TEC Monitoring Pilot Course

Department of Environment and Conservation

November 2008

Monitoring threatened ecological communities – introduction

Val English

Species and Communities Branch

Background - why have this Pilot course?

- No set monitoring methods or policy that describes TEC monitoring
- To increase expertise and knowledge sharing about monitoring TECs in DEC, with likelihood of adaptation of course for NRM etc
- Milestones for RCM project:
  Provide basic training to NRM regional staff on TEC monitoring protocols.

To be covered:

DAY 1

- Introduction
- TEC database
- monitoring design

EXAMPLES

- hydrological monitoring
- microbial community

Plant ECs

- weed and boundary
- fire and dieback
- salinisation
- grazing impacts

FIELD - Plant ECs

- new TEC report form
- weed transects
- photopoints

DAY 2

- broadscale change
- monitoring scenarios
- course evaluation

FIELD - Plant ECs

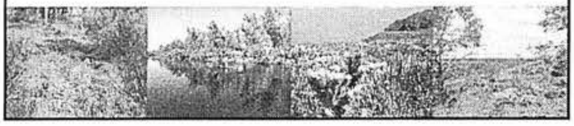
- fire monitoring
- mapping boundaries
- weed, condition mapping
- PDA and DGPS use

NOT INCLUDED:

- statistics
- additional regional examples
- invertebrate monitoring

This presentation

- Policies/legislation re monitoring
- Identifying and mapping TECs (*by request*)
- Monitoring in Recovery Plans:
  - Monitoring extent and boundaries
  - Surrogates for monitoring invertebrates



Legislation and Policies

No WA legislation that specifically protects TECs, or defines need for RPs, or for monitoring

EPBC – defines EIA compliance monitoring, wildlife trade compliance; and can fund monitoring for TSC through Bioregional Plans (but no obligation to do so)

New Biodiversity Bill for WA
- Monitoring not mentioned in discussion paper, but refers to RPs

Biodiversity Consn Strategy for WA
- Discussion Paper refers to monitoring of biodiversity in general, and RPs

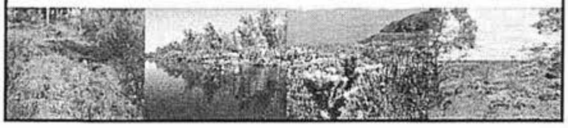
DEC's New Draft Policy 9: *'Conserving threatened species and ecological communities'*
- Describes process of TEC conservation ('Recovery Process')
- Requirement for Recovery Plans
- Requirement for monitoring

Biodiversity Conservation Strategy (draft)

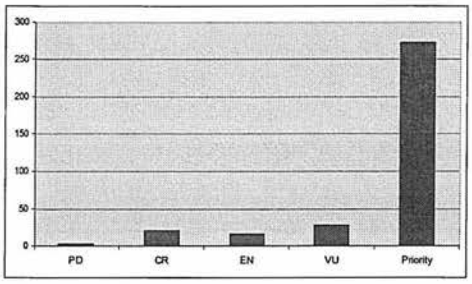
WA terrestrial biodiversity monitoring program framework and protocols developed by 2008. WA marine biodiversity monitoring program framework and protocols developed by 2008. Monitoring program established in priority areas in the rangelands, Swan Coastal Plain, wheatbelt and south-west forests by 2010. Monitoring program established in priority areas in State waters, including marine conservation reserves, by 2010.	8. Establish a statewide marine, terrestrial and aquatic monitoring capability to determine and report on the state of and trends in biodiversity and to identify the causes of change (this should include development of an effective monitoring and reporting framework, identification of bio indicators and development of standard approaches and protocols for monitoring biodiversity).	Area covered by program(s).	Trends in biological indicators under State monitoring system.	TBI	TBI	EEAH

New Draft Policy 9

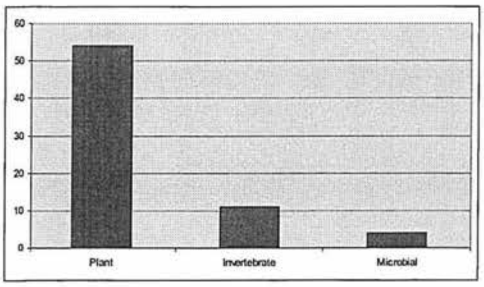
- *Populations of threatened species and occurrences of threatened ecological communities **will be regularly monitored**, with the frequency of monitoring reflecting the threat status of species or community, and the threat status of the specific occurrence.*
- *Recovery Plans (either 'full' Recovery Plans or Interim Recovery Plans) will be prepared for species and ecological communities on a priority basis, commencing with those ranked for conservation action by the Minister as 'Critically Endangered'.*



TEC Rankings

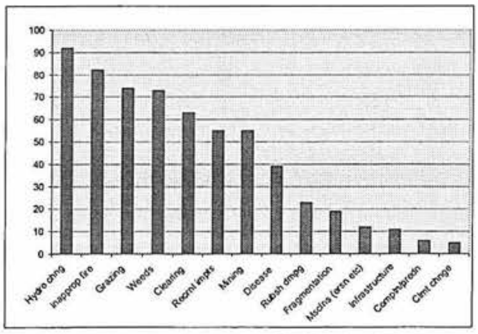


TECs based on different biota



TECs and PECs

Number TECs/PECs subject to threat



TEC LISTING AND RECOVERY RESPONSIBILITIES

Nominations TECs and PECs - SCB, Regions, Districts

↓

Listings of TECs and PECs - SCB

↓

Recovery Planning - usually SCB (in consultation with others), Regions, Districts, Recovery Teams

↓

On ground recovery (inclds monitoring) – Recovery Teams, Districts, Regions, Science Division, community groups, landholders, NRM groups.

↓

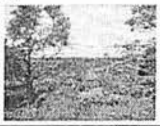
Review of effectiveness of recovery, review, update of plans - SCB, Districts, Regions, Recovery Teams

(C'wealth funding important)

Why Monitor TECs/PECs?

- To inform ranking changes (changes to condition eg – when is occurrence totally destroyed? (ie when is it too late!); EN to CR; Priority to TEC)
- As part of implementing recovery plans
- Addressing knowledge gaps
- To inform land management (eg):
  - impact of threats and need for amelioration
  - how burn frequency affects species composition
  - weed control effectiveness
  - requirement for hydrological management/amelioration
  - EIA eg what buffer required to protect hydrology

THERE ARE OVERLAPS BETWEEN THESE



TEC/PEC monitoring examples

South Coast
Recovery of serotinous species in montane ECs
Impact of dieback and fire in Stirlings montane TEC

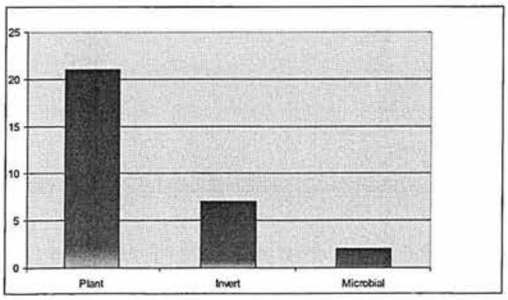
Swan
Recovery following fire in limestone ridge TEC, northern ironstone TEC
Cave invertebrates and water levels/quality
Sedgelands – monitoring following weed control, fire

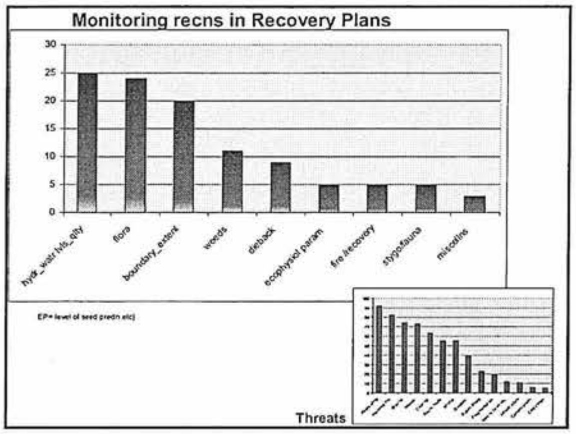
South West Region
Cave TECs monitoring
Busselton Ironstone EC –key component DRF monitoring – pop boundaries, numbers, water level monitoring
Effectiveness of weed control at Waterloo TECs

Midwest
Mound springs invertebrates

Wheatbelt
Toolibin vegetation condition related to hydrological amelioration

Numbers of Recovery Plans for TECs



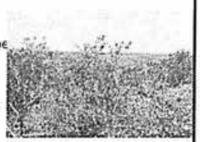


Flora monitoring example in RP

Billeranga Hills

Design and implement a program for flora monitoring

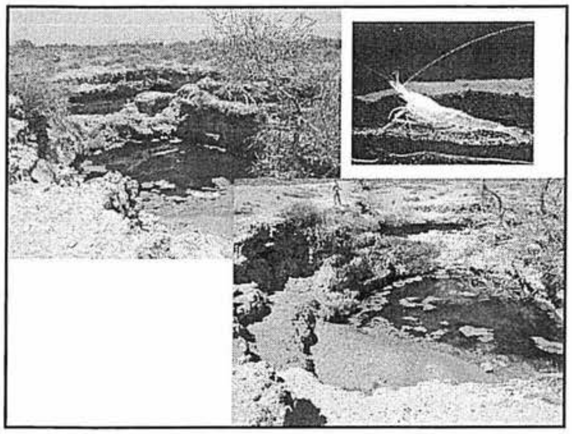
- Data collected will include plant species diversity, species richness and weed levels. Occurrences will be monitored regularly to provide information on condition.
- Program could include installing permanent quadrats on occurrences 1, 2 and 3, and re-scoring quadrats erected in 1997 (True and O'Callaghan 1998) on occurrences 4 and 5, as well as taking photographs from the same area.
- This information will be added to the TECs database as recommended in English and Blyth (1999).



Hydro monitoring example in RP

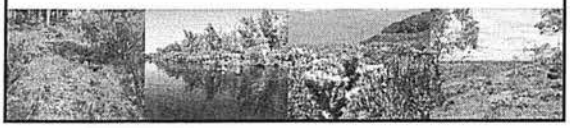
Bundera Sinkhole

- *Monitor water quality and levels in Bundera Sinkhole to establish long term trends and continue to investigate water quality requirements of the Cape Range Remipede Community*
- Only an elementary understanding exists of the complex ecosystem that sustains subterranean fauna in Bundera Sinkhole. There is a lack of basic data on the gross physico-chemical environment in Bundera Sinkhole, on groundwater movement, and on temporal changes in the profile resulting from the effects of episodic rainfall on surface input as well as groundwater flow (Humphreys 1999).
- Determine long term changes, particularly the establishment and maintenance of the complex redox profile, its associated chemolithotrophic organisms and the significance of these processes to the remipede community (Humphreys 1999).



Defining and mapping TECs/PECs

- Beard System mapping
- Ag WA land system reports
- Regional flora and vegetation surveys (eg CALM/DEC, Ag WA, consultants flora and vegetation reports)
- Soil and landform mapping, geological mapping,aerial photography
- Any of the above, plus aerial photography and on ground validation



Beard vegetation 'systems'

...Consists of a particular series of plant communities recurring in a catenary sequence or mosaic pattern, linked to topographic, pedological and/or geological features (Beard 1969)

Eg Koolanooka Hills

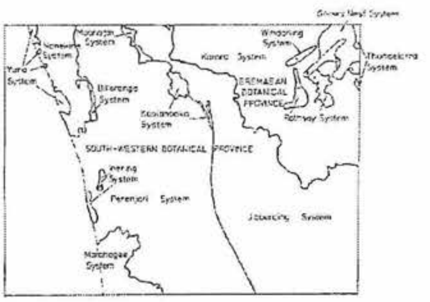


FIG. 2 Vegetation systems in the Perenjori District

From Beard (1976) 1:250,000 mapping

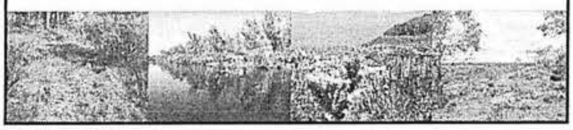
Beard System Mapping

TECs

- Koolanooka System (VU)
- Moonagin System (VU)
- Billeranga System (VU)
- Inering System (VU)
- Greenough River Flats (PD)
- Broomhill System (PD)

PECs

- Moresby Range (P1)
- Wongan Hills (P4)



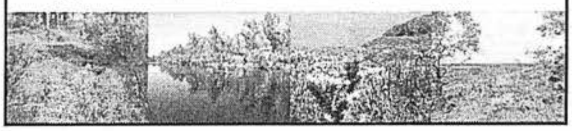
Other reports

Described but not mapped:

- 'A floristic survey of the southern Swan Coastal Plain' - defined 17 TECs and 10 PECs (Gibson *et al.* 1994).
- 'Biological survey of mountain protected areas in southern Western Australia' defined 1 TEC, 3 PECs (Barrett and Gillen 1996)
- 'A floristic survey of the Whicher Scarp' - nominations for 6 PECs (Keighery *et al.* 2008)
- Ag WA floristic surveys eg Coomberdale Chert Hills TEC (Griffin 1992)

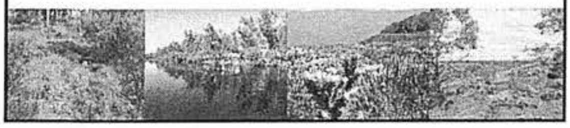
Sometimes mapped:

- Consultants reports that state vegetation is 'unique' (eg Bentonite Lakes, BIF reports to describe PECs/possible TECs)



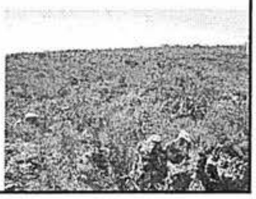
SCP Floristic Community types

- Mapping places boundaries on a transition or continuum.
- Captures unique map unit boundaries that are not always distinctly definable in nature.
- Map units - an assemblage of plant species discernable on interpretive base (i.e. aerial photography, soil mapping) and are similar floristically and form repeatable units across the landscape.
- Vegetation units defined in reports/plots mapped onto interpretative materials (aerial photography, soil/landform mapping), and verified in the field.



Mapping example - Limestone Ridges SCP

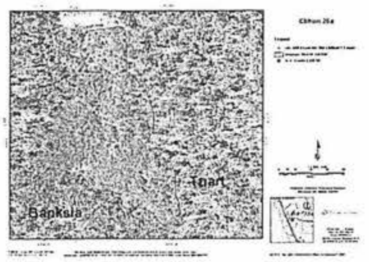
- *Melaleuca huegelii –M. systena* shrublands of limestone ridges (FCT 26a)
- Endangered TEC.
- Species rich thickets, heaths or scrubs dominated by *Melaleuca huegelii, M. systena* (previously *M. acerosa*), on skeletal soil on ridge slopes and ridge tops (as described by Gibson *et al.* 1994).
- Mapped from aerial photo, plot location, on-ground verification



Limestone Ridges - SCP

Lower slopes – in pockets where soil is deeper, Tuart, *E. foecunda, E. petrensis* woodlands or mallee over dense heath (=26b heaths – 'Woodlands and mallees on limestone')

- Can also map 26a based on massive outcropping of limestone on skeletal soils
- ***Boundary needs to be DEFENSIBLE!***

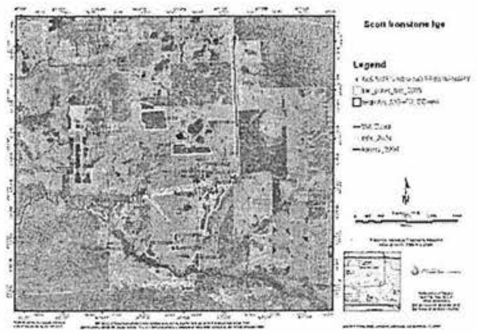


- Approximate boundary mapped from aerial photo
- Boundary checked on ground using GPS

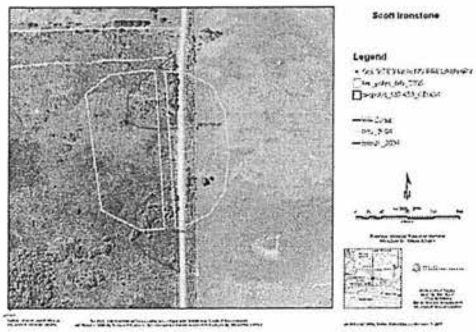
Example 2: Scott Ironstone TEC – boundary mapping / monitoring

- Scott River Ironstone Association - Ranked Endangered
- Community located on skeletal soils developed over massive ironstone and undergoes seasonal inundation with fresh water.
- Heath and shrublands variously dominated by *Melaleuca preissiana, Hakea tuberculata, Kunzea micrantha* or *Melaleuca incana* subsp. Gingilup depending on the degree of waterlogging. Understorey generally dominated by *Loxocarya magna*.
- Mapped based on Tille and Lantzke soil and landform mapping

Bush Forever Condition Scales



Boundary changes 2005-2008 – accuracy and clearing

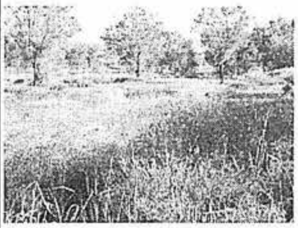


Example 3: Monitoring of condition and extent in Muchea limestone TEC

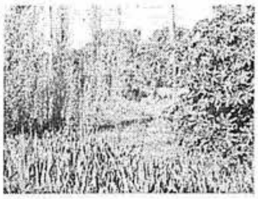
- Shrublands and Woodlands on Muchea Limestone - Ranked EN
- On heavy soils of the eastern side of the Swan Coastal Plain.

- Typical and common native species (from Keighery and Keighery 1995) *Casuarina obesa*, the mallees *Eucalyptus decipiens* and *Eucalyptus foecunda* and a series of limestone adapted shrubs.

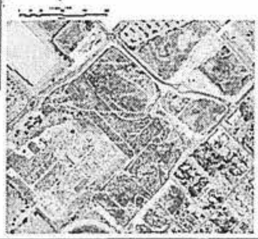
Muchea Limestone Extent / Condition Mapping



Excellent Condition



Totally Degraded

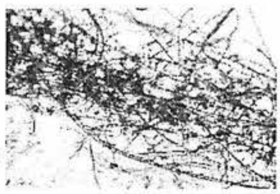


Boundary changes 2005-2008 – condition

- Mapped from aerial
- Checked on ground with GPS

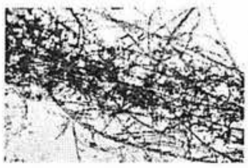
Example 4: Leeuwin Caves – invertebrate monitoring

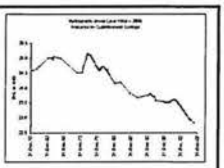
- Aquatic root mat communities numbers 1-4 of caves of the Leeuwin-Naturaliste Ridge
- Ranked CR 1996
- Rootlets of karri, marri, peppermint and associated microflora are primary food source
- A series of aquatic cavernicoles (cave animals) occur.

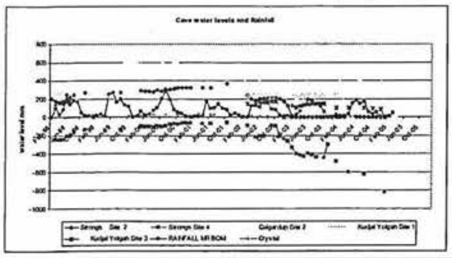


Leeuwin Caves

- The roots from living trees reach the waters of these cave streams or pools.
- Invertebrate assemblage able to survive due to the permanent water supply.
- Fauna are aquatic animals – can't survive drying
- ***Continuing decline in water level is the primary threat***

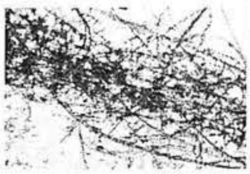






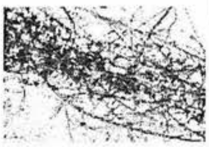
Leeuwin Caves - invertebrates

- IRP updated May 2008
- ***Monitor the extent and condition of the four threatened root mat communities***
    - ·Monitoring extent and condition in 2002 by University of Western Australia (Storey and Knott 2002), and for Eberhard (2006).
    - ·Samples of root mat material removed to sample fauna



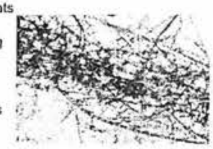
Leeuwin Caves surrogates for invertebrates

- Previous methods too destructive for ongoing monitoring of the communities.
- Now non-destructive method -measuring water level and quality, and visual inspection of root mats and fauna, including the presence of any known exotic species such as yabbies (*Cherax destructor*) ($5,000 pa)
- **= Surrogate indicators of ecosystem health**



Surrogate indicators of ecosystem health

- Water levels, quality
- Visual inspection of habitat
- Photographic monitoring of habitat = record of physical condition and possibly extent of the root mats.
- Evidence of grazing or of clogging of the root mats
- Observations of larger fauna – part of monitoring program.
- *CHEAPER, FASTER, LESS DESTRUCTIVE,* (?BETTER) (eg could indicate when water levels thresholds reached prior to total loss of EC)
- **BUT – invert studies still required for characterisation, and as ultimate test of status of EC**



Conclusions 1

- DEC has no set monitoring protocols for TECs (eg through policy/legislation)
- Specific monitoring protocols are being developed through District/Regional work, RCM project, Science Division, Recovery Teams, and other means (eg research institutions - caves)
- Protocols developed on as-needs basis – often for recovery plan implementation.

