Terrestrial Biodiversity: Key issues for WA for climate change adaptation

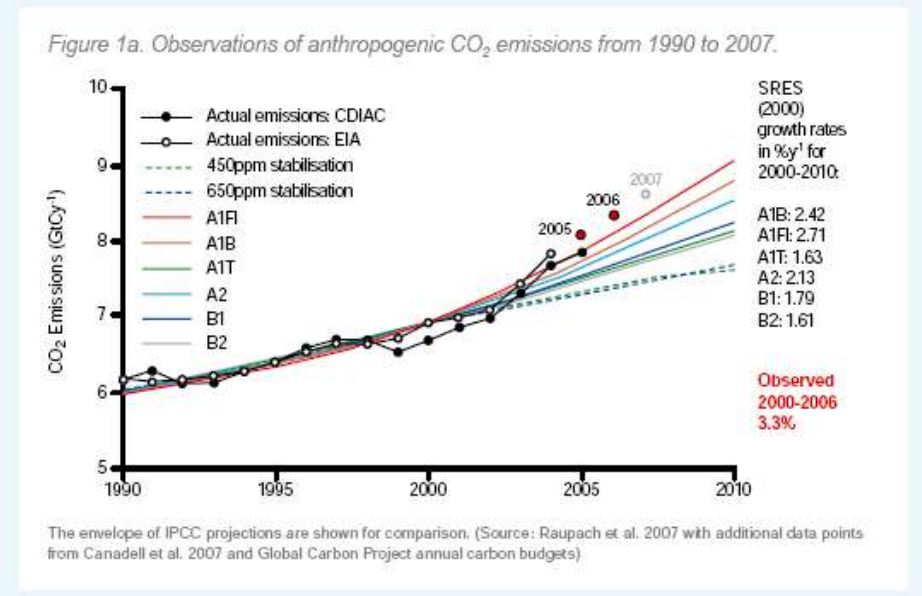
Earth, Fire, Air & Water : an elemental ecology of climate change

Grant Wardell-Johnson
Institute for Biodiversity & Climate, Curtin University
g.wardell-johnson@curtin.edu.au

Curtin University
CURTIN INSTITUTE FOR BIODIVERSITY AND CLIMATE

Anthropogenic climate change

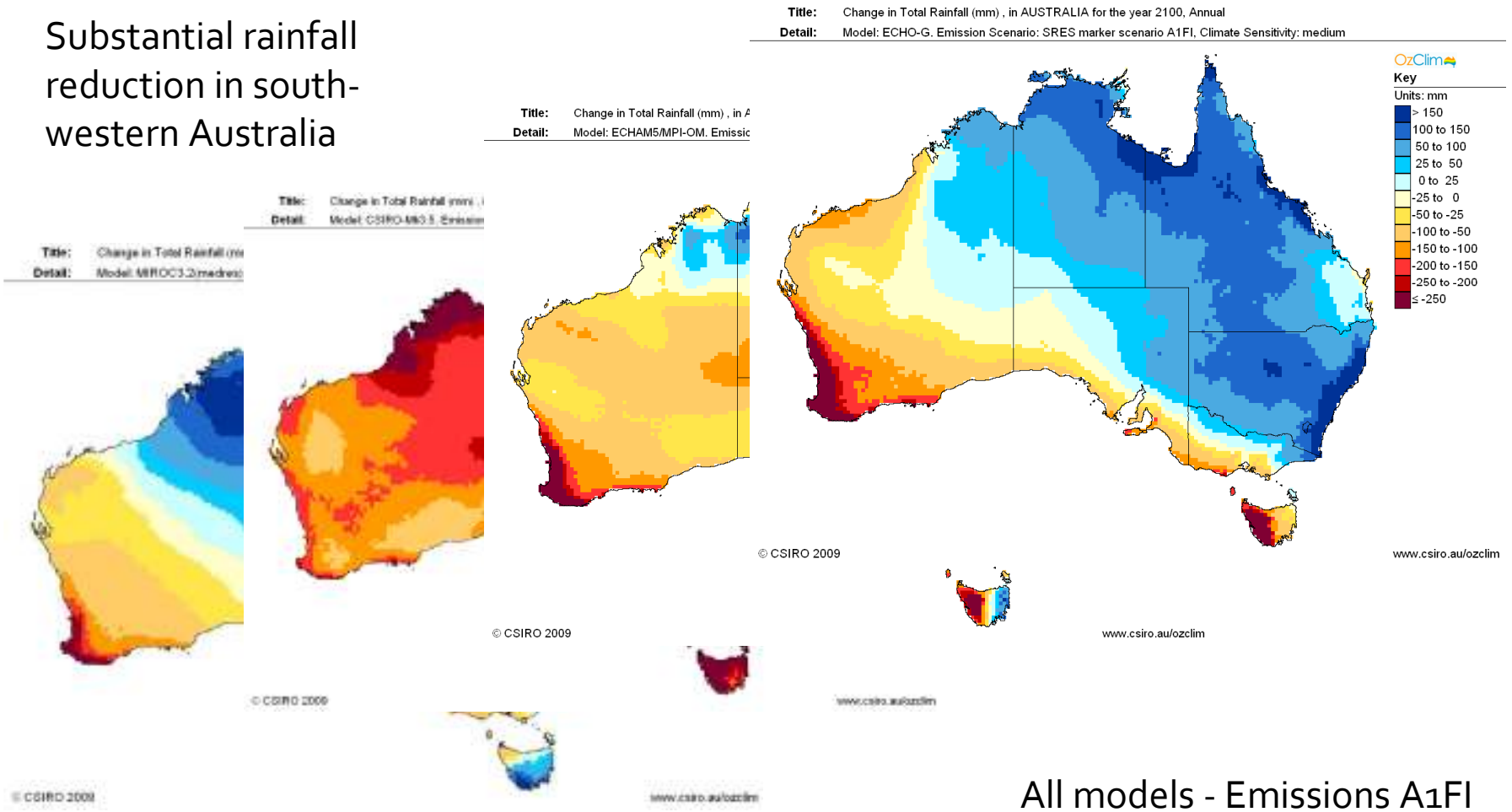
- Climate system changing faster that previously thought
  - Rate of CO2 accumulation
  - Global ocean temperature trends
  - Loss of Arctic sea ice
  - Sea level rise trends
  - Uncertainty - more rapid & severe
  - Impacts greater because of threshold events or tipping points



Steffan (2009) Climate Change 2009: Faster Change & More Serious Risks

Congruence among models for scenarios in Mediterranean-climate SWA

Substantial rainfall reduction in south-western Australia



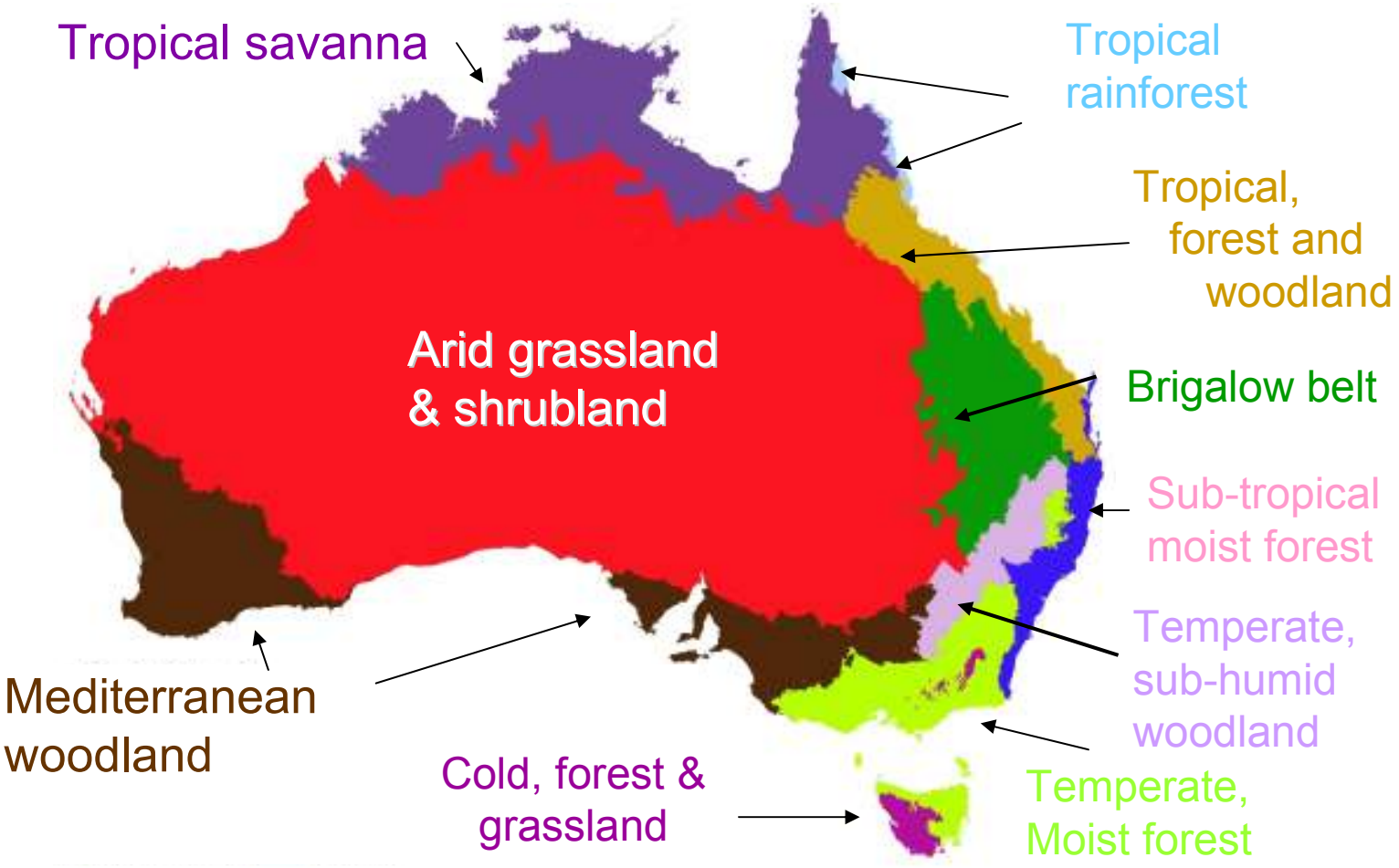
All models - Emissions A1FI
- Medium sensitivity
- Time 2100

