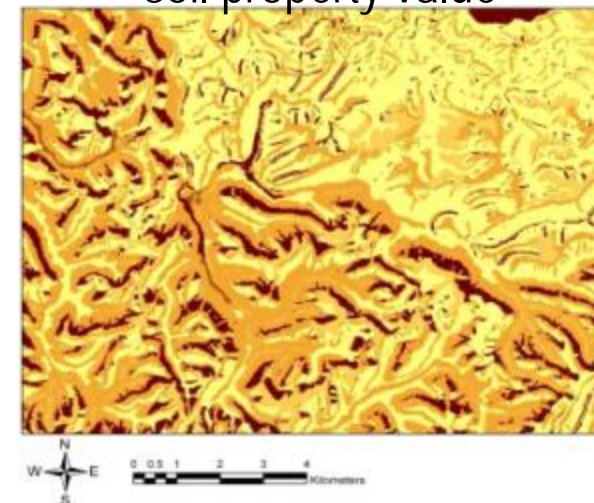


Soil Maps: Disaggregation

NRCS – Jim Thompson Approach: Disaggregation into component soils or land facets



Each component has a single soil property value



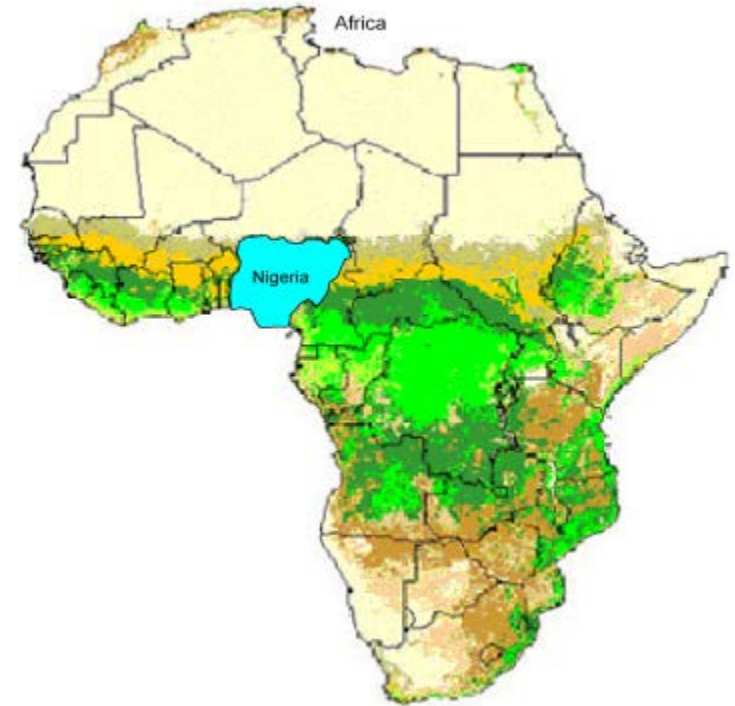
Thompson et al. 2010



Digital Soil Mapping in Nigeria (Yemefack, 2012)

Digital soil property mapping for Nigeria from legacy soil data:

Working towards the first approximation



FACULTY OF AGRICULTURE,
FOOD
& NATURAL RESOURCES

Inakwu O.A. Odeh, with contributions from Hannes Reuter, Johan Leenaars, Alfred Hartemink

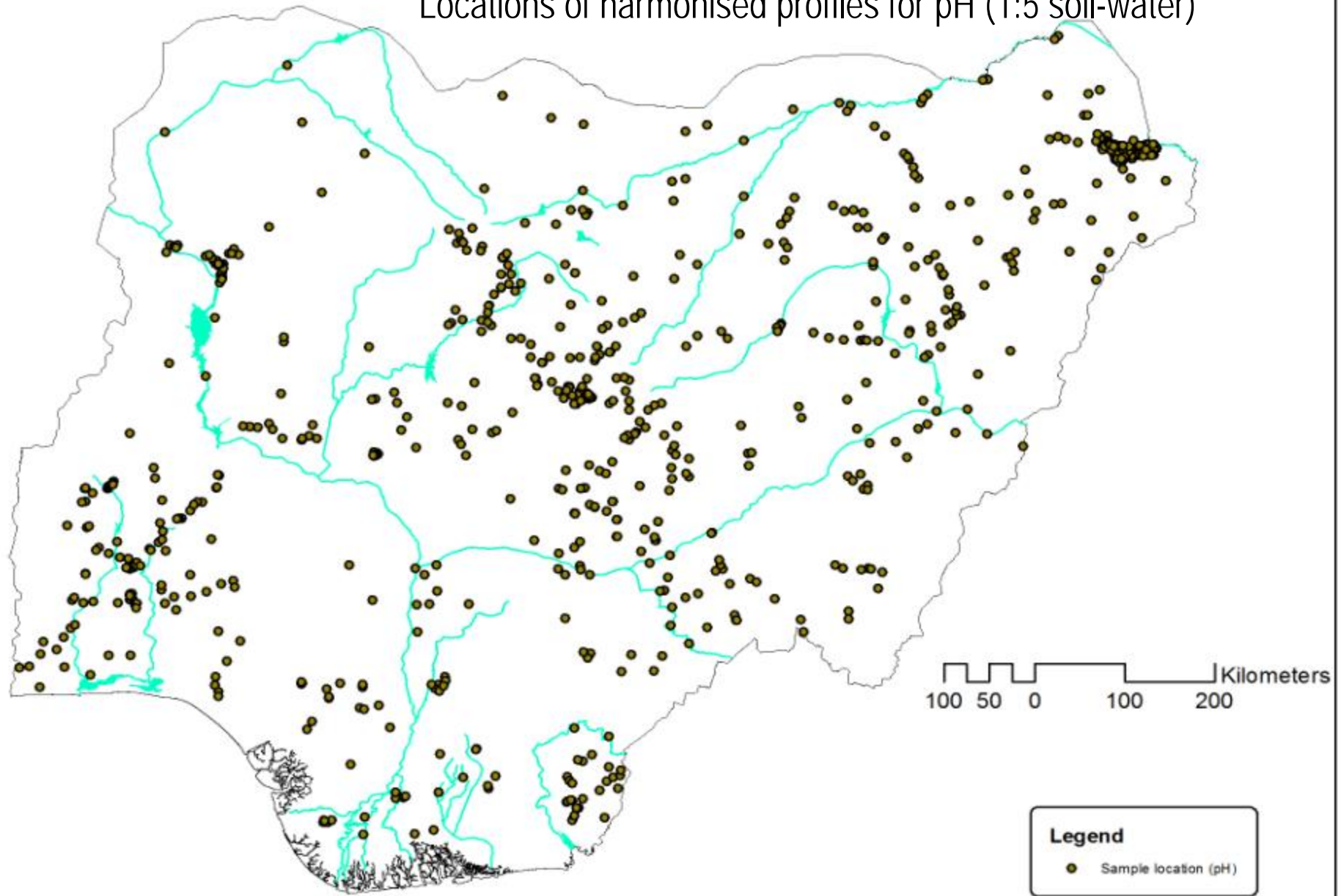


THE UNIVERSITY OF
SYDNEY



World Soil Information

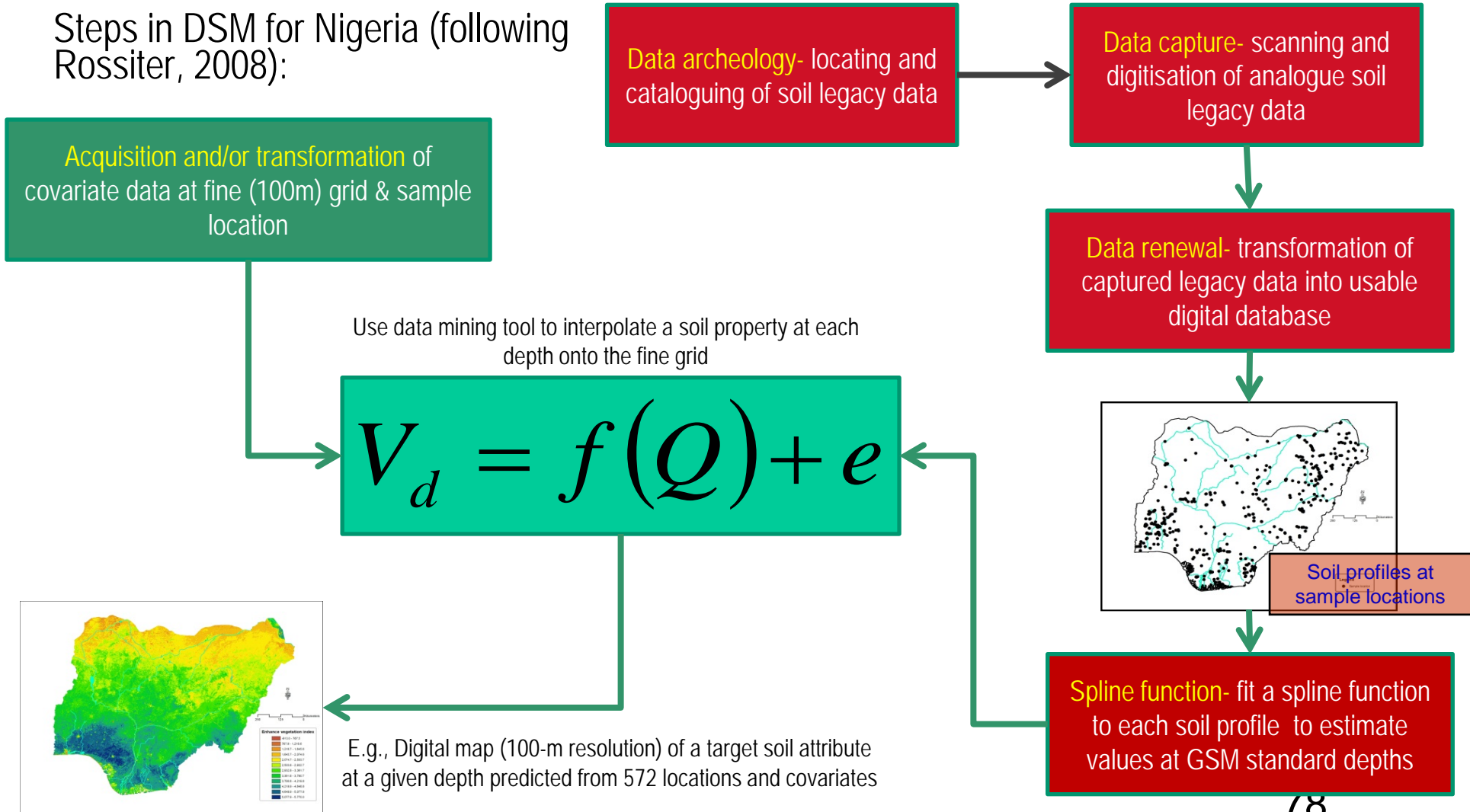
Locations of harmonised profiles for pH (1:5 soil-water)



