The role of forests and bioenergy in climate-change mitigation

JOANNEUM RESEARCH

Carbon sequestration versus biomass energy

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Outline

- Global overview
- Mechanisms through which forestry and bioenergy can mitigate climate change
- Saturation and permanence
- Bioenergy or carbon sequestration?
- Some IPCC AR4 findings

The global carbon cycle

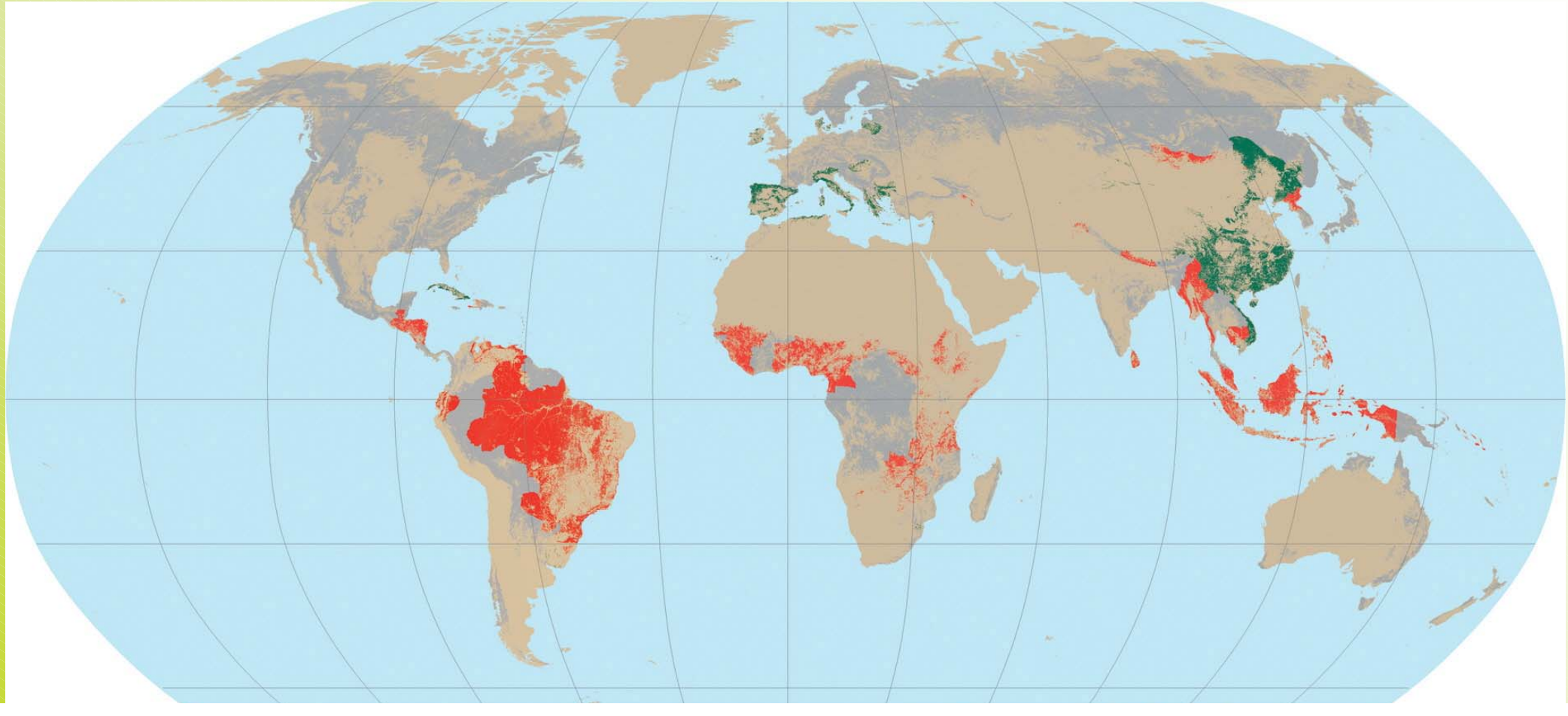
- 30% of emissions over past 200 years (400 GtC) from land use and land-use change.

All numbers in GtC/yr	**1989 to 1998**
(1) Emissions from fossil fuel combustion and cement production	6.3 ± 0.6
(2) Increase in the atmosphere	3.3 ± 0.2
(3) Ocean uptake	2.3 ± 0.8
(4) Net terrestrial uptake = (1)-[(2)+(3)]	0.7 ± 1.0

Deforestation (-1.6)

Other terrestrial uptake (+2.3)

Dynamic in forested areas 2000-2005: hotspots of deforestation and forestation



Deforestation in the south, while forests increase in the north.

> 0.5 % Decrease per year

> 0.5 % Increase per year

Change rate below 0.5 % per year

Source: FAO, 2006

Role of forests and forest-based products in climate change (1)

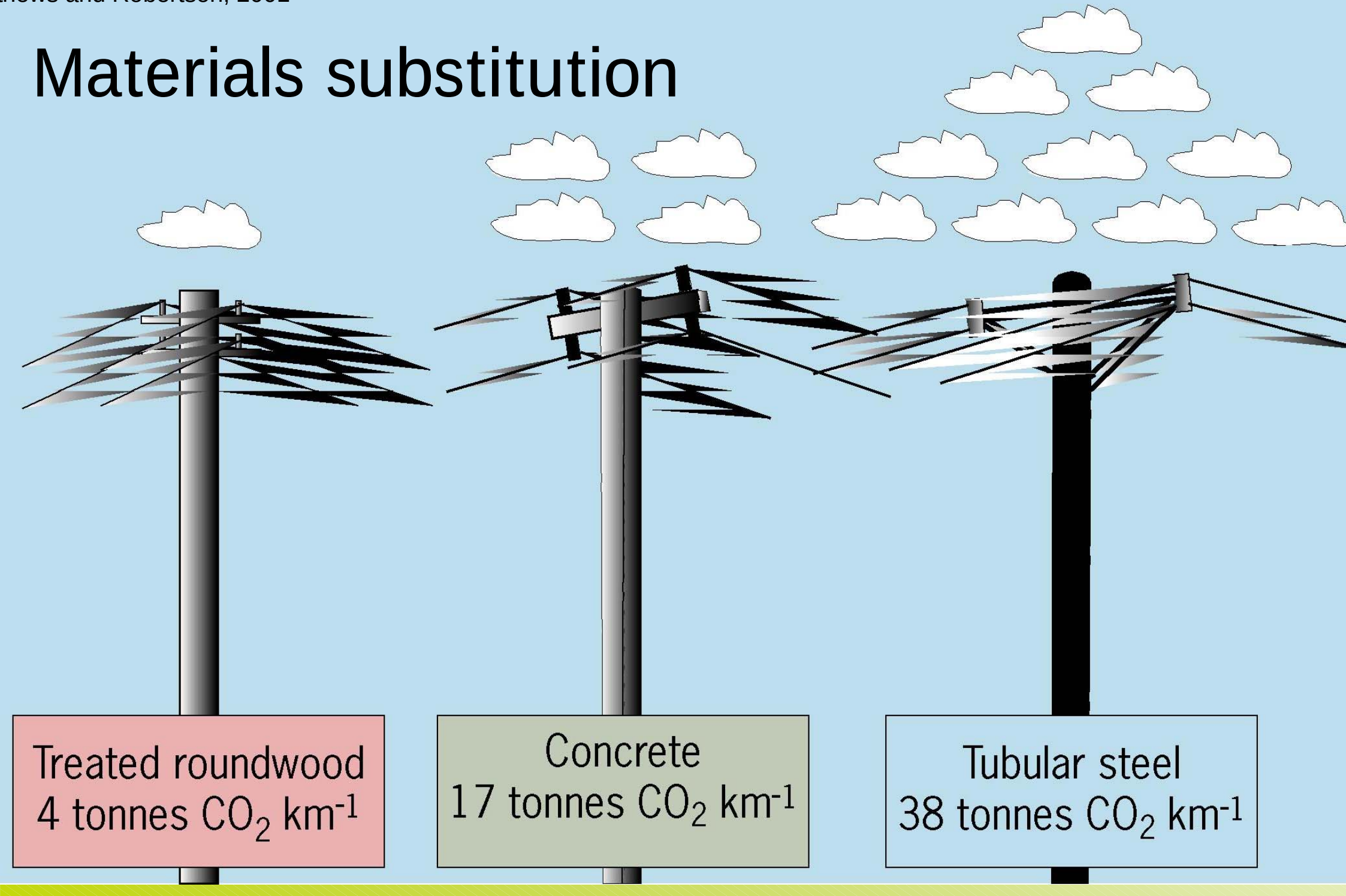
- Photosynthesis: only process to remove large amounts of CO2 from the atmosphere

