Vegetation Classification

Who is classifying and what for?










Why do we classify vegetation?

The reasons are numerous but often include

- Mapping
- Conservation & Biodiversity
- Monitoring
- Land use planning
- Climate change adaptation
- Carbon accounting
- Fire hazard
- General resource management e.g. forestry

Global (Biomes) to within a small patch (Synusia - pyro-sequences, seasonal)

General background

- Formally classifying vegetation for c. 200 yrs
- Many schools of thought exist
- In the past based on the 'opinion' of a few experts (still prevalent in the Australian context)
- Vegetation plots are now widely used
- Large national and international plot databases are now standard
- General widespread adoption of statistical methods in the last 40 years
- Collaboration across borders is increasing *and increasingly necessary - rarity, climate change, resources know no borders (rare in the Australian context)*

Phytosociology

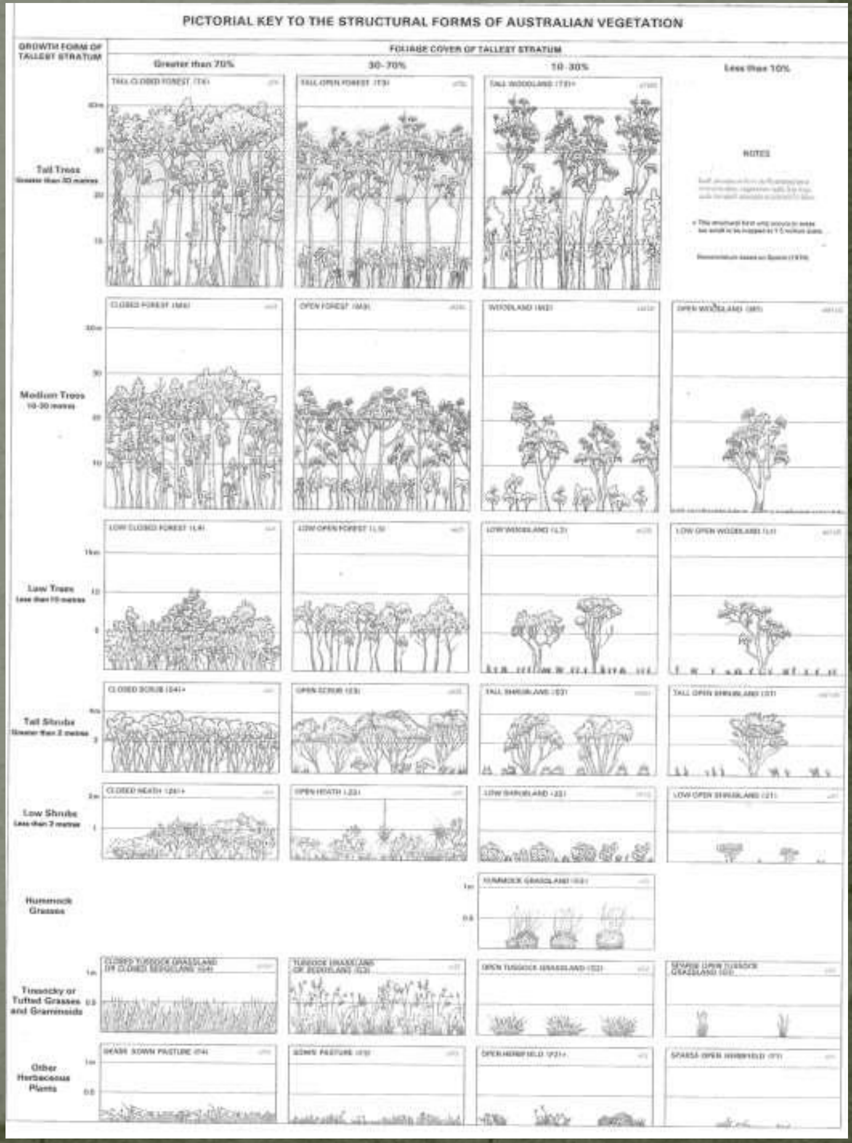
- Phytosociology – the description of plants based solely on how they group together – Floristic Composition.
  - Most notable is the Zurich-Montpellier Method (1930s)
  - Composition is of utmost importance irrespective of habitat
  - Braun-Blanquet "*Prodromus der Pflanzengesellschafen*" Europe/Mediterranean etc.
    - Fundamental unit is the "Association" created from association tables and fidelity – each unit is defined by species with high fidelity to that unit – also Presence, Constancy and Dominance
    - Associations are arranged within Alliances, Orders and Classes
    - Vegetation associations are described formally like species in plant systematics

