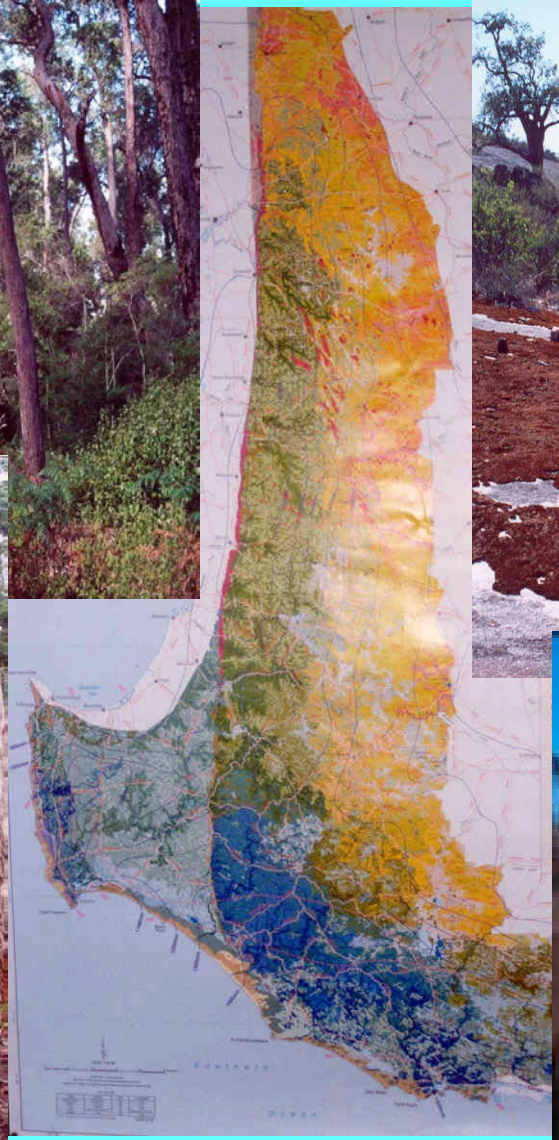
Fire & plants: complex interactions in south-west ecosystems

Neil Burrows & Grant Wardell-Johnson

What we will do

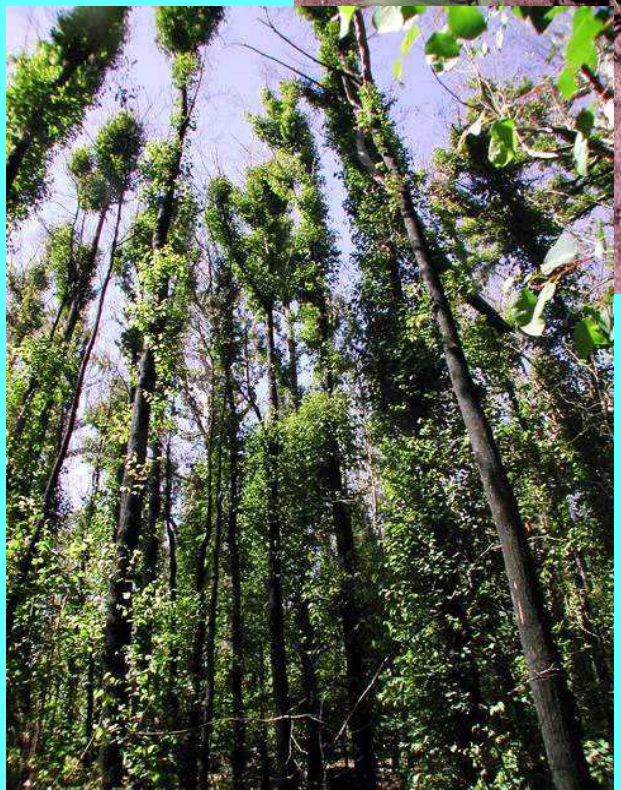
- Introduce fire-adaptive traits of plant species
- Plant community responses to a fire
- Plant community responses to fire regimes
- Overstorey population responses to fires & fire regimes
- Landscape patterns in forested south-western ecosystems