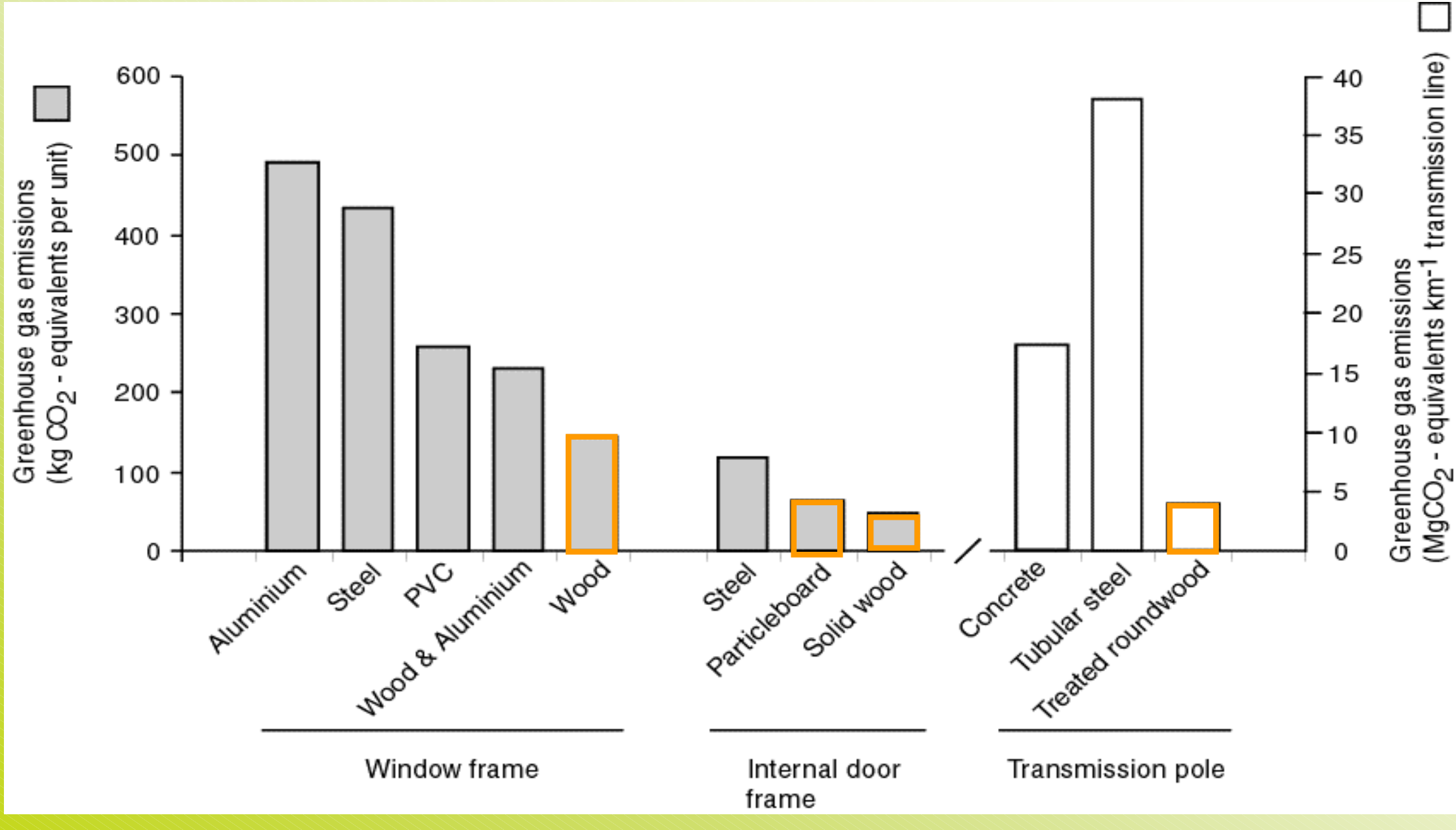
- Wood products store carbon
  - Wood = 50% carbon
  - 1 m^3 of wood stores about 1 ton of CO_2

- Without wood products, we would be using other, more GHG intensive materials
  - Steel, concrete, glass, aluminum, etc.

