Interactions between Climate Change, Fire Regimes and Biodiversity in Australia: A Preliminary Assessment

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International and national context

Climate change and risk to biodiversity

- Thomas et al. 2004 *Nature*; Hannah *et al.* 2007 *FEE; talks* this session

Climate change will interact with changed disturbance regimes

- Little knowledge

Climate change and fire

Climate drives the occurrence of large fires in USA subalpine forests

Climate change has lead to fire regime change

- Earlier snowmelt
- Higher summer temperatures
- Longer fire season
- Not landuse

Westerling et al. 2006

Climate change-fire regimes-biodiversity interactions

Impact of climate change on fire weather - recent; projected

- **More severe**

Impact of climate change on fuels

- **Decreased due to declining moisture? Increase due to CO_2?**

Modelling climate change impacts on fire regimes

- **Increased risk of area burnt**

Climate change-fire regimes-biodiversity interactions

A national framework for the biogeography of fire regimes

- **Climate change will impact in different ways in different places**

Climate change, fire regimes and biodiversity responses

- **Effects on fire intervals and post-fire regeneration climate**

Implications for adaptation of ecosystem management

- **More complex? Are we ready?**

Recent climate change and fire weather

Trends in cumulative Forest Fire Danger Index, 1972-2007

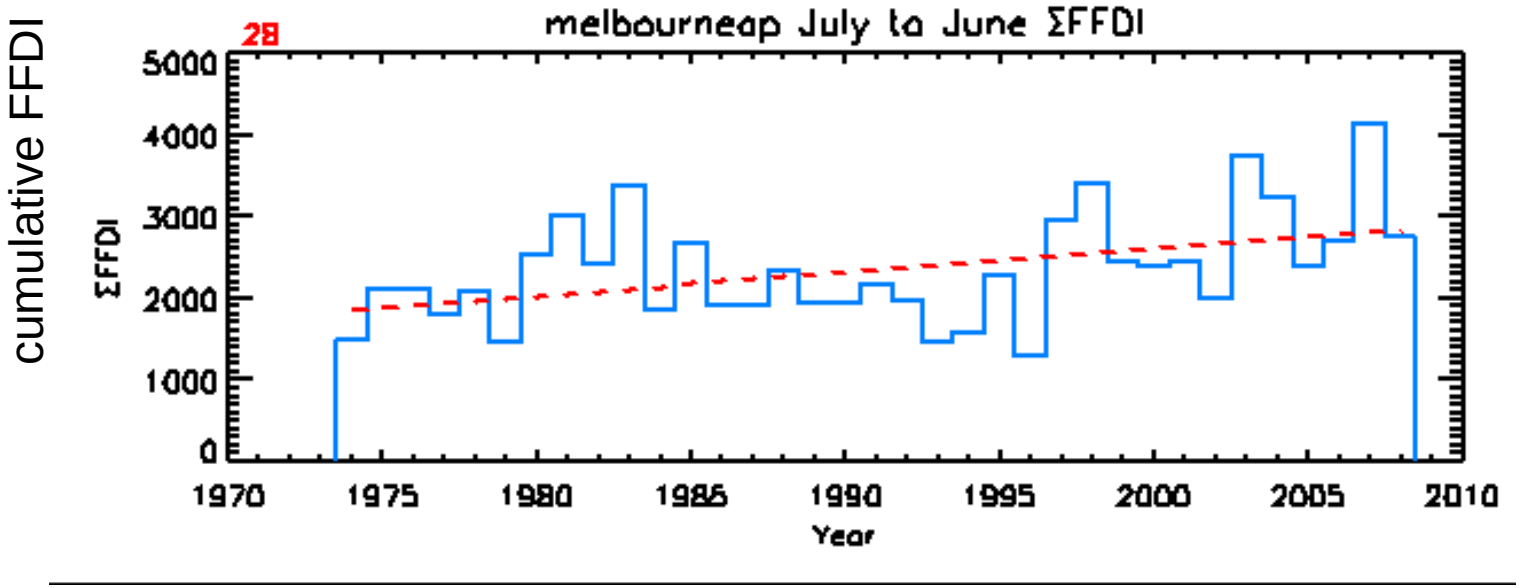
FFDI = Temperature, humidity, wind, drought; 0 to >100

