Can Planting Trees Reduce Global Warming?

Some insights into the combined climate and carbon-cycle

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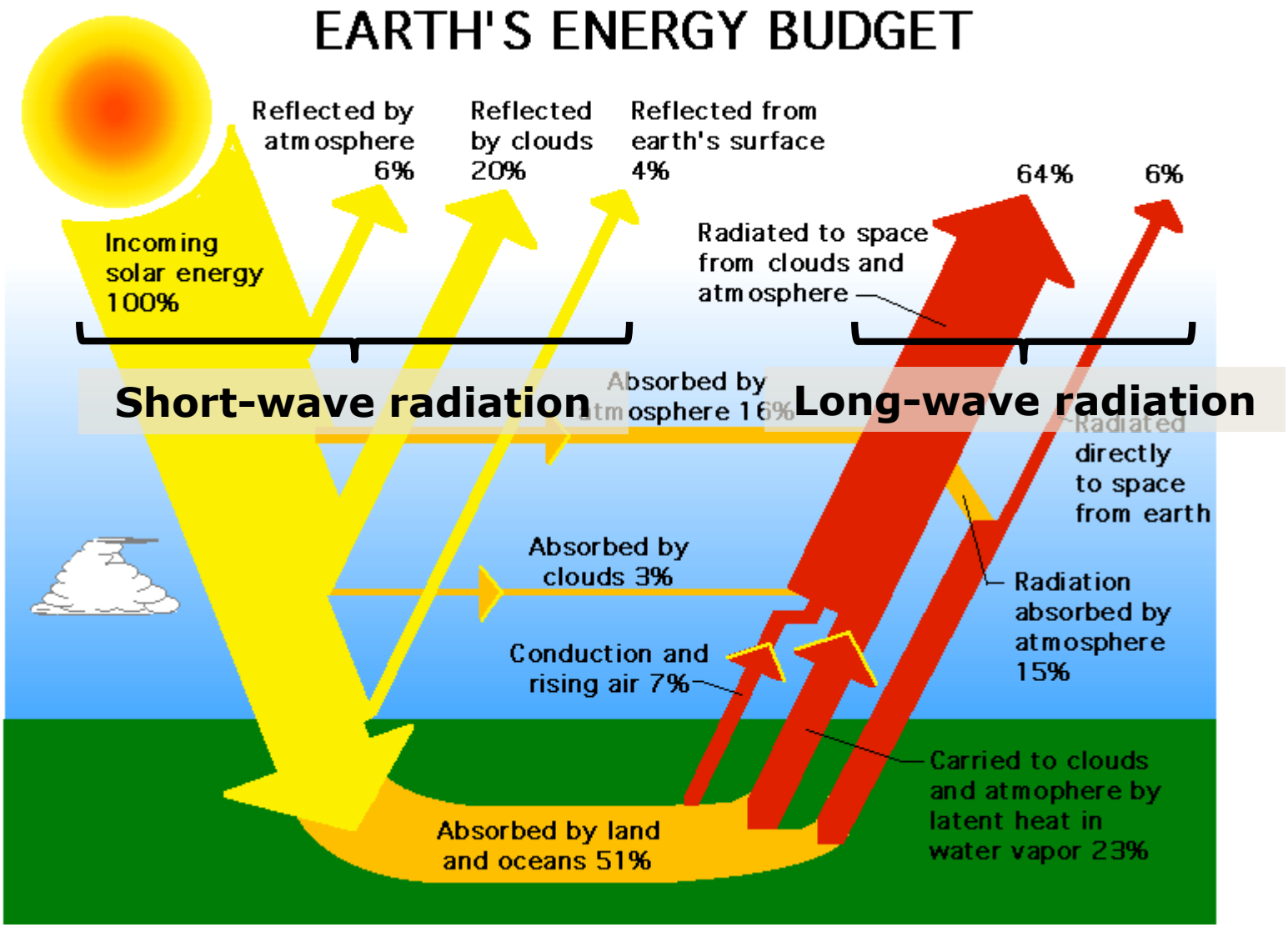
An introduction to who I am

- Completed PhD at University of Queensland, March 2007

- Thesis: “Carbon sequestration in native rainforest tree plantations”

- Now Postdoc at Macquarie University, April 2007

- Studying nitrogen (influence of root symbioses on uptake) and water (sapwood water storage) relations within a plant functional trait framework