thews and Robertson, 2001

Materials substitution

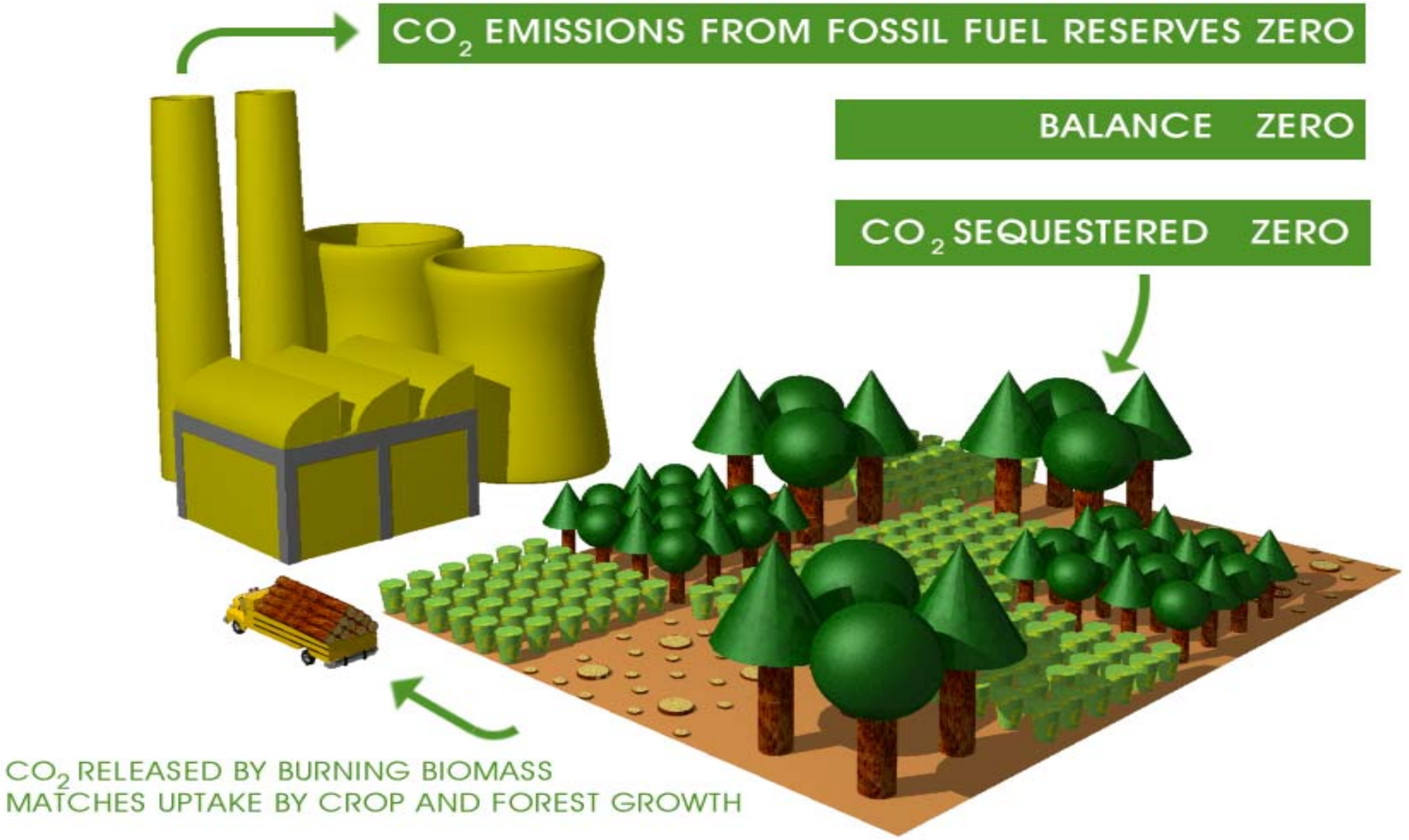



Greenhouse gas emissions
(kg CO_2 - equivalents per unit)
600
500
400
300
200
100
0
Aluminium
Steel
PVC
Wood & Aluminium
Wood
Steel
Particleboard
Solid wood
Concrete
Tubular steel
Treated roundwood
Window frame
Internal door frame
Transmission pole
40
35
30
25
20
15
10
5
0
Greenhouse gas emissions
($MgCO_2$ - equivalents km^{-1} transmission line)

Role of forests and forest-based products in climate change (2)

- Wood can be used as an energy source to replace fossil fuels
  - Can come as logs, wood chips, pellets, briquettes, black liquor etc.
  - From forest: Logging residues, pre-commercial thinning
  - Wood processing residues
  - Recovered wood
  - Wood plantations using fast-growing species

Closed carbon cycle



Role of forests and forest-based products in climate change (3)

- Enhance carbon stocks, or reduce depletion of carbon stocks, in forests
  - Afforestation, reforestation
  - Improve forest management
  - Reduce forest fires
  - Reduce forest degradation
  - Reduce deforestation (20% of global GHG emissions)

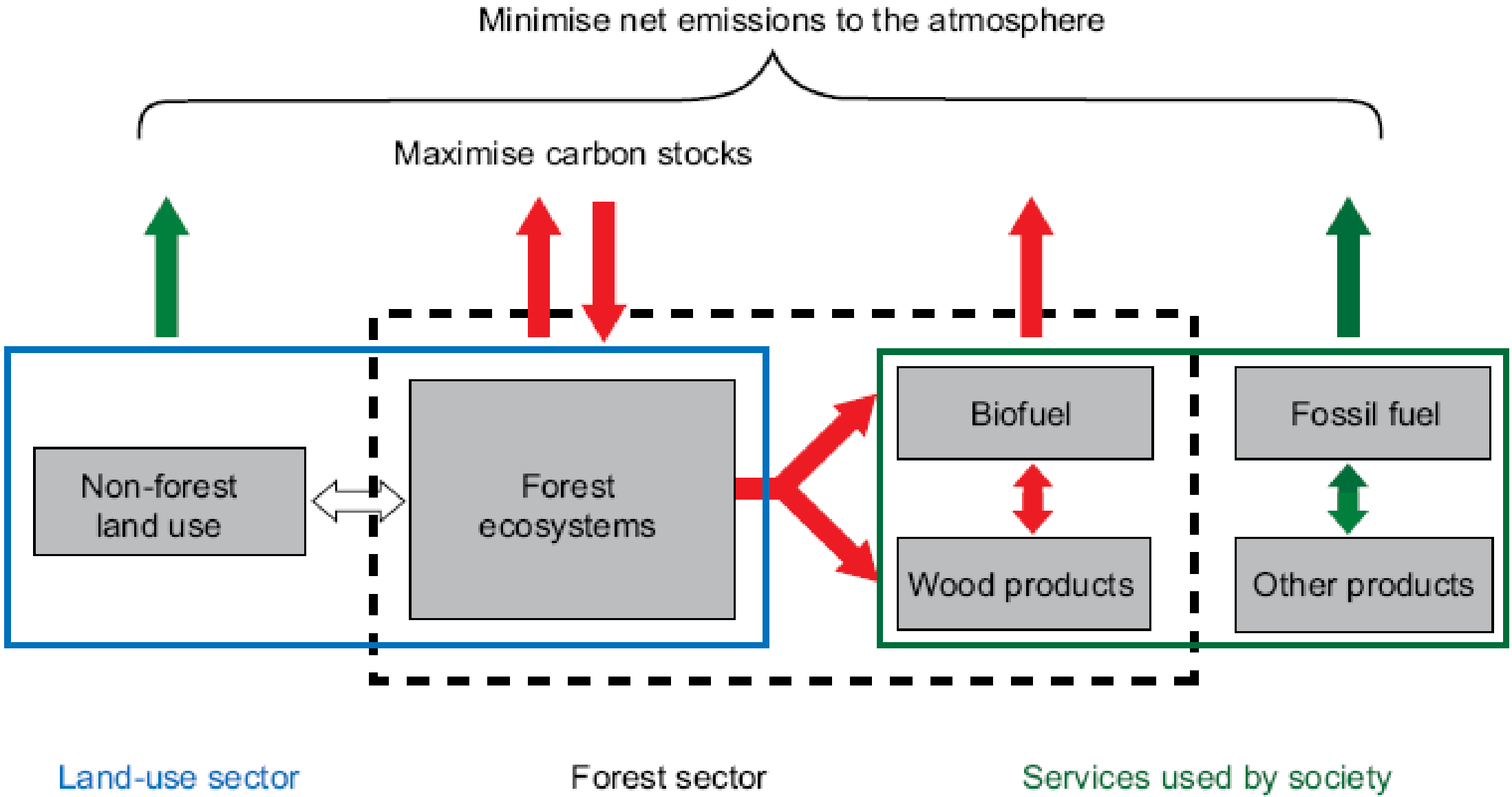
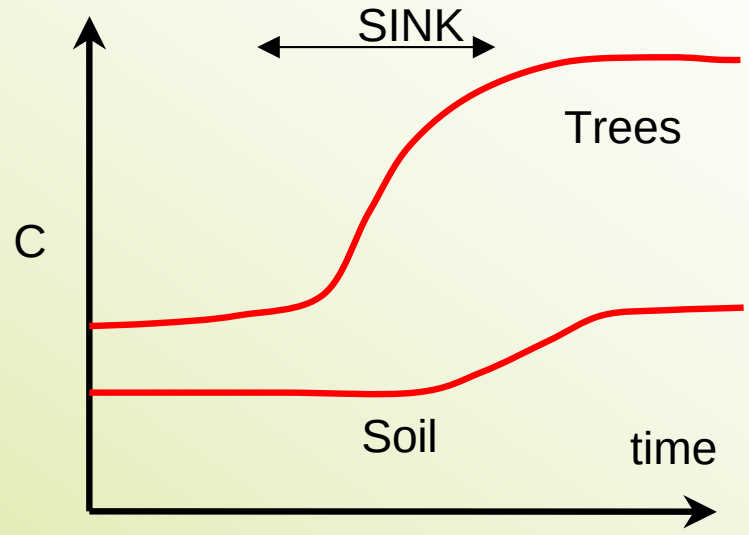