We must limit emissions & warming urgently

- Must limit to < 2° C (~ 450 ppm CO_2)

- Requires GHG emissions to be reduced by 60-80% below 1990 levels by 2050 & must peak & decline before 2015

WA in context - Biomes of Australia



McIntyre & Hobbs 2007

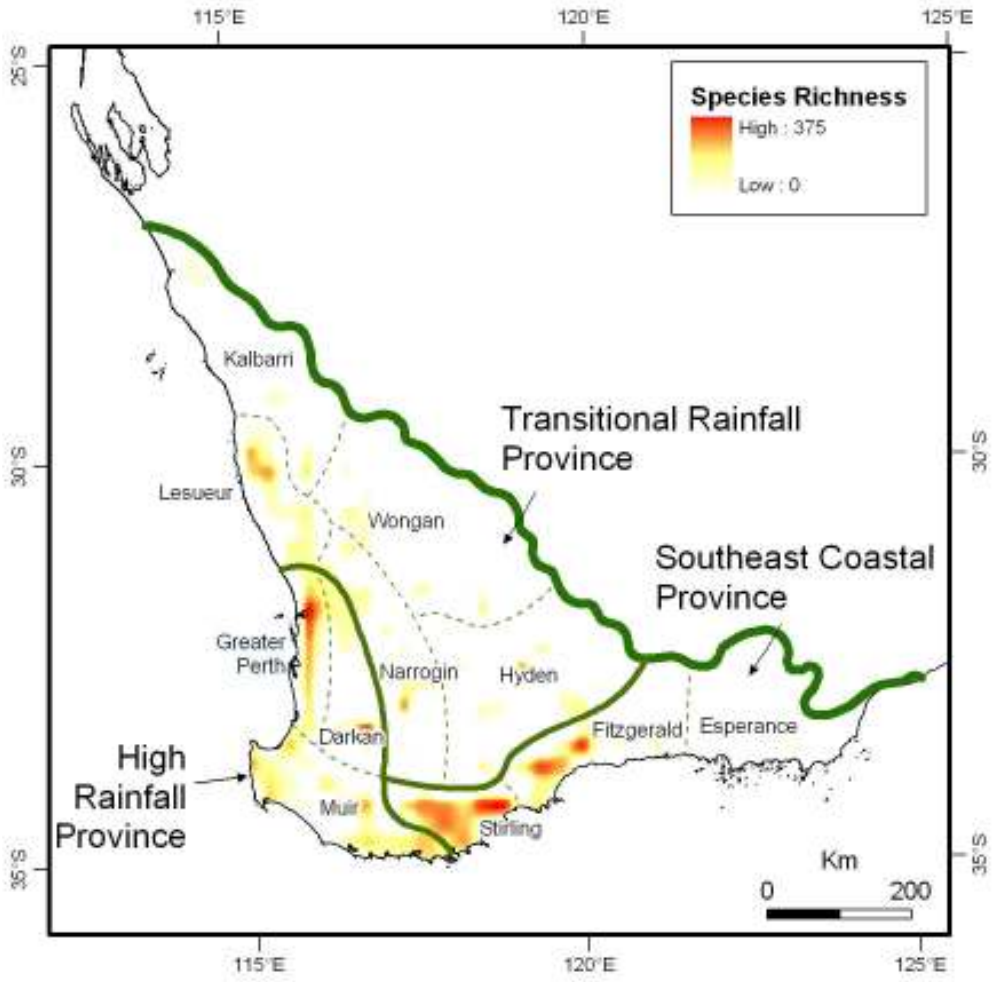
Climate change & the four classical elements

- **Classical elements** that reflect essential parts and principles of which everything consists
- **Jackson (1968).** 'Fire, air, water and earth - an elemental ecology of Tasmania' Proc Ecol Soc Aust. 3: 9-16
- Climate change is **all encompassing** – interactive with all environmental elements

- Earth
- Fire
- Air
- Water

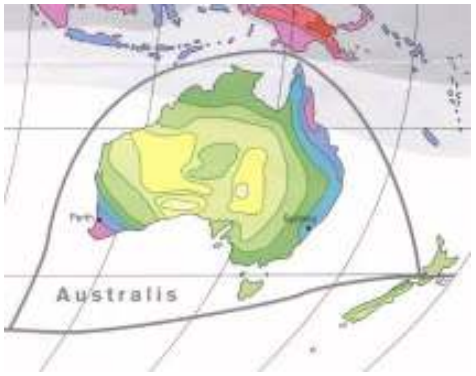
Earth

SWA as a global Biodiversity hotspot



Hopper & Gioia 2004

- South-west Australian Floristic Region (SWAFR)
  - 302,600 km²
  - Mediterranean climate
  - 7380 native vascular plants
  - 49 % endemic



Barthlott *et al*. 1996

Venerable biota of SWAFR reflects landscape age, climatic stability & disturbance regime

- Limited dispersability
- Old lineages of taxa
- Longevity of individuals
- The pursuit of heterozygosity
- Adaptation to saline soils
- Nutritional specialisation
- Vulnerability to nutrient & soil removal
- High resilience

(After Hopper 2009)




Parasitism, Insectivory, specialized pollination syndromes




Ancient & vulnerable local endemics abound

Copeia, 1997(2), pp. 373–381

Taxonomy, Relationships and Conservation of a New Genus and Species of Myobatrachid Frog from the High Rainfall Region of Southwestern Australia

J. Dale Roberts, Pierre Horwitz, Grant Wardell-Johnson, Linda R. Maxson, and Michael J. Mahony

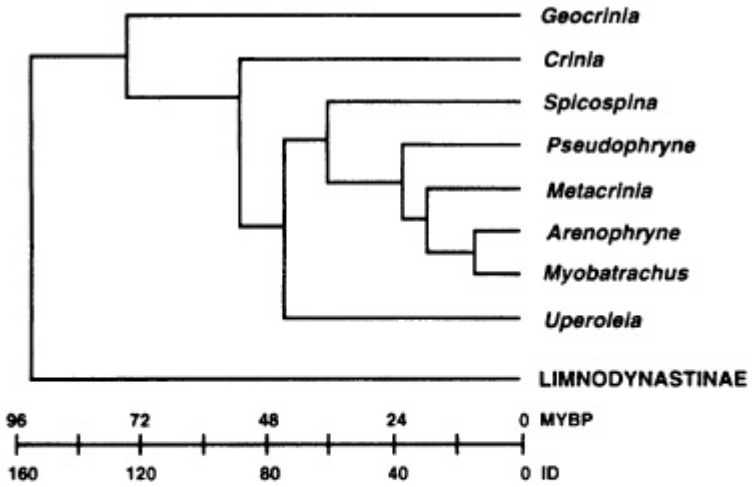


Fig. 5. Probable relationships of *Spicospina flammocaerulea*. Basic relationships of myobatrachine frogs are from Maxson (1992). Placement of *Spicospina* inferred from karyotype and immunological distance data.

