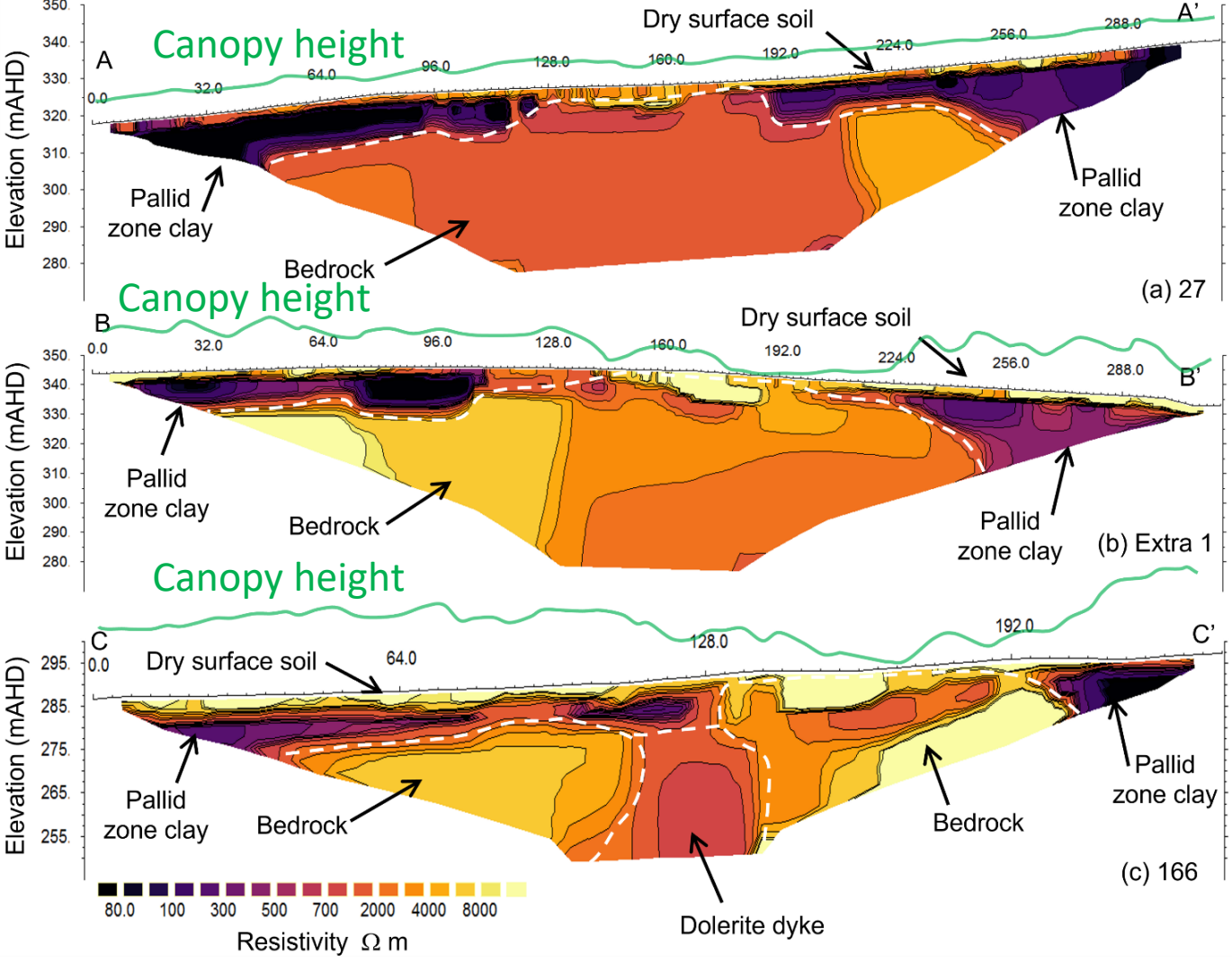
A gamma ray signature of forest die-off

Gavan McGrath[1,2,3], Joe Fontaine[4], Ricky Van Dongen[1], Diego Hernandez Villamil[1], Alannah Rowe[1], Lauren Hayles[1,] Katinka Ruthrof[1,4]

1. Department of Biodiversity Conservation and Attractions
2. UWA School of Earth and Environment
3. School of Earth and Planetary Sciences, Curtin University
4. School of Environmental and Conservation Sciences, Murdoch University, Murdoch