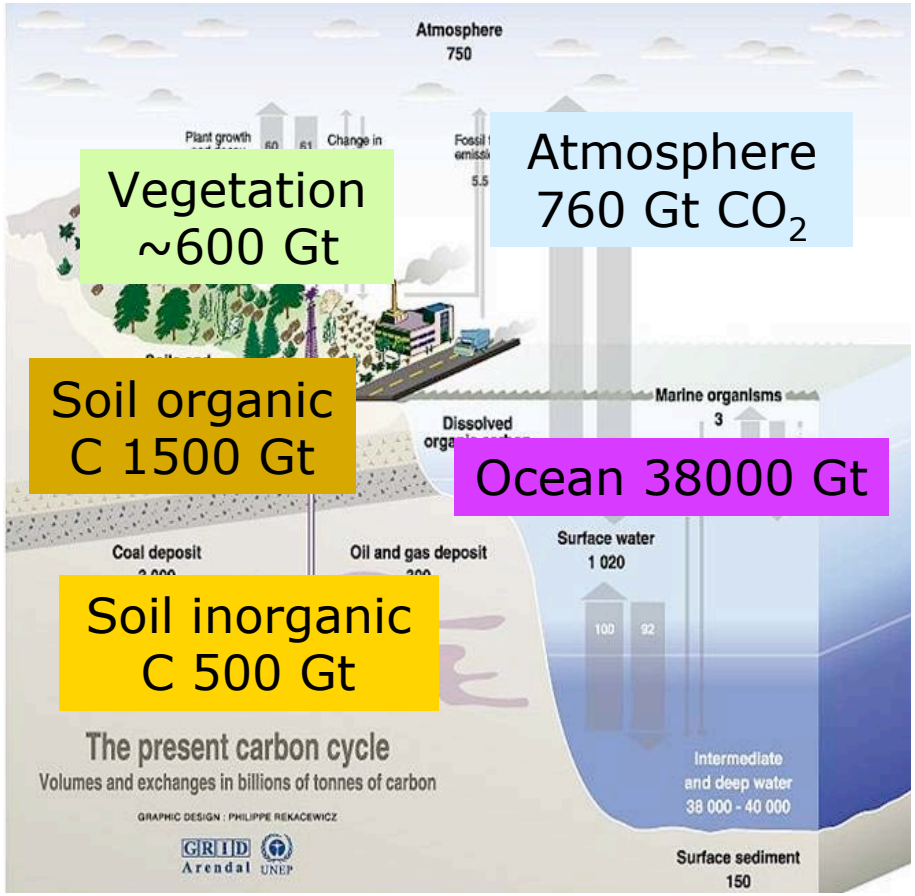


Greenhouse gases: CO_2, methane, N_2O

-absorb & re-emit long-wave radiation causing warming

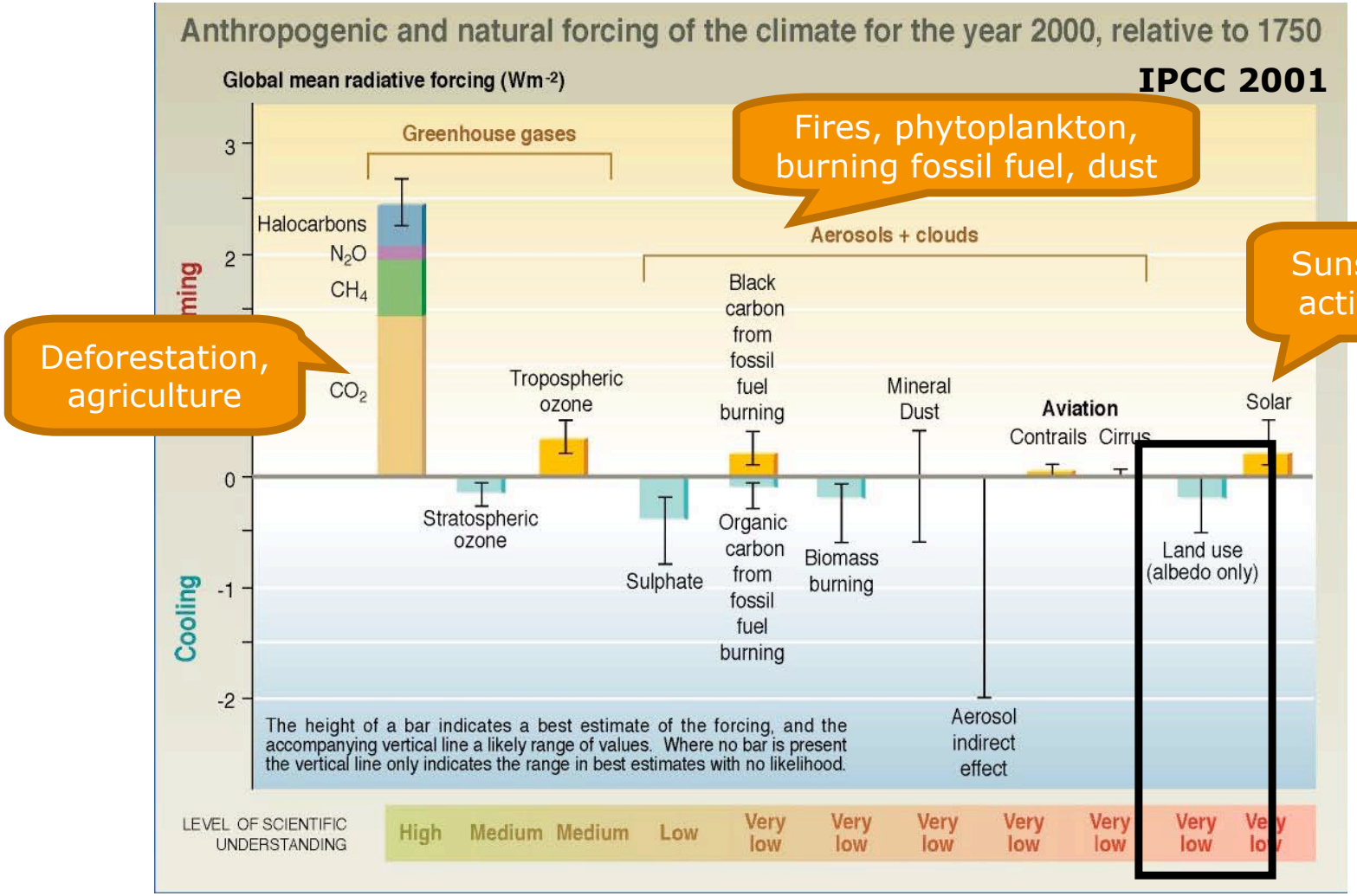
The carbon cycle and global warming in brief

