Scope to map soil management units at district level from γ-ray (remote) and EM (proximal) data

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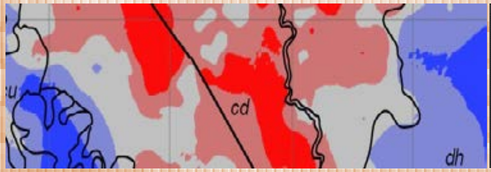
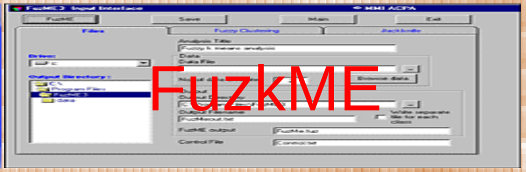
Triantafilis J

Problem Definition?

Materials and Methods





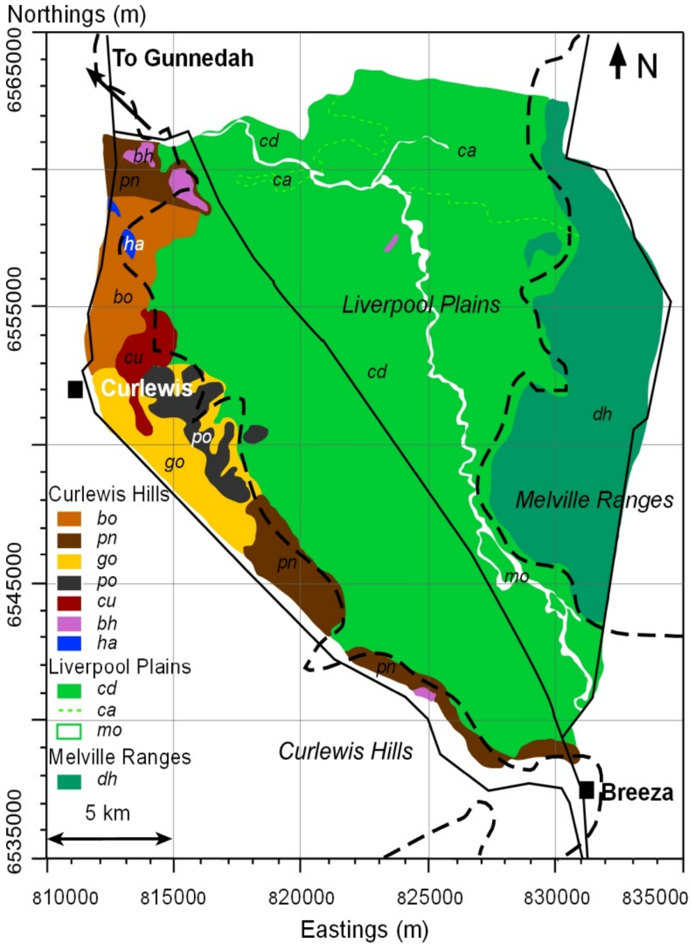
Results, Discussion & Conclusions

Talk Outline

Problem Definition

- Traditionally requires
  - Field survey and morphological data and limited chemical data
  - Followed by classification of soil profile into pre-existing soil classification system
- Expensive, time-consuming, labour-intensive & not useful for management (e.g. soil colour)

Problem Definition



- Results in a soil map
  - Limited samples due to cost
  - Based on extrapolation using air-photos
  - Based on subjective interpretation of field surveyor to classify the profile and extrapolate and identify the soil landscape units

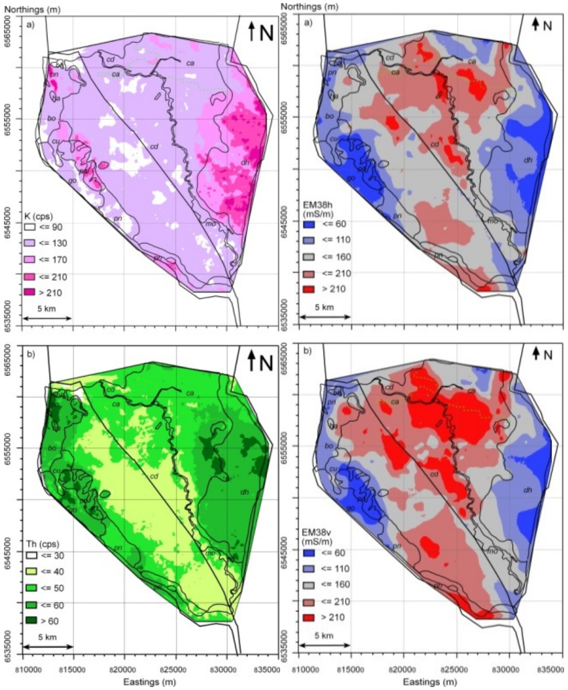
Aim: Is there an alternative?

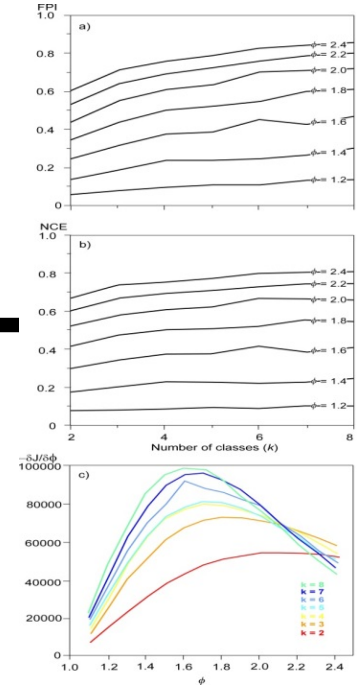
- Digital soil mapping (DSM) is the use:

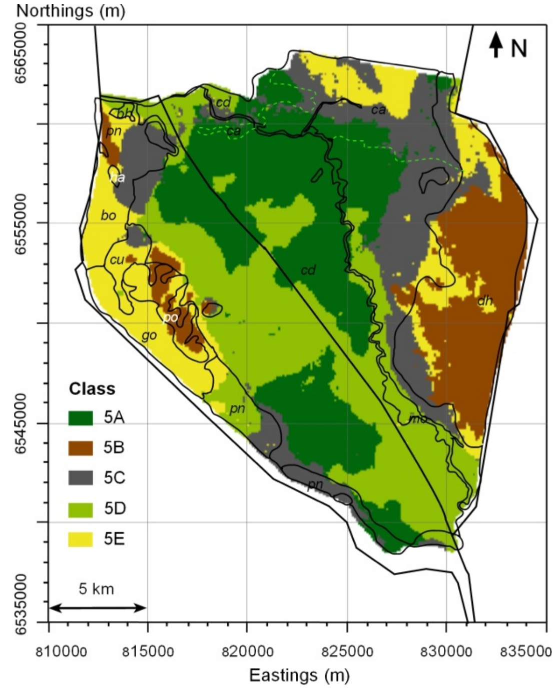
ancillary data (proximal or remote)

Statistical/mathematical techniques

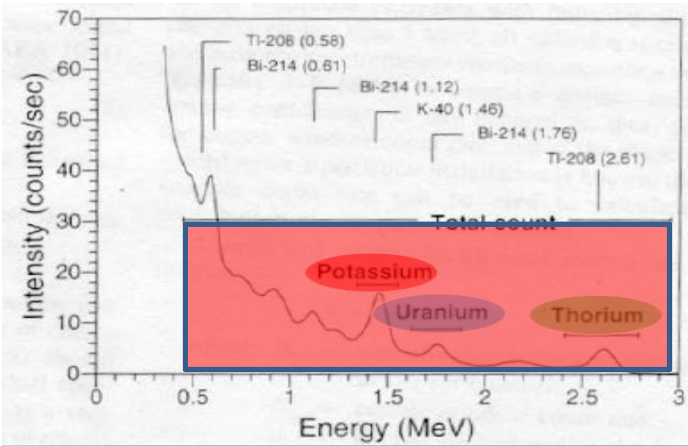
to map soil type and individual soil properties

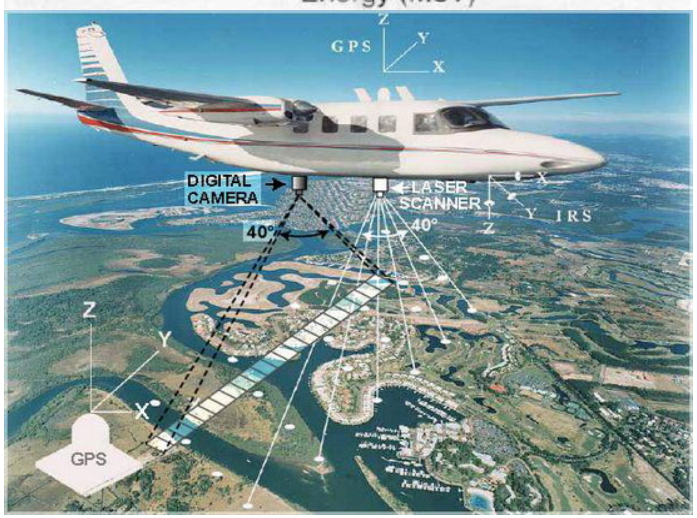






Ancillary data: γ-ray (remote)

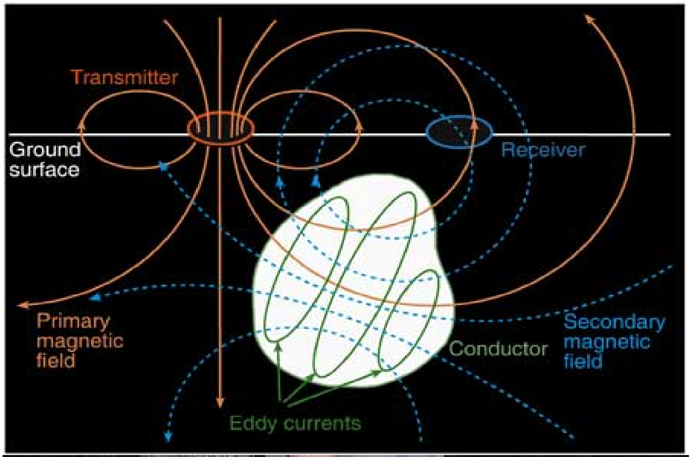




- Natural radiation from Earth's
  - Rocks, and
  - Soil

- Commonly measures
  - K,
  - Th and
  - U counts
  - with Total Count (TC)

