Native forests, carbon & climate change

Presentation for Conservation Council W.A. community seminar
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Image: NASA

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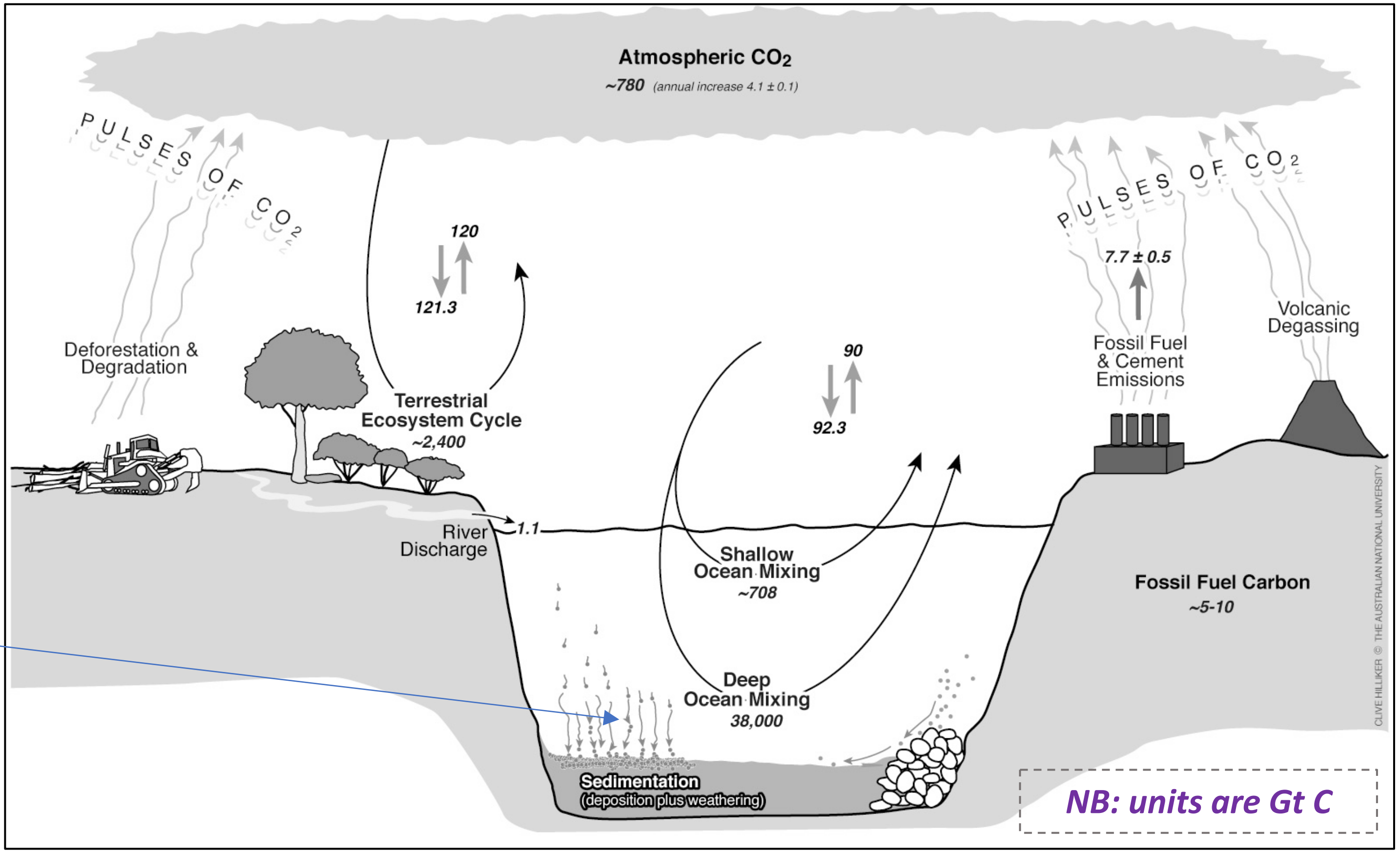
www.griffith.edu.au/climate-change-response-program

Global C-cycle (simplified)

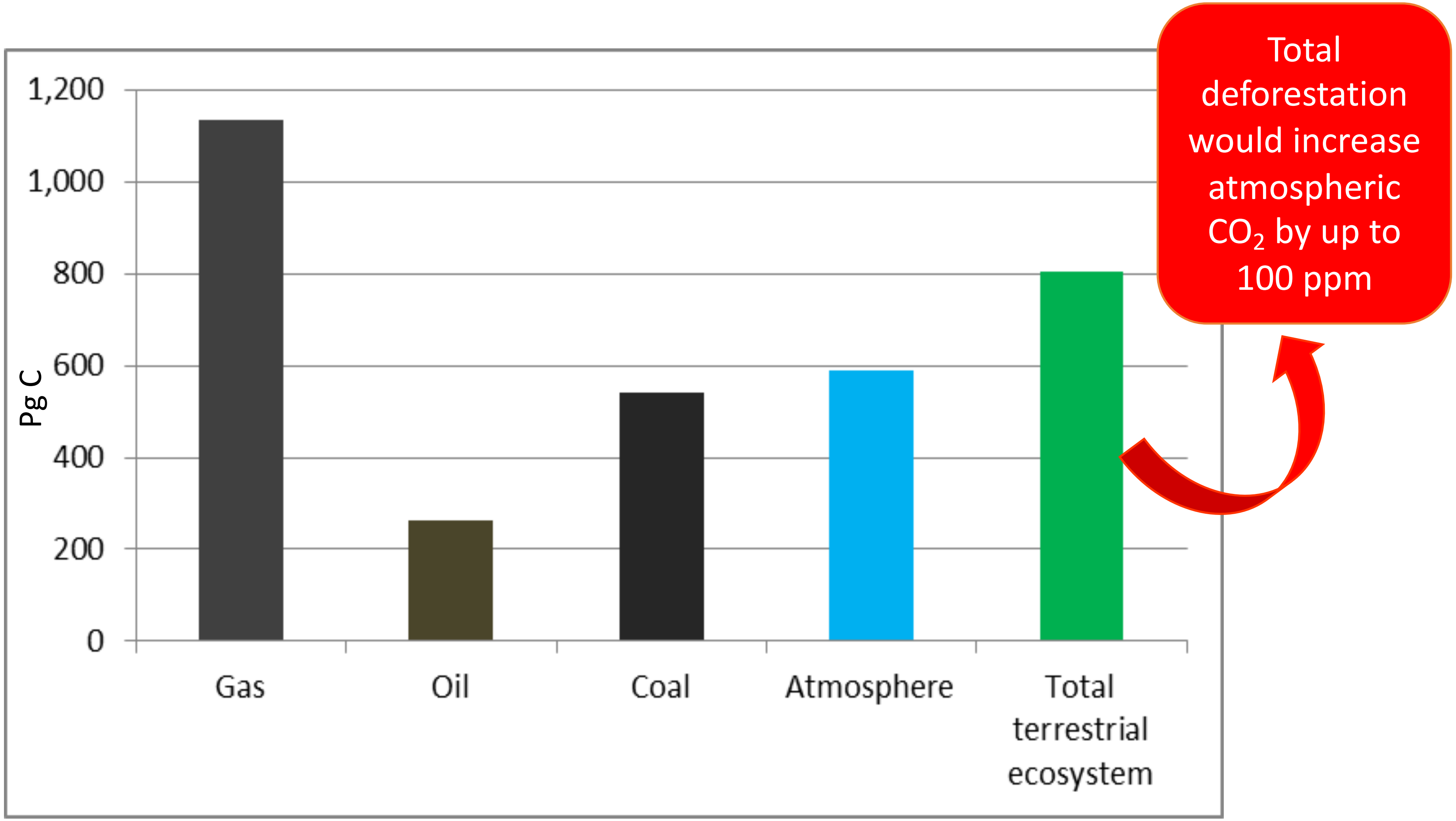
The only real fossil fuel offset is the bottom of the deep ocean through long-term (~100K yr) sedimentation processes (weathering & dead organic matter)



