# About TERN

The Terrestrial Ecosystem Research Network (TERN) is an overarching and integrated network designed to serve ecosystem research in Australia. It builds on significant past investments by scientists and governments to understand Australian ecosystems. It does this by focussing on collating, calibrating, validating and standardising existing data sets. TERN is also funding new research infrastructure and collection systems, expanding observation and monitoring programs into unrepresented ecosystems, and building digital infrastructure to store and publish this information in a form that can be searched and accessed freely under licenses that acknowledge the data provider(s) and build collaborative research.

While TERN is essentially a network of infrastructure, the inherent collaboration between facilities also creates a network for sharing ideas. Thus, TERN is able to support high-level analysis and synthesis of complex ecosystem data across the science-policy-management continuum, which in turn helps advance ecosystem research.

By providing the means to share data sets and develop collaborations as part of our data sharing processes, TERN is the catalyst for a culture shift to a more open and collaborative form of ecosystem science in Australia. Our goal is to see more scientists working together, rather than in isolation, and being rewarded for sharing data and knowledge. Together, they will build knowledge more effectively to address key terrestrial ecosystem problems.

TERN's legacy will be a sustainable long-term ecosystem research network for Australia, with shared access to research data for improved understanding and management of our unique ecosystems.

TERN
Terrestrial Ecosystem Research Network

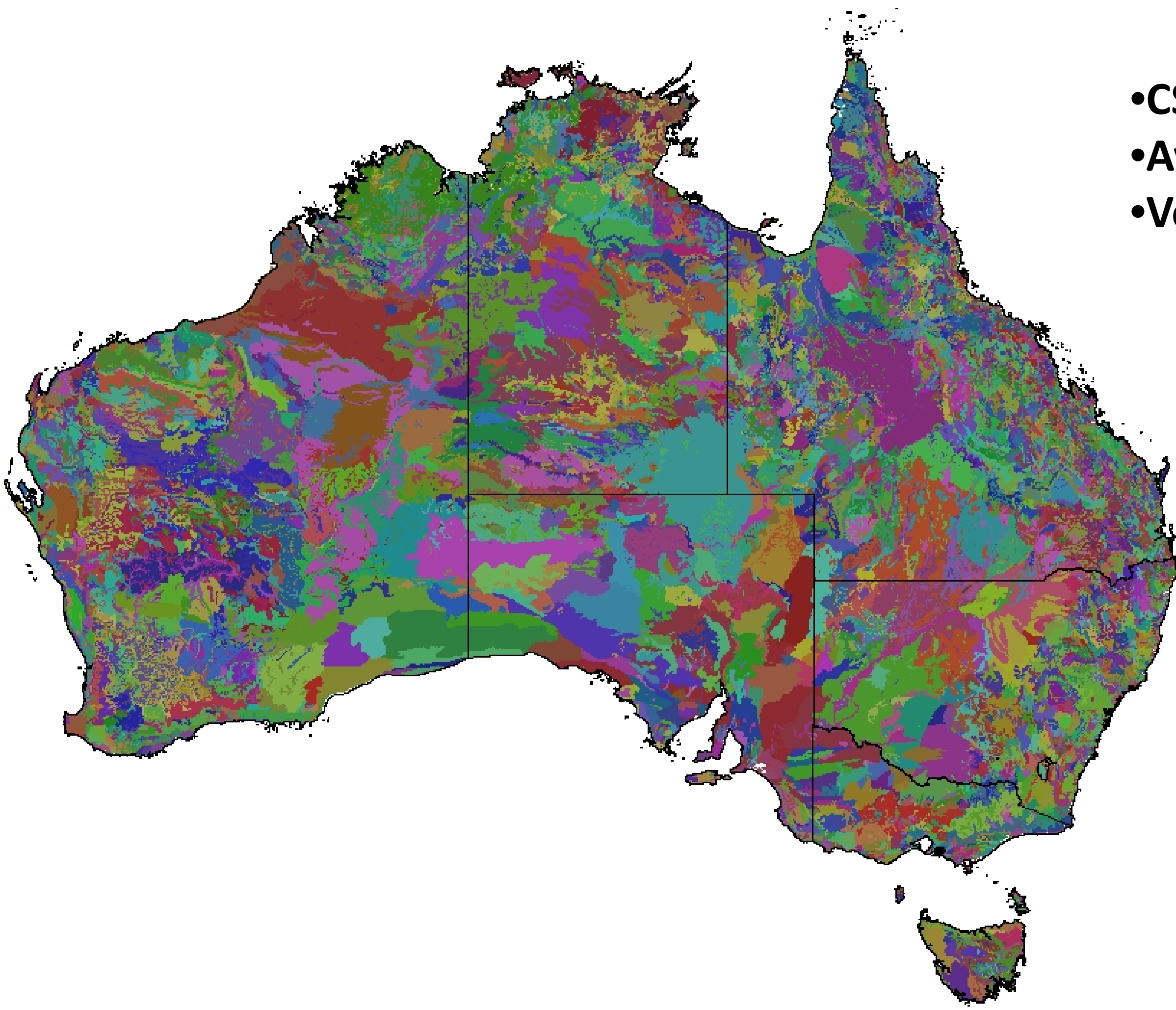
TERN is supported by the Australian Government through the National Collaborative Research Infrastructure Strategy and the Super Science Initiative.

An Australian Government Initiative
National Collaborative Research Infrastructure Strategy

# Australia - Existing Soil Information

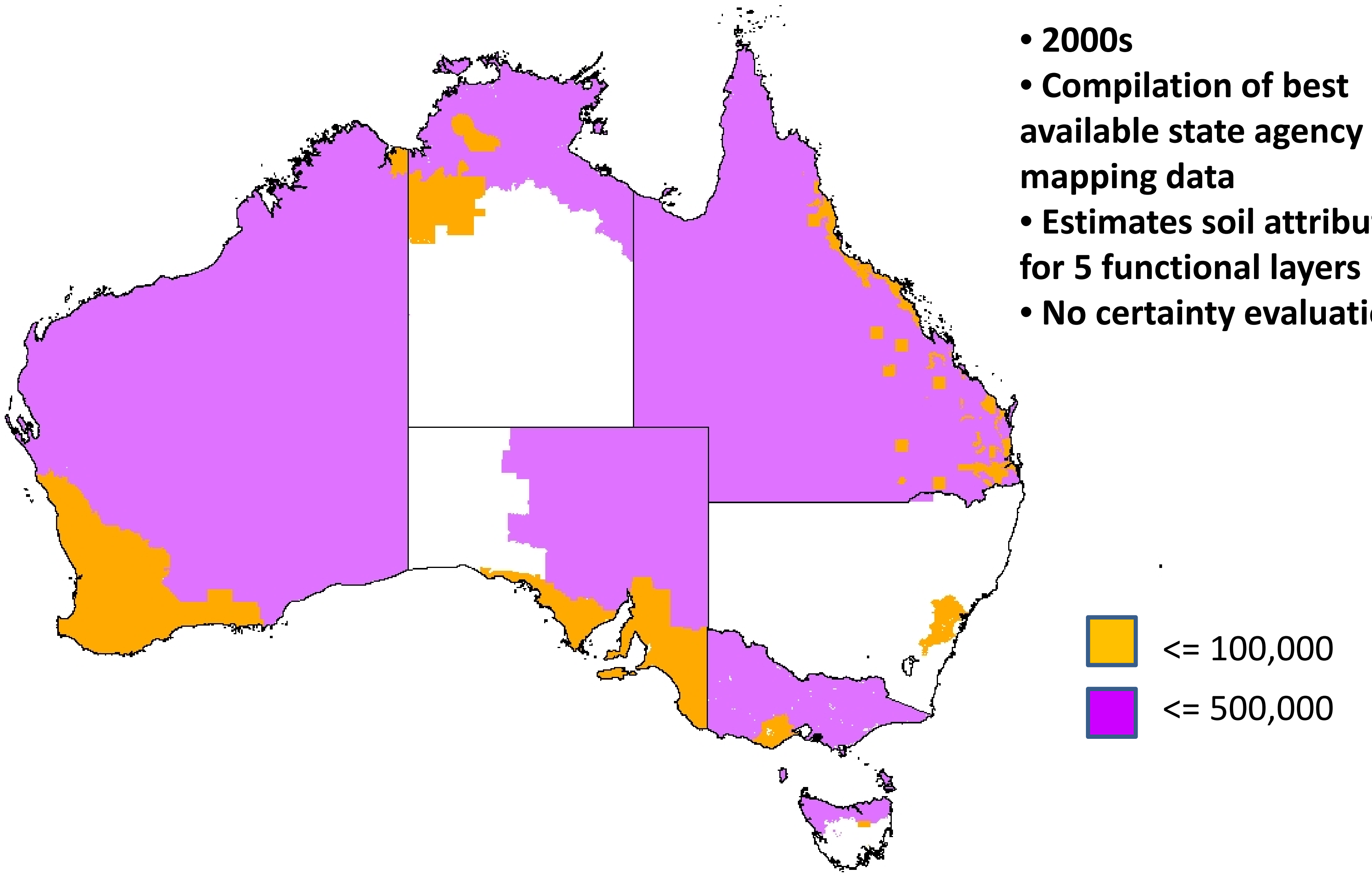
- No national soil survey program
  - State agencies
  - CSIRO
  - Universities
  - Geosciences Australia
- All scales and purposes

# Polygon\Map Data



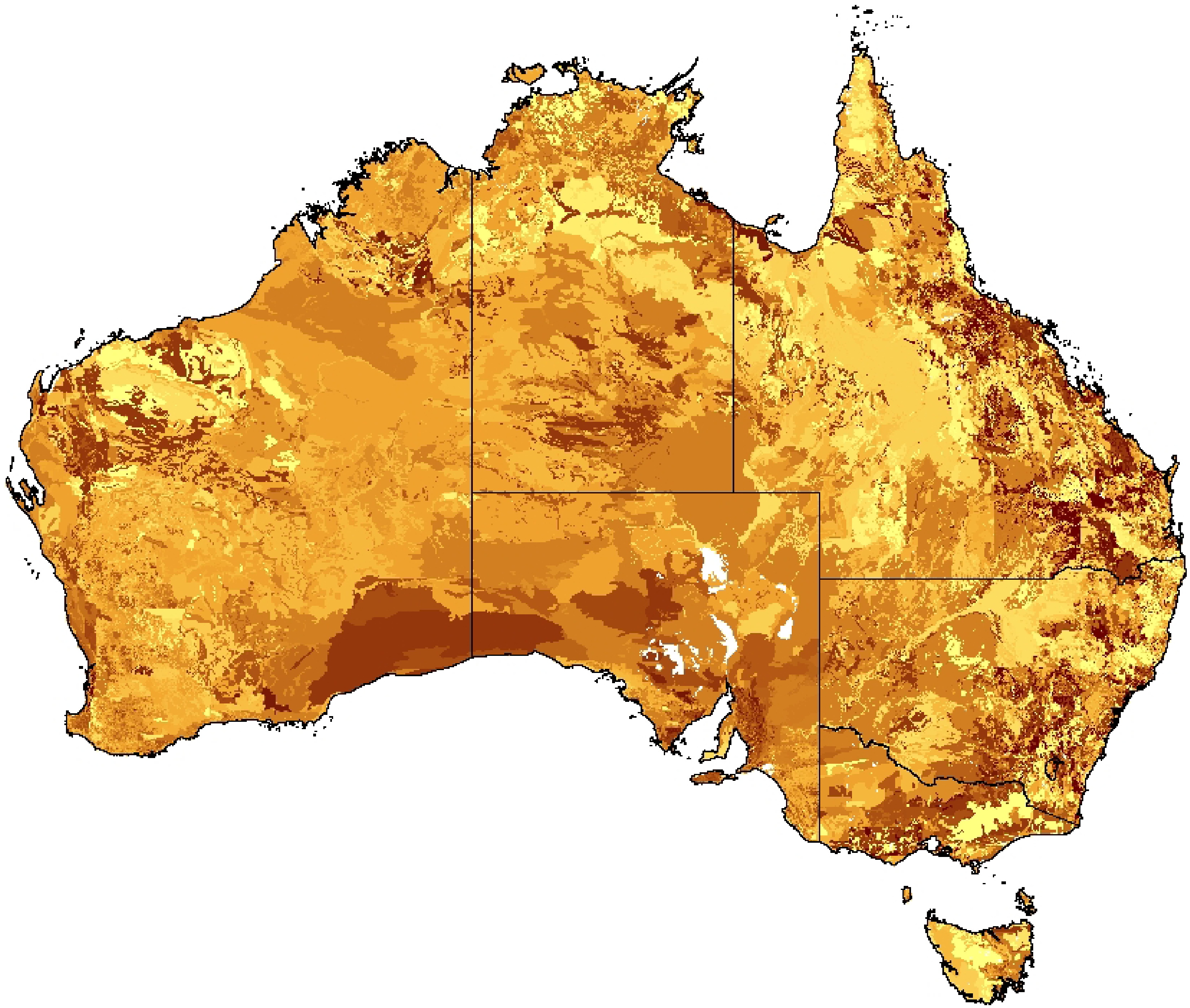
- CSIRO – 1960s
- Avg polygon area 342km$^2$
- Very limited attribution
  - Soil type
  - Landscape

# Australian Soil Resource Information System (ASRIS)

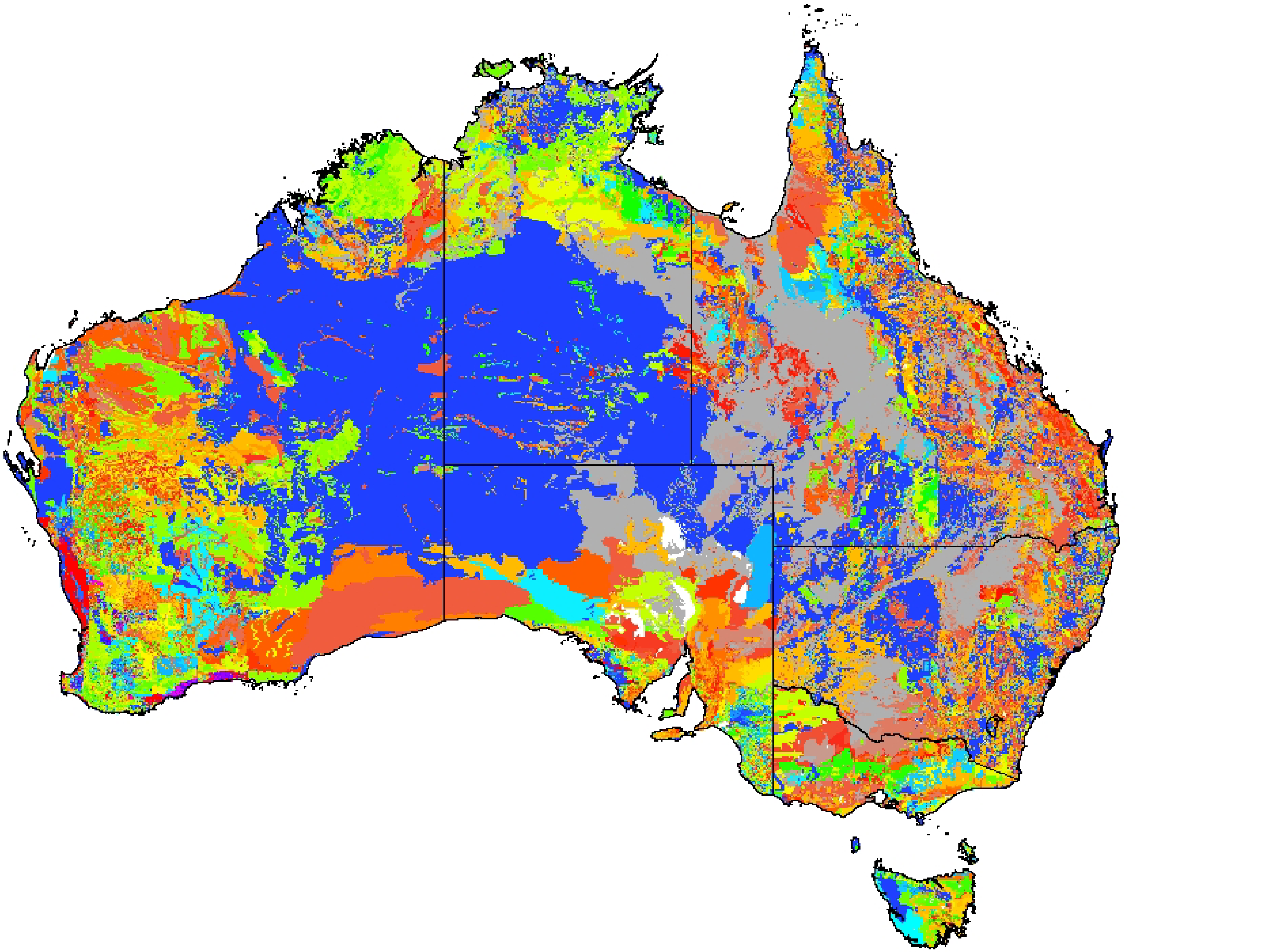


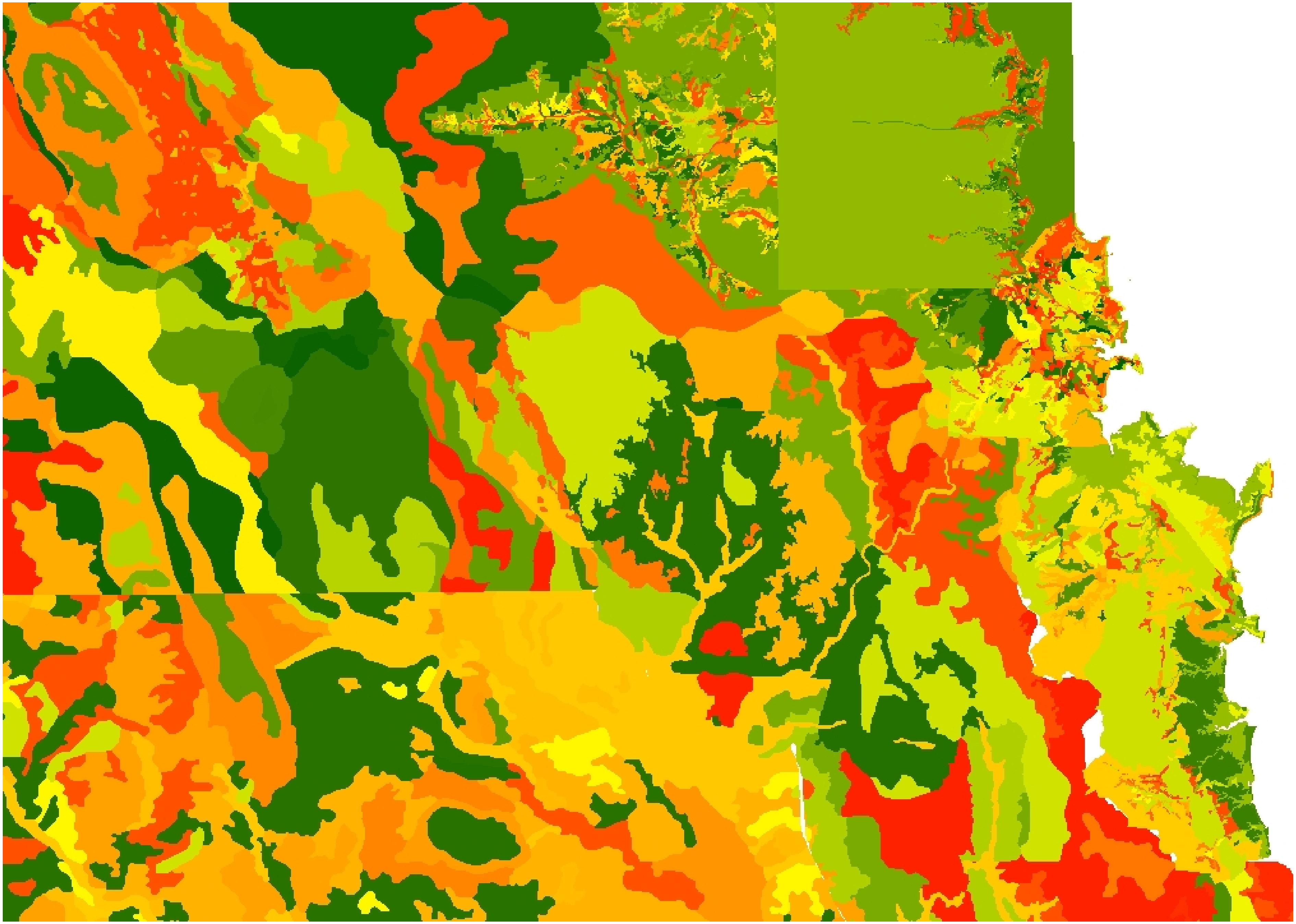

- 2000s
- Compilation of best available state agency mapping data
- Estimates soil attributes for 5 functional layers
- No certainty evaluation