  For example Beadle in Australia

Physionomy

- Physical features and arrangement of plants
- Classifications based on the physical structure of plants
- e.g. Specht System

& Webb & Tracy Rainforest Classification based on leaf size and type



Why use plots and analysis?

Expert based methodologies have been the norm in the Australian context

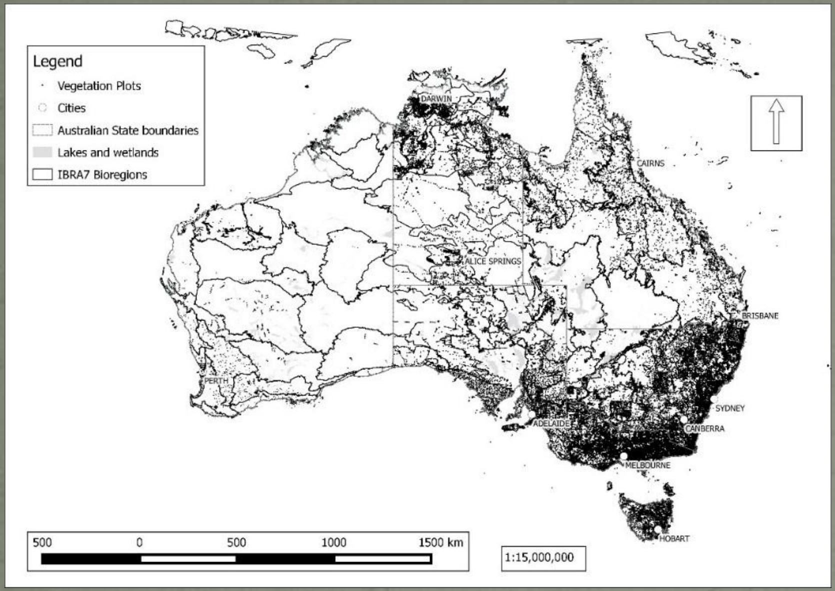
- Expert based are usually:
  - Inconsistent in application
  - Methods are not formalised so difficult to repeat
  - Idiosyncratic and hard to integrate with other systems
  - Experts are inconsistent in weighting the importance of species
- *Why analyse?*
  - A number of studies have confirmed floristic concepts, community boundaries & ability to allocate plots to communities is increased
  - Addicott (*in review*) using well defined expert protocols
    - Congruence was greatest where steep environmental gradients exist
    - Gradual environmental gradients produced near random correlation between the two methods
    - Internal (community & species based criteria) & external evaluation criteria (landscape context) all better with analysis