Conclusions 2

Ideally, need for the strategy would be included in Nat Cons Strategy and a related Policy, would outline the following:

- recommended frequency of monitoring based on category of threat, and other factors eg the type of community (eg – communities based on plants, invertebrates or microbes)
- detailed monitoring protocols applicable to various factors (eg impact of hydrological change, fire frequency/intensity, weed invasion, grazing) and types of communities to be monitored, and logical steps to select the most appropriate methods for a particular situation
- protocols for evaluating which occurrences and sites should be monitored
- guidance on utilising trigger levels/benchmarks to prompt management action.

Conclusions 3

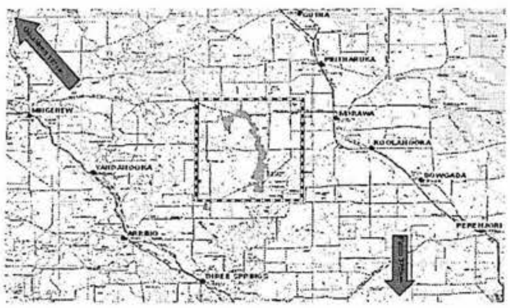
- **Good outcomes:**
- *The requirement for monitoring/monitoring strategy would be specified in new Biodiversity Bill;*
- *overall monitoring strategy and Policy that relates will be developed for monitoring TECs; and*
- *Details of monitoring protocols to be implemented would be held in recovery plans*

Monitoring of the Billeranga System

RCM team September 2008

- Vulnerable TEC
- Very distinct, small, localised vegetation system restricted to the ridgeline landscape west of Morawa
- Description
  "*Melaleuca filifolia – Allocasuarina campestris thicket on clay sands over laterite on slopes and ridges; open mallee over mixed scrub on yellow sand over gravel on western slopes; Eucalyptus loxophleba woodland over sandy clay loam or rocky clay on lower slopes and creeklines; and mixed scrub or scrub.*"

Location of the Billeranga System, Morawa, Western Australia.



- 85 ha (3.7%) of this TEC occurs in conservation reserves (Mt Nunn Nature Reserve) whilst approximately 2250ha (96.3%) is on privately owned land.
- A small portion of privately owned land is under covenant.
- Major threat: grazing and trampling by stock and native animals
- Only parts of some occurrences are fenced
- Other threats: clearing, weed invasion, drought, high intensity and/or too frequent fires
- Limited baseline and no monitoring data

- Opportunity to monitor across different tenures with varying levels of management (fenced and unfenced private property and nature reserve)

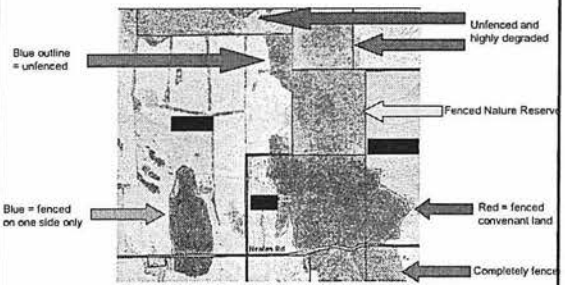


Figure 1. Small section of TEC (remnant veg areas) showing fenced and unfenced private property and nature reserve

Choosing what to monitor

- It is thought that stock and weed invasion are impacting the community structure and plant diversity
- Grazing ⟹ alterations in species composition due to:
  - selective grazing of edible species;
  - introduction of weeds and nutrients;
  - trampling; and
  - general disturbance .

Our monitoring program is designed to answer the following questions:

- is stock access affecting the plant community composition and structure?;
- are weeds more prevalent in unfenced occurrences?; and
- is the nature reserve occurrence in better condition than occurrences on private property?

At a later date it may be possible to determine if:

- on-ground management, such as weed control, has a positive effect on native plant composition of the community?

The challenges

- Limited baseline info available
- Gaining landholder permission
- Conducting monitoring in spring (fitting into work schedules)
- Long-term resources – who will monitor in the future?
- Finding areas of same vegetation type to put transects in
- Finding areas in good condition to put in quadrats
- Establishing enough quadrats and transects for statistical analyses

The monitoring method

- 15 permanently marked 20x20m quadrats in areas of good condition for baseline survey
- DEC BIF surveys establishing 20x20m quadrats

- 8 x 20m long transects sampled at 50cm intervals (point intercept method) in:
  - fenced from stock on private property;
  - unfenced private property; and
  - nature reserve

To be monitored every 5 years

Data logistics

- Bushland Plant Survey Recording Sheets used for quadrats
- Ruggerdised laptop with Excel spreadsheets used for transects
- DGPS and Nomad PDA used to record co-ordinates
- Info entered into TEC database
- Co-ordinates converted to shapefiles and maps created
- Info to be entered into Site Species

Compilation and analysis

- Currently identifying all specimens collected
- Statistical analyses will focus on comparison of changes to native and introduced plant taxa diversity and densities

Statistical power of the data

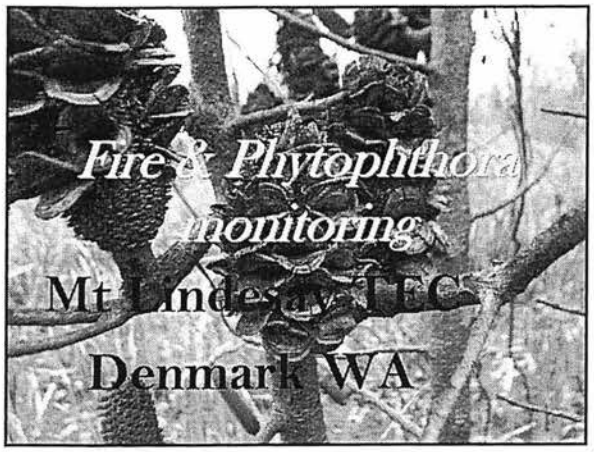
- Still to be discussed with a biometrician
- PATN (ordination of species alignment)
  - Quadrat data
- Primer analyses
  - Transect data
- May find that more monitoring transects need to be established

Report & Review

- Data summaries and reports after every monitoring occasion
- Quadrat data
  - Benchmark for acceptable degree of change is our baseline data
- Transect data
  - Indicators of a detrimental change to the TEC:
    - a continued increasing trend in weed abundance and diversity; and
    - a sustained decreasing trend in native plant taxa diversity and abundance.
  - These indicators should trigger adaptive management

Where to from here?

- Monitoring of transects every 5 years in collaboration with landholders,Geraldton District and SCB
- Fencing off occurrences
- Adaptive management e.g. weed control



What you have learnt so far:

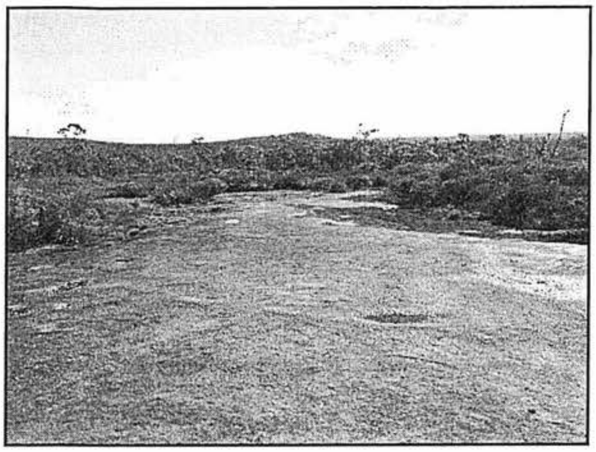
- the definition of monitoring;
- why we monitor – or collect data;
- how we identify 'what' we are monitoring;
- some methods that are available; and
- how we deal with the analysis of the information we collect – i.e. Adaptive Management.

Fire and Pc Monitoring Example

A TEC monitoring protocol was developed to provide information and procedures for monitoring the effects of fire and *Phytophthora* on the shallow soil plant communities of the Mt Lindesay threatened ecological community in Denmark, Western Australia.

- Mt Lindesay and Little Lindesay are located within Mt Lindesay National Park;
- 15km due north of the town of Denmark, 400km or 5 hours drive south of Perth;
- The Mt Lindesay TEC is currently ranked as endangered (endorsed by the Minister in 2001); and
- the TEC boundary is based on the description and mapping by Beard (1979) (**Figure 2**):

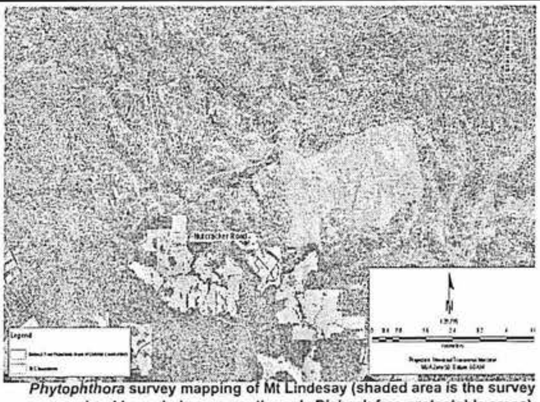
"E. marginata shrub-mallee and heath predominates on the upper slopes and summit area with mixed E. marginata – E. calophylla – E. megacarpa low woodland in gullies. Soils are shallow or skeletal. In these areas, typical (occurring in more than 60% of quadrats) shrub species include Banksia grandis, Hakea varia and Beaufortia decussata, and typical sedges are Mesomelaena gracilipes and Tetraria capillaris. Priority taxa on the upper slopes and summit area include: Sphenotoma parviflorum, Gastrolobium brownii and Sollya drummondii. Andersonia sp. Mt Lindesay, which occurs on the lower slopes, and Andersonia aff. setifolia are endemic to Mt Lindesay and Little Lindesay. Relatively bare granite rock slabs dominate the middle slopes and support a unique community of scrub and open herbs, which includes a number of species endemic to Mt Lindesay and Little Lindesay. These include Borya longiscapa, Grevillea fuscolutea, Lasiopetalum aff. cordifolium, Cryptandra congesta and an undescribed species of Laxmannia."



Relevant issues to note:

- Threats listed for this TEC include *Phytophthora* spp., inappropriate fire regimes, and high intensity fires;
- *Phytophthora* spp. infestation on Mt Lindesay has been recently surveyed by DEC staff and the TEC area has been mapped largely as infested with only a few areas, generally in the uplands, of uninfested or protectable areas (**Figure 3**); and
- Mt Lindesay National Park is proposed for a prescription burn in late spring 2008 by Frankland District.

- Also, Barrett (1996) noted:
- in montane communities both inappropriate fire regimes and *Phytophthora* were altering not only species composition but also plant community structure;
- resistant species, especially herbaceous perennials, and in particular sedges, became more prevalent;
- a high level of disease impact was observed in more frequently burnt sites; and
- vegetation restricted to the shallow soils around granite outcrops has been noted to be more severely affected by inappropriate fire regimes and *Phytophthora*.



Phytophthora survey mapping of Mt Lindesay (shaded area is the survey area and red bounded areas are the only Dieback free protectable areas).

Why Monitor this particular TEC?

- ranked as endangered;
- the opportunity to work with district and regional staff to monitor this community pre and post fire;
- Mt Lindesay has recently been surveyed for *Phytophthora* and the results have been mapped; and
- proposed for late spring burn 2008.

What to monitor?

- The effects of fire and *Phytophthora* on the plant community structure and composition are proposed as the subjects of this monitoring proposal.
- Over time, the data collected should indicate if the species dominance and composition is changing in response to the identified threats.

Where?

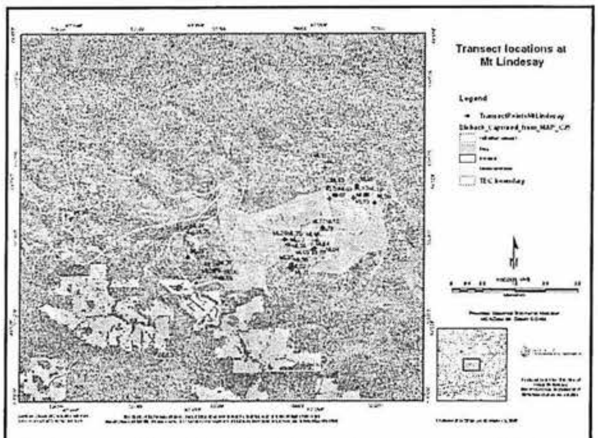
The plant communities of the shallow soils were targeted as these are thought to be more adversely affected by inappropriate fire regimes and *Phytophthora*.

How?

- Point intercept transects have been selected for the appropriate method to answer the monitoring questions relating to plant diversity and dominance responses to perceived threats.
- A short transect length was selected to facilitate the establishment of transects that would fit within the restricted pockets of granitic vegetation on shallow soil areas of Mt Lindesay, the focus area of this monitoring.

- Monitoring sites were randomly placed within shallow soil habitats of the TEC and stratified to encompass the following variables:
  - burnt and unburnt areas;
  - *Phytophthora* infested and uninfested areas; and
  - combinations of all variables.

The frequency of monitoring should be: monitoring in the spring immediately prior to the prescription burn; and then two years, five years and ten years post fire. When a subsequent prescription burn (or wildfire) occurs the same monitoring frequency should apply.

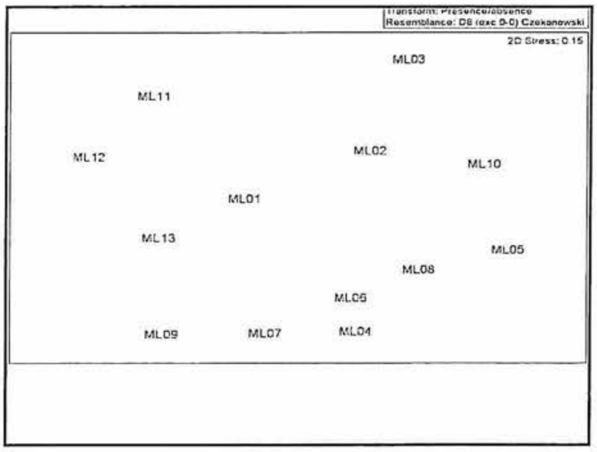


Results - Data analysis

- pilot sampling was undertaken in May 2008;
- an analysis was run on the 14 pilot transects to get an indication of how many transects would be required during the spring transect establishment; and
- *Primer* and *SPSS (minimum detectable distance), were indicated whether the number of replicates installed will provide enough power in analysis to detect significant changes in the data collected).*

	ML01	ML02	ML03	ML04	ML05	ML06	ML07	ML08	ML09	ML10	ML11	ML12	ML13
Bare ground	31	25	22	34	30	13	17	17	11	30	14	16	13
? Lomandra hermaphrodita	0	0	1	0	0	0	0	0	0	0	0	0	0
?Astartea	0	0	0	0	0	2	4	0	0	0	1	0	0
?Baeckea	0	0	0	0	0	3	4	2	4	0	0	0	0
?Darwinia	0	0	0	0	0	0	0	0	1	0	0	0	0
Acacia triptycha	0	0	0	0	0	7	0	9	0	3	0	0	0
Agonis theiformis	0	0	0	0	0	0	0	0	0	0	2	2	0
Allocasuarina ?microstachya	0	0	0	0	0	0	0	0	3	0	0	0	0
Allocasuarina humilis	0	0	0	0	0	0	0	0	0	0	0	0	2
Andersonia sprengelioides	3	20	22	0	0	0	0	0	0	0	3	21	0
Astartea sp	0	0	0	1	0	0	0	0	0	0	0	1	0
Astroloma? pallida	0	0	2	0	0	0	0	0	0	0	0	0	0
Banksia nivea/lindleyana	0	0	0	0	0	0	0	0	0	0	0	3	0
Borya longiscapa	0	3	2	0	11	0	0	3	0	0	0	0	0
Calytrix ?flavescens	2	1	0	0	0	0	0	0	0	0	11	0	0
Conostylis pusilla	2	0	0	0	0	0	0	0	11	0	0	4	6
Cryptandra congesta	0	0	0	0	0	0	0	0	10	0	0	0	0
Desmocladus fasicularis	0	0	0	0	0	0	3	0	0	0	6	2	3
Fine sedge	0	0	0	1	0	0	0	0	0	0	0	0	0
fine aml sedge - Schoenus	4	1	0	6	0	5	1	2	2	0	0	0	4
Gompholobium ?venustum ?cyaninum	0	0	0	0	0	0	0	0	0	0	0	0	1
Grevillea cirsiifolia	0	0	0	0	0	0	0	0	0	1	0	0	0
Grevillea fuscolutea	0	3	2	0	0	0	4	0	0	4	0	0	0
Hibbertia microphylla	8	0	0	2	0	0	2	0	1	0	0	0	7

	ML01	ML02	ML03	ML04	ML05	ML06	ML07	ML08	ML09	ML10	ML11	ML12	ML13
Bare ground	1	1	1	1	1	1	1	1	1	1	1	1	1
? Lomandra hermaphrodita	0	0	1	0	0	0	0	0	0	0	0	0	0
?Astartea	0	0	0	0	0	1	1	0	0	0	1	0	0
?Baeckea	0	0	0	0	0	1	1	1	1	0	0	0	0
?Darwinia	0	0	0	0	0	0	0	0	1	0	0	0	0
Acacia triptycha	0	0	0	0	0	1	0	1	0	1	0	0	0
Agonis theiformis	0	0	0	0	0	0	0	0	0	0	1	1	0
Allocasuarina ?microstachya	0	0	0	0	0	0	0	0	1	0	0	0	0
Allocasuarina humilis	0	0	0	0	0	0	0	0	0	0	0	0	1
Andersonia sprengelioides	1	1	1	0	0	0	0	0	0	0	1	1	0
Astartea sp	0	0	0	1	0	0	0	0	0	0	0	1	0
Astroloma? Pallida	0	0	1	0	0	0	0	0	0	0	0	0	0
Banksia nivea/lindleyana	0	0	0	0	0	0	0	0	0	0	0	1	0
Borya longiscapa	0	1	1	0	1	0	0	1	0	0	0	0	0
Calytrix ?flavescens	1	1	0	0	0	0	0	0	0	0	1	0	0
Conostylis pusilla	1	0	0	0	0	0	0	0	1	0	0	1	1
Cryptandra congesta	0	0	0	0	0	0	0	0	1	0	0	0	0
Desmocladus fasicularis	0	0	0	0	0	0	1	0	0	0	1	1	1
Fine sedge	0	0	0	1	0	0	0	0	0	0	0	0	0
fine aml sedge - Schoenus	1	1	0	1	0	1	1	1	1	0	0	0	1
Gompholobium ?venustum ?cyaninum	0	0	0	0	0	0	0	0	0	0	0	0	1
Grevillea cirsiifolia	0	0	0	0	0	0	0	0	0	1	0	0	0
Grevillea fuscolutea	0	1	1	0	0	0	1	0	0	1	0	0	0
Hibbertia microphylla	1	0	0	1	0	0	1	0	1	0	0	0	1


Transform: Presence/absence
Resemblance: D8 (exc 0-0) Czekanowski
2D Stress: 0.15
ML03
ML11
ML12
ML02
ML10
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ML13
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ML06
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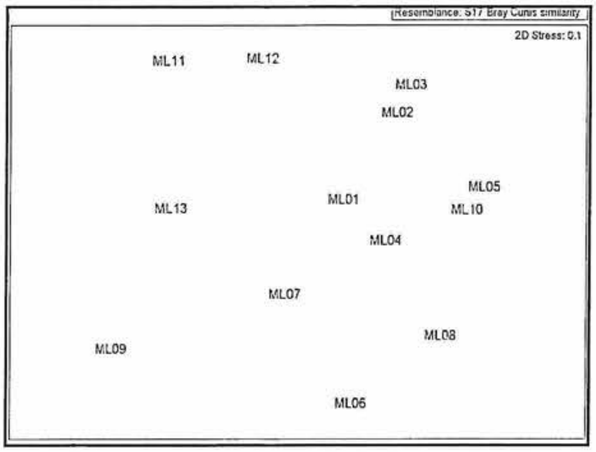
ML07
ML04


Resemblance: S17 Bray Curtis similarity
2D Stress: 0.1
ML11
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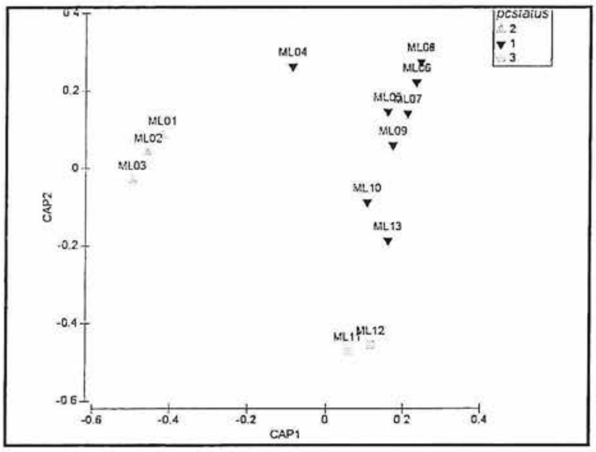

pcstatus
2
1
3
ML04
ML08
ML06
ML05
ML07
ML09
ML01
ML02
ML03
ML10
ML13
ML11
ML12
0.2
0
-0.2
-0.4
-0.6
-0.6
-0.4
-0.2
0
0.2
0.4
CAP1
CAP2

What does this analysis tell us?

