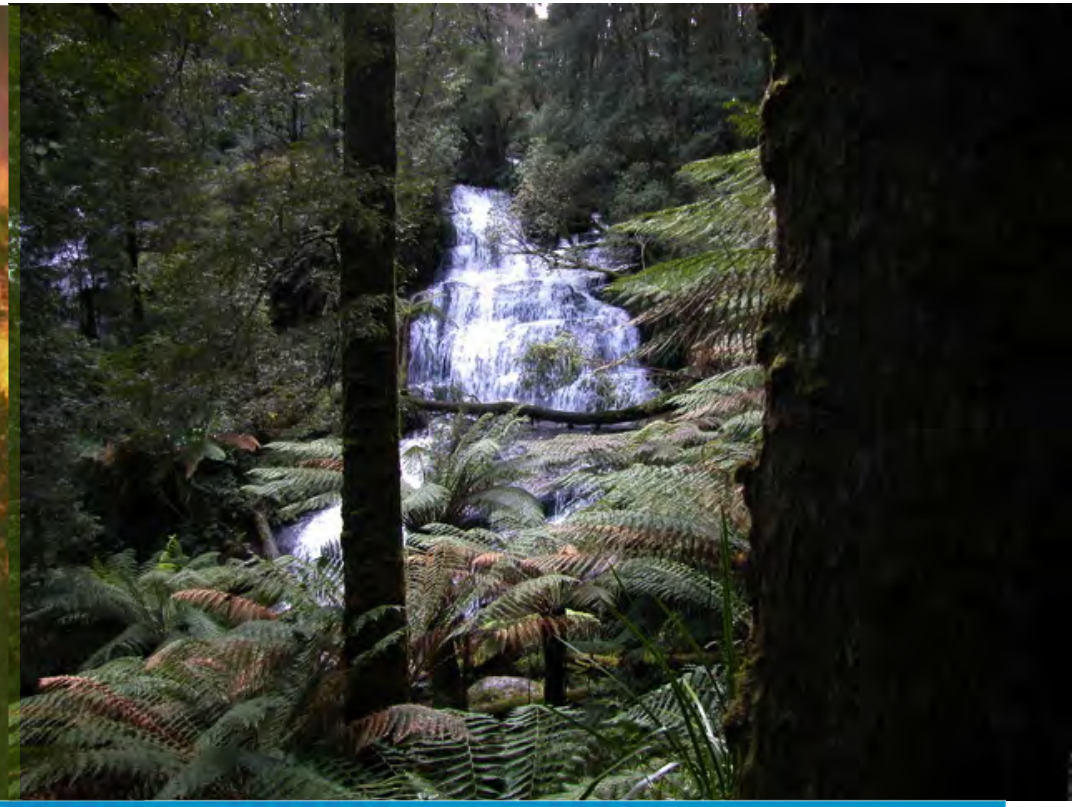

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Forests, fire, carbon and water

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CSIRO Sustainable Ecosystems, Canberra

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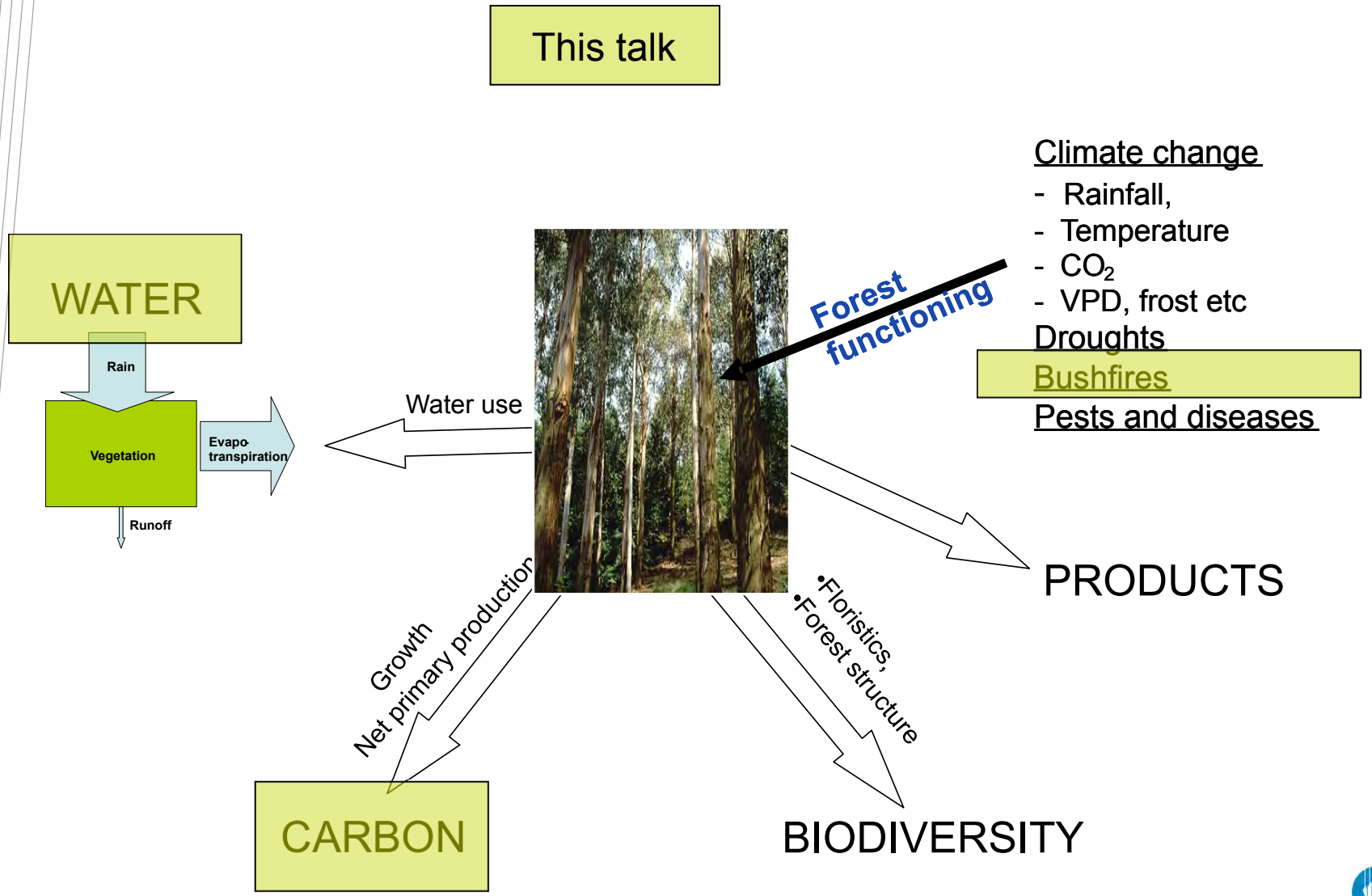
Forests are central to ecosystem goods and services valued by society

This talk



Three ways for forests to mitigate climate change

1. Protection of existing forests

2. Establishment of new forests (afforestation/ reforestation)

This talk

3. Bioenergy - substitution for fossil fuel use

Global stocks of terrestrial carbon

Biome	Area (Gha)	% of total area		Carbon (Gt)	% of total carbon
Tropical forests	1.75	11.6		340	52.0
Temperate forests	1.04	6.9		139	21.3
Boreal forests	1.37	9.1		57	8.7
Tropical savannas	2.76	18.3		79	12.1
Temperate grasslands	1.78	11.8		23	3.5
Deserts	2.77	18.3		10	1.5
Tundra	0.56	3.7		2	0.3
Croplands	1.35	8.9		4	0.6
TOTAL	**15.1**	**100**		**654**	**100**

Prentice et al, 2001

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Global areas and stocks of terrestrial carbon

Biome	Area (Gha)	% of total area		Carbon (Gt)	% of total carbon
Tropical forests	1.75	11.6		340	52.0
Temperate forests	1.04	6.9		139	21.3
Boreal forests	1.37	9.1		57	8.7
Tropical savannas	2.76	18.3		79	12.1
TOTAL FORESTS	**6.92**	**45.9**		**615**	**94**
Temperate grasslands	1.78	11.8		23	3.5
Deserts	2.77	18.3		10	1.5
Tundra	0.56	3.7		2	0.3
Croplands	1.35	8.9		4	0.6
TOTAL	**15.1**	**100**		**654**	**100**