Forests - a complex mosaic



Fire Adaptations

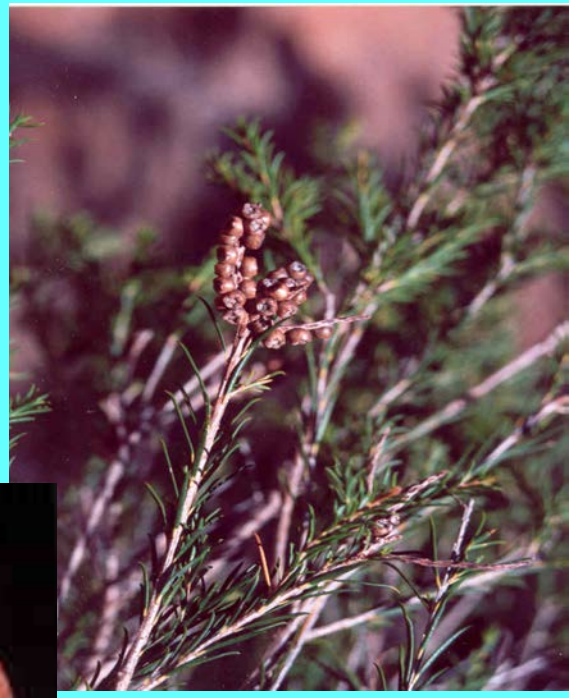
Regeneration Strategies: Resprouters



Fire Adaptations

Regeneration Strategies: seeders

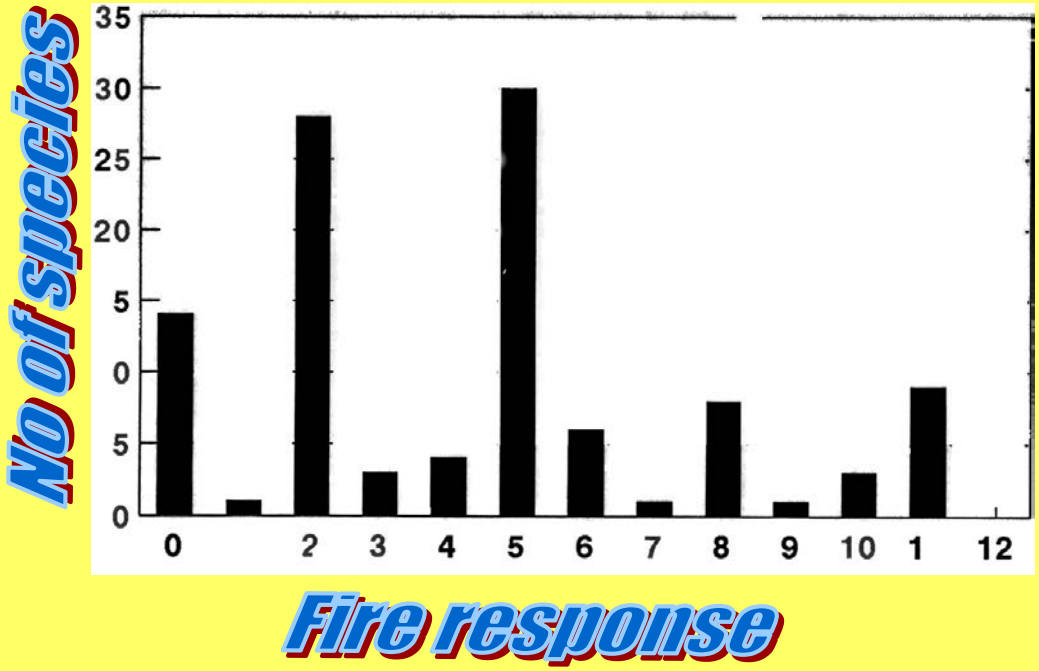
Canopy stored seed



Soil stored seed

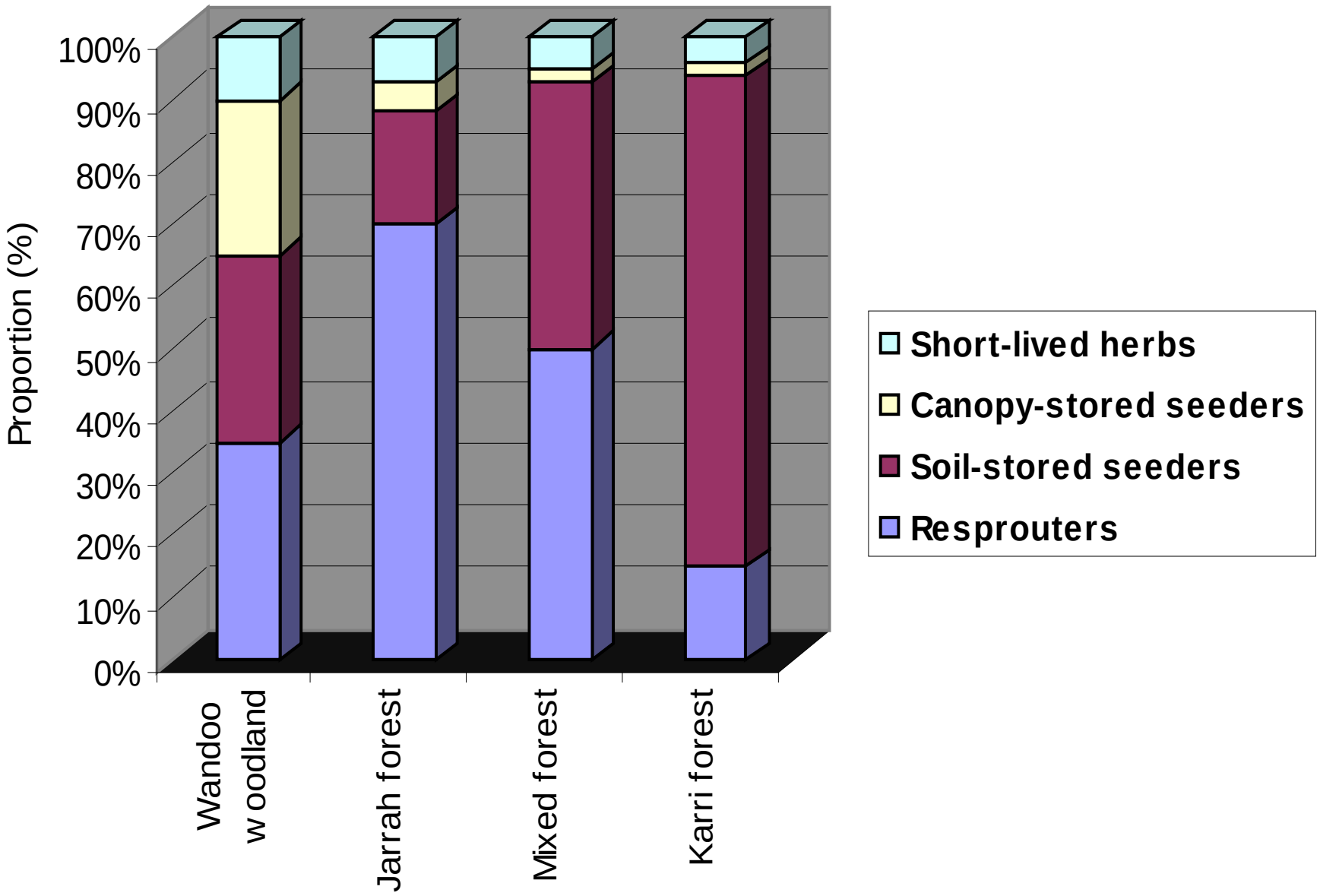
Species responses vary within a community

Response of mature plants following 100 % scorch in red tingle forest community- Walpole



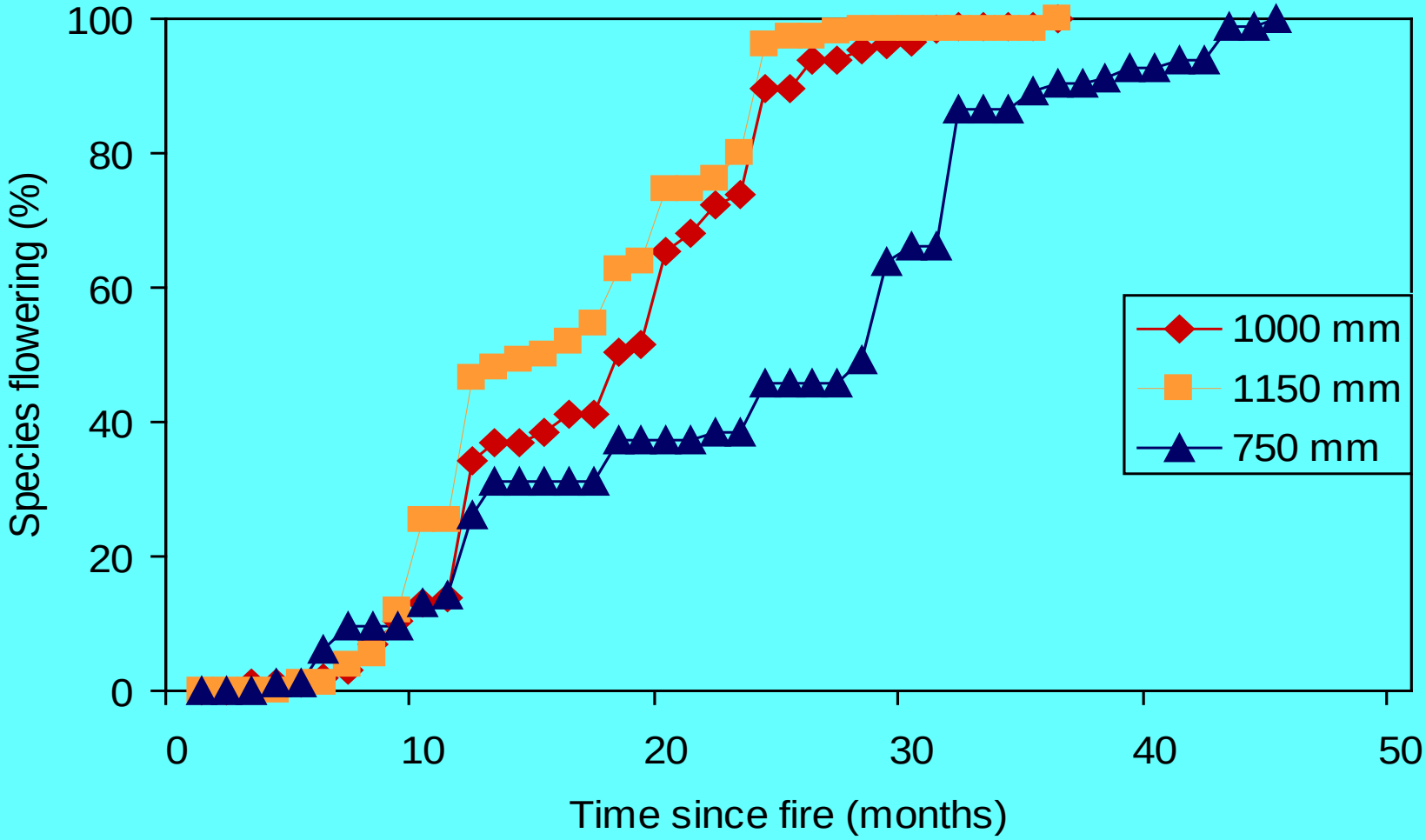
	Plant dies
1	Viable canopy-stored seed
2	Viable soil-stored seed
3	No propagules at site
8	Plant dies (no info)
	Plant survives
4	Root suckers
5	lignotubers
6	Epicormic shoots
7	Terminal buds
9	Plant survives (no info)
10	Ferns (rhizomes & spores)
11	Corm or bulb

Composition of forest understorey species by life forms



Fire Adaptations
Post-fire flowering

Time to first flower after fire (juvenile period): 3 upland jarrah forest understoreys



Setting fire intervals (using plants as indicators)

- Minimum fire interval: 2x juvenile period to allow seed-bank replenishment?
- Maximum fire interval: Less than longevity of fire sensitive, serotinous species.

