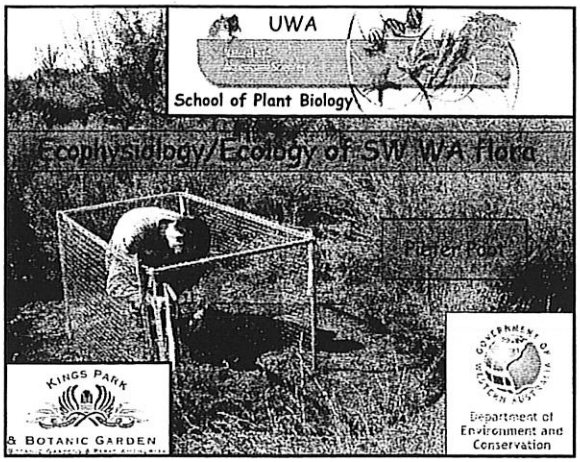
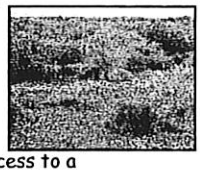


Outline of presentation

- Adaptations of species confined to a Threatened Ecological Community

Ironstone communities:

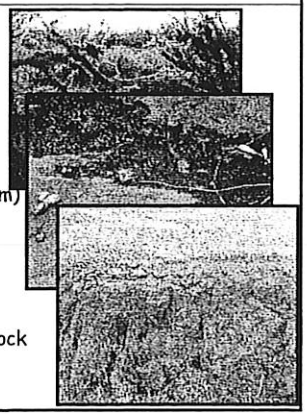


- Consequences of a Threatening process to a widespread community

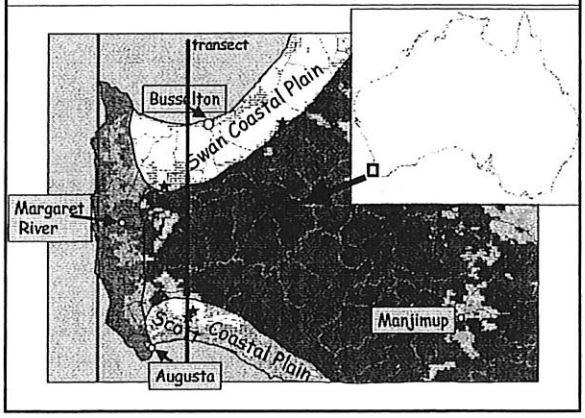
Wandoo woodland decline: is climate change responsible?

Ironstone communities: what are they ?

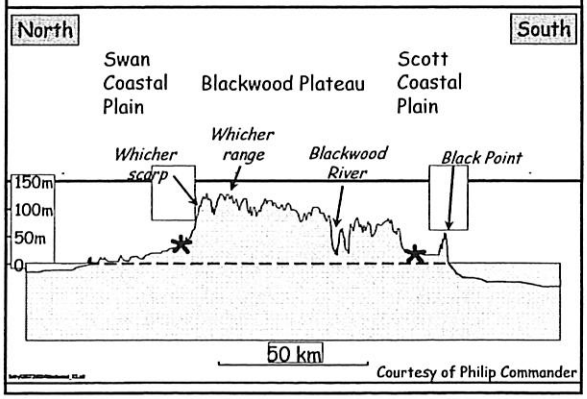
- Winter-wet shrublands
- Skeletal red soils (0-15 cm) (sandy loams)
- Over massive ironstone rock (up to 4m deep)



Where are they? → Geography

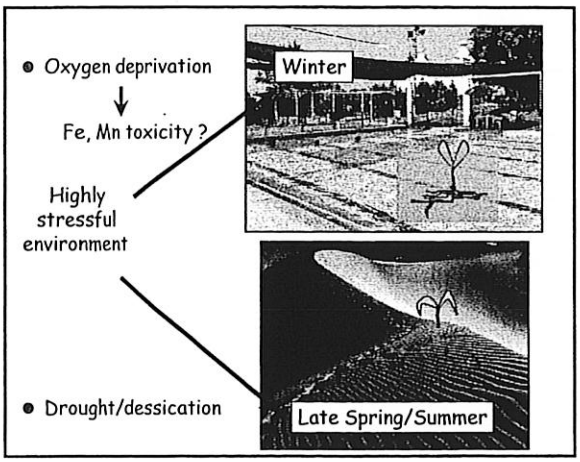


Where are they ? → Topography



How were they formed?

- could have been forming since ± 1.5 million years ago
  - → run-off of Fe rich water from scarp laterites
  - → precipitation of Fe oxides/Fe hydroxides in zone of water table fluctuation (winter)
  - ↓
  - coffee rock formation
- iron rich impeding layers are common on coastal plain but at much greater depth !
  - → <u>ironstone communities</u>: "islands" in a "sea" of much deeper Quaternary sand deposits



Main question

- Why are ironstone endemics so restricted in their distribution ?

→ Maybe: they are too specialised !