South-western Australia: landscapes are flat & impacts are high

SWAFR – characterised by old stable landscapes

Richard Woldendorp: 1999

Fire

Mediterranean environments as fire-prone landscapes

Climate and **landforms**, together with **fire**, set the stage on which the **interplay of species** takes place and determines the **structure** and **composition** of the vegetation (Havel 2000)

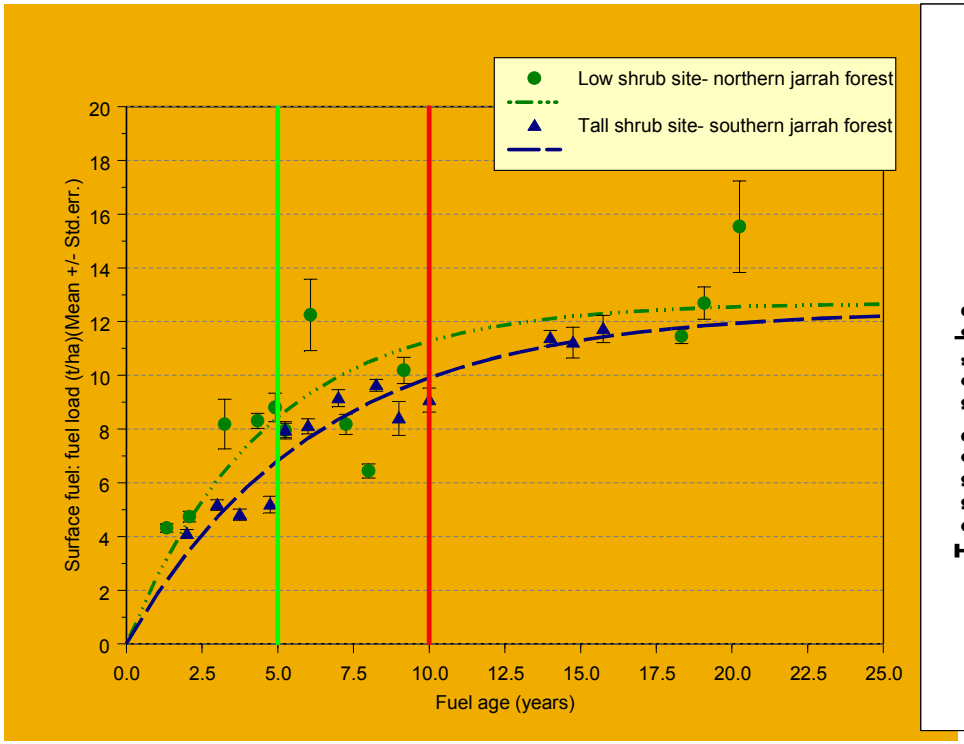
A framework to evaluate potential effects – the four switch model (Williams et al. 2009, 2010)

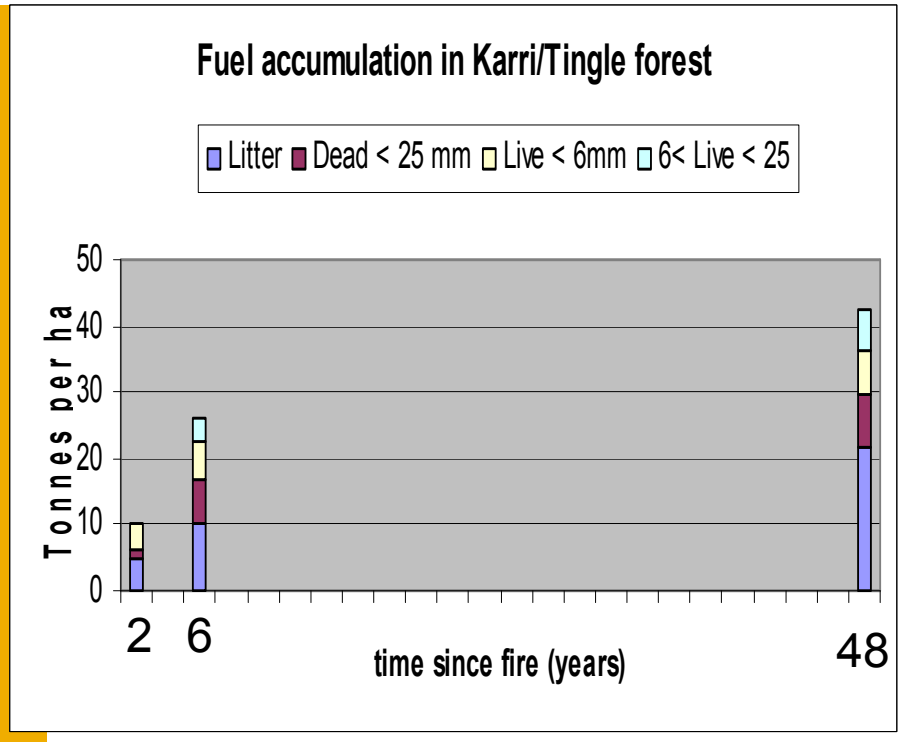
- Four components determine fire regime under various climate & ecosystem circumstances:
  - Biomass production & mass
  - Moisture content
  - Suitable fire weather
  - Ignition
- The four switch model shows how the realisation of potentials varies with biome



Surface fuel loads – south-western Australia

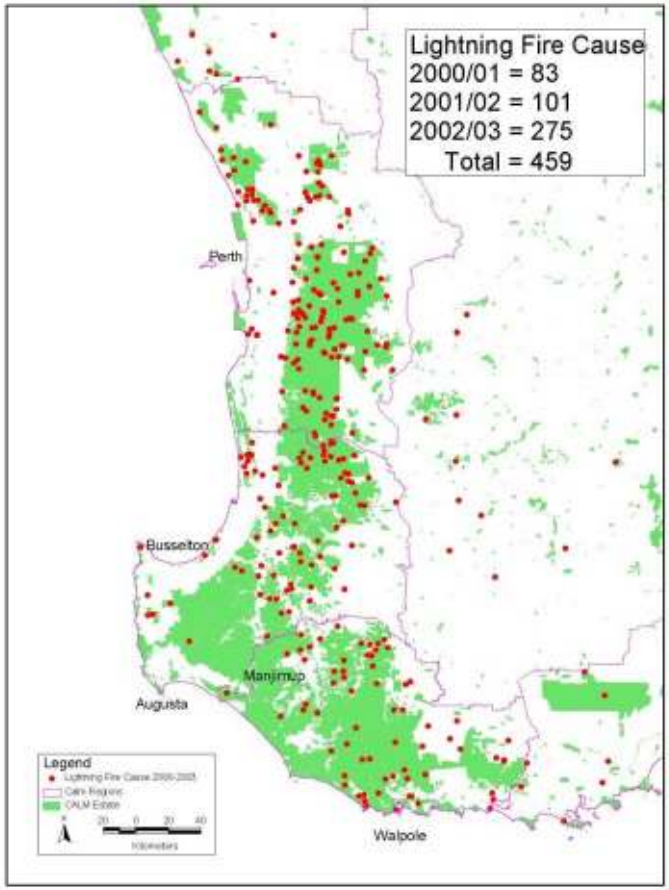
There is rapid fine biomass (fuel) accumulation in all vegetation types





McCaw pers. comm. 2004

Fires & lightening

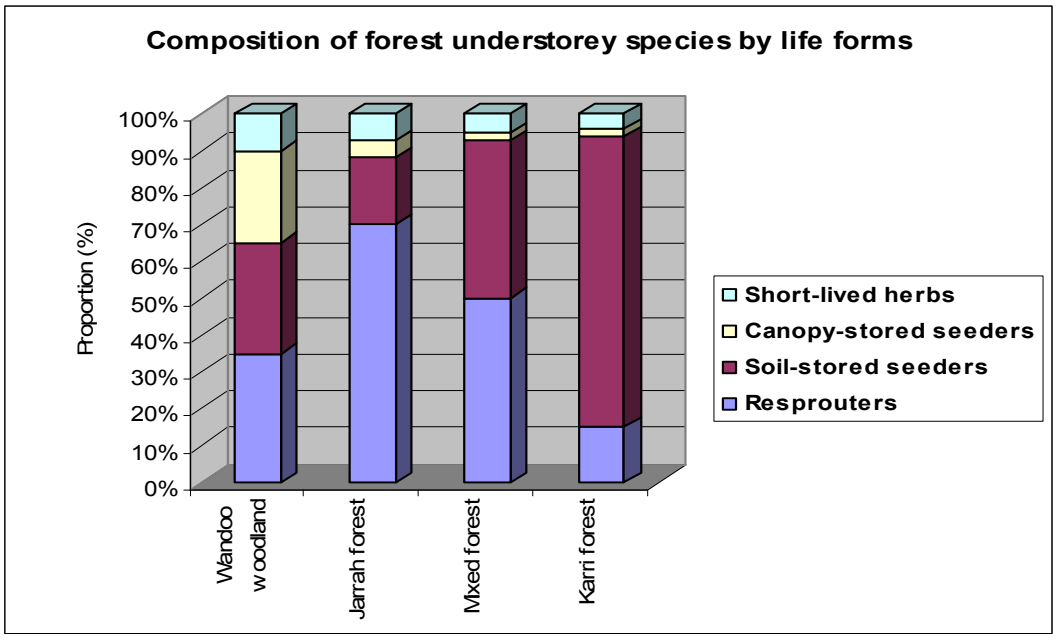


- Lightning-caused fires (2001-2003)
- 459 on DEC lands

Bushfires & influences

- Bushfires & impacts influenced by many factors
  - Vulnerability of people & infrastructure
  - Land cover patterns
  - Invasions of exotic species
  - Extreme weather events
  - Management practices