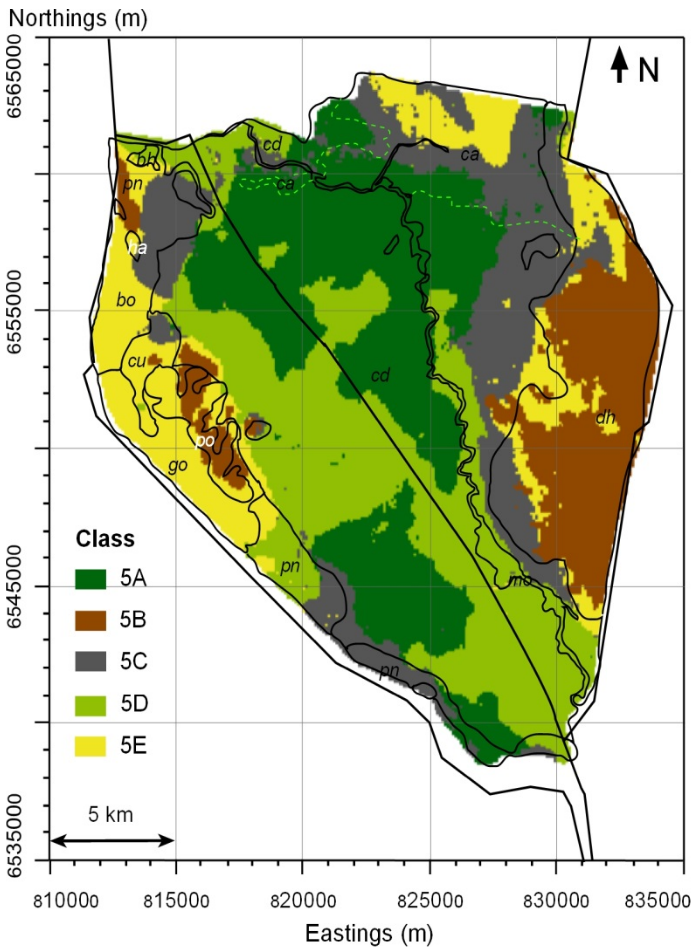
Ancillary data: EM (proximal)



- Relationship with morphological and chemical properties, for example;
  - clay content,
  - CEC,
  - salinity,
  - moisture

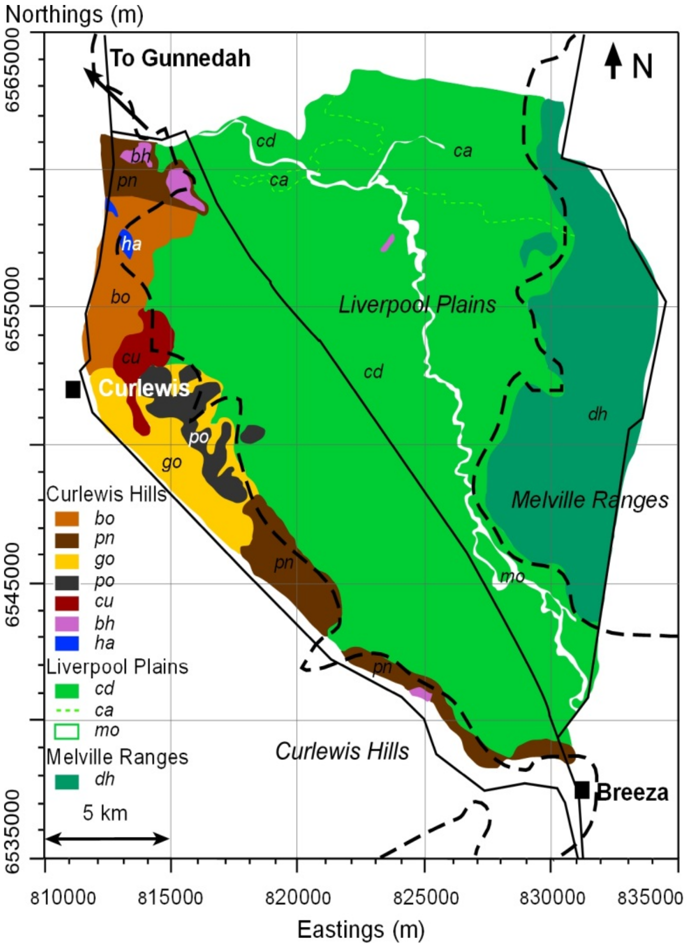
- Measures apparent electrical conductivity EC_a (mS/m)

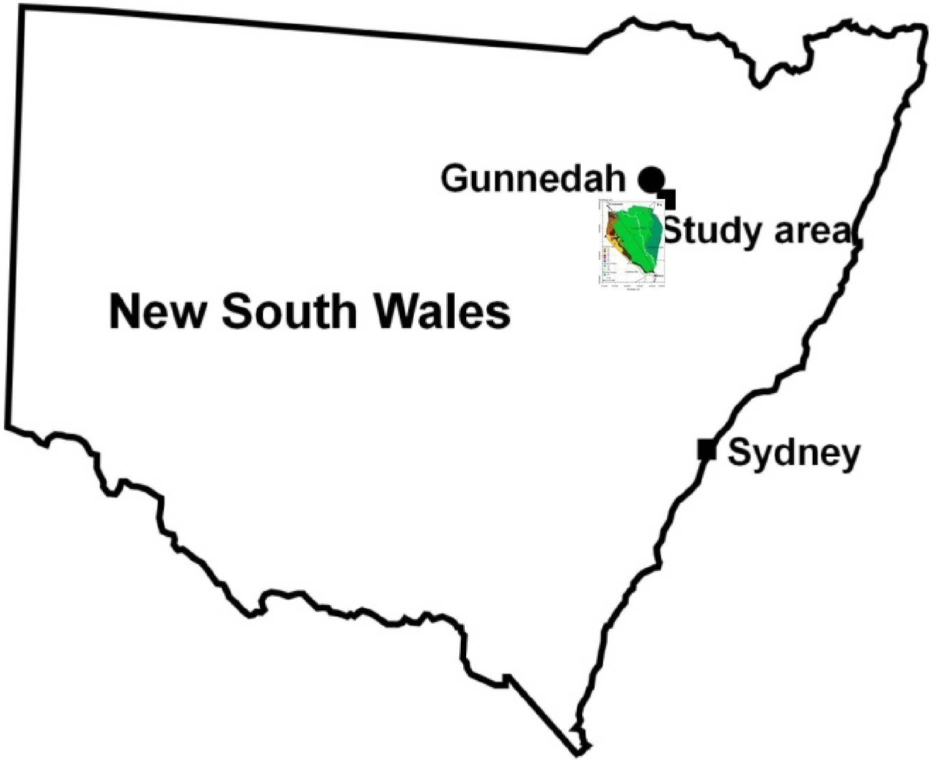
Aims



- To assess merit of ancillary data, such as remote (γ-ray) and proximal (EM), to identify soil management units using FKM
- To minimise the MSPE of soil properties for greater accuracy in classifying landscape units
- To produce soil map direct implications for farmers

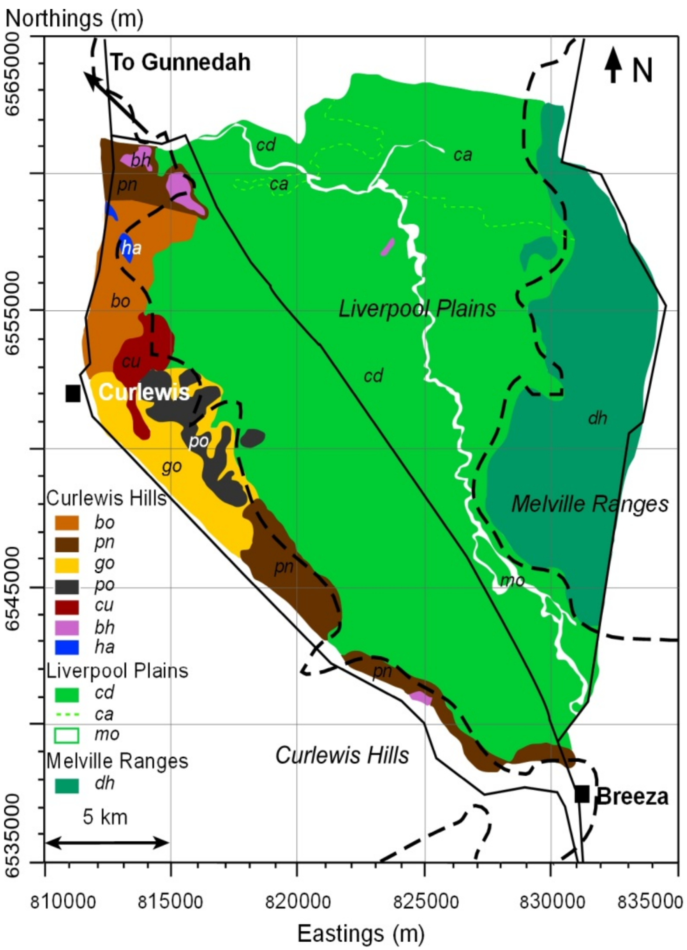
Materials & Methods: Study Area (Physiography)





