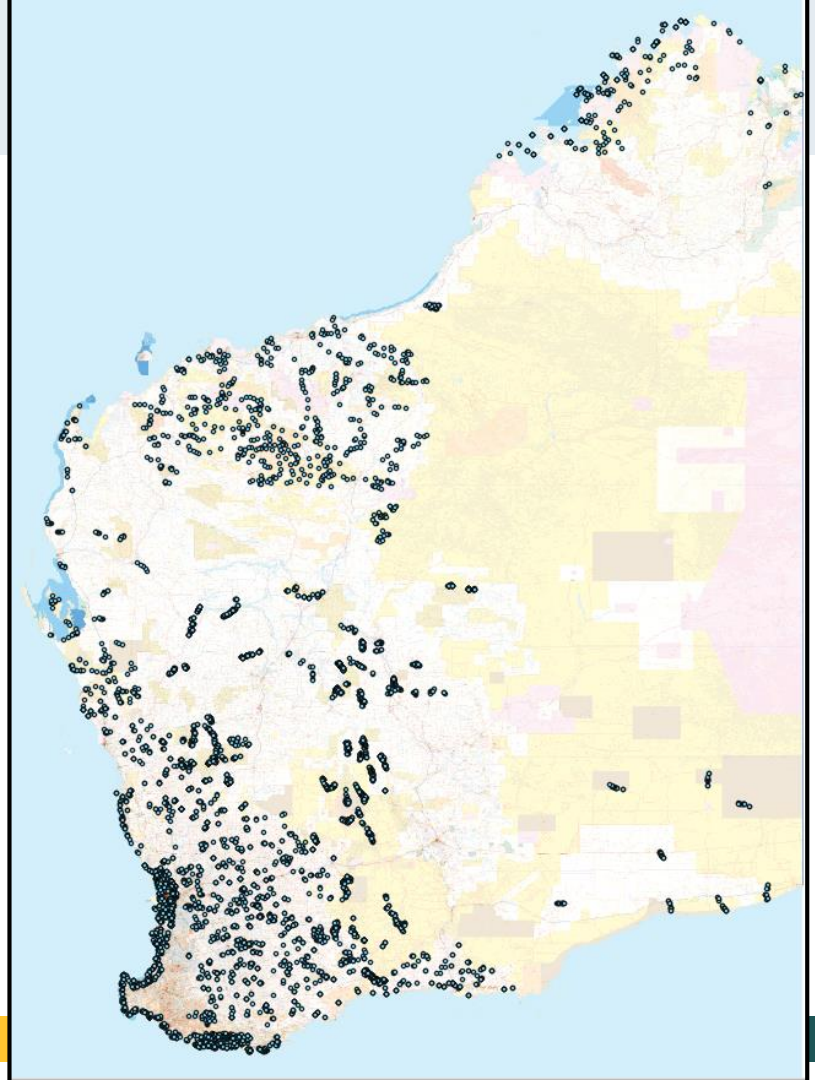
The Gypsum flora and plant communities of Western Australia

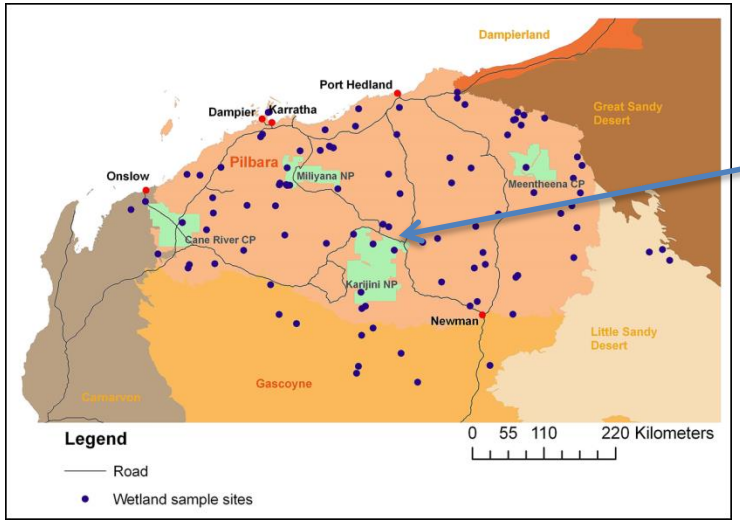
Michael N. Lyons

Biological survey of WA

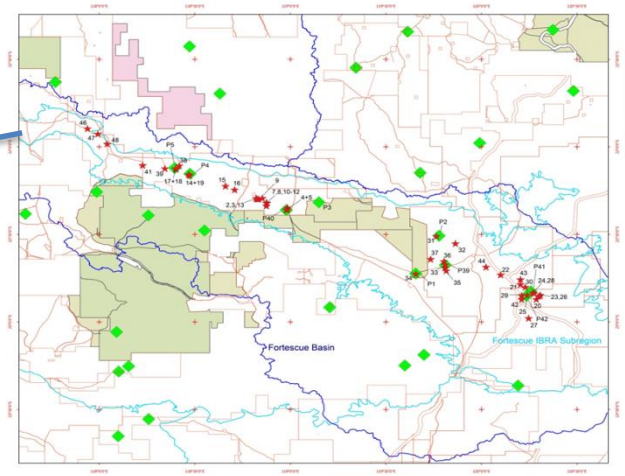
- Integrated plot based biological survey
- Terrestrial and wetlands
- 6100 systematic floristic survey plots
- Conservation status of species and communities
- Conservation planning



- Regional scale
  - Regional conservation planning
  - Reserve system design
  - Determining environmental drivers of compositional patterning

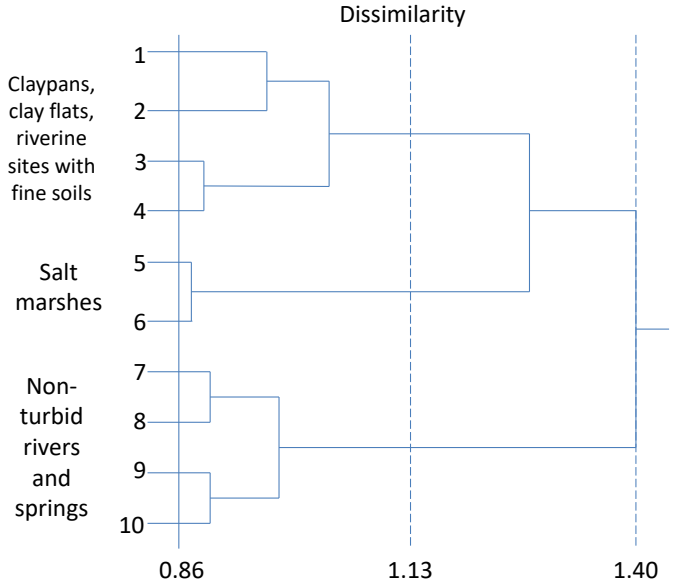


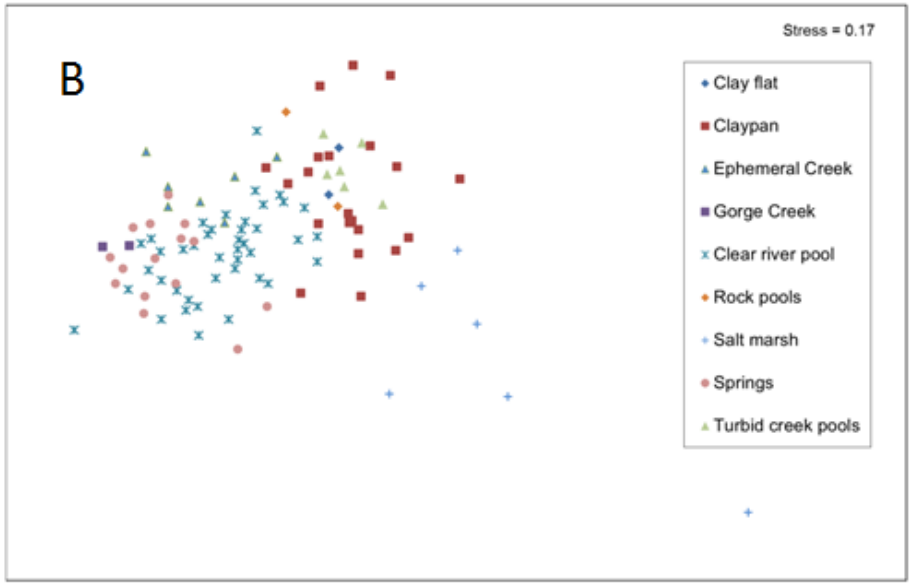
- Sub regional scale
  - More detailed compositional patterns identified
  - Planning for management actions
  - Identifying high conservation value wetlands