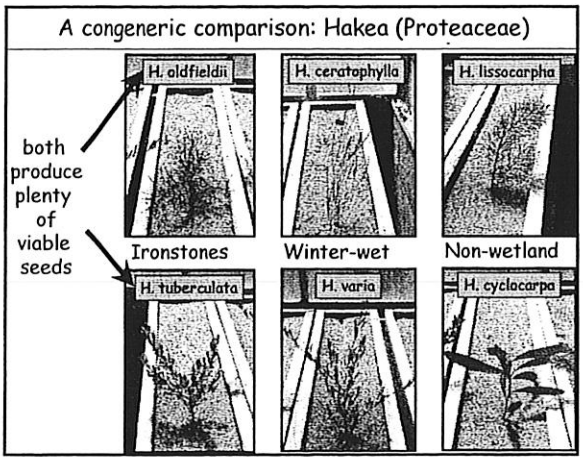
↓

Adaptations needed to be successful in their own highly stressful habitat

are not very useful (or too extreme) in other environments...

↘

'kind of handy' to know also in terms of TEC management...



First 'growth analysis' experiments

Are ironstone species in <u>any way</u> different from their common congeners ?

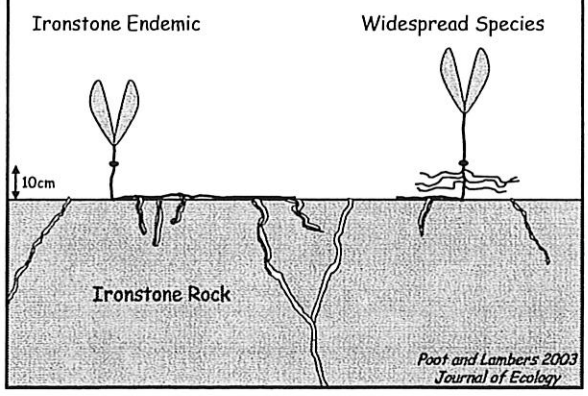
↓

It's all in the roots...

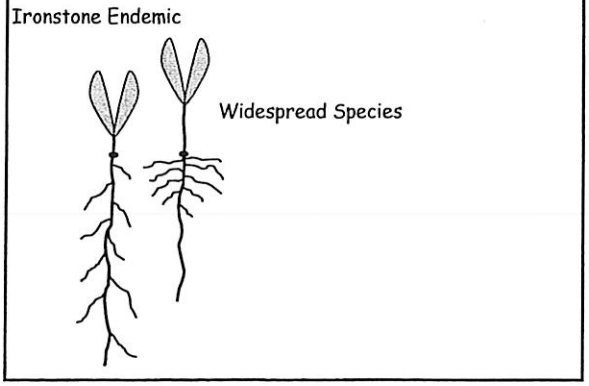
Ironstone endemics:

- initially invest more in roots
- initially have thinner roots
- main root axis does not respond to bottom of pots
- much more roots in bottom of pot

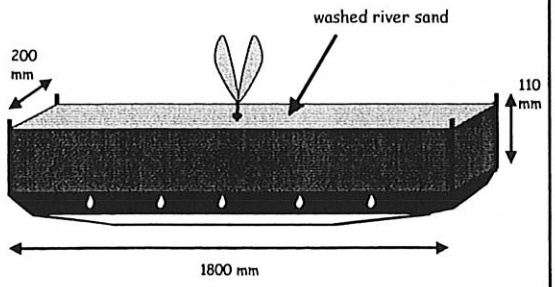
Model: a shallow ironstone habitat

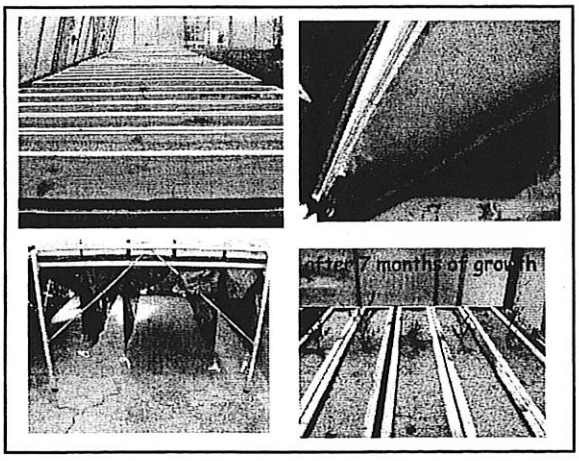


Model: a deeper soil

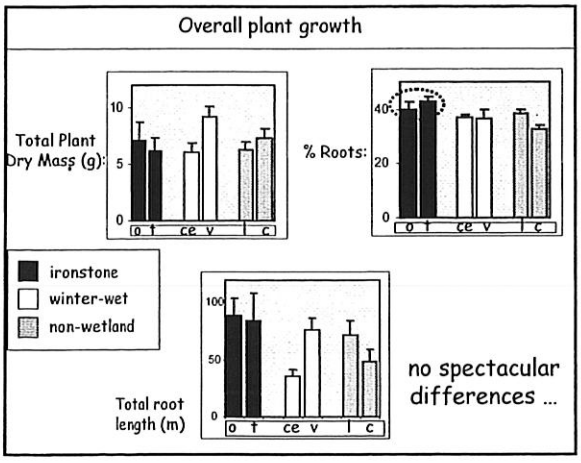


A more realistic pot design





Overall plant growth

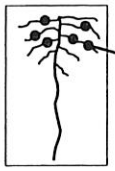


Detailed look at root systems:

1. Spatially: where did they put their roots?

2. Temporally: when did they put them there?

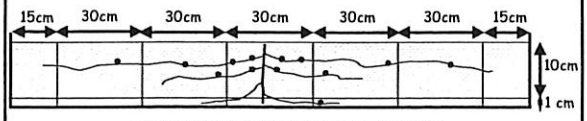
3. Functional: what type of roots did they put where? (cluster versus non-cluster)

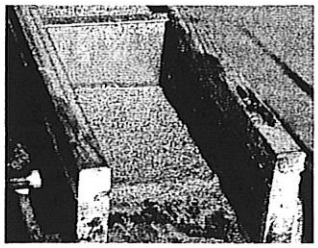


clusters: dense outgrowth of lateral rootlets

(involved in nutrient acquisition: mainly P and micronutrients)

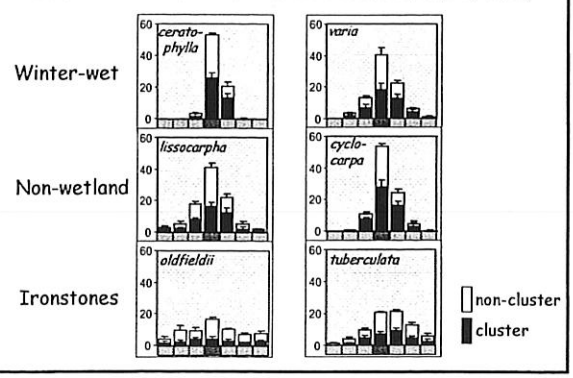
14 root compartments





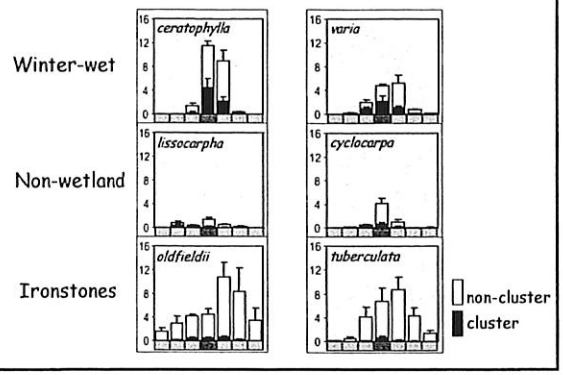
Spatially: where did they put there roots (superficial)?

Relative allocation of root fresh mass: 0-10 cm depth **(% of total)**

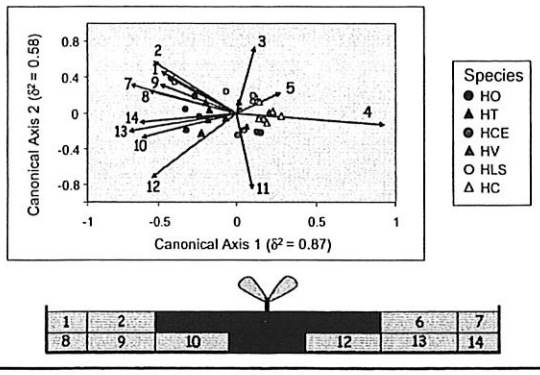


Spatially: where did they put there roots (deep)?

Relative allocation of root fresh mass: 10-11 cm depth (% of total)

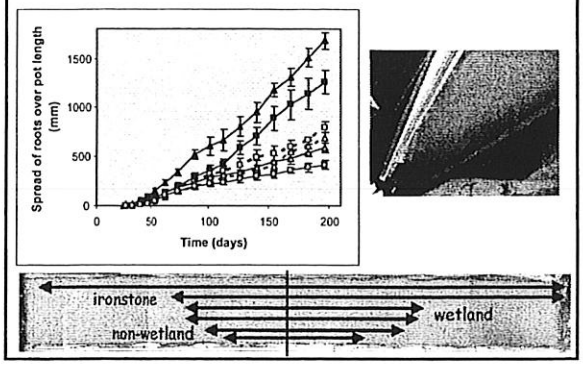


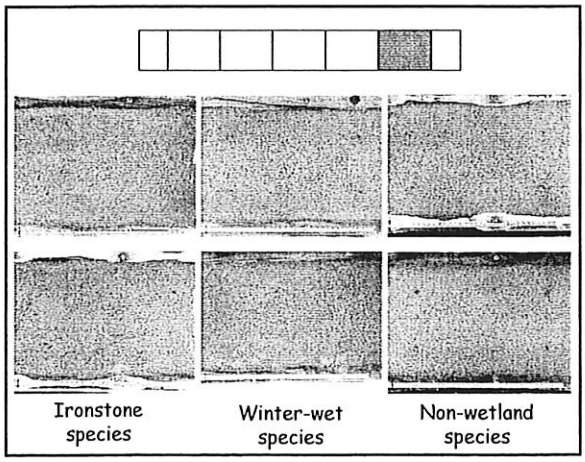
Similarities in root distribution pattern:
Multivariate analysis (CAP)



Temporally: when did they put them there (deep)?