A fire - plant - animal interaction

Fire & weeds

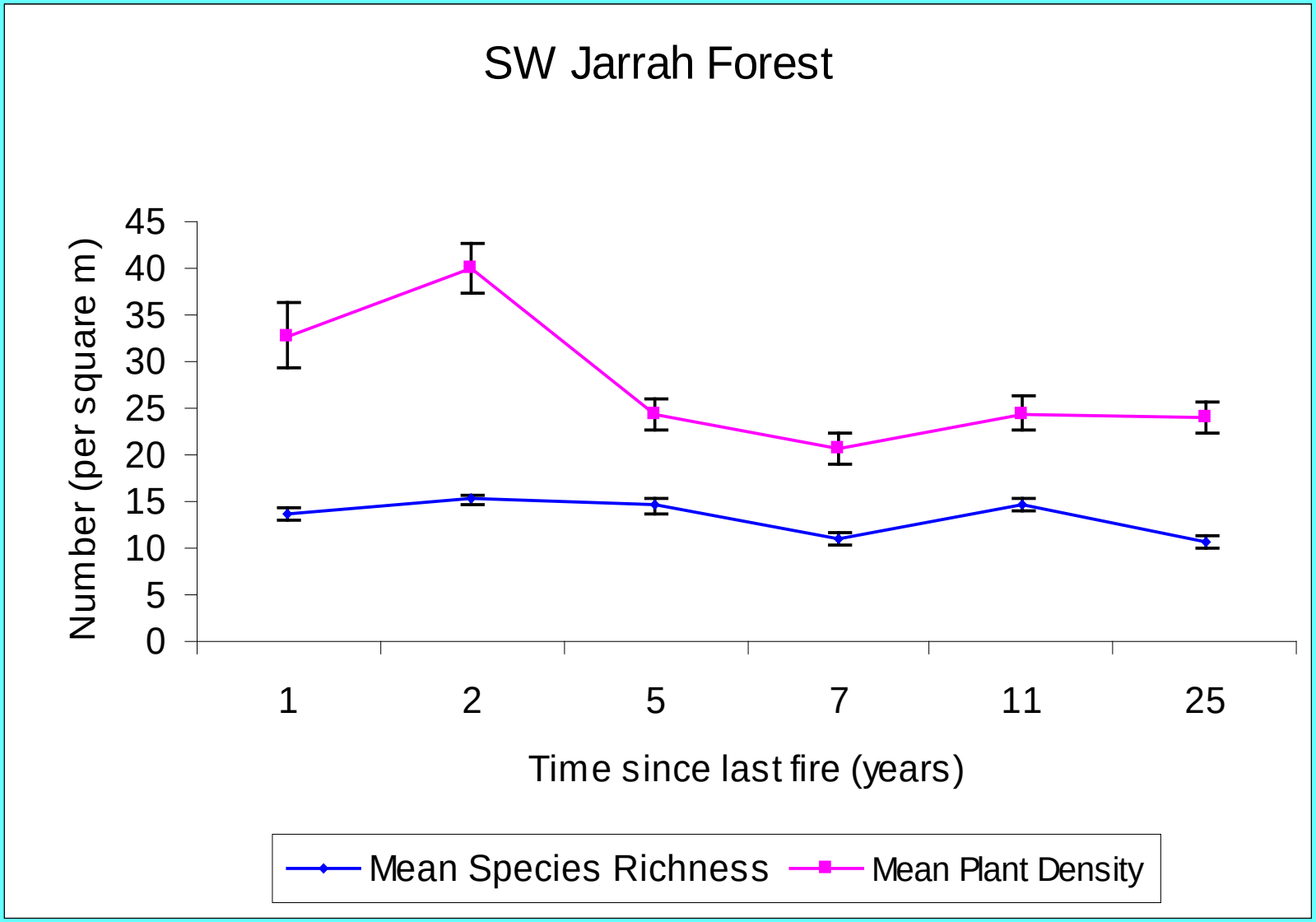
Most vulnerable to weeds:

- Remnant patches
- Road verges
- Forest edge
- Some wetlands & riparian zones

Weed invasion depends on proximity to source of weeds and frequency and severity of disturbance

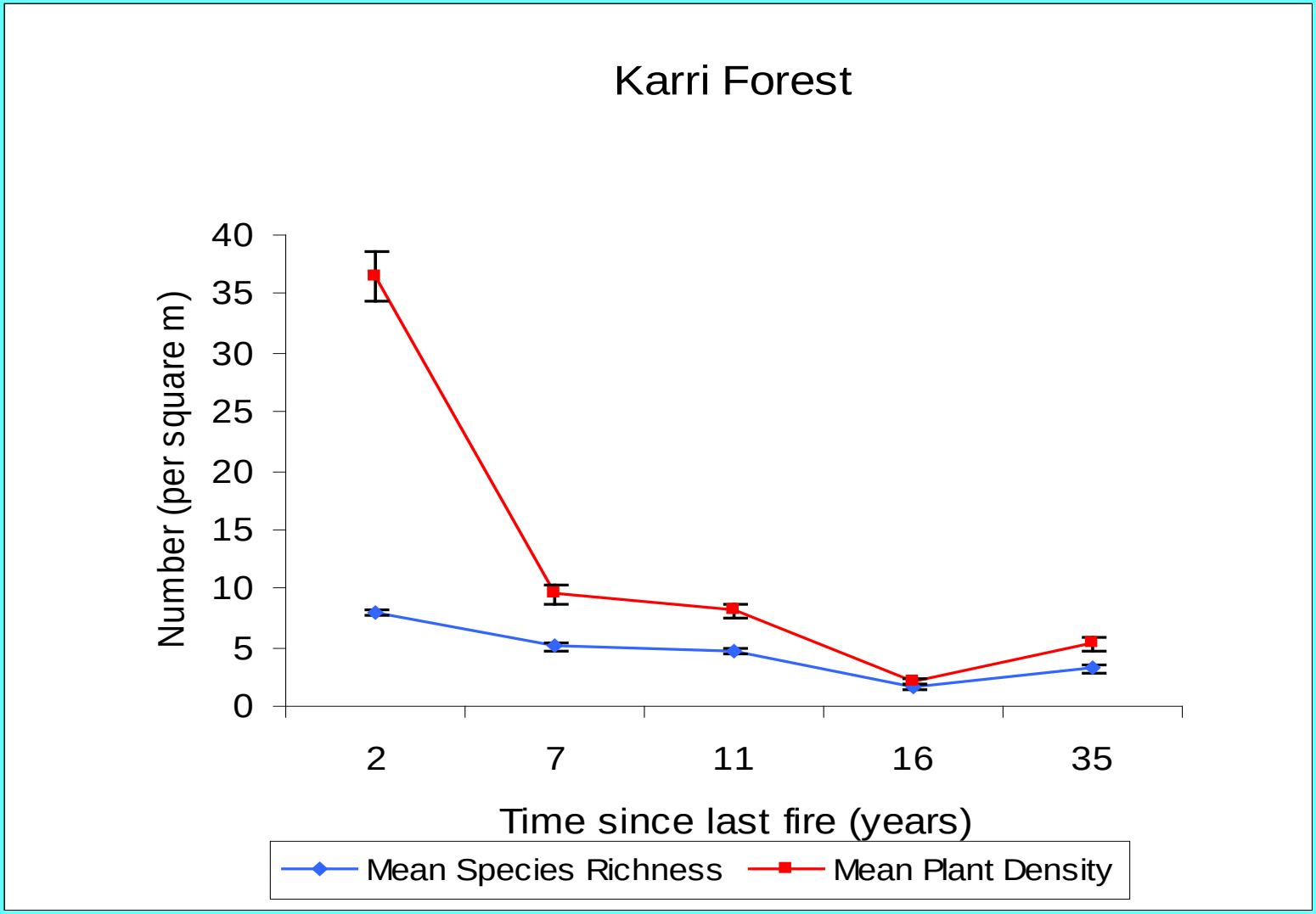
Plant community responses to a fire

Species richness & abundance with time since fire



Plant community responses to a fire

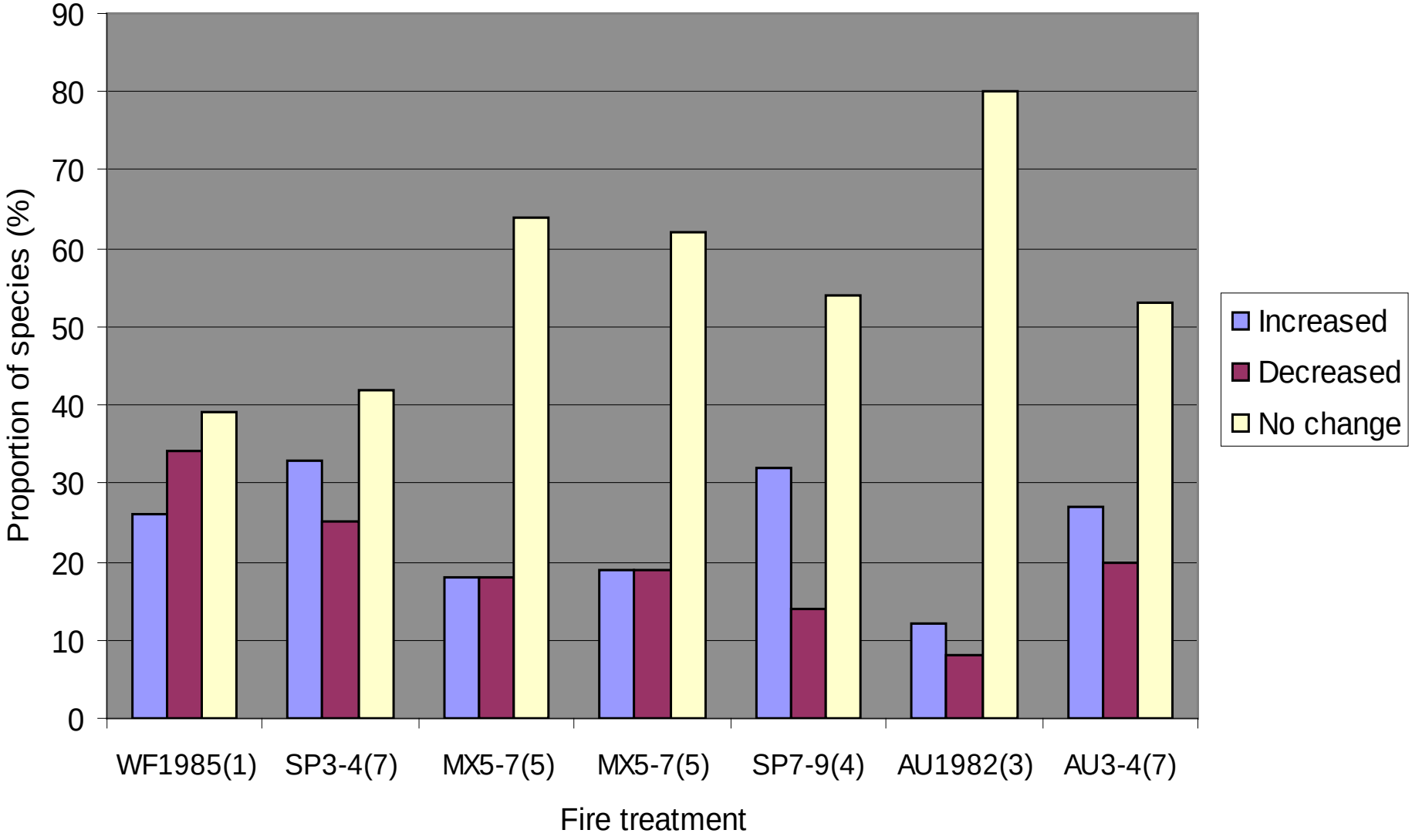
Species richness & abundance with time since fire