We aren't as good at it as we think we are – experts can get in the way

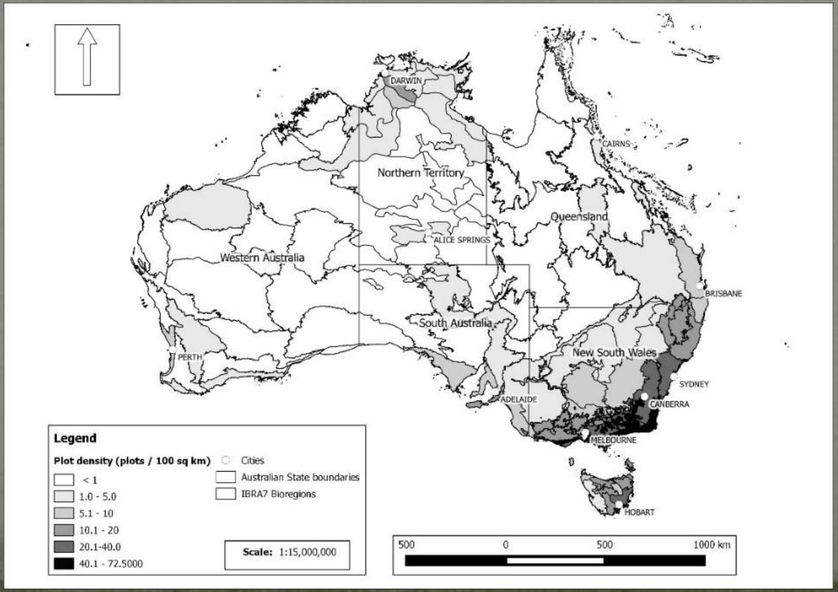
Some world plot numbers

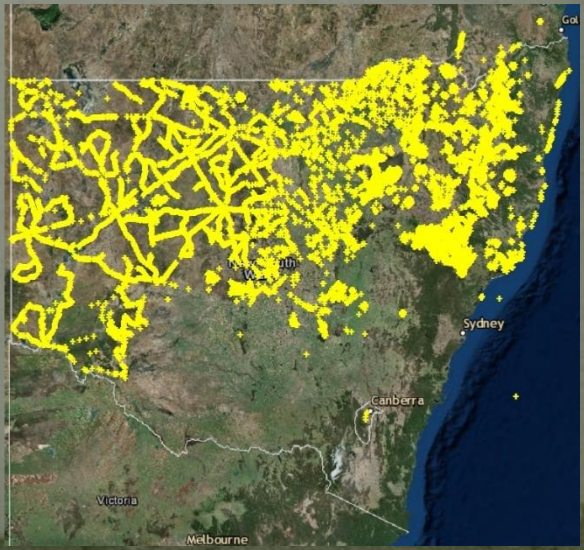
- UK 33,000
- South Africa >46,000
- New Zealand 13,500
- Arctic 31,000
- China >1,000,000
- Czech Republic 152,000
- Carolina, USA 20,000

Australian Plot Densities



Australia Wide	ca. 200,000
ACT	900
NSW	67,000
NT	43,000
Qld	11,500
WA	6,000
SA	16,000
TAS	5,000
VIC	46,700





Plot data

- High quality, updateable, open access, secure, databased plot data, collected in standardised ways with nomenclatorial integrity is essential and becoming the norm worldwide
- It is necessary to underpin good quality classifications, particularly at the lower levels of classification e.g. association
- Any classification based on plot data should as much as possible be unsupervised or at least semi-supervised with clear repeatable protocols

However …

We also need temporal (monitoring) plot data

Temporal considerations

- Seasonal changes in woodlands (Tamworth NSW)
  - Surveyed the same plots every 2 months
  - At any one survey period only a maximum of 50% of potential taxa found in plots over a 3 yr period
  - Recommendation that 2 survey periods required, Spring and late Summer to capture the most taxa
    - Schultz et al. (2014)
- Ephemeral wetlands (New England, NSW)
  - These can change from grassland to sedgeland to open water ephemerally within a year or decades