Very high 25-49; Extreme >50; 7 Feb 2009 >150

Σ FFDI = annual sum of daily FFDI

Recent climate change and fire weather

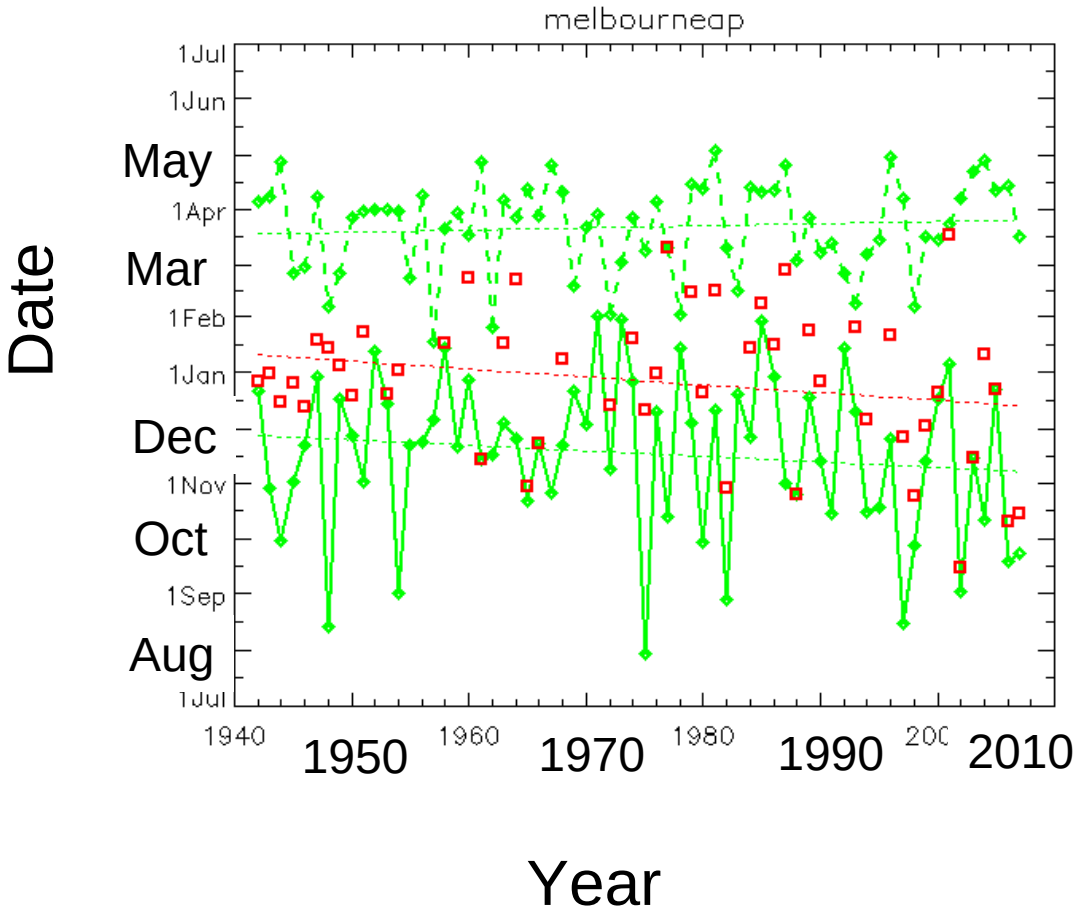
Trend of increased cumulative Forest Fire Danger Index, 1972-2007