Different species have different responses



Burrows & Wardell-Johnson 2003

Fire danger & Climate Change (Williams et al. 2009, 2010)

- Analysis of weather records (1973-2007) shows:
  - Increased fire danger
  - More days of extreme weather
- Model simulations indicate:
  - Continued warming
  - Decreased humidity
  - Reduced rainfall in central & southern Australia
  - Changes in wind speed
- As a consequence:
  - Increases in intensity & frequency of extreme weather events are likely

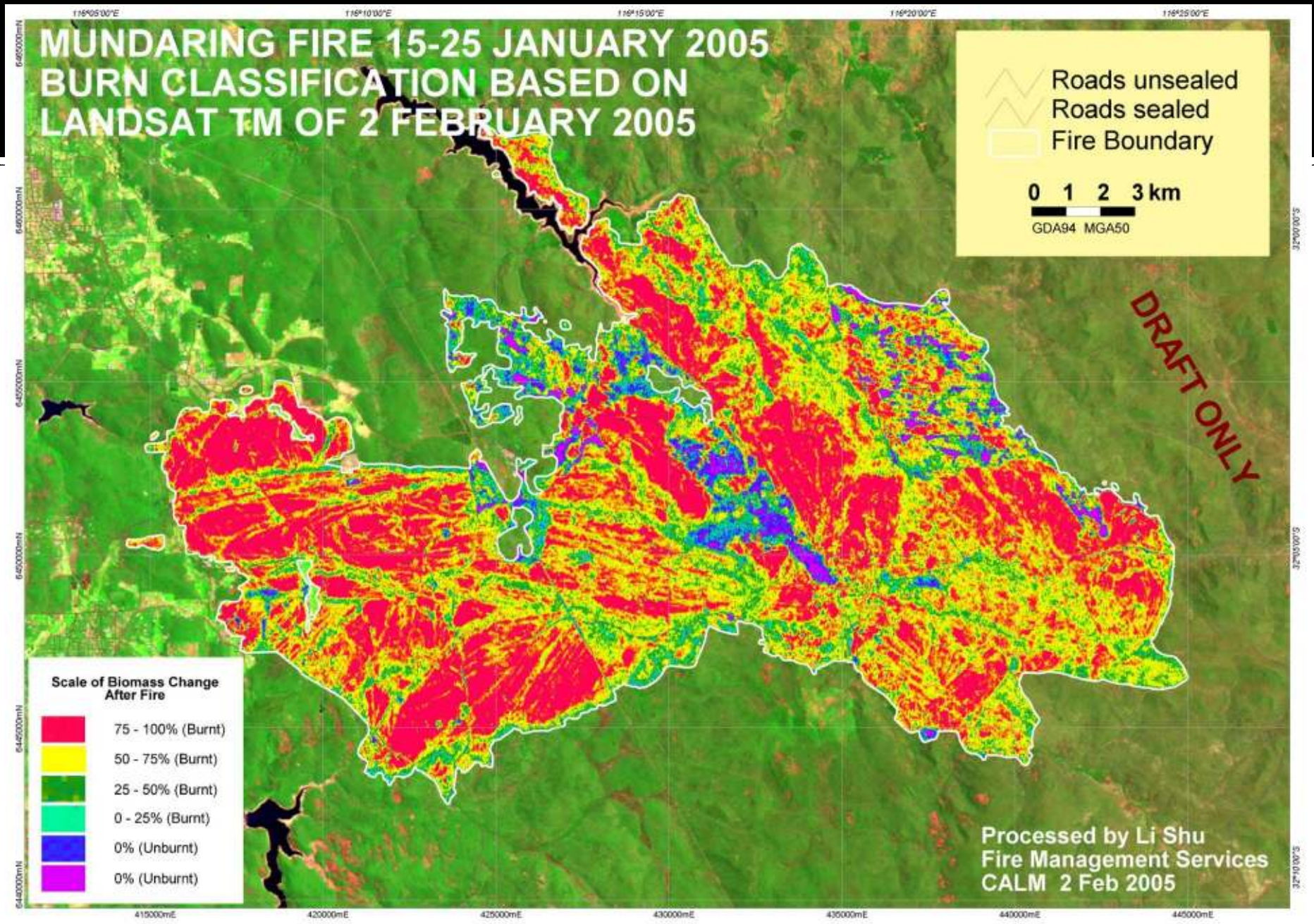
Impact of Climate Change on Fire Regimes & Biodiversity (Williams et al. 2009, 2010)

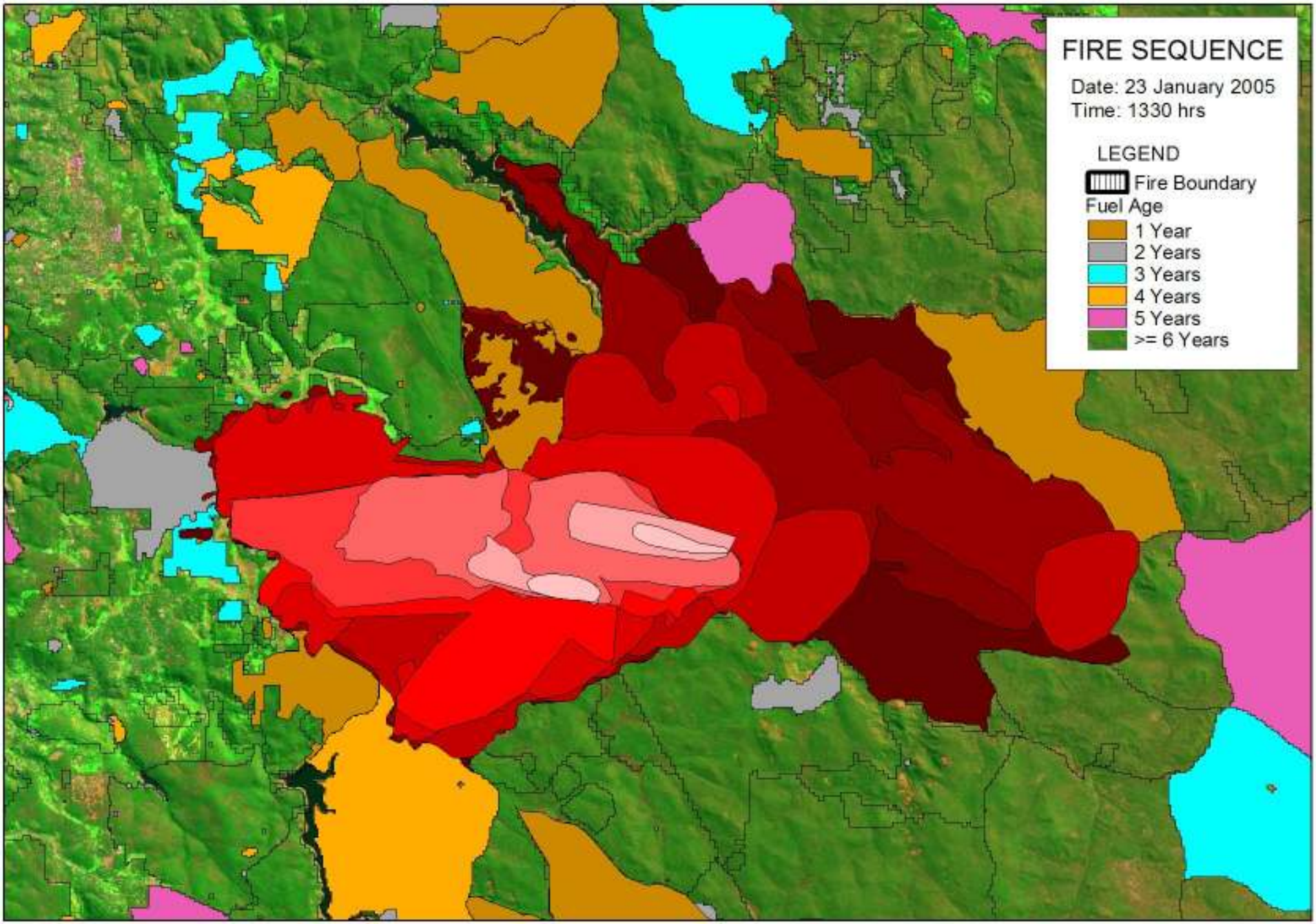
- Impact will be a function of:
  - Direct impacts of climate change on fire regimes
  - Responses of biota to changes in climate, elevated CO_2 & fire regimes
  - The choices Australian society makes in dealing with both climate change & fire management