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

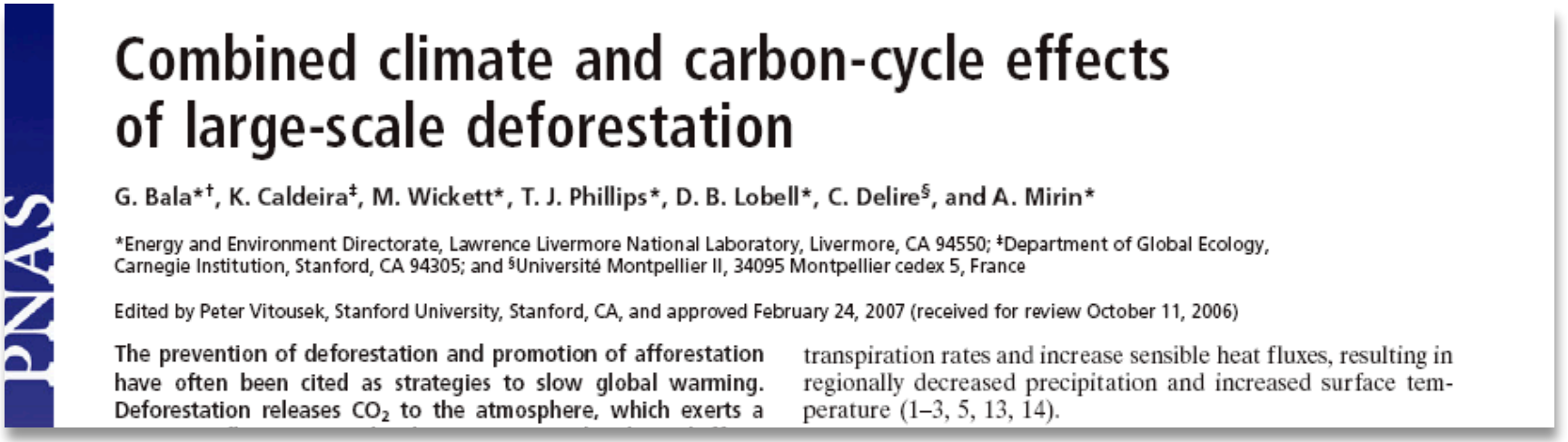


Main vegetation influence on climate (besides C storage): **albedo**, soil water, surface roughness, plant physiology, leaf area & rooting depth

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

Surface	Albedo
Fresh snow	0.80 - 0.95
Desert	0.20 – 0.45
Grassland	0.16 – 0.26
Deciduous forest	0.15 – 0.20
Coniferous forest	0.05 – 0.15
Urban areas	0.15
Water	0.03 – 0.10



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Combined climate and carbon-cycle effects of large-scale deforestation

