Flora Management Course

Department of Environment and Conservation

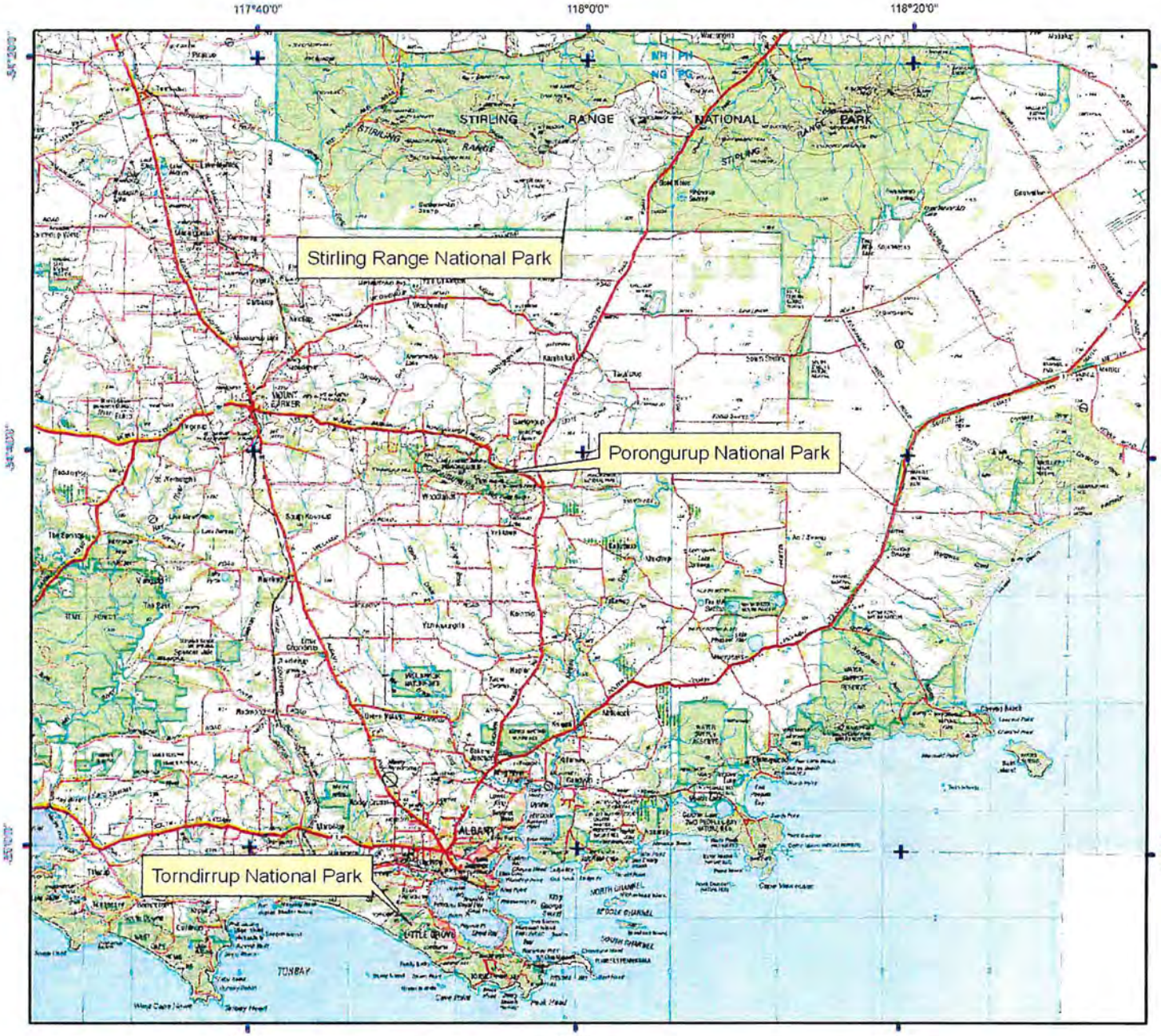
Our environment, our future

Porongorups
17-21 September 2007

Flora Management 2007
Course Notes

Contents

Albany District



N

0 5 10 20

Kilometres

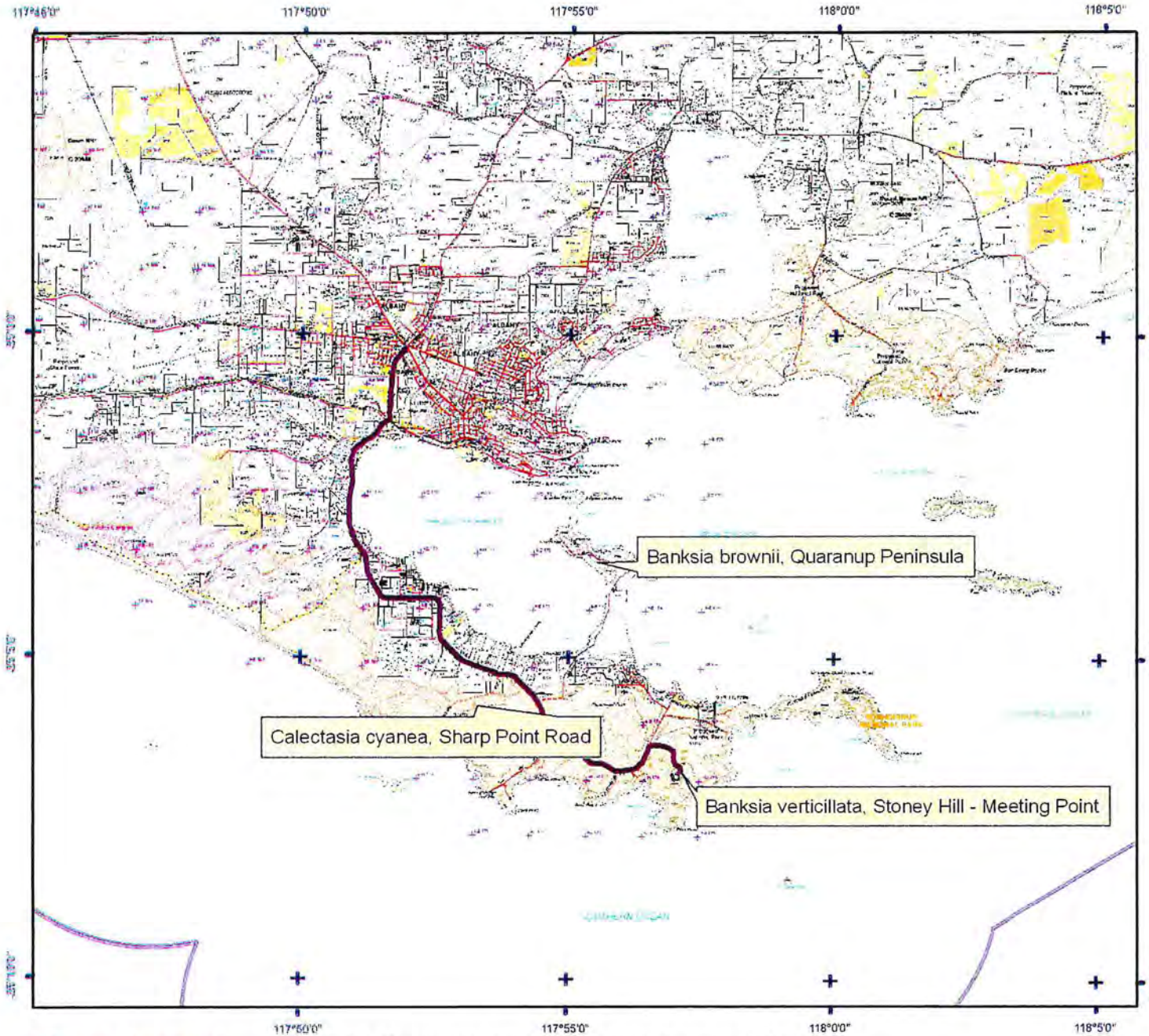
Projection: Universal Transverse Mercator
MGA Zone 50. Datum: GDA94

Department of Environment and Conservation

Produced by FMS
Under the Direction of
Keiran McNamara
Director General, Department of
Environment and Conservation

Graticule shown at 20 minutes intervals
Grid shown at 10000 metre interval

Produced at 11:42am, on September 7, 2007



Torndirrup National Park

Monday pm 17/09/2007

Route 20.25km

0 0.5 1 2 3 4

Kilometers

Projection: Universal Transverse Mercator
MGA Zone 50 Datum: GDA94

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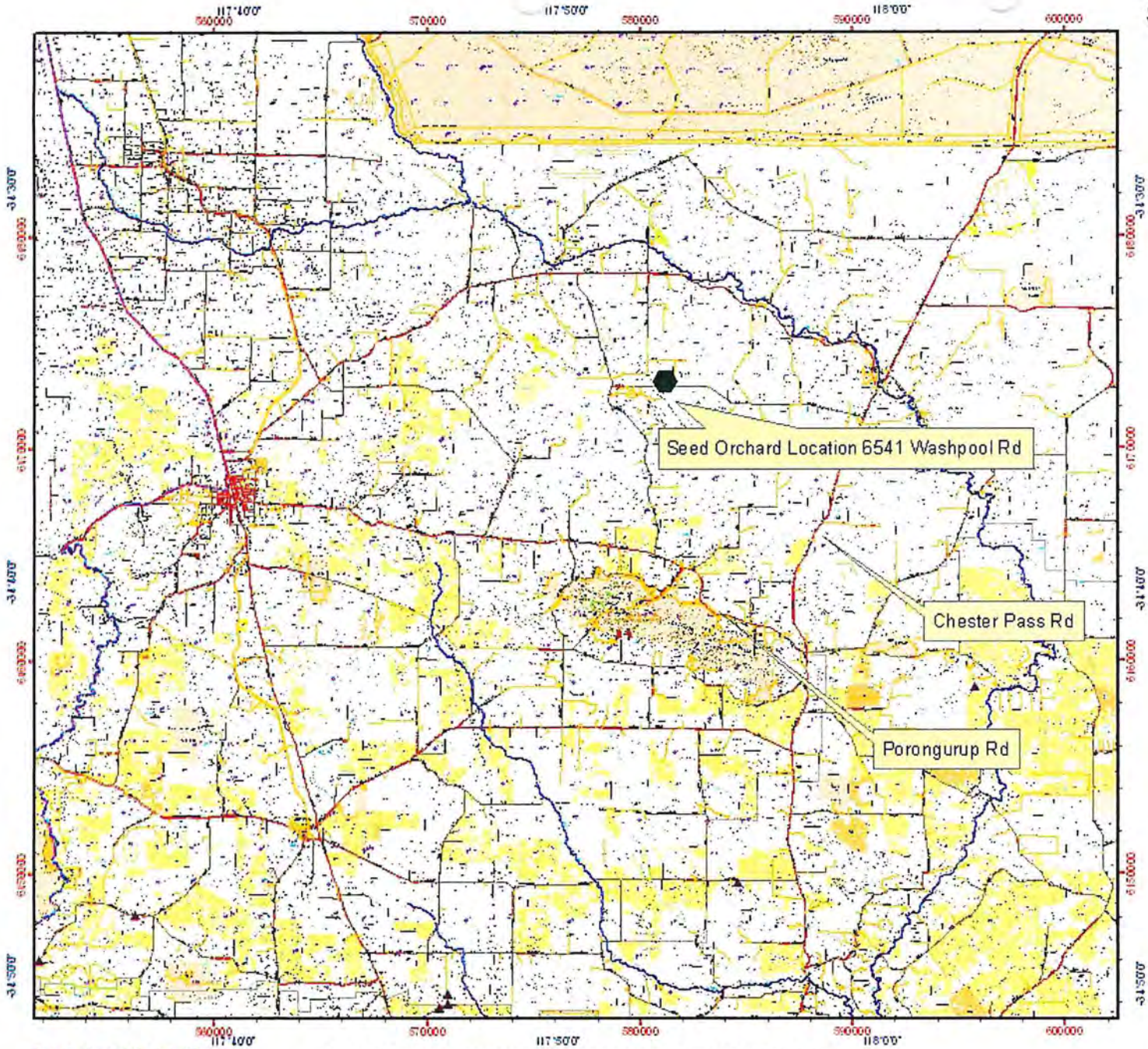
Graticule shown at 5 minutes intervals
Grid shown at 5000 metre interval

Produced at 10:38am, on September 7, 2007

Seed Orchard Washpool Rd. approx 10 km west of Chester Pass Rd Tuesday pm 18/9/07



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1:250,000 (A4)

0 2 4 8 12 16

Kilometers

Projection: Universal Transverse Mercator
MGA Zone 50 . Datum: GDA94

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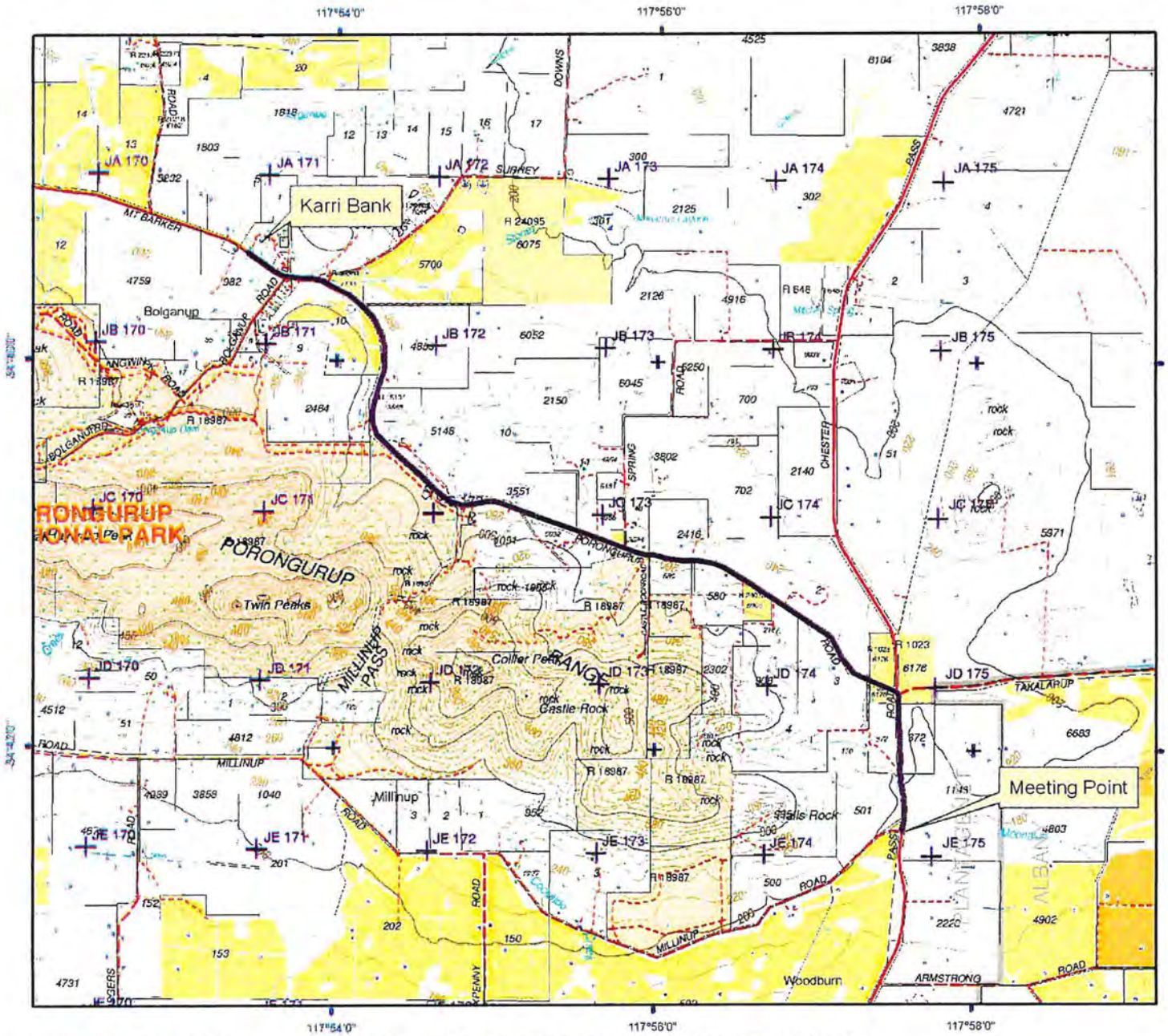
Gridlines shown at 10 minute intervals
Grid shown at 10000 metre intervals

Produced at 13:42pm, on September 6, 2007



Porongurup National Park

Route 9.6km

0 0.5 1 2

Kilometres

Projection: Universal Transverse Mercator
MGA Zone 50. Datum: GDA94

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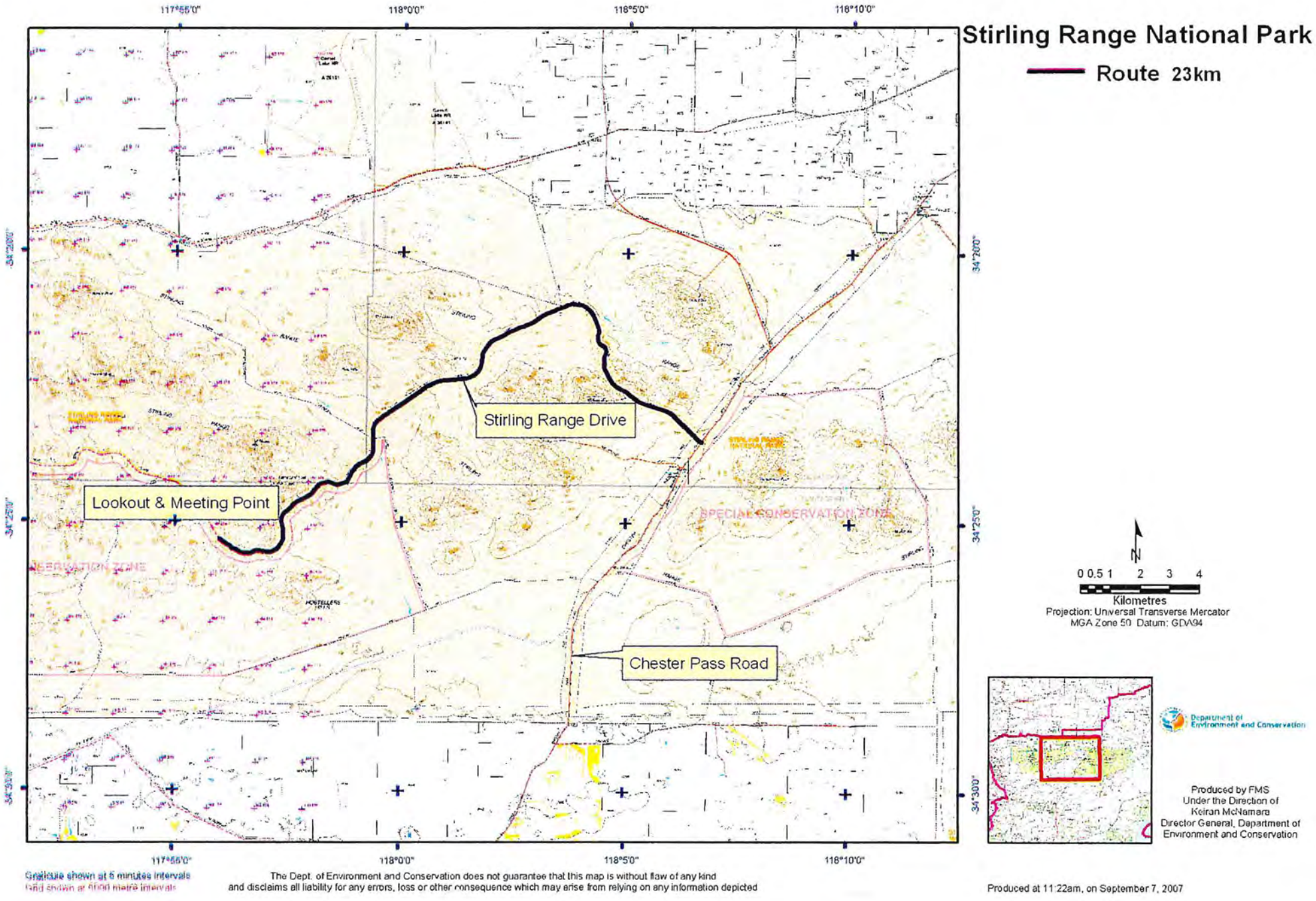
Graticule shown at 2 minutes intervals
Grid shown at 2000 metre intervals

Produced at 11:35am, on September 7, 2007


117°55'0"
118°0'0"
118°5'0"
118°10'0"
34°20'0"
34°25'0"
34°30'0"
Stirling Range National Park
Route 23km
Stirling Range Drive
Lookout & Meeting Point
Chester Pass Road
SPECIAL CONSERVATION ZONE
0 0.5 1 2 3 4
Kilometres
Projection: Universal Transverse Mercator
MGA Zone 50 Datum: GDA94
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Graticule shown at 5 minutes intervals
Grid shown at 5000 metre intervals
The Dept. of Environment and Conservation does not guarantee that this map is without flaw of any kind
and disclaims all liability for any errors, loss or other consequence which may arise from relying on any information depicted
Produced at 11:22am, on September 7, 2007

COURSE PARTICIPANTS

Jessica Allen Asst Operations Officer Mundaring	Monica Batista Project Officer SSS Kensington	David Blood Ops Officer Geraldton
Gregory Byrne Resource Assistant Manjimup	Victoria Cunningham Tech Officer Seed Centre Kensington	Claire Dornan Nature Cons Officer Donnelly
Lorraine Duffy Conservation Officer Narrogin	Cheryl Ehlers Asst Fire Ops Officer Donnelly	Todd Erickson Seed Collection Seed Centre
Megan Flowers HVP Officer Kensington	Tim Gamblin NRM Project Officer Kensington	Megan Jones Research Officer Geraldton
Ben Lullfitz Conservation Officer – Flora Merredin	Jane Mansergh Asst Fire Officer Jurien	Adam Meyer Wildlife Officer Kensington
David Mickle Senior Env. Officer Kensington	Ana Negreiros Sustainable Resource Officer Manjimup	Grace Patorniti NRM Officer Perth
Gemma Phelan Cons Officer – Flora Geraldton	Emma Richardson Conservation Officer-Flora Back from the Brink Moora	Michael Roberts Land Use Planning Officer Wanneroo
Jo Smith Conservation Officer Donnelly	Sandra Thomas BCI-SOS Translocation Officer Kensington	Wendy Thompson Conservation Officer Kalgoorlie
Benson Todd Conservation Officer Jurien	Mark True Ranger Two Peoples Bay	Cressida Wilson Roadside Veg Officer Kensington

COURSE PRESENTERS

Ken Atkins Manager Species and Communities Branch Kensington	Sarah Barrett Conservation Officer Albany	Dave Coates Principal Research Scientist Herbarium	Anne Cochrane Senior Research Scientist Albany	Sarah Comer Ecologist Albany
Colin Crane Senior Tech Officer Kensington	Andrew Crawford Senior Tech Officer Herbarium	Alan Danks Nature Cons Leader Albany	Rob Davis Tech Officer Herbarium	Chris Dunne Research Scientist Kensington
Val English Principal Ecologist Kensington	Amrit Kendrick Species and Comm Training Kensington	Nicholas Lander Principal Research Scientist Herbarium	Gavan Mullan Reveg Dev Officer Narrogin	Pieter Poot Lecturer Plant Biology UWA
Jill Pryde Course Organiser Kensington	Kim Williams Nat Cons Project Leader Bunbury	Andrew Webb Blackwood District Flora Cons Officer Busselton		Colin Yates Principal Research Scientist Herbarium

September 2007 Flora Conservation Course Timetable

	Sun 16	Mon 17	Tue 18	Wed 19	Thur 20	Fri 21
		Karribank and field - Torndirrup	*Karribank and Field*	*Field Stirling Range NP Lookout area and Karribank*	*Karribank and Field Porongorup NP*	*Karribank*
0800	Travel to Porongorups	Welcome to South Coast Region (AD) (15 min)	**Assessments (1hr)**	Travel	**Assessments (1.5hr)**	Plant ID, Florabase and use of electronic keys (NL/RD) (2hr)
		Course Intro: Flora Conservation in WA (DC) (1.5hr)		PC field (CD/CC) (2 hr)		
0900		**Morning Tea (15 min)**	Ex-situ conservation /seed colln talk (ACo) (1.5hr)		Travel	
1000		Flora Legislation talk (KA) (1.5hr)			Field quadrat (KW+JP, +SB, SC, ACo, VE) (all day - groups moving)	Morning Tea (30 min)
			Morning tea (30 min)	**Morning Tea (30 min)**	Specimen collection with the various groups (RD) All day	Plant ID and **assessment for plant ID and monitoring** (NL/RD) (2.25hr)
1100			Translocation talk and scenarios (AC) (1.5hr)	Seed collection – field (ACo/AC) (1.5hr)	**Morning Tea (30 min)**	
1200		Ecophysiology (PP) (1 hr)			Quadrats and specimen collection continues	Summing up (VE) (10 Mins) Farewell from Region (AD) (15 Mins)
		Lunch	**Lunch**	**Lunch**		**Lunch**
1300		Travel	Course summary to date (DC) (15 mins)	Field TEC (SB/VE) (1.5hr)		Depart 1.30pm
		Intro to South Coast Flora (AD) Field walk Visit rare flora pops (AD/SB) (3.5hr)	TEC talk (VE) (1hr)		**Lunch**	
1400					Field monitoring, survey (KW, JP, SB, SC, ACo, VE) (all day - groups moving)	
1500			Plant disease/diagnosis talk (CC) (1.5hr)	Travel		
1600			Travel			
			Seed orchard/translocation site (SB) (1hr)	Recovery Catchment talk (GM) (1hr)	Travel	
1700						
		Travel	Travel	Monitoring techniques talk (KW) (1hr)	Free time	
1800		Free Time	Free time	Free time		
1900	Dinner	Dinner	Dinner	Dinner	Dinner	
2000						

Key

AC = Andrew Crawford
ACo = Anne Cochrane
AD = Alan Danks
CD = Chris Dunne
CC = Colin Crane
DC = Dave Coates
GM = Gavan Mullan
KA = Ken Atkins
KW = Kim Williams
JP = Jill Pryde
NL = Nicholas Lander
RD = Rob Davis
SB = Sarah Barrett
SC = Sarah Comer
VE = Val English

Delivery and Assessment Strategy

Department of Environment and Conservation

Name of RTO	**Department of Environment and Conservation**
Course Title	**Flora Management Course**
Target Groups	DEC staff who require knowledge of flora conservation both in the field and theory or those who view it as an area for career and knowledge development.
Duration of Course	Four and a half days. Beginning 8am on the Monday and finishing 1pm on the Friday
Location	Albany Combination of approximately 50% classroom time and 50% field component
Purpose of Course	To provide departmental staff with field based knowledge and skills to implement flora conservation through an understanding of management issues and techniques
Alignment of course with competency standards and their codes	RTD4504A Monitor Biodiversity
Towards which qualification	Attainment of the Unit RTD4504A will contribute towards a Certificate IV in Conservation and Land Management
Texts/references	INTRODUCTION INCLUDING FLORA CONSERVATION • Hopper, S.H., Chappell, J., Harvey, M., George, A. Eds 1996. *Gondwanan Heritage: Past, Present and Future of the Western Australian Biota*. Sydney. Surrey Beatty. • Lindemeyer, D. and Burgman, M. 2005. Practical Conservation Biology. CSIRO Publishing. Melbourne. • Coates, D. J. and Atkins, K. (2001) Priority setting and the conservation of Western Australia's diverse and highly endemic flora. *Biological Conservation*. 97, 251-263 • Coates , D.J. and Dixon K. (2007) Current Perspectives in Plant Conservation Biology. *Australian Journal of Botany* 55 (in press) • Yates, C. J., Coates, D. J., Elliott, C. and Byrne, M. Composition of the pollinator community, pollination and the mating system for a shrub in fragments of species rich kwongan in south-west WesternAustralia. *Biodiversity and Conservation*, 1-18. • Byrne M., Elliott, C. P., Yates C. J. and Coates, D. J. Extensive pollen dispersal in a bird-pollinated shrub, *Calothamnus quadrifidus* , in a fragmented landscape. *Molecular Ecology* 16, 1303-1314 LEGISLATION (SPECIES AND COMMUNITIES BRANCH AND THREATENED FLORA LEGISLATION) • Brown, A., Thomson-Dans, C., Marchant N. eds. 1998. *Western Australia's Threatened Flora. Perth*: Department of Conservation and Land Management • Cropper, S.C. 1993. *Management of Endangered Plants*. Melbourne. CSIRO. • Australian Department of Premier and Cabinet. 1997. *Wildlife Conservation Act 1950*. http://www.slp.wa.gov.au/index.html [Section 23] • United Kingdom. International Union for Conservation of Nature and Natural Resources. 2001. *IUCN Red List of Threatened Species: Categories and Criteria*. http://www.iucnredlist.org/info/categories_criteria

PHYTOPHTHORA

- Hardy, G.E. St. J. 2001. The Future of Phosphite as a Fungicide to Control the Soil Borne Plant Pathogen *Phytophthora cinnamomi* in Natural Ecosystems. Reprint. *Australasian Plant Pathology* 30: 133-139
- Shearer et al 2007. *Phytophthora cinnamomi* invasion, a major threatening process to conservation of flora diversity in the south-west botanical province of Western Australia. *Australian Journal of Botany* **55**, 225-238

Pathogen of the month
http://www.australasianplantpathologysociety.org.au/
Dieback http://www.dwg.org.au/
Dieback http://www.dieback.org.au/

SURVEYING

- Brown et al. 1996. *An Area Based Multiple Species Approach to Threatened Flora Conservation and Management in the Merredin Area of Western Australia.* N.p. Stephens and Maxwell.
- Keighery, B. 1994. *Bushland Plant Survey: A Guide to Plant Community Survey for the Community.* Nedlands: Wildflower Society of Western Australia.
- Muir, B.G. 1977. Vegetation and Habitat of Bending Reserve *in Biological Survey of the Western Australian Wheatbelt.* Part 2. Perth: Western Australian Museum.
- *Rare Flora Report Form.* n.d.n.p. *WA Herbarium Field Data Sheet.* N.p. Department of Conservation and Land Management

MONITORING

- Brown, A.C., Tomson- Dans, Marchant, N. eds. 1998. *Western Australia's Threatened Flora.* Perth: Department of Conservation and Land Management.
- Hopkins, A. 1995. *Monitoring: An essential Component of Living Natural Resources Management.* n.p. Wellington Mills
- Hopper, S.D., Van Leeuwen, S., Brown, A.P., Patrick, S.J.1990. *Western Australia's Endangered Flora and other Plants under Consideration for Declaration.* Como: Department of Conservation and Land Management.
- Saunders, D.A., Burbidge, A.A., Hopkins, A.J.M. 1987. *Nature Conservation: The Role of Remnants of Native Vegetation.* Chipping Norton: Surrey Beatty.
- Coote, M., Moller, S., Claymore, K. *Monitoring and evaluating biodiversity conservation projects.* Bushcare and CALM.

EX SITU SEED CONSERVATION

- Bradby, K. and Morris, V. 1997. *Seed Collection from Native Plants.* Como: Department of Conservation and Land Management.
- Cochrane, A. n.d. *Seed Collection and Storage- a Strategy for Ex situ conservation of flora in Western Australia.* n.p.
- Cochrane, A. n.d. *Some Seed Collection Guidelines.* n.p
- Cochrane, A. n.d. *Guidelines for Timing Seed Collection.* n.p
- Cochrane, A. *Seed Accreditation: the effects of seed quality and germinability on field establishment.* n.p
- Australia Florabank. 2004 *Florabank* http://www.florabank.org.au
- Ralph, M. 1994. *Seed Collection of Australian Native Plants for Revegetation, Tree Planting and Direct Seeding.* 2nd ed. Fitzroy: Ralph, M.
- *Native Seed Collection and Storage.* Department of Conservation and Land Management. 1987. Department of Conservation and Land Management: Perth
- Wildflower Society of Western Australia, 2002. *Seed Notes for Western Australia.* Nedlands: Wildflower Society of Western Australia

	THREATENED ECOLOGICAL COMMUNITIES (TEC) • English, V., Keighery, G.J., Blyth, J. 1996. *Threatened Plant Communities on the Swan Coastal Plain*. Landscope. Vol 12: No1. • English, V., Blyth, J. 1999. *Development and Application of Procedures to Identify and Conserve Threatened Ecological Communities in the South West Botanical Province of Western Australia*. Pacific Conservation Biology. Vol 5: 124-138 • Western Australia. Department of Conservation and Land Management. *2003*. NatureBase: *Plants and Animals- Identifying WA's Threatened Ecological Communities*. http://www.naturebase.net/sciences/science.html • Gibson, N., Keighery, G.J., Lyons, M.N. and Keighery, B.J. *Threatened plant communities of Western Australia. 2 The seasonal clay-based wetland communities of the South West*. Pacific Conservation Biology, 2006, Vol 11, Number 4 TRANSLOCATIONS • Australian Network for Plant Conservation- Translocation Working Group. 1997. *Guidelines for the Translocation of Threatened Plants in Australia*. Canberra: The Network PLANT IDENTIFICATION • Western Australian Herbarium. 2004 *FloraBase- The Western Australian Flora*. http://florabase.calm.wa.gov.au Wheeler, J., Marchant, N. and Lewington, M. *Flora of the South West: Bunbury-Augusta- Denmark*. University of Western Australia Press, 2002.
Participant resources	Participants will be supplied with a file which includes session notes, PowerPoint's, handouts, schedule etc Participants should bring pen, paper, hand lens and secateurs. Appropriate field apparel will be required for the field based component and may include but not be limited to helmet, gloves, insect repellent, sunscreen, warm clothing and wet weather gear etc.
Pre-requisites	There are no pre-requisites for this course
Workplace Safety and Health	Departmental personnel will operate in accordance with occupational safety and health guidelines and organisational procedures. They will be required to demonstrate safe-working practices at all times and to operate in accordance with any relevant legislative requirements and applicable Australian Standards.

Key Principles	The organisation is committed to developing training that takes into account the language, gender, culture, access and support strategies that allow for equitable learning for all participants.
Recognition	Participants who have completed current and appropriate training or through prior learning and experience believe that they have gained the pre-requisites and course content stipulated for this course, may be granted Recognition of Prior Learning based on that claim. Evidence of prior learning may include a combination of the following, which assess all aspects of the relevant Units of Competency and course content: • Evidence of current competency • Projects or assignments • Written presentations • Oral and written tests • Demonstrations
Mutual Recognition	Department of Environment and Conservation endorses the requirement to recognise relevant student achievements to ensure that "Statements of Attainment" and Qualifications issued by other Registered Training Organisation's and Australian Quality Framework Qualifications issued by other Registered Training Organisations are portable between Registered Training Organisations and across the state.
Appeals Process	Department of Environment and Conservation is committed to providing all participants with the opportunity to lodge an appeal against an assessment outcome or process if the person undergoing assessment feels they have been disadvantaged or discriminated against. The participant has 12 months to appeal after the results have been given. The appeals procedure applies to: • Assessment conducted within a course • Assessment or decisions within a skills recognition process
Course Delivery Modes	The delivery of this course should incorporate a range of effective teaching strategies; using on-the-job examples and group learning activities. Strategies may include: • Syndicate exercises and group work • Individual exercises • Training room presentations and activates • Demonstrations • Activities • Audio/ visual presentations • On the job training • To ensure access and equity it is important that teaching strategies are modified when required.

Course Content	The following topics should be addressed: • Introduction to Western Australia Flora (1hr 30mins)) • Legislation and the role of Threatened Species and Communities Branch (1hr 30mins) • Introduction to flora of the area- Field (3hrs) • Weed management (1hr 20mins) • Survey techniques (1hr) • Monitoring techniques (1hr) • Plant ID and the WA Herbarium (1hr lecture, 2hrs practical) • Field component including: quadrats, transects, priority flora, DRF survey and monitoring (all day- 9hrs) • Ex situ conservation (1hr 30mins) • Translocations (1hr) • Plant diseases (1hr 15mins) • Phytophthora- Field (1hr 30mins) • Seed collection- Field (1hr 30mins) • Recovery catchments (45mins) • Threatened Ecological Communities (1hr 15mins) • TEC- Field (1hr)
Session titles and approximate session timings	See above
Learning Outcomes	Upon completion of this course, the participant will be able to:
Learning Outcome 1.	Demonstrate an understanding of the patterns of Western Australian Flora
Learning Outcome 2.	Understand and outline the key roles of Species and Communities Branch and Threatened Flora legislation
Learning Outcome 3.	Understand and explain the reasons for surveying and the techniques utilised in the field
Learning Outcome 4.	Demonstrate an understanding of long term management, monitoring and recovery of threatened flora
Learning Outcome 5.	Demonstrate an understanding of the understanding of the WA Herbarium, Regional Herbarium, FloraBase and other electronic keys
Learning Outcome 6.	Outline the reason, strategies and processes of ex-situ seed conservation
Learning Outcome 7.	Demonstrate and understanding of plant translocations including procedures and management plans
Learning Outcome 8.	Demonstrate knowledge of the three major disease groups in WA- *Phytophthora*, Armillaria and Canker
Learning Outcome 9.	Demonstrate an understanding of Threatened Ecological Communities including databases, recovery processes and examples.
Purpose of Assessment	The assessment is used as both a knowledge summary for the participants and a way to assess whether the participant is competent in the Unit RTD4504A
Assessment Task(s) (in summary)	Theory Assessment Day 2- Summarises and assesses the knowledge gained from the first two days of the course. Theory Assessment Day 5- Summarises and assesses the knowledge gained from the course, predominantly days three to five. Practical Assessment Checklist- Assesses the actions of the participants in the field.