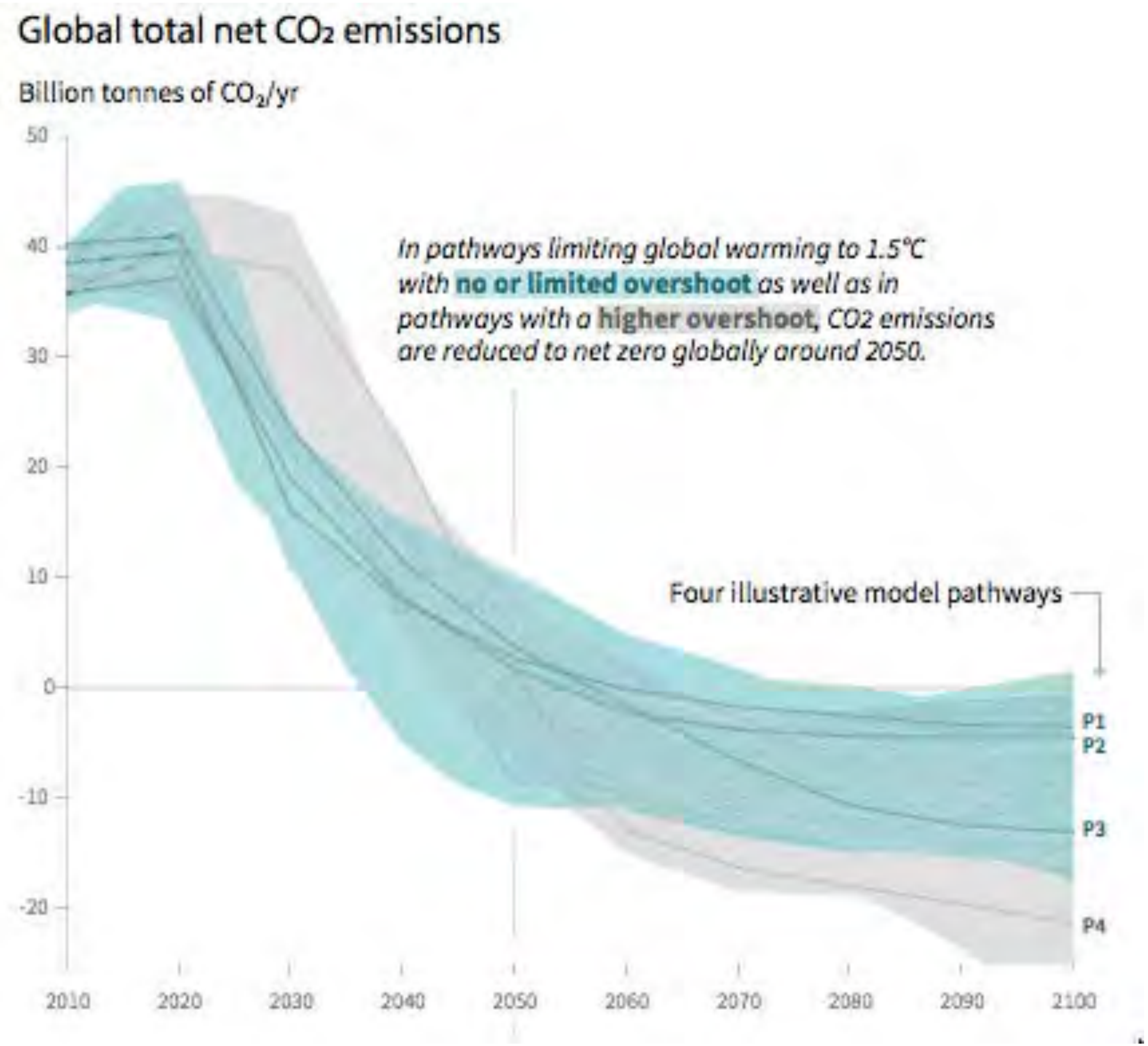
Of the total emissions from human activities during the period 2004-2013, about 44% accumulated in the atmosphere, 26% in the ocean and 30% on land

Source: Mackey (2014) *Significance,* www.significancemagazine.org February 19-23; Global Carbon Project

Current estimates of non-ocean global C stocks

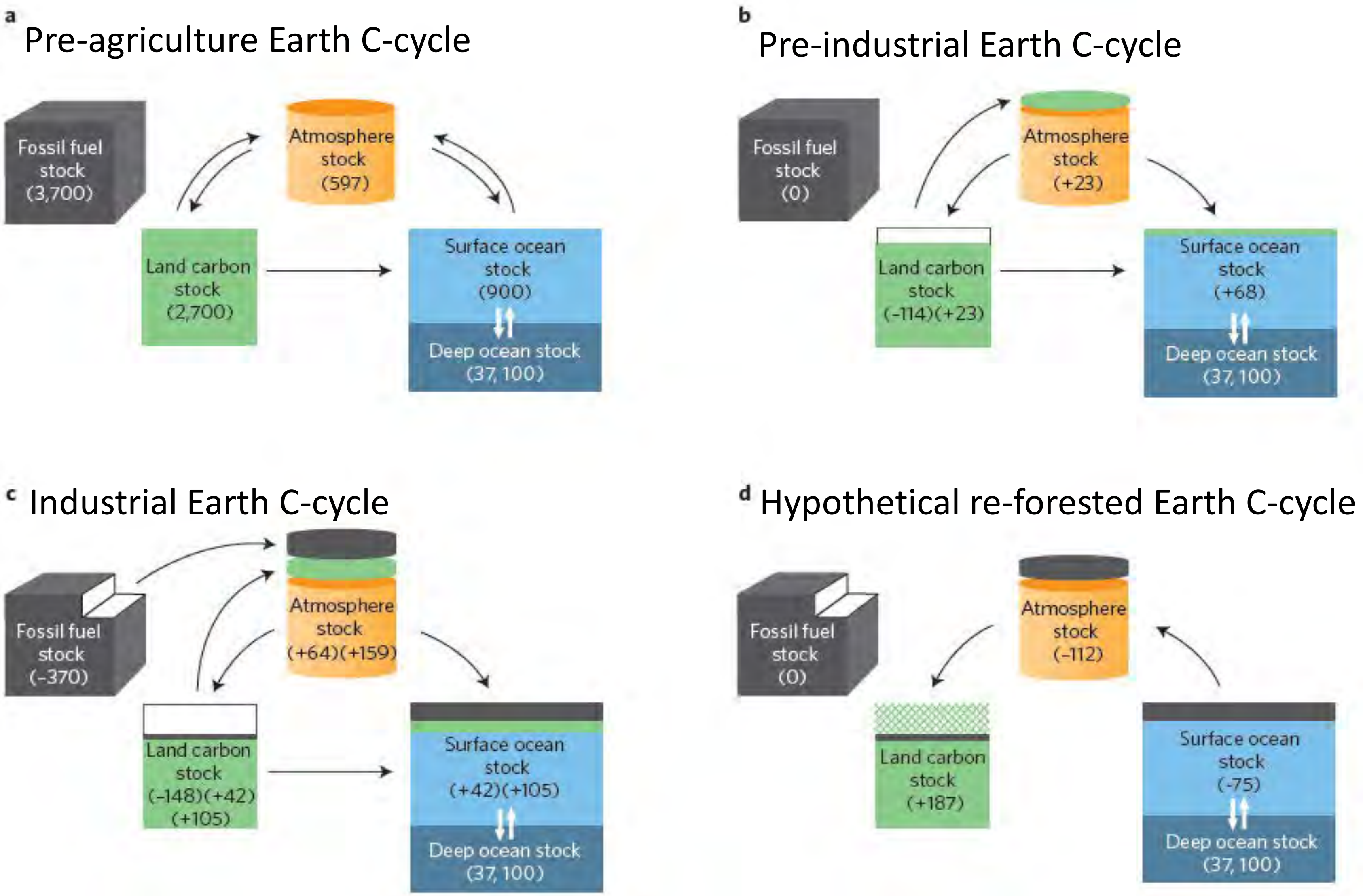


Source: IPCC AR5 WGI; House et al. (2002) *Glob. Change Biol.* **8,** 1047–1052



The mitigation imperative

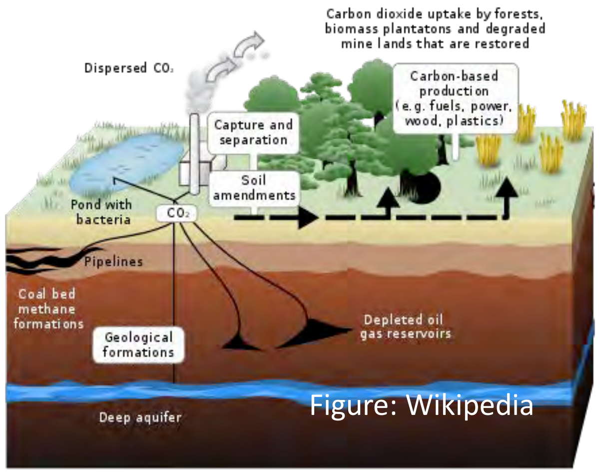
- For limiting global warming to 1.5 °C, CO_2 emissions must be reduced by 45-50% by 2030 and net zero around 2050
- Pathways limiting global warming to 1.5°C require rapid and far-reaching transitions in energy, land, urban and infrastructure (including transport and buildings), and industrial systems
- These systems transitions are unprecedented in terms of scale, but not necessarily in terms of speed, and imply deep emissions reductions in all sectors
- **Plus** <u>mitigation strategies to avoid emissions from deforestation & degradation</u>



Source: Mackey B. et al. (2013) Untangling the confusion around land carbon science and climate change mitigation policy. *Nature Climate Change* **3**, 552–557; doi:10.1038/nclimate1804

Need to mitigate both fossil fuel and land carbon emissions

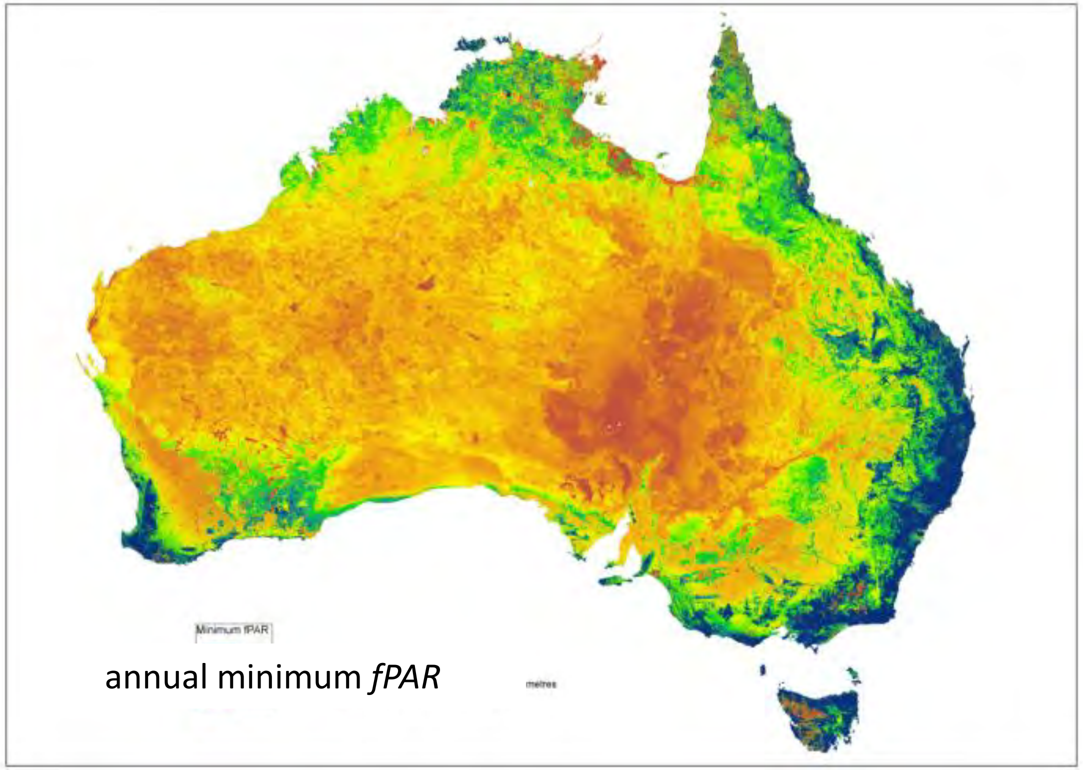
✓ Stop further FF emissions
✓ Minimise land carbon emissions
✓ Replenish as much as possible depleted ecosystem C-stocks