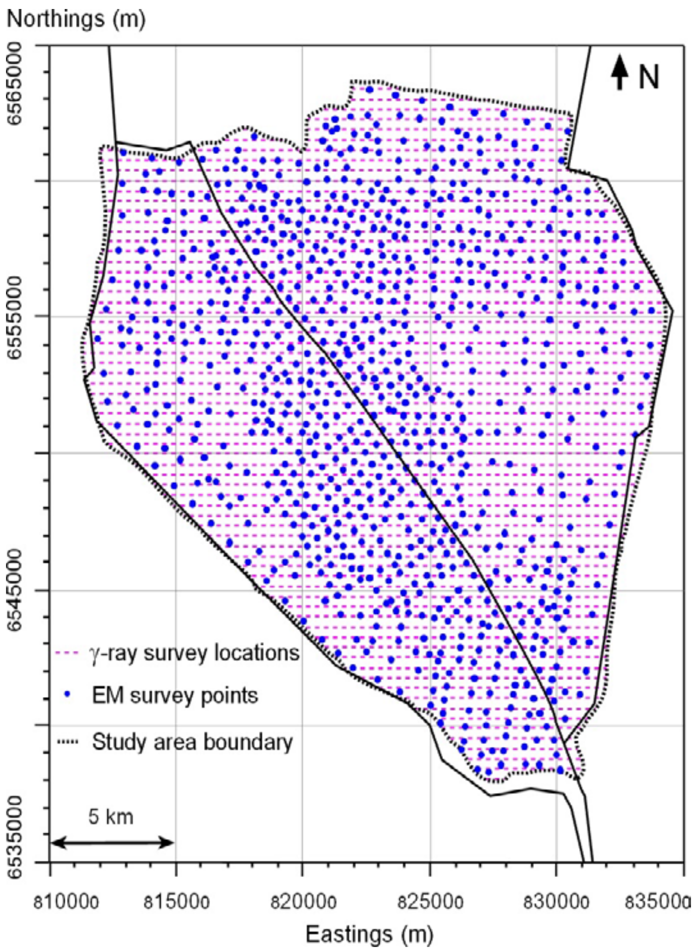
Banks, 1995

Materials & Methods: Study Area (soil associations)



- Curlewis Hills
  - *bo* – **Booloocooroo**
    alluv., sandstone & basalt
  - *cu* – Curlewis Swamp
    deep clays under peat
  - *bh* – Battery Hill
    shallow stoney basaltic soil
  - *ha* - Hartfell
    rhyolitic soil
- Liverpool Plains
  - *cd* – **Conadilly**
    Floodplain alluv. from basalt
- Melville Ranges
  - E.g. *dh* – **Dead horse**
  - Diverse, undifferentiated T and Q alluvial

Materials & Methods: ancillary data collection



- γ-ray

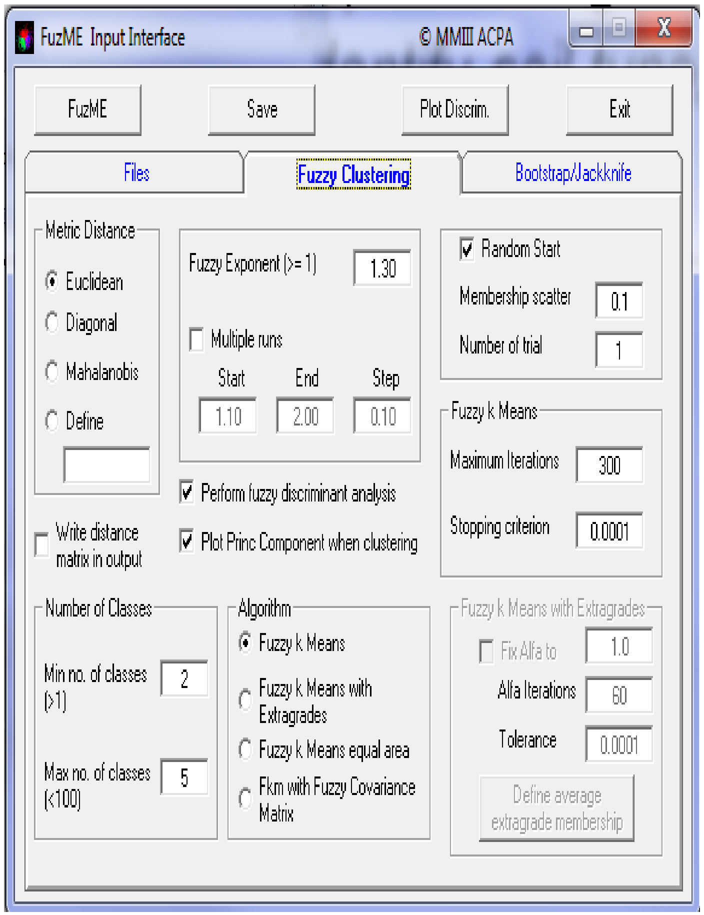
  – 400m spacing flight lines;
  – K, Th, U & TC

- EM38

  – 500m spacing in irrigated and 1km on dryland;

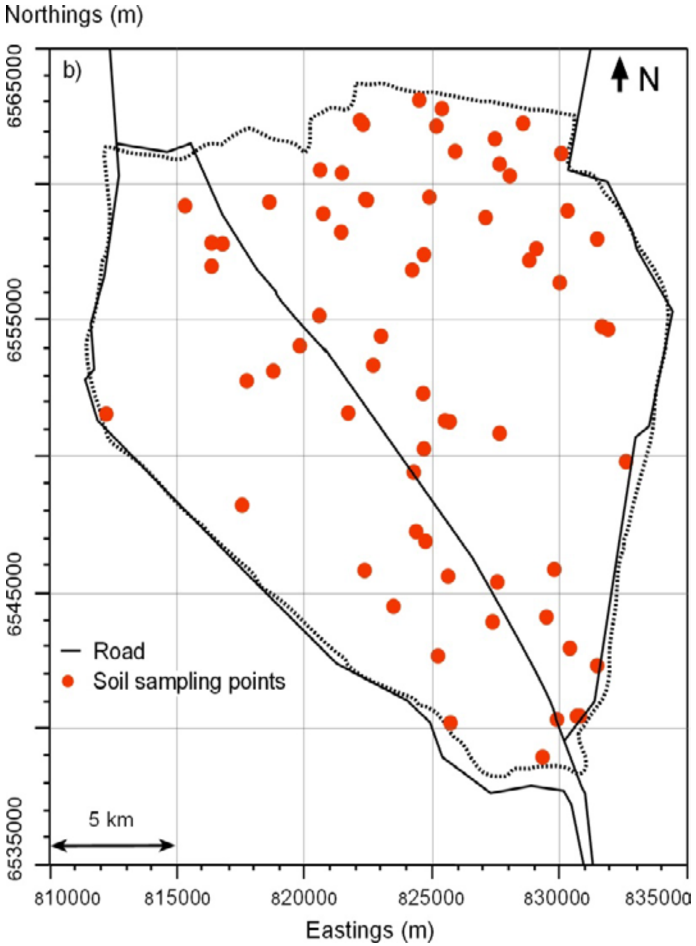
- Kriged
  – Common 100m grid

Materials & Methods: Clustering



- Fuzzy k-means (FKM) analysis of ancillary data only
- FuzME program (Minasny et al., 2012)
  - (ver. 3.5c)
- k = 2, 3, 4, 5, 6, 7 and 8

Materials & Methods: : laboratory analysis



- Soil sampling locations: 71
- Two representative depths;
  - topsoil 0-0.3m, and
  - subsoil 0.9-1.2m
- Texture: Clay, silt & sand %;
- EC_e and pH;
- Exch. cations – Ca, Mg, K, Na
- CEC; and ESP

Materials & Methods: statistics and mathematics

$$\mathbf{y} = \mathbf{X}\boldsymbol{\tau} + \mathbf{Z}\mathbf{u} + \boldsymbol{\varepsilon}$$

Response

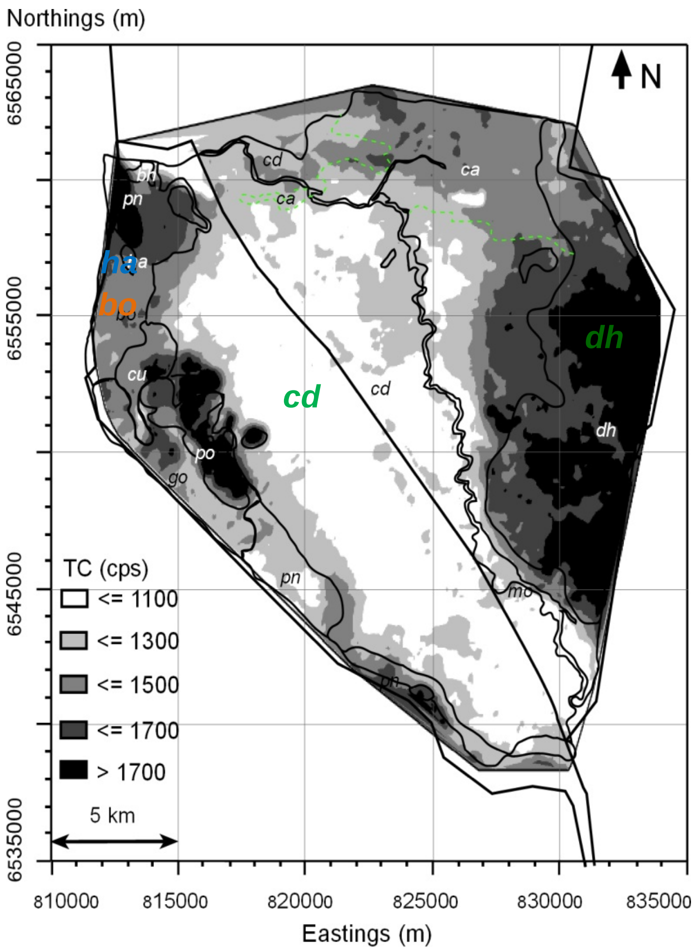
Fixed effect

Random effect

Residual

- Residual Maximum Likelihood Analysis (REML)
- Calculate Mean Squared Prediction Error (MSPE) of soil properties of each of the numerical classes
- Minimise MSPE

Results: γ-ray (Total counts – cps)