Drought and heatwave die-off event 2009/2010

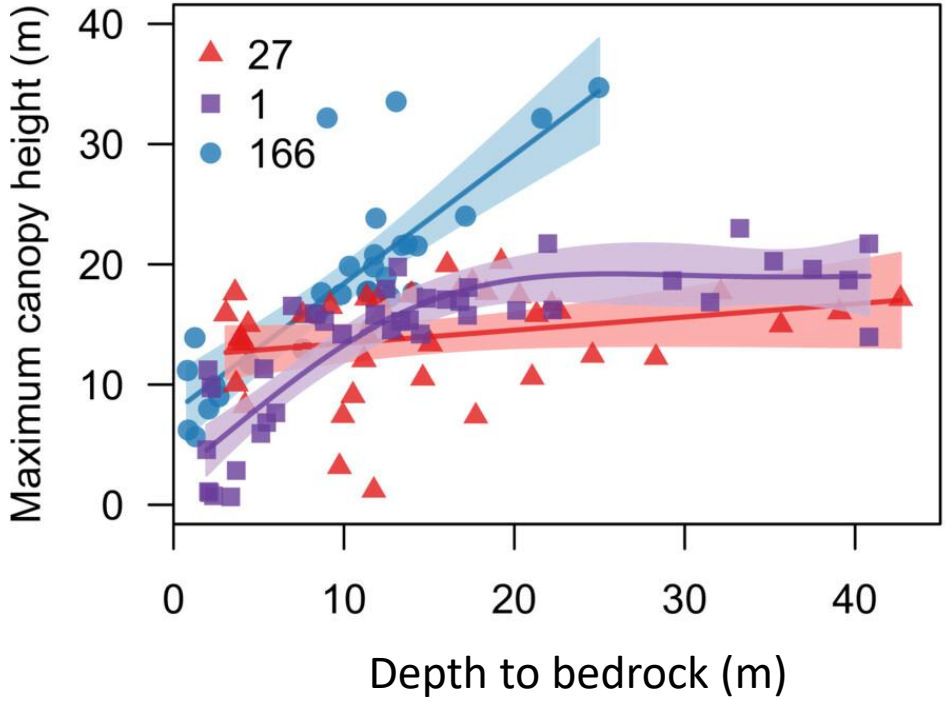


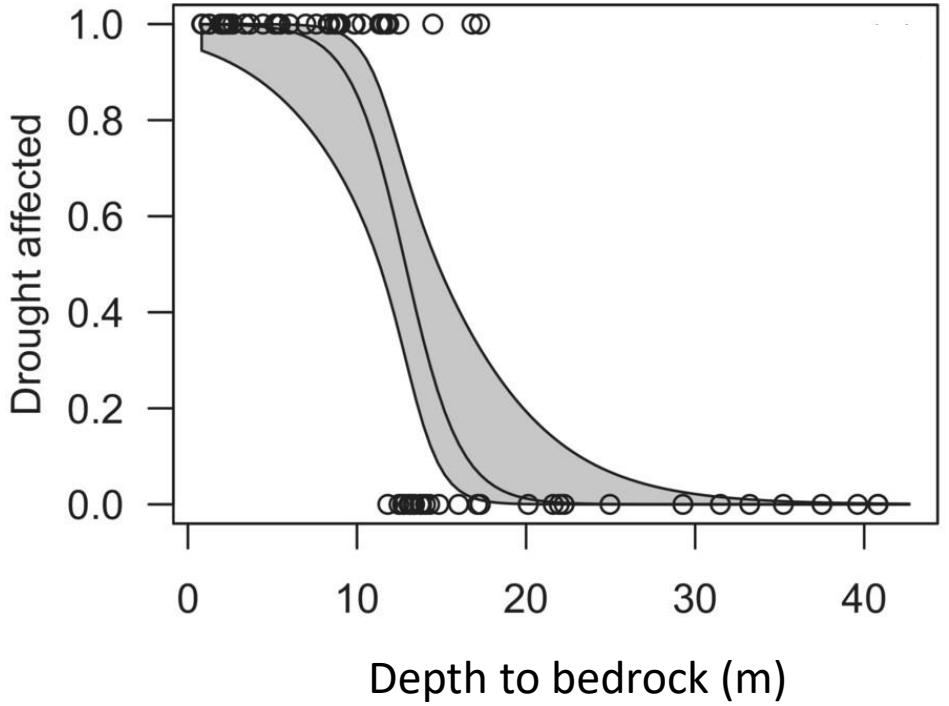
Geophysics reveals vulnerability

- Common subsurface all sites.
- Shorter, drought affected forest over shallow bedrock.

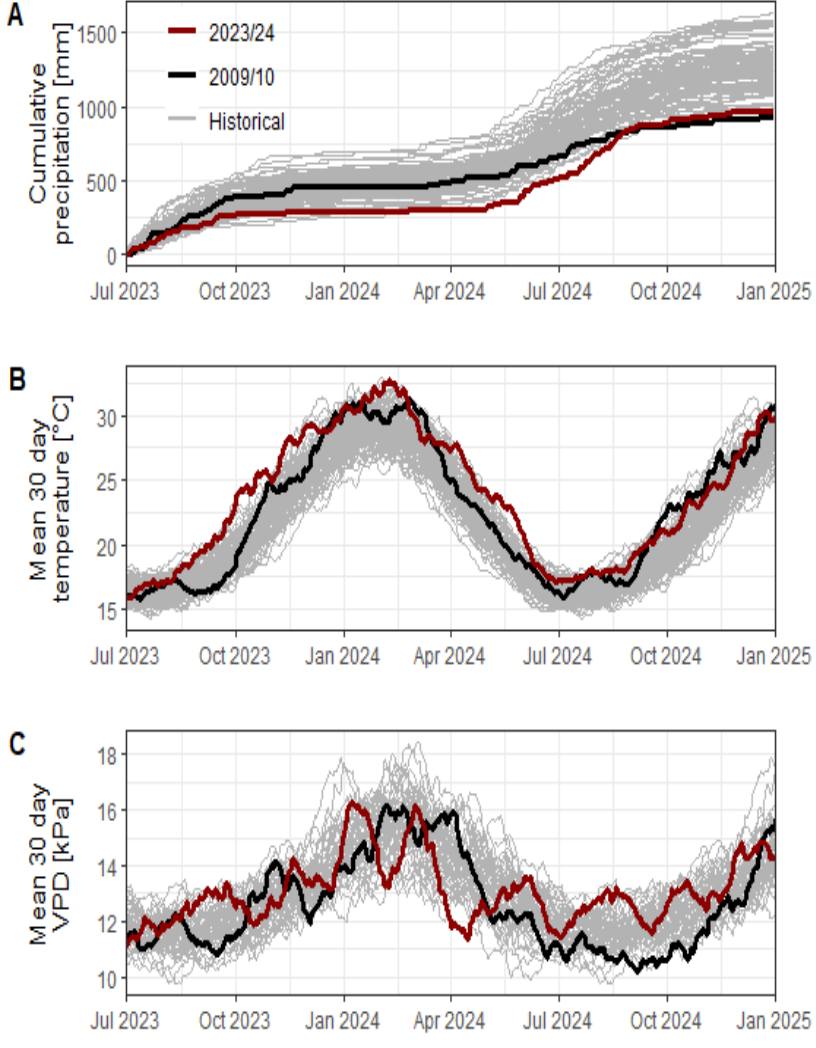
McGrath et al., (2023) Ecohydrology

Critical regolith thickness ~ 12m





2023/2024 die-off event



Fears of another 'forest collapse' event in Western Australia after record dry spell

By Briana Shepherd | Stateline | Water

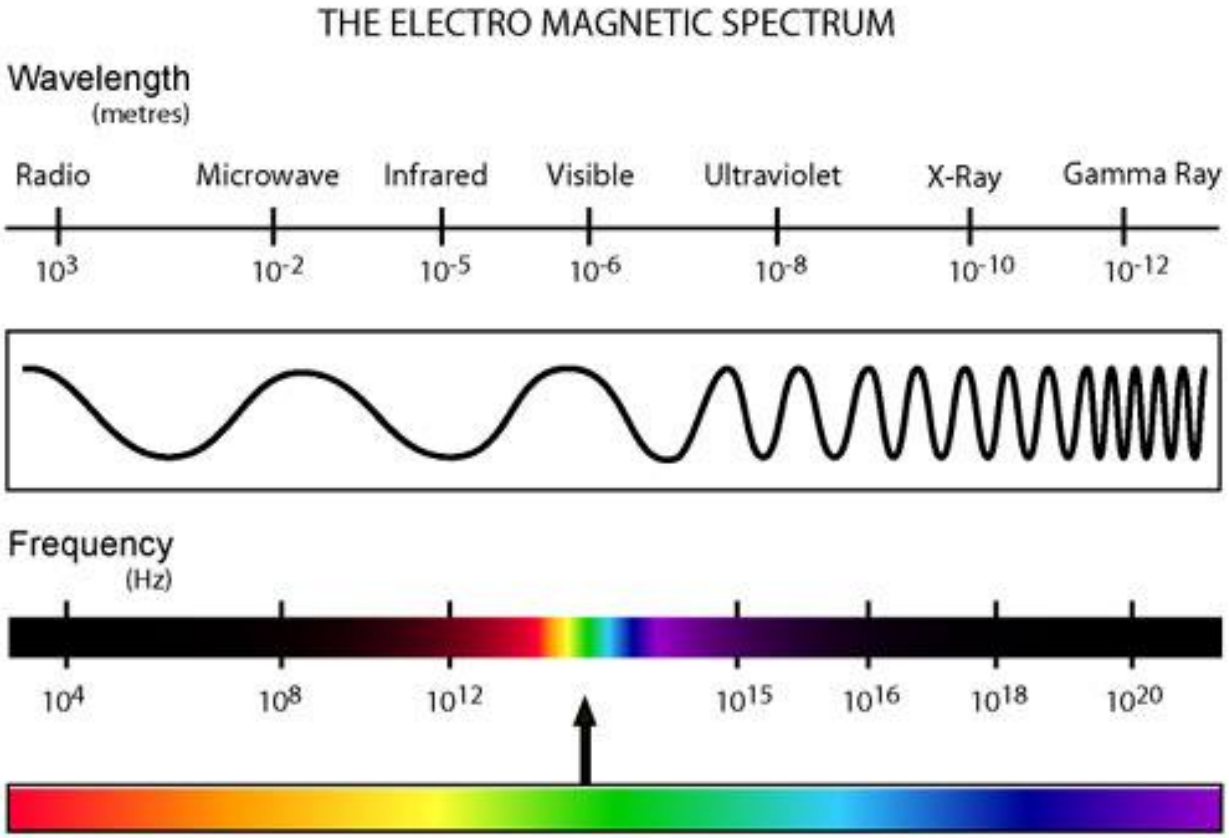
Thu 11 Apr 2024

There are fears WA's record dry spell could lead to another 'forest collapse' event, which the state last suffered more than a decade ago.