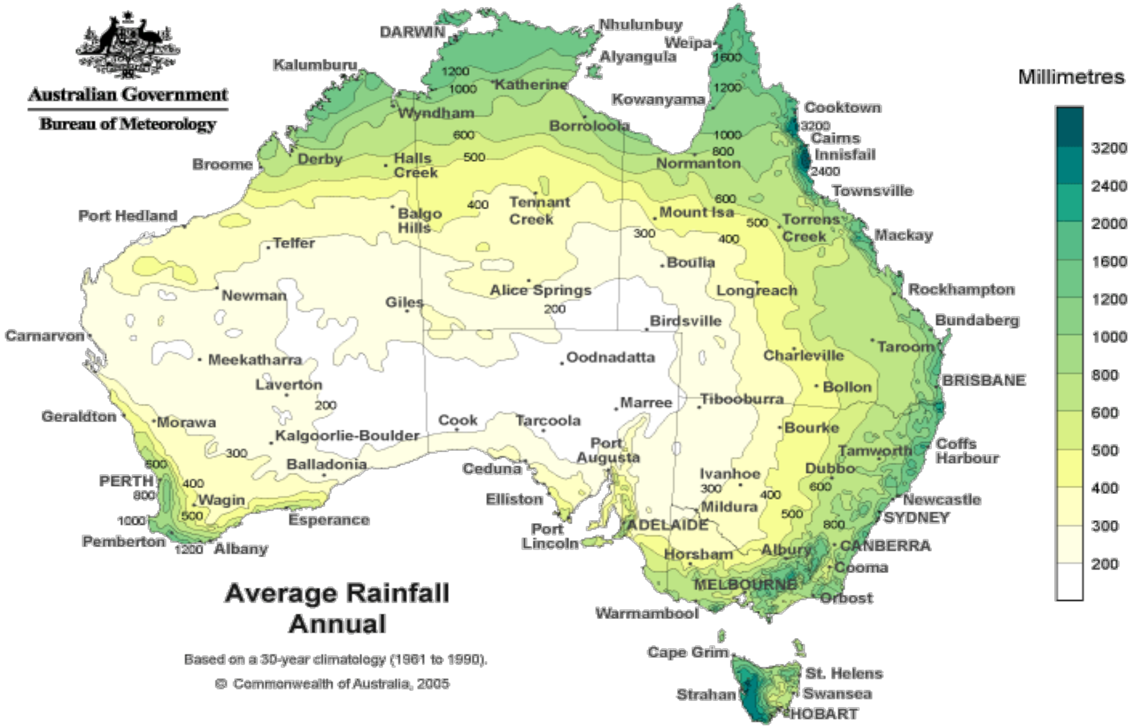
- We can partially refill the depleted ecosystem carbon stocks through ecological restoration
- We cannot ‘refill’ the depleted fossil fuel carbon stocks - CCS is a nice idea but the problem is not capturing C but the storage as natural geo-cavities leak and degas
- If Anthropogenic emissions were to cease, the additional atmos. CO_2 would be naturally offset through ‘bottom of ocean sedimentation processes’ but this would take ~100K years

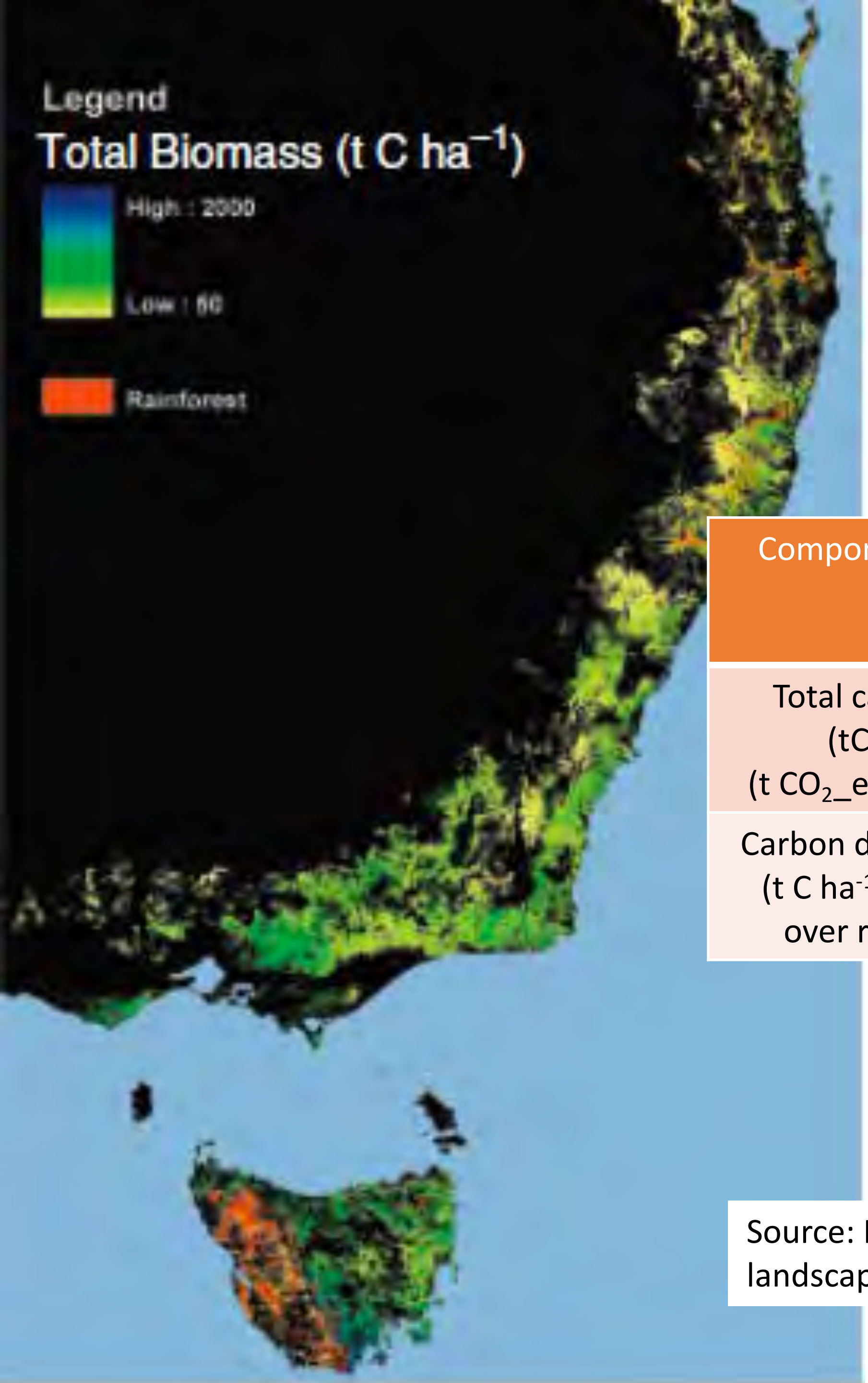
Native ecosystems are natural ‘carbon capture & storage systems’

but landscapes with sufficient water to support carbon dense native forest ecosystems (forests) are restricted in Australia