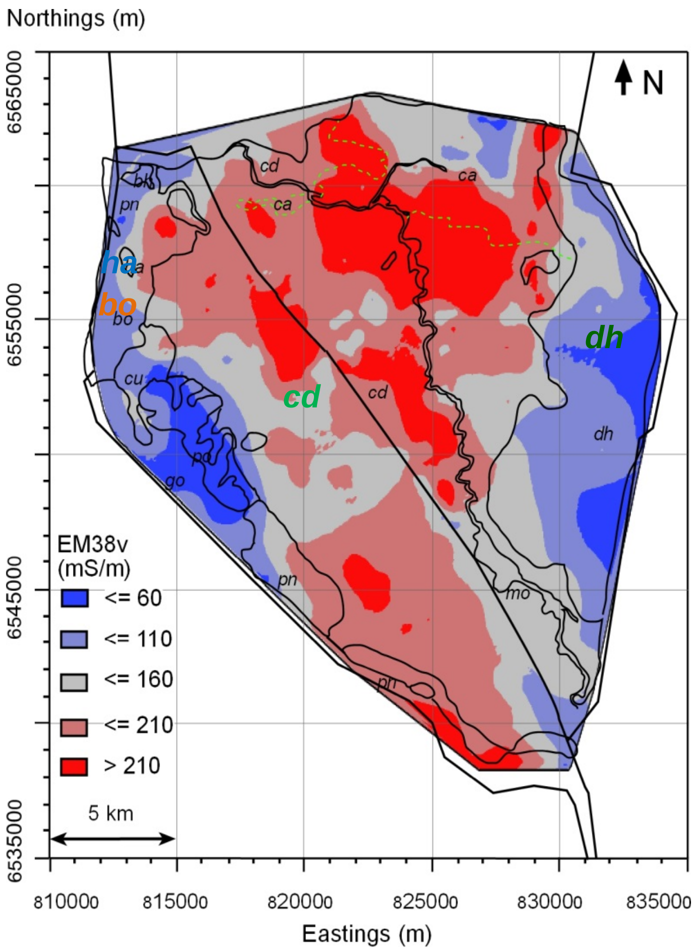
bo: 1,300 - 1,500 - Intermediate

ha > 1,700- high

cd: < 1,100 - small

dh > 1,700- high

Results: EM38v (mS/m)



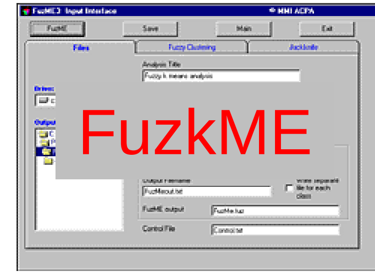
bo: 110 - 160 – Intermediate

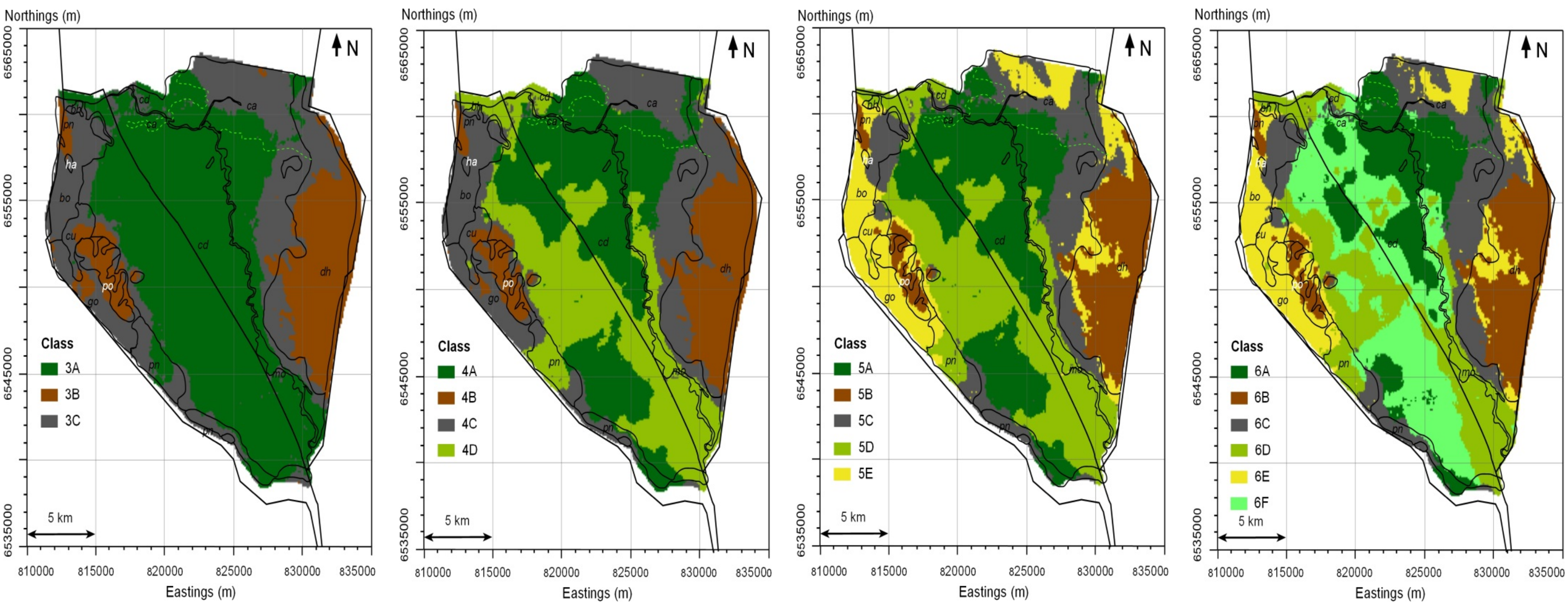
ha: < 60 – 110 low/medium

cd: 160 – 210 high/very high

dh: 60 - 110 low/intermediate

Results: Cluster maps





$k = 3$ $= 4$ $= 5$ $= 6$

Results: MSPE for topsoil

No. of Classes (k)	2	3	4	5	6	7	8
Clay	159.97	106.68	114.72	93.37	115.16	104.84	97.26
Silt	57.31	49.15	53.12	47.62	49.40	52.15	51.73
Sand	213.46	66.88	65.39	60.68	71.30	62.31	62.57
EC_e	2.07	2.15	2.17	2.18	2.22	2.35	2.36
pH	0.33	0.35	0.35	0.34	0.34	0.36	0.37
CEC	364.88	174.49	179.93	136.75	177.66	138.80	169.46
Ca	102.74	84.04	90.95	81.07	85.85	76.52	90.30
Mg	70.48	59.90	46.49	35.20	53.08	37.28	42.63
K	0.64	0.59	0.64	0.56	0.64	0.58	0.65
Na	7.51	7.47	7.48	7.49	7.96	7.76	7.94
ESP	37.42	37.21	38.09	39.05	40.47	39.20	41.22
No. of lowest MSE	2	2	0	6	0	1	0

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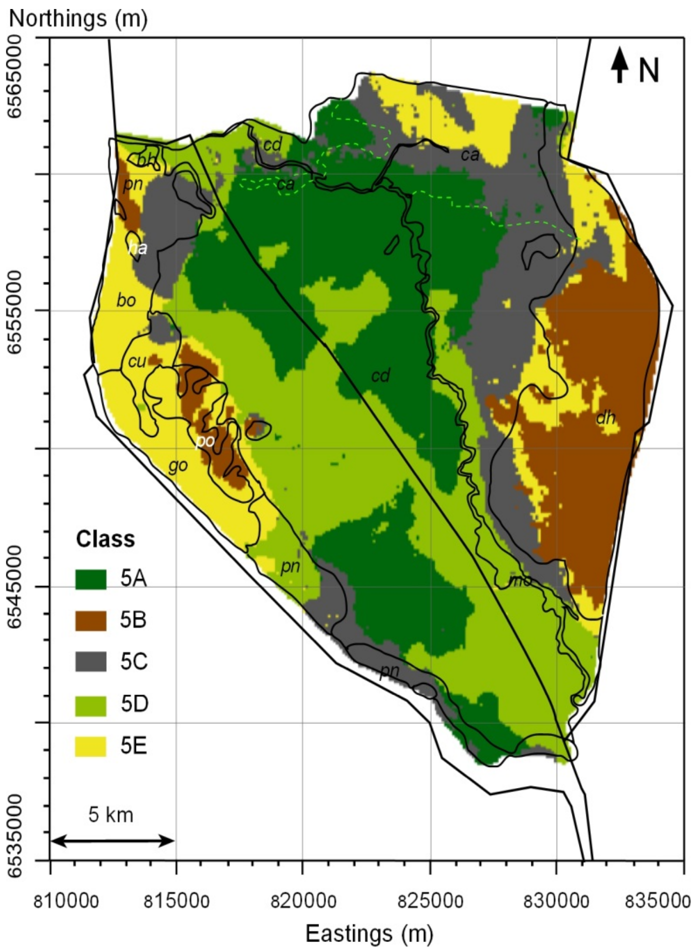
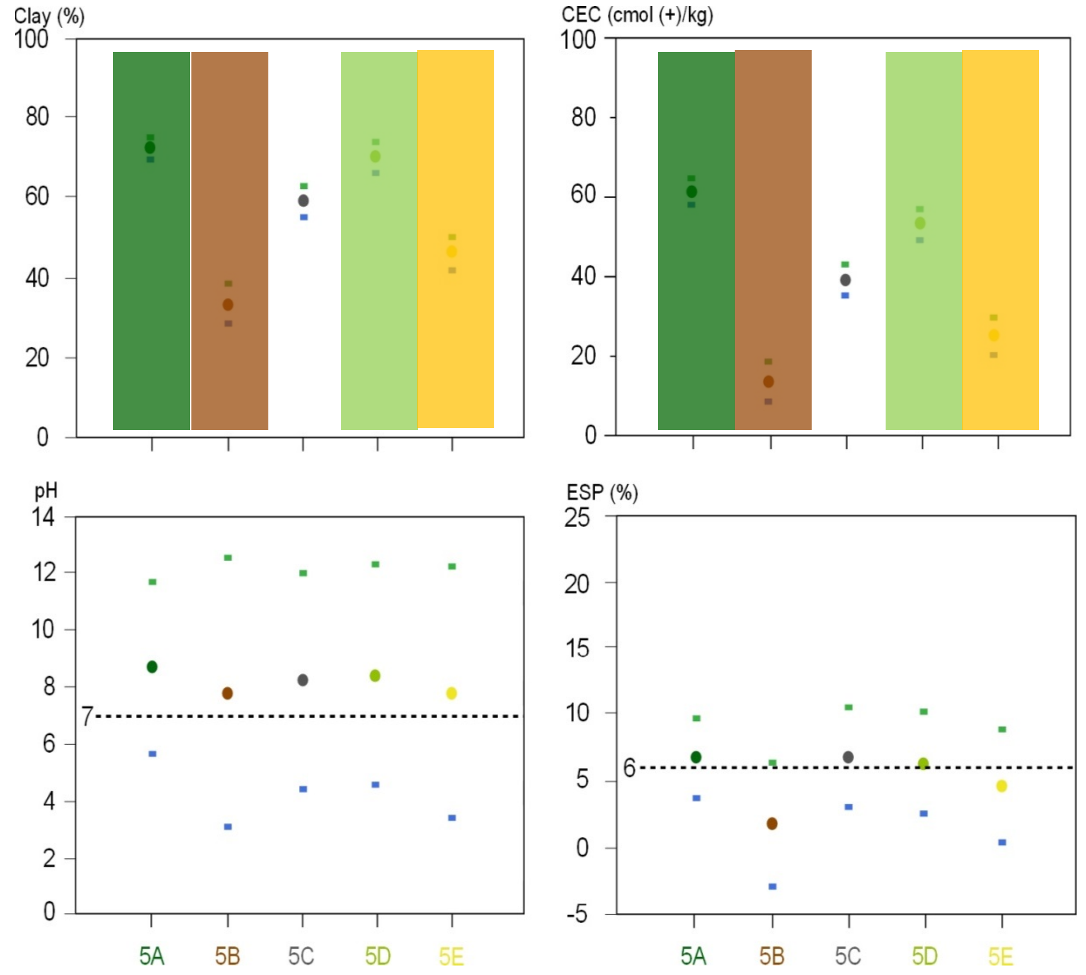
Results: MSPE for subsoil

