BUILDINGENERGY BOSTON

# How Forests and Biogenic Carbon Can Convert Buildings into Carbon Sinks

Peter Pinchot (Whole Forest)
Garrett Siegers (Whole Forest)

Curated by Michael Simons (Abode)

Northeast Sustainable Energy Association (NESEA)
March 1, 2022

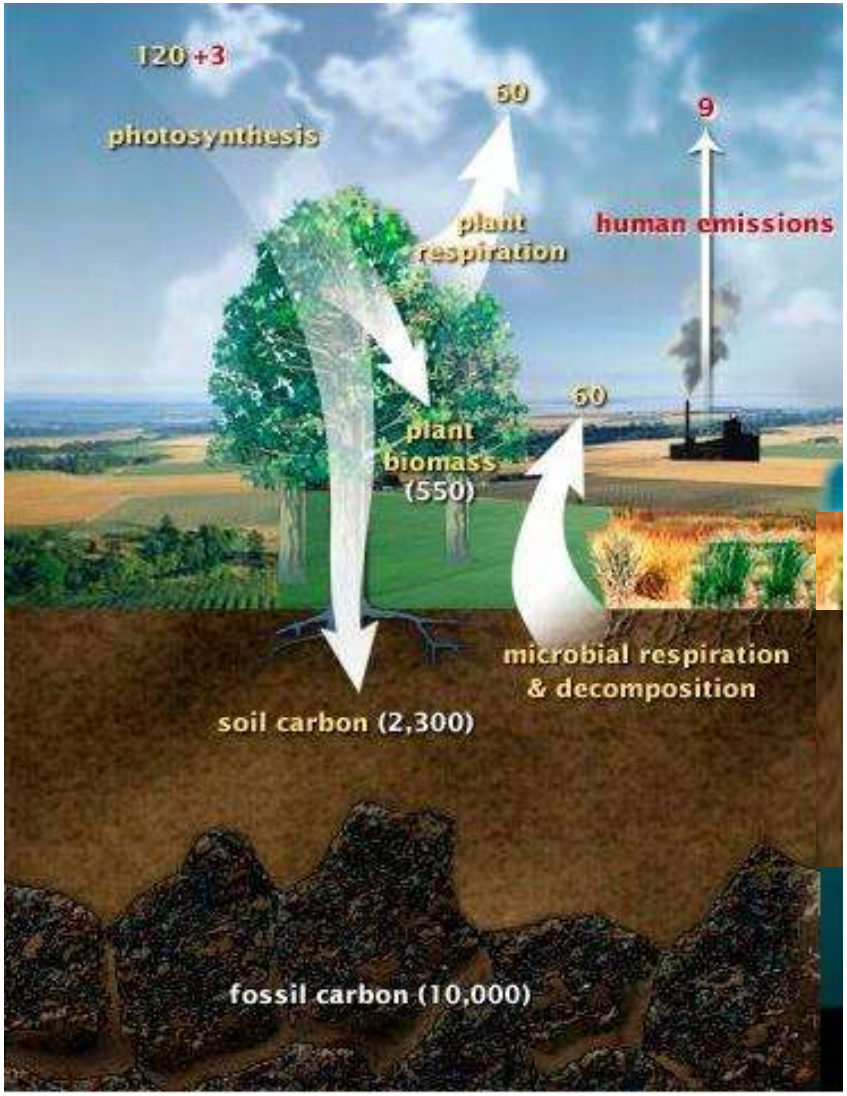
**Session Format: Three Presentations each followed by a 10-minute discussion**

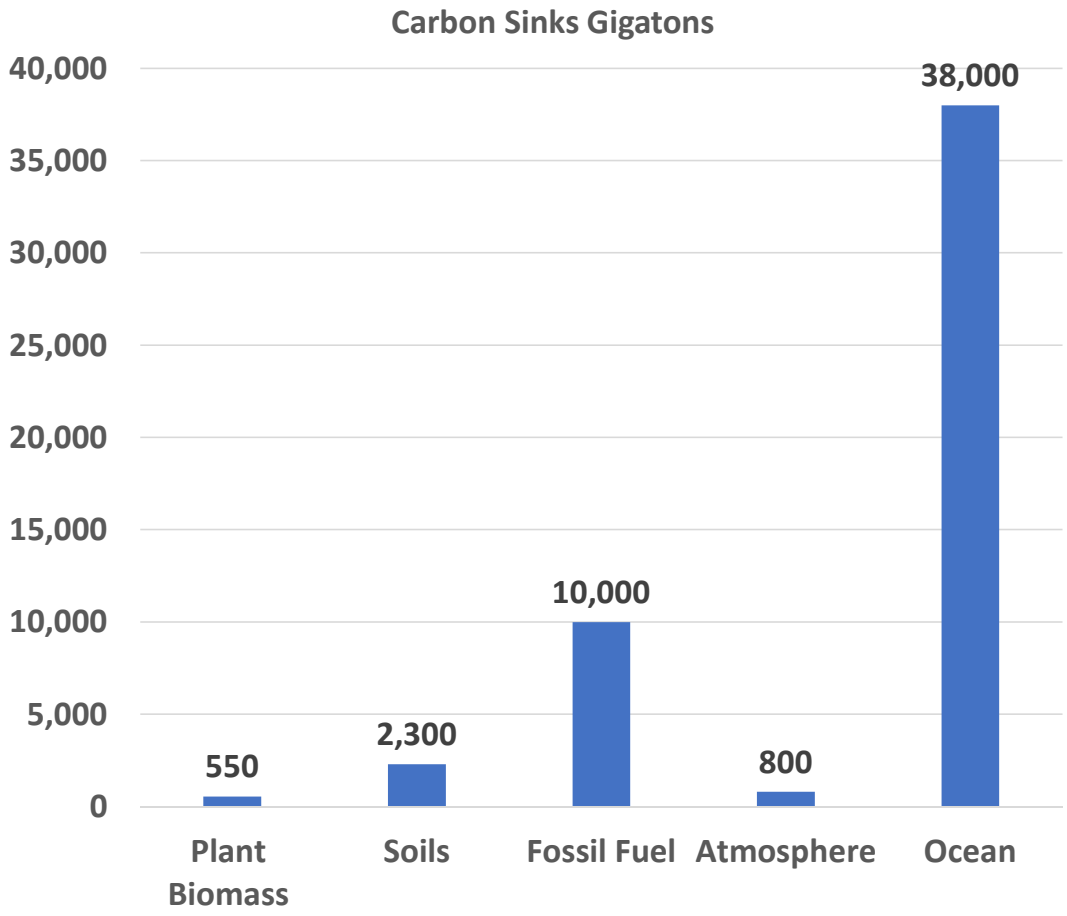
1) Carbon emissions and mitigation context: Forestry, Agriculture, and Buildings

2) Biogenic carbon materials: Opportunities, Carbon Accounting, Expanded LCA

3) New Biogenic Material Opportunity: Tropical Forest Products – Case Study

## Session 1: Carbon Emissions and Mitigations Context

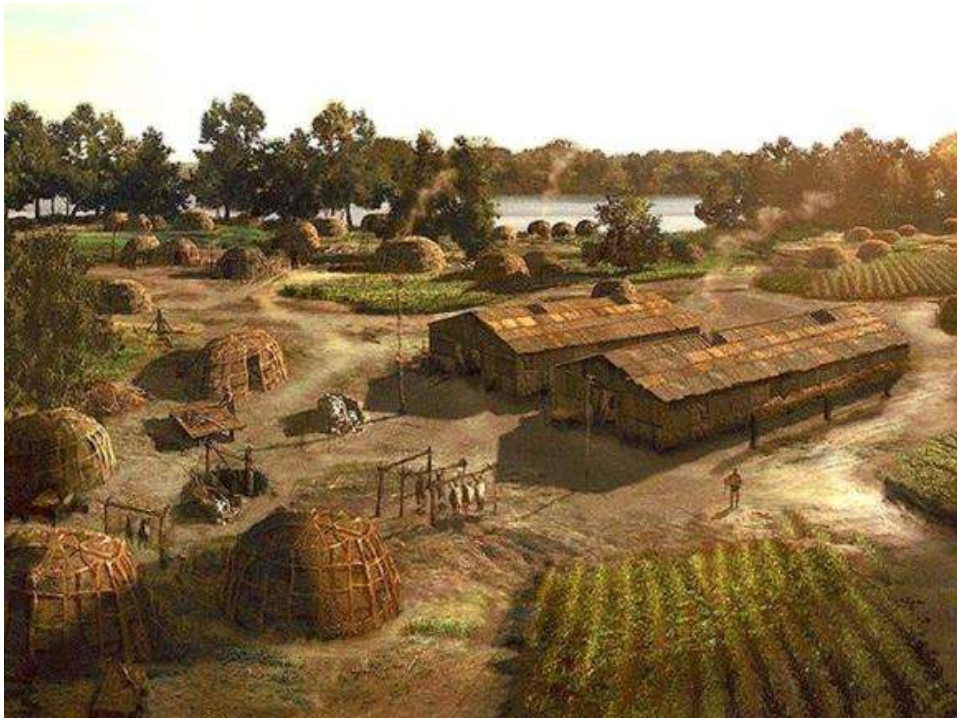


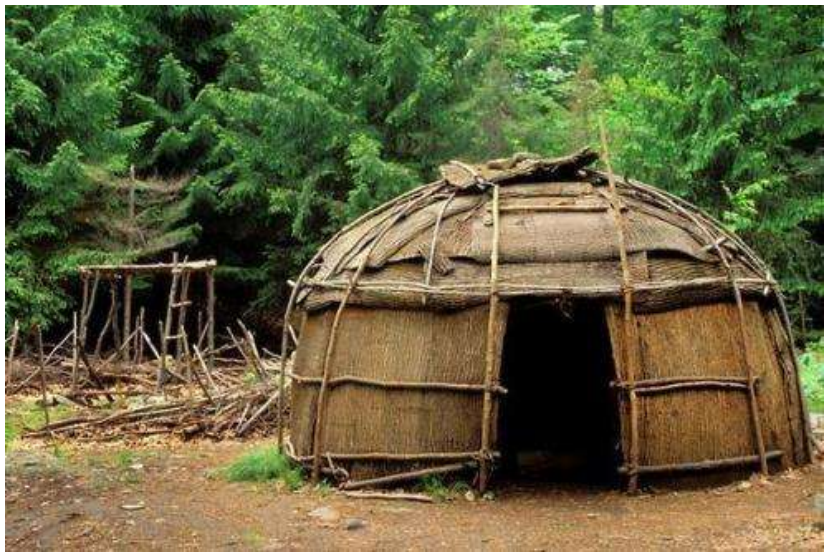

(Landscape carbon)