Assessment Methods:

Units of Competency	A	B	C	D	E	F	G	H	I
RTD4504A Monitor Biodiversity	✓	×	✓	×	×	×	✓	×	×

KEY	A	Demonstration	C	Interview	E	Role play	G	Written test
	B	Questioning	D	Scenario-problem solving	F	Case study-fault finding	H	Critical incident report
	I	Post Course assessment						

Assessment Validation Process	The processes used to validate assessment activity in this program are: • Workshops on assessment policy and processes to be held after each course, for the first year, for RTO staff. • Client satisfaction surveys request information on satisfaction with assessment tools and processes. • At internal audit samples of assessment process used in each course are reviewed. • Course custodian convenes annual meeting of assessment panel comprising subject specialists to review evidence-gathering tools. • Moderation meetings attended by all assessors to ensure validation of judgements made on assessments and assessment tools after each course for the first 12 months
Physical Resource requirements for Delivery and Assessment	Facilitation of this program will require: • An environment conducive to learning including comfortable seating, adequate lighting, temperature control and noise control, etc. • Access the appropriate field sites • Access to field specialists • Field equipment as required- field notes, flora/ survey forms, hessian bags, GPS, maps, plant presses, syringes/ spray packs/ phosphorous for dieback session • Computers and internet access/ electronic keys for plant ID session • Appropriate reading material • Other teaching aids as required
Delivery and Assessment staff requirements	**Other human resource requirements:** Due to the diverse topics covered in the Flora Management Course, the Course Custodian will utilise CALM staff specialists in the delivery of each session. These specialists will present course material and assist in the field component of the course, and where necessary assist in the assessment of participants, under the supervision of the Course Custodian.
Schedule	Refer to Flora Management Course Schedule
Course Custodians Endorsement	
Date	

Program area	Staff	Delivery/Assessment	Workplace Assessor	Workplace Trainer	Vocational Training
Course Custodian	Val English	✓			

Introduction

Version 2

Western Australia's Flora: Origins, Endemism, Rarity and Conservation

David Coates and Colin Yates

Science Division
Department of Environment and Conservation

Department of Environment and Conservation

Science Division

Science Support
Margaret Byrne (Pilbara)
Work centre finance & budgets, administration, infrastructure, library, Vegetation Health Service, Directorate support.

Director
Neil Burrows (Goldfields)

Science Applications
Ian Abbott (Swan)
Naturebank, Naturemap, (Bioinformatics), biometrics. Facilitate integration, partnerships and science uptake. Directorate support

DOE 7

Biogeography
Norm McKenzie (Kimberley)
Patterning of biodiversity, inventory of biodiversity, CAR reserve system

Flora Conservation and Herbarium
David Coates (Wheatbelt, MidWest)
Species approach. Plant ecology, biology, genetics. Threatening processes. Collections Systematics

Fauna Conservation
Keith Morris (South West)
Species approach. Animal ecology, biology, genetics. Threatening processes.

Landscape Conservation
Lachie McCaw (South Coast, Warren)
Ecology of ecosystems and communities. Landscape restoration. Landscape monitoring Landscape fire.

Marine
Chris Simpson

Observatory
James Biggs
Astronomy information. Astronomy research Astronomy education

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Flora Conservation And Herbarium
20 Scientists (14.1 FTE)
30 Tech Officers (22.7 FTE)

Herbarium Collections - Information Systems

Threatened Flora Seed Centre

Vegetation Health Service

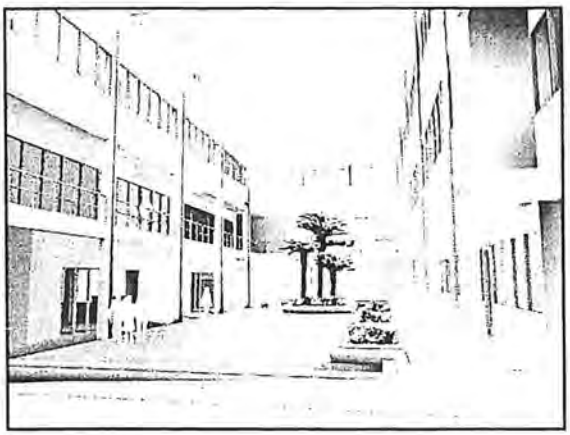
Taxonomy - Systematics

Population Ecology

Molecular Ecology - Systematics

Translocations

***Phytophthora* Control**



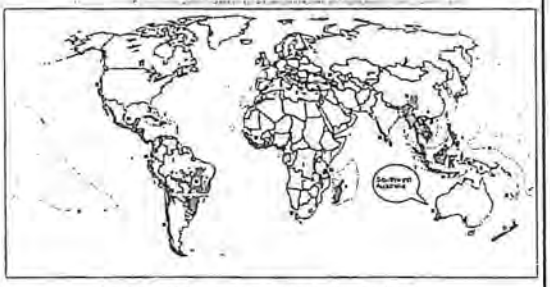
Outline of talk

- Patterns of plant diversity in south-west Western Australia
- Ancient flora and evolutionary history
- Taxonomy of the banded ironstone ranges
- Large scale habitat destruction and fragmentation effects
  - Inbreeding, reproductive output
  - Gene flow
- Rarity and threat in the flora
- Threatened flora
- Ecological studies and implications for recovery
- Recovery of threatened flora
- FloraBase

Patterns of plant diversity in the south-west

- Ancient flora with many relict species
- Large number of species have geographically restricted ranges
- Many species have naturally fragmented disjunct distributions
- Unusually high proportion of naturally rare plants in the south-west

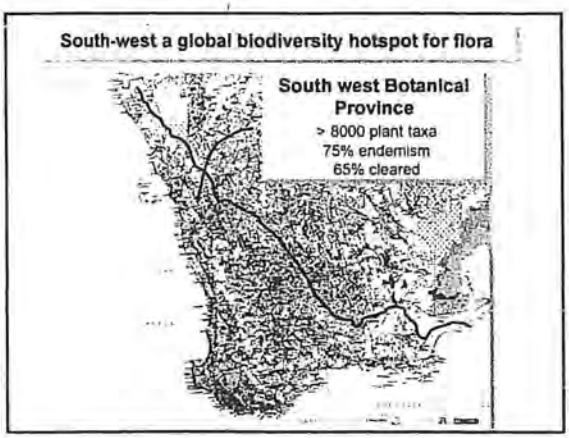
The 25 global biodiversity hotspots (Myers *et al.* 2000)



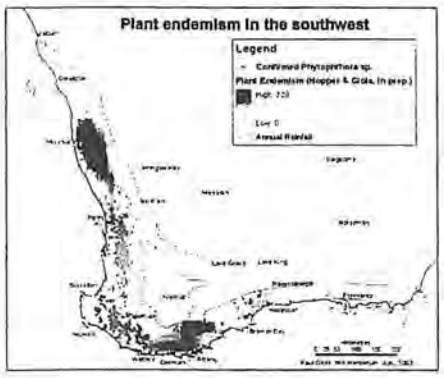
Places richest in endemic species under threat

Conservation International - Aug 2002

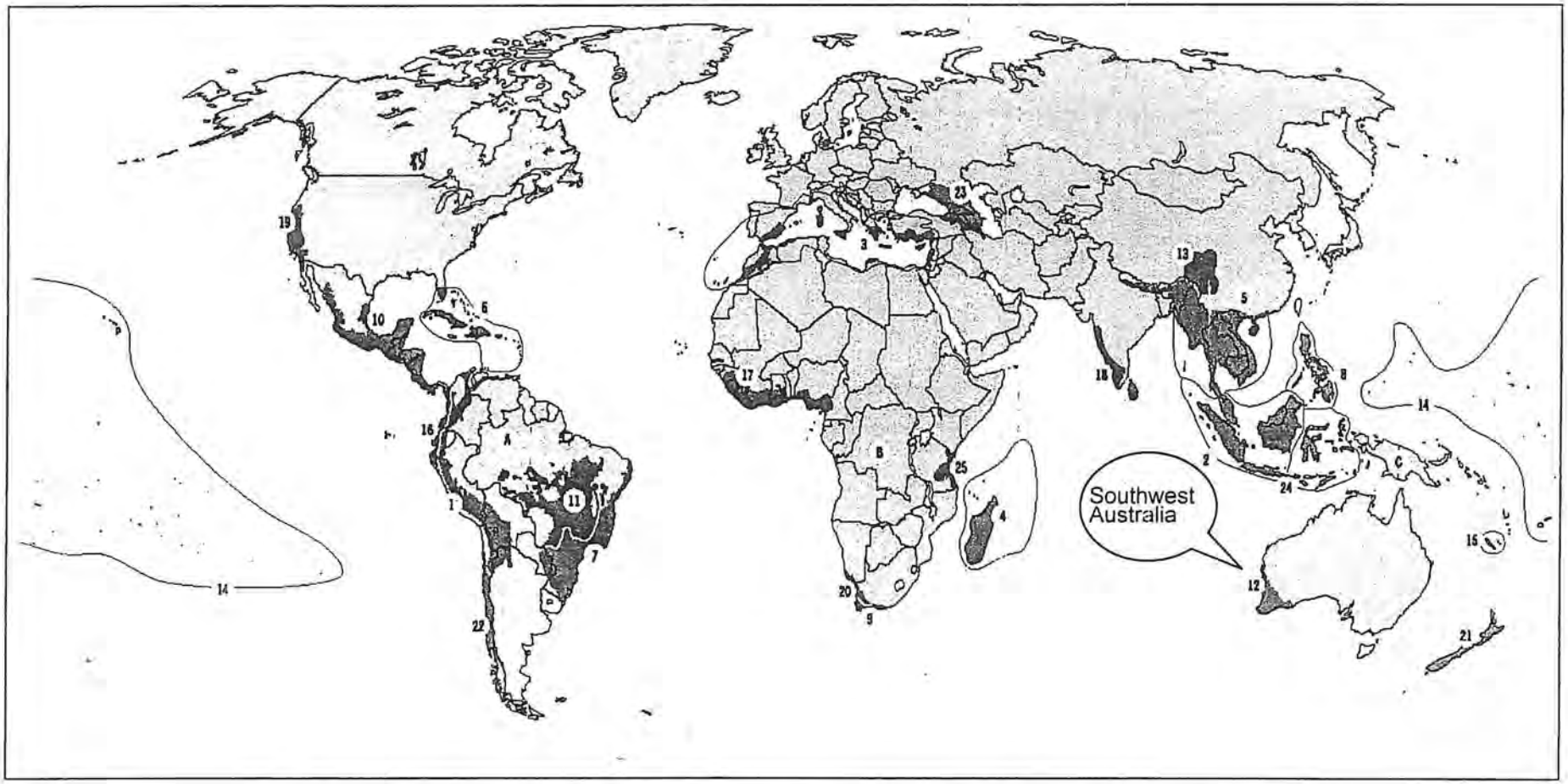
South-west a global biodiversity hotspot for flora



Plant endemism in the southwest

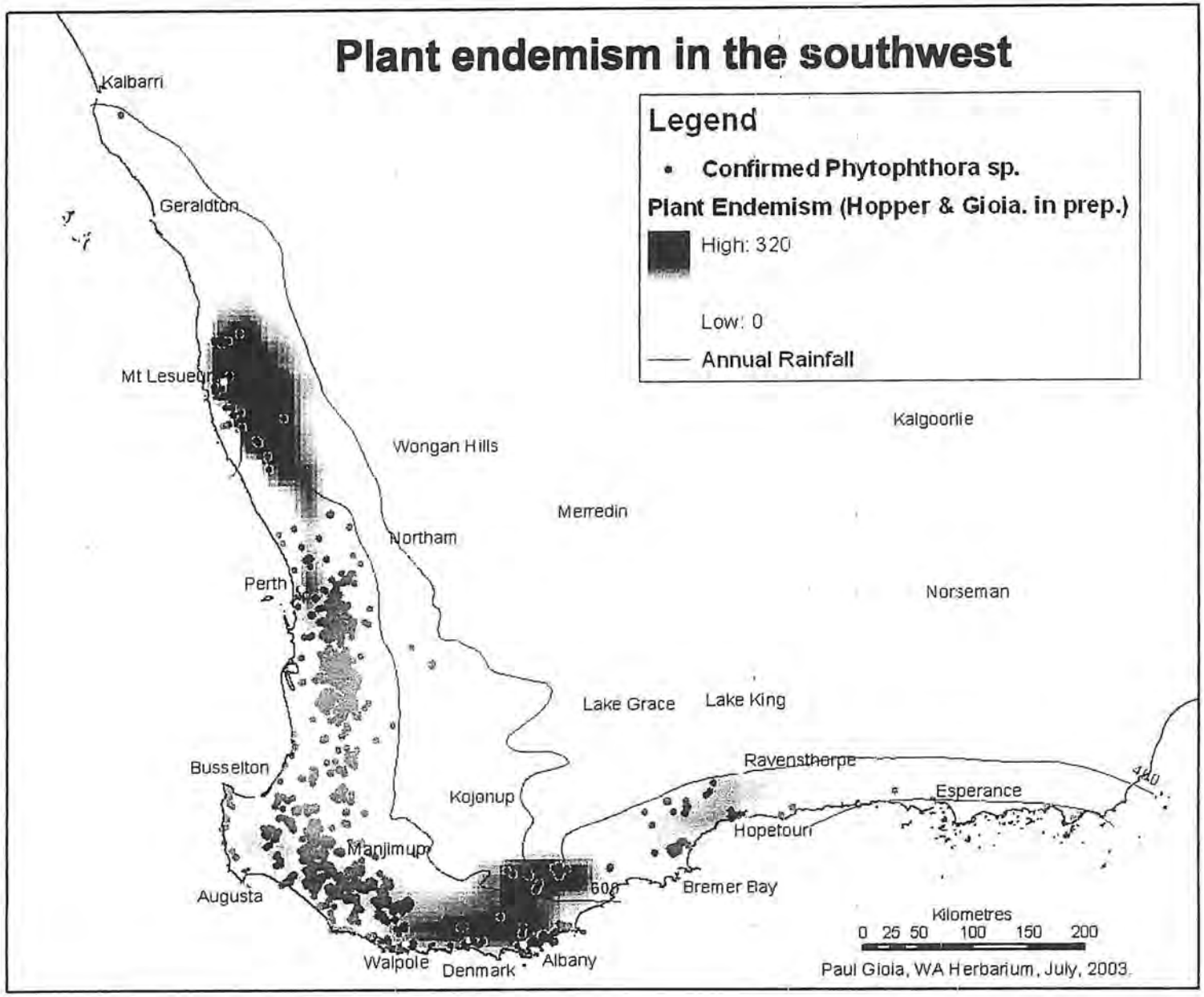


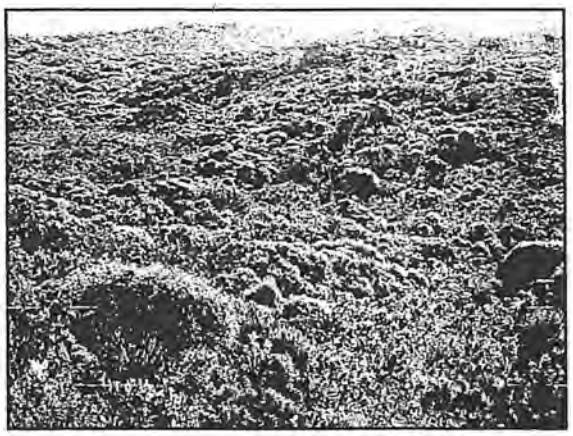
The 25 global biodiversity hotspots (Myers *et al*. 2000)

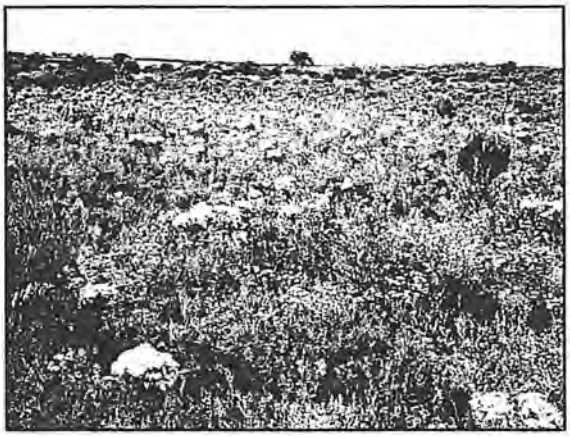


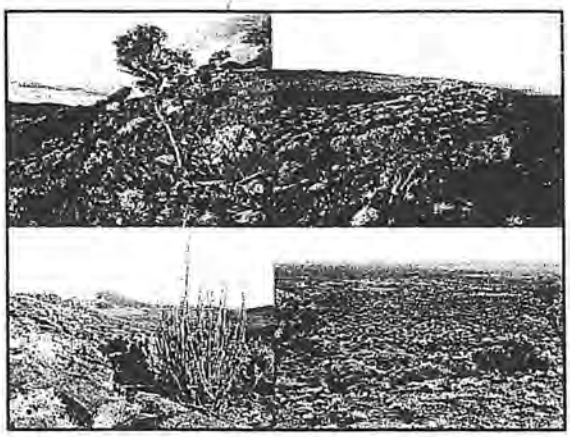
Places richest in endemic species under threat

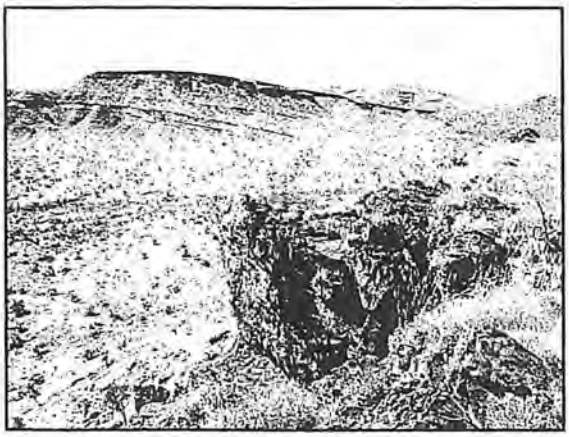
Conservation International - Aug 2002


Plant endemism in the southwest
Legend
Confirmed Phytophthora sp.
Plant Endemism (Hopper & Gioia. in prep.)
High: 320
Low: 0
Annual Rainfall
Kalbarri
Geraldton
Mt Lesueur
Wongan Hills
Kalgoorlie
Merredin
Northam
Perth
Norseman
Lake Grace
Lake King
Busselton
Ravensthorpe
Esperance
Kojonup
Hopetoun
Manjimup
Augusta
Bremer Bay
Walpole
Denmark
Albany
Kilometres
0 25 50 100 150 200
Paul Gioia, WA Herbarium, July, 2003.







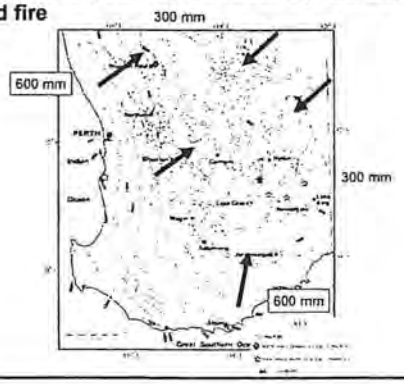


Fossil record and molecular DNA studies indicate an ancient flora

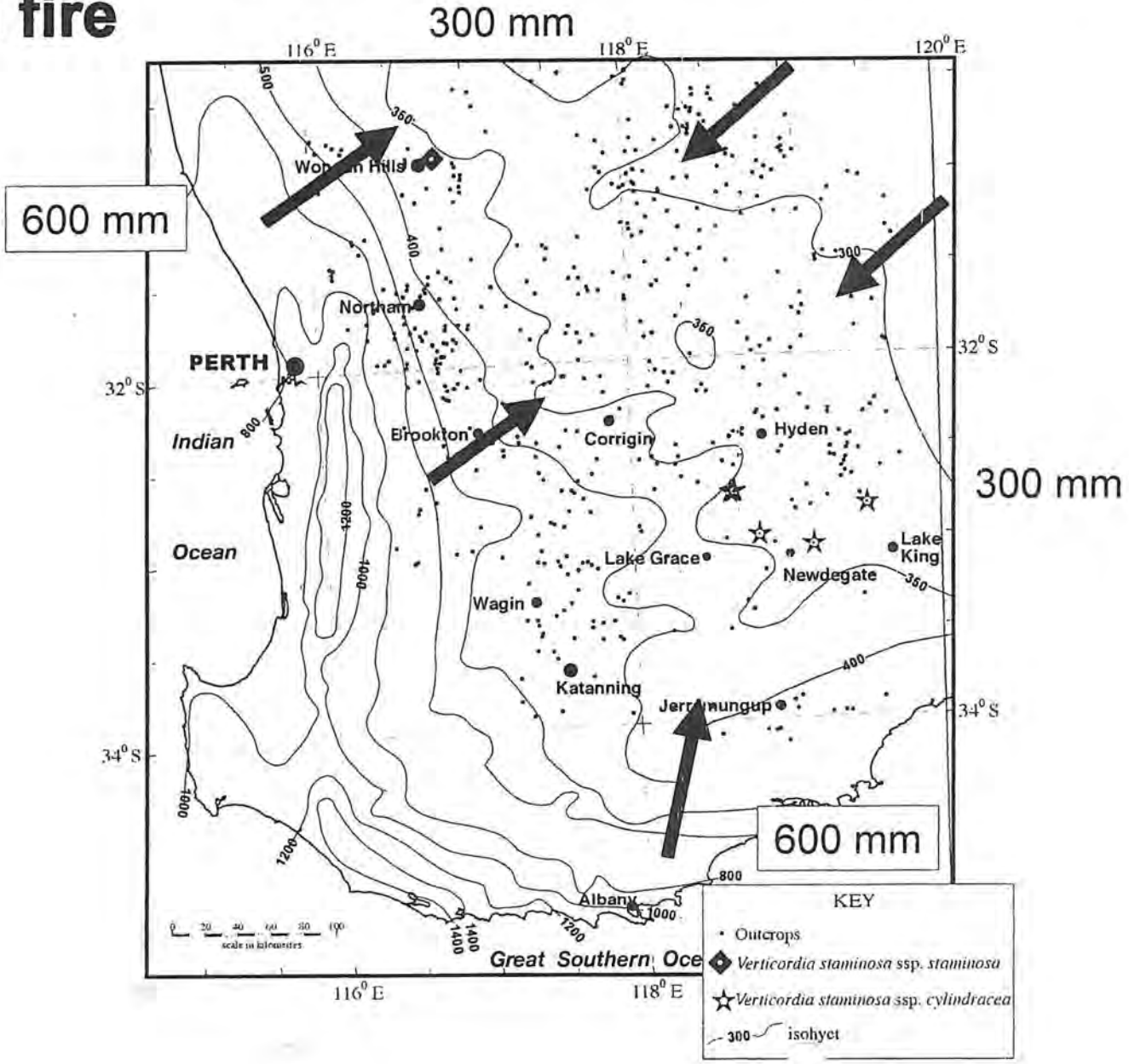
Major Factors in the Evolution of the South West Flora

- Ancient landscape remaining **unglaciated** and above sea level for 200 million yrs
- No significant mountain uplifting / volcanic activity
- Complex soil mosaics
- Dynamic climatic changes during the late Tertiary - Quaternary (1.6 mill yrs bp to present)

Evolutionary history – climatic dynamism and fire



Evolutionary history – climatic dynamism and fire



Taxonomy Banded Ironstone Ranges

Taxonomic studies on the flora of the Banded Ironstone Formations

Juliet Wege, Kelly Shepherd Ryonen Butcher and Terry MacFarlane

Saving Our Species Initiative
WA Herbarium, Science Division
Department of Environment and Conservation

WA Flora - State of Play

- > 13,000 taxa (species, subspecies, varieties)
- 1,800 unpublished
  - phrase names
    - e.g. *Mirbelia* sp. Helena & Aurora (B.J. Lepschi 2003)
  - manuscript names
    - e.g. *Acacia karina* Maslin & Buscumb ms
  - many lack suitable guides to their identification
  - many are poorly known, under-collected or rare
    - 538 have conservation listing (50 DRF; 232 Priority 1)
- Estimate 10-15% remain unknown to science

Saving Our Species Taxonomy Project objectives

- Resolve the taxonomy and expedite the description of new taxa
  - occurring in areas where they may be vulnerable to future mining activities
    - BIF of the Yilgarn
    - Ravensthorpe Range and Bandalup Hill
  - listed as being of conservation priority
    - across Western Australia
- publish a special issue of 'Nuytsia

Significant Achievements to Date: Resolution of New Plant Species

- 50 Botanists contacted [WA 35, Eastern States 15]
- Contributions from at least 35 local and interstate botanists
- 83 new taxa currently being described
  - 20 families, 34 genera
  - 30 from BIF
- Special issue of the Herbarium peer-reviewed journal "Nuytsia" is in preparation
- This edition will contain approximately 40 manuscripts

Large scale habitat destruction and fragmentation effects

- Inbreeding
- Reproductive output

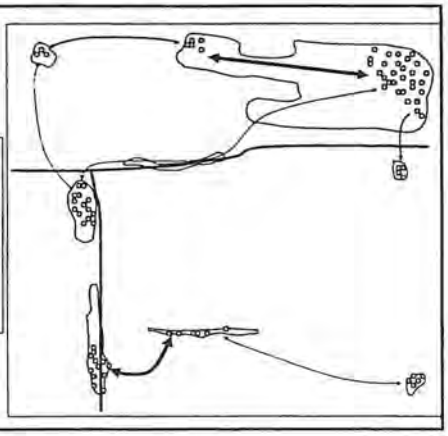
} *Calothamnus quadrifidus*

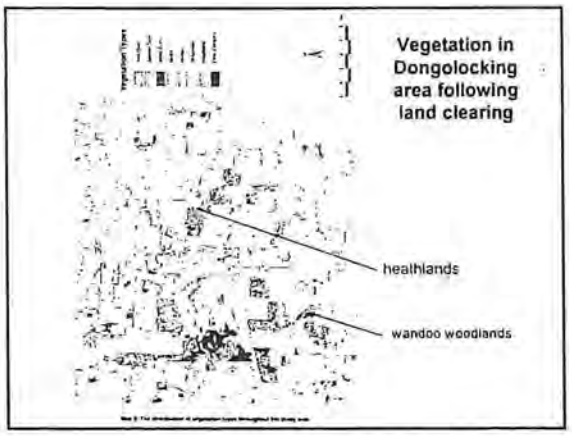
The fragmentation of habitat is a major and pervasive threat to species and ecosystems in south-west Australia

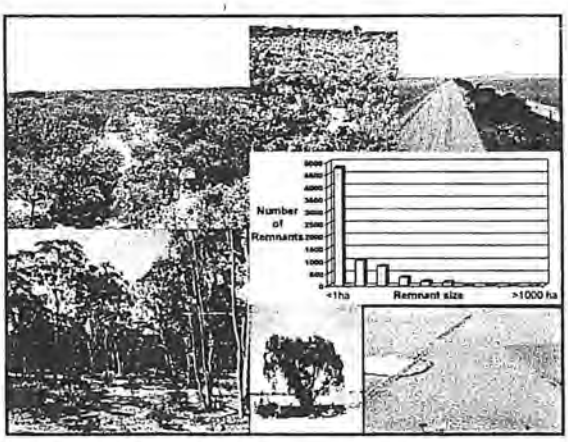
Key questions associated with land clearing and habitat fragmentation

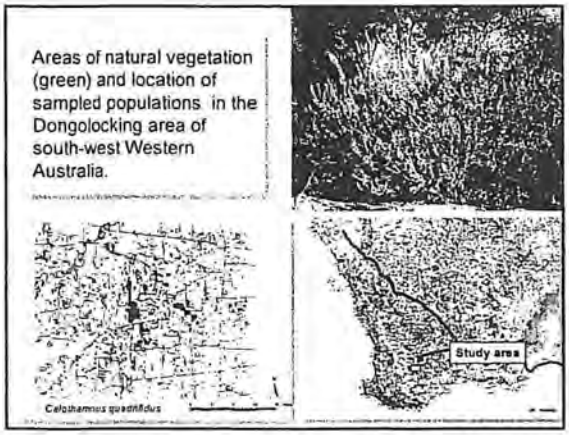
- What impact does the loss of species from remnants have on species persistence?
  - Of particular concern is the loss of mutualisms between some plant species and their animal pollinators
  - Or the loss of predators which regulate herbivore populations
- What impact do changes in abiotic environment (e.g. hydrology) have on species persistence?
- What impact do introduced pathogens, feral predators, environmental weeds have on species persistence?
- What impact do changes in the fire regime have on a species persistence?
- **What impact does population size and landscape context have on species persistence**

Gene flow in fragmented landscapes may be affected by **remnant**:
size
shape
quality
connectivity




Vegetation in Dongolocking area following land clearing
heathlands
wandoo woodlands


Number of Remnants
<1ha
Remnant size
>1000 ha

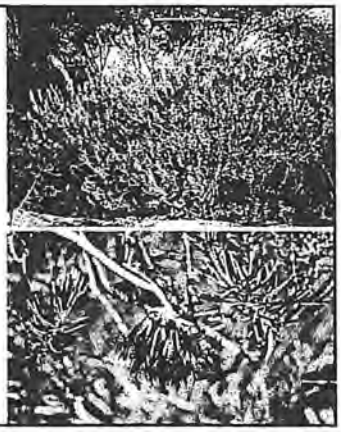

Areas of natural vegetation (green) and location of sampled populations in the Dongolocking area of south-west Western Australia.
Study area
Calothamnus quadrifidus

Calothamnus quadrifidus sites

Pop	Population Location	Landscape context	Pop size (no. plants)
M	Hill Rd	Disturbed road verge	1
K	Hill Rd	Disturbed road verge	3
T	Painell Rd	Undisturbed road verge	3
L	Hill Rd	Disturbed road verge	4
J	Dongolocking Rd	Undisturbed road verge	13
N	Tinjunjen Rd	Disturbed road verge	22
B	Toolibin South Rd/Old Line Rd junction	Large undisturbed remnant	23
D	Owelyerdinz Rd	Small undisturbed remnant	26
G	Dongolocking Rd	Undisturbed road verge	173
S	Wenbone Rd	Disturbed road verge	64
O	Roberts - private property	Small undisturbed remnant	74
C	Toolibin Rd South	Disturbed Road Verge	57
R	Grey Rd, Hamsmith Rd junction	Undisturbed road verge	42
P	Temby - private property	Small undisturbed remnant	285
Q	Temby - private property	Small undisturbed remnant	174
H	White Well Rd	Undisturbed road verge	485
E	Dongolocking Nature Reserve A19096	Large undisturbed remnant	6+5
F	Dongolocking Nature Reserve A19096	Large undisturbed remnant	1938
A	Dongolocking Nature Reserve A19096	Large undisturbed remnant	2014
I	Hindle Creek Nature Reserve 20070	Large undisturbed remnant	1029

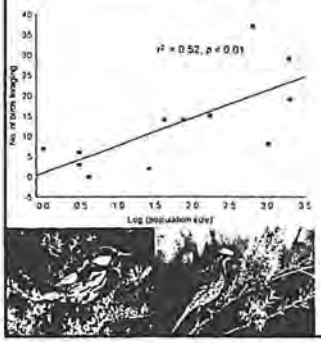
Calothmnus quadrifidus

- **Long-lived woody shrub**
- **Bird – mammal pollinated**
- **Common but patchy distribution in scrub/heath**



Calothamnus quadrifidus

Number of birds foraging decreases with decrease in population size

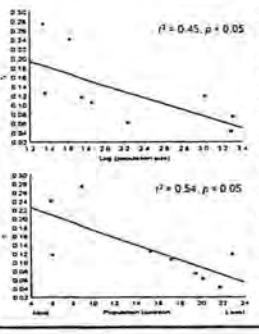


Consequences as populations get smaller

- Fewer fathers contribute to progeny (seed production) per plant
- Increased selfing per plant
- Increased inbreeding

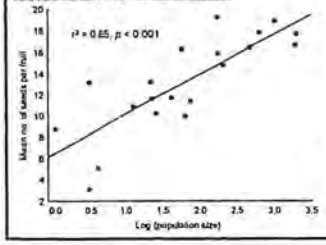
Therefore might expect increased inbreeding depression

Calothamnus quadrifidus
Relationship between population size / isolation and correlated paternity



- As populations become smaller and more isolated fewer fathers contribute pollen to seed production on individual plants.
- Over time this will lead to increased inbreeding in small isolated populations

Calothamnus quadrifidus
Relationship between population size and number of seeds per fruit



Consequences as populations get smaller

- Fewer seeds produced per fruit (increased seed abortion)

Direct evidence for increased inbreeding depression

Summary

Effects observed in small populations (< 100 –200 mature plants) of both species

- Reduced pollinator service (*C. quadrifidus*)
- Reduced seed set – increased seed abortion
- Reduced effective size of pollen pools (also in relation to isolation)
- Loss of genetic variation
- Increased inbreeding (also in relation to isolation in *E. wandoo*)
- No relationship with seedling fitness

Large scale habitat destruction and fragmentation effects

- Geneflow (*Eucalyptus wandoo*)

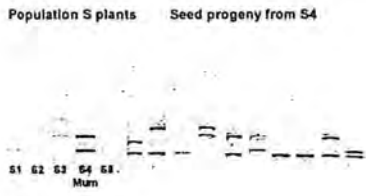
Eucalyptus wandoo

- Long-lived tree
- Insect / bird pollinated
- Common but patchy distribution. Key component of woodland remnants.

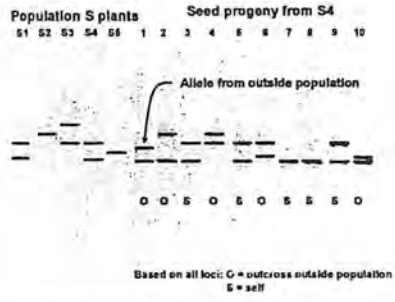
Eucalyptus wandoo sites

	Population Location	Landscape context	Pop. size (no. plants)
J	Ben Ord Rd	Disturbed road verge	2
L	Springhurst Rd	Disturbed road verge	5
S	Ward Rd	Disturbed road verge	5
K	Ben Ord Rd	Disturbed road verge	9
R	Fox Rd	Disturbed road verge	40
O	Painters Rd	Disturbed road verge	40
F	Rowells Rd	Disturbed road verge	47
N	Wickepin Rd - Shire reserve	Undisturbed small remnant	173
C	114 Rd - Shire reserve	Undisturbed small remnant	107
G	Murray Rd/Wishbone Rd	Undisturbed small remnant	493
E	Wickepin Rd - Shire reserve	Undisturbed small remnant	244
Q	Dongolocking Nature Reserve 19083	Undisturbed large remnant	761
M	Nippering Rd - Shire reserve	Disturbed small remnant	1898
B	Dongolocking Rd - Shire reserve	Undisturbed small remnant	605
I	Dwelyerdine Rd - rd reserve	Disturbed small remnant	704
H	Wedin Reserve	Undisturbed large remnant	14732
D	Dongolocking Nature Reserve 19083	Undisturbed large remnant	17556
P	Robinson Rd - Shire reserve	Undisturbed large remnant	2581
A	Dongolocking Rd - Shire reserve	Undisturbed small remnant	2315

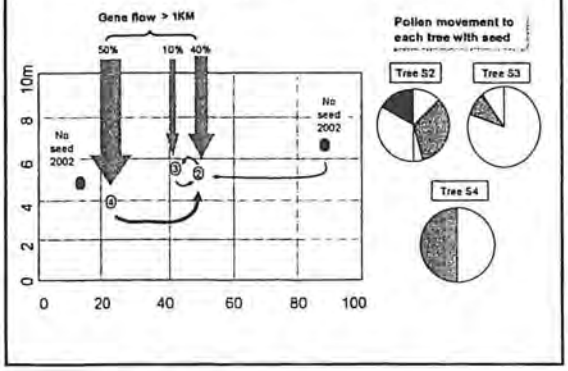
Paternity analysis - SSR locus EMBRA 6

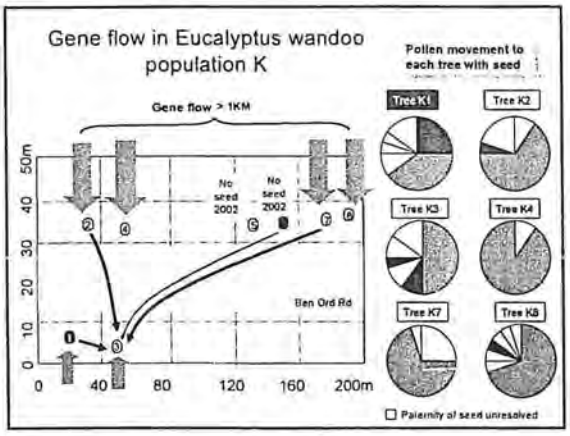


Paternity analysis - SSR locus EMBRA 6



Gene flow in Eucalyptus wandoo population S





Summary

Gene Flow:

- *E. wandoo* – very high levels of gene flow within and into (> 1km) small remnant populations with paddock trees likely to be important
- *C quadrifidus* – lower levels of gene flow into small isolated populations but still significant

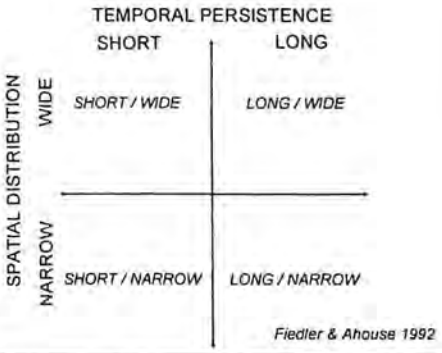
Key issues

- Thresholds of size (100 – 200 plants?) and possibly isolation below which population persistence is unlikely
- Small and or isolated populations / remnants are less suitable as sources of seed for re- vegetation
- High levels of gene flow in *E. wandoo* but much lower levels in the bird pollinated *C. quadrifidus* why ?
- Paddock trees and small vegetation remnants are likely to be critical for gene flow in the landscape but may not themselves be viable

Biological rarity

- Rarity is an intuitive, relative, scale dependent concept
- In biology it generally relates to:
  - geographic range
  - habitat specificity
  - abundance of a taxon
- Rare plants are often characterised by :
  - small populations
  - fragmented / isolated populations
  - small geographic range
- Over 2000 plant taxa are currently considered rare in south-west Western Australia, approx. 25% of the flora

Four categories of rarity in vascular plants



Fiedler & Ahouse 1992

Many causes of rarity

- Geologic and evolutionary history
- Myriad of ecological interactions (e.g. edaphic factors, predation, competition, pollination, fire sensitivity, climate)
- Reproductive biology
- Habitat specificity
- Population dynamics and influence of environmental and demographic stochasticity
- Human activities - habitat conversion, land management, harvesting

Rarity and Threat in SW Australia

Significant component of the south west flora:

- Occurs in the agricultural region where 75% of native vegetation is cleared
- Exists in remnants of native vegetation of varying size, shape and connectivity
- Occurs In a landscape where disturbance and hydrological regimes have changed
- Occurs In a landscape where exotic weeds and diseases have been introduced and are prevalent

Case studies: rarity and threat

***Lambertia echinata* complex**

***Verticordia fimbrilepis* complex**

***Tetratheca aphylla* complex**

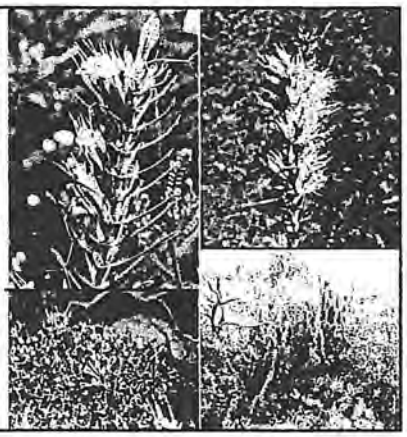
Banded Ironstone communities

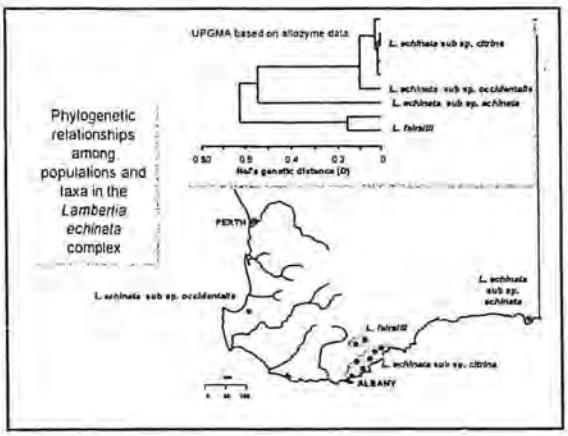
Lambertia echinata sub sp.*echinata*: geographically restricted, locally rare

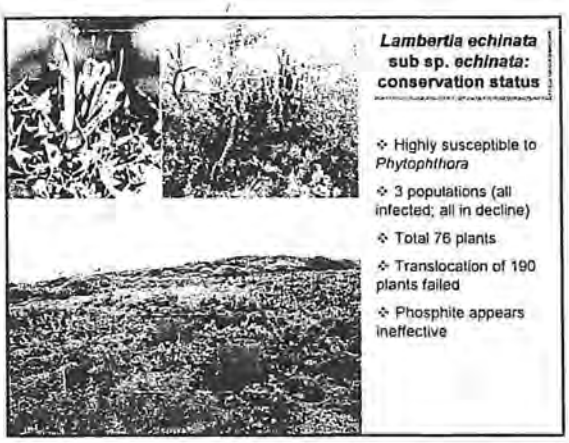
Lambertia echinata sub sp.*occidentalis*: geographically restricted, locally rare

Lambertia echinata sub sp.*citrina*: regionally distributed, patchy distribution, locally abundant

Lambertia fairallii: geographically restricted, locally abundant.