- the Non-metric Multi-Dimensional Scaling shows that there is some variety in the vegetation sampled across the range but it is not a problem in the analysis;
- the second figure which takes into account Pc status shows clear clustering according to whether Pc is present or not; and
- there is an indication that more Pc free plots would strengthen the analysis.

Where to from here?

- 40 transects (including the 14 pilot transects) now installed across Mt Lindesay;
- identifications are complete;
- analysis to be undertaken;
- burn is proposed for November;
- post-fire monitoring is recommended 2, 5 and 10 years post-fire; and

Management

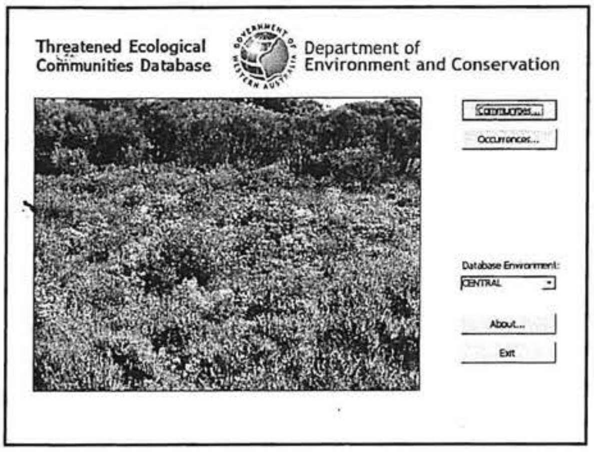
The trend in the data over the longer term should indicate whether a change in management is required→

- Phosphite spraying?
- changes to burn prescription

(Indicated by changes in plant composition and community structure; a decrease in fire or Pc sensitive taxa; and conversely an increase in Restionaceae/Cyeraceae taxa).


Questions?

Threatened and Priority Ecological Communities Data



General Information

- The Threatened Ecological Communities database provides information about occurrences of TECs and PECs throughout Western Australia
- Data included in the database are from a variety of sources, primarily from:
  - Regional surveys
  - Expert knowledge in specific areas (usually caves and microbial assemblages)
  - Local surveys that have been verified in a regional context.
- This data is dependent on the availability of survey information for any specific area

Information held in the database

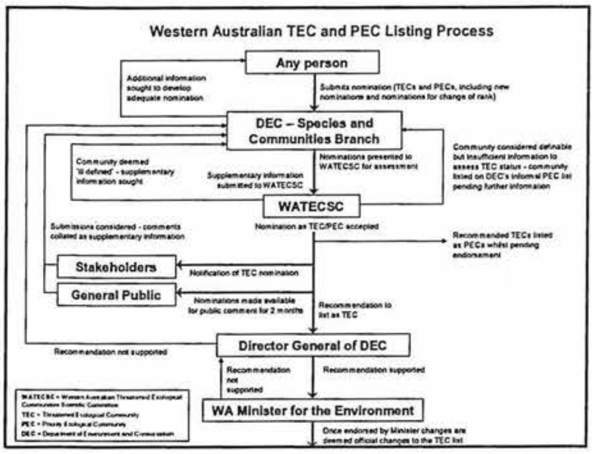
- The database includes:
  - Descriptions of each community
  - State and Commonwealth ranking
  - References
  - Component species
  - Survey information
  - Threats
  - Management actions and recommendations
  - Land use and land tenure

Distribution of the database

- Updated quarterly on the Corporate Data
- Sent to other government departments and utilities every 6 months
- Sent to local governments once a year
- CD snapshot sent to nat cons representative of each district/office twice a year
- Updates fortnightly to staff involved in development assessments

PECs

- The database contains a complete coverage of known locations of listed TECs but is not complete in terms of priority communities
- There are 273 known PECs ,131 (48%) of these are on the TEC/PEC database
- The location of priority communities is therefore not entirely reliable or consistent across the state
- There is a formal list of PECs on the web
- Many PECs are awaiting endorsement as TECs



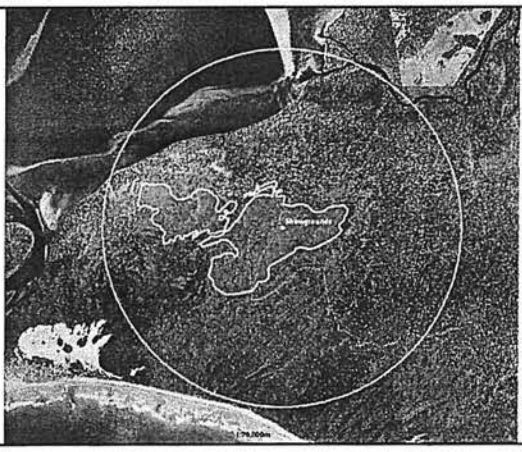

Sugar Loaf Granite priority ecological community

Point and boundary data

- Site information in GDA94 is available for all occurrences on the database
- Boundary information is available for most occurrences, the accuracy of this varies according to recency and source

Buffers

- The buffer radius is to help ensure that developments with potential to impact the TEC/PEC are picked up.
- For wetland ECs we seek to include an area to protect groundwater and surface water. The area required to protect different types of wetlands from a variety of hydrological impacts will, of course, differ.
- For ECs believed not to be groundwater dependent, the buffer area radius extends at least to the furthest point in the occurrence. This means that some linear occurrences may need a larger buffer radius to encompass the entire occurrence.
- Buffers with a value of 0 are no longer extant



Critical Habitat

- The *EPBC Act 1999* states that habitat eligible to be declared critical habitat is *"the whole or any part or parts of the area or areas of land comprising the habitat of an endangered species, population or ecological community that is critical to the survival of the species, population or ecological community....".*
- Will be outlined in the new Biodiversity Bill
- Will replace buffer radius

Terminology in the Database

- **Occurrence**: a discrete example of an ecological community, separated from other examples of the same community by more than 20 metres of a different ecological community, an artificial surface or a totally destroyed community in a degraded condition or better.

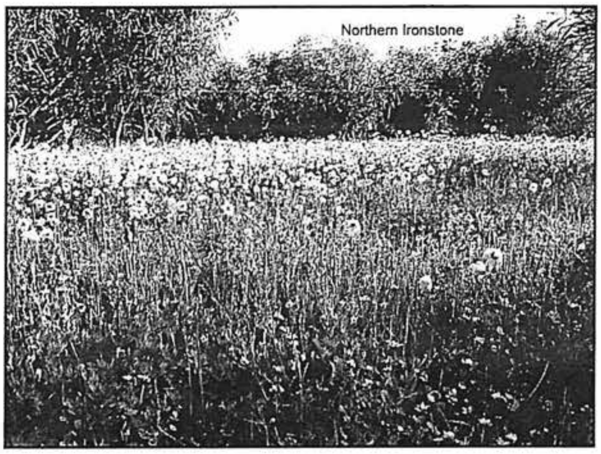
Terminology 2

- **PLOT** 'Identified'
- **NOT A PLOT** 'Believed to be'
- **PLOT (Yet to be Analysed)** – 'Believed to be'

Terminology 3

As a category of threat

- **Preliminary**
- **Awaiting Endorsement**
- **DE-LIST**

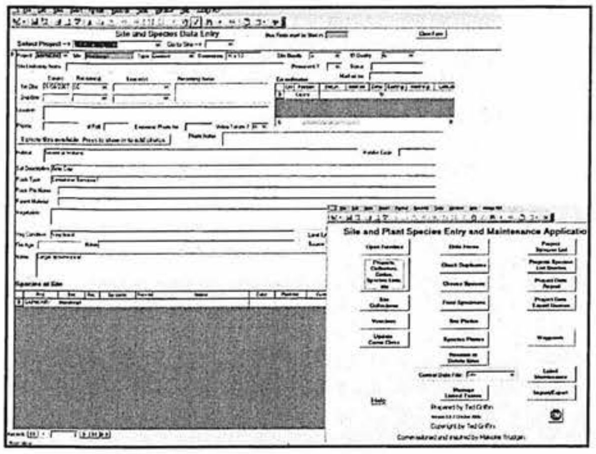


The TEC/PEC Database as a form of 'monitoring'

- The database was not specifically designed to store 'monitoring data'
- Archived database snapshots
- Species lists, the accuracy of which varies
- Information under 'survey' on threats and condition rating
- Emergence of new threats
- Actions table to record monitoring events
- Possible future link to 'site species' Ted Griffin's database or capacity for database to store monitoring data

Site Species Database – Ted Griffin

- An organised and standardised system for which data can be compiled across the botanical sector. It is designed to manage the:
  - capture of,
  - manipulation of, and
  - reporting on
  - information related to collections of plants in a systematic manner.
- Can store information from quadrats, transects and releves
- Can be converted into a format to undertake statistical analysis
- Can be converted into a collecting book for submission of herbarium samples
- Must be purchased

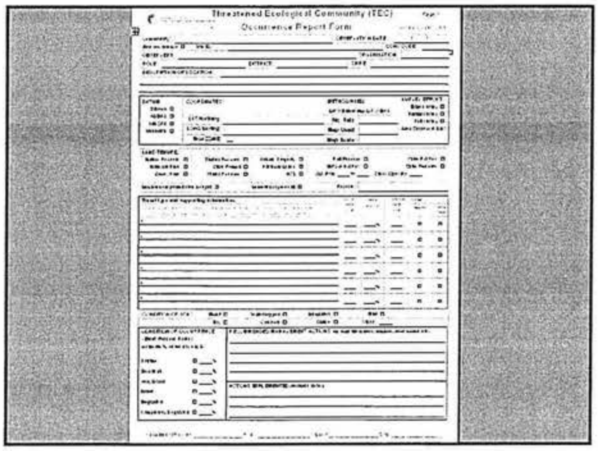


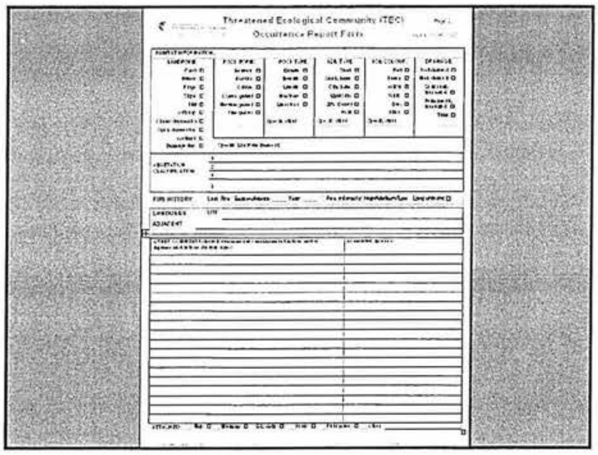
TEC/PEC spatial data as a form of 'monitoring'

- Boundary mapping, historical records
- Condition mapping, historical records
- Records of spatial changes entered in the database under 'Extents landuse'
- May be due to increased information on the community or reduction of community size due to threats
- Retains records on Presumed Totally Destroyed communities and extinct occurrences, also in the database

TEC/PEC occurrence report form as a form of 'monitoring'

- Under development
- Capacity to store only limited information
- Dependent on surveyors time and level of experience
- Supplementary document available soon
- Can record location, land use, threats, condition, landform, vegetation and soils information
- Needs increased regional awareness & participation to ensure the database is current
- Future potential to submit information directly onto the database


Threatened Ecological Community (TEC)
Occurrence Report Form


Threatened Ecological Community (TEC)
Occurrence Report Form

Resource Condition Monitoring Project for Threatened Ecological Communities

Department of Environment and Conservation

TEC Monitoring Course November 2008

Project aims

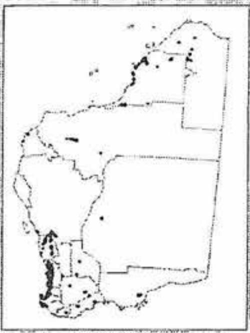
- Establish effective long term monitoring
- Document monitoring through:
  - Development of monitoring protocols
  - Standard operating procedures
  - Make protocols available on the internet
- Documentation should avoid data loss, help with knowledge sharing

To achieve monitoring aims we need:

- Repeated measurement(s) over time
- Incorporate research
- Clarity in how threat expresses itself – change?
- Method, location and replication of monitoring points to best track change - biometrician
- Understand the type and magnitude of expected change – sufficient power from data?
- Determine how our monitoring would be linked to adaptive management?

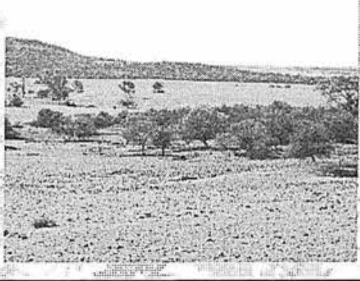
Where to start?

- 69 TECs
- Different regions of the state
- Range of threats
- Range of community types
- Multiple occurrences of some TECs
- Multiple threats for some TECs



Threats

- Recreational use
- Hydrological changes
- Impacts from feral animals



- •Fire
- •Dieback
- •Weed invasion
- •Clearing

Tailor protocol to your TEC and specific threats

Information considered

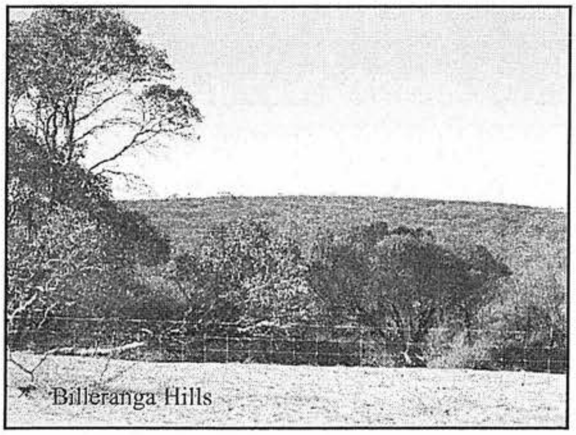
- DEC Regional Nature Conservation staff priorities for TEC monitoring
- TEC database
- threats
- number of occurrences
- tenure of land, access
- current monitoring and methodologies used
- proposed methodology for future monitoring
- change we would aim to monitor

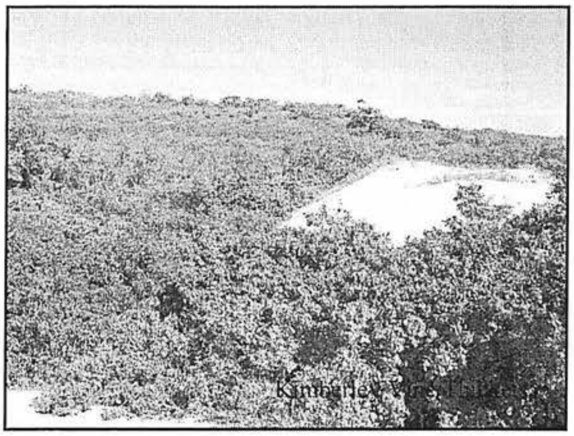
Developing monitoring

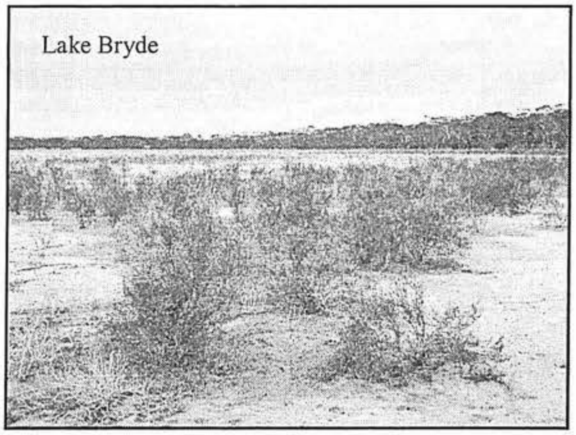
- Once prioritised, each team member became central contact for several TECs
- Research and gather relevant data
- Reconnaissance field trips, met landowners & DEC
- Method for monitoring effects of threats
- Logistics of establishing monitoring

Monitoring Established

- Monitoring established:
  - Mt Lindesay, Billeranga Hills, Kimberley Vine Thickets, Lake Bryde
- Participating in Swan Coastal Plain monitoring – SCP07
- Monitoring protocols developed with experts:
  - Invertebrate Sampling in Mound Springs, Augusta Microbial and others


Billeranga Hills


Kimberley


Lake Bryde

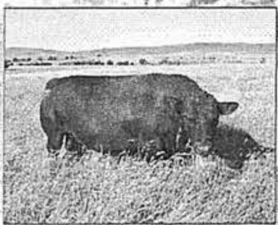
Outcomes

Monitoring developed includes methodology for assessing effects of:

- *Phytophthora* dieback
- fire frequency
- increasing salinisation
- effects of grazing
- weed infestation
- habitat clearance

Depending on the relevant threat for specific TECs

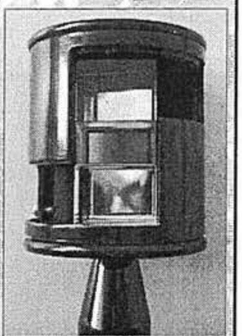
Additional protocols developed



- Future monitoring:
  - Effects of grazing *Themeda* Grasslands
- Document current monitoring:
  - Effects of grazing Busselton Ironstones
  - Effectiveness of weed control – Brixton wetlands

Outcomes

- Standard Operating Procedures developed
- Shapefiles of monitoring locations
- More data for TECs
- Collaboration regional Nat Cons staff, NRM groups and local land managers – longevity of projects



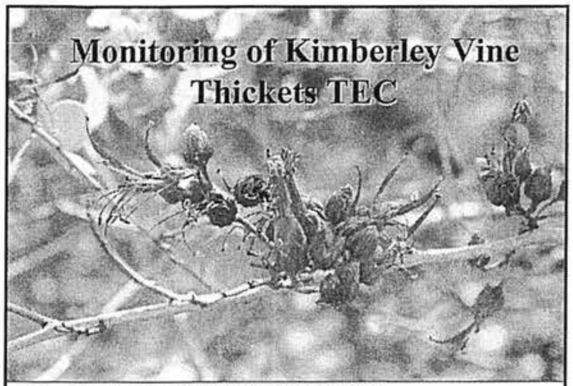
SOP Use of Optical Square

Considerations

- Understanding your community/site/threat(s)
- Time, resource limitations
- Access to sites
- Ability to detect what you're aiming to (power/thresholds?)
- Promoting ongoing monitoring and adaptive management

Where to?