# ASRIS Bulk Density



# ASRIS Hydraulic Conductivity



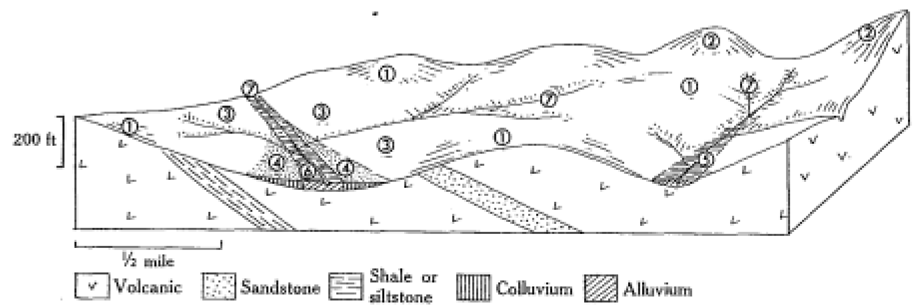


## (33) Ohio Land System (470 sq miles)

Strongly undulating volcanic country, mainly with silver-leaved ironbark, in the east and north-east.

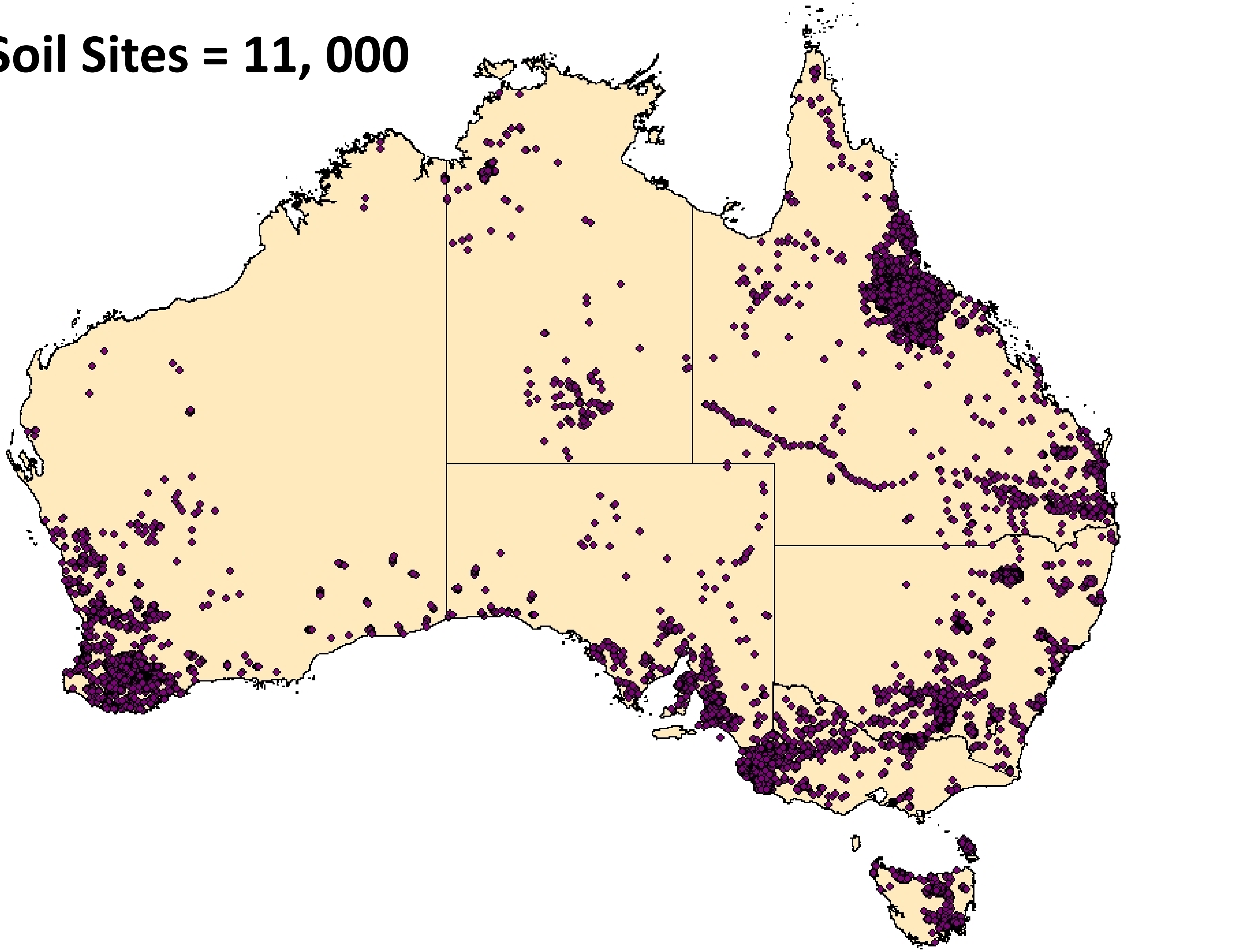
**Geology.**—Mainly moderately to steeply dipping andesitic volcanics with agglomerate, siltstone, tuffaceous sandstone, tuff, and limestone, of Lower Permian to Upper Carboniferous age.

**Geomorphology.**—Eroded in relatively unweathered rocks—strongly undulating plains: up to 15 miles across, with extensive upper slopes and minor erosional or depositional lower slopes; moderately dense dendritic pattern of incised valleys with through-going alluvial drainage floors; local relief mainly up to 300 ft but attaining 500 ft.

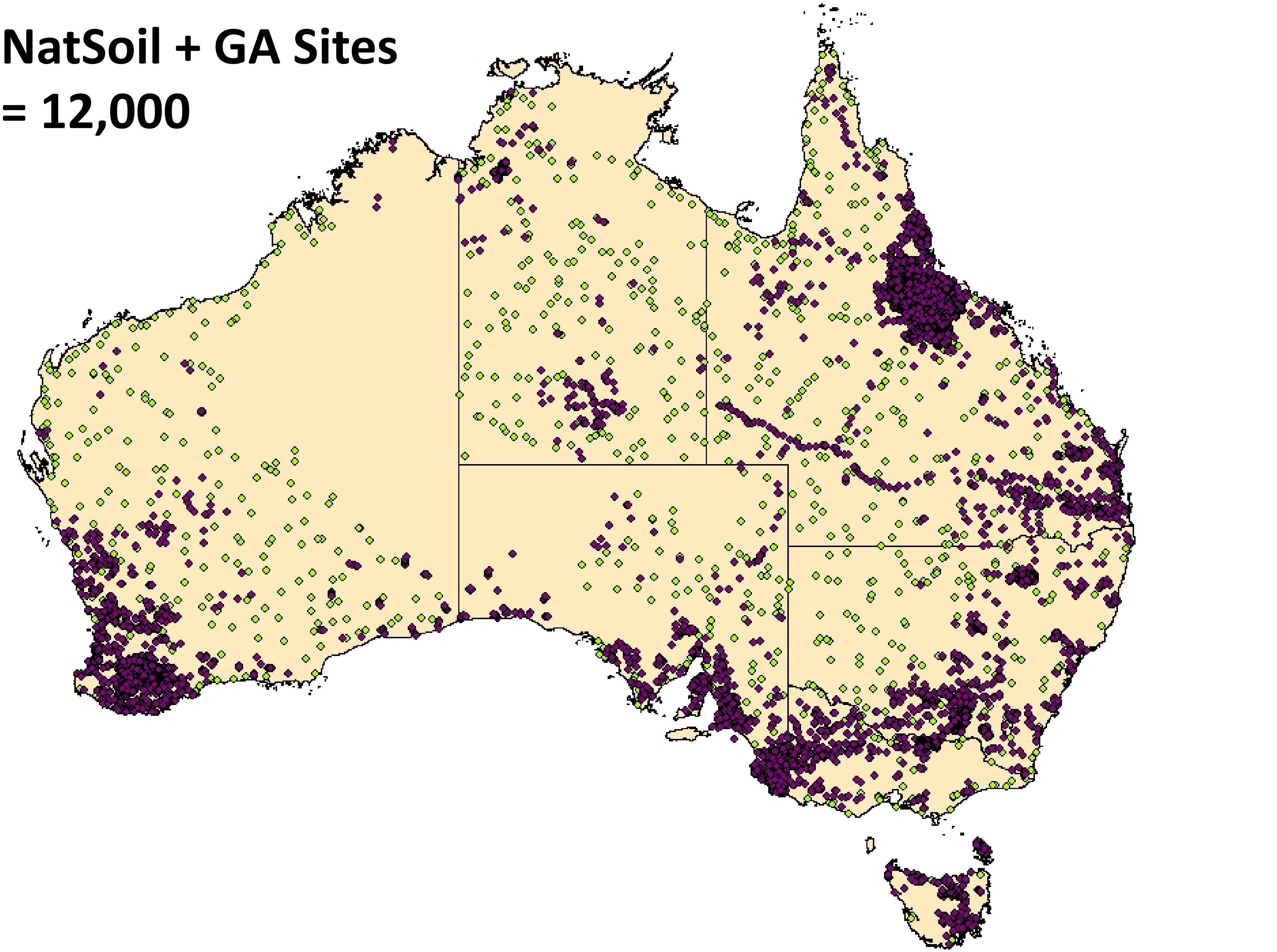



| Unit | Area (%) | Land Form | Soils | Vegetation | Land Class |
|---|---|---|---|---|---|
| 1 | 65 | Land facet 13: gentler upper slopes | Shallow to moderately deep gritty texture-contrast soils, Medway, minor Retro (Dr2.12, Dy2.23) | Silver-leaved ironbark grassy woodland, occasional *E. crebra* or *E. papuana* | IV–VI$t_5$, $p_{2-4}$, $e_{2-4}$ |
| 2 | 5 | Steeper upper slopes: concavo-convex, mainly 10–20% but up to about 60%, and mainly less than ½ mile long; cobble-strewn surfaces with scattered rock outcrops | Very shallow gritty clay soils, Rugby (Uf6.32) | Shrub woodland (48). Mainly closely spaced *E. crebra*; moderate shrubs; eastern mid-height grass. This community in many places modified to grassy woodland | VII–VIII$t_{5-8}$, $r_5$ |
| 3 | 10 | Erosional lower slopes: concave, up to 3% but mainly less than 2%, and up to ½ mile long; sealed, cracking surfaces with pebble-cobble patches | Moderately deep to deep cracking clay, May Downs; locally shallower, Bruce (Ug5.15, 5.16, 5.13) | Grassy woodland (56). Openly spaced *E. melanophloia* and *E. dichromophloia*; sparse shrubs; eastern mid-height grass | III$e_{2-3}$, $k_{2-3}$ |
| 4 | 10 | Land facet 15: colluvial slopes | Moderately deep to deep texture-contrast soils, Retro (Dy2.43) | Poplar box grassy woodland with sandalwood | IV$p_{2-4}$ |
| 5 | <5 | Land facet 16: tributary drainage floors | Deep texture-contrast soils, Retro (Dd1.43) | Poplar box–narrow-leaved ironbark grassy woodland | IV$p_{2-4}$ |
| 6 | 5 | Main drainage floors: up to ½ mile wide, gradients below 1 in 100; sealed, locally cracking surfaces | Deep alluvial cracking clay soils, Vermont (Ug5.15); non-cracking, Clematis (Uf6.11) | Grassy woodland (62). Closely spaced *E. populnea*; sparse shrubs; eastern mid-height grass | IV$w_{2-4}$ |
| 7 | 5 | Channels: up to 100 ft wide and 10 ft deep | Bed loads silt to cobbles | Fringing vegetation | |