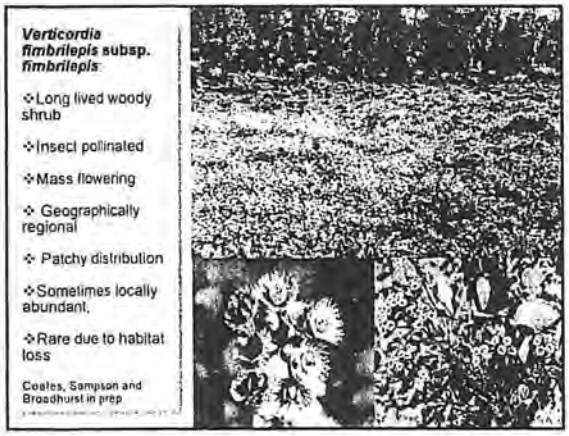






***Lambertia echinata* sub sp. *echinata*: conservation status**

- Highly susceptible to *Phytophthora*
- 3 populations (all infected; all in decline)
- Total 76 plants
- Translocation of 190 plants failed
- Phosphite appears ineffective

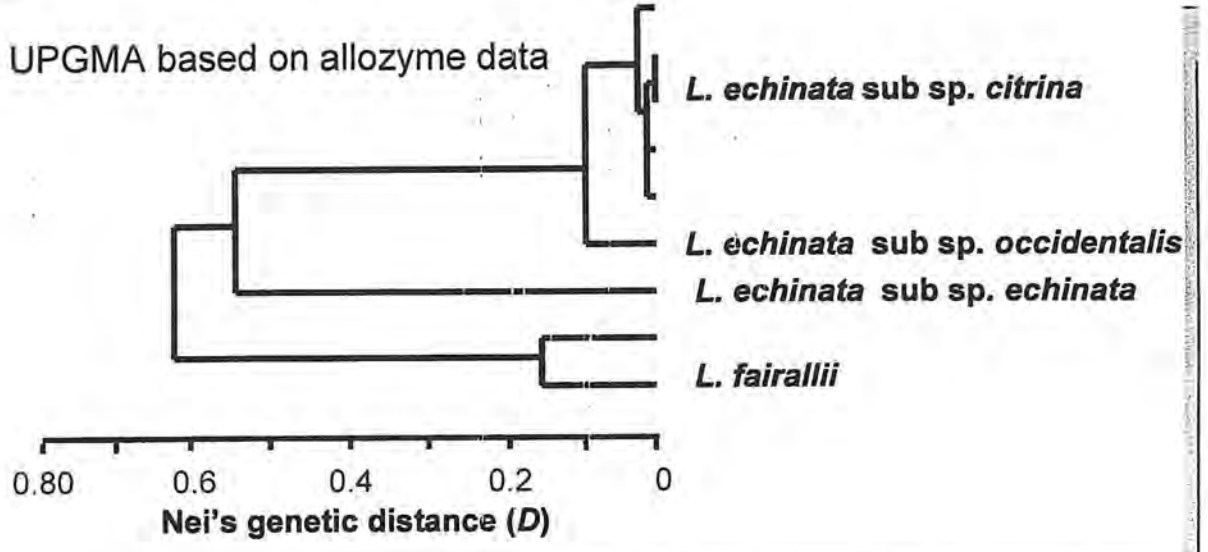


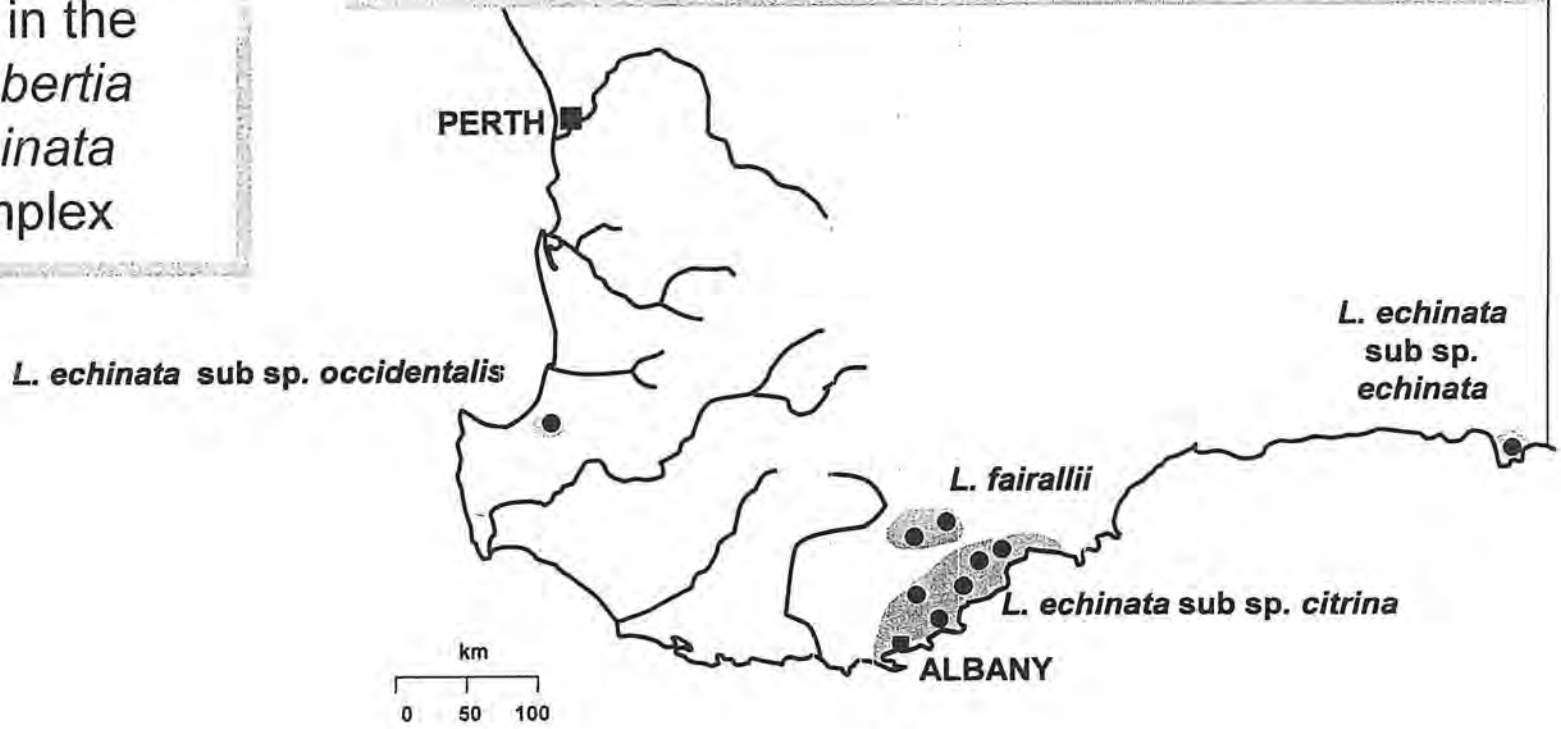
***Verticordia fimbrilepis* subsp. *fimbrilepis*:**

- Long lived woody shrub
- Insect pollinated
- Mass flowering
- Geographically regional
- Patchy distribution
- Sometimes locally abundant,
- Rare due to habitat loss

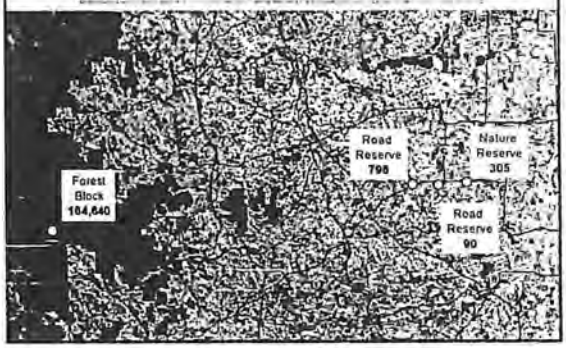
Coates, Sampson and Broadhurst in prep

Phylogenetic relationships among populations and taxa in the *Lambertia echinata* complex

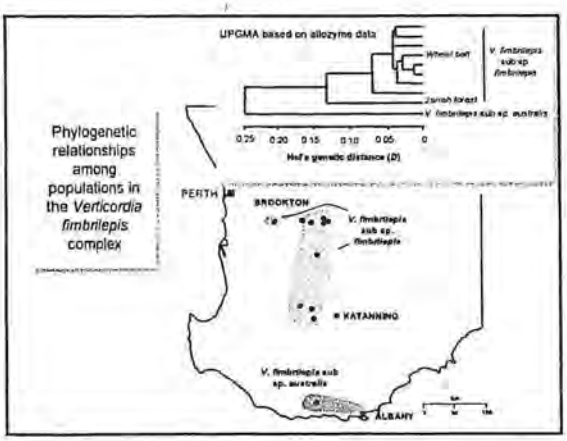




Distribution of *Verticordia fimbrilepis* subsp. *fimbrilepis* populations analysed for mating systems



Phylogenetic relationships among populations in the *Verticordia fimbrilepis* complex



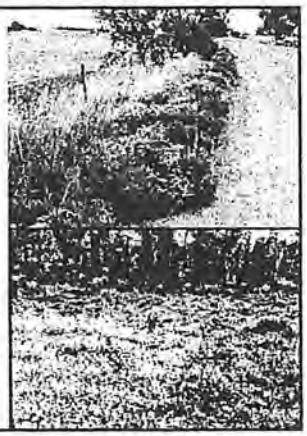
***Verticordia fimbrilepis* subsp *fimbrilepis* conservation status:**

Wheatbelt

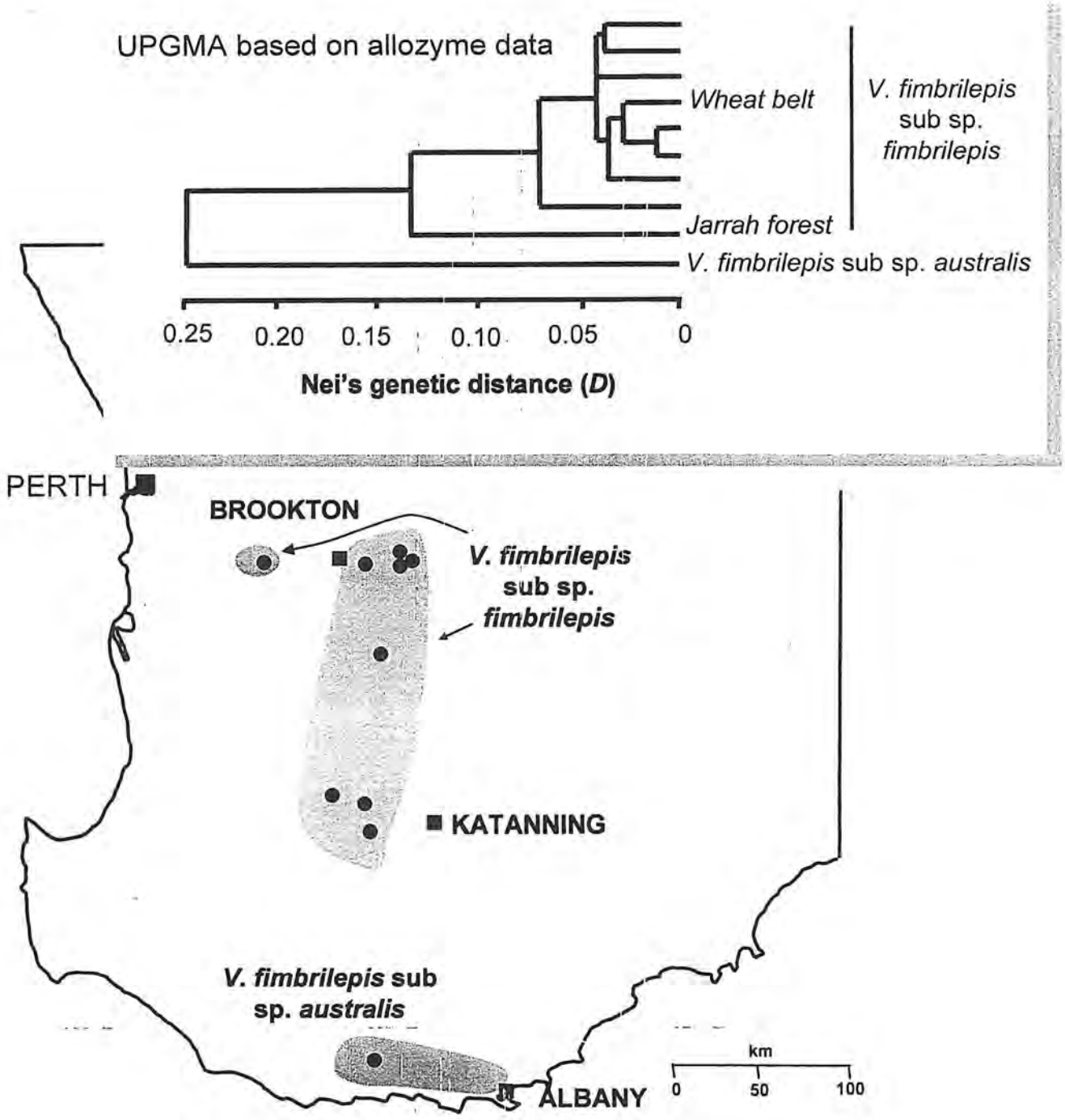
- 7 populations (1,631 plants)
- 5 road reserve (914 plants)
- Significant weed infestation on road reserves

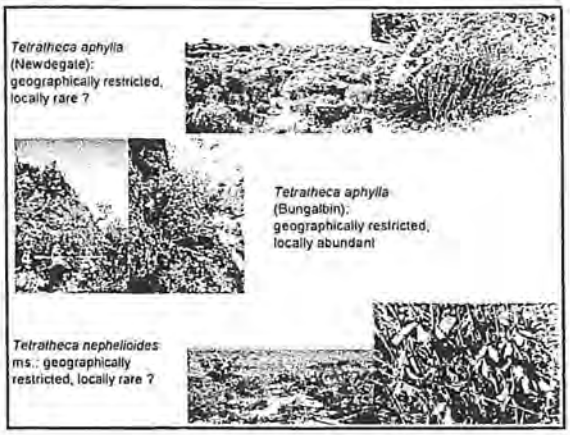
Jarrah Forest

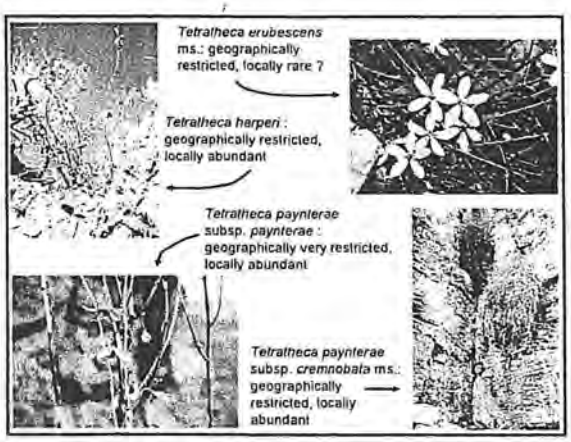
- 2 populations (69,071)

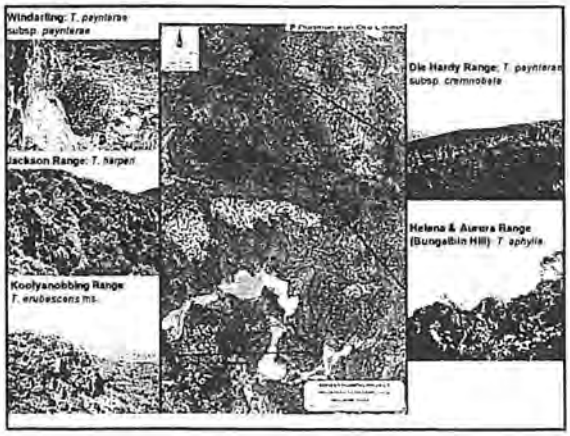


Phylogenetic relationships among populations in the *Verticordia fimbrilepis* complex

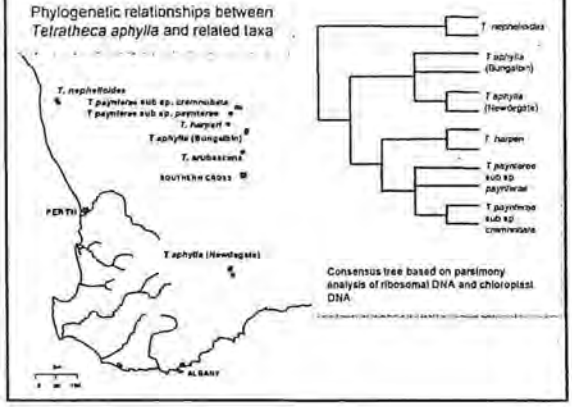



Tetratheca aphylla (Newdegate): geographically restricted, locally rare ?
Tetratheca aphylla (Bungalbin): geographically restricted, locally abundant
Tetratheca nephelioides ms.: geographically restricted, locally rare ?


Tetratheca erubescens ms.: geographically restricted, locally rare ?
Tetratheca harperi : geographically restricted, locally abundant
Tetratheca paynterae subsp. *paynterae* : geographically very restricted, locally abundant
Tetratheca paynterae subsp. *cremnobata* ms.: geographically restricted, locally abundant

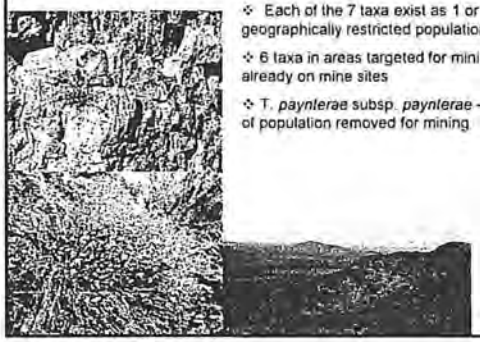

Windarling: *T. paynterae* subsp. *paynterae*
Jackson Range: *T. harperi*
Koolyanobbing Range *T. erubescens* ms.
Die Hardy Range: *T. paynterae* subsp. *cremnobata*
Helena & Aurora Range (Bungalbin Hill) *T. aphylla*

Phylogenetic relationships between *Tetratheca aphylla* and related taxa



Consensus tree based on parsimony analysis of ribosomal DNA and chloroplast DNA

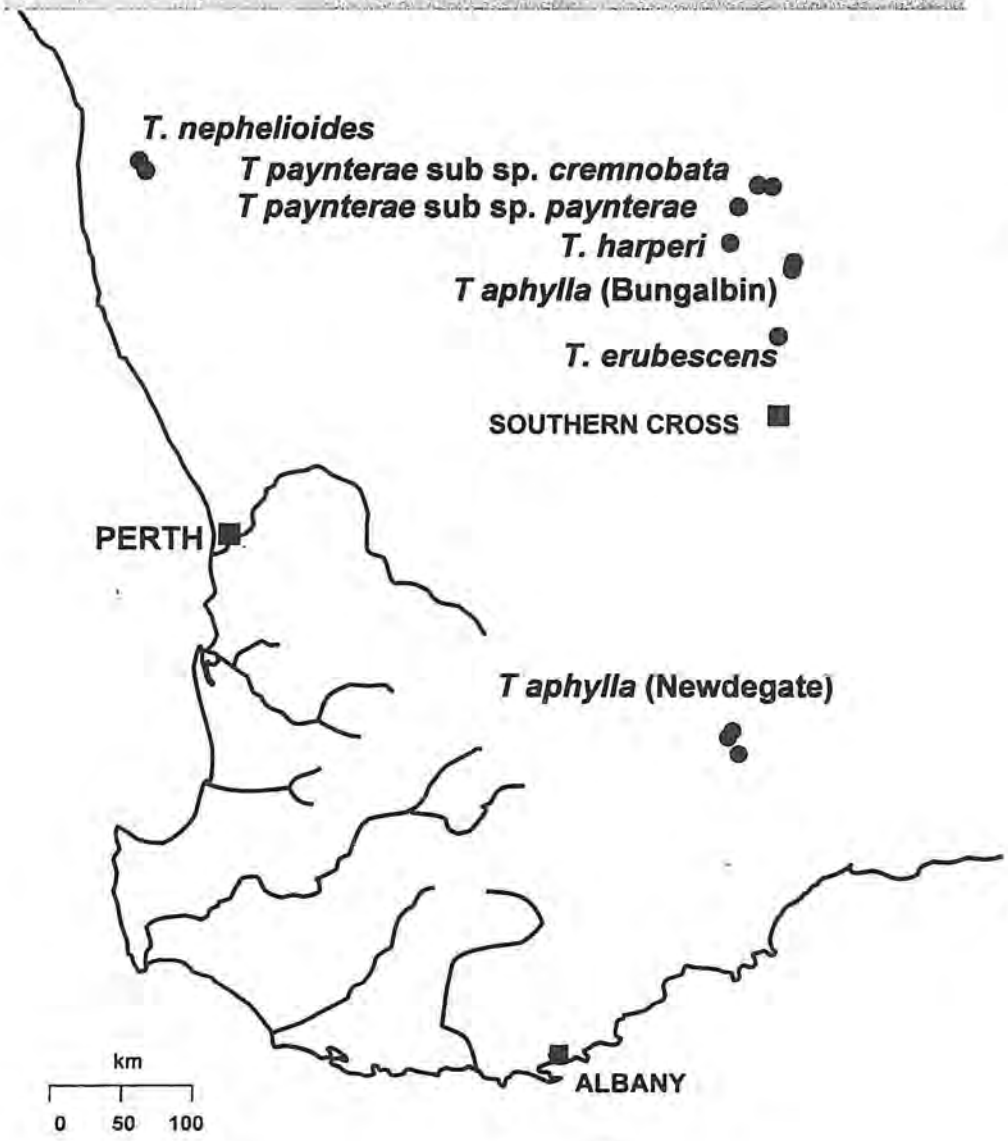
***Tetratheca* species conservation status:**

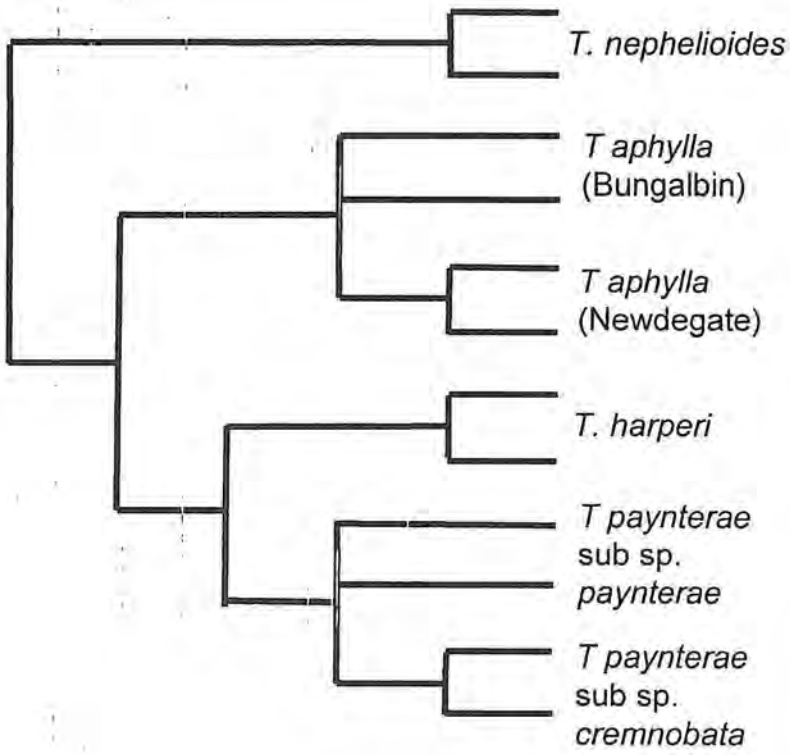


- Each of the 7 taxa exist as 1 or a few geographically restricted populations
- 6 taxa in areas targeted for mining or already on mine sites
- T. *paynterae* subsp. *paynterae* – 30% of population removed for mining

Distribution of Rare and Priority Flora in the Die Hardy Range - Bungalbin Hill Area

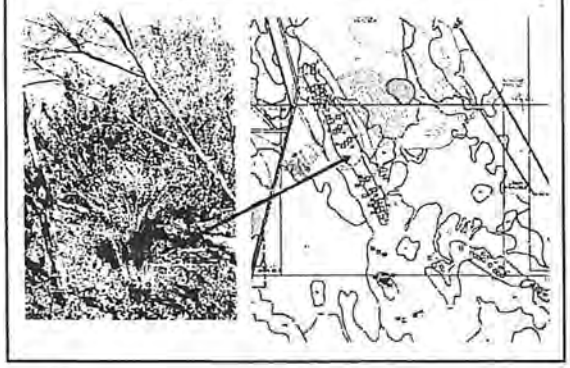
Phylogenetic relationships between *Tetratheca aphylla* and related taxa





Consensus tree based on parsimony analysis of ribosomal DNA and chloroplast DNA

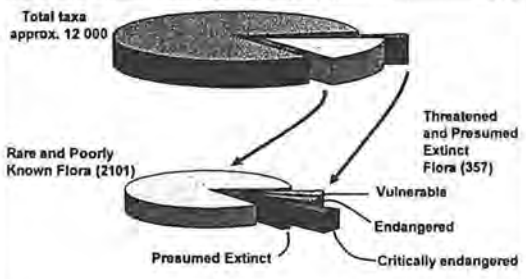
Implications – Mt Gibson example

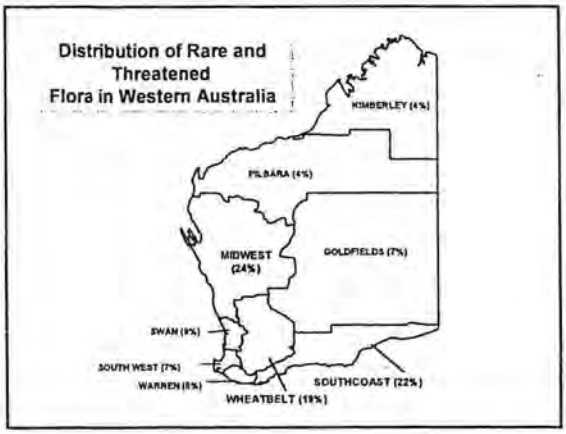


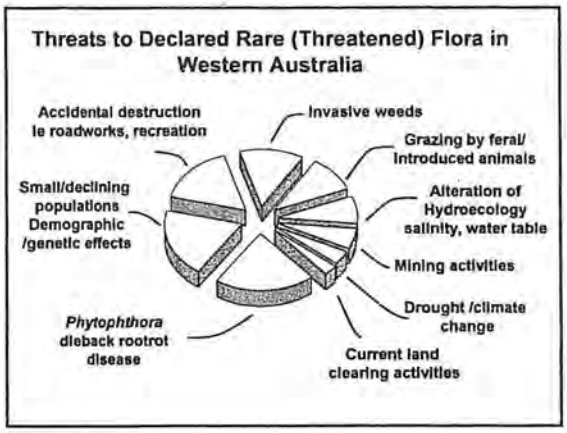
Threatened plant species in the south-west

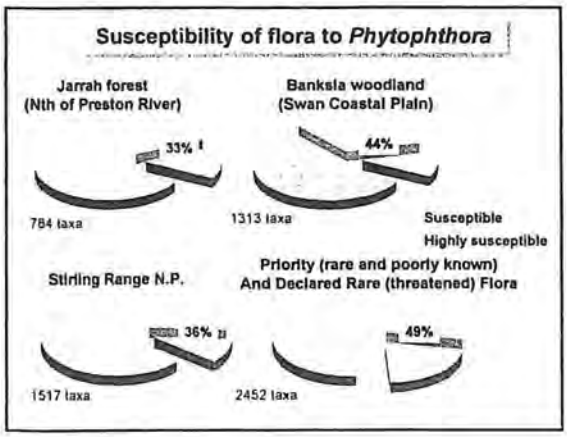
- 357 plant taxa are listed as threatened under IUCN guidelines
- Although many were probably naturally rare habitat destruction and degradation are the most likely reasons for their threatened status
- Ongoing threats associated with the contemporary landscape are contributing to the continued decline of remaining populations

Proportion of threatened (critically endangered, endangered and vulnerable) rare and poorly known flora in Western Australia



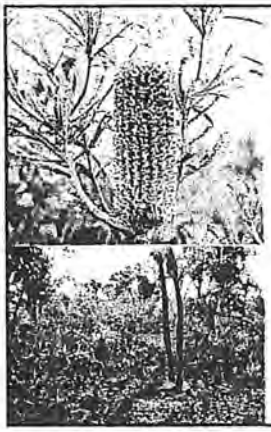

Distribution of Rare and Threatened Flora in Western Australia
KIMBERLEY (4%)
PILBARA (4%)
MIDWEST (24%)
GOLDFIELDS (7%)
SWAN (9%)
SOUTH WEST (7%)
WARREN (8%)
WHEATBELT (19%)
SOUTHCOAST (22%)


Threats to Declared Rare (Threatened) Flora in Western Australia
Accidental destruction ie roadworks, recreation
Invasive weeds
Grazing by feral/ introduced animals
Small/declining populations Demographic /genetic effects
Alteration of Hydroecology salinity, water table
Mining activities
Drought /climate change
Phytophthora dieback rootrot disease
Current land clearing activities


Susceptibility of flora to Phytophthora
Jarrah forest (Nth of Preston River)
Banksia woodland (Swan Coastal Plain)
33%
44%
784 taxa
1313 taxa
Susceptible
Highly susceptible
Priority (rare and poorly known) And Declared Rare (threatened) Flora
Stirling Range N.P.
36%
49%
1517 taxa
2452 taxa

Susceptibility of flora in the South West Botanical Province

Total in south west Botanical Province
5710 species and > 8,000 taxa



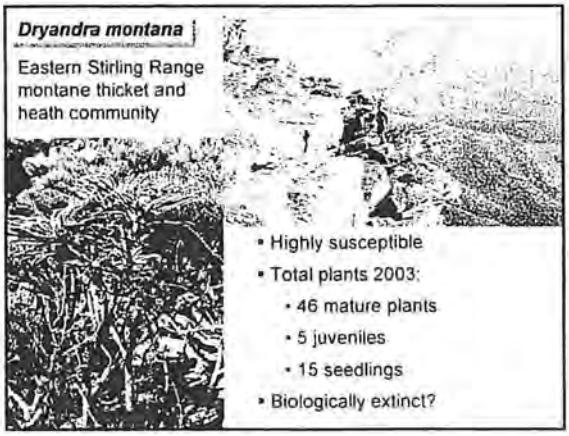
Banksia brownii

Heathland from Stirling Ranges to Cheyne Beach and Albany

- Highly susceptible
- 10 populations extinct
- 3 populations near extinction
- 12 populations extant
  - 7 populations 4 to 200
  - 5 populations 1000 –2000
- All populations infected
- All populations in decline
- Phosphite effective

Dryandra montana

Eastern Stirling Range montane thicket and heath community

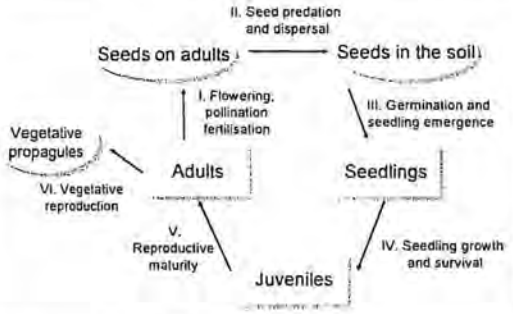


- Highly susceptible
- Total plants 2003:
  - 46 mature plants
  - 5 juveniles
  - 15 seedlings
- Biologically extinct?

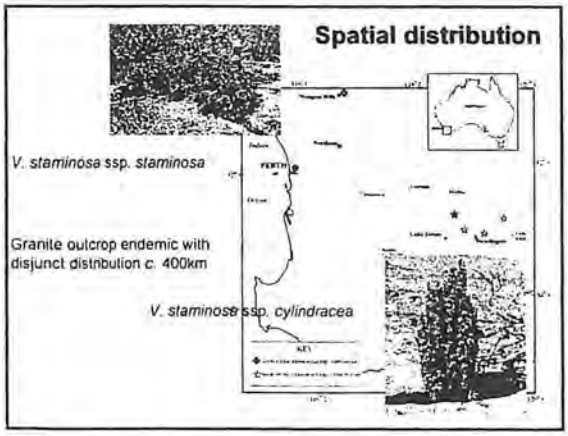
Lambertia fairallii

- 2 populations (SE Ellen recently extinct)
- Success 300+/- mature, 300 juveniles.
- SW of Gog: 300+ mature 1000+/- juveniles,
- *P. cinnamomi* sprayed with phosphite 2003, however most of population removed from infection at present.

