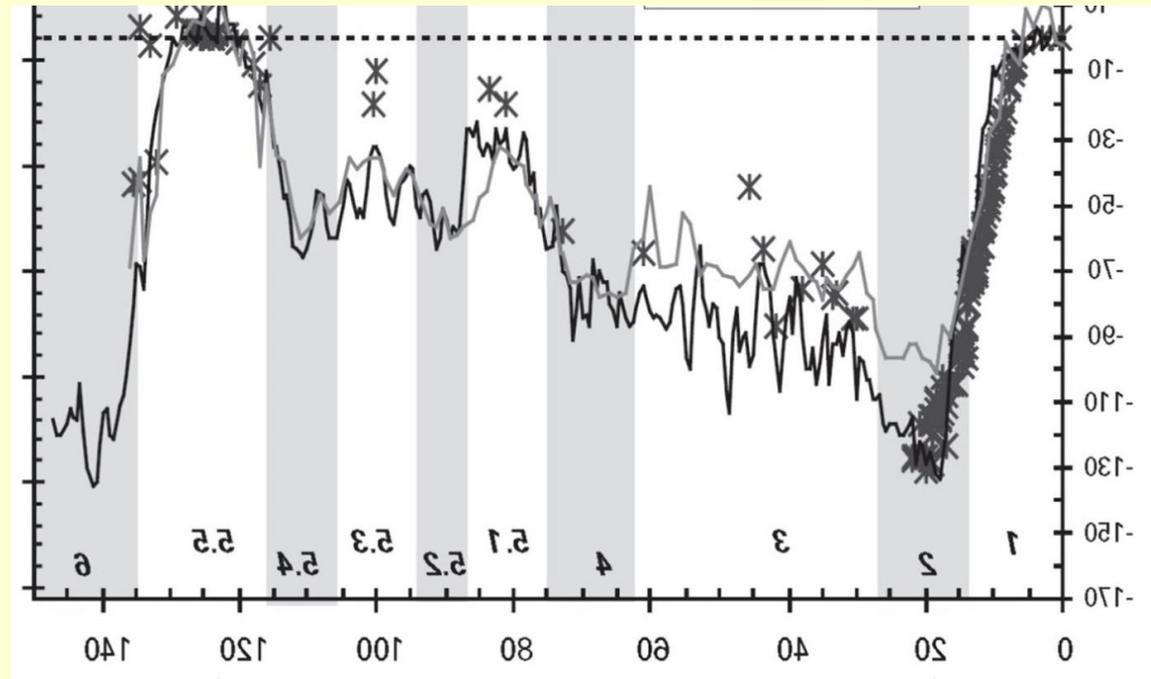


The Last Glacial Maximum (LGM) landscape - vegetation on the continental shelf coastal plain off Sydney and impacts of its subsequent loss, as indicated by plant species distributions and disjunctions

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↑
Last interglacial
120,000 years ago

↑
LGM 20,000 years ago
sea level 120 m lower

For up to 100 000 years, the continental shelf off eastern Australia, from Torres Strait to Tasmania, was exposed to some degree, before final re-inundation about 7 000 years ago.



At 18 000-20 000 years ago the LGM coastal plain extended about 8-15 km beyond the present Sydney foreshore

Between the Hunter and Shoalhaven Rivers there was a coastal strip of about 250 000 ha of terrestrial habitat i.e. nearly ten times the combined areas of Kuring-gai Chase and Royal National Parks

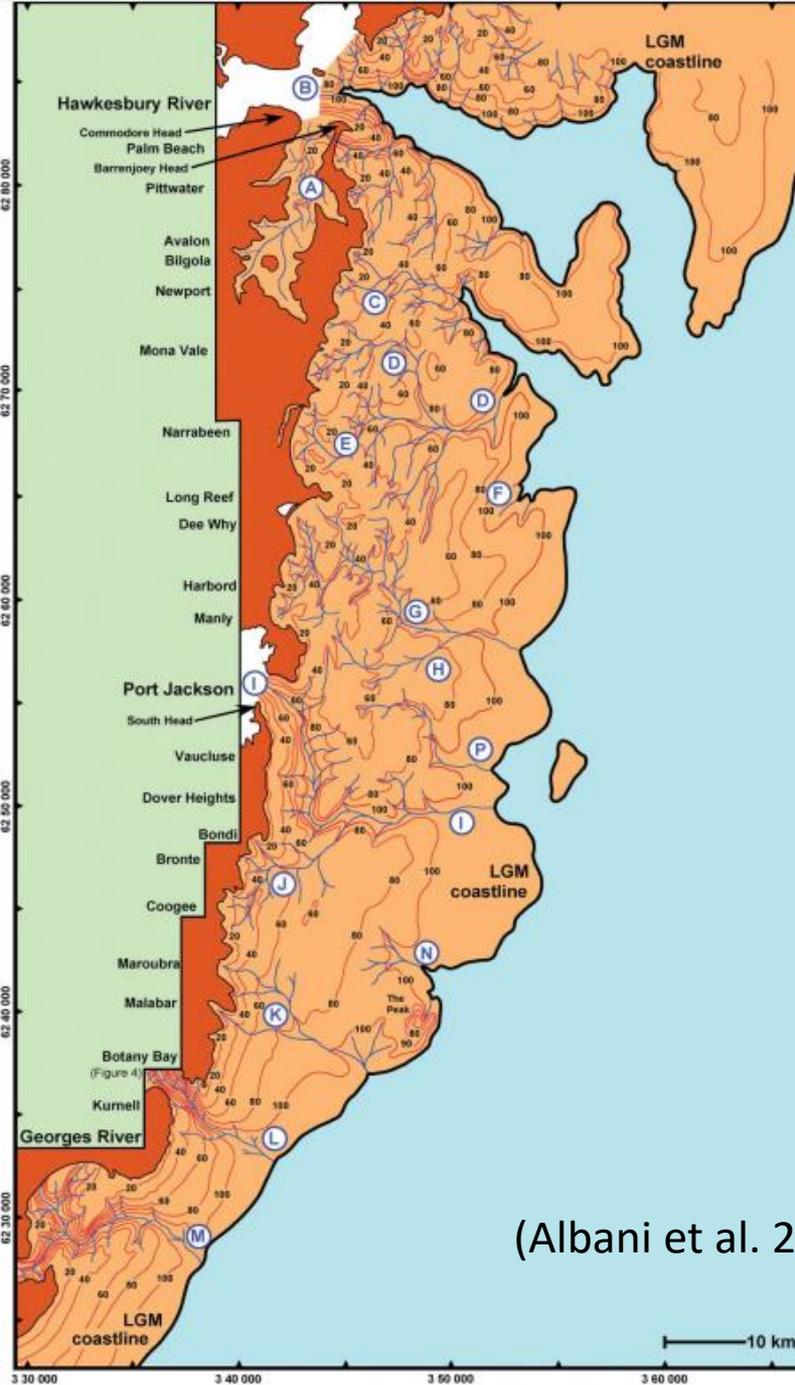
LGM climate was
Colder
Drier
Windier
Lower atmospheric CO₂