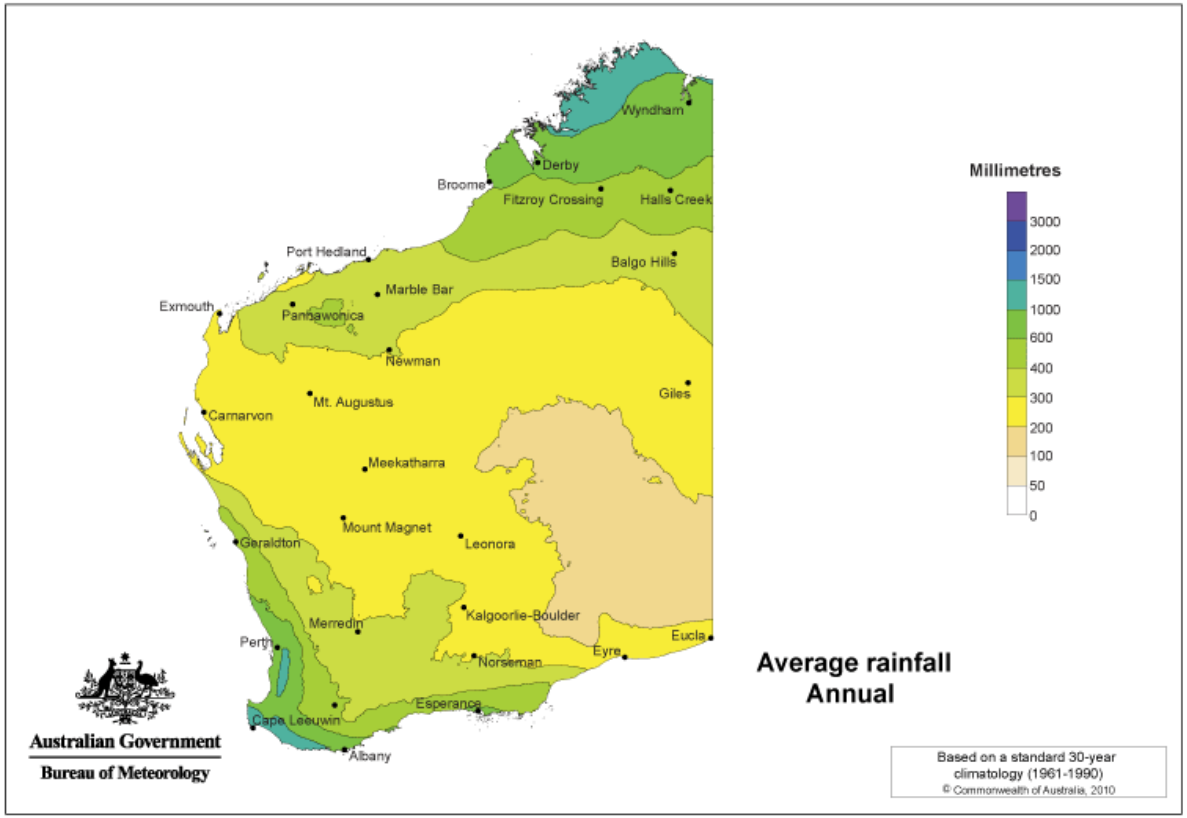


Data analysis

Classification and ordination based on species composition






Wyndham
Derby
Broome
Fitzroy Crossing
Halls Creek
Port Hedland
Balgo Hills
Marble Bar
Exmouth
Pannawonica
Newman
Giles
Mt. Augustus
Carnarvon
Meekatharra
Mount Magnet
Geraldton
Leonora
Kalgoorlie-Boulder
Merredin
Perth
Eucla
Eyre
Norseman
Esperance
Cape Leeuwin
Albany
Millimetres
3000
2000
1500
1000
600
400
300
200
100
50
0
Average rainfall
Annual
Based on a standard 30-year climatology (1961-1990)
© Commonwealth of Australia, 2010
Australian Government
Bureau of Meteorology


IBRA 5.1 bioregions
Northern
VB
NK
CK
DL
Broome
Halls Creek
OVP
TAN
GSD
Karratha
PIL
LSD
GD
CAR
GAS
CR
Wiluna
Eremaean
GS
YAL
MUR
GVD
Geraldton
Kalgoorlie
NUL
SWA
AW
COO
Perth
HAM
JF
MAL
Esperance
ESP
WAR
Albany
Southwest

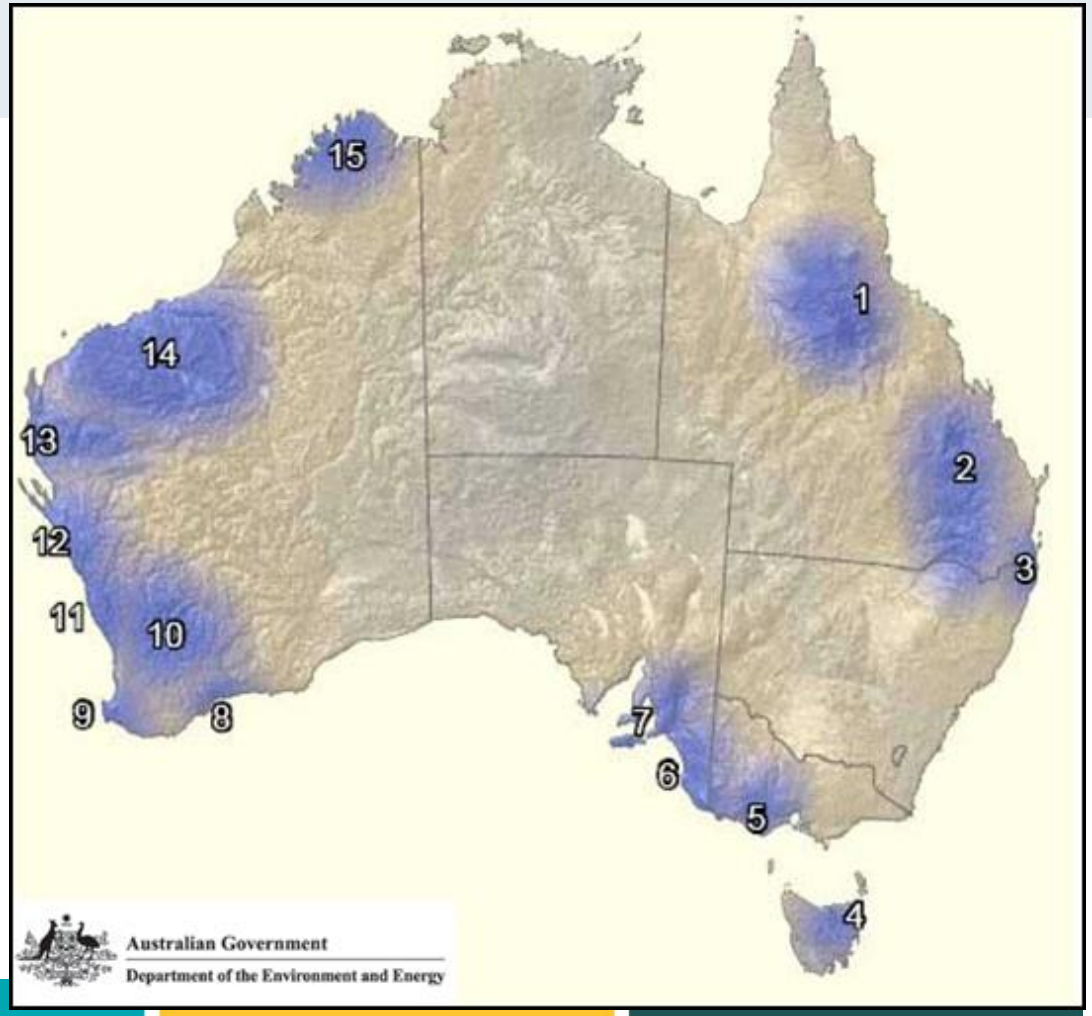
Western Australian Flora

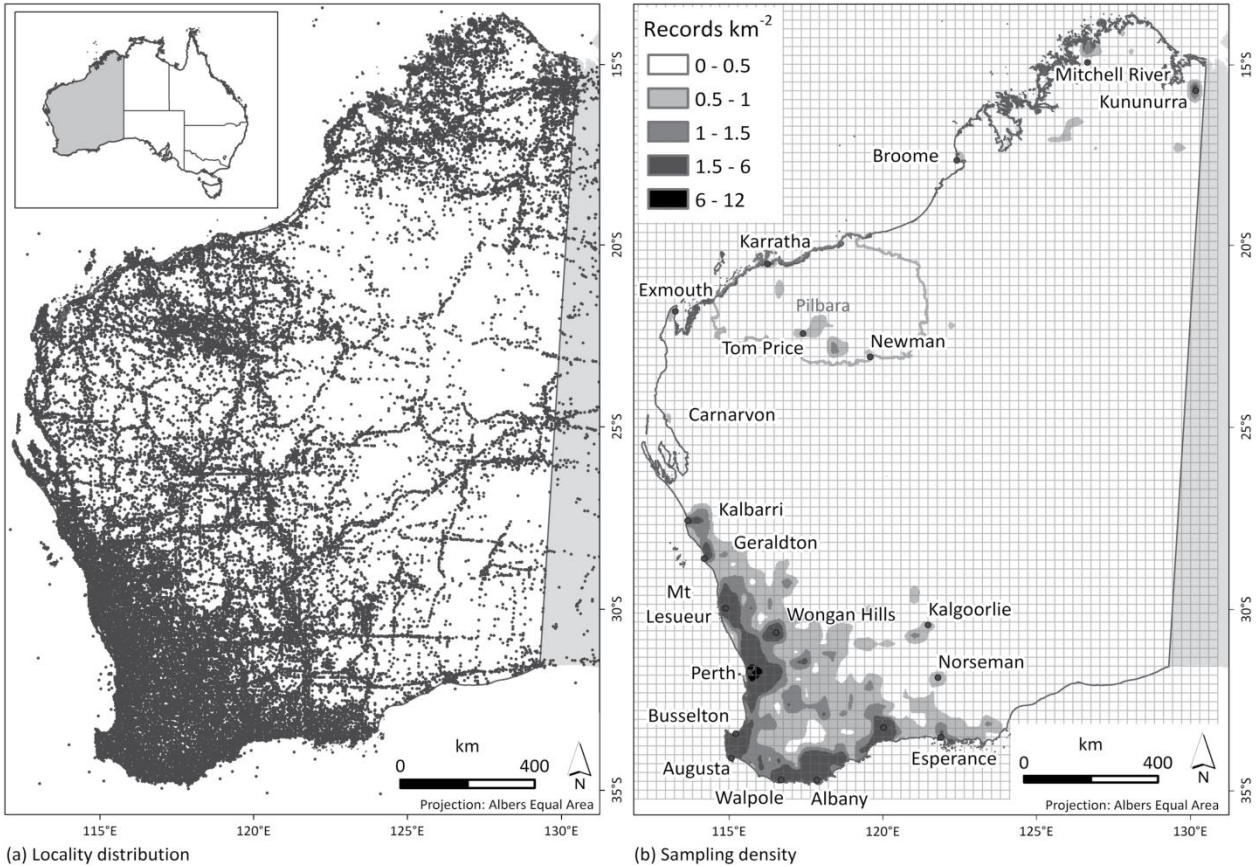
- 12 500 native taxa
- Includes 1200 phrase named taxa
- 300+ new taxa described in last 5 years

SWAFR

- Global biodiversity hotspot
- Ancient landscape with nutrient poor soils
- 8379 native vascular plant taxa of which 47% are endemic and 49% have been described since 1970. (Gioia & Hopper, 2017)

- National biodiversity hotspots
- Recognition of the semi-arid transition to the SWAFR
  - Fragmentation
  - Secondary salinization