**Four Historic Stages of Landscape Management and Building Materials**

Act 1:  Indigenous culture, pre-European settlement



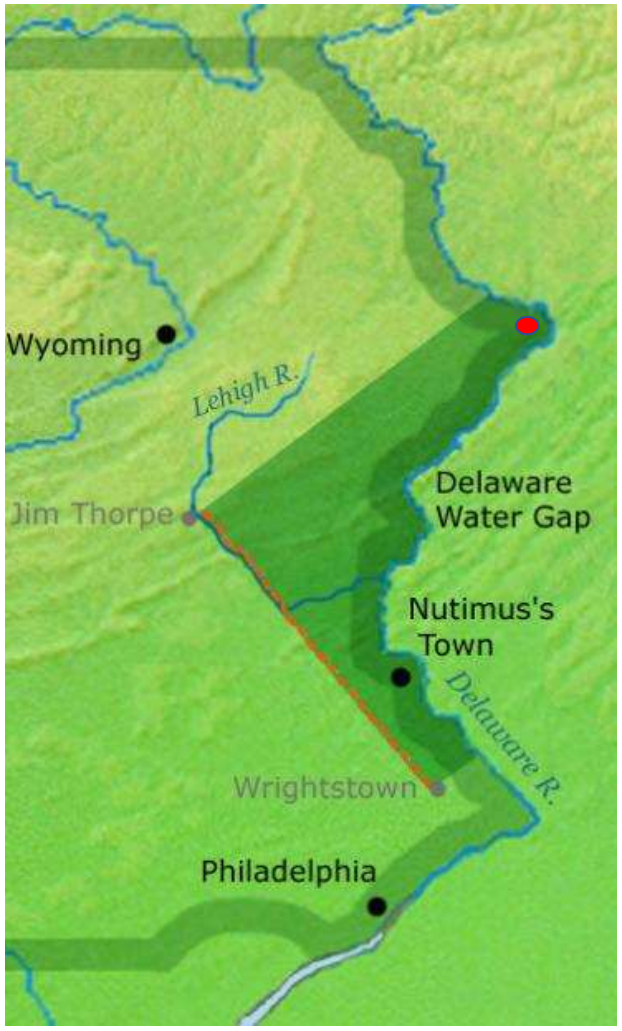
Shawnee Indian settlement



Re-creation of a Lenape hogan

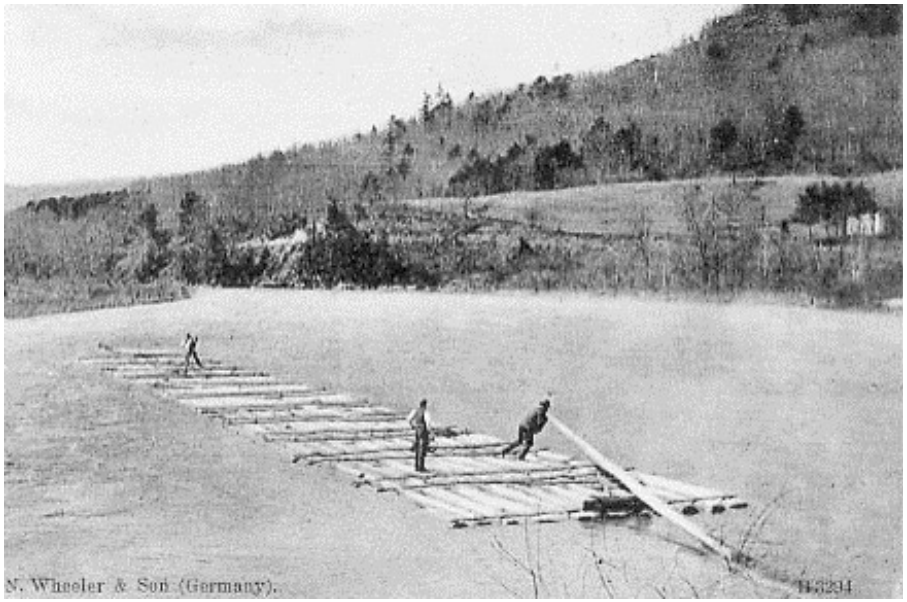
**Act 2: European settlement and land theft of Indian territory followed by deforestation**

1737: The Walking Purchase




Territory of Federally Recognized Indigenous Nations

**1800 to 1920 Timber Exploitation and Clearing Forest for Agriculture**



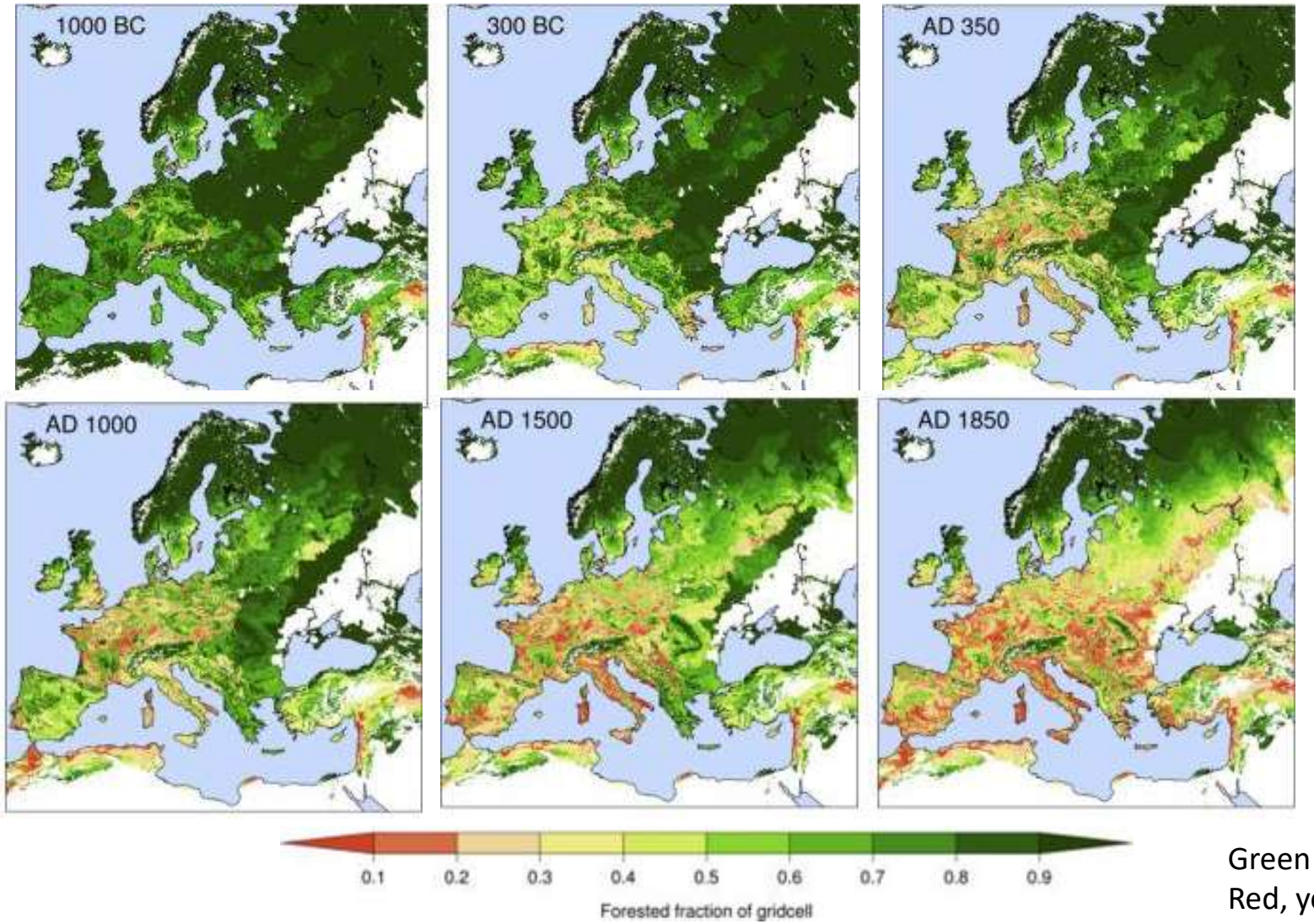


Deforestation of eastern old growth forests


Clearing for small-scale agriculture

Railroads in 1860s opened access to markets for lumber and agriculture

**Deforestation in Europe 1000 BC to 1850**




Green = forest.
Red, yellow = agriculture.

## Deforestation and Fossil Fuel Emissions: 30% Land Use Change

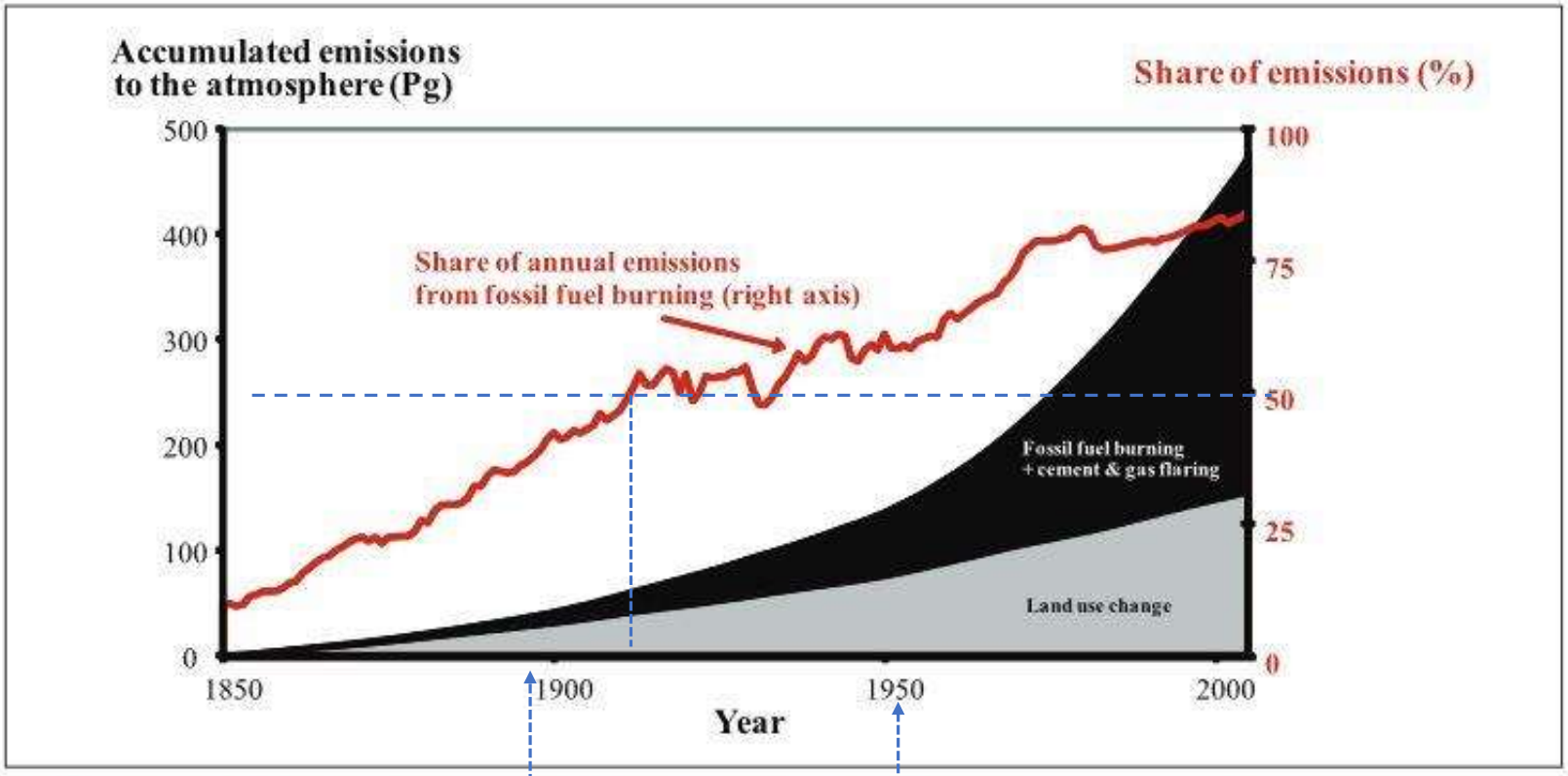



**Figure 2.** *Accumulated anthropogenic C emissions to the atmosphere since 1850. The contribution from cement manufacturing and gas flaring is 1-2% of the total accumulated emissions. Data source: The Carbon Dioxide Information Analysis Center (CDIAC) of the US Department of Energy (DOE).*