Stages and transitions in the plant life cycle

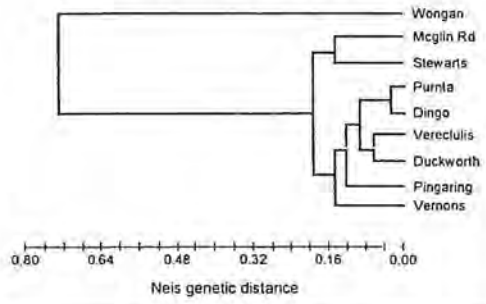


Spatial distribution



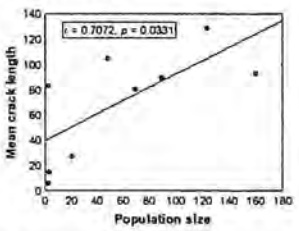
Temporal persistence

Phylogenetic relationships among populations of *Verticordia staminosa*



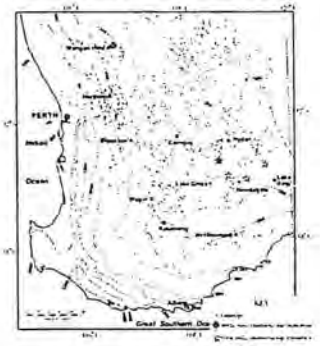
Taxon ecology

Taxon ecology - habitat specificity within outcrops



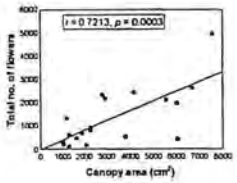
V. staminosa *is very habitat specific, being restricted to growing within cracks in the granite*

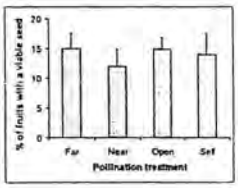
Taxon ecology- habitat specificity, location of granite outcrops across the landscape



Reproductive biology

- Bird pollinated, but introduced honeybee now the most frequent flower visitor
- Flowers abundantly
- Self-compatible

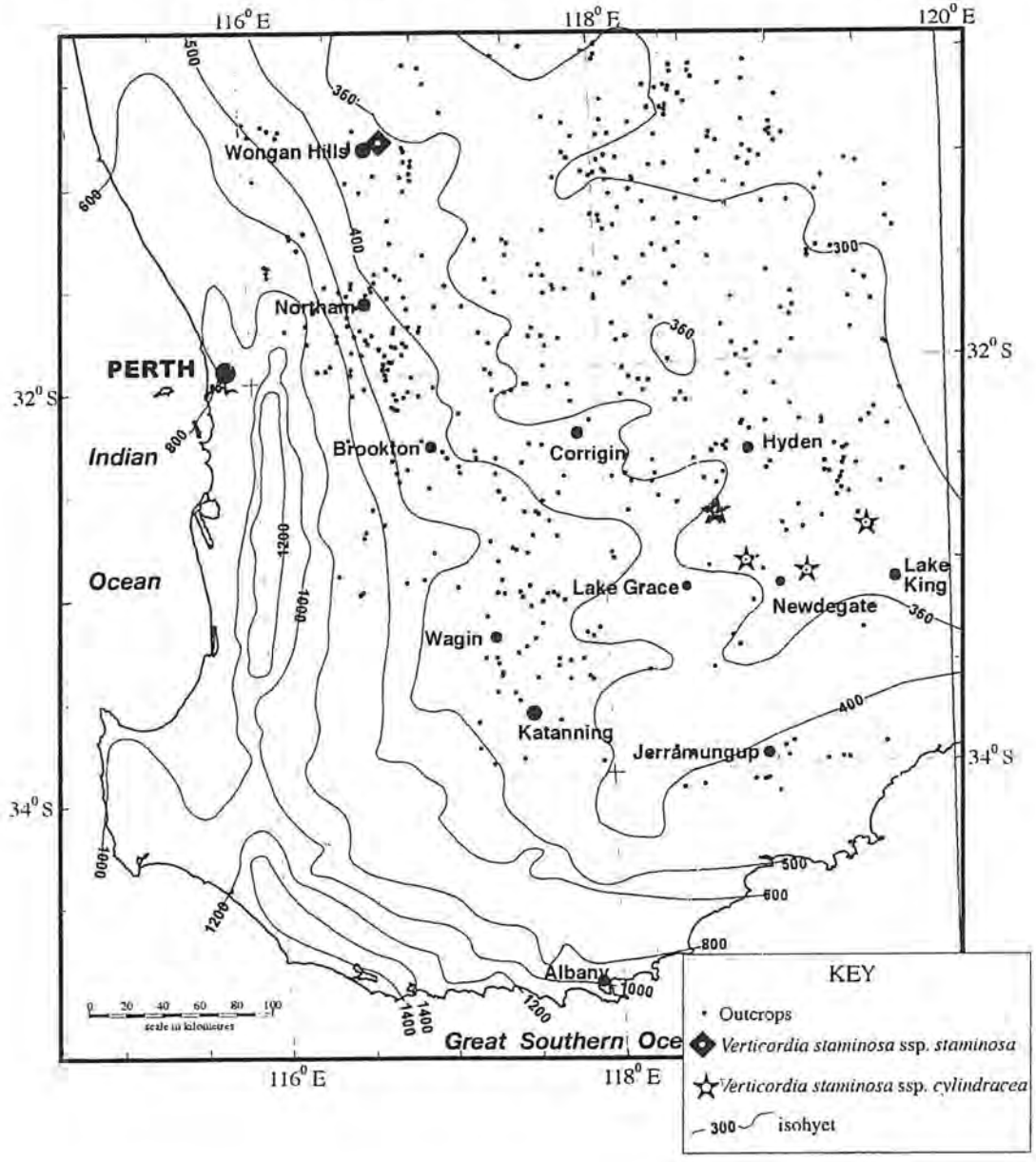




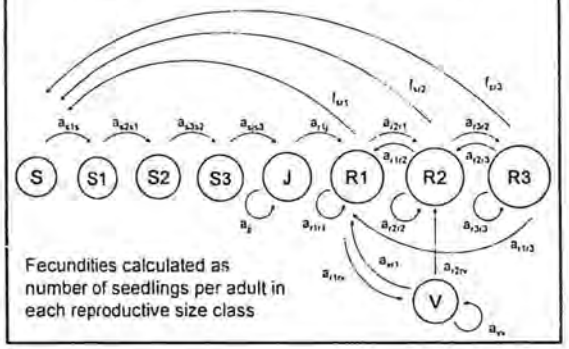
Environmental stochasticity and population dynamics

- Rainfall variation (161-675 mm, mean 392 mm)
- Fire (two fires in 20 years on a granite complex to the north-east, receiving 90 mm less rainfall)
- We investigated the influence of both sources of environmental stochasticity on population dynamics and viability with a stage structured transition matrix model built using the software RAMAS metapop v.5

Taxon ecology- habitat specificity, location of granite outcrops across the landscape



Conceptual stage structured model of life cycle pathways for *V. staminosa* ssp. *staminosa*



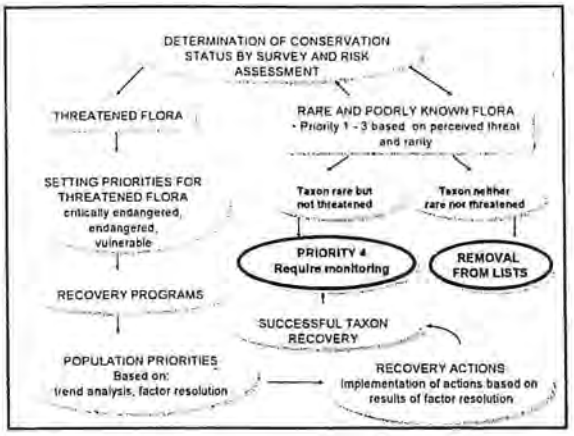
Fecundities calculated as number of seedlings per adult in each reproductive size class

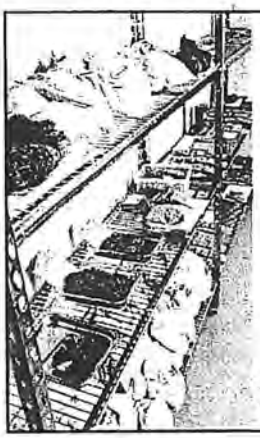
Conclusions

The results concur with the hypothesis that the interaction of environmental history and population biology are more important than ecological factors such as habitat specificity and intrinsic characters like reproductive biology for understanding rarity in *V. staminosa* ssp. *staminosa*

Conservation implications

- Land-tenure and need to protect granite rock habitats
- Enhanced greenhouse effect and climate change
- Climate models predict for a range of emission scenarios that winter wet season rainfall will decline across most of southwestern Australia
- Population Viability modelling indicates that under increased aridity the population will decline
- If continued monitoring shows an increase in adult mortality we should be concerned – increased incidence of fire maybe particularly important in this respect





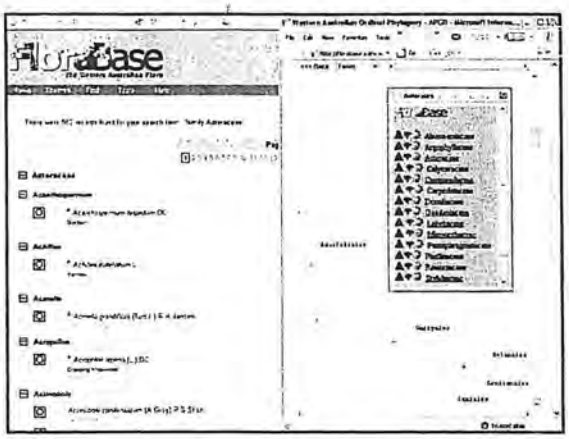
MILLENNIUM SEED BANK PROJECT
2001-2111
Anne Cochrane, Andrew Crawford

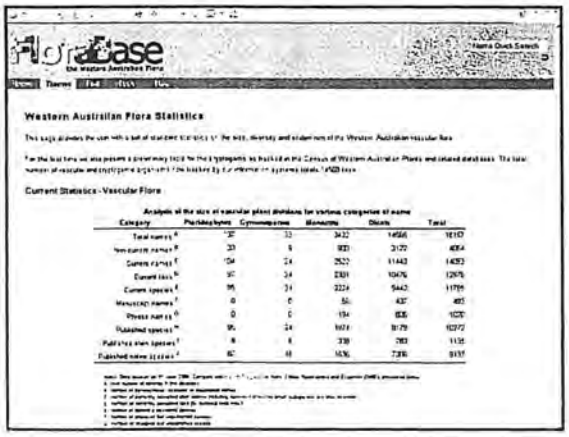
1. Benefit Sharing Agreement signed April 2001 with Royal Botanic Gardens Kew
2. CALM Threatened Flora Seed Centre to collect 1,000 Priority Flora including SAP species over 10 years
3. Seed to be processed / stored in TFSC duplicate collections to be housed at Millennium Seed Bank, UK.
4. Threatened Flora Seed Centre to collect = 100 species/taxa per year
5. Total funding over 10 years £439,300 = $ 1,1800,000. TFSC to receive = $850,000

Western Australian flora and major conservation issues

- Manage and ameliorate major threatening processes
  - Habitat fragmentation – small population effects
  - Altered hydrological regimes
  - *Phytophthora* dieback
  - Inappropriate fire regimes
  - Invasive weeds
- Understand the interactions between small population effects, fire regimes and weed invasion/competition
  - Small remnant management
  - Rangelands management
- Taxonomic knowledge of the flora
  - 1717 taxa (13.7%) not formally named
  - 458 taxa (18.6%) DRF and Priority Flora not formally named
  - 1780 taxa are rare but conservation status not known
  - Very poor knowledge of non vascular flora (2033 out of 100,000+)


FloraBase
the Western Australian Flora
Western Australian


FloraBase
the Western Australian Flora


FloraBase
the Western Australian Flora
Western Australian Flora Statistics
Current Statistics - Vascular Flora

FloraBase
the Western Australian Flora

Home Themes Find Tools Help

There were 952 records found for your search term: 'family:Asteraceae'

Pag

1 2 3 4 5 6 7 8 9 10 11 12 13

- **Asteraceae**
  - ***Acanthospermum***
    - * *Acanthospermum hispidum* DC.
      Starburr
      Prod. 5:527 (1836)
  - ***Achillea***
    - * *Achillea millefolium* L.
      Yarrow
      Sp. Pl. 2:899 (1753)
  - ***Acmella***
    - * *Acmella grandiflora* (Turcz.) R.K.Jansen
      Nord. Jour. Bot. 5:75 (1985)
  - ***Acroptilon***
    - * *Acroptilon repens* (L.) DC.
      Creeping Knapweed
      Prod. 6:662 (1838)
  - ***Actinobole***
    - *Actinobole condensatum* (A.Gray) P.S.Short
      Muelleria 4:413 (1981)
    - *Actinobole drummondiana* P.S.Short

Western Australian C .nal Phylogeny - APGII - Microsoft Interne...

File Edit View Favorites Tools

Address http://florabase.calm.w Go Google

<<< Back Zoom

Asterales

FloraBase

- Alseuosmiaceae
- Argophyllaceae
- Asteraceae
- Calyceraceae
- Campanulaceae
- Carpodetaceae
- Donatiaceae
- Goodeniaceae
- Lobeliaceae
- Menyanthaceae
- Pentaphragmataceae
- Phellinaceae
- Rousseaceae
- Stylidiaceae

Aquifoliales

Garryales

Solanales

Gentianales

Lamiales

Trusted sites

Western Australian Flora Statistics

This page provides the user with a set of standard statistics on the size, diversity and endemism of the Western Australian vascular flora.

For the first time we also present a preliminary table for the cryptogams as tracked in the Census of Western Australian Plants and related databases. The total number of vascular and cryptogamic organisms now tracked by our information systems totals 14568 taxa.

Current Statistics - Vascular Flora

Analysis of the size of vascular plant divisions for various categories of name

Category	Pteridophytes	Gymnosperms	Monocots	Dicots	Total
Total names [A]	137	33	3422	14565	18157
Non-current names [B]	33	9	900	3122	4064
Current names [C]	104	24	2522	11443	14093
Current taxa [D]	97	24	2381	10476	12978
Current species [E]	95	24	2224	9442	11785
Manuscript names [F]	0	0	56	437	493
Phrase names [G]	0	0	194	826	1020
Published species [H]	95	24	1974	8179	10272
Published alien species [I]	8	6	338	783	1135
Published native species [J]	87	18	1636	7396	9137

Notes. Data sourced on 1st June 2006. Compare with the 2005 figures or Table 3 from Paczkowska and Chapman (2000), presented below.
A - total number of records in the database
B - number of synonymous, excluded or misapplied names
C - number of currently accepted plant names including species names for which subspecies are also recorded
D - number of currently accepted taxa (ie. terminal taxa only)
E - number of currently accepted species
F - number of proposed but unpublished species
G - number of assigned but unpublished species
H - number of formally published speci... mes

Legislation

SPECIES AND COMMUNITIES BRANCH AND THREATENED FLORA CONSERVATION

Version 3: 17 September 2007

Department of Environment and Conservation

AIM OF THE COURSE

To provide Departmental staff with knowledge of the Department's Species and Communities Branch, threatened flora legislation and conservation, and the application process necessary to acquire permits to take

CONTENT

- Role of Species and Communities Branch
- Key Definitions
- Flora conservation legislation
- Declared Rare Flora
- Threatened Species Scientific Committee
- Applications to 'take'
- Ranking of threatened flora
- Priority Flora
- Flora Conservation and Recovery

LEARNING OUTCOMES

1. Outline the key roles and responsibilities of Species and Communities Branch
2. Demonstrate an understanding of Declared Rare Flora, its legal protection, and the administrative process associated with applications to take Declared Rare Flora

LEARNING OUTCOMES (2)

3. Explain the IUCN ranking system
4. Demonstrate an understanding of Priority Flora
5. Outline the key processes involved in conservation and management of threatened flora

SPECIES AND COMMUNITIES BRANCH ROLES:

- Legislation development & advice
- Policy development & advice
- Management and licensing advice
- Species & community recovery planning
- Operation of biodiversity conservation programs
- Maintenance of data and information
- Processing DRF permits

SPECIES AND COMMUNITIES BRANCH ROLES (2):

- Flora Management

Threatened flora – listing process
- ranking process
- interim recovery plans
- management support
- permits to take
- databases

Other flora – general flora management advice
- industry management plans
- licensing advice

SPECIES AND COMMUNITIES BRANCH ROLES (3):

- Fauna Management

Threatened fauna - listing process
- ranking process
- interim recovery plans
- management support
- licences to take
- Western Shield
- databases

western shield

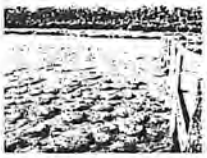
Other Fauna – general flora management advice
- industry management plans
- licensing advice

SPECIES AND COMMUNITIES BRANCH ROLES (4):

Threatened ecological communities
- listing process
- ranking process
- interim recovery plans
- management support
- database

SPECIES AND COMMUNITIES BRANCH ROLES (5):

Wetlands Conservation



- Ramsar
- classification
- assessment
- EIA advice
- management support
- database

SPECIES AND COMMUNITIES BRANCH ROLES (6):

- Off-reserve Conservation
  - Land for Wildlife
  - Nature Conservation Covenants
  - Roadside Conservation Committee
  - Incentive Programs

THREATENED FLORA

Three levels of formal protection:

International – CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora)

Commonwealth – EPBC Act 1999

State – Wildlife Conservation Act 1950

Wildlife Conservation Act 1950 - 1979

'Protected Flora' is all W.A. native flora in:

Spermatophyta	(flowering, conifers, cycads)
Pteridophyta	(ferns, fern allies)
Bryophyta	(mosses, liverworts)
Thallophyta	(algae, fungi, lichens)

'To take' flora includes both direct (gather, pluck, cut, destroy, dig up or remove) and indirect (to cause taking) means.

Wildlife Conservation Act

Section (S23F): 'Rare Flora'
is flora declared by the Minister to be
- likely to become extinct;
- is rare; or
- otherwise needs special protection

'Declared Rare Flora' = 'Threatened Flora'

Only applies to natural or recovery popns.

Listed as 'Extant' and 'Presumed Extinct'

THREATENED SPECIES SCIENTIFIC COMMITTEE (TSSC)

- Ministerially appointed
- appointment by expertise (incl. DEC, BGPA, Museum and university)
- meets at least annually
- recommends additions, deletions and rank
- recommends specific management actions

Recommendations endorsed by DEC Corp Exec & Cons Commission of WA, and referred to Minister for approval

DEPARTMENTAL POLICY STATEMENTS

No 9 - Conservation of Threatened Flora in the Wild

No 29 - Translocation of Threatened Flora and Fauna

No 44 - Wildlife Management Programs

No 50 - Setting Priorities for the Conservation of Western Australia's Threatened Flora and Fauna

CALM Policy 9 – Conservation of Threatened Flora in the Wild

To be replaced with the draft Policy 9 - Conserving Threatened Species and Ecological Communities, that incorporates other existing Policies

A species [of flora] may be recommended for declaration as threatened flora by the Western Australian Threatened Species Scientific Committee if it satisfies the following criteria:

(i) The species occurs naturally in Western Australia, is well defined and represented by a voucher specimen in a State or National Herbarium. While it need not necessarily be formally described under conventions in the International Code of Botanical Nomenclature, such a description is preferred and should be undertaken as soon as possible after listing on the schedule.

(ii) It has been established that the species in the wild:

a) is extinct, ie, there is no reasonable doubt that the last individual has died, or

b) meets criteria for listing as threatened in the current version of *IUCN Red List Categories Prepared by the IUCN Species Survival Commission.*

(iii) In the case of hybrids, or suspected hybrids, the following criteria must also be satisfied:

(a) they must be a distinct entity, that is, the progeny are consistent within the agreed taxonomic limits for that taxon group;

(b) they must be capable of self perpetuation, that is, not reliant on the parent stock for replacement; and

(c) they must be the product of a natural event, that is, both parents are naturally occurring and cross fertilisation was by natural means.

Wildlife Conservation Act 1950

Wildlife Conservation (Rare Flora) Notice 2006

Made by the Minister for the Environment under section 23F(2) of the Act.

1. **Citation**

This notice may be cited as the *Wildlife Conservation (Rare Flora) Notice 2006*.

2. **Interpretation**

In this notice —

"extant" means known to be living in a wild state;

"protected flora" means any flora belonging to the classes of flora declared by the Minister under section 6 of the Act to be protected flora by notice published in the *Gazette* 9 October 1987, at p. 3855;

"taxon" includes any taxon that is described by a genus name and any other name or description.

Note: The plural form of "taxon" is "taxa".

3. Rare flora

Subject to clause 4, protected flora —

(a) specified in Schedule 1, being taxa that are extant and considered likely to become extinct or rare and therefore in need of special protection; and

(b) specified in Schedule 2, being taxa that are presumed to be extinct in the wild and therefore in need of special protection,

are declared to be rare flora for the purposes of section 23F of the Act throughout the State

4. Application

Clause 3 does not apply to those plants of a taxon of protected flora specified in Schedule 1 or 2 that have been planted for any purpose other than such plants that have been planted for the purpose of conservation of that taxon and in accordance with approval given by the Director General

5. Revocation

The *Wildlife Conservation (Rare Flora) Notice 2005* is revoked

(i) The species occurs naturally in Western Australia, is well defined and represented by a voucher specimen in a State or National Herbarium. While it need not necessarily be formally described under conventions in the International Code of Botanical Nomenclature, such a description is preferred and should be undertaken as soon as possible after listing on the schedule.

Wildlife Conservation Act 1950 - 1979

'Protected Flora' is all W.A. native flora in:

Spermatophyta	(flowering, conifers, cycads)
Pteridophyta	(ferns, fern allies)
Bryophyta	(mosses, liverworts)
Thallophyta	(algae, fungi, lichens)

Wildlife Conservation (Rare Flora) Notice 2006

Division 2 — Pteridophyta (ferns and fern allies)

371. *Asplenium obtusatum* subsp. *northlandicum*

Division 3 — Bryophyta (mosses and liverworts)

372. *Rhacocarpus rehmannianus* var. *webbianus*

DECLARED RARE FLORA

Ministerial Permission to 'Take' (*s* 23F(4))

Binding on the Crown

Application Process for Permit to Take :

1. Species and Communities Branch
2. Director Nature Conservation
3. Minister for the Environment

ISSUES REGARDING APPLICATIONS TO TAKE:
eg with fire

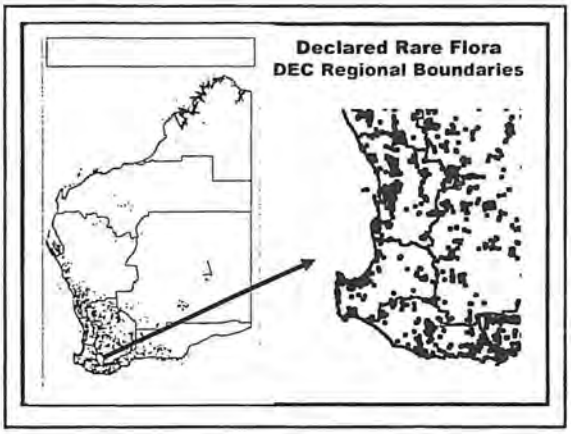
Timing	- flowering period - seeders/reshooters - annuals/orchids
Frequency	- seeders
Intensity	- patchiness - % of population - local/regional representation
Conservation Status	- ranking - recovery plans

DECLARED RARE FLORA IN W. AUST

- 378 extant taxa (1/12/06)
- 30% of Aust Threatened Flora
- 6.8% of World Threatened Flora

Distribution of Declared Rare Flora in WA

Lands managed by DEC



Declared Rare Flora, 2001 by Tenure

TENURE	% POPS	% PLANTS	Av. POPN. SIZE (467)
Conservation Reserves	27.5	44.9	763
State Forest	4. 3	1. 5	159
Local Government	24.3	12.0	230
Main Roads	4.8	1.1	111
Railway Reserves	3.0	0.4	61
Other Vested Crown Land	3.3	2.5	354
Unvested Crown Land	11.9	28.2	1106
Private	20.0	9.5	222

IUCN RANKING:

- Presumed Extinct
- Threatened
  - Critically Endangered
  - Endangered
  - Vulnerable
- Conservation Dependent
- Data Deficient

Schedule 1 — Extant taxa

[cl. 3(a)]

Division 1 — Spermatophyta (flowering plants, conifers and cycads)

1. *Acacia anomala*
2. *Acacia aphylla*
3. *Acacia aprica*
4. *Acacia aristulata* ms
5. *Acacia ataxiphylla* subsp. *magna*
6. *Acacia auratiflora*
7. *Acacia awestoniana*
8. *Acacia brachypoda*
9. *Acacia chapmanii* subsp. *australis*
10. *Acacia cochlocarpa* subsp. *cochlocarpa*
11. *Acacia cochlocarpa* subsp. *velutinosa*
12. *Acacia denticulosa*
13. *Acacia depressa*
14. *Acacia forrestiana*
15. *Acacia imitans*
16. *Acacia insolita* subsp. *recurva*
17. *Acacia lanuginophylla*
18. *Acacia leptalea*
19. *Acacia lobulata*
20. *Acacia pharangites*
21. *Acacia pygmaea*
22. *Acacia recurvata*
23. *Acacia rhamphophylla*

90. *Chamelaucium* sp. Hamersley (N.McQuoid 379)

316. *Rulingia* sp. Trigwell Bridge (R.Smith s.n. 20.6.89)

Schedule 1 — Extant taxa

[cl. 3(a)]

Division 1 — Spermatophyta (flowering plants, conifers and cycads)

1. *Acacia anomala*
2. *Acacia aphylla*
3. *Acacia aprica*
4. *Acacia aristulata* ms
5. *Acacia ataxiphylla* subsp. *magna*
6. *Acacia auratiflora*
7. *Acacia awestoniana*
8. *Acacia brachypoda*
9. *Acacia chapmanii* subsp. *australis*
10. *Acacia cochlocarpa* subsp. *cochlocarpa*
11. *Acacia cochlocarpa* subsp. *velutinosa*
12. *Acacia denticulosa*
13. *Acacia depressa*
14. *Acacia forrestiana*
15. *Acacia imitans*
16. *Acacia insolita* subsp. *recurva*
17. *Acacia lanuginophylla*
18. *Acacia leptalea*
19. *Acacia lobulata*
20. *Acacia pharangites*
21. *Acacia pygmaea*
22. *Acacia recurvata*
23. *Acacia rhamphophylla*

90. *Chamelaucium* sp. Hamersley (N.McQuoid 379)

316. *Rulingia* sp. Trigwell Bridge (R.Smith s.n. 20.6.89)

Schedule 2 — Taxa presumed to be extinct

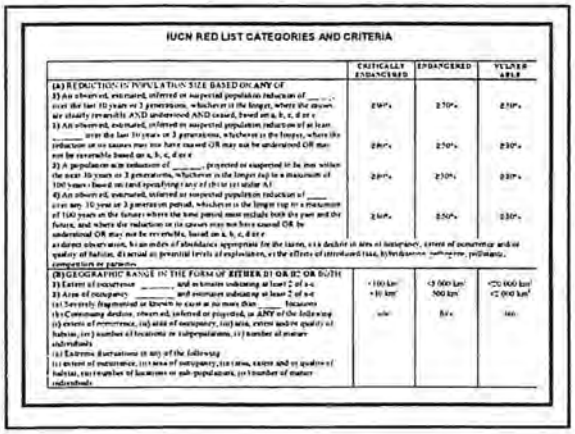
[cl. 3(b)]

Spermatophyta (flowering plants, conifers and cycads)

1. *Acacia kingiana*
2. *Acacia prismifolia*
3. *Coleanthera virgata*
4. *Frankenia decurrens*
5. *Lepidium drummondii*
6. *Leptomeria dielsiana*
7. *Leucopogon cryptanthus*
8. *Opercularia acolytantha*
9. *Philotheca falcata*
10. *Ptilotus caespitulosus*
11. *Ptilotus pyramidatus*
12. *Taraxacum cygnorum*
13. *Tetratheca fasciculata*
14. *Thomasia gardneri*

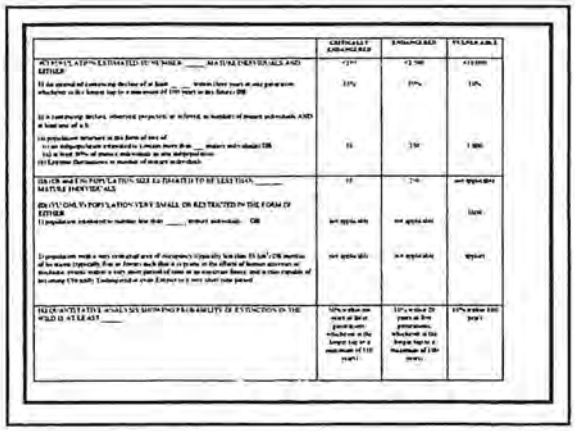
IUCN RED LIST CATEGORIES AND CRITERIA

	CRITICALLY ENDANGERED	ENDANGERED	VULNERABLE
(A) REDUCTION IN POPULATION SIZE BASED ON ANY OF			
1) An observed, estimated, inferred or suspected population reduction of _____, over the last 10 years or 3 generations, whichever is the longer, where the causes are clearly reversible AND understood AND ceased, based on a, b, c, d or e	≥90%	≥70%	≥50%
2) An observed, estimated, inferred or suspected population reduction of at least _____ over the last 10 years or 3 generations, whichever is the longer, where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible based on a, b, c, d or e	≥80%	≥50%	≥30%
3) A population size reduction of _____, projected or suspected to be met within the next 10 years or 3 generations, whichever is the longer (up to a maximum of 100 years) based on (and specifying) any of (b) to (e) under A1	≥80%	≥50%	≥30%
4) An observed, estimated, inferred or suspected population reduction of _____ over any 10 year or 3 generation period, whichever is the longer (up to a maximum of 100 years in the future) where the time period must include both the past and the future, and where the reduction or its causes may not have ceased OR be understood OR may not be reversible, based on a, b, c, d or e	≥80%	≥50%	≥30%
a) direct observation, b) an index of abundance appropriate for the taxon, c) a decline in area of occupancy, extent of occurrence and/or quality of habitat, d) actual or potential levels of exploitation, e) the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.			
(B) GEOGRAPHIC RANGE IN THE FORM OF EITHER B1 OR B2 OR BOTH			
1) Extent of occurrence _____ and estimates indicating at least 2 of a-c	<100 km^2	<5 000 km^2	<20 000 km^2
2) Area of occupancy _____ and estimates indicating at least 2 of a-c	<10 km^2	500 km^2	<2 000 km^2
(a) Severely fragmented or known to exist at no more than _____ locations	one	five	ten
(b) Continuing decline, observed, inferred or projected, in ANY of the following: (i) extent of occurrence, (ii) area of occupancy, (iii) area, extent and/or quality of habitat, (iv) number of locations or subpopulations, (v) number of mature individuals.			
(c) Extreme fluctuations in any of the following: (i) extent of occurrence, (ii) area of occupancy, (iii) area, extent and/or quality of habitat, (iii) number of locations or sub-populations, (iv) number of mature individuals.			

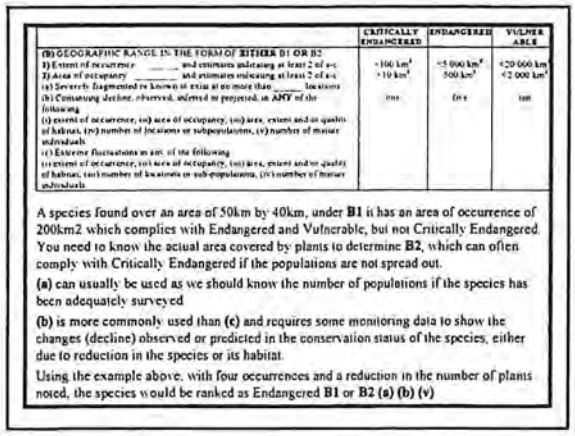


IUCN RED LIST CATEGORIES AND CRITERIA

	CRITICALLY ENDANGERED	ENDANGERED	VULNERABLE
(A) REDUCTION IN POPULATION SIZE BASED ON ANY OF			
1) An observed, estimated, inferred or suspected population reduction of ____ over the last 10 years or 3 generations, whichever is the longer, where the causes are clearly reversible AND understood AND ceased, based on a, b, c, d or e	≥90%	≥70%	≥50%
2) An observed, estimated, inferred or suspected population reduction of at least ____ over the last 10 years or 3 generations, whichever is the longer, where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible based on a, b, c, d or e	≥80%	≥50%	≥30%
3) A population size reduction of ____ projected or suspected to be met within the next 10 years or 3 generations, whichever is the longer (up to a maximum of 100 years) based on (and specifying any of) (b) (c) and/or (d)	≥80%	≥50%	≥30%
4) An observed, estimated, inferred or suspected population reduction of ____ over any 10 year or 3 generation period, whichever is the longer (up to a maximum of 100 years in the future) where the time period must include both the past and the future, and where the reduction or its causes may not have ceased OR be understood OR may not be reversible, based on a, b, c, d or e	≥50%	≥20%	≥10%
a) direct observation, b) an index of abundance appropriate for the taxon, c) a decline in area of occupancy, extent of occurrence and/or quality of habitat, d) actual or potential levels of exploitation, e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites			
(B) GEOGRAPHIC RANGE IN THE FORM OF EITHER B1 OR B2 OR BOTH			
1) Extent of occurrence ____ and/or	<100 km²	<5 000 km²	<20 000 km²
2) Area of occupancy ____ and/or	<10 km²	500 km²	<2 000 km²
(a) Severely fragmented or known to exist at no more than ____ locations	one	five	ten
(b) Continuing decline, observed, inferred or projected, in ANY of the following:			
(i) extent of occurrence, (ii) area of occupancy, (iii) area, extent and/or quality of habitat, (iv) number of locations or subpopulations, (v) number of mature individuals			
(c) Extreme fluctuations in any of the following:			
(i) extent of occurrence, (ii) area of occupancy, (iii) area, extent and/or quality of habitat, (iv) number of locations or sub-populations, (v) number of mature individuals			



	CRITICALLY ENDANGERED	ENDANGERED	VULNERABLE
(C) ESTIMATES INDICATING NUMBER OF MATURE INDIVIDUALS AND EITHER			
1) An observed continuing decline of at least ____ within [three years or one generation, whichever is the longer (up to a maximum of 100 years in the future)] OR	25%	20%	10%
(2) a continuing decline, observed, projected, or inferred, in number of mature individuals AND at least one of a-b:			
(a) population structure in the form of one of: (i) no subpopulation estimated to contain more than ____ mature individuals OR (ii) at least 90% of mature individuals in one subpopulation	25	250	1 000
(b) Extreme fluctuations in number of mature individuals			
(D) VERY SMALL OR RESTRICTED POPULATION			
(D) POPULATION SIZE ESTIMATED TO BE LESS THAN ____ MATURE INDIVIDUALS	50	250	not applicable
(D) VERY SMALL POPULATION OR RESTRICTED IN THE FORM OF EITHER			
1) population estimated to number less than ____ mature individuals OR	not applicable	not applicable	1000
2) population with a restricted area of occupancy (typically less than 20 km²) OR number of locations (typically five or fewer) such that it is prone to the effects of human activities or stochastic events within a very short period of time in an uncertain future, and is thus capable of becoming CR or EN or even EX in a very short time period	not applicable	not applicable	typically
(E) QUANTITATIVE ANALYSIS SHOWING PROBABILITY OF EXTINCTION IN THE WILD OF AT LEAST ____	50% within ten years or three generations, whichever is the longer (up to a maximum of 100 years)	20% within 20 years or five generations, whichever is the longer (up to a maximum of 100 years)	10% within 100 years



	CRITICALLY ENDANGERED	ENDANGERED	VULNERABLE
(B) GEOGRAPHIC RANGE IN THE FORM OF EITHER B1 OR B2			
1) Extent of occurrence ____ and/or	<100 km²	<5 000 km²	<20 000 km²
2) Area of occupancy ____ and/or	<10 km²	500 km²	<2 000 km²
(a) Severely fragmented or known to exist at no more than ____ locations	one	five	ten
(b) Continuing decline, observed, inferred or projected, in ANY of the following:			
(i) extent of occurrence, (ii) area of occupancy, (iii) area, extent and/or quality of habitat, (iv) number of locations or subpopulations, (v) number of mature individuals			
(c) Extreme fluctuations in any of the following:			
(i) extent of occurrence, (ii) area of occupancy, (iii) area, extent and/or quality of habitat, (iv) number of locations or sub-populations, (v) number of mature individuals			

A species found over an area of 50km by 40km, under **B1** it has an area of occurrence of 200km2 which complies with Endangered and Vulnerable, but not Critically Endangered. You need to know the actual area covered by plants to determine **B2**, which can often comply with Critically Endangered if the populations are not spread out.

(a) can usually be used as we should know the number of populations if the species has been adequately surveyed

(b) is more commonly used than **(c)** and requires some monitoring data to show the changes (decline) observed or predicted in the conservation status of the species, either due to reduction in the species or its habitat.

Using the example above, with four occurrences and a reduction in the number of plants noted, the species would be ranked as Endangered **B1** or **B2 (a) (b) (v)**

	CRITICALLY ENDANGERED	ENDANGERED	VULNERABLE
(C) POPULATION ESTIMATED TO NUMBER _____ MATURE INDIVIDUALS AND **EITHER**	<250	<2 500	<10 000
1) An estimated continuing decline of at least _____ within three years or one generation whichever is the longer (up to a maximum of 100 years in the future) **OR**	25%	20%	10%
2) A continuing decline, observed, projected, or inferred, in numbers of mature individuals AND at least one of a-b (a) population structure in the form of one of (i) no subpopulation estimated to contain more than ___ mature individuals) **OR** (ii) at least 90% of mature individuals in one subpopulation	50	250	1 000
(b) Extreme fluctuations in number of mature individuals			

C can be used where we know the number of plants (usually) and **(1)** we have sufficient monitoring data to give a quantitative estimate to a decline in the number, or where this is not possible, **(2)** the population structure or dynamics indicates a degree of risk

For example, a species with 200 plants, that are declining (with not adequate quantitative data on the rate of decline), but one occurrence has 150 plants would be ranked as **Endangered** even though it has less than 250 plants because not all populations are less than 50 plants and the single largest population is 75% of the total:

i.e. Endangered **C (2) (a) (i)**

	CRITICALLY ENDANGERED	ENDANGERED	VULNERABLE
(D) (CR and EN) POPULATION SIZE ESTIMATED TO BE LESS THAN _____ MATURE INDIVIDUALS	50	250	not applicable
(D) (VU ONLY) POPULATION VERY SMALL OR RESTRICTED IN THE FORM OF **EITHER** 1) population estimated to number less than _____ mature individuals **OR**	not applicable	not applicable	1000
2) population with a very restricted area of occupancy (typically less than 20 km^2) OR number of locations (typically five or fewer) such that it is prone to the effects of human activities or stochastic events within a very short period of time in an uncertain future, and is thus capable of becoming Critically Endangered or even Extinct in a very short time period	not applicable	not applicable	applies

D is the most straight forward criterion as it revolves around the number of plants – but it is reliant on a recent and reliable plant count.

Species can be ranked as **Vulnerable** under **D(2)** if they have larger numbers of plants (over 1000), but these are either in a relatively small area or number of locations, which makes the species vulnerable to threatening processes that could result in the species becoming **Critically Endangered**.

IUCN RANKING:

Presumed Extinct	14
Threatened	
Critically Endangered	131
Endangered	115
Vulnerable	132
Conservation Dependent	
Data Deficient	

YEAR	PRESUMED EXTINCT	NUMBER DELETED	NUMBER ADDED
1991	53		
1992	43	10	
1993	40	4	1
1994	39	3	2
1995	39	0	
1996	27	12	
1997	25	2	
1998	23	2	
1999	22	2	1
2001	17	6	1
2002	16	1	
2003	15	1	
2004	15	0	
2005	14	1	
2006	14	0	
2007	14	0	
		44	**5**

DELETIONS:

25 Rediscovered in the field
8 Recent collections discovered in Herbarium collection (curatorial discoveries)
11 Deleted due to taxonomic revision

POORLY KNOWN FLORA IN W. AUST

- 1903 taxa (21/12/06)
- 76% of Aust in 1995
- cf. British flora of ~1200
- Rich and endemic flora / habitat loss
- Good Herbarium processes
- Need to prioritise => Priority Flora List
- Also 331 rare but not threatened

PRIORITY FLORA

The need for further survey of poorly known taxa is prioritised into three categories depending on the perceived urgency for determining the conservation status of those taxa, as indicated by the apparent degree of threat to the taxa based on the current information.

1 – 3: Poorly known taxa

4: Rare but not threatened

Priority One - Poorly known Taxa

Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat, e.g. road verges, urban areas, farmland, active mineral leases, etc., or the plants are under threat, e.g. from disease, grazing by feral animals, etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

Priority Two - Poorly Known Taxa

Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

Priority Three - Poorly Known Taxa

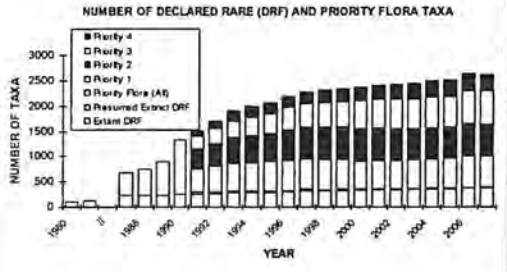
Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but are in need of further survey.