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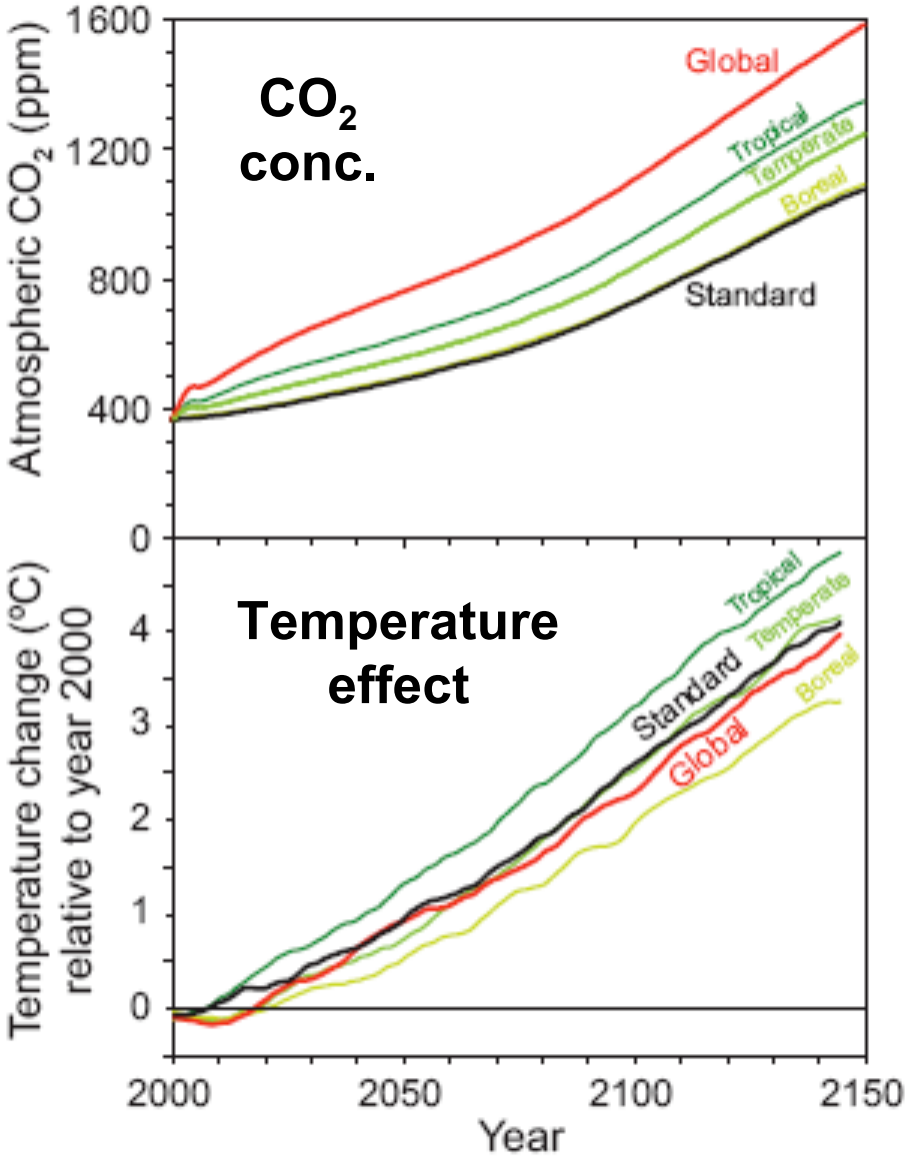
The prevention of deforestation and promotion of afforestation have often been cited as strategies to slow global warming. Deforestation releases CO_2 to the atmosphere, which exerts a transpiration rates and increase sensible heat fluxes, resulting in regionally decreased precipitation and increased surface temperature (1–3, 5, 13, 14).

What happens if we cut down all the trees on the globe?

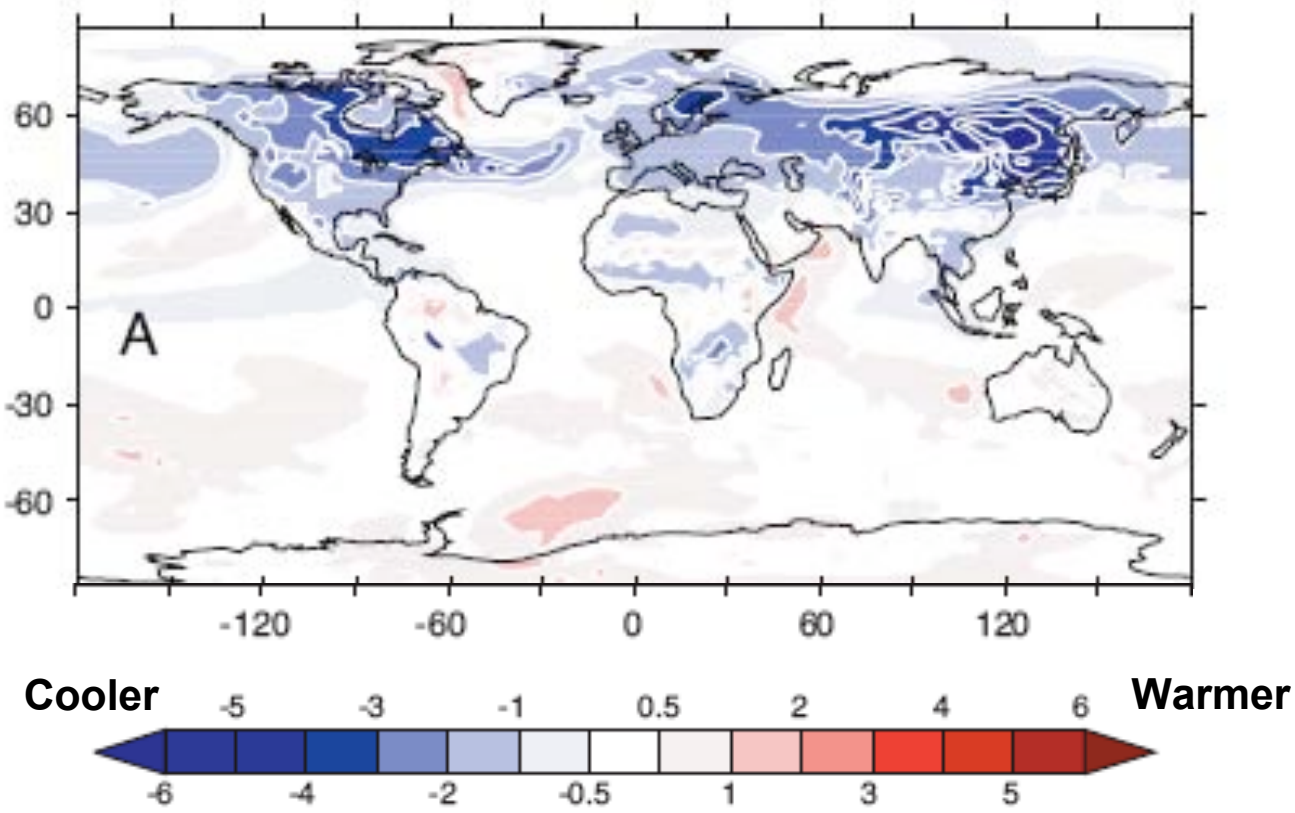
Bala et al (2007) studied these scenarios for yr 2100:

1. **STANDARD:** no deforestation, CO_2 emissions cause 3.2 ºC warming
2. **CONTROL:** no CO_2 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)

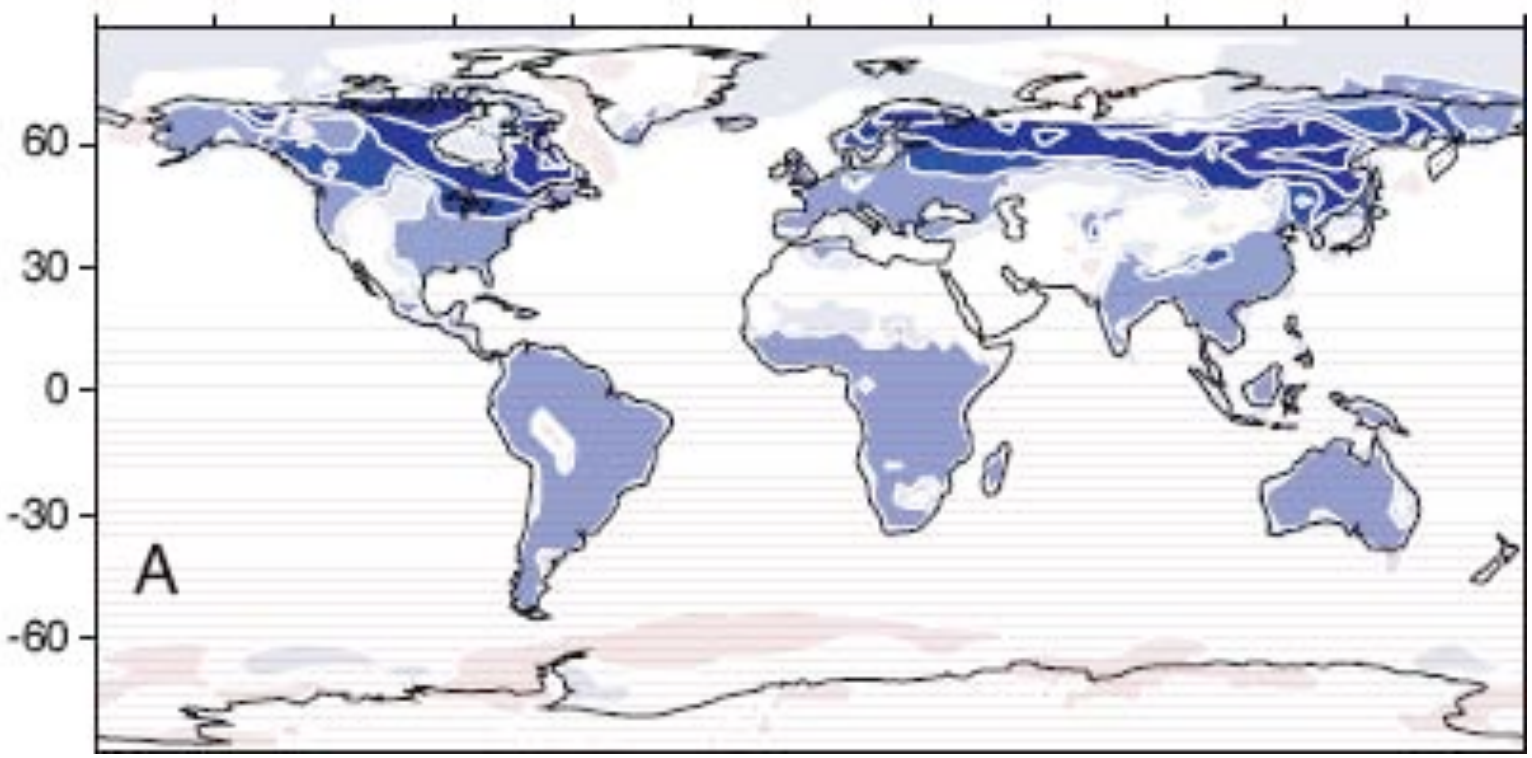


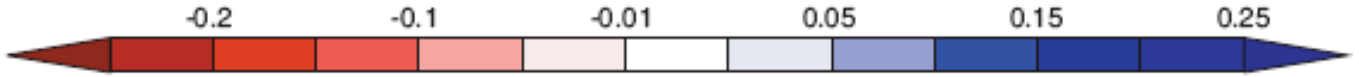
- Highest atmospheric CO_2 with global deforestation – release of C stored in trees & no CO_2 fertilization effect of forests

- Global deforestation results in a cooler world (0.3ºC) than standard predictions