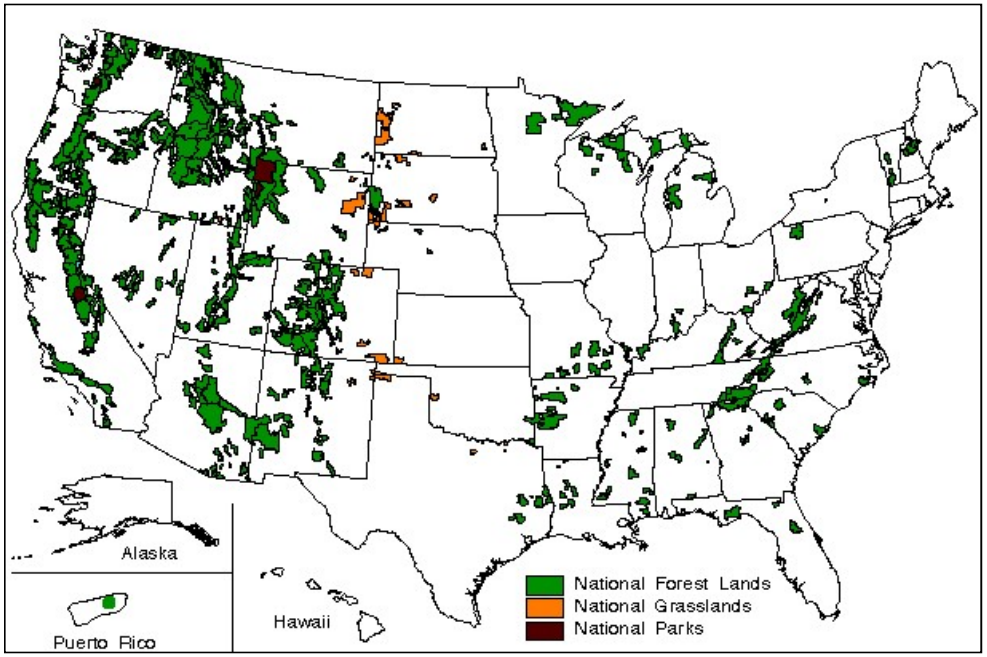
Temperate deforestation

Tropical deforestation

Early Settlement -- Wood, Stone, Brick, Plaster – Regional Low Emissions Materials

But Major Emissions from Deforestation and Land Use:  What is the embodied carbon of this wood?


## Act 3: Industrial Revolution, Fossil Fuels, and Conservation Movement to Protect Natural Resources




National Forests – 10% of US continent by 1908

BLM lands another 18% federally protected 1946


Secondary Forest Recovery

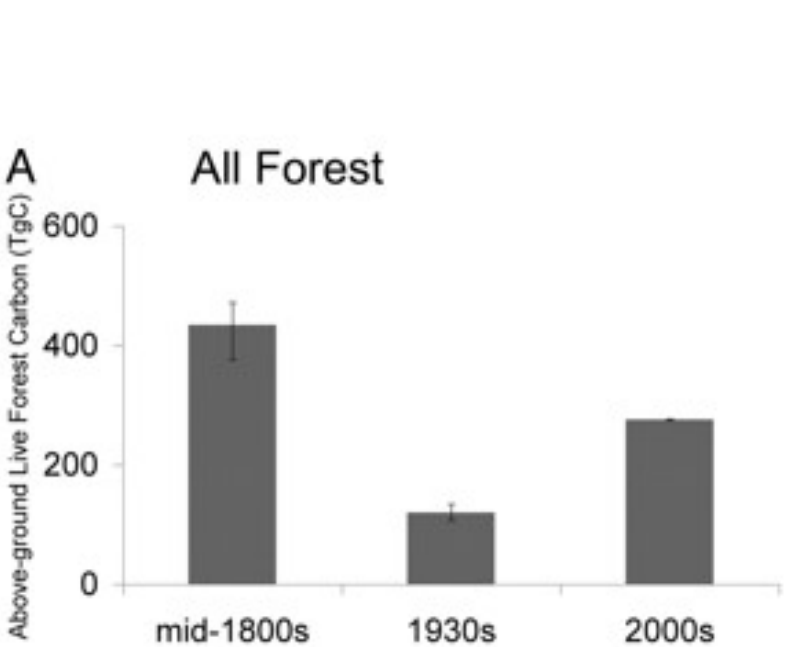
Emergence of forest products industry

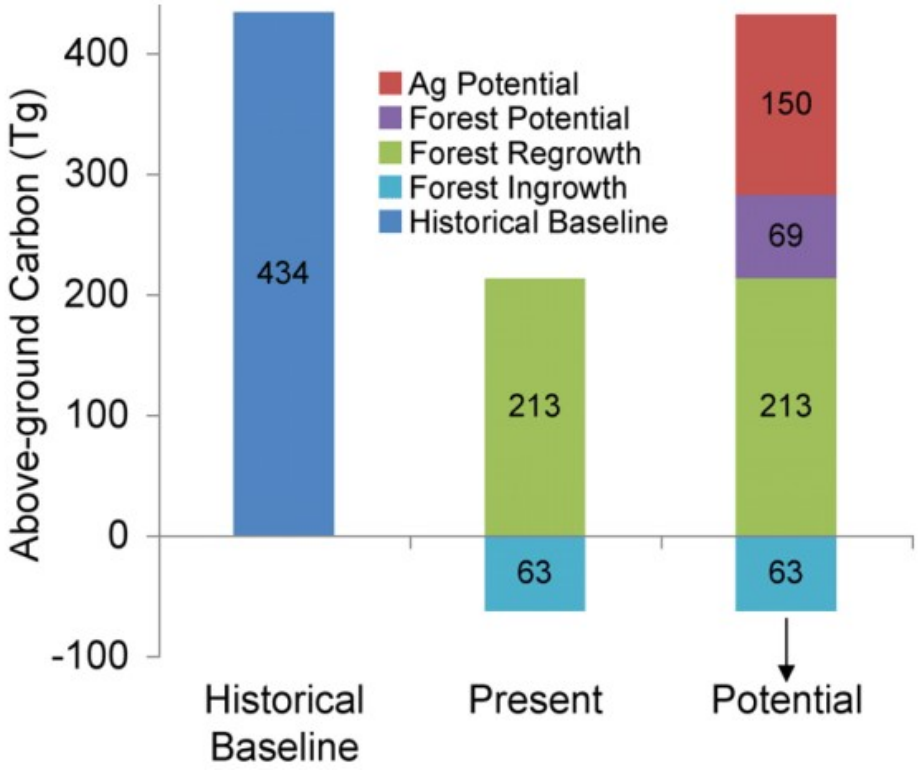
2018: 2.9 million jobs: $55 billion salaries

Landowner income $10.1 billion

https://nafoalliance.org/wpcontent/uploads/2018/11/Forest2Market_Economic_Impact_of_Privately-Owned_Forests_April2019.pdf

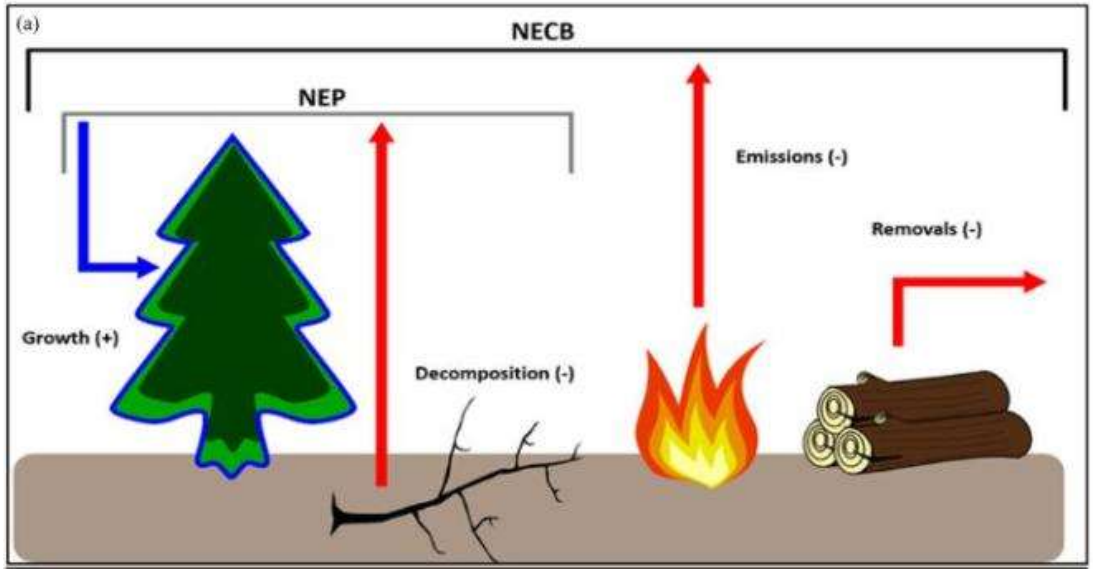
**Forest Carbon in Wisconsin -- Potential for Restoration Forestry**