What was the landscape like?

Landscapes off Sydney

18 000 yrs ago — Broken Bay- Botany Bay

1. Estuarine deposits associated with rivers e.g. Hawkesbury
2. Alluvial floodplains and infilled sandstone valleys
3. Sandstone plateaus and a rocky sandstone coastline, up to 20 m higher than the LGM sea level,
4. Dune sands overlying bedrock
5. Areas of non sandstone bedrock- shales



1. Estuaries predominantly saltmarsh

- LGM too cold for mangroves (essentially **tropical**)
- Saltmarsh flora is ecologically **temperate** and southern in origin.

e.g. of 53 saltmarsh dominants in Victoria, only about 25 species also occur in NSW)



Isolated outlier occurrences of essentially southern (Vic) saltmarsh species as evidence of past more extensive distributions



Wilsonia backhousei, in the Parramatta River and Jervis Bay
Wilsonia rotundifolia at Royal NP and Jervis Bay,
Gahnia filum in Georges River saltmarsh, Jervis Bay and Moruya
Tecticornia pergranulata subsp. *pergranulata*, in up-river saltmarsh in Homebush Bay.

2. Alluvial floodplain and infilled valley landscapes –

Are likely to have had Scrub with Southern shrub species e.g.

Myoporum insulare,

Acacia sophorae subsp. *sophorae*,

Melaleuca ericifolia



The large coastal swamp forest species of today,

Melaleuca quinquenervia,

Melaleuca armillaris,

Eucalyptus robusta,

Casuarina glauca,

Leptospermum laevigatum,

have substantially northern distributions and are likely to have been confined to the North Coast.

