Forest ecosystem accounts in Australia
bringing the contribution of ecosystems into decision-making

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Case study forest region
scaling up from tree to plot to landscape

Wet sclerophyll eucalypt forest

Region with conflicting land uses:

- Regional Forest Agreement for the supply of native timber
- Proposal for an expanded reserve system as the Great Forest National Park
- Water supply catchments for Melbourne Water
- Endangered wildlife and degradation of habitat
- High demand for recreational areas
- Adjacent highly productive agricultural land
Ecosystem accounts contributing to the decision-making process

Ecosystem extent, condition and services:

- Integrate all assets and services in a region
- Translate environmental values into economic terms
- Allow quantitative comparisons within a common framework
- Evaluates trade-offs explicitly and spatially

[Keith et al. 2017 Nature Ecology and Evolution DOI: 10.1038/s41559-017-0309-1]
Ecosystem extent
Local classification of ecological vegetation classes and forest types

Ecosystem condition
Forest age – determined from stand-replacing events of wildfire and logging

Age Class
- years old
- regeneration period

- > 75
- before 1939
- 75 – 56
- 1939 – 1959
- 56 – 33
- 1960 – 1982
- 33 – 7
- 1983 – 2008
- 7 – 0
- 2009 - 2015

## Carbon stock account

<table>
<thead>
<tr>
<th>MtC</th>
<th>Atmosphere</th>
<th>Biocarbon</th>
<th>Terrestrial</th>
<th>Natural ecosystems</th>
<th>Semi-natural ecosystems</th>
<th>Plantations</th>
<th>Agriculture</th>
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<td>Total</td>
<td>Biocarbon</td>
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<td>Rainforest</td>
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<td>Peatlands</td>
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<td>Opening stock of carbon (C t₀)</td>
<td>12.139</td>
<td>111.570</td>
<td>0.322</td>
<td>30.210</td>
<td>4.258</td>
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<tr>
<td></td>
<td>Additions to stock</td>
<td>Natural expansion (growth)</td>
<td>0.010</td>
<td>1.368</td>
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<td>Additions to stock</td>
<td>Managed expansion (growth)</td>
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<td>Upward reappraisals</td>
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<td>Additions to stock</td>
<td>Reclassifications</td>
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<td>0.489</td>
<td>1.368</td>
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<td>Reductions in stock</td>
<td>Natural contraction (emissions)</td>
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<td>Reductions in stock</td>
<td>Managed contraction (emissions)</td>
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<td>Managed contraction (harvest transfer)</td>
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<td>Total reductions in stocks</td>
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<td>Closing stock of carbon (C t₁)</td>
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<td>30.245</td>
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<td>Net ecosystem carbon balance (C t₁ - C t₀)</td>
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<td>-0.012</td>
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[Keith et al. 2021 Science of the Total Environment 769: 144341]
Carbon flows for supply and use accounts

- Natural input (timber)
- Sawlogs
- Pulplogs
- Sawn timber
- Paper products
- CO₂ emissions

[Keith et al. 2021 Science of the Total Environment 769: 144341]
### Ecosystem Services

#### Carbon sequestration
- Total: 1.368 Gt

#### Carbon storage
- Total: 111.570 Mt

#### Carbon sink
- Total: 0.796 Mt

### Physical Supply

#### Economic Units
- Agriculture, Forestry & fisheries
- Wood & paper product manufacturing
- Other industries (ex-forestry)
- Households
- Waste management
- Energy
- Government*
- Inventory
- Imports
- Production
- Woodland/Shrubland
- Harvested native forest
- Hardwood plantation
- Softwood plantation
- Crop and horticulture
- Grasslands
- Crop and horticulture
- Total biosphere
- Atmosphere
- TOTAL SUPPLY

### Physical Use

#### Economic Unit
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### Use

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<tr>
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<th>Environment Units</th>
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<tr>
<td>Agriculture, Forestry &amp; fisheries</td>
<td>1.368</td>
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<tr>
<td>Wood &amp; paper product manufacturing</td>
<td>0.632</td>
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<tr>
<td>Other industries (ex-forestry)</td>
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<td>Energy</td>
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<td>Imports</td>
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<td>Production</td>
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<td>Crop and horticulture</td>
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<td>Total biosphere</td>
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<td>Wood &amp; paper product manufacturing</td>
<td>35.293</td>
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<td>Other industries (ex-forestry)</td>
<td>111.892</td>
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<td>Softwood plantation</td>
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<td>Crop and horticulture</td>
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<td>Grasslands</td>
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Primary forests – naturally regenerating forest of native species whose composition, structure and function are dominated by ecological and evolutionary processes that maintain ecological integrity.


[Keith et al. 2010 Global Change Biology 16: 2671 – 2989]
Ecosystem service of global climate regulation

Climate regulation depends on the magnitude and longevity of the carbon stored in the biosphere, and the consequent stock in the atmosphere.

Information needed from carbon accounts to inform policy about climate regulation?

1. Carbon stocks and flows
2. Carbon stocks related to ecosystem condition
3. Carbon stock change as additions and reductions
4. Ecosystem services of storage and sequestration
5. Consistent reference condition for carbon stocks

Policy signal: Retention of stocks best reflects storage of carbon in the biosphere
Value of ecosystem services

[Keith et al. 2017 Nature Ecology and Evolution
DOI: 10.1038/s41559-017-0309-1]
Balancing trade-offs between land use activities

Ceasing native timber harvesting increases ecosystem services for:

- Carbon sequestration and water provisioning – calculated known gain
- Plantation timber provisioning and recreational services – estimate potential gain
- Biodiversity - undefined gain

[Keith et al. 2017 Nature Ecology and Evolution
DOI: 10.1038/s41559-017-0309-1]
Spatial distribution of ecosystem services

Spatial distribution calculated as continuous variables and range-normalized to an index and displayed as five classes

Water yield

Carbon stock density

Native timber

Identifying spatial trade-offs

Interaction index of ecosystem services of water, carbon and timber provisioning. ‘Hotspots’ are the highest values for all ecosystem services. Trade-offs are required when land uses conflict.

All native forest

Native forest available for harvesting

Evidence from ecosystem accounts to inform environmental management and decision-making

1. Quantified change in condition of ecosystem assets and services over time assessed against the reference condition of the natural ecosystem state

2. Capability to track progress towards targets, such as restoration, climate mitigation

3. Valuation of ecosystem services, including those previously un-recognised

4. Valuation of economic uses of ecosystem services by industries and society

5. Identified spatial distributions of high conflict between land uses

6. Quantified relative values and potential gains and losses involved with impacts and trade-offs between land uses. → economic gains from increased water supply and carbon storage exceeded losses from ceasing native timber harvesting.

7. Allows judgements about relative values of conservation of biodiversity and habitats, without monetary valuation. → reducing the threat of extinction of a species by conserving habitat is worth the loss of revenue from timber harvesting.
Implementing SEEA EA carbon accounts to inform the GHG inventory reported to the UNFCCC will greatly enhance the policy relevance of the data and reveal greater opportunities for managing forests for integrated climate mitigation, biodiversity conservation and restoration outcomes.

Comprehensive carbon accounts using a reference condition of high ecosystem integrity will allow operationalising the ecosystem provisions of the Paris Agreement and synergistic climate and biodiversity action by bridging the UNFCC and CBD.