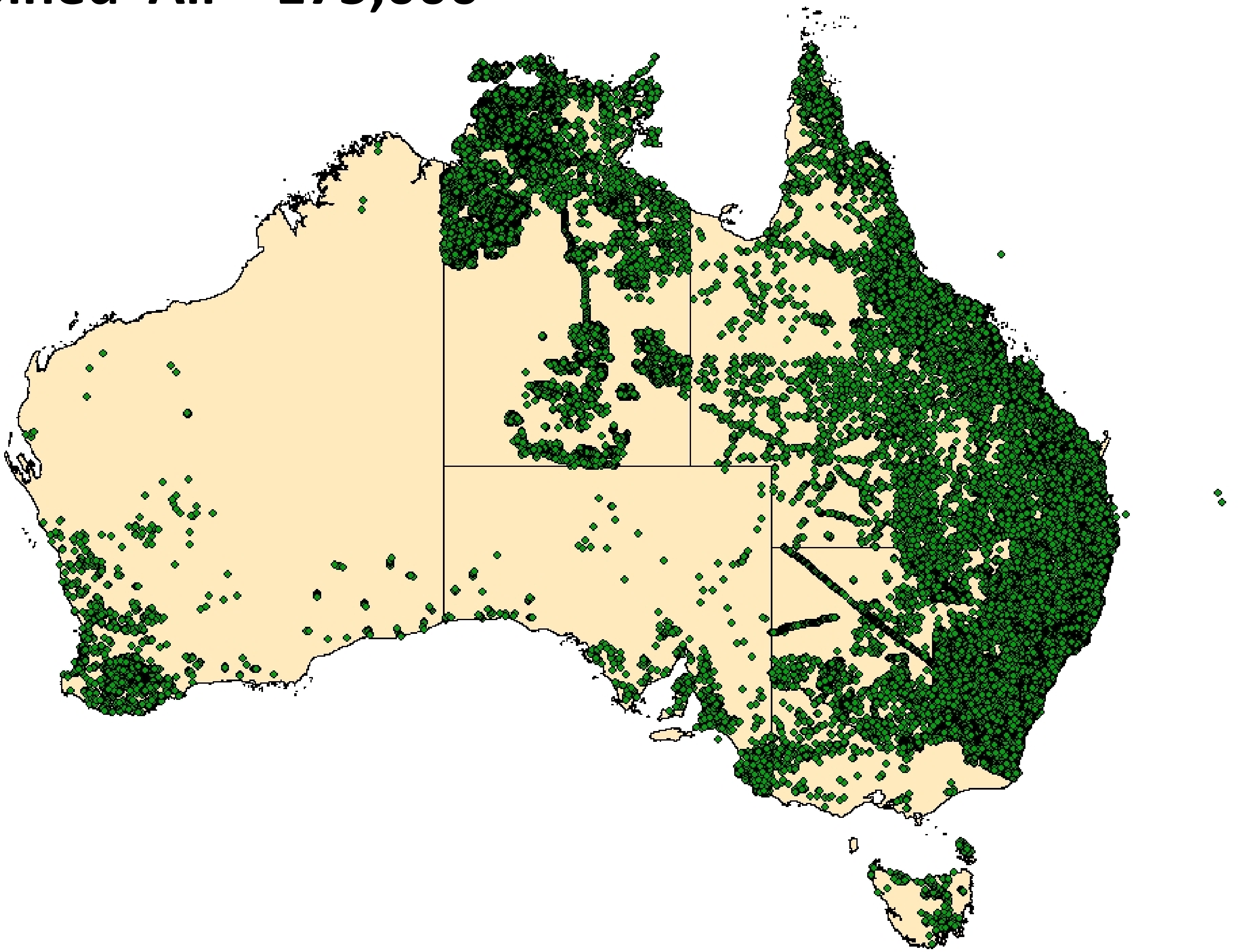
# NatSoil Sites = 11, 000

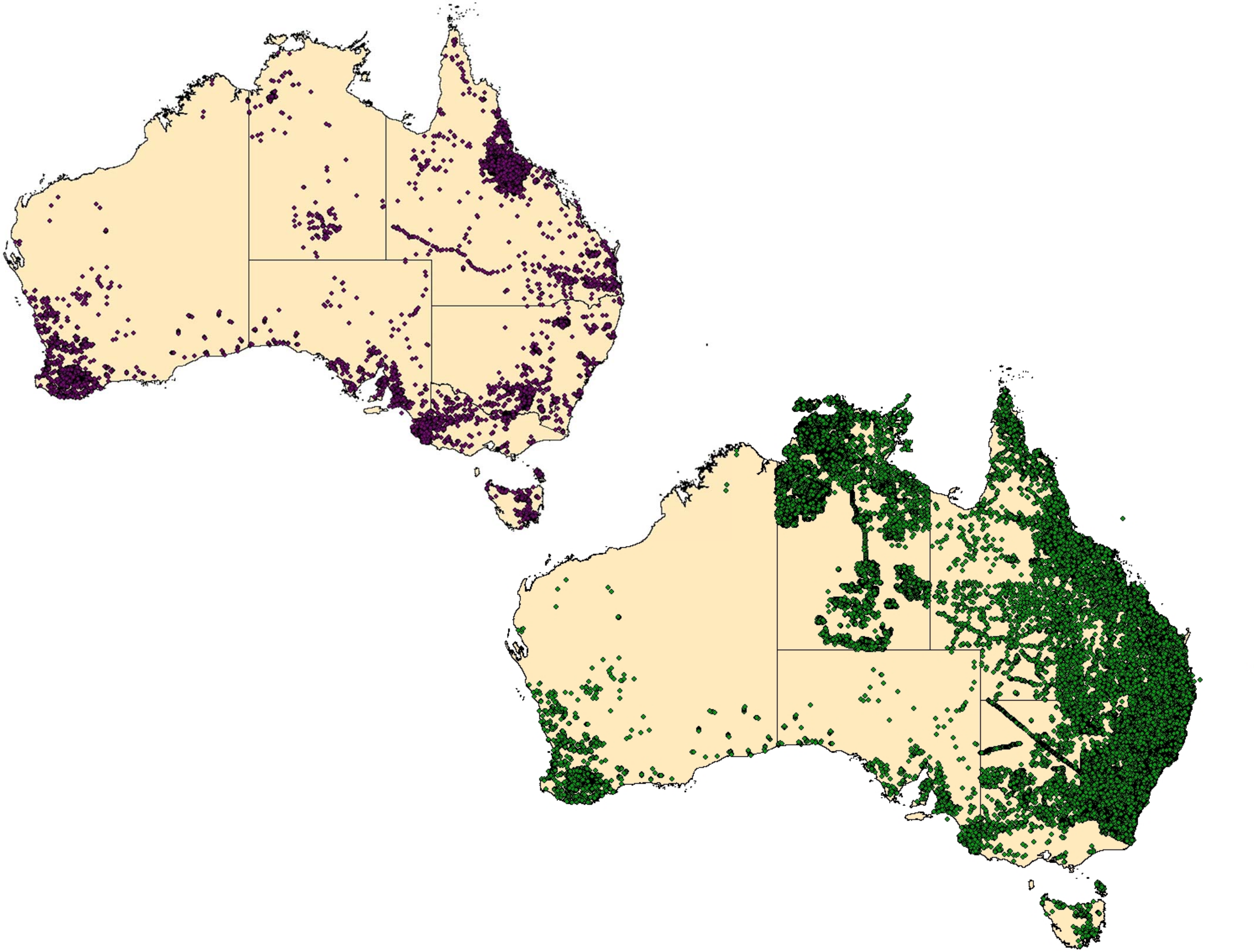


**NatSoil + GA Sites**
**= 12,000**

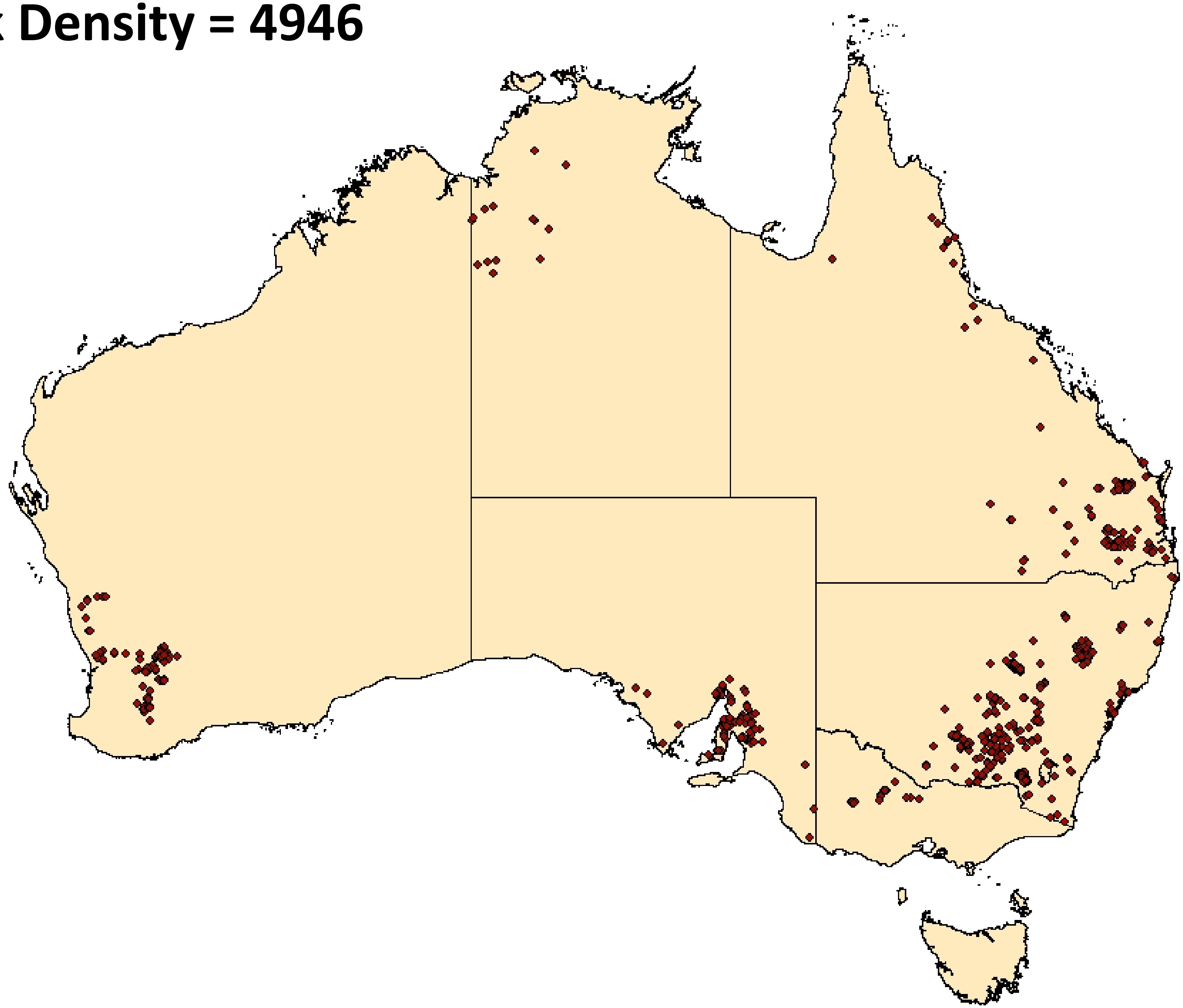


# Combined All = 175,000

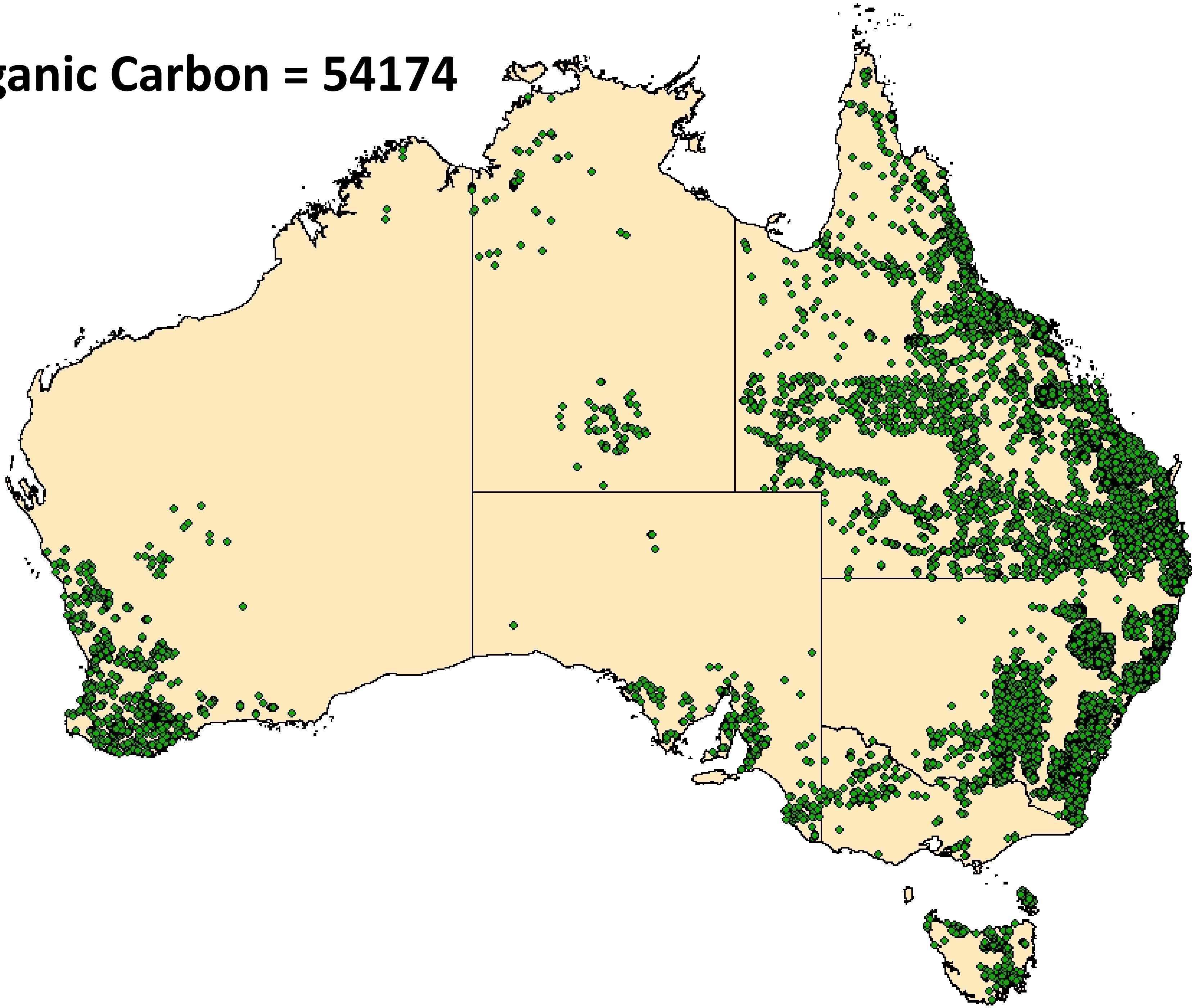




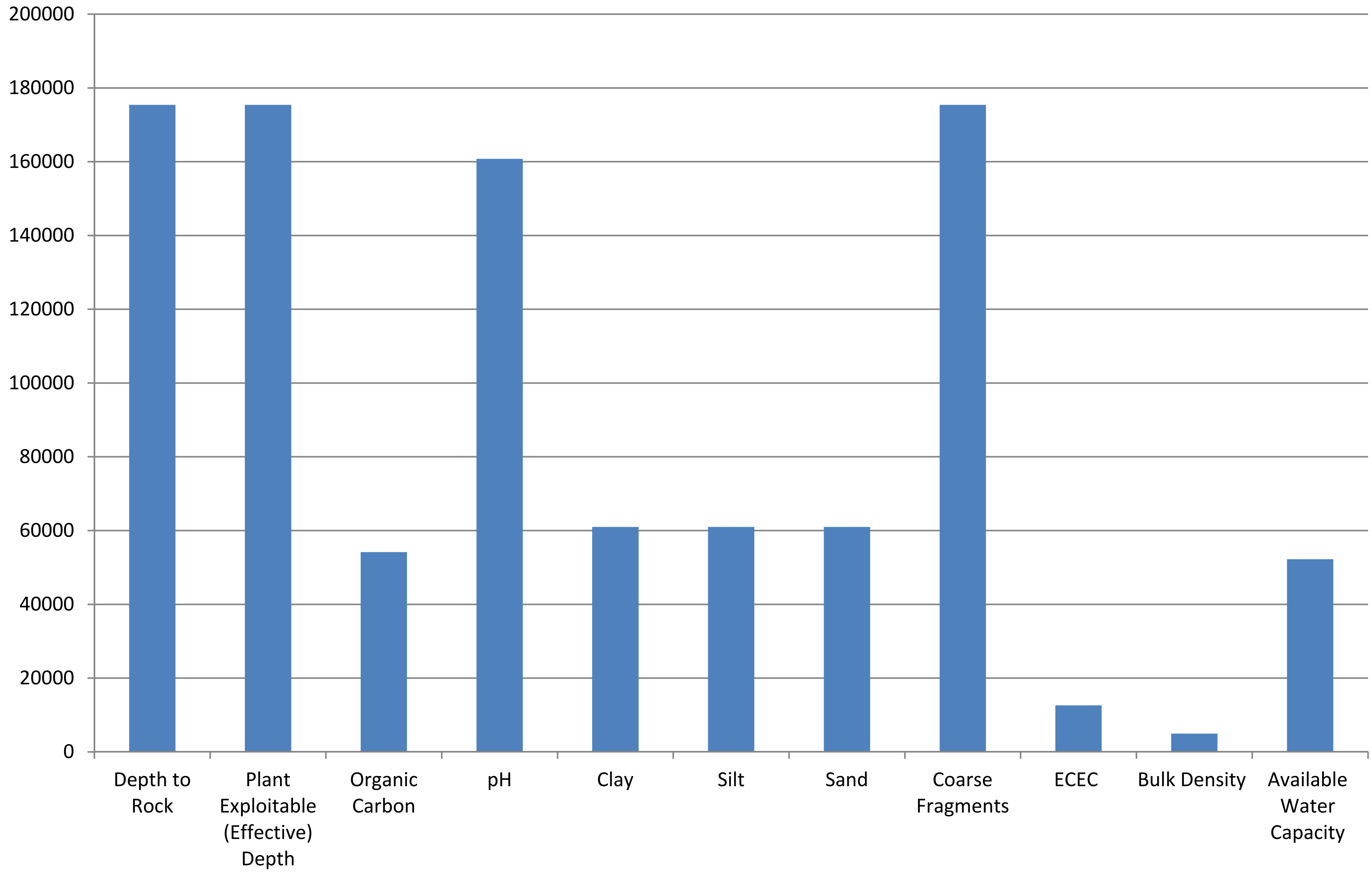
# Bulk Density = 4946



# Organic Carbon = 54174



- Number sites with lab data 30628 ( 1/252 km$^2$)



# Spatial disaggregation of soil map unit polygons

Nathan Odgers, Sun Wei, Alex McBratney, Budiman Minasny

THE UNIVERSITY OF SYDNEY

# Why?

- Generalisation and refinement of Sun et al. (2010)
- Aim is to map the constituents of soil map units individually
  - Finer-scale representation of soil continuum
- May help to harmonise depiction of soil distribution at soil map boundaries

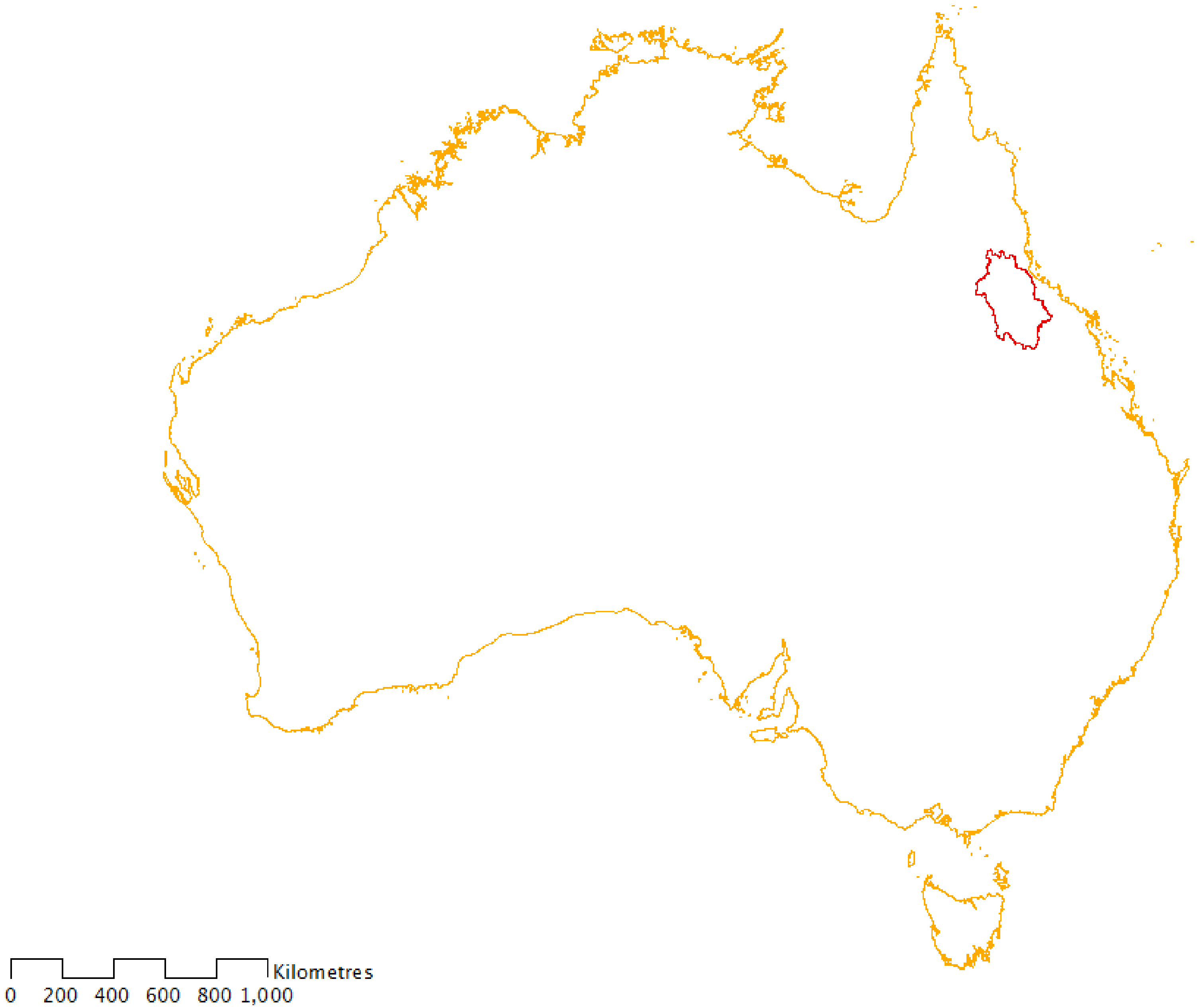
Sun, W., McBratney, A.B., Hempel, J.W., Minasny, B., Malone, B.P., D'Avello, T., Burras, L., Thompson, J.A., 2010. Digital harmonisation of adjacent analogue soil survey areas—4 Iowa counties, Proceedings of the 4th Global Workshop on Digital Soil Mapping, Rome.