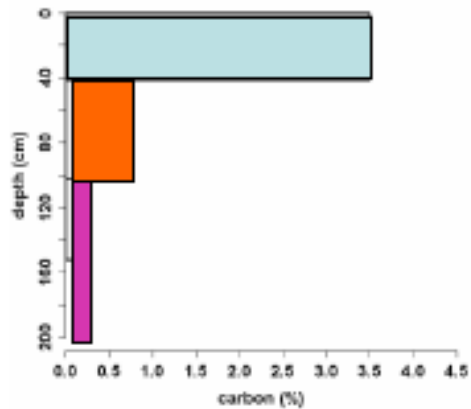
$N = 878$

Digital Soil Mapping For Nigeria

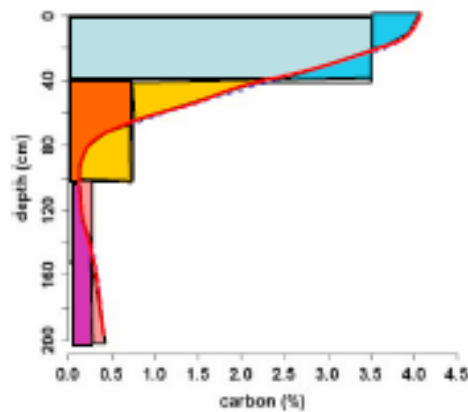
Steps in DSM for Nigeria (following Rossiter, 2008):



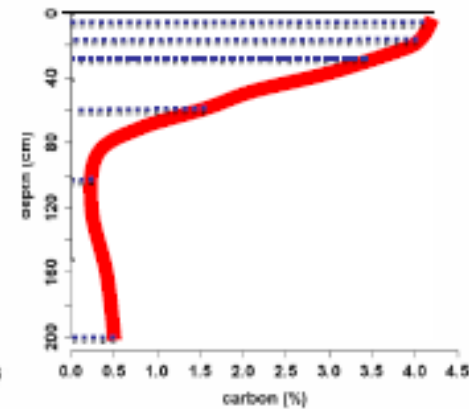
Spline functions for depth harmonization



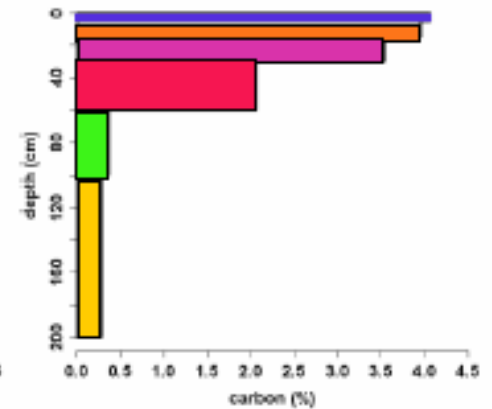
'Modal'
profile



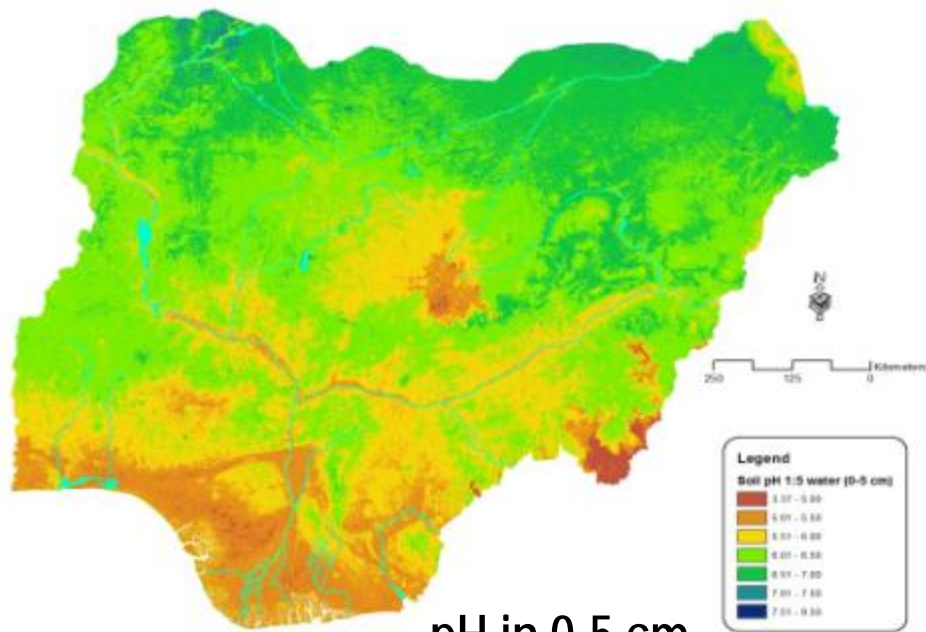
Fit mass-
preserving
spline



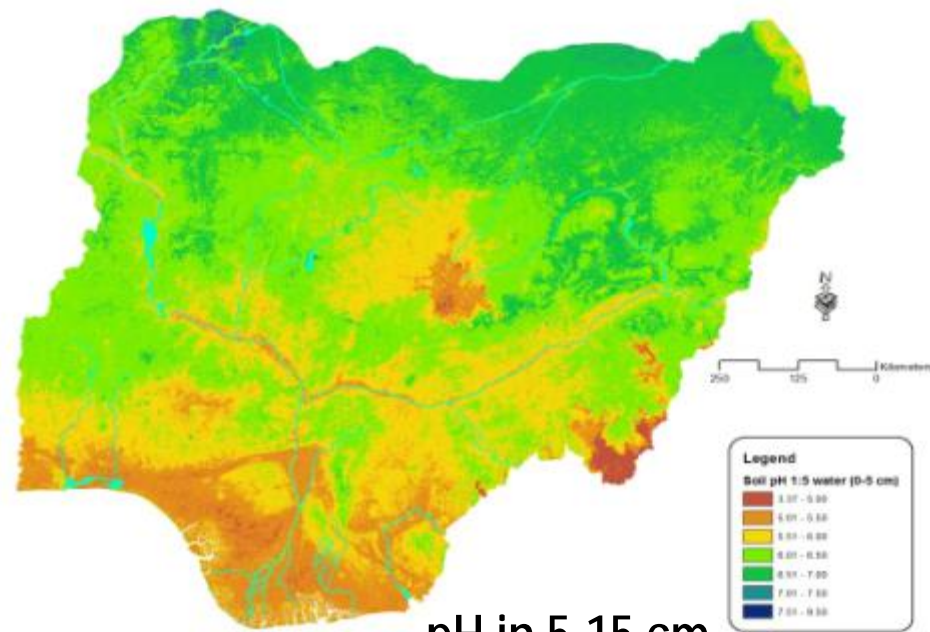
Fitted
Spline



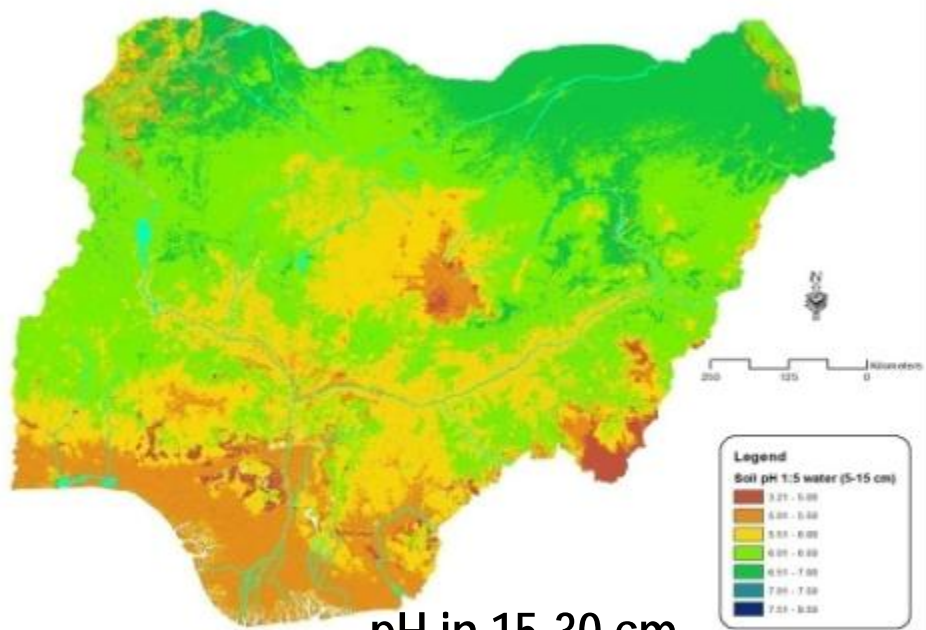
Estimate
averages for
spline at
standardised
depth ranges,
e.g.,
GlobalSoilMap
depth ranges