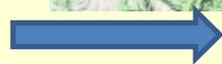


3. The LGM Sandstone plateaus and rocky sandstone coastline - sclerophyll vegetation colonising from the west

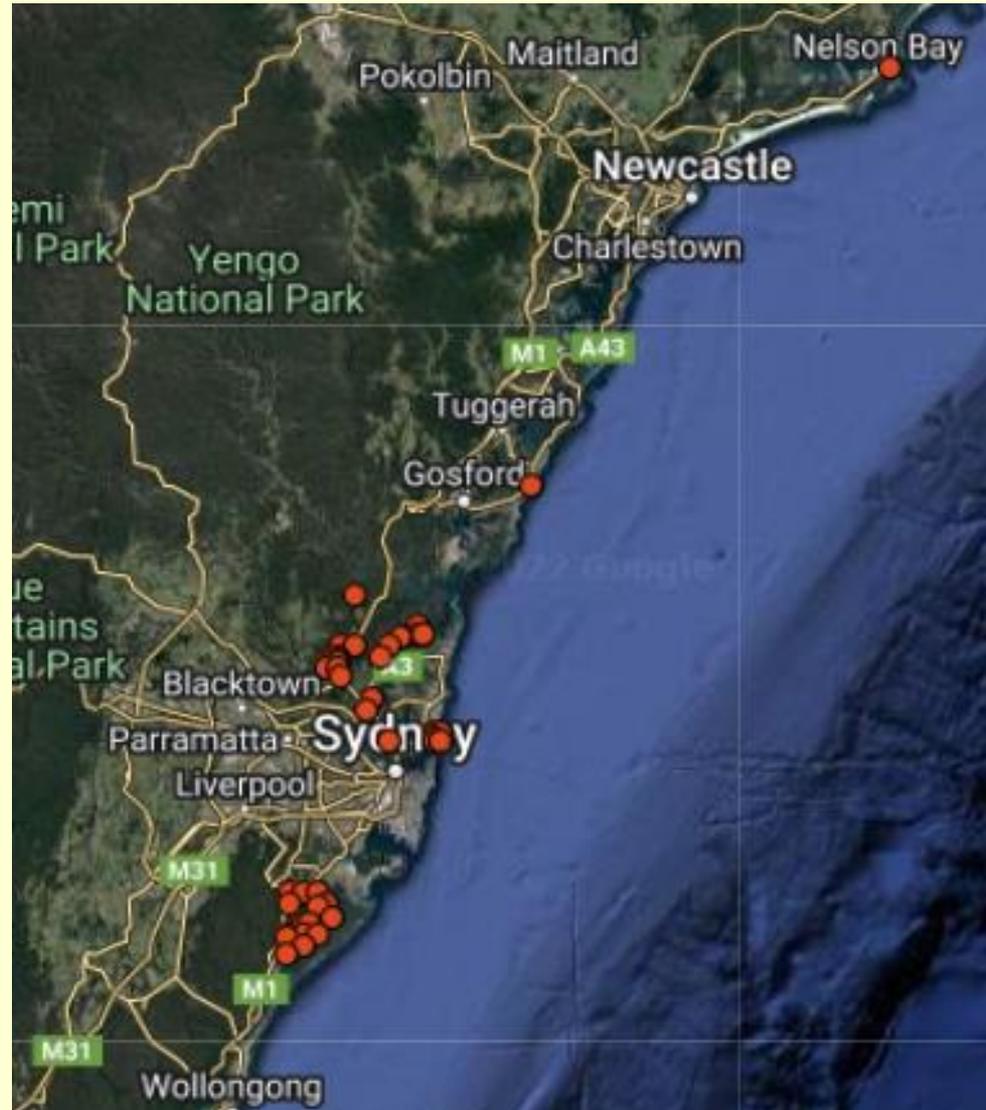
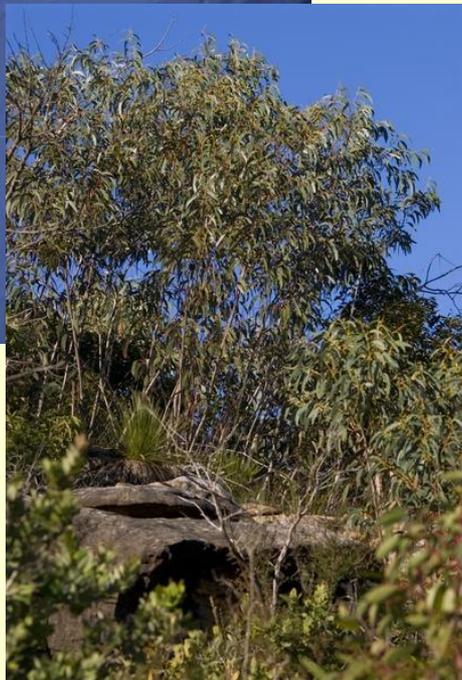
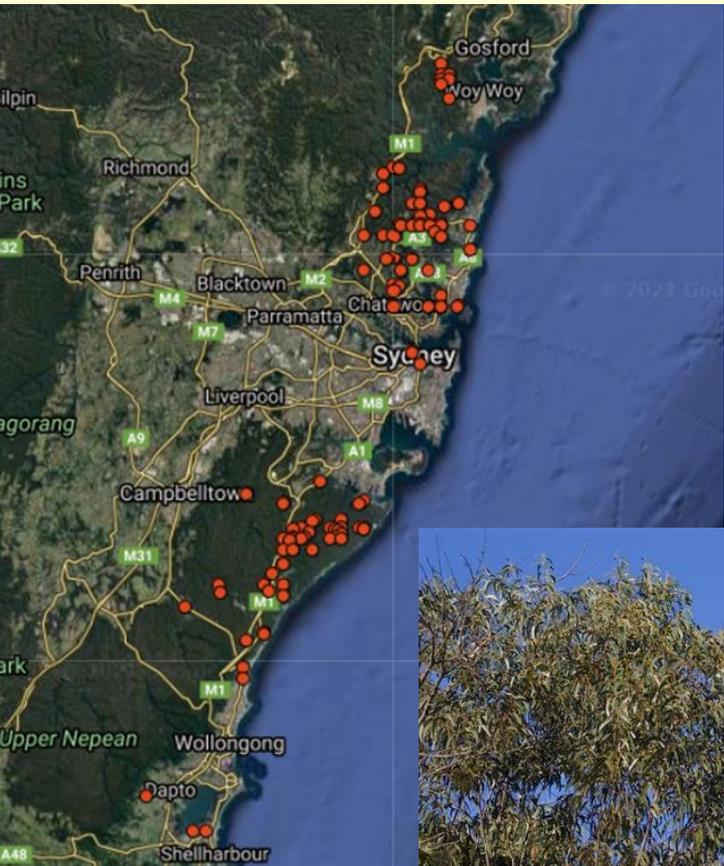
Sydney sandstone plateaus are OCBIL landscapes - Old Climatically Buffered Infertile Landscapes with many taxa that have evolved in situ over a very long time.

Characteristics of OCBIL taxa include stress tolerance, slow growth, longevity and persistence, features that would have been beneficial in the harsh LGM conditions.

The LGM sandstone vegetation is likely to have been predominantly resprouters - mallee eucalypts, low shrubs, and monocots such as *Eucalyptus stricta* and *Allocasuarina nana*.



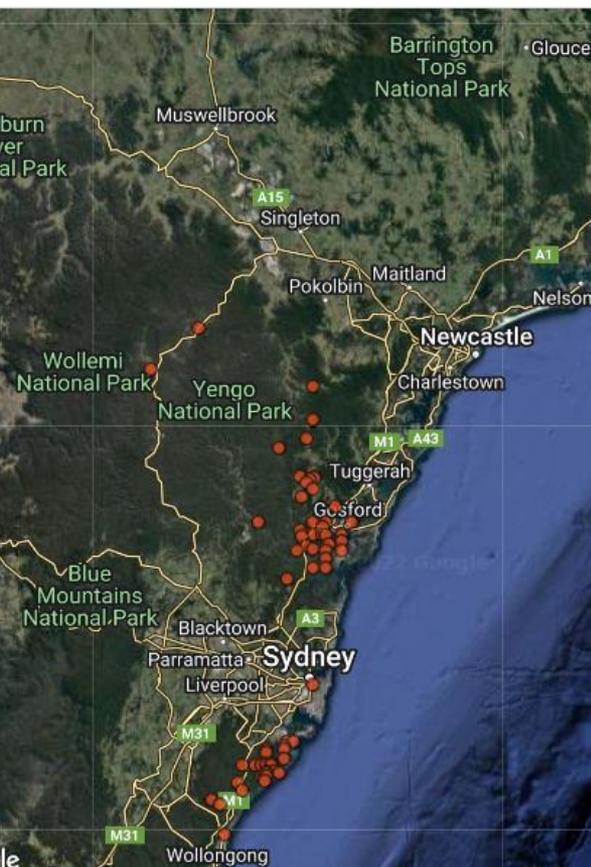
Sydney Coastal sandstone plateau endemic mallees - *Eucalyptus luehmanniana* (L) and *Eucalyptus camfieldii* (R)