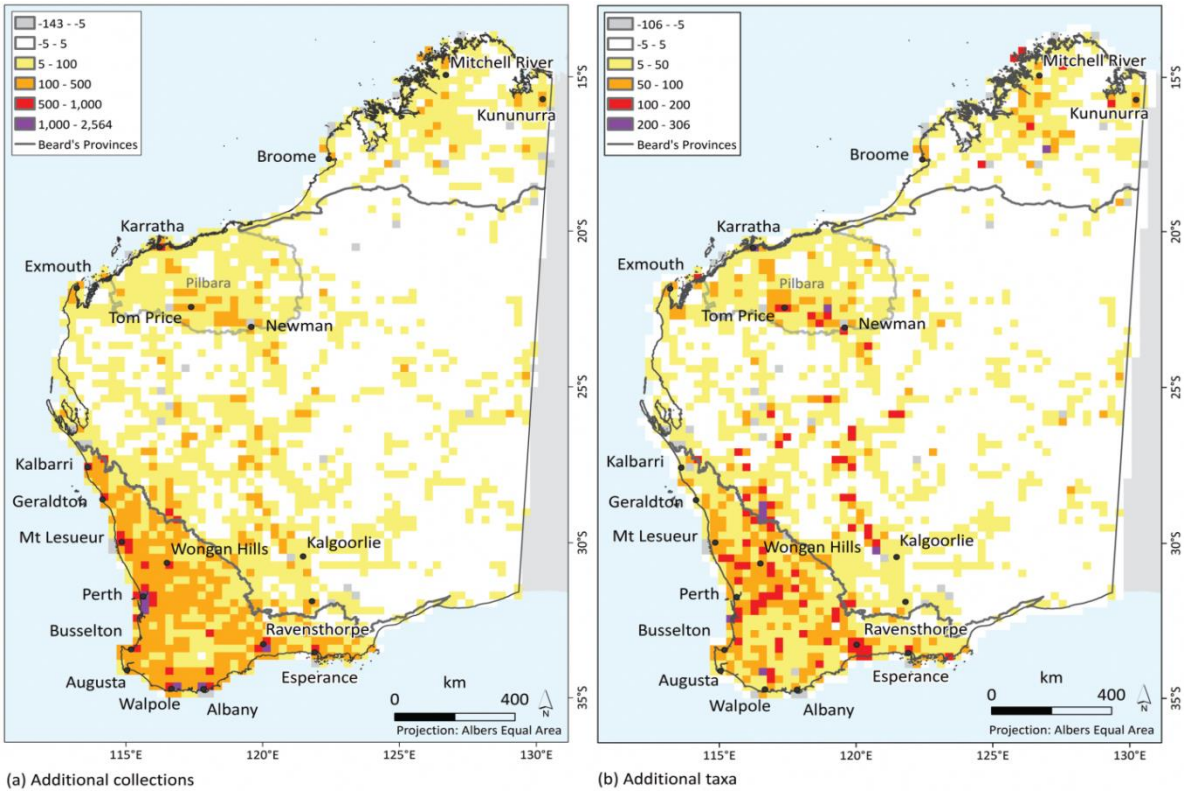




(a) Locality distribution

(b) Sampling density

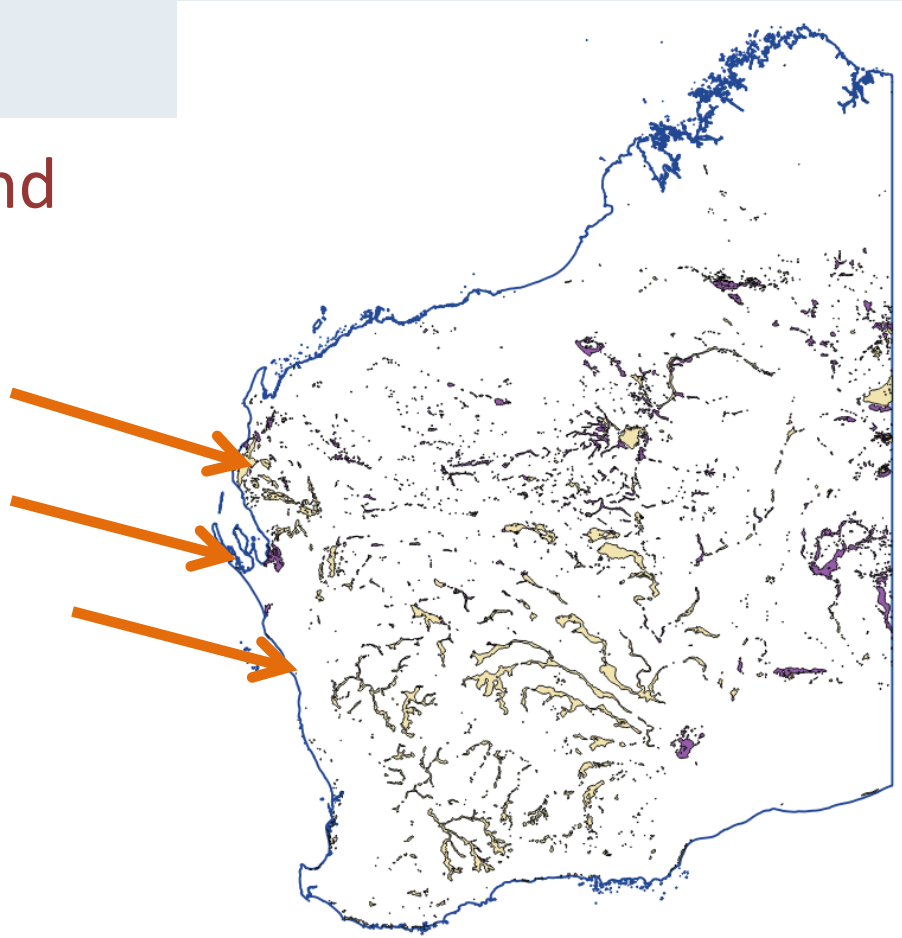
Botanical Journal of the Linnean Society, Volume 184, Issue 1, 04 May 2017, Pages 1–15,
https://doi.org/10.1093/botlinnean/box010



Gioia P, Hopper SD (2017).

Gypsum occurrences and landforms

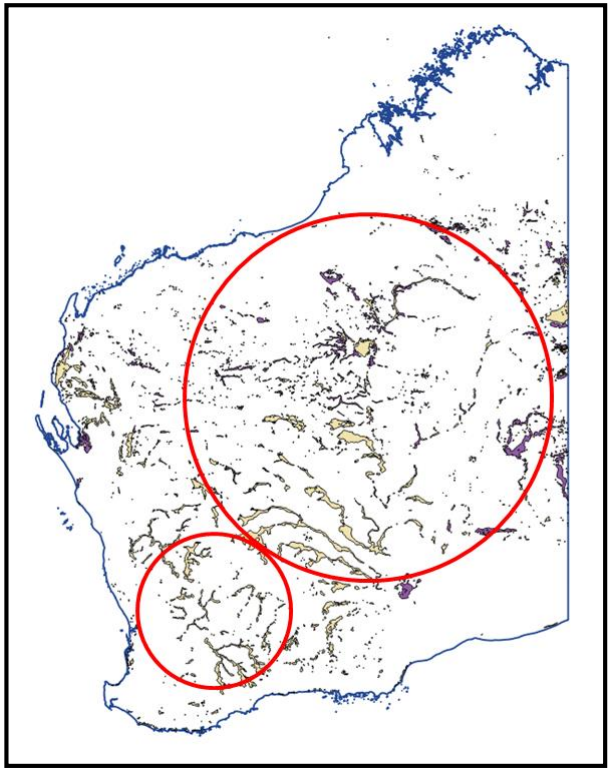
- Holocene coastal lagoons
  - Lake McLeod
  - Shark Bay
  - Jurien and Hutt Lagoons

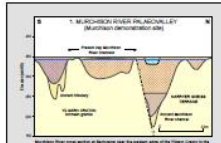


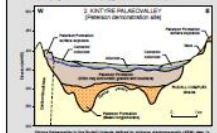
Paleo-river wetland chains

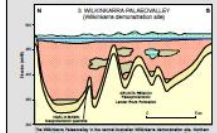
- Formed on vast system of ancient Tertiary river valleys that filled with sediments as flows declined as a result of tectonic shifts and aridification over the late Tertiary/ Quarternary.

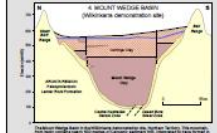
- Aquifers within these ‘palaeovalleys’ have become saline through evapo-concentration of rain-derived salts and weathering and limited flushing.

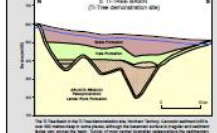


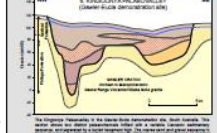


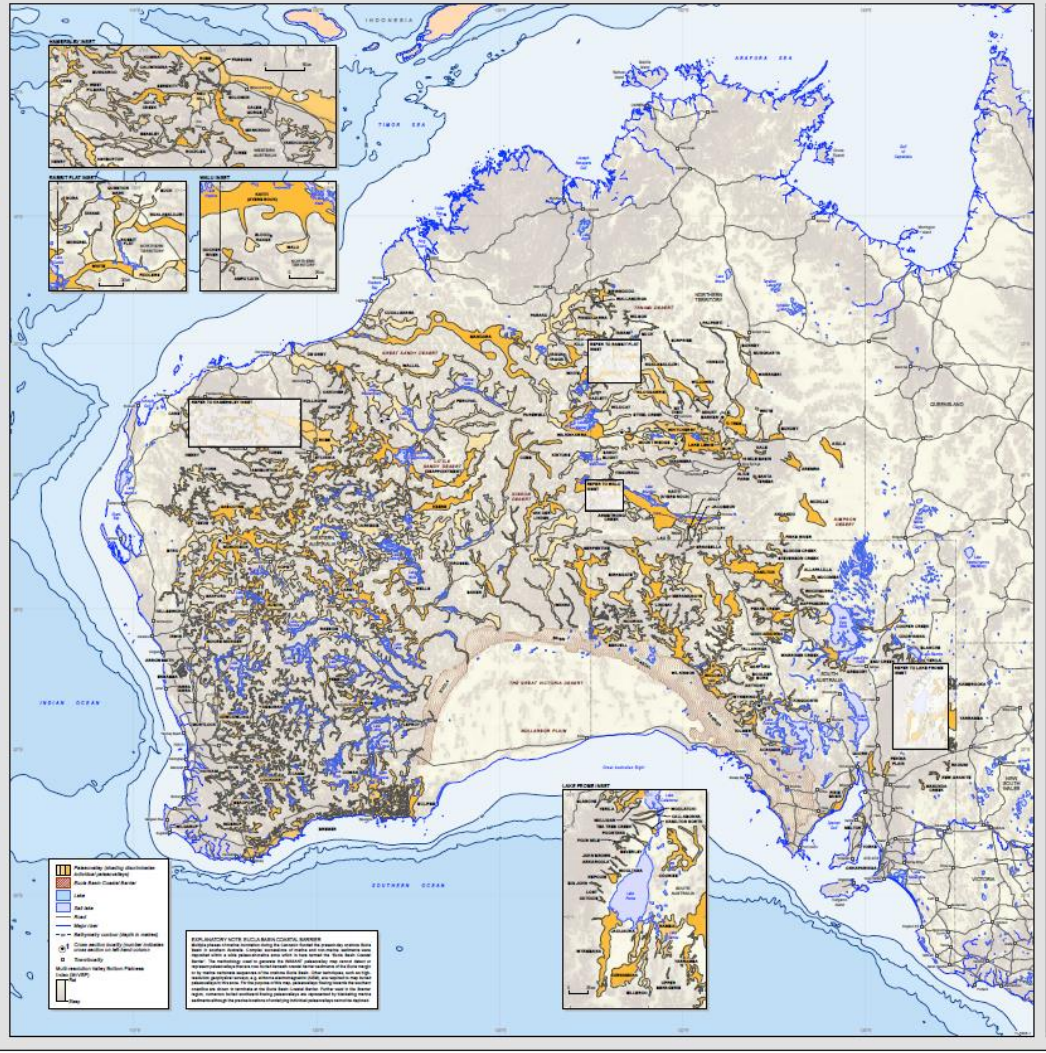












CROSS SECTION NOTES:
Detailed technical reports for each demonstration site listed in these cross sections are available as Geoscience Australia Records 2004 Numbers 24 (WASANT) 2005 and can be downloaded from the Australian Government Publishing Service (AGPS) website at http://www.agps.gov.au/agpsbookshop/

Australian Government
Geoscience Australia
National Water Commission

WASANT PALAEOVALLEY MAP

SCALE 1:4 000 000
0 100 200 300 400 500 Kilometres

MAP PROJECTION
Central Meridian 130°E Standard Parallels 18°S
Geocentric Datum of Australia

PREFACE
This map of palaeovalleys in arid and semi-arid parts of Western Australia (WA), South Australia (SA) and the Northern Territory (NT), shows the interpreted distribution of palaeovalleys including those obscured beneath desert dunefields. The map extent is defined by the Köppen-Geiger classification of arid and semi-arid zones of WA, SA and NT (Figure 1). This map was produced as part of the Water for Australia's Arid Zone – Identifying and assessing Australia's palaeovalley groundwater resources project (termed the 'Palaeovalley Groundwater Project') that was funded by the National Water Commission (NWC) and led by Geoscience Australia, with support from respective state and territory government agencies. The four-year project (2008-2012) aimed to provide information about the role of palaeovalleys as significant widespread regions where groundwater resources are scarce or need to be investigated for the future.