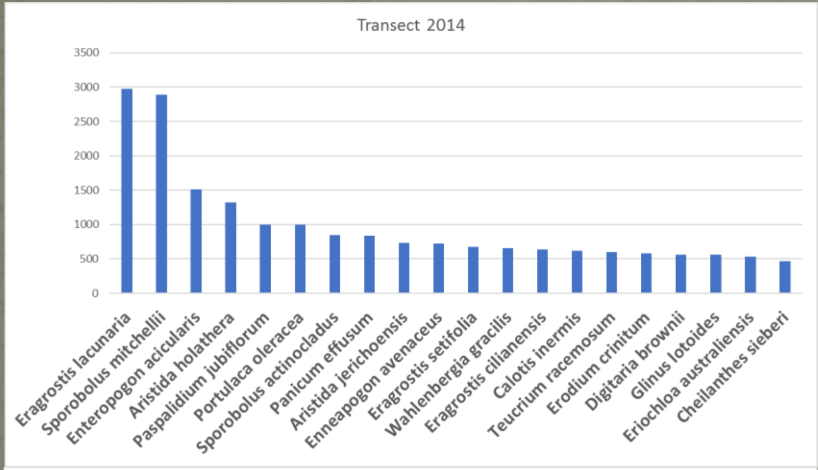


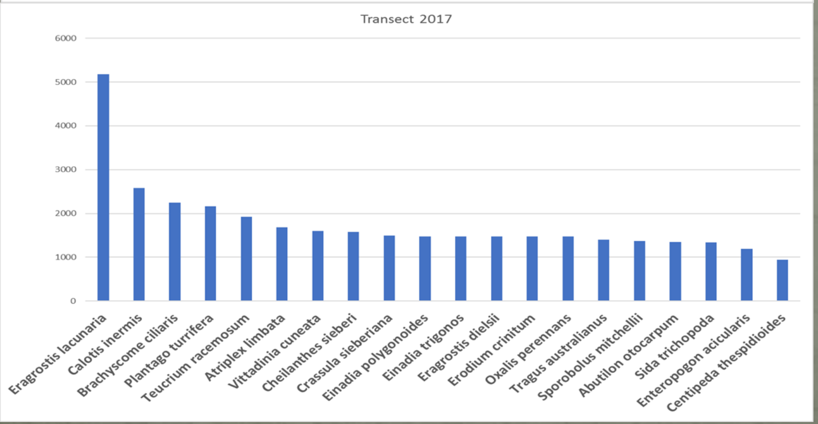


Unpredictable climates

5 Years of monitoring 80 plots within semi-arid north western NSW

1st year just after above average rainfall – drought every year after





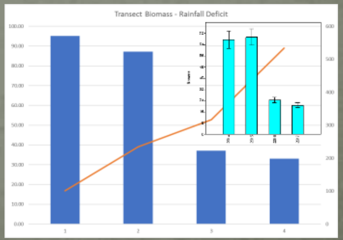
13 Grasses
7 Forbs

5 Grasses
15 Forbs

Average richness
20 taxa (2015)
16 taxa (2017)
5 tax (2018)

Major changes in structure were also found grassland to shrubland

Some changes due to season of rainfall and to flooding



Disturbances .... e.g. fire

Unburned	Insularity Guild	Fire Response	Burned	Insularity Guild	Fire Response
Kunzea bracteolata (S)	6	Obligate seeder	*Pelargonium australe* (H)	2	Resprouter
Leionema ambiens (S)	6	Obligate seeder	*Ozothamnus obcordatus* (S)	3	Resprouter
Trachymene sp. aff *incisa* (H)	6	Resprouter	*Lomandra multiflora* (H)	2	Resprouter
Leptospermum polygalifolium subsp. *montanum* (S)	3	Resprouter	*Stylidium lauricifolium* (H)	4	Obligate Seeder
Lomandra filiformis (H)	2	Resprouter	*Petrophile canescens* (S)	2	Resprouter
Schoenus apogon (H)	4	Obligate seeder	*Rytidosperma monticola* (G)	3	Resprouter
Callitris monticola (S)	6	Obligate seeder	*Rytidosperma racemosum* (G)	2	Resprouter
Philotheca epilosa (S)	6	Obligate seeder	*Amperea xiphoclada* (H)	2	Resprouter
Gonocarpus micranthus (H)	2	Obligate seeder	*Lepidosperma gunnii* (H)	4	Resprouter
Mirbelia speciosa (S)	3	Obligate seeder	*Pomax umbellata* (H)	2	Obligate Seeder
Leucopogon melaleucoides (S)	2	Resprouter	*Brachyscome stuartii* (H)	6	Resprouter
Leptospermum novae-angliae (S)	6	Obligate seeder	*Patersonia glabrata* (H)	2	Resprouter
Acacia latisepala (S)	6	Obligate seeder	*Boronia anemonifolia* (S)	3	Obligate Seeder

Do you have to wait for comprehensive data?