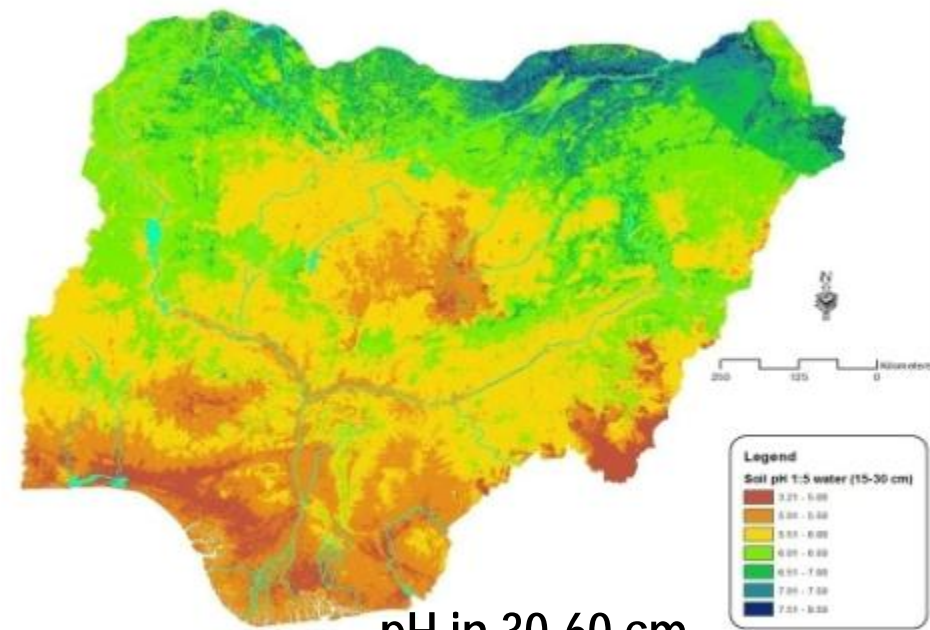
pH in 0-5 cm



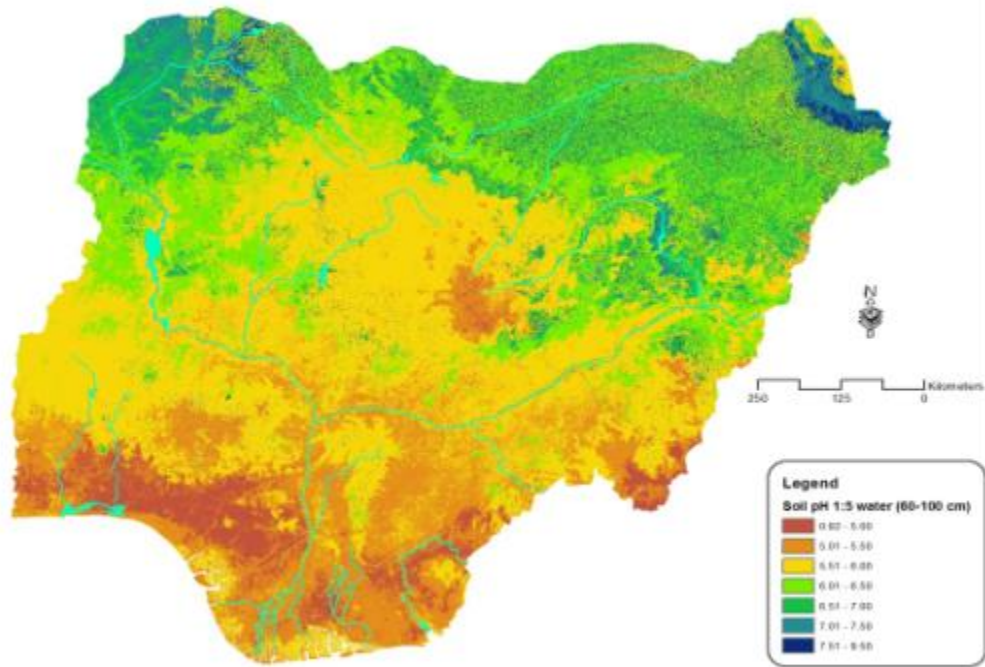
pH in 5-15 cm



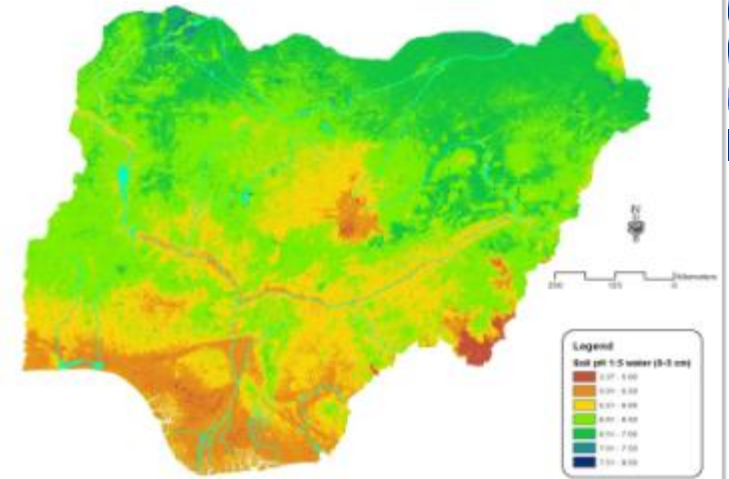
pH in 15-30 cm



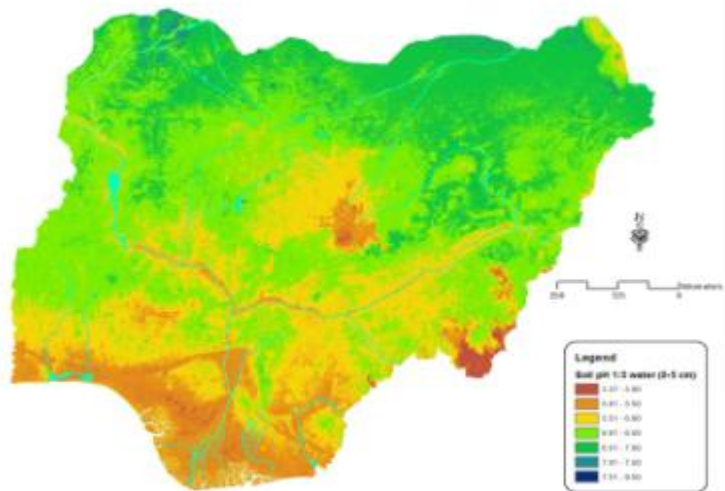
pH in 30-60 cm



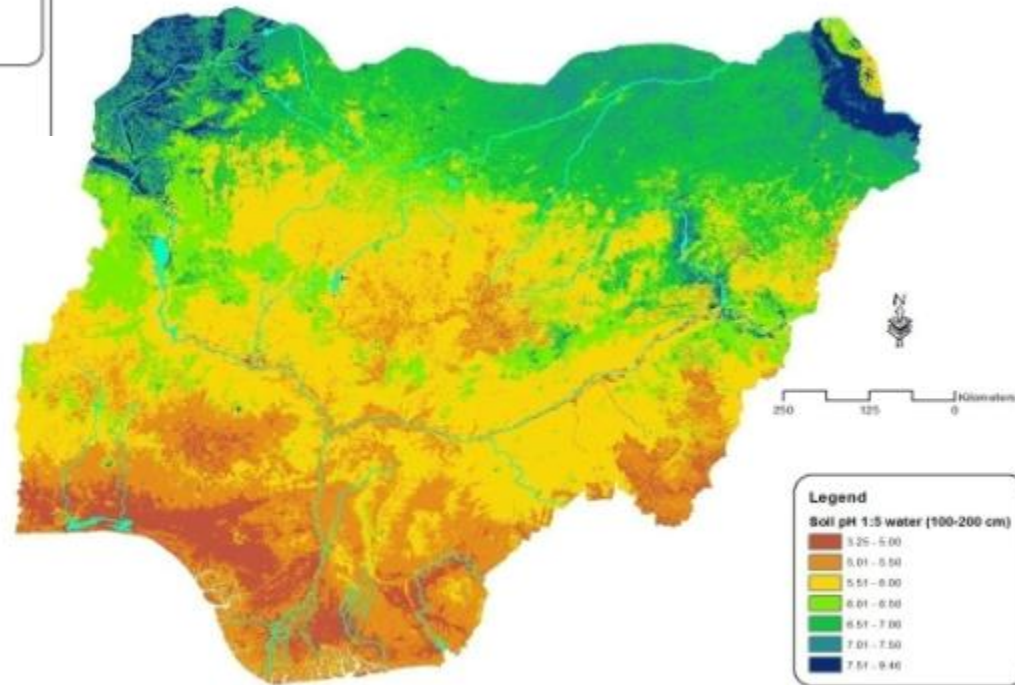
pH in 60-100 cm



pH in 0-5 cm



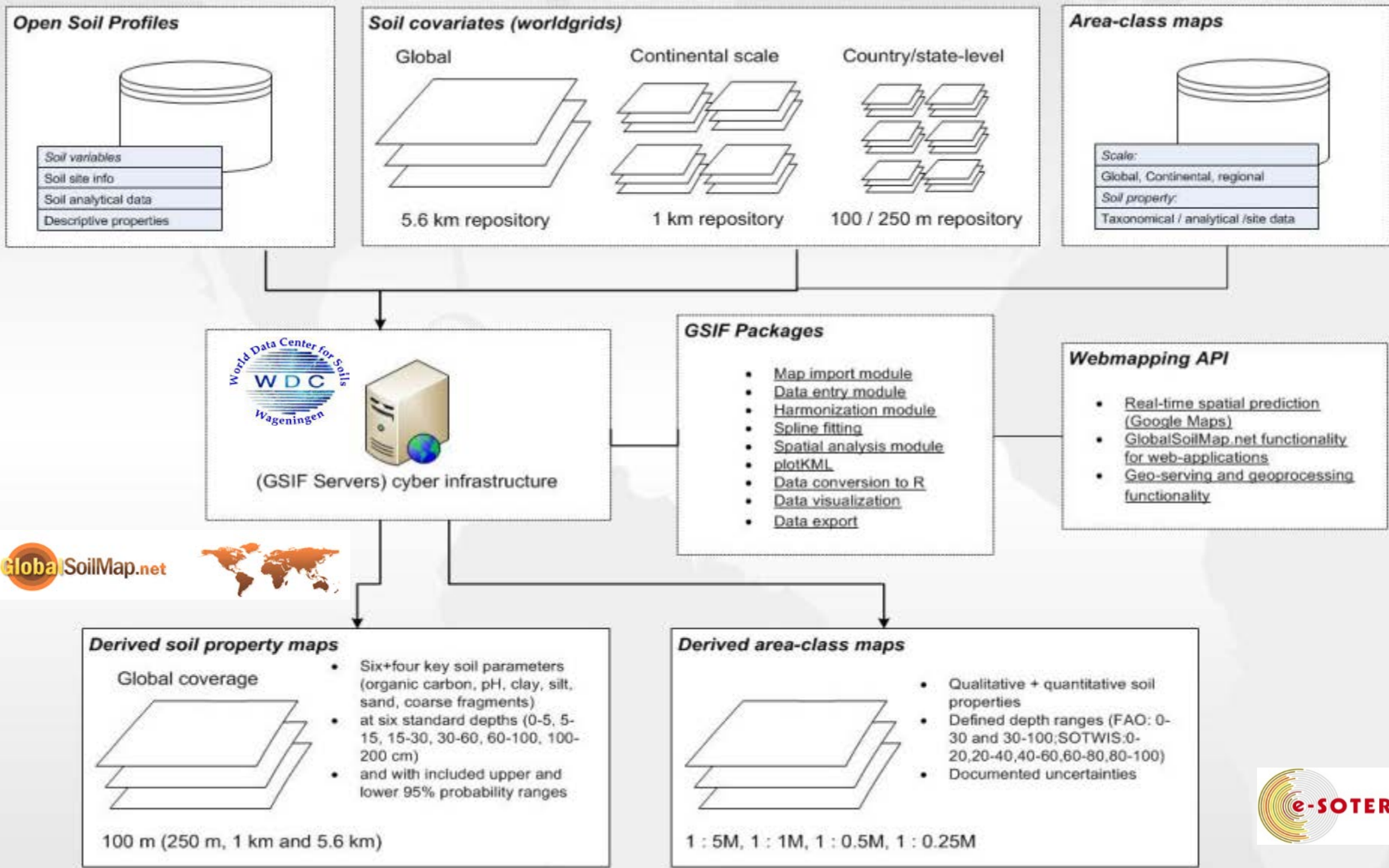
pH in 5-15 cm



pH in 100-200 cm 81



Global Soil Information Facilities (ISRIC, 2012)



Why do we need SoilProfile.org?