Figure 9.3: *Forest sector mitigation strategies need to be assessed with regard to their impacts on carbon storage in forest ecosystems on sustainable harvest rates and on net GHG emissions across all sectors.*

Carbon sinks vs. emission reductions

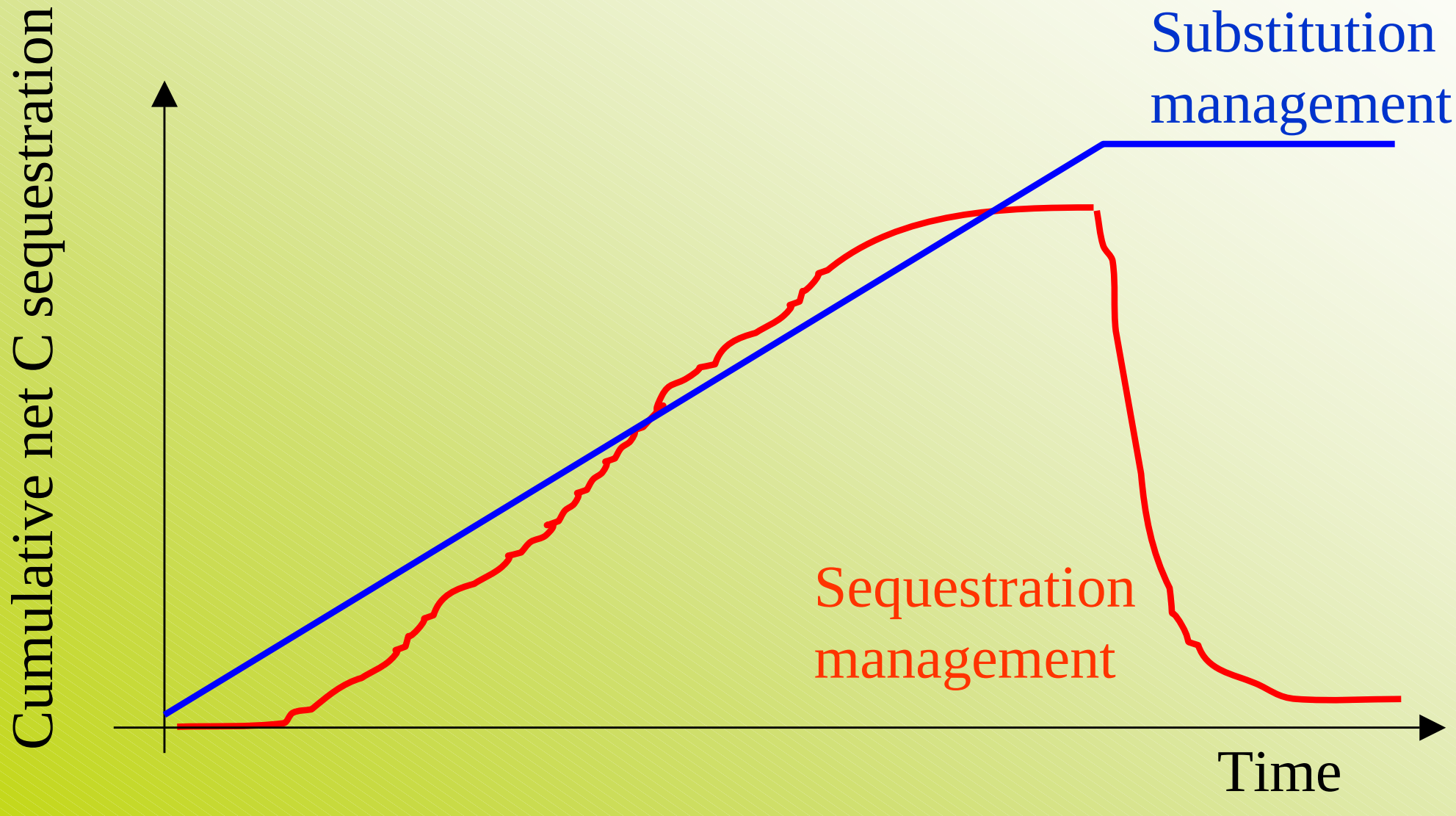
- Saturation
  - Amount of land available
  - Amount of C per unit land



  - 12-15% of global fossil-fuel emissions in next 50 years

- Permanence

Permanence


Cumulative net C sequestration
Substitution management
Sequestration management
Time

Optimizing GHG benefits

- If land is limited, then
  - Input / output ratio for bioenergy is irrelevant
  - GHG emissions /kWh or /km are irrelevant
  - **Emission reduction per hectare of land** compared to fossil reference system must be compared and optimized

Source: IEA Bioenergy Task38: Optimising the GHG benefits of bioenergy systems, 2005