Prentice et al, 2001

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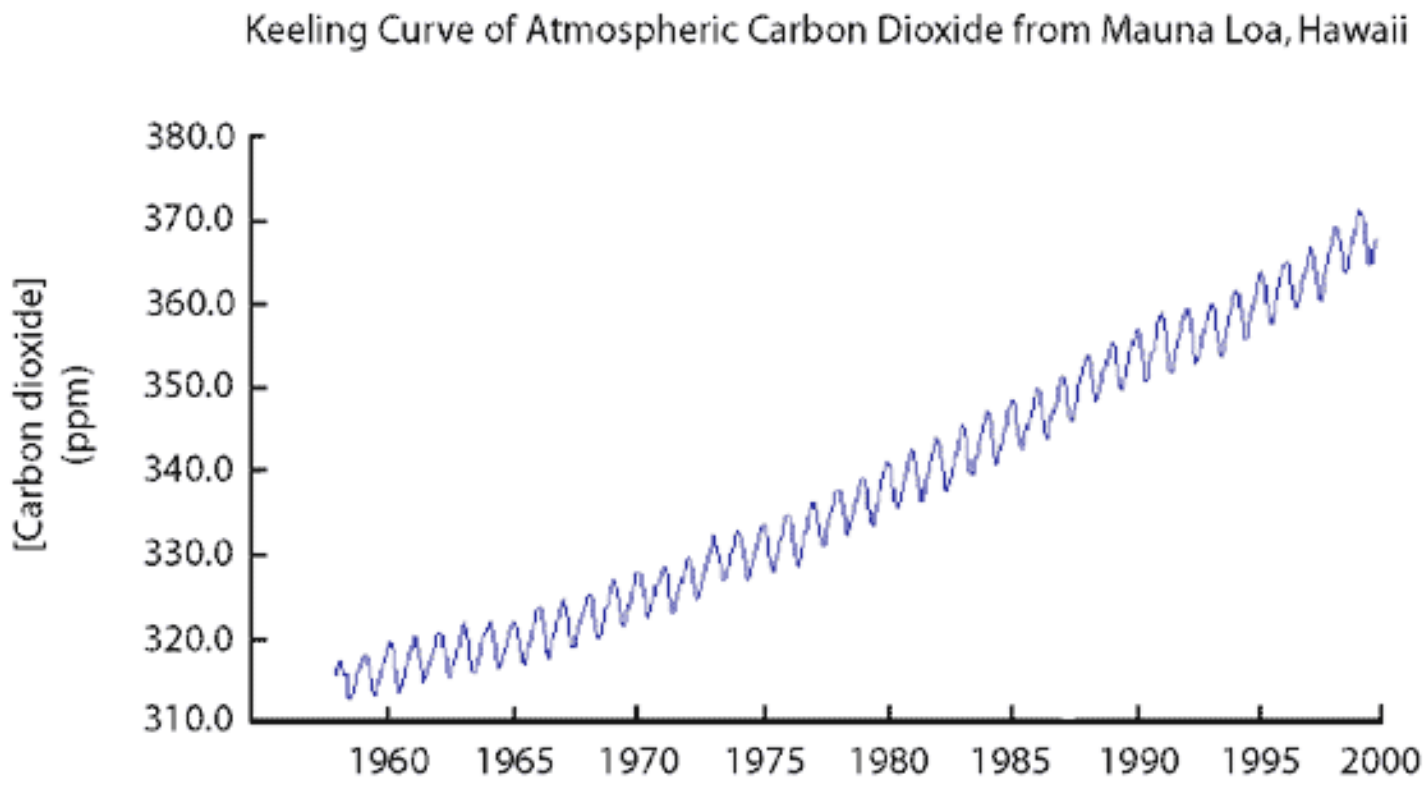
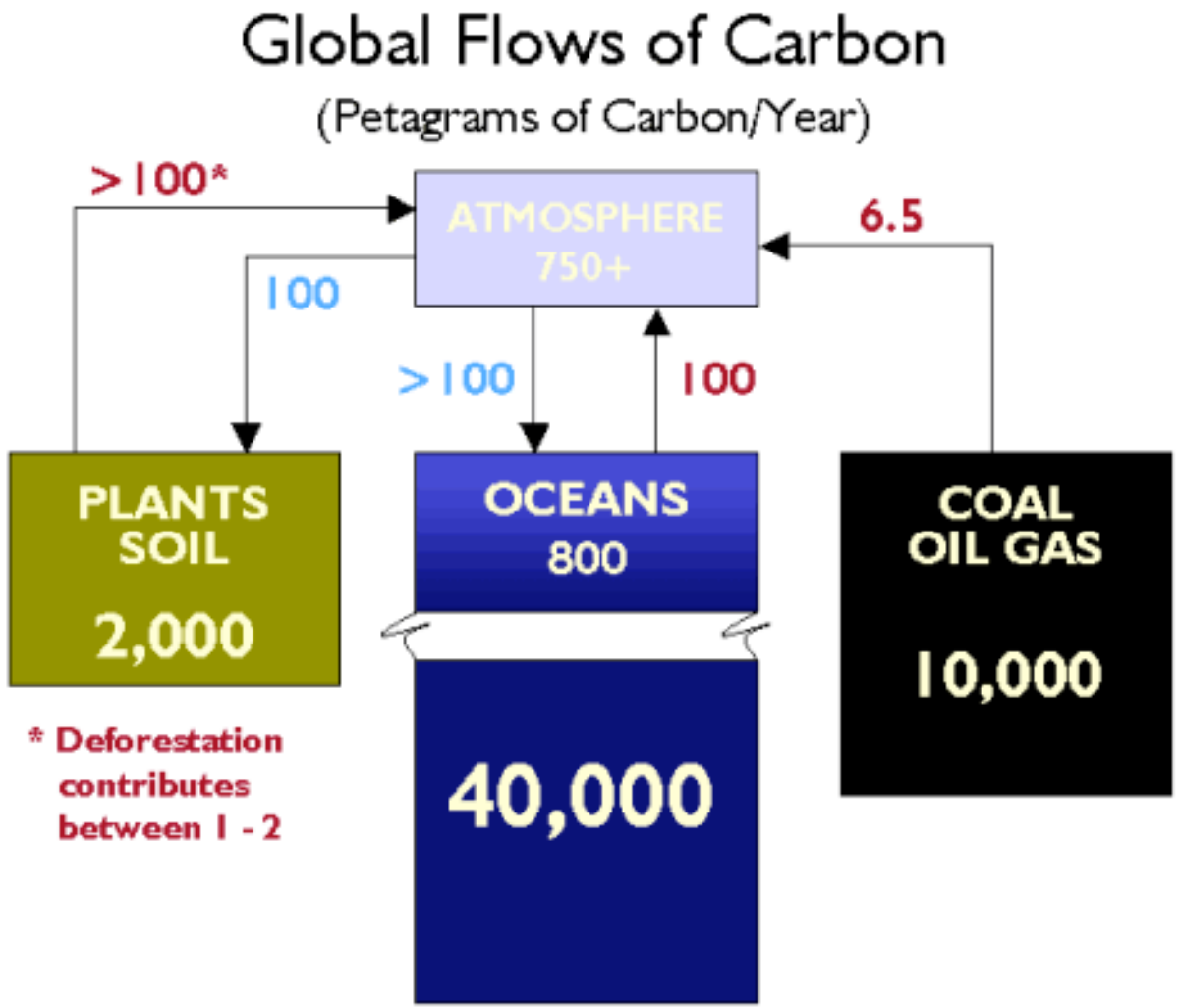
‘Keeling curve’ – The role of forests in controlling seasonal CO_2 concentrations



The global carbon cycle



The global carbon cycle – annual changes

Billions of tonnes of carbon per year (Gt/year)

	1990s	2000-2005
Sources		
Fossil fuel emissions		
Deforestation		
Total emissions		
Sinks		
Accumulation in atmosphere		
Ocean		
Total sinks		
'Residual' forest sink		

1PCC, 2008

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The global carbon cycle – annual changes

Billions of tonnes of carbon per year (Gt/year)

	1990s	2000-2005
Sources		
Fossil fuel emissions	6.4	
Deforestation		
Total emissions		
Sinks		
Accumulation in atmosphere		
Ocean		
Total sinks		
'Residual' forest sink		

1PCC, 2008

The global carbon cycle – annual changes

Billions of tonnes of carbon per year (Gt/year)

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1PCC, 2008

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The global carbon cycle – annual changes

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Total sinks		
'Residual' forest sink		

1PCC, 2008

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The global carbon cycle – annual changes

Billions of tonnes of carbon per year (Gt/year)

	1990s	2000-2005
Sources		
Fossil fuel emissions	6.4	
Deforestation	1.6	
Total emissions	**8.0**	
Sinks		
Accumulation in atmosphere	3.2	
Ocean		
Total sinks		
'Residual' forest sink		