- Objective:

SoilProfile is a (de)-central repository for collecting, storing, accessing and interacting with soil profile observations

- Rationale:

SoilProfile is a part of a larger GSIF. It is the physical implementation of ISRICs contribution to fulfil its mandate as World data centre for soil to “Serve the scientific community as custodian of global soil information”



Open Soil Profiles

Open Soil Profiles is an unified soil profile database of the World. **This website is under construction. To test the functionality, please consider [registering](#).**



all countries ▼
 [\[advanced search\]](#)

Enter a soil variable and a country name, example: "soil pH ", "Brazil". To list all profiles in a country simply select country and press "search by country".

Browse fields

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- [How to prepare data for OSP?](#)
- [Column naming conventions](#)
- **Software tools**

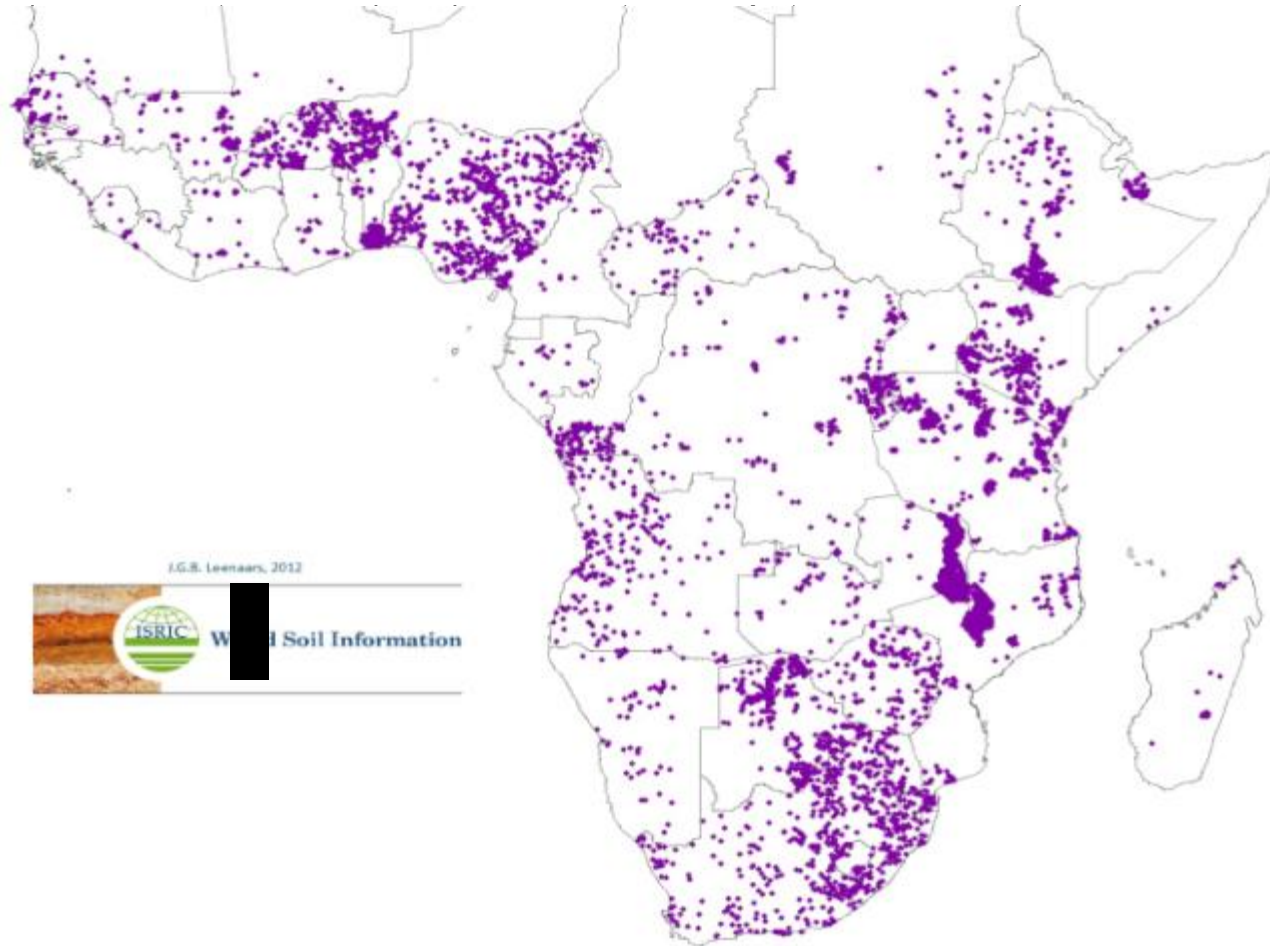
Download data

- **Browse data**
- [Disclaimer and the default license](#)
- [How to link to MySQL db?](#)