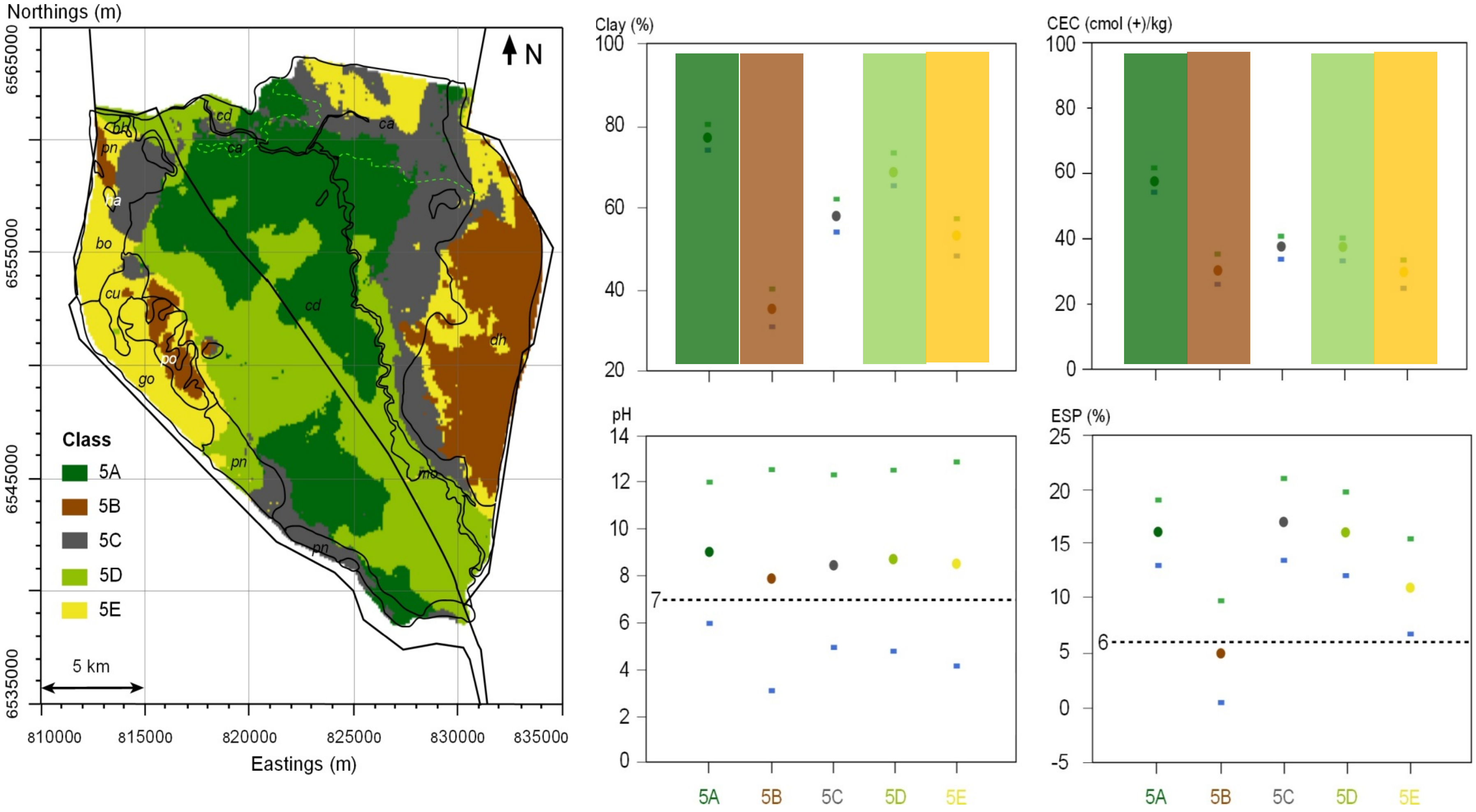
No. of Classes (*k*)	2	3	4	5	6	7	8
Clay	248.79	203.58	202.30	**168.72**	455.98	176.93	183.97
Silt	89.05	84.24	87.60	75.64	91.51	**74.61**	79.27
Sand	208.65	127.28	122.02	**115.45**	123.38	121.96	128.71
EC_e	**11.91**	12.36	12.89	12.73	12.52	13.54	13.32
pH	0.36	0.34	0.36	0.35	0.37	**0.31**	0.35
CEC	**122.50**	123.88	126.17	128.76	137.91	137.06	144.36
Ca	77.36	62.42	64.32	54.06	61.33	**53.28**	55.12
Mg	0.39	35.11	0.40	**0.36**	0.40	0.37	0.40
K	19.51	**18.96**	19.37	19.02	20.77	19.80	20.18
Na	63.59	60.49	62.39	**60.14**	63.79	60.40	63.97
ESP	289.23	254.89	255.51	**242.44**	281.78	244.08	261.83
No. of lowest MSE	2	1	0	**5**	0	3	0