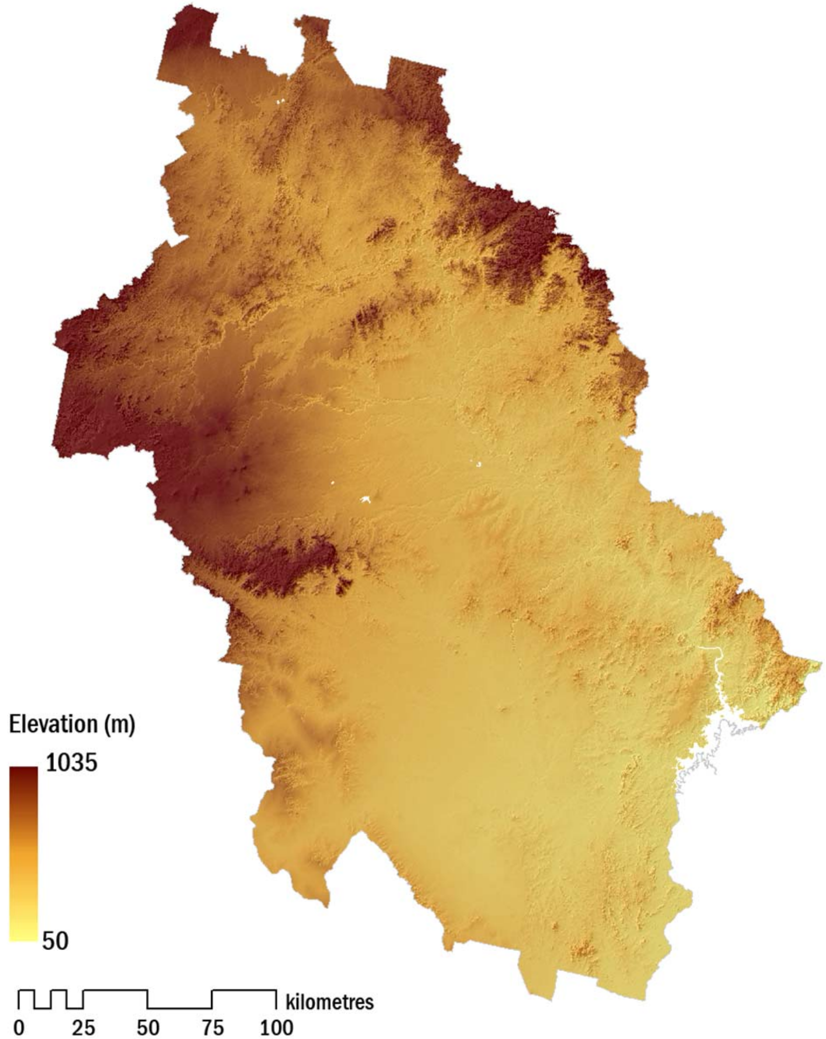
# Workflow

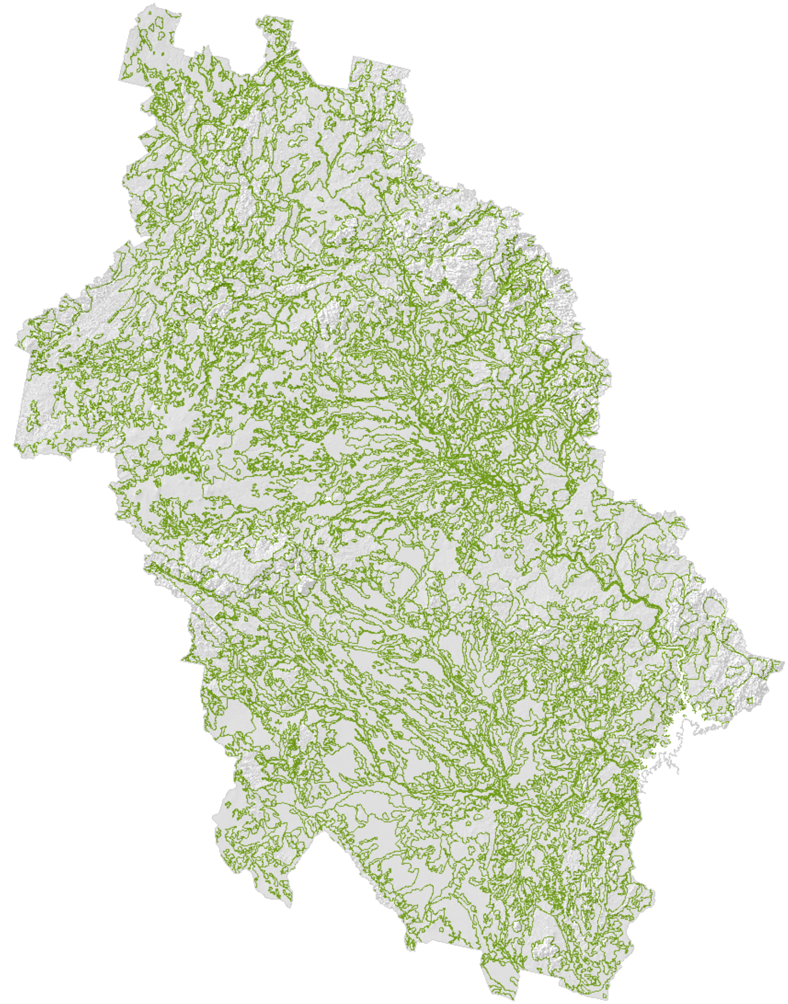
1. Prepare database of soil polygons, covariates
2. Take *n* random samples from each polygon
3. Assign a soil class to each sampling point
4. Build See5 decision tree with sampling points
5. Apply tree to map grid

iterated *i* times

6. Count number of times each cell is allocated to each soil type
7. Calculate probabilities from counts
8. Generate maps

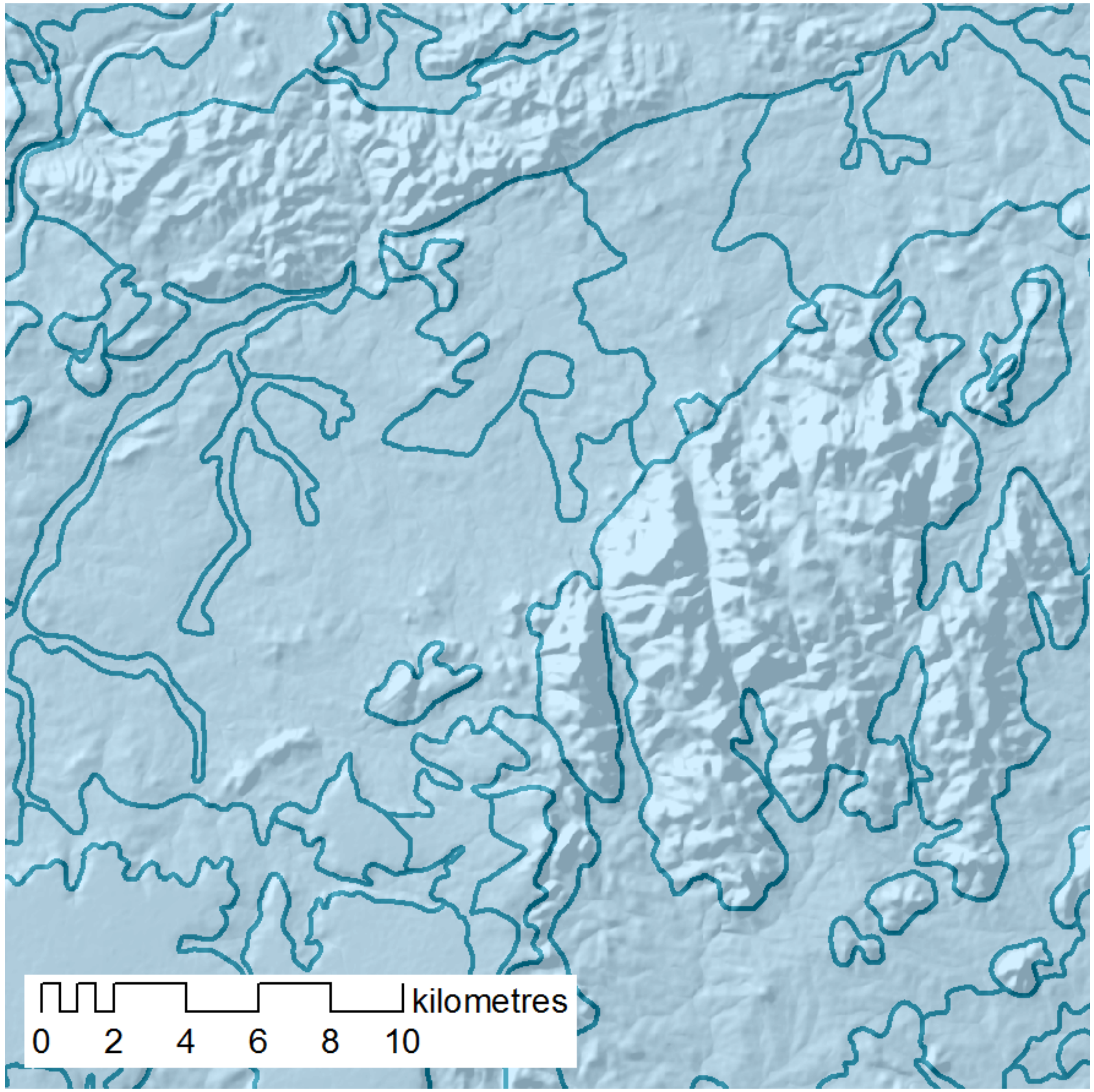

Kilometres
0 200 400 600 800 1,000

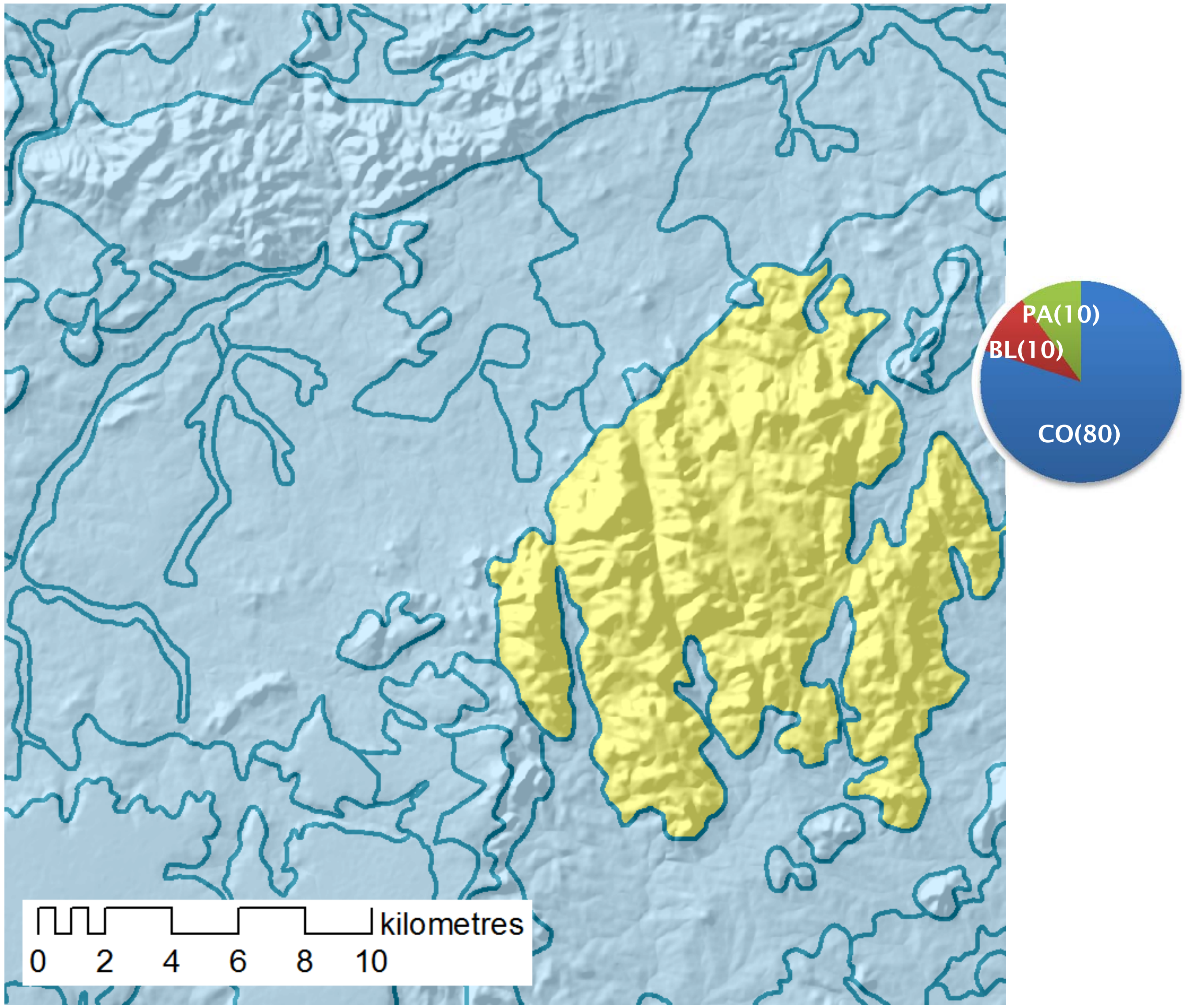


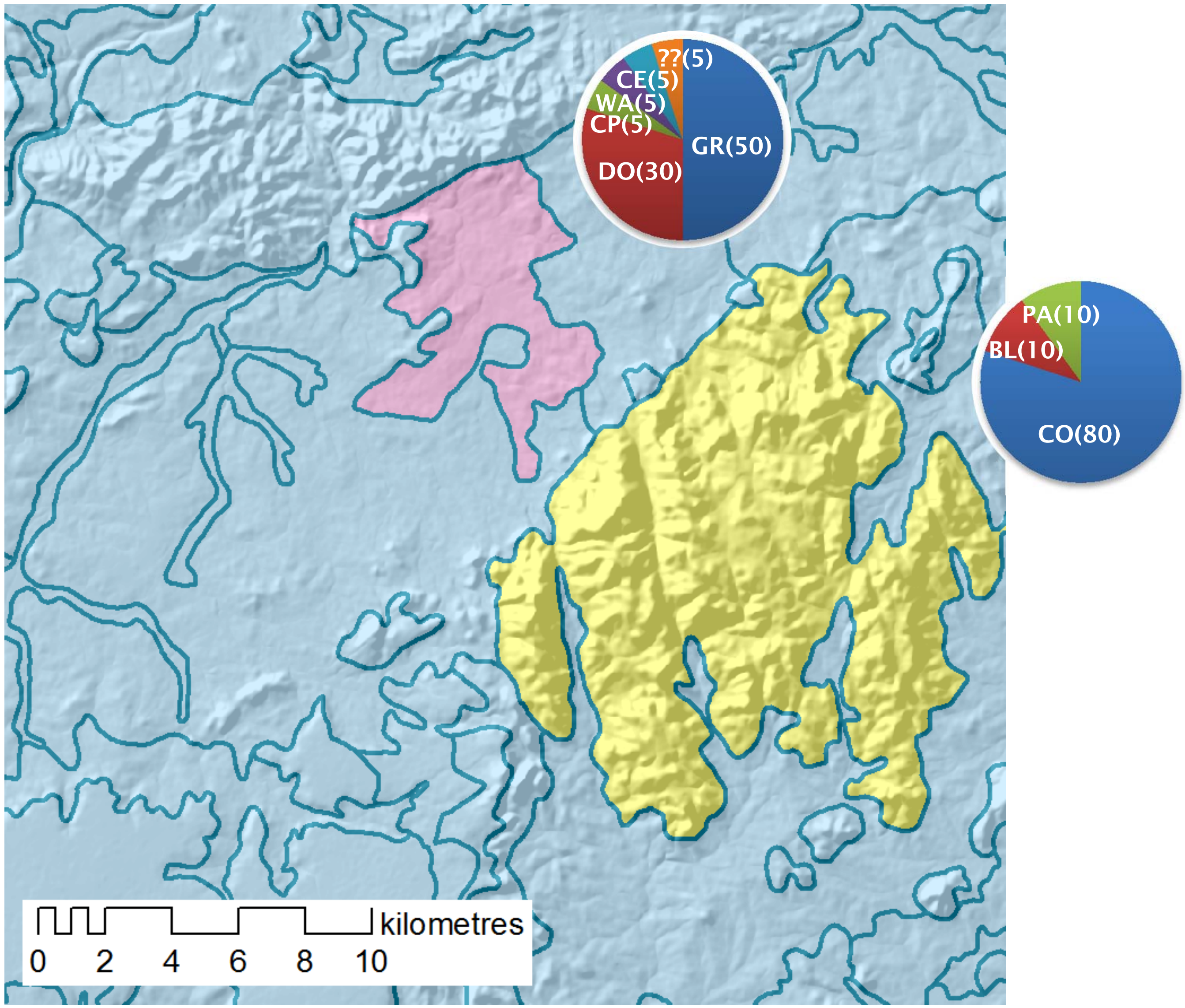



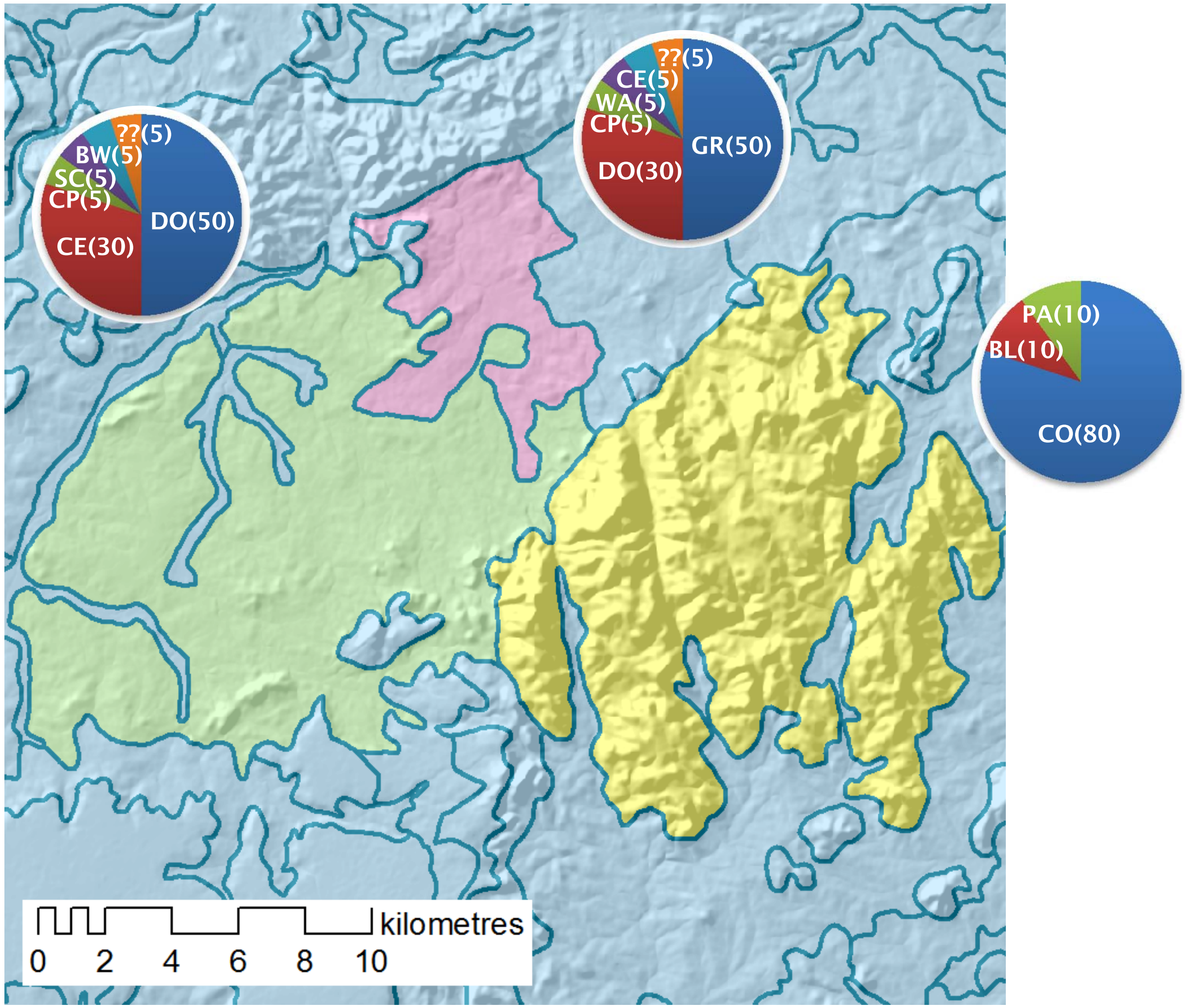
Rogers, L.G., Cannon, M.G., Barry, E.V., 1999. **Land resources of the Dalrymple Shire, 1.** Land Resources Bulletin DNRQ980090, Queensland Department of Natural Resources, Brisbane, Queensland.