Challenge of scaling vulnerability assessment

- “Soil depth data” not reliable
- Geophysics requires investment and research to scale up
- Forest structure/quality metrics are subjective/coarse
- The forest is non-stationarity!
  - Future climate
  - Legacy human impacts

Gamma Rays
May Help



Gamma rays

High energy electromagnetic radiation

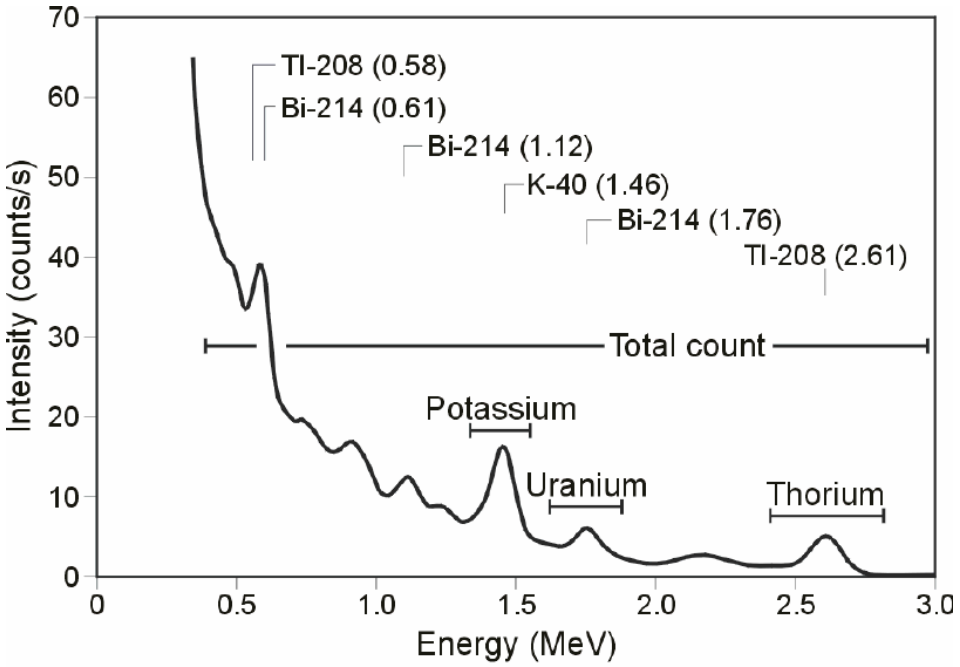
Gamma rays from natural radio isotope decay

