

TROPICAL FOREST CARBON AND CLIMATE CHANGE

How should adaptation be incorporated into climate change mitigation schemes?

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Outline

- Forest and climate change
- Forest cover change and impacts
- Forest carbon stock and fluxes studies
- Plant species response to climate change
- Adaptation and mitigation

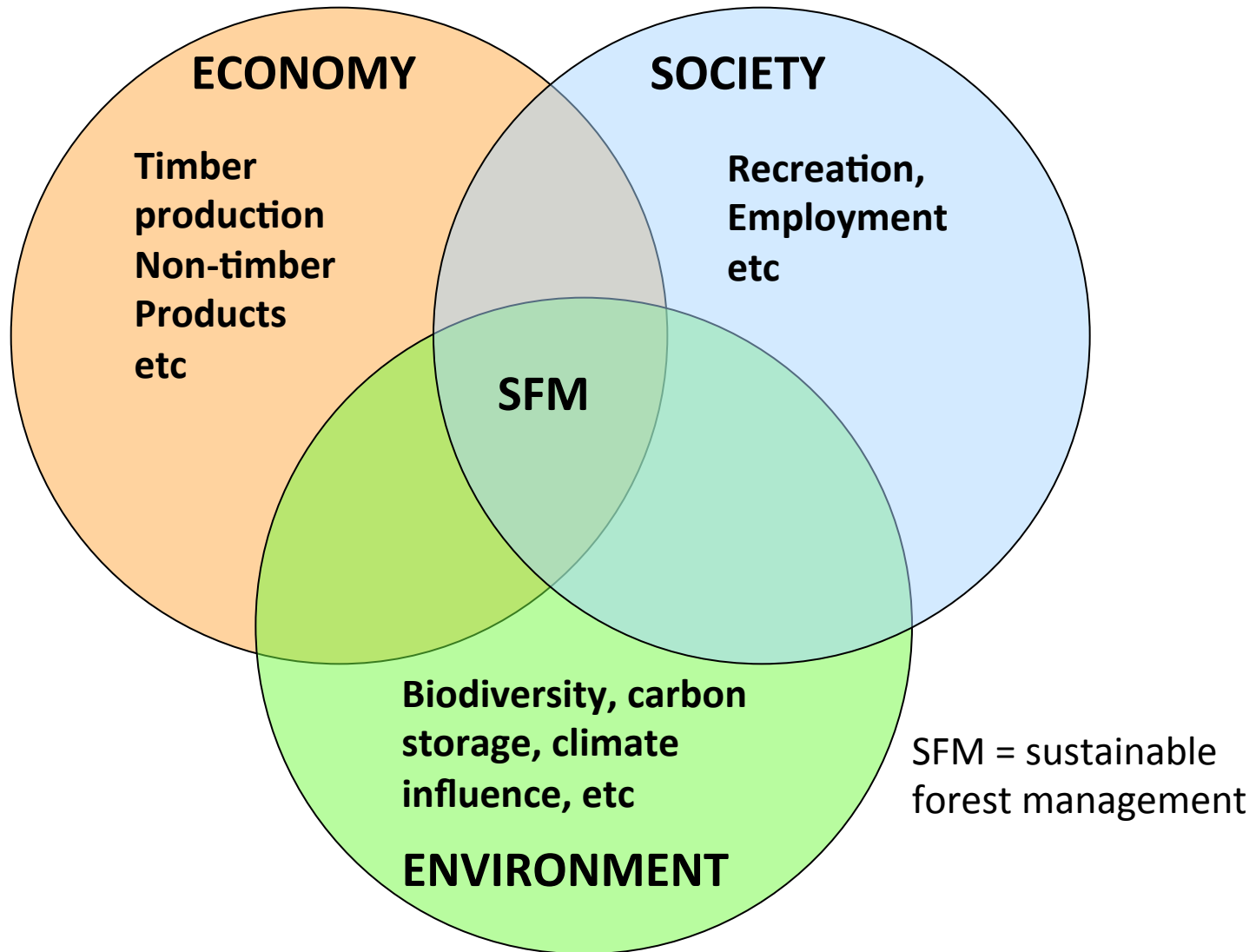
Forest Carbon

- Carbon is major component of biomass, = 50% in living biomass

Climate change

- Climate change trends: increase in air T and decrease in precipitation
- Human-induced climate change: emission of greenhouse gases (mainly CO₂ from fossil fuel and land use changes), aerosols, etc