1PCC, 2008

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The global carbon cycle – annual changes

Billions of tonnes of carbon per year (Gt/year)

	1990s	2000-2005
Sources		
Fossil fuel emissions	6.4	
Deforestation	1.6	
Total emissions	**8.0**	
Sinks		
Accumulation in atmosphere	3.2	
Ocean	2.2	
Total sinks		
'Residual' forest sink		

1PCC, 2008

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The global carbon cycle – annual changes

Billions of tonnes of carbon per year (Gt/year)

	1990s	2000-2005
Sources		
Fossil fuel emissions	6.4	
Deforestation	1.6	
Total emissions	**8.0**	
Sinks		
Accumulation in atmosphere	3.2	
Ocean	2.2	
Total sinks	**5.4**	
'Residual' forest sink		

1PCC, 2008

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The global carbon cycle – annual changes

Billions of tonnes of carbon per year (Gt/year)

	1990s	2000-2005
Sources		
Fossil fuel emissions	6.4	
Deforestation	1.6	
Total emissions	**8.0**	
Sinks		
Accumulation in atmosphere	3.2	
Ocean	2.2	
Total sinks	**5.4**	
'Residual' forest sink	**2.6**	

1PCC, 2008

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The global carbon cycle – annual changes

Billions of tonnes of carbon per year (Gt/year)

	1990s	2000-2005
Sources		
Fossil fuel emissions	6.4	7.2
Deforestation	1.6	?
Total emissions	**8.0**	?
Sinks		
Accumulation in atmosphere	3.2	4.1
Ocean	2.2	2.2
Total sinks	**5.4**	**6.3**
'Residual' forest sink	**2.6**	?

1PCC, 2008

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Forest fires and the global carbon cycle

Region	1997-2001 average fire emissions (Gt C/ yr)	Additional emissions due to El Nino anomaly (1997-1998) (Gt C/ yr)
Central and northern Sth America	0.27	0.45
Southern Sth America	0.80	0.23
Northern Africa	0.80	-0.14
Southern Africa	1.02	0.04
Southeast Asia	0.37	1.34
Boreal	0.14	0.23
Other	0.13	-0.03
Global	**3.53**	**2.13**

(van der Werf et al, 2004)

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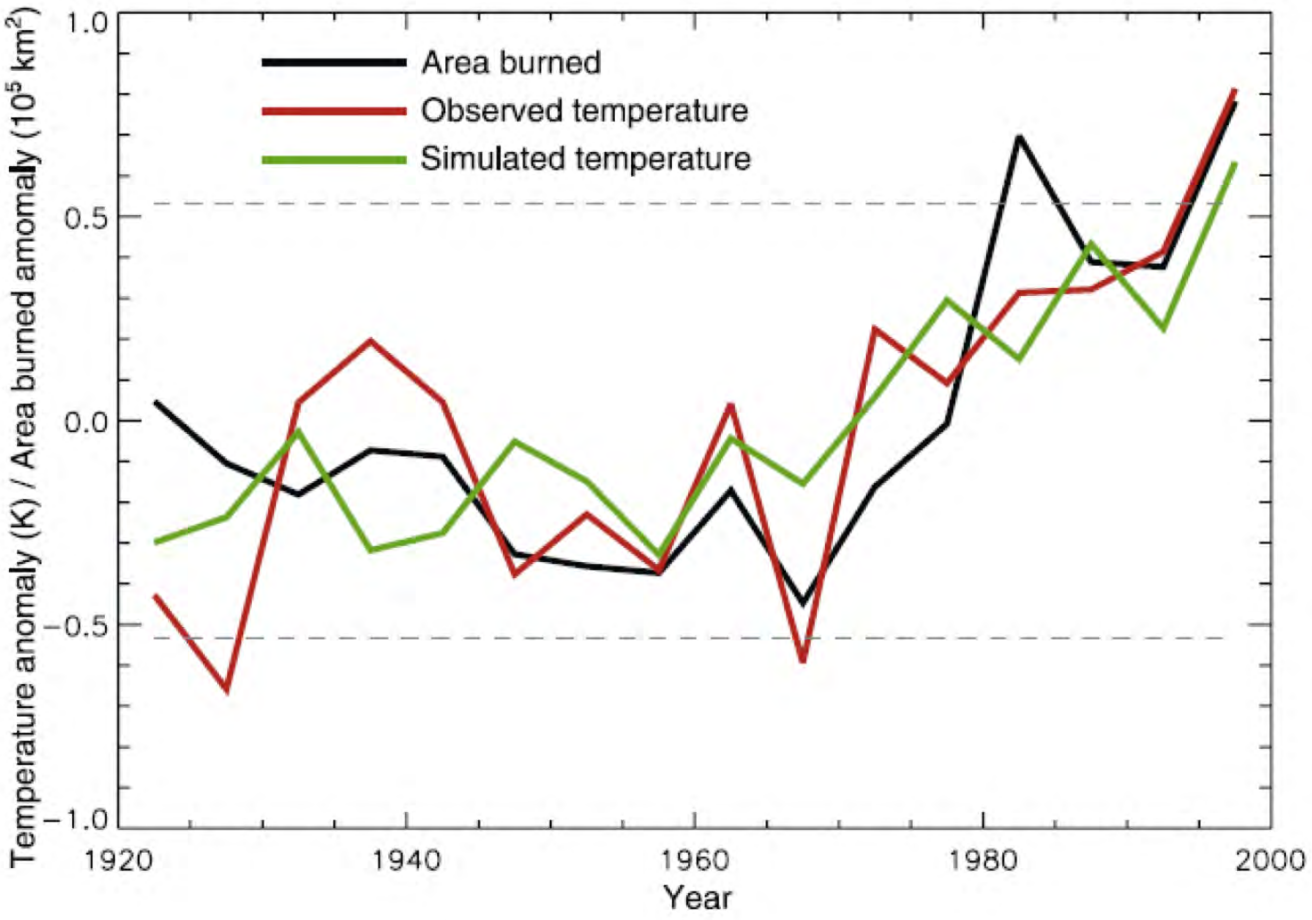
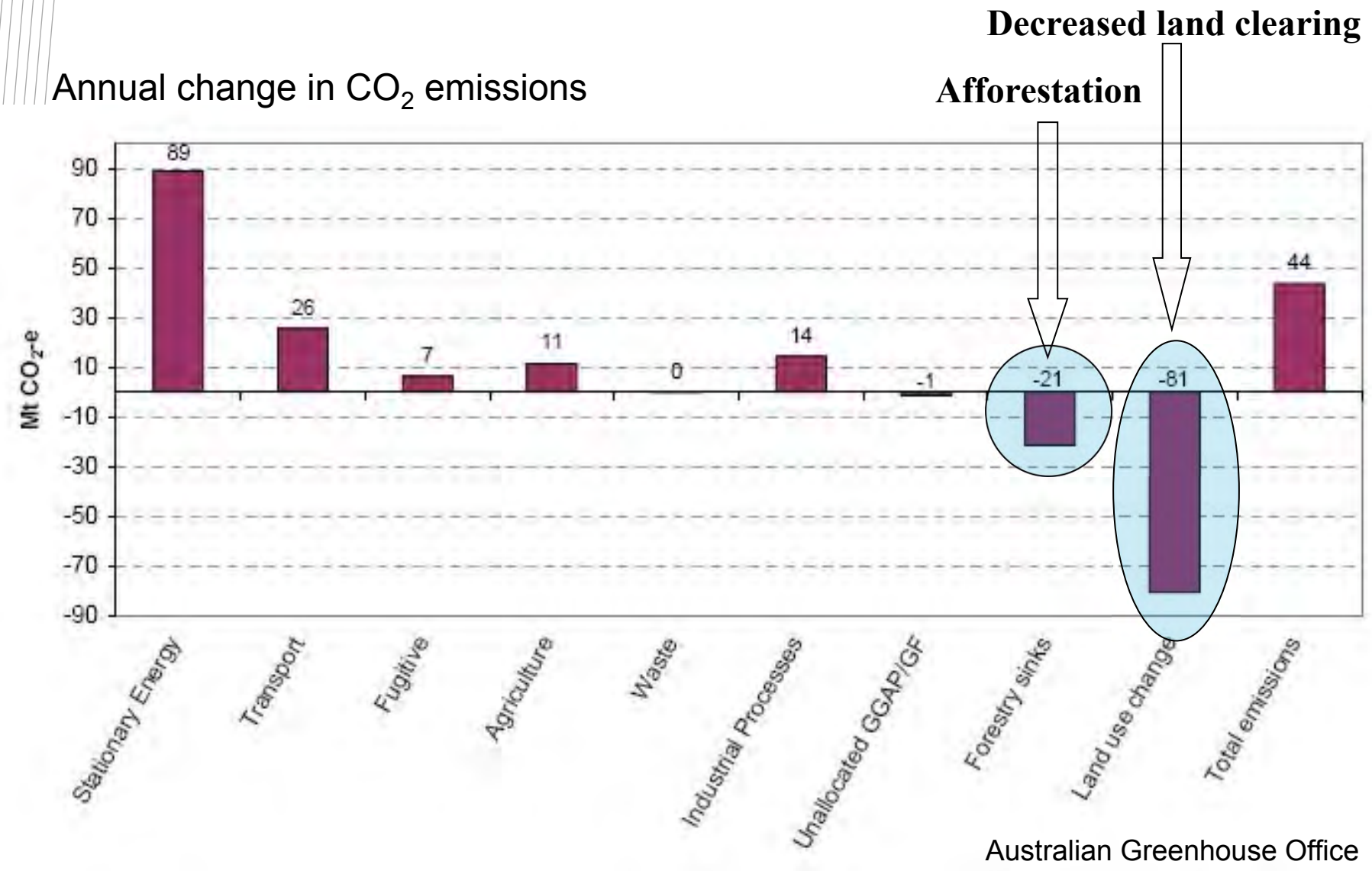
Increases in temperature and forest area burnt in Canada