Long-term monitoring of fire effects on plants

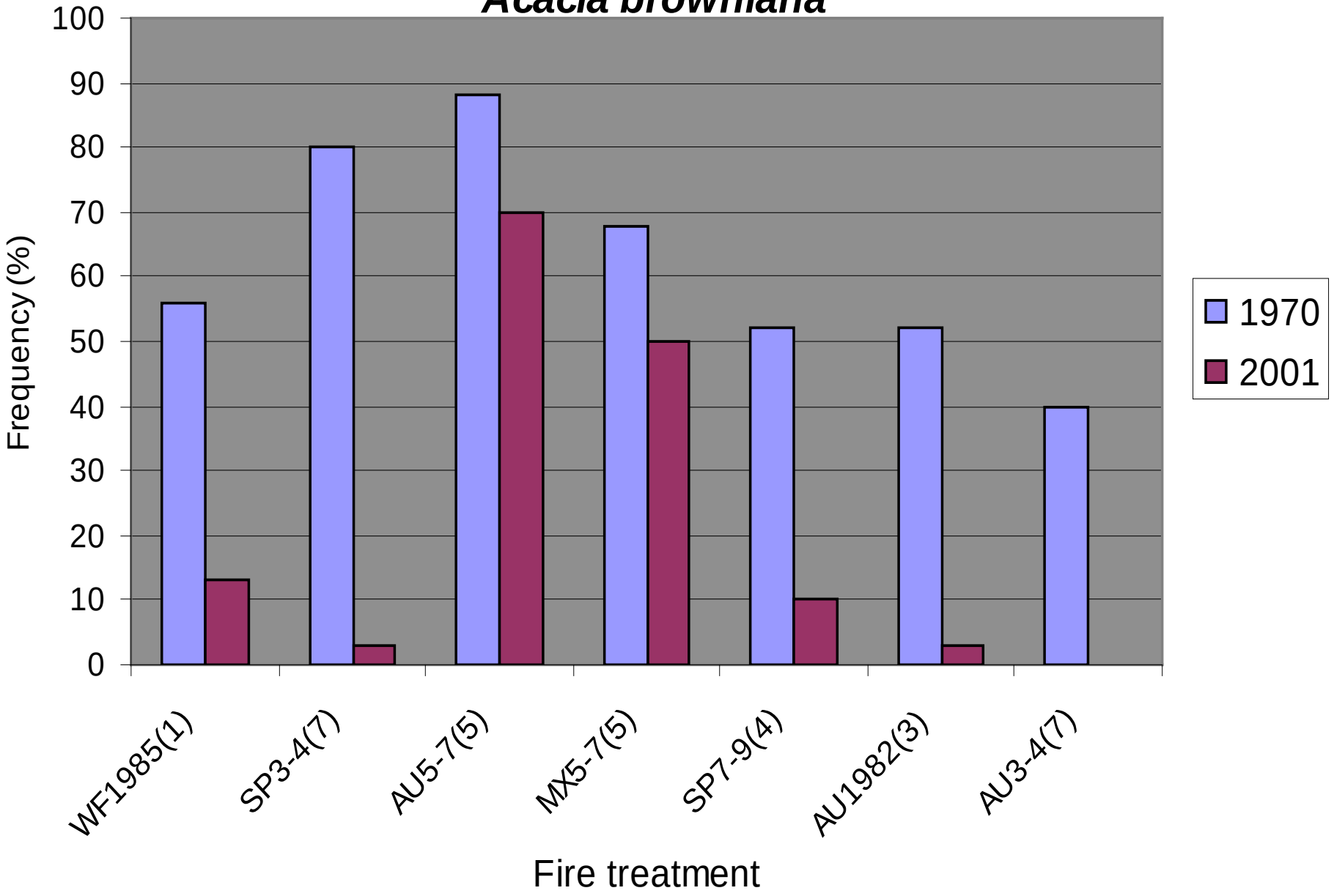
- Southern jarrah forest - commenced 1970
  - Unburnt control (Wildfire 1985)
  - Spring 3-5 yrs (7 fires)
  - Spring & autumn 5-7 yrs (5 fires)
  - Spring 7-9 yrs (4 fires)
  - Unburnt control (Autumn 1982)
  - Autumn 3-4 yrs (7 Fires)

Proportion of species that changed in abundance over the period 1970-2001



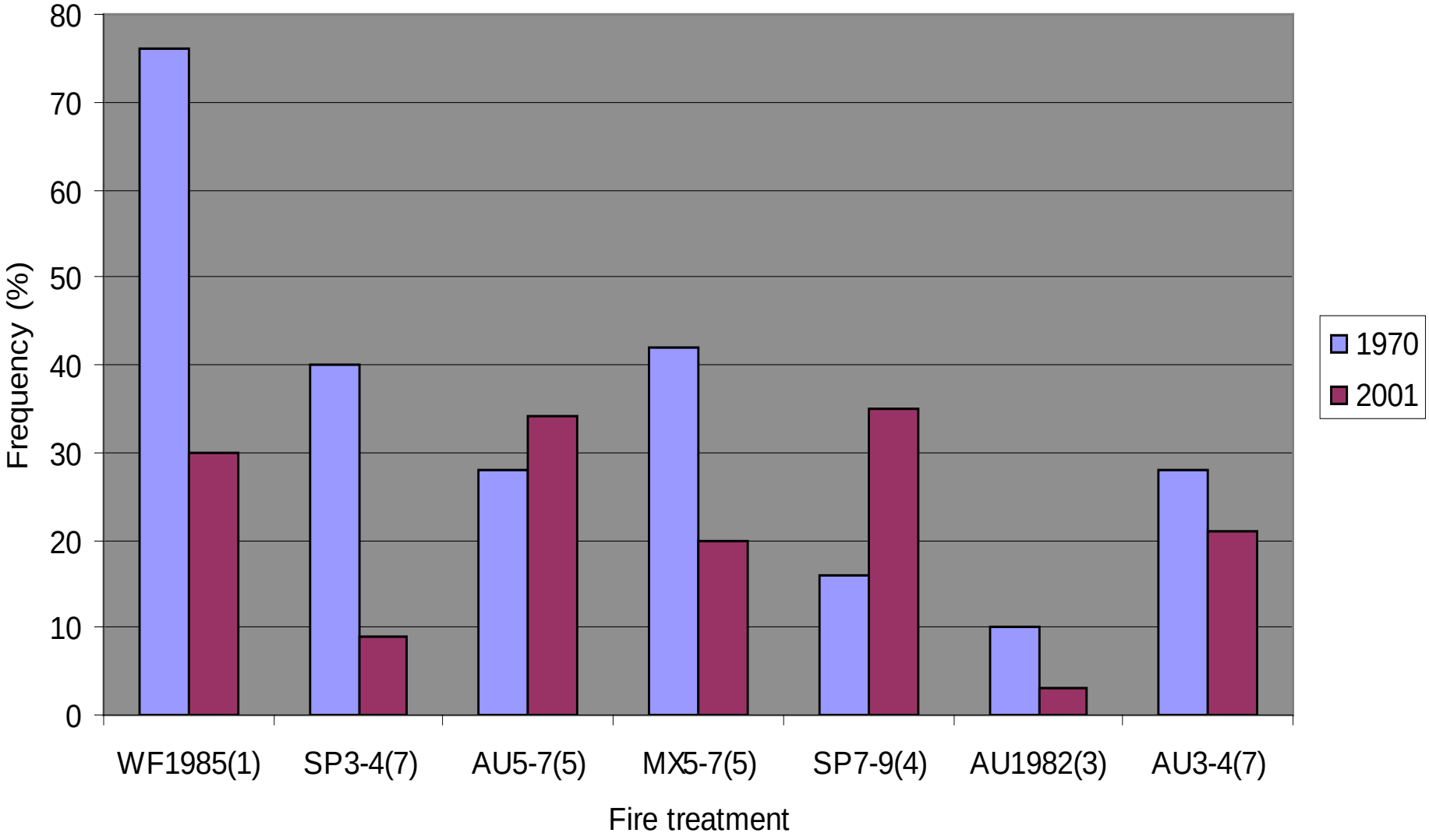
Changes in frequency of occurrence 1970-2001