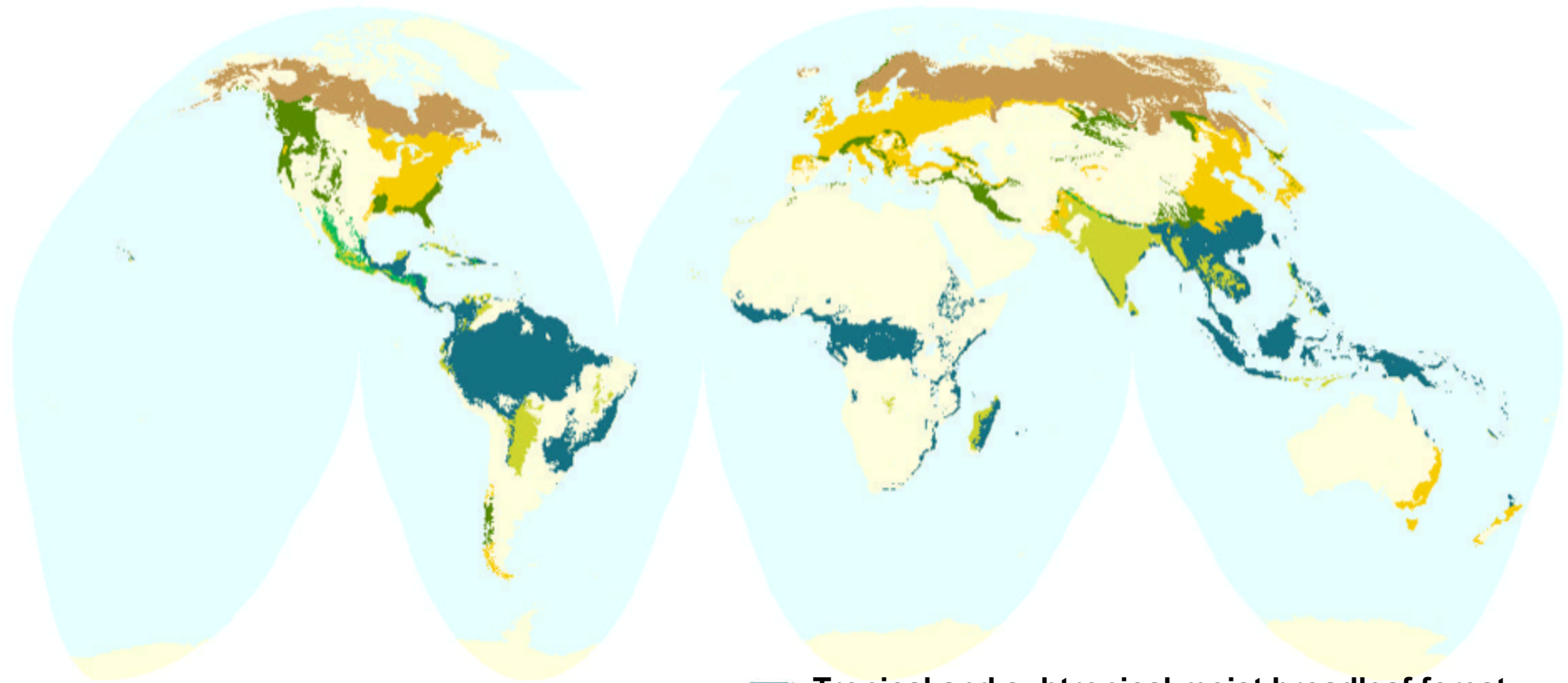
Forest Functions



Forest influence on climate

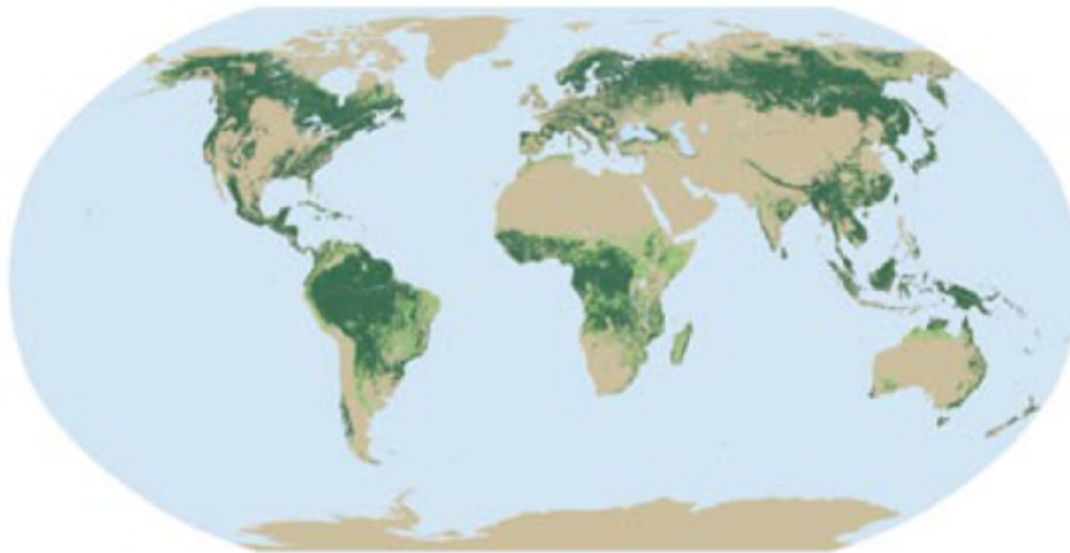
- Forest reflect less heat back into atmosphere
- Play very significant role in global carbon cycle
- Provide shade and absorb heat energy, producing cooling effect
- Reduce wind velocity and evaporative losses of water, moderating soil temperature and reducing RH
- Forest sustain hydrologic cycle

Potential Pre-agricultural Forest Cover

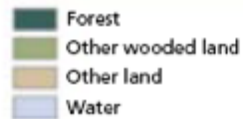


- Tropical and subtropical moist broadleaf forest
- Tropical and subtropical dry broadleaf forest
- Temperate broadleaf and mixed forest
- Temperate conifer forest
- Tropical and subtropical conifer forest
- Boreal forest/Taiga
- Non-forest ecoregions