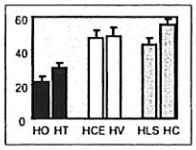
Temporal spread of roots (mm) over the bottom of the pots:





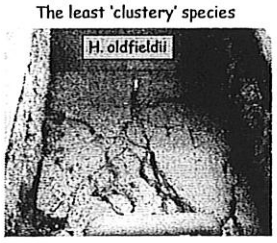
Functionally: different types of roots

% Cluster:



Cluster versus non-cluster roots

The least 'clustery' species



The most 'clustery' species

Can these differences really explain:

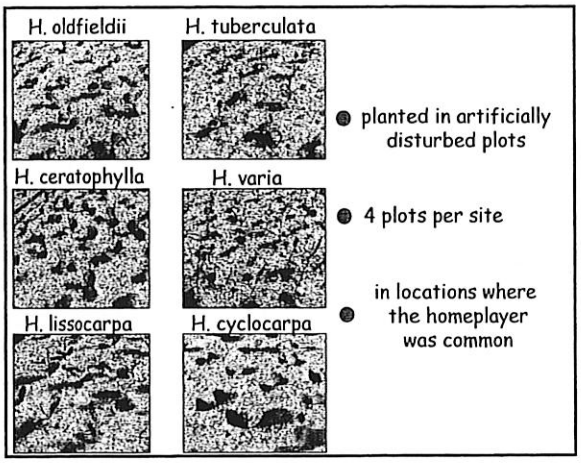
a) their success in their own habitat

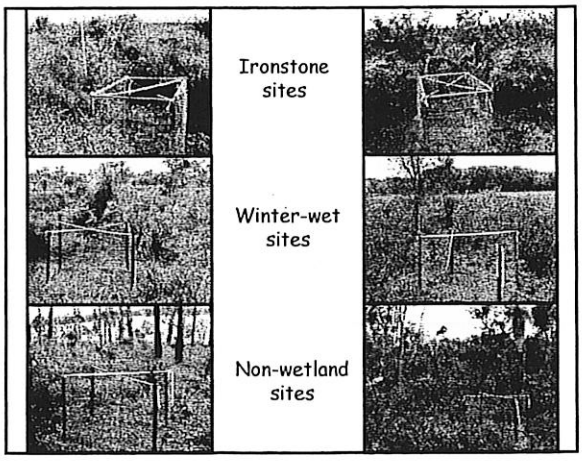
b) their failure in most others

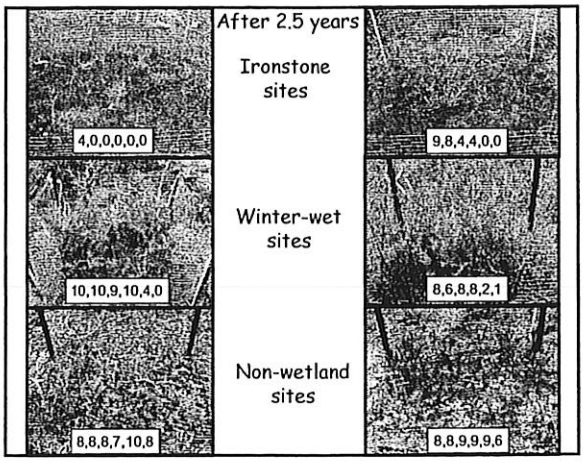
Back to the field: a reciprocal transplant experiment

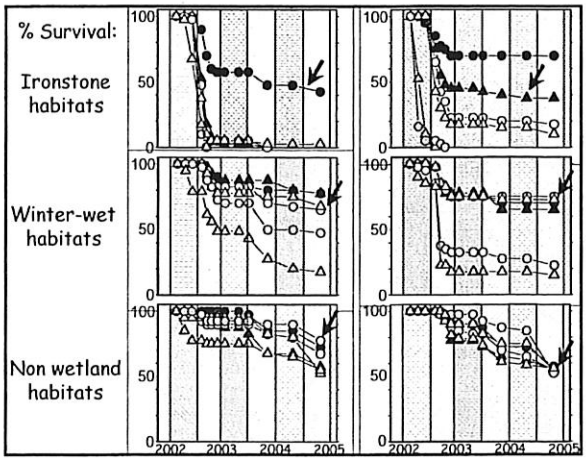
- collect seeds of the 6 Hakea species
- germinate species in glasshouse
- transplant young seedlings to kangaroo-proof plots in field

Each site has 1 'homeplaying' species


H. oldfieldii
H. tuberculata
H. ceratophylla
H. varia
H. lissocarpa
H. cyclocarpa
planted in artificially disturbed plots
4 plots per site
in locations where the homeplayer was common


Ironstone sites
Winter-wet sites
Non-wetland sites


After 2.5 years
Ironstone sites
4,0,0,0,0,0
9,8,4,4,0,0
Winter-wet sites
10,10,9,10,4,0
8,6,8,8,2,1
Non-wetland sites
8,8,8,7,10,8
8,8,9,9,9,6



Conclusions ironstone communities

- ironstone Hakea's have a specialised root system morphology

SPECIALISTS!

↓

increased chance of finding a crack

↓

increased chance of surviving summer drought in their own habitat

↓

decreased competitive ability in habitats on deeper soils ???

NOT SHOWN YET...