annual minimum *fPAR*





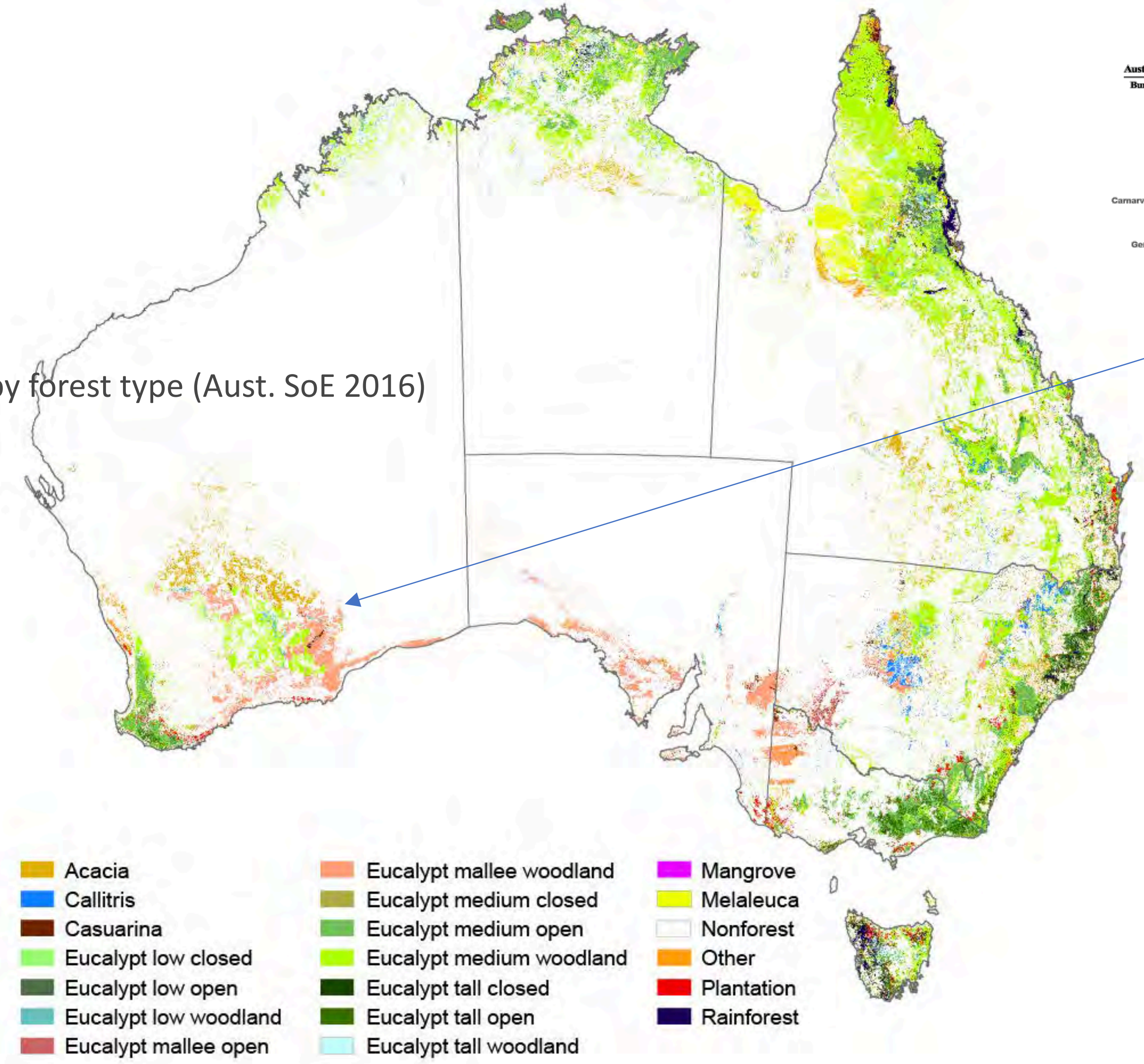
South East Australian Native Forest Carbon Accounts

Total and mean estimates for eucalypt forests of S.E . Australia covering 14.5 million ha^{-1}

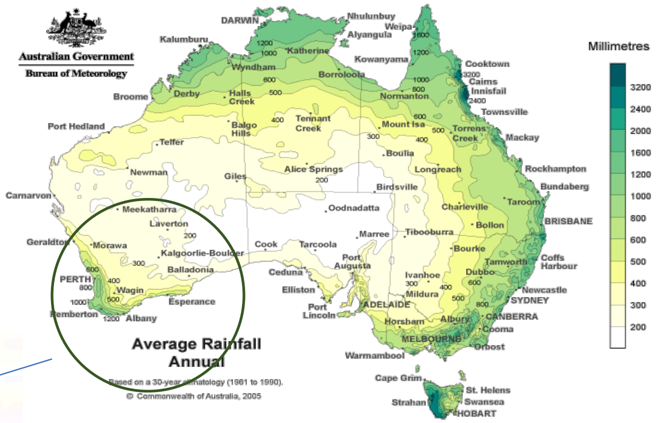
Component	Soil carbon carrying capacity	Living biomass CCC	Total biomass (living + dead) CCC	Total ecosystem CCC	Current total carbon stocks	Carbon sequestration potential
Total carbon (tC x 10^6) (t CO_2_e x 10^6)	4,060 14,888	4,191 15,368	5,220 19,142	9280 34,030	~7,000 25,500	~2000 7,500
Carbon density (t C ha^{-1}) (S.D. over region)	280 (161)	298 (226)	360 (277)	640 (383)	179 (living biomass only)	

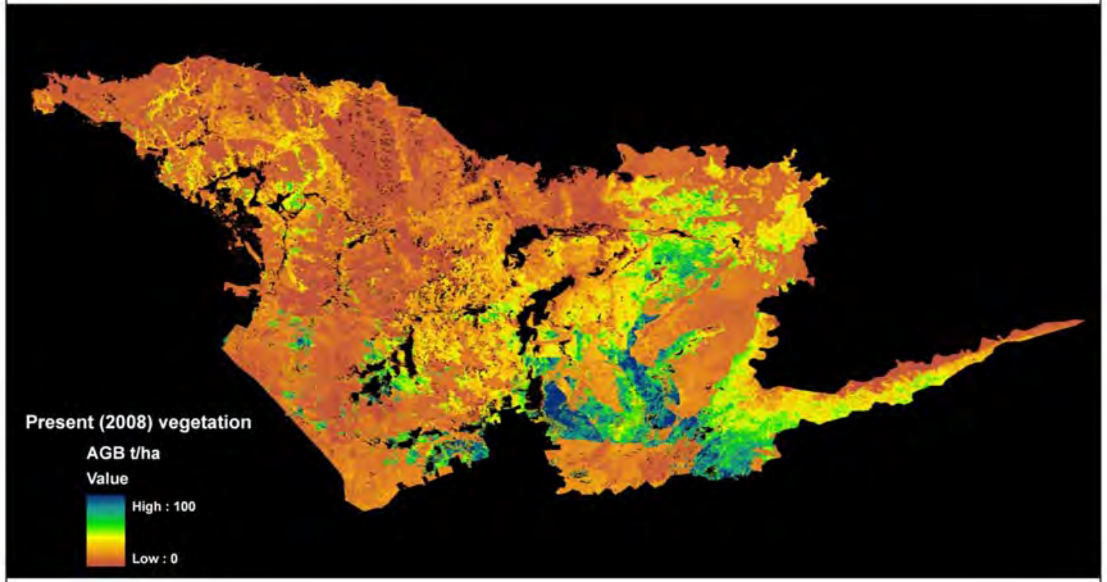
Source: Keith et al. (2009) Estimating carbon carrying capacity in natural forest ecosystems across heterogeneous landscapes: addressing sources of error. Global Change Biology https://doi.org/10.1111/j.1365-2486.2009.02146.x

…and native forests are naturally restricted to wetter landscapes of W.A



Australia’s forest extent by forest type (Aust. SoE 2016)





Great Western Woodlands Carbon Accounts

Estimated current total carbon stock of the soil and vegetation in the GWW is 950 Mt C (0.95 Gt C)

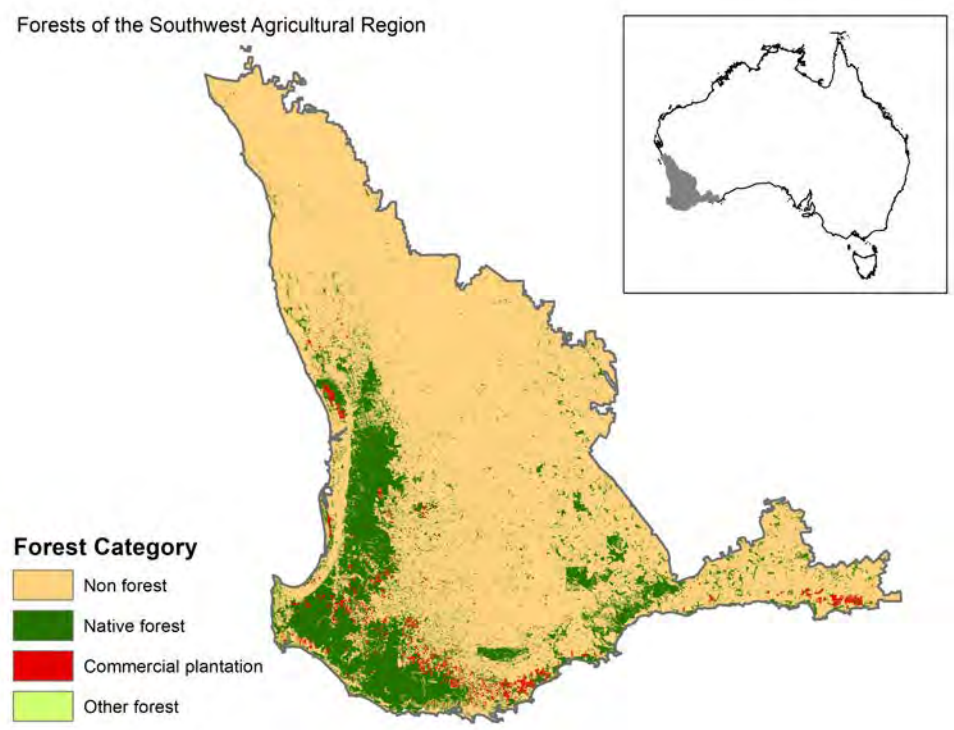
- 305 Mt C vegetation; ~50 t C per ha
- 639 Mt C soil

- Current above-ground biomass of woodlands recovering from timber cutting (mostly for bio-fuel) in the first half of the past century could be at just 40–50% of above-ground biomass carbon carrying capacity
- The above-ground biomass carbon of woodlands impacted by mineral exploration is ~70% of carbon carrying capacity
- If the woodlands had not been impacted on by fire, timber cutting, mineral exploration and pastoral land management, a total of 13 million ha (double the current extent and 80 % of the GWW) would be woodland, and the total biomass carbon stock would be 915 Mt C (triple the current stock)
- Under the hypothetical 'no-disturbance' condition, the total carbon stock is estimated at 1,550 Mt C.