Data is limited in many areas of the world

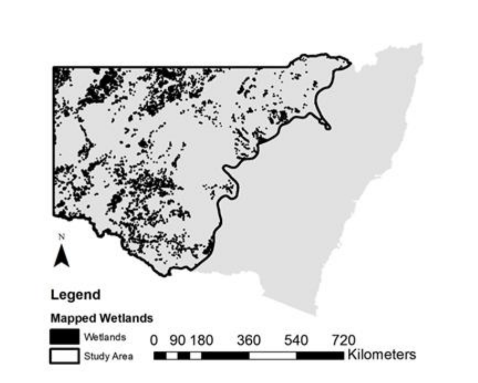
Resources to survey plots are often limited

Elements of hierarchical classifications using semi- or unsupervised methods can still occur by

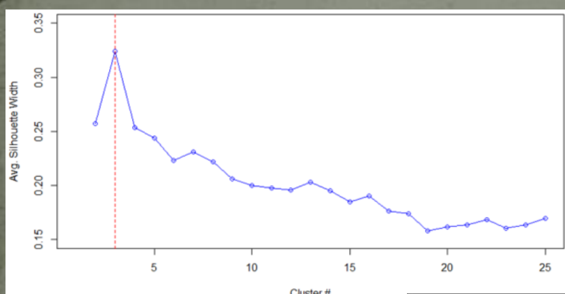
- Choosing appropriate methods
- At appropriate scales
- And defining vegetation types at appropriate levels
- A classification can be built in parts – vertical (hierarchical schema) – horizontally (major vegetation units)

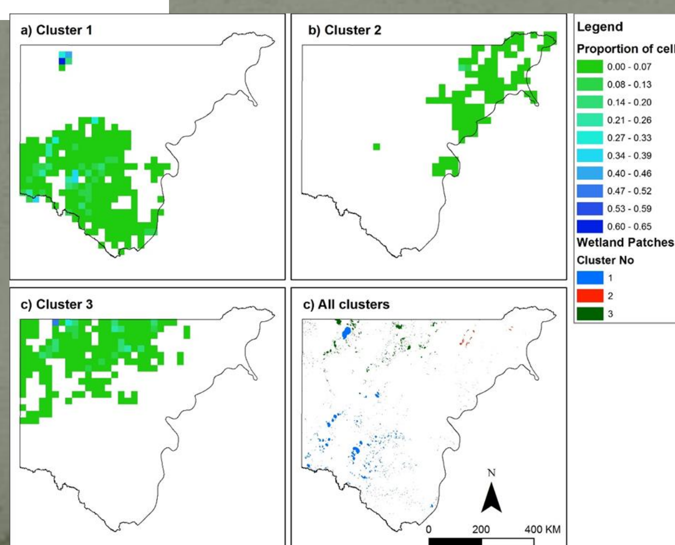
Exploration of methods: ecoregionalisation