Source: Lucas, Hennessy et al. 2007

Recent climate change and fire season in SE Australia

Trend towards lengthening of fire season



Last ‘very high’ FFDI day later

First ‘extreme’ FFDI day earlier

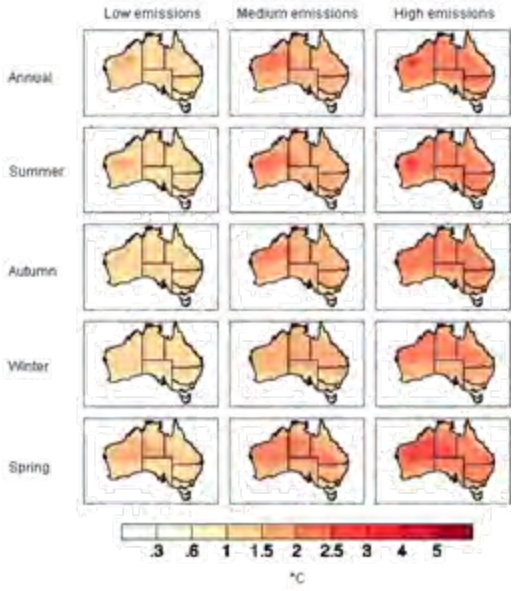
First ‘very high’ FFDI day earlier

Source: Lucas, Hennessy et al. 2007

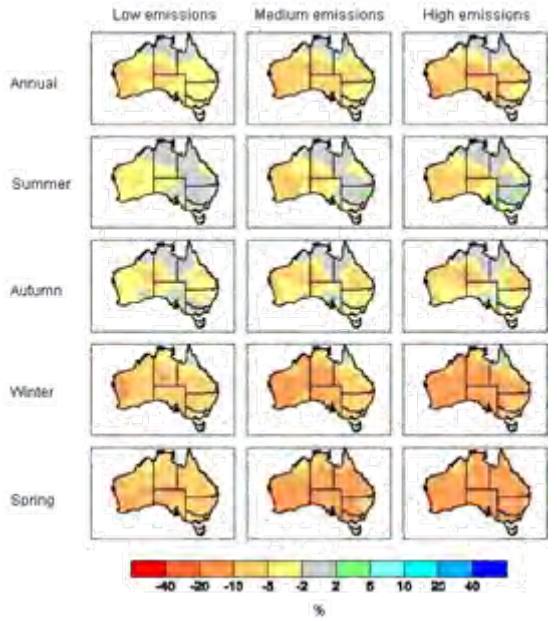
2050 vision of fire weather

CSIRO Climate Projections – warmer and drier

Annual Temperature



Annual Rainfall



Source: CSIRO/BOM 2007

Climate change projections and cumulative annual FFDI

Percentage increases to 2020 and 2050 in SE Australia

Site	Present ΣFFDI	% change							
		2020 low mk2	2020 high mk2	2020 low mk3	2020 high mk3	2050 low mk2	2050 high mk2	2050 low mk3	2050 high mk3
Adelaide	2708	2	5	3	8	3	16	5	25
Brisbane airport	1990	1	5	0	4	3	19	2	16
Canberra	2493	3	9	3	11	6	30	7	37
Hobart	1314	-1	-1	0	0	-1	-1	0	3
Melbourne airport	2306	2	7	3	9	4	22	6	30
Sydney airport	1897	1	4	3	10	2	11	6	31

Source: Lucas, Hennessy et al. 2007

Climate change, fire weather and fire regimes

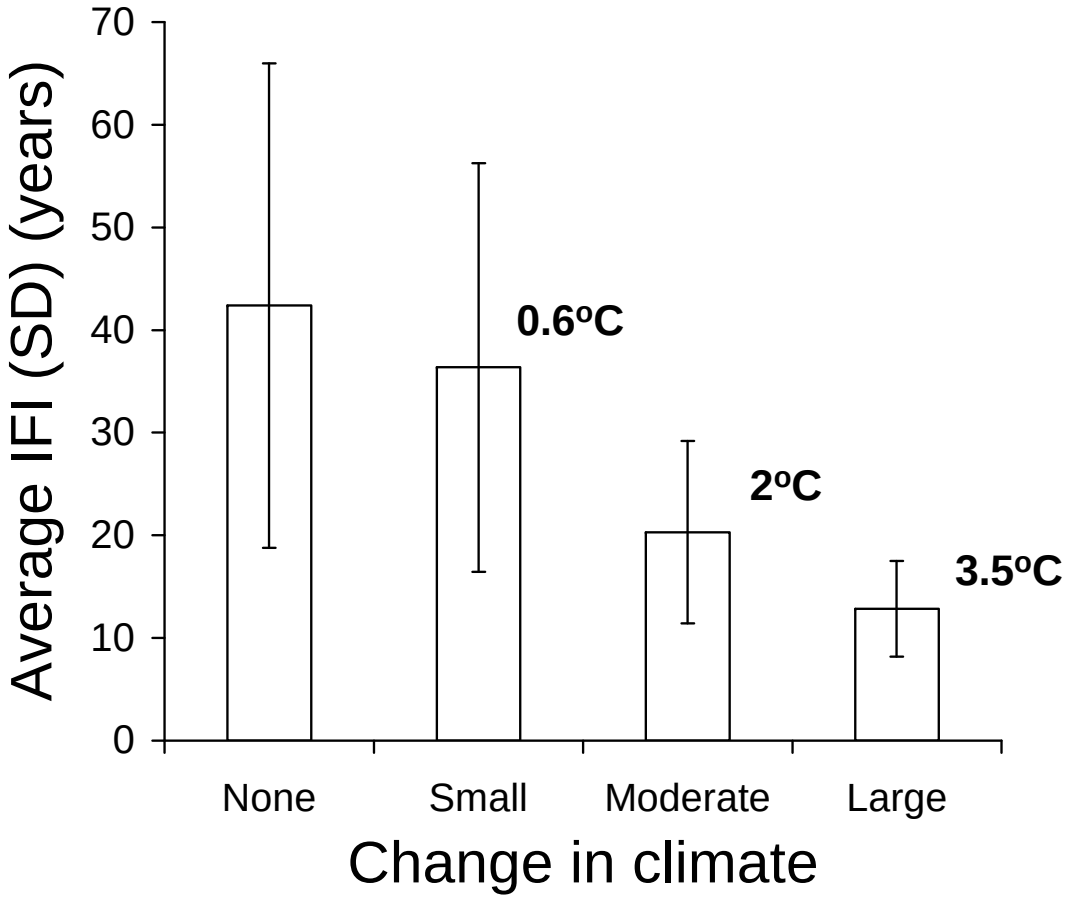
Warming = higher fire weather risk; clear signal