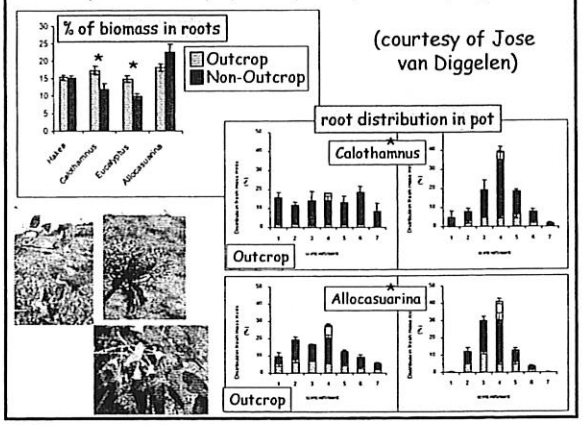
WHY?

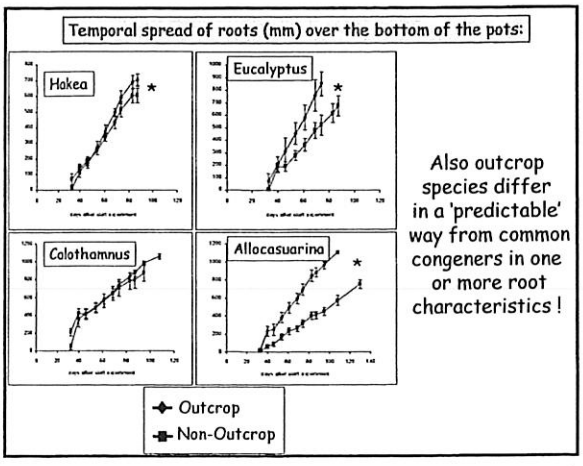
Apparently no disadvantage in other habitats... why?

- time...?
- climate change ?
- setup of transplant experiment ?
  - real regeneration: fire (nutrients) ?
  - start with seeds ?
  - cages/kangaroos ?
  - initial weeding ?
- local herbivores not 'trained' for rare species ?
- there is no disadvantage ?

Are findings relevant for other shallow-soiled habitats ?

4 outcrop/non-outcrop species-pairs: preliminary experiments





Conclusions shallow-soiled communities (1)

shallow-soil habitats: very drought-prone environments

↓

strong selection for drought avoidance (tolerance)

↓

root specialization

↓

root system characteristics are more rigid

↓

loss in phenotypically plasticity

local specialisation traded off against flexibility to adapt to other environments (commonness versus rareness)

What works best?

- adapt locally (specialisation: ecotypes) → costs?
- just be flexible ! (increased phenotypic plasticity)!

↓

limit/costs?

Models evaluating costs and benefits of plasticity:

- variable/unpredictable high resource environment → phenotypic plasticity
- predictable stressfull environment → specialisation

→ shallow-soil environments → many rare species worldwide !

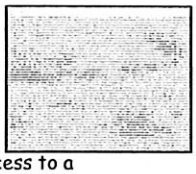
Management implications ?

- revegetation/replanting or perennial vegetation can only be successful when there are 'available cracks'
  - after fire
  - after death of adults
  - open, less dense areas are like that for a reason !
- since it's all in the roots: using pot plants or cuttings with altered shoot-root ratio's may be problematic
- young seedlings need enough time to grow their roots (plant early winter, irrigate with unseasonal drought)
- prevent competition with weeds or non-target species
- climate change (drought) may decrease recruitment

Outline of presentation

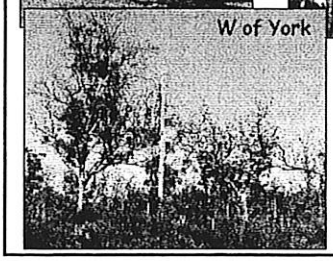
- Adaptations of species confined to a Threatened Ecological Community

Ironstone communities:



- Consequences of a Threatening process to a widespread community

Wandoo woodland decline: is climate change responsible?



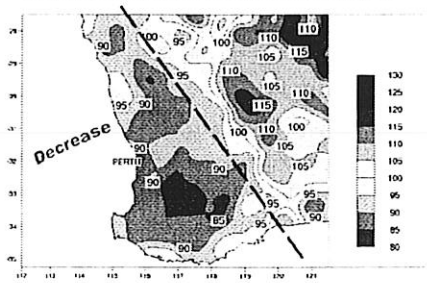
What many wandoos currently look like ...

reports of crown decline, from 1970's onward, becoming widespread in 1990's

What is causing the decline ? → Drought ?

SW Australia has experienced a 'sudden' drop in rainfall since the mid 1970's (2002, Indian Ocean Climate Initiative)

Last quarter century winter rain as % of previous 75 years

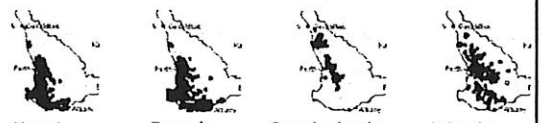


Other co-occurring eucalypt species seem less affected

↓

is Wandoo more vulnerable to drought ?