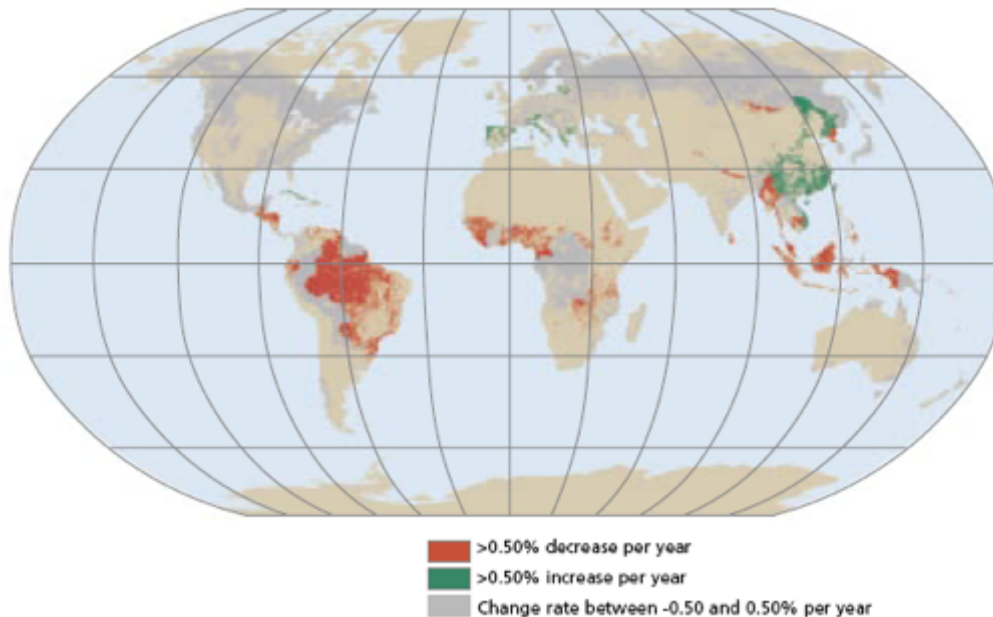
World's forest



30%



Forest area changes in 2000-2005



Deforestation in
tropical regions

- Area of natural forest decreased 5 Mha per year
- Forested area affected by insects and other disturbances was 1.1 Mha per year
- 4.5 Mha per year decrease in productive forest

Deforestation causes and consequences

- Agricultural extension, agriculture is major livelihood activity, Increasing demand of food, cash crops
- Increasing demand of forest goods (e.g. fibre, fuel wood) and services (e.g. carbon storage)
- Forest is major source of cooking energy
- Loss of biodiversity, species composition and productivity are likely to change
- Emission of greenhouse gases & Climate change

Area and carbon stocks in major forest biomes (Malhi et al, 1999)

Forest biome	Area (Mha)	C Density: vegetation (t ha ⁻¹)	C Density: soils (t ha ⁻¹)	C Pool: vegetation (Gt)	C Pool: soils (Gt)
Boreal	1372	64	343	88	471
Temperate	1038	57	96	59	100
Tropical	1755	121	123	212	216
Total	4165	Mean 86	Mean 189	359	787

Area change and C emission

Biome	Area 1850 (Mha)	Area 1980 (Mha)	Area change (%)	Net C release (Gt C)
Boreal	1172	1167	0.5	4
Temperate	1583	1492	6	27
Tropical	2675	2167	19	52
Total Forest	5430	4827	11	83

Publications

Tropical forests and global atmospheric change: a synthesis

Yadvinder Malhi¹ and Oliver L. Phillips^{2*}

¹*School of GeoSciences, Darwin Building, University of Edinburgh, Edinburgh EH9 3JU, UK*

²*Earth and Biosphere Institute, School of Geography, University of Leeds, Leeds LS2 9JT, UK*

that could lead to substantial forest decline in the near future. During the coming century, the Earth's remaining tropical forests face the combined pressures of direct human impacts and a climatic and atmospheric situation not experienced for at least 20 million years. Understanding and monitoring of their response to this atmospheric change are essential if we are to maximize their conservation options.