What does this mean for fire regime components?

- Intensity of individual fires
- Intervals between fires

Modelling climate change impacts on fire intervals

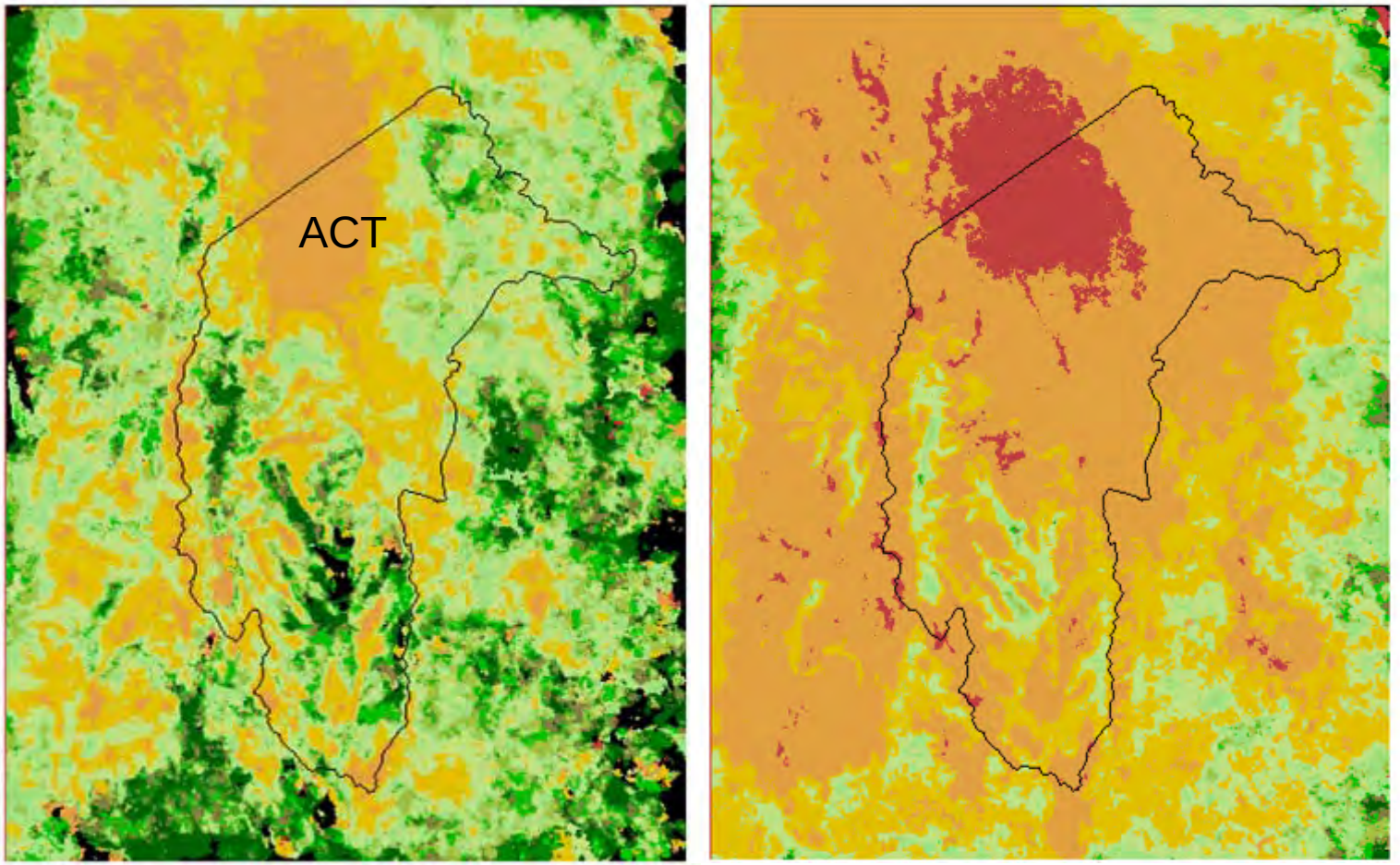
Geoff Cary – climate change shortens simulated intervals between fires in the ACT to 2050