Results: topsoil properties w/ mean + SD

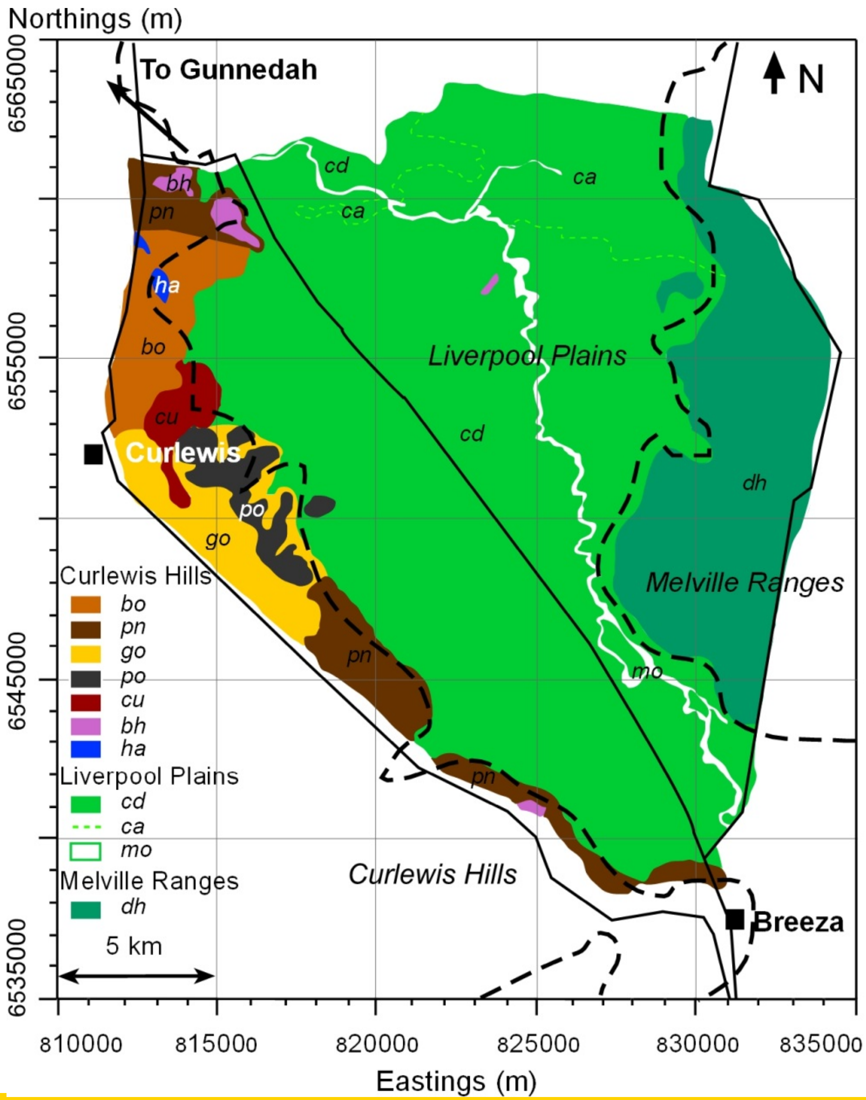


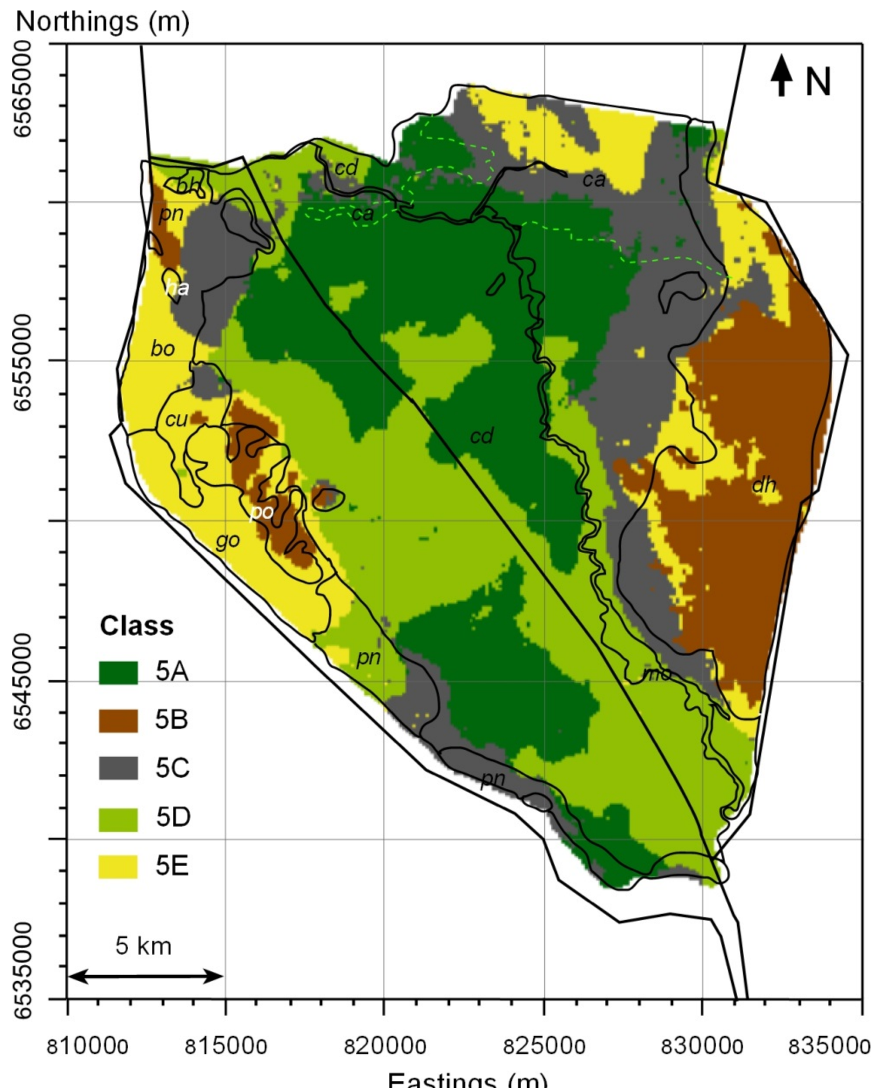


Results: subsoil properties w/ mean + SD



Discussion: Comparison





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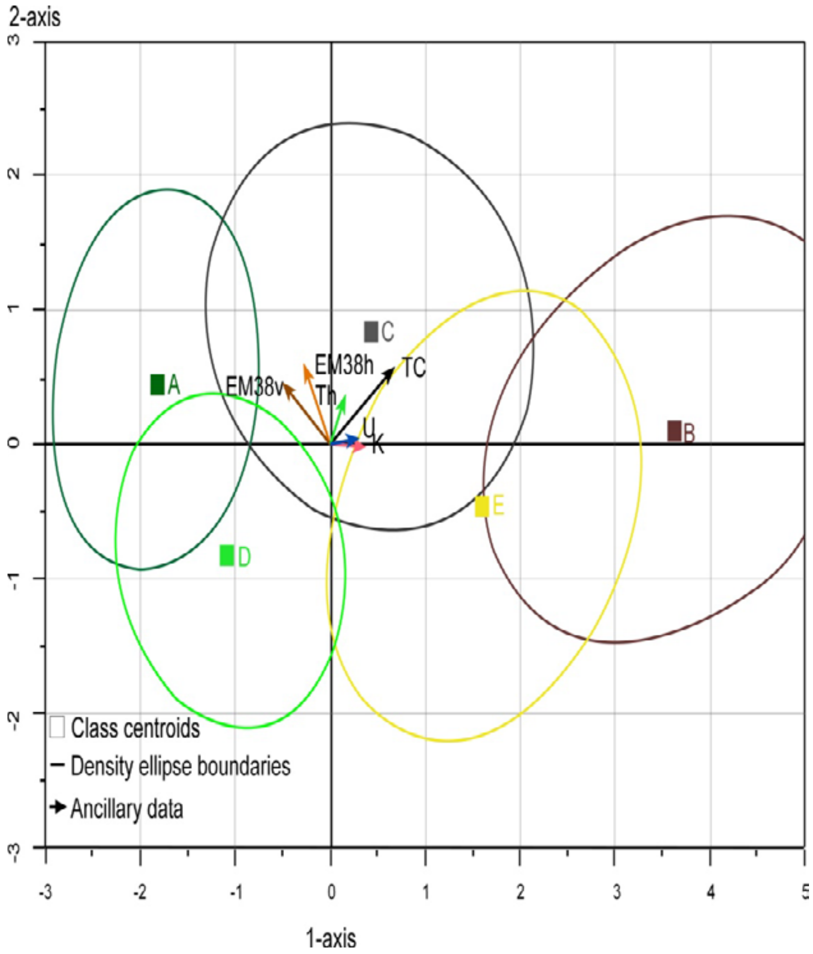
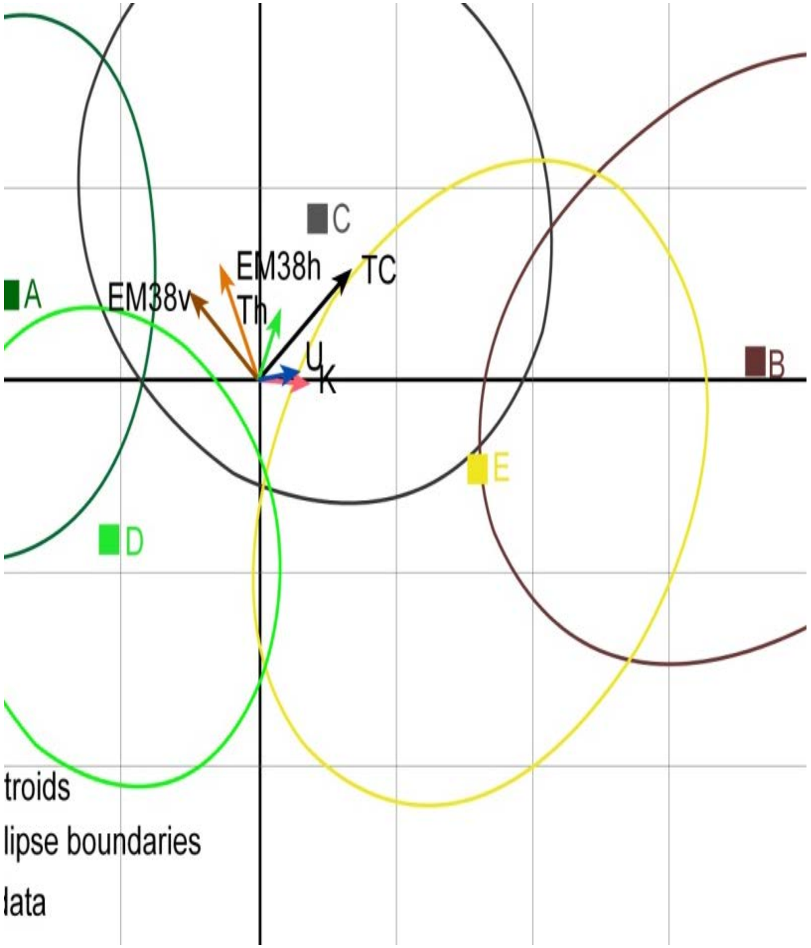
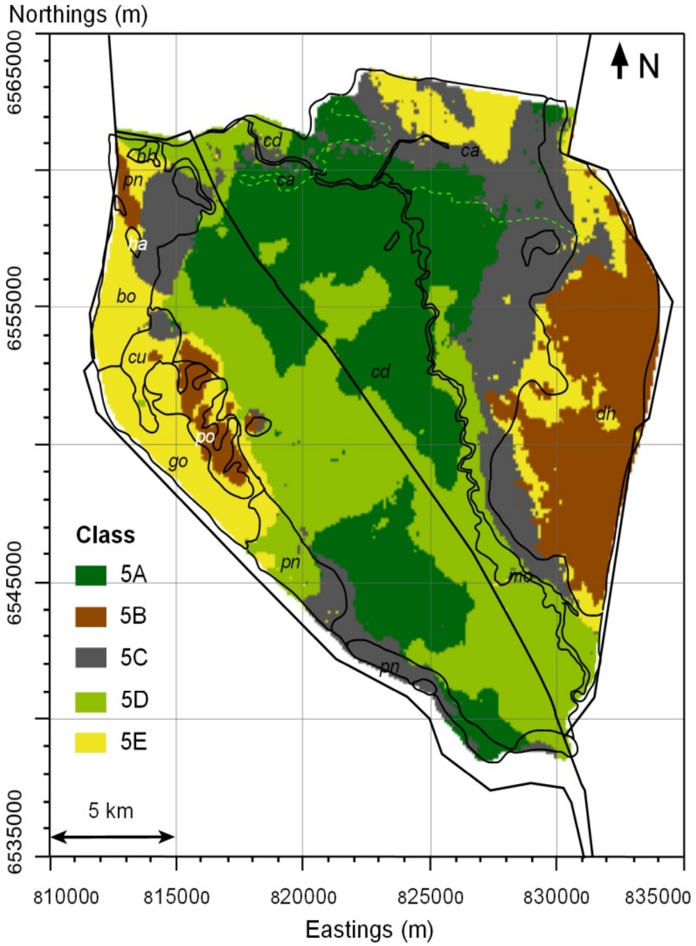
Results: Canonical analysis



