Native forests, carbon & climate change

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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.

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

For limiting global warming to 1.5 °C, CO₂ 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 mitigation strategies to avoid emissions from deforestation & degradation.

The mitigation imperative
Pre-agriculture Earth C-cycle

Pre-industrial Earth C-cycle

Industrial Earth C-cycle

Hypothetical re-forested Earth C-cycle

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
South East Australian Native Forest Carbon Accounts

Total and mean estimates for eucalypt forests of S.E. Australia covering 14.5 million ha⁻¹

<table>
<thead>
<tr>
<th>Component</th>
<th>Soil carbon carrying capacity (tC x 10⁶)</th>
<th>Living biomass CCC (t C)</th>
<th>Total biomass (living + dead) CCC (t C)</th>
<th>Total ecosystem CCC (t C)</th>
<th>Current total carbon stocks (t C)</th>
<th>Carbon sequestration potential (t C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total carbon</td>
<td>4,060 (14,888)</td>
<td>4,191 (15,368)</td>
<td>5,220 (19,142)</td>
<td>9280</td>
<td>~7,000</td>
<td>~2000</td>
</tr>
<tr>
<td>(t CO₂-e x 10⁶)</td>
<td></td>
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<tr>
<td>Carbon density</td>
<td>280 (161)</td>
<td>298 (226)</td>
<td>360 (277)</td>
<td>640 (383)</td>
<td>179 (living biomass only)</td>
<td></td>
</tr>
<tr>
<td>(t C ha⁻¹) (S.D. over region)</td>
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...and native forests are naturally restricted to wetter landscapes of W.A
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.

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.

**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

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??

<table>
<thead>
<tr>
<th>Forest Category</th>
<th>Total Area (ha)</th>
<th>ABG biomass (Mg)</th>
<th>Biomass C (Mg)</th>
<th>Biomass C (~Gt)</th>
<th>t C per ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native Forest</td>
<td>8,422,423</td>
<td>1,313,876,742</td>
<td>656,938,371</td>
<td>0.66</td>
<td>78</td>
</tr>
</tbody>
</table>

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](http://globbiomass.org/products/global-mapping) and clipped to the Southwest Agricultural Region boundary [data, info].


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

What about the carbon stored in wood products?

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 ≠ 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

The frequency of extreme weather is increasing

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

New fire danger ratings
Now, index value >>100

Current Fire Danger Rating System introduced in 2010
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

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<tr>
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<th>Very low risk</th>
<th>Medium risk</th>
<th>Very high risk</th>
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<tbody>
<tr>
<td>Present 1.0°C</td>
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<tr>
<td>Near term (2030-2040) 1.5°C</td>
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<tr>
<td>Long term (2080-2100) 2°C</td>
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Source: K. Hennessey CSIRO & IPCC
Removing other human pressures is most cost-effective adaptation response for managing climate change impacts on ecosystems.
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

<table>
<thead>
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<th>Emissions (positive)</th>
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<tr>
<td>Current net accounting (M t CO₂_e)</td>
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<tr>
<td>Mitigation outcomes from forest protection (M t C CO₂_e)</td>
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<tr>
<td>Forest land remaining forest land (harvested and regrown)</td>
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<tr>
<td>Land converted to forest land</td>
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<tr>
<td>Deforestation</td>
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<td>Benefit to atmosphere</td>
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</table>

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