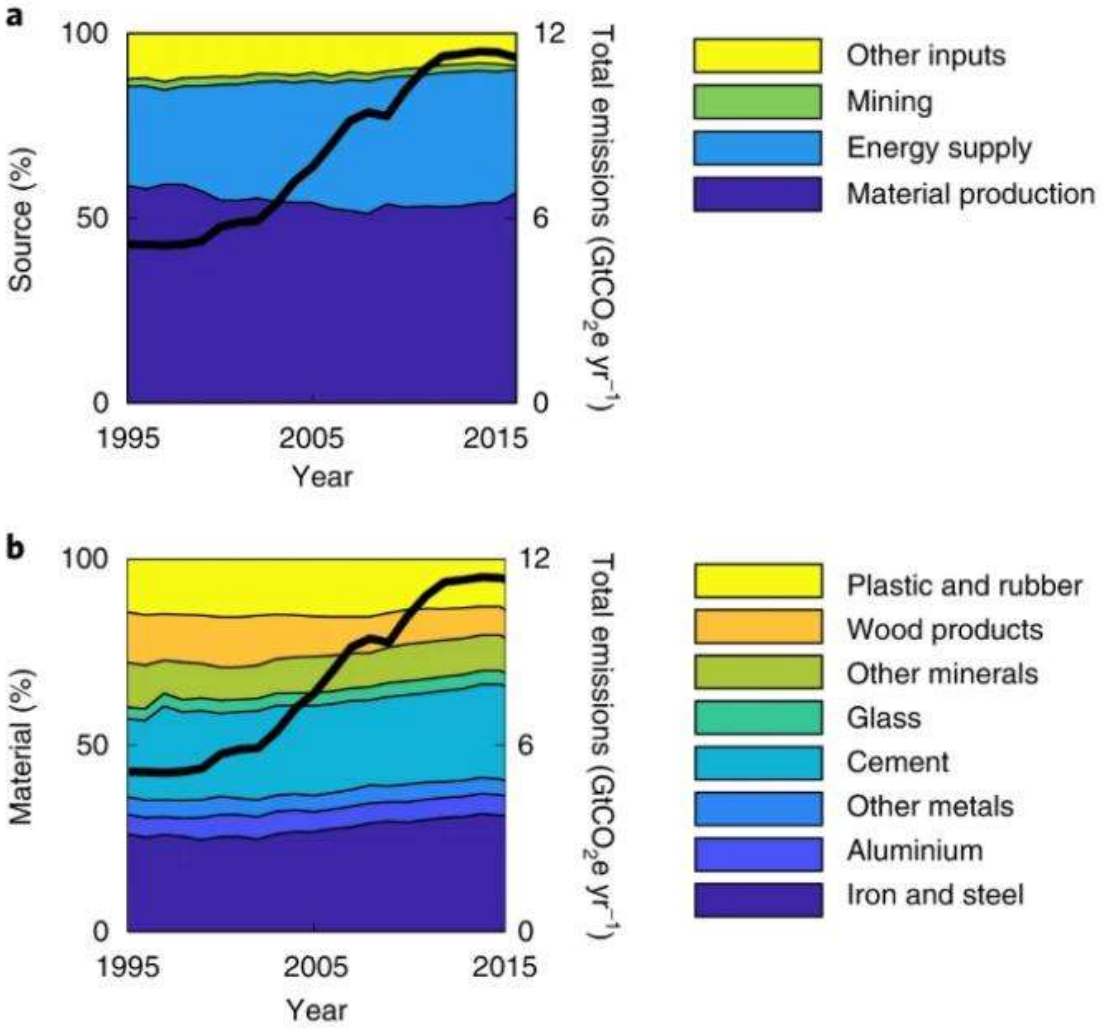

https://www.pnas.org/content/106/15/6082

## US Pacific Forests Regional Carbon Balance 2018




| Ecosystem | Washington | Oregon | California | Total |
|---|---|---|---|---|
| 1. Forested area (million hectares) | 9.7 | 12.4 | 11.9 | 34.0 |
| 2. Net ecosystem production (NEP) | **−89.9** | **−102.0** | **−99.8** | **−291.6** |
| 3. Fire emissions | 5.1 | 5.3 | 10.3 | 20.7 |
| 4. Harvest removals | 18.5 | 30.5 | 11.5 | 60.5 |
| Net ecosystem carbon balance (NECB) (sum of rows 1 through 4) | **− 66.4** | **−66.2** | **−78.0** | **−210.5** |

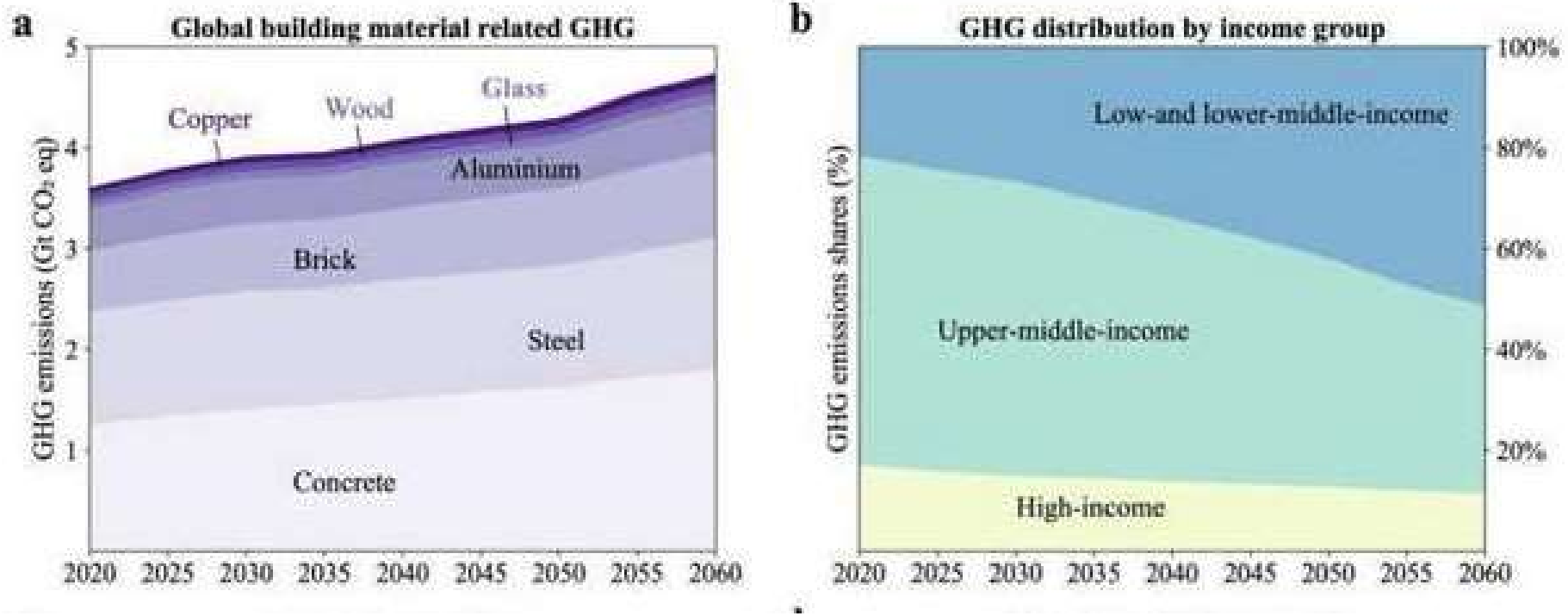
**Fig. 1: GHG emissions from material production.**