Publications

Spatial patterns and recent trends in the climate of tropical rainforest regions

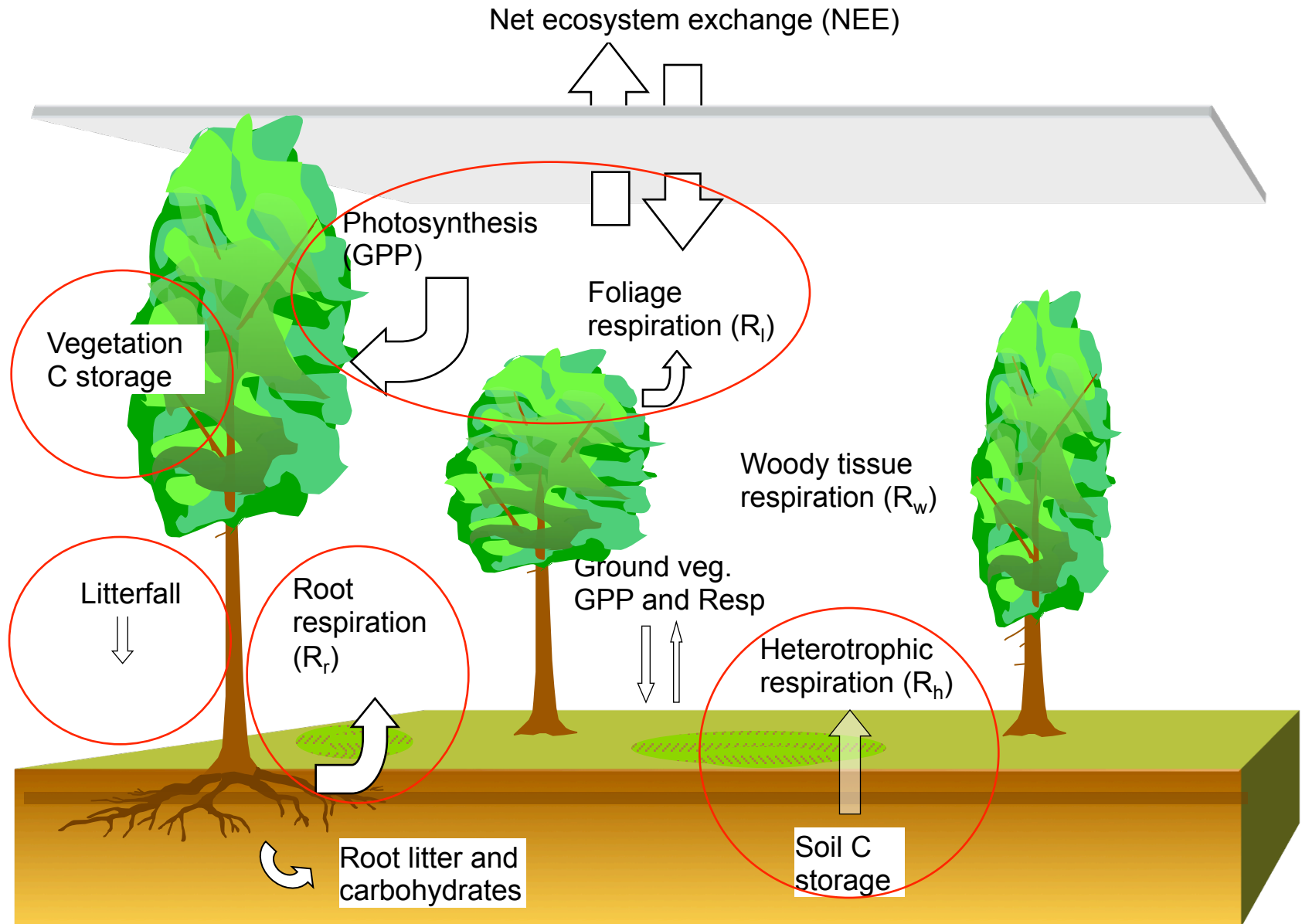
Yadvinder Malhi^{1*} and James Wright^{1,2}

¹*School of Geosciences, University of Edinburgh, Edinburgh EH9 3JU, UK*

²*School of Geography and the Environment, University of Oxford, Mansfield Road, Oxford OX1 3TD, UK*

period 1960–1998, with the aid of explicit maps of forest cover and climatological databases. Until the mid-1970s most regions showed little trend in temperature, and the western Amazon experienced a net cooling probably associated with an interdecadal oscillation. Since the mid-1970s, all tropical rainforest regions have experienced a strong warming at a mean rate of 0.26 ± 0.05 °C per decade, in synchrony with a global rise in temperature that has been attributed to the anthropogenic greenhouse effect. Over the study period, precipitation appears to have declined in tropical rainforest regions at a rate of $1.0 \pm 0.8\%$ per decade ($p < 5\%$), declining sharply in northern tropical Africa (at 3–4% per decade), declining marginally in tropical Asia and showing no significant trend in Amazonia. There is no evidence

Tropical Forest Carbon Fluxes Studies



Tropical Forest Carbon Stock and Fluxes Studies

- Tropical forest biomass well studied in Tropical America, less studies in Africa and Tropical Asia
- Carbon fluxes are less studied
- **Consequence:** estimating carbon balance and emissions in relation to climate change is linked with large uncertainties
- **Climate predicted with climate stations from outside forested areas**



