Digital soil mapping at the University of Sydney

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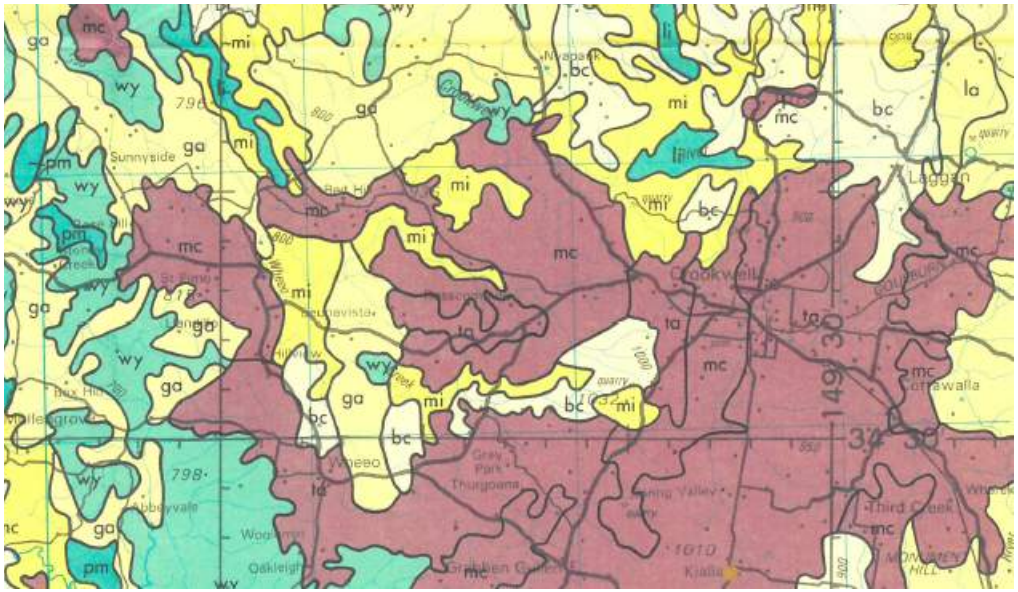
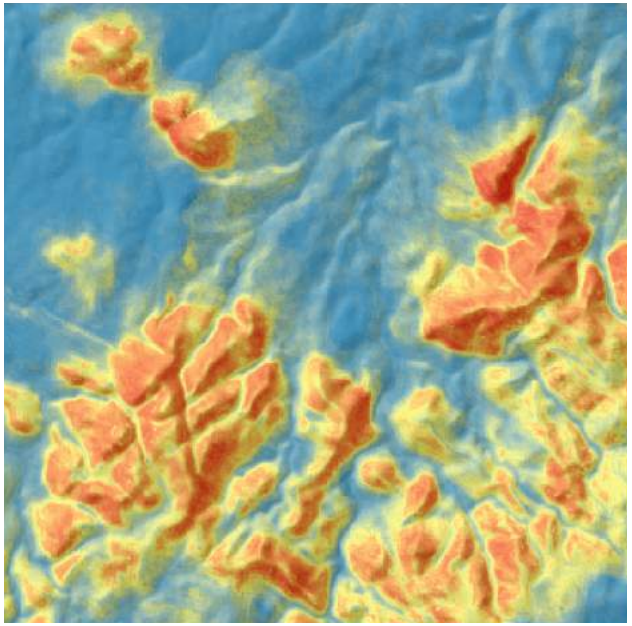
Digital soil mapping



"Legacy" map made using traditional methods



Digital soil map

- Contemporary developments in soil mapping:
  - Digitisation of legacy resources
  - Creation of digital soil information *ab initio*

Digital soil mapping

- Spatial predictions of soil based on limited observations
- Predictions are usually made on a *grid*, not *per-polygon*
- Heart of many contemporary methods:

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

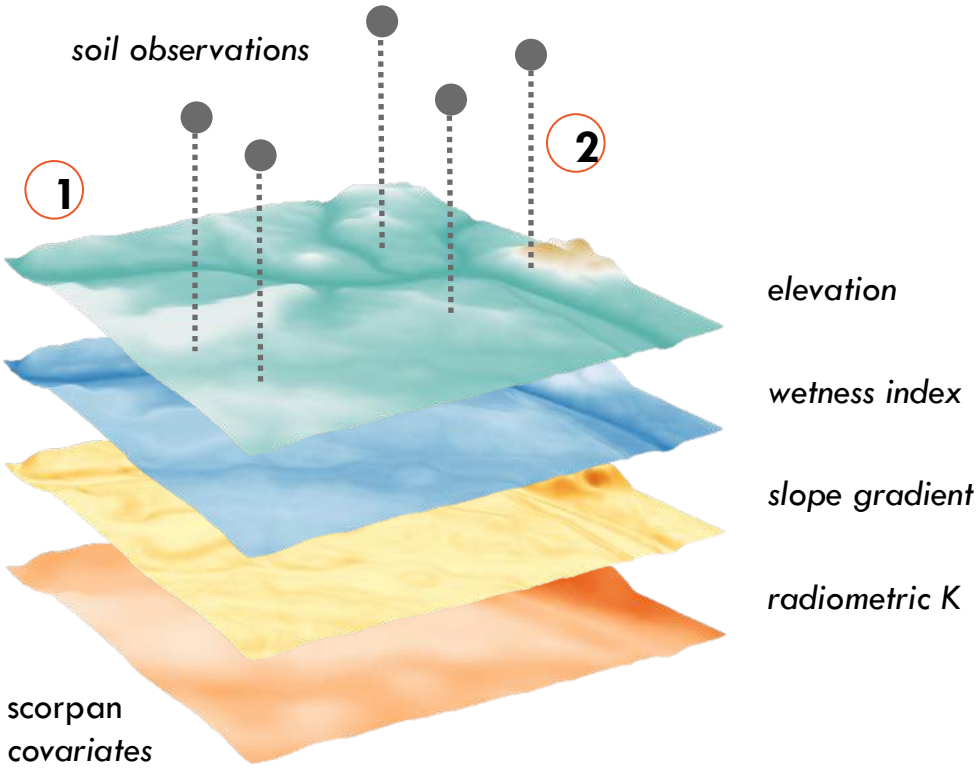
s	soil	p	parent material
c	climate	a	age
o	organisms	n	spatial position
r	relief (topography)		

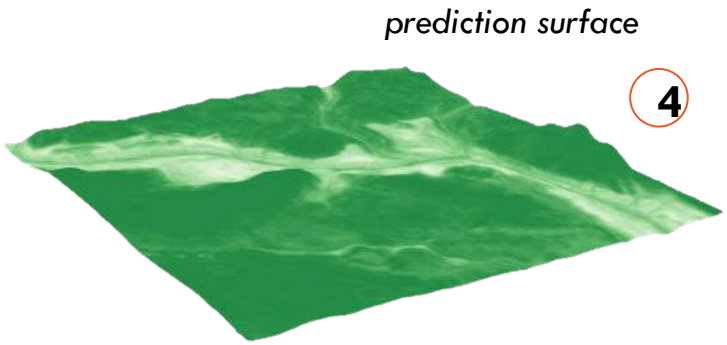
Digital soil mapping

Symbol	Factor	Represented by
s	Soil	Legacy soil data (profile observations, soil maps)
c	Climate	Precipitation, temperature, etc.
o	Organisms	Remotely-sensed imagery (Landsat and derivatives, land use information), vegetation maps
r	Relief (topography)	Digital elevation model and its derivatives
p	Parent material	Geology maps, gamma radiometrics
a	Age	Weathering intensity
n	Spatial position	Easting, northing, distance from feature of interest (road, river, etc.)