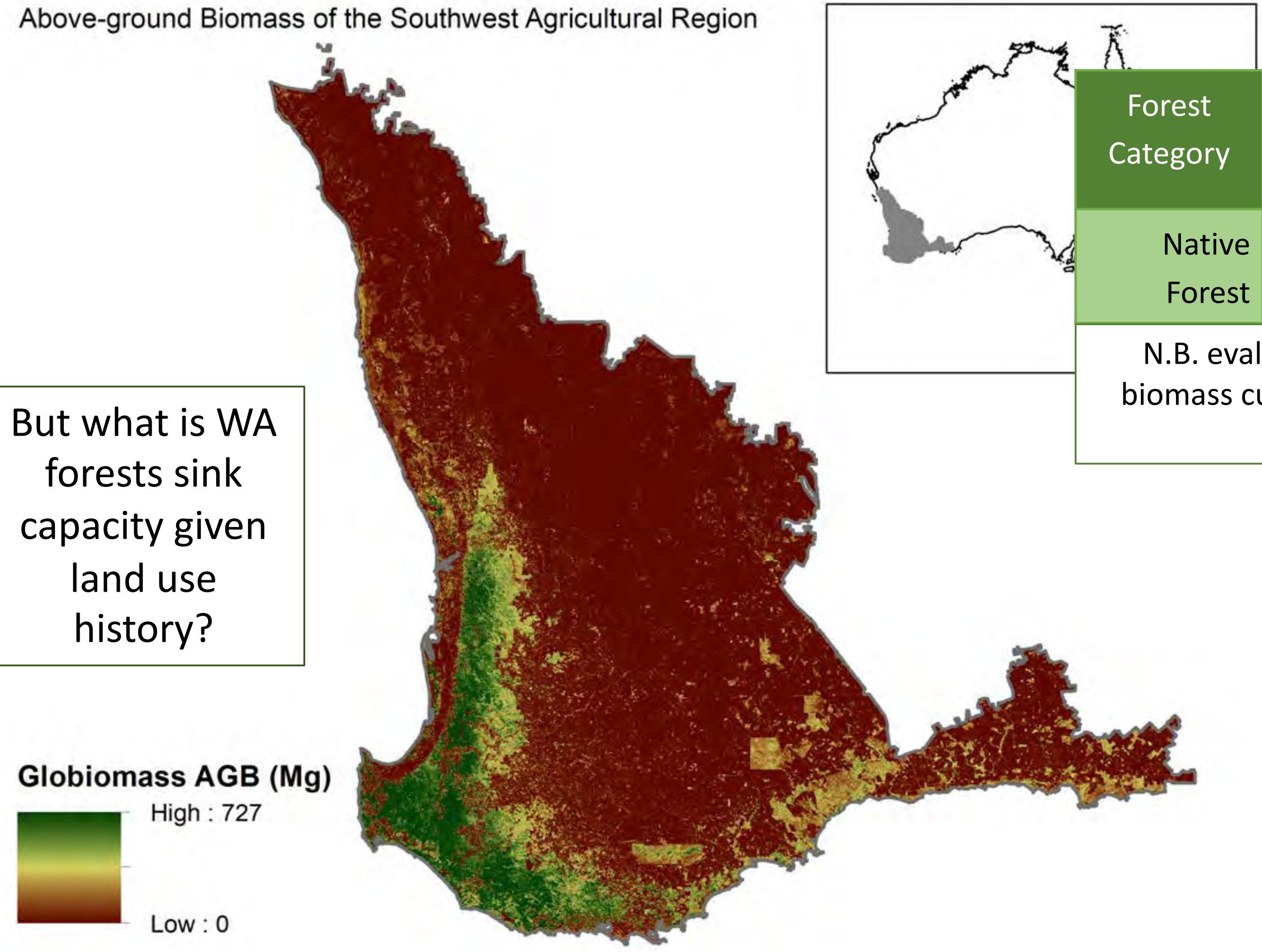
Source Berry et al. (2010) Green carbon: the role of natural forests in carbon storage. Part 2. Biomass carbon stocks in the Great Western Woodlands. ANU Press.

What about W.A. forest carbon stocks?

In the absence of being able to find any published data, we estimated forest above ground living biomass stocks for W.A. forests using a global database of modelled values (remote sensing + ground calibration data)



Indicative results??



But what is WA forests sink capacity given land use history?

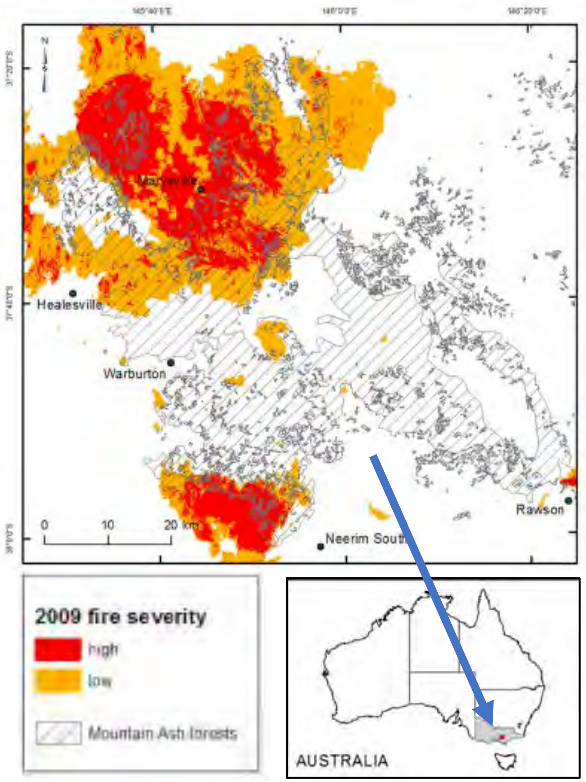
Forest Category	Total Area (ha)	ABG biomass (Mg)	Biomass C (Mg)	Biomass C (~Gt)	t C per ha
Native Forest	8,422,423	1,313,876,742	656,938,371	0.66	78

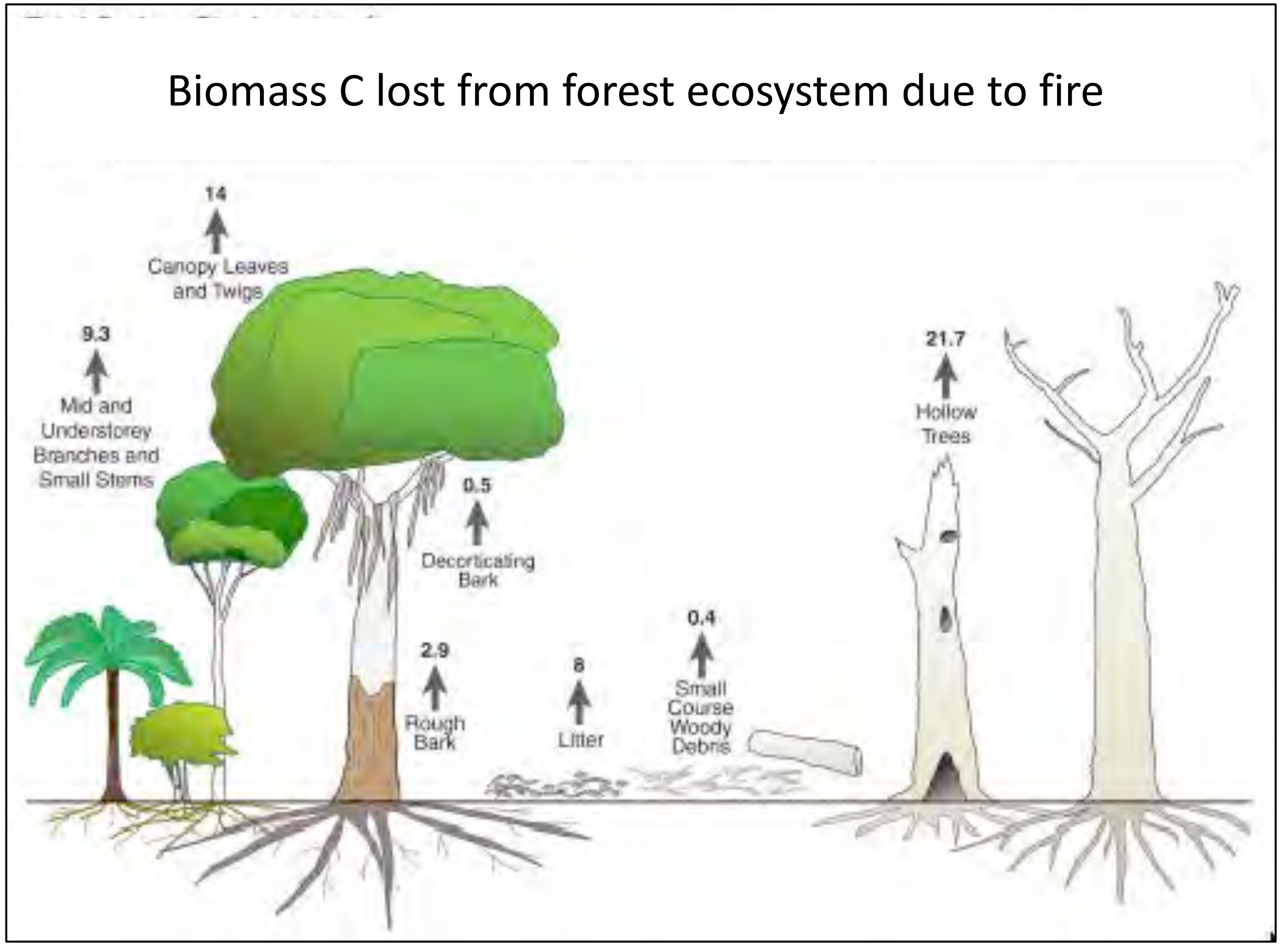
N.B. evaluation in other locations suggest this model underestimates forest biomass current stocks e.g. SE Australian forests living biomass C ~179 t per ha and GWW ~50 t per ha