Gamma rays emitted

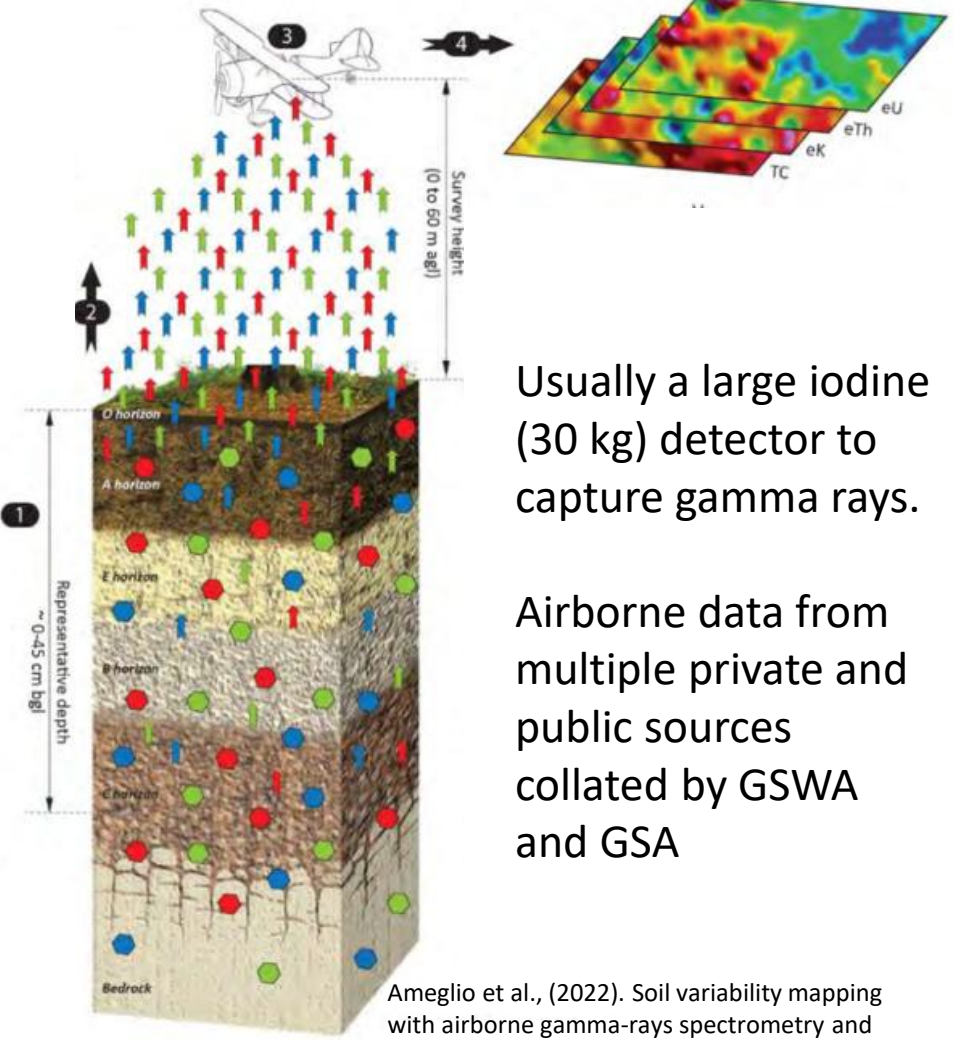
^{40}K -> ^{40}Ar

^{232}Th -> intermediaries -> ^{208}Pb

^{238}U -> intermediaries -> ^{207}Pb, ^{206}Pb

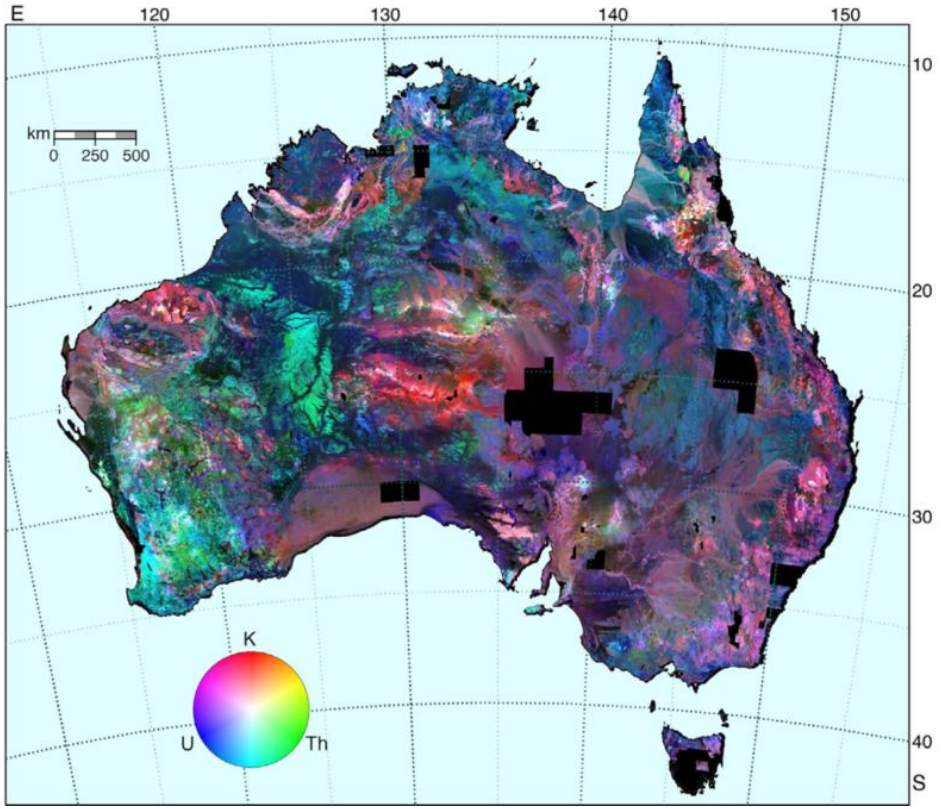


Radiometric measurements



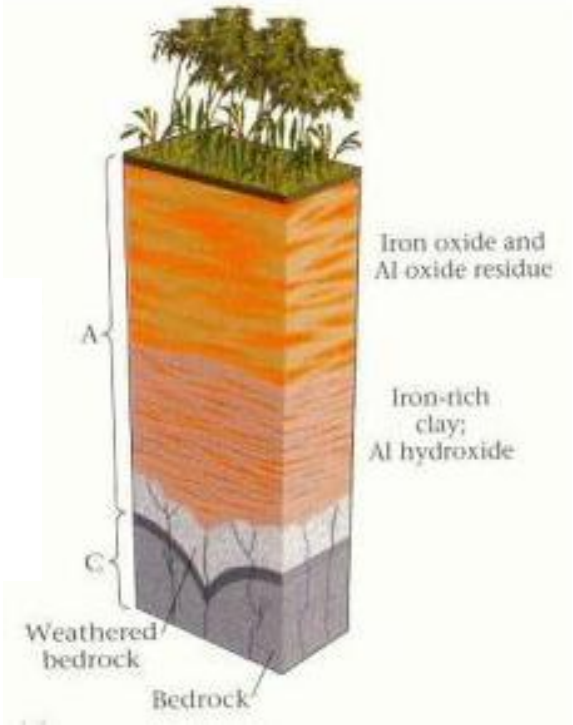
Usually a large iodine (30 kg) detector to capture gamma rays.

Airborne data from multiple private and public sources collated by GSWA and GSA

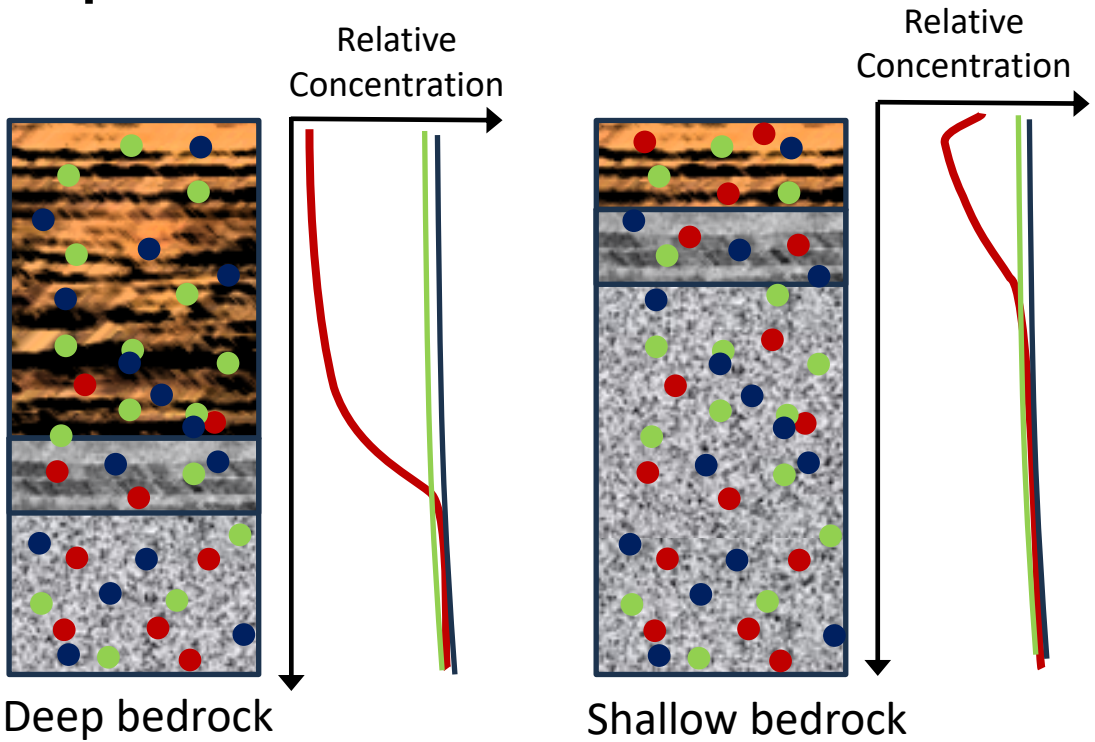


Ameglio et al., (2022). Soil variability mapping with airborne gamma-rays spectrometry and magnetics.