Digital soil mapping

1. Collation
2. Intersection
3. Modelling
4. Prediction





3 Spatial inference function $f()$:

- Regression models
- Decision trees
- Neural networks
- …

Some recent developments

1. Spatial disaggregation
2. Model averaging
3. Enterprise suitability mapping

Pentland soil is a dark reddish brown to dark brown sandy clay loam grading to earthy red light clay. The landform is level to gently

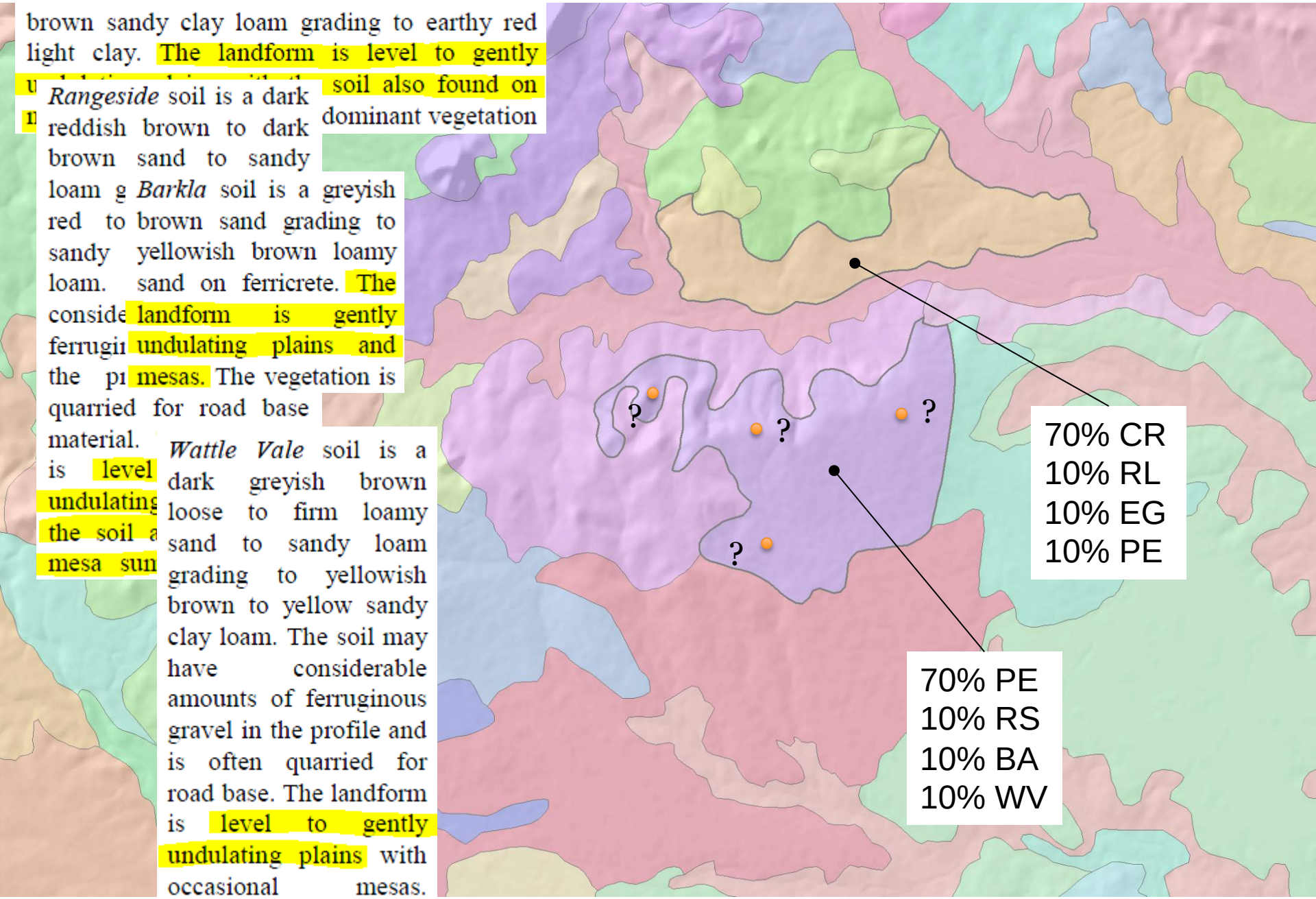
soil also found on

Rangeside soil is a dark reddish brown to dark brown sand to sandy loam g

dominant vegetation

Barkla soil is a greyish red to brown sand grading to sandy yellowish brown loamy loam. sand on ferricrete. The conside landform is gently ferrugi undulating plains and the pı mesas. The vegetation is quarried for road base material. is level undulating the soil a mesa sun

Wattle Vale soil is a dark greyish brown loose to firm loamy sand to sandy loam grading to yellowish brown to yellow sandy clay loam. The soil may have considerable amounts of ferruginous gravel in the profile and is often quarried for road base. The landform is level to gently undulating plains with occasional mesas.