- Forest categories were defined by the Forests of Australia 2018 continental spatial dataset (link) and clipped to the Southwest Agricultural Region boundary (data, info).
- Biomass data sourced from Santoro, M. et al. (2018) GlobBiomass global above-ground biomass and growing stock volume datasets.http://globbiomass.org/products/global-mapping

Fire impacts on carbon stocks different to impacts on wood supply

We studied the impacts of a wildfire in 2009 that burnt temperate forest of tall, wet eucalypts in south-eastern Australia



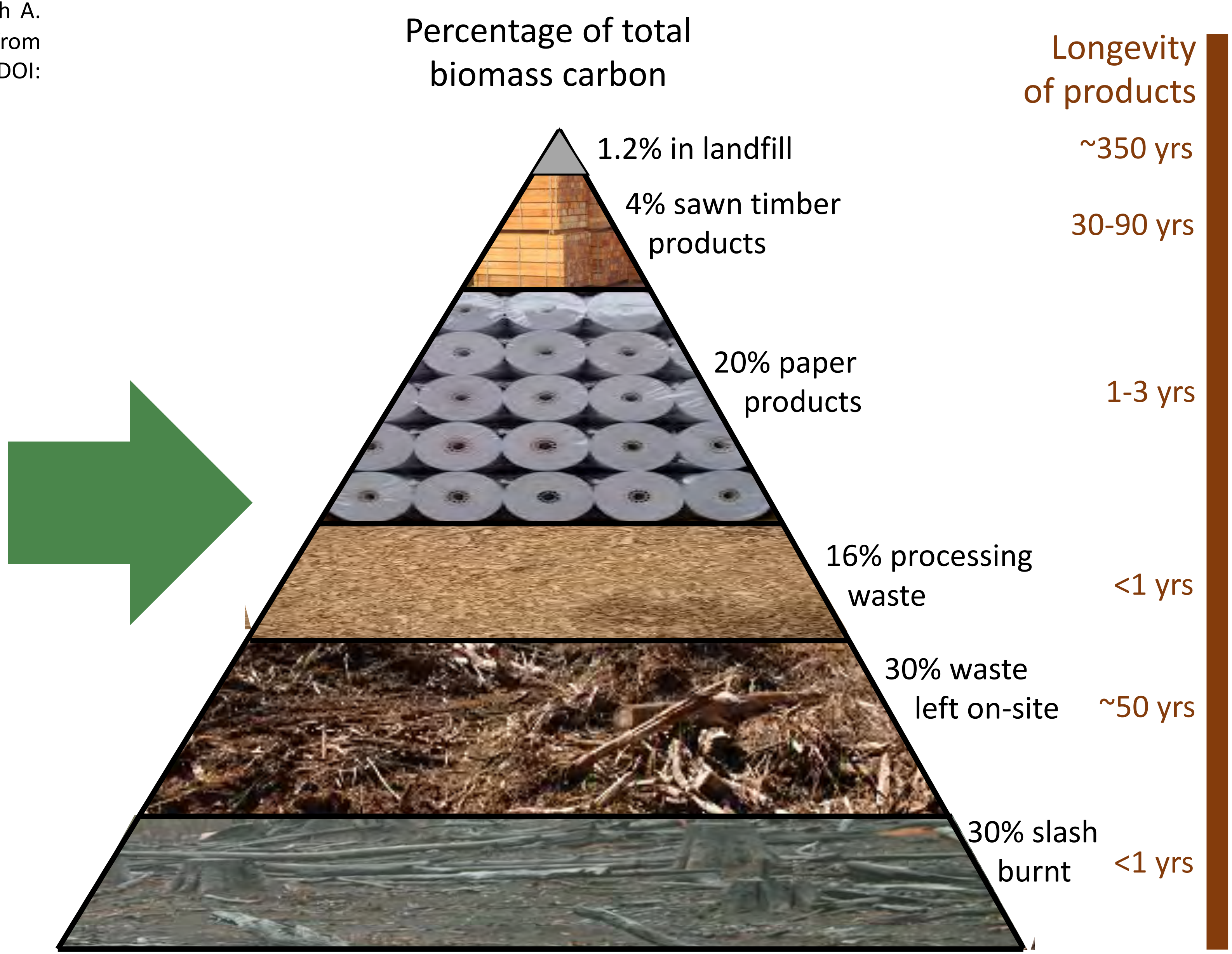


- Biomass combusted ranged from 40 to 58 tC ha^{-1}, which represented 6–7% and 9–14% in low- and high-severity fire, respectively, of the pre-fire total biomass carbon stock
- But with shift from living to dead biomass pools: in ‘highest severity’ burnt forest, 75% of biomass C was transferred from living to dead biomass pool

Source: Keith H, Lindenmayer DB, Mackey BG, Blair D, Carter L, et al. (2014) Accounting for Biomass Carbon Stock Change Due to Wildfire in Temperate Forest Landscapes in Australia. PLoS ONE 9(9): e107126. doi:10.1371/journal.pone.0107126

What about the carbon stored in wood products?

Source: Keith H., Lindenmayer D., Mackey B. and McIntosh A. (2015) Under What Circumstances Do Wood Products from Native Forests Benefit Climate Change Mitigation? *PlosOne* DOI: 10.1371/journal.pone.0139640.



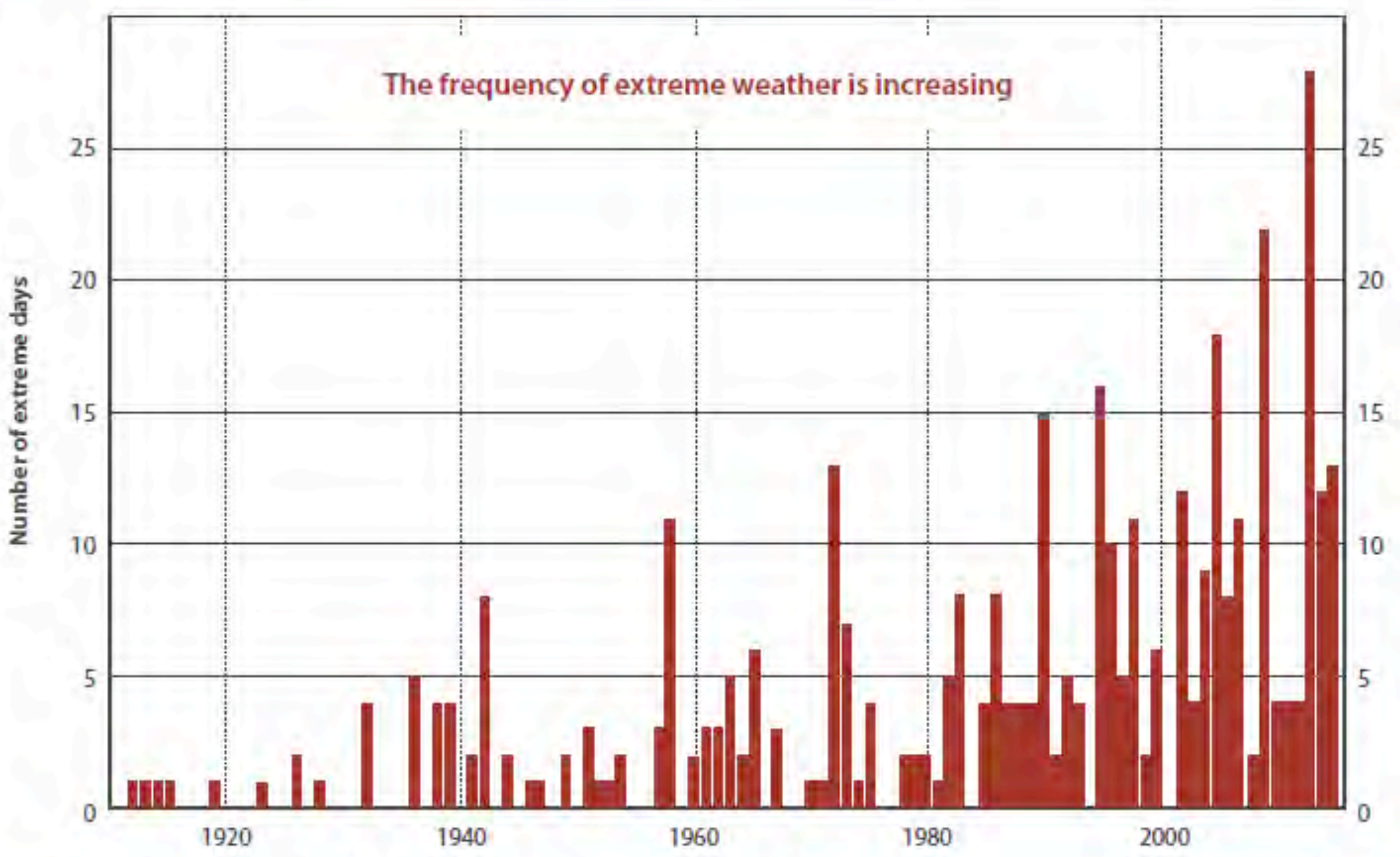
Forest ecosystem carbon stocks: key facts

- Australia's forest carbon stock in 2013 was estimated at ~12.8 Gt of which 98% was stored in living forest (Aus. SoF 2013).
- Most biomass carbon is in woody stems & roots of big old trees
- *Forest ecosystem carbon = living biomass carbon* + *dead biomass carbon* + *soil carbon* $\neq$ commercial wood volume
- Primary forests store 30-70% more carbon than commercially logged forests and plantation forests plus only ~5% forest C ends up in 'long lived'(>30 years) wood product
- The biodiversity of natural forest ecosystems provide them with resistance (stability), resilience and adaptive capacity
- Forest ecosystem carbon stocks are quickly depleted but slowly restored

What about climate change impacts on forests?