Air

Fire in non-extreme conditions
(Bradstock 2010)

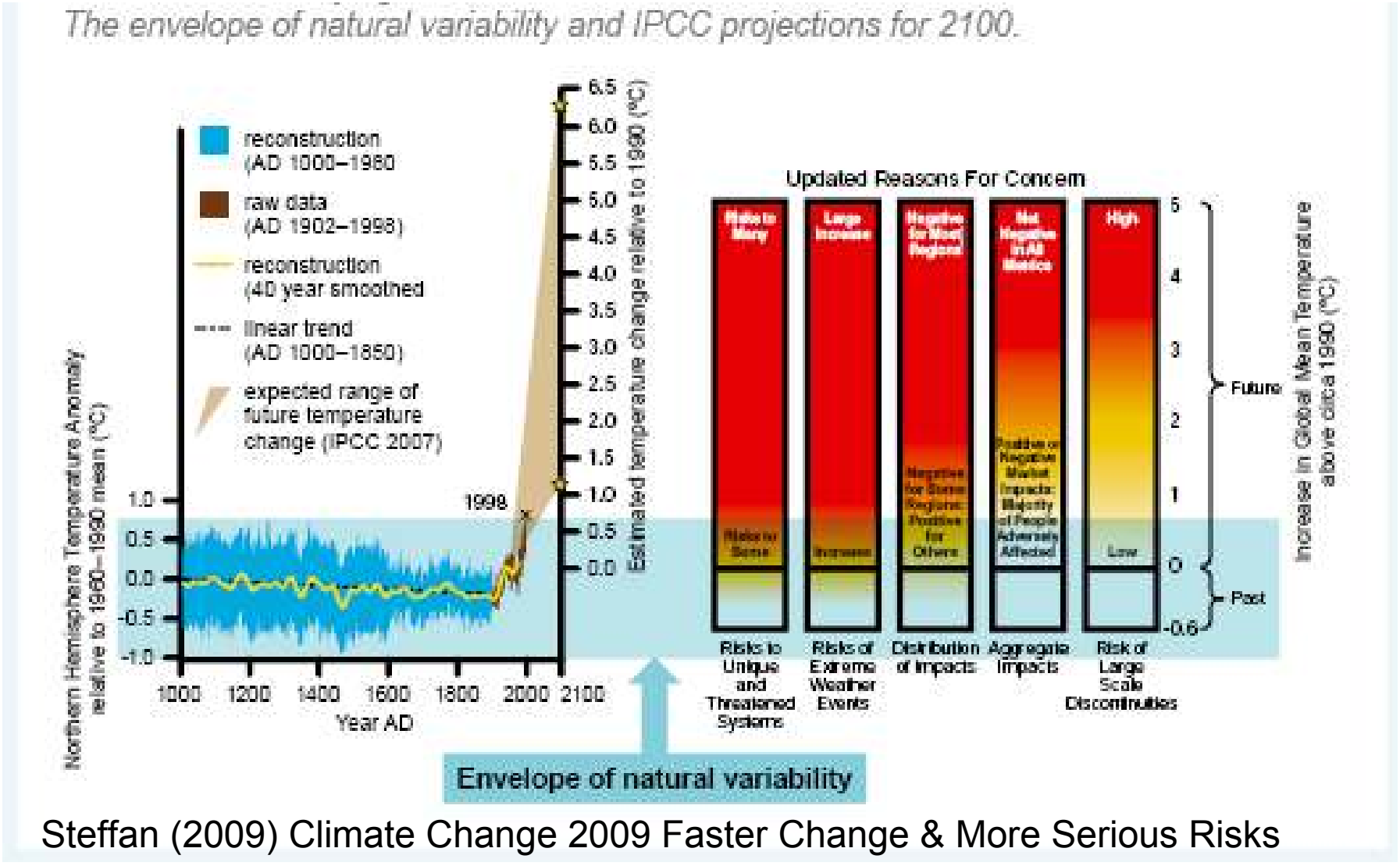
- In forested ecosystems (e.g. SWA)
  - Under non-extreme weather, fires **suppressible** and burn **heterogeneously**
  - Fires influenced by **topographic** position, **slope** and **fuel** load.
  - **Crown fire** is generally **absent** under non-extreme weather


MUNDARING FIRE 15-25 JANUARY 2005
BURN CLASSIFICATION BASED ON
LANDSAT TM OF 2 FEBRUARY 2005
Roads unsealed
Roads sealed
Fire Boundary
0 1 2 3 km
GDA94 MGA50
DRAFT ONLY
Scale of Biomass Change After Fire
75 - 100% (Burnt)
50 - 75% (Burnt)
25 - 50% (Burnt)
0 - 25% (Burnt)
0% (Unburnt)
0% (Unburnt)
Processed by Li Shu
Fire Management Services
CALM 2 Feb 2005
116°05'00"E
116°10'00"E
116°15'00"E
116°20'00"E
116°25'00"E
415000mE
420000mE
425000mE
430000mE
435000mE
440000mE
445000mE


FIRE SEQUENCE
Date: 23 January 2005
Time: 1330 hrs
LEGEND
Fire Boundary
Fuel Age
1 Year
2 Years
3 Years
4 Years
5 Years
>= 6 Years

Faster change & more serious risks

(Increase in extreme climatic events - waves, floods, fires)