https://www.nature.com/articles/s41561-021-00690-8

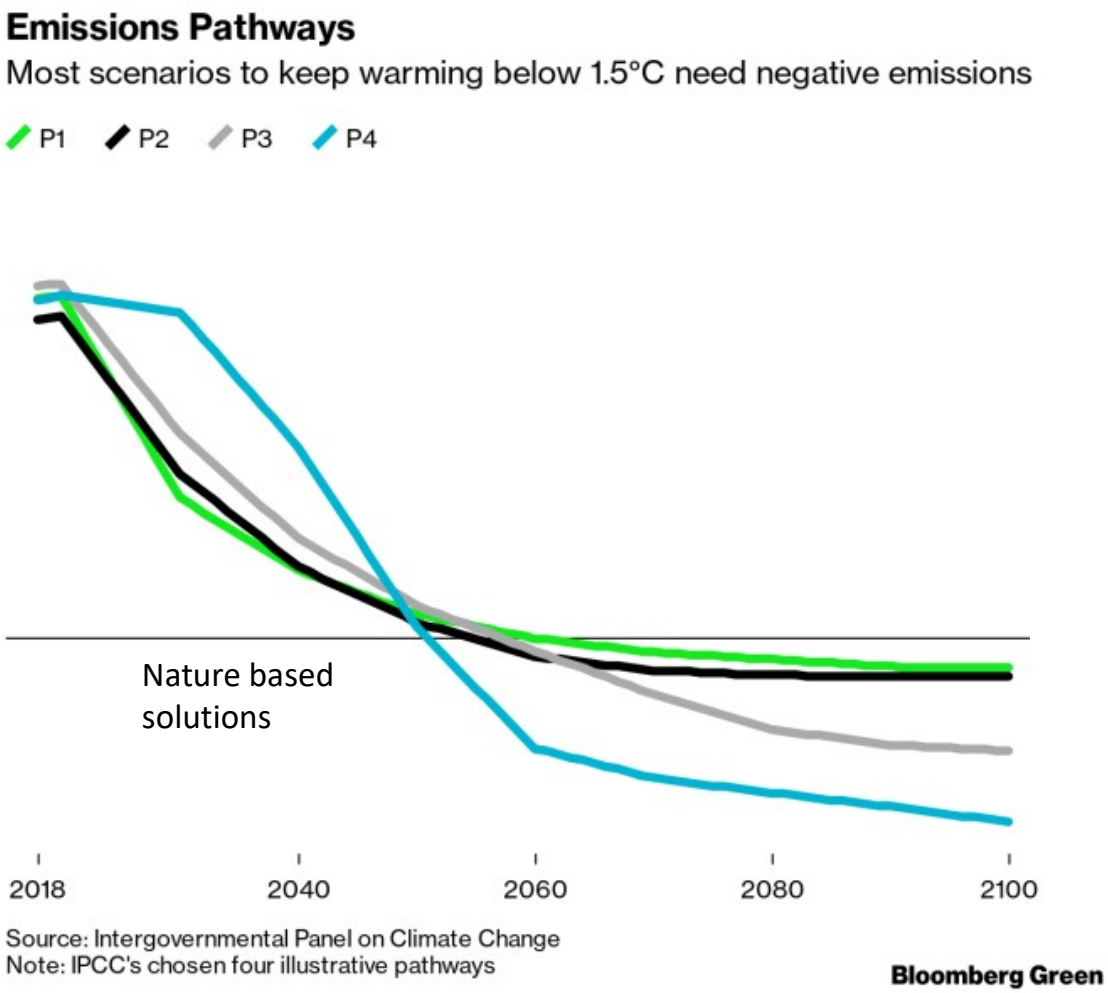
OCTOBER 21, 2021

# Building materials drive carbon emissions, and they're set to grow




https://phys.org/news/2021-10-materials-carbon-emissions-theyre.html

**Act 4: Managing Forests & Agriculture to Increase Carbon Sinks. Biogenic Materials to Reduce Building Carbon**

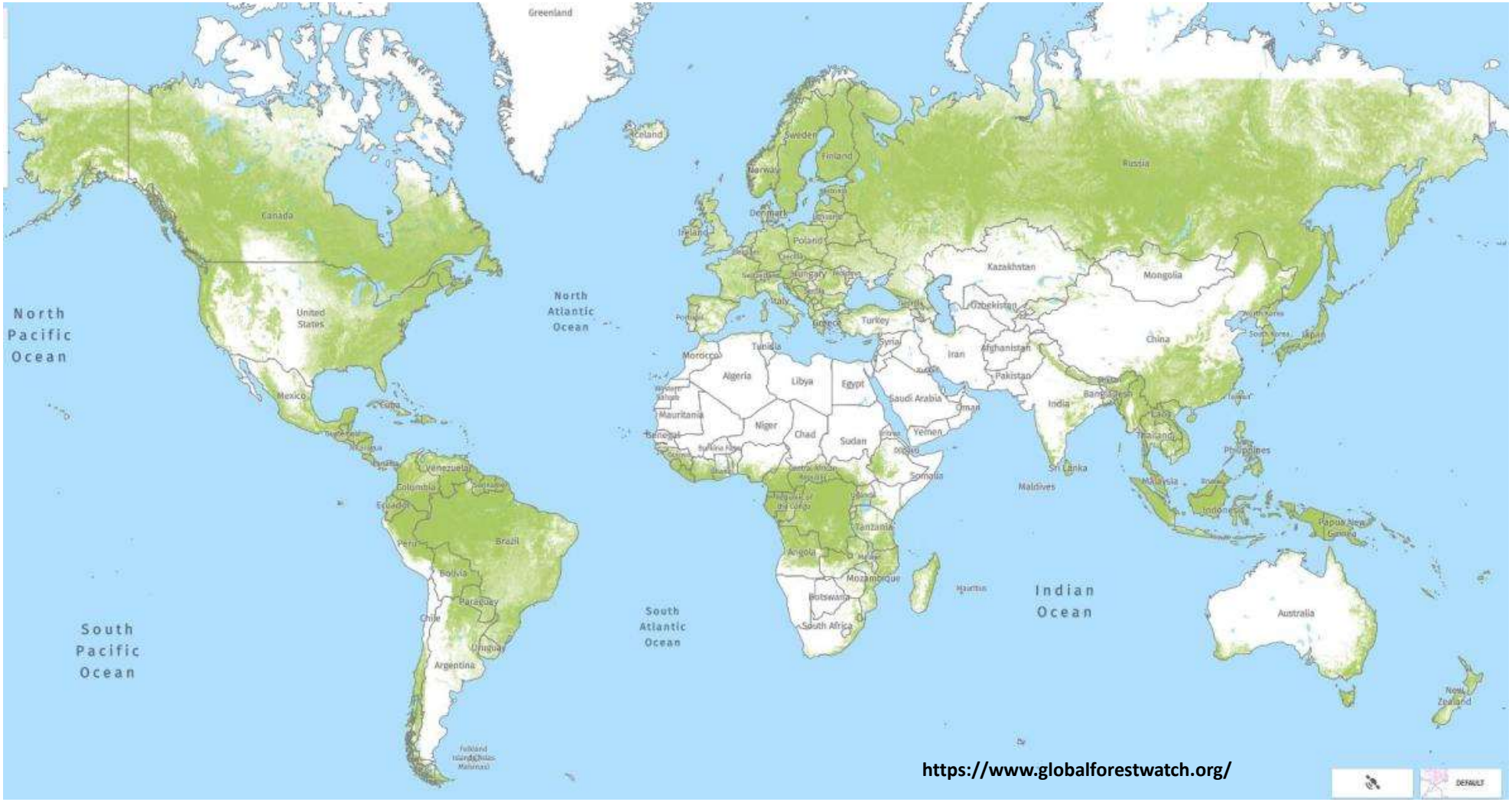



Carbon drawdown:

Nature Based Solutions next 20 years to sequester $CO_2$

Innovation in Geoengineering carbon capture and storage in geological sinks for later

**Global Forest Opportunity: Carbon Capture and Storage Infrastructure at Scale**



## Climate Positive Landscapes Producing Negative Carbon Building Materials

Expand carbon sinks and reduce emissions in forests and farms by climate smart management → Certify landscape carbon impact and gain carbon credits → Provide biogenic building products plus a large carbon benefit to building project → Provide a financial incentive for sustainable landscape practices by specifying biogenic products

US Greenhouse Gas Emissions and Sinks by IPCC Sector (MMT $CO_2^{Eq}$)

| IPCC Sector/Category | 1990 | 2005 | 2019 |
|---|---|---|---|
| Energy | 5,340.2 | 6,318.9 | 5,411.9 |
| Industrial Processes and Product Use | 346.2 | 365.9 | 378.2 |
| Agriculture | 551.9 | 573.6 | 622.9 |
| Waste | 214.2 | 175.6 | 159.6 |
| **Total Gross Emissions[a] (Sources)** | **6,452.5** | **7,433.9** | **6,572.5** |
| **LULUCF Sector Net Total[b]** | **(860.6)** | **(789.8)** | **(730.5)** |
| **Net Emission (Sources and Sinks)[c]** | **5,591.9** | **6,644.2** | **5,842.0** |

Agriculture emissions: 10%

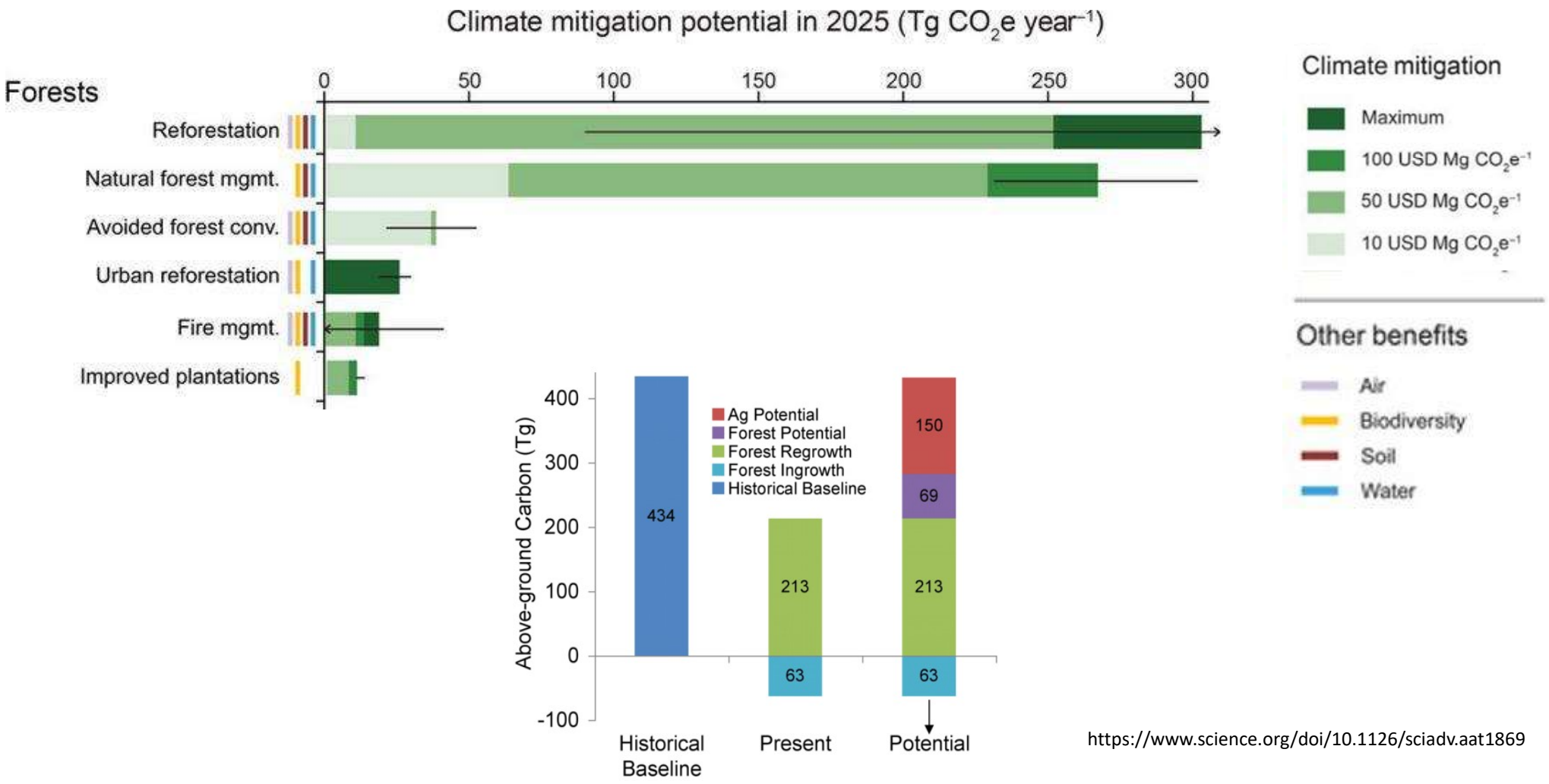
Forest sequestration: -12%

**Forest Carbon Balance Drives the Carbon Impact of Biogenic Building Materials**

Black Spruce forest carbon source or sink?