Reforesting surplus agricultural land

”Reforestation of today provides the biomass fuels of tomorrow“

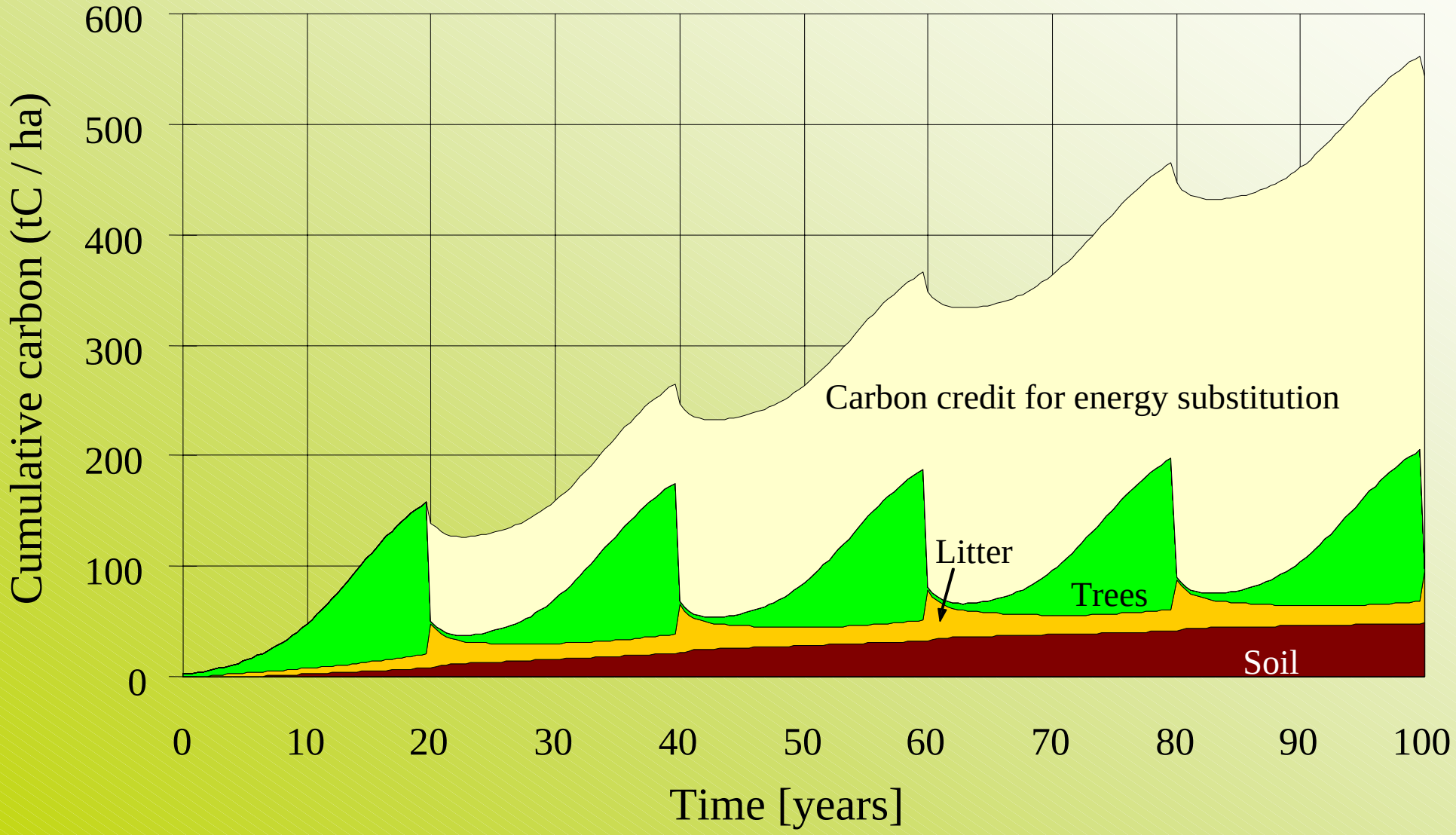
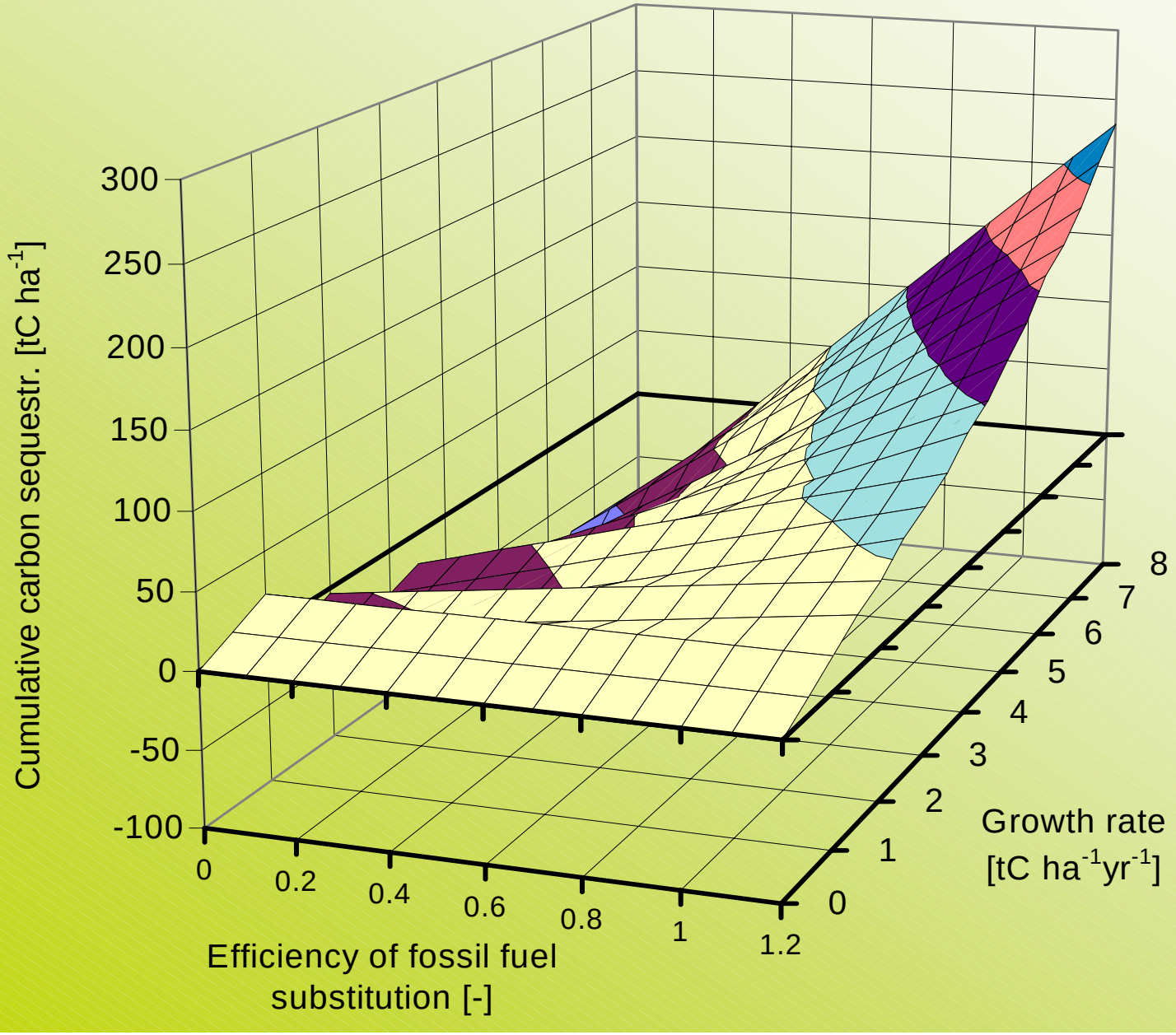
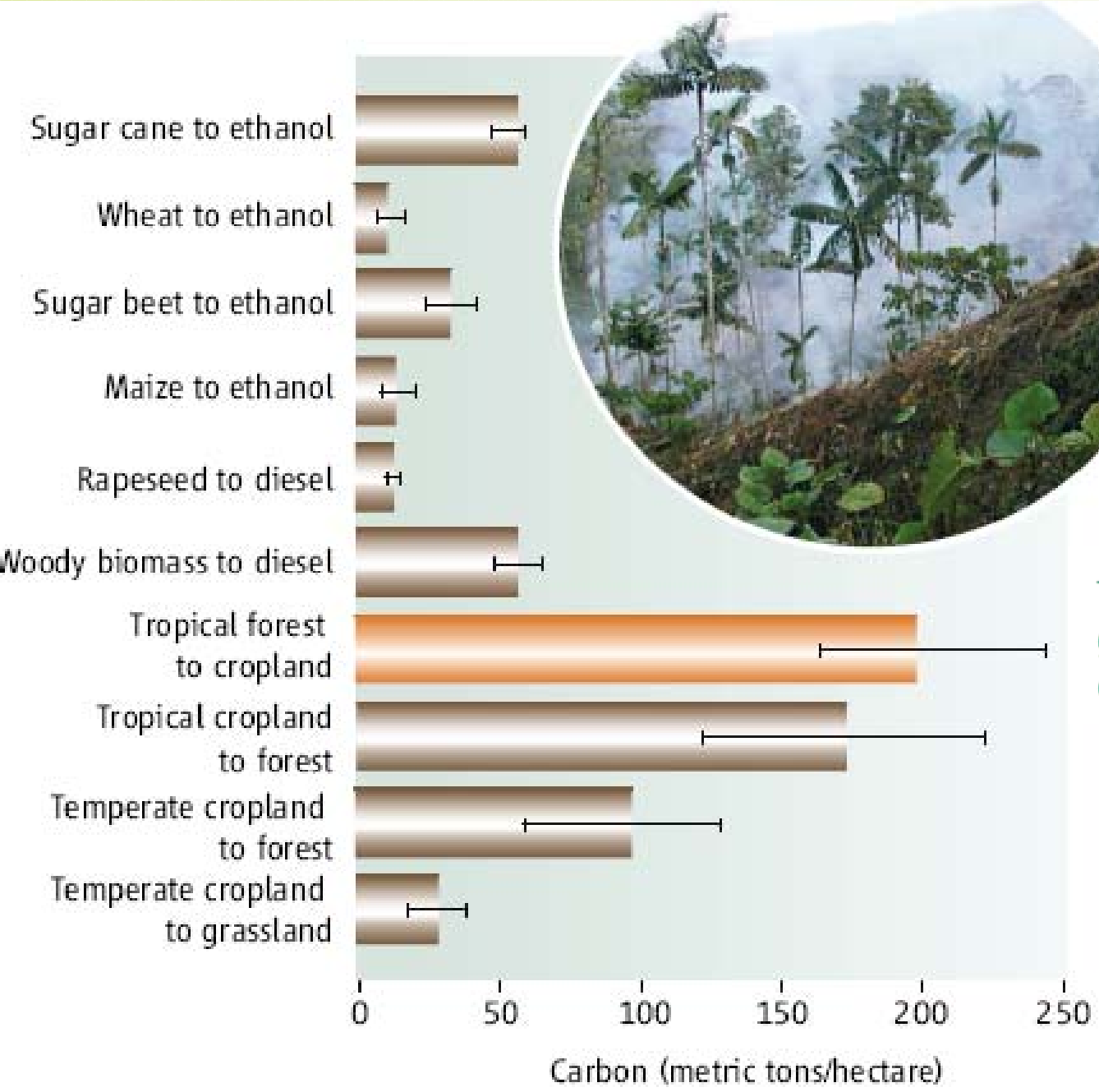