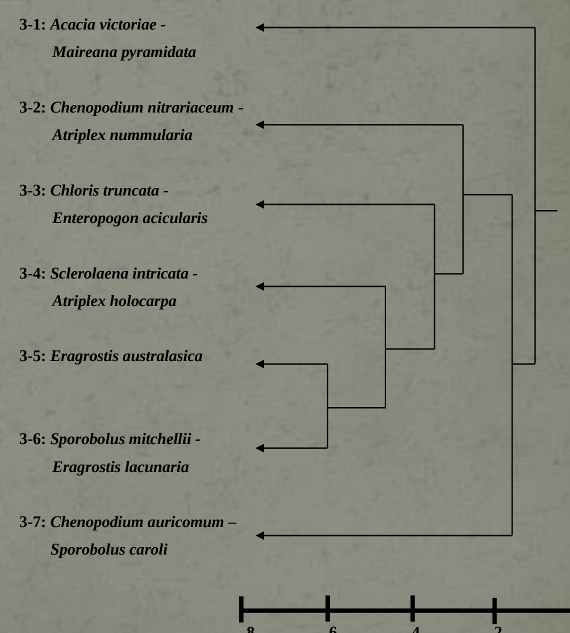
- Ephemeral wetlands of arid & semi-arid NSW – Plot Based
  - Limited vegetation plot data but many vegetation mapping programs – 722 full floristic ephemeral wetland plots (between 1998-2016)
  - 200 vegetation GIS layers combined and all wetland patches extracted and new file created
  - Additional mapping of wetlands to enhance final layer (final total of 7,258 wetlands – 1,033,598 ha)
  - Environmental influences known to affect the formation of wetlands gathered and modelled for each mapped wetland
    - Hunter & Lechner (2017)



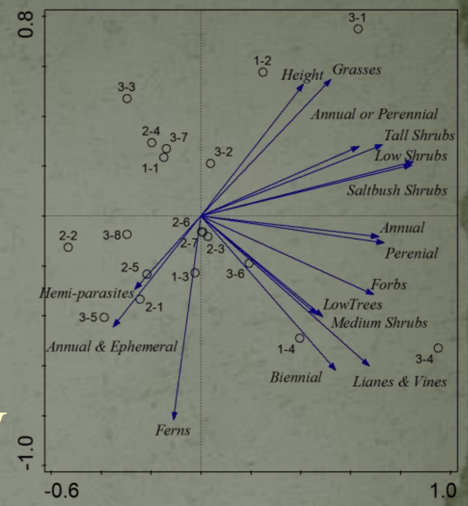
- Using Partitioning Around Medioids (PAM) & Euclidean distances to calculate pairwise dissimilarities between clusters
- Then calculated mean silhouette widths to measure cluster isolation and define the most appropriate number of clusters







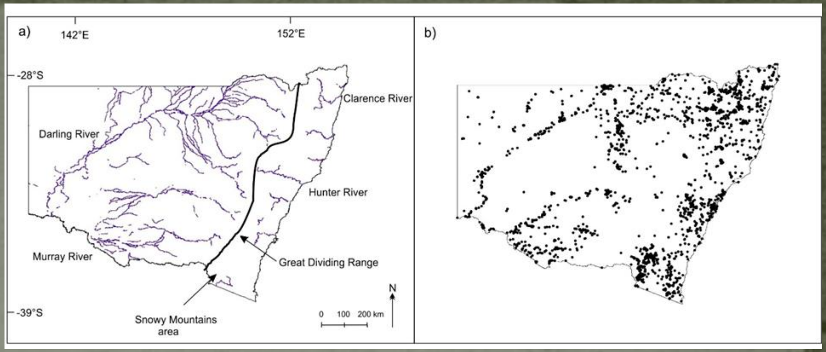
- Clustering by SIMPROF permutation tests (Primer E)
- All plots assigned to the 3 ecoregions
- SIMPER analysis of species & CCA of functional type used to define highly diagnostic taxa & life history
- Groups defined by diagnostic, non-diagnostic, common taxa with high fidelity and dominance with reference to life form from PCA analysis
- 55% of our groups have no representation in the NSW classification