- Finalise review of protocols
- Finalise SOPs
- Management implementation
- Seek further funding for ongoing monitoring
- Web resource centre



Department of Environment and Conservation

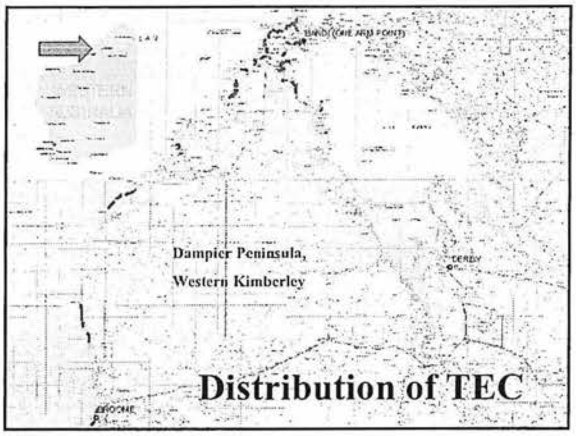
TEC Monitoring Course November 2008

TEC description

- Vine thickets on coastal sand dunes of Dampier Peninsula
- Semi-deciduous vine thicket communities on leeward slopes of coastal sand dunes on Dampier Peninsula
- Can include a range of overstorey, understorey and vine species, on deep dune sands
- Currently ranked as vulnerable and awaiting endorsement for re-ranking as endangered
- 72 occurrences, less than 2% in conservation reserve

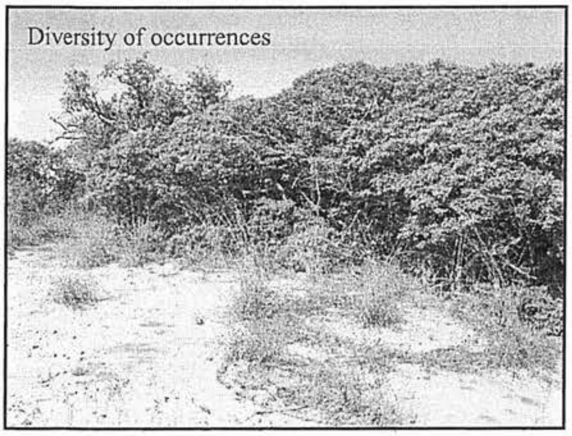
Threats

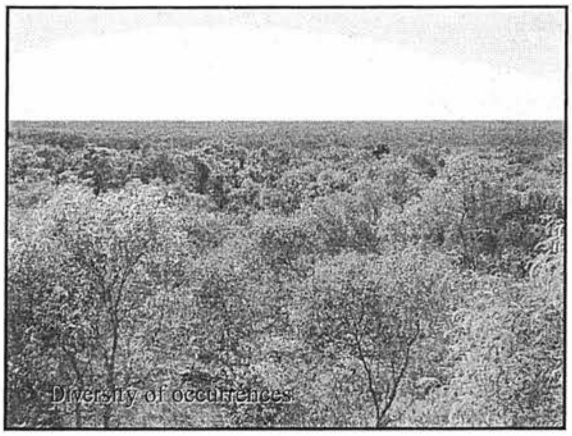
- Climate change and rising sea levels
- Clearing
- Groundwater drawdown
- Impacts of feral animals
- Inappropriate fire regime
- Disturbance due to recreational activities
- Altered surface drainage pattern - road construction
- Impacts of stock
- Storm water runoff
- Trampling by recreational users
- Weed invasion

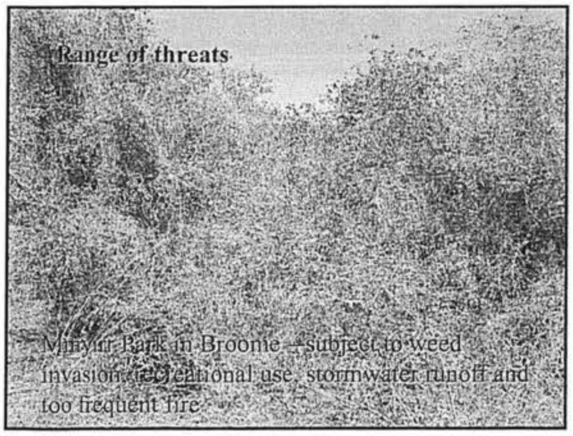


Why monitor this TEC ?

- Vulnerable, awaiting re-ranking as endangered
- Opportunity to work with district and regional staff to monitor this community
- Local land managers working in community
- Detailed vegetation surveys had been undertaken for many occurrences
- Recommendations made after detailed surveys


Diversity of occurrences


Diversity of occurrences


Range of threats
Minyirr Park in Broome – subject to weed invasion, recreational use, stormwater runoff and too frequent fire

What to monitor?

- Magnitude of extent decline unclear (~40% since European settlement?) and accurate mapping recommended with regard to clearing
- Weed control work undertaken by local people – effectiveness?
- To monitor impacts of dominant threats we want to answer these questions:
  - Is the extent of this TEC declining?
  - Are current weed control activities effective in reducing weed cover?

Two separate monitoring protocols developed:

- One for monitoring extent of occurrences (habitat clearance)
- One for monitoring effectiveness of weed control work in reducing weed cover

Consultation

Extent mapping:

- DEC West Kimberley district - logistics
- Kimberley Land Council - access
- Bardi Jawi Rangers – access and logistics

Effectiveness of Weed Control:

- DEC West Kimberley
- Environs Kimberley
- Bardi Jawi Rangers
- Kimberley TAFE

Occurrences to monitor?

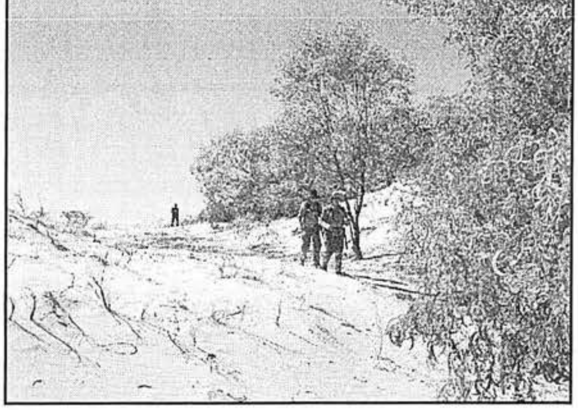
- Seventy two occurrences
- Limited time, mobilising from Perth

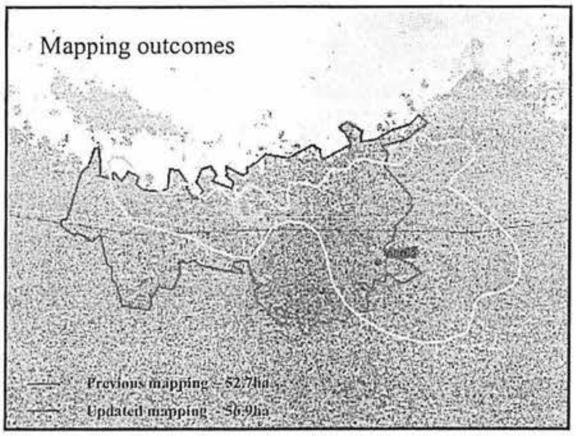
Mapping:

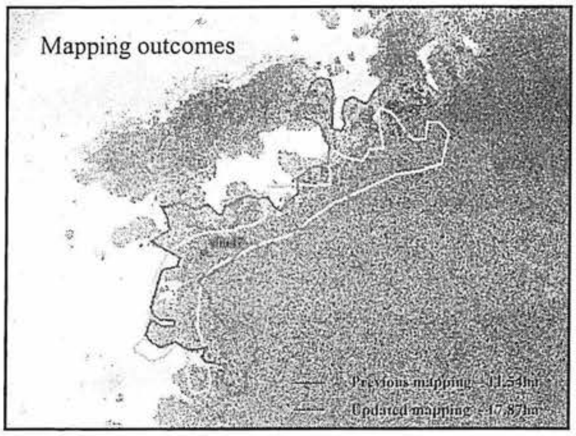
- Some sites of cultural significance restricted access
- Sites under greatest development pressure recommended as highest priority for mapping – near Broome and One Arm Point

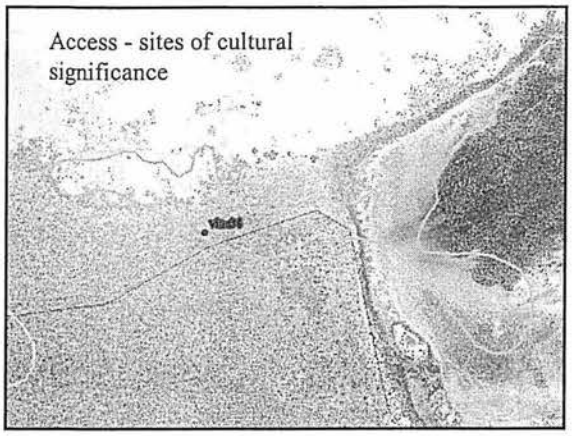
Weeds:

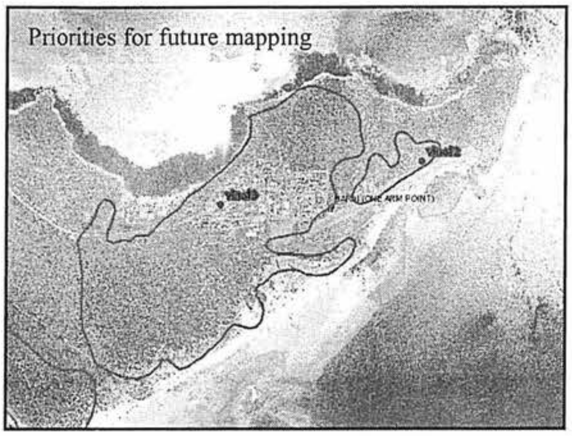
- Sites with existing weed control work




Mapping outcomes
Previous mapping – 52.7ha
Updated mapping – 56.9ha


Mapping outcomes
Previous mapping – 11.54ha
Updated mapping – 17.87ha





Data management and analysis

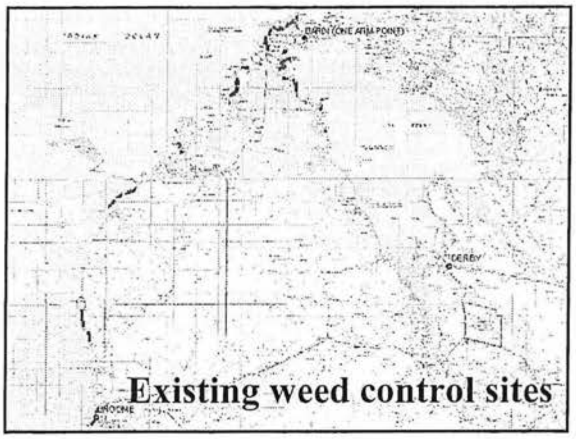
- Data stored in shapefiles with the TEC group
- Shapefiles sent to local land managers
- Quantitative mapping data will allow us to detect any decrease in extent of TEC habitat
- Future mapping data incorporated
- Any decrease in extent – management

Time requirements

- Consultation, several weeks (change of DEC staff)
- Reconnaissance and preparation – two weeks
- Monitoring protocol development – two weeks
- Mapping field work and preparation – four weeks (field work seven days x four people)
- Data entry – two days x one person
- Specimen identifications – two weeks x two people
- Review of monitoring protocols – two days
- Herbarium field books – one week x one person

Methodology for monitoring effectiveness of weed control

- Currently being reviewed by regional staff
- Detect effectiveness of weed control using point intercept transects to measure weed cover
- Minimum six transects in areas of weed infestation in each occurrence – three in weed control, three in no weed control (preferably in similar levels of weed cover)



Existing weed control sites

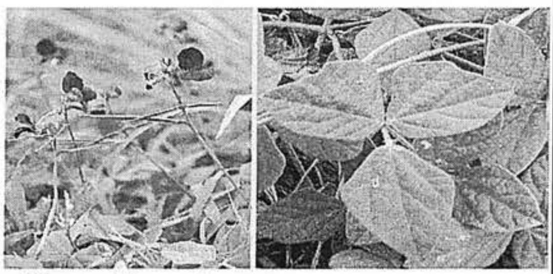
Current target weed species

- *Macroptilium atropurpureum* (vine) Siratro, Black Pea, Purple Bean
- *Clitoria ternatea* (vine) Darwin Pea
- *Merremia dissecta* (vine) Hairy Morning Glory
- *Leucaena leucocephala* (tree) Coffee bush
- *Azadirachta indica* Neem tree
- *Cryptostegia madagascariensis* Rubber vine (declared plant)
- *Hyptis suaveolens* (herb) Horehound
- *Peltophorum pterocarpum* (tree) Yellow Poinciana

Data analysis

- Discuss approach with biometrician
- Once established weed control is effective, further transects may also be established in weed free areas so that control can be implemented if weed cover crosses a predetermined threshold in those transects
- Weed cover goes beyond for eg 5% then spray – this assists if there is problem of not having sufficient power to detect pre-specified changes

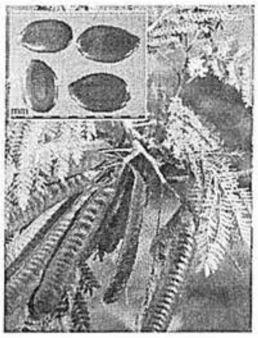
Target weed species



Macroptilium atropurpureum

Target weed species

Leucaena leucocephala



Frequency of monitoring

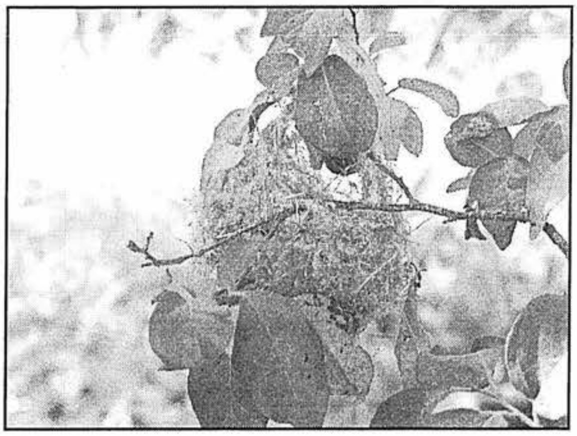
- Extent mapping – every 3 years
- Weeds control – after each weed control event, then every 2, 3 and 5 years
- Advantage of collaboration with local land managers means that this could be achieved
- Monitoring protocols will be adapted where necessary – too frequent, not frequent enough?

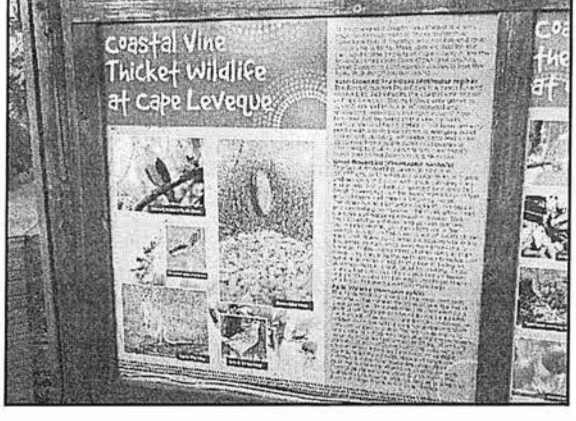
Personnel Involved

Abrus precatorius - Crab Eye

Considerations

- Mapping work revealed additional threat – dune encroachment – management?
- Access issues
- Burnt areas difficult to map
- Monitoring developed here is only appropriate for some of the threats to the TEC
- Importance of adaptive management – TECs & threats not static
- Developing collaborative projects beneficial, local monitoring
- Sharing knowledge and protection of TECs
- Good aerial photography/remote sensing may aid mapping




Coastal Vine
Thicket wildlife
at Cape Leveque


Coastal Vine Thicket &
the Bardi Aboriginal People
at Cape Leveque

Monitoring change in condition Swan Coastal Plain TECs

Jill Pryde, Species & Communities Branch, DEC

Background

- 2002 – following recommendations of WA Threatened Ecological Communities Scientific Committee
- before changing category of threat
- demonstrate significant change in condition of TECs since first assessed
- quantitative data required to demonstrate change

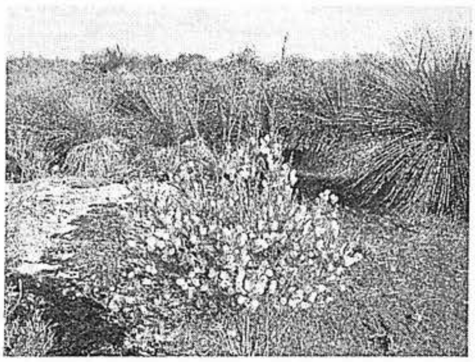
Background...cont

- four (of 12) TECs selected
- sought input from DEC / literature
- no specific monitoring protocol for TECs in place
- spring 2003 - trial monitoring program
- seek change in condition of SCP EN and VU plant communities
- consider feasibility of this type of monitoring

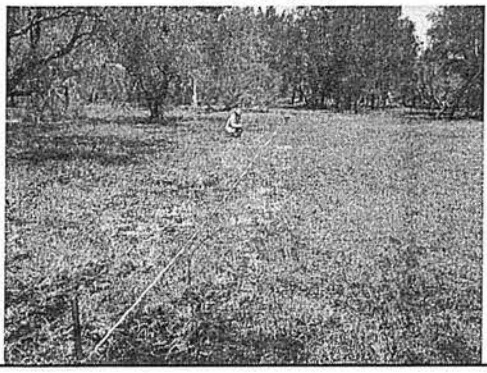
Southern wet shrublands (EN)

Herb rich shrublands in clay pans (VU)

Shrublands on calcareous silts (VU)



Forests and Woodlands of deep seasonal wetlands (VU)



Identify threat, choose method

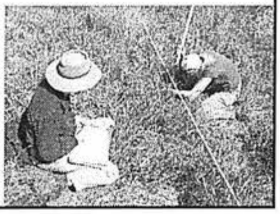
- weeds – series of fixed points through community
- transects – quantitative and can used as a baseline
- photographic monitoring - qualitative
- weed mapping
- condition/ boundary mapping

also consider...

- rank by category – threat rating
- size (choose small areas)
- each must be case specific
- apply minimum monitoring - set up *fixed quardats, well marked and fire proof*

Outcome

- 22 transects installed at various lengths in a number of occurrences
- plant species recorded at regular intervals (point intercept)
- ideally at peak flowering time for herbs; and
- apply condition rating (BF scales)
- photopoints



Difficulties encountered

- ➢part time project – no specific resources
- ➢lack of assistance from specialist staff
- ➢time clash with other priorities
- ➢transects too long for realistic time frame
- ➢point intercept – can be time consuming, cannot account for variability or spatial change
- ➢Plants can be difficult to ID
- ➢seasonal variation

Other considerations

- ➢community groups – quality control issue
- ➢long interval time – changes of personnel
- ➢capture / input / storage of data
- ➢technological advances
- ➢lost markers
- ➢fire
- ➢other threats

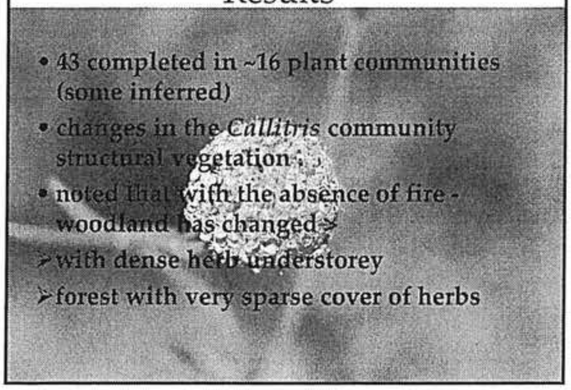
Community type and time taken to score transects

FCT type	Community description	location	details of transect	no. personnel	hours taken	no flora sp recorded	mean species richness
FCT 18	Shrublands on calcareous silts	Ellis Road, Yalgorup NP	50m transect score @ 05cm	four DEC	5	34	39.5
		Ellis Road, Yalgorup NP	2 x 10m transect score @ 10cm	four DEC	2.5	24	39.5
		Hay Park, Bunbury	70m transect score @ 20cm	four DEC plus 3 vollies	5	23	39.5
FCT 2	Southern wet shrublands	Ambergate, Busselton	20m transect score @ 20cm	two DEC plus 4 vollies	4.5	23	51
		Ambergate, Busselton	10m transect score @ 05cm	three DEC plus 1 vollie	2.5	32	51

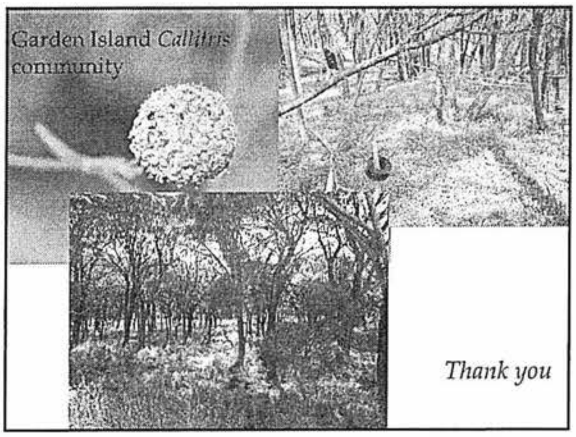
Additional monitoring

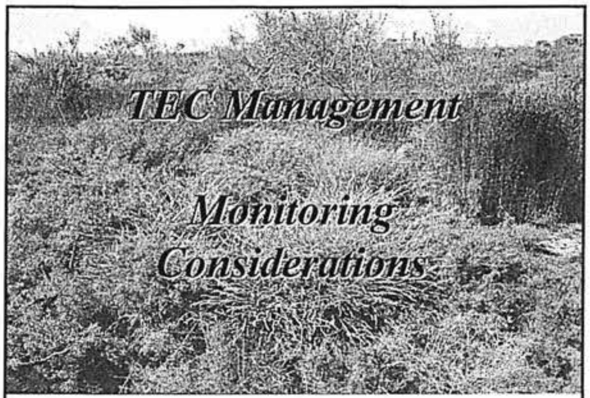
- 2007 – selected plots to re-survey
- targeting '94 floristic survey of the southern SCP / Bush Forever vegetation quadrats (~1500)
- to seek changes in plants species present, major changes in condition and structure of the vegetation
- rescore selected plots at least twice
- collect / submit specimens for id
- Analyse using same methods used in survey

Results



- 43 completed in ~16 plant communities (some inferred)
- changes in the *Callitris* community structural vegetation :
- noted that with the absence of fire - woodland has changed >
  - >with dense herb understorey
  - >forest with very sparse cover of herbs


Garden Island *Callitris* community
Thank you



Dept Environment & Conservation

Kim Williams
TEC workshop Nov 2008

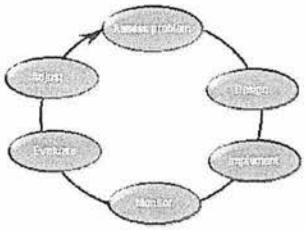
Monitoring – What is it ?