Gillet et al (2004)

Australia is meeting its emission targets due to trees



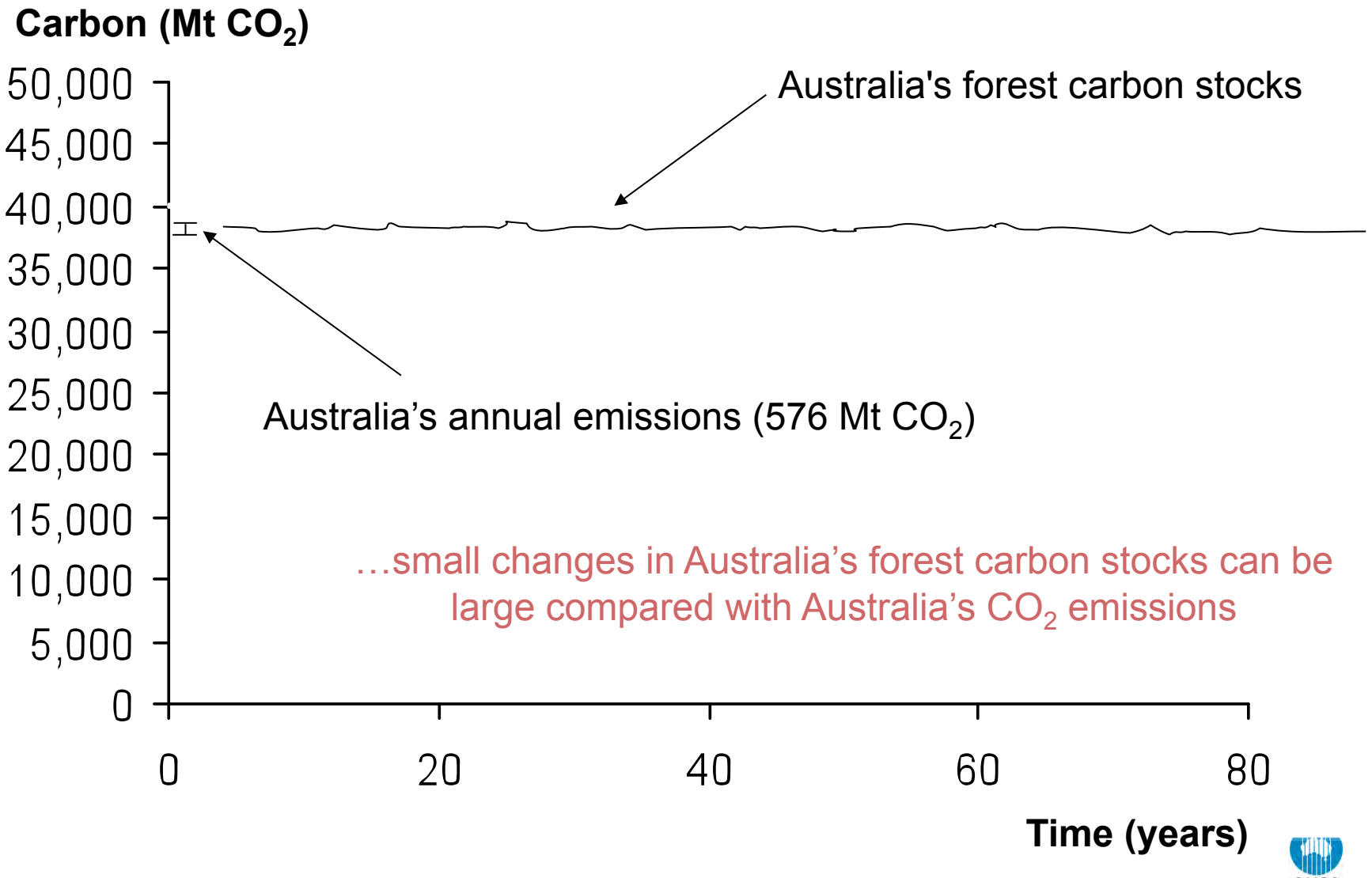
Australian Greenhouse Office

Australia's native forest areas and carbon stocks

	Area ('000 ha)	% total area		Carbon (Mt of CO_2)	% total carbon
Acacia	10,365	7.0		1,560	4.1
Callitris	2,597	1.8		198	0.5
Casuarina	2,229	1.5		117	0.3
Eucalypt	116,449	79.0		28,446	74.1
Melaleuca	7,556	5.1		2,198	2.3
Rainforest	3,280	2.2		4,995	5.7
Other	4,922	3.3		1,361	13.0
Total	**147,398**	**100**		**38,385**	**100**