Coastal sandstone endemic resprouter shrubs

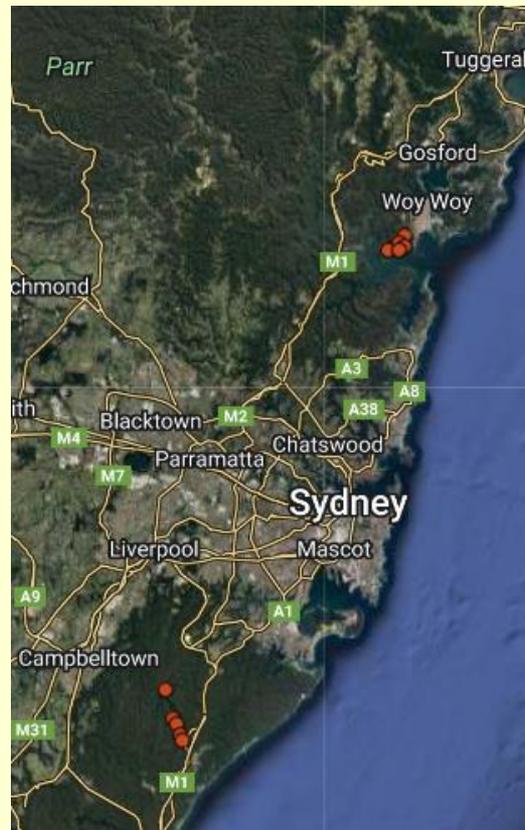
Tetratheca shiressii

Newcastle - Bulli



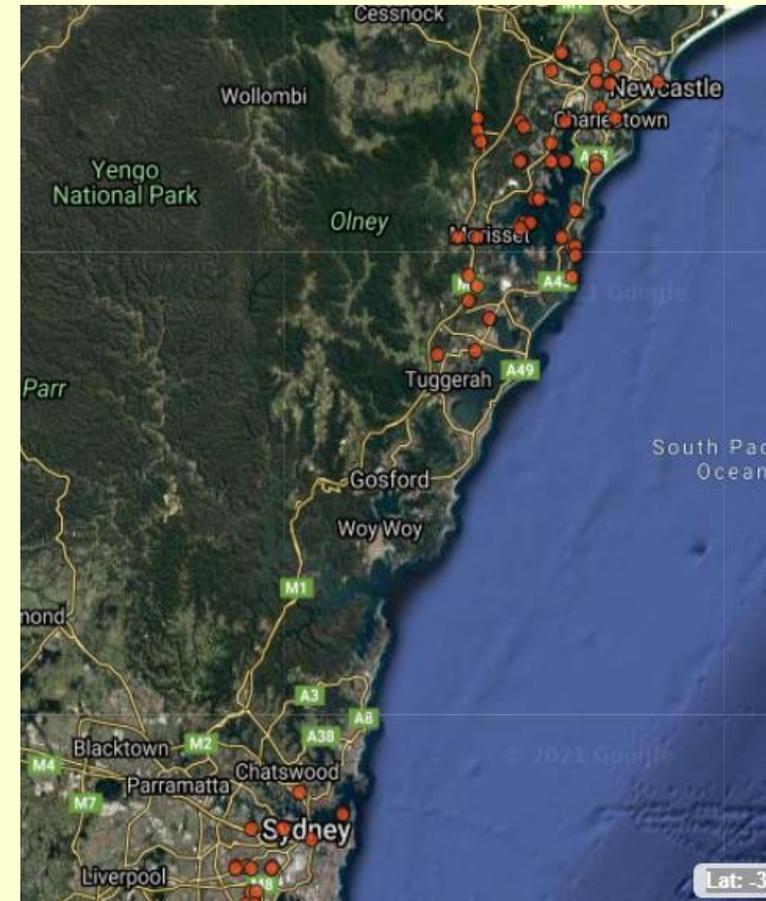
Astrotricha crassifolia

Woy Woy - Appin



Tetratheca juncea Lake

Macquarie - Georges River



Also orchid *Genoplesium baueri* Ku-ring-gai - Jervis Bay

For sandstone fire sensitives

The LGM coast is likely to have been a refugial area for fire dependent and serotinous Proteaceae taxa e.g. *Banksia ericifolia*



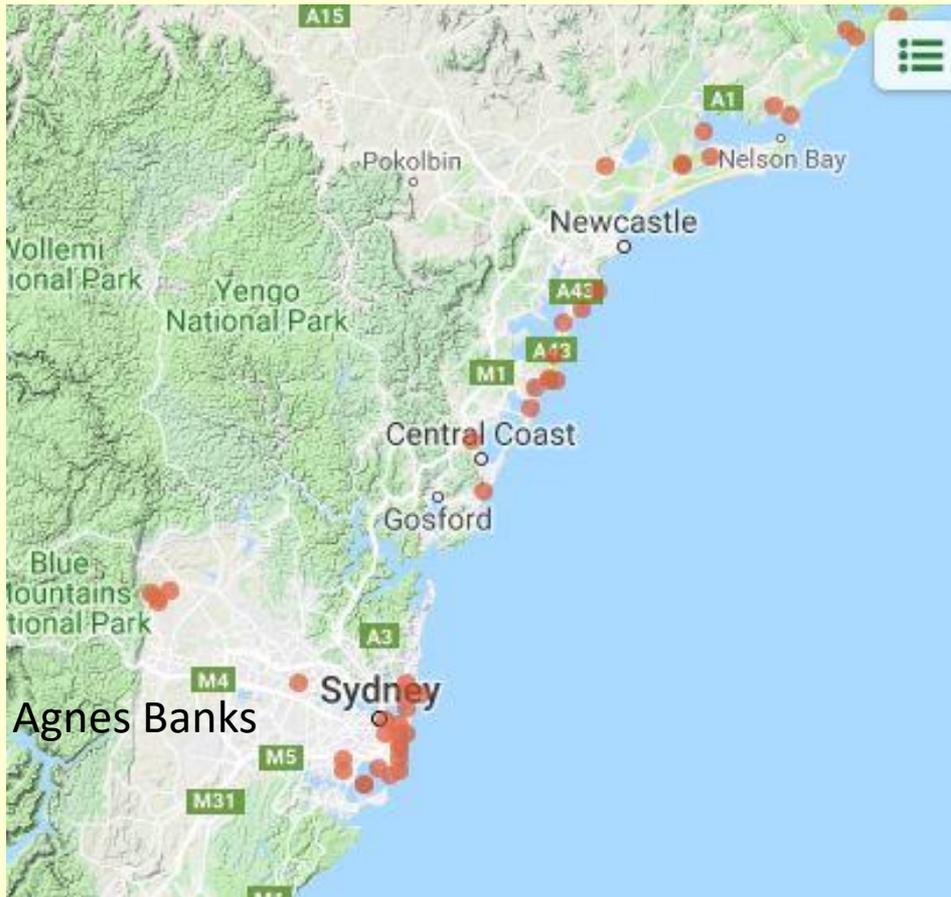
4. Areas of dune sands overlying bedrock