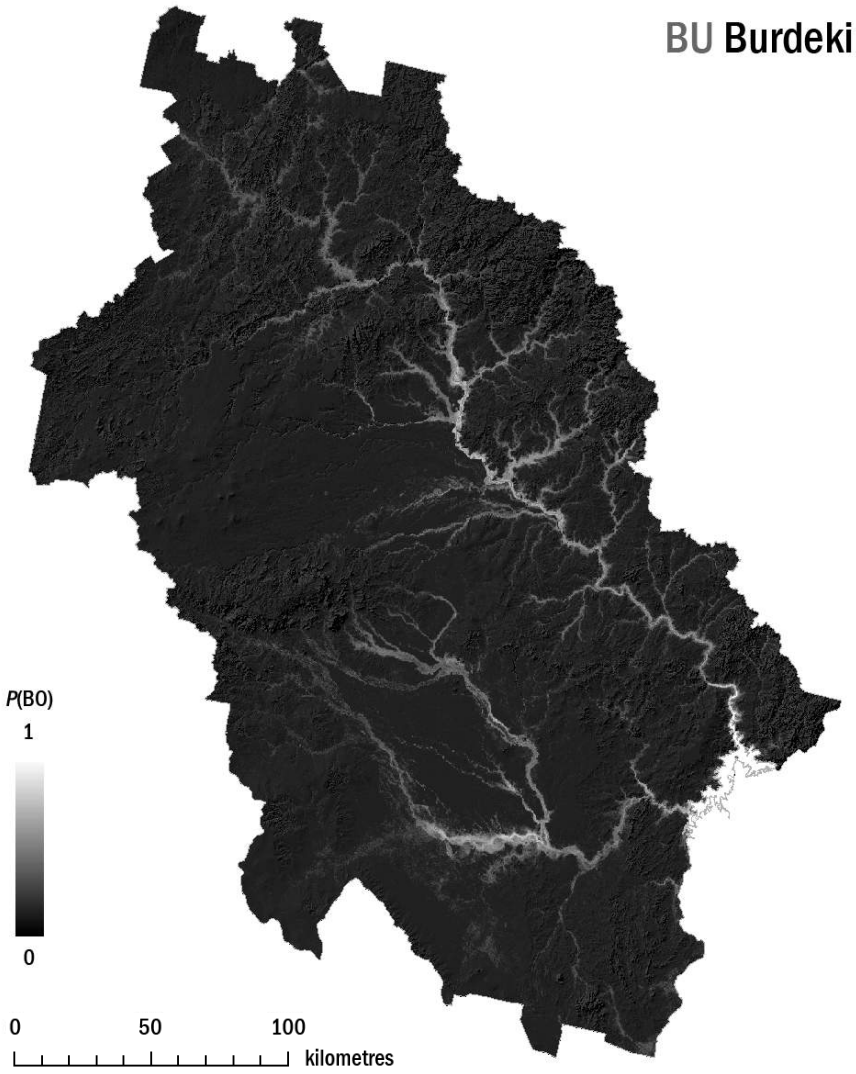


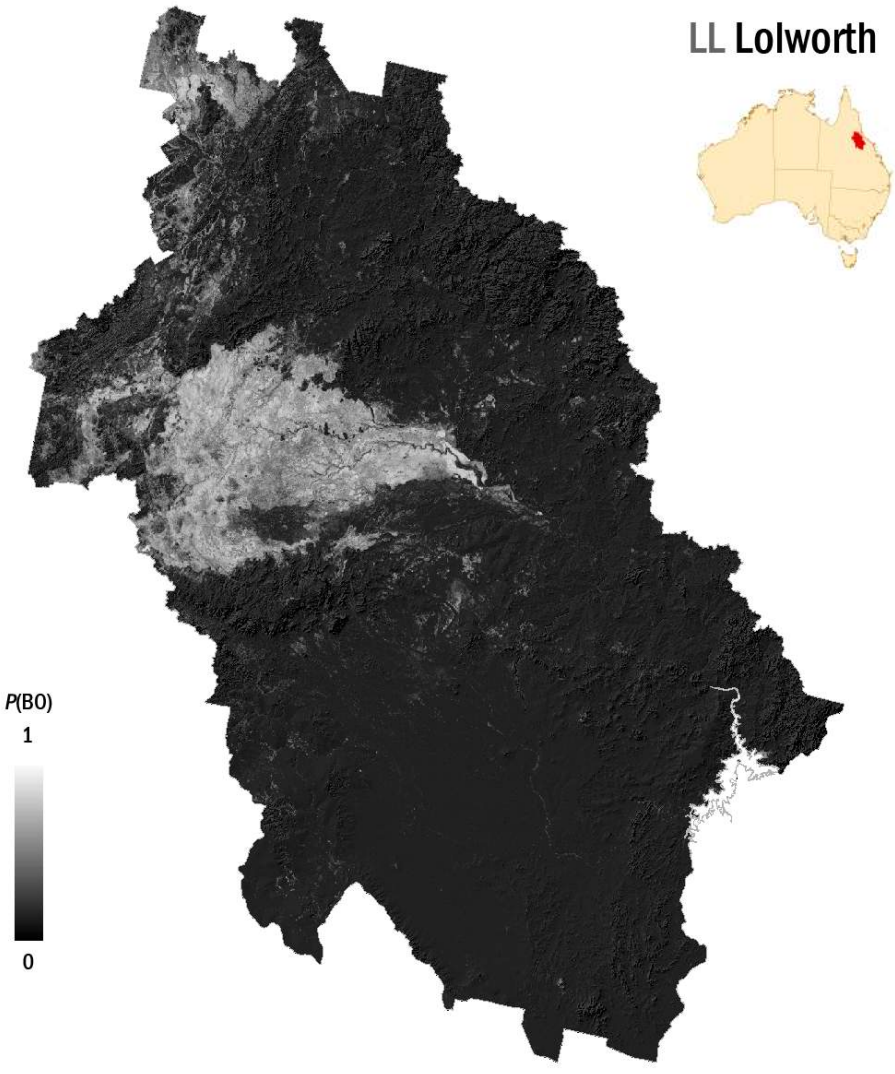
DSMART algorithm

1. Iteratively resamples legacy soil map
2. Generates realisations of potential soil class distribution
3. Merges realisations to estimate probabilities of occurrence