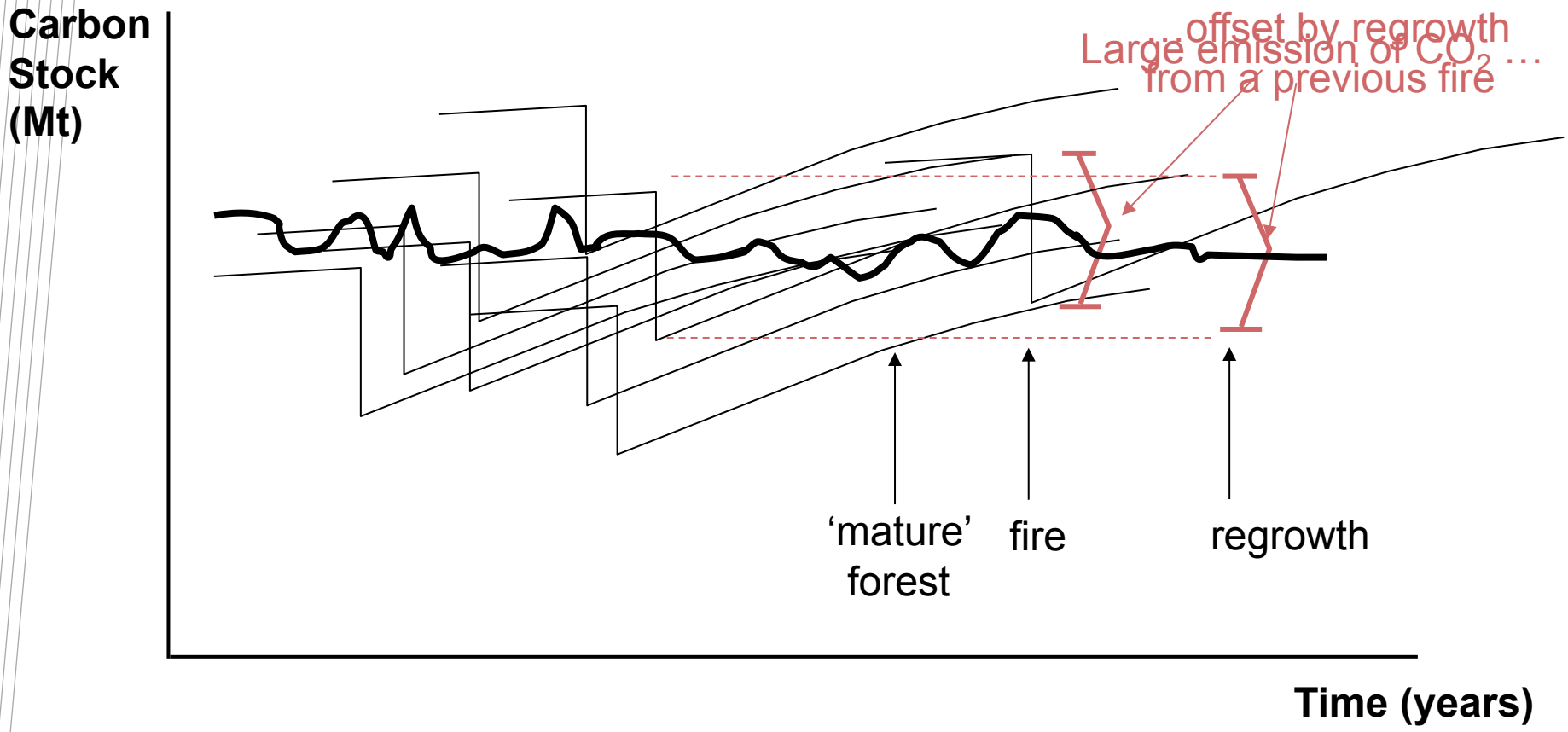
BRS, 2008

Australia's forest carbon stocks are large compared with national emissions

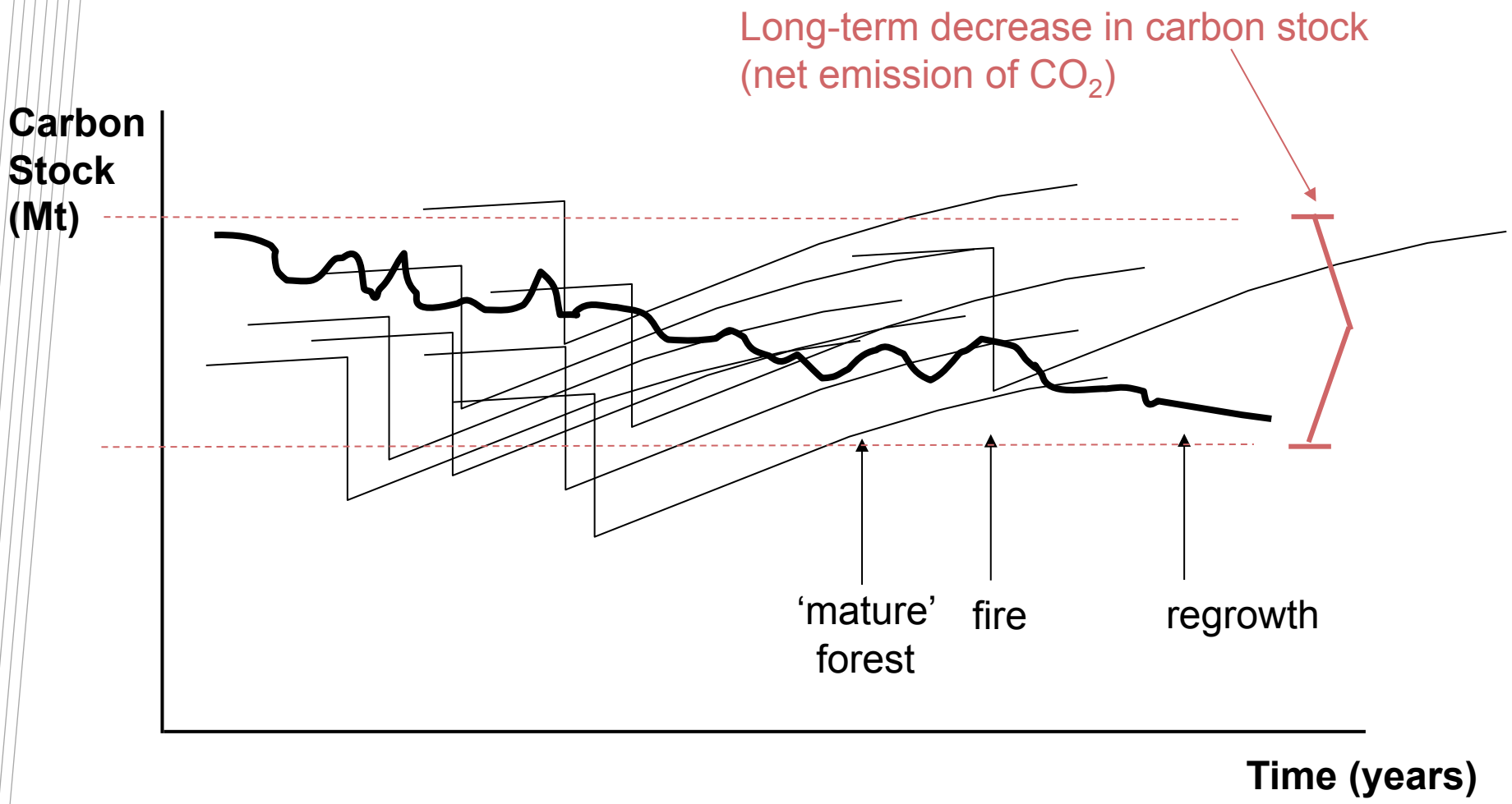


Regional forest carbon stocks and fire impacts

Every 1 mill ha of southern forest burnt = 10-20% of Australia's total emissions?



Regional forest carbon stocks and fire impacts



Forest fire areas in south-east Australia

State	NSW	Vic	Tas	Total
Area burnt (ha/yr)	398,529[1]	402,596[2]	21,062[1]	822,187

[1]2001-2006
[2]2001-2007

By **2050**, the percent change in the number of days with Very High or Extreme fire weather are:

- Number of '**Very High'** fire danger days: **+20-100%**
- Number of **'Extreme'** fire danger days: **+100-300%**

Lucas et al., 2007.

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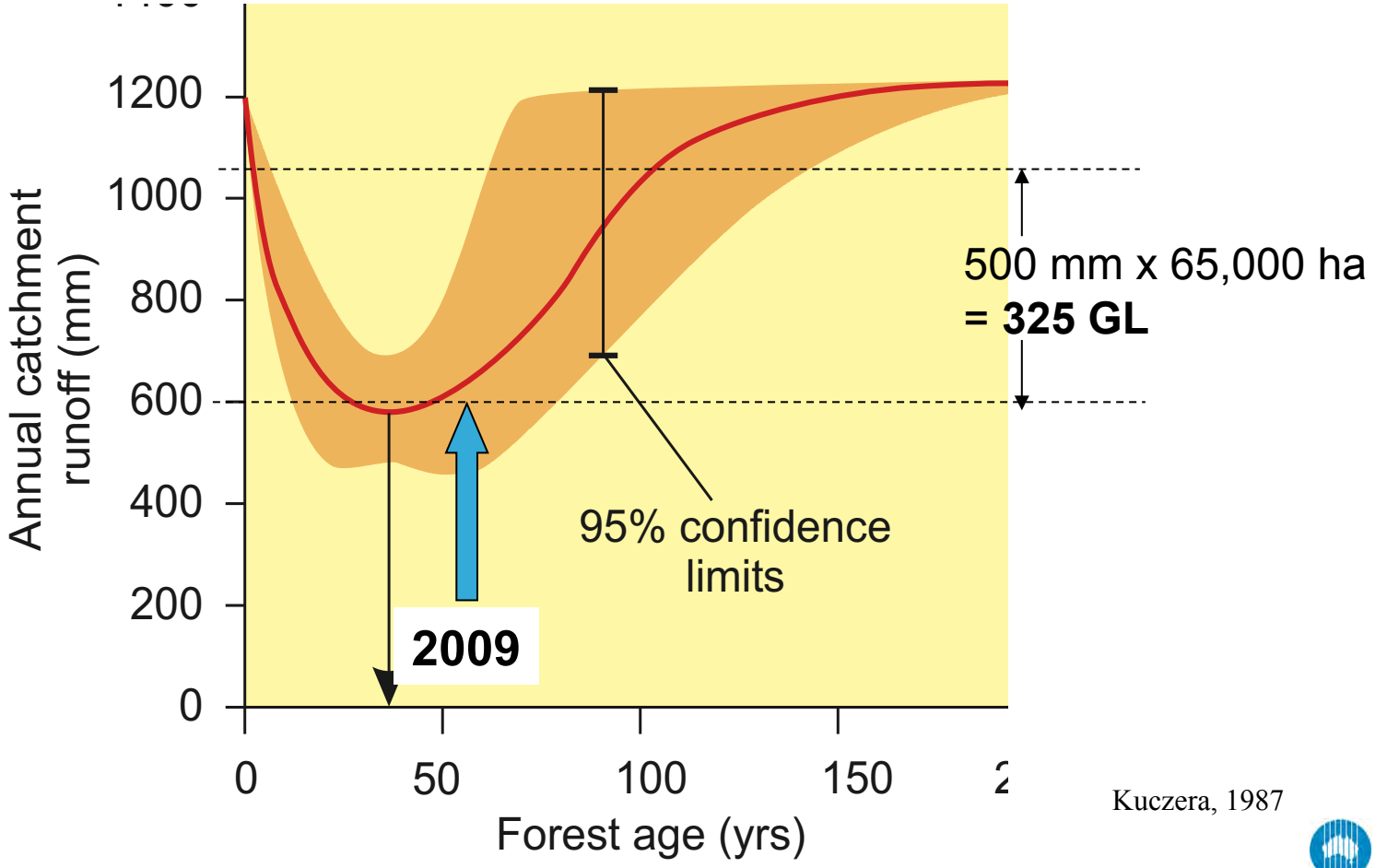
Forest fires and water supply