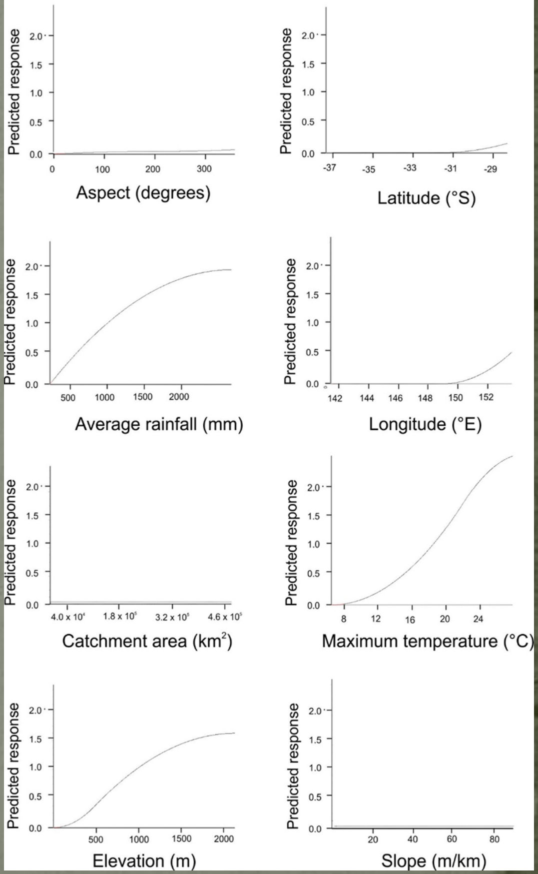


Hierarchy	Positive diagnostic (SIMPER)	Negative diagnostic (SIMPER)	Common taxa	Notes and distribution
Macrogroup 1: South West Ephemeral Wetland Province of arid and semi-arid regions of NSW	*Juncus aridicola, Nitraria billardierei, Diplachne fusca, Walwhalleya proluta, Carex inversa, Atriplex vesicaria, Rumex tenax, Sclerolaena tricornis, Centipeda cunninghamii.*	*Nymphoides crenata, Centipeda minima, Goodenia gracilis, Marsilea hirsuta, Epaltes australianus, Acacia stenophylla, Glosostigma diandra, Gratiola pedunculata, Sclerolaena birchii, Sclerolaena bicornis.*	*Eragrostis australasica, Dissocarpus paradoxus, Sclerolaena muricata, Nitraria billardierei, Atriplex lindleyi, Marsilea drummondii, Sclerolaena tricuspis, Maireana pyramidata, Juncus aridicola, Tecticornia tenuis*	Common overstorey taxa: *Eucalyptus populnea, Eucalyptus camaldulensis, Eucalyptus largiflorens, Acacia stenophylla, Acacia pendula, Geijera parviflora, Acacia melvillei*
Group 1-1: *Atriplex vesicaria – Atriplex nummularia* herbfield & shrubland	*Atriplex vesicaria, Atriplex nummularia, Chenopodium carinatum, Maireana sedifolia, Omphalolappula concava, Atriplex leptocarpa, Sclerolaena calcarata, Maireana ciliata, Tecticornia indica, Duma horrida.*	*Juncus aridicola, Marsilea drummondii, Eragrostis australasica, Lachnagrostis filiformis, Sporobolus mitchellii, Eleocharis plana, Sclerolaena muricata, Carex inversa, Diplachne fusca, Rumex tenax.*	*Atriplex vesicaria, Nitraria billardierei, Atriplex lindleyi, Tecticornia indica, Sclerolaena intricata, Disphyma crassifolia, Sclerolaena calcarata, Mairena sedifolia, Maireana pyramidata, Sclerolaena calcarata.*	West from Booligal and Balranald on clay pans, riverine lakes and flood plains. PCT18, 62.