- *Banksia* Wallum vegetation on the Queensland sand islands dates back to the LGM and north coast *wallum* species have gradually moved south along the LGM coast.
- At Myall Lakes *Banksia wallum* - Dry heath occurs on leached low-nutrient Pleistocene sand podsols

Distribution of wallum
Banksia aemula



Further south *Banksia aemula* and other wallum species occur on similar leached coastal sands remnants south to Sydney e.g Redhead, Bouddi, North Head ESBS-La Perouse



Wallum species with similar Sydney area distributions and limits

- *Macarthuria neocambrica*,
- *Bauera capitata*,
- *Acacia baueri* subsp. *baueri*,
- *Sprengelia sprengelioides*,
- *Baloskion pallens*
- *Acacia quadrilateralis*

Isolated inland leached dune sand with *Banksia aemula* wallum vegetation at Agnes Banks near Richmond indicates possible extent of LGM sandplain influence.

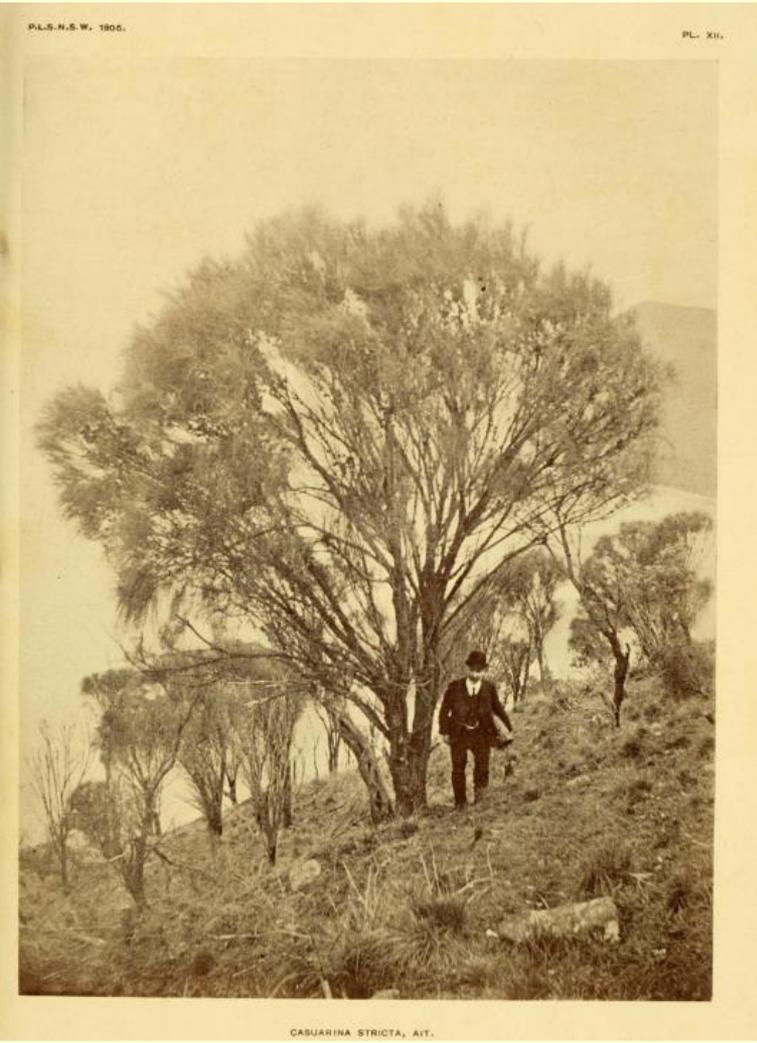


Dune vegetation at Agnes Banks has 47% of species in common with Myall Lakes and 25% with North Stradbroke Island

Isolated southern limit of *Baloskion pallens* at Agnes Banks



5. Vegetation on non sandstone bedrock - Isolated coastal occurrences of *Allocasuarina verticillata* on Narrabeen shales at Mona Vale and Stanwell Park were described by R H Cambage in 1906