EXPLANATORY NOTES
The map was compiled using national scale datasets (including Digital Elevation Models and geological maps), existing groundwater data and reports in combination with expert knowledge. New information was obtained through demonstration studies in selected sites (Figure 2), examples of palaeovalley cross sections from these sites are shown on the left-hand column of the map. The methodology used to produce the map is described in the companion project summary report by Bryan et al. (2012), cited below. This broad-scale map is intended to enhance our knowledge of Australian arid zone palaeovalleys as widespread but little understood geologic elements and potentially contribute to an improved understanding of palaeovalley aquifers. The palaeovalleys shown on the map do not necessarily correspond with underlying groundwater resources or indicate prospective borehole sites. Rather, the map serves as a guide for more detailed future hydrogeological investigation in areas of interest.

Figure 1: Köppen-Geiger classification of arid and semi-arid zones (reference 4 below).

Figure 2: Palaeovalley demonstration sites

CROSS SECTION NOTES:
1. Examples of cross sections shown in the left-hand column illustrate the heterogeneity and complexity (in terms of fabric, shape, structure and sediment infill) of palaeovalleys within these arid zone areas.
2. Most palaeovalleys shown on the map are now infilled with variably thick sequences of Cenozoic sediments, although some contain older Mesozoic and Palaeozoic basin sequences, such as the Permian glacial-marine sediments in the Pirlanpin Province (Figure 2).
3. The infill sequences depicted in these sections range from unconsolidated sediments to fully lithified sedimentary rocks. For consistency, the Cenozoic sediments are not here refer to the primary sediment type regardless of the degree of lithification.
4. The sediment infill sequences are variably affected by chemical weathering. In places this has overprinted the original sediment characteristics, resulting in the formation of duricrusts (e.g. silcrete).
5. In most cases relatively thin (less than two metres) deposits of regolith and residual soils cover the present-day land surface. Aeolian sand layers, although dunes up to 20 metres high may occur in desert regions. These cover sequences were not deposited by fluvial or lacustrine processes associated with the palaeovalleys so have not been shown.
6. To maximise the display of information the cross sections have inconsistent scales, conveying the significant variations in palaeovalley depths and widths.

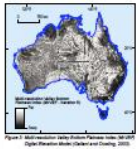


Figure 3: Multi-resolution Valley Bottom Flatness Index (MrVBF) Digital Elevation Model (Gallant and Dowling, 2003).

Figure 4: Geological provinces within the WASANT study area

REFERENCES
1. Bryan, P.M., Lewis, S.J., Ball, J.D. Wischusen, J.D.H. Woodgate, M.P., Bastakoti R.N., Wayland, M.K., and Kilgour, P.L., 2012. Water for Australia's arid zone – identifying and assessing Australia's palaeovalley groundwater resources. Project summative. National Water Commission. Waterlines Report Series, August 2012.
2. Gallant, J.C. and Dowling, T.I., 2003. A multi-resolution index of valley bottom flatness for mapping depositional areas. Water Resources Research 39 (12): 401-410.
3. Hou, B., 2009. Ningaloo palaeochannel project South Australia. Department of Primary Industries and Resources. Report Book: 2009/1.
4. Köppen-Geiger classification charts and seven arid zones http://www.geo.uni.edu/research/climate/Publications_Koppen.html

ACKNOWLEDGEMENTS
This map has been produced by Geoscience Australia and funded by the National Water Commission. The map was compiled by J.D. Bell, P.L. Kilgour, P.M. Bryan, S.J. Lewis and J.D.H. Wischusen (Geoscience Australia) and M.P. Woodgate (NT Department of Natural Resources, Environment, the Arts and Sport (NRETAS)) with contributions from D.H. Commander, A.M. Hein and S.L. Tickell (NT NRETAS), Department of Water), B. Hou (Geological Survey of South Australia), and S.J. Tickell (NT NRETAS).

Published by Geoscience Australia, Department of Resources, Energy and Tourism, Canberra, Australia, issued under the authority of the Federal Minister for Resources, Energy and Tourism.

Compiled by the Groundwater Group, Geoscience Australia.
Cartography by Silvia Mezzomo and Theo Christie, Products and Promotion, Geoscience Australia.

BIBLIOGRAPHIC REFERENCE
Bell, J.D., Kilgour, P.L., Bryan, P.M., Woodgate, M.P., Lewis, S.J. and Wischusen, J.D.H. (compilers), 2012.
WASANT Palaeovalley Map - Distribution of Palaeovalleys in Arid and Semi-arid WA, NT and SA. Scale: 1:4 000 000.
Geoscience Australia Thematic Map (Record No 73980) - hard copy and digital data publication. http://www.ga.gov.au/metadata-gateway/metadata/record/73980/

Mernagh, T.P. (ed.), 2013. Geoscience Australia Record 2013/39.

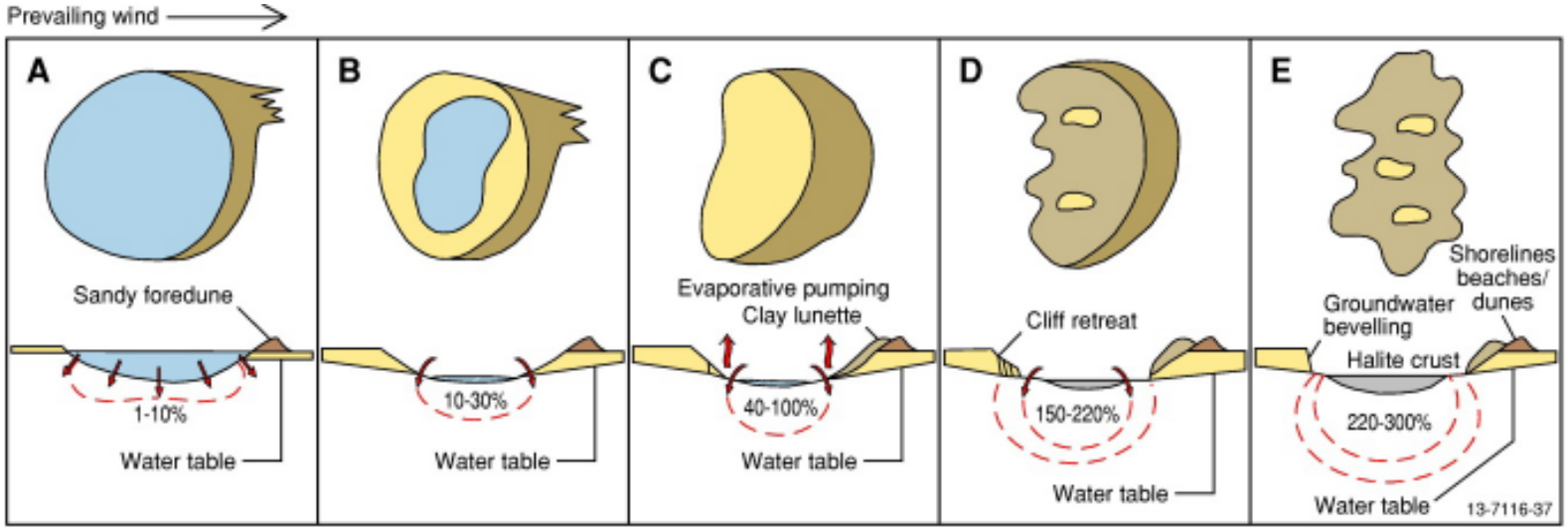
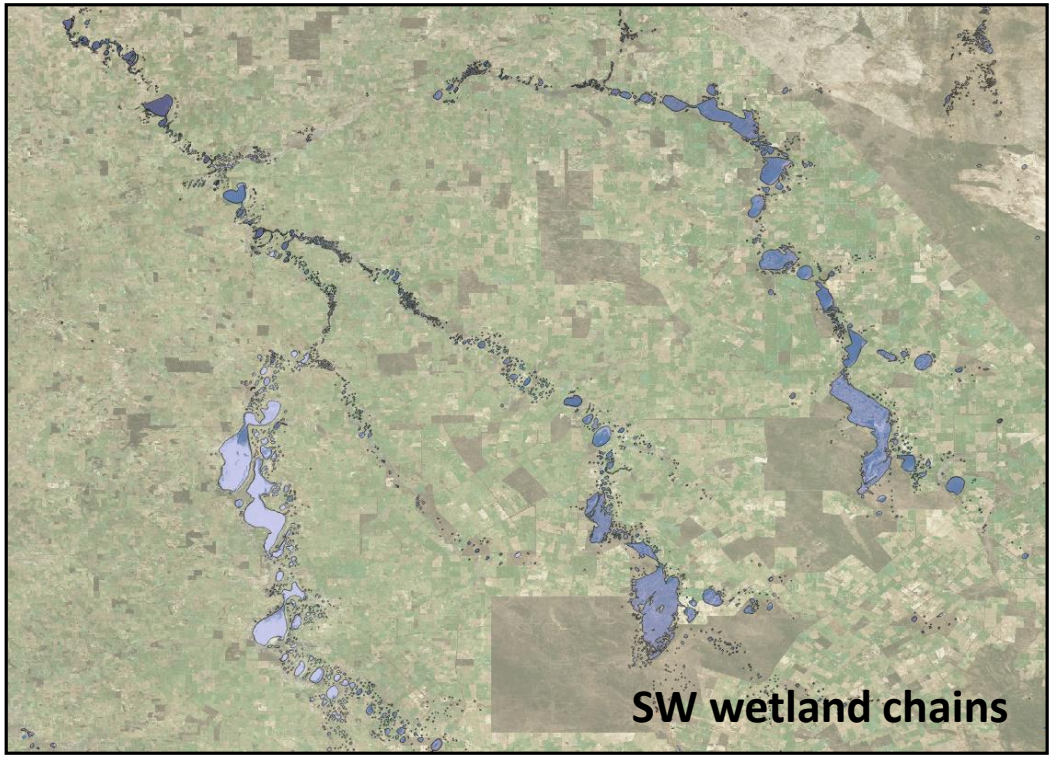
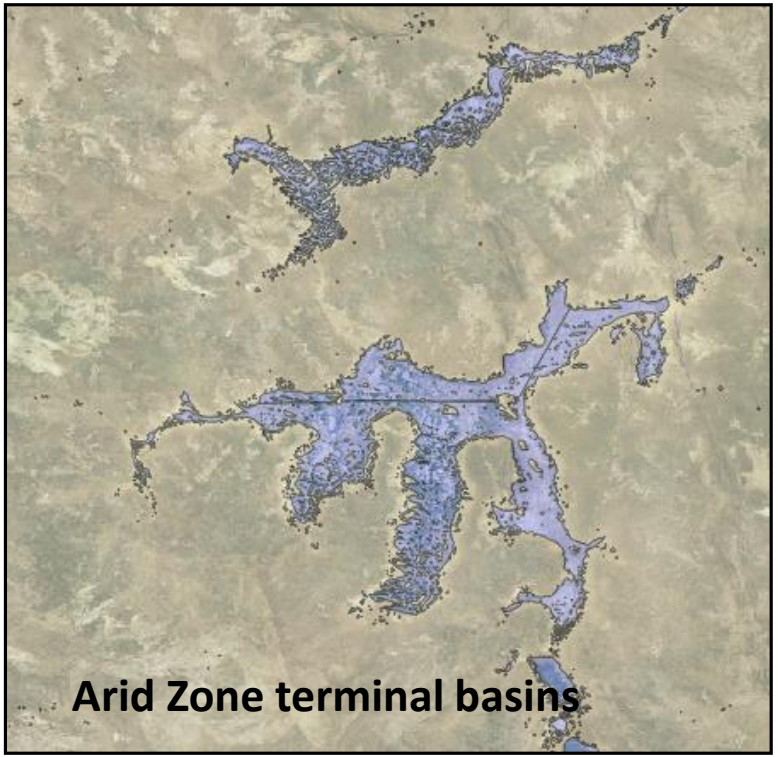


