Can Planting Trees Reduce Global Warming?

Some insights into the combined climate and carbon-cycle

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Thesis: “Carbon sequestration in native rainforest tree plantations”

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Studying nitrogen (influence of root symbioses on uptake) and water (sapwood water storage) relations within a plant functional trait framework
Greenhouse gases: CO$_2$, methane, N$_2$O
-absorb & re-emit long-wave radiation causing warming
The carbon cycle and global warming in brief

1. Current C cycle: 3.2 Gt C added to atmosphere y\(^{-1}\) from combustion of fossil fuels

2. Kyoto Protocol includes vegetation sinks mechanism to reduce CO\(_2\) fluxes

3. Currently plantation establishment is increasing especially in temperate areas of China, Europe & USA

This all seems quite straightforward....
Some other ways vegetation contributes to climate change

Main vegetation influence on climate (besides C storage): **albedo**, soil water, surface roughness, plant physiology, leaf area & rooting depth
A bit more about Albedo

• Albedo is fraction of incident short-wave radiation reflected from a surface

• High albedo = less solar radiation absorption and a cooler surface

<table>
<thead>
<tr>
<th>Surface</th>
<th>Albedo</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh snow</td>
<td>0.80 - 0.95</td>
</tr>
<tr>
<td>Desert</td>
<td>0.20 – 0.45</td>
</tr>
<tr>
<td>Grassland</td>
<td>0.16 – 0.26</td>
</tr>
<tr>
<td>Deciduous forest</td>
<td>0.15 – 0.20</td>
</tr>
<tr>
<td>Coniferous forest</td>
<td>0.05 – 0.15</td>
</tr>
<tr>
<td>Urban areas</td>
<td>0.15</td>
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<tr>
<td>Water</td>
<td>0.03 – 0.10</td>
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What happens if we cut down all the trees on the globe?

Bala et al (2007) studied these scenarios for yr 2100:

1. **STANDARD**: no deforestation, CO₂ emissions cause 3.2 °C warming
2. **CONTROL**: no CO₂ emissions
3. **GLOBAL**: same as standard but all trees decompose in year 2000 (release 818 Gt C), leaving shrubs and grasses
4. **TROPICAL**: deforestation in tropics only (release 422 Gt C)
5. **TEMPERATE**: deforestation in temperate areas only (release 319 Gt C)
6. **BOREAL** – deforestation in nth boreal areas only (release 80 Gt C)
Highest atmospheric CO$_2$ with global deforestation – release of C stored in trees & no CO$_2$ fertilization effect of forests

Global deforestation results in a cooler world (0.3°C) than standard predictions
Global deforestation causes greater cooling in boreal regions up to year 2100.
Greater cooling in boreal regions is due to increased albedo by replacing forest with grasslands, brighter snow.
- Highest atmospheric CO$_2$ conc. with tropical deforestation – release of C stored in trees & no CO$_2$ fertilization effect of forests

- Tropical deforestation results in warmer world (0.7ºC) than standard predictions
- Decrease in evapotranspiration in the tropics

- Decrease in cloudiness in the tropics

 Conversion of tropical forests to grasslands increases surface albedo & decreases cloudiness leading to no net change in planetary albedo
Tropical deforestation warms the planet everywhere due to higher atmospheric CO$_2$.

Temperate deforestation produces regional cooling due to albedo effects but warming at tropics & high latitudes.

Boreal deforestation cools the planet everywhere due to albedo effects.
Initial Conclusions

Large-scale afforestation projects for climate change mitigation:

1. In high latitudes might actually cause warming
2. In temperate latitudes may have no net benefit
3. In tropical latitudes would be beneficial

- But, forests are important: biodiversity, timber & non-timber products, protect watersheds, store CO₂-reducing ocean acidification
- Global deforestation should not be considered a mitigation option!

One part of the C cycle not well understood is soil carbon storage esp. in tropical areas (focus of tree planting efforts)
e.g. Hoop Pine
Soil C input by hoop pine: slow. Total pool still 39 t ha\(^{-1}\) lower than rainforest after 63 y
Radiative forcing of the climate by hoop pine plantations

Back-of-envelope calculations:

Radiative forcing for CO$_2$:
$\Delta F = \alpha \ln(C/C_0)$

Radiative forcing for albedo:
$\Delta F = -I_\downarrow (\alpha_2 - \alpha_1)$

For 1 ha of hoop pine plantation the radiative forcing due to CO$_2$ emissions of 39 t is negligible, but for albedo (predicted change of 0.02) maximum radiative forcing = + 5.2 W m$^{-2}$
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