Spatial modelling fire interval change under climate change

Current climate

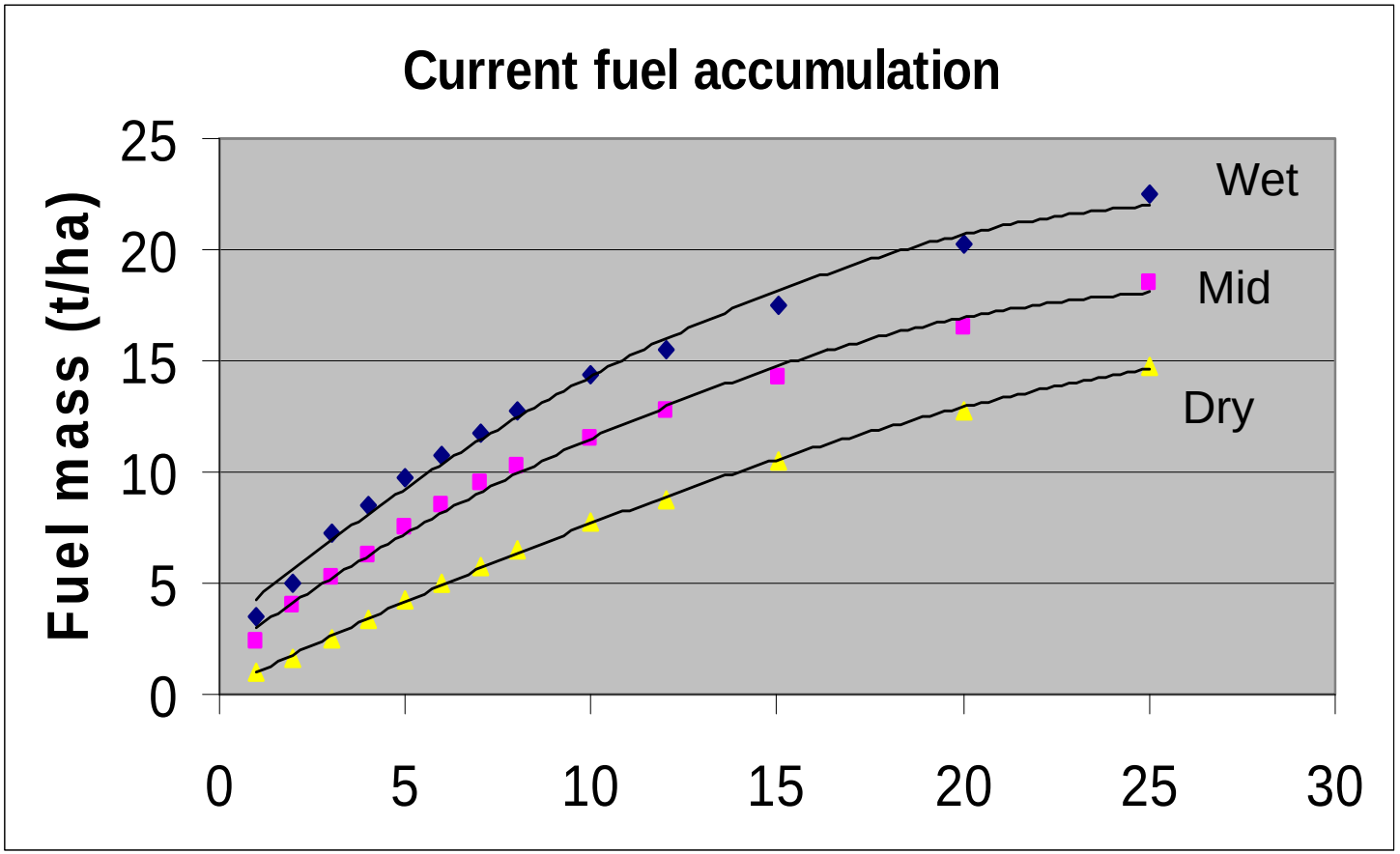
2ºC warmer; 2050



Source: Cary (2002)