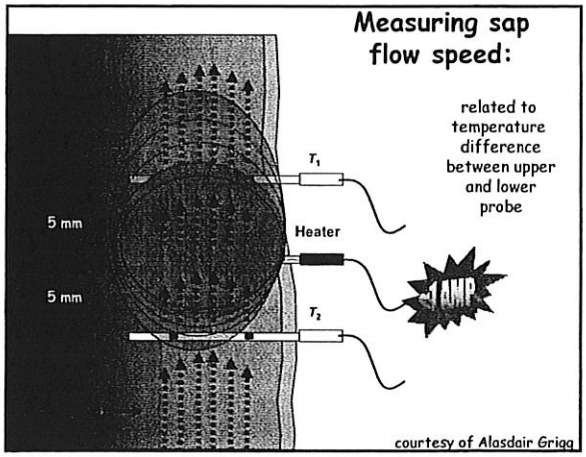
→ compare wandoo's daily and seasonal water relations with that of co-occurring eucalypts



Marri	Jarrah	Powderbark	Wandoo
variety of soils	*variety of soils*	*lateritic breakaways*	*often clay flats*

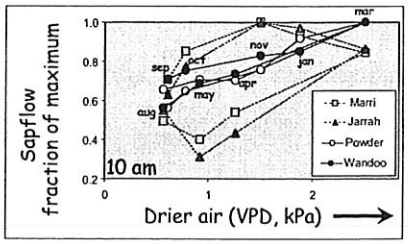
Measuring sap flow speed:

related to temperature difference between upper and lower probe



courtesy of Alasdair Grigg

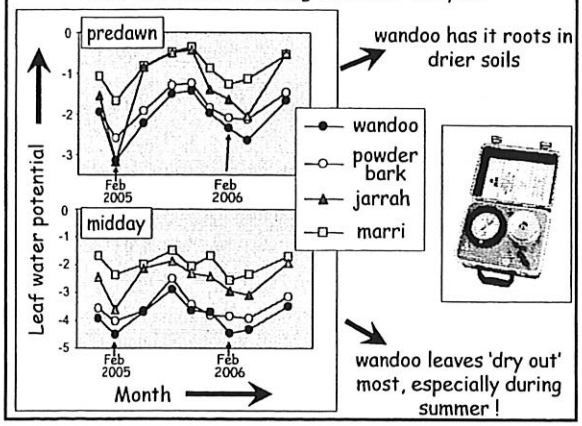
Relative sapflow velocity over the seasons:



Powderbark + Wandoo:
tight coupling between 'dryness' of air and water loss (sapflow)

Marri + Jarrah:
coupling lost after Nov, greatly reduced sapflow rates in autumn

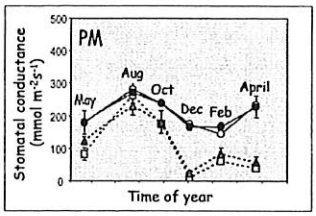
Leaf water status during course of the year



wandoo has it roots in drier soils

wandoo leaves 'dry out' most, especially during summer !

Leaf stomatal conductance during course of the year



Jarrah and Marri show much more stomatal closure during drier part of the year

Conclusions of ecophysiology work:
Wandoo + Powderbark differ from Jarrah and Marri

- Stay more 'active' during the day
- Stay more 'active' during dry season

↓

Loose more water

↓

Have more negative leaf water potential

↓

Larger water potential gradient (leaf-soil)

↓

Better able to extract water from dry soil

↓

have a more inland (drier regions) distribution

Period of biggest drought stress (Feb/March)

↓

wandoo has most negative pre-dawn midday water potentials of all species

↙ best in obtaining water from driest soil + most superficial root system

↘ in trouble ?

↓

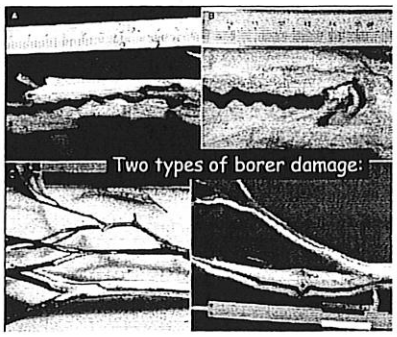
least conservative water user ?

↓

water spender relying on its ability to still obtain water from a very dry soil (but with least control)?

most stressed → most susceptible to pests???

Involvement of pests
(Ryan Hooper - Phytopathology - UWA)



Type-1 Jewel Beetle larvae Type-2

General conclusions

- no clear indications about cause of the decline yet

↓

beetle larvae and fungi seem involved indirectly

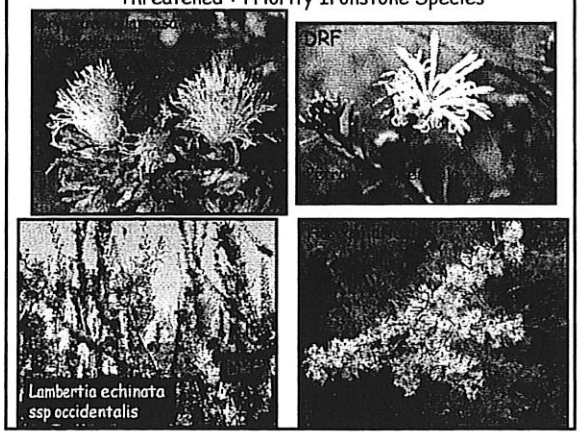
→ Why now?