- Monitoring is the **repeated measurement** of a factor or range of factors at one or more locations over time to **determine change**.
- But **WHICH FACTORS** ?
- Evaluation is the **analysis** of the "raw information" collected during monitoring.
- But What **TYPE of ANALYSIS ?**
- and **interpretation** of the analysis to enable **conclusions** to be made and the **effectiveness** of management actions to be assessed.
- How do we **MEASURE EFFECTIVENESS ?**

Monitoring – What is it ?

- To be effective monitoring programs need to be designed so that they can identify the cause(s) of detected change. - it needs **diagnostic power**.
- Ecological monitoring should be part of an adaptive management framework - **Adaptive Management** is;
  - *"a systematic process for continually improving management policies and practices by learning from the outcomes of operational programs."*

Adaptive Management Cycle:



What is the Condition of a TEC ?

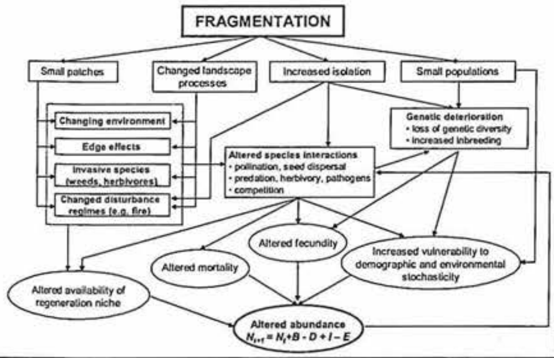
- Condition/Health means so many things…
- Which parameters do you measure ? And why ?

- Persistence
- Growth
- Resilience – implies knowledge of thresh-holds ?
- Reproduction
- Recruitment
- Dispersal/ Expansion

- Manage Conservation at 3 Levels: Ecosystem, Species, Genetic

Approach's to Monitoring Threat Vs Ecological Functions

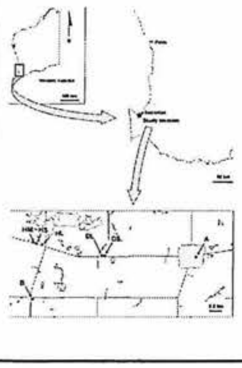
Effects of fragmentation on plant population viability



Study objectives

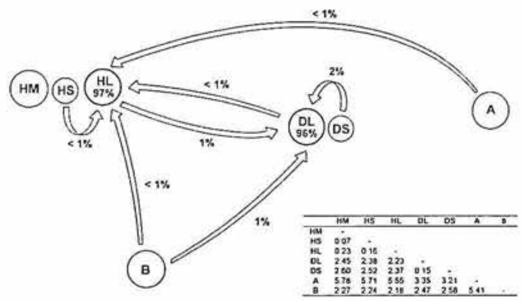
- ***a) Population biology study:*** To develop an understanding of the demographics, reproductive biology and pollination systems operating in four endemic ironstone taxa (provisionally *Calothamnus* sp. Whicher (BJK & NG 230), P4; *Dryandra nivea* subsp. *uliginosa*, DRF; *Hakea oldfieldii*, P2; *Loxocarya magna*, P3) in nine different sized remnants over four years.
- ***b) Mating system study:*** To quantify the effects of inbreeding on three of these endemic ironstone taxa in terms of population size and isolation.
- ***c) Landscape level gene flow study:*** To assess gene flow between fragmented populations of different sizes of the three endemic ironstone taxa.

Population genetics – genetic structure and mating system



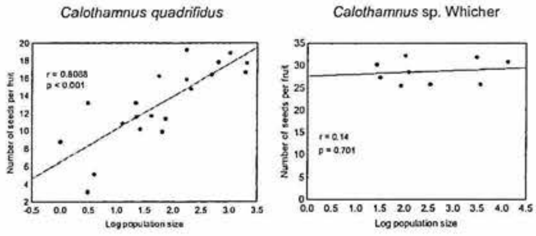
	C. which	*C. quad*
F_{st}	0.256	0.105
F_s	46-58%	17-42%

Gene flow among and within populations

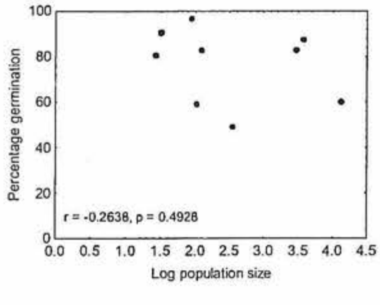


	HM	HS	HL	DL	DS	A	B
HM	-						
HS	0.07	-					
HL	0.23	0.16	-				
DL	2.45	2.38	2.23	-			
DS	2.60	2.52	2.37	0.15	-		
A	5.76	5.71	5.55	3.35	3.21	-	
B	2.27	2.24	2.18	2.47	2.58	5.41	-

Relationship between seed set and population size in *C. quadrifidus* and *C.* sp. *Whicher* population fragments

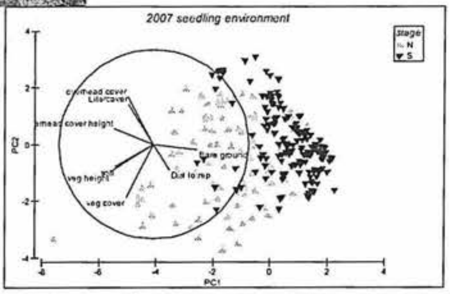


Relationship between germination and population size in *C.* sp. *Whicher* population fragments

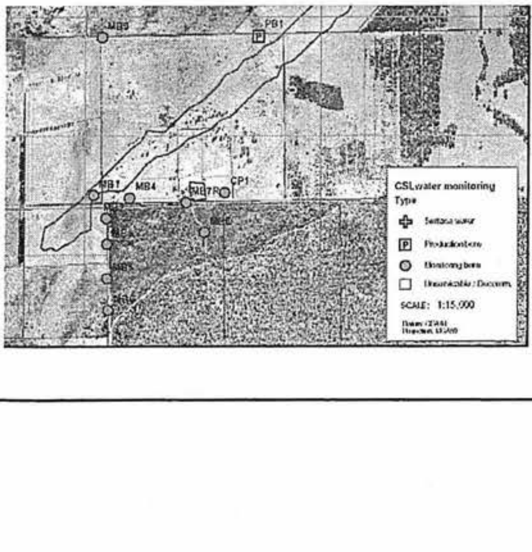


C. sp. *Whicher*

Demography – seedling environments



Threat Based Monitoring



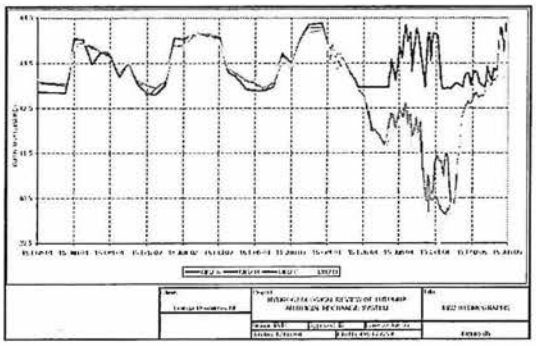
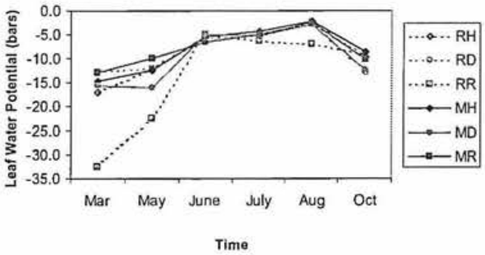
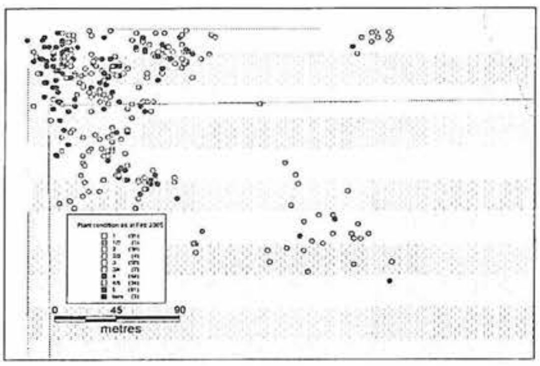


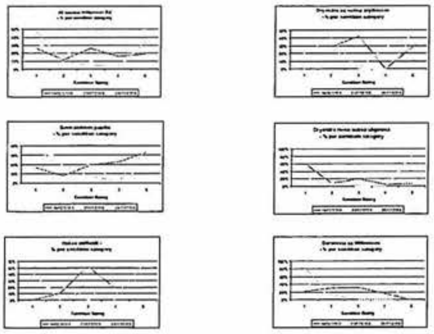
Figure 1. Pre-dawn leaf water potentials (bars) for three endangered species growing within ironstone communities.



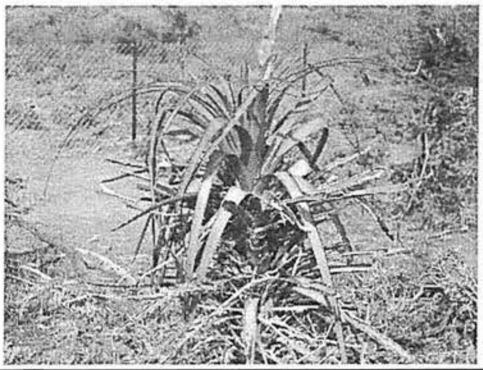
CR flora deaths within a CR TEC – Busselton Ironstone

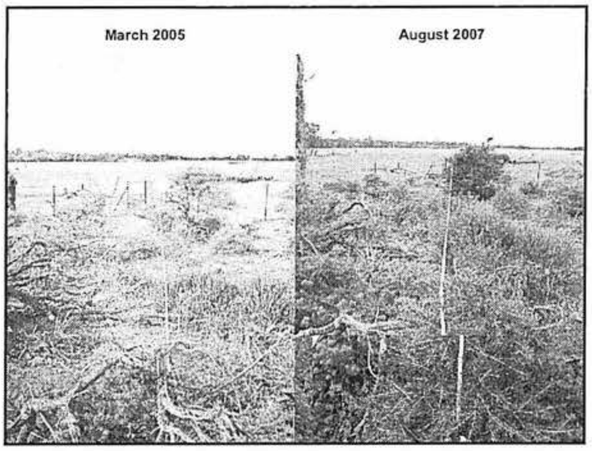


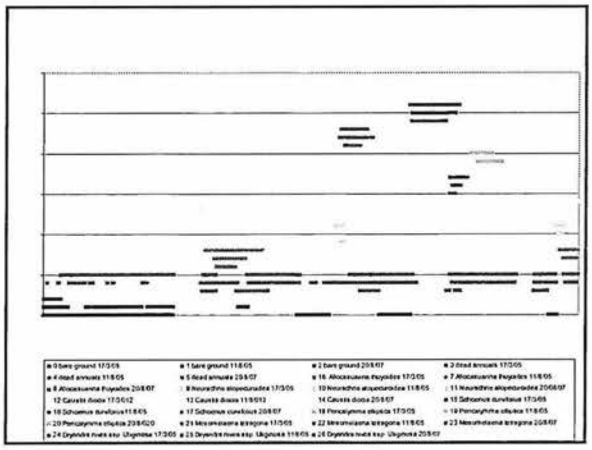
Condition Monitoring charts



Grazing Impacts – CR Busselton Ironstone TEC

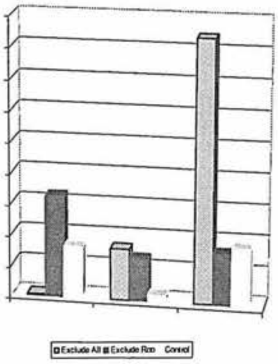




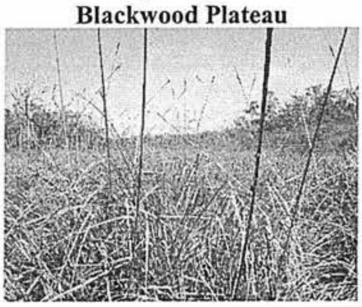


Exclude All transect

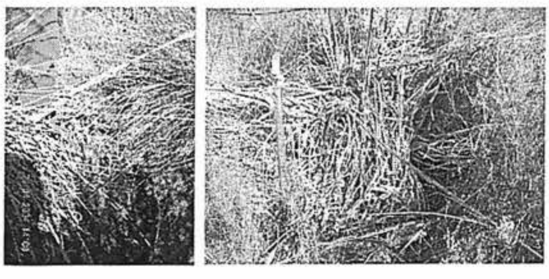
Name	2005	2007	Change %
Herbs			
Bare ground	516	44	91% decrease
Annuals	455	906	99% increase
Neurachne alopecuroidea	9	40	344% increase
	980	990	1% increase in herbs
Sedges			
Caustis dioica	348	395	13% increase
Lepidosperma squamatum	0	30	Recruitment
Mesomelaena tetragona	41	70	71% increase
Schoenus curvifolius	14	45	221% increase
Tremulina tremula	33	40	21% increase
	436	580	33% increase in sedges
Shrubs			
Allocasuarina thuyoides	51	200	292% increase
Dryandra nivea subsp. uliginosa	92	130	41% increase
Pericalymma ellipticum	0	55	Recruitment
	143	385	169% increase in shrubs



***Reedia spathacea, Empodisma gracillimum, Sporodanthus rivularis* dominated floodplains of the Blackwood Plateau**



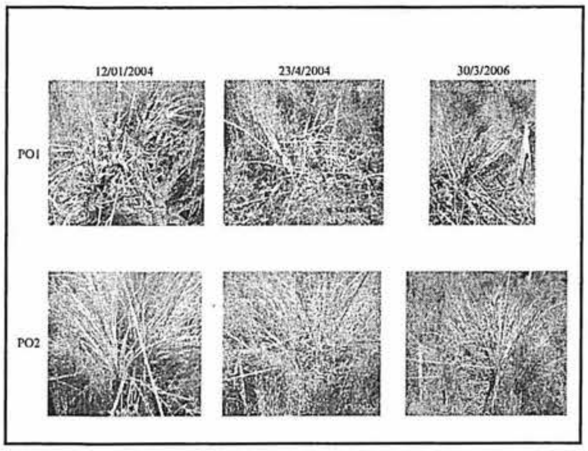
Feral Pig Impacts

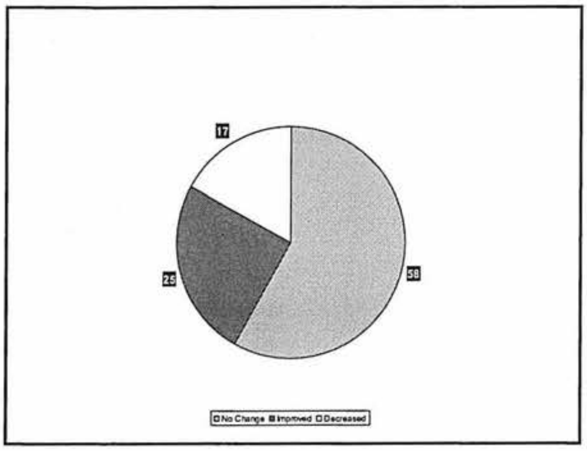


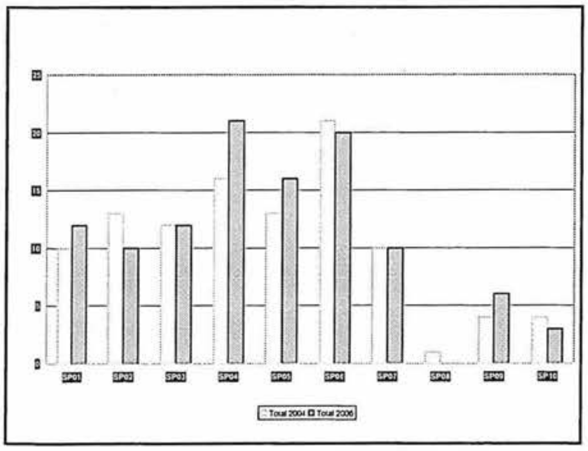
- **Individual Plant Monitoring**
- 12 plants tagged, monitor decline or recovery post disturbance. 4 examples each of low, medium and high condition category.
  - Low – >80% of leaves on plant brown/ discoloured
  - Medium – 20-70% of leaves on plant brown/ discoloured
  - High – no/few leaves on brown/ discolouration
- Plant condition is determined by the health of the surviving leaves, and does not include senescent leaves at the base of the plant.

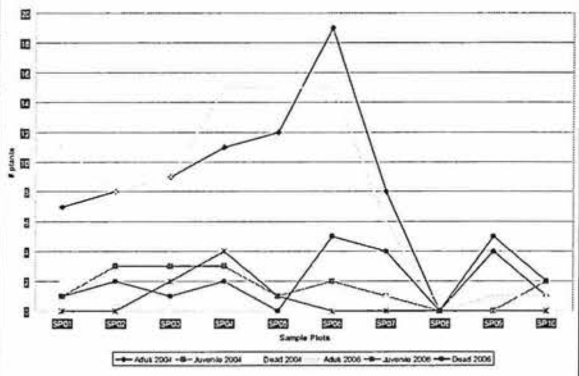
- **Community Monitoring 5m Plots**
- Sample plots were positioned throughout the system to include varying areas of *Reedia spathacea* intensity.
- 10 plots , radius of 5m ea.
- Information recorded included;
  the general condition of the habitat,
  evidence of pigs,
  evidence of secondary grazing (new leaf tips grazed by kangaroos),
  number of plants (adults and juveniles),
  condition of plants.


Date
Pig Tracks
Pig Comments
Secondary Grazing
Plant Condition


12/01/2004
23/4/2004
30/3/2006
PO1
PO2


17
25
58
No Change
Improved
Decreased


25
20
15
10
5
0
SP01
SP02
SP03
SP04
SP05
SP06
SP07
SP08
SP09
SP10
Total 2004
Total 2006



Conclusions Blackwood Road

- Initial monitoring indicates no direct correlation between feral pig grazing and plant decline. In general, some plants not impacted are in poorer health.
- Results do not suggest broadscale grazing by pigs, rather opportunistic grazing. One quadrat with high evidence of pigs ie fresh tracks and scats showed little evidence of feral pigs impacting on the immediate plants
- The general health of the creekline is impacted detrimentally by the presence of pigs - vegetation is trampled thus allowing other animals to use the paths, demonstrated by a high incidence of kangaroos grazing new leaf tips on Reedia

End

Big thankyou to Erica Shedley, Andrew Brown, Russell Smith, Colin Yates for allowing parts of their presentations to be "borrowed".