Laterite



Depth to bedrock & K, Th, U



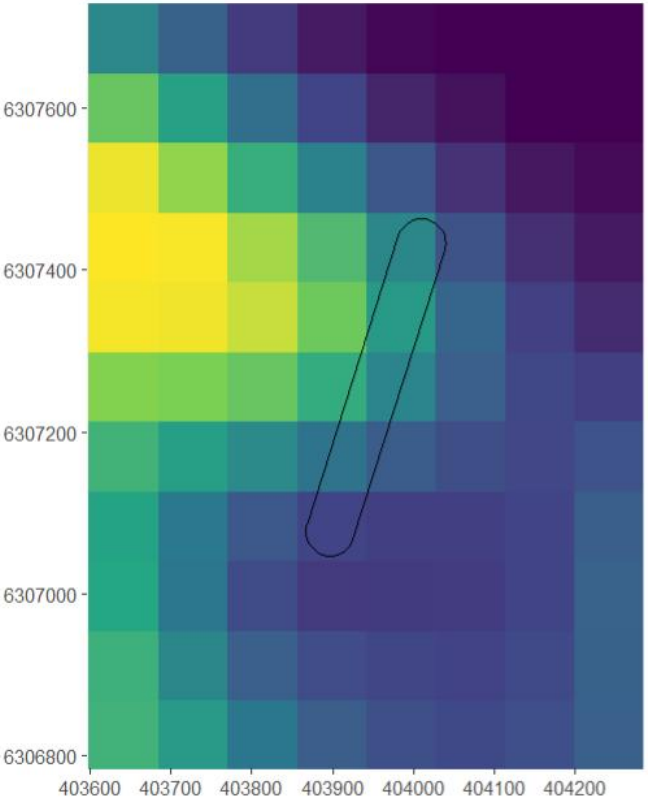
www.slideserve.com/xarles/chapter-5-weathering-and-soil

Methods

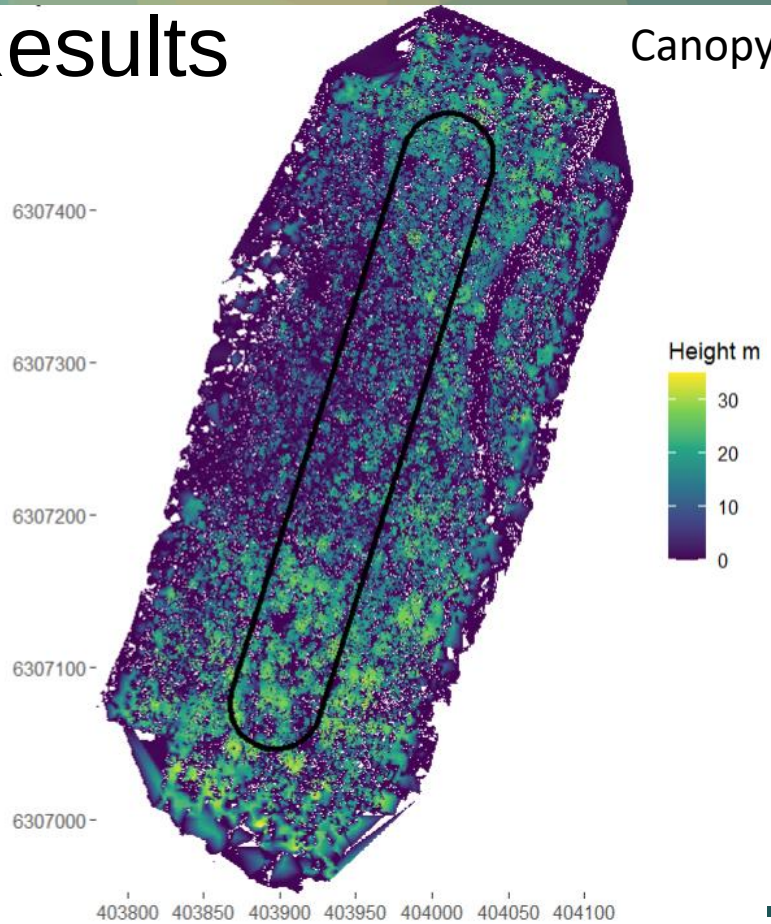
- Regional drought impact assessment
  - Remote sensing
  - On-ground health assessment during die-off event
  - Developed/validated across forest types
- Intensive site assessments
  - On-ground geophysics
  - RPA spectral/LiDAR surveys
  - Transects across potassium & die-off gradients
- Regional spatial statistical models