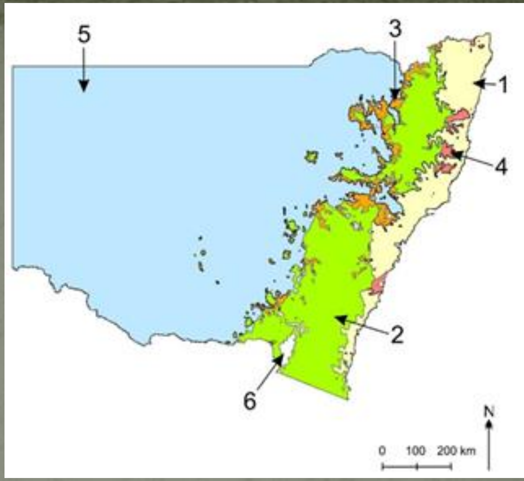
2nd example
- Point data based

- Riparian vegetation of NSW
  - Inconsistent to no plot data
  - Using point source – mainly herbarium data of highly diagnostic riparian species
  - Ca. 7000 records.
  - 1 x 1 degree grid cells chosen that had a minimum of 3 species (1,731)
  - 8 climatic and landscape variables
  - Generalised dissimilarity modelling of turnover in assemblages to produce ecoregions
  - Using SIMPER to derive positive diagnostic taxa for each macrogroups
    - Hunter et al. (*in review*)





Riparian macrogroups of NSW



Macrogroup	Area (km²)	Positive diagnostic
1: Central east & north east coastal province of sub-tropical regions of NSW	54,536	*Casuarina cunninghamiana, Grevillea robusta Tristania neriifolia, Waterhousia floribunda, Elaeocarpus grandis, Leptospermum polygalifolium ssp. polygalifolium, Tristania neriifolia, Lachnagrostis filiformis, Potamophila parviflora, Lenwebbia prominens.*
2: Great Dividing Range Escarpment & south coast province of temperate regions of NSW	49,724	*Carex gaudichaudiana, Stellaria angustifolia, Leptospermum brachyandrum, Leptospermum emarginatum, Melaleuca bracteata, Leptospermum grandiflorum, Lachnagrostis filiformis, Hydrocotyle sibthorpioides.*
3: Montane temperate province of NSW	92,230	*Leptospermum gregarium, Leptospermum minutifolium, Leptospermum obovatum, Callistemon pungens, Carex gaudichaudiana, Epilobium billardiarianum, Epilobium gunnianum, Montia fontana, Hypericum japonicum, Gonocarpus micranthus, Neopaxia australasica, Ranunculus pimpinellifolius, Baloskion australe.*
4: Eastern escarpment high rainfall temperate province of NSW	16,040	*Casuarina cunninghamiana, Asperula gunnii Gonocarpus micranthus, Hydrocotyle sibthorpioides, Hypericum japonicum.*
5: Western temperate to semi-arid low altitude province of NSW	599,094	*Duma florulenta, Acacia stenophylla, Acacia salicina, Eucalyptus camaldulensis, Eucalyptus coolabah, Eucalyptus largiflorens, Eucalyptus ochrophloia, Melaleuca densipicata, Melaleuca trichostachya.*
6: Alpine to high altitude temperate montane to province of NSW	48,120	*Poa costiniana, Oreomyrrhis ciliata, Asperula gunnii, Carex appressa, Leptospermum argenteum.*

Hallmarks of a good classification system

- Comprehensiveness – include as much as possible – full range of variation, spatial, temporal, ecological and incorporate traditional and rare types.
- Consistency – must explicitly define *Consistent Classification System* and can't satisfy too many users.
- Robustness – minor changes in data should not affect the outcome.
- Simplicity – simple definitions and assignment rules.
- Distinctiveness of units – distinct in terms of value of primary vegetation attributes.
- Identifiability of units – easy to identify in landscape – clear, reliable and simple assignment rules, may compliment more complex consistence assignment rules.
- Identification of context – reflect and be predictive in context i.e. soil, climate biogeography
- Compatibility – clear relationships with vegetation types of other systems.

Purpose – last thoughts

- Classification is purpose driven
- While a classification schema can be flexible it is usually fit for purpose and cannot answer all needs
- Mapping and vegetation classification are different ways to perceive and categorise the world – *they are not the same*