Summary

- Monitoring is the **repeated measurement** of a factor or range of factors over time to **determine change**.
- Evaluation is the **analysis** of monitoring data to enable **conclusions** to be formulated and management **effectiveness** assessed.
- **Objectives** – must be clear, relevant and achievable.
- Use the **correct monitoring tool** to achieve the objective.

Summary

- **Rare Flora Report Forms** – Used to obtain population data (number of plants, reproductive state, threats, general condition etc.)
- **Photo Points** – Used to illustrate change over medium to long time periods but don't produce "hard" (quantitative data).
- **Transects and Quadrats** - Useful when monitoring individual plants and threatening processes.
- **Information Storage** is essential– Corporate (DEFL, TEC, WAHerb) and Local databases.

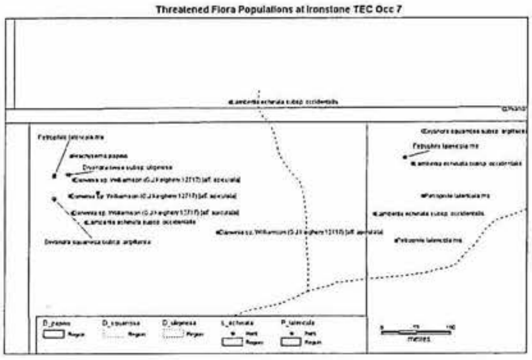
When to Monitor ?

- **Day of disturbance** (eg: burn)
- **Within a few days** of disturbance.
- Time **determined by Biological Response** (germination, green pick grazing, canopy closure/biomass recovery, phenological reproduction age & breeding success)
- **Frequency** - once off, intermittent or cyclic - seasonal, annual, 5yr etc

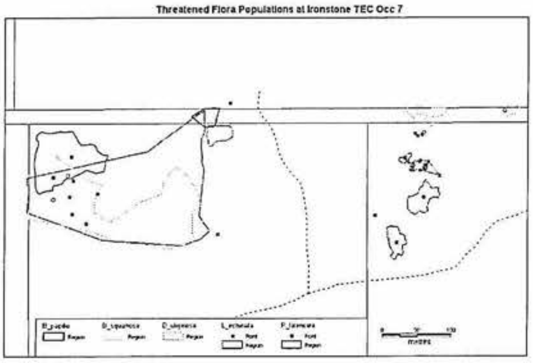
Monitoring -

variety of tools/techniques for a range of results

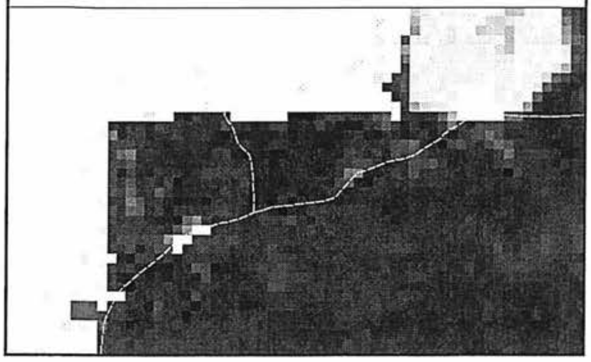
Threatened Flora Populations at Ironstone TEC Occ 7

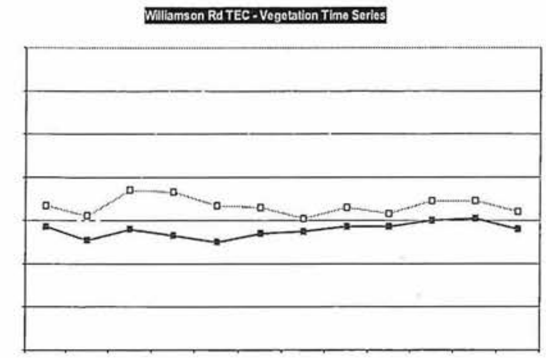


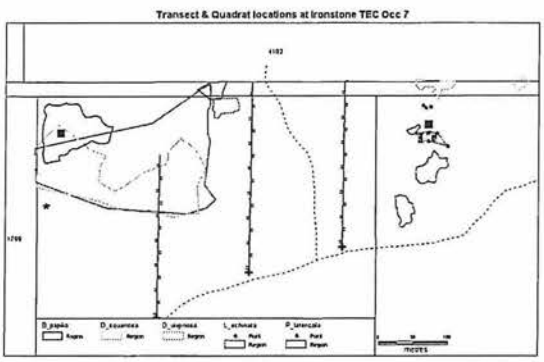
Threatened Flora Populations at Ironstone TEC Occ 7



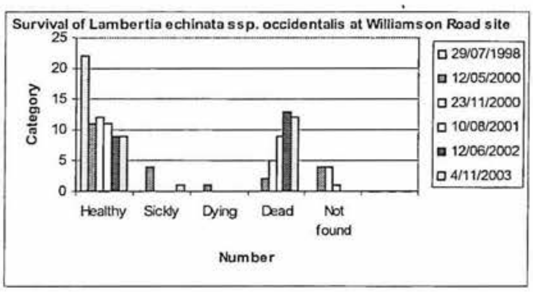
"Veg Machine" - Cumulative Vegetation Trend





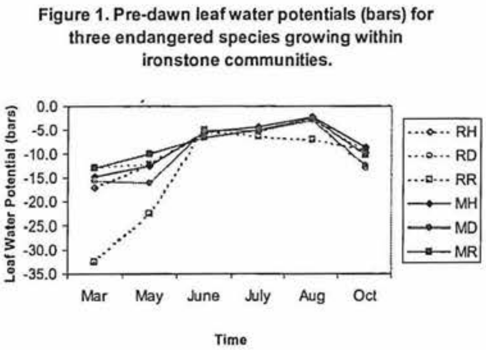


TRANSECT	DISTANCE (m)	TAG NO	TAXON	PHENOLOGY	STRESS	HT (cm)	LONG AXIS (cm)	SHORT AXIS (cm)	NOTES
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



Tissue analysis phosphite concentrations of 3 ironstone species, 2002

	Marks	Phosphite	*		
		mg/kg	Confirmed		
Species	Site	as received	*	mean (s.e.)	2001 levels
Dryandra squarrosa ssp. argillacea	Wonnerup Road	260			
Dryandra squarrosa ssp. argillacea	Wonnerup Road	230			
Dryandra squarrosa ssp. argillacea	Wonnerup Road	200			
Dryandra squarrosa ssp. argillacea	Wonnerup Road	69	*	240 (68)	
Dryandra nivea ssp. uliginosa	Williamson Road - west	8.5			
Dryandra nivea ssp. uliginosa	Williamson Road - west	4.6			
Dryandra nivea ssp. uliginosa	Williamson Road - west	4.2			
Dryandra nivea ssp. uliginosa	Williamson Road - west	3.0	*	5.0 (1.2)	
Lambertia echinata ssp. occidentalis	Williamson Road - west	130			140
Lambertia echinata ssp. occidentalis	Williamson Road - west	170	*		190
Lambertia echinata ssp. occidentalis	Williamson Road - west	25			310
Lambertia echinata ssp. occidentalis	Williamson Road - west	120		111 (31)	220
					215 (36)



Monitoring Quality

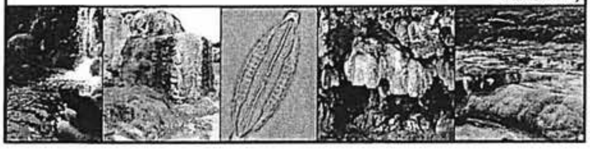
- Do we have clear objectives?
- Is the monitoring designed to meet the objectives?
- Is the data collected in a rigorous, repeatable way?
- Can the data be readily accessed, analysed and queried by staff?
- Can we get more value from the monitoring effort?
- Is the data being used to improve management decisions?
- Hint: Do you have a <u>monitoring plan ?</u>

Department of Environment and Conservation

SOUTH WEST CATCHMENTS COUNCIL

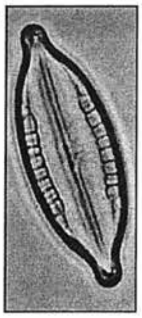
Augusta Microbial TEC

Kim Onton
Conservation Officer (Marine & Coastal)
DEC Bunbury



Overview

- What is the Augusta Microbial TEC
- Threats
- Work to date
- Monitoring program
  - Objectives
  - Site selection
  - Methods
  - Results
  - Challenges
  - Management Implications
- Future work



Augusta Microbial TEC (Tufa)

- "Rimstone pools and cave structures formed by microbial activity on marine shorelines"
- Chemical sedimentary rock composed of calcium carbonate precipitated from freshwater streams and springs.
- Formed through the growth and metabolic activity of microbes.

Threats

- Reduced water quality
- Altered water flow or availability
- Trampling
- Physical collapse

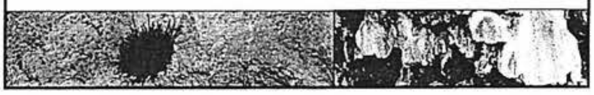
Work to date

- Tufa identified as TEC
- All occurrences mapped and "states" identified (active, inactive & dead)
- Potential monitoring sites identified
- Microbial analysis commenced
- Tufa occurs elsewhere

Objectives

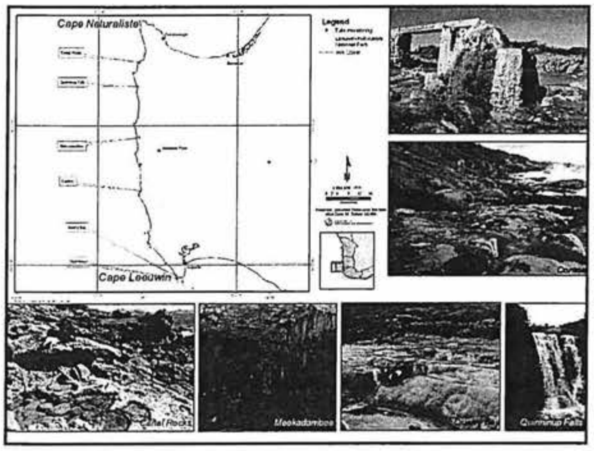
1) Determine ecological water requirements
2) Understand seasonal tufa growth
3) Determine microbial composition

- Quantify threats
- Implement management actions



Site selection

- Representative of various formations
- Water present all year around
- Sufficient water volume to sample
- Accessible
- Geographical separation



1) Ecological Water Requirements

What are water requirements of tufa?

- In-water testing
  - 6-8 weeks
  - pH, DO, EC, Redox, alkalinity
- Samples for laboratory analysis
  - 8 weeks
  - Total N & P, basic cations & anions
- CTD divers
  - Ongoing logging
  - Conductivity, Temperature, Depth

Results

- Methods consolidated
- Loggers working, samples analysed

Challenges

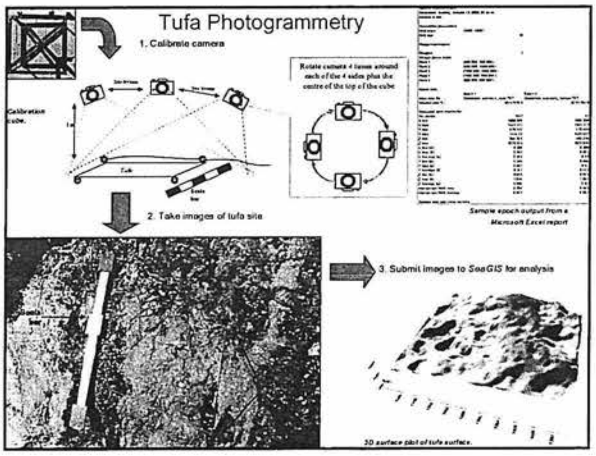
- How to monitor at seepage sites
- Selecting sites with water all year round to measure
- Seasonality
- Location for loggers
- Vandalism of loggers
- Difficult access locations

2) Tufa growth

How does tufa grow over time & over seasons?

- Photogrammetry
- Technique used to measure sponge growth
- Consultant (SeaGIS), software

Tufa Photogrammetry



Results

- Summer and winter images analysed
- Loss of some targets making analysis difficult at some sites

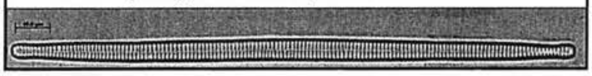
Challenges

- New method to be applied to tufa
- Permanent "targets" need to be stable and not change over time (difficult in growing tufa)
- Need to be rust proof
- Sites restricted to shallow flow

3) Microbial Composition

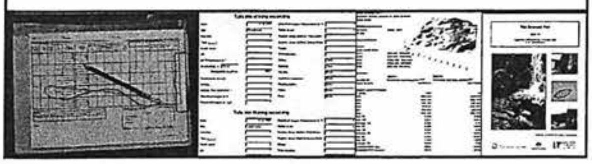
What is the species composition of tufa – assemblage variations between occurrences, formations, seasons.

- Collect samples in winter and summer (wettest and driest)
- Prof Jacon John undertakes analysis and reporting
- Compare variables with species composition – water quality, formations, locations



Data Compilation & Analysis

- Datasheets
- Access database (Region), HYDSTRA (Dept)
- Photographs & maps
- Reports for consultants for microbial analysis & photogrammetry
- Ongoing and final report to SWCC

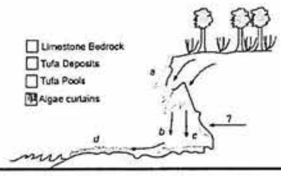


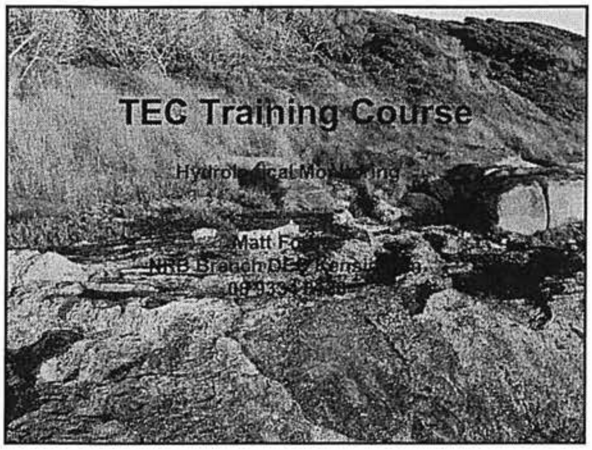
Management Implications

- Investigate sources of any decreased water quality (e.g. nutrient runoff upstream)
- Investigate threats to water flow (e.g. water extraction/flow diversion)
- Understanding seasonal growth will give an indication of possible recovery after physical disturbance
- Understanding of microbial assemblages may guide priorities (distinct management units)

Future Work

- Continue regular water monitoring & photogrammetry (intensity is funding-dependent)
- Explore water flow monitoring
- Geological analysis
- May be applicable to other monitoring projects?





Outline

- Ecological Water Requirements (EWR) & Groundwater Dependent Ecosystems (GDE).
- Hydrological Monitoring and Assessment.
- Examples.
- Questions.

Groundwater Dependent Ecosystems

- Terrestrial vegetation
- River base flow systems
- Aquifer and cave ecosystems
- Wetlands
- Terrestrial fauna
- Estuarine and near-shore marine ecosystems

(modified after Froend)

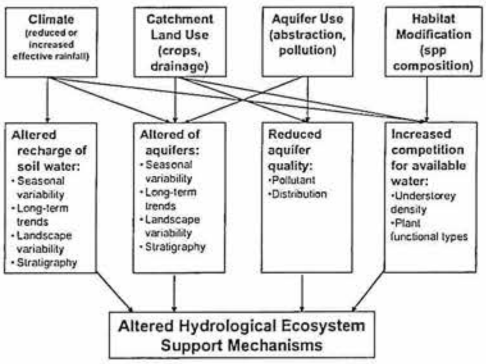
Entirely Dependent Ecosystems

- mound springs
- karst systems of Exmouth, Yanchep, Nullarbor, etc.
- Tufa communities of the Cape to Cape region SW WA.
- saline discharge and other playa lakes of Western Murray Basin.
- streamside woodlands along inland groundwater gaining rivers in arid zone.
- Some of the lake and fringing vegetation ecosystems of Swan Coastal Plain.
- spring systems of the Pilbara.
- inland mangrove stand near Eighty Mile Beach.

EWR

- **Environmental Water Requirements (EWR)**
  - Describe water regimes (spatial and temporal) needed to sustain ecological values of water-dependent ecosystems at a low level of risk.
  - Basically what an ecosystem needs

Threats to Groundwater Dependant Ecosystems



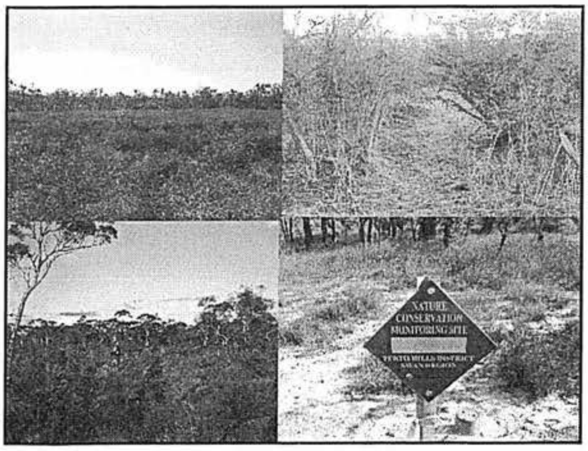
(modified after Froend)

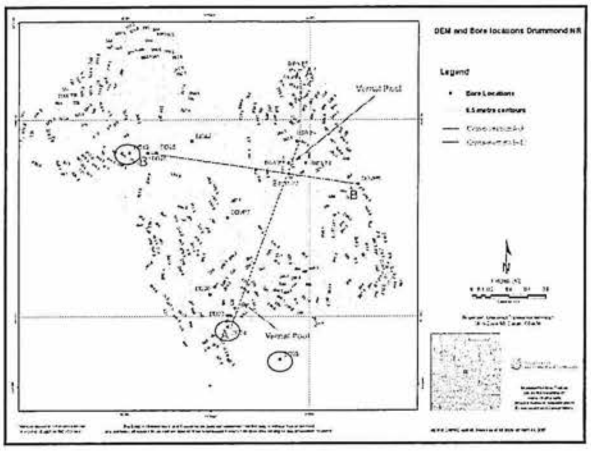
Hydrological Monitoring

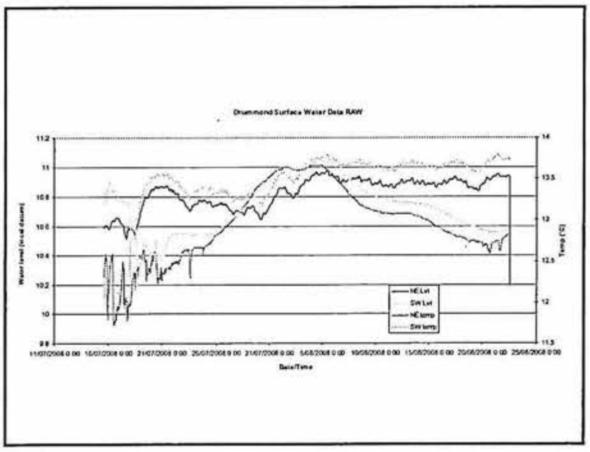
- 1. Understand the system
  - Topography.
  - Geology.
  - Climate.
  - Vegetation.
- 2. Identify and Assess potential threats.
  - Determine EWRs.
  - Preliminary Hydrological assessment.
- 3. Develop Hydrological Baselines.
- 4. Install and continue monitoring Regime.

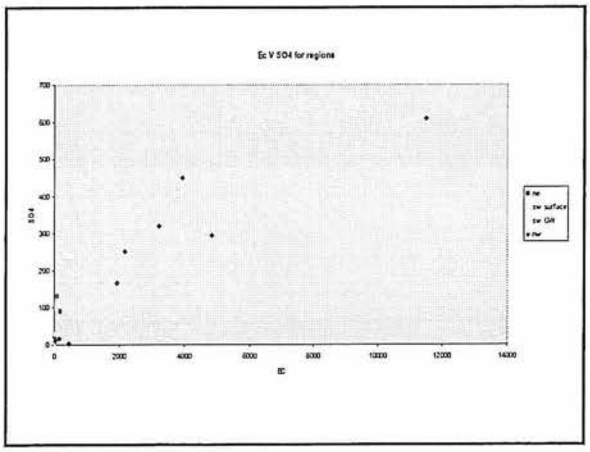
What to monitor.

