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

[Email Address]
Climate system changing faster than 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

Substantial rainfall reduction in south-western Australia

All models - Emissions A1FI
- Medium sensitivity
- Time 2100
We must limit emissions & warming urgently

- Must limit to $< 2^\circ$ C ($\sim 450$ ppm CO$_2$)
- Requires GHG emissions to be reduced by 60-80% below 1990 levels by 2050 & must peak & decline before 2015
Classical elements that reflect essential parts and principles of which everything consists


Climate change is all encompassing – interactive with all environmental elements

- Earth
- Fire
- Air
- Water
SWA as a global Biodiversity hotspot

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

Hopper & Gioia 2004

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)
Ancient & vulnerable local endemics abound

Fig. 5. Probable relationships of *Spicospina flammocoerulea*. 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
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

- 459 on DEC lands
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

Composition of forest understorey species by life forms

- Short-lived herbs
- Canopy-stored seeders
- Soil-stored seeders
- Resprouters

Banksia gardneri

Quadrat 4015, Soho Hills

Acacia pentadenia

Quadrat 4263, Soho Hills

- 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 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

(Williams et al. 2009, 2010)
Air
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
Faster change & more serious risks
(Increase in extreme climatic events - waves, floods, fires)

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)
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
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

Rainfall

- 2001, 36% less
- 14% less
- 21% less

Streamflow

- 2001, 88% less
- 52% less
- 64% less

Percentage changes are relative to 1911-1974 period

Notes:
- Year is taken as May to April and labelled year is start (winter) of year
- Some rainfall filled from other stations
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*)
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.

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’

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
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

2. Resourcing adaptation
Increased interest in adaptation approaches

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

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

A coal power plant in Germany.

Restoration planting – North Stirlings.
5. Reduce other stresses
The future of prescribed burning

- Increased recognition of:
  - ‘Threat’ & ‘risk’ (insurance industry)
  - Need for targeted prescribed burning
  - Need for increasingly sophisticated planning processes
  - Necessary to inform & involve people in life decisions
  - Need for broader perspectives of fires & landscapes
6. Increase area of reserves
Low but continued growth in protected areas

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

Figure 2: Growth in protected areas 1991 - 2004

AUSTRALIAN PROTECTED AREA SYSTEM: DIRECTIONS AND ISSUES
Summary Paper
Fiona Leverington, Penny Figgis, Marc Hockings, Paul Sattler, Graeme Worboys
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
9. Increase landscape connectivity
Reserve provides connectivity & habitat (*Geocrinia alba*)
10. Amend conservationist agenda
Engineering solutions for the recovery of Lake 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.

Audrey Bird (Mist on Toolibin)
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)