Global deforestation causes greater cooling in boreal regions up to year 2100

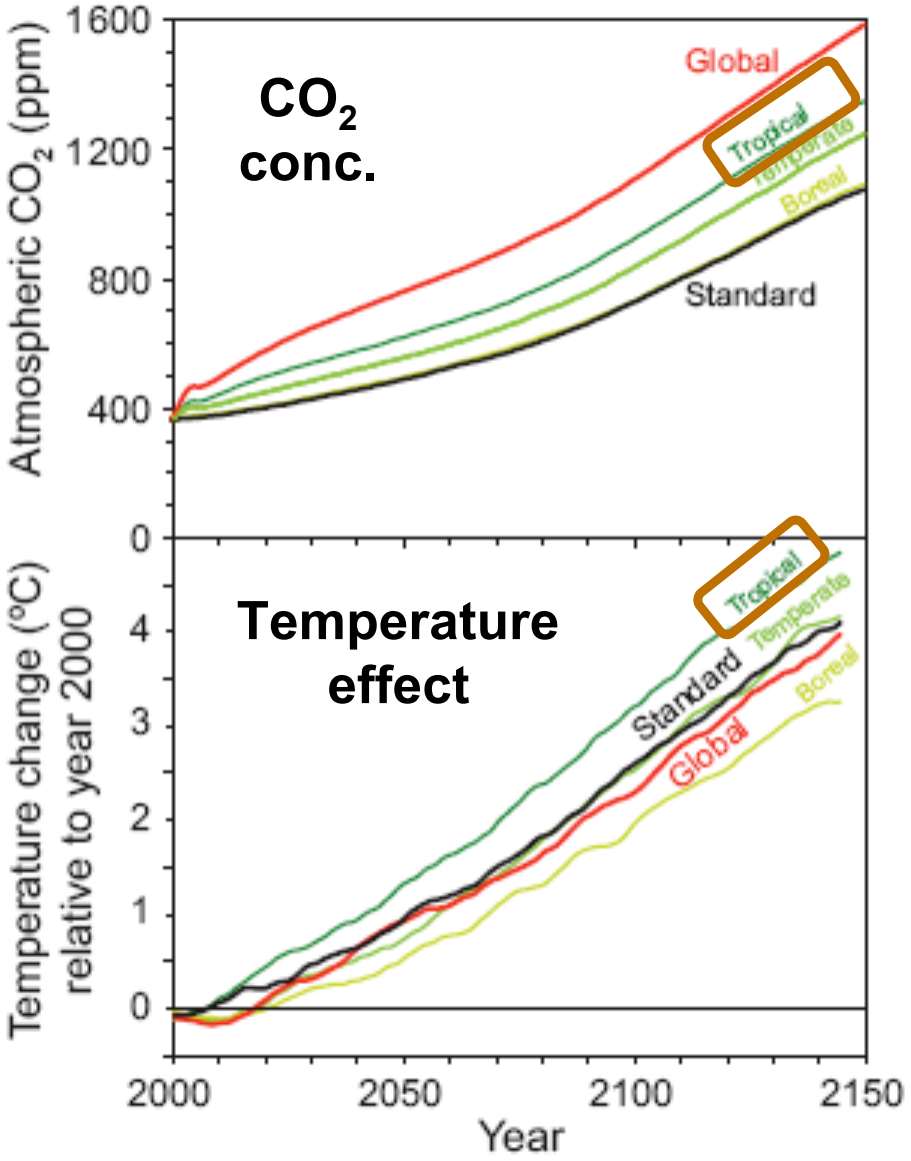




Decreased albedo

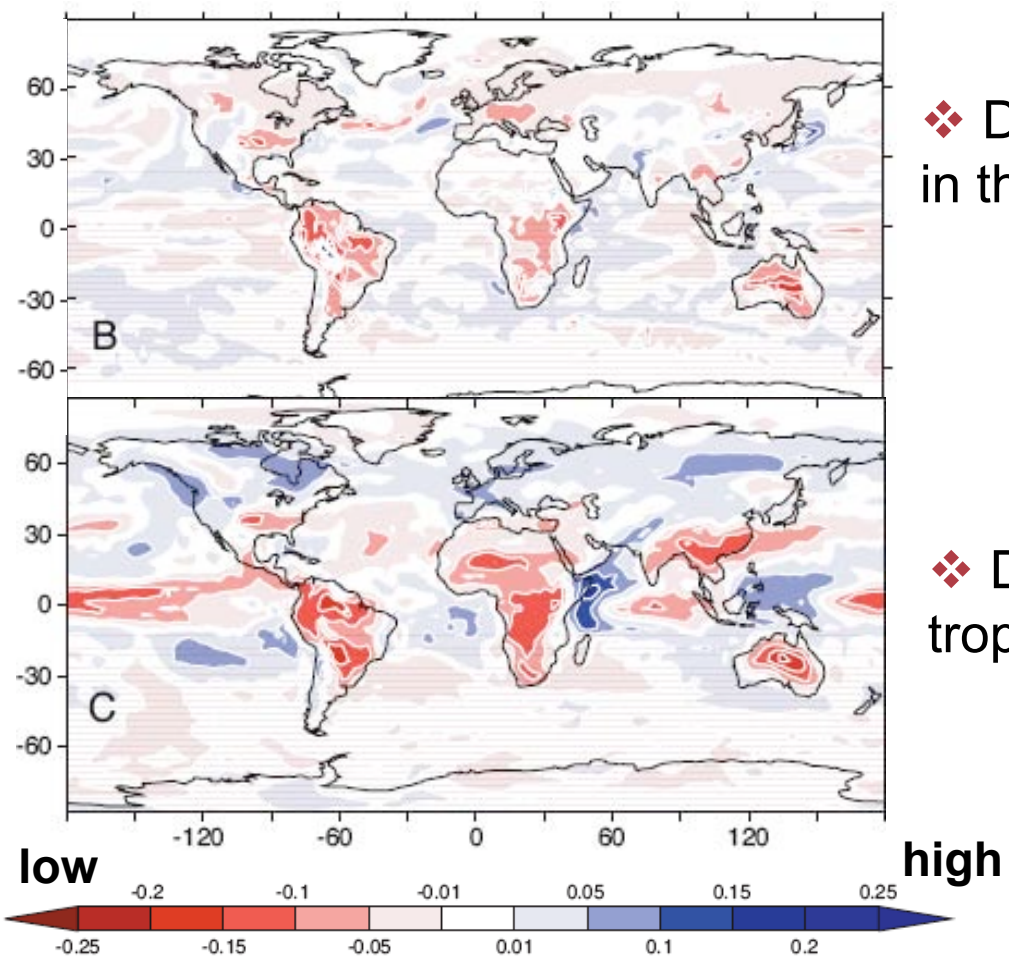
Increased albedo

Greater cooling in boreal regions is due