(1:250,000)


kilometres
0 2 4 6 8 10


PA(10)
BL(10)
CO(80)
0 2 4 6 8 10 kilometres

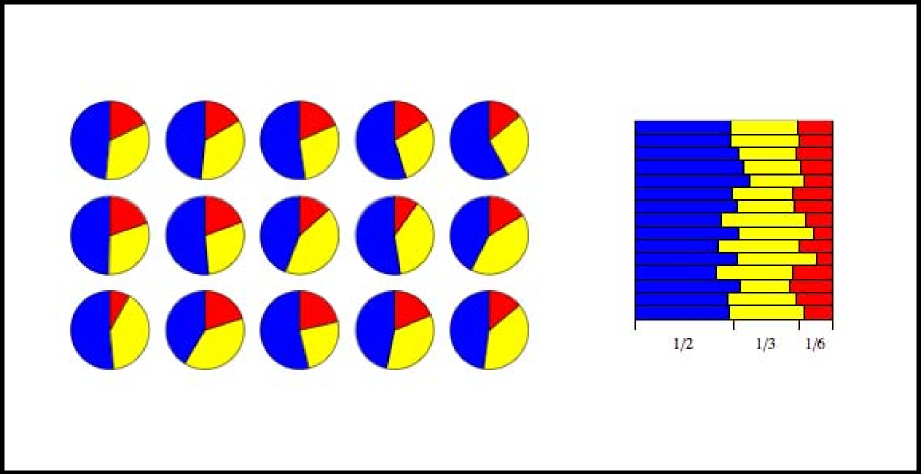

??(5)
CE(5)
WA(5)
CP(5)
GR(50)
DO(30)
PA(10)
BL(10)
CO(80)
kilometres
0
2
4
6
8
10



??(5)
BW(5)
SC(5)
CP(5)
CE(30)
DO(50)
??(5)
CE(5)
WA(5)
CP(5)
DO(30)
GR(50)
PA(10)
BL(10)
CO(80)
kilometres
0
2
4
6
8
10

# Sampling each map unit

- Currently, sampling *n* random points within each map unit polygon
  - How does this compare to sampling on a regular grid?
- Soil class assignment: weighted random choice according to soil class proportions
  - Use Dirichlet distribution to simulate uncertainty in soil class proportions
  - Can simulate how uncertain we think the proportions are



# Decision tree

- At each iteration, build a See5 decision tree using that iteration's sampling points to relate soil classes and *scorpan* covariates
- Apply the decision tree to the study area grid to map soil classes and See5 prediction confidence

$$\text{confidence} = \frac{(n - m + 1)}{n + 2}$$

$n$ = number of training samples covered by the rule
$m$ = number of samples that do not belong to the same class the rule is trying to predict

Powers, R.P., Hay, G.J., Chen, G., 2012. How wetland type and area differ through scale: a GEOBIA case study in Alberta's Boreal Plains. Remote Sensing of Urban Environments 117, 135–145. doi: 10.1016/j.rse.2011.07.009

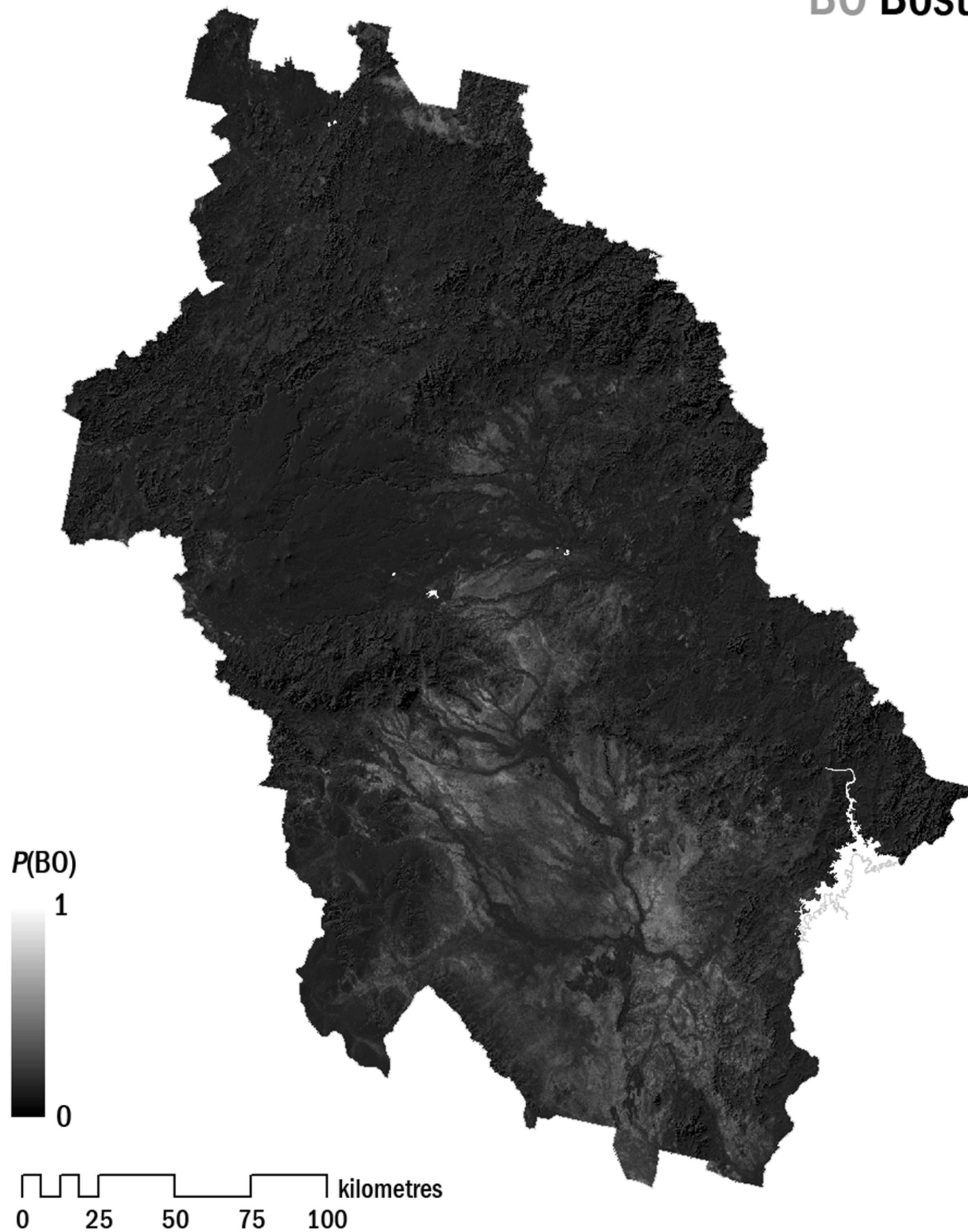
# Covariates

- Terrain attributes
  - DEM, slope, aspect, MRVBF, wetness index etc.
- Gamma radiometrics
  - K, Th, U

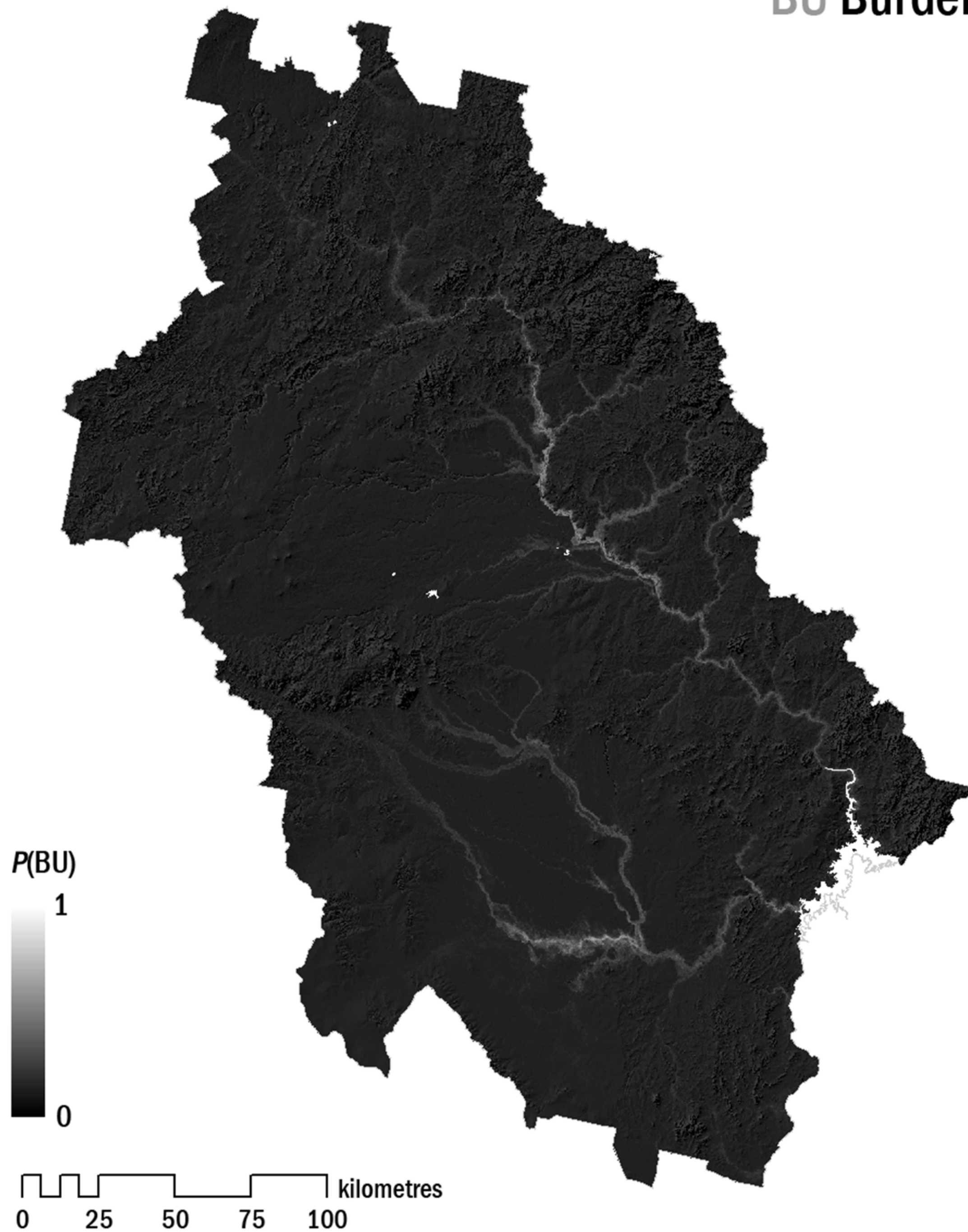
# Probabilities

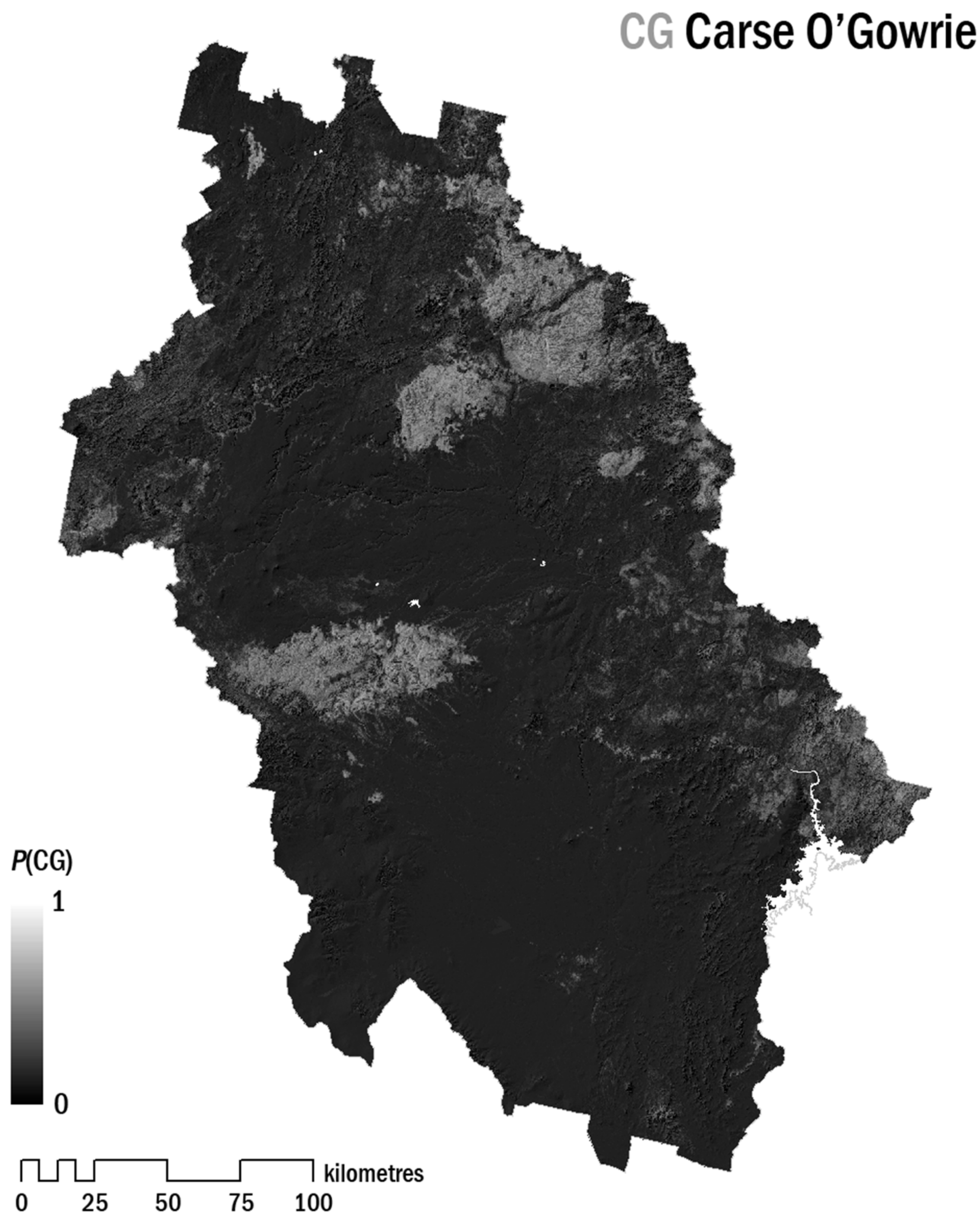
- Count the number of times each cell is classified as each soil class
- Probability of occurrence = count / number of iterations