Figure: The difference after 40 years between a scenario where land is reforested with fast growing species to produce biomass energy, and a scenario where land is reforested with the main purpose of storing carbon.



Positive numbers on vertical axis:
benefits of biomass energy exceed those of carbon sequestration

Liquid fuels or reforestation?



Cumulative avoided emissions per hectare over 30 years for a range of biofuels compared with the carbon sequestered over 30 years by changing cropland to forest and the loss of carbon to the atmosphere by conversion of forest to cropland. Error bars indicate the ranges of values in the literature cited. Details are in the SOM.

The carbon sequestered by restoring forests is greater than the emissions avoided by the use of the liquid biofuels.

Renton Righelato* and Dominick V. Spracklen

Carbon Mitigation by Biofuels or by Saving and Restoring Forests?

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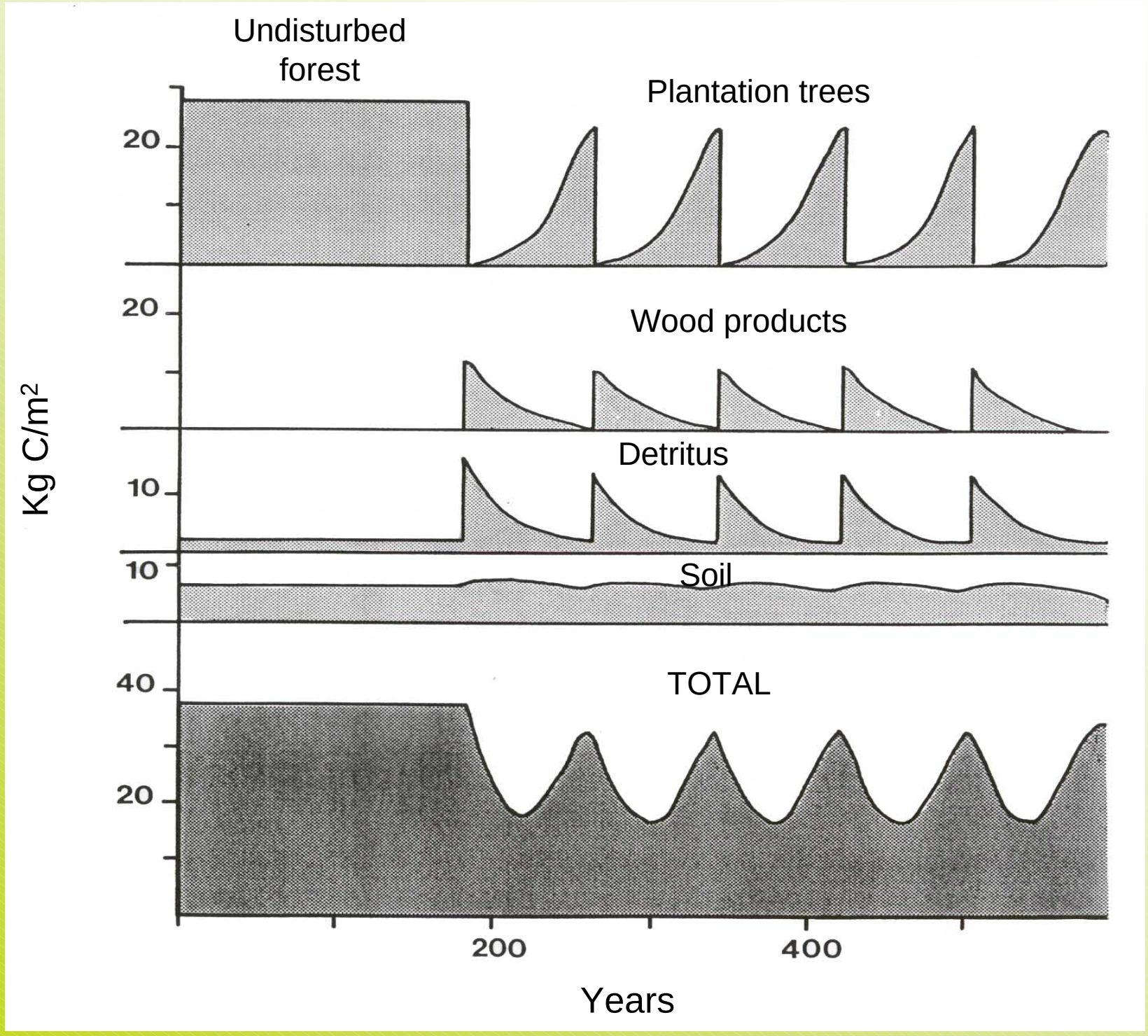
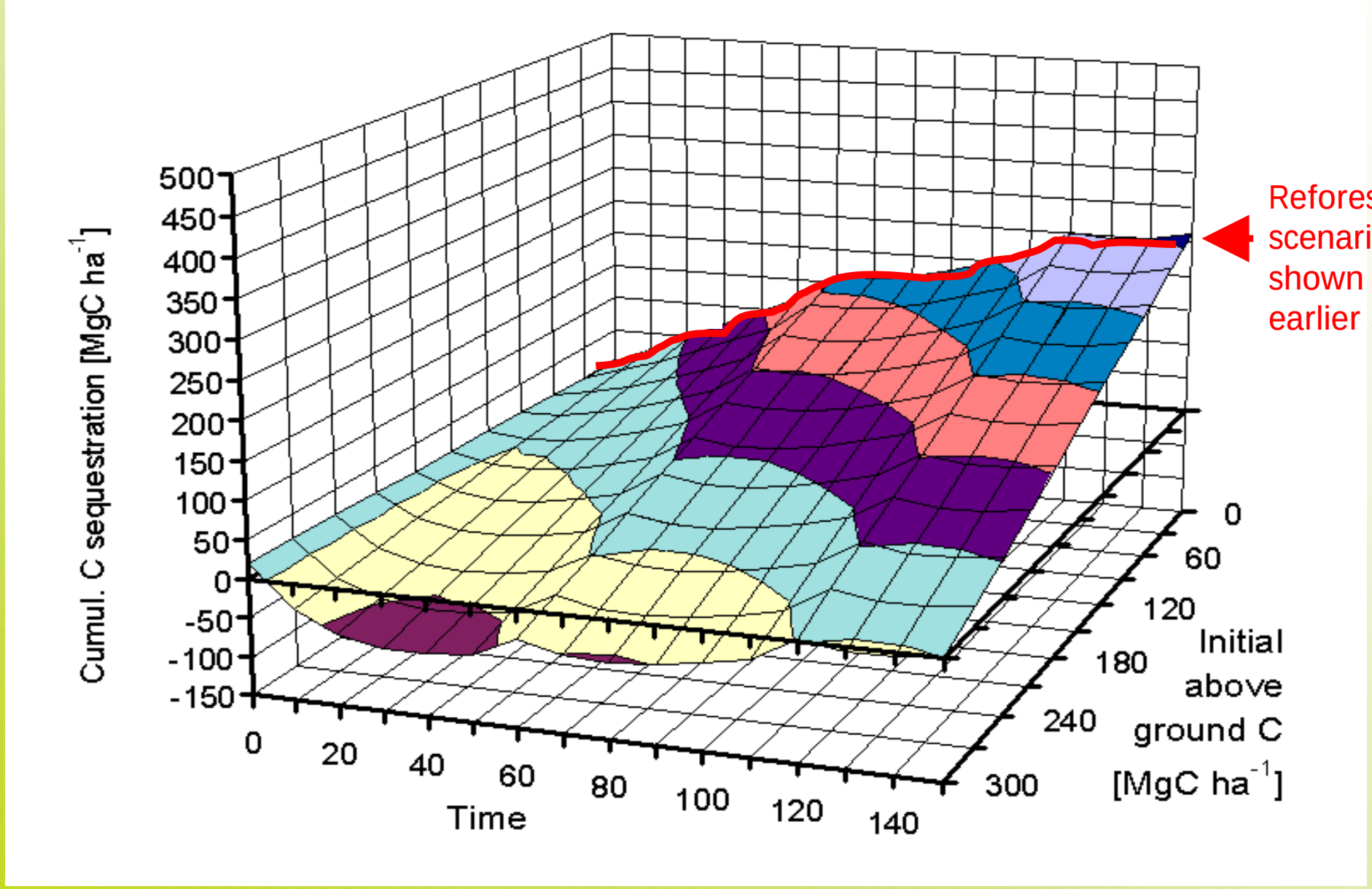