Priority Four - Rare Taxa

Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

SUMMARY OF PLANT TAXA WITH PRIORITY FOR CONSERVATION BY DEC ADMINISTRATIVE REGIONS
21/12/2006

	DECLARED RARE FLORA		PRIORITY CODES				TOTAL NO OF TAXA
REGION	R	X	1	2	3	4	
Kimberley	4	0	51	43	35	5	138
Pilbara	2	0	41	34	55	7	139
Goldfields	15	0	90	41	65	20	231
Midwest	114	1	194	171	239	74	793
Swan	58	0	42	54	84	77	315
South West	46	1	23	33	66	49	218
Warren	21	0	15	47	51	37	171
Wheatbelt	116	4	120	140	178	85	643
South Coast	93	5	112	196	188	141	735
Unknown		3	2				5
STATE*	378	14	615	634	654	331	2626



TAKING PRIORITY FLORA

cf. DRF – Minister/Director Nature Conservation

Priority 1 & 2 – Species & Communities Branch

Priority 3 & 4 – Regional/District Manager

2/10/02 DEPARTMENT OF CONSERVATION AND LAND MANAGEMENT Page 1
DECLARED RARE AND PRIORITY FLORA LIST
23 August 2001

SPECIES / TAXON	CONS CODE	CALM REGION	DISTRIBUTION	FLOWER PERIOD
Baeckea sp. Walkaway (AS George 11249)	3	MW	Nanson, Ambania, Walkaway, Burma Road Reserve, Mt Fanny, Mt Horner	Jan,Apr
Banksia scabrella	4	MW	Burma Rd Reserve, Walksway, Casuarina,Strawberry	-
Eremaea acutifolia	2	MW	Burma Road, East of Walkaway	Sep-Oct
Grevillea erinacea	3	MW,SW	Walkaway, Eneabba, Strawberry, Three Springs, Toodyay	Aug-Dec
Grevillea hirtella	3	MW	Walkaway, Burma Road, Geraldton	-
Hemigenia saligna	3	MW	Walkaway	Jun-Oct
Lechenaultia longiloba	4	MW	Walkaway, Strawberry, Mt Horner, Casuarina	Jul-Dec
Stylidium pseudocaespitosum	1	MW	Booksra, Walkaway	Sep

FLORA CONSERVATION

Species level:
- survey/inspection
- site management, eg. markers
- recovery plans

Habitat:
- impact on associated species
- regional processes, eg salinity

Threatening processes

FLORA RECOVERY

- Flora recovery teams
- Interim Recovery Plans
- Research, experimental management
- Full Recovery Plans
- Regional Management Programs
- Species & Communities Branch
- Threatened Flora Seed Centre
- Other agencies – BGPA

REGIONAL FLORA MANAGEMENT PROGRAMS

- Geographic area basis – focus on south west
- Preceded by survey program
- One/two page summary of each taxon
- Highlight threatening processes
- Set priorities for management and research
- 12 plans in place (two plans in Swan and 'Merredin')

INTERIM RECOVERY PLANS

- Policy to prepare within 12 months for Critically Endangered. As resources available for other.
- 5 year time frame, then review
- Detailed costed actions & responsibility
- Research, experimental management
- Aim to maintain or improve status

RECOVERY TEAMS

- Responsible for coordinating and driving program implementation
- Recovery teams – broad membership of land managers/owners, government, local government, community
- Departmental role in implementation
- Recovery Team may include specialist agencies – BGPA / Zoo
- Threatened Flora Seed Centre

RECOVERY TEAMS (2)

- 10 regional/district teams in place
- Threatened Flora Conservation Officers in place for each regional program (10)
- Regional Recovery Team will usually also incorporate species-based flora recovery plans
- Fauna recovery teams

Department of Environment and Conservation

RARE FLORA REPORT FORM

TAXON: _____ **DEFL POPULATION No.:** _____

DRF ☐ Priority Species: P____ Partial Survey ☐ Full Survey ☐ New Population ☐

FROM: _____ **TITLE:** _____ **SURVEY DATE:** ____/____/____

REGION: _____ **DISTRICT:** _____ **SHIRE:** _____

LOCATION: _____

_____

_____ **Reserve No:** _____

LATITUDE: ____° ____' ____" S **LONGITUDE:** ____° ____' ____" E **Map Used:** _____

GPS DATUM: AGD84 ☐ GDA94 ☐ GDA94-Compatible (e.g. WGS84) ☐ Unknown ☐ None ☐

LAND STATUS: Nature Reserve ☐ Private ☐ Gravel Res. MRD ☐ Rail Reserve ☐
National Park ☐ Pastoral Lease ☐ Gravel Res. Shire ☐ Rd. Verge Shire ☐
State Forest ☐ UCL ☐ Other Shire Res. ☐ Rd. Verge MRD ☐
Water Reserve ☐ Other ☐ Specify: _____ SLK _____ to _____
Landowner/manager present during inspection: ☐

LANDFORM: Hilltop ☐ Cliff ☐ Slope ☐ Valley ☐ Swamp ☐
Outcrop ☐ Breakaway ☐ Low Plain ☐ Gully ☐ Riverbank ☐
Ridge ☐ Sand Dune ☐ Flat ☐ Drainageline ☐ Lake Edge ☐
Firebreak ☐ Other ☐ Specify: _____

ROCK TYPE: Laterite ☐ Granite ☐ Dolerite ☐ Limestone ☐ Other: _____

ROCK FORM: Sheet ☐ Boulder ☐ Fluviatile Gravel ☐ Concretionary Gravel ☐

SOIL TYPE: Sand ☐ Loam ☐ Clay ☐ Peat ☐ Gravel ☐

SOIL COLOUR: Red ☐ Brown ☐ Yellow ☐ White ☐ Grey ☐

SOIL CONDITION: Moist ☐ Inundated ☐ Dry ☐ Saline ☐ Other: _____

VEGETATION CLASSIFICATION (Muir's): _____

ASSOCIATED SPECIES: _____

_____

_____

No. of PLANTS: Mature: _____ Seedlings: _____ Dead: _____ Actual ☐ Estimate ☐ Area Occupied: _____
(Leave blank if unable to observe, or no attempt made to count plants)

REPRODUCTIVE STATE: Clonal ☐ Flower bud ☐ Flower ☐ Immat. fruit ☐ Fruit ☐ Old Fruit ☐ Vegetative ☐

POLLINATORS: Native bees ☐ Honey bees ☐ Other insects ☐ Birds ☐ Mammals ☐
Other observations: _____

CONDITION OF POPULATION: Healthy ☐ Moderate ☐ Poor ☐ Disturbed ☐ Comment:

_____

_____

_____

POTENTIAL THREATS: Firebreaks ☐ Mining ☐ Recreation ☐ Roadworks ☐ Grazing ☐ Weeds ☐
Salinity ☐ Disease ☐ Prescribed Burning ☐ Other ☐ Comment: _____

FIRE HISTORY: Not known ☐ Burnt in 19____ Summer ☐ Autumn ☐ Winter ☐ Spring ☐

FENCING: Not Required ☐ Fenced ☐ Required ☐ Replace/Repair ☐

ROADSIDE MARKERS: Not Required ☐ Present ☐ Required ☐ Replace ☐ Reposition ☐

OTHER COMMENTS (include action taken/required): _____

_____

_____

_____

_____

VOUCHER SPECIMEN: Regional Herb. ☐ District Herb. ☐ WA Herb. ☐ Other ☐

_____

ATTACHED: Map ☐ Mudmap ☐ Illustration ☐ Photo ☐ Field Notes ☐

COPY SENT TO: Regional Office ☐ District Office ☐ Other ☐ Specify: _____

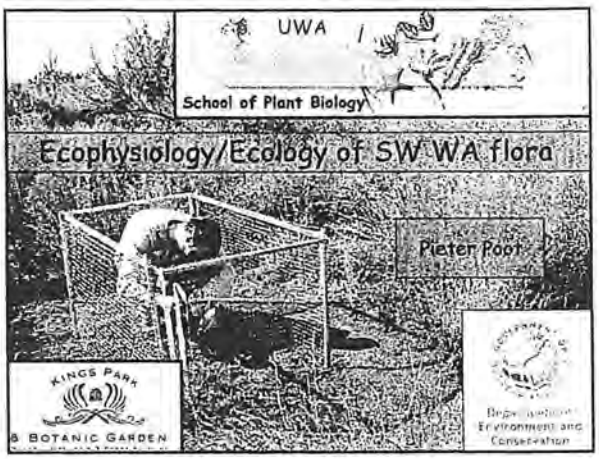
Signed: _____ Date: ____/____/200____

NOTE: Map or further information may be attached or given on the back of this form.

Please return completed form to Director General, DEC, Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983

RECORDS: PLEASE FORWARD TO ADMINISTRATIVE OFFICER, FLORA, SPECIES AND COMMUNITIES BRANCH

Ecophysiology



Outline of presentation

- Adaptations of species confined to a Threatened Ecological Community

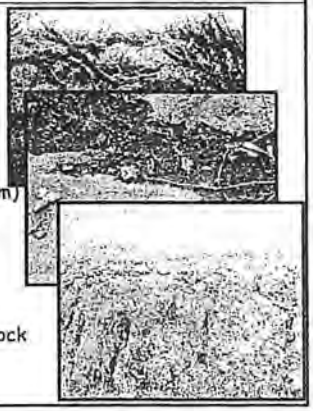
Ironstone communities:

- Consequences of a Threatening process to a widespread community

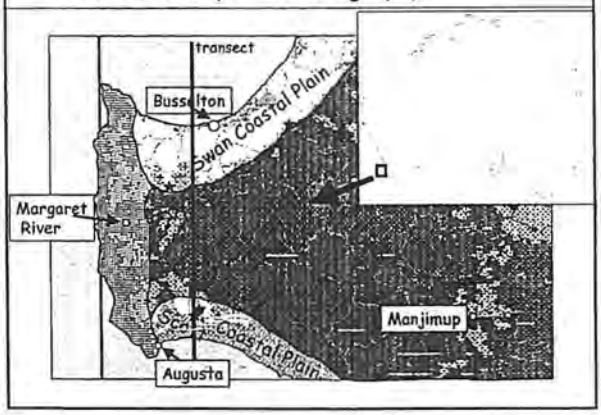
Wandoo woodland decline:
is climate change responsible?

Ironstone communities: what are they ?

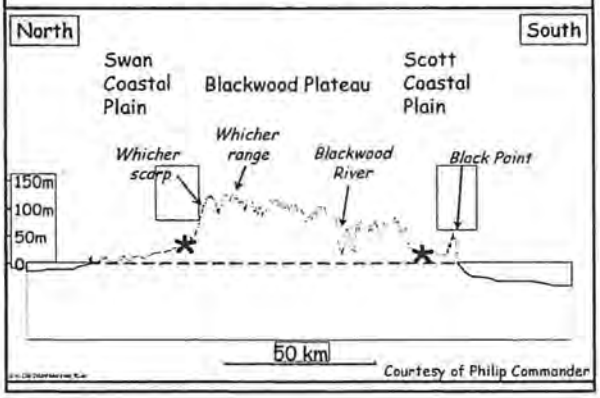
- Winter-wet shrublands
- Skeletal red soils (0-15 cm)
  (sandy loams)
- Over massive ironstone rock
  (up to 4m deep)



Where are they? → Geography

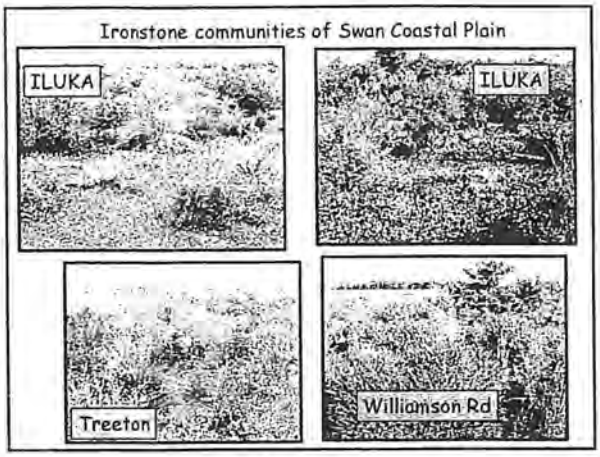


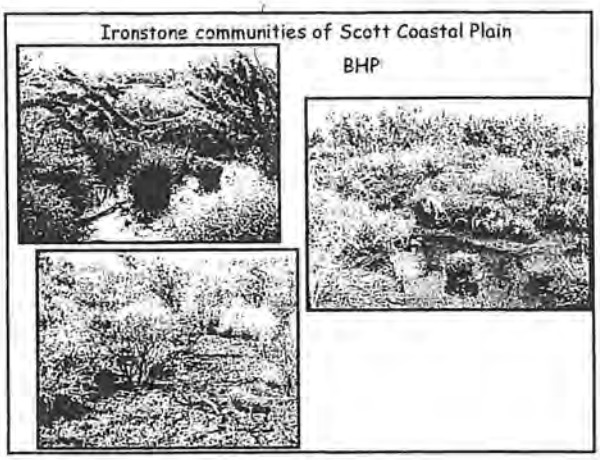
Where are they ? → Topography

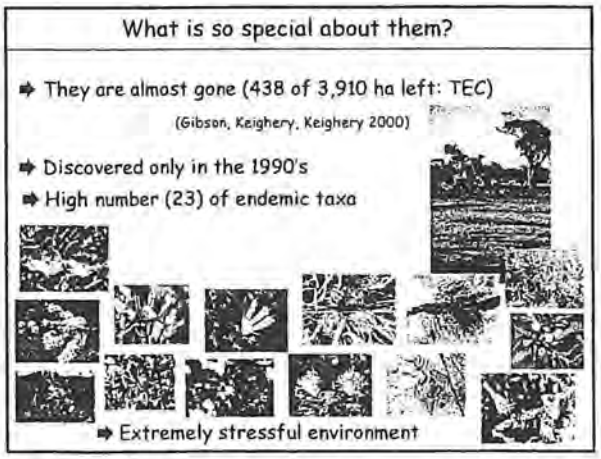


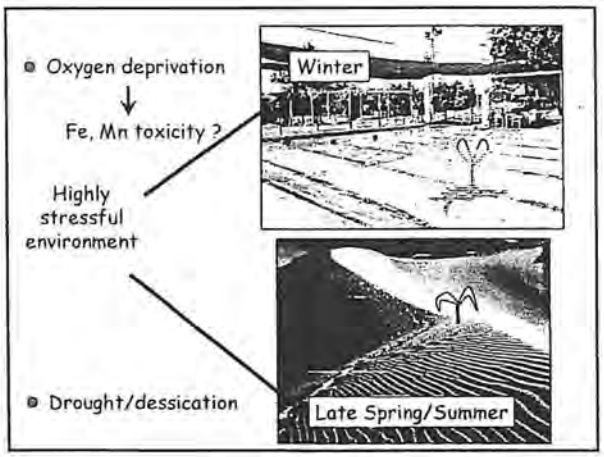
How were they formed?

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


Ironstone communities of Swan Coastal Plain
ILUKA
ILUKA
Treeton
Williamson Rd


Ironstone communities of Scott Coastal Plain
BHP


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



Main question

- Why are ironstone endemics so restricted in their distribution ?

→ Maybe: they are too specialised !

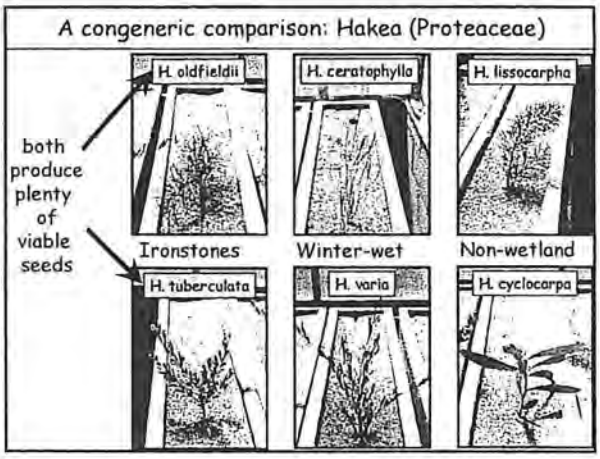
↓

Adaptations needed to be successful in their own highly stressful habitat

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

↘

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



First 'growth analysis' experiments

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

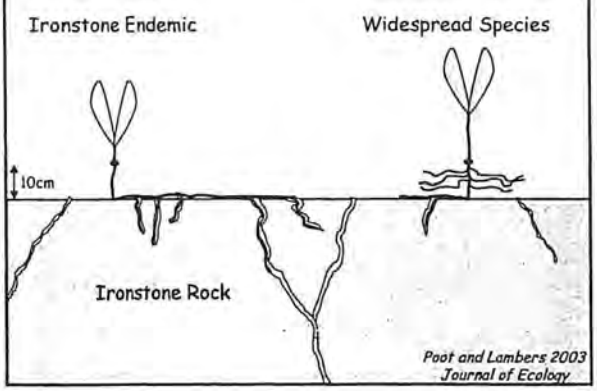
↓

It's all in the roots...

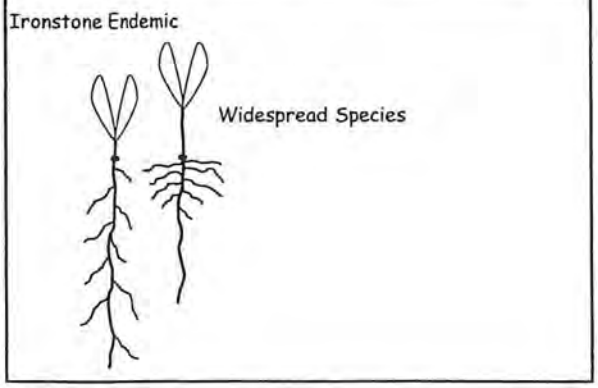
Ironstone endemics:

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

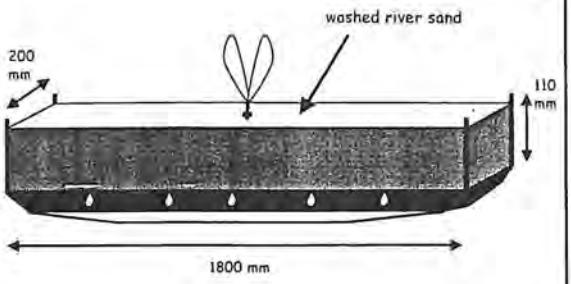
Model: a shallow ironstone habitat

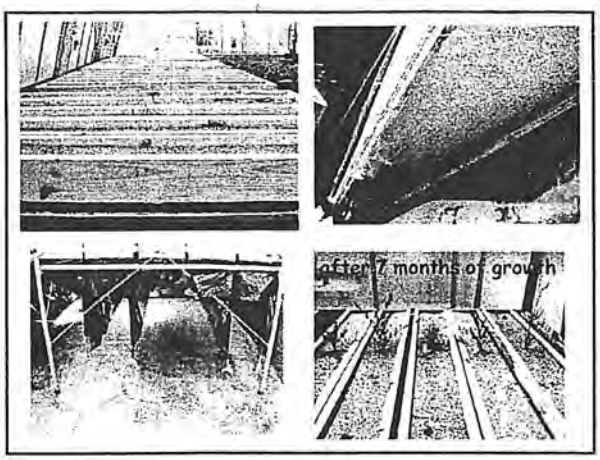


Model: a deeper soil

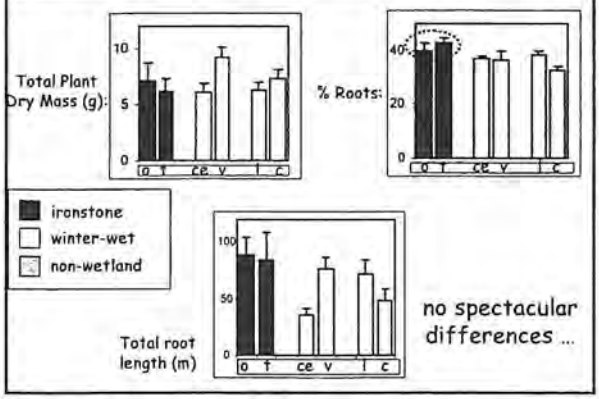


A more realistic pot design





Overall plant growth

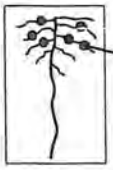


Detailed look at root systems:

1. Spatially: where did they put their roots?

2. Temporally: when did they put them there?

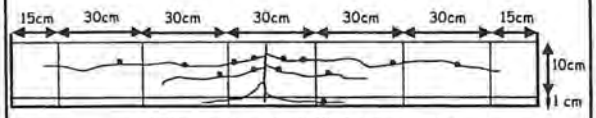
3. Functional: what type of roots did they put where? (cluster versus non-cluster)

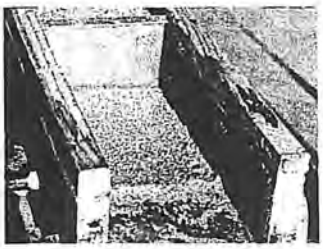


clusters: dense outgrowth of lateral rootlets

(involved in nutrient acquisition: mainly P and micronutrients)

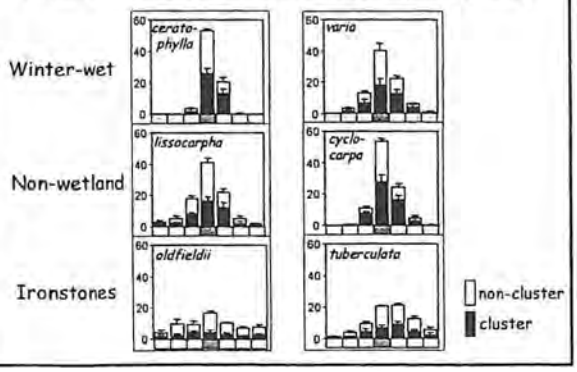
14 root compartments





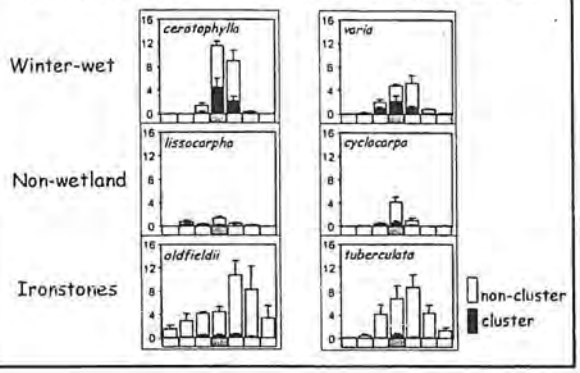
Spatially: where did they put there roots (superficial)?

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

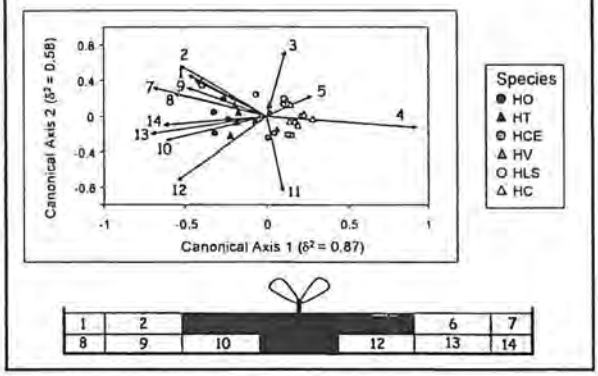


Spatially: where did they put there roots (deep)?

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

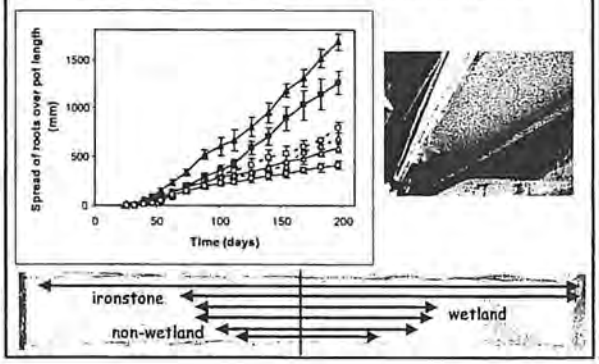


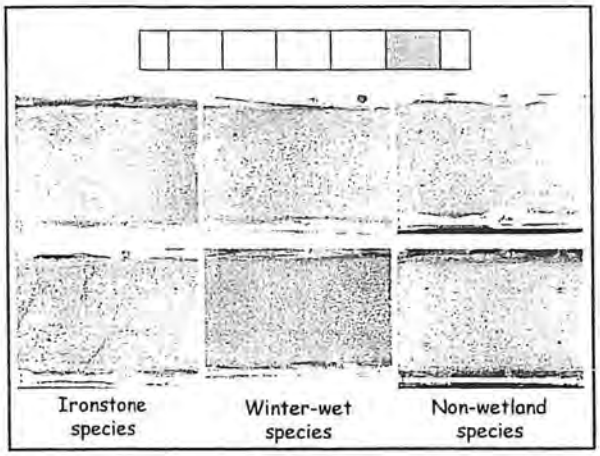
Similarities in root distribution pattern: Multivariate analysis (CAP)



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

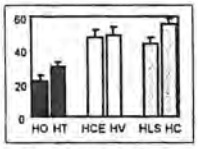
Temporal spread of roots (mm) over the bottom of the pots:





Functionally: different types of roots

% Cluster:



Cluster versus non-cluster roots

The most 'clustery' species

The least 'clustery' species

Can these differences really explain:

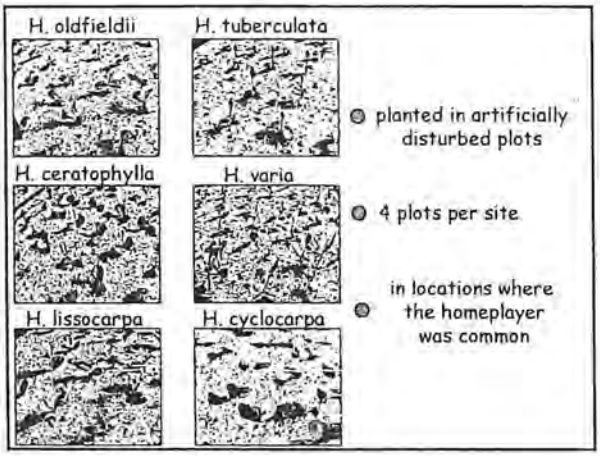
a) their success in their own habitat

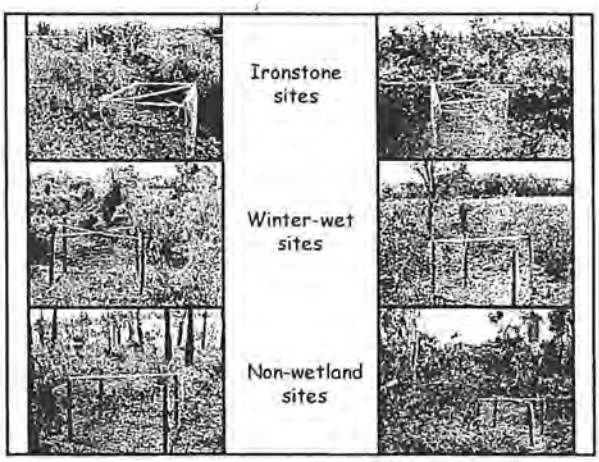
b) their failure in most others

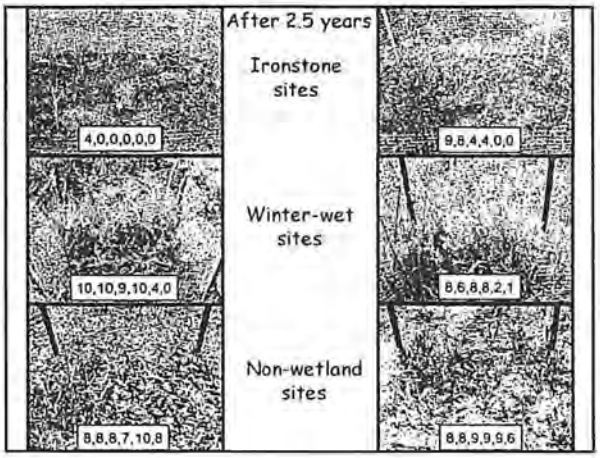
Back to the field: a reciprocal transplant experiment

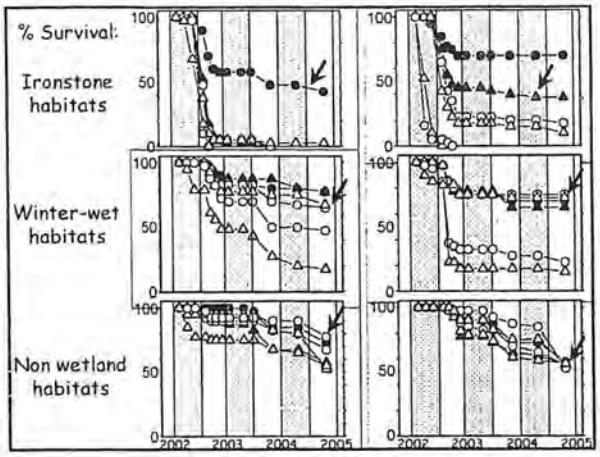
- collect seeds of the 6 Hakea species
- germinate species in glasshouse
- transplant young seedlings to kangaroo-proof plots in field

Each site has 1 'homeplaying' species


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


Ironstone sites
Winter-wet sites
Non-wetland sites


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



Conclusions ironstone communities

- ironstone Hakea's have a specialised root system morphology

SPECIALISTS!

↓

increased chance of finding a crack

↓

increased chance of surviving summer drought in their own habitat

decreased competitive ability in habitats on deeper soils ???

NOT SHOWN YET...

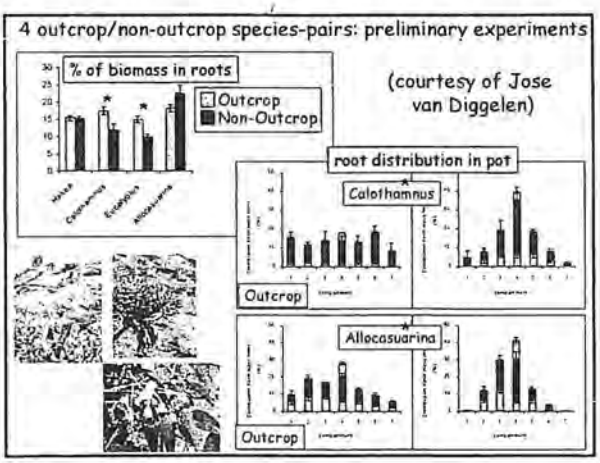
WHY?

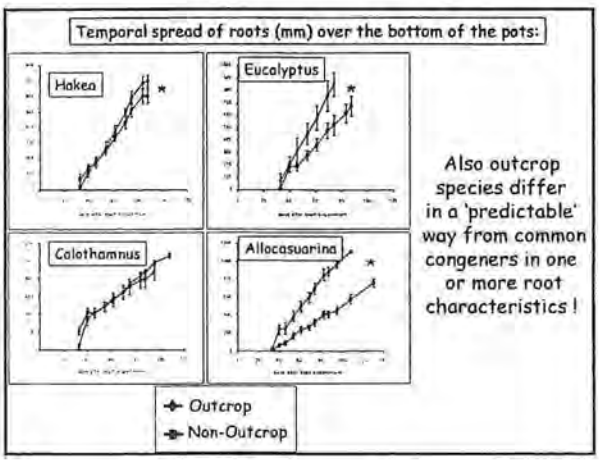
Apparently no disadvantage in other habitats... why?

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

Are findings relevant for other shallow-soiled habitats ?

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





Also outcrop species differ in a 'predictable' way from common congeners in one or more root characteristics !

Conclusions shallow-soiled communities (1)

shallow-soil habitats: very drought-prone environments

↓

strong selection for drought avoidance (tolerance)

↓

root specialization

↓

root system characteristics are more rigid

↓

loss in phenotypically plasticity

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

What works best?

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

↓

limit/costs?

Models evaluating costs and benefits of plasticity:

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

→ shallow-soil environments → many rare species worldwide !

Management implications ?

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

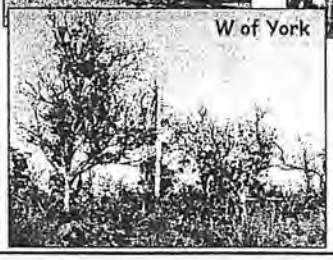
Outline of presentation

- Adaptations of species confined to a Threatened Ecological Community

Ironstone communities:

- Consequences of a Threatening process to a widespread community

Wandoo woodland decline:
is climate change responsible?



What many wandoos currently look like ...

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

What is causing the decline ? → Drought ?

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

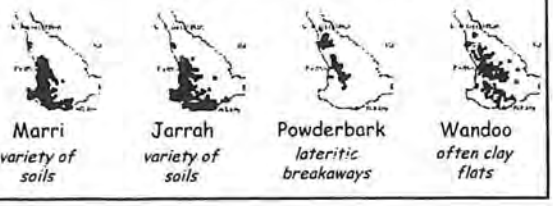
Last quarter century winter rain as % of previous 75 years

Other co-occurring eucalypt species seem less affected

↓

is Wandoo more vulnerable to drought ?

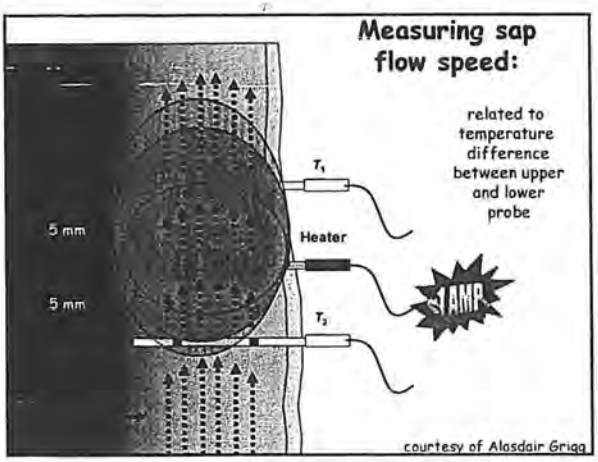
→ compare wandoo's daily and seasonal water relations with that of co-occurring eucalypts



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

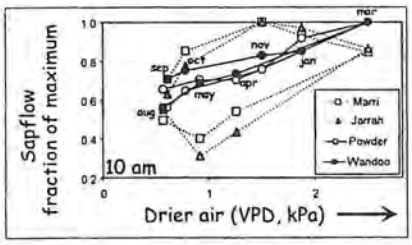
Measuring sap flow speed:

related to temperature difference between upper and lower probe



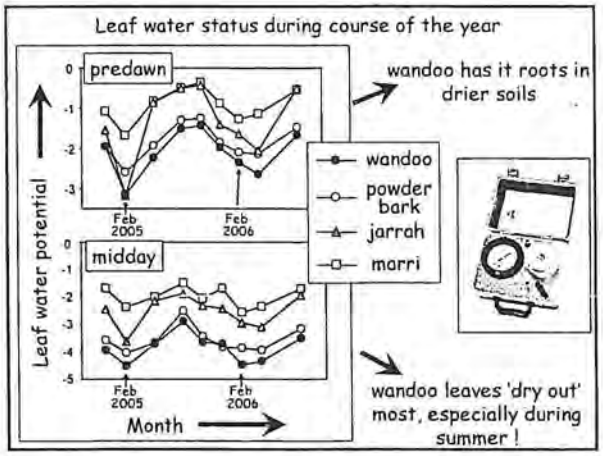
courtesy of Alasdair Grigg

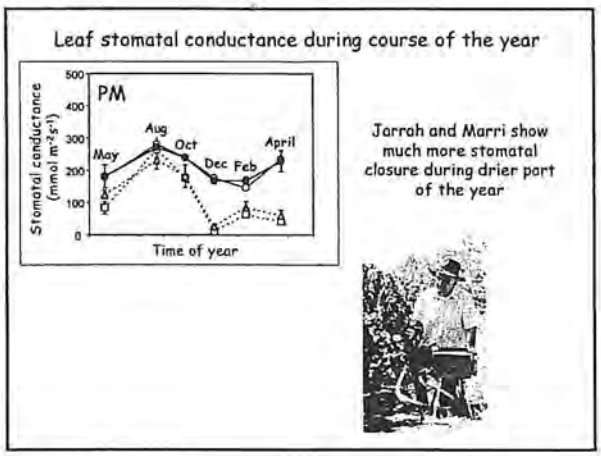
Relative sapflow velocity over the seasons:

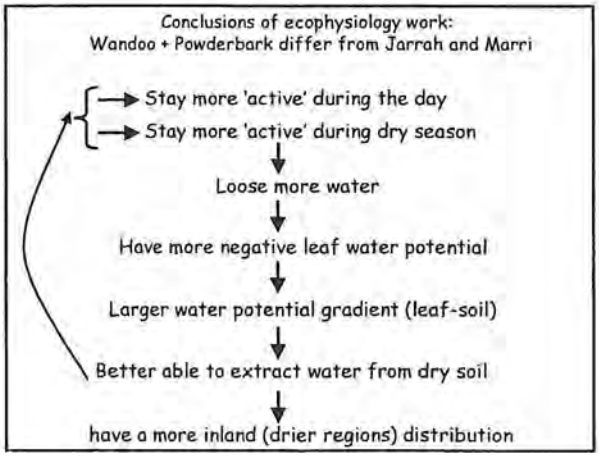


Powderbark + Wandoo:
tight coupling between 'dryness' of air and water loss (sapflow)

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


Leaf water status during course of the year
predawn
midday
Leaf water potential
Feb 2005
Feb 2006
Month
wandoo
powder bark
jarrah
marri
wandoo has it roots in drier soils
wandoo leaves 'dry out' most, especially during summer !


Leaf stomatal conductance during course of the year
PM
Stomatal conductance (mmol m-2s-1)
May
Aug
Oct
Dec
Feb
April
Time of year
Jarrah and Marri show much more stomatal closure during drier part of the year


Conclusions of ecophysiology work:
Wandoo + Powderbark differ from Jarrah and Marri
Stay more 'active' during the day
Stay more 'active' during dry season
Loose more water
Have more negative leaf water potential
Larger water potential gradient (leaf-soil)
Better able to extract water from dry soil
have a more inland (drier regions) distribution

Period of biggest drought stress (Feb/March)

↓

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

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

in trouble ?