# BO Boston

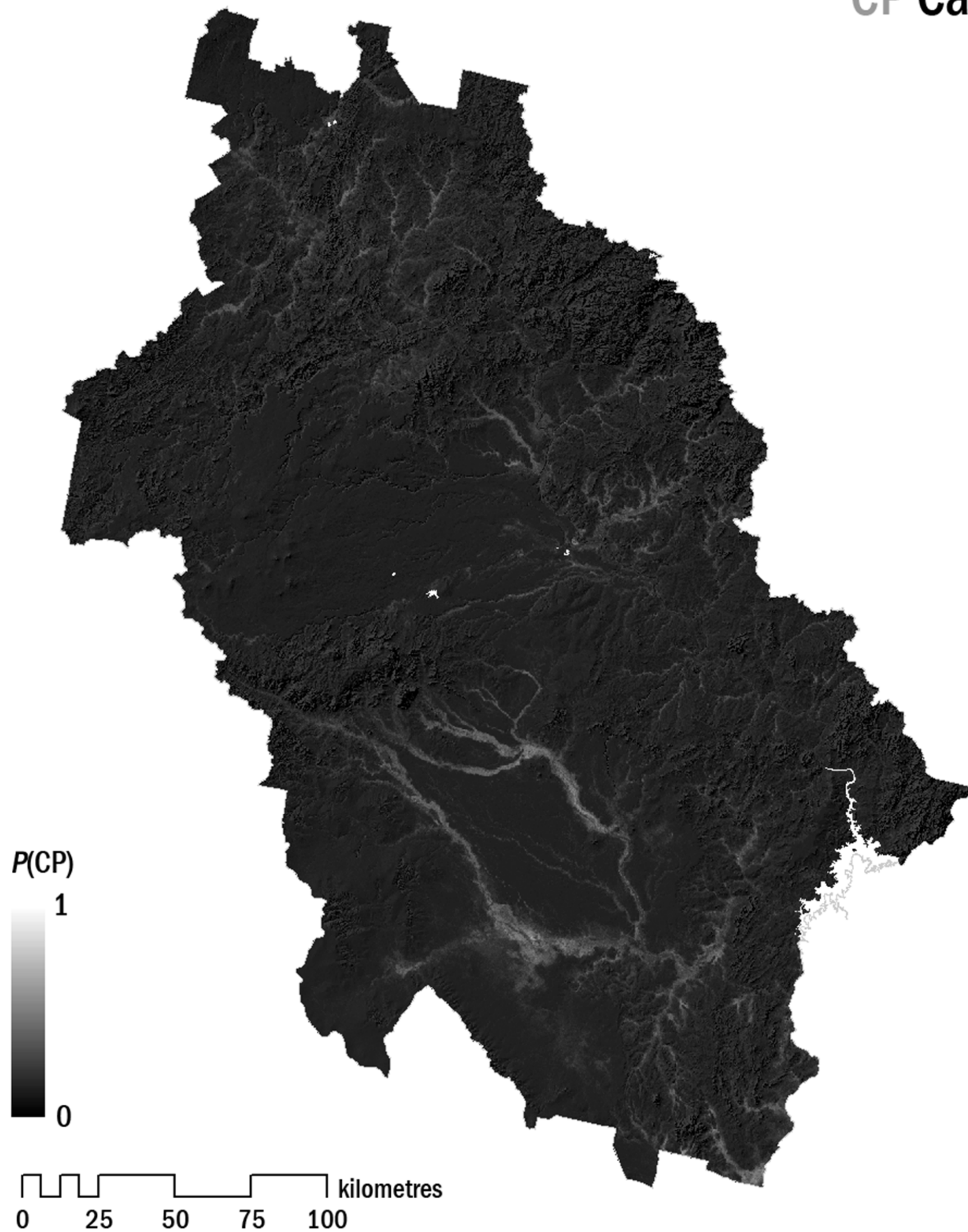


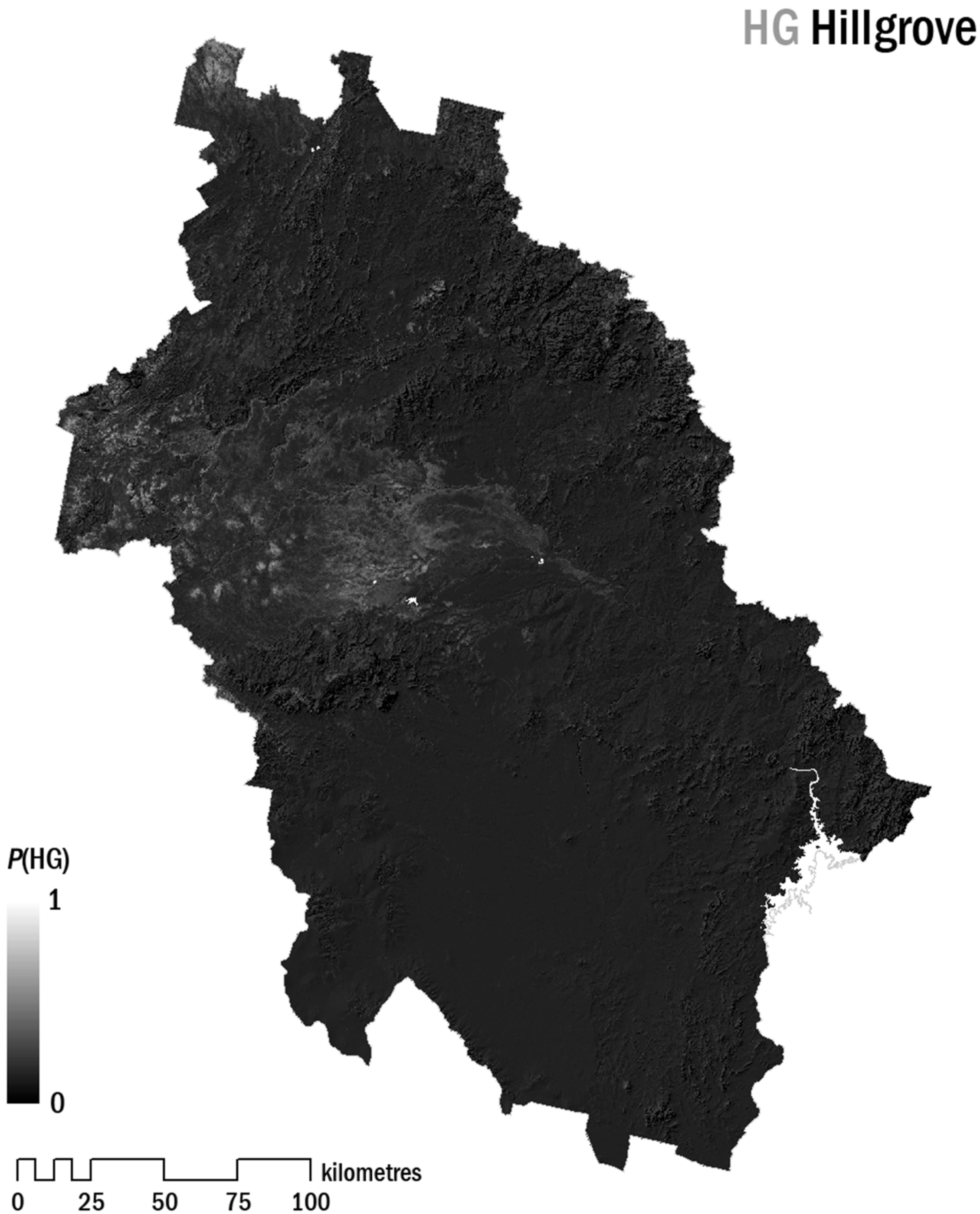
# BU Burdekin

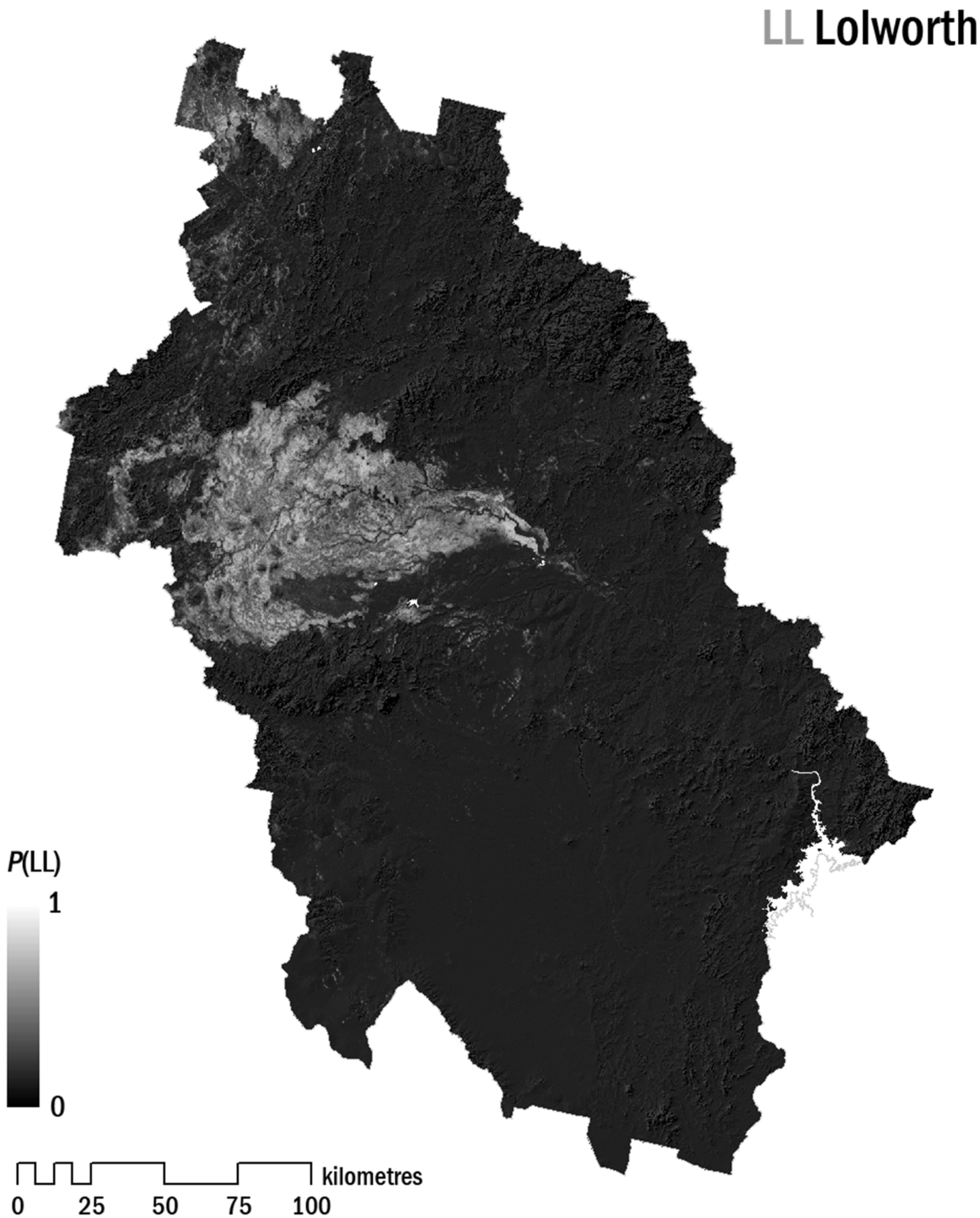



CG Carse O'Gowrie
P(CG)
1
0
kilometres
0
25
50
75
100

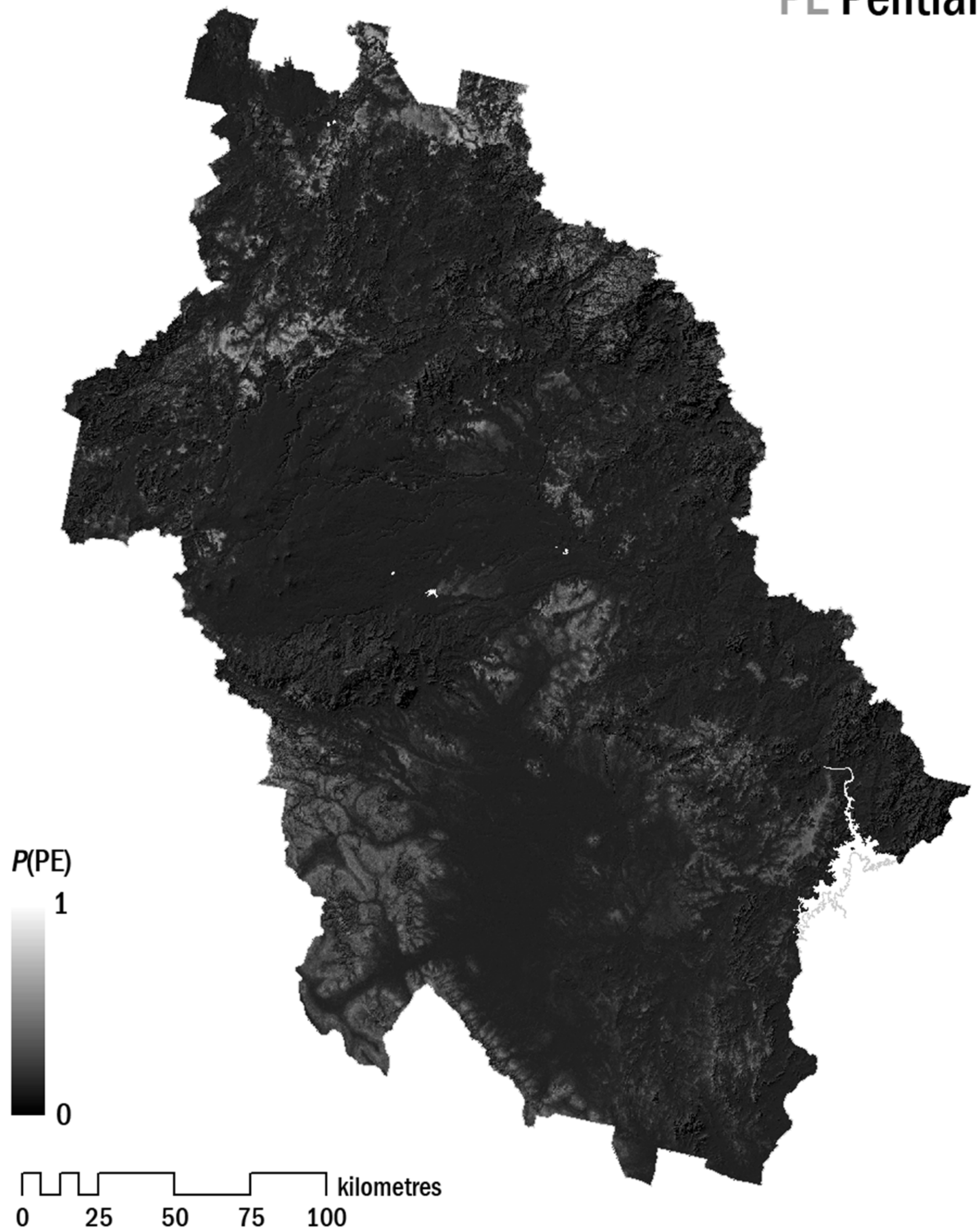
# CP Cape

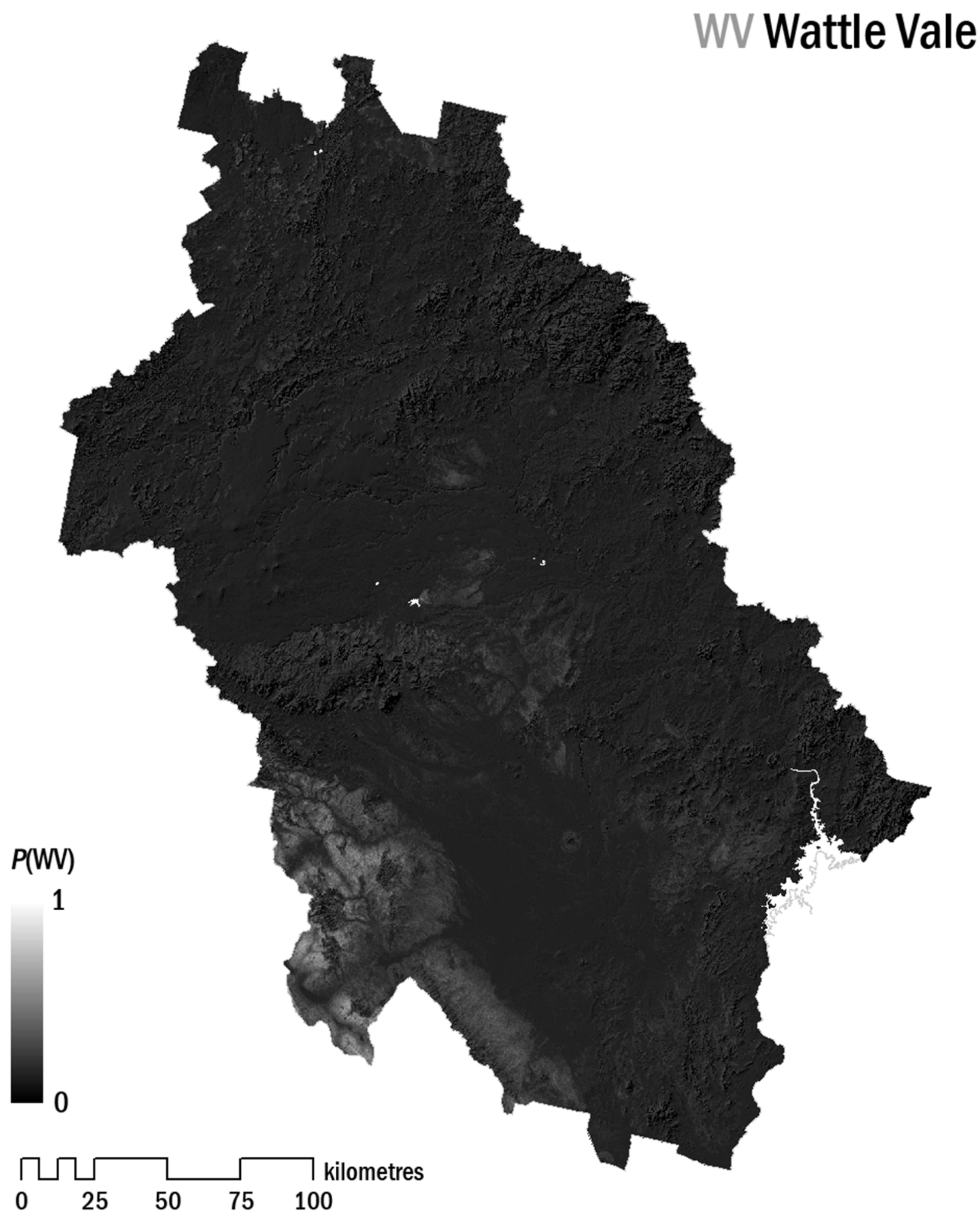


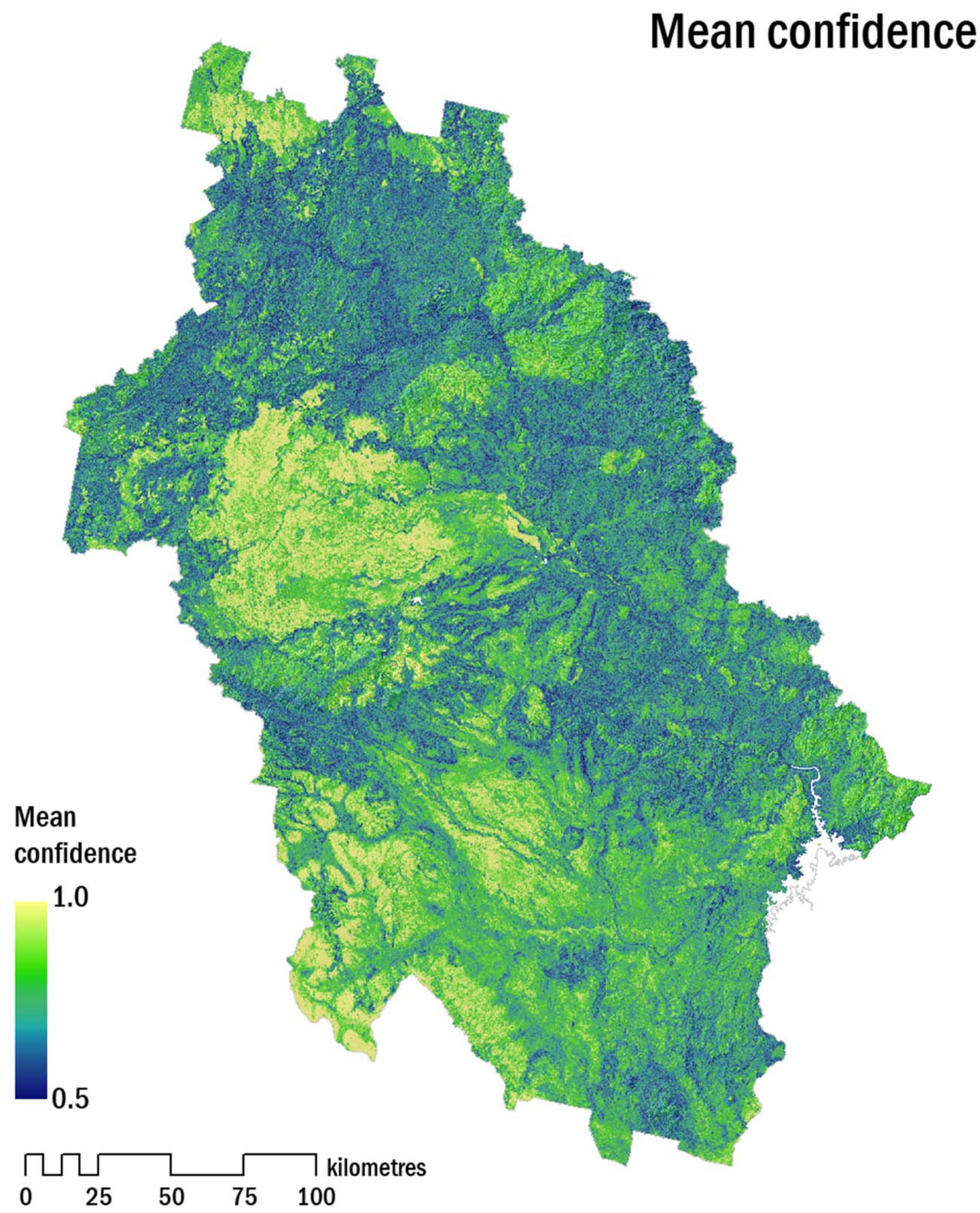

HG Hillgrove
P(HG)
1
0
kilometres
0
25
50
75
100


LL Lolworth
P(LL)
1
0
kilometres
0
25
50
75
100

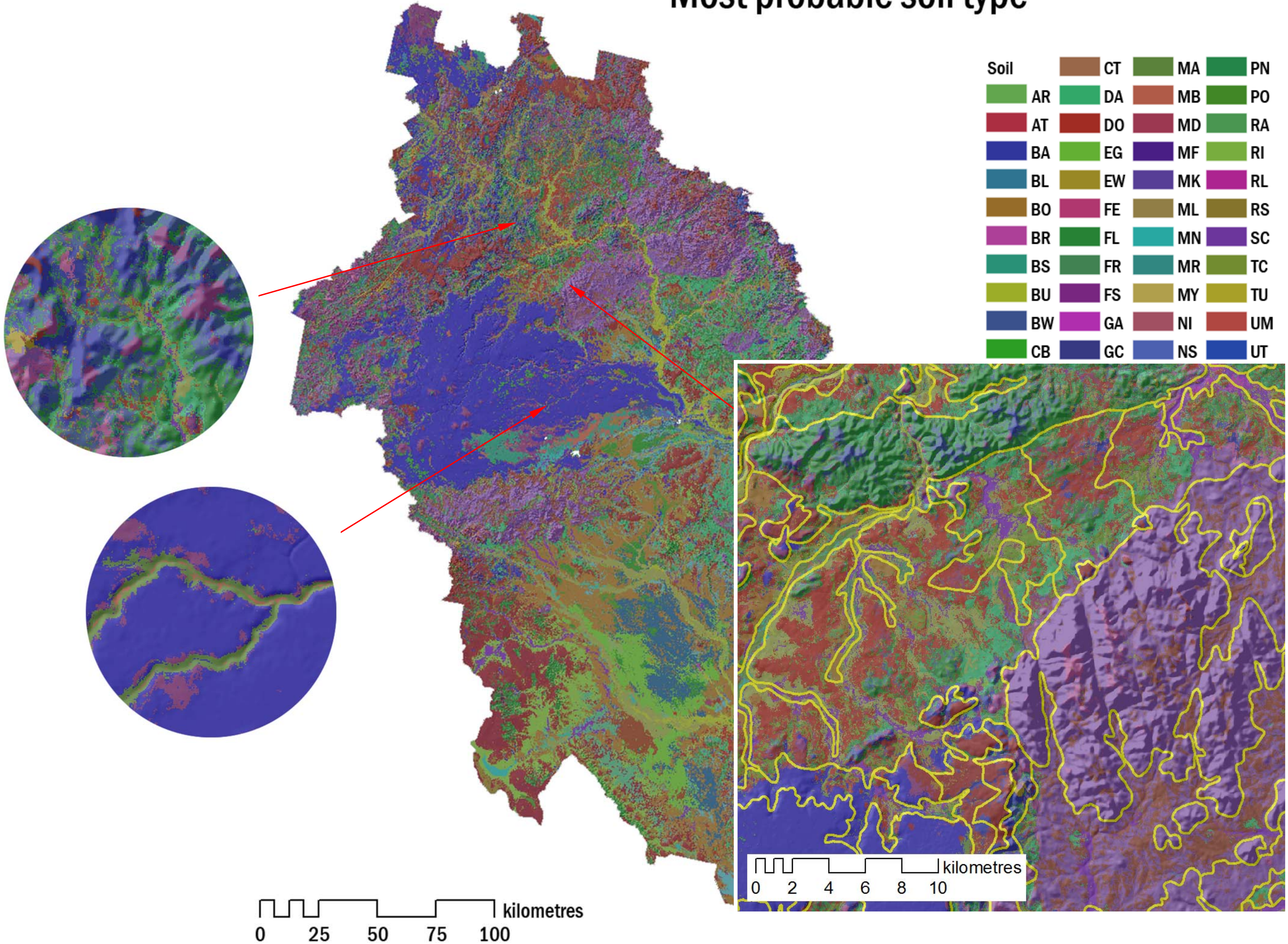
# PE Pentland




WV Wattle Vale
P(WV)
1
0
0
25
50
75
100
kilometres


Mean confidence
Mean
confidence
1.0
0.5
kilometres
0
25
50
75
100

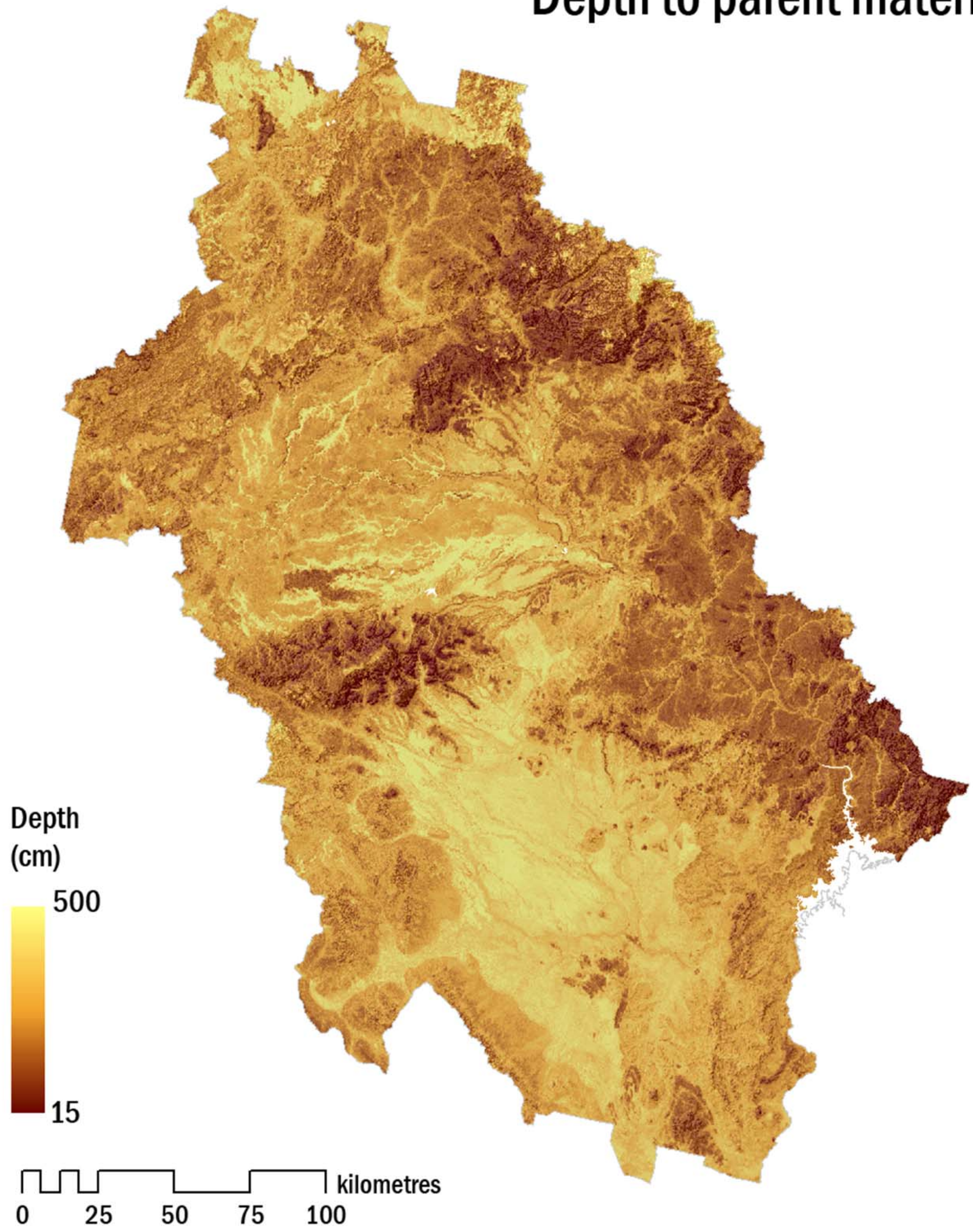
# Most probable soil type



# Soil property calculation

- (At each depth) perform a weighted mean calculation at each cell using soil class probabilities as weights
- **Depth to parent material** from soil profile descriptions
  - If absent, used lower boundary of deepest reported soil horizon