Acacia browniana



Changes in frequency of occurrence 1970-2001

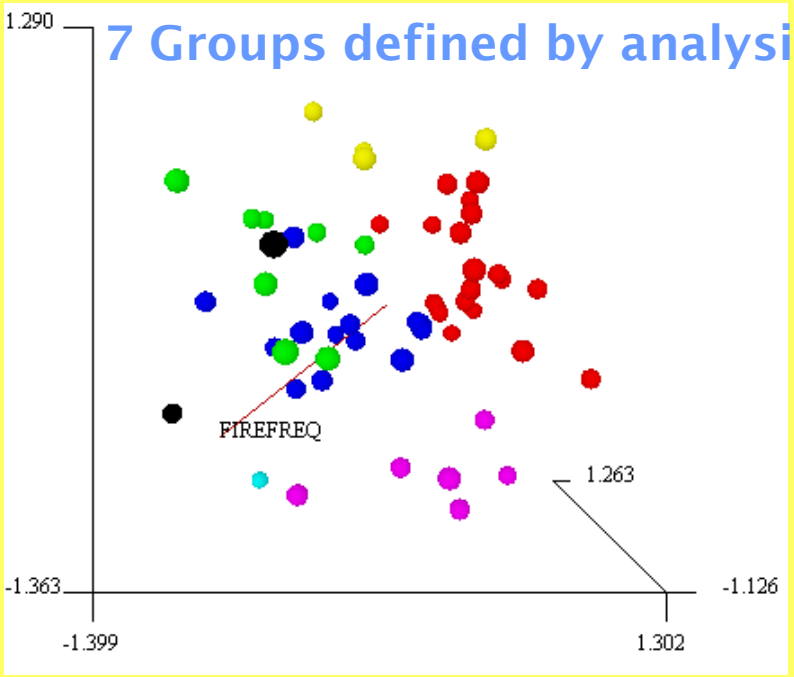
Crowea angustifolia

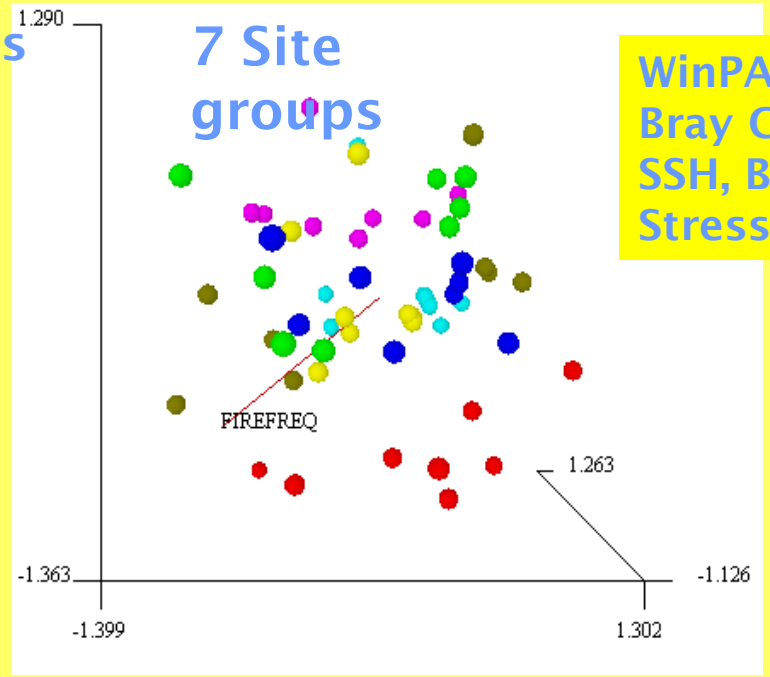


Summarising

- Forests are a complex mosaic of plant communities that vary in their response to fire.
- Forest plants display a variety of fire adaptive traits.
- Many (but not all) plants & communities benefit from fire at some stage in their life cycle to stimulate regeneration & reproduction.
- No single fire regime benefits all species.
- Diverse fire regimes at appropriate temporal & spatial scales promotes floristic and structural diversity.

Patterns of floristic assemblages (+/-) in jarrah forest near Manjimup over 31 years





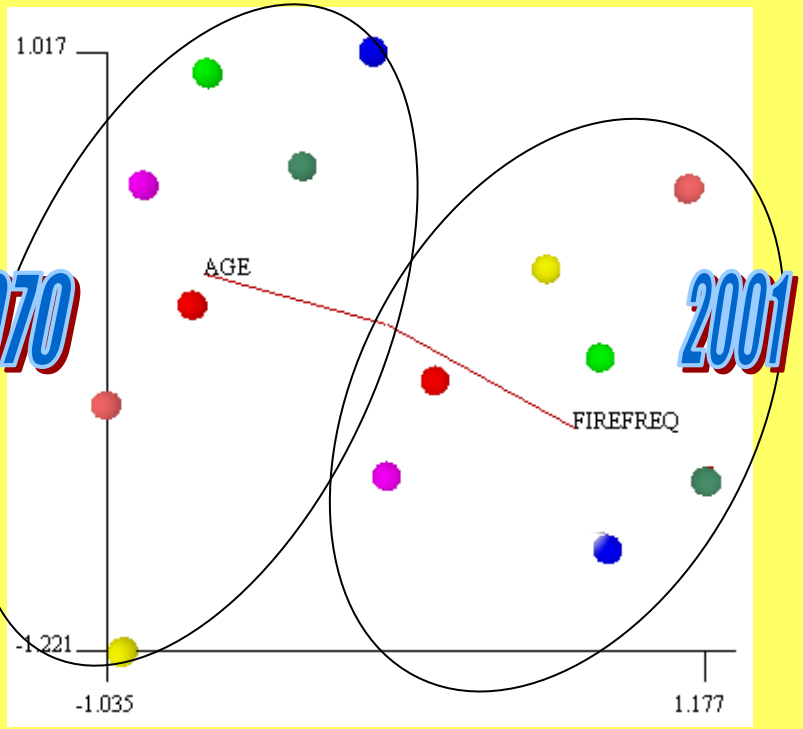
WinPATN
Bray Curtis metric
SSH, B = -0.1
Stress = 0.18

Number of fires (FIREFREQ) highly significantly correlated with floristic ordination

Time since fire not as important as the number of fires in determining floristic composition

Sites move across groups over time

Patterns of floristic assemblages (frequency) in jarrah forest in 1970 & 2001



WinPATN
Bray Curtis metric
SSH, B = -0.1
Stress = 0.22

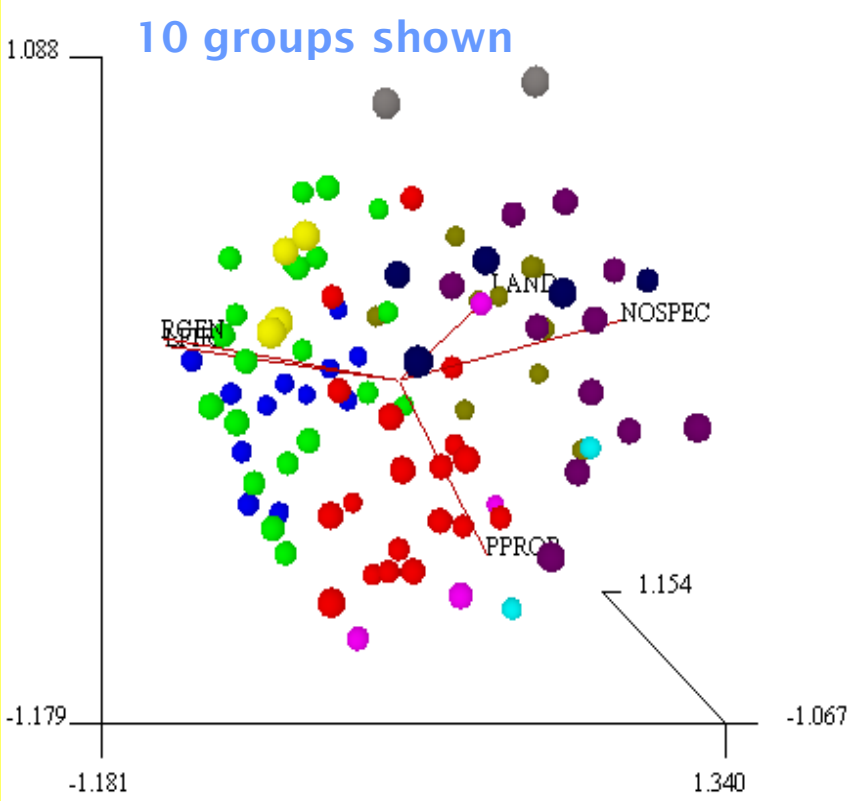
All sites ‘moved’ in assemblage patterns over 31 yrs