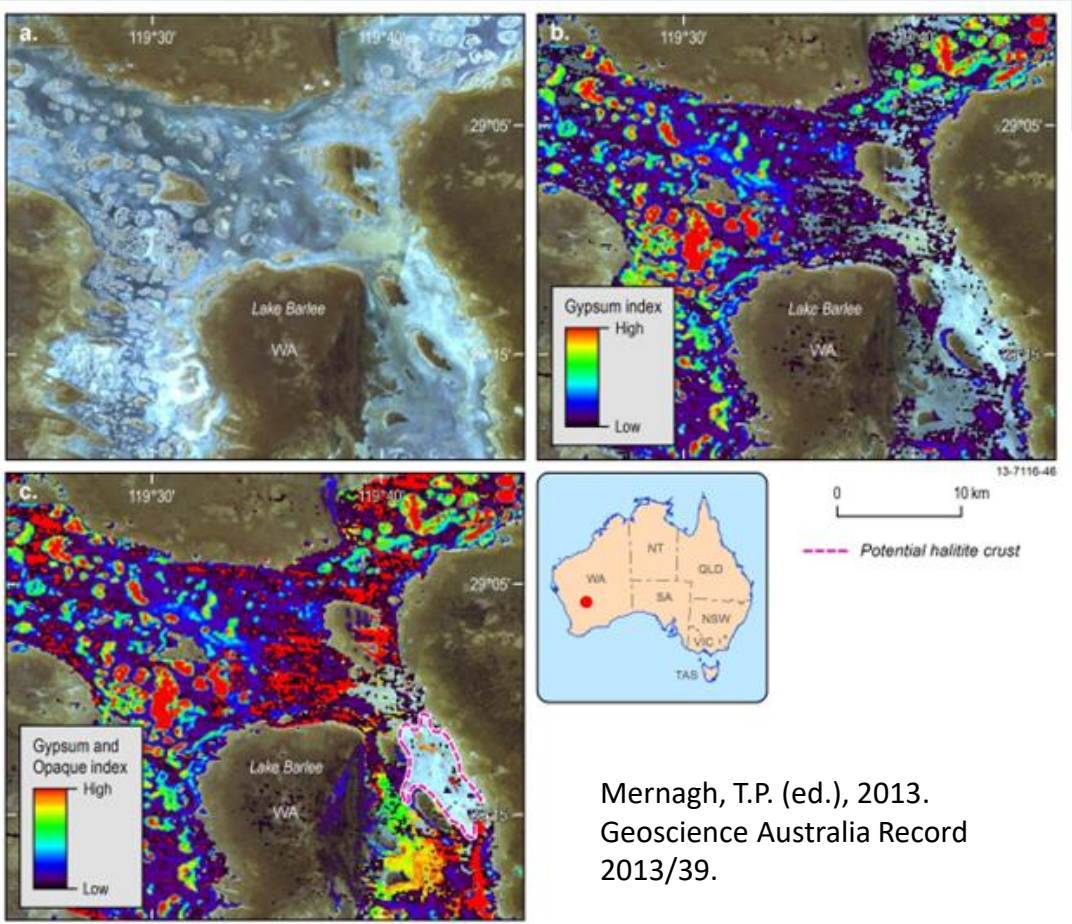
Figure 2.5 Classification of Australian lake/playa basins across a climatic gradient which extends from humid to arid conditions. Five lake/playa basin types, A to E, are differentiated by morphological and sedimentological features, which reflect successive stages in a hydrological series from surface-water to groundwater dominated systems including the evolution of a sub-playa brine pool. Figure is modified from Figures 2 and 5 of Bowler (1986a). Lake George, NSW, near Canberra, ACT, and Lake Kielembete, western Victoria, both located in the humid climate zone, are endorheic lakes, i.e., closd basins with no outflow.


SW wetland chains


Arid Zone terminal basins

Gypsum deposits are spatially and morphologically complex

- Size
- Elevation
- Stratigraphy
- Edaphic composition
- Gypsum islands within saline and non-saline soils



Mernagh, T.P. (ed.), 2013. Geoscience Australia Record 2013/39.

ASTER (Advanced Space borne Thermal Emission and Reflection Radiometer)

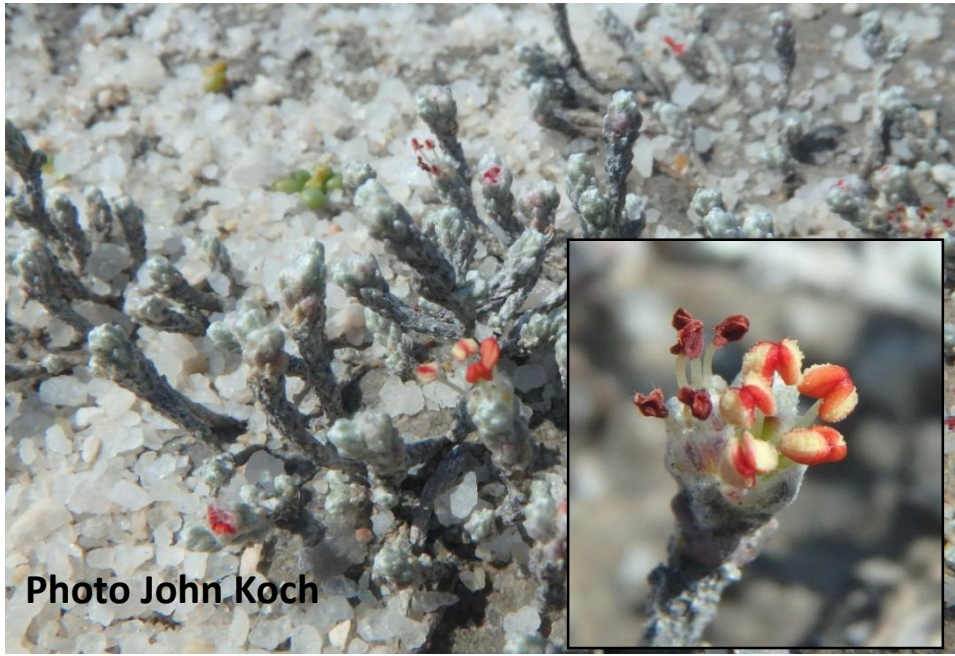
Radiation of halophytic flora

- Molecular phylogenetic data for Chenopodiaceae (Subfamily Salicornioideae
- Endemic *Tecticornia* diversified from SW coastal ancestors during Late Miocene to Pliocene

Shepherd *et al*. 2004

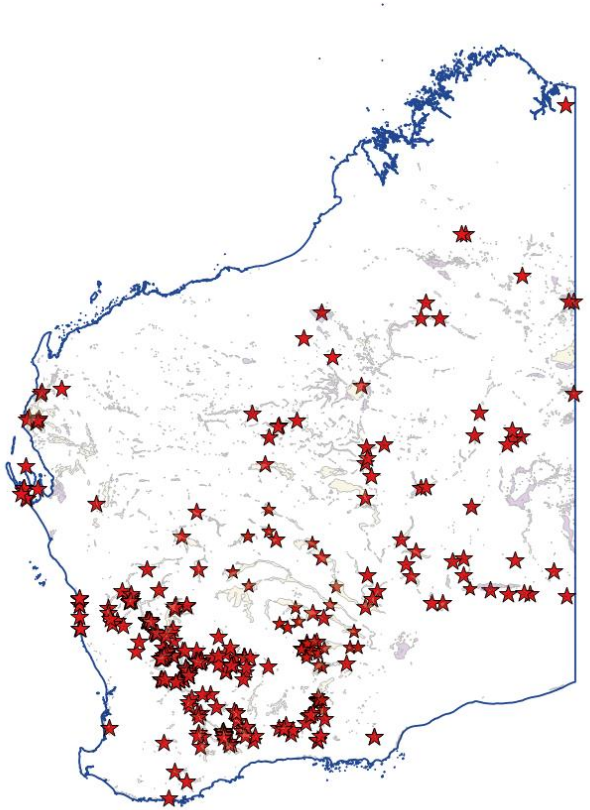
Tribe Camphorosmeae

- Most diverse tribe of Chenopodiaceae including *Scleroleana, Maireana* and *Atriplex* (99% endemic Aust.)
- Late Miocene to Pliocene radiation from SW



Where are the gypsum deposits?