- **Soil pH** for each GlobalSoilMap depth increment from soil profile descriptions
  - 0-5, 5-15, 15-30, 30-60, 60-100, 100-200 cm

# Depth to parent material

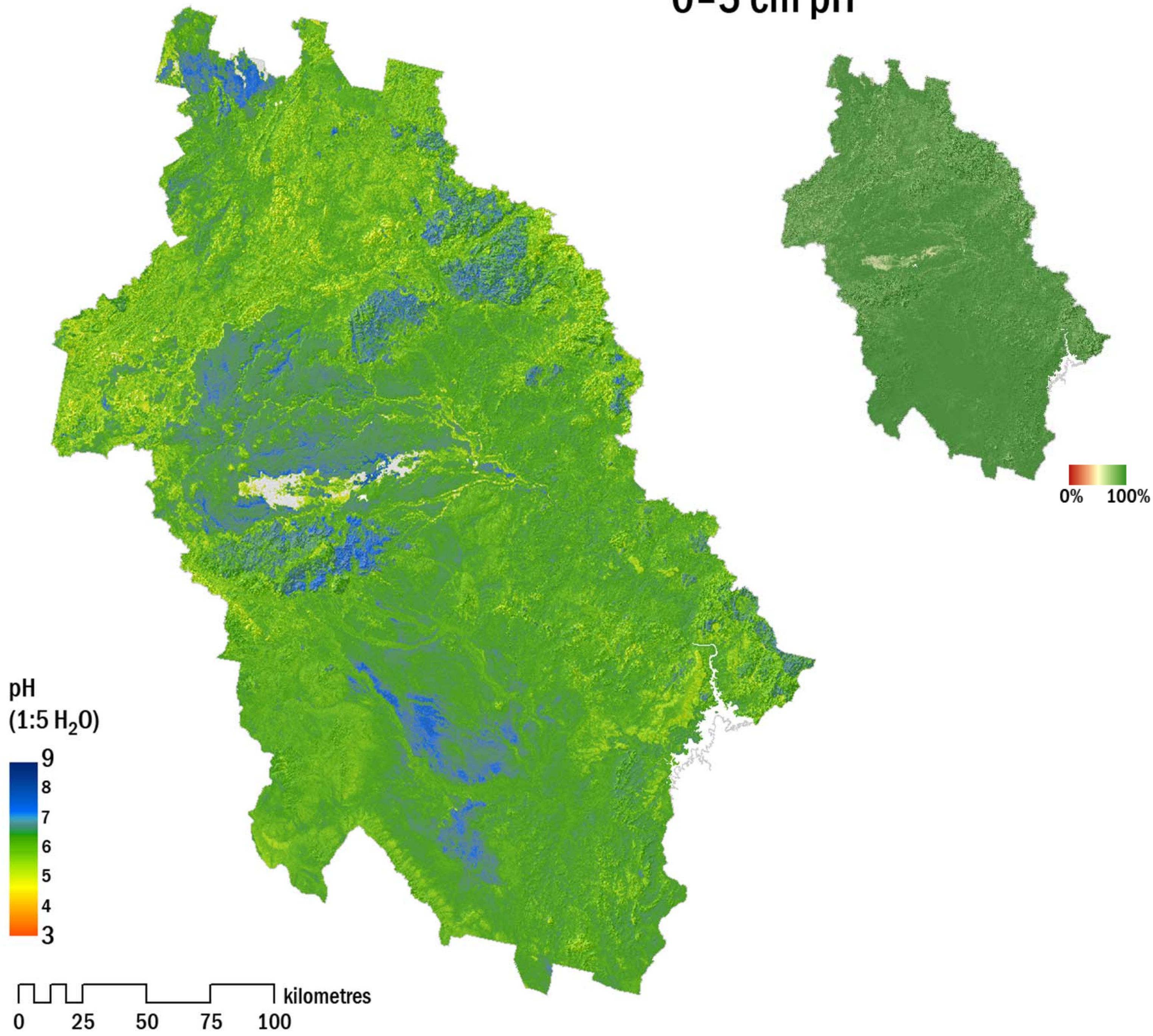


# Soil property calculation

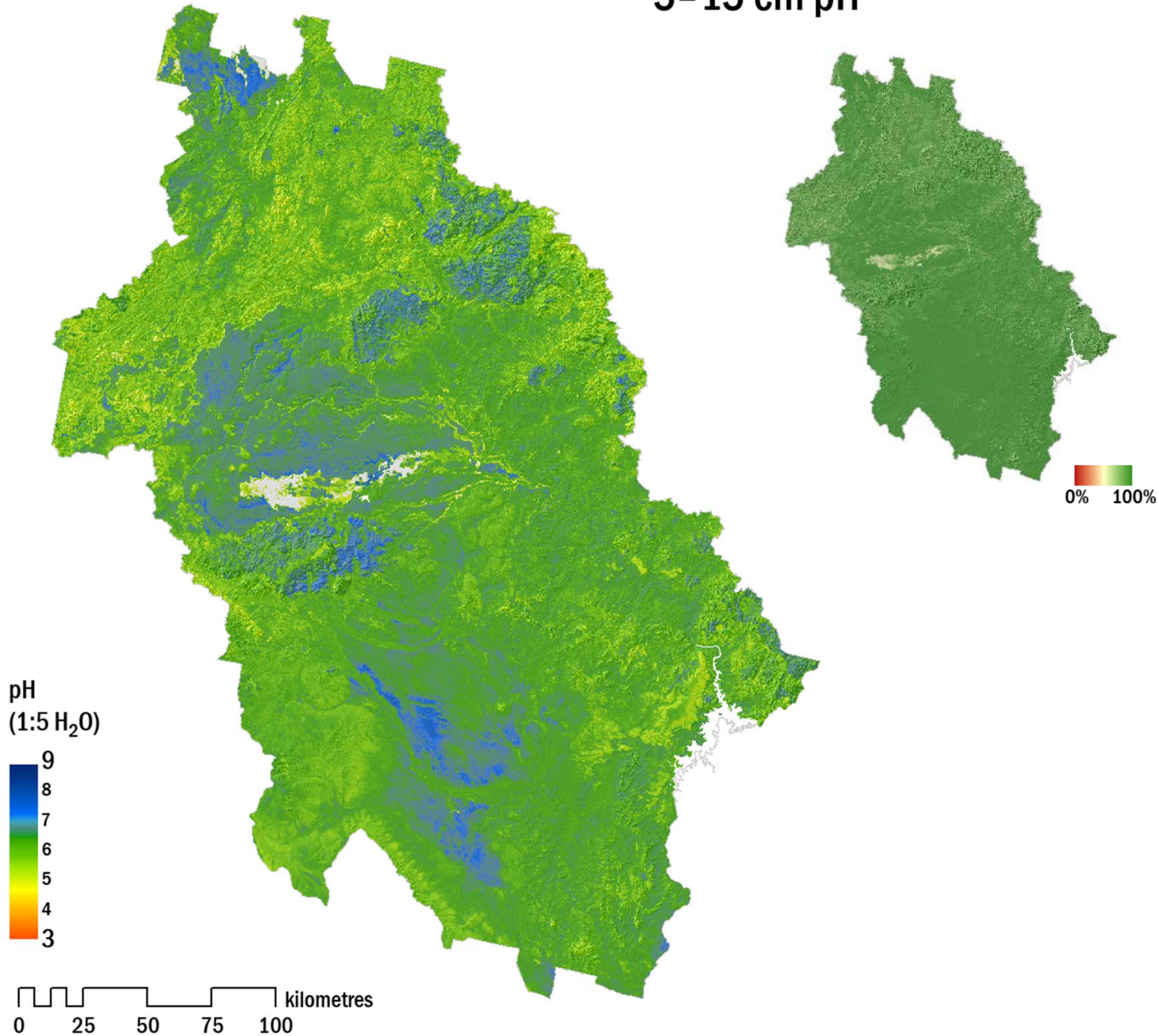
- **Soil pH** for each GlobalSoilMap depth increment:
  - Spline (modal) profiles to obtain pH estimates at GlobalSoilMap increments
  - Weighted mean of soil pH values using soil class probabilities as weights
  - Don't include soils that have missing data
    - Often 100–200 cm increment
    - 8 profiles with no pH data at all
  - Incomplete dataset results in unrealistic pH values (even if scaled)

  - For each depth increment:
    - Masked out cells where estimated depth to PM is shallower than depth increment
    - Masked out cells where cumulative probability of soils with property data is less than some threshold (here, used 70%)