Records of floristic patterns a function of measurement time after fire as well as treatment effects

Floristic assemblages in a single community type in regenerating karri forest

- Space-for-time substitution
- Karri site type 10 (Inions *et al.* 1989)
- 92 quadrats, 20 m x 20 m throughout geographic spread of type
- Assessment of floristics using modified Braun Blanquet scale
- Recording of site and disturbance
- Multivariate analysis using WinPATN

Floristic assemblages in a single community type in regenerating karri forest



5 extrinsic variables correlated with floristic ordination

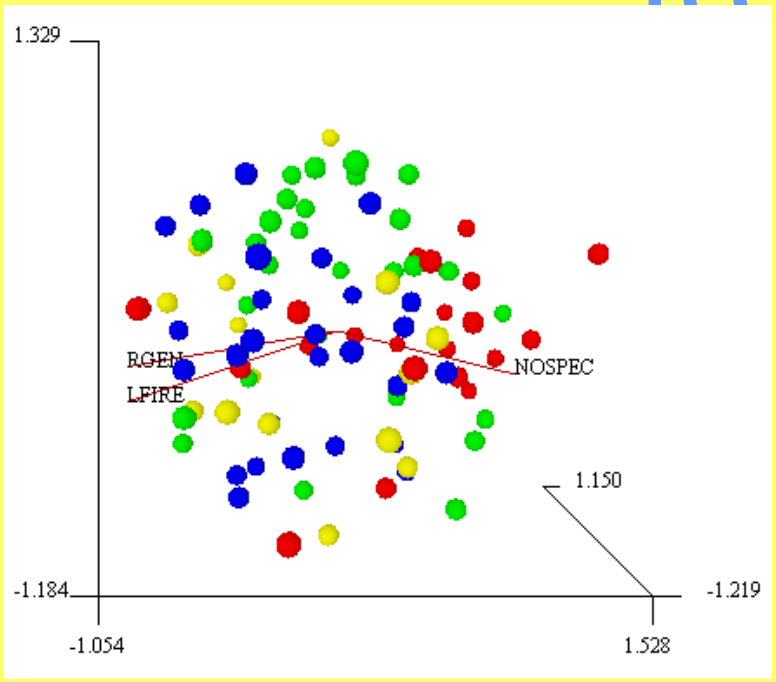
REGEN	Time since regeneration
LFIRE	Time since fire
LAND	Landscape position
NOSPEC	Species richness
PPROP	Distance to PP

Fire intensity & number of fires not correlated with floristic ordination

WinPATN
Bray Curtis metric
3 D, SSH, B = -0.1
Stress = 0.22

Interpretable groupings of sites not evident

Floristic assemblages (a priori groups) based on time since most recent fire



Time since fire

- 1-3 yrs
- 4-10 yrs
- 11-20 yrs
- 21 + yrs

WinPATN
Bray Curtis metric
SSH, B = -0.1
Stress = 0.22

- Interpretable groupings of sites on floristic composition based on time since fire are not evident
- Species richness negatively correlated with time since fire ($P < 0.002$) and time since regeneration ($P < 0.002$ if mature sites not included)
- Greatest species richness soon after disturbance

Pairwise ANOSIM of floristic assemblages (a priori groups) based on time since most recent fire

Time since fire

1 1-3 yrs
2 4-10 yrs
3 11-20 yrs
4 21 + yrs

	1	2	3
2	***		
3	***	***	
4	***	***	***

Different ages since fire have different floristic assemblages

Number of fires not significantly correlated with ordination

Pairwise ANOSIM of floristic assemblages (a priori groups) based on age since regeneration

Age of regeneration

1 1-3 yrs
2 4-10 yrs
3 11-20 yrs
4 21 -114 yrs
5 Not logged

	1	2	3	4
2	***			
3	***	***		
4	***	***	NS	
5	***	0.07	NS	***

Different ages since regeneration have different floristic assemblages

Assessment of fire responses of overstorey species at the population level

Overstorey species are disproportionally important components of forest ecosystems

Structually important members of the community

Longevity ensures that populations integrate environmental influences

Assessment of fire responses

- Fire responses at different stages in the growth cycles of trees
- Regeneration success
- Dry siding & hollow butting
- Bark thickness (not today)
- Diameter distributions (not today)
- Ageing & longevity (not today)

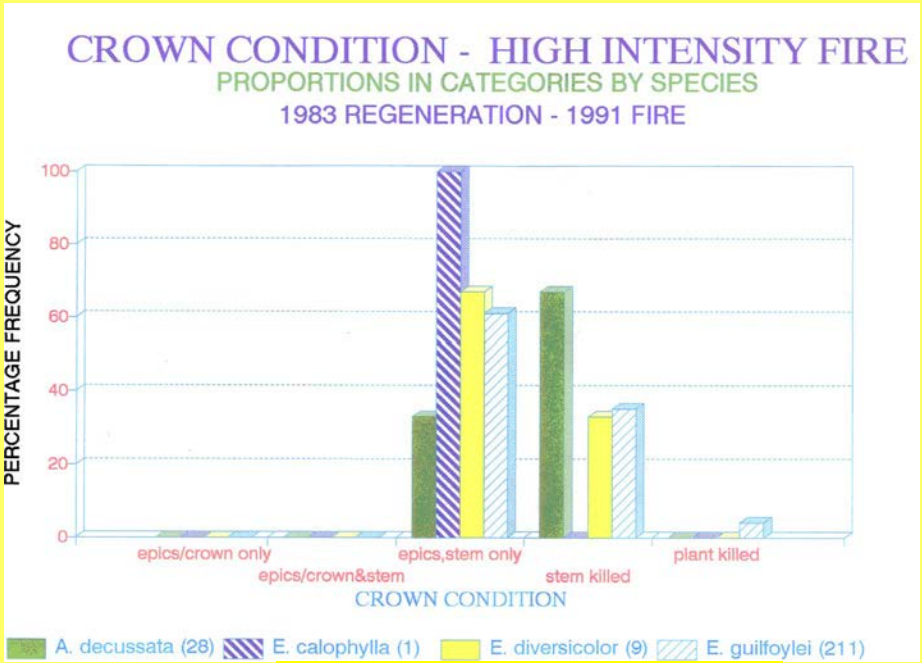
Examine four locally endemic and four regionally distributed species

Wardell-Johnson 2000

Response following high intensity fire at Casuarina Rd, Jan 1991: Karri & Yellow Tingle