Dynamic responses of African ecosystem carbon cycling to climate change

Mingkui Cao*, Quanfa Zhang, Hank H. Shugart

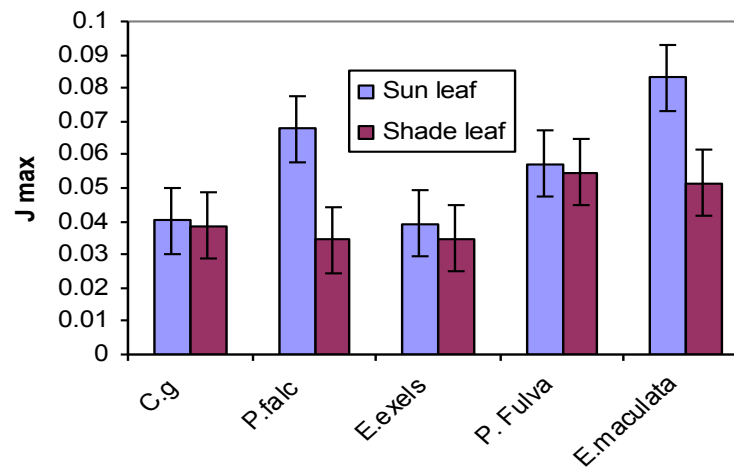
Department of Environmental Science, University of Virginia, Charlottesville, Virginia 22904-4123, USA

Climate change reduces plant production and soil carbon stock and cause net CO₂ release but fertilization effect of increasing atm CO₂ on photosynthesis reverses the reduction

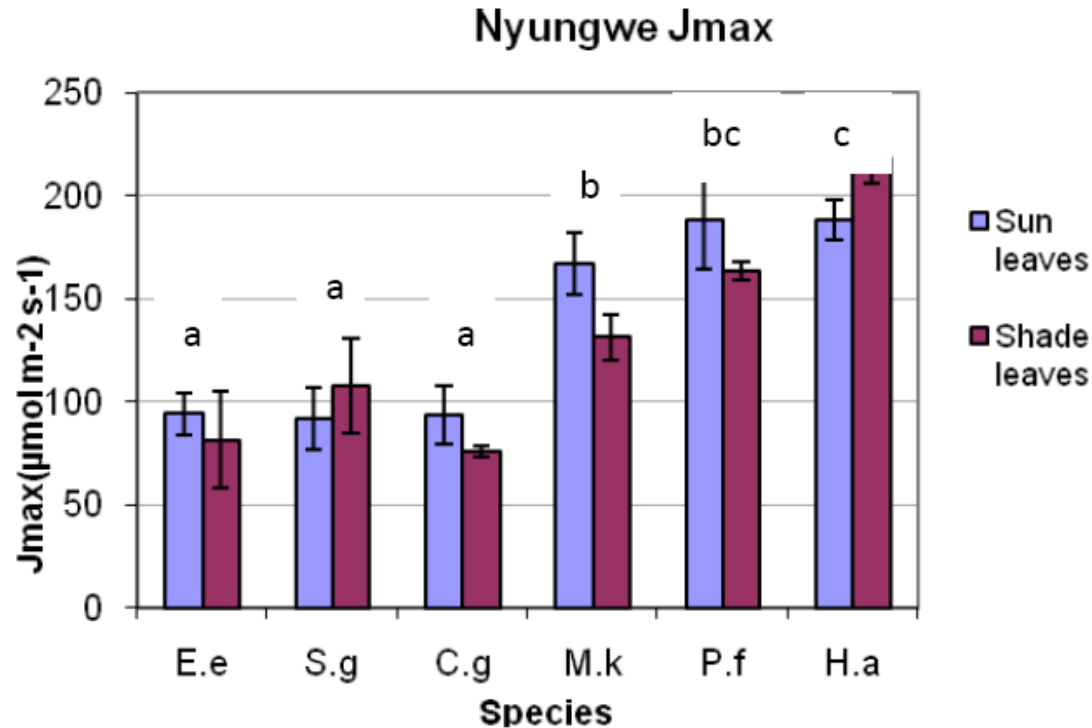
Plant species response to climate change

- Species physiological response to dryer climate is not well known
- Plant phenology will be modified and carbon allocation into soil, litter, biomass will change

Photosynthetic capacity of tree species in relation to climate change



Rate of carboxylation efficiency (J_{max}) by different tree species



Rate of carboxylation efficiency (Jmax) by different tree species in Nyungwe: *Entandrophragma e*, *Makaranga k*, *Sizigium guinense*, *podocarpus falcatus*, *Hagenia a*, *Carapa grandiflora*

Native vs planted forests: source or sink of Carbon?