John Olver Design Building UMass

**Nature Based Solutions for Increasing Carbon Capture and Storage in US Forests**

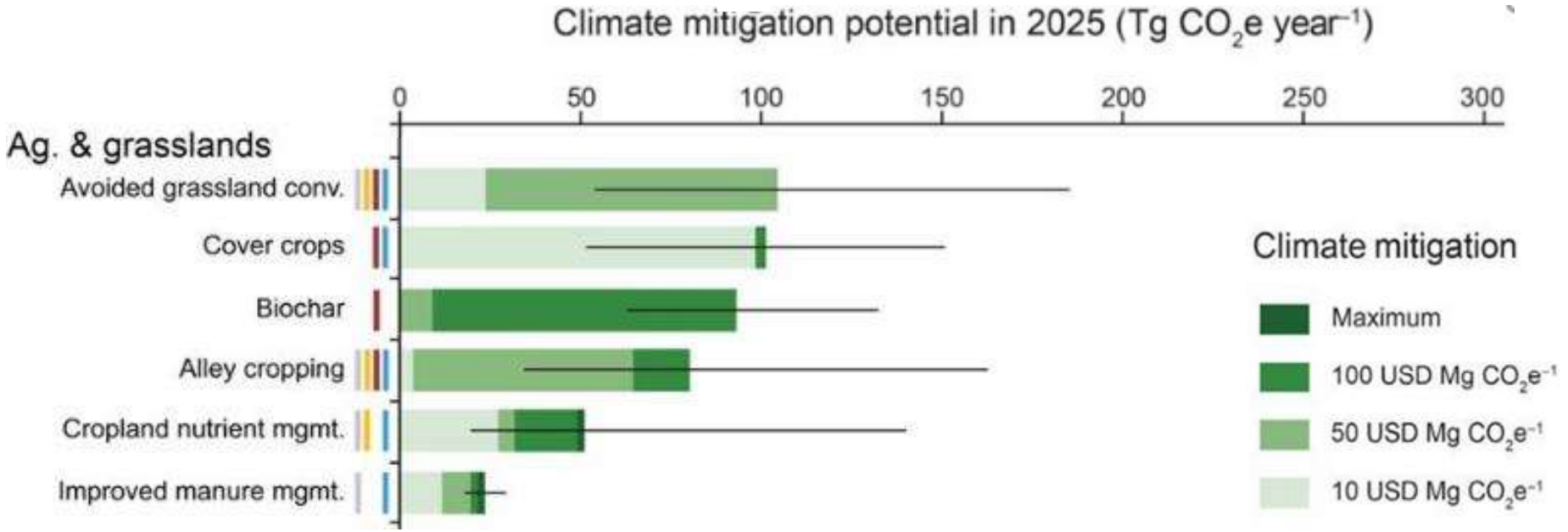



https://www.science.org/doi/10.1126/sciadv.aat1869

Agriculture = 10% of Total US Emissions: 60% From Nitrogen Fertilizer

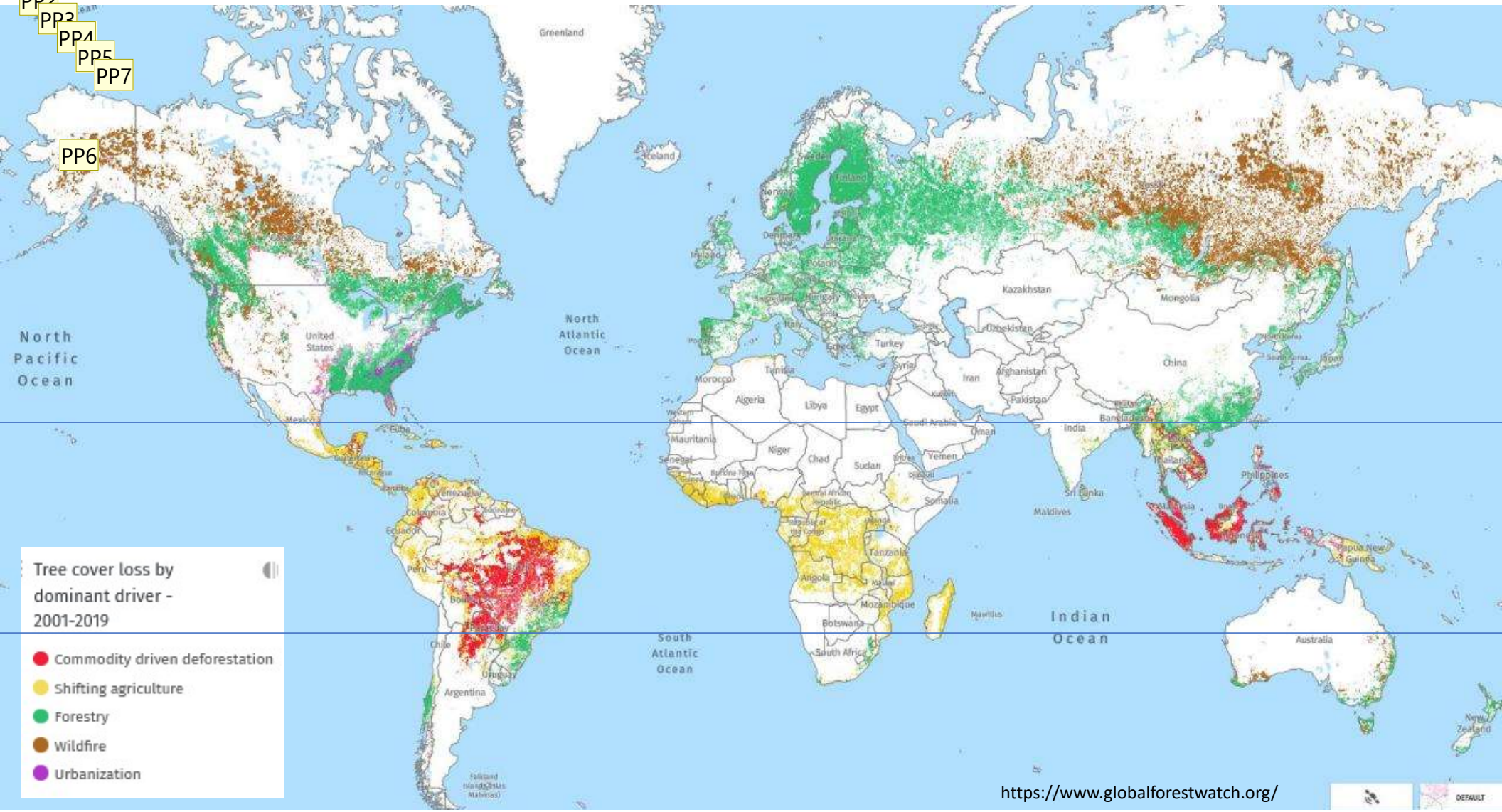
Intervention: Organic Farming or Regenerative Farming

**Reducing Emissions from US Agriculture**




https://www.science.org/doi/10.1126/sciadv.aat1869

# Forest Capture and Storage Opportunity




https://www.globalforestwatch.org/

**Slide 23**

**PP1** Double built environment by 260 -- huge material sdemand
Peter Pinchot, 9/24/2021

**PP2** Land Use Change -- 10 to 12% of emissions. Not slowing. UN REDD+ program. Needs funding. Carbon markets not enough $ to make a difference.
Peter Pinchot, 9/24/2021

**PP3** Forest communities in most tropical forests. Poor. Need economic opportunities. Drives deforestation and degradation.
Peter Pinchot, 9/24/2021

**PP4** Impact investment large scale wants to invest, but REDD+ not easily investible
Peter Pinchot, 9/24/2021

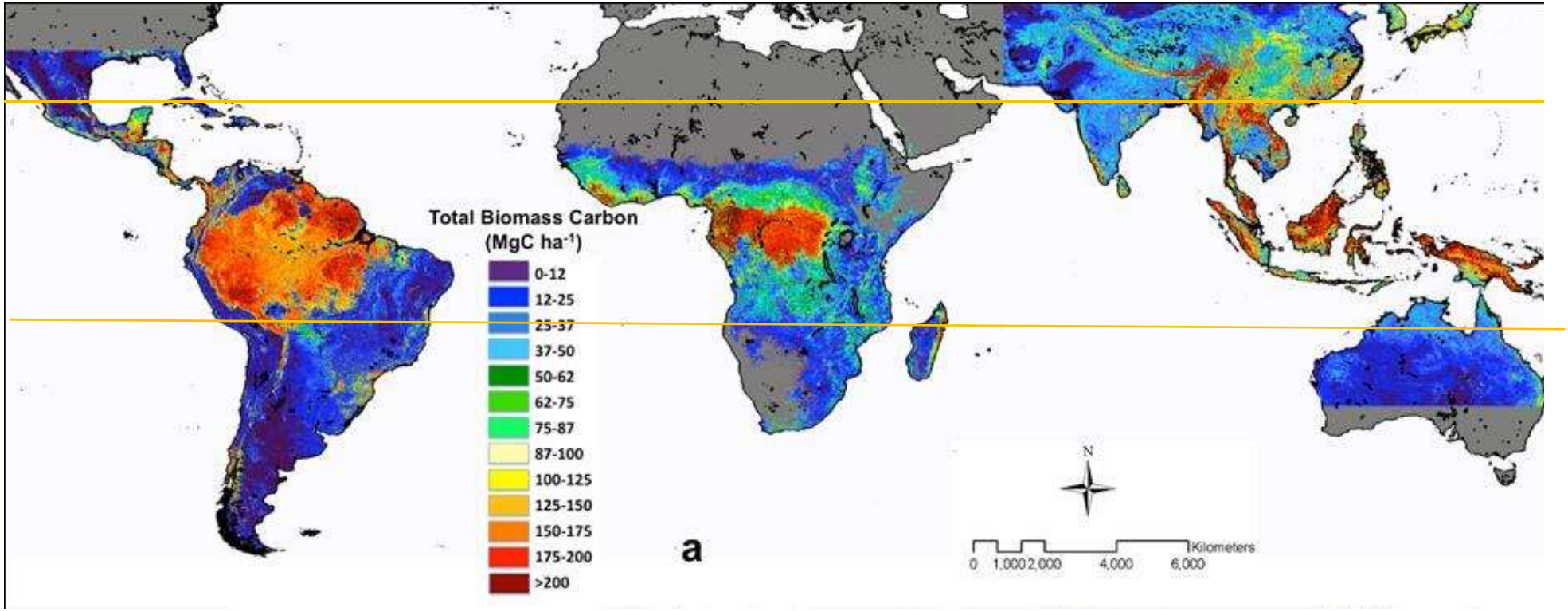
**PP5** Need business model that connects forests and communities to good markets to support conservation and restoration.
Peter Pinchot, 9/24/2021

**PP6** Wood product market for forests under Climate Smart Forestry management with Building markets -- certified carbon impact
Peter Pinchot, 9/24/2021

**PP7** Think beyond wood as renewable biogenic carbon building material. Think connecting buildings to forests and driving large carbo impact.
Peter Pinchot, 9/24/2021

## Carbon in Tropical Forests

920 gigatons of $CO_2^e$ stored in tropical forests (trees only) -- 20 years of global emissions at current rate

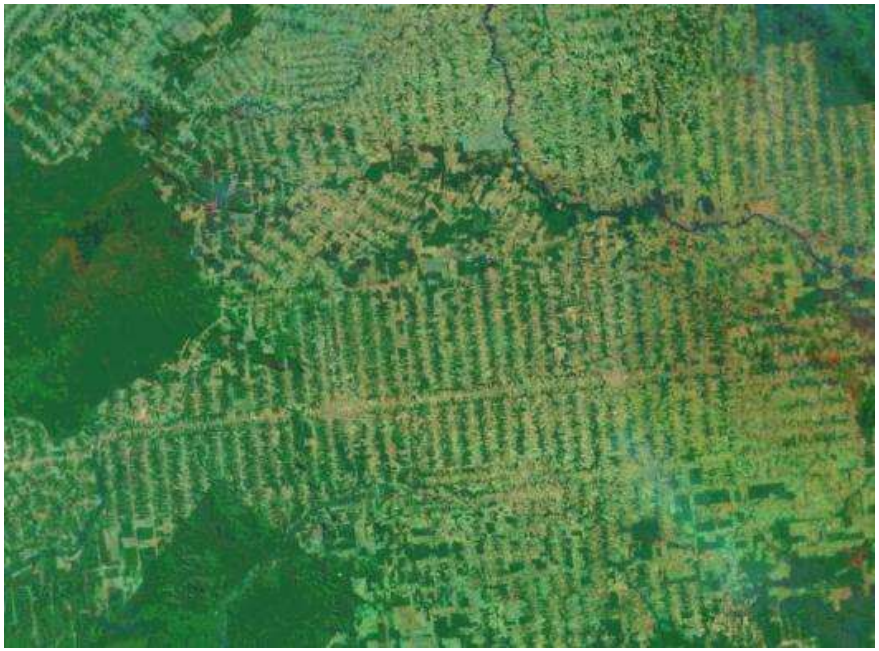



https://www.nasa.gov/topics/earth/features/earth20110531-i.html
https://www.sciencedaily.com/releases/2020/03/200304141623.htm

Architecture 2030
By 2030: 65% reduction in embodied carbon emissions,
By 2040:  Zero embodied carbon emissions

New York Declaration on Forests 2014
By 2030, a 50% reduction of deforestation.  By 2050, a 100% reduction
By 2030, Restore 350 million hectares of degraded landscapes and forestlands

Meeting the forestry targets would double forest carbon capture, potentially reducing global emissions by 25%.

