Exceptionally High Carbon Stocks of Mangroves and their Potential Conservation through Global Carbon Markets

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Mangroves - a relatively rare forest type
138,000 - 152,000 Km$^2$ (145,000 Km$^2$)
123 countries
Critical provision of ecosystem services
Values - $2000-9000$/ha/yr

Spaulding et al. (2010)
Blue Carbon sinks include tall mangrove: Mangle Caballo (*Rhizophora racemosa*) Estero Damas, Costa Rica
Altura de canopia -30-35m
Profundidad de suelos - >3m
Otros – *Peliceara rhizophorae, Rhizophora mangle, Avicennia germinans, Laguncularia racemosa*
Tropical Wetlands Initiative on Climate Change Adaptation and Mitigation (TWINCAM)

A global research project on ecosystem services of tropical wetlands throughout the world.
“Small islands, have characteristics which make them especially vulnerable to the effects of climate change, sea level rise and extreme events” (IPCC 2007).

Yap, Federated States of Micronesia
C-stocks in mangroves: The Indo-Pacific

<table>
<thead>
<tr>
<th>Distance from Ocean (m)</th>
<th>Total C stock (Mg ha⁻¹)</th>
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<tbody>
<tr>
<td></td>
<td>Aboveground pools</td>
</tr>
<tr>
<td></td>
<td>Roots</td>
</tr>
<tr>
<td></td>
<td>Soil</td>
</tr>
<tr>
<td></td>
<td>Down wood</td>
</tr>
<tr>
<td></td>
<td>Trees</td>
</tr>
<tr>
<td>0</td>
<td>863.3</td>
</tr>
<tr>
<td>20</td>
<td>891.9</td>
</tr>
<tr>
<td>40</td>
<td>1044.4</td>
</tr>
<tr>
<td>60</td>
<td>1038.8</td>
</tr>
<tr>
<td>80</td>
<td>1073.4</td>
</tr>
<tr>
<td>100</td>
<td>1047.8</td>
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</tbody>
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Donato et al. 2011; Murdiyarso et al. (2010)
Ecosystem C stocks, Sian Kaan, MX. Adame et al. (in prep)
Ecosystem Carbon stocks - Costa Rican upland forests compared to carbon stocks of mangroves

Kauffman, Cifuentes, et al. (In prep)
Forest Carbon stocks

Currently, on average, between 1-7% of blue carbon sinks are being lost annually:

- Upstream disruptions
- Aquaculture
- Rice/Agriculture
- Road development/hydrological disruptions
- Coastal development
Direct evidence of emissions rates from land conversion – mangroves coastal ecosystems?

Abandoned shrimp pond with mangroves on the edge, Costa Rica
The core on the left is from an intact mangrove while the core on the right is from an adjacent abandoned shrimp pond formed in mangrove. The differences in carbon and root mass are very apparent suggesting large emissions with conversion
Soil Carbon Stocks Intact mangroves and shrimp ponds, Costa Rica (mean difference = 421 Mg/ha*)

* A CO₂ equivalent of 1545 Mg/ha (C mass * 3.67)
Data are from Kauffman et al 2004, Steele 2000, de Castro 1996, and Donato et al. 2011
Data from rainforest and methods to predict emissions from fires are from Guild et al. (2004) *Ecol Apps* 14:232-246.
Mangrove emissions are based on the assumptions of the oxidation of top 30 cm of soil C.
Modeled fire emissions - forest conversion

Data are from Kauffman et al 2004, Steele 2000, de Castro 1996, and Donato et al. 2011
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Mangrove emissions are based on the assumptions of the oxidation of top 30 cm of soils C.
Shrimp pond conversion are calculated emissions from stock change approaches from field measurements Kauffman and Cifuentes In prep)
Estimates of carbon released by land-use change in coastal ecosystems. Pendleton et al. (In press).

<table>
<thead>
<tr>
<th>Ecosystem</th>
<th>Inputs</th>
<th>Results</th>
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<tbody>
<tr>
<td></td>
<td><strong>Global extent (Mha)</strong></td>
<td></td>
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<td></td>
<td><strong>Current conversion rate (% yr⁻¹)</strong></td>
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<td></td>
<td><strong>Near-surface carbon susceptible (top meter soil + biomass, Mg CO₂ ha⁻¹)</strong></td>
<td><strong>Carbon emissions (Pg CO₂ yr⁻¹)</strong></td>
</tr>
<tr>
<td>Tidal Marsh</td>
<td>2.2 – 40 (5.1)</td>
<td>237 – 949 (593)</td>
</tr>
<tr>
<td>Mangroves</td>
<td>13.8 – 15.2 (14.5)</td>
<td>373 – 1492 (933)</td>
</tr>
<tr>
<td>Seagrass</td>
<td>17.7 – 60 (30)</td>
<td>131 – 522 (326)</td>
</tr>
<tr>
<td>Total</td>
<td>33.7 – 115.2 (48.9)</td>
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The net tropical deforestation emission is about 4.8 Pg CO₂e year⁻¹ (Pan et al. 2011 Science).
REDD+ - Reducing Emissions from Deforestation and Forest Degradation

REDD mechanisms use market/financial incentives to reduce the emission of greenhouse gases from deforestation and forest degradation.
SUMMARY

Why are mangroves and other tropical wetlands so attractive for REDD+ and other NAMAs?

1. Exceptionally large Carbon stocks and C sinks
2. High rates of land conversion and degradation
3. Exceptionally high emissions from land cover change
4. Critical ecosystem services both globally and locally