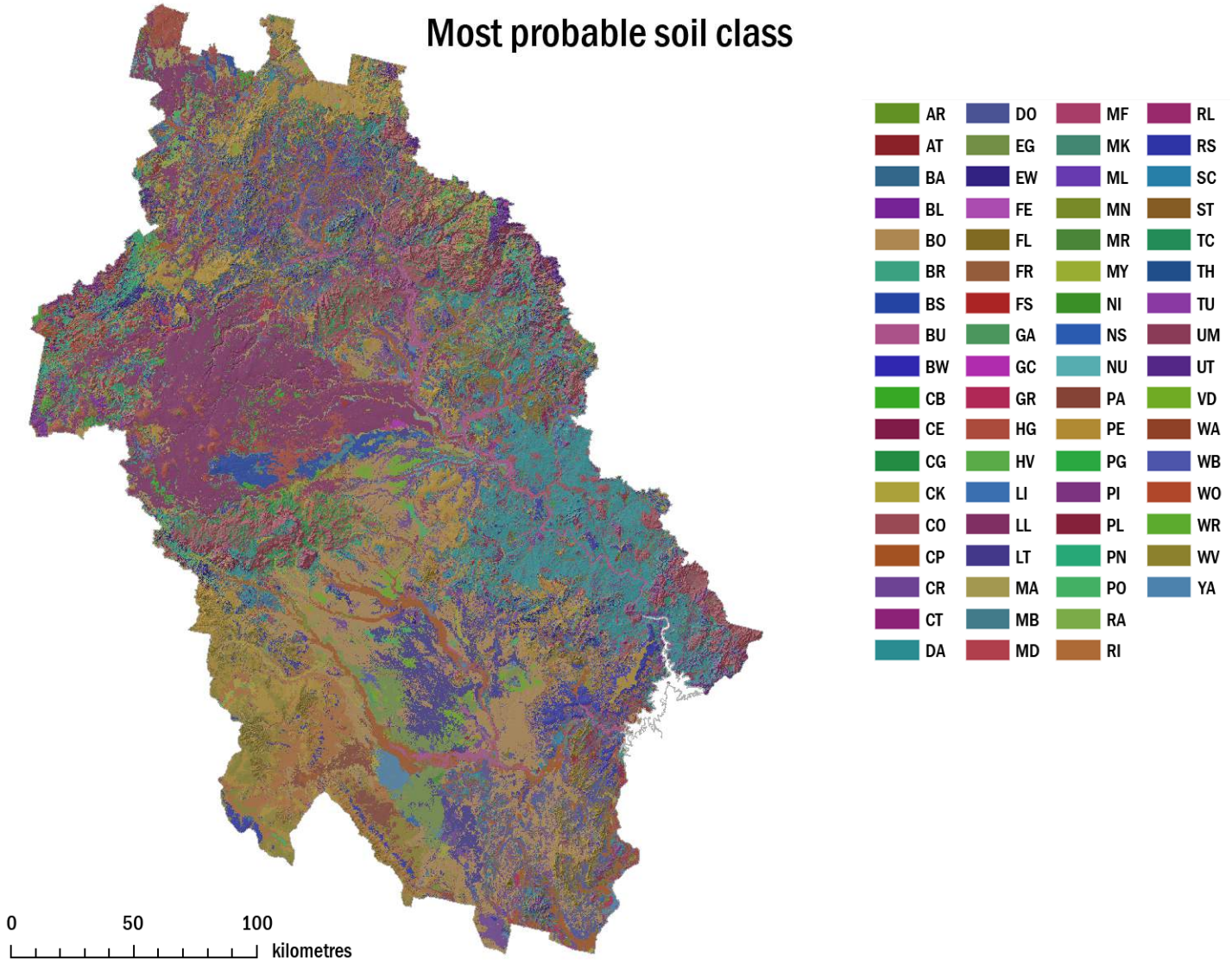
Aim: to rediscover the spatial distribution of soil classes (generate new soil information at a finer level of detail than the original)

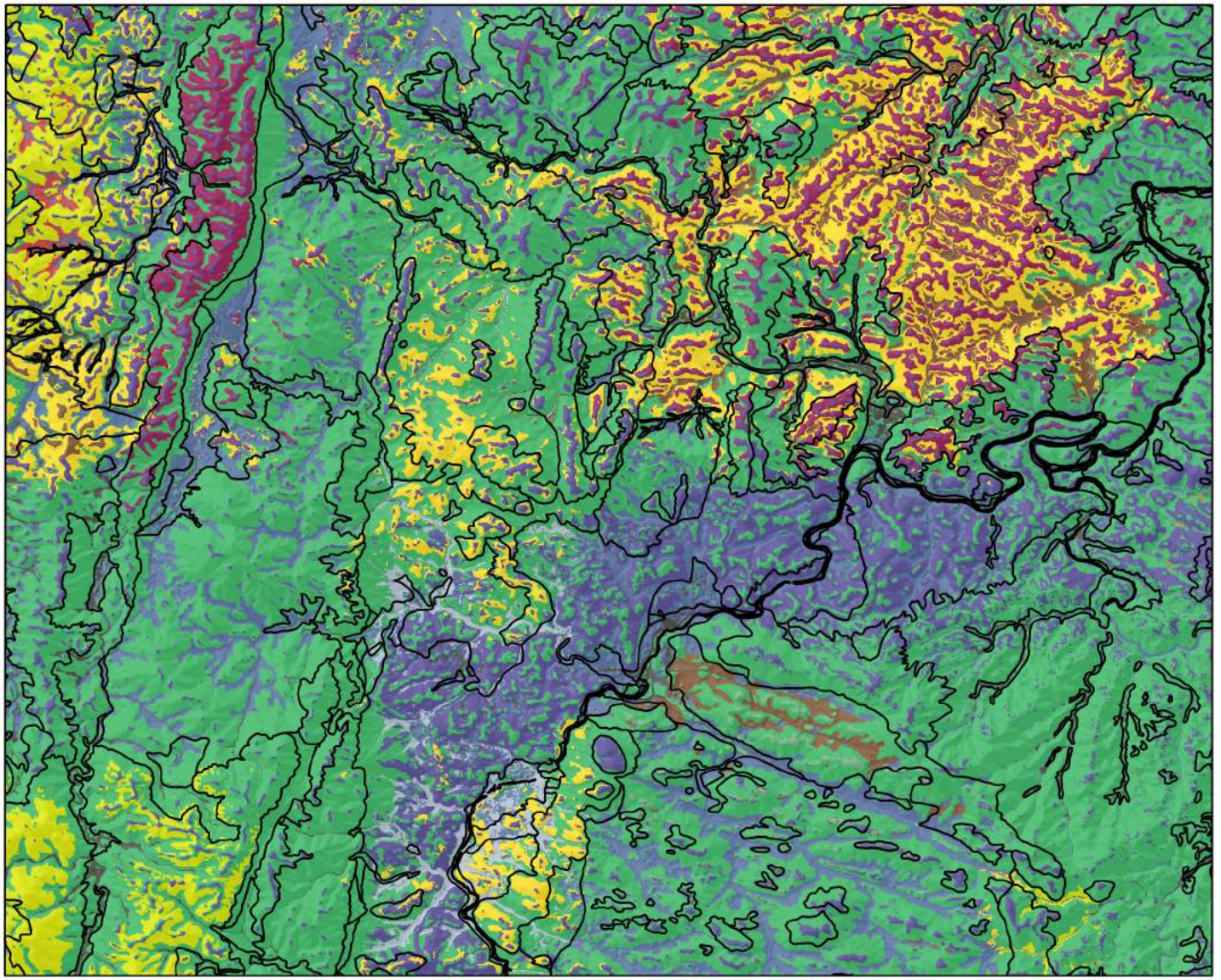
Probability surfaces (30-m grid cells)

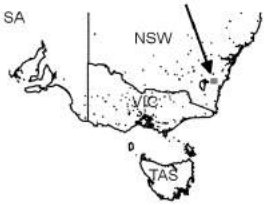




Most probable soil class







0 1 2 3 4 5 km

Most probable class

- Alluvial Soils
- Alpine Humus Soils
- Black Earths
- Chocolate Soils
- Earthy Sands
- Gleyed Podzolic Soils
- Grey-Brown Podzolic Soils
- Humic Gleys
- Lithosols
- Loams
- Non-Calcic Brown Soils
- Prairie Soils
- Red Earths
- Red Podzolic Soils
- Sands
- Shallow Earths
- Siliceous Sand/Yellow Earth
- Siliceous Sands
- Solodic Soils
- Solodised Solonetz
- Soloths
- Yellow Earths
- Yellow Podzolic Soils