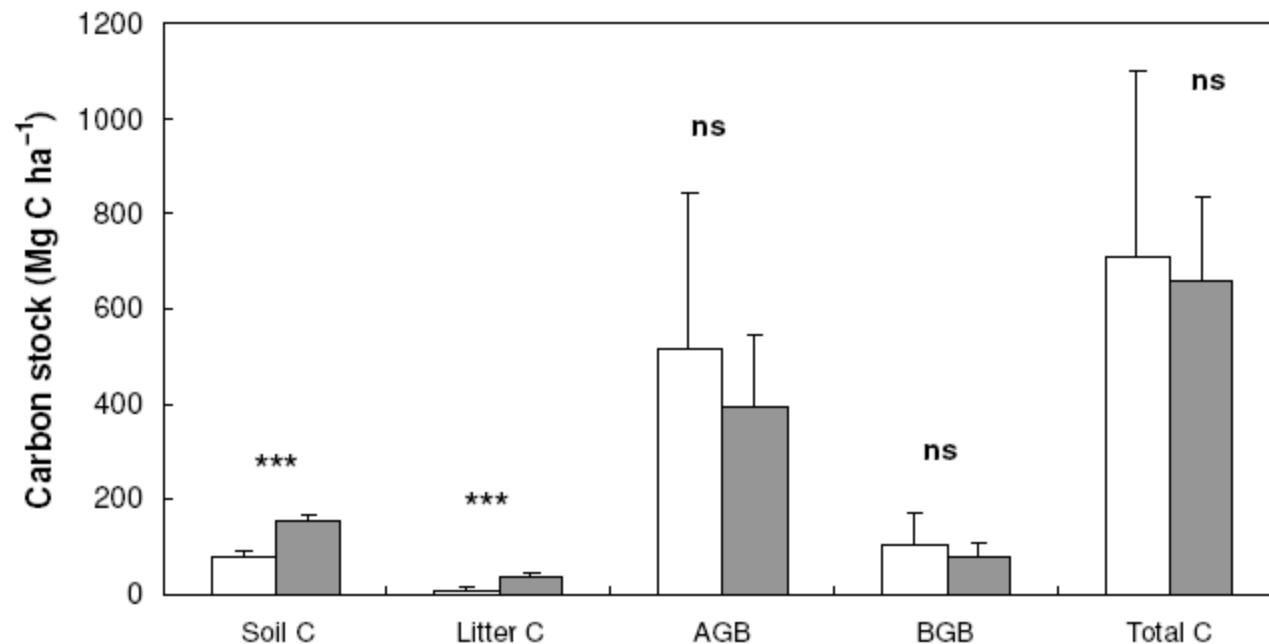
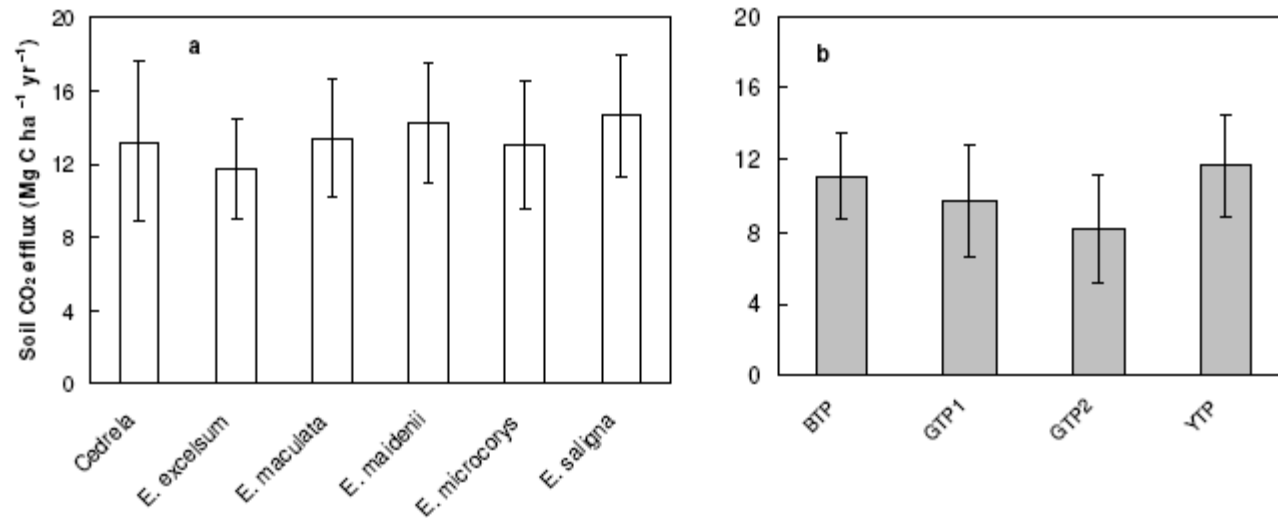