- Depends on EWR and/or perceived threats.
- SW and GW physical attributes.
  - Water levels.
  - Flow paths.
- SW and GW chemical attributes.
  - pH, acidity, salinity, alkalinity, temp, DO.
  - Cations, anions and complex chemistry.



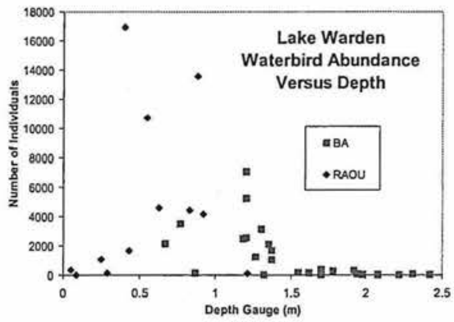

DEM and Bore locations Drummond NR
Legend
Bore Locations
0.5 metre contours
Vernal Pool
Vernal Pool
A
A'
B
B


Drummond Surface Water Data RAW
11.2
11
10.8
10.6
10.4
10.2
10
9.8
14
13.5
13
12.5
12
11.5
Water level (local datum)
Temp (°C)
11/07/2008 0:00
16/07/2008 0:00
21/07/2008 0:00
26/07/2008 0:00
31/07/2008 0:00
5/08/2008 0:00
10/08/2008 0:00
15/08/2008 0:00
20/08/2008 0:00
25/08/2008 0:00
Date/Time
NE Lvl
SW Lvl
NE temp
SW temp

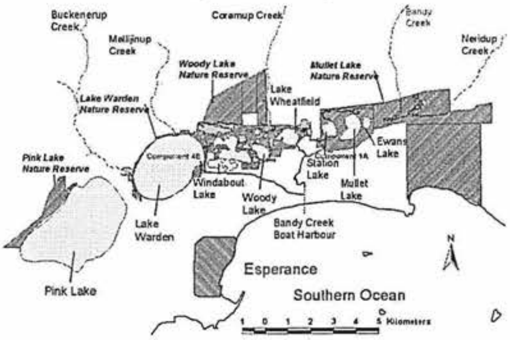

Ec V SO4 for regions
700
600
500
400
300
200
100
0
SO4
0
2000
4000
6000
8000
10000
12000
14000
EC
ne
sw surface
sw GW
nw

Lake Warden Esperance.

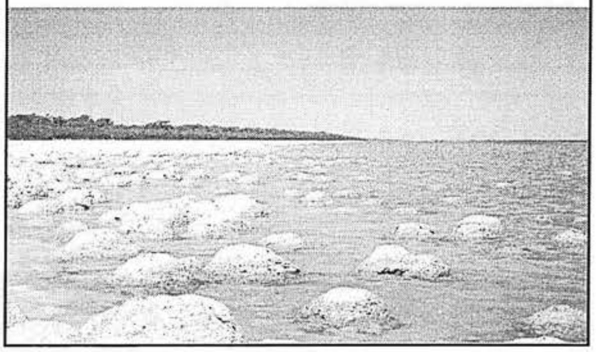
Habitat loss due to rising water

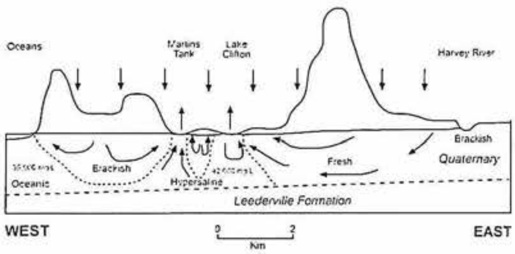


Engineering



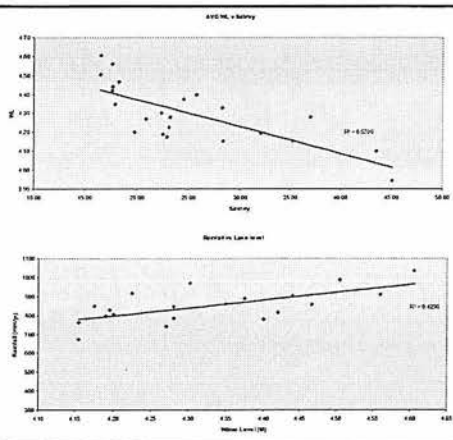
Lake Clifton

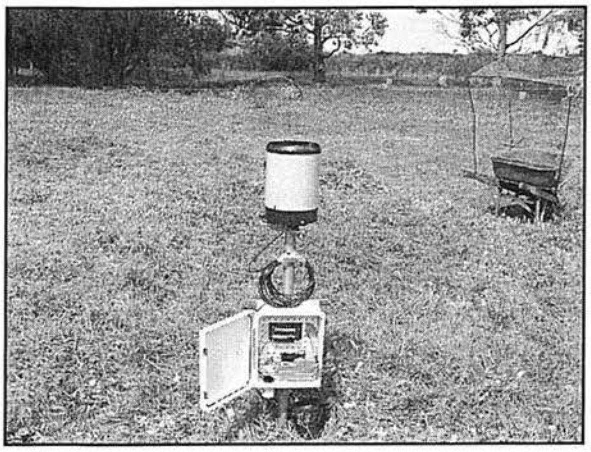


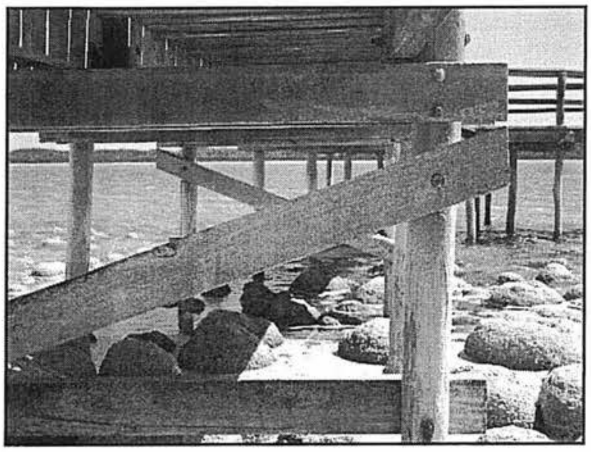


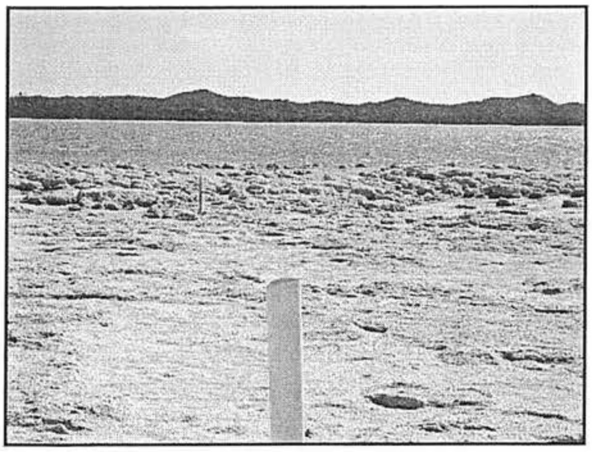
Fresh water rich in carbonate enters the lake from the eastern side as GW.

Development and Industry pressure in the area may be affecting the system.

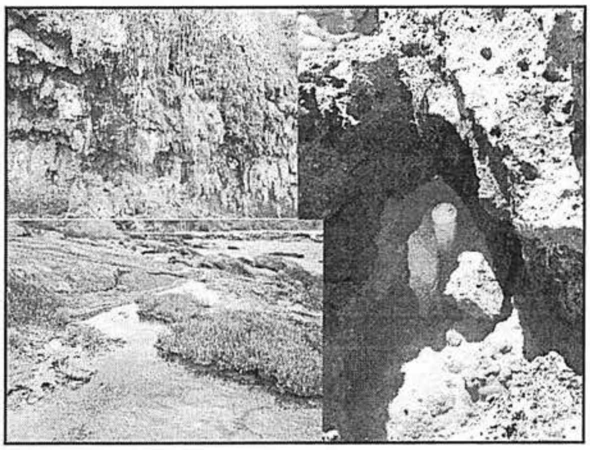


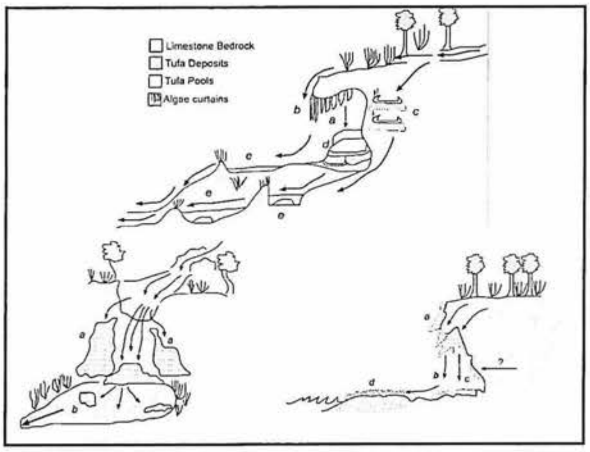






SW Tufas




Limestone Bedrock
Tufa Deposits
Tufa Pools
Algae curtains

Callitris in the woodlands and shrublands of southern Western Australia: ancient landscapes, contemporary issues.

Lachlan McCaw RPF
Department of Environment and Conservation,
Science Division, Manjimup WA 6258

Abstract: Western Australia is renowned for its iconic tall forests of jarrah, karri and tingle in the mesic south-west corner of the state. Less well known, but of equal interest and significance are the extensive woodlands and shrublands of the semi-arid zone. These ecosystems occur on land surfaces of great antiquity, with *Callitris* prominent as a small to medium sized tree. Six species of *Callitris* occur in Western Australia, with *C. drummondii* and *C. roei* endemic to the South West Botanical Province. *C. columellaris* and *C. preissii* are the most widespread and exhibit remarkable flexibility in the sites on which they occur and in their growth habit, varying from small stunted trees on granite and ironstone substrates through to stately trees on more favourable sites. The longevity and distinctive growth rings of *Callitris* make them well suited to dendrochronology and exploratory research has demonstrated the feasibility of establishing cross-dated chronologies extending back 350 years or more. Tree ring chronologies from *Callitris* have potential to provide a much needed historical context for projected climate change scenarios across southern Western Australia. The sandplain shrublands where *C. preissi* and *C. roei* principally occur tend to burn every few decades with fires of sufficient intensity to kill mature trees. Ring counts of *Callitris* stems provide a means to determine the time interval since the last fire and can assist in validating fire history information obtained from air photography and satellite imagery. Fire regimes in landscapes where eucalypt woodlands are interspersed with sandplain shrublands deserve further study as the recent history of large, intense fires appears incompatible with the development and continued persistence of mature eucalypt woodlands. The forestry profession has a long association with the woodlands of southern Western Australia through its management of harvesting operations for sandalwood and mining timber. Future opportunities for the forestry profession include raising awareness of the value of woodlands, managing fire regimes to optimize carbon sequestration in long-lived woody vegetation, and unlocking information about past climate variability.

Introduction

Western Australia is renowned for its iconic tall forests of jarrah (*Eucalyptus marginata*), karri (*E. diversicolor*), marri (*Corymbia calophylla*) and tingle (E. *jacksonii*, *E. guilfoylei* and *E. brevistylis*) in the mesic south-west corner of the state. Less well known, but of equal interest and significance are the extensive semi-arid woodlands and shrublands of the southern interior of the state (Kessell and Stoate 1936, Kealley 1991, Yates *et al.* 2000). These ecosystems occur on land surfaces of great antiquity derived from Archean granite and gneiss of the Yilgarn craton, intersected by greenstone ranges and banded ironstone formations (Beard 1998). The surface of the Yilgarn plateau is gently undulating at elevations between 200 and 600 m above sea level. Drainage is occluded with extensive salt lakes associated with ancient paleo-drainage systems.

Semi-arid woodlands and shrublands once extended throughout the Coolgardie and Mallee bioregions (Thackway and Cresswell 1995) but much of the western half of the Mallee bioregion has been cleared for agriculture. The State vermin barrier fence extends north-west from Ravensthorpe and forms a distinct boundary between agricultural lands in the west and the sparsely populated tracts of unallocated crown land and conservation reserve that lie to the east. Areas to the north and east of the town of Coolgardie are held under pastoral lease. The large extent and relatively intact condition of woodlands and shrublands in southern Western Australia make them significant on a national scale, akin to the brigalow and cypress woodlands of western NSW and southern Queensland.

Callitris species occur as shrubs and small to medium sized trees throughout much of the woodland and shrubland in southern Western Australia. However *Callitris* has received little attention from foresters and ecologists in the state, probably because most species are of small stature, rarely form pure stands over large areas and have not been exploited commercially on a significant scale. Kessell and Stoate (1936) make no mention of *Callitris* in their paper on the arid forests of southern Western Australia, while Bowman and Harris (1995) drew attention to the paucity of information for a number of *Callitris* species. Arid zone forestry in Western Australia has focused on the Goldfields eucalypts which have been harvested on an extensive scale for firewood and mining timber and on Sandalwood (*Santalum spicatum*) which has been exploited for its aromatic oil (Kealley 1991, Bunbury 1997).

My aim in preparing this paper is to draw attention to some notable aspects of the distribution and ecology of *Callitris* in southern Western Australia, and in doing so to highlight important land management issues affecting the woodlands and shrublands in which *Callitris* occurs.

Distribution and occurrence of *Callitris* in Western Australia

Six of the *Callitris* species recognized in the recent taxonomic revision by Farjon (2005) occur in Western Australia namely *C. canescens*, *C. columellaris*, *C. preissii*, *C. verrucosa*, *C. roei* and *C. drummondi*, the latter two species being endemic to the South West Botanical province. *C. columellaris* is broadly distributed across the continent and within Western Australia occurs extensively on the Yilgarn plateau and in the Pilbara, Kimberley and arid interior. Specimen records indicate that *C. columellaris* occurs in 14 of the 26 IBRA bioregions in Western Australia (Table 1). This distribution spans a remarkable range of climatic conditions from the dry mediterranean environment of the south west to the wet-dry tropics of the north Kimberley and the low, irregular rainfall of the arid zone.

C. preissi is also widely distributed throughout southern Western Australia, with specimen records from 8 bioregions including the Swan Coastal Plain. The distribution of *C. preissi* overlaps with that of *C. verrucosa* towards the drier inland margins in the Murchison and Great Victoria Desert bioregions, although *C. verrucosa* is probably poorly collected due to the remoteness of the areas in which it occurs. *C. canescens* is widespread throughout the Avon Wheatbelt and western parts of the Mallee bioregion, and also occurs on the Geraldton Sandplain in association with *Actinostrobus*, a native conifer genus endemic to the South West Botanical province.

Table 1. Occurrence of *Callitris* species by IBRA bioregions based on specimen records from the Western Australian Herbarium (http://florabase.dec.wa.gov.au).

IBRA Bioregion	*C canescens*	*C. columellaris*	*C. drummondii*	*C. preissii*	*C. roei*	*C. verrucosa*
Avon Wheatbelt	Y	Y		Y	Y	
Carnavon						
Central Ranges		Y				
Central Kimberley		Y				
Coolgardie	Y	Y		Y		Y
Dampierland						
Esperance Plains	Y		Y	Y	Y	
Gascoyne		Y				
Geraldton Sandplain	Y	Y				
Gibson Desert		Y				
Great Sandy Desert						
Great Victoria Desert		Y		Y		Y
Hampton				Y		
Jarrah forest						
Little Sandy Desert						
Mallee	Y	Y	Y	Y	Y	
Murchison	Y	Y		Y		Y
North Kimberley		Y				
Nullarbor						
Ord Victoria Plain						
Pilbara		Y				
Swan Coastal Plain	Y					
Tanami						
Victoria Bonaparte		Y				
Warren						
Yalgoo		Y		Y		

The two *Callitris* species endemic to Western Australia (*C. drummondii, C. roei*) have a southerly distribution concentrated in the Esperance Sandplains and Mallee bioregions, with scattered outliers of *C. roei* in the Avon Wheatbelt (Table 1). *Callitris* does not occur in the main belt of tall forest covered by the Jarrah Forest and Warren bioregions, although the distributions of *C. drummondii* and *C. roei* overlap with that of jarrah and marri at the southern end of the Stirling Ranges.
C. columellaris and *C. preissii* exhibit remarkable flexibility in the sites on which they occur and in their growth habit, varying from small stunted trees on granite and ironstone substrates through to tall trees on more favourable sites (Figure 1). Both species also occupy sites at a range of positions in the landscape. *C. columellaris* is commonly found around the margins of salt lakes on the Yilgarn plateau but also occurs at elevations approaching 1200 m above sea level near the highest summits in the Hamersley Range in the Pilbara. The elevation range for *C. preissii* is also substantial and extends from sea level to above 600 m on the summit of Peak Charles.

The population of *C. preissii* on Bald Island 50 km east of Albany offers an interesting insight into the growth potential of this species under mild coastal conditions with annual rainfall >800 mm and low potential evaporation. In this environment *C. preissii* grows to a stately single-stemmed tree >15 m tall with fine branching resulting from densely stocked sapling stands (McCaw 1997). Interestingly, trees of such stature are not found on comparable sites on the nearby mainland and there is scant evidence that they may have existed in the period since Europeans settled at Albany in 1826. Abbott (1981) noted that sea level rise during the Holocene has resulted in substantially different fire regimes for island and mainland ecosystems along the south coast of Western Australia.

C. canescens, *C. drummondii* and *C roei* appear to have more specific site requirements, with the result that the variability in growth habit is less than for *C. columellaris* and *C. preissii*.

Figure 1. Examples of the wide variation in growth habit of *C. preissii* in south-western Australia. Tall trees on Bald Island, near Albany (left), fire-killed mature tree in sandplain scrub heath east of Lake King (centre), dwarf plant growing in fissure of granite inselberg at Peak Charles (right).

Dendrochronology of *Callitris* – a window into the past or a glimpse of the future?

Callitris has several attributes that make it attractive for dendrochonological studies including longevity, durability and formation of annual growth rings (Ogden 1978, Banks and Pulsford 2001). Pearman's (1971) study of *C. preissii* growth rings on Garden Island near Perth, represents an important milestone in Australian dendrochonology, despite the fact that intra-annual and missing rings resulted in poor accuracy of dating. The next significant development in Western Australia came 15 years later with the development of a 650 year chronology for *C. columellaris* at Lake Barlee in the Murchison district (Perlinski 1986). Stem sections came from trees at least several hundred years old growing around the margins of the salt lake.

Growing awareness of climate change has stimulated interest in denrochronology, and tree ring chronologies have the potential to provide a much needed historical context for projected climate change scenarios. Cullen and Grierson (in press) investigated natural variability in rainfall in south-west Western Australia using a 350-year chronology from *C. columellaris* located on the southern edge of Lake Tay in the Coolgardie bioregion. The chronology showed significant correlation with regional rainfall anomalies over the autumn-winter (March to September) period and explained 54 % of variation in rainfall over a 90 year calibration period. Autumn-winter rainfall was reconstructed back to 1655 AD, revealing considerable multi-decadal variability in rainfall. Rainfall exhibited fluctuations from dry periods often lasting 20 to 30 years to periods of above average rainfall that persisted for 15 years or so.

A recent study by Sgherza (2006) has shown that *C. preisii* and *C. cansecens* also have considerable potential for use in climate reconstructions. These species are of particular interest as they occur within the Avon Wheatbelt, Esperance and Mallee bioregions where current trends of declining autumn-winter rainfall and increased temperatures are ominously similar to climate change predictions (Indian Ocean Climate Initiative 2001, Whetton *et al.* 2005). Finding old trees suitable for dendronchonology will be difficult for *C. canescens* because so much of the Avon Wheatbelt has been cleared for agriculture.

Fire in *Callitris* landscapes

Summer brings hot dry winds and regular lighting storms to southern Western Australia and in remote areas fires can burn for months growing to very large size (> 400 00 ha). Fire spread patterns are strongly influenced by landscape features such as salt lakes and by the pattern of fuel ages resulting from previous burning (McCaw and Hanstrum 2003). The sandplain shrublands where *C. preissi* and

C. roei principally occur tend to burn every few decades with fires of sufficient intensity to kill mature trees. Fires limit tree longevity and consume dead wood, thereby eliminating evidence of past distribution and stand structure. Ring counts of *Callitris* stems provide a means to determine the time interval since the last fire and can assist in validating fire history information obtained from air photography and satellite imagery. Such information is important in remote areas where no other fire history records exist. Fire regimes in landscapes where eucalypt woodlands are interspersed with sandplain shrublands deserve further study (McCaw *et al.* 2006) as the recent history of large, intense fires appears incompatible with the development and continued persistence of mature eucalypt woodlands (Figure 2). Despite the difficulties in finding old trees in fire prone landscapes a systematic search of rocky breakaway slopes, granite outcrops and salt lakes might yield valuable dendrochronological information to improve our understanding of climate variability over the past 2-3 centuries.