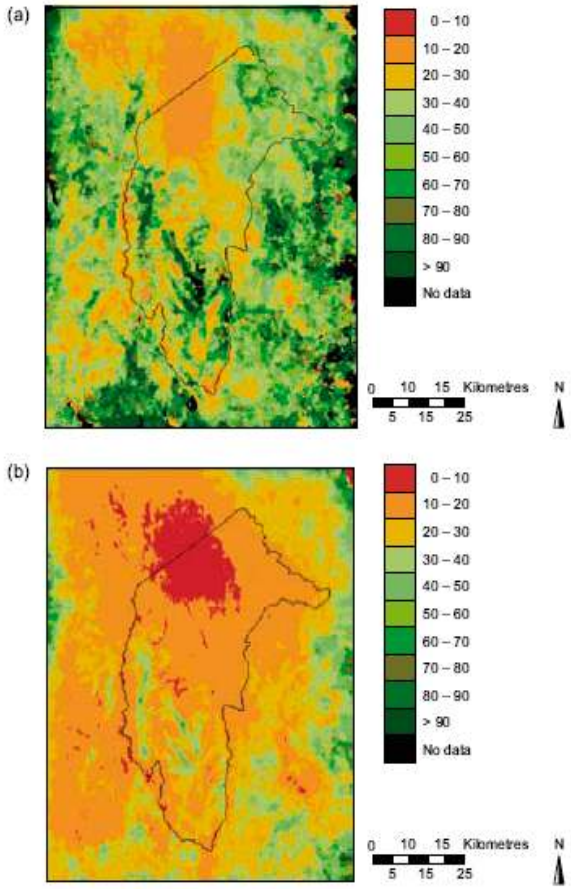


Steffan (2009) Climate Change 2009 Faster Change & More Serious Risks

Fire modelling & change

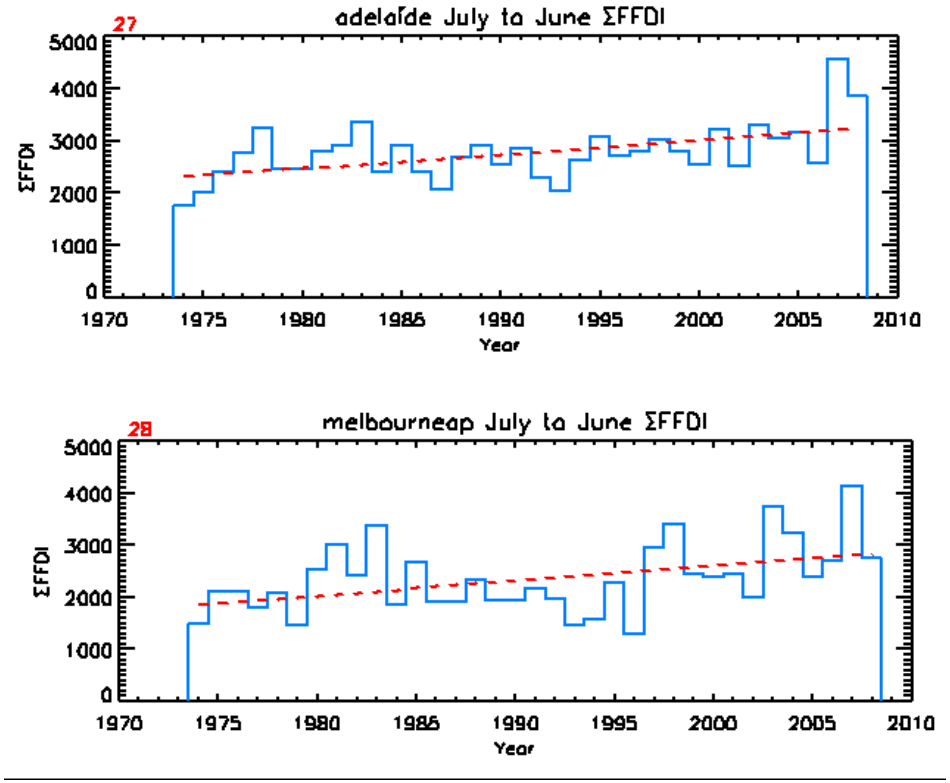
- Simulations for ACT using fire models
  - show increased burnt area
  - shorter interval between fires
  - Increase of 25% in fire intensity with 2 degree increase in MAT (above pre-industrial levels) (Carey 2006)

Figure 27: Projected shift in the Australian Capital Territory bushfire regime.



Average inter-fire interval for the Australian Capital Territory from a 500-year simulation with (a) current climate, and (b) moderate (mid-range IPCC projection) change in climate. (Source: Cary 2002)

Trends in Forest Fire Danger Index



Time-series plots of summation of Forest Fire Danger Index at two locations in south-eastern Australia (after Williams et al. 2009, 2010).
Increases of 10- 40% 2001-2007 cf 1980-2000 are generally evident associated with increases in extreme weather

Fire in extreme conditions
(Bradshaw 2010)

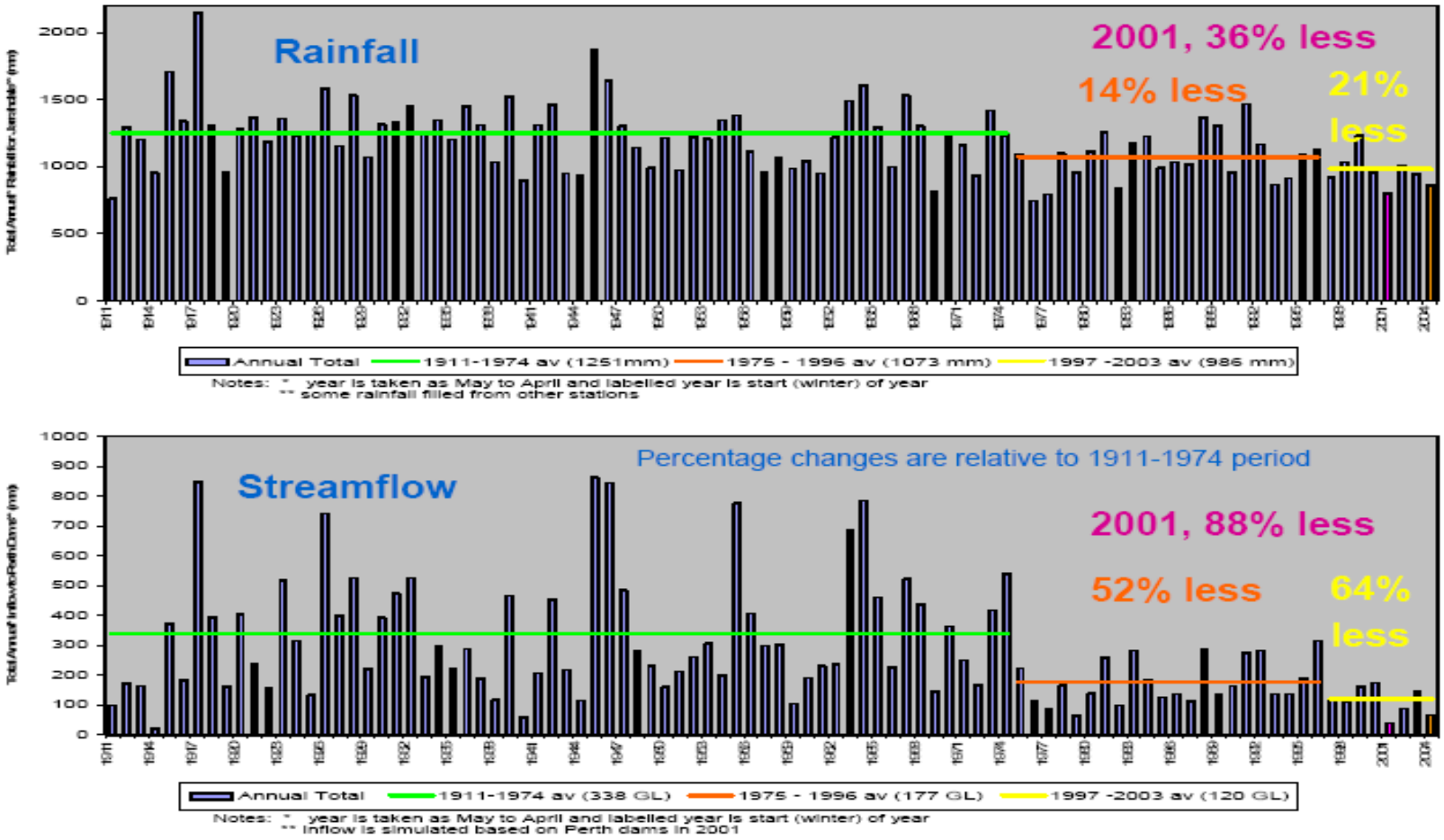
- In forested ecosystems (e.g. SWA)
  - Weather is **the major influence** on fire severity in extreme conditions.
  - **Crown fire** more likely under **extreme** weather.
  - As weather increases in severity – **fire behaviour less** influenced by fuel age & topography

Water

Water & south-western Australia

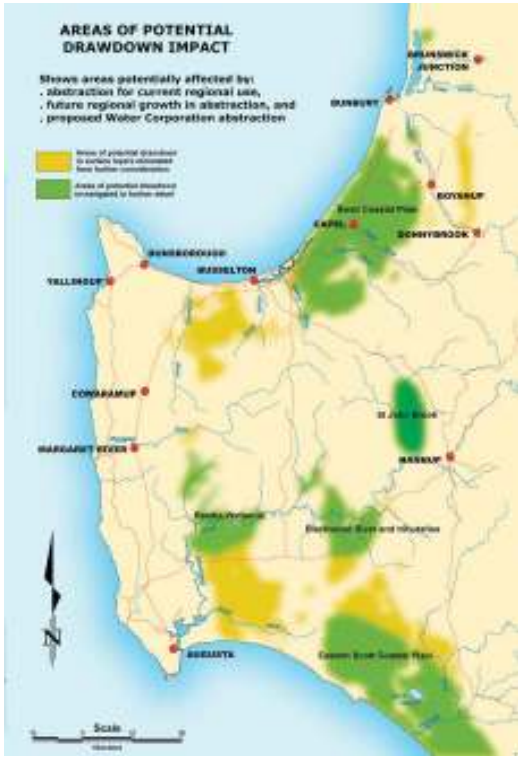
- Southern Australia, reduced rainfall, stream flows and recharge.
- Perth area - mean annual rainfall decline by 20% by 2030 & 60% by 2070 (cf to 1990).
- Perth area - since 1990 annual rainfalls decreased by 10%, > 50% reduction in flows to water supply dams

Climate change & reduced stream flow



South-west Yarragadee water supply development

- Currently 35 GL/year locally (2007)
- Proposed additional 45 GL/year by Water Corporation to supply Perth
- Controversy - rejection of plan by Gvmt WA 2007
- Proposed additional desalination plant



Water & vulnerable species (e.g. *Geocrinia alba*)

Water in the news (ABC News)

- **5/11/2010: Murray Darling Basin Authority faces Forbes and Dubbo crowds** Irrigators say the Murray Darling Basin Authority's explanation of its proposed cuts to water have failed to ease their concerns.
- **10/11/2010: Minister confident water is allocated responsibly** The [WA] Water Minister Graham Jacobs says he has every confidence the Water Corporation is doing the right thing when it comes to its allocation of water from the Gnangara mound.