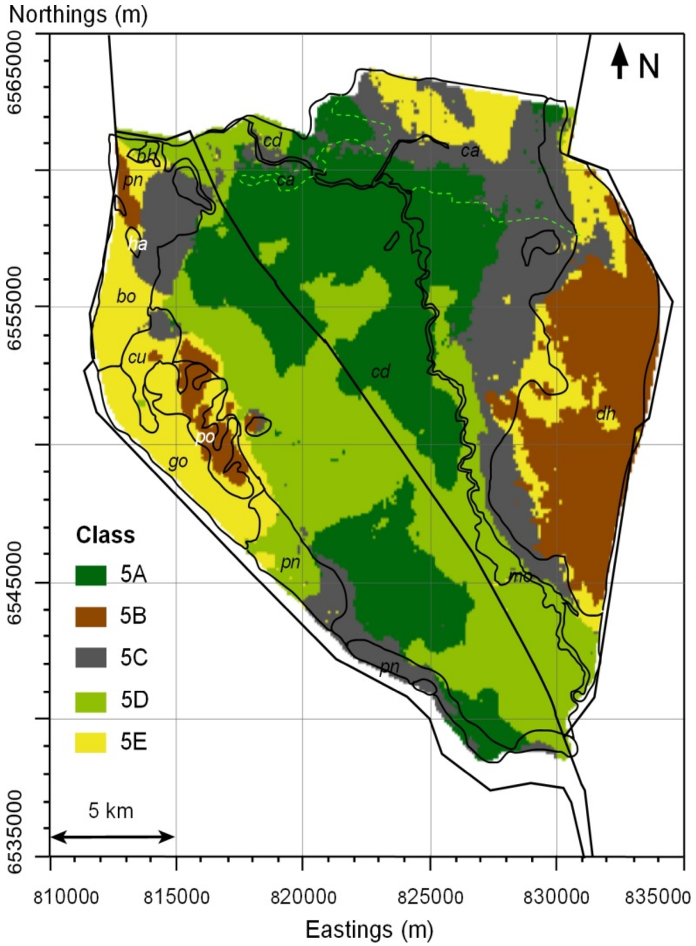


Conclusions: Key findings



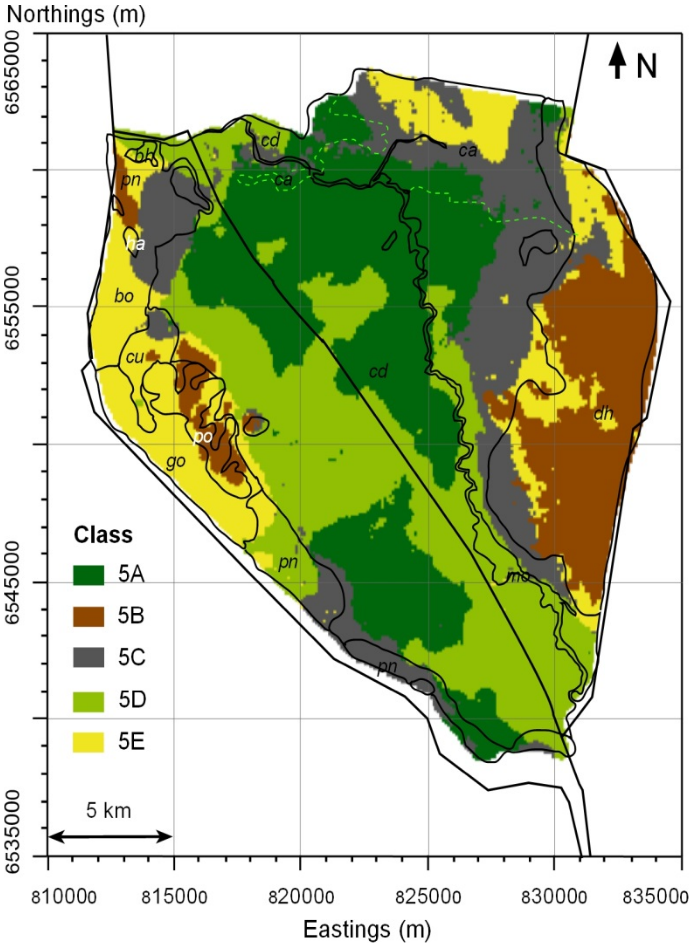
- MSPE minimised when $k = 5$
- DSM consistent with major physiographical units
- DSM revealed subtle differences in highly productive Liverpool Plains physiographic unit

Conclusions: Key limitations



- Some smaller soil landscape units not reflected in DSM (e.g. *cu*, *ha*)
  - Add in more ancillary data such as DEM?
  - Due to significant local relief these units occupy
  - Because of resistant igneous outcrops of these units (e.g. basalt, rhyolite)

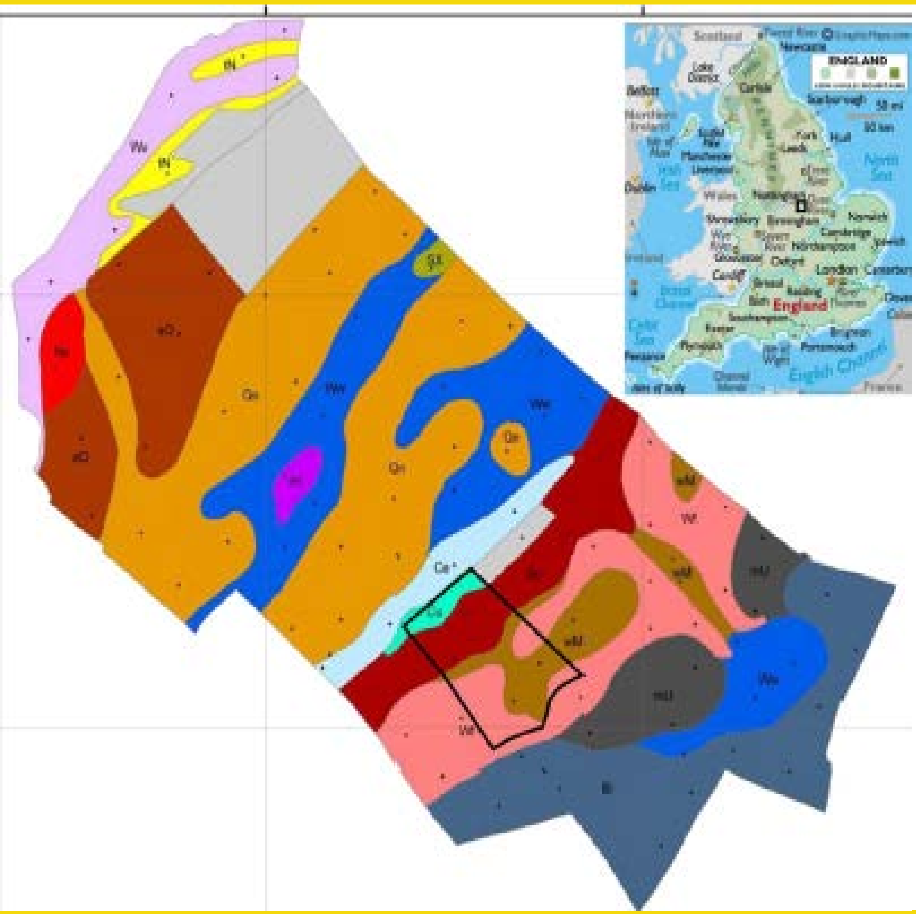
Conclusions

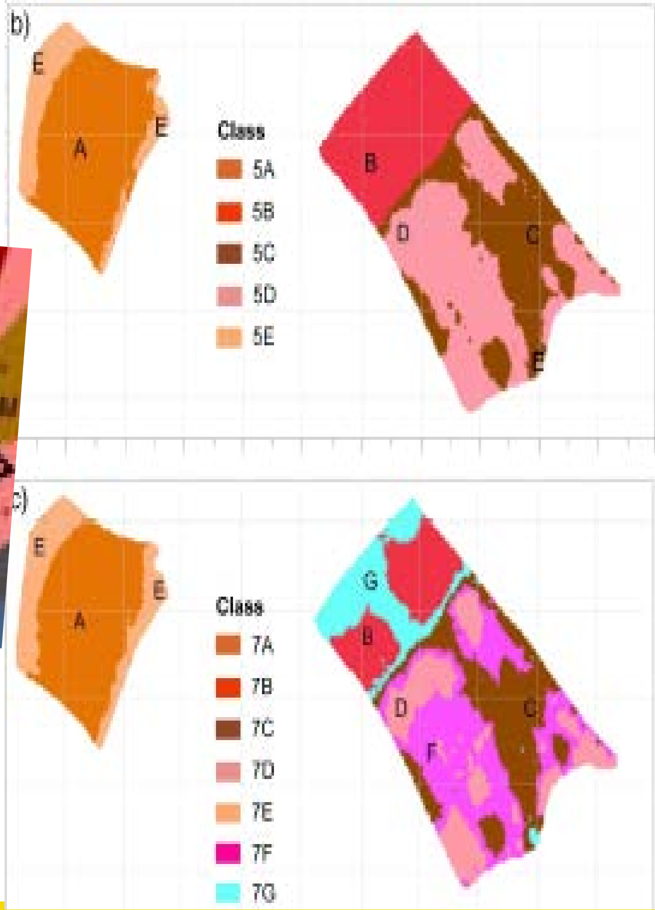


- γ-ray and EM can be combined to identify soil mgt classes;
- DSM was able to highlight subtle differences in diverse physiography;
- Addition of DEM may improve identification of smaller units;
- Potential for cheap, fast, objective, accurate and meaningful DSM for farmers on districts scales

Scope to predict soil type using proximally sensed gamma-ray spectrometer and EM induction data

Huang, J., Lark, R.M., Robinson, D.A. Lebron, I., Keith, A.M.,
Rawlins, B., Tye, A., Kuras, O., Raines, M., Triantafilis, J.