to increased albedo by replacing forest with grasslands, brighter snow



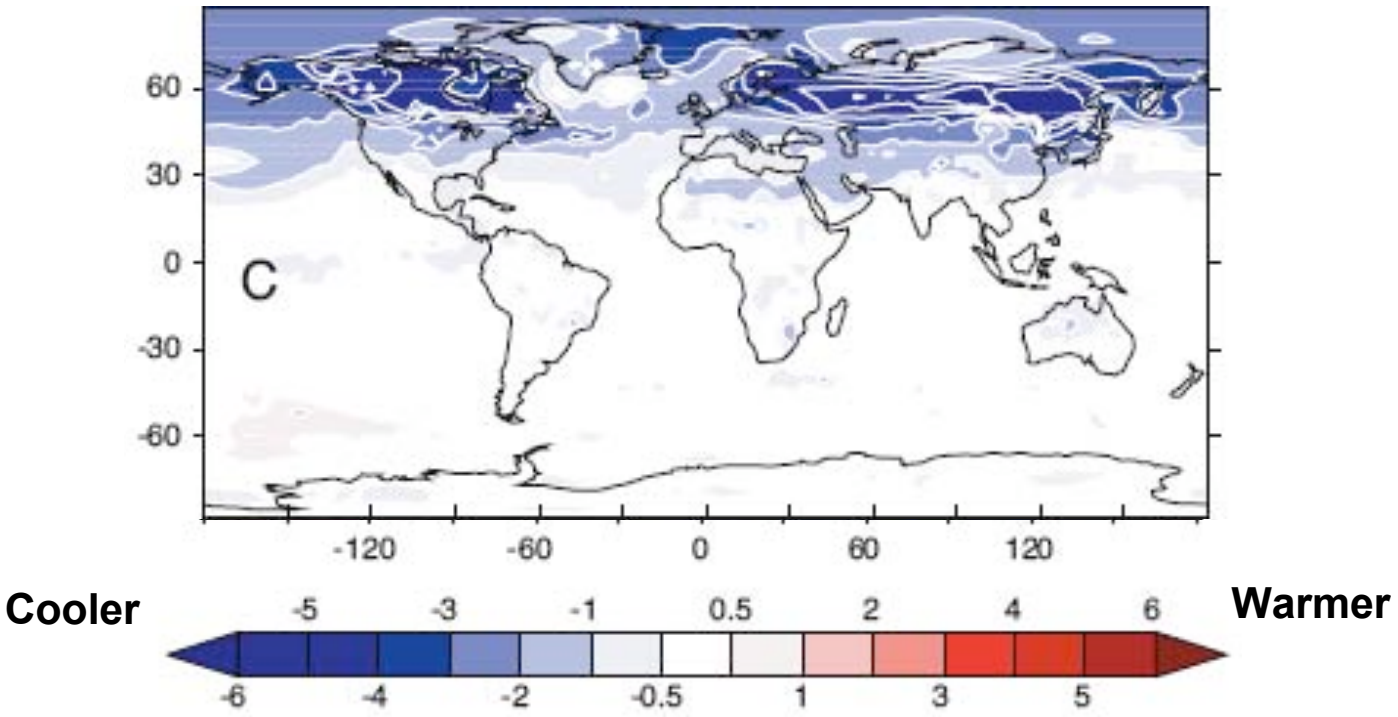
- Highest atmospheric CO_2 with tropical deforestation – release of C stored in trees & no CO_2 fertilization effect of forests