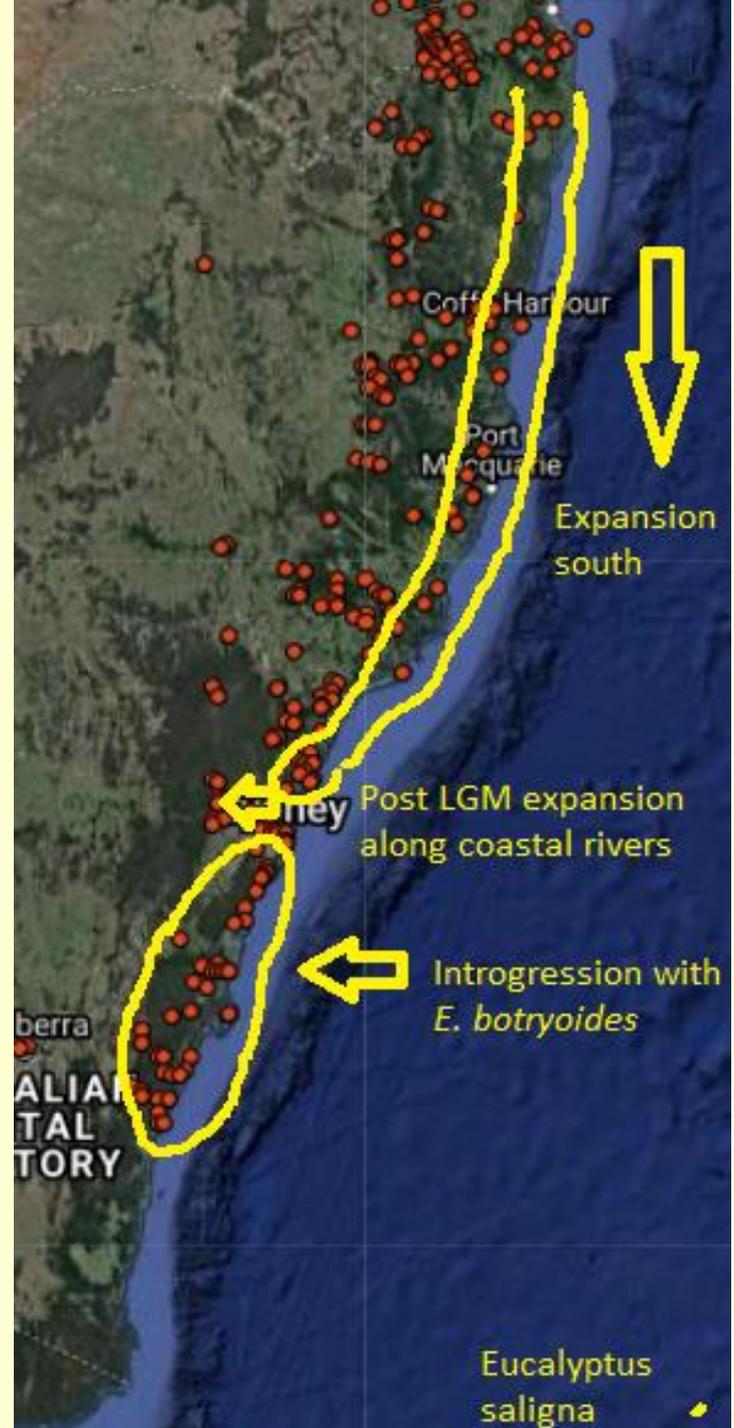
Cambage concluded ...having in view the isolated occurrence of *Allocasuarina verticillata* [*Casuarina stricta*] along the east coast of NSW, the suggestion that it formed part of the latest flora on the present continental shelf before its final submergence, seems to me less open to destructive criticism than any other put forward. (Proc Linn Soc NSW 30: 376-391).

Holocene warming from 12 000 BP

Increasing rainfall and CO2 would enhance quick growth

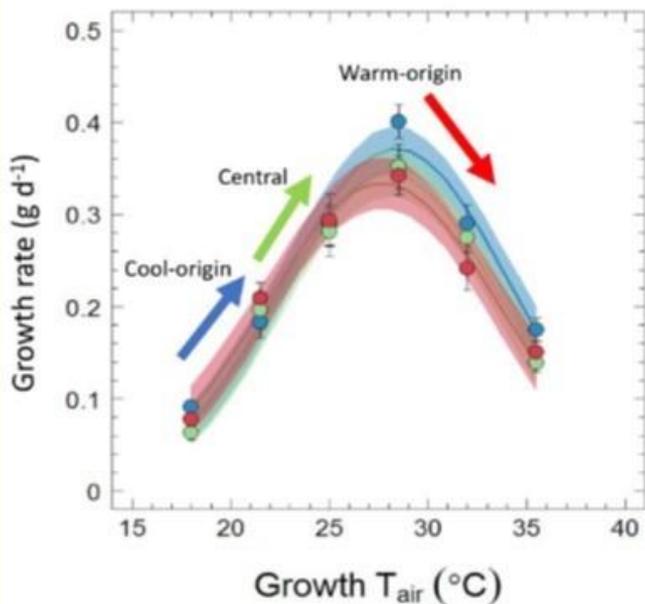
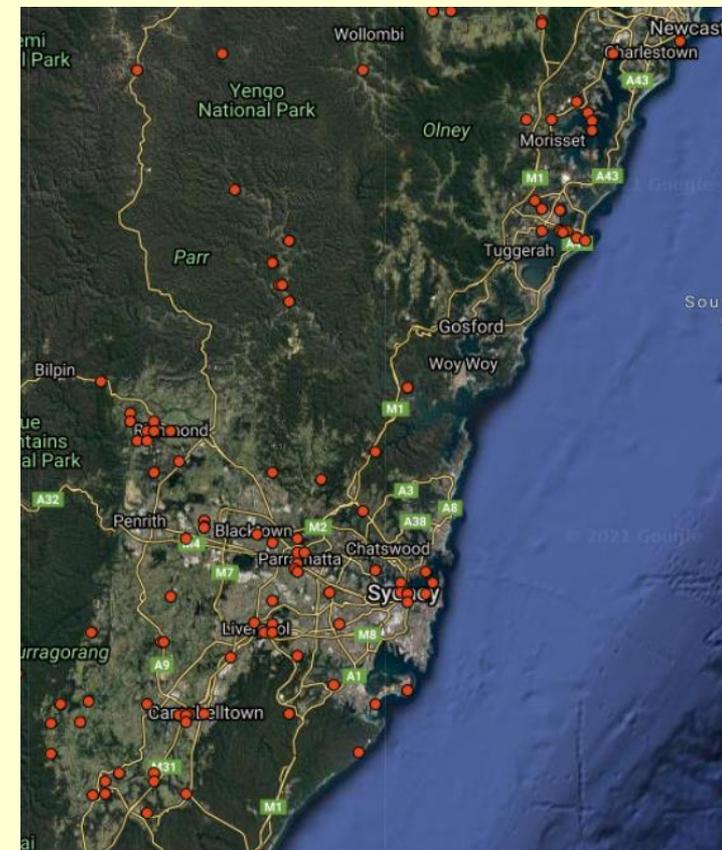
Quick growing woody species could now outcompete the slow-growing LGM shrubs for light