- Regolith mapping 1:500 000 scale
- Regolith materials mapping 1:250 000
  - Limited coverage
- Gypsum mining project database
- ASTER remote sensing



Developing a gypsum flora list for Western Australia

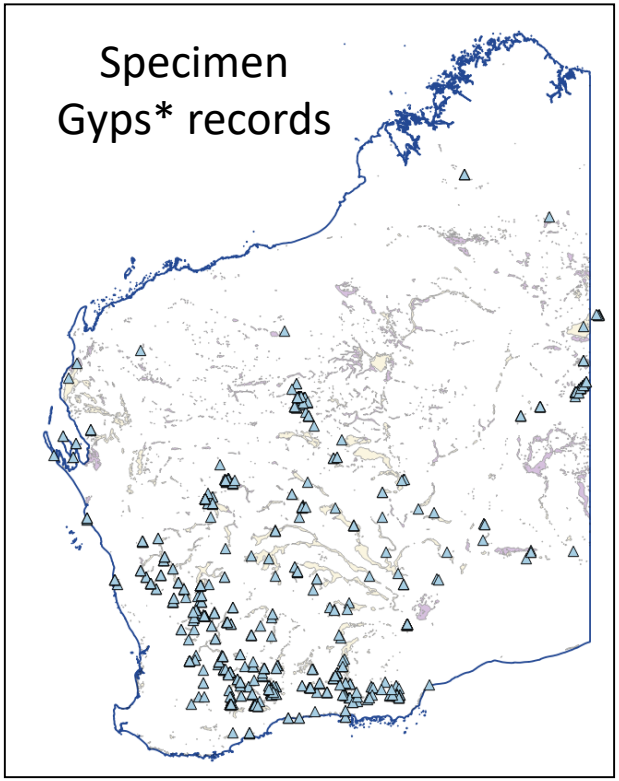
- Data sources for candidate taxa
  - Herbarium specimen data
    - Gypsum, Gypseous or kopi in descriptions
    - GIS intersection with known gypsum mining projects
  - Plots based data
    - Mattiske et al. (1995)
    - Lyons et al (2004)
    - Rick (2010)

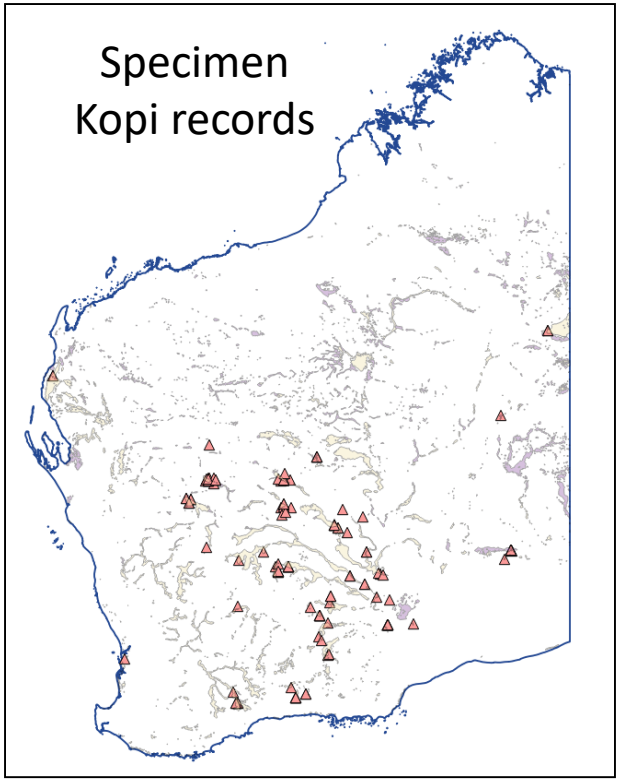
Calandrinia sp. Gypsum (F. Obbens & L. Hancock FO 10/14)

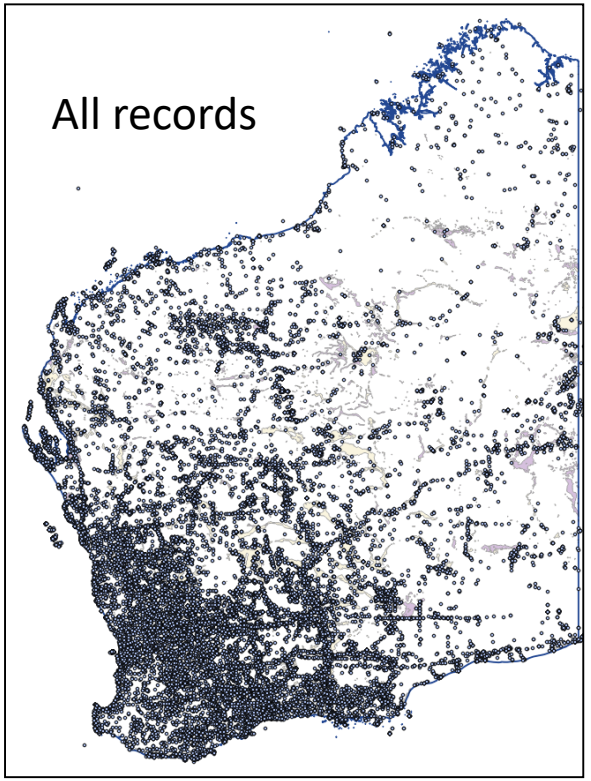
WAHERB collections databases

- Records selected based on search terms, gyps* and kopi
- Collectively these taxa have 43500 specimen records

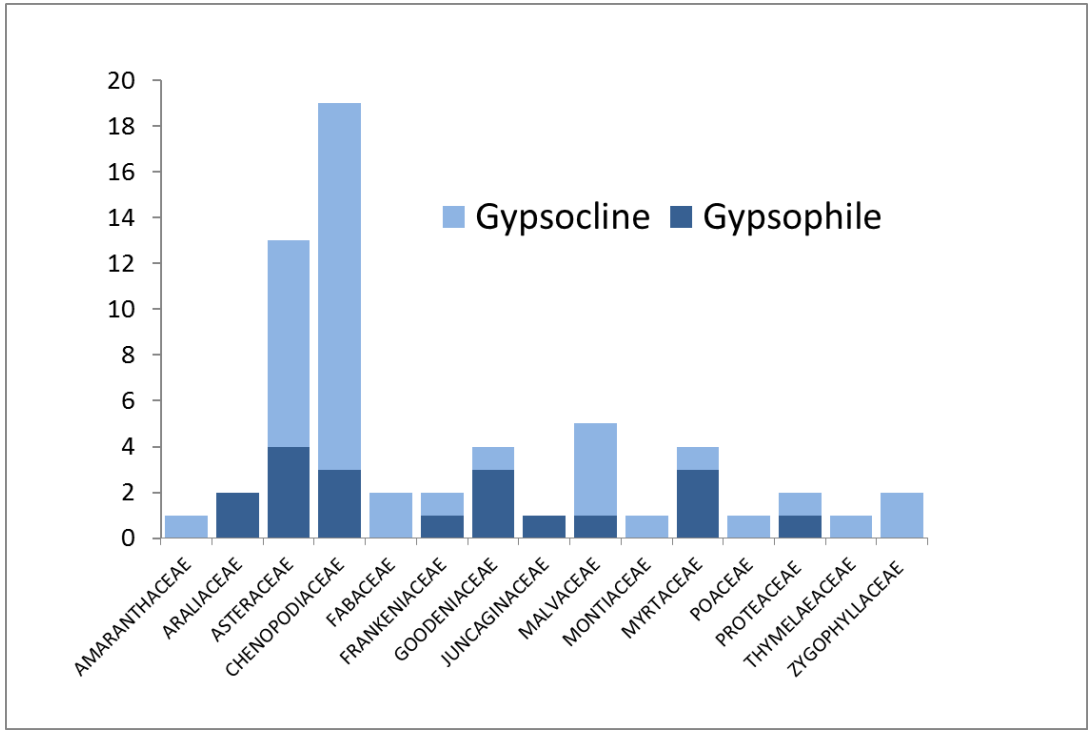
Search term	No. specimen records	No. taxa
Gyps*	1030	463
kopi	157	96
	Unique taxa	499


Specimen
Gyps* records


Specimen
Kopi records

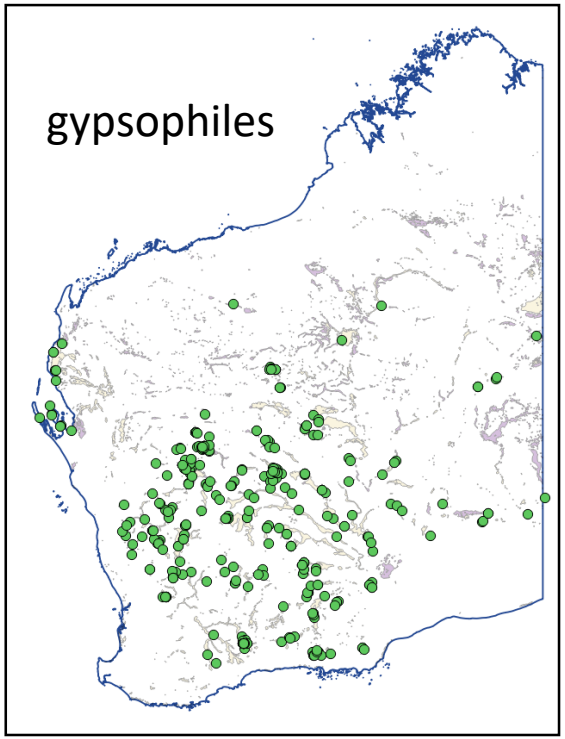

All records

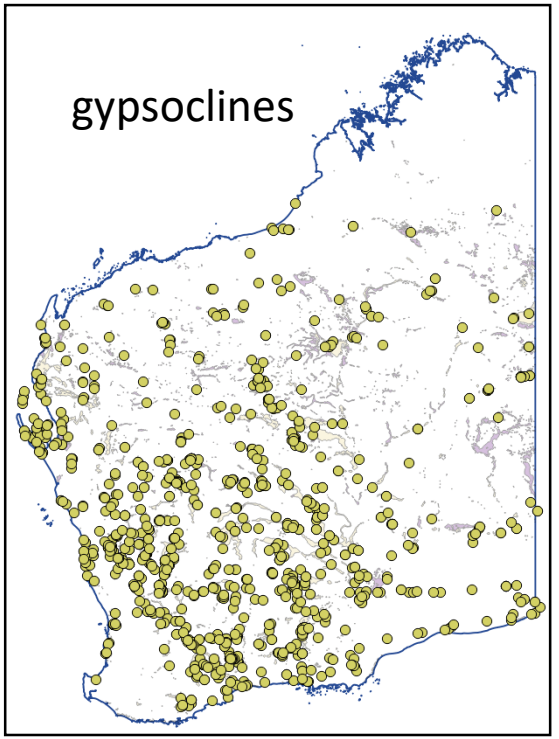
- 20 gypsophiles
- 40 gypsoclines
- Dominated by
  - Chenopodiaceae
    - *Tecticornia* spp.
  - Asteraceae
    - 9 genera