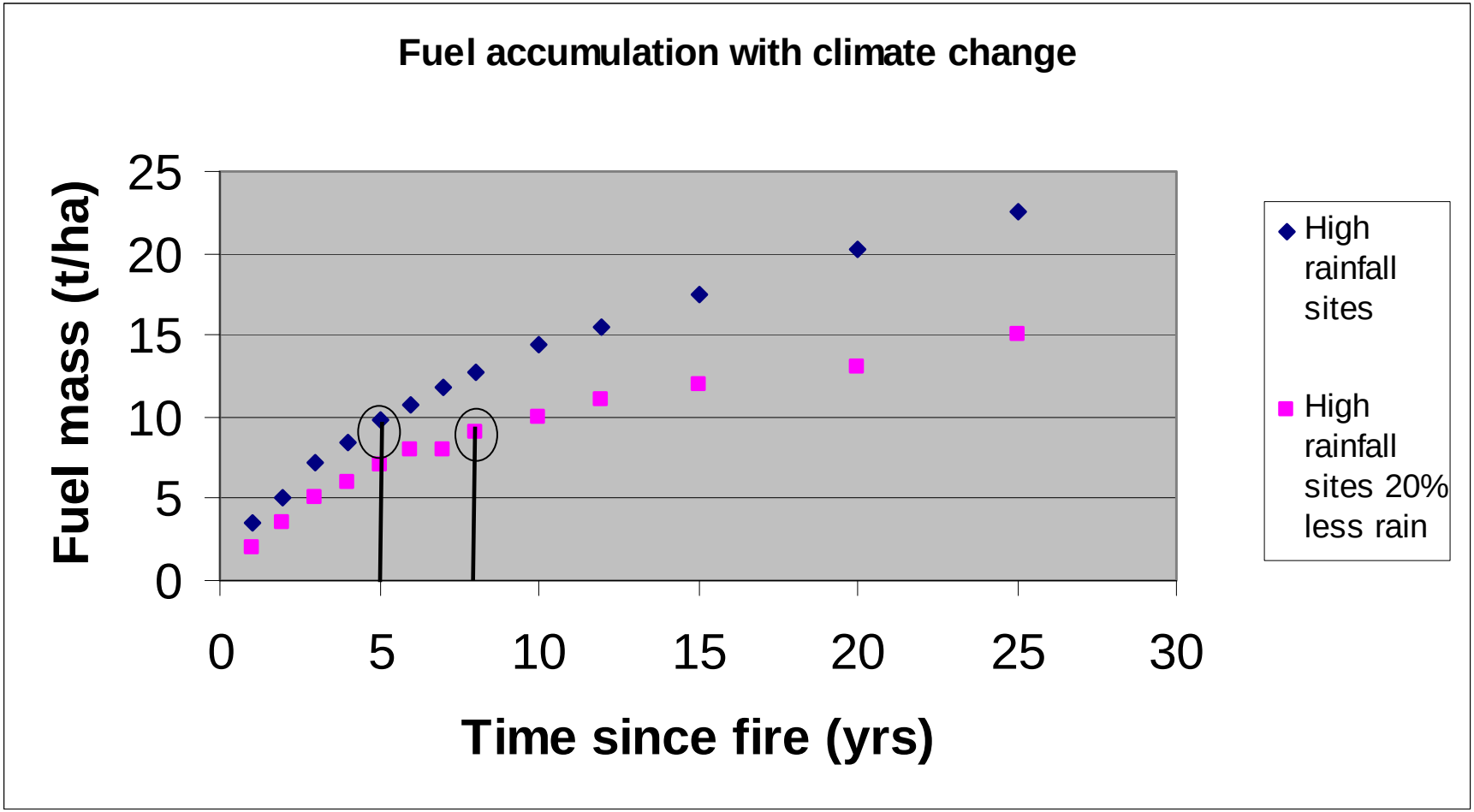
Climate change and fuels

Fuel accumulation along aridity gradient in Jarrah forests SW WA



What about a 20% reduction in Mean Annual Precipitation

on fuel accumulation, wet jarrah sites SW WA?



Climate change and fuels

Effect of decline in rainfall on time for fuel to accumulate to 10t/ha

	Wet sites		Inter. sites		Dry sites	
	current	-20% rainfall	current	-20% rainfall	current	-20% rainfall
Time (yr) to 10 t/ha	5	8	7	12	15	>25

Climate change and fuels

Rainfall/moisture decline = decline in rate of fuel production

Potentially antagonistic effect to warming and increased fire weather danger

BUT

Is this enough to offset fire weather effect?