Model averaging

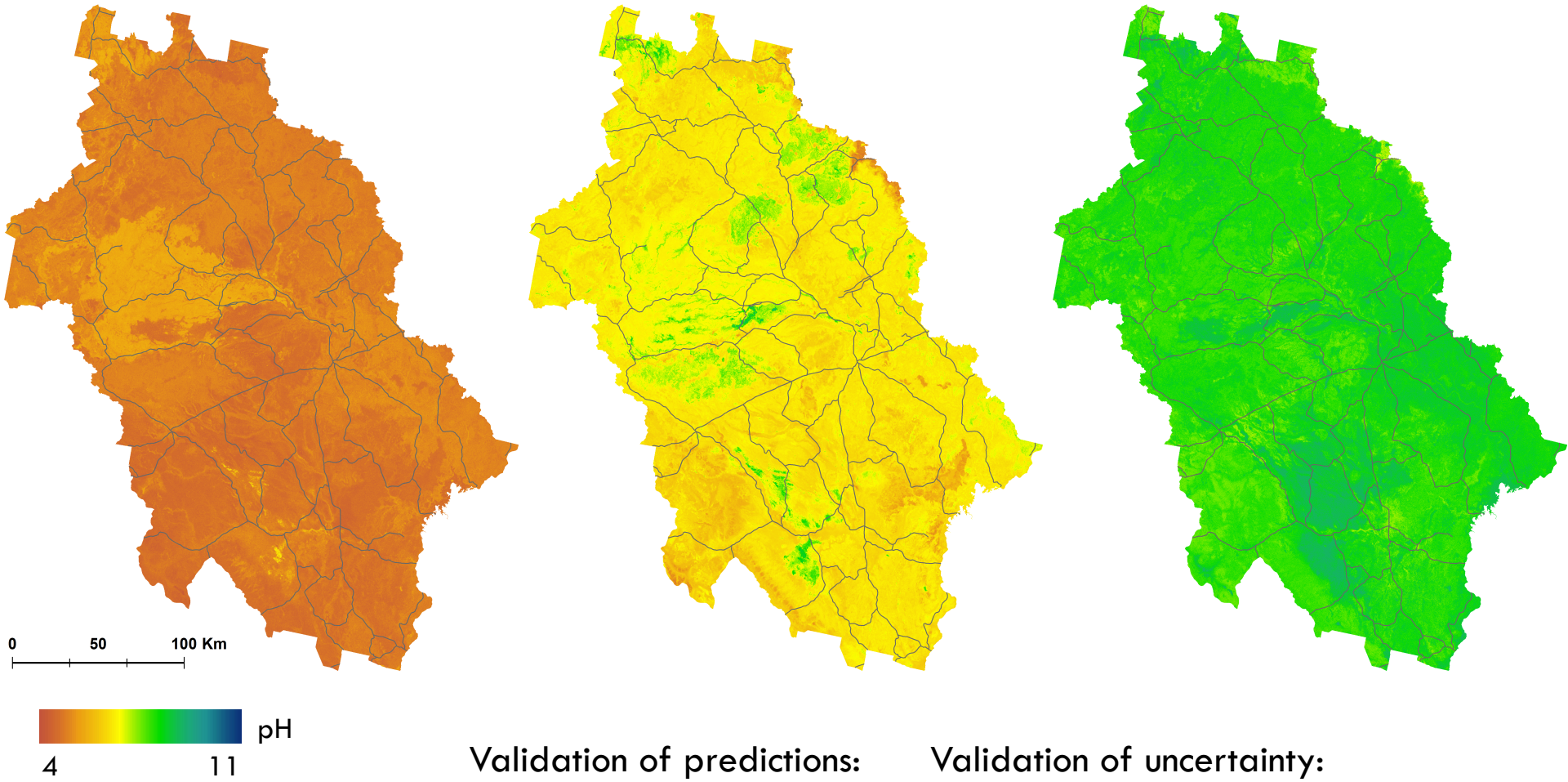
- What if we have more than one soil map for the same area?
- How can we combine them?
- Model-averaged predictions are weighted averages of the contributing maps
  - Task is to define the weights for each map
  - Many options for doing so (*equal weights*, *variance-weighted averaging*, *Granger-Ramanathan averaging*, …)

0–5 cm pH maps (disaggregated soil information)