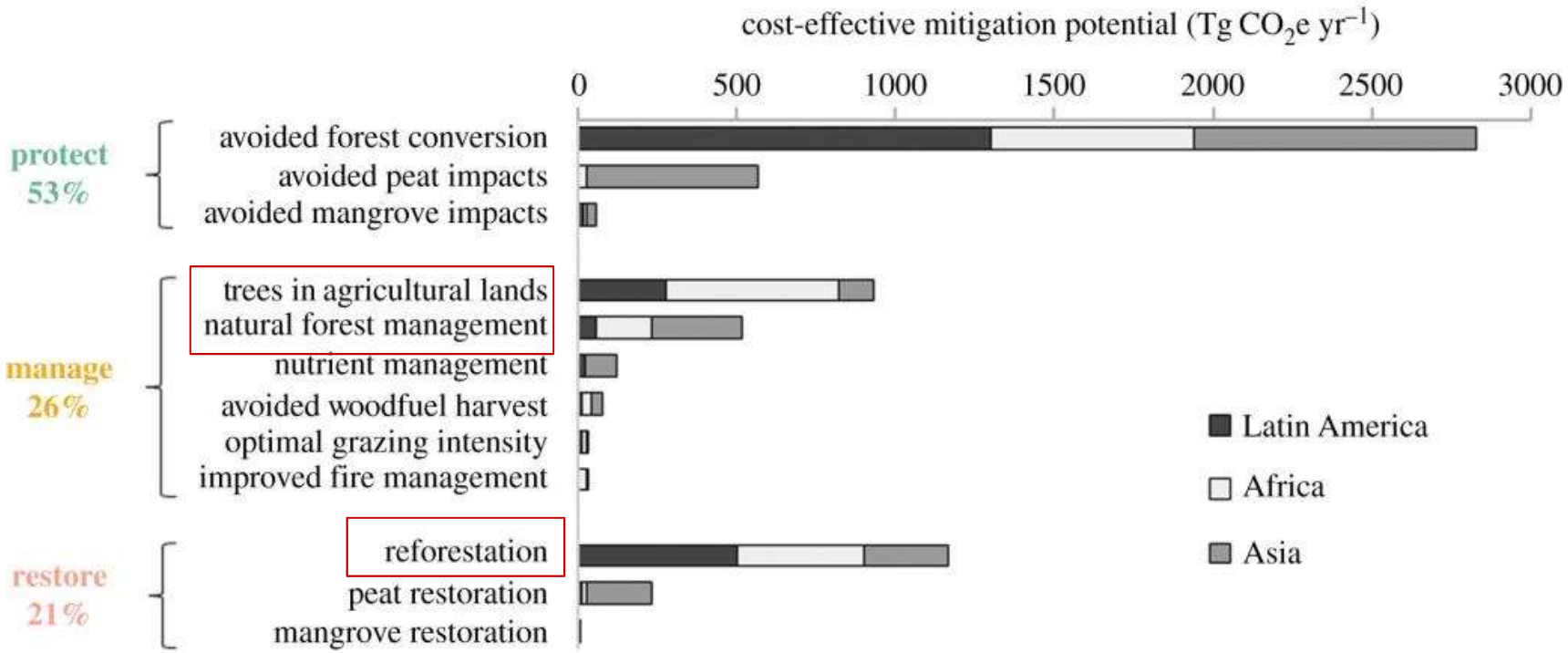


Deforestation Brazil

Degraded Land Early Restoration

**Natural Climate Solutions**

Climate Smart Forestry in Tropical Forests

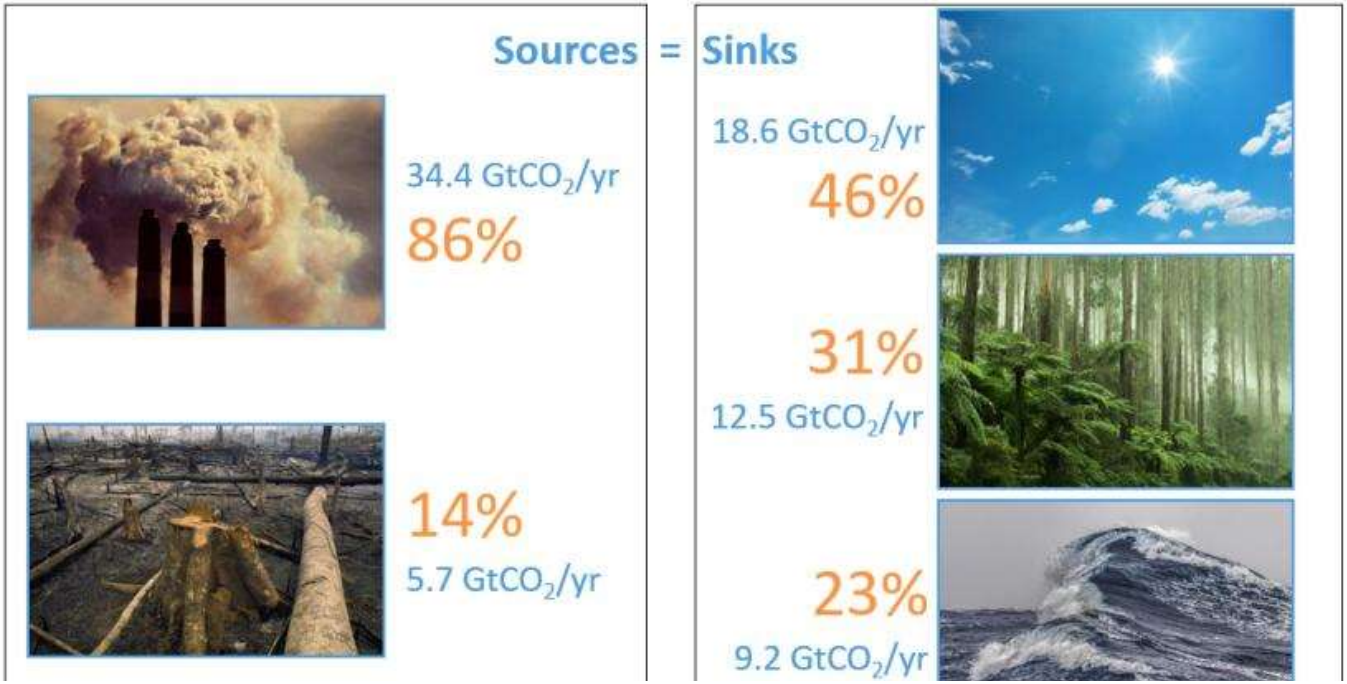



6 Gigatons $CO_2$e per year emissions reduction. Potential net mitigation of 27% of global fossil fuel emissions

https://www.pnas.org/content/114/44/11645

GLOBAL CARBON PROJECT

## Fate of anthropogenic $CO_2$ emissions (2010–2019)




Land use: deforestation and agriculture

2020 Forests
Net benefit = removal of 17% of global emissions

With Natural Climate Solutions
Estimated 30% total removal

Source: Friedlingstein et al 2020; Global Carbon Budget 2020

https://essd.copernicus.org/articles/12/3269/2020/


Discussion

Factors Supporting Evolution of Climate Smart Supply Chain – Forests to Biogenic Carbon Materials

February 3, 2022 | Climate Finance

## Rising price of carbon starts to hit balance sheets – and corporate decision-making

2021 Voluntary carbon prices rose from $7/ton to $15/ton for forestry mitigation projects.

https://impactalpha.com/rising-price-of-carbon-starts-to-hit-balance-sheets-and-corporate-decision-making/

Landscape opportunity Big ag emissions can be reduced N2O)and CH4

Big Forest Sequestration can be doubled

Climate risk hits wall street and corporations  ESG and Market for green solutions.

Carbon price skyrocketing

Impact investment in Climate Solutions Business Models  Forest, Agriculture, Green Building

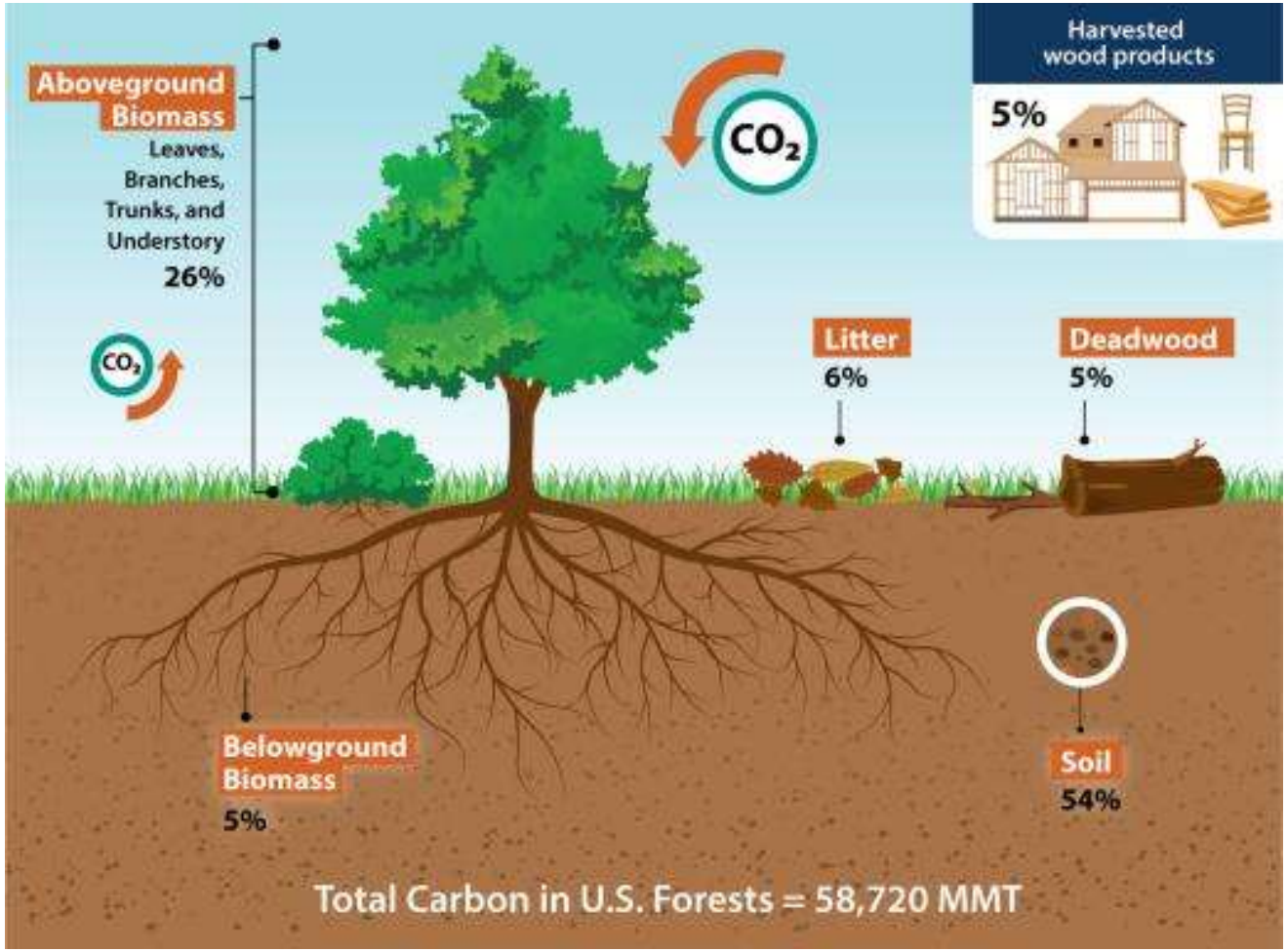
Connect innovation in forestry and agriculture climate management to innovation in biogenic building materials.  Requires carbon accounting in both sectors.

Global Climate Targets

IPCC goal to achieve 1.5 C cap
by 2030: 45% reduction below 2010 emissions
by 2050: Net zero emissions

Architecture 2030
By 2030: All new buildings and major renovations shall be carbon-neutral
By 2050:  All buildings will be net carbon zero
By 2030: 65% reduction in embodied carbon emissions,
By 2040:  Zero embodied carbon emissions

**US Forest Sinks – Carbon Capture and Storage in the Biosphere and in Buildings**




| | |
|---|---|
| Soil organic carbon | 54% |
| Above Ground Tree | 26% |
| Roots | 5% |
| Litter and Deadwood | 11% |
| Products | 5% |

Opportunity:  Managing Forests and Agriculture to Sequester Carbon and Provide Negative Carbon Building Materials

Climate Smart Forestry and Agriculture and Biogenic Building Materials
Manage landscapes for carbon sequestration – Restoration Forestry and Regenerative Agriculture

From Steel, Concrete, and Synthetics to Biogenic Building Materials

FSC is necessary,  but not adequate
Need to know the impact the biomass harvest is having on the carbon balance of the ecosystem.  Is it enhancing carbon sequestration?  Is the carbon balance after the harvest at least carbon neutral if not higher carbon storage?  That is the responsibility of green sourcing.  Best is carbon certification of the ecosystem including the harvest and the carbon performance until the next harvest cycle.  Lipke rotation carbon model.

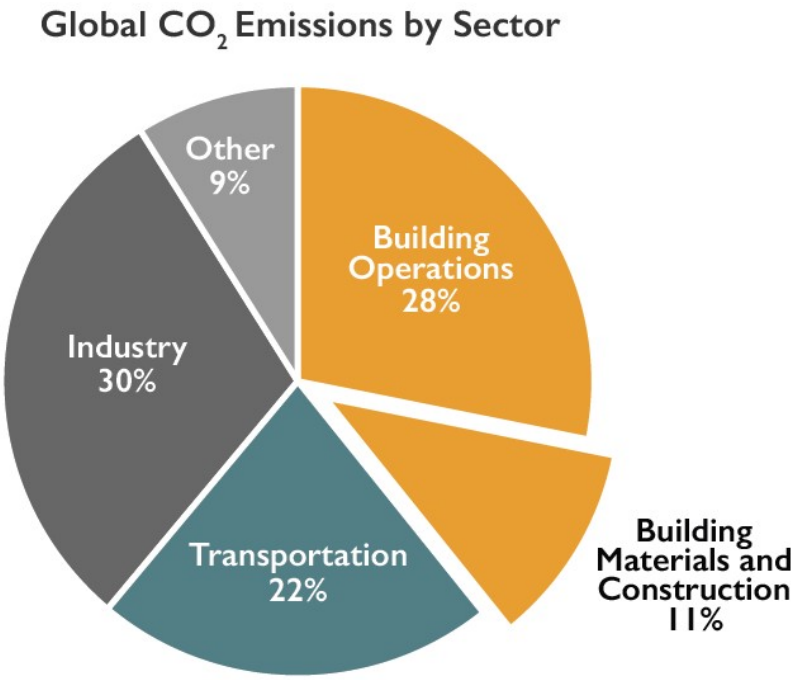
Managing Forests For Carbon Capture and Storage and for Forest Products

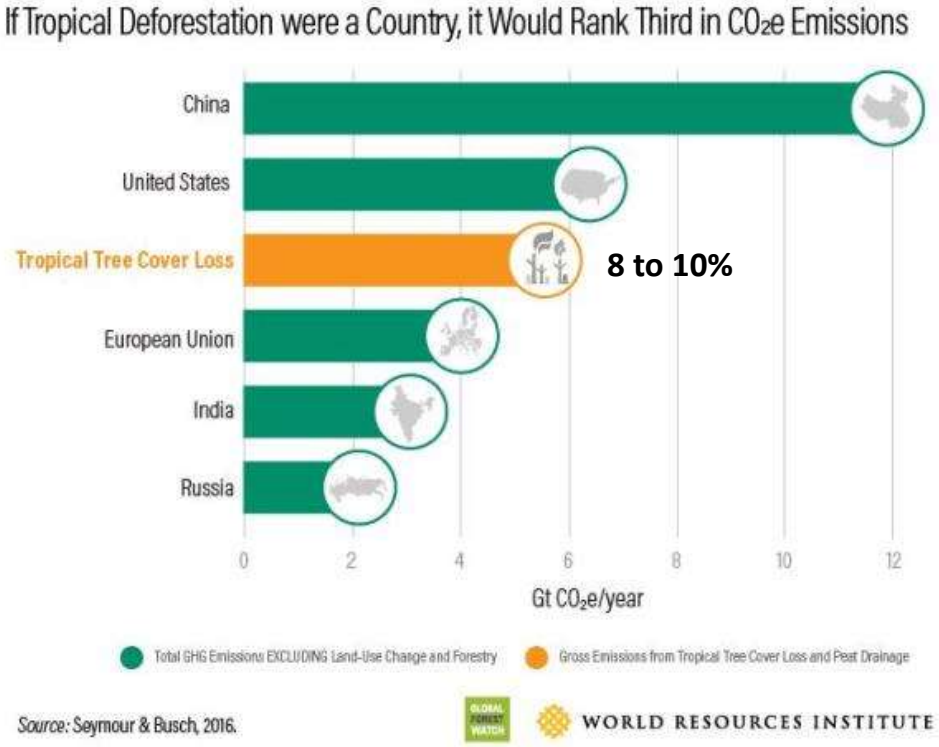
Capital Markets Responding to Climate Risk – Carbon Markets Doubled Price 2021
Blacklash against greenwashing and sustainability claims.  Impact investing soaring.

February 3, 2022 | Climate Finance

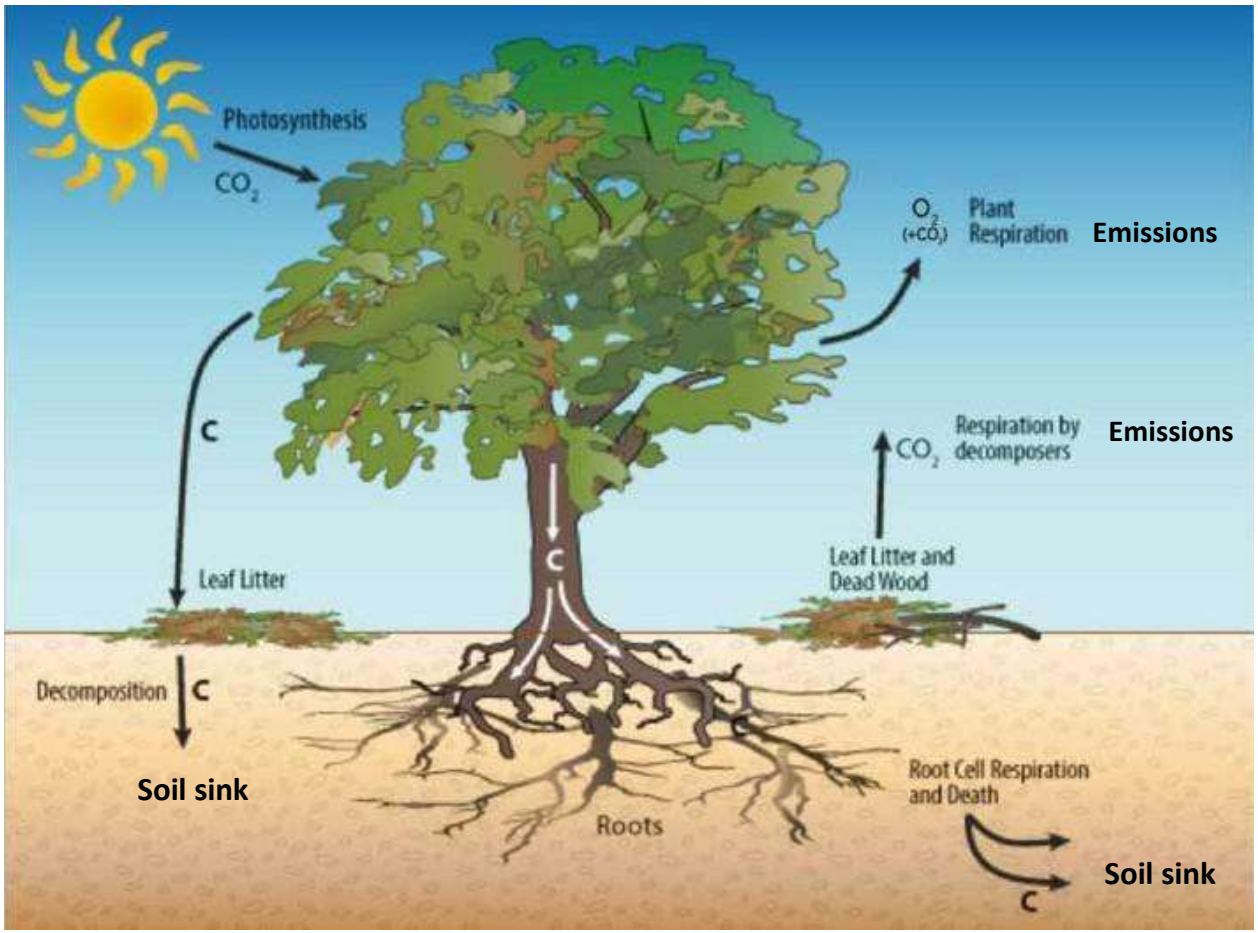
# Rising price of carbon starts to hit balance sheets – and corporate decision-making