Results

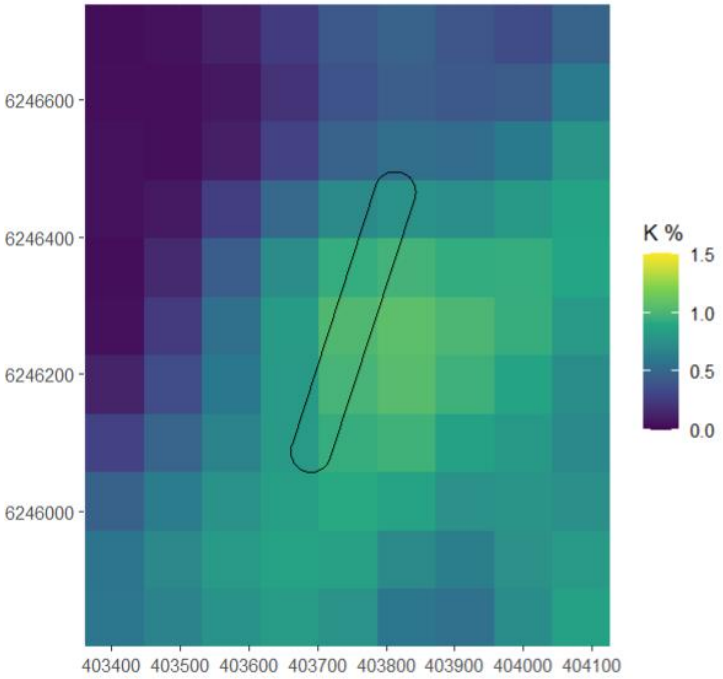
Radiometric potassium



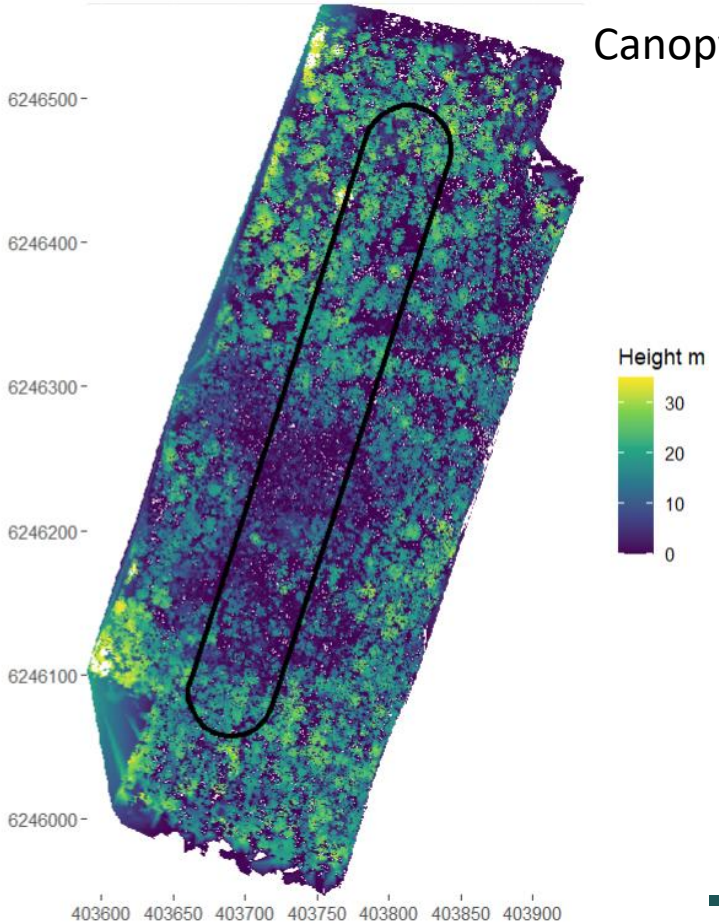
Canopy height

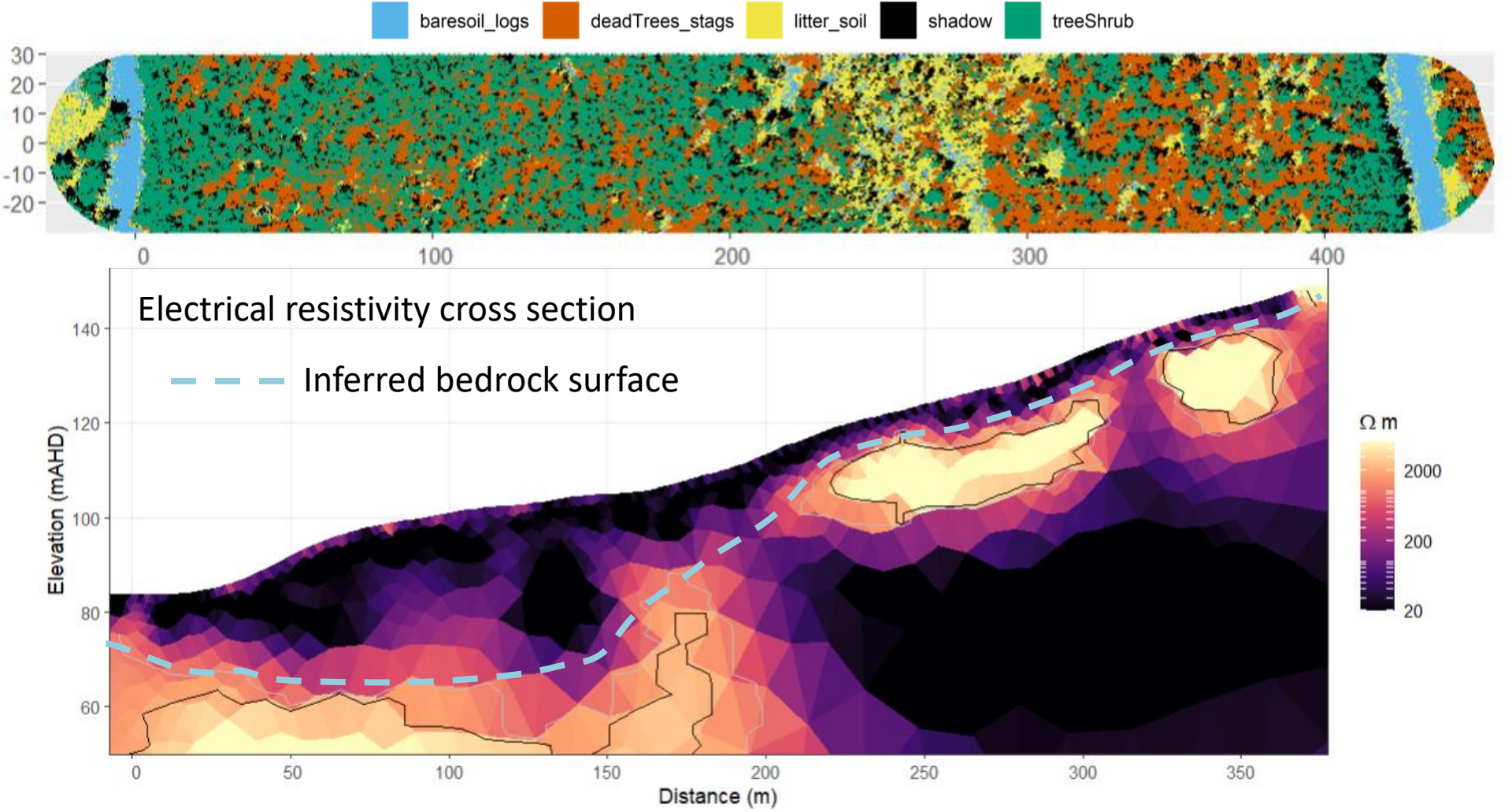


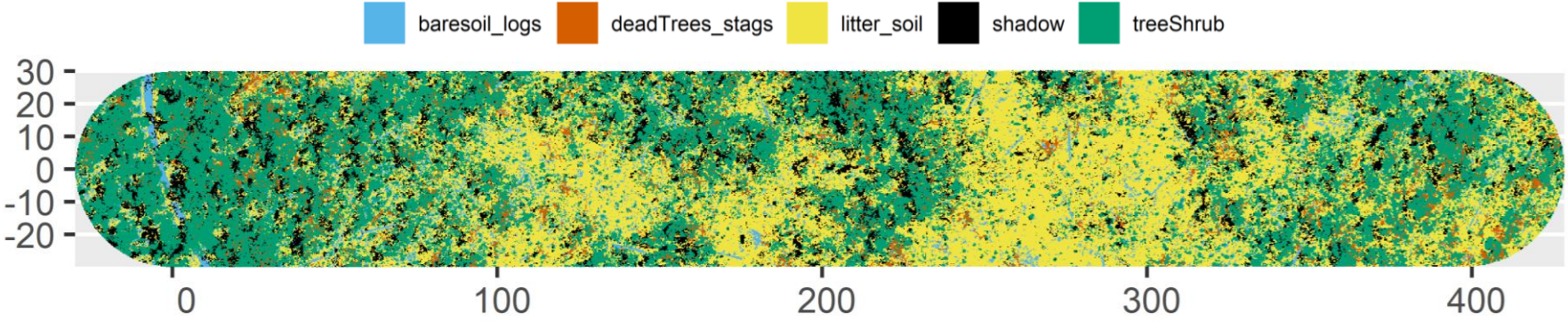
Radiometric potassium



Canopy height




baresoil_logs
deadTrees_stags
litter_soil
shadow
treeShrub
30
20
10
0
-10
-20
0
100
200
300
400
Electrical resistivity cross section
Inferred bedrock surface
140
120
100
80
60
Elevation (mAHD)
0
50
100
150
200
250
300
350
Distance (m)
Ω m
2000
200
20