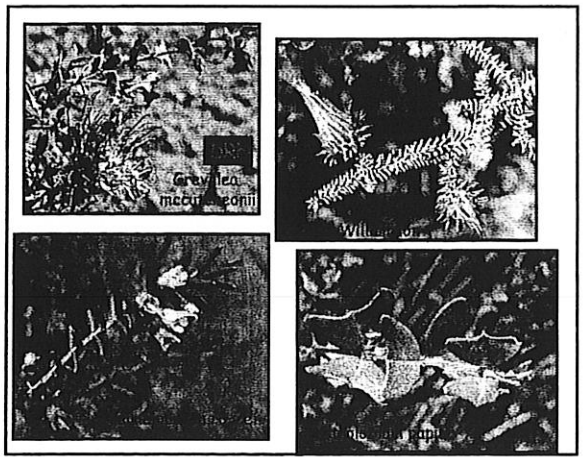
Increased stress:
- climate change
- salinity (clearing)

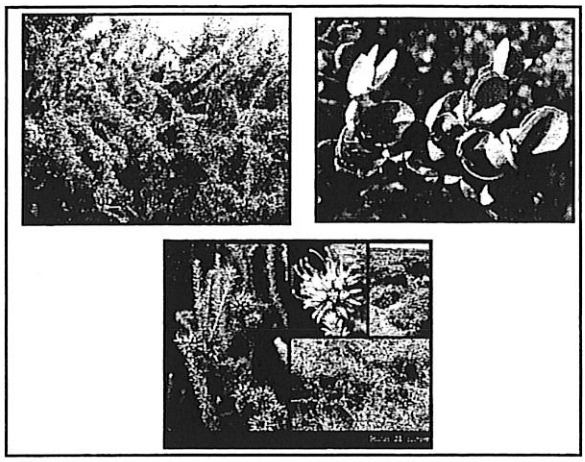
Future work (funds allowing...)

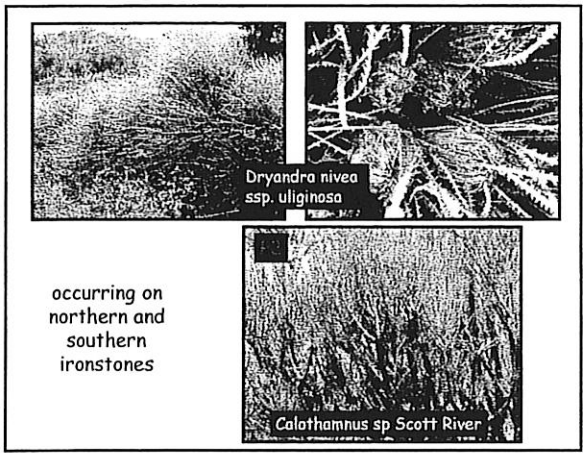
- Leaf physiology: what mechanism enables wandoo and powderbark to 'sustain such dry leaves'
- Start digging: get more insight in location and functioning of root systems
- Link between drought stress and pest/disease susceptibility