Southward expansion of big quick growing eucalypts e.g. Sydney Blue Gum *Eucalyptus saligna* along coastal rivers →



Similarly *Eucalyptus tereticornis* southward expansion along coastal floodplains, and into western Sydney, leaving remnant coastal populations e.g. Mosman, Port Hacking

Eucalyptus tereticornis has no local growth provenances indicating recentness of spread (Tjoelker et al. 2017)



Mangroves spread in warmer ocean currents

Warmer ocean temperatures would have allowed saltwater-dispersed mangrove *Avicennia marina* propagules to drift southward with the East Australian Current and, with increased CO₂ assisting growth rates, colonise saltmarsh areas. *Avicennia marina* recorded at Botany Bay and Bulli by 7000 years ago



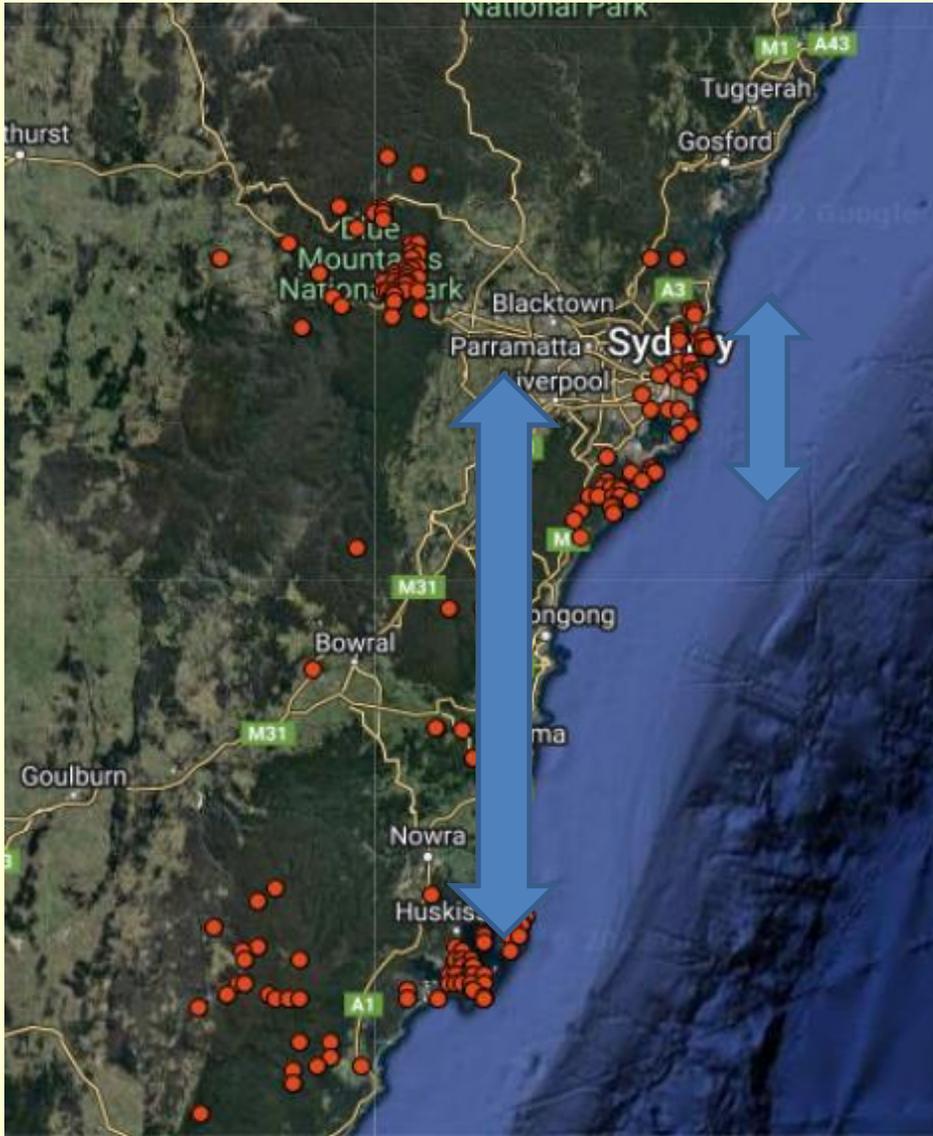
By about 7 000 yrs BP sea level rise had caused Loss of the coastal plain and fragmentation of coastal species



Isolated relics of the lost coast include

- Only known population of almost extinct *Casuarina portuensis* is at Neilsen Park on Sydney Harbour
- *Acacia terminalis* subsp. *terminalis* North Head and Eastern Suburbs Banksia scrub
- *Eucalyptus parramattensis* subsp. *decadens* at Tomago and Kurri Kurri

Loss of coastal connection resulting in genomic differentiation is evident for coastal Green Ash mallee *Eucalyptus obstans/burgessiana*



(Rutherford et al. (2018) found no genomic differentiation for populations within Sydney, 40 km apart (Beacon Hill and Royal NP), but population-level differentiation between Sydney and Jervis Bay populations, about 100 km apart.