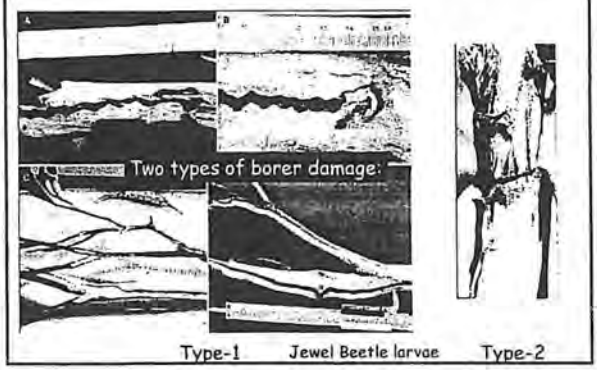
least conservative water user ?

↓

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

most stressed → most susceptible to pests???

Involvement of pests
(Ryan Hooper - Phytopathology - UWA)



General conclusions

- no clear indications about cause of the decline yet

↓

beetle larvae and fungi seem involved indirectly

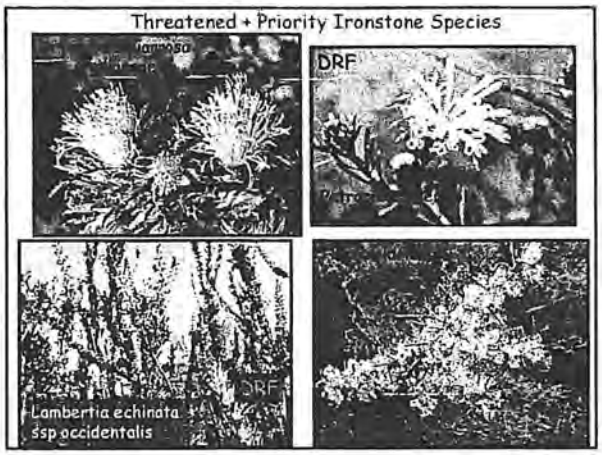
→ Why now?

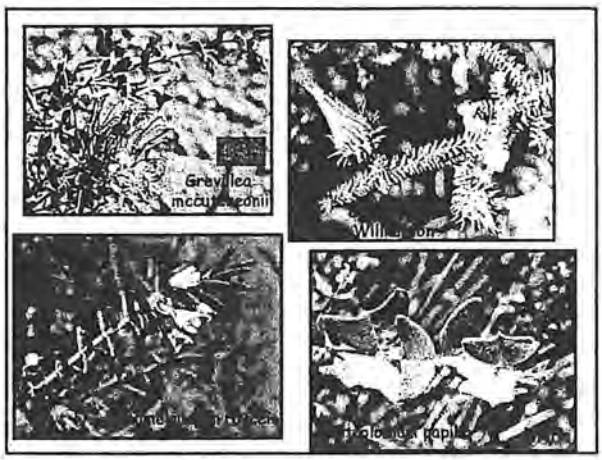
Increased stress:
- climate change
- salinity (clearing)

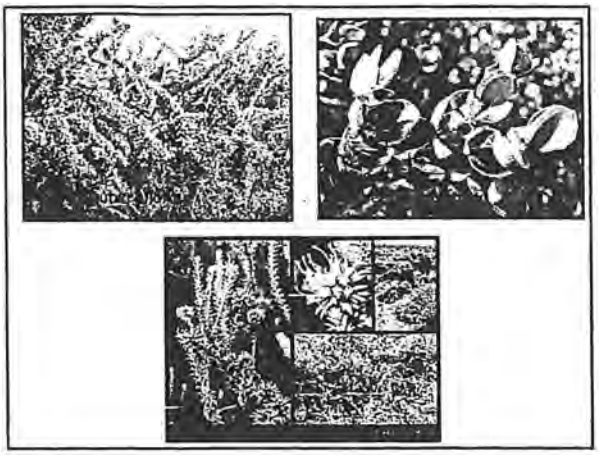
Future work (funds allowing...)

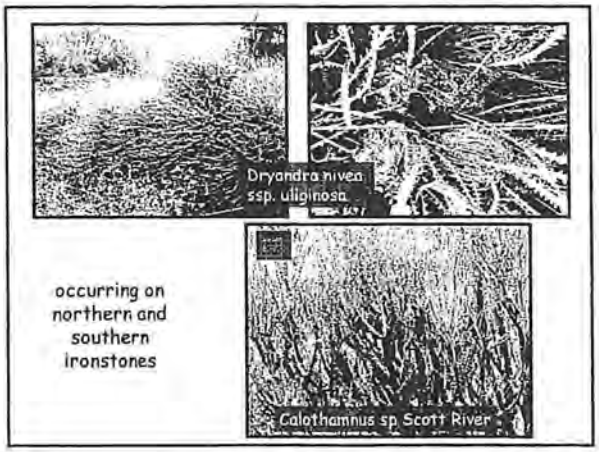
- Leaf physiology: what mechanism enables wandoo and powderbark to 'sustain such dry leaves'
- Start digging: get more insight in location and functioning of root systems
- Link between drought stress and pest/disease susceptibility

Threatened + Priority Ironstone Species








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

Ex-situ Seed Conservation

Ex Situ Seed Conservation

Flora Management Course 2007

Anne Cochrane & Andrew Crawford
Threatened Flora Seed Centre
Science Division

Department of Environment and Conservation

Course Content

Ex situ conservation
- DEC's Threatened Flora Seed Centre
- Millennium Seed Bank Project

Seedbanking strategies
- Provenance, timing of seed collection, fruit ripeness & seed predation
- Documentation
- Seed handling & storage

Assessment (multi-choice)

Aim of Course

To provide an understanding of the importance of seed collection for conservation purposes and to provide knowledge of basic seed identification, collection and processing

Ex situ conservation

Defined as the maintenance of samples of organisms away from their natural habitat

- seed
- pollen
- vegetative propagules
- tissue or cell culture
- living plants
- DNA

= "germplasm"

Opposite of *in situ* (on site) conservation

Can be readily incorporated into an integrated conservation strategy

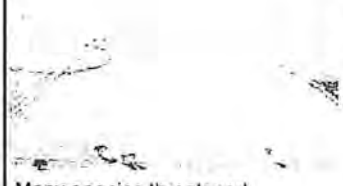
Ex situ conservation

Ex situ conservation is used as an interim solution to prevent loss of genetic diversity due to threatening processes such as salinity, disease, weed invasion and habitat loss.

It is a strategy that can be used as a last resort in preventing the extinction of a species

BUT <u>not</u> a substitute for in situ *conservation and is <u>not</u> a mandate for destruction of habitat*

Habitat fragmentation threatens the survival of many species in the agricultural zone of Western Australia



Many species threatened with extinction are found only in fresh or naturally saline lowlands, which are directly threatened by rising ground water and salinity

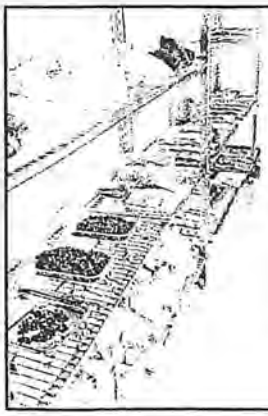
Phytophthora cinnamomi - dieback

"Unparalleled example of an introduced pathogen with a wide host range causing immense irreversible damage to unique and diverse plant communities"

Seed conservation

- Plants can produce seed in quantity
- Seeds are small & naturally dispersed
- Seeds are mostly desiccant tolerant
- Potentially long storage life
- Useful for propagation in the future
- Wide species applicability
- Technology is easy & cost effective

Seedbanking is a cheap insurance policy



Seed Longevity

Seeds of many flowering plants can be stored under low temperature and low moisture conditions for long periods of time without significantly reducing viability

Seed conservation

It allows access to biodiversity material for research both in- and out of-season thus removes pressure off *in-situ* populations.

It may represent the only option available if the remaining natural populations are to be conserved in the face of destruction of their habitat

Banking of seed is a means to an end

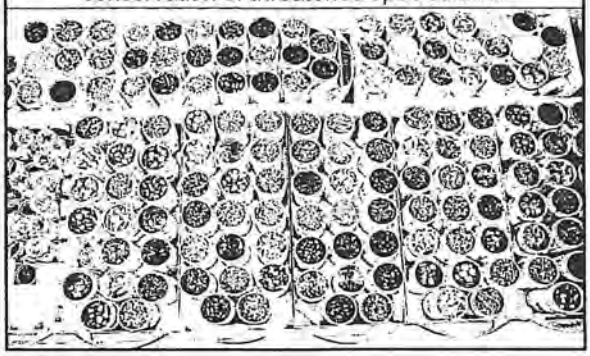
Seed conservation

In some cases material may be held in storage from populations that no longer exist in wild.....

Banksia brownii (at least 3 pops)

Dryandra anatona (1 pop)

But hopefully this will not be the last option for conservation of threatened species.....



Alternative methods

If plants do not produce viable seed

Vegetative propagation

1. Cuttings
2. Tissue culture

– More expensive, technology

Drawback *- use of clonal material requires many individuals to conserve diversity*

Natural Resource Management in Western Australia – The Salinity Strategy (2000)

Section 4.4.1 *Seed collection, storage and databasing*

...CALM (DEC) will establish and maintain a long term storage facility for seed of rare and threatened plant species located in saline environments...

National Strategy for the Conservation of Australia's Biological Diversity (1996)

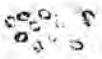
Objective 1.9: *Ex-Situ Conservation*

...to complement *in situ* measures, establish and maintain facilities for *ex situ* research into and conservation of plants, animals and micro-organisms...

Global Strategy for Plant Conservation (2002)

Target: *Conserving Plant Diversity*

... 60 per cent of threatened plant species in accessible *ex situ* collections, preferably in the country of origin, and 10 % of them included in recovery and restoration programmes...



Threatened Flora Seed Centre (TFSC)

- Established at CALM in 1992
- Initial commonwealth funding (ANCA)
- *Phytophthora* susceptible rare and threatened species
- Principle long term seed storage facility in Western Australia
- Additional funding – state, commonwealth & international

Objective of the TFSC

....to ensure the maintenance of genetically representative seed collections of Western Australian threatened flora under long term storage conditions as an interim solution to the prevention of genetic degradation or local extinction of threatened flora populations.....

A recent partnership with the Millennium Seed Bank of the Royal Botanic Gardens Kew, UK

has facilitated Western Australian seedbanking efforts through generous financial and technological inputs

Seed Collection Strategy

- What species will be collected?
- How many populations sampled?
- How many plants sampled?
- How much seed to collect per plant?
- Multi-year sampling may be required

Seed Collection Strategy

- What species will be collected?
- How many populations sampled?
- How many plants sampled?
- How much seed to collect per plant?
- Multi-year sampling may be required

What Species?

- Degree of threat
- Range of the species
- Number of individuals and populations
- Conservation status of the species
- Intended purpose of the collection

Intended Purpose of Collection

- Recovery and restoration
- Long term storage (insurance policy)
- Research - Disease susceptibility
  - Salinity tolerance
  - Seed biology
  - Genetic
- Display and Education
  - Botanic Gardens
  - Schools

TFSC Collecting Priorities

- Declared Rare & Priority Flora
- Species associated with Threatened Ecological Communities & Recovery Catchments
- Biodiversity Hotspots

Biodiversity Hotspots

Australian Department of the Environment and Heritage 2003

Seed Collection Strategy

- What species will be collected?
- How many populations sampled?
- How many plants sampled?
- How much seed to collect per plant?
- Multi-year sampling may be required

Sampling Populations

- Pops evolved & adapted to local conditions
- Local pops most suitable for site rehabilitation (long term survival & ecological processes)
- Variation between pops may reflect critical reproductive and physiological differences
- Sample from all populations if possible to maximise diversity of collection
- Keep seed from different populations separ

Seed Collection Strategy

- What species will be collected?
- How many populations sampled?
- How many plants sampled?
- How much seed to collect per plant?
- Multi-year sampling may be required

Sampling Plants

- Sample at least 50 plants in a population to increase variation
- Random stratified sampling throughout pop & equal proportions of seed from each individual plant sampled
- Sample from a range of sizes, shapes etc and include those from a range of ecotypes
- Ideally, keep seed from separate plants in separate bags (particularly if DRF)

Seed Collection Strategy

- What species will be collected?
- How many populations sampled?
- How many plants sampled?
- How much seed to collect per plant?
- Multi-year sampling may be required

- Take no more than 10-20 % of the seed crop of a particular plant unless that plant and the immediate habitat will be destructed eg clearing, road maintenance etc.
- Remaining seed will allow natural regeneration to occur & provide material for the soil seed bank

Objective: *collect genetically representative sample of the population without damaging any plants prospects for survival in the wild.*

Seed Collection Strategy

- What species will be collected?
- How many populations sampled?
- How many plants sampled?
- How much seed to collect per plant?
- Multi-year sampling may be required

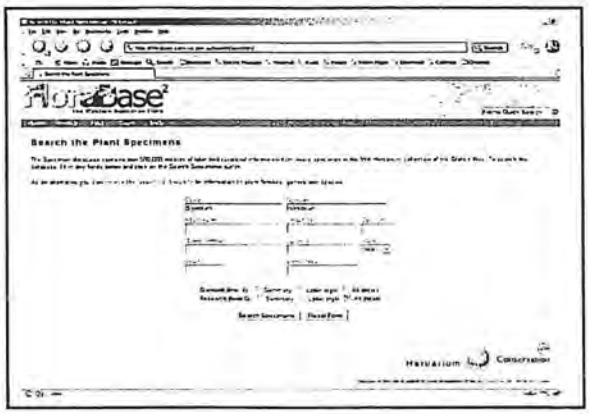
Repeat Sampling

It is not always possible to collect sufficient seed for the desired purpose all in one go without affecting the demography and/or reproductive capacity of the population.

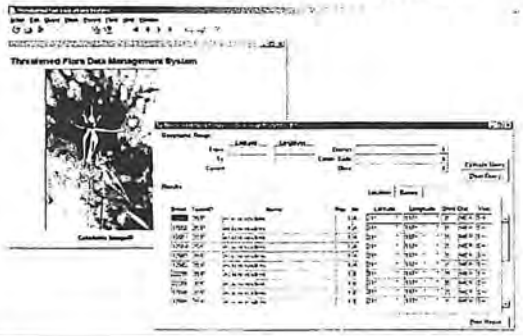
Multi-season or multi-year sampling may be required.

Planning a Collecting Trip

- Florabase records
- DEFL Records
- RFRF
- Mud maps
- Species information
- Herbarium specimens
- Topographic maps
- ARCVIEW tool to collate



DEFL Threatened flora database

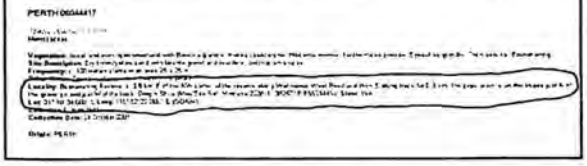


Paper Files (RFRF & mud maps)

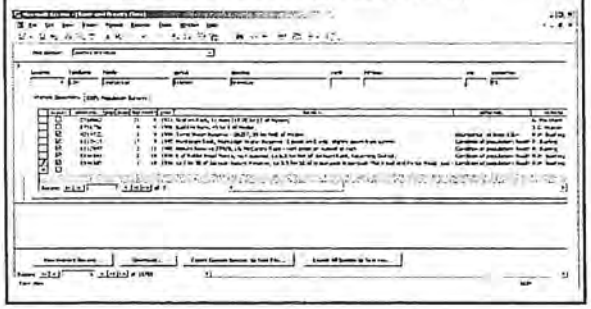
Species Information

Data Gathering

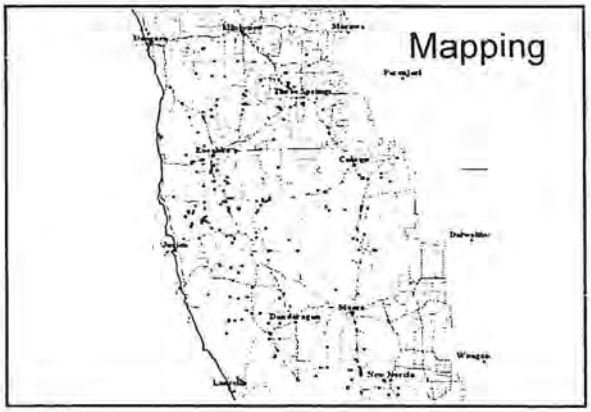
- Good location information
- Recent record
- Good site/habitat description
- Information on plant numbers

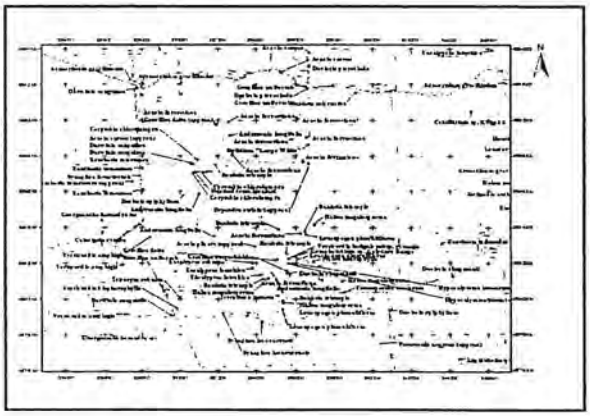


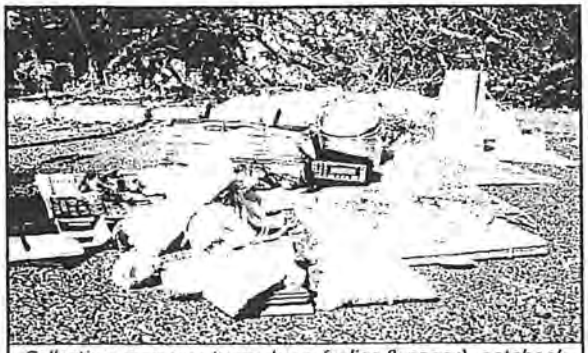
Collating Information
(TFSC collecting database)



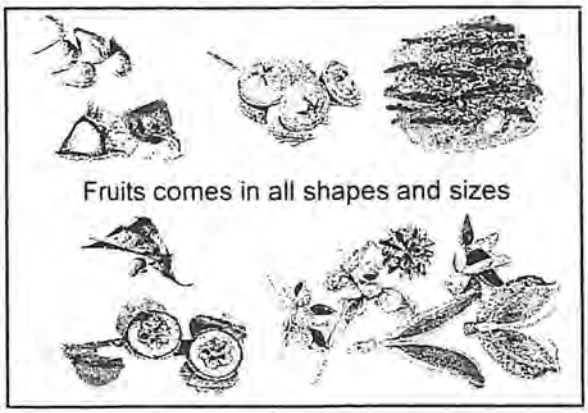
Mapping

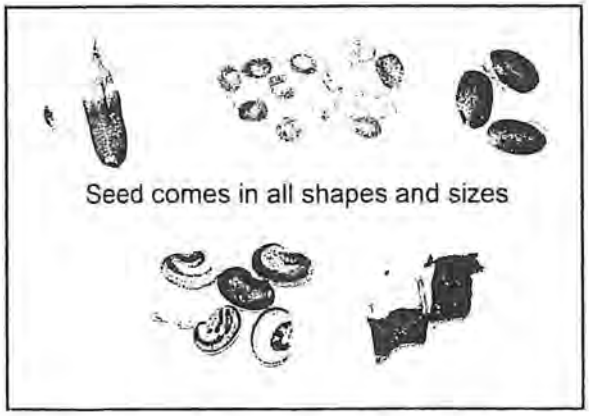






Collecting gear: secateurs, bags (calico & paper), notebook, plant press, maps, GPS.....





Seed Collection Techniques

- Hand picking (individual seed/ fruits)
- Pruning with secateurs
- Bags (eg stockings/ muslin)
- Extended pole pruners
- Stripping
- Shaking branches
- Collecting from ground
- Seed traps

Hand picking *Goodenia*

Stocking bags over *Grevillea* fruits

Seed trap for *Adenanthos*

Pole sling shot for collecting seed from tall trees

Timing of Collections

- Take into account natural seed storage and dispersal mechanisms
- Sample at point of natural dispersal when fruits/seed are mature
- Time to maturity varies from species to species, from site to site and is dependant on environmental factors
- Recollect over several weeks if necessary

Info on reproductive biology helps to decide on time of collection

There is very little known about the interval between flowering and fruiting

Fruit Ripeness

- changes in fruit colour
- changes in seed coat colour
- fruit splitting or breaking open
- fruit that are hard and dry
- seed rattling
- some seed already dispersed
- fleshy fruits going soft

There are always exceptions!

Seed Quality is partly determined by:

- the stage at which the seeds were collected
- how seeds were handled after collection

Seed quality affects seed longevity & germination

Darwinia acerosa
Fruit on left empty; fruit on right full

Insect Predation

Signs of insect activity include -

- frass (looks like sawdust)
- holes
- webbing

Collect good fruit and seed only
Predated fruit/ seed may be damaged

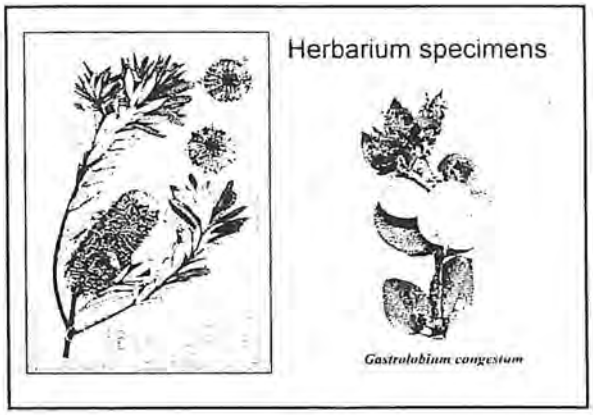
Insect predation of *Grevillea* fruits

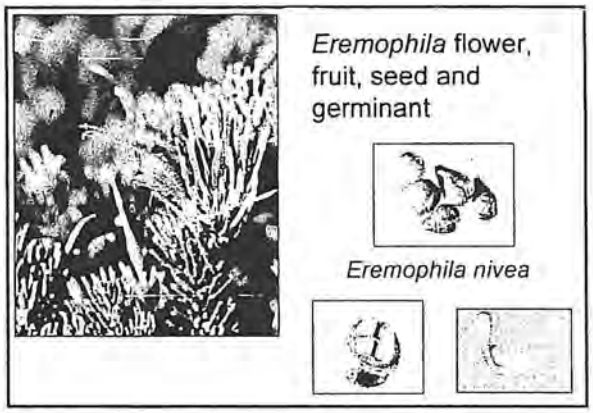
Insect predation of *Acacia* fruits

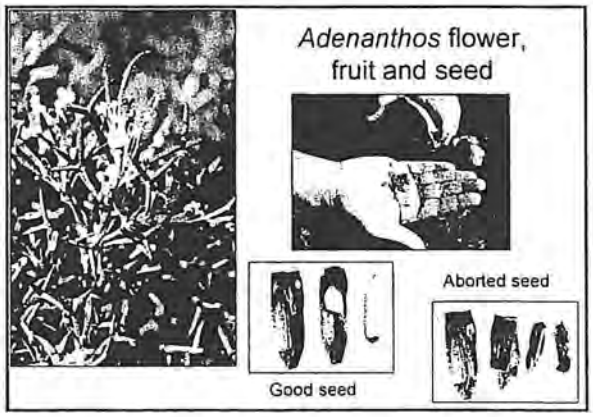
Collection Information

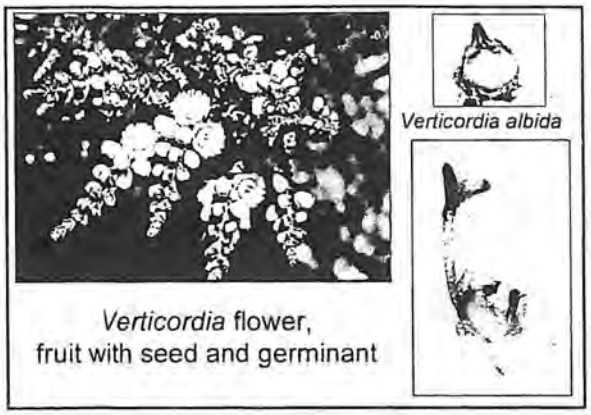
- Genus, species, subspecies
- Exact location (GPS if possible)
- Collector, collection date & collecting number
- Number of plants sampled
- Additional information (eg pollinators, health, ecology, associated species, soils, phenology)

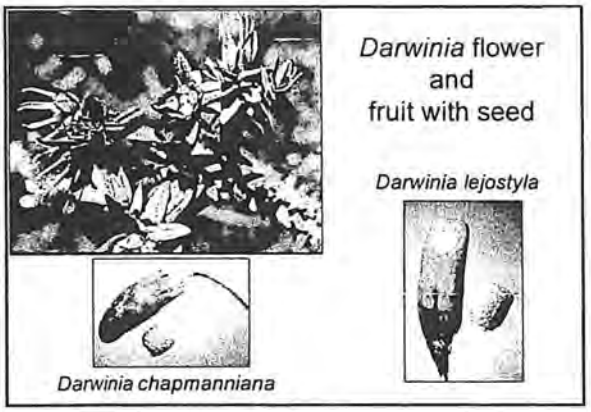
Information is almost as important as the seed itself

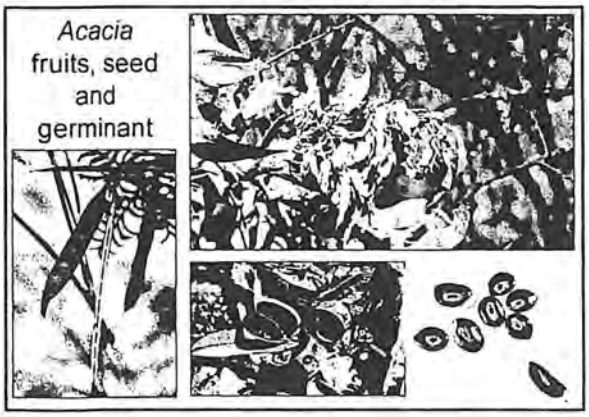

Herbarium specimens
Gastrolobium congestum


Eremophila flower, fruit, seed and germinant
Eremophila nivea


Adenanthos flower, fruit and seed
Aborted seed
Good seed


Verticordia albida
Verticordia flower,
fruit with seed and germinant


Darwinia flower
and
fruit with seed
Darwinia lejostyla
Darwinia chapmanniana


Acacia
fruits, seed
and
germinant

Hints for Seed Collection

- Know your species
- Examine bounds of pop. Is there a mixture of species?
- Examine seed carefully - collect ripe /mature seed only
- Random & equal sampling
- Ensure equipment is clean - **don't introduce disease**
- Collect sufficient seed but don't over collect
- Collect herbarium specimen(s)
- Collect in dry weather if possible
- Reduce risk of herbivory/fungal growth
- Use breathable containers - paper and calico bags
- Label containers and do not damage seed

Remember!

It is illegal to collect any plant material (seed, herbarium specimens, cuttings etc) in Western Australia without a licence.

What makes a good collection?

- Priority species, accurately identified
- Good quality seed
- Sufficiently sized to meet needs (be aware of predation, low seed set, aborted & immature seed)
- Plants & populations not damaged or over collected
- Genetically representative of species/pop
- Single species – no hybridisation or mixed pops
- Adequate data (incl herb spec)

Remember!

- Plants may not seed all year round so allow time to plan & execute collections
- More than one visit may be required to collect sufficient seed for intended use
- Consider costs associated with collections – eg vehicle running, time in field...

Threatened Flora Seed Centre staff can provide advice on protocols for:

- Seed collection
- Seed germination/viability testing
- Seed storage

Seed handling & storage

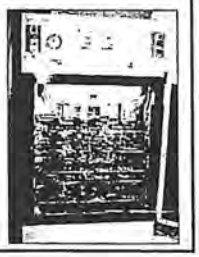
- Handle seed gently & keep cool and dry
- Store seeds in calico/paper not plastic
- Make sure that the bags are well sealed & well labelled

Store seed temporarily under conditions which will maintain maximum viability until incorporation into long term storage facilities.

Don't let time in the field be wasted

After the field work.....

1. Seed cleaning
2. Seed quality assessment
3. Seed quantification
4. Seed germination



Then seed is ready for packing, storage and monitoring of viability

Good seed can last 50+ years in storage

Translocation

Translocation of Threatened Flora.

Leonie Monks
and Andrew Crawford

Course content

- Background on translocations
- Method of translocating
- Monitoring translocations
- Case Studies

General Aim of the Presentation

To provide the participants with the basic knowledge of translocation methodology and the understanding of how translocations can be used in the conservation of threatened flora.

Learning Outcomes

1. Demonstrate an understanding of plant translocations and how they can be used as part of Threatened Species Management Programs.
2. Discuss the procedures that need to be followed when planning, setting up, and monitoring a plant translocation.

What is a translocation?

A translocation is the deliberate transfer of plant material from one area to another for conservation purposes.

(from the "Guidelines for the Translocation of Threatened Plants in Australia" by the Australian Network for Plant Conservation, 2004).

Categories of translocations.

- Re-stocking: increase of population size by adding individuals to an existing population.
- Re-introduction: establishment of a population in a site where it formerly occurred.

Categories of translocations

- Introduction: establishment of a population in a site where it is not known to have occurred, but is within the known range and habitat.
- Conservation Introduction: establishment of a population in an area that is outside the known range, but which is appropriate habitat.

Aims of translocation.

1. Increase the number of individuals and viable populations of threatened plant taxa.
2. Investigate different techniques that will enhance establishment and survival of these translocated taxa.

When to consider translocation.

Translocations are considered when:

- the species is rare and/or threatened.

AND

- threats to natural populations cannot be successfully managed on site.

In addition consideration must be given to:

- ability to grow plants.
- availability of long term funding.

Protocols used for developing a translocation.

1. Site selection

- Sites are selected based on the following criteria:
  - –Absence of threatening processes
  - –Security of land tenure
  - –Similarity of associated vegetation type & structure
  - –Similarity of soil type

- How many sites should be selected?

Protocols used for developing a translocation.

2. Translocation proposal

- This document describes all aspects of the proposed translocation.
- It must be endorsed by all interested parties.

- It is then submitted to the Species and Communities Branch for departmental approval.

Protocols used for developing a translocation.

3. Plant propagation phase

This may utilise either:

- The seed resources of the Threatened Flora Seed Centre for
  - - direct seeding
  - - raising seedlings
- Cutting material
- Material raised from tissue culture techniques.

Protocols used for developing a translocation.

4. Raising of the plants

- plants should be raised at an accredited nursery to ensure plants and soil are disease free.
- it is **VITAL** that good records are kept of the origin of the plant material and the method in which the plants were raised.

Protocols used for developing a translocation.

4. Raising of the plants
   - sufficient time must be allowed to collect seed or cutting material and grow propagules on to an suitable age for planting.
   - how many plants?

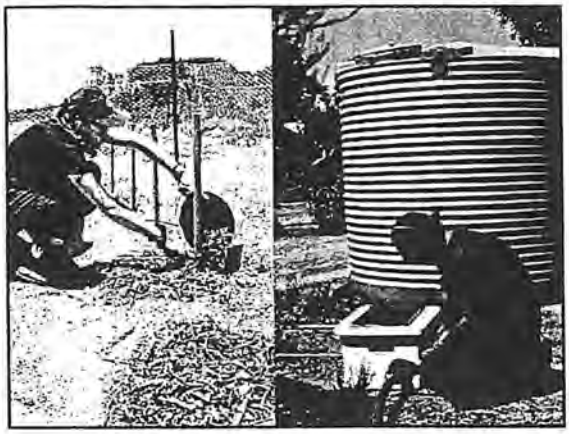
Protocols used for developing a translocation.

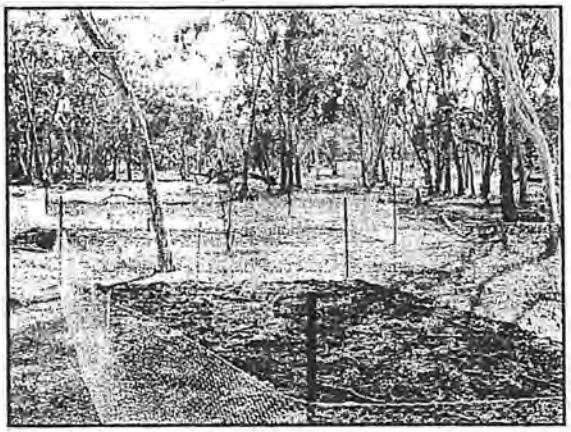
5. Planting
- Consider the best time for planting.
- When planting need to:
  - permanently tag transplants
  - consider the layout of the plants within the translocation site.

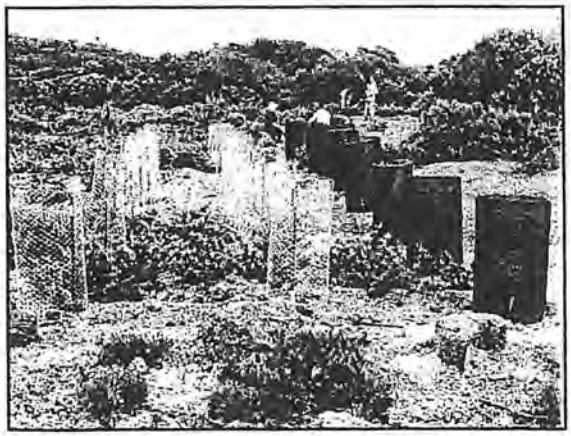
Protocols used for developing a translocation.

5. Planting

When planting consideration should also be given to level of after planting care.
- -watering
- -mulching
- -protection against herbivores
- -protection against sun and wind.







Protocols used for developing a translocation.

6. Monitoring.

- Should include counts of:
  - survival
  - measurements of growth
  - counts of buds,flowers, fruit.

Protocols used for developing a translocation.

6. Monitoring.

- Should also include these same measurements for the natural populations.
- It is essential that monitoring data is forwarded to the translocation database at Kensington.

Protocols used for developing a translocation.

7. Assessing the success of the translocation

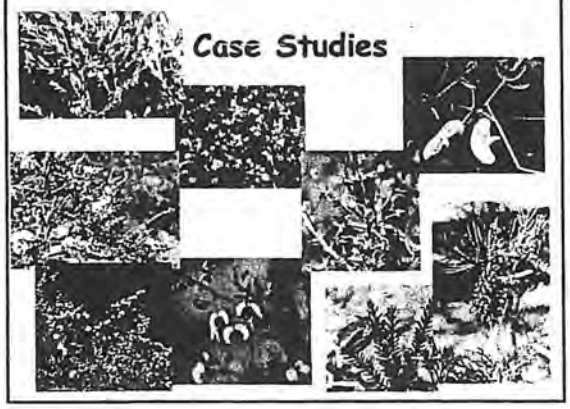
Success can divided into 2 phases:

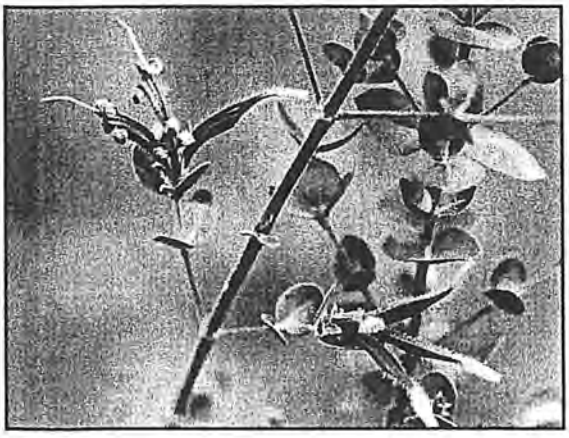
- Short term
  - Survival, growth and reproduction of plants
- Long term
  - new population able to be self sustaining
  - maintenance of adequate level of genetic diversity.

Protocols used for developing a translocation.

7. Assessing the success of the translocation.
- Comparison with natural population.
- Whether you successfully achieved the aims of the project.

Case Studies

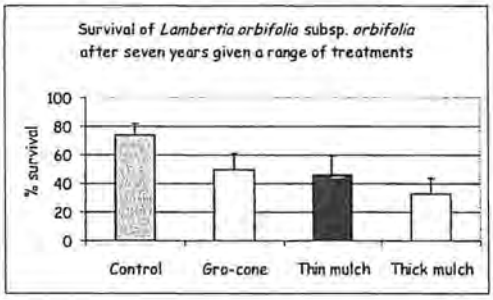




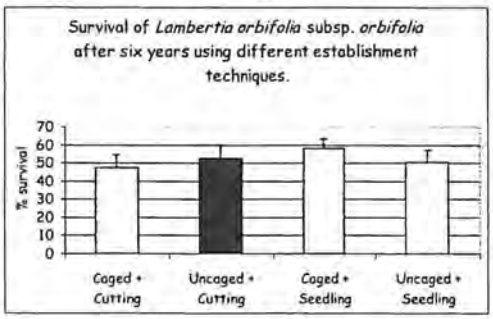
Case Study: *Lambertia orbifolia* subsp. *orbifolia*.

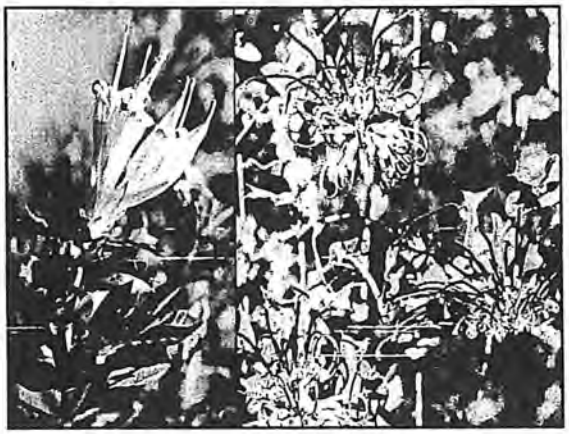
- 55% survival overall in 2005
- 104 naturally recruited seedlings (second generation suggests population has potential to be self sustaining).

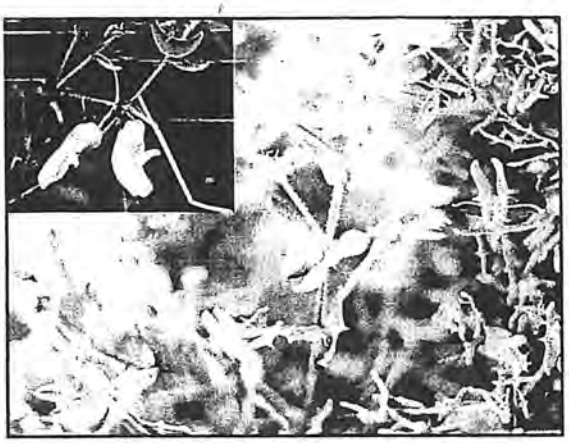
Case Study: *Lambertia orbifolia* subsp. *orbifolia*.