Wildfires in 1939 have decreased stream flows to Melbourne by about 300 GL per year (40%) due to increased forest water use in just 65,000 ha of regenerating forest.



Kuczera, 1987

Forests and climate change

What will happen if:

- Temperatures increase by 3 ^{o}C?
- Rainfall decreases by 20%?
- Droughts become more frequent and severe?
- Fires become more frequent and severe?
- Atmospheric CO_2 increases to 500 ppm?

Forest functioning

Climate change
- Rainfall,
- Temperature
- CO_2
- VPD, frost etc

Droughts

Bushfires

Pests and diseases

Note: Tasmania may be different!

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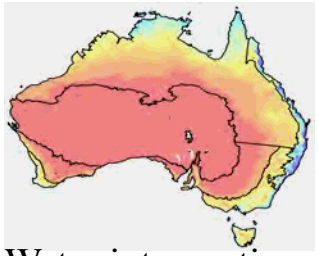
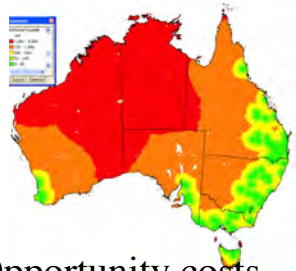
‘Prospecting’ for opportunities for new forests

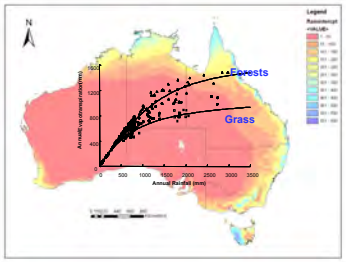
Growth/ carbon



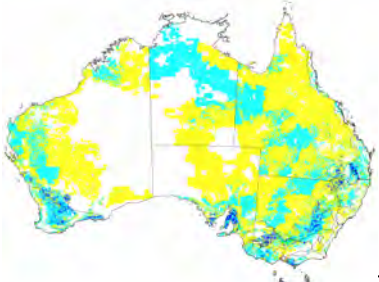
Transport costs



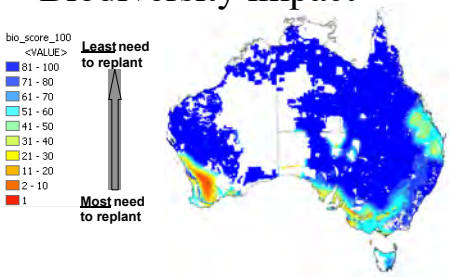
Water interception



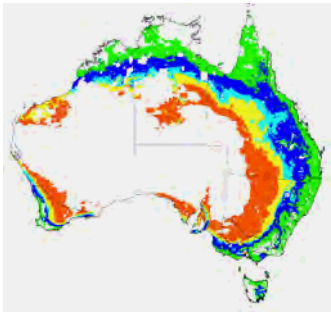
Opportunity costs



Biodiversity impact



Economic outcome



- Funded by the RIRDC
- National assessment (1 km scale) of various forest systems: hardwood sawlog, softwood sawlog, pulpwood, bioenergy, carbon plantings
- Considered economic and environmental impacts
- Data set can be used explore opportunities for forest systems and controlling factors

Polglase et al. 2008

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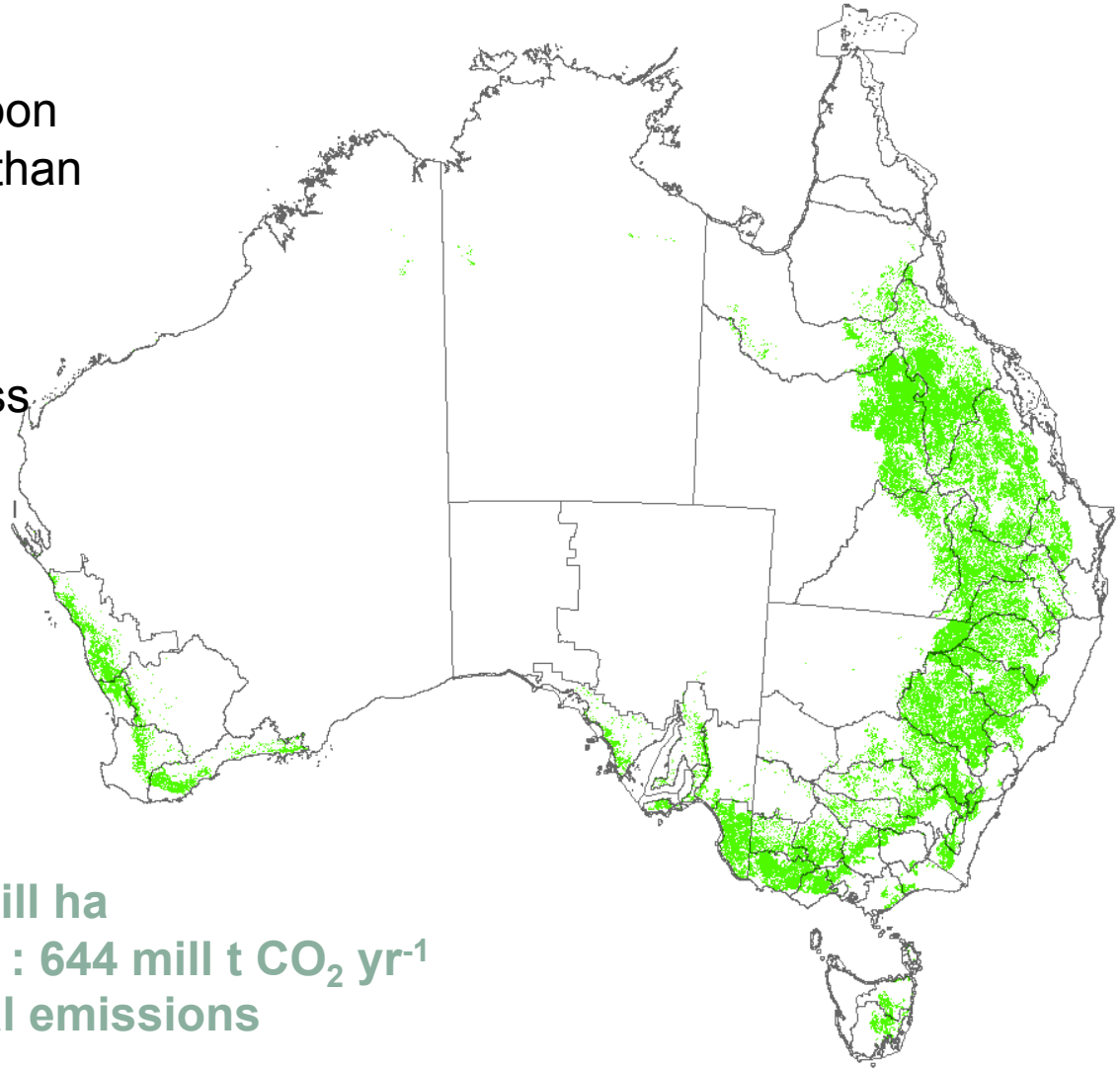
‘Prospecting’ for opportunities for carbon farming

- All areas where forest carbon farming is more profitable than the preceding agricultural enterprise
- Water yield reduction is less than 150 mm/yr



- **Area of opportunity: 69 mill ha**
- **Total carbon sequestered : 644 mill t CO_2 yr^{-1}**
- **111% of Australia's annual emissions**