Undisturbed forest
Plantation trees
20
20
Wood products
Kg C/m²
Detritus
10
10
Soil
40
TOTAL
20
200
400
Years

Figure: A forest (with an Initial above ground carbon stock between 0 and 300 tons per ha according to the axis to the right) is harvested for timber and biomass fuel and replanted.



Harvesting for biomass and timber yields greater benefits if ...

- growth rates are high
- harvested material is used efficiently
- a long-term view is taken
- initial carbon stocks are at low/medium levels

- Virtually all policies and incentives focus on substitution, not sequestration (e.g., EU ETS)

Baseline emissions: Forests

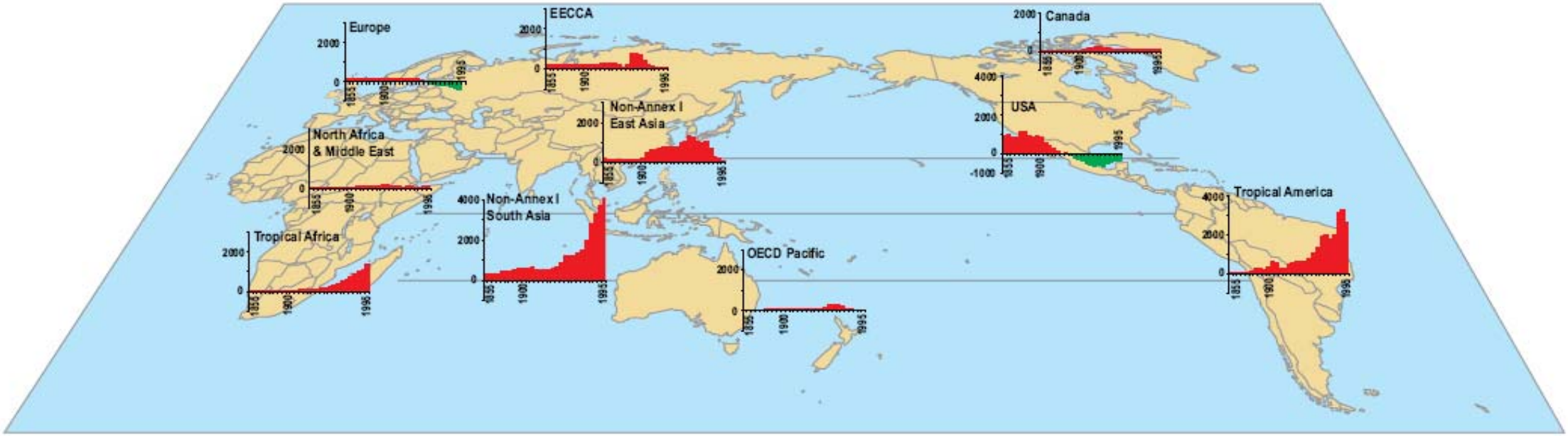


Figure 9.2: *Historical forest carbon balance ($MtCO_2$) per region, 1855-2000.*

Notes: green = sink. EECCA=Countries of Eastern Europe, the Caucasus and Central Asia. Data averaged per 5-year period, year marks starting year of period.
Source: Houghton, 2003b.

Economic Mitigation Potential

	Economic Potential 2030 ($GtCO_2$-eq/yr)	
Carbon price (US/tCO_2-eq)	**Agriculture**	**Forests**
20	**1.6** (0.3-2.4)	**1.2** (0.5-1.8)
50	**2.7** (1.5-3.9)	**2.1** (0.9-3.2)
100	**4.4** (2.3-6.4)	**2.7** (1.3-4.2)
Emissions 2030	**8.2**	**5.8**