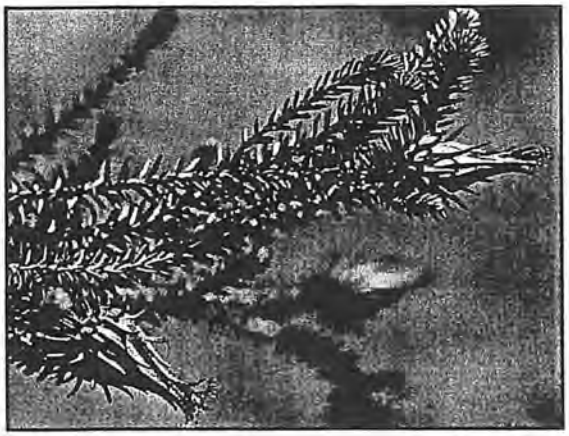


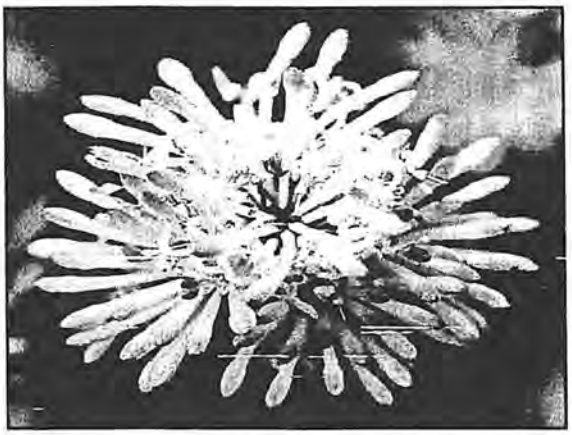
Case Study: *Lambertia orbifolia* subsp. *orbifolia*.

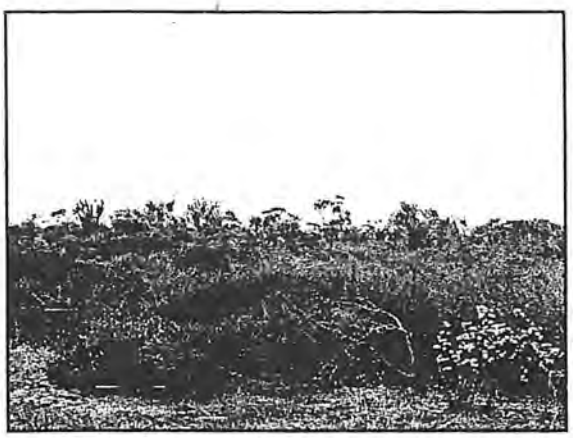












Case Study: Ironstone species

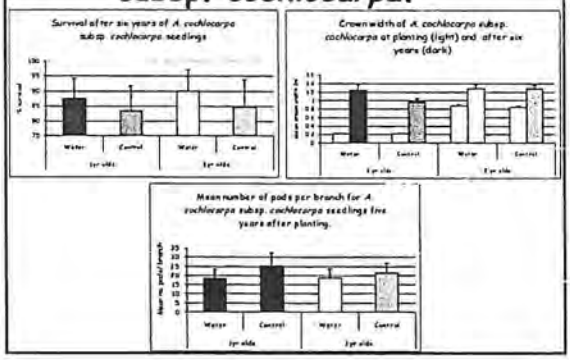
Percent survival of translocated *Grevillea maccutcheonii* after three years.

Treatment	% survival
Mounded	32
Mounded/Ripped	51
Mounded/Shaded	50
Mounded/Ripped/Shaded	62
Mounded /Ripped/Watered	42
Mounded/Ripped/ Watered/Shaded	78

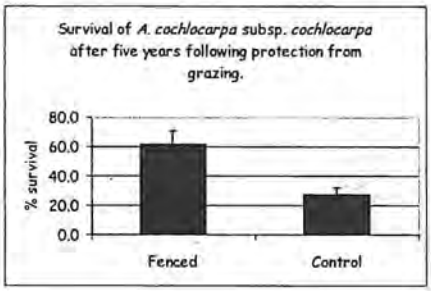
Case Study: *Acacia cochlocarpa* subsp. *cochlocarpa*.

- 779 seedlings and 1500 seed planted.
- 65% survival of seedlings in 2005.
- 6% of seed germinated.
- 64% of germinated seeds survive in 2005.

Case Study: *Acacia cochlocarpa* subsp. *cochlocarpa*.



Case Study: *Acacia cochlocarpa* subsp. *cochlocarpa*.



Acknowledgements

- Conservation and Land Management staff.
- Kings Park nursery.
- Numerous volunteers.
- Natural Heritage Trust.
- World Wide Fund for Nature.
- Salinity Action Plan.

Scenarios

There are now some scenarios about translocations for you to discuss in small groups.

Threatened Ecological Communities

To be covered:

- Elements of biodiversity
- Plans, Policies and Legislation
- Identifying TECs
- Recovery process
- Examples

Levels of biodiversity

- Ecosystems/landscapes
- Communities
- Species
- Populations
- Individuals
- Genes

Legislation and Policies 1

- *Wildlife Conservation Act 1950* (very out of date)
- Does not provide for listing TECs
- New Biodiversity Bill – planned
- Non-statutory listing process developed in WA (new draft Policy 9 describes)
- Some WA TECs listed under EPBC Act

Legislation and Policies 2

- Other WA legislation used to protect TECs, eg EP Act, NOIs under *Soil and Land Conservation Act 1948*
- 16 WA TECs listed under C'wealth EPBC Act

Legislation and Policies 3

EP ACT CLEARING REGULATIONS

- July 2004 *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* made under the *Environmental Protection Act 1986* came into operation.
- Clearing of vegetation requires a permit, unless for exempt purpose

Legislation and Policies 4

EP ACT CLEARING REGULATIONS

- TECs are defined as Environmentally Sensitive Areas (ESAs)
- Routine day-to-day activities of vegetation clearing allowed with no permit do not apply to ESAs
- Any clearing proposals for ESAs to be under a specific permit

CALM's Corporate Plan 1

Conserving Biodiversity

First Objective:

To protect, conserve and where necessary and possible, restore WA's natural biodiversity

CALM's Corporate Plan 2

4th strategy under first objective:

To recover threatened flora, fauna and ECs.

- Identify and specially protect TSCs
- Priority rank them for conservation
- Prepare and implement RPs for the most threatened TSCs

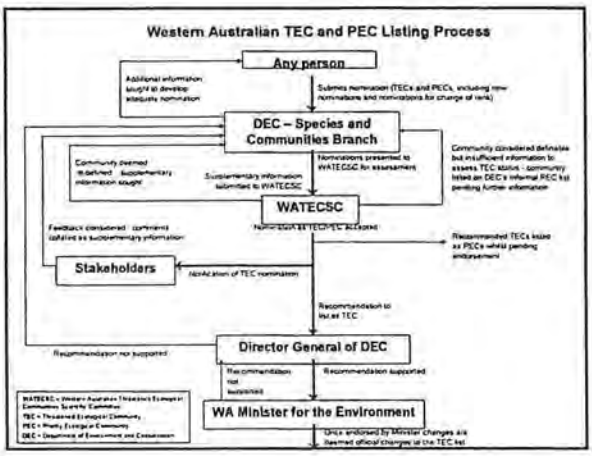
New Draft Policy 9

'*Conserving threatened species and ecological communities*'

- Describes process of TEC conservation ('Recovery Process')
- Objective 'No listed threatened species or ecological community to be lost through human action or inaction'

New Policy 9

- Describes constitution of TEC Scientific Committee
- Recommendations of TECSC sent to Director Nature Conservation
- Endorsement of Minister required



Ecological Community defns 1

- **Ecological Community:**

  A naturally occurring biological assemblage that occurs in a particular type of habitat.

Ecological Community defns 1

A **threatened ecological community** (TEC): is one that meets the criteria as;

- 'presumed totally destroyed',
- 'critically endangered',
- 'endangered' or
- 'vulnerable'.

Ecological Community defns 2

- **Priority Ecological Community (PEC):** A possible threatened ecological community
- does not meet survey criteria or is not adequately defined,
- is adequately known and rare but not threatened, has recently been removed from threatened list and requires regular monitoring,
- or is conservation dependent (high priority for further work to clarify status).
- P1-5 (indicates urgency for further work to clarify status)

Identifying TECs 1

- Defined based on Regional Vegetation survey (eg Beard, SCP survey, Kimberley Rainforest survey, South Coast mountain top survey)
- Some defined from smaller scale surveys (eg PhDs, consultants reports, reports on caves, mound springs), put into regional context

Identifying TECs 2

Information requirements:

- Community well described/defined
- Distribution known
- Know when it is considered 'destroyed'
- Can allocate to a threat category

Identifying TECs 3

- Nominated to TECSC as 'threatened' or Priority by Regions/Project Officers
- If accepted, endorsement (of TECs) of listing by DNC, Minister
- Deemed to be a TEC in WA (69 to date)

TEC database 1

TEC database

- Database of TECs resides at Kensington
- Consists of Access tables and Arcview spatial components
- Contains location and boundary data for occurrences

TEC database 2

TEC database

- Includes description, category, threats, recommendations and actions
- Is distributed regularly to many users (DEC users too!)

TECs/PECs by IBRA Region

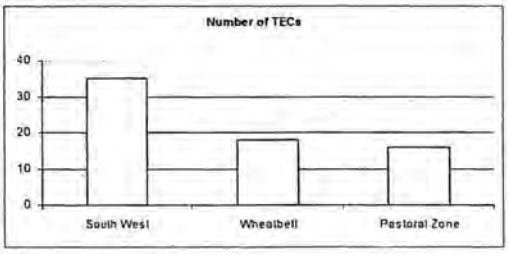
TEC Hotspots 1

- Wetlands in young coastal dunes
- Claypans
- Soils on eastern side SCP (eg Pinjarra Plain, Ridge Hill Shelf, Dandaragan Plateau)
- Wetlands on the eastern side of the SCP
- Limestone ridges
- Vegetation on Muchea Limestone (E side SCP)
- Coastal vegetation with *Callitris preissii (*Rottnest Tea tree*)* or *Melaleuca lanceolata (*moonah*)*

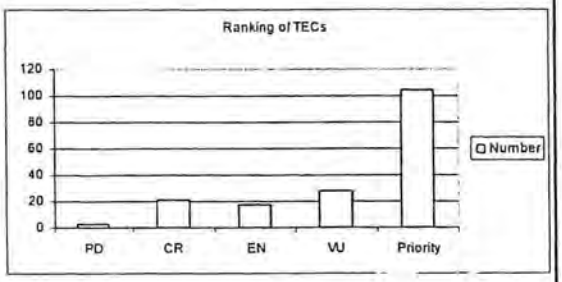
TEC Hotspots 2

- Unusual substrates eg Chert, *ironstone*
- Caves (especially wet caves)
- Microbial formations
- Springs (permanently wet areas)
- Ironstone hills
- Hills with remnant vegetation in largely cleared landscapes (W'belt)
- Mountains, larger hills in the South West (outside of jarrah forest)

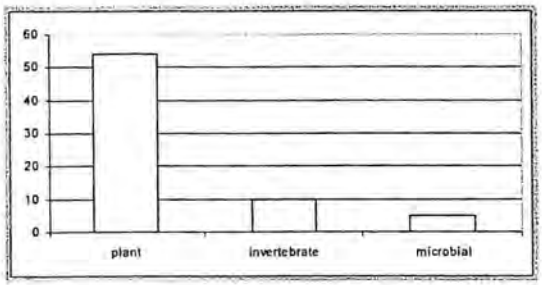
Numbers of TECs



TEC Ranking



TECs based on different biota



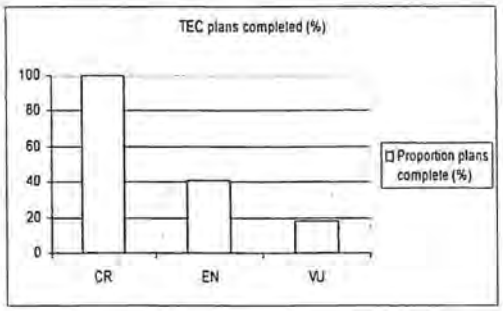
New Policy 9

- Formalises recovery processes including Recovery Teams and Recovery Plans (as for flora)

Recovery Plans

- Policy 9 formalises recovery processes including Recovery Teams and Recovery Plans (as for flora)
- RPs developed for Critically Endangered TECs first (highest priority for recovery)
- Usually written by Recovery Teams
- Are a management plan for a threatened community

TEC plans completed



Implementation of Recovery

- Coordination of recovery of TECs through Nature Conservation Division
- Primarily through Species and Communities Branch and Recovery Teams
- On-ground recovery work → Districts/Regions, Science Division, community etc.

Lake Richmond

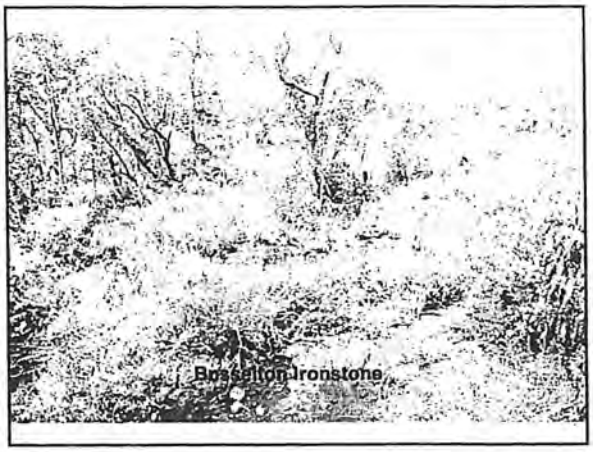
- **Formed by complex community of microbes**
- **EPBC listed (EN), CR in WA**
- **Threats include changed water quality, trampling, weed invasion, sediment (fire)**
- **Managed by Naragebup Environment Centre and Shire**
- **Actions include monitoring, education, liaison, boardwalks, fire management, weed control.**

Mound Springs

- Continuous groundwater discharge in raised areas of peat: created unique permanently moist habitats
- Unusual invertebrate fauna – described by Jasinska
- Four remaining vegetated springs
- Under threat from changed hydrology, weeds, fire
- EPBC listed (EN), CR in WA
- Recovery Plan in place
- Actions include investigating, monitoring hydrology, weed control, fire management

Toolibin Lake

- Listed as CR in WA, EN under EPBC Act
- One of last remaining 'Perched wetlands of the Wheatbelt region with extensive stands of *Casuarina obesa* and *Melaleuca strobophylla*'
- Under threat from altered hydrology
- Recovery Team working to recover/ maintain hydrology, including engineering solutions

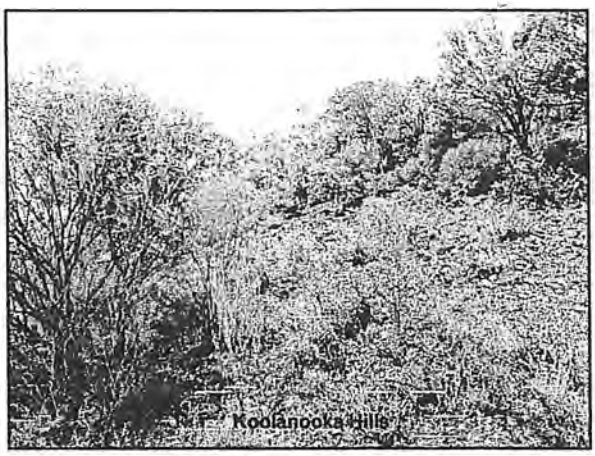


Busselton Ironstone 1

- Described by Gibson *et al.* (1994)
- Listed as CR in WA, EN under EPBC
- 15 occurrences remaining; area ~140 ha
- 11 DRF and 6 Priority taxa (many endemic to TEC
- Threats – dieback, fire, hydrological change.

Busselton Ironstone 2

- Recovery Plan drafted 1999, update 2005
- Recovery implemented by SW Region Recovery Team
- Actions include monitoring, phosphite treatment, translocations, fire management



Koolanooka Hills

- **Identified by Dr John Beard as unique vegetation system on ironstone hills**
- **Vulnerable in WA, not EPBC listed**
- **Total hill system covers about 5,500 ha**
- **Under threat from mining, weeds**
- **Recovery Plan in place**
- **Actions include seeking to acquire for conservation, liaison re mining, fencing, monitoring, weed control**

Conclusion

- The Department places a high priority on conservation of TECs, many staff, other scientists, volunteers involved
- Various legislation and policies are used to conserve TECs in Western Australia
- Better ways to manage them are being developed with Recovery Teams

Plant Disease

Plant Disease Diagnosis and Management for South-western Australian Flora

Bryan Shearer, Colin Crane and Chris Dunne

Science Division DEC

Aims:

- Understand and recognise the major diseases affecting south-west Australian flora
- Diagnose the cause of poor plant health
- Application of appropriate management options

Outline for rest of day:

- Afternoon (Inside):
  - Disease diagnosis relevant to south-western Australian flora with examples
- Tomorrow morning (Outside):

  At *Phytophthora cinnamomi* disease centre:
  - Diagnosis – what to look for
  - Sampling procedure
  - Control – demonstration of various phosphite application methods

Disease Diagnosis

Proper diagnosis essential because:

- Accurate diagnosis extremely important in preventing problem on other plants and preventing the problem in the future
- Management options depend on proper diagnosis of disease and the causal agents
- Misidentification of disease leads to wastage of time and money and further plant losses – e.g *Omphalotus* misidentified as *Armillaria* – control measure a waste of money

How does one go about diagnosing plant problems?

- Must have good observation skills;
- Be a good detective
- Keep an open mind until all the facts related to the problem have been collected – recording sheets to help this
- The possibility of multiple causal factors must also be considered

7 Basics steps of disease diagnosis:

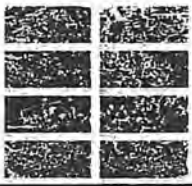
1. KNOW WHAT IS NORMAL
2. CHECK FOR SIGNS & SYMPTOMS
3. KNOW THE MAJOR DISEASES
4. OBSERVE PATTERNS
5. ASK QUESTIONS
6. LABORATORY TESTS
7. FINAL DIAGNOSIS

1. KNOW WHAT IS NORMAL

Proper plant identification:

Recognise healthy plant appearance:

- If you do not know what to expect of the plant you cannot recognise when something is wrong.
- Understand the growth habits, colours, growth rates and habitats of the plants of interest. e.g. many plants undergo colour changes associated with dry conditions in summer



1. KNOW WHAT IS NORMAL

Proper plant identification:

Recognise healthy plant appearance:

- If you do not know what to expect of the plant you cannot recognise when something is wrong
- Understand the growth habits, colours, growth rates and habitats of the plants of interest. e.g. many plants undergo colour changes associated with dry conditions in summer.
- Healthy plants have background damage from environment, low level insect and fungal attack
- Complicated by declines such as Wandoo and Tuart decline. Not associated with a particular pathogen or cause – often a combination of environmental, and insect interactions

2. CHECK FOR SIGNS AND SYMPTOMS OF DISEASE

What is disease?

- Using the strict definition:
  Result of an infectious organism (pathogen) that can multiply and spread to other nearby plants and interact with the environment and host plant to produce plant damage and characteristic symptoms
- Most pathogens are microscopic and include bacteria, fungi, nematodes, viruses, mollicutes, protozoa and parasitic plants

2. CHECK FOR SIGNS AND SYMPTOMS OF DISEASE

- **Conditions necessary for disease?**
- Three conditions must be met for biotic plant disease to occur:
  - » the host must be susceptible
  - » a pathogen must be present
  - » the environment must be favourable
  - » All three of these factors must occur simultaneously

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- Three conditions must be met for biotic plant disease to occur:
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  - » All three of these factors must occur simultaneously – The Disease Triangle

2. CHECK FOR SIGNS AND SYMPTOMS OF DISEASE

- Signs
  - Physical evidence of the pathogen causing disease such as fruiting bodies (see display)
  - mycelium, mushrooms and spore bodies – go into greater detail shortly

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- Signs
  - Physical evidence of the pathogen causing disease such as fruiting bodies (see display)
  - mycelium, mushrooms and spore bodies – go into greater detail shortly

  - problem with *Phytophthora* in that pathogen structures are microscopic – depend on symptoms, sampling and laboratory tests

2. CHECK FOR SIGNS AND SYMPTOMS OF DISEASE

- Symptoms
  - The visible effects of disease such as:
    - plant death, lesions, wood decay– go into greater detail shortly

3. KNOW THE MAJOR DISEASES OF SOUTH-WESTERN FLORA

- Major pathogens are fungi – 3 main groups
  - Diseases caused by species of *Phytophthora*
  - Disease caused by *Armillaria luteobubalina*
  - Diseases caused by canker fungi
  - Web page - Pathogen of the Month provided by Australasian Plant Pathology Society

http://www.australasianplantpathologysociety.org.au/

3. KNOW THE MAJOR DISEASES OF SOUTH-WESTERN FLORA

- Major pathogens are fungi – 3 main groups
  - Diseases caused by species of *Phytophthora*
  - Disease caused by *Armillaria luteobubalina*
  - Diseases caused by canker fungi

  Briefly mention rusts and other pathogens

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Phytophthora*

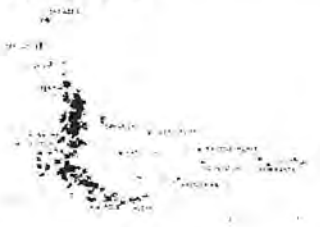
CAUSAL ORGANISM(s):

P. cinnamomi (introduced)
P. citricola
P. cryptogea
P. megasperma
P. drechsleri
P. nicotianae
P. cambivora
P. inundata

+ 9 other species undetermined

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Phytophthora*

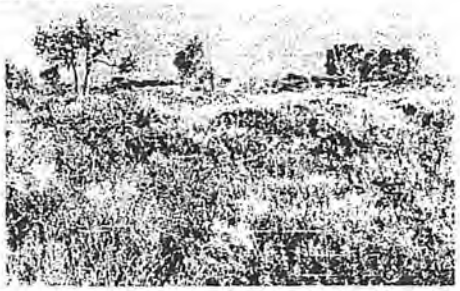
DISTRIBUTION:



Eneabba to Cape Arid, old inner dunes to W edge of wheatbelt – mainly on leached laterites and sands.

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Phytophthora*

DAMAGE:



Pc - W of Eneabba

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Phytophthora*

DAMAGE:

Pm - Badgigarra National Park

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Phytophthora*

DAMAGE:

Pc - jarrah forest

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Phytophthora*

DAMAGE:

Pc - jarrah forest

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Phytophthora*

DAMAGE:

Pc - *Banksia brownii* - South Coast

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Phytophthora*

DAMAGE:

Pc – *Lambertia* - *Banksia* shrubland, Bell Track FRNP

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Phytophthora*

DAMAGE:

Pc - *Banksia occidentalis* Cape Arid National Park

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Phytophthora*

DETECTION & DIAGNOSIS:

Crown symptoms

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Phytophthora*

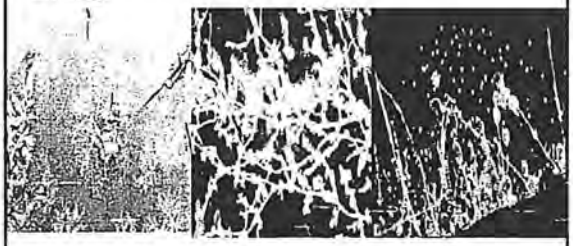
DETECTION & DIAGNOSIS:

Crown symptoms

Basal symptoms

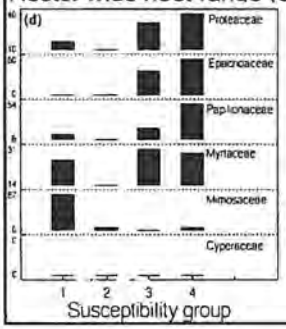
MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Phytophthora*

Signs: determined in the lab by plating and baiting



MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Phytophthora*

Hosts: wide host range (e.g.) threatened flora



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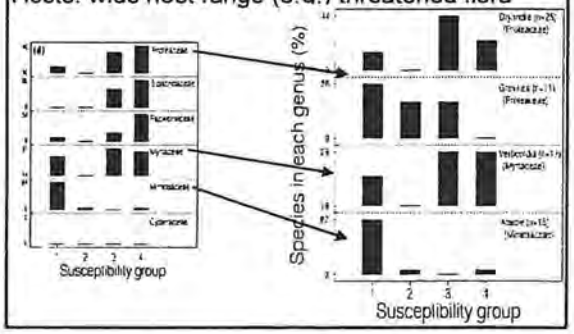


MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Phytophthora*

Hosts: wide host range

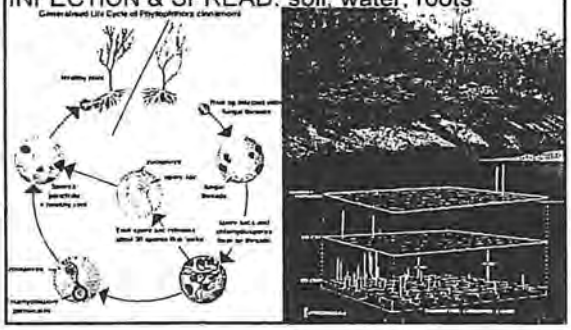
Susceptibility of South-western flora to *Phytophthora cinnamomi*

Database	Infection	Susceptible (%)	Highly susceptible (%)
Jarrah forest	natural	44	12
Banksia woodland	natural	33	15
Stirling Range NP	natural	36	10
Threatened flora	artificial	49	21
Mean		40 ± 4 [A]	14 ± 2 [B]

[A] 2300 species of the 5710 species in the South-west Botanical Province
[B] 800 species of the 5710 species in the South-west Botanical Province

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Phytophthora*

INFECTION & SPREAD: soil, water, roots



MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Phytophthora*

MANAGEMENT: Hygiene, translocation, phosphite

Dieback Working Group

A very useful contacts point for all things Phytophthora in Western Australia

http://www.dwg.org.au/

http://www.dieback.org.au/

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Armillaria*

CAUSAL ORGANISM:

Armillaria luteobubalina (native)

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Armillaria*

DISTRIBUTION:

Cervantes to Cape Arid, coastal dunes to W edge of wheatbelt – on wide range of soil types

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Armillaria*

DAMAGE:

Armillaria - coastal dune Cervantes

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Armillaria*

DAMAGE:

Armillaria - gardens metropolitan area

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Armillaria*

DAMAGE:

Armillaria - coastal dune Yalgorup National Park

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Armillaria*

DAMAGE:

Armillaria - jarrah forest

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Armillaria*

DAMAGE:

Armillaria - wandoo forest

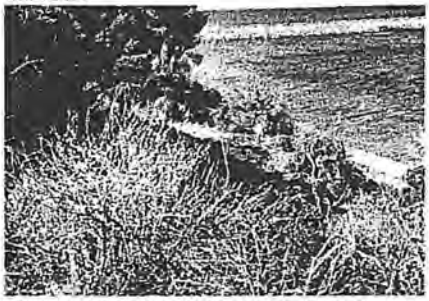
MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Armillaria*

DAMAGE:

Armillaria - karri forest

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Armillaria*

DAMAGE:



Armillaria - coastal dune Hopetoun, south coast

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Armillaria*

DETECTION & DIAGNOSIS:

Crown symptoms

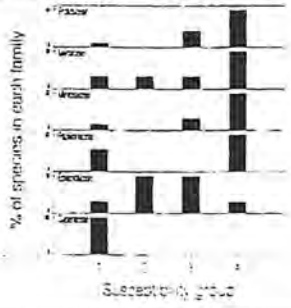
Basal symptoms

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Armillaria*

Signs: mycelial sheaths, fruiting (unreliable)

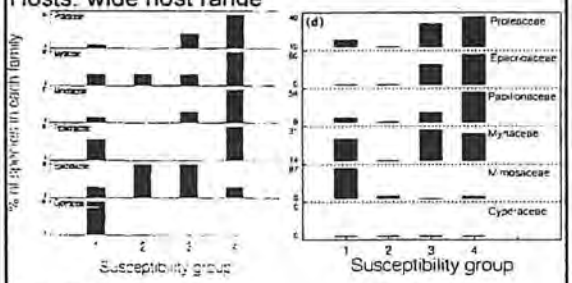
MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Armillaria*

Hosts: wide host range - few threatened flora



MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Armillaria*

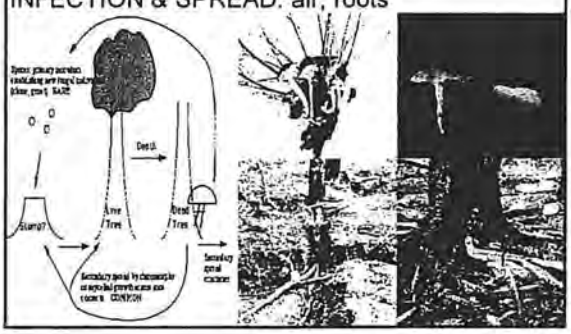
Hosts: wide host range



Armillaria *Phytophthora*

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Armillaria*

INFECTION & SPREAD: air, roots



MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Armillaria*

MANAGEMENT:

Hygiene - no movement of infected roots

Prevent stress

MAJOR DISEASES OF SOUTH-WESTERN FLORA - Canker

CAUSAL ORGANISM(s): (most native)

Cryptodiaporthe
Endothia, Quamballaria
Botryosphaeria
Zythiostroma

MAJOR DISEASES OF SOUTH-WESTERN FLORA - Canker

DISTRIBUTION:

Very widespread – on wide range of soil types

MAJOR DISEASES OF SOUTH-WESTERN FLORA - Canker

DAMAGE:

Canker - Tuart Mandurah

MAJOR DISEASES OF SOUTH-WESTERN FLORA - Canker

DAMAGE:

Canker - Marri throughout the south-west

MAJOR DISEASES OF SOUTH-WESTERN FLORA - Canker

DAMAGE:

Canker - *Banksia coccinea* Bald Island 1989

MAJOR DISEASES OF SOUTH-WESTERN FLORA - Canker

DAMAGE:

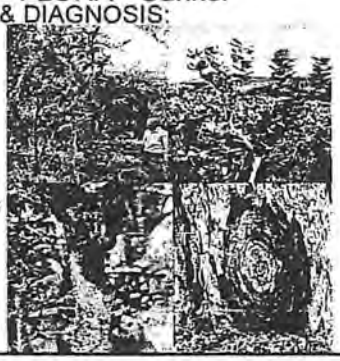
Canker - *Banksia coccinea* Bald Island 1989, 1995

MAJOR DISEASES OF SOUTH-WESTERN FLORA - Canker

DETECTION & DIAGNOSIS:

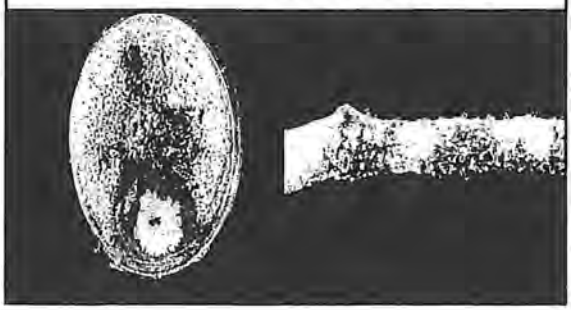
Crown symptoms

Stem cankers diffuse perennial



MAJOR DISEASES OF SOUTH-WESTERN FLORA - Canker

Signs: often determined in the lab by plating



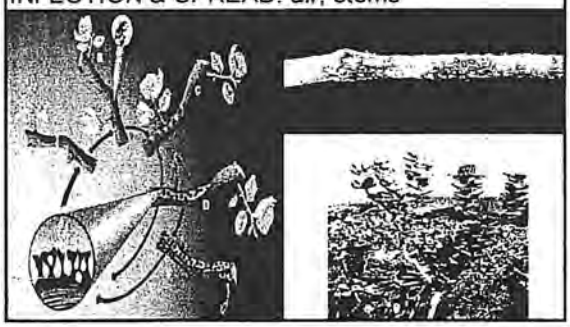
MAJOR DISEASES OF SOUTH-WESTERN FLORA - Canker

Hosts:

- Wide host range
- Many proteaceae - threatened *Banksia* susceptible to *Zythiostroma*
- Eucalypts resistant to *Phytophthora* susceptible to canker

MAJOR DISEASES OF SOUTH-WESTERN FLORA - *Canker*

INFECTION & SPREAD: air, stems



MAJOR DISEASES OF SOUTH-WESTERN FLORA - Canker

MANAGEMENT: Hygiene, destroy affected stems
Prevent stress

MAJOR DISEASES OF SOUTH-WESTERN FLORA - Other

CAUSAL ORGANISM(s):

- Rusts
- Leaf spots

MAJOR DISEASES OF SOUTH-WESTERN FLORA - Rusts

DISTRIBUTION:

Very widespread, especially wheatbelt and goldfields

MAJOR DISEASES OF SOUTH-WESTERN FLORA - Rusts

MAJOR DISEASES OF SOUTH-WESTERN FLORA - Leaf Spots

MAJOR DISEASES OF SOUTH-WESTERN FLORA - Rusts and Leafspots

Hosts:

- Wide host range
- Threatened flora
- Hosts resistant to *Phytophthora* susceptible to rust or leafspot

DO NOT CONFUSE DISEASE SYMPTOMS WITH INSECT DAMAGE

IN SUMMARY

- Plant diseases of south-western Australia mediate plant community dynamics
- Plant diseases significantly affect biodiversity
- Plant diseases differ in their responses to host and site
- Site management must ensure that changes made do not favour disease

4. OBSERVE PATTERNS

- Timing of symptoms
  - Sickness or death occurred once – more often abiotic (associated with drought, waterlogging, herbicide) than biotic
  - Symptoms occur over time – biotic
  - Can the outbreak be related to a specific event e.g death due to *P. megasperma* often associated with summer flooding

4. OBSERVE PATTERNS

- Check for host specificity
  - Plants highly resistant to *Phytophthora cinnamomi* such as most *Acacia* and *Eucalyptus wandoo* are highly susceptible to *Armillaria luteobubalina*

4. OBSERVE PATTERNS

- Are symptoms and signs associated with specific plant parts?
  - *Phytophthora* and *Armillaria* kill from the roots up
  - Cankers kill from the tops down

4. OBSERVE PATTERNS

- Are symptoms and signs associated with specific plant parts?
  - *Phytophthora* and *Armillaria* kill from the roots up.
  - Cankers kill from the tops down
- Are symptoms associated with particular soil types?
  - *Phytophthora* highest impact on infertile acidic sandy soils, low impact on loamy and calcareous soils
  - *Armillaria* tends not to occur on acidic sands and will have high impact on loamy and calcareous soils
  - Cankers can occur everywhere

4. OBSERVE PATTERNS

- Spatial distribution of symptoms:
  - Uniform damage – more often abiotic (non-living) factors
  - Indicator species present:
    - Death on a front – often with *Phytophthora*, especially in proteaceae dominated communities, sometimes with *Armillaria* rarely with canker
    - Death associated with water movement, roading, disturbance – *Phytophthora*
    - Spot occurrence – can occur with all 3 diseases
    - Individual dead or sick plants– can occur with all 3 diseases
  - No indicator species present
    - Old infections of *P. cinnamomi* – may be difficult to interpret because the pathogen has removed susceptible hosts e.g. the lack of *B. grandis* in John Forest National Park – botanists tend to call these new communities!
    - Communities dominated by resistant species – uninterpretable for *P. cinnamomi*

5. ASK QUESTIONS

- What is the history of symptom expression?
- What are predisposing factors?
  - Site characteristics
  - Host susceptibility
- Any inciting factors?
  - What is the disturbance history of the area (altered drainage, roading, herbicide etc)
  - Changes in weather and climate patterns
  - Insect attack

6. LABORATORY TESTS

- Role of the Vegetation Health Service

- Sampling
- Baiting

- Plating (see examples)

7. FINAL DIAGNOSIS

- Sample results
- Summary table of major pathogens
- AND REMEMBER
  - Be a good detective
  - Keep an open mind until all the facts related to the problem have been collected – sheets to help this;
  - The possibility of multiple causal factors must also be considered e.g may have *Phytophthora* in wet area but deaths of *Banksia* on sandy upland – may be drought rather than disease
  - Go for help – Disease contacts
    - Chris Dunne, Colin Crane, Richard Robinson – Research
    - Mike Stukely – Vegetation Health Service
    - Mike Pez - DEC interpreters for Phytophthora interpretation & mapping

Recovery Catchments

Natural Diversity Recovery Catchments

Gavan Mullan
Revegetation Development Officer
Midwest Region

Department of Environment and Conservation

Buntine Marchagee Catchment

Version 1

Contents

- Background to NDRCs;
- Snapshot of the:
  Buntine-Marchagee Natural Diversity Recovery Catchment (BMRC); and
- Case study of:
  Native vegetation management in the BMNDRC

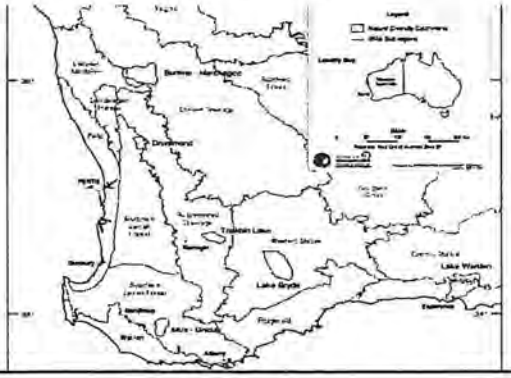
Background

- DEC, through the Salinity Strategy (2001) is responsible for ensuring regionally significant natural areas, such as wetlands, threatened by salinity are protected.
- This is achieved through the selection of priority catchment areas, called Natural Diversity Recovery Catchments (NDRC), that have been identified under the State Salinity Investment Framework (SIF).

Aim of Natural Diversity Recovery Catchments

- To protect and where possible restore high priority biodiversity assets, particularly wetlands, that are threatened by salinity, and which are regionally significant.