Polglase et al, 2008

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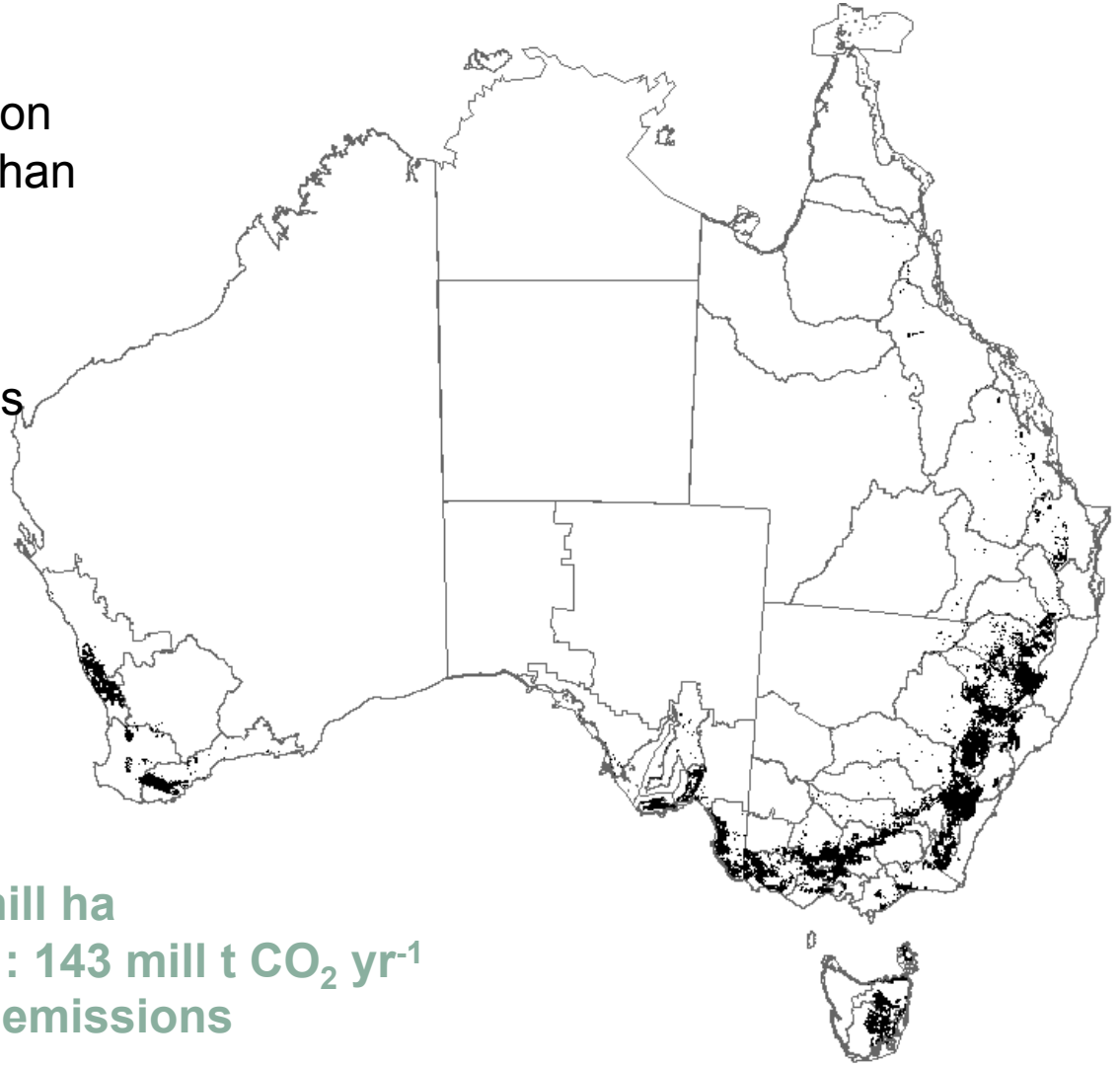
‘Prospecting’ for opportunities for carbon farming

- All areas where forest carbon farming is more profitable than the preceding agricultural enterprise by $150/ha/yr
- Water yield reduction is less than 150 mm/yr



- **Area of opportunity: 9.1 mill ha**
- **Total carbon sequestered : 143 mill t CO_2 yr^{-1}**
- **25% of Australia's annual emissions**

Polglase et al, 2008

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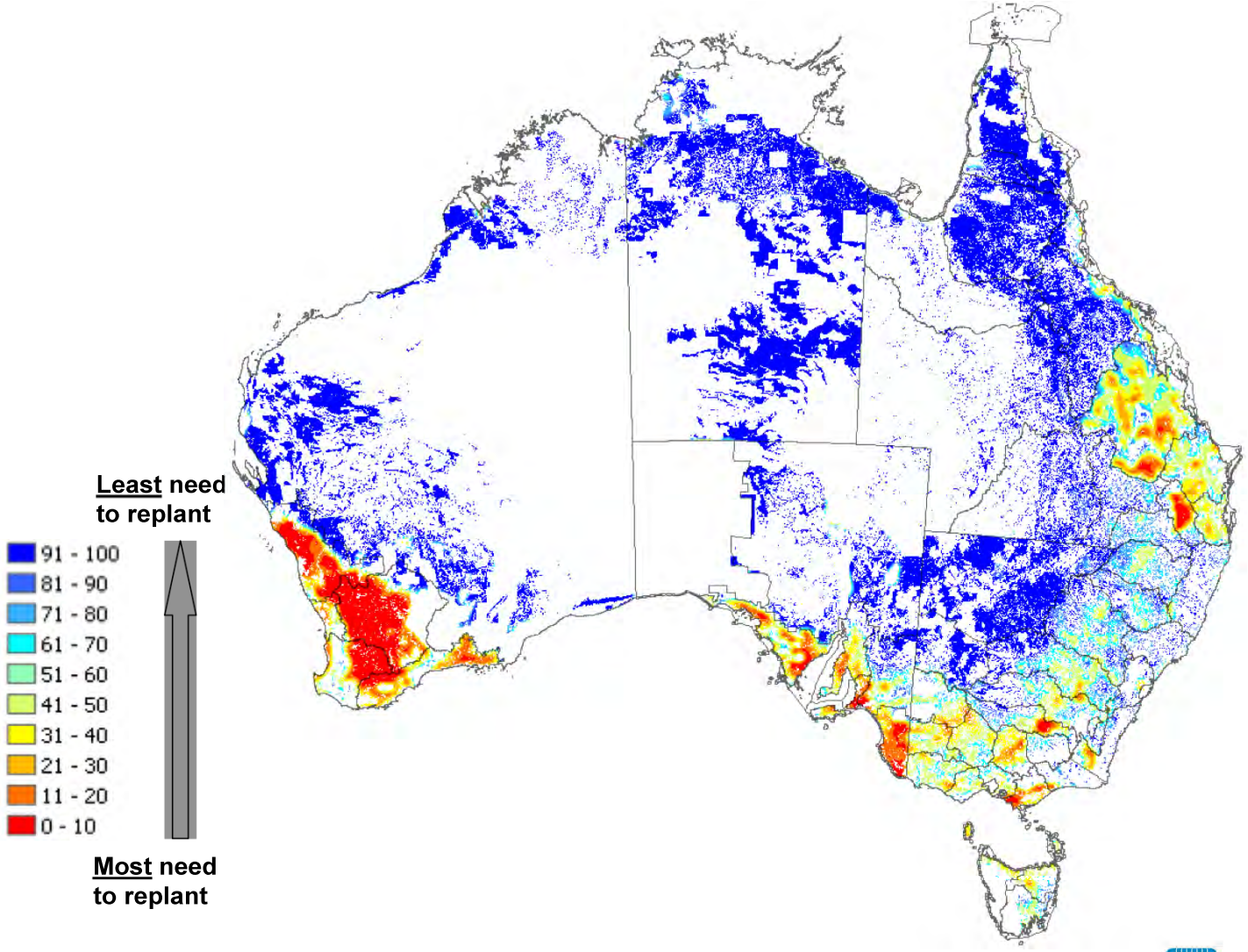
Biodiversity benefit from planting new forests



