Relationships between geodiversity and vegetation in southeastern Australia

David Keith,
- NSW Dept. Environment, Climate Change & Water
- University of NSW
Landscape patterns in geodiversity & biodiversity

Non-random association between vegetation and geological substrates

Early phytosociological studies                   Modern biogeographical theories

Brough et al. (1924) - contrasting vegetation on basalt & sandstone at Mt Wilson

Fraser & Vickery (1939) - contrasting vegetation on basalt & granodiorite at Barrington Tops
Landscape patterns in geodiversity & biodiversity

Mechanism - substrates influence availability of essential plant resources:
- mineral nutrients
- soil moisture
- soil oxygen

Compositional & structural features of geological substrates are critical:
- weathering
- permeability
- soil texture
- soil fertility
- soil depth
Understanding the role of geodiversity in sustaining biodiversity

Biodiversity conservation depends on geodiversity conservation
- Resolving geodiversity-biodiversity relationships
- Understanding geological constraints on biodiversity response to climate change
Understanding the role of geodiversity in sustaining biodiversity

Aim:

- To explore the strength and nature of association between vegetation types and substrate types at bioregional scales

Maps provide a means to examine:

- fidelity of vegetation types to substrate types
- influence of substrate on vegetation relative to other environmental factors (e.g. climate)
  - relative strength of geological & climatic influences
  - independence of geological & climatic influences
- geological influences on vegetation under climatic change
Preparing subcontinental-scale maps of substrate and vegetation

1. Available spatial data sets
   - Geological survey of NSW 1:250k scale series
   - Ensemble of regional & local veg maps (1:25k -1:1m scale)

2. Reclassification of map units (generality cf. precision)
   - 218 geological units assigned to 16 ‘plant substrate types’
   - >1000 vegetation units assigned to 16 vegetation formations (contrasting structural, physiognomic & functional features), 100 vegetation classes (contrasting species composition)
Substrate types

Groups of lithological units that produce soils with contrasting ranges of mineral composition, texture/porosity and profile depth.
Vegetation formations

Groups of plant communities with contrasting structural, physiognomic & functional features

- Semi-arid woodlands (Shrubby)
- Grassy woodlands
- Semi-arid woodlands (Grassy)
- Arid shrublands (Acacia)
- Arid shrublands (Chenopod)
- Dry sclerophyll forests (Shrubby)
- Dry sclerophyll forests (Shrub/grass)
- Grasslands
- Wet sclerophyll forests (Grassy)
- Forested wetlands
- Wet sclerophyll forests (Shrubby)
- Freshwater wetlands
- Rainforests
- Heathlands
- Alpine complex
- Saline wetlands

Extent (% of NSW)
Vegetation classification - formations
Construction of vegetation map

- Each legend category of each source map assigned to a regional class
- Primary criterion: floristic similarity (shared spp)
- Regional classification adjusted when multiple source maps suggest alternative arrangement
- Spatial integration
Vegetation classes

• Broad groupings of plant communities that share overall floristic similarity (i.e. shared species)

• 100 vegetation classes assigned to formations according to most common structural form

• Floristic descriptions allow analysis of relationships
Floristic relationships between vegetation classes & formations
How many substrates does each vegetation formation occupy?

- Most vegetation formations are primarily restricted (>90% distribution) to fewer than 5 of the 16 substrate types.
- Number of substrates occupied was unrelated to formation extent.
- Grassy wet sclerophyll forests occupy the broadest range of substrate types (6).
- Heathlands, Estuarine Wetlands & Arid (chenopod) Shrublands occupy the narrowest range of substrate types (2).
How many vegetation formations occupy each substrate type?

- Most substrate types (>90% distribution) support fewer than 5 of the 16 vegetation formations
- Number of substrates occupied was unrelated to formation extent
- Estuarine sediments had a single vegetation formation
- Low-quartz sedimentary lithologies had the greatest range of vegetation formations (7)
How many vegetation classes occupy each substrate type?

- Most vegetation classes (>90% distribution) occur on fewer than 5 of the 16 substrate types

- 20 classes occur on 1-2 substrates

- note sampling error

Sthn Tablelands WSF
- mafic volcanics
- felsic volcanics
- felsic intrusives
- low quartz sediments
- high quartz sediments

West Slopes Grassy WLs
- mafic volcanics
- felsic volcanics
- low quartz sediments
- ultramafics

Subtropical Rainforests
- mafic volcanics
- floodplain alluvium

Saltmarshes
- estuarine sediments
Other sources of environmental variation: climate

Climates vary from subtropical to cool temperate to alpine to arid.
How much floristic variation between vegetation classes is attributable to substrate and climate?

- **Canonical Correspondence Analysis**
  - series of constrained & unconstrained ordinations
  - floristic variation partitioned between substrate & climate matrices

- Substrate & climate account for independent components of floristic variation (2% overlap)

- Substrate accounts for more floristic variation than climate
Floristic ordination constrained by substrate & climate

- Two independent climatic gradients
- Multiple substrate gradients
- Climatic gradients exert stronger influence on floristics and any one substrate type
Implications of climate change

- Climate will change during next century, but substrate will essentially remain static
- How will vegetation respond?
Implications of climate change

- Substrate & climate interactive effects on vegetation
- Substrate may constrain climate change response of vegetation

Habitat suitability
Hakea constablei
- Maximum Entropy models

Substrate included
2100

Substrate excluded
Conclusions

- Strong relationships exist between vegetation (structure & floristics) and lithological substrate in SE Australia.
- These relationships are largely independent of climate (i.e. they account for a separate component of variation).
- At sub-continental scale, individual climatic variables exert stronger influence on vegetation than any lithological substrate.
- Substrate types appear to account for more floristic variation, collectively, than climate factors combined.
- Lithological substrate may impose significant constraints on responses of plant communities to climate change.