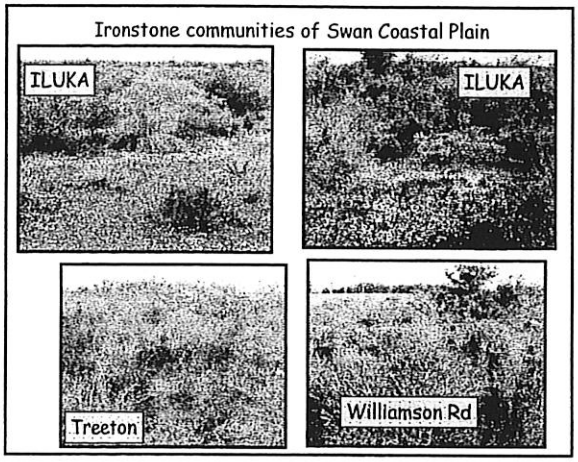
Threatened + Priority Ironstone Species

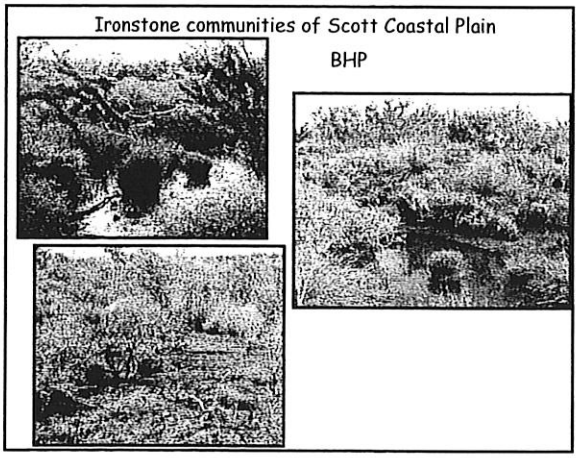


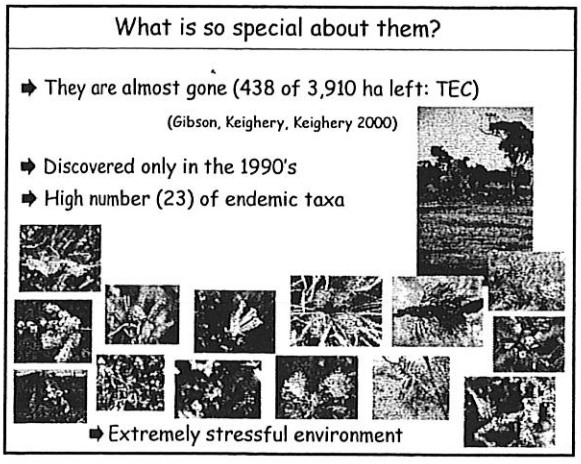


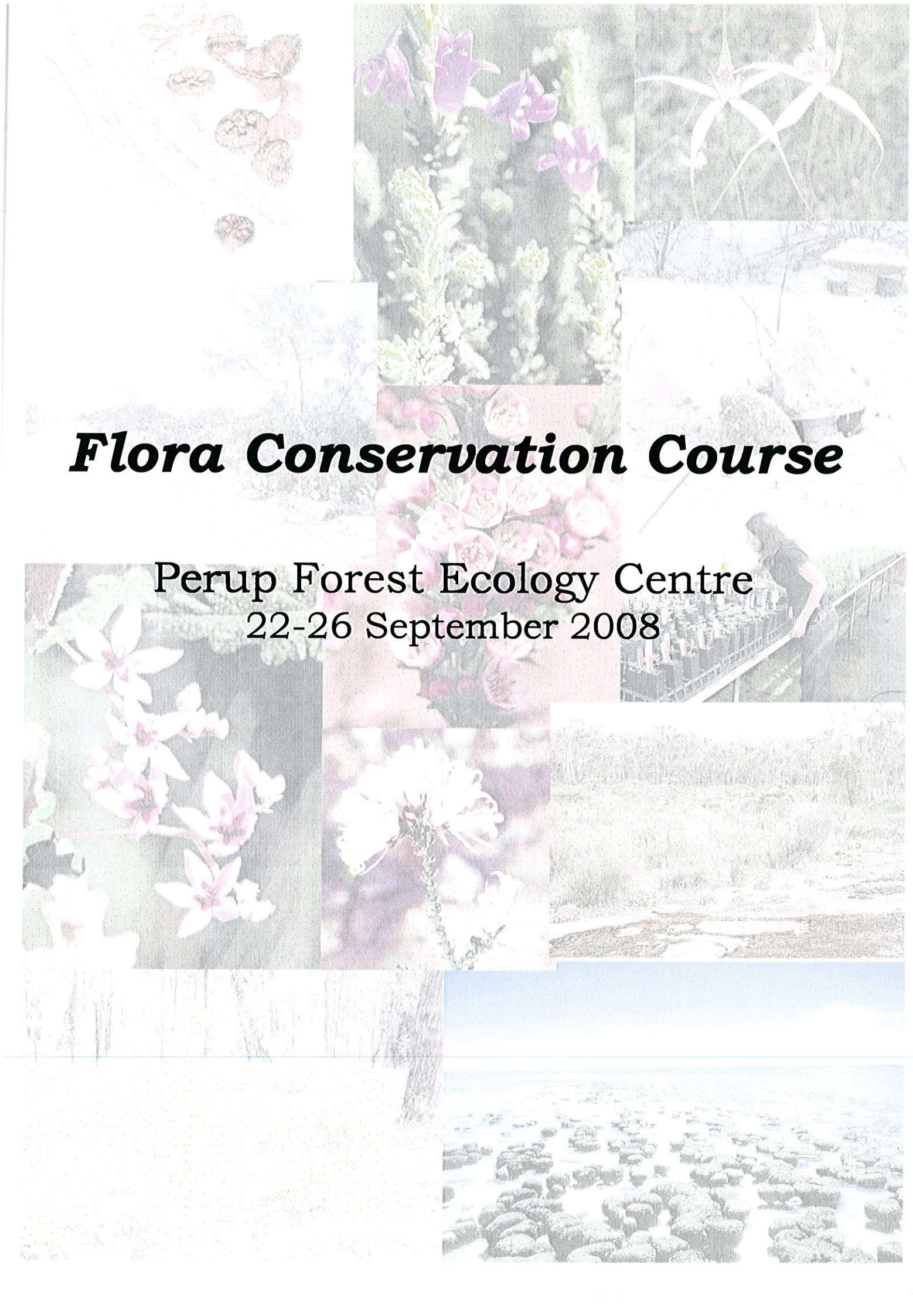



Dryandra nivea
ssp. uliginosa
occurring on
northern and
southern
ironstones
Calothamnus sp Scott River


Ironstone communities of Swan Coastal Plain
ILUKA
ILUKA
Treeton
Williamson Rd


Ironstone communities of Scott Coastal Plain
BHP


What is so special about them?
They are almost gone (438 of 3,910 ha left: TEC)
(Gibson, Keighery, Keighery 2000)
Discovered only in the 1990's
High number (23) of endemic taxa
Extremely stressful environment



Flora Conservation Course

Perup Forest Ecology Centre
22-26 September 2008