Figure 4. Estimates of carbon stock (Mg C ha⁻¹) in soil, litter, aboveground biomass (AGB), belowground biomass (BGB), and total carbon stock (Total C) in the Ruhande Arboretum (white bars) and the Nyungwe forest (grey bars). Vertical bars indicate standard deviation from the mean. Statistical analysis (t-test): *** $P < 0.001$; ns: not significant (**Paper V**).

Carbon emission from planted forest and Nyungwe forest



MITIGATION AND ADAPTATION TO CLIMATE CHANGE

Concept

- **Mitigation**: all human interventions that reduce the sources or enhance the sinks of greenhouse gases
- **Adaptation**: response to actual or expected climatic conditions
- Adaptation and Mitigation initiatives can be at policy, legal, institutional or farmers levels.

International initiatives

- UNFCCC, Kyoto protocol, reporting national greenhouse gases, Clean development mechanisms, REDD+, carbon market, afforestation and reforestation projects, emission reduction,

Ref.: <http://unfccc.int/>

Afforestation and reforestation

- Increase wood production for energy and service needs
- Control soil erosion, protect hydrological regime
- Mitigate climate change
- Reforestation must use species with high growth rate, with minor ecological impacts: native and exotic species



Opportunity for carbon market: 10 USD per T of C stored

Issue: limited availability of land for reforestation, price of carbon is low, competition with arable land

Natural Forest Conservation

- Agriculture is major threat to natural forests
- Natural forests are major Carbon stocks and major carbon sinks, thus mitigate climate change.
- Conservation of natural forests reduce emission of C when these forest are burned or cut



Issues: Overpopulation around protected areas, fragmentation, fires,

Agroforestry

- Agroforestry restores soil fertility, increase agricultural productivity, increase honey production, provide fuel wood and poles, influence microclimate, and provide fodder to livestock.
- These benefits help farmers adapt to effects of climate change.
- Agroforestry practices also provide mitigation to effects of climate change by carbon sequestration.



Agriculture Intensification

- Radical terraces, and other soil conservation practices
- Improved agricultural technology, fertilizer use, mechanization,



Land use consolidation

- Land use consolidation, with one crop on larger area will increase crop production, provide food for livestock, increase livestock production, maximize carbon storage, mitigate climate change



Alternative source of energy

- The use of solar energy, biogas, improved cooking stoves and micro hydropower generation help people especially those in rural areas to cook and light, reduce deforestation.
- This will in turn reduce release of green house gases into the atmosphere, hence mitigating effects of climate change.

Conclusions

- Forest ecosystems are important for the global carbon balance.
- Forest ecosystems are under pressure, mainly in the tropics, large carbon source to atmosphere.
- Small number of Carbon balance studies in the Tropics
- Mitigation and adaptation projects need to be multiplied and strengthened.
- Mitigation and adaption activities accessible to lower income population

THANKS