Observed change in extreme heat events from 1 °C of global warming

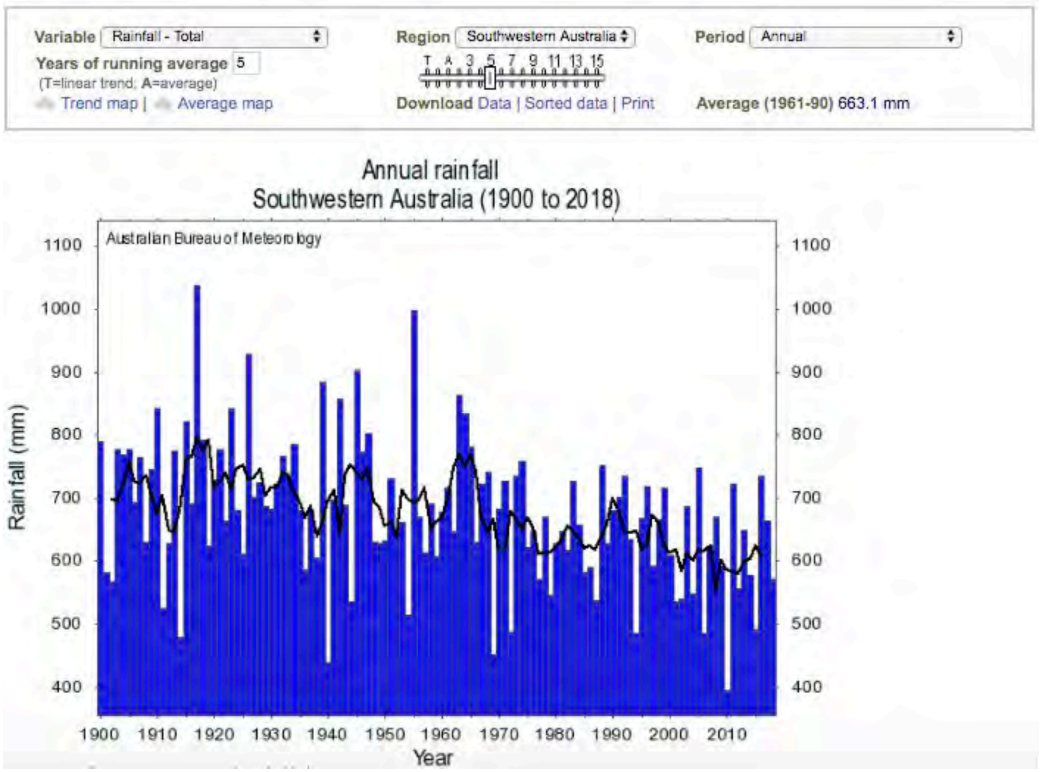
Figure 2.6: Frequency of extreme heat events 1910-2015

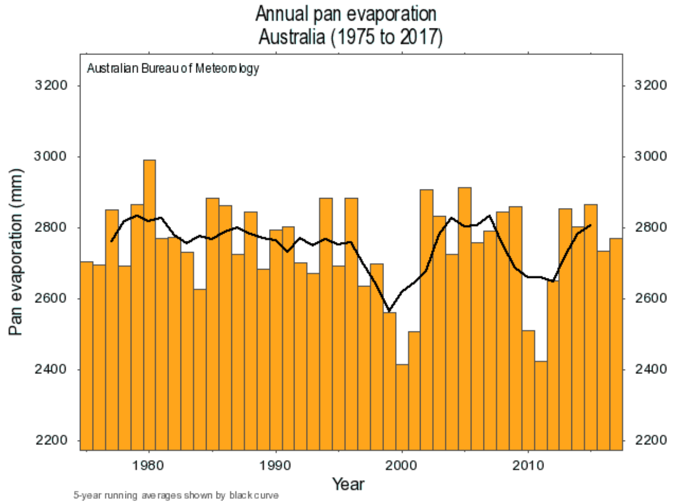


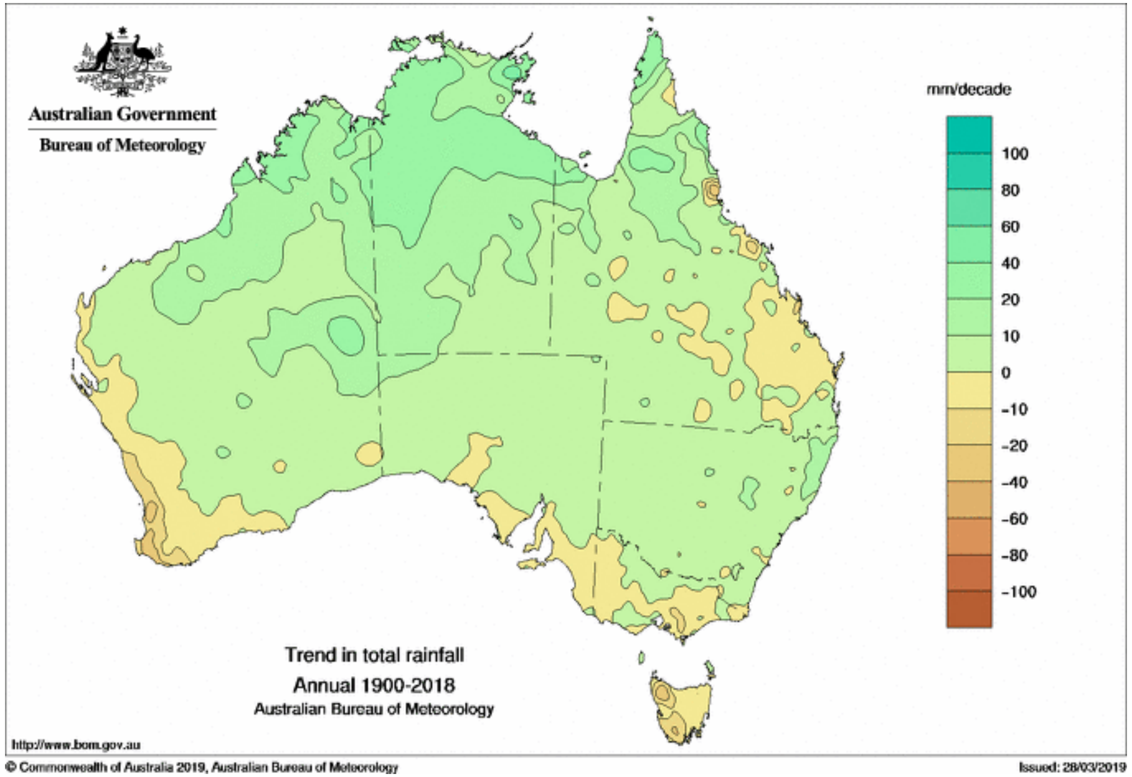
Number of days each year where the Australian area-averaged daily mean temperature is extreme. Extreme days are those above the 99th percentile of each month from the years 1910–2017. These extreme daily events typically occur over a large area, with generally more than 40 per cent of Australia experiencing temperatures in the warmest 10 per cent for that month

Source: Bureau of Meteorology, State of the Climate 2016

Change in sw W.A. rainfall & evaporation from 1 °C global warming





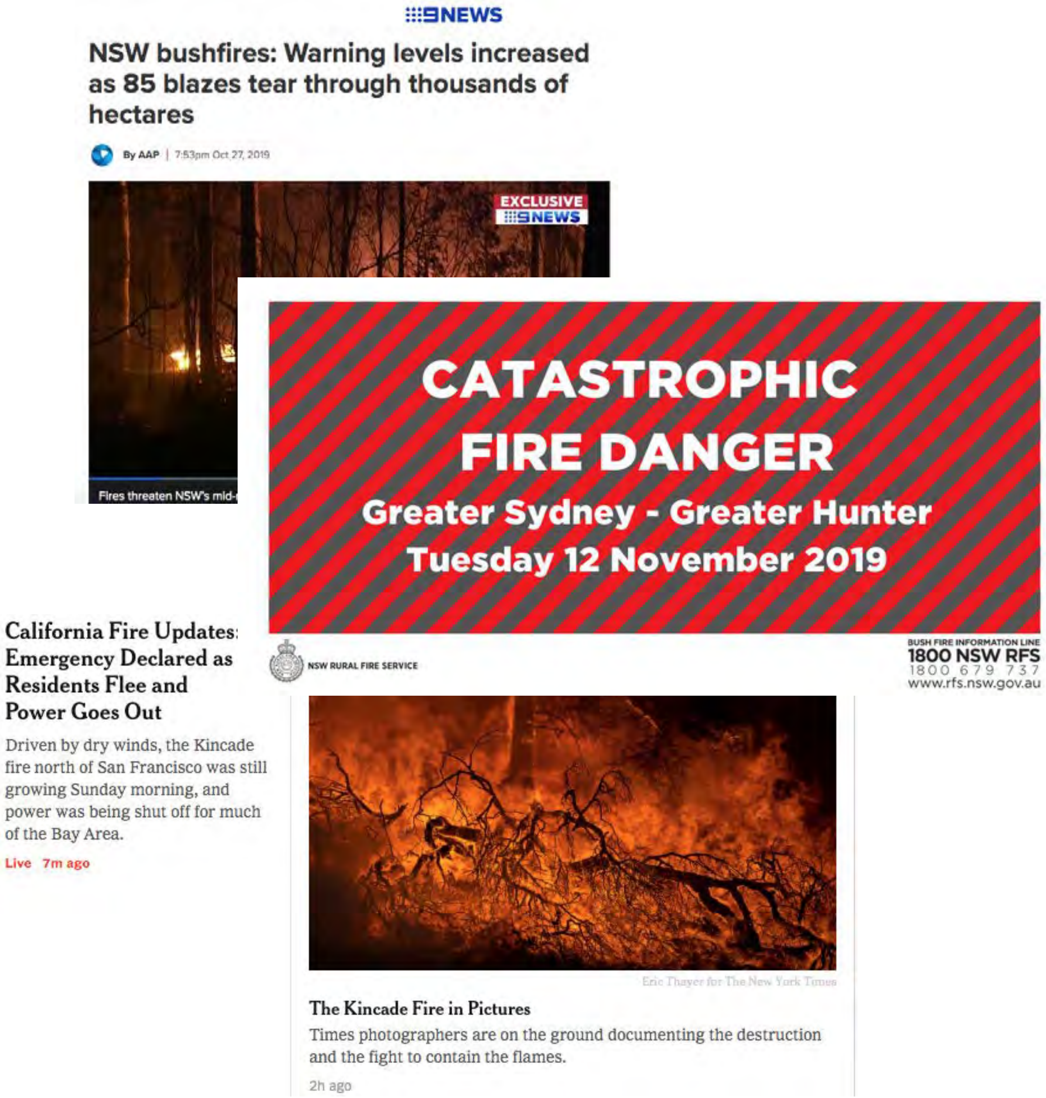


Source: www.bom.gov.au

1 °C global warming has led to fire danger escalating

Weekly bushfire frequencies in Australia have increased by 40% between 2008 and 2013 (Dutta et al. 2016)