Lower prediction limit

Prediction

Upper prediction limit



Validation of predictions:
R^2: 0.06
RMSE 0.75

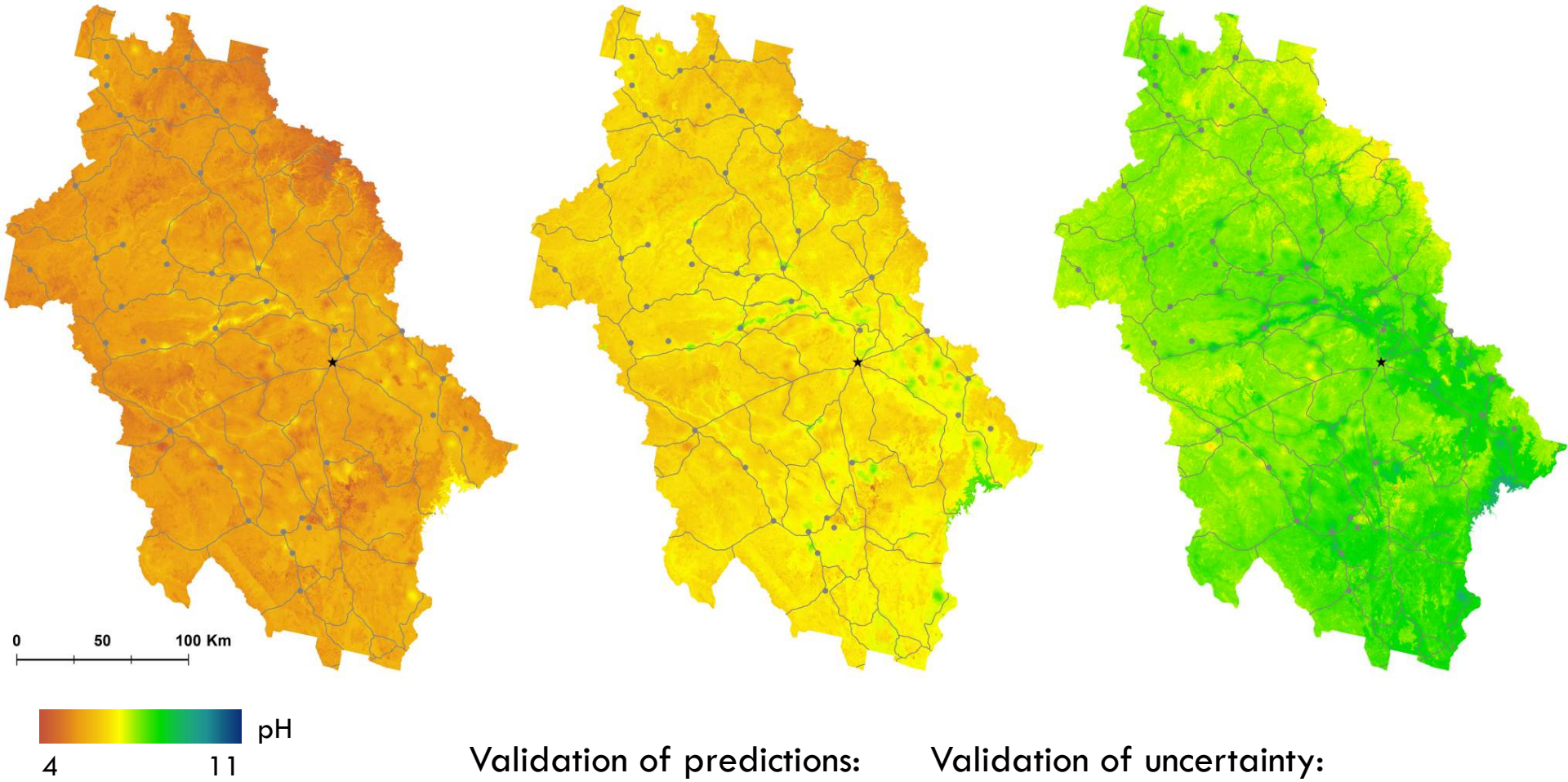
Validation of uncertainty:
PICP: 0.95

0–5 cm pH maps (regression-kriging procedure)

Lower prediction limit

Prediction

Upper prediction limit



Validation of predictions:
R^2: 0.14
RMSE 0.69

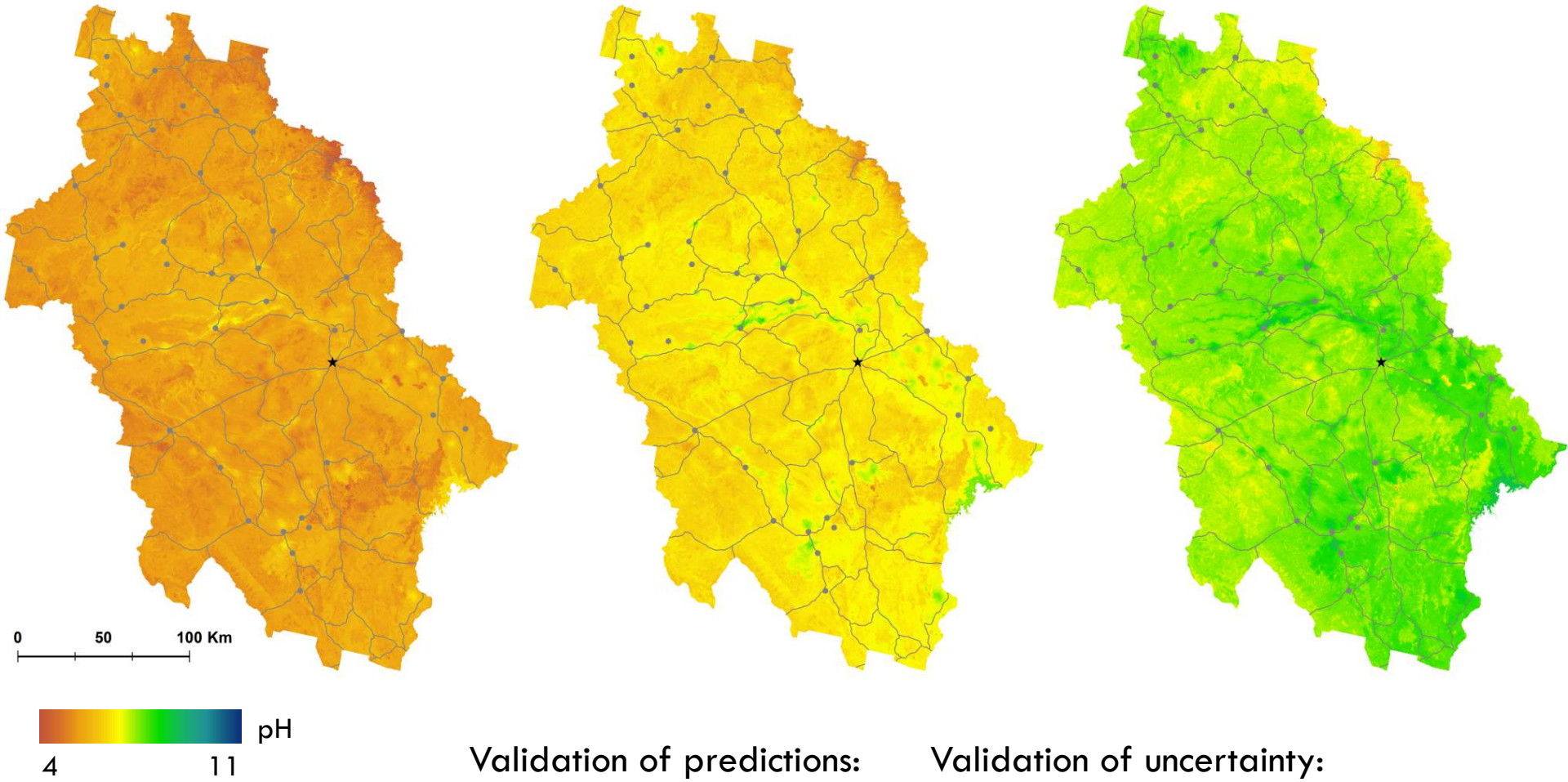
Validation of uncertainty:
PICP: 0.90

0–5 cm pH maps (model-averaged predictions)