Polglase et al, 2008

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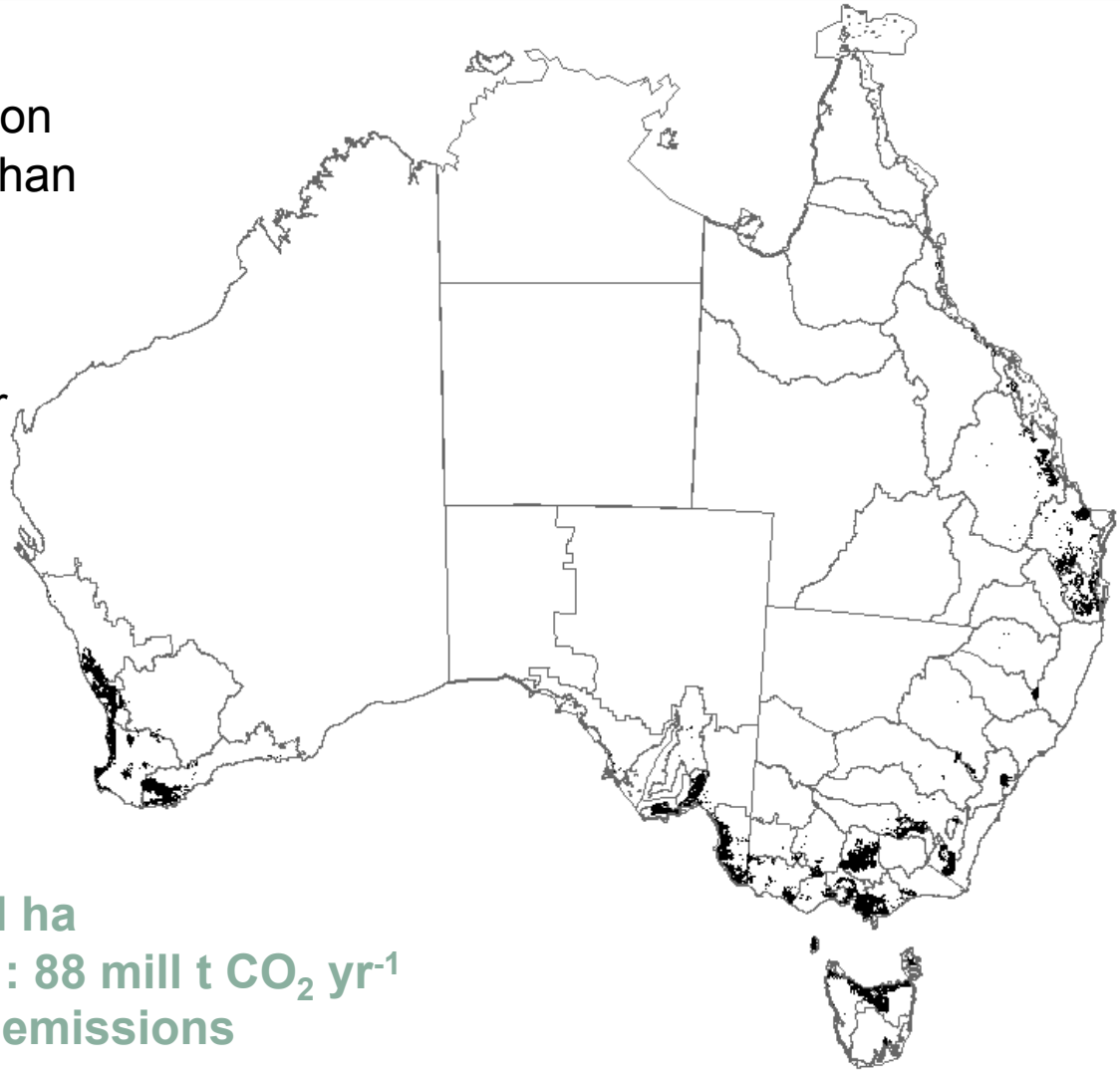
‘Prospecting’ for opportunities for carbon farming

- All areas where forest carbon farming is more profitable than the preceding agricultural enterprise by $150/ha/yr
- Biodiversity need is greater than 50 units.



- **Area of opportunity: 5 mill ha**
- **Total carbon sequestered : 88 mill t CO_2 yr^{-1}**
- **15% of Australia's annual emissions**

Polglase et al, 2008

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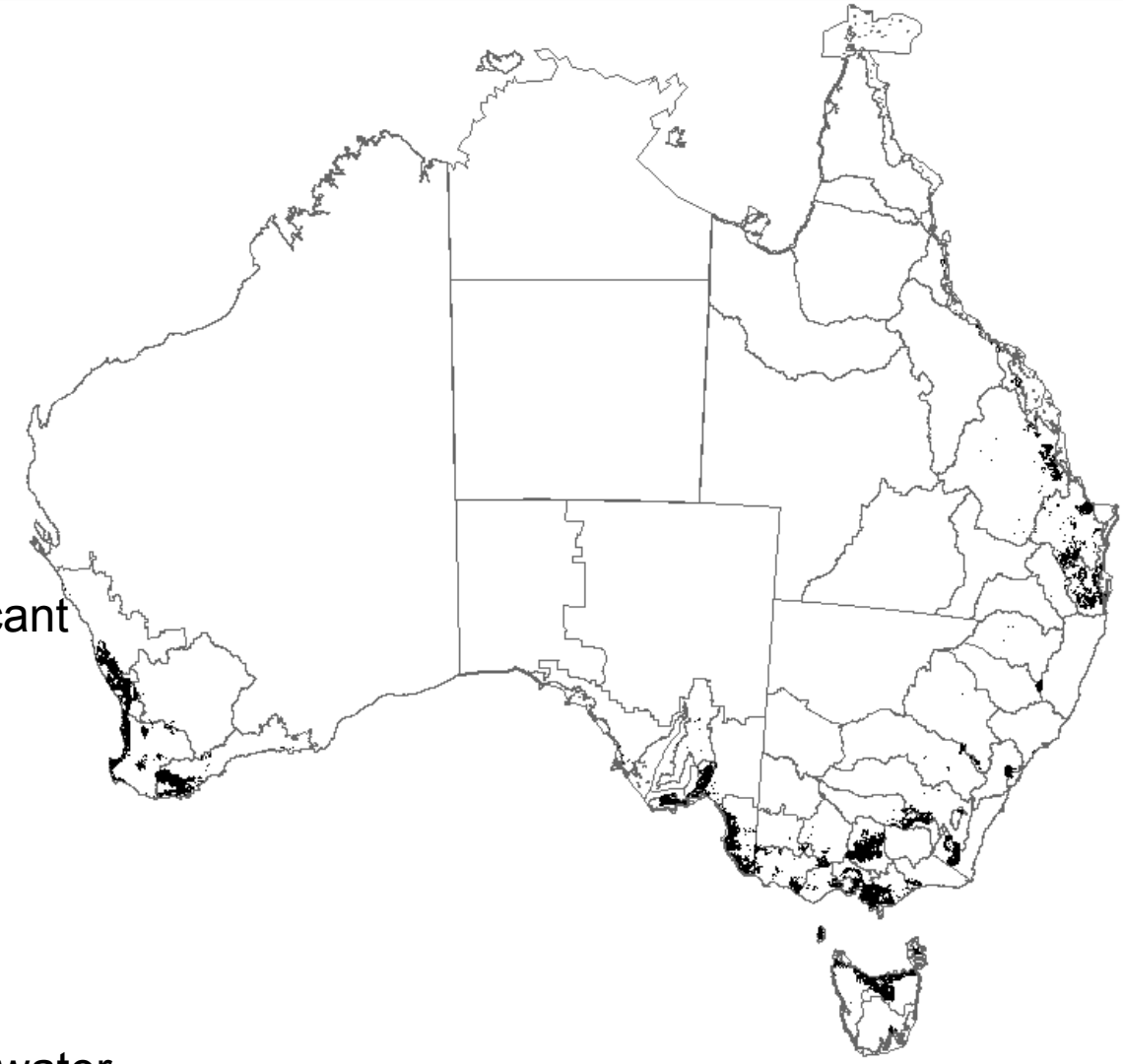
‘Prospecting’ for opportunities for carbon farming

- Australia is a big place!
- There are many regional opportunities
- Lots of new forests = significant contribution to emission reductions
- Plantings can be dispersed around the country to:
  - mitigate risk
  - maximise benefits
  - minimise conflicts with, eg water.



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Conclusions

- Forests dominate carbon and water cycles, globally and in Australia
- Australia's forest carbon stores about 46 years worth of Australia's 2006 emissions, thus…
- …small percentage changes in the forest carbon stock are significant
- Changes in climate and associated impacts (eg fire, cyclones) pose, by far, the biggest threat to forest carbon stocks (… and we should be worried about that).
- New forests could sequester a significant proportion of Australia's emissions…
- …and if planted in the right place, other benefits can be maximised and trade-offs minimised.