Interactions - Earth, Fire, Air & Water interact with societies decisions

- More severe and frequent drought
- More frequent and intense fires
- Each form of disturbance increases impact of others
- Alteration more quickly than separate studies of fire & drought suggest
- Land-use transformations add to impacts

Interactions - Fire and Climate Change

- Increased disease, insect attacks & weeds
- Higher storm intensity, increasingly episodic rainfall, more frequent fires
- Lower productivity & more stress
- SWA-Karri-forest→Karri-Marri→Marri-Jarrah (lower biomass)→emissions

- Unlikely a smooth transition

Interactions - Dire predictions of species loss due to climate change

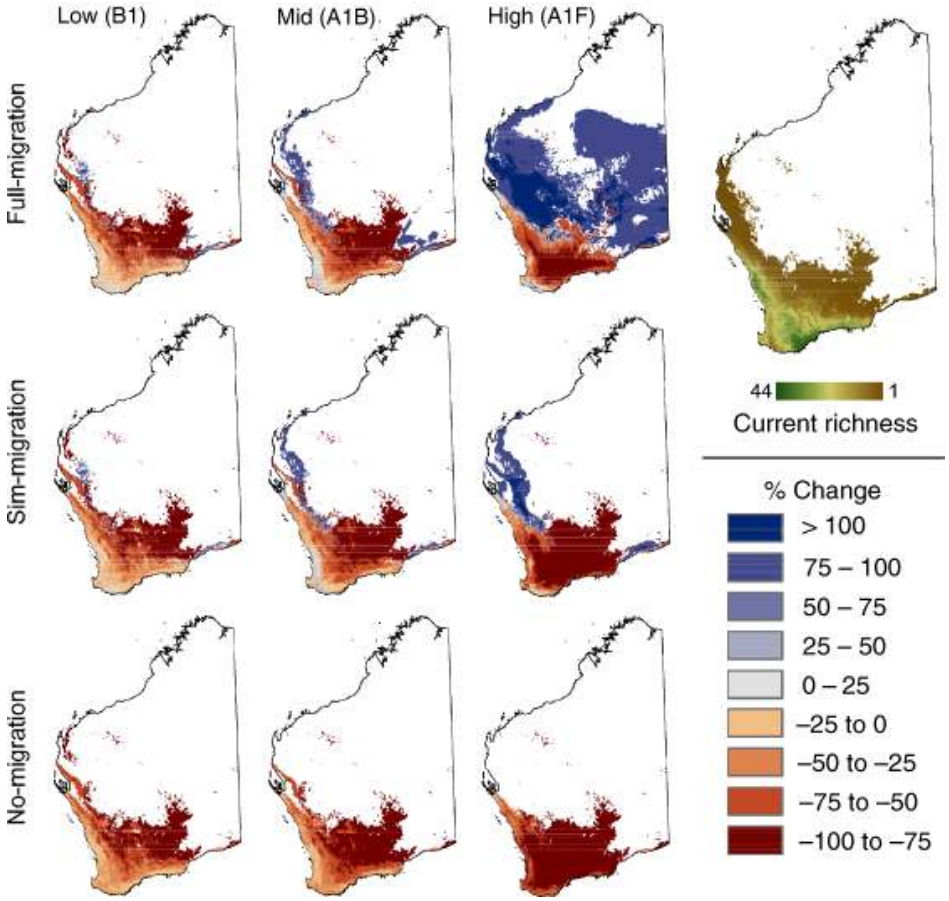


Fig. 5 Projected percent change in Western Australian endemic Banksia (Proteaceae) species richness by 2080 vs. predicted current richness

Colour scale indicates the percent increase (blues) or decrease (reds) in species richness.

Fitzpatrick et al. (2008) Global Change Biology 14, 1337–1352.

Species loss & climate change

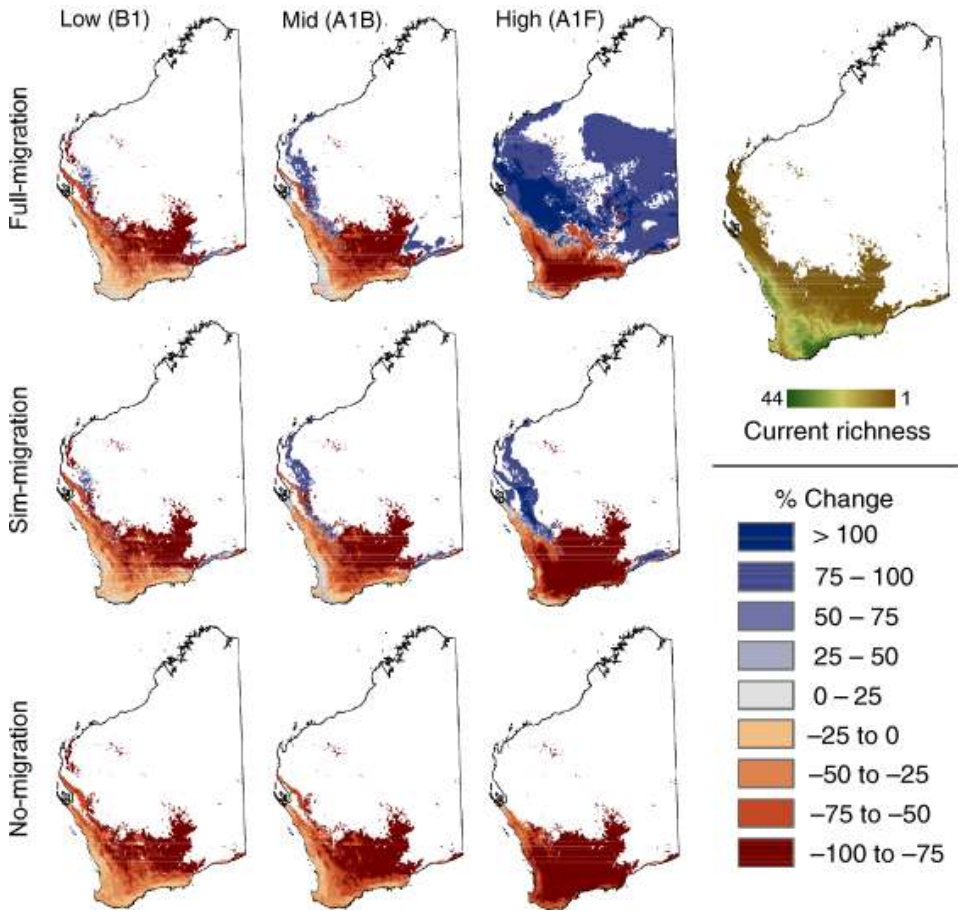


Fig. 5 Projected percent change in Western Australian endemic *Banksia* (Proteaceae) species richness by 2080 vs. predicted current richness

1. **Assumptions of flat landscapes & simplistic behaviour of the biota.**
2. **Possibilities of 'refugia' & the 'dynamic nature of species biology in space & time '**

Fitzpatrick et al. (2008) Global Change Biology 14, 1337–1352.

Refugia & climate adaptation strategies

- 'The identification and management of **climate refugia** is a vital component of **climate change adaptation strategies** and will be crucial in determining **priority conservation and management areas'**

Keppel et al. in press

Red Tingle forest, Walpole

What are refugia?

- 'Refugia are **habitats** that components of biodiversity retract to, expand from and persist under **changing** environmental conditions'
- 'Places providing environmental diversity & stability **facilitating persistence** as regional biotic & abiotic environments change'

Keppel et al. in press

Refugia not enough - 10 things to do about climate change

- Biota have **limits** to **adaptation**
- No comfort if refugia are the **last strongholds** before **extinction**

1. Mitigate, mitigate, mitigate
2. Fund adaptation
3. Stop clearing
4. Trade emissions
5. Reduce other stresses
6. Increase reserve area
7. Reserve criteria
8. Private land conservation
9. Build connectivity
10. Conservationist agenda

http://hosting2.arcs.org.au/terrestrialbiodiversity/index.php/resources/presentations.html

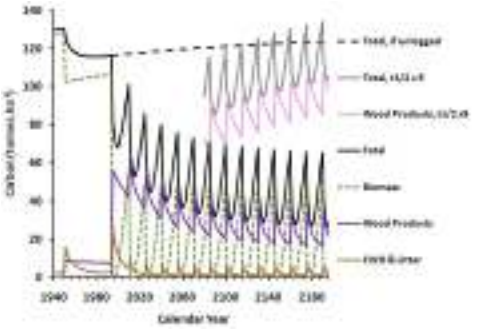
2. Resourcing adaptation

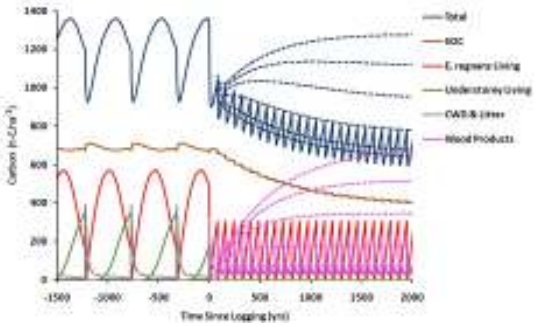
Increased interest in adaptation approaches

- 2010 NCCARF Climate Adaptation conference Gold Coast, the first of its kind & attracted > 800 delegates

3. Stop clearing
Valuing & managing old-growth forests

- Valuing and managing old-growth forests has led to significant industry changes
- Carbon modelling & old growth forest
  - Significant emissions from logging old-growth forest
  - 'Typical' scenario for long term emissions 167 & 550 t-C ha^{-1}
  - GHG emissions higher than for 'natural' disturbance





Dean & Wardell-Johnson 2010

4. Emissions trading

Increased imperatives recognised by industry leaders

- Emissions trading will lead to coal becoming less competitive than other fuels.
- A major tool towards mitigation

A coal power plant in Germany.