Lower prediction limit

Prediction

Upper prediction limit



Validation of predictions:
R^2: 0.16
RMSE 0.68

Validation of uncertainty:
PICP: 0.87

Enterprise suitability mapping

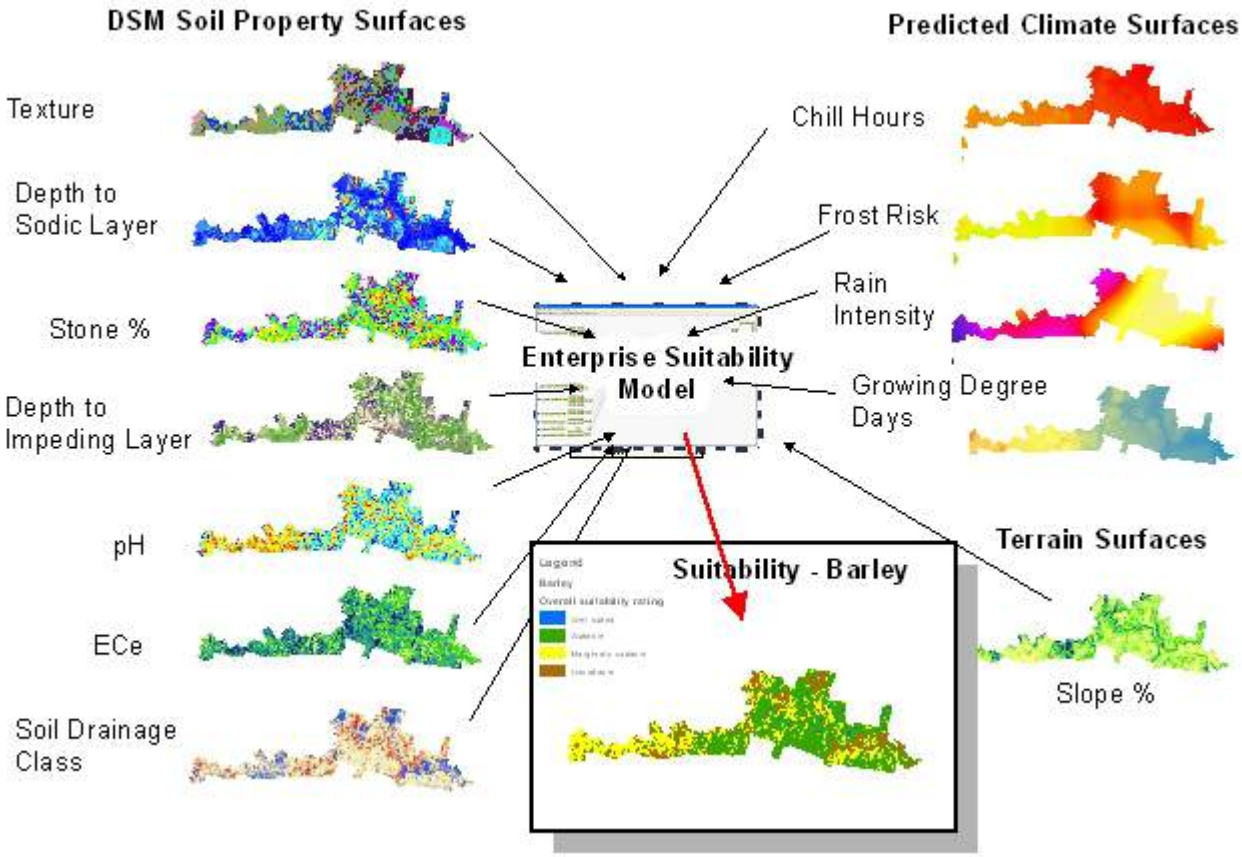
- An aid to assess the potential for growing new crops in an area
- Suitability assessment makes use of:
  - Digital soil mapping (e.g. soil depth, drainage index, clay content)
  - Local climate mapping (e.g. frost risk, growing degree days, chill hours)
  - Crop suitability rules

- Trialled in Tasmania for 20 agricultural crops
  - Collaboration with Tasmanian Institute of Agriculture, Department of Primary Industries, Parks, Water and Environment (Tasmania)

Suitability rules for hazelnut

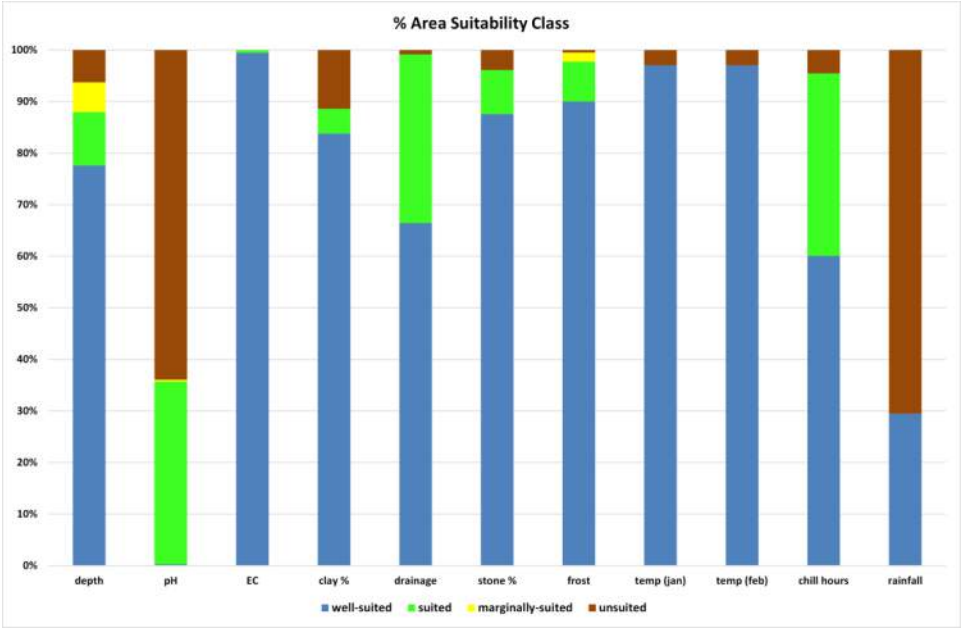
Suitability class	Soil depth (cm)	0–15 cm pH	0–15cm EC (dS m^{-1})	0–15 cm clay content (%)	Soil drainage class	0–15 cm stone content (>20cm, %)	Frost 0 days <-6°C, June–August	Mean month T_{max}, Jan–Feb (°C)	Mean March rainfall, (mm)	April–August chill hours 0-7°C
Well suited	>50	>6.5	<0.15	10–30	Well to moderately well	<10	4/5 years	20–30	<50	>1200
Suited	40–50	5.5–6.5	<0.15	30–50	Imperfect	10-20	3/5 to 4/5 years	30–33 or 18–20	<50	600–1200
Marginally suited	30–40	6.5–7.1	<0.15	30–50	Imperfect	10-20	2/5 to 3/5 years	33–35	<50	600–1200
Unsuited	<30	<5.5 or >7.1	>0.15	>50 or <10	Poor to very poor	>20	<2/5 years	>35 or <18	>50	<600