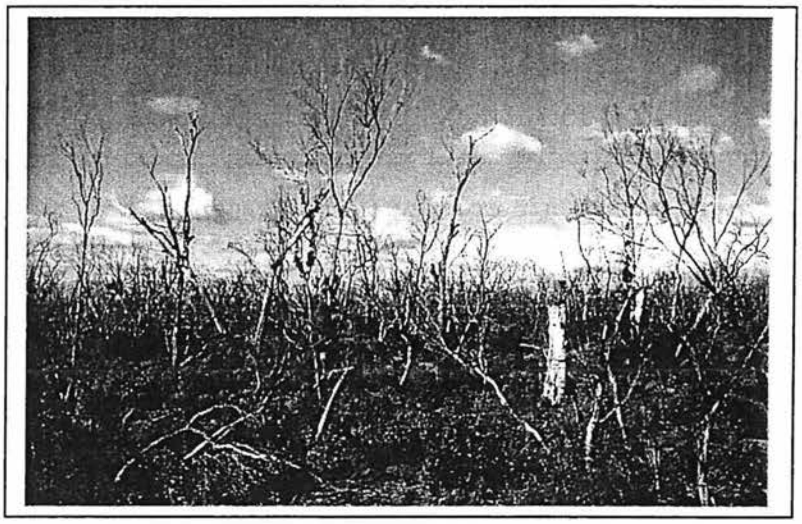


Figure 2. Severe fire damage to eucalpyt woodland north-west of Peak Charles. following a lightning-caused fire in January 1991. Photographed May 1993.

Much remains to be learnt about the regeneration ecology and population dynamics of *Callitris* species across their environmental and geographic ranges. My observations of *C. preissii* regeneration following wildfires suggest that on occasions seedling emergence may be delayed for a number of years after seed is released from cones on fire-killed trees. Four years after an extensive wildfire north-west of Peak Charles in January 1991 I was unable to find more than a handful of seedlings around fire-killed mature trees. A return visit to the same trees in May 2000, nine years after fire, revealed abundant seedling regeneration. Seedling densities around parent trees were roughly proportional to the size of the tree and the number of cones present (Table 2).

Table 2. Attributes of ten *C. preissii* trees killed by fire in January 1991 and seedling regeneration recorded within 5 m radius of each tree in May 2000.

Tree No.	Height (m)	Diameter (cm)	No. of cones	Seedling density (m^{-2})	Seedling height min-mean-max (cm)
1	2.1	5	50-100	0.42	10-15-31
2	1.4	3	<50	0	-
3	2.6	7	<50	0	-
4	2.6	6	<50	0	-
5	4.6	17	>200	0.82	10-26-60
6	6.0	20	50-100	0.24	12-21-53
7	3.0	13	<50	0.16	8-19-32
8	2.5	9	<50	0	-
9	3.5	8	<50	0.05	15-19-26
10	2.5	8	100-200	0.18	20-29-52

What role for the forestry profession in managing *Callitris* landscapes ?

The forestry profession has a long association with the woodlands of southern Western Australia through its management of harvesting operations for sandalwood and mining timber (Kealley 1991, Bunbury 1997). While *Callitris* has traditionally provided the mainstay of the timber industry in western New South Wales and southern Queensland, harvesting of *Callitris* in Western Australia has been limited by the small and scattered resource with most timber destined for local use on pastoral stations. Slow growth rates are a disincentive to silvicultural intervention in natural stands or afforestation with *Callitris*.

Prospecting and mining continues to be the dominant economic activity throughout the more remote areas of southern Western Australia with major operations extracting gold, nickel and iron ore. Recent strong demand for iron ore driven by the booming Chinese economy has resulted in a number of new mine developments based on extraction of ore from banded ironstone formations. Banded ironstones occur on many of the major ranges in the southern interior of the state, which also have high conservation value because of their unusual soils and topography. These ranges are likely to have acted as refugia during past climate fluctuations and support a distinct flora with a high level of local speciation (Gibson and Lyons 1998 a, b). While most mining operations are confined to a relatively small part of an otherwise vast landscape, there are significant flow-on effects from road construction and improved access to previously remote areas. While not necessarily negative, these effects need to be recognized and any adverse impacts managed accordingly.

Land management issues in the semi-arid zone are now attracting greater attention from the conservation movement. The Gondwana Link project (www.gondwanalink.org) is a landscape scale vision to reconnect country across south-western Australia in which entire ecosystems, and the fundamental ecological processes that underpin them, are restored and maintained. The project involves individuals and local, regional and national conservation groups working to restore ecological connectivity from the woodlands of the drier interior to the tall wet forests in the far south-west corner. Engagement with projects such as Gondwana Link could provide important opportunities for the forestry profession to raise awareness of the value of woodlands, and to contribute the professions considerable knowledge of woodland ecology, silviculture, fire management and environmental history. Forestry expertise could also contribute to designing and implementing fire regimes to optimize carbon sequestration in long-lived woody vegetation.

References

Abbott I (1981) Vegetation maps of four large islands near Albany, Western Australia. Western Australian Herbarium Research Notes 5: 5-18.

Banks J and Pulsford I (2001) Dendrochronology of Australian cypress pines. In: Perfumed Pineries – environmental history of Australia's Callitris forests (J Dargavel, D Hart and B Libbs eds) pp 30-38. Centre for Resource and Environmental Studies, Australian National University.

Beard JS (1998) Position and development history of the central watershed of the Western Shield, Western Australia. Journal of the Royal Society of Western Australia 81: 157-164.

Bowman DMJS and Harris S (1995) Conifers of Australia's dry forests and open woodlands. In: Ecology of the Southern Conifers (NJ Enright and RS Hill eds) pp.252-270. Melbourne University Press.

Bunbury B (1997) Timber for gold. Fremantle Arts Centre Press.

Cullen LE and Grierson PF (in press) Multi-decadal scale variability in autumn-winter rainfall in south-west Western Australia since 1655 AD as reconstructed from tree rings of *Callitris columellaris* (Cupressaceae). Climatic Change

Farjon A (2005) A monograph of *Cupressaceae* and *Sciadopitys*. Royal Botanical Gardens, Kew, England, 643 pp.

Gibson N and Lyons MN (1998) Flora and vegetation of the Eastern Goldfields Ranges: Part 2 Bremer Range. Journal of the Royal Society of Western Australia 81: 107-118.

Gibson N and Lyons MN (1998) Flora and vegetation of the Eastern Goldfields Ranges: Part 3 Parker Range. Journal of the Royal Society of Western Australia 81: 119-130.

Indian Ocean Climate Initiative (2001) Second research report – Towards understanding climate variability in south western Australia. Indian Ocean Climate Initiative Panel, Perth. 193 pp.

Kealley I (1991) Management of inland arid and semi-arid woodland forest of Western Australia. In: Forest management in Australia (F.H. McKinnell, E.R. Hopkins and J.E.D. Fox) pp. 286-295. Surrey Beatty and Sons, Chipping Norton, NSW.

Kessell SL and Stoate TN (1936) The forests of the arid southern interior of Western Australia. Australian Forestry 1: 16-20.

McCaw WL (1997) *Callitris preissii* on Bald Island, Western Australia : preliminary observations on distribution, stand structure and tree age. Report available from Department of Environment and Conservation Library, Perth. 6 pp.

McCaw WL and Hanstrum B (2003) Fire environment of Mediterranean south-west Western Australia. In: Fire in ecosystems of south-west Western Australia: impacts and management (I. Abbott and N. Burrows eds.) pp. 87-106. Backhuys Publishers, Leiden, The Netherlands.

McCaw L, O'Donnell A, Boer M, Shu L and Grierson P (2006) Fire and vegetation patterns in semi-arid southern Australia. Presentation to the Third Fire Managers Research Workshop, Wollongong, Bushfire Cooperative Research Centre.

Ogden J (1978) On the dendrochronological potential of Australian trees. Australian Journal of Ecology 3: 339-356.

Pearman GI (1971) An exploratory investigation of the growth rings of *Callitris preissii* trees from Garden Island Naval Base. Western Australian Naturalist 12: 12-17.

Perlinski JE (1986) The dendrochronology of *Callitris columellaris* F. Muell. in arid, sub-tropical continental Western Australia. M.A. thesis, University of Western Australia, Perth 197 pp.

Sgherza C (2006) Tree-ring width and $\delta^{13}C$ chronologies of *Callitris* in the south-eastern wheatbelt of Western Australia. Honours thesis, University of Western Australia, Perth, 64 pp.

Thackway R and Cresswell I (1995) An interim biogeographic regionalization for Australia: a framework fore setting priorities in the National Reserves Sytsem Co-operative program. Reserve Systems Unit, ANCA, Canberra, ACT.

Whetton PH, McInnes KL, Jones RN, Hennessy KJ, Suppiah R, Page CM, Bathols J and Durack PJ (2005) Australian climate change projections for impact assessment and policy application: a review. CSIRO Marine and Atmospheric Research Paper 001. 34 pp.

Yates CJ, Hobbs RJ and True DT (2000) The distribution and status of eucalypt woodlands in Western Australia. In: Temperate eucalypt woodlands in Australia (RJ Hobbs & CJ Yates eds.). Surrey Beatty & Sons, Chipping Norton, NSW.

Monitoring *Callitris preissii* responses to fire – Trigg Bushland

Background:

Callitris preissii is an indicator species of TEC SCP 30a, and individual plants are thought to be killed by fire (Powel and Emberson, 1981). The advent of too frequent fires is thought to be impacting the recruitment of this species, as individuals may have insufficient time to flower, fruit and set seed (the stock of seed is exhausted) before they are burnt. Too frequent fire therefore may be threatening the integrity of this TEC.

Figure 1: Trigg Bushland

Monitoring Question:

What is the minimum fire frequency that the *Callitris preissii* can tolerate?

Monitoring Method:

Establish a series of 10m x 10m plots within patches of *Callitris preissii* in Trigg Bushland. Plots will be distributed in order to gain representation of *Callitris* over the site, and where possible in different fire ages.

Within each plot, all *Callitris preissii* plants will be:

- Recorded with DGPS
- tagged
- have the stage of fruiting/flowering recorded

A photo will also be taken from the NW corner of each plot.

In addition, it is intended that ten younger (smaller) *Callitris* plants in fruit will have cores taken for tree ring chronologies, to determine the age of each plants (see attached paper by Lachlan McCaw). If few plants are in fruit, the ten smallest trees will be cored.

Monitoring Frequency:

Monitoring will take place about two months after any fire, to determine whether the tagged plants within plots have been killed by fire.

Callitris preissii is thought to flower from October to January, so it is hoped that by collaborating with the Friends of Trigg Bushland, we may find volunteers to undertake monthly checks on the fruiting of the younger trees that have been cored for dendrochronology.

Figure 2: Suggested preliminary plot locations

Equipment required:

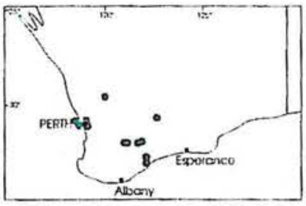
- Pegs for plots
- Mallets
- Measuring tapes
- Optical squares
- DGPS and Nomad/PDA
- Tags
- Wire
- Data sheets

Species Information:

Callitris preissii MIQ. IN LEHM.

FAMILY CUPRESSACEAE

Rottnest Island Pine, Rottnest Cypress, Sand Cypress



DISTRIBUTION

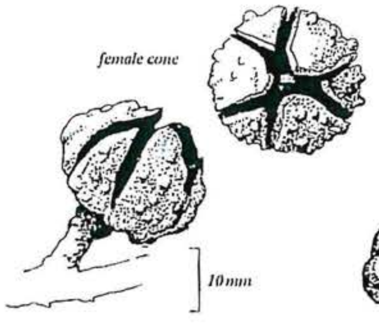
Populations have declined markedly along the Perth coast, although it is still common at Woodman Point and on Garden Island.

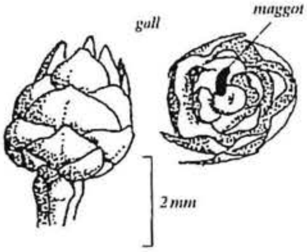
DESCRIPTION

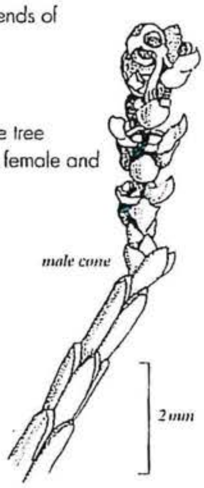
This is a small dark tree up to 10 m high, whose branches end in dense rounded crowns of foliage. Male and female cones grow on the same tree. The leaves, about 3 mm long, are pressed closely against the stem. The male cones, about 5 mm long, are at the ends of branchlets. The female cones are globular, 20–30 mm long, woody and have three large and three small valves, which split open to release winged seeds, which are dispersed by wind. The rounded cone-like structures often seen at the ends of branchlets are insect galls.

FLOWERING PERIOD

Female cones remain on the tree throughout the year. Young female and male cones are present in October–November.







Notes

Ludwig Preiss (after whom this species and *Acanthocarpus preissii* were named) was a German botanist who collected plant specimens in the Perth area between 1839 and 1842.

Aboriginal mothers used to burn leafy twigs in the belief that the fragrant smoke was good for their babies (Cribb & Cribb 1981).

CALLITRIS

Callitris preissii (Rottnest Island Pine, Rottnest Cypress)

Large shrub or tree with whorled scale-like leaves with only tiny free tips; male and female cones separate but usually on the same plant; female cones lacking basal empty scales.

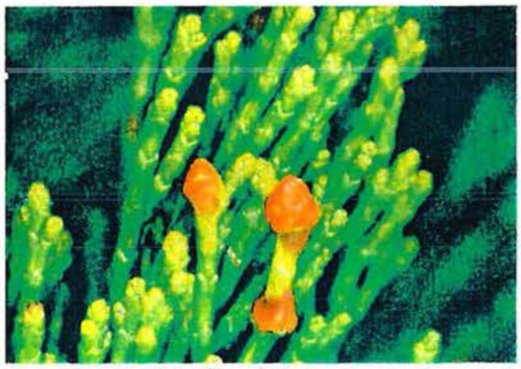
Usually found in shrubland or coastal heath in sandy soils. Possibly in the region, known only from a single early record from Busselton; occurs along the coast near Perth, and from Wiluna to Albany and Balladonia; also in SA, NSW and Vic. Pollen shed in spring.

Shrub or small *tree* to 6 m. *Leaves* in whorls of 3, 2-4 mm long and 0.5-1 mm wide, free and linear in the young plant, becoming fused to the stem so that only the minute scale-like triangular tip remains free. *Inflorescence* replaced by male and female cones which occur on the same plant. *Male cones* cylindric up to 5 mm long, terminating branchlets, with several whorls of cone scales, each scale with 2-4 pollen sacks. *Female cones* solitary or several together, cone scales (valves) 6 in 2 unequal whorls, with several erect ovules at the base of each scale. *Mature cones* globular, woody, 25-35 mm long, conspicuously wrinkled and warty, the warts usually to 3 mm across; seeds winged.

Note: As the collection from Busselton dates from 1909 and has not been recollected, this species may no longer occur within the region.

Male and female cones occur on the same tree; the cylindrical male cones terminate the branchlets and the globular female cones occur on short, thick side branches (Bennett 1998).

Mature Fruit



Fertile plant

Other work undertaken within Trigg Bushland:

- Griffin 1993 and Weston et al. 1992
- Gibson et al. 1994
- Perth Region Plant Biodiversity Project
- Fire History Mapping, City of Stirling
- Friends of Trigg Bushland

References:

Barrett, R. 2005. *Perth Plants: a Field guide to the Bushland and Coastal Flora of Kings Park and Bold Park.* Published Scott Print, Perth.

Bennett, E. 1998. *The Bushland Plants of Kings Park Western Australia.* Printed Scott Four Colour Print, Perth.

McCaw, L. 2007. *Callitris in the woodlands and shrublands of southern Western Australia : ancient landscapes, contemporary issues : paper for presentation at the Australian and New Zealand Institutes of Foresters Conference, Coffs Harbour, 3-7 June 2007.* Department of Environment and Conservation, Manjimup.

Powel, R. and Emberson, J. 1981. *Woodman Point: A relic of Perth's coastal vegetation.* Published Artlook, Western Australia

Rippey, E. 2004. *Coastal Plant, Perth and the South West Region.* Published University of Western Australia Press, Western Australia.

Wheeler, J. 2002. *Flora of the South West Volume 1 and 2.* Published by Australian Biological Resources Study, Western Australian Herbarium and University of Western Australia Press.

Data collection:

Date	Plot Number	DGPS Coordinate	Tree Tag Number	Flowering?	Bud?	Fruit?

Plots should be recorded as CM (Callitris monitoring) – so CM01, CM02 etc

Establishing transects using point intercept method for monitoring weed cover

The proposal is to establish two example ten metre transects on the dune vegetation at Ern Halliday Recreation Camp.

The session will cover:

- Establishment of transects within site to assess weed encroachment;
- Using the point intercept method;
- Importance of noting where the first and last point intercept intervals start and finish (actual measurement from start and end transect), to ensure consistency between monitoring events;
- Brief discussion of specimen collections for reference books;
- Looking at the environmental variables within and between sites and considerations for monitoring, including the fact that each of the transects will be in different:
    - vegetation types;
    - vegetation condition; and
    - aspects.

Note, if we were establishing monitoring:

- We would want to clearly understand what question our monitoring would be helping us to answer.
- We would establish transects in other occurrences of this TEC, comparable vegetation types, condition, soil type, aspect etc. This would allow us to draw conclusions about trends in the community by ensuring that we are looking at comparable vegetation.
- We would consult a biometrician/environmental statistician about our monitoring to discuss replication requirements.
- We would need to understand the importance of knowing what is happening within our sites when establishing monitoring transects, for example;
    - documenting weed control works that have/will occur,
    - disturbances,
    - hydrological changes etc,

  to see if that changes (or lack thereof) in diversity and density may be attributable to these factors;
- We would want to understand;
    - the range of diversity of species within the community,
    - the known threats and how they express themselves (eg for TEC SCP30a community - inappropriate fire regimes, too frequent fire, clearing, weed invasion, disturbance due to recreational activities and the fact that "*Callitris* and *Melaleuca lanceolata* both require lengthy periods between fires to set seed" and that "Armillaria appears to kill old *Callitris* and *Melaleuca* trees"), how threats would express themselves and how we might best monitor for effects of these threats;
    - the tenure and accessibility of the occurrences.
- We would undertake literature research to seek further information about our community and threat.

Logistics:

- Two people set up transect
- One person record data
- One person take point intercept 'measurements'
- One person to take photos
- One person collects specimens
- One person puts samples into collection book.

Recording of point intercept data can be undertaken from each end of the transect if necessary.

Transect 1 will be placed running down the south-western side of the dune in vegetation in good condition (photo from top of dune):

Transect 2 will be placed running down the north-western side of the dune in vegetation in degraded condition:

Photo from top of dune

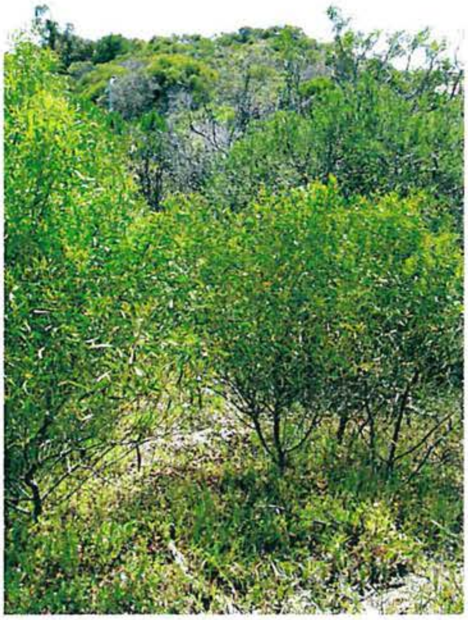


Photo from base of dune