Gypsoclines also occur in

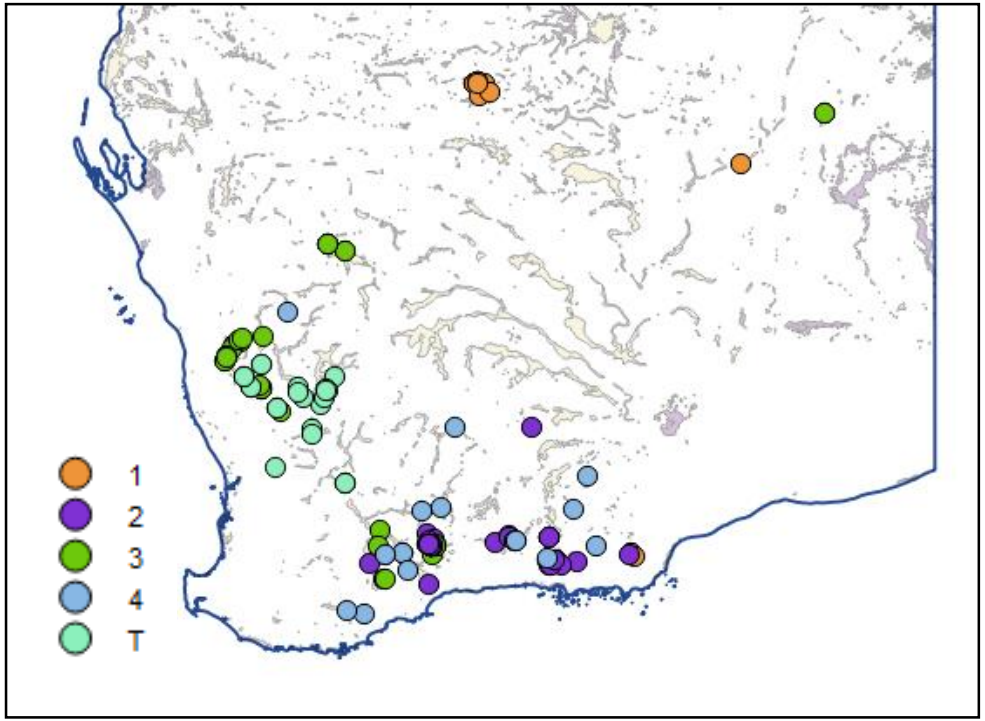
- near coastal saline habitats
- calcareous landforms
- arid zone saline wetland fringes

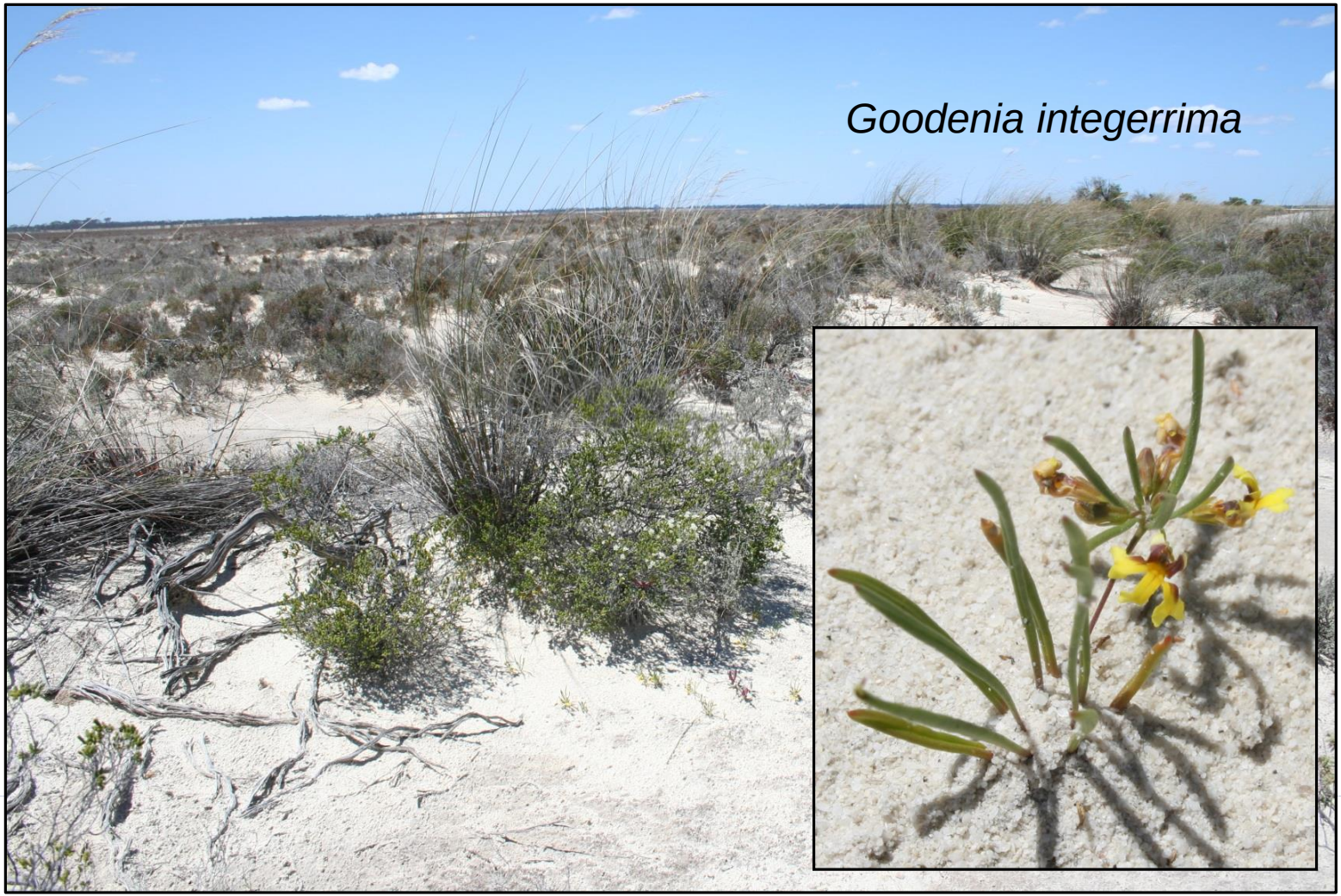




Conservation taxa

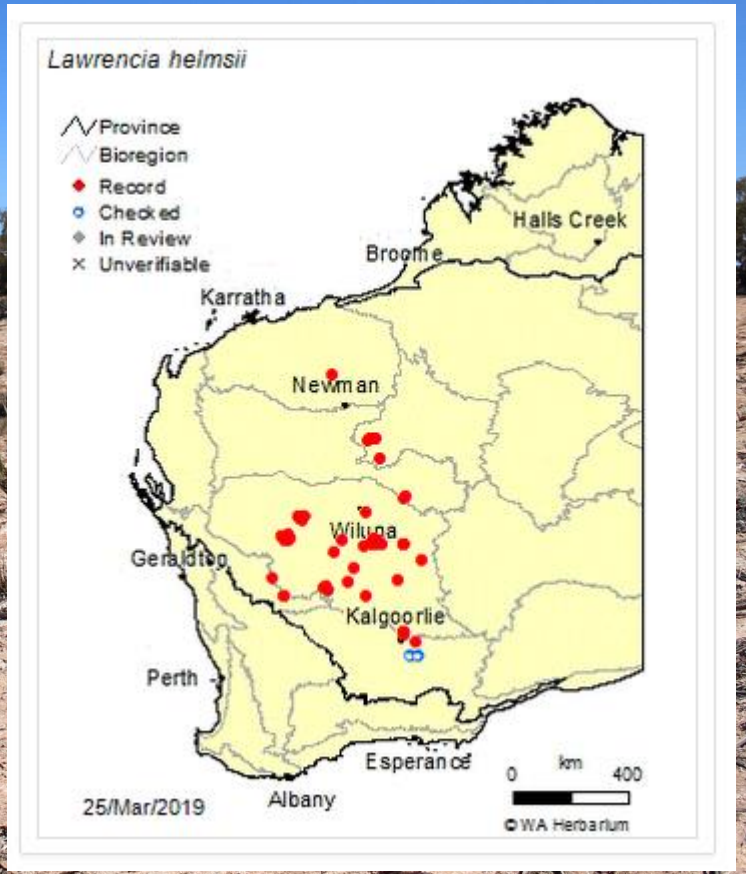
- 16 Taxa with limited distributions, poorly known and/or unreserved
- Threatened
  - *Frankenia conferta*
  - *Goodenia integerrima*




Goodenia integerrima


Triglochin sp. nov

Angianthus globuliformis


Lawrencia helmsii
Province
Bioregion
Record
Checked
In Review
Unverifiable
Halls Creek
Broome
Karratha
Newman
Wiluna
Geraldton
Kalgoorlie
Perth
Esperance
Albany
0
km
400
25/Mar/2019
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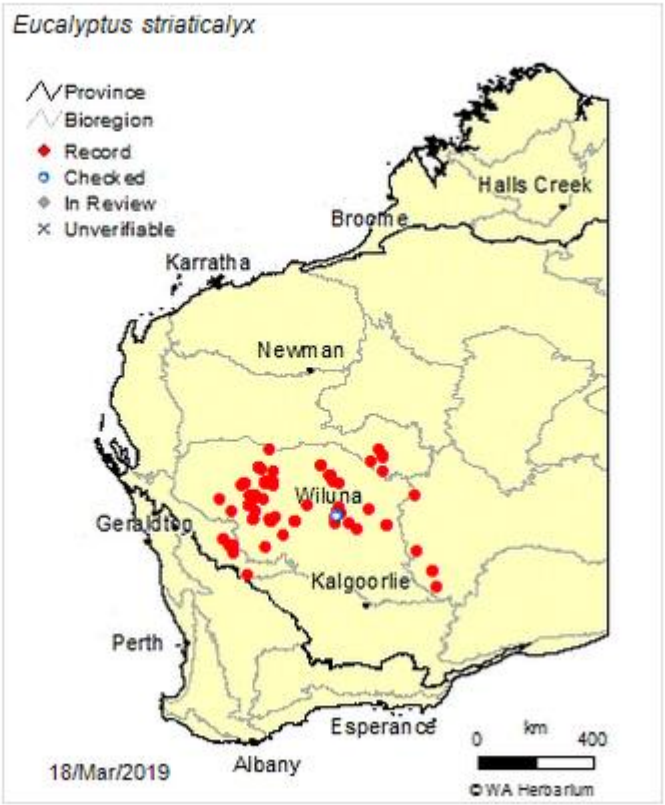
Eucalyptus striaticalyx
Photos: A. Doley & M. French