baresoil_logs
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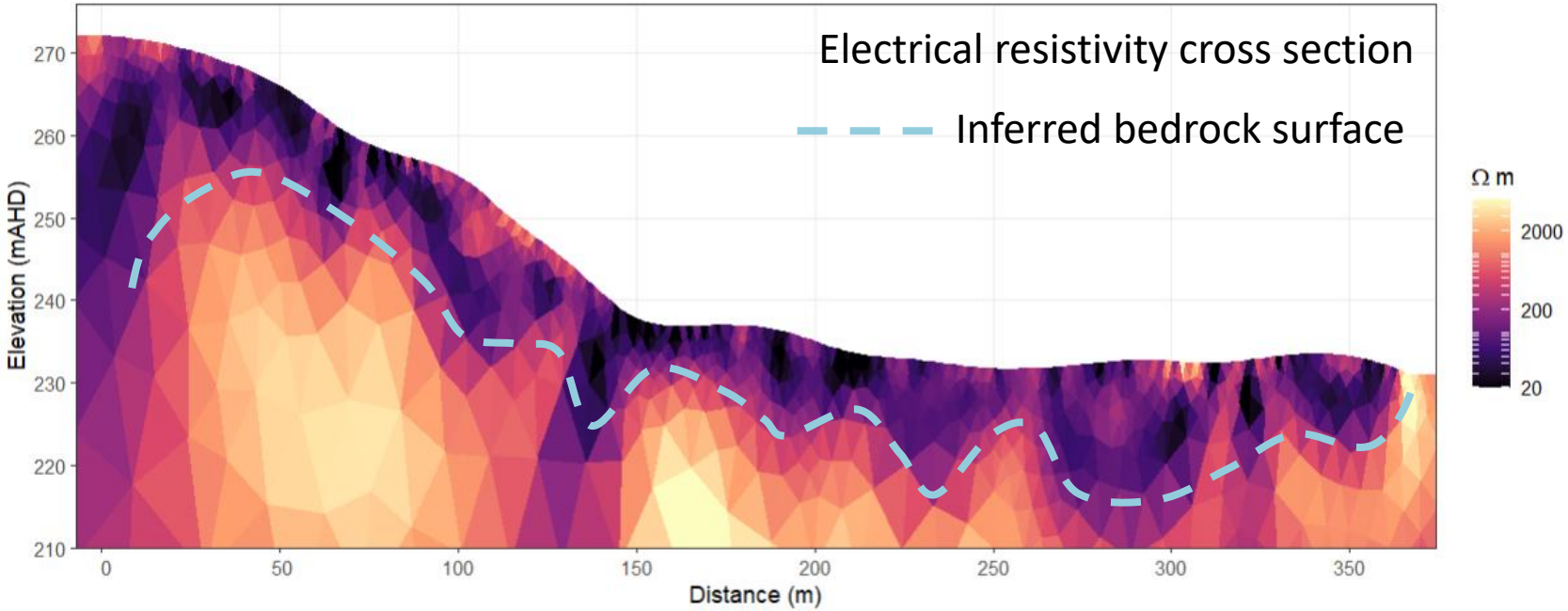
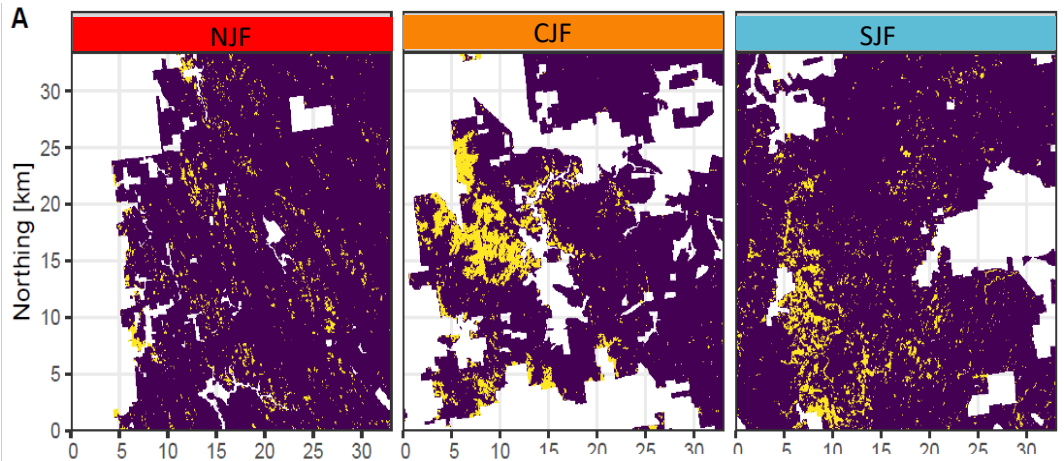
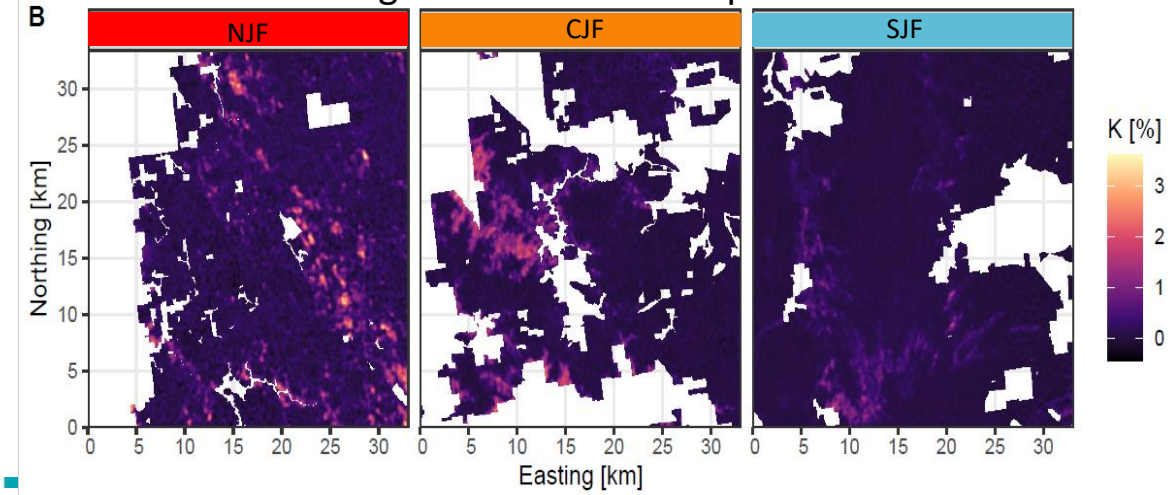

Electrical resistivity cross section
Inferred bedrock surface
Elevation (mAHD)
270
260
250
240
230
220
210
0
50
100
150
200
250
300
350
Distance (m)
Ω m
2000
200
20