Suitability process

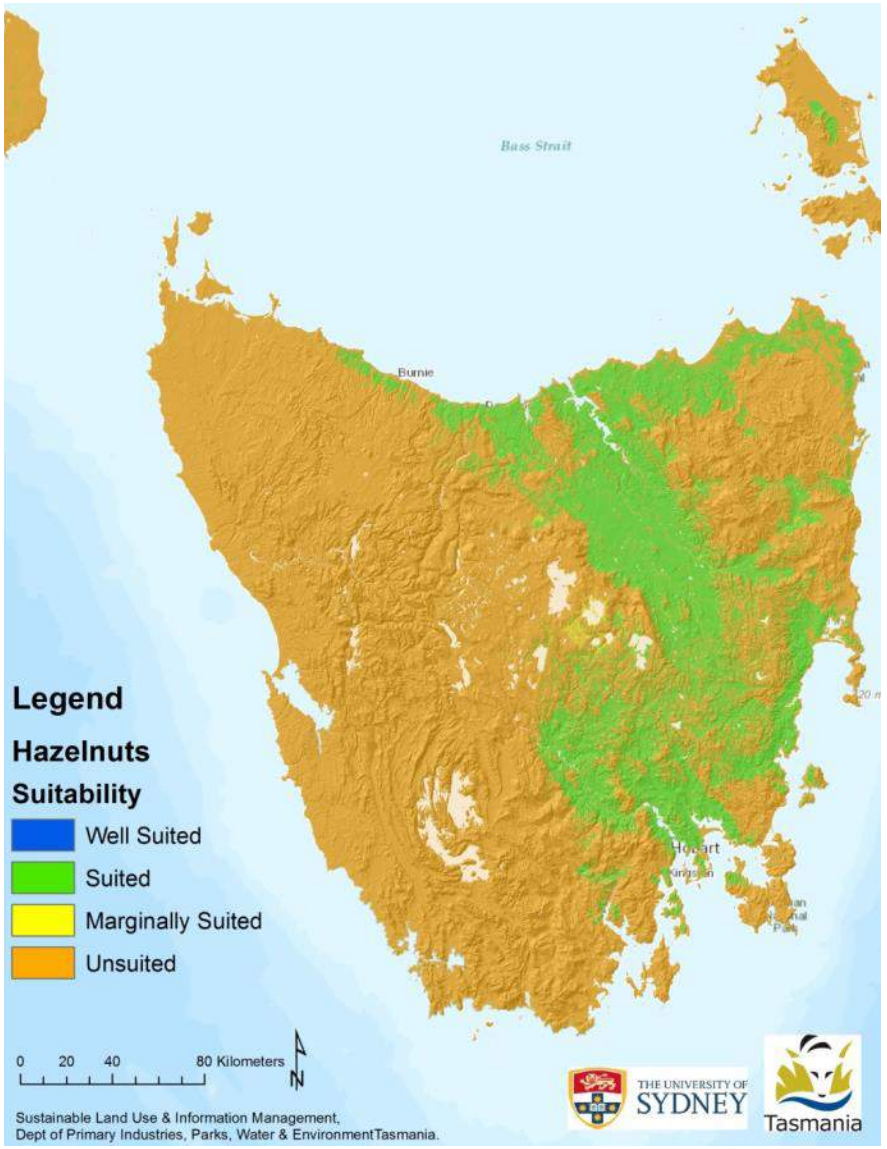


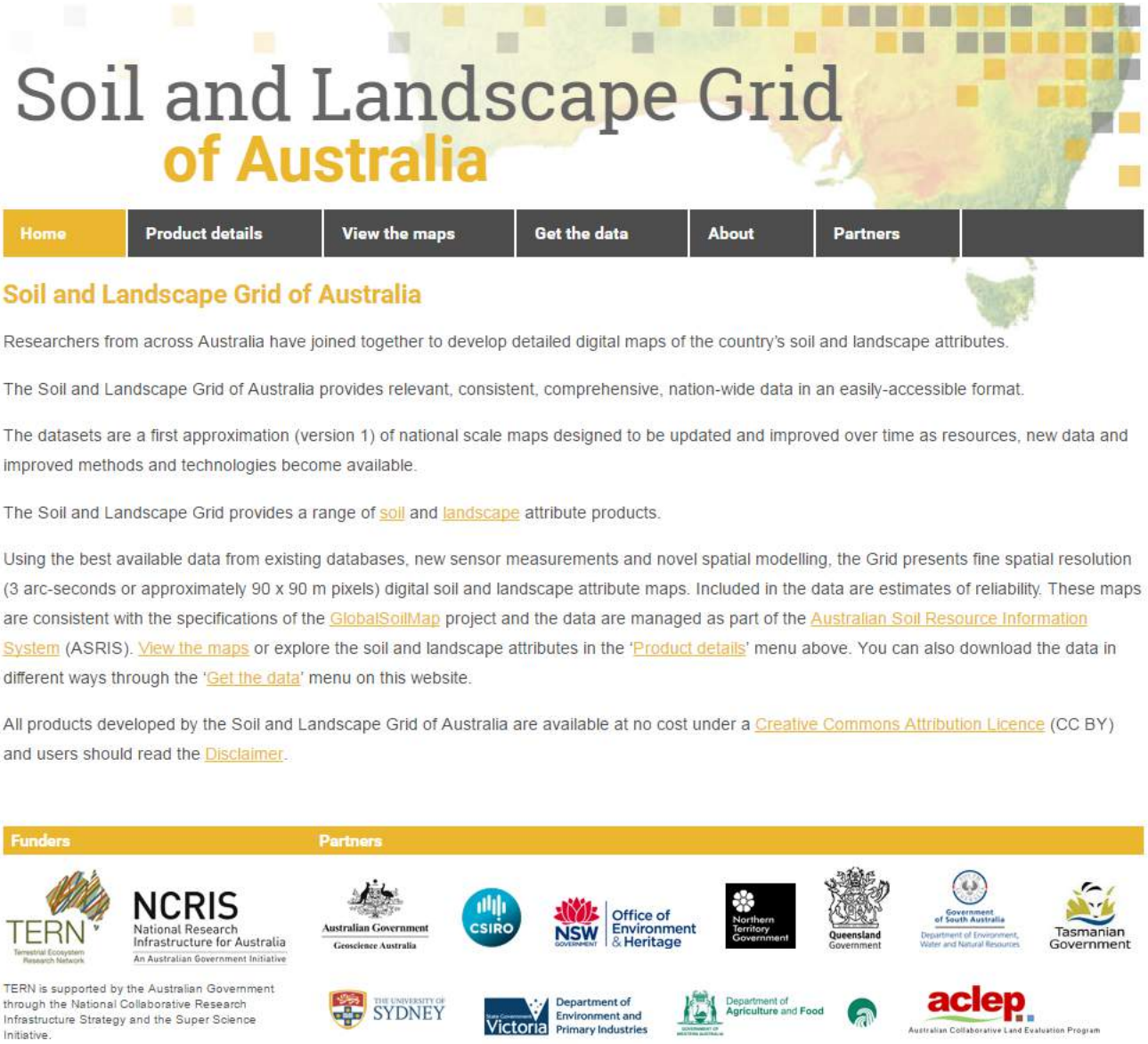
- Suitability class assigned according to most limiting factor

State-wide enterprise suitability, hazelnuts



- Suited to most of Tasmania's ag. area
- Most of the rest of the state unsuitable because of topsoil pH and excessive March rainfall





http://www.clw.csiro.au/aclep/soilandlandscapegrid/

Grazie mille!

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