1983 regrowth

1976 regrowth



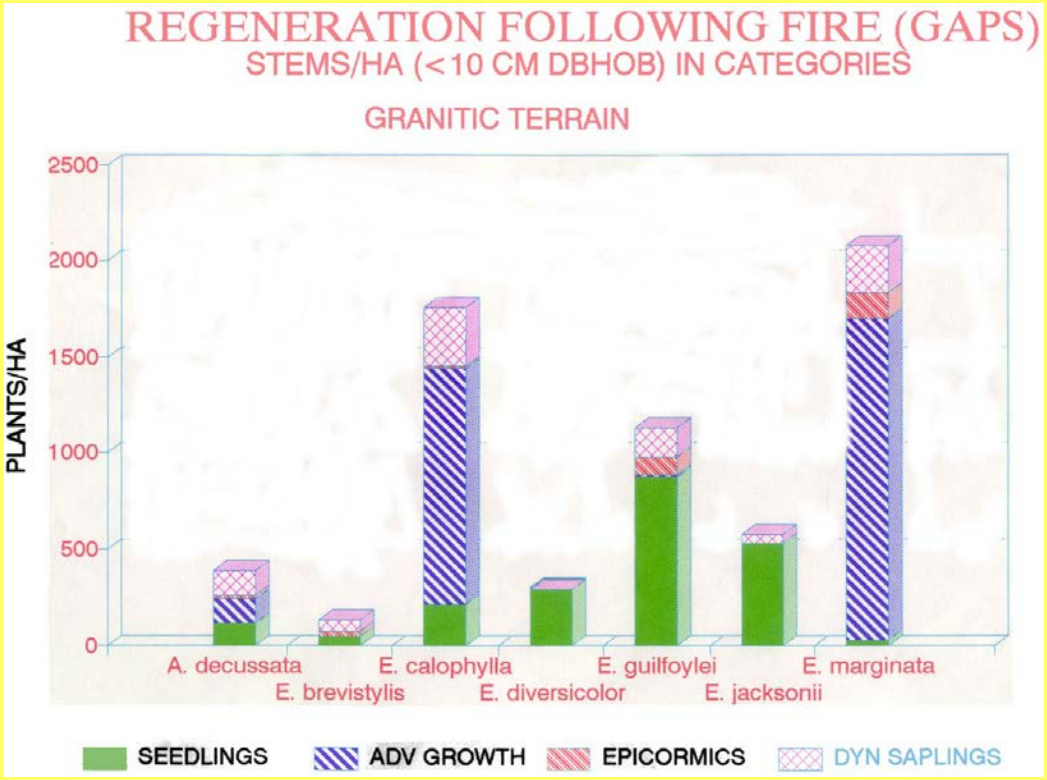
1983 regrowth

Few eucalypts killed and most plants of Karri, Marri and Yellow Tingle resprouted following high intensity fire in 8 & 14 year-old regrowth

Regeneration following high intensity fire

Epicormic shoots

Seedlings



Species vary in their regeneration responses

Jarrah & Marri regeneration dominate in gaps & non gaps alike

All dominant overstorey species in south-west forests develop lignotubers

Red Tingle

Yellow Tingle

Karri

Responses of mature trees following high intensity fire

Red Tingle (1 yr) Nuyts Fire

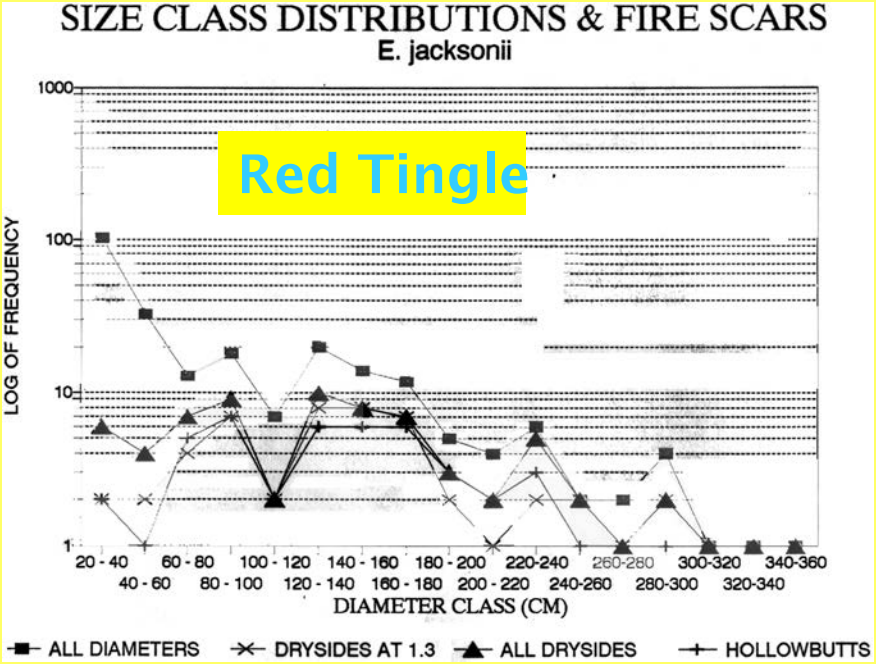
Yellow Tingle (1 yr) Casuarina Rd Fire

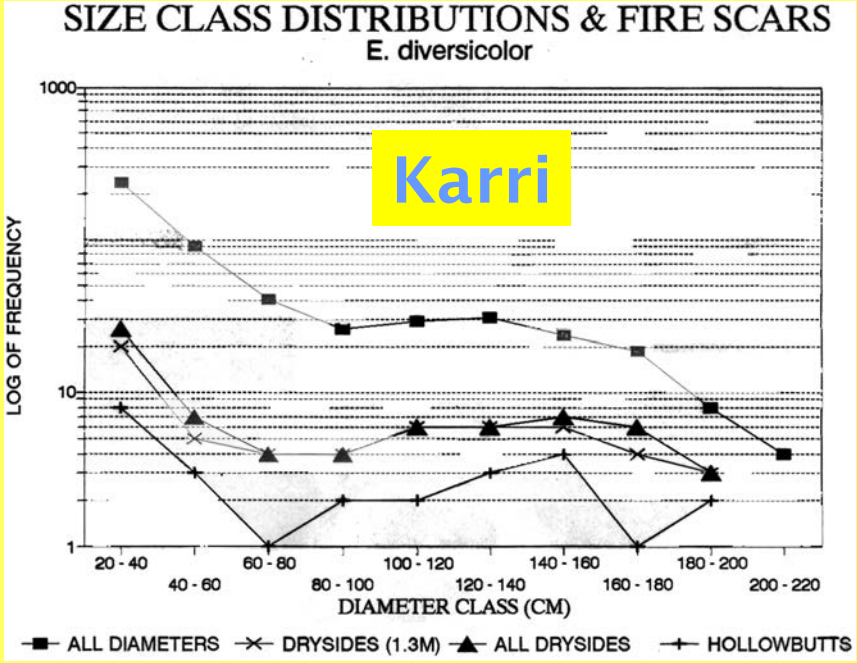
Karri (5 yrs) Brockman Fire

Jarrah & Marri are toughest but few overstorey trees killed by high intensity fires

Patch sizes of regrowth naturally one or a few trees in size, even following high intensity fire

Fire regimes & relictual species:
Damage to mature trees through fire

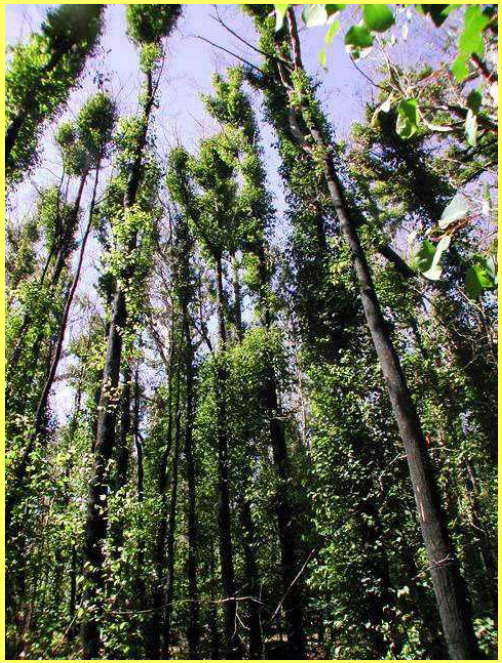




- Proportionally more mature Red Tingle trees damaged by fire than Karri trees
- High frequency of fires may cause more damage than high intensity fires at longer intervals

Many possible reasons for the restrictedness of local endemics in the forested ecosystems of south-western Australia

- Restricted to locally endemic habitat
- Long term trends in climatic patterns
- Genetically depauperate populations
- Changed patterns of disturbance



Red Tingle (1 yr)
Nuyts Fire

All of these factors interact

A single fire is rarely of evolutionarily significance

Fire sensitivity:

None of the dominant forest eucalypts in south-western Australia are fire sensitive

Wardell-Johnson 2000

River Banksia

Yellow Tingle

Fire sensitivity & economic sensitivity

Area estimated of karri on all CALM land in 2040 (in 1991) based on logging and regeneration history