At about 6900 cal BP sea level rose a further 1 m higher (Mid Holocene highstand/Post-glacial Marine Transgression) (and appears to have remained at this level until about 2000 yr BP, when it fell back to its present position)



Estuarine vegetation patterns such as in Patonga Creek (*Avicennia/ Aegiceras/* saltmarsh are less than 2000 years old, in contrast to >20 000 years for some sandstone mallee/heath vegetation)

To understand our flora it is important to maintain local occurrences of rare species in their original habitats, in situ, not translocated and not just in seedbanks and cultivation. Otherwise we lose their individual contributions to the history of our ancient landscape.

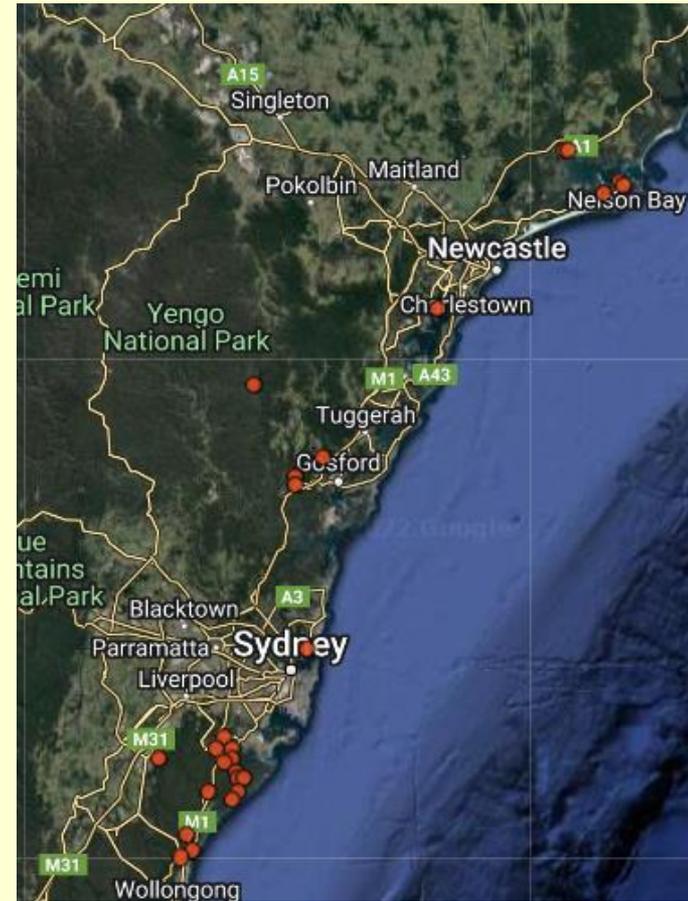
References

Cambage RH (1906) Proc Linn Soc NSW 30: 376-391).

Rutherford, S., Rossetto, M., Bragg, J. G., McPherson, H., Benson, D., Bonser, S. P. & Wilson, P.G. (2018) Speciation in the presence of gene flow: population genomics of closely related and diverging *Eucalyptus* species. *Heredity* **121**, 126–141.

Tjoelker, M.G., Medlyn, B.E. & Drake, J.E. (2017) Climate suitability of diverse provenances of a widely-distributed eucalypt: Testing the 'local is best' paradigm under climate warming. *Australasian Plant Conservation* **26**, 7-9.

*Doryanthes
excelsa* Gymea



Acknowledgement

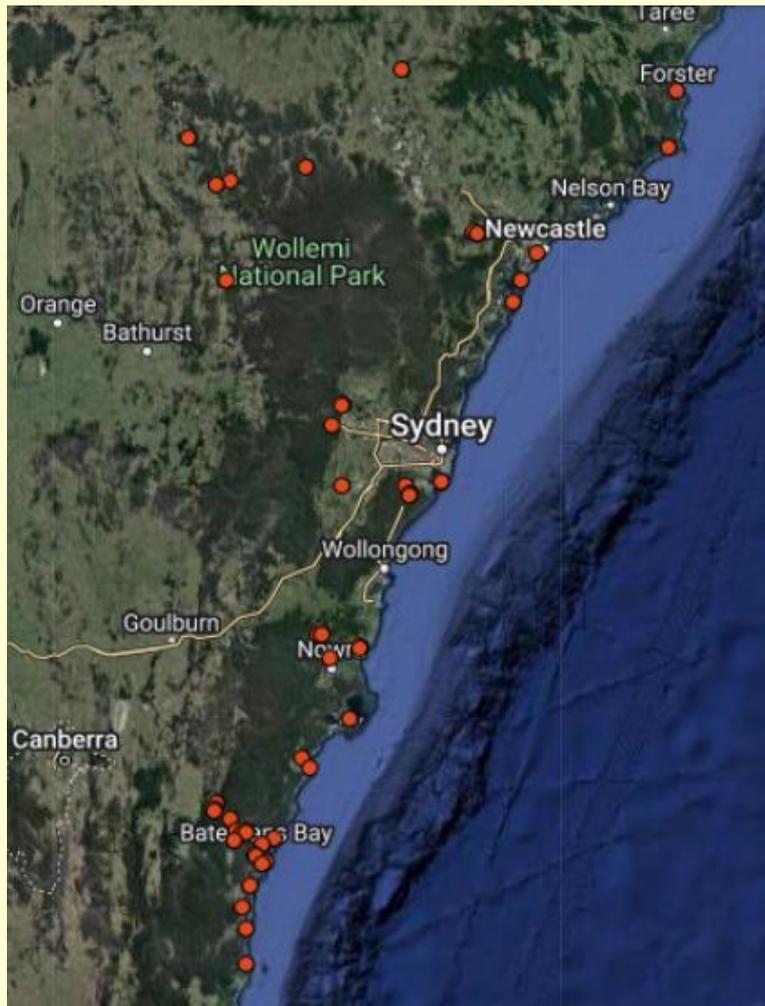
Australasian Virtual Herbarium for dotmaps

Dioecious fleshy fruited shrubs.

Southward movement with gaps from loss of LGM littoral sands

Possible some human-assisted dispersal for *Macrozamia* ?

Macrozamia communis NC-Bega



Podocarpus elatus Q-Jervis Bay