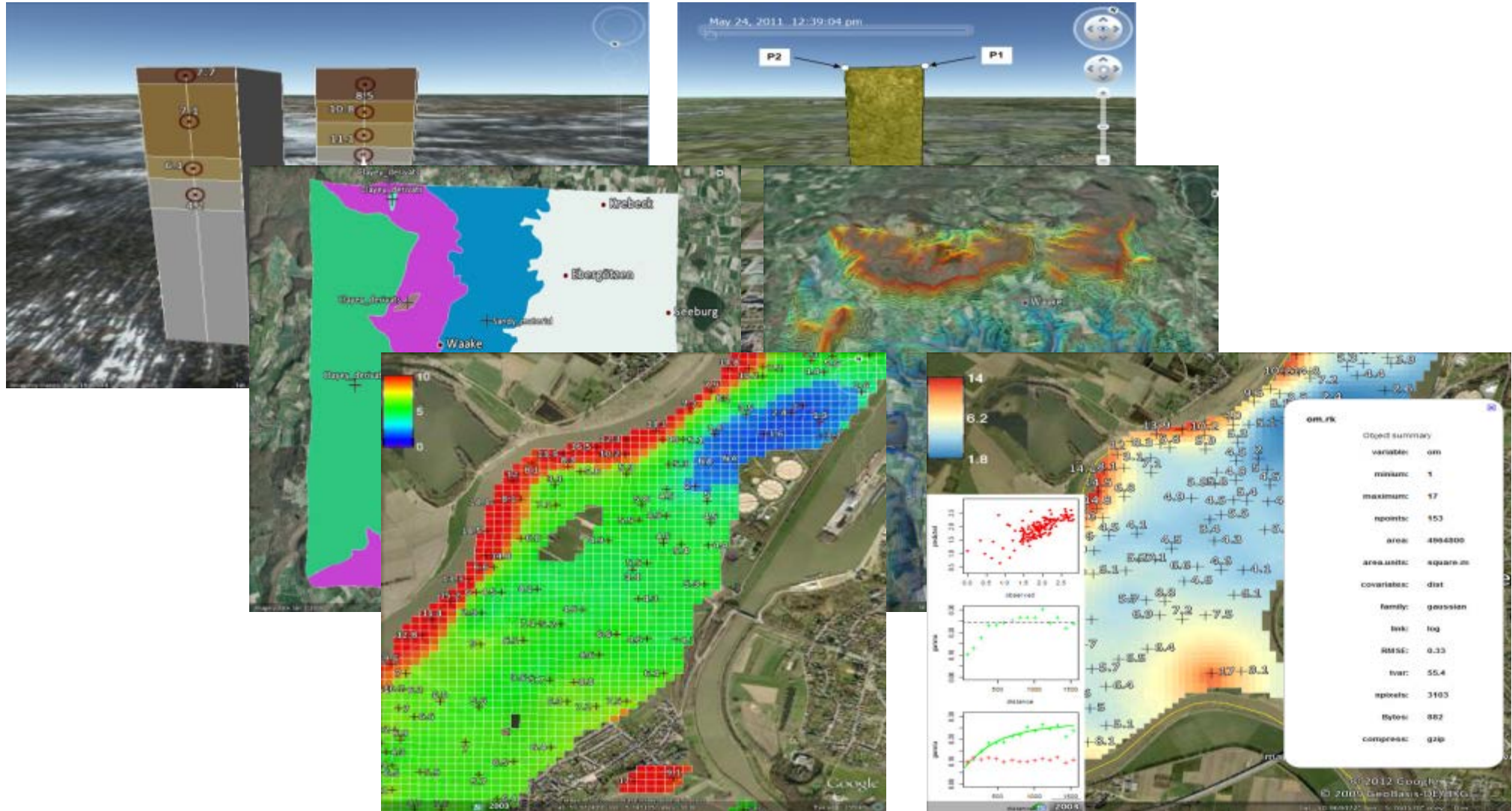
<http://soilprofile.org/>

2012 AfSP 3rd version : 12500 profiles

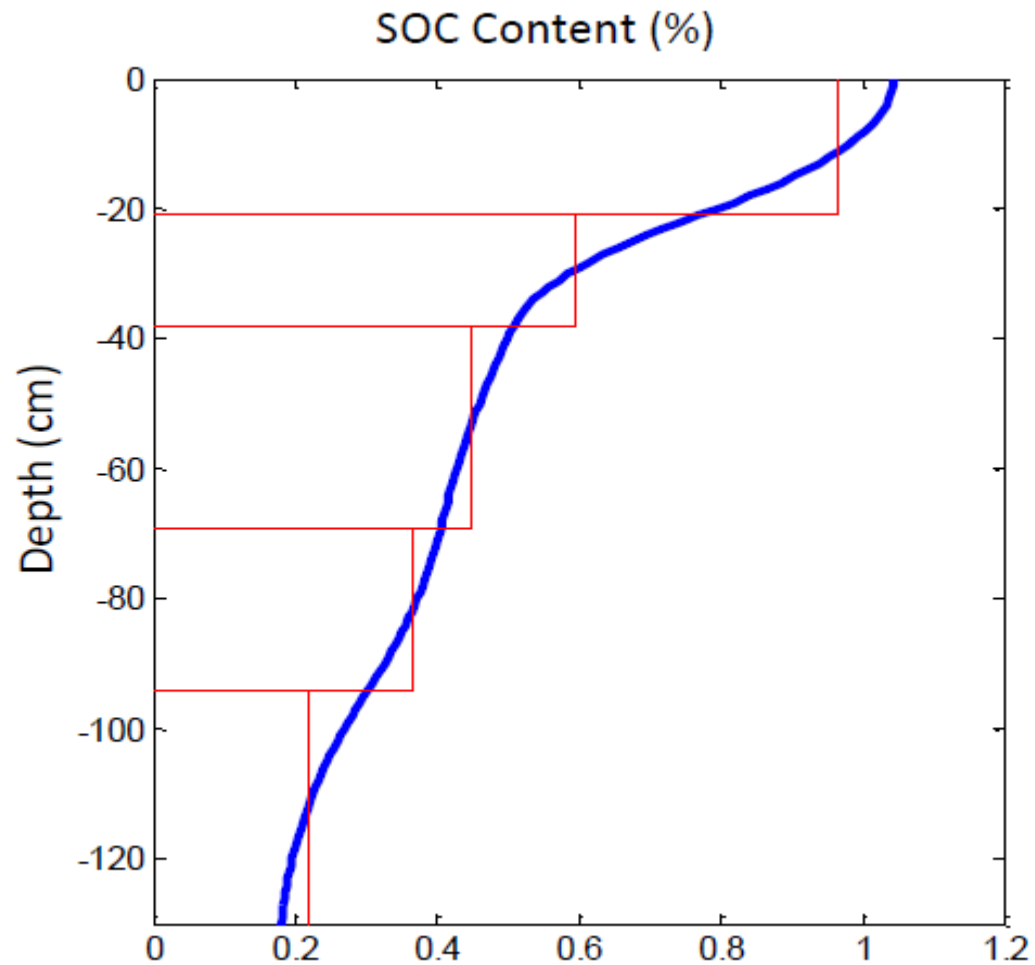
Malawi
Ethiopia
Ivory Coast



Facilitating Soil Production - Visualisations



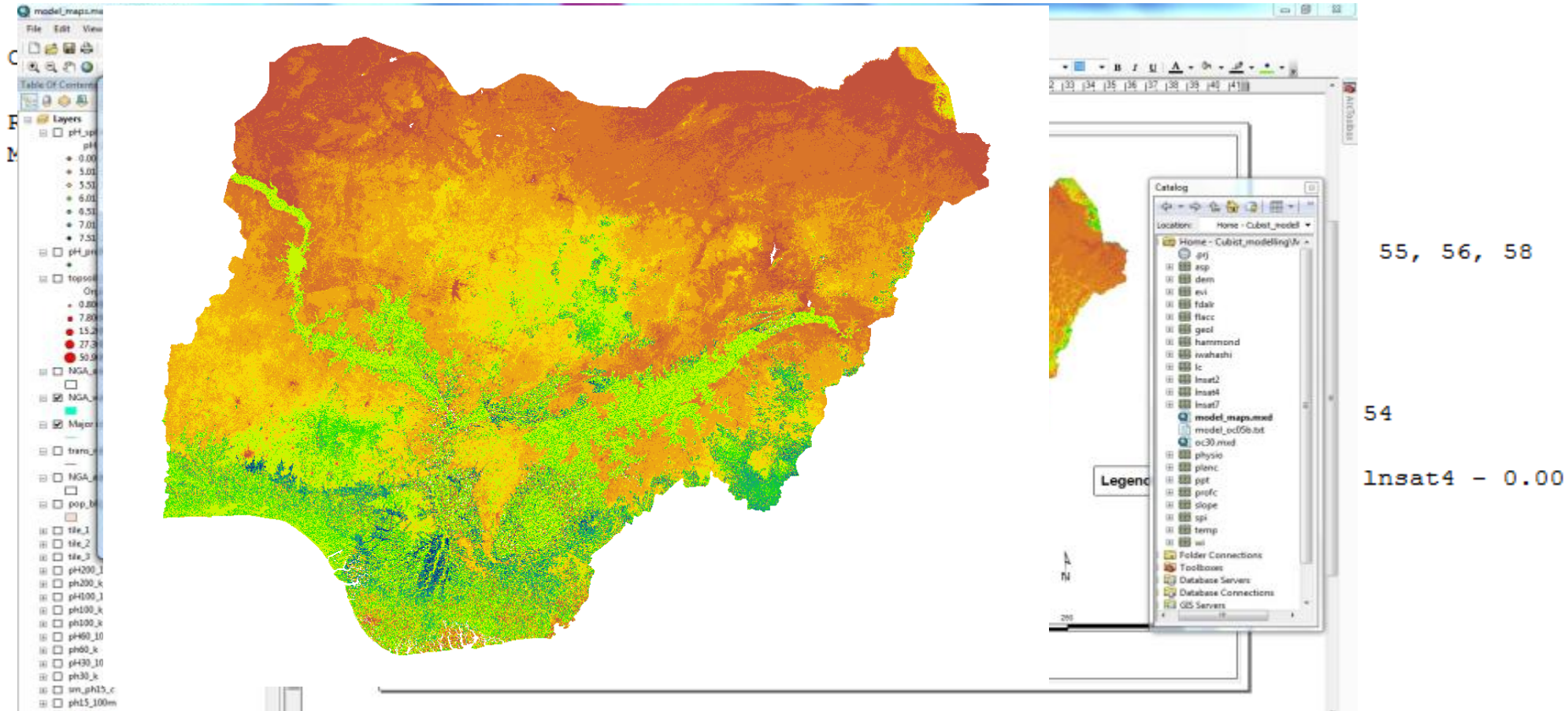
Facilitating Soil Production - Fit the spline




SC: Minasny & Malone, 2011)