Old fire danger ratings scaled in 1970's



Current Fire Danger Rating System introduced in 2010

New fire danger ratings
Now, index value >>100

CLIMATE CHANGE IN AUSTRALIA

CLIMATE CHANGE IN AUSTRALIA
PROJECTIONS FOR AUSTRALIA'S NRM REGIONS

SOUTHERN AND SOUTH-WESTERN FLATLANDS
CLIMATE FUTURES

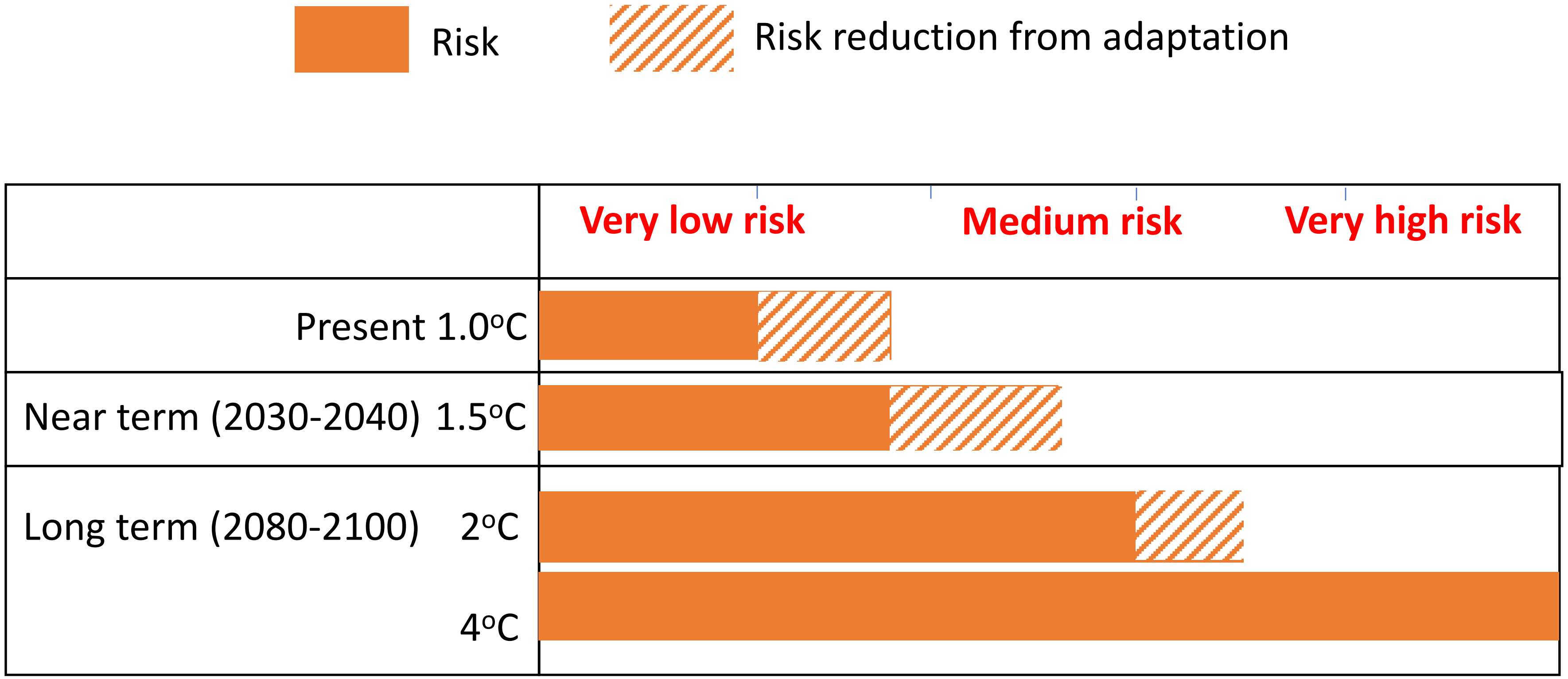
Go back
Change scenario: RCP 8.5
Change time period: 2090

Consensus	Proportion of models
Not projected	No models
Very Low	< 10%
Low	10% - 33%
Moderate	33% - 66%
High	66% - 90%
Very High	> 90%

		Annual Rainfall (%)				
		Much Drier < -15.00	Drier -15.00 to -5.00	Little Change -5.00 to 5.00	Wetter 5.00 to 15.00	Much Wetter > 15.00
Annual Rainfall (%)	Much Wetter > 15.00					+ 1 of 70 (1%)
	Wetter 5.00 to 15.00				+ 2 of 70 (3%)	
	Little Change -5.00 to 5.00			+ 5 of 70 (7%)		
	Drier -15.00 to -5.00		+ 18 of 70 (26%)			
	Much Drier < -15.00	+ 44 of 70 (63%)				

Projected future change in rainfall in s.w. W.A assuming business-as-usual global emissions

Adaptation interventions can reduce climate-related risks, up to a point



Source: K. Hennessey CSIRO & IPCC

Removing other human pressures is most cost-effective adaptation response for managing climate change impacts on ecosystems

Australian Government
Department of the Environment and Energy

Managing and protecting the Great Barrier Reef

Snorkelling on the Great Barrier Reef

Contents [show]

We all have a common goal—protecting and managing the Great Barrier Reef for current and future generations. The Australian and Queensland governments are jointly investing approximately $200 million annually in the reef's health.

- Great Barrier Reef Marine Park Authority
- Great Barrier Reef - Queensland Government

Climate readiness for native forest ecosystems

- Most effective adaptation response to prepare native forests for climate change impacts is to remove other land use pressures on forest ecosystems to facilitate natural adaptation responses through ecological processes and natural selection that promote ecosystem:
  - ✓ *Resistance* (stability)
  - ✓ *Resilience*, and
  - ✓ *Adaptative Capacity*

- Ecosystems are optimized for *RRAC* – Forest subject to conventional silvicultural management for commodity production are optimized for commercial wood/fibre productivity

- So, conservation management is needed

✓ Weeds & feral controls
✓ End commercial logging & allow proforestation
✓ Protect water table
✓ Put fires out when they start & more spatially targeted fuel reduction burning - only effective in low intensity fire weather; avoid creating fire landscape traps

Implications of C-accounting system and forest management policies

- Need gross emissions and removals reported – not 'net reporting'
- Enable the mitigation benefits of different forest management strategies to be recognized

Emissions (positive) Removals (negative)	Current net accounting (M t CO_2_e)	Mitigation outcomes from forest protection (M t C CO_2_e)
Forest land remaining forest land (harvested and regrown)	5	-5 avoided emissions if logging is prevented
Land converted to forest land	-14	-14
Deforestation	0.5	-0.5 avoided emissions if forest loss prevented
Benefit to atmosphere	- 8.5	- 19.5

Source of data: State and Territory Greenhouse Gas Inventories 2017. Table 8 Western Australia emissions and sink accounts

This presentation drew upon materials from these publications

Berry S. and Mackey B. (2018) Modelling fpar and climatic wetness. *Scientific Reports* 8:9066 DOI:10.1038/s41598-018-27139-0.

Keith H., Lindenmayer D., Mackey B**.** and McIntosh A. (2015) Under What Circumstances Do Wood Products from Native Forests Benefit Climate Change Mitigation? *PlosOne* DOI: 10.1371/journal.pone.0139640.

Keith H., Lindenmayer, D., Mackey, B., Blair, D., Carter, L., McBurney, L. and Okada, S. (2014) Accounting for biomass carbon stock change due to wildfire in temperate forest landscapes in Australia. *PLOS One* Published: September 10, 2014 DOI: https://doi.org/10.1371/journal.pone.0107126

Mackey B., Prentice I.C., Steffen W., House J.I., Lindenmayer D., Keith H. and Berry, S. (2013) Untangling the confusion around land carbon science and climate change mitigation policy. *Nature Climate Change* **3**, 552–557; doi:10.1038/nclimate1804.

Ajani J.A., Keith H., Blakers M., Mackey B.G. and King H.P. (2013) Comprehensive carbon stock and flow accounting: a national framework to support climate change mitigation policy. *Ecological Economics* **89**, 61–72. http://www.sciencedirect.com/science/article/pii/S092180091300030X

Keith H., Mackey B., Berry S., Lindenmayer, D. and Gibbons P. (2010) Estimating carbon carrying capacity in natural forest ecosystems across heterogeneous landscapes: addressing sources of error. *Global Change Biology* **16**, 2971-2989.

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Keith K, Mackey B. and Lindenmayer D. (2009) Re-evaluation of forest biomass carbon stocks and lessons from the world's most carbon-dense forests. *PNAS* **106**, 11635-11640.