Uncertain at this stage

A continental biogeography of fire

Four switch model of fire regimes

Biomass

net moisture

Availability

Drought; fuel moisture

Spread

wind, temp, RH, topog

Ignition

Lightning;
people

All switches need to be on for landscape fire

There is a characteristic "limiting" switch

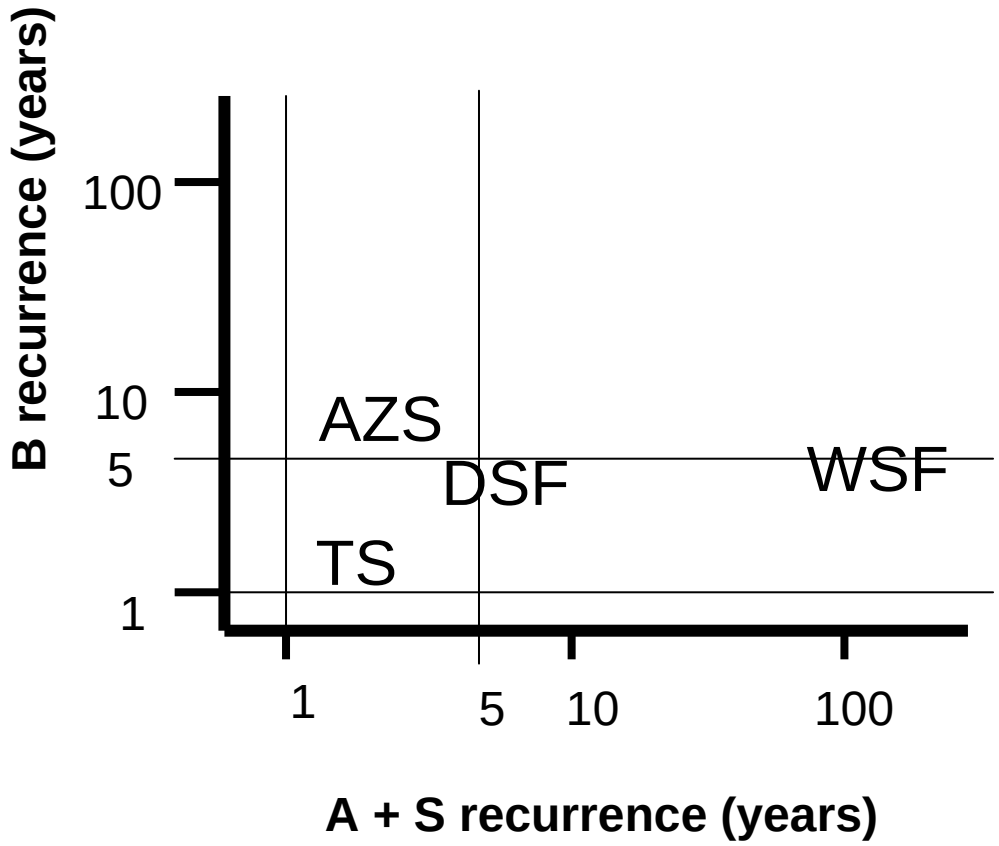
Switches are characteristically turned on at differing rates in differing ecosystems

Different fire regimes result

Climate change will be differentially important to different switches in different places