Eucalyptus striaticalyx
Province
Bioregion
Record
Checked
In Review
Unverifiable
Halls Creek
Broome
Karratha
Newman
Wiluna
Geraldton
Kalgoorlie
Perth
Esperance
Albany
0
km
400
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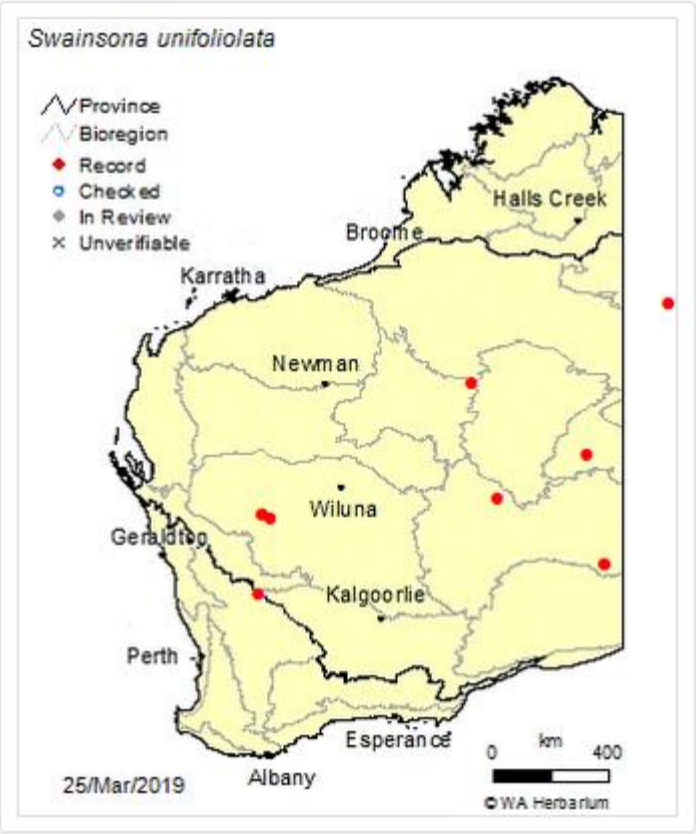
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Province
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Halls Creek
Broome
Karratha
Newman
Wiluna
Geraldton
Kalgoorlie
Perth
Esperance
Albany
0
km
400
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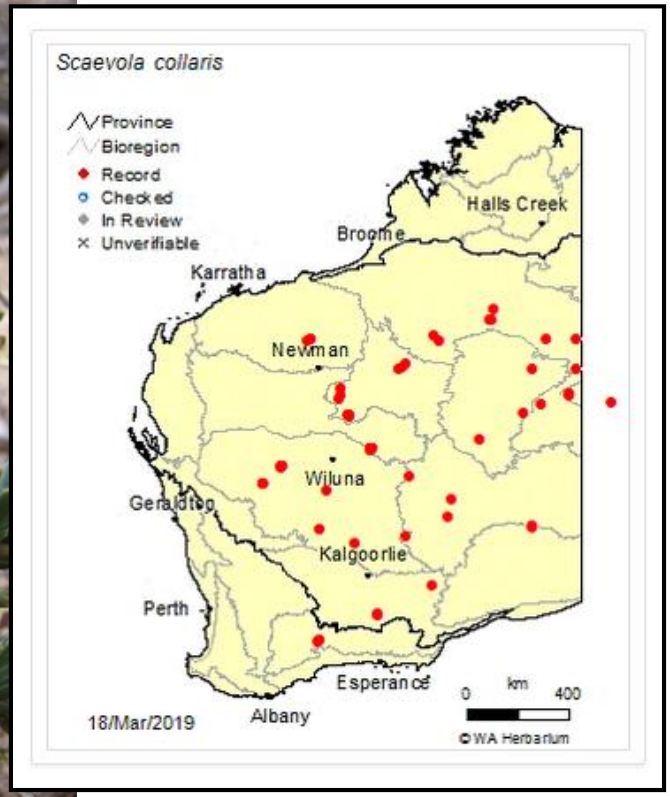
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km
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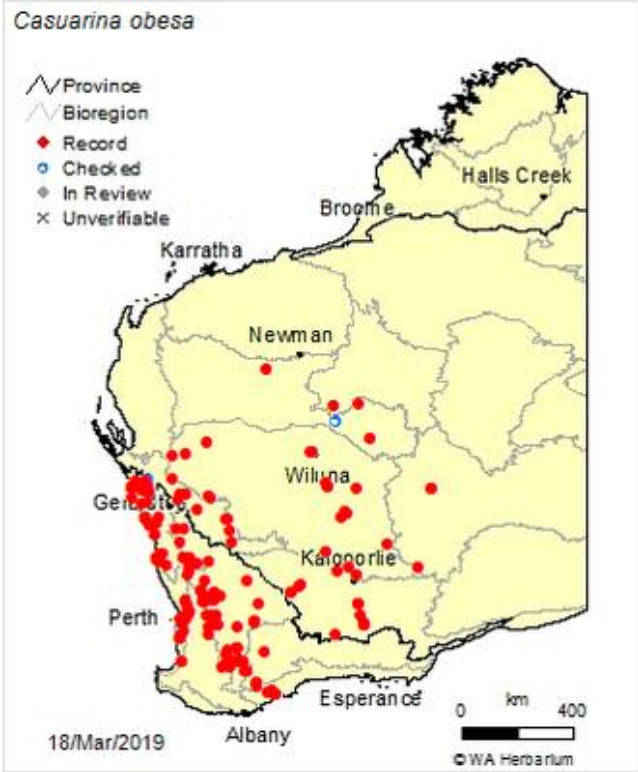
Casuarina obesa
Photos: J.M. Richardson & K.R. Thiele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Halls Creek
Broome
Karratha
Newman
Wiluna
Kalgoorlie
Perth
Esperance
Albany
0
km
400
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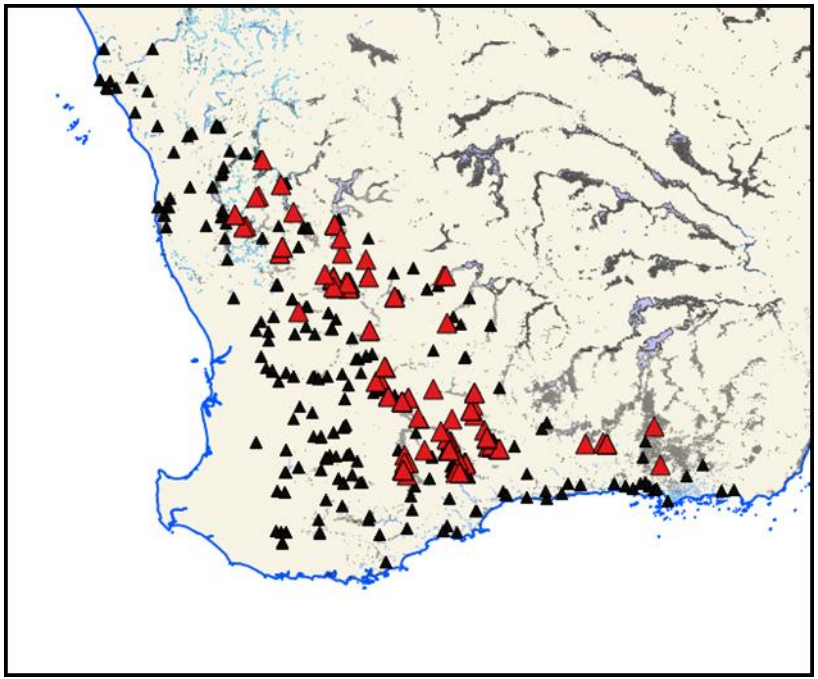
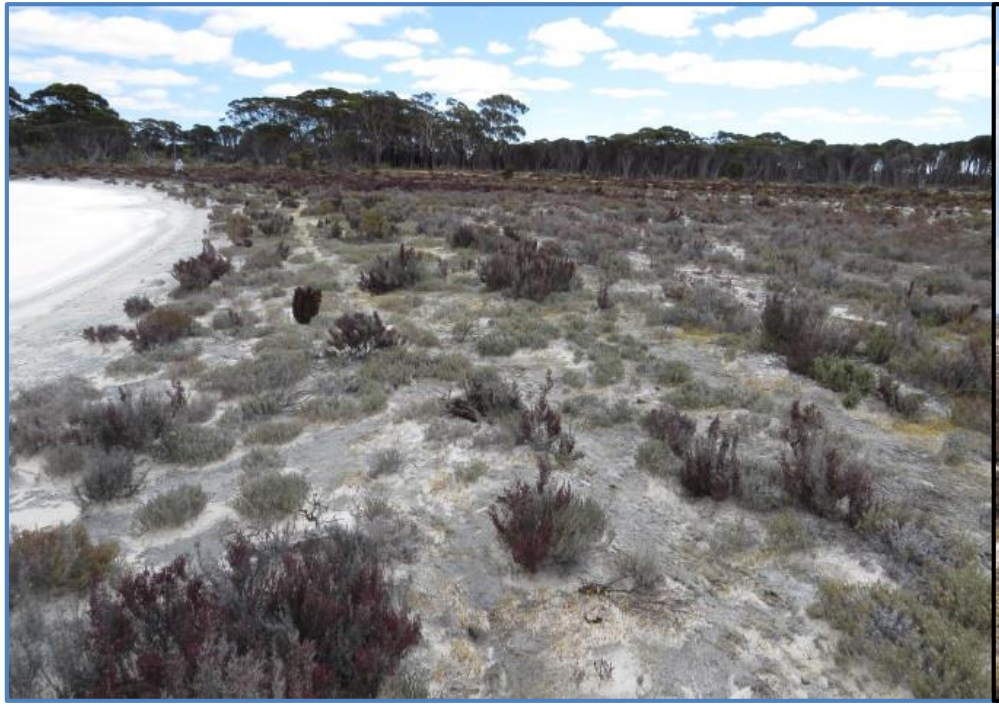
Gypsum community classification

(Lyons et al. 2004, Rick A. 2010)

- Strong biogeographical component in patterning in SW that parallels saline flora
- Gypsum plant communities in SW dominated by gypsovags (e.g. *Casuarina obesa)*
  - Does not hold for species poor berms and raised flats





Conservation impacts

- Gypsum mining
  - Soil structure improver applied to clay soils degraded by tillage
  - Usage economic only within moderate distances <200km
- 895,510 tonnes 2017/18
  - Approvals process for small projects limited

Gypsum species and community conservation

Legislative protection

- Threatened and priority flora
- Threatened and priority ecological communities

Future tasks

- Explore the utility of ASTER remote sensing layers to interrogate specimen and quadrat data
- Finalise contribution to World List
- Undertake combined analysis of all relevant floristic community data
- GYPWORLD expedition to WA 2019