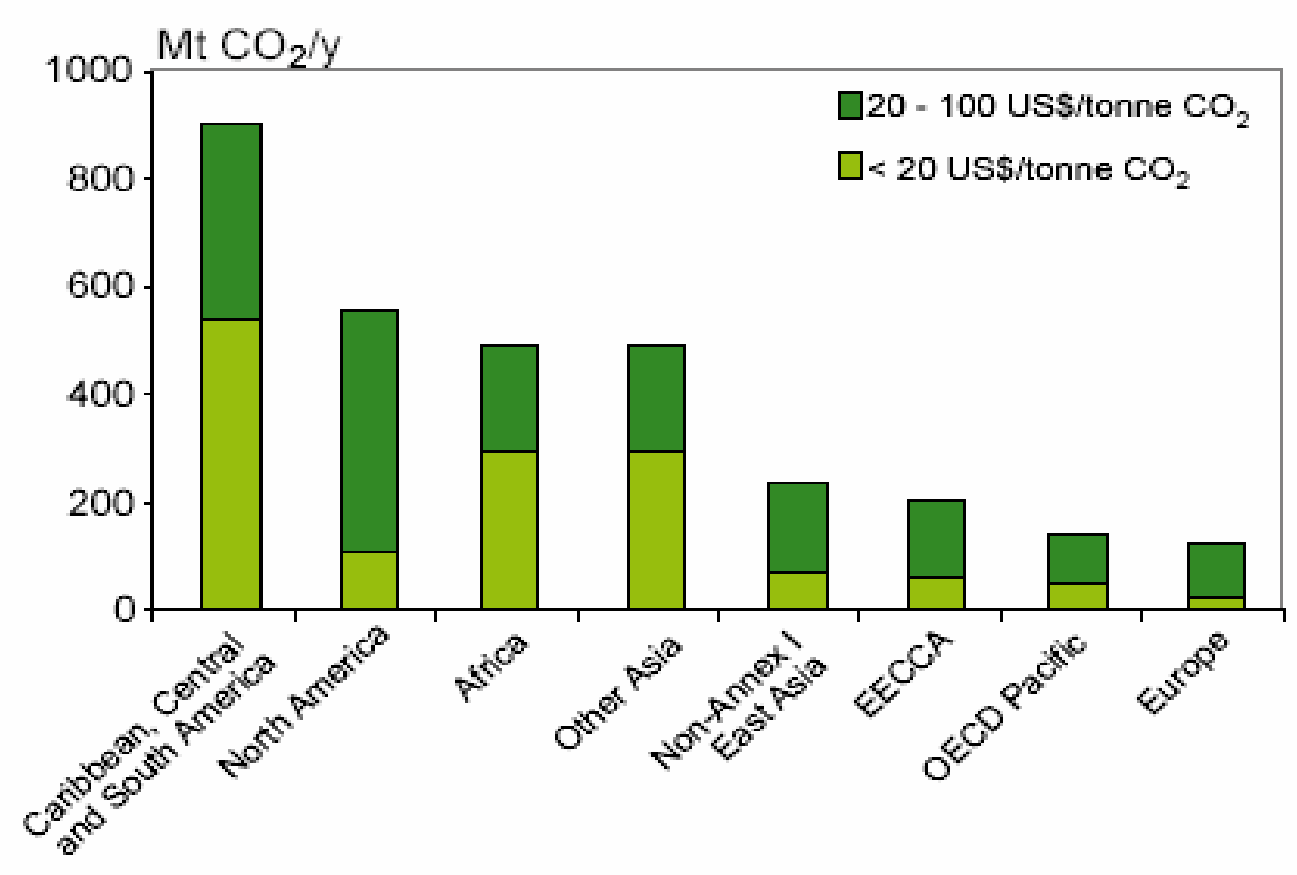
Mitigation practices in Agriculture

Cropland management; Restoration of organic soils; Rice management; Grazing land management – 90% of potential is carbon sequestration

Mitigation practices in Forests

Reduced emissions from deforestation; afforestation; forest management

Forests: Regional Distribution of Economic Potential (US$ 100/tCO_2-eq)



65% of potential is in developing regions
Developing countries: reduced deforestation 40% of potential
Developed countries, EIT: forest management 63-72% of potential

Biomass as Feedstock for Energy

- Agriculture:
  - Biomass for energy produced in agricultural land may cause indirect emissions reductions of 70-1,260 Mt CO_2-eq./yr (at US$ 20/tCO_2) by 2030.
  - In addition, emissions reductions of 770 Mt CO_2-eq./yr can be achieved through energy efficiency
- Forests:
  - Indirect emissions reductions of 40-4,000 Mt CO_2-eq./yr (at US$ 20/tCO_2) can be achieved by 2030.
  - Increasing stocks of harvested wood products can also contribute (not estimated in the report).

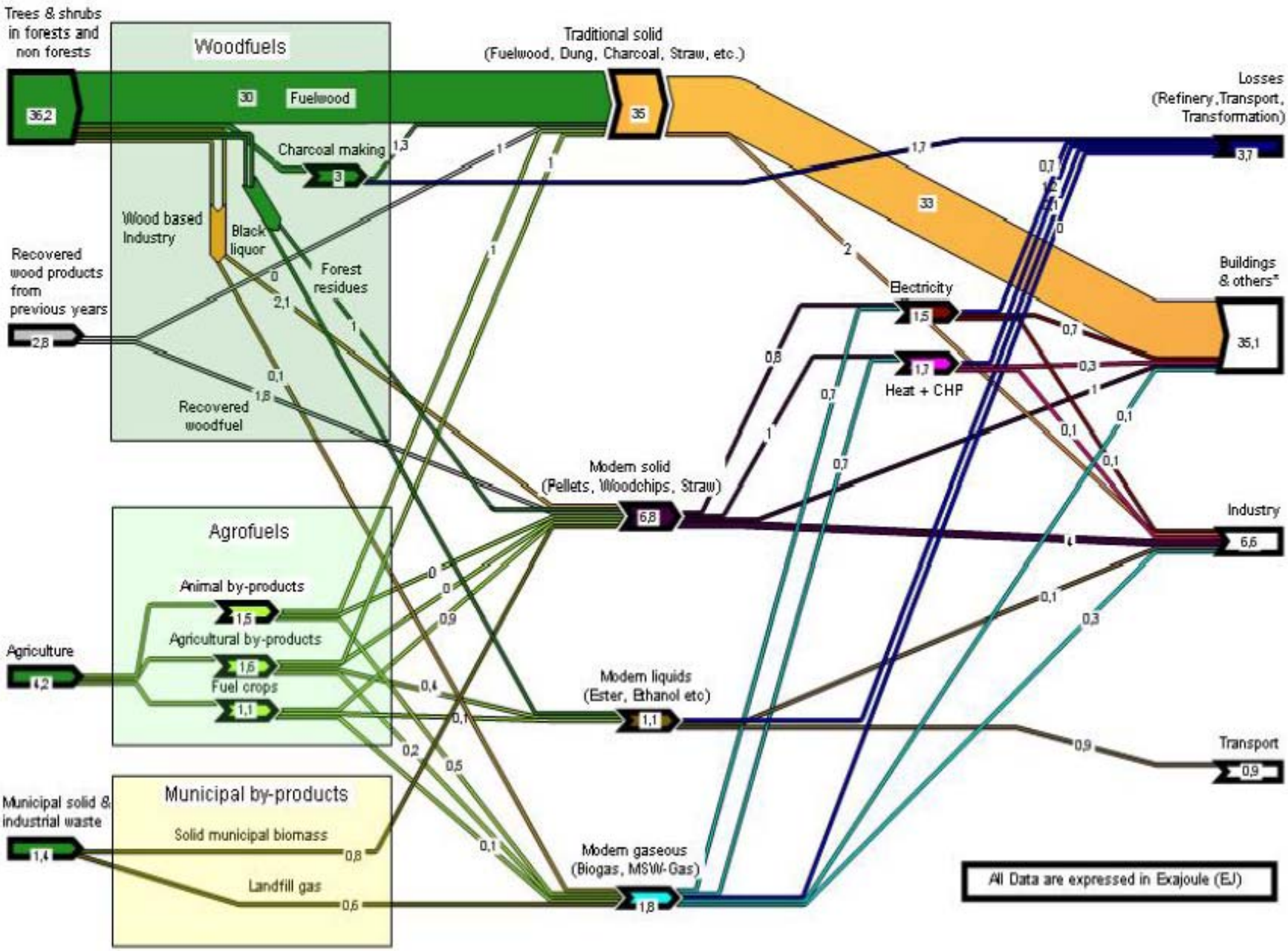


Figure 4.14: *World biomass energy flows (EJ/yr) in 2004 and their thermochemical and biochemical conversion routes to produce heat, electricity and biofuels for use by the major sectors.*

Note: much of the data is very uncertain, although a useful indication of biomass resource flows and bioenergy outputs still results.

Conclusions

- Potential for GHG mitigation through forests and forest products is significant
  - Carbon sequestration
  - Reducing deforestation
  - Biomass energy
- Systems view is essential (carbon stock changes, energy and materials substitution, energy inputs)
- Trade-offs between C sequestration and bioenergy
  - Biomass productivity is key
  - Use biomass efficiently to replace fossil fuels
  - Focus on lands that are depleted in C stocks (degraded lands) → both C sequestration and bioenergy benefits