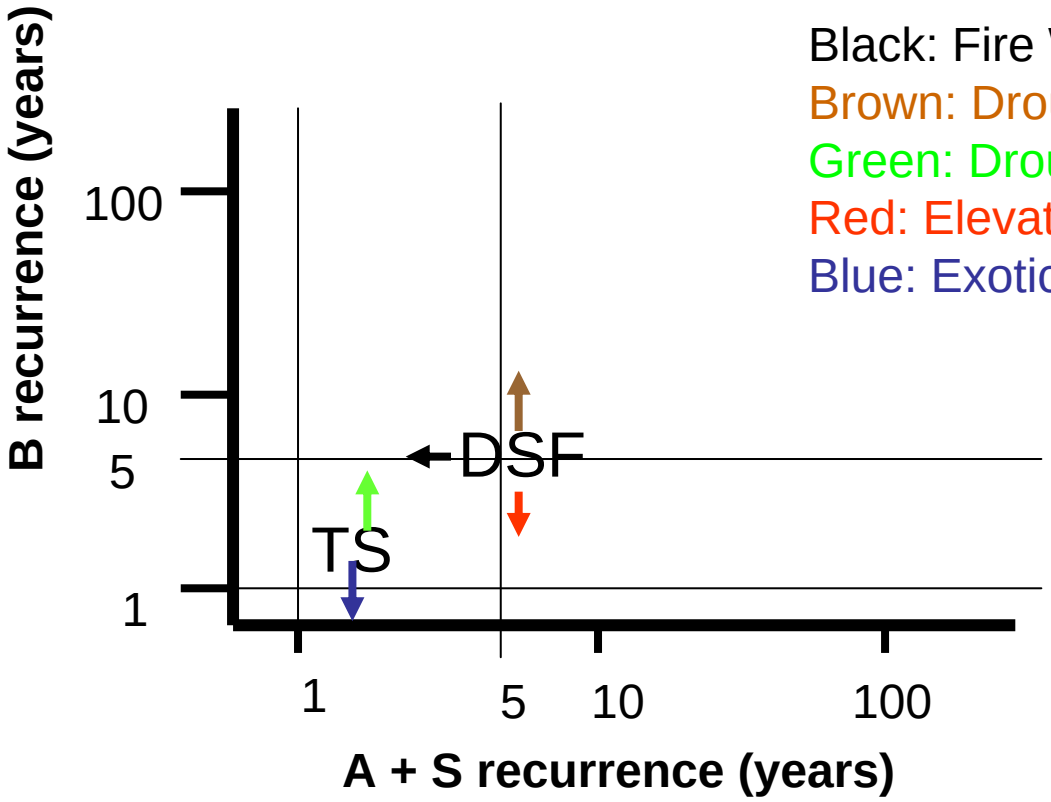
Bradstock in press *Global Ecology and Biogeogr.*

Climate change, switches and recurrence rate



Climate change, switches and recurrence rate

Synergistic and antagonistic effects on fire regimes



Black: Fire WEATHER danger

Brown: Drought/Litter fuel effect

Green: Drought/Grass effect

Red: Elevated CO2

Blue: Exotic grasses

Future pyro landscapes???

Biogeography of future fire regime change: Contrasting tales

SE, SW Temperate: strongly weather limited

- Climate change effect on fire weather and consequently area burnt and interval

Future pyro landscapes???

Tropical savannas: fuel and ignition limited

- Climate change moisture regime (and CO2?) and effect on fuel
- Exotic grasses a real worry

Arid zone: strongly fuel limited

- Fire follows rain and will do so under climate change
- Exotic grasses a real worry

Potential biodiversity impacts

Biodiversity impacts will depend on:

- The component of fire regime to which elements are sensitive (interval, intensity)
- AND the extent to which climate change affects interval and/or intensity via fuel or weather

4 case studies:

- Alpine ash forests
- SW WA sclerophyllous vegetation
- Tropical savannas
- Sclerophyllous vegetation of Sydney basin

Future fire regimes and biodiversity
Key messages –intensity; interval; regeneration

Intensity

- Potential for intensity to increase under climate change
  - Fire weather in south
  - Exotic grasses in north

Future fire regimes and biodiversity
Key messages

Interval

- Potential for intervals to shorten under climate change
  - Greater risk of area burnt; many interval sensitive species
  - Particular risk to temperate sclerophyllous ecosystems

Future fire regimes and biodiversity
Key messages

Regeneration

- Need for longer intervals for regeneration because of reduced moisture
  - Particular risk to temperate sclerophyllous ecosystems

Pyro-change and ecosystem management

Ecosystems in flux
Ecosystems will look, smell, feel different
Change gonna come

Pyro-change and ecosystem management

A way forward from the recent past

Thresholds of potential concern (TPC) approach –

- What distribution of intervals should we be concerned about?

Analyses of plant funtional types (PFTs) in relationship to the distribution of inter-fire intervals in the landscape

- Seeders
- Resprouters

How manage biodiversity in the face of threats and change?

Bradstock & Kenny 2003 – fire management in protected areas

Obligate seeder shrubs in temperate sclerophyll vegetation

- Too frequent – seedlings die; seed bank exhausted, local extinction (<7years)
- Too infrequent – old individuals die out (>30 years)

How manage biodiversity in the face of threats and change?

If >50% of landscape in interval classes between these extremes, within domain of acceptability

If < 50% of landscape in interval classes between these extremes, within domain of concern

Adaptive approach highly suited to managing for climate change

Future adaptation in ecosystem management

Review current management capacity to identify and accommodate change

- Fire regime components
- Critical species
- Habitat complexity

Future adaptation in ecosystem management

Explore approaches to domains and thresholds of concern

- Powerful and flexible

Benefit-cost analyses of potential management responses

- Trade-offs
- Risk is the universal currency