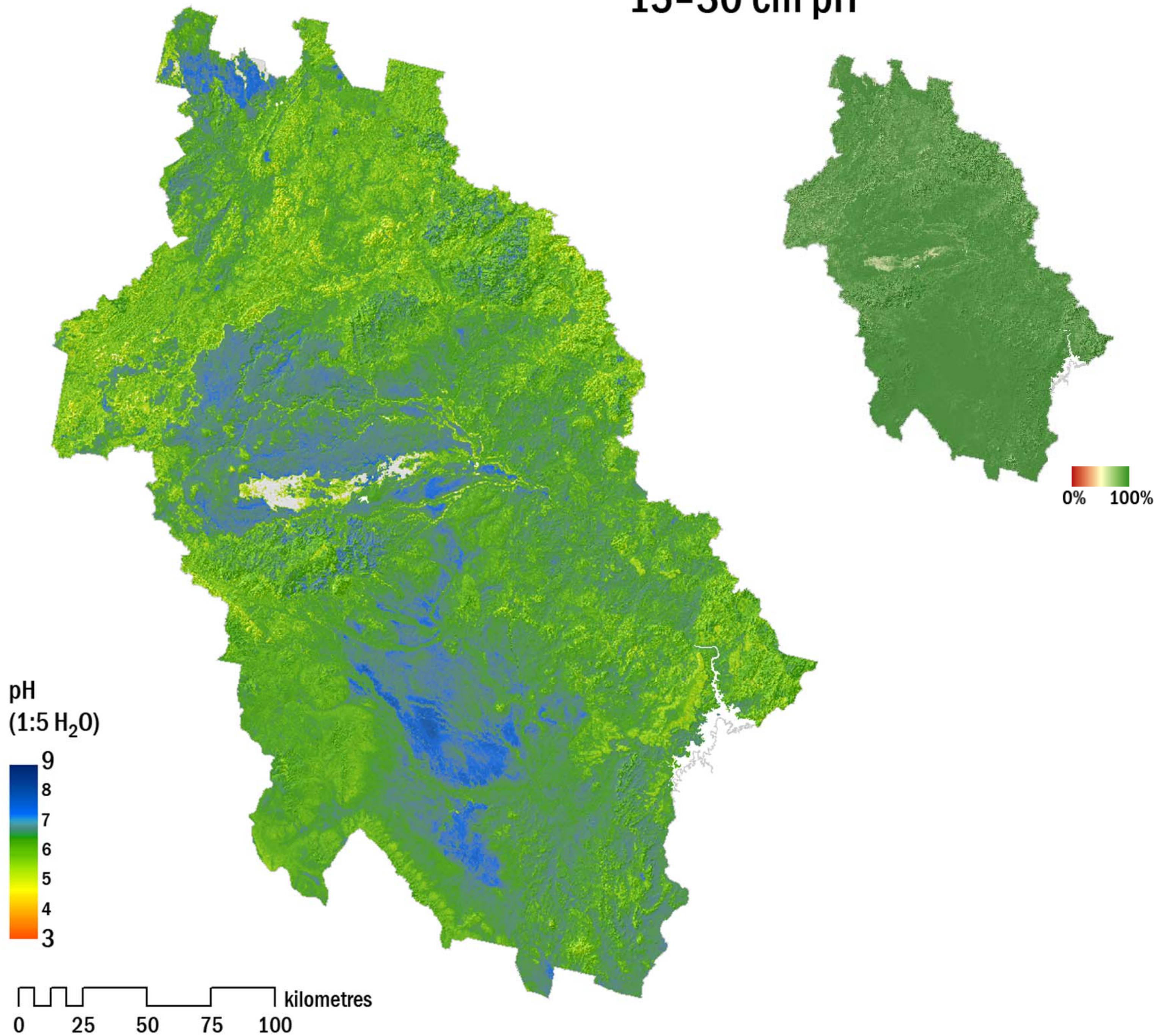
# 0–5 cm pH



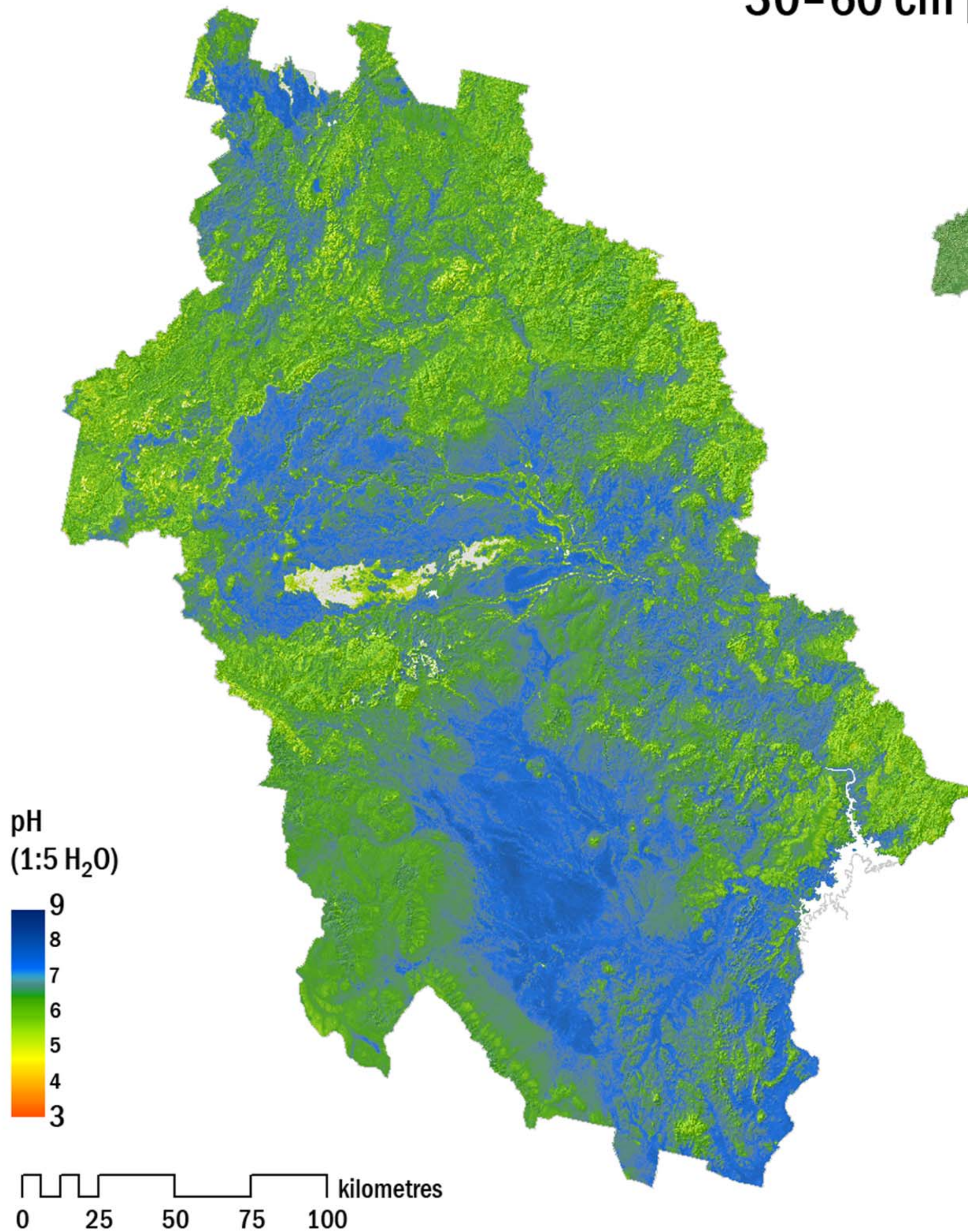
# 5–15 cm pH

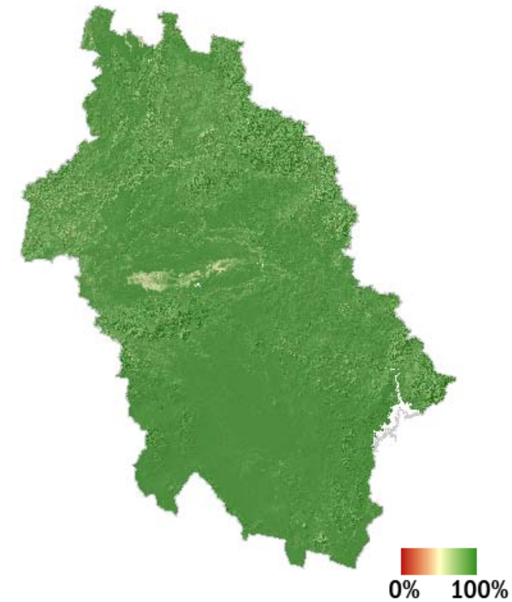


# 15–30 cm pH

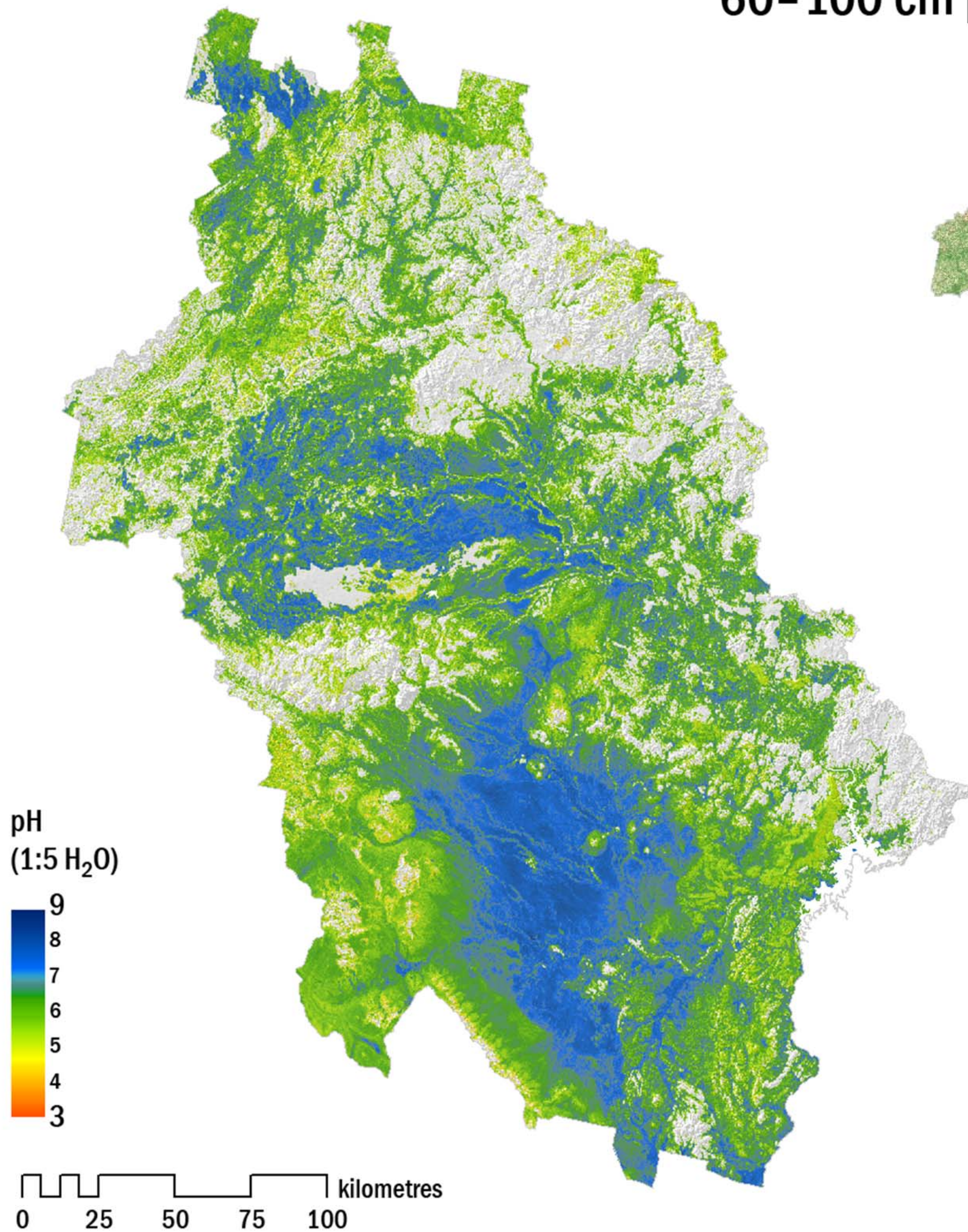


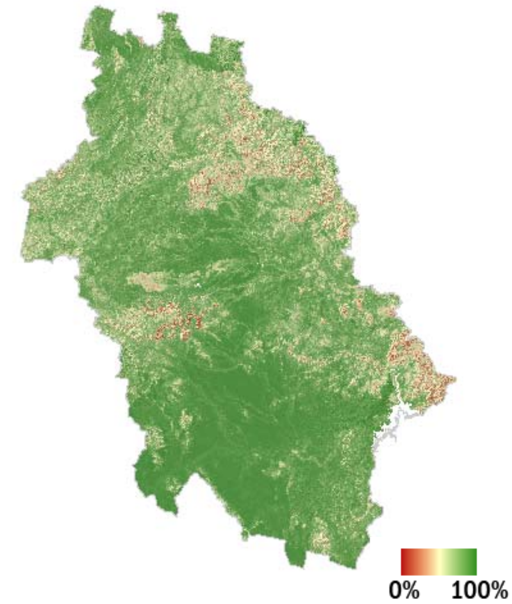
# 30–60 cm pH



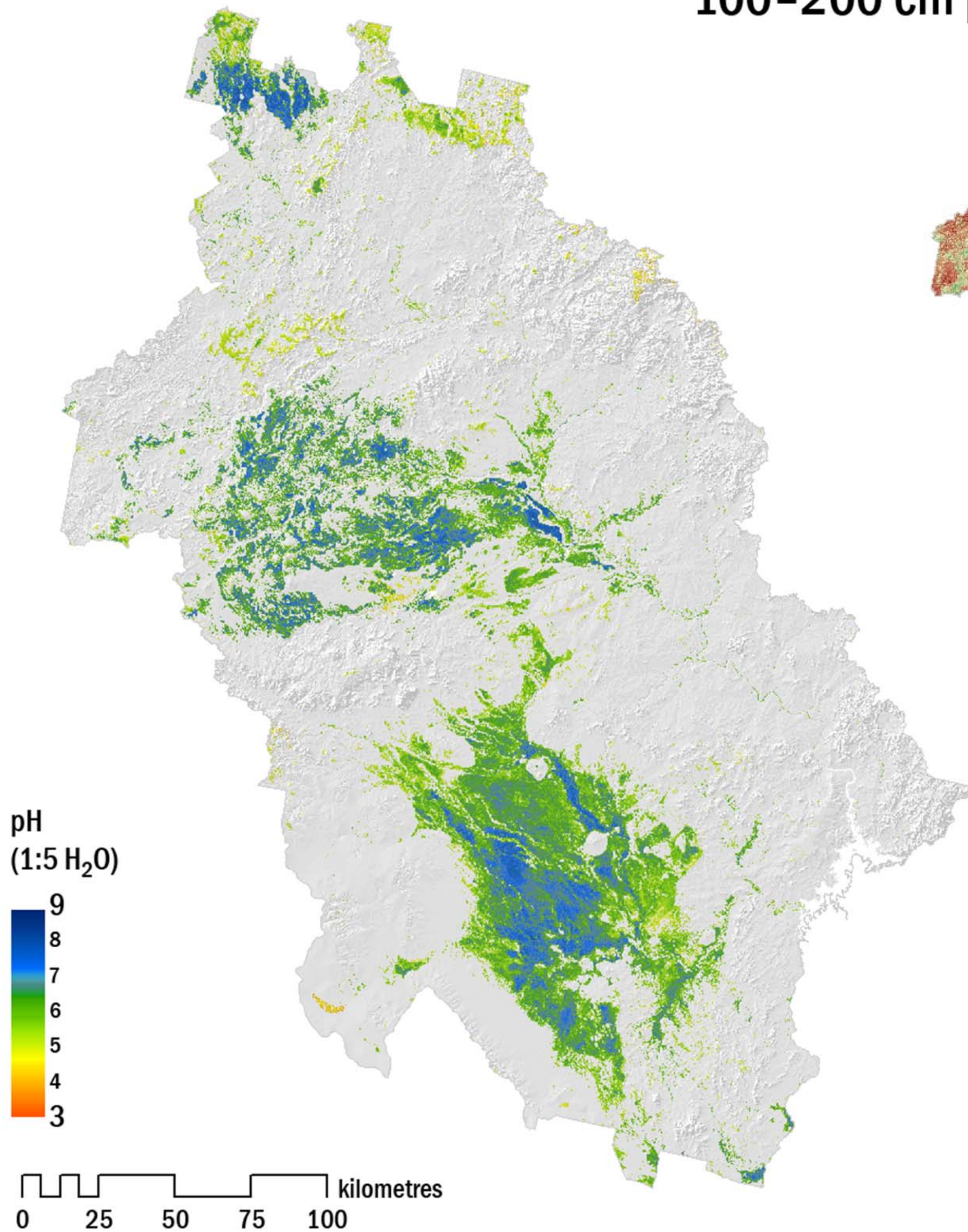



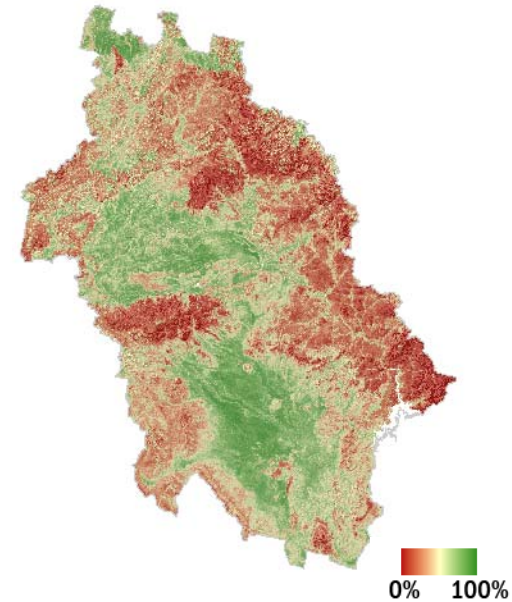
# 60–100 cm pH



# 100–200 cm pH



# Future work

- Sampling scheme
  - More samples per iteration → increase mean confidence? Capture more soil classes?
- Uncertainty for weighted soil property calculations

# Uncertainty

- Several unanswered questions:
  - Uncertainty in proportion of map unit that each soil occupies
  - (Map unit delineations)
  - Uncertainty of “most probable” soil
  - Uncertainty in input (modal) soil property values
  - Uncertainty in output soil property maps