- 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

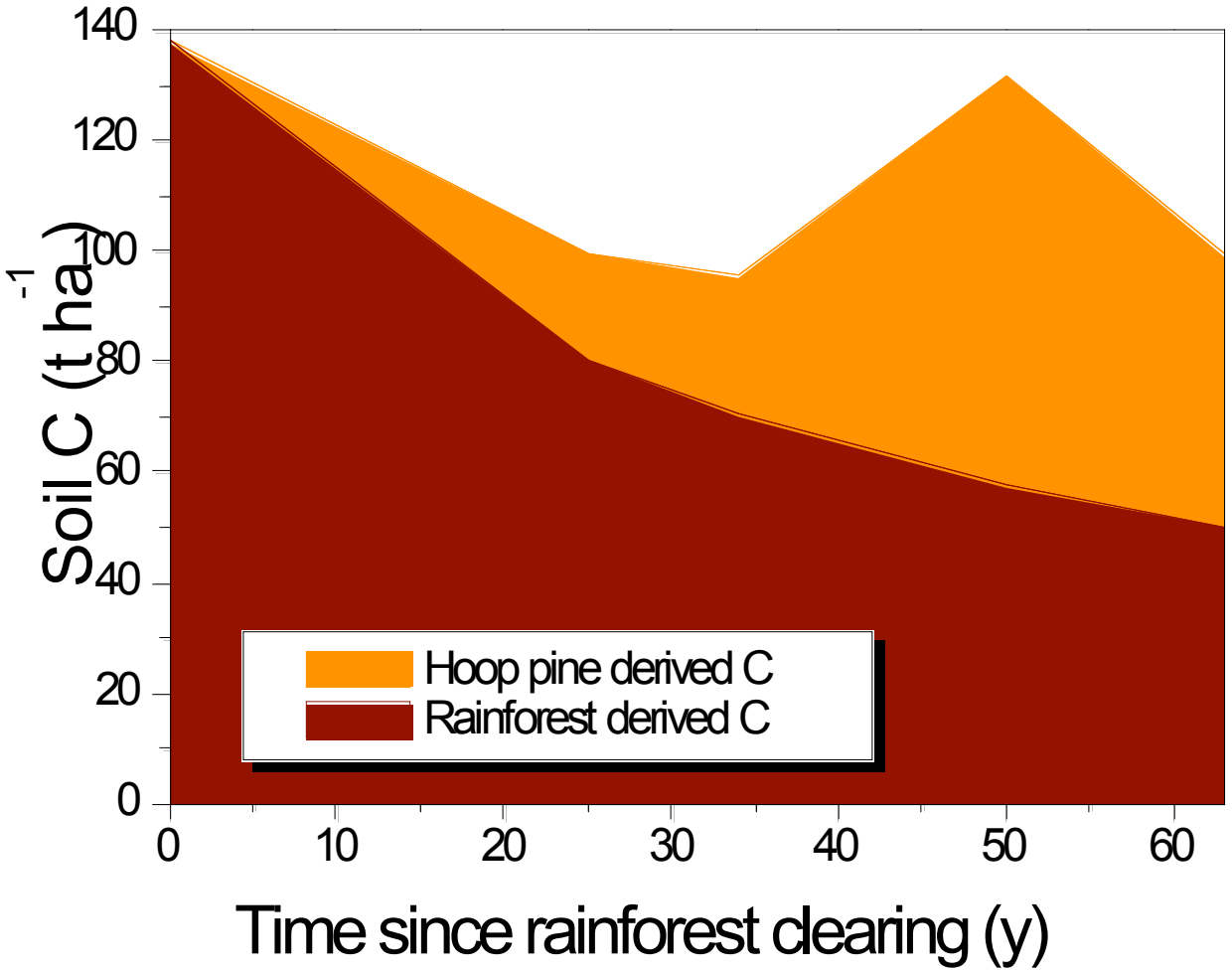
Large-scale afforestation projects for climate change mitigation:

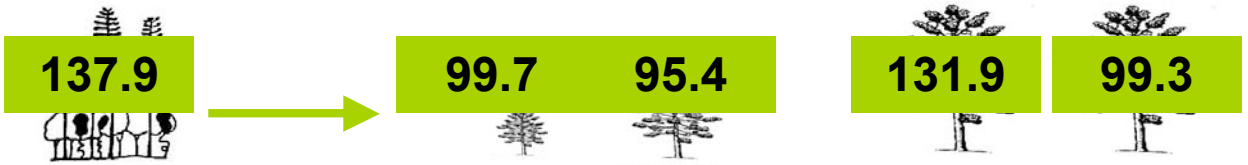
1. In high latitudes might actually cause warming
2. In temperate latitudes may have no net benefit
3. In tropical latitudes would be beneficial

- But, forests are important: biodiversity, timber & non-timber products, protect watersheds, store CO_2-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

Subtropical Hoop Pine Plantations





➔ 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

Back-of-envelope calculations:

Radiative forcing for CO_2:
$\Delta F = \alpha.\ln(C/C_o)$

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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*Bala, G., Caldeira, K., Wickett, M., Phillips, T. J., Lobell, D. B., Delire, C., Mirin, A. (2007) Combined climate and carbon-cycle effects of large-scale deforestation. Proceedings of the National Academy of Sciences USA, 104(16): 6550-6555.