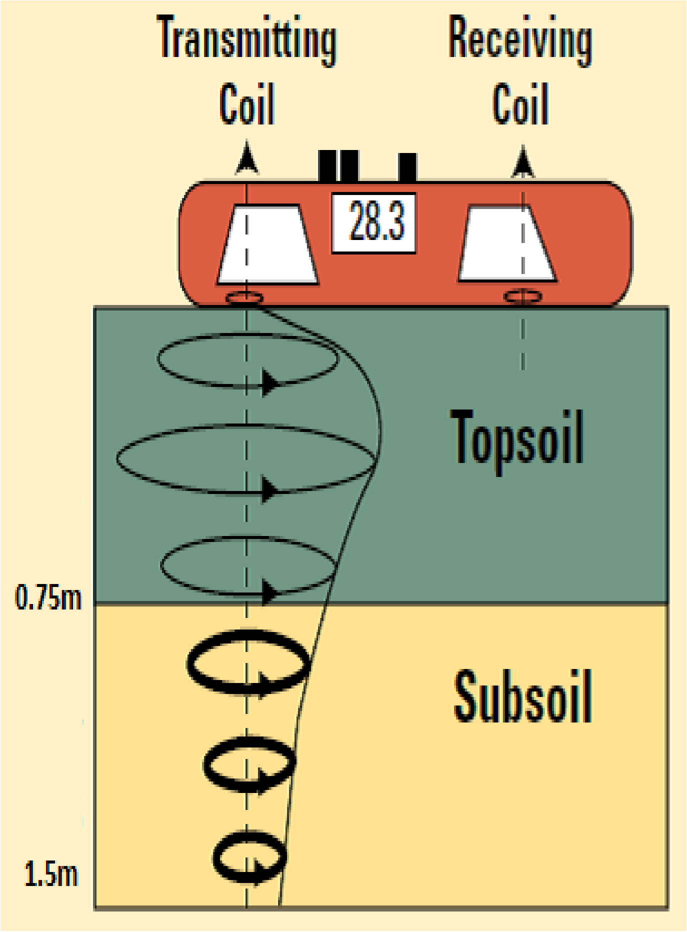
Geoderma 232-234, 69-80

Case Study

Ancillary data: γ-ray (remote)

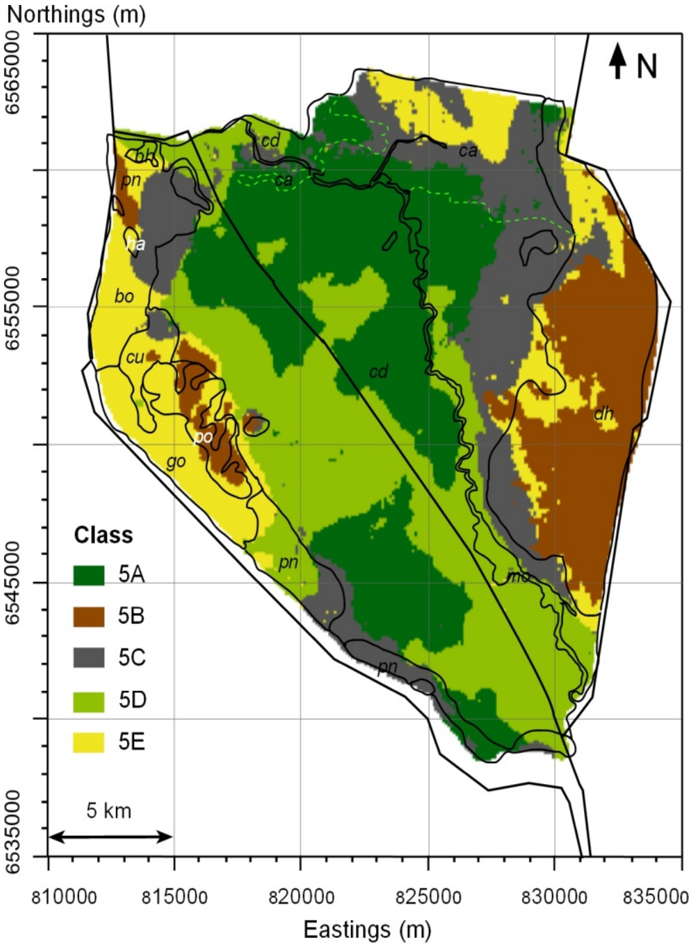
- Relationship with underlying;
  - geology, and
  - parent materials ($f\{weathering\}$)
- For example soil derived from;
  - Basalt = low signatures,
  - Granite = high signatures
- Airborne
  - helicopter
  - fixed-wing
- Depths up to 0.3-0.4 m

Ancillary data: EM (proximal)



- Mobile – can be mounted behind tractors or handheld
- Depths up to
  - 0.75m for horizontal mode
  - 1.5m for vertical mode

Discussion: Identification of soil associatons



bo: resolved to some extent

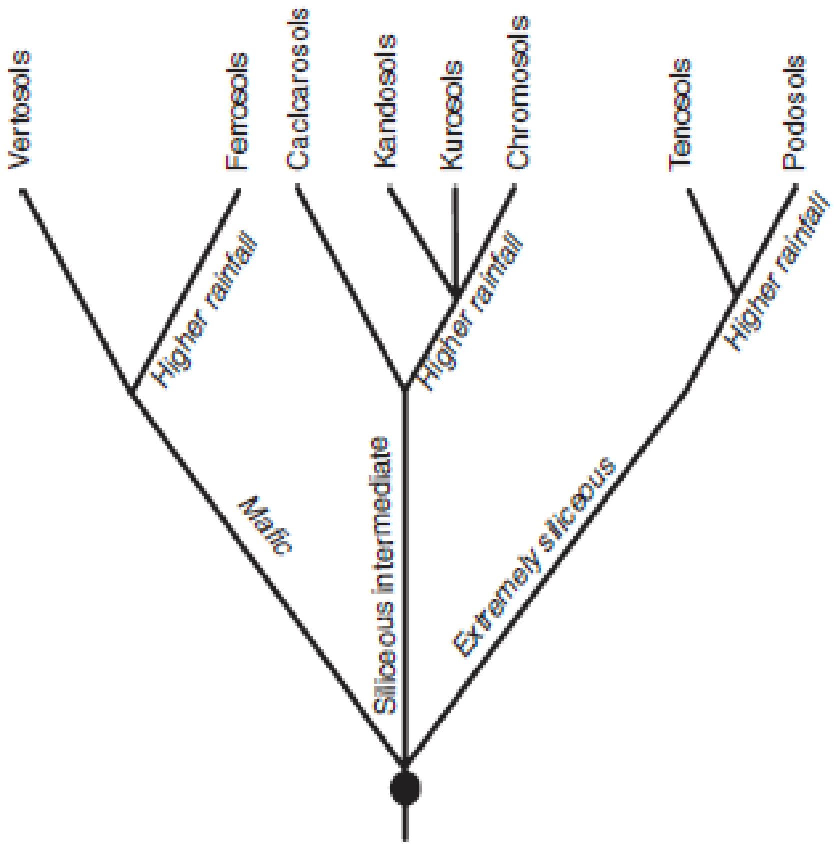
ha: not identified (too small)

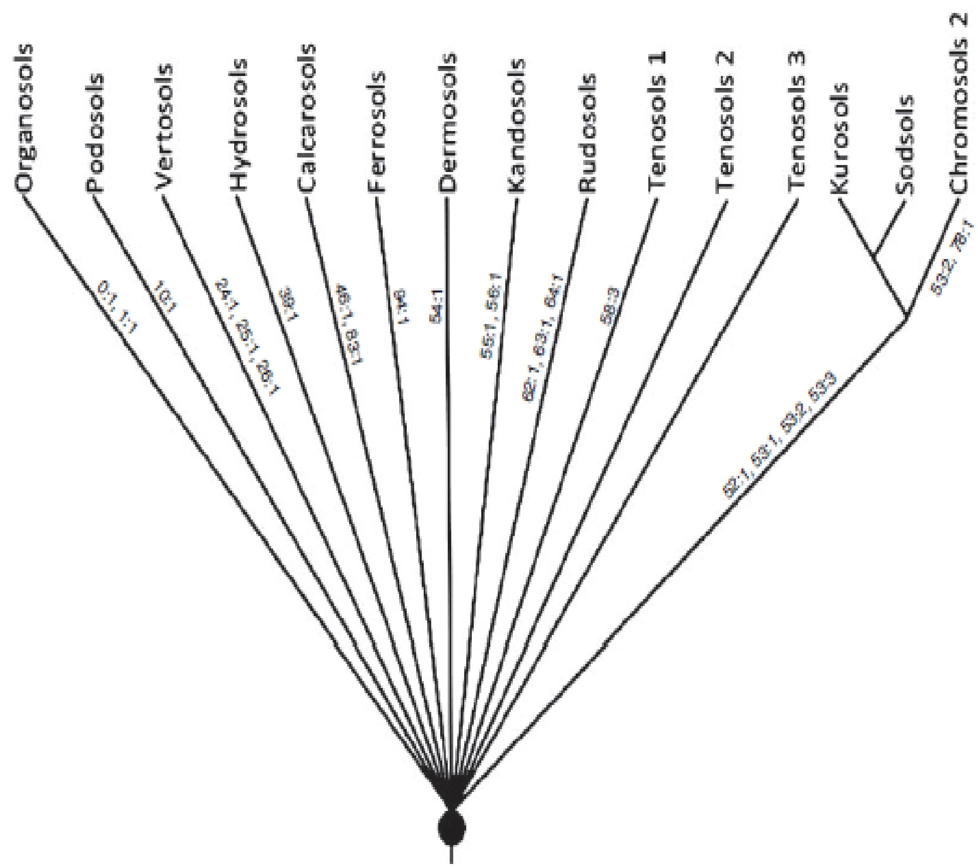
cd: actually 2 units maybe 3

dh: resolved to some extent

Assessing the Australian Soil Classification using cladistic analysis

Miltenyi GPL, Malte MC,
Triantafilis J





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