- Plantation establishment & restoration will be encouraged by giving carbon value

Restoration planting – North Stirlings.

5. Reduce other stresses
The future of prescribed burning

- Increased recognition of:
  - '**Threat**' & 'risk' (insurance industry)
  - Need for t**argeted** prescribed burning
  - Need for increasingly sophisticated **planning** processes
  - Necessary to i**nform** & **involve** people in life decisions
  - Need for b**roader perspectives** of fires & landscapes

6. Increase area of reserves

Low but continued growth in protected areas

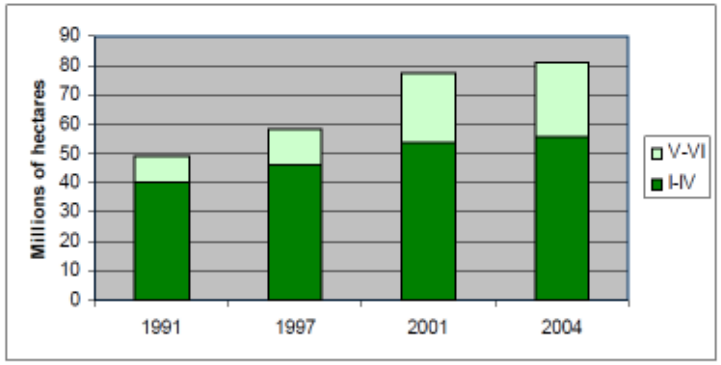


Figure 2: Growth in protected areas 1991 - 2004

AUSTRALIAN PROTECTED AREA SYSTEM: DIRECTIONS AND ISSUES

Summary Paper

Fiona Leverington[1], Penny Figgis[2], Marc Hockings[3], Paul Sattler[4], Graeme Worboys[5]

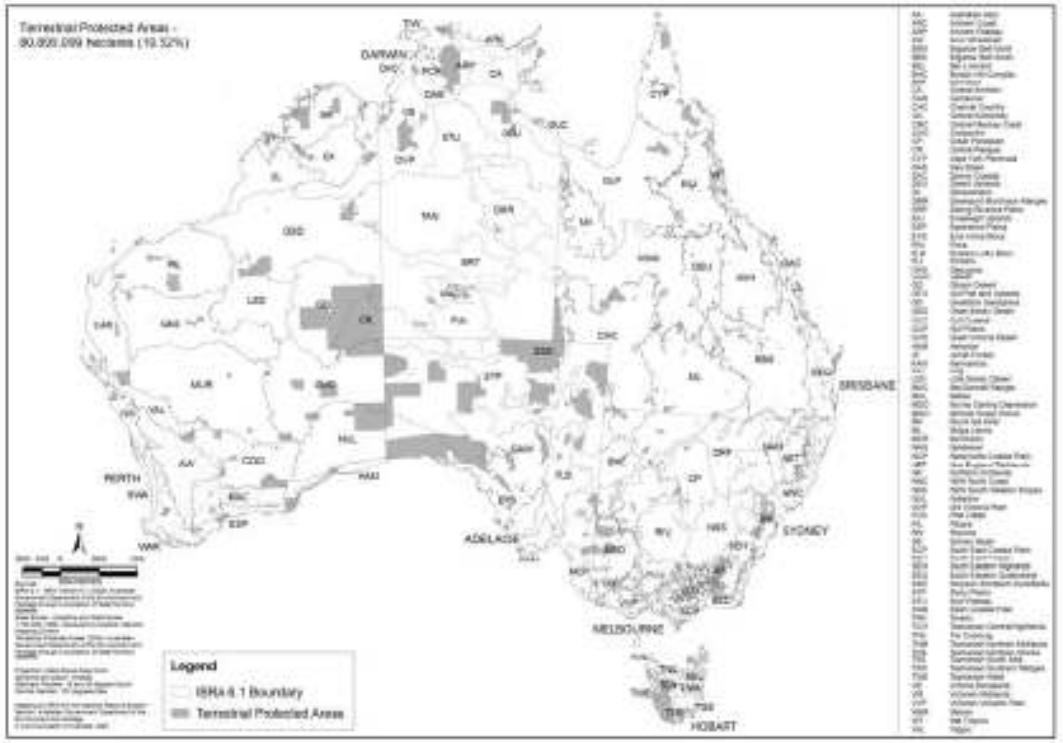


Figure 1: Protected areas and bioregions in Australia 2004. Source: Department of the Environment and Heritage (2004.)

7. Develop reserve criteria
New approach to translocations

- Review of the Environmental Protection (Western Swamp Tortoise Habitat) Policy 2002 as required under section 36 of the Environmental Protection Act 1986

8. Private land conservation

New plantations to build carbon & biodiversity

Oil Mallee ASSOCIATION

9. Increase landscape connectivity

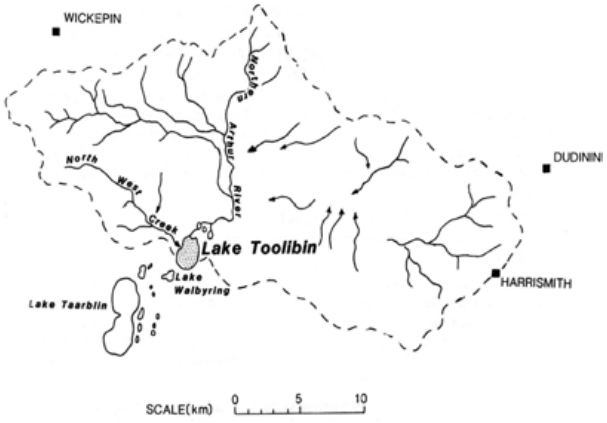
Reserve provides connectivity & habitat (*Geocrinia alba*)

10. Amend conservationist agenda

Engineering solutions for the recovery of Lake Toolibin

Audrey Bird (Mist on Toolibin)

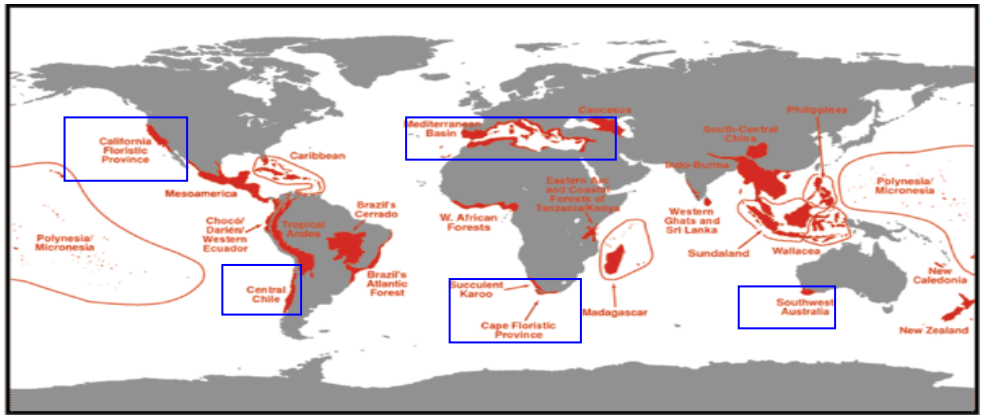
- The Toolibin Lake Recovery Project awarded the Institute of Engineers (Australia), 2002 National Salinity Prize
- Recognition of integrated approach to salinity management and strong community support.



10. Amend conservationist agenda
Conservation & 'Return on Investment'

- **'High conversion and low protection in projected stable areas make Australia the highest priority region for investment in climate-adaptation strategies to reduce the threat of climate change to the rich biodiversity of the Mediterranean biome.'**

- Klausmeyer & Shaw (2009). PLoS one 7(4) e6392



Myers et al. (2000)