Facilitating Soil Map Production - DSM

any arbitrary soil map production process - which uses auxiliary information

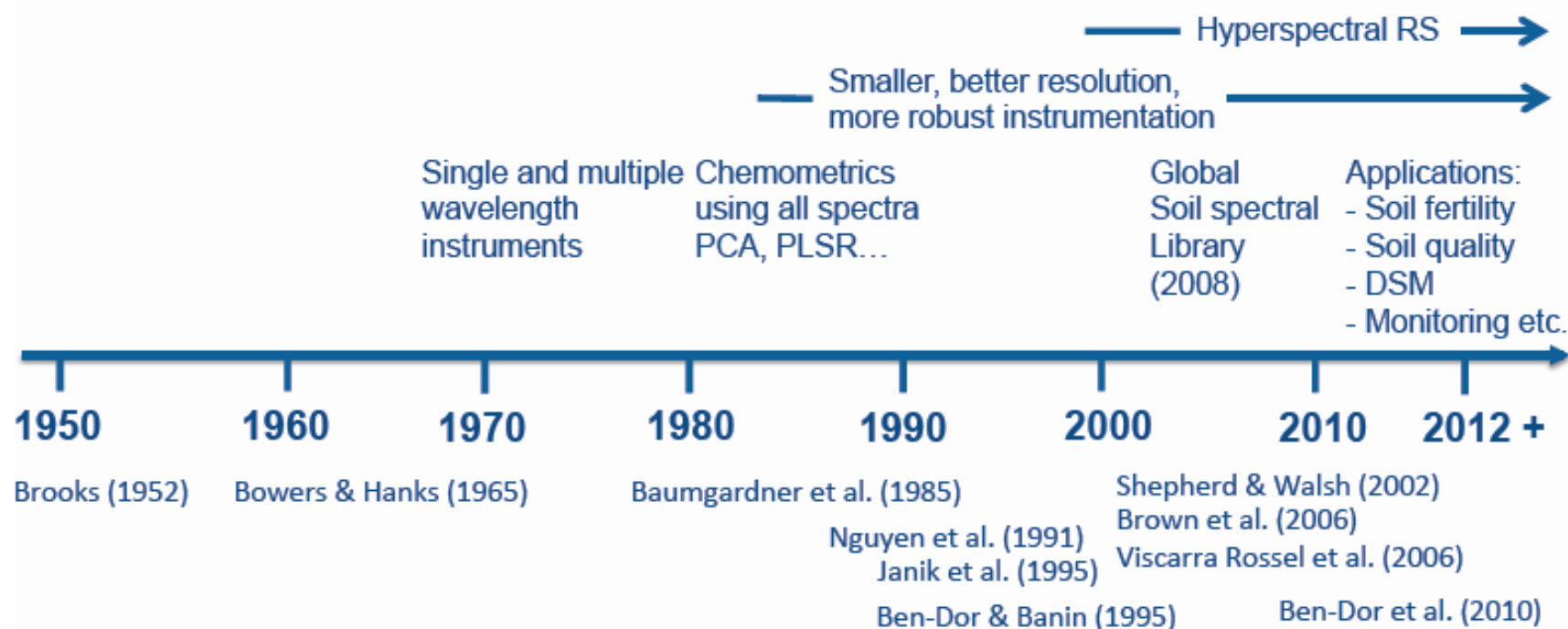


www.globalsoilmap.net



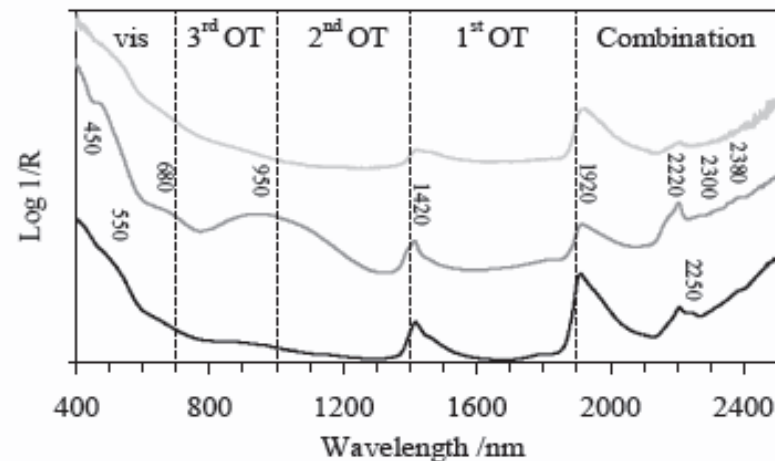
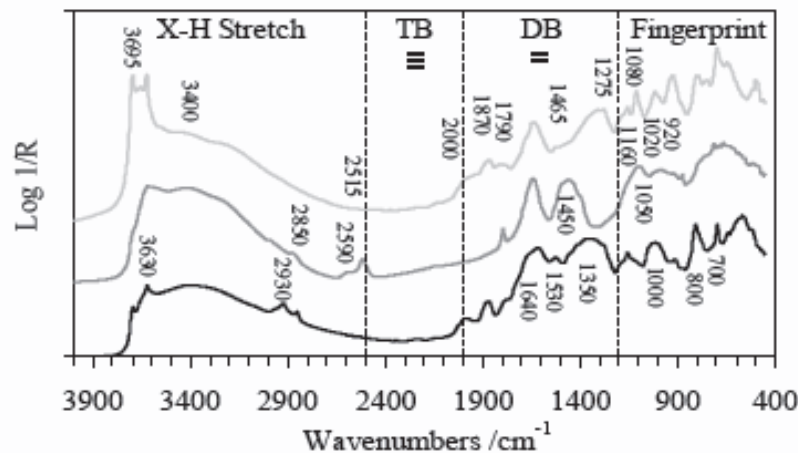
**Using Soil Spectroscopy for Soil Mapping
(Viscarra-Rossel, 2012)**

The soil spectroscopy timeline



Soil spectroscopy is not new, but important developments have occurred over the last 15 years...and now it's the time for adoption and applications!

The information content of soil spectra



A spectrum is a multi-parameter property:

- iron oxides
- clay minerals
- carbonates
- colour
- organic matter
- water
- particle size

SOILS and their properties

mid-IR measurement platforms

Remote sensing

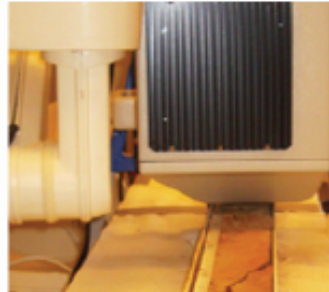
satellite



airborne



laboratory

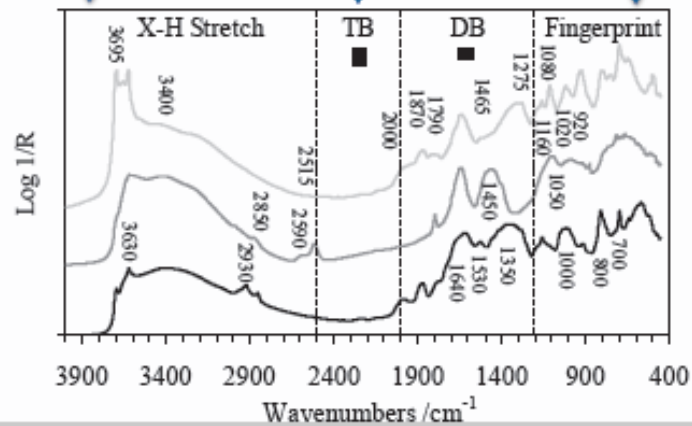


Proximal sensing

static



on-the-go



Vis-NIR measurement platforms

Remote sensing

satellite



airborne



laboratory

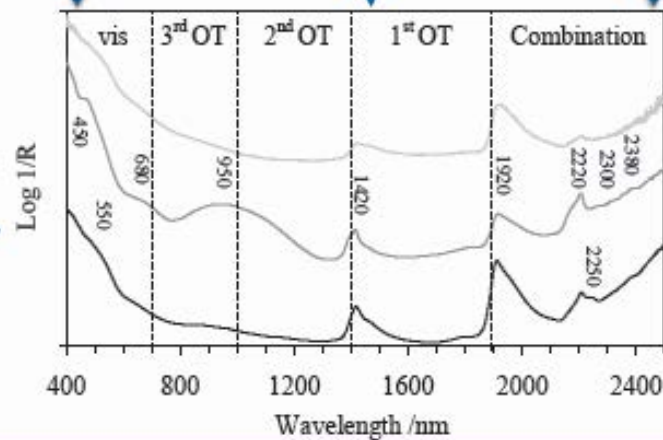


Proximal sensing

static



on-the-go



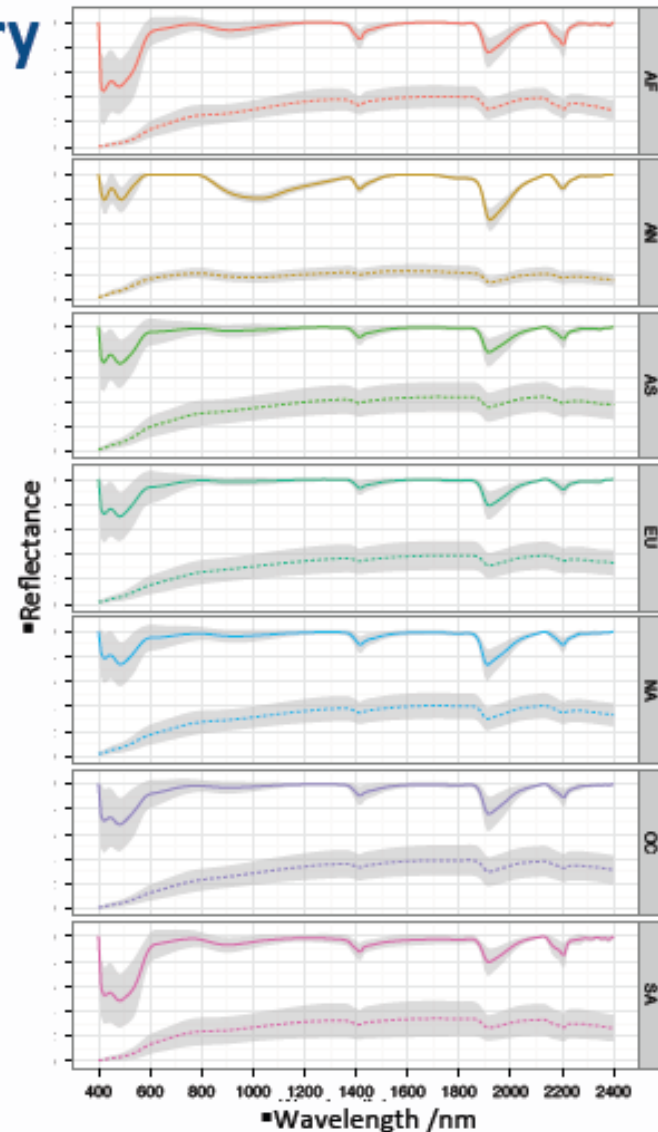
The Global soil spectroscopic library

Initiated its development in 2008

Response to growing interest by soil scientists

To further the research, encourage development of applications and adoption

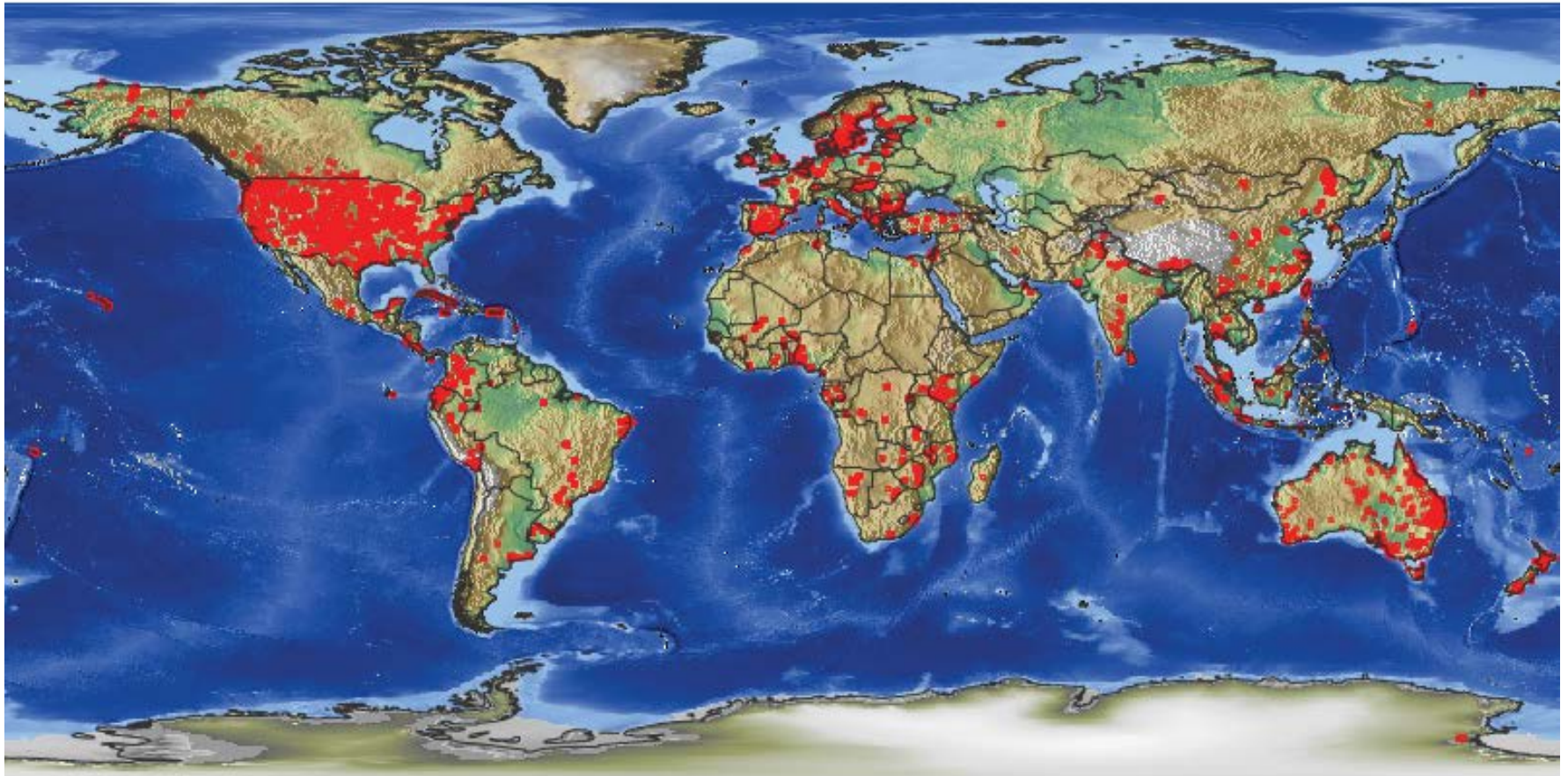
Demonstrate the usefulness of the spectra