Location of N.D. Recovery Catchments



Natural Diversity Recovery Catchments

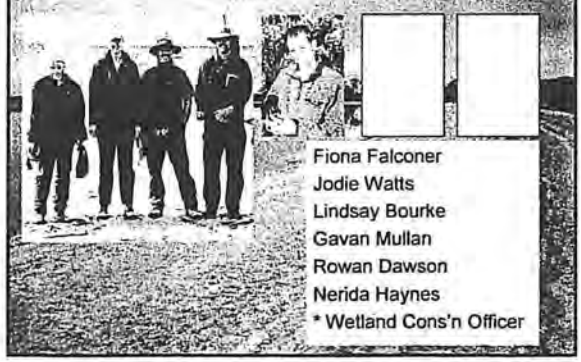
- Six in WA (BMNDRC is one of the biggest);
- Substantial investment (~ half of the annual $6.5 million salinity program budget goes into Recovery Catchments);
- Long term projects; and
- Focus for all expertise…giant pilot study.

Why was Buntine-Marchagee selected?

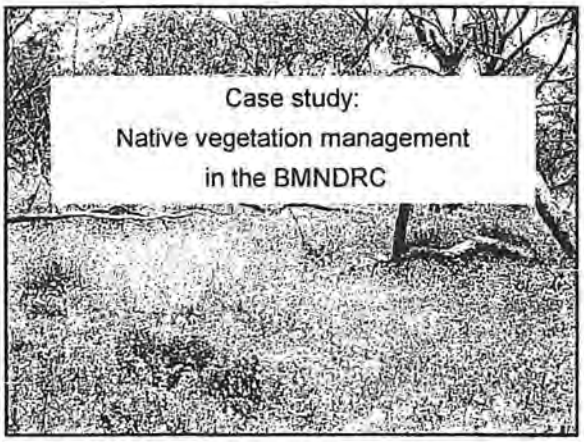
- Biological Values – flora and fauna
- Represents landform types typical of the northern wheatbelt
- Naturally Saline System
- Acceptable risk
- Community Support

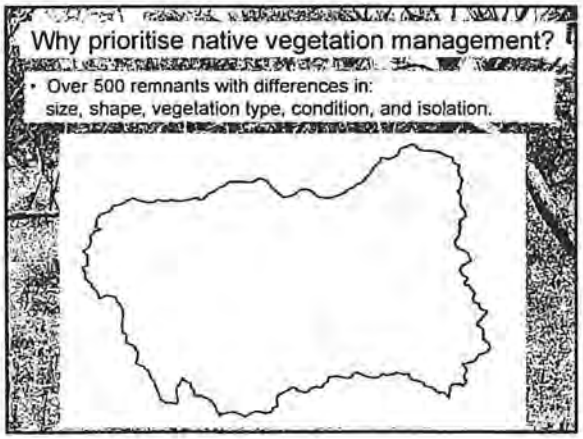
Establishment of the BMNDRC Steering Committee

BMNDRC Staff



Fiona Falconer
Jodie Watts
Lindsay Bourke
Gavan Mullan
Rowan Dawson
Nerida Haynes
* Wetland Cons'n Officer





Priority setting options

Five options considered. They were:

- well documented;
- trialled (to some degree); and
- scrutinised.

Priority setting options

CAR reserve system:

- national reserve system
- vegetation based
- based on criteria:
  - C: Comprehensive: full range of biodiversity (community, species, genes)
  - A: Adequate: sufficient to ensure persistence
  - R: Representative: include areas throughout geographic range of communities and species
    - 15% of pre-1750 ecosystem distributions.
    - prioritise rare/endangered ecosystems & species.

Limitations:

- ecosystem complexity
- population persistence
- spatial factors

Priority setting options

Habitat Hectares:

- Scores 10 attributes of each remnant to derive a ranking number. Attributes are weighted differently. Attributes are:

large trees	tree canopy cover
understorey	lack of weeds
natural recruitment	organic litter
logs	patch size
distance to core area	neighbourhood characteristics

Limitations:

- scoring system
- vegetation based
- ground-based selection

Priority setting options

Focal species approach:

- use of indicator species...assumed to represent most other species
- based on the sensitivity of the indicator species to various threats

Limitations:

- indicator species may not be a good indicator!
- persistence of indicator species

Priority setting options

Population Viability Analysis:

- Quantitative computer modelling approach
- Indicates the level of population persistence over time and under various management techniques

Limitations:

- dependant on life history data
- very expensive in time requirements
- lack of broader ecosystem scope

Priority setting options

Market Based Instruments (MBI's):

- Non-directive economic instruments
- Types of MBI's

Price based: e.g. tenders	Bushland Benefits Program: Price-based tendering program in SW of W.A. Tenders assessed on biodiversity value, management value & cost effectiveness.
Quantity based: e.g. tradable permits	Carbon trading

Limitations:

- focussed on economic efficiency
- depends on valuing market items

Option used in the BMNDRC

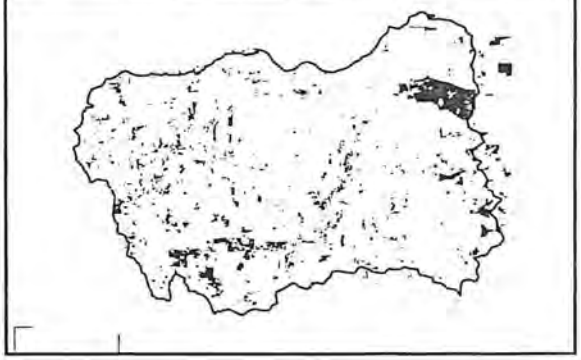
Combination of:

- CAR; and
- the Focal Species approach (using birds as indicators).

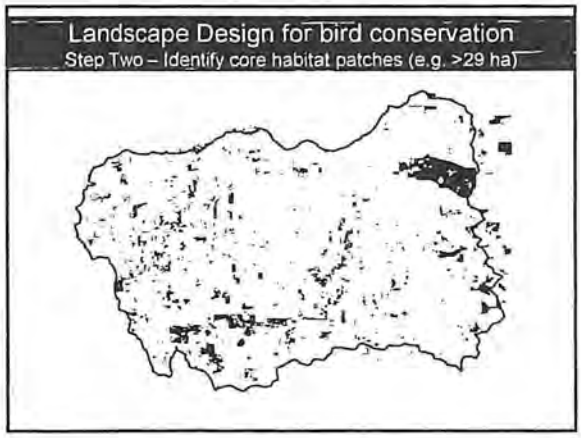
Main elements used:

- area;
- connectivity;
- condition;
- intersection with priority wetlands;
- vegetation associations with a very low area remaining in south-west WA, e.g. woodlands; and
- woodlands down-slope of granite rock outcrops (as identified in the biodiversity survey of the WA agricultural zone, Keighery *et al.* 2004).

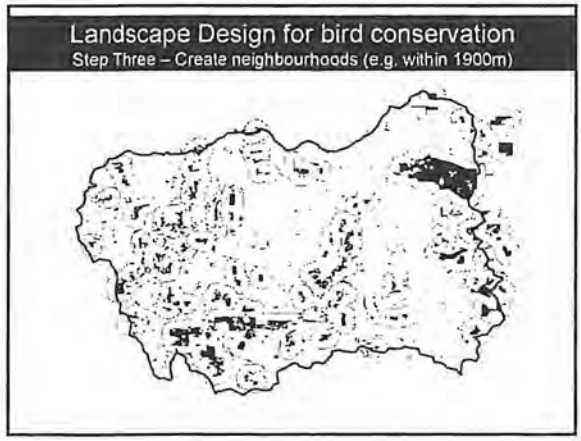
Landscape Design for bird conservation
Step One – Identify all habitat patches



Landscape Design for bird conservation
Step Two – Identify core habitat patches (e.g. >29 ha)

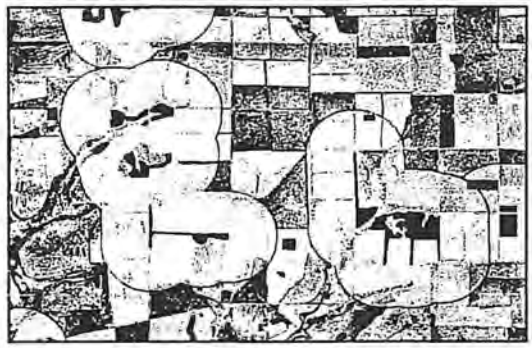


Landscape Design for bird conservation
Step Three – Create neighbourhoods (e.g. within 1900m)



Landscape Design for bird conservation

Step Four – Plan for new habitat to join neighbourhoods



Landscape Design for bird conservation

Step Five – Plan for linkages between remnants to increase connectedness

Landscape Design for bird conservation

Prioritise remnants for habitat management based on size and condition

Summary

- Natural Diversity Recovery Catchments...

Case study

- Native vegetation management priority setting techniques...
- Management actions...

Thank you

Gavan Mullan
DEC Midwest Region

Buntine Marchagee
Catchment

Monitoring

Monitoring

Monitoring is the repeated measurement of a factor or range of factors over time to determine change.

Evaluation is the analysis of the "raw information" collected during monitoring to enable conclusions to be drawn and the effectiveness of management actions to be assessed.

Why Monitor?

There are several triggers which lead to the initiation of monitoring programs. One is when there are legislative and/or statutory requirements to start monitoring. These may be required on a "permit to take", or as part of an ethics committee condition. Another trigger is when there is a management plan or recovery plan and the monitoring forms part of management considerations. This can sometime happen in controlled fire burn prescription, or in other disturbance operations.

Another reason to start monitoring is to address gaps in biological knowledge. For management it is often useful to understand the regeneration biology for a species, for example whether it reseeds or re-sprouts after fire. Baseline data and improved currency are two other reasons to monitor. The quality and comprehensiveness of knowledge can be improved with collection of monitoring data. Another use is to determine and measure impacts of key threats and to ascertain ecological patterns and processes.

Other reasons to monitor are to support operations and improve management. It is sometimes a way to engage stakeholders on the local, state or federal level. Monitoring is also done to inform government and the public.

To be sure that the monitoring is carried out well, there are a series of criteria to be met:

- Have clear objectives
- Design the monitoring to meet the objectives
- Collect the data in a rigorous repeatable way
- Check that the data can be readily accessed analysed and queried by district and regional staff
- Look at ways of getting more value from the monitoring effort
- Use the data to improve management decisions.

What to monitor?

- Biological data, such as changes to biodiversity condition, the structure and composition of the community; this information can be examined at individual, population or species level.
- Ecosystem process and function data, such as pollination vectors, nutrient distributions, or hydrological patterns (at a larger scale)
- Behavioural impacts, such as the regeneration mechanism used in response to varied intensity of fire
- Disturbance processes, including fire behaviour, site conditions, soil moisture, groundwater levels, grazing impact, dust and other pollution

- Objectives/ strategy implementation, such as whether the project was successful and cost effective

Tools and Techniques of Monitoring for a Range of Results

- Opportunistic or ad hoc, as in DOB observation
- Qualitative, such as photo points
- Repeated measurements, including
  - baseline survey
  - presence, absence, condition, RFFRF
  - Change or trend
  - permanent quadrats and transects
  - hypothesis testing
  - relational determining causative factors
- Different spatial and temporal scales, such as point data versus area data
- Differences between auditing, monitoring and research
- Monitor the impact rather than the cause, which requires knowledge of a direct dependency relationship

Examples of Methods

Rare Flora Field Report Form (RFFRF)
The RFFRF provides a snapshot of all or part of a population at one point in time. The minimum requirements recorded on the form are the species name, the Department's population number, whether it is a new or known population, accurate location info (GPS coordinates and a description), the number of adult and seedling plants, their reproductive state, the condition of the population, and what the existing or potential threats are.

Other information which can be included is the landform, the soil type, the vegetation type using Muir's classification, associated species, fire history, pollinators, specimen collection information.

This data is entered in the Declared Endangered Flora Listing (DEFL) administered by the Species and Communities Branch of DEC.

Photographic Monitoring
This is the simplest and most convenient method. The benefits are that it provides information over a long period if there is adequate standardization, and it visually communicates the nature of changes over time. The shortfalls are that it is difficult to explain changes interpreted from the photographs, and it does not readily produce quantitative data for entry into a database.

Quadrats and Transects

Quadrats and transects are used to ascertain long term natural dynamics of populations. Also they can show the effect of threatening processes, the effect of active management recovery work. These also provide information on threats and trends. The samples are only a subset of the population or its occurrence.

It is essential that the sites are permanently marked so that *repeatability* is ensured. The marking is done on a north-south or east-west aspect, using a compass. The size of the quadrat or transect is determined by the size and density of the plants being monitored. Nested quadrats of 1 to 2 metres make it easier to record presence-absence data.

Count mature flowering plants and seedlings separately.
Make note of:

- The reproductive state (flowering, fruiting or vegetative)
- The reproductive method (seed, vegetative)
- The method of seed storage (on plant, in soil)
- The level of seed produced (an indication of suitable pollinators being active or absent)
- The health of each plant
- The height and width measured
- The active growth or dormancy stage recorded

NB: this data is used to determine the reproductive potential of the population and to provide information for ranking when using IUCN criteria

Other useful data to record with quadrats and transects is:
Associated plants should be noted with the 10 most dominant being listed from the most common to least common. ***System cards*** can be used to show an example of each associated species found.

Canopy cover should be noted as it may impact on the health of the threatened species, i.e. many species are opportunists that appear after fire and soil disturbance. They are often short-lived and are crowded or shaded out by other species over time.

Transects are most **useful for larger species** that are scattered over a wide area in the landscape.
Transects **vary in length and width** but are commonly 30 metres by 1 metre or 30 m x 2 m in size.
Normally a transect is positioned from **just outside the edge** through a dense part of the population being monitored.

When to Monitor?
It is common to monitor on the day of a disturbance, such as a burn. Or it may be done within a few days of the disturbance.

The time for monitoring is determined by a biological response, such as when germination occurs, when green pick grazing occurs, when there is a recovery of the closure of the canopy biomass or at a time when reproduction is occurring.

Frequency
Monitoring can be carried out at a once off, or intermittently. It can be done cyclically, such as by season or annually, or every 5 years.

Monitoring Emphasis
Those species which are Critically endangered **(CR)** are of highest priority should be monitored at least annually.

Those species which are Endangered **(EN)** are the next highest priority and should be monitored at least bi-annually.

The species which are Vulnerable **(VU)** are the next highest priority and should be monitored at least every three years (preferably more frequently).

Where to Monitor?
On site versus Off site

Displacement effects
- Brushtail vs. ringtail possum
- Water abstraction vs local effects
- Riparian habitat vs feral pigs

Impact of transported matter
- Sediment
- Nutrient
- Water quality

Implemented on both departmental and other lands

Who monitors?
- Nature Conservation staff
- Specialists--local and non-regional
- Assisted by other District staff
- Volunteers and community groups
- Tertiary students
- Other agencies

Funded how?
It is proposed when:
- a species is identified in a Recovery Plan, or Interim Recovery Plan or Wildlife Management Plan or Area Management Plan.
- The species is identified in an annual OPP Process.
- The species is identified in annual Region/District strategic operational plans/action plans.

External funding from the Commonwealth's NHT, Bio prospect and the State Salinity Strategy.

Storage of Information

- Regional and corporate databases
- New DEFL proposed to store additional population, threat and management information obtained from future monitoring
- A monitoring form will be developed as part of this process

Reporting

- Routine reporting should included post-burn reporting associated with the prescription; annual Threatened Species/ Recovery Team Reports; Corporate datasets-DEFL, WAHERB, TEC
- Permit to take reporting conditions
- External funding sources report (NRM, NHT)
- Office of PP Annual Report on achievements
- Occasional reporting will include EPBC Act referral conditions reporting, advisory committees and the Conservation Commission.

Summary

Monitoring is the repeated measurement of a factor or range of factors over time to determine change. Objectives must be clear, relevant and achievable. It is important to choose the correct monitoring "tool" to achieve the objective.

- Rare Flora Report Forms are used to obtain the population data (number of plants, reproductive state, threats, general conditions)
- Photo points are used to illustrate change over medium to long time periods but don't produce "hard" quantitative data
- Transects and quadrats are useful when monitoring individual plants and threatening processes
- Information storage is essential—Corporate (DEFL, TEC, WAHERB) and local databases.

Authors: Kim Williams, Russell Smith, Erica Shedley, Andrew Brown

Plant Identification

Plant Identification

The WA Herbarium and its online plant information system, FloraBase

Nicholas Lander
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Department of Environment and Conservation
Principal Research Scientist

Department of Environment and Conservation

Version 1

Introduction

- Content
- General Aim of the Course
- Learning Outcomes
- Assessment

Content

- Role of the WA Herbarium and the staff who work there
- Biodiversity
- Biosystematics
- Conservation
- FloraBase
- Regional Herbarium Network
- Volunteer program

General Aim of the Course

- To provide Departmental staff with the understanding and knowledge of the WA Herbarium and how it can be used to access information (particularly via FloraBase) on rare and threatened flora.

Learning Outcomes

- Demonstrate an understanding of the WA Herbarium and the work carried out by staff there
- Demonstrate an understanding and awareness of the facilities available for flora research.
- Describe the Regional Herbarium Network

Learning Outcomes

- Describe the Volunteer Program
- Demonstrate an understanding of how to use the FloraBase website to retrieve information on rare and threatened flora species

Assessment

- 15 minute theory exam - short answer and/or multi-choice
- Approximately ¾ hour - Computer simulation assessment (Interactive Keys)

The WA Herbarium

- Part of the Department
- Responsibility - Description and documentation of Western Australia's botanical species diversity

The WA Herbarium

- Unique state-wide team
- Gathers, manages, researches and communicates information on our unique and precious flora
- Vital role in a national and international network of herbaria and allied biodiversity conservation agencies

Biodiversity

- Collections of native and alien plant specimens
- Documented
- 650, 000 specimens
- Variation of vegetation types

Biosystematics

- Basis for understanding and ordering of taxonomic biodiversity
- Current research, identification applications and manuals
- Taxonomic journal *Nuytsia*

Biosystematics

Benefits:

- Analyse evolutionary patterns
- Delimitation and characterisation of species
- Identify species at risk - target for next collection
- Highlight potential weed threats

Conservation biology

- Complemented by the Threatened Flora Seed Centre and biological studies on CR species
- Complemented by Molecular genetics facility
- WA Herbarium provides baseline data for assistance

Biodiversity Information Systems

- Biodiversity data is managed using sophisticated information technologies
- Allows for communication of results

Biodiversity Information Systems

Information Systems Include:

- Census WA
- Specimen database
- Plant descriptions database
- Botanical library and database
- Plant images database
- Spatial data
- Biological attributes of plants

FloraBase

- Statewide
- Integrates all previous datasets
- Provides - Lists of plants, up-to-date classification, short descriptions, range maps, and a representative image
- Primary method for staff and public to access botanical information

Regional Herbarium Network

- 70 regional community groups - maintain local reference collections of duplicate specimens
- Trains volunteers to accurately record data
- Contributes new documented specimens
- Maintains accuracy of identification

Volunteer Program

- Allows for active public participation
- Assistance with on-ground projects reduces time, money and individual labour

Volunteer Program

Current Projects:

- Specimen processing
- Image capture, and storage
- Plant identification
- Provision of plant information to the tourism industry
- Regional herbaria network coordination

Volunteer Program

Current Projects

- Contributions to FloraBase
- Collection, identification, and documentation of invasive species
- Curation and identification in specialist plant groups

Field Survey

MONTANE MALLEE THICKET OF THE STIRLING RANGE TEC

Name: Mallee-heath and mallee-thicket community on mid to upper slopes of Stirling Range mountains and hills

Description: Mallee heath or mallee thicket community above approximately 400 m above sea level in the Stirling Range. The community occurs on sandy clay-loam over sandstone and metamorphosed sandstone on the mid to upper slopes of mountains and hills in the Range, predominantly east of Red Gum Pass.

Status: TEC, endangered, not endorsed by Minister

No of Occurrences: 22 significant occurrences, 1,400 ha ± in total, 350 ha considered to be predominantly *Phytophthora cinnamomi* –free.

Location: Stirling Range National Park

Dominant species: Species-rich plant community dominated by *Phytophthora*-susceptible members of the Proteaceae, Papilionaceae, Myrtaceae and Epacridaceae. *Banksia solandri* is a key indicator species

Extent: Due to extensive infestation of the Stirling Range by *P. cinnamomi* and loss of key susceptible species and changes in plant community structure, it is difficult to determine the full historical extent of the community.

The community generally extends further down-slope on the southern aspects of these hills, which may be due to the moister cooler conditions experienced on these southern aspects.

The community does not occur on the higher summits east of Chester Pass (above 900 m a.s.l), which is occupied by the Montane heath and thicket TEC. The Montane mallee thicket community may occur on the mid-slopes of these higher mountains.

Extent of Phytophthora *cinnamomi* infestation: The only summit above 700 m that is still Phytophthora-free are Mondurup Peak. Current occurrences of the TEC that are considered to be largely *Phytophthora*-free are the summit and upper slopes of Wedge Hill, Yungemere, the ridge southwest of Gog, Toll Peak, Baby Barnett, Hosteller Hills and Little Mondurup. However, there are small infestations on four of the southerly ridge systems off the main ridge southwest of Gog as well as the eastern end of this ridge. There are significant spot infestations on Yungemere, Wedge, Hostellers and Little Mondurup. The remaining occurrences (the Abbey, Barnett Peak, Baby Barnett, Henton Peak, Twin Hills, Magog, Gog, Talyuberlup, Mt Hassell, Mt Trio, Toolbrunup, South-east Ellen Peak and Mt Success) have extensive infestations with small remnants of intact vegetation.

Rates of spread of *P. cinnamomi* of up to 250 m per annum down-slope have been observed in the Stirling Range.

Fire: The TEC is characterised by a number of fire sensitive species, many key species occupying the wet gullies and thickets of upland areas typically require a longer fire-free interval than those occupying the seasonally dry lowland mallee-heath.

Other issues to consider: recreation and climate change

Field Activities

Break into groups to complete the following activities:

Mapping: Discuss how you would map the Montane mallee-thicket TEC? What additional information would be useful in defining the community boundary?

Identifying threats: List threats to the community.

Managing Threats: Once you have your list of threats, identify ways in which these threats could be managed. Also state who would need to be involved in the planning and implementation of recovery actions and how this should be coordinated.

Monitoring: Describe methods you could use to monitor the condition of the community and assess whether management activities have been successful.

Resources: Map of TEC

The risk of extinction resulting from disease caused by *Phytophthora cinnamomi* to threatened flora endemic to the Stirling Range National Park, Western Australia

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Keywords
Phytophthora cinnamomi, extinction risk, threatening processes, susceptibility

Aims and Introduction
The Stirling Range National Park (SRNP) contains more than 1500 of Western Australia's plant taxa, 26 of these are threatened, with 85 endemic to the Park. Phytophthora dieback resulting from the introduced root pathogen, *Phytophthora cinnamomi* Rands (Oomycetes) is considered to be the foremost threatening process for rare and endemic flora of the SRNP (Grant and Barrett 2003; Barrett 2005). Some 36 % of the SRNP flora is estimated to be susceptible to *P. cinnamomi* with 10 % considered highly susceptible (Shearer *et al.* 2004). More than 60 % of the SRNP is estimated to be currently infested. Climate, soils, topography and susceptible plant communities combine to provide ideal conditions for the sporulation, survival and dispersal of the pathogen (Grant and Barrett 2003, Barrett 2005). Other threatening processes may interact with Phytophthora dieback to increase extinction risk. Fire has the capacity to increase the extinction vulnerability of narrow range endemics (Yates *et al.* 2003). Grazing also adds to extinction vulnerability while summer drought, predicted to be exacerbated by climate change (IOCI 2002), is considered to be a significant threat to those taxa associated with refugial habitat. This paper estimates the risk of extinction caused by *P. cinnamomi* for 28 conservation-listed or endemic taxa, all but one taxon restricted to the SRNP. Of the 28 taxa assessed 12 were listed as threatened and 13 as 'Priority' or 'data deficient' flora.

Materials and Methods
All plants were propagated from seed collected from *in-situ* populations with the exception of *Leucopogon gnaphalioides* and *Persoonia micranthera* which were grown from cuttings. Pots were soil-inoculated with *P. cinnamomi* in a shade-house environment as described by Shearer *et al.* (2004). The percentage of plants with collar lesion or percentage mortality was calculated for the 5-month assessment period. The upper asymptote K_{max}, lag time $t_{½K}$ and intrinsic rate of increase were calculated from mortality curves. The susceptibility score of each taxon was then calculated as follows: Susceptibility $score_{taxa} = K_{max} + (100 - t_{½K}) + (100 \times r)$. The Direct Impact Score = (Susceptibility $score_{taxa}$/ Susceptibility $score_{max}$) x 10. Data on the number of extant and extinct populations, habitat type and condition, life history characteristics, threatening processes and population condition were collated from the Western Australia Department of Environment and Conservation (DEC) databases and records, Interim Recovery Plans and Herbarium records. The presence of *P. cinnamomi* in populations, the location of the nearest infestation adjacent to populations and the topographical position of infestations in relation to populations were determined from DEC records and survey of *P. cinnamomi* within the Park (Grant and Barrett 2003; Barrett 2005). Distance of populations from the nearest known *P. cinnamomi* infestation and nearest track or road was calculated using GIS. Extinction risk was scored and ranked based on the number of extant populations, whether population extinction in association with *P. cinnamomi* had already occurred, Direct Impact Score, percentage of extant populations infested by *P. cinnamomi*, percentage of populations less than 500 m from a disease infestation and the nearest track, firebreak or road; the percentage of populations at least 100 m upslope of the nearest disease infestation, and the presence of other significant threatening processes (Table 1).

Results
Direct impact scores ranged from zero (four taxa) to the maximum score of 10 for *Isopogon latifolius*. Two taxa had scores greater than nine (*Dryandra montana* and *Banksia brownii*). All taxa but one (*Acacia awestoniana*) occurred in susceptible habitat and this taxon was not assessed further. Taxa listed as threatened had in general low numbers (<6) of populations with the exception of *B. brownii, Darwinia squarrosa, Deyeuxia drummondii* and *Leucopogon gnaphalioides*, while two Priority flora (*Dryandra ferruginea* ssp *pumila, Gastrolobium vestitum*) had less than five populations. Previous population extinctions were recorded in 12 taxa including eight threatened and four Priority flora. For 26 of the 27 taxa with susceptible habitat assessed, more than 50% of populations were infested by *P. cinnamomi*, the exception was *Banksia aculeata.* All 27 taxa had more than 50% populations within 500 m of a *P. cinnamomi* infestation while 14 taxa had no populations at least 100 m upslope of a *P. cinnamomi* infestation. For 14 taxa, more than 60% of populations were less than 500 m from tracks or roads while for all taxa over 20% of populations were less than 500 m from access tracks. Four significant additional threatening processes were identified: frequent fire, grazing, climate change and other plant disease. Eight taxa, of which five were threatened, had three additional threatening processes, another eight had two, and 11 taxa had one additional threatening process. Based on the total extinction risk score, eight taxa had a very high, five a high, five a moderate, six a low, three a very low and one no risk of extinction due to *P. cinnamomi*. All taxa with a very high risk of extinction are currently listed as threatened and

ranked critically endangered. However, none of the five taxa with a high extinction risk are currently listed as threatened. Three taxa currently listed as threatened had a low (2) or zero (1) risk of extinction.

Discussion

The Commonwealth of Australia Environment Protection and Biodiversity Conservation Act (1999) was enacted to prevent extinctions and to maintain Australia's high level of biodiversity. Many taxa in the SRNP have narrow range specificity. Where a taxon is rare and geographically restricted any degree of susceptibility may have a major effect on its continued survival. This paper clearly shows the very high risk of complete extinction for eight SRNP taxa all of which have already undergone population extinction. The extent of *P. cinnamomi* infestations within the SRNP is clearly demonstrated by the percentage of populations that are within 500 m of a known infestation. While 13 taxa had at least 40% of populations more than 500 m removed from tracks or roads, this has not resulted in greater protection from Phytophthora dieback. Observations of apparently new infestations at considerable distances from down slope infestations, and that appear unrelated to human vectoring along tracks, are not readily explained. Current management in the SRNP includes access restrictions and hygiene measures to prevent new outbreaks of disease in currently healthy areas and to control extension from existing infected sites. Phosphite application activates plant host defence responses (Barrett 2003) and is currently applied to 11 of 12 threatened taxa assessed in this paper, the exception being *A. awestoniana,* and to 13 of the remaining taxa assessed. Phosphite has been effective in slowing population decline in many of these populations (Barrett 2003). While phosphite is a valuable short- to medium term management tool, *ex-situ* conservation is vital to conserve genetic material. Seeds of 25 taxa assessed are conserved at the DEC Threatened Flora Seed Centre. Six taxa (*D. montana, P. micranthera, L. gnaphalioides, Lambertia fairallii* and *B. brownii*) have been translocated to *Phytophthora* –free sites outside the SRNP. This study suggests that five high risk taxa need further monitoring and evaluation as to whether listing as threatened is required. However, as this study did not use numbers of individuals in populations or area of occupancy as a measure of rarity this also requires evaluation for listing purposes. Although this research assessed only a small proportion of the threatened and endemic flora of the SRNP; these results highlight the need to assess the risk extinction of all endemic flora in the SRNP that may be susceptible to *P. cinnamomi.*

References

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Grant M and Barrett S. 2003. The distribution and impact of Phytophthora *cinnamomi* Rands in the south coast region of Western Australia. Pages 34-40 in 'Phytophthora in JA McComb, GE StJ Hardy and IC Tommerup, editors. Phytophthora in Forests and Natural Ecosystems, 2nd International IUFRO Working Party 7.02.09 Meeting, Albany, Western Australia.

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Yates CJ, Abbott I, Hopper SD and Coates DJ. 2003. Fire as a determinant of rarity in the south-west Western Australian global biodiversity hotspot. Pages 395-420 in I Abbott and N Burrows, editors. Fire in Ecosystems of South-West Western Australia, Backhuys Publishers: Leiden, The Netherlands.

Table 1. Method of scoring risk of extinction caused by *Phytophthora cinnamomi*

Direct Impact Score (0-10)	No. of extant popul-ations (0-5)	Exisiting population extinctions (0,5)	% of extant populations infested by *P. cinnamomi* (0-5)	% of extant populations <500m from *P. cinnamomi* (0-5)	% of extant populations >100m upslope of *P. cinnamomi* (0- -3)	% of extant populations <500m from track (0-3)	No. of additional threatening processes (1-3)	Extinction Risk (Total score: 0-36)
	1-5=5	Yes=5	>75=5	>75=5	None=0	>60=3		>30= very high (VH)
	6-10=3	No=0	>50-75=3	>50-75=3	0-20=-1	>20-60=2		>25-30= high (H)
	11-20=2		>25-50=2	>25-50=2	>20-60=-2	1-20=1		>20-25= moderate (M)
	20+=0		1-15=1	1-25=1	>60=-3	0=0		>15-20= low (L)
			0=0	0=0				>1-15= very low (VL)

SPECIES	Cons. status	no. of extant pops:	No of extinct pops	habitat susceptible Y/N	Direct impact score	% of extant populations with PC	% of extant populations <500m from PC	% upslope from PC	% of extant populations <500m from track/rd	no. of other threats	Threats	Life history charactaristics	Topography: High, mid, lower slope	Extinction risk
Dryandra ferruginea ssp pumilo	P2	4	0?	y	8.7	100	100	0	50	2	fire, drought	shrub, obligate re-seeder, serotinous	high-mid	
Lambertia fairallii	CR	4	1	y	8.4	100	100	0	25	2	fire, drought	shrub, obligate re-seeder, serotinous	mid	
Banksia solandri	P4	25	5	Y	8	80	100	12	61	2	fire, drought	shrub, obligate re-seeder, serotinous	high-mid	
Lambertia ericifolia	none	20+	0	y	7.9	71.4	80.9	28	65	2	fire, drought	shrub, obligate re-seeder, weakly serotinous	summit-mid-low	
Dryandra hirsuta	P3	18	0	y	7.5	77.8	100	16	33.3	2	fire, drought	shrub, obligate re-seeder, serotinous	high-mid	
Calothamnus affinis	P4	17	0	y	3.5	41.2	58.8	11.8	70.6	1	fire	shrub, obligate re-seeder, serotinous	ridge	
Banksia aculeata	P2	6	0	y	0	16.7	83	17	100	1	fire	shrub, obligate re-seeder, serotinous	low	
Acacia veronica	P3	15	0	y	0	73.3	86	0	66.7	1	drought	shrub, obligate re-seeder, soil-stored seed bank	high-mid	

WEDNESDAY 19 SEPTEMBER 2007

STIRLING RANGE NATIONAL PARK FIELD COMPONENT 8000-1530

Activities:

- Threatened Ecological Community (SRNP Montane Mallee Thicket) and disease risk assessment exercise (leaders SB, NM)
- Disease sampling (leaders BS, CC, CD)
- Seed collection (leaders AC & ACo)

Participants will split into two groups and swap at designated times

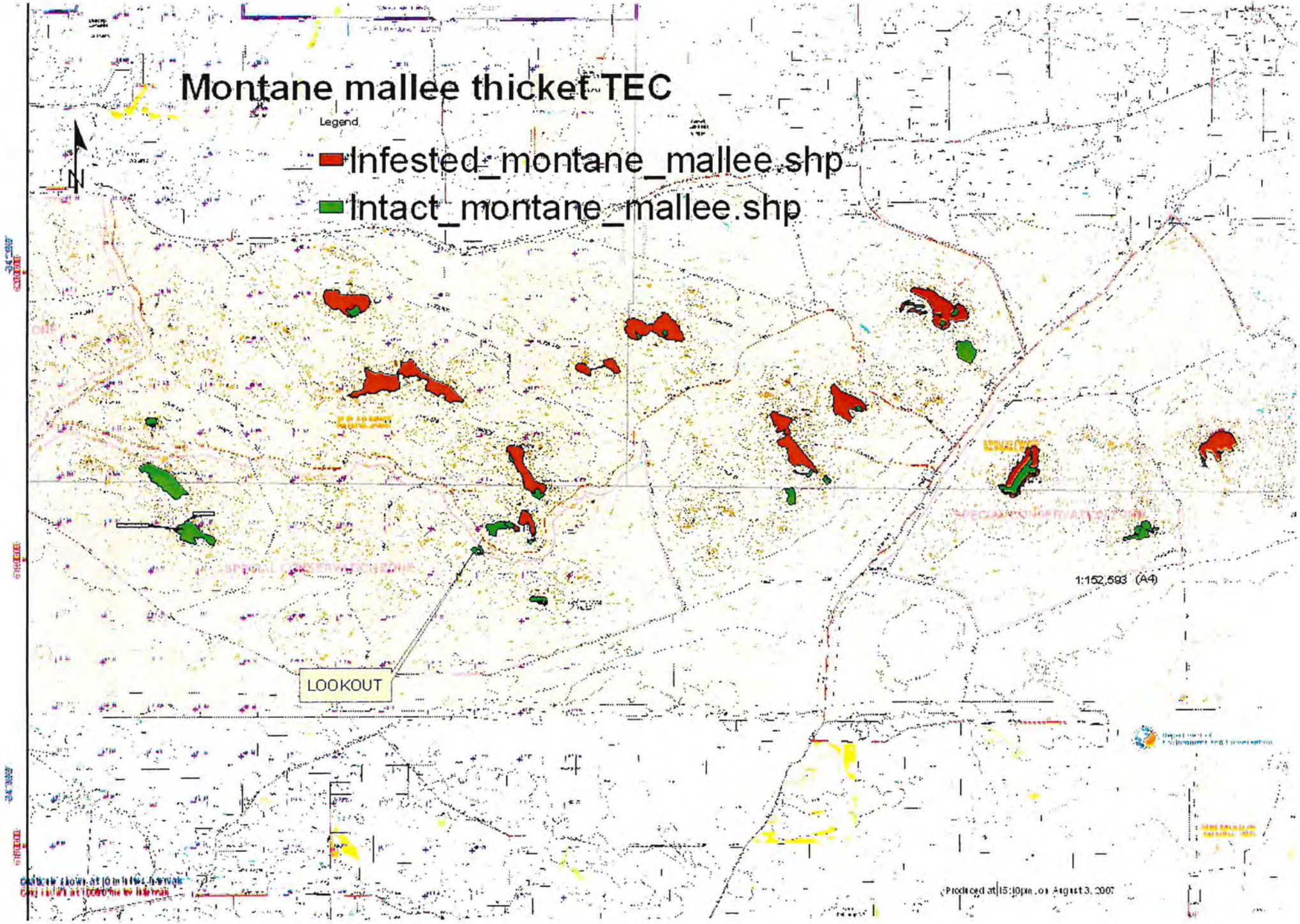
- 1 group for seed collection activity
- 1 group (split again into 2 subgroups) for TEC and disease activities

Equipment:

Binoculars
Secateurs
Field sheets

Attachments:

1. Map of Montane mallee thicket TEC
2. TEC notes / activity
3. Disease risk assessment methodology (Conference abstract) and
4. Species information / extinction risk activity.


Montane mallee thicket TEC
Legend
Infested_montane_mallee.shp
Intact_montane_mallee.shp
N
1:152,593 (A4)
LOOKOUT

Glossary and Websites

Congener-a member of the same taxonomic genus

Disjunct-separated from usually contiguous population

Edaphic-of or relating to the soil

Endemism-restricted to a locality or region

Gene flow-the passage and establishment of genes typical of one breeding population into the gene pool of another;
Phenology-a branch of science dealing with the relations between climate and periodic biological phenomena (as bird migration or plant flowering); periodic biological **phenomena** that are correlated with climatic conditions
Plasticity-capacity for being molded or altered; the capacity of organisms with the same genotype to vary in developmental pattern, in phenotype or in behaviour according to varying environmental conditions;
Provenance-origin or source

Relic-a survivor or remnant

Sclerophyllous-with leathery leaves, as in eucalyptus

Stochastic-involving a random variable; involving chance or probability

Taxon-a taxonomic group, such as a species

Homeplaying

CAR: prioritizing system for reserves, which uses *comprehensive, adequate and representative* as criteria

MBI: market based instruments

Where to find:

Policy 9

http://calmweb.calm.wa.gov.au/drb/edo/mab/pol.htm

Tree Seed Information
http://www.ensisjv.com/WorkingwithEnsis/AustralianTreeSeedCentre/ATSCOperationsManual/tabid/452/Default.aspx

Millenium Seed Bank
http://www.kew.org/msbp/scitech/publications/info_sheets.htm

Threatened Flora Seed Centre
http://www.naturebase.net/content/view/945/1292/