Potassium maps forest die-off

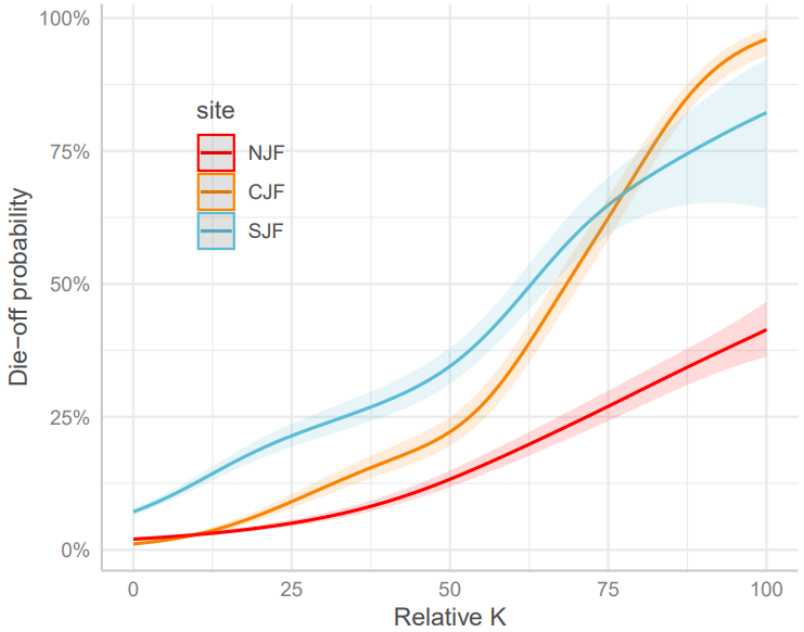
A satellite derived die-off index

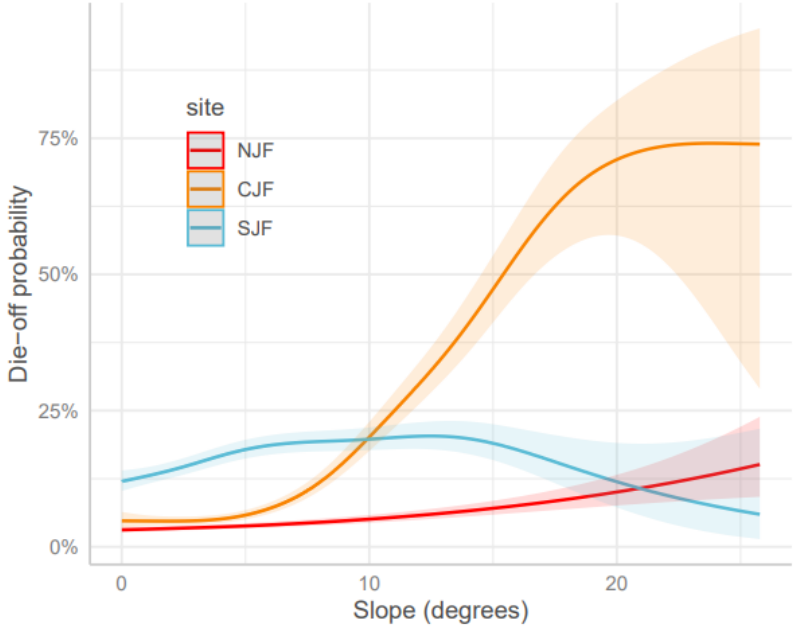


Airborne gamma radiometric potassium



Spatial predictors



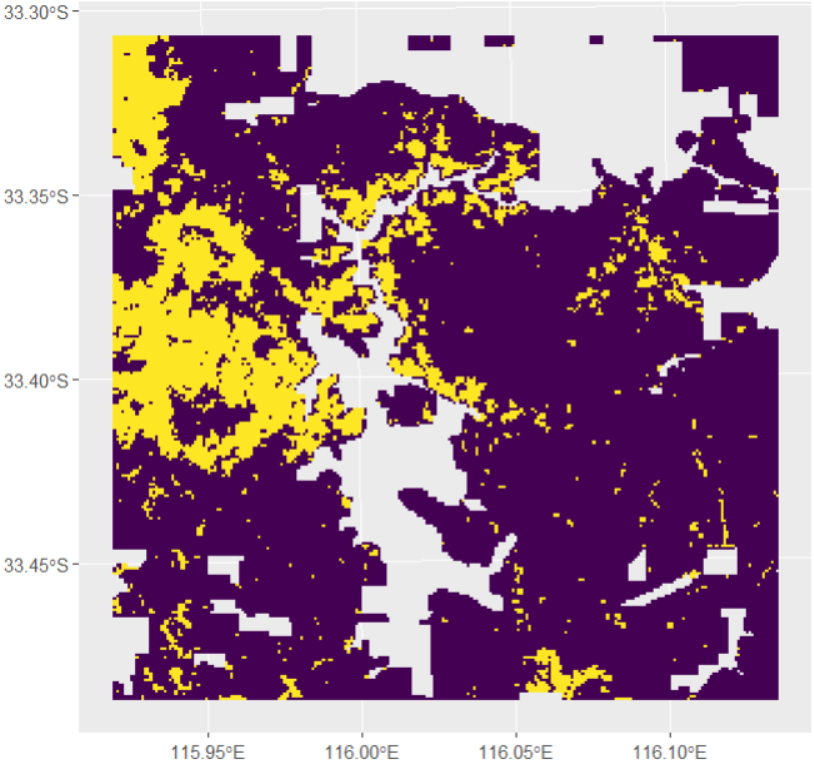


Potassium > Slope >> Aspect > Stream distance > other geomorphic variables

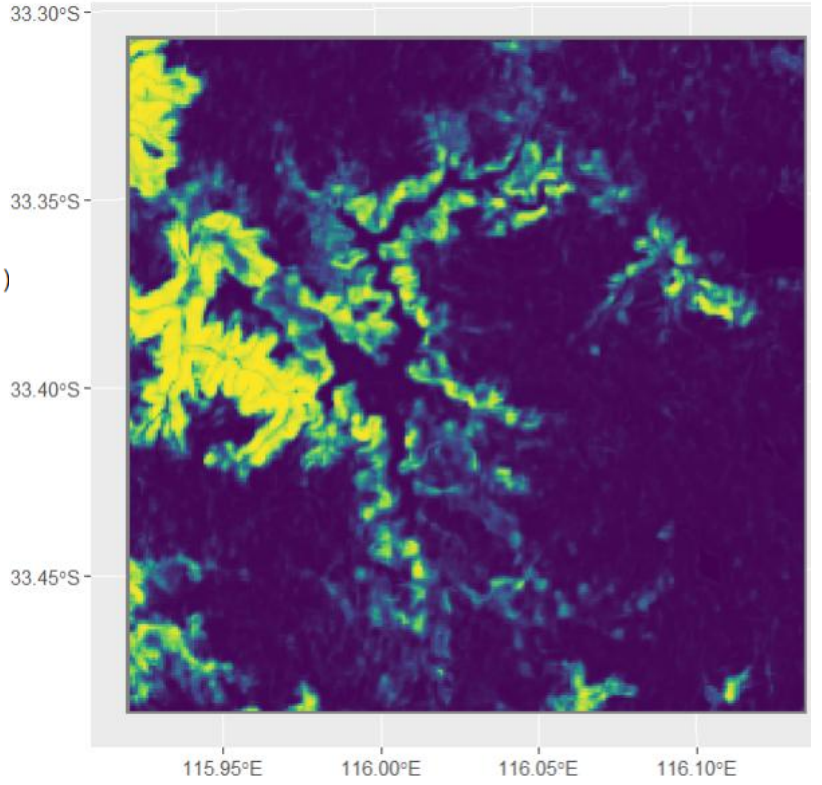
Northern Jarrah Forest has weaker response than Central and Southern Jarrah forests

Spatial predictions of die-off

Observed



Modelled



Conclusions and Outlook

- K predicts
  - the presence of shallow bedrock
  - areas of forest vulnerable to drought
  - forest structural responses to water limitation
- Currently putting final numbers on K effects
- Upcoming
  - What does forest structure say about bedrock?
- Adaptive forest management
  - e.g. can ecological thinning mitigate impacts?


Thank you