Wardell-Johnson et al. 1991

Fire sensitivity & fire vulnerability

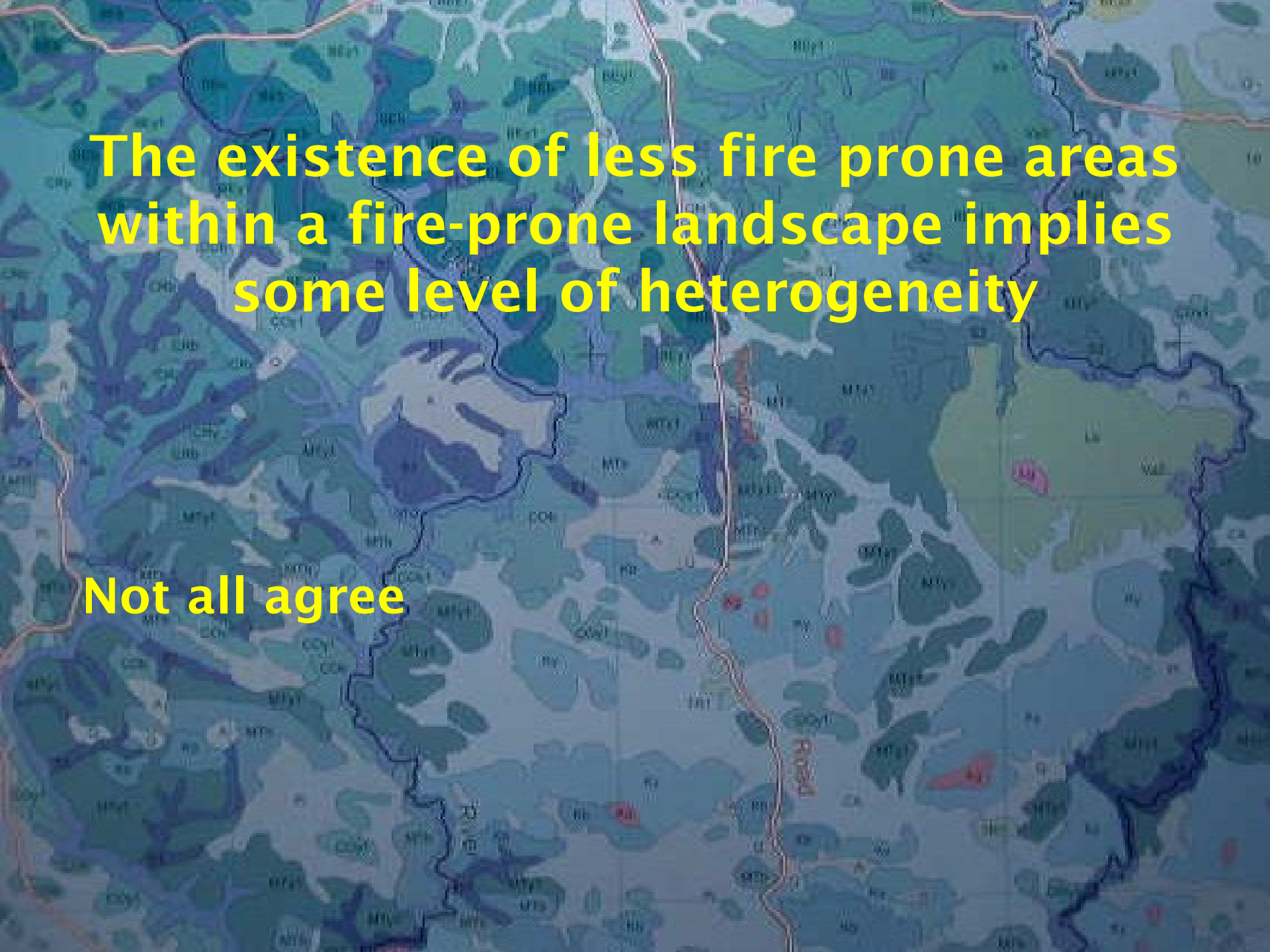
White's gum

Red Tingle

Relictual endemic species are not necessarily fire sensitive but may occur in naturally less fire prone areas

Where are these areas and what specific fire management approaches are required?

Compromises between management of relictual species and commercially productive species if biodiversity conservation outcomes sought


The existence of less fire prone areas within a fire-prone landscape implies some level of heterogeneity
Not all agree

Implied homogeneity

'…ageing grasstrees and determining their fire history over the last 250 years…'

'…a reconstruction of the fire history of the jarrah forest over the last 250 years.'

'results suggest marked changes in the fire regime of southwestern Australia over a relatively short period.'

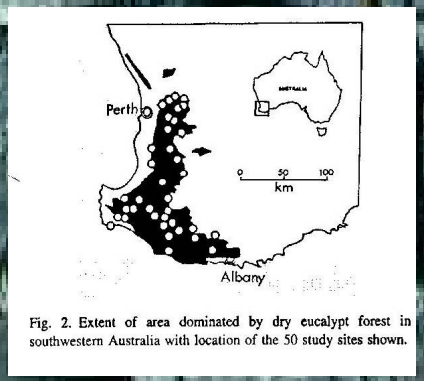


Fig. 2. Extent of area dominated by dry eucalypt forest in southwestern Australia with location of the 50 study sites shown.

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Patterns of fire across landscapes

To what extent do burnt grass trees record fire incidence at a landscape scale?

How homogenous is the south-western landscape?

Did Nyungar People see or manage the environment as if it were homogenous?

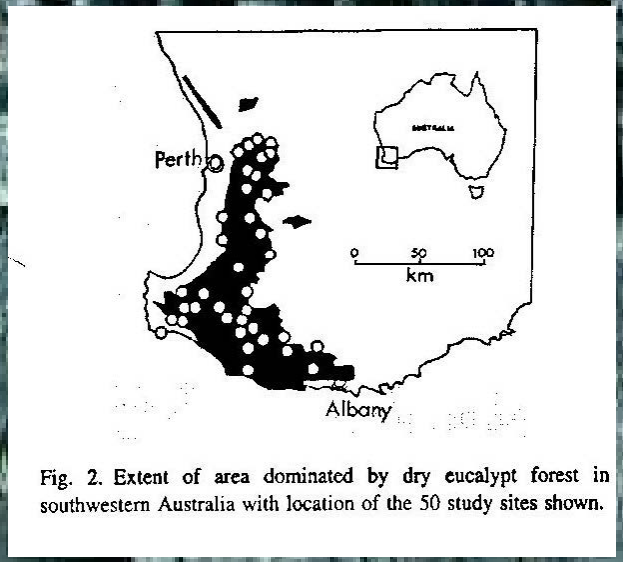
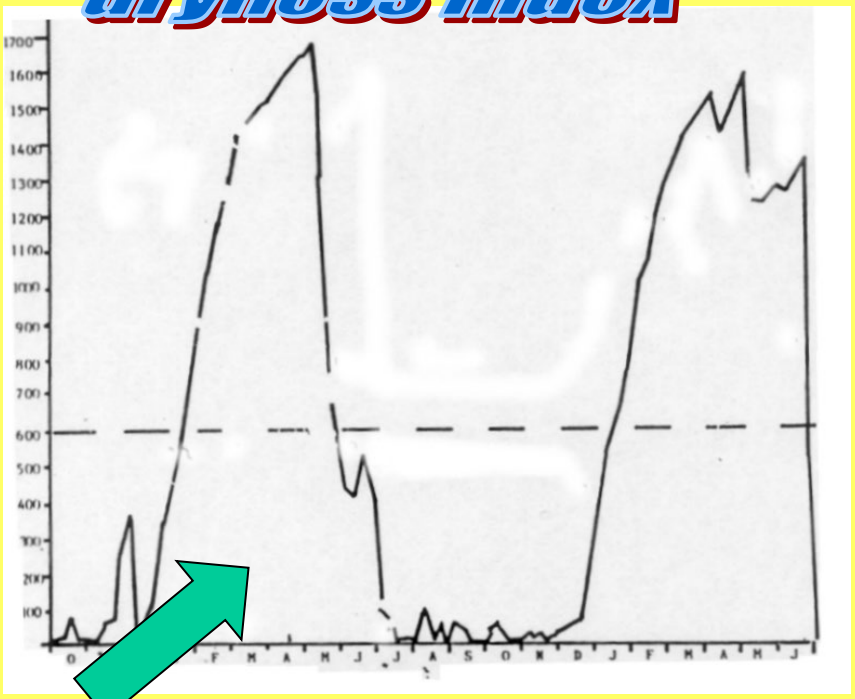


Fig. 2. Extent of area dominated by dry eucalypt forest in southwestern Australia with location of the 50 study sites shown.

Soil dryness index for two forest types:
an indicator for when the forest will burn
(after Christensen & Annells 1985)

Southern Jarrah forest dryness index

Karri forest dryness index



Forest too wet to burn

Patterns of fire across landscapes

To what extent have edaphic and vegetation changes acted as natural fire boundaries over millennia?


Bunya Mtns


NG highlands


Nyka Plateau
Malawi

How homogenous is the south-western forested landscape with respect to fire?


Nile Creek


Pingerup Plains


Romance Forest Block


Mt Gardner

Patterns of fire across landscapes

Plant communities have faced a long uninterrupted history and long isolation.

Sharp edaphic changes predominate with little change in relief.

Complex mosaic plant communties are the rule in the forested landscapes of south-western Australia.

Complex structural changes and patterns of fuel accumulation.

Fire behaviour will vary over short distances, influencing regime

Conclusion

Climate changes predict greater seasonality & greater frequency of fires.

Homogenising influences of invasion by introduced species, dieback disease and European land use.

Use fire management to enhance opportunities to maintain heterogeneity & complexity

Fire management for biodiversity conservation outcomes will contribute to maintaining heterogeneity.