Contributors to the GSSL – a truly global effort

Europe		Africa	
Bosse Stenberg, Jan Eriksson	SWEDEN	Keith Shepherd, Andrew Sila	KENYA
Anton Thomsen, Maria Knadel	DENMARK	Aichi Hamouda	TUNISIA
Harm Bartholomeus	NETHERLANDS	Martial Bernoux, Bernard Barthes	MADAGASCAR
Antoine Stevens, Valerie Genot	BELGIUM	Didier Brunet, Martial Bernoux	SENEGAL
Christian Walter, Cecile Gomez	FRANCE	Marco Nocita, Anita Bayer	SOUTH AFRICA
Cesar Guerrero	SPAIN	Asia	
Thorsten Behrens	GERMANY	Eyal Ben Dor	ISRAEL
Kristin Boetcher, Michelle Sellito	ITALY	Zhou Shi, Du Changwen	CHINA
Barry Rawlins, Arian Chappell	UK	Hakime Abbaslou	IRAN
Andreas Gubler	SWITZERLAND	Anthony Ringrose-Voase	BRUNEI
Lukas Brodsky	Czech Republic	Young Hong and Eunyoung Cho	KOREA
North America		Sakae Shibusawa, Masakazu Kodaira	JAPAN
David Brown, Ken Sudduth, Sabine Grunwald	USA	Oceania	
Paul Sanborn	CANADA	Raphael Viscarra Rossel	AUSTRALIA
Leigh Winowiecki	COSTA RICA	Carolyn Hedley, Bambang Kusumo	NEW ZEALAND
South America		Antarctica	
Alexandre Dematte	BRAZIL	Carolyn Hedley, Pierre Roudier	ROSS DEPENDENCY
Leonardo Ramirez	COLOMBIA	Additionally	
Héctor J. M. Morrás	ARGENTINA	ISRIC	OTHER COUNTRIES
Eleazar Rufasto Campos	PERU		

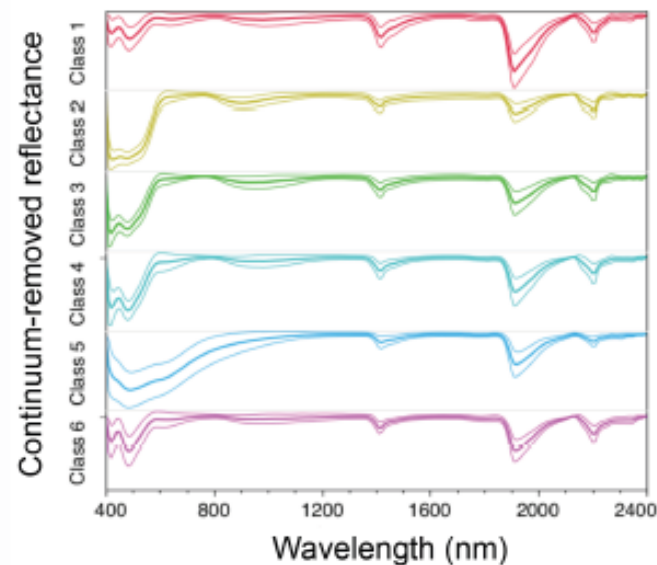
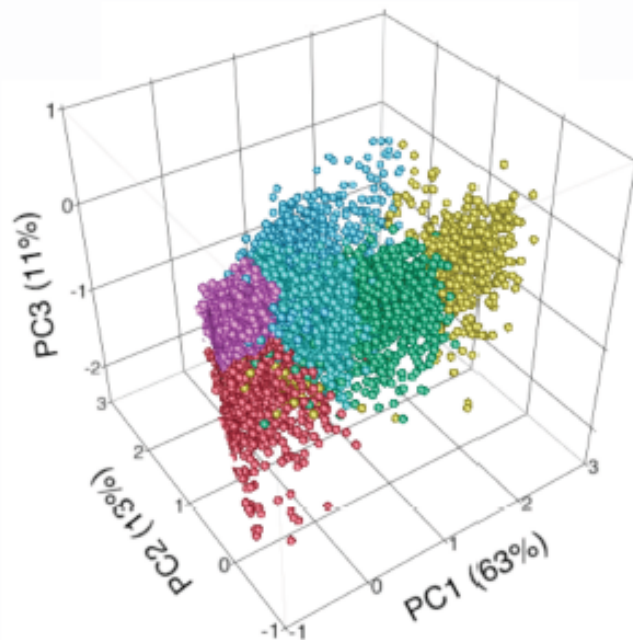
Spatial distribution of the spectra in the GSSL



New contributions: Greenland, Czeck Republic, more Antarctica ..., Bolivia...(?)...any others??

Summarising the soil information content of vis–NIR spectra

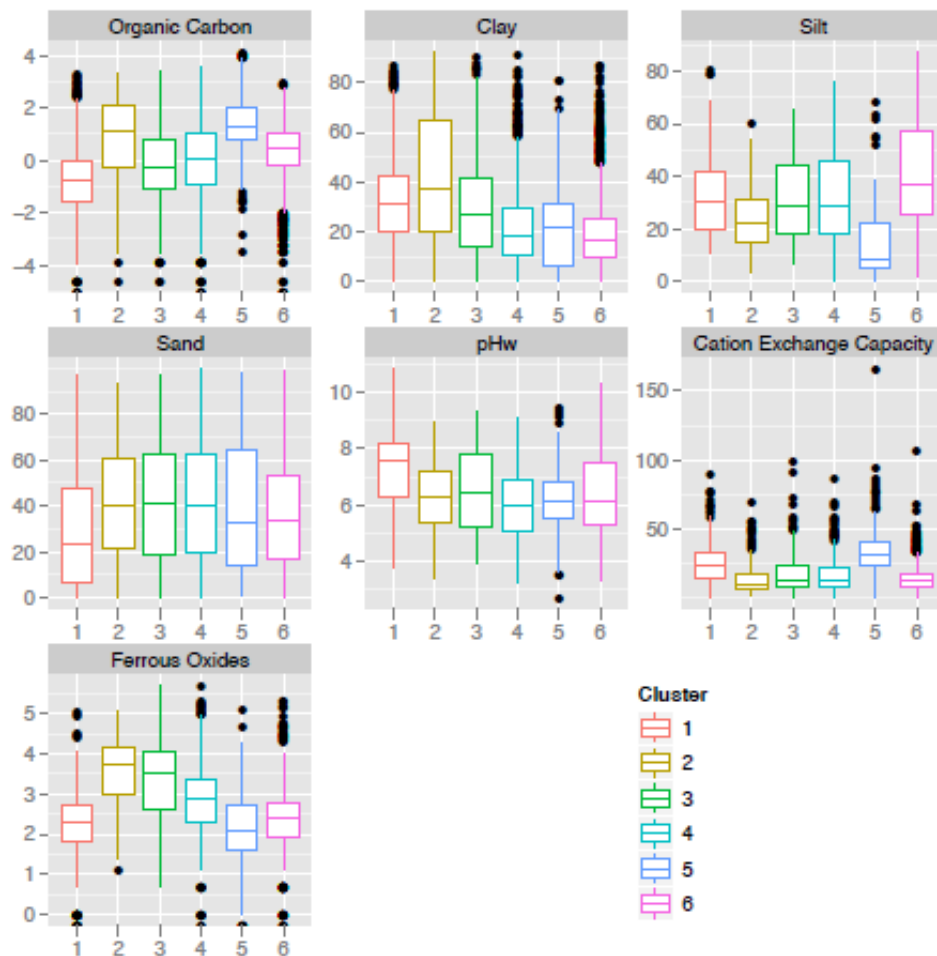
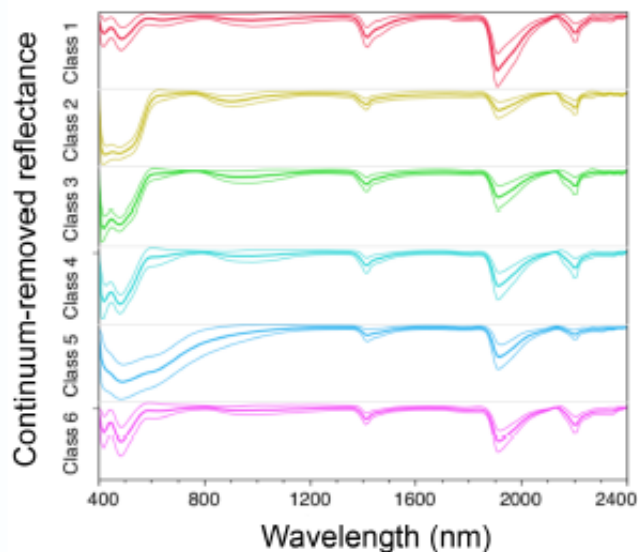
- Summarised the spectra with PCA
- Classified the scores with fuzzy-c-means
- Plotted mean and st. deviation for spectra in each class



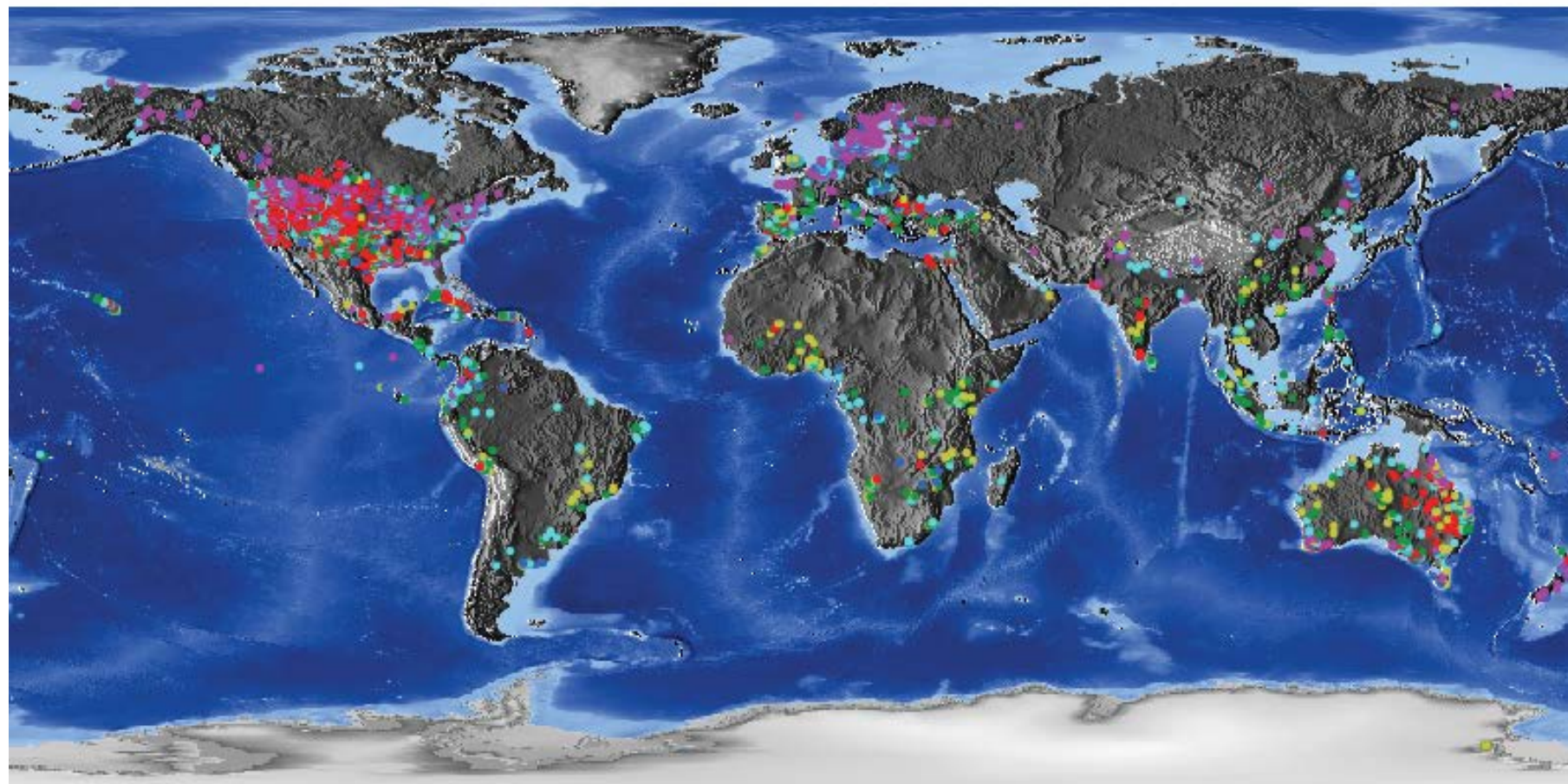
Viscarra Rossel, et al. 201x – *In prep.*

Relating the classes to attributes

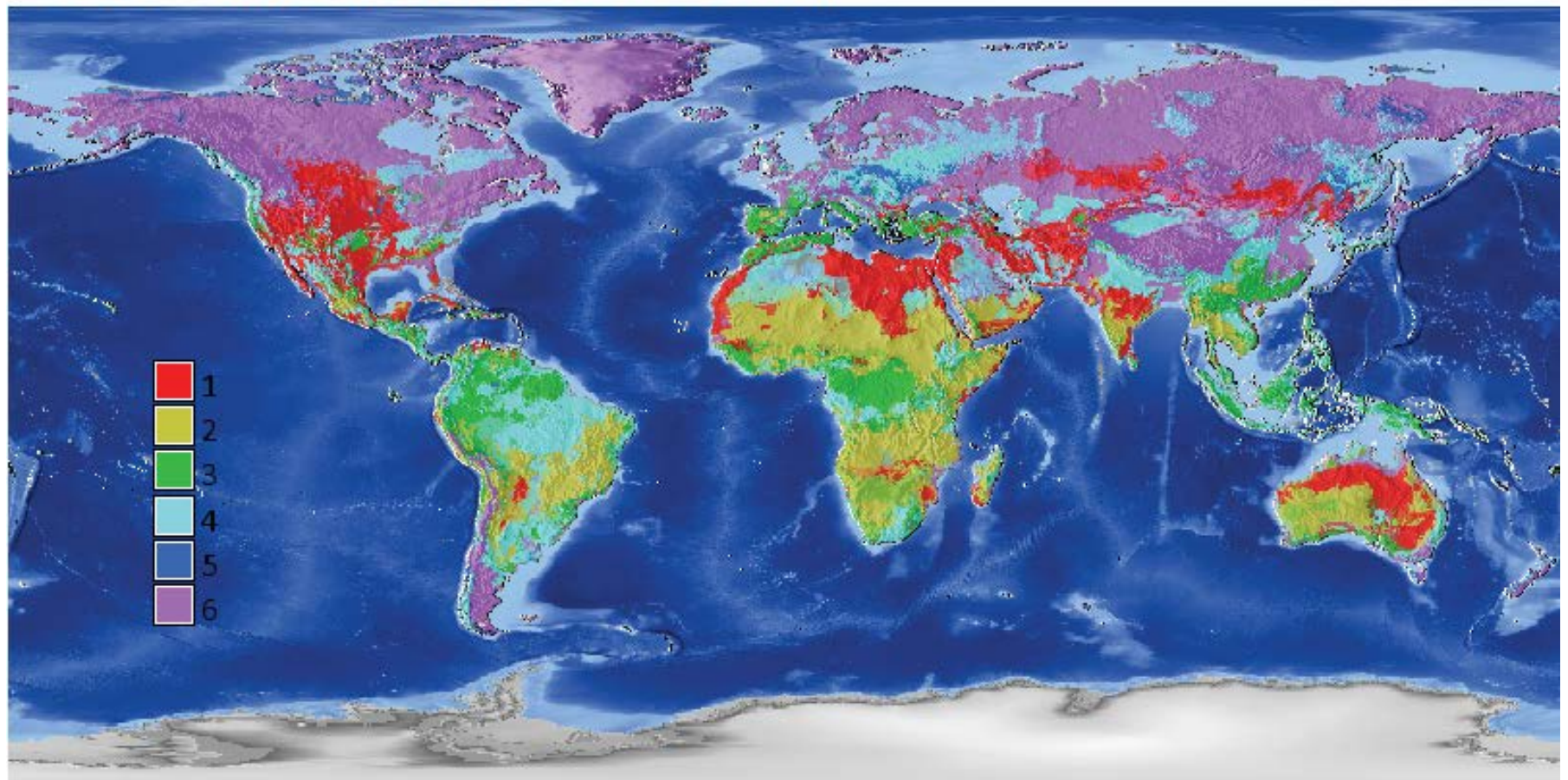
- Good correlation between classes and different soil attributes e.g. Class 1 has large amounts of clay, large pH, CEC...small OC...etc.



The soil spectral classes

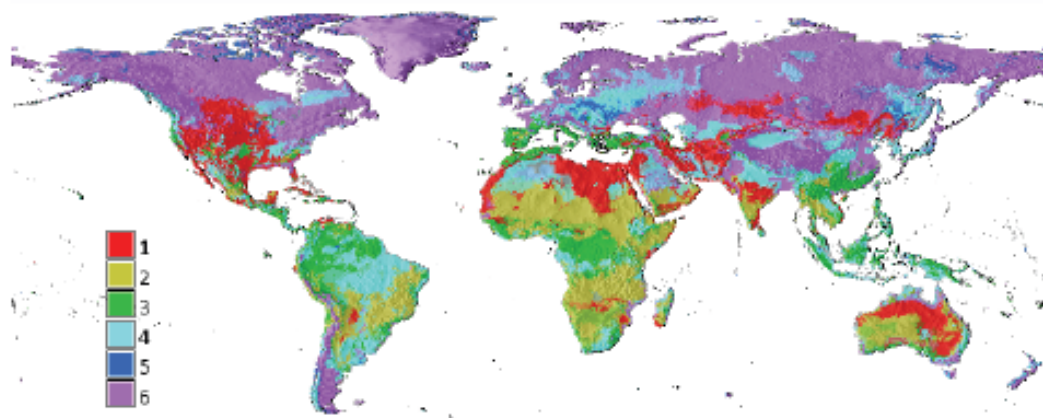


A (fuzzy) soil spectral class map

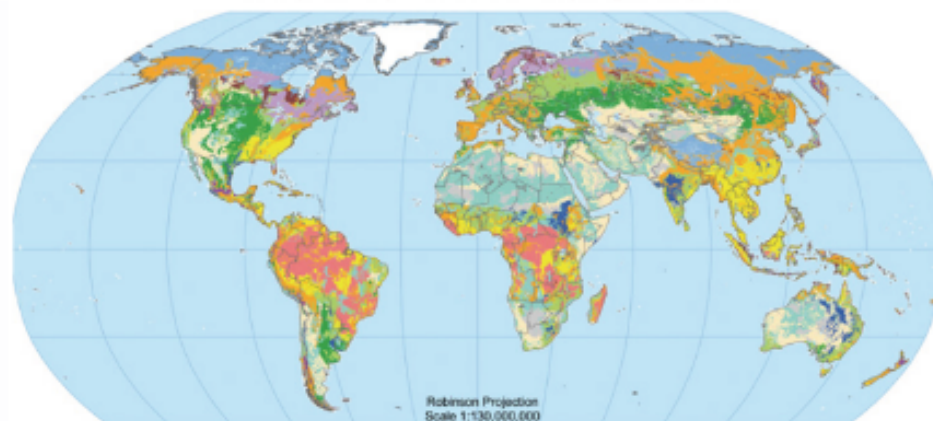


Spatial modelling: CLORPT/SCORPAN using Random Forest algorithm
Predictors: monthly rainfall and temperature (min, max), DEM, land cover, soil type
Resolution: 1 km pixels

How does it compare to the Soil Taxonomy?



Global Soil Regions



There are similarities:

- In NA, EU, AS, Mollisols ~ Class 1
- In SA, Oxisols ~ Classes 2, 3, 4
- In AF, Entisols ~ Class 2
- In AS, Ultisols ~ Classes 2, 3, 4
- In AU, Vertisols ~ Class 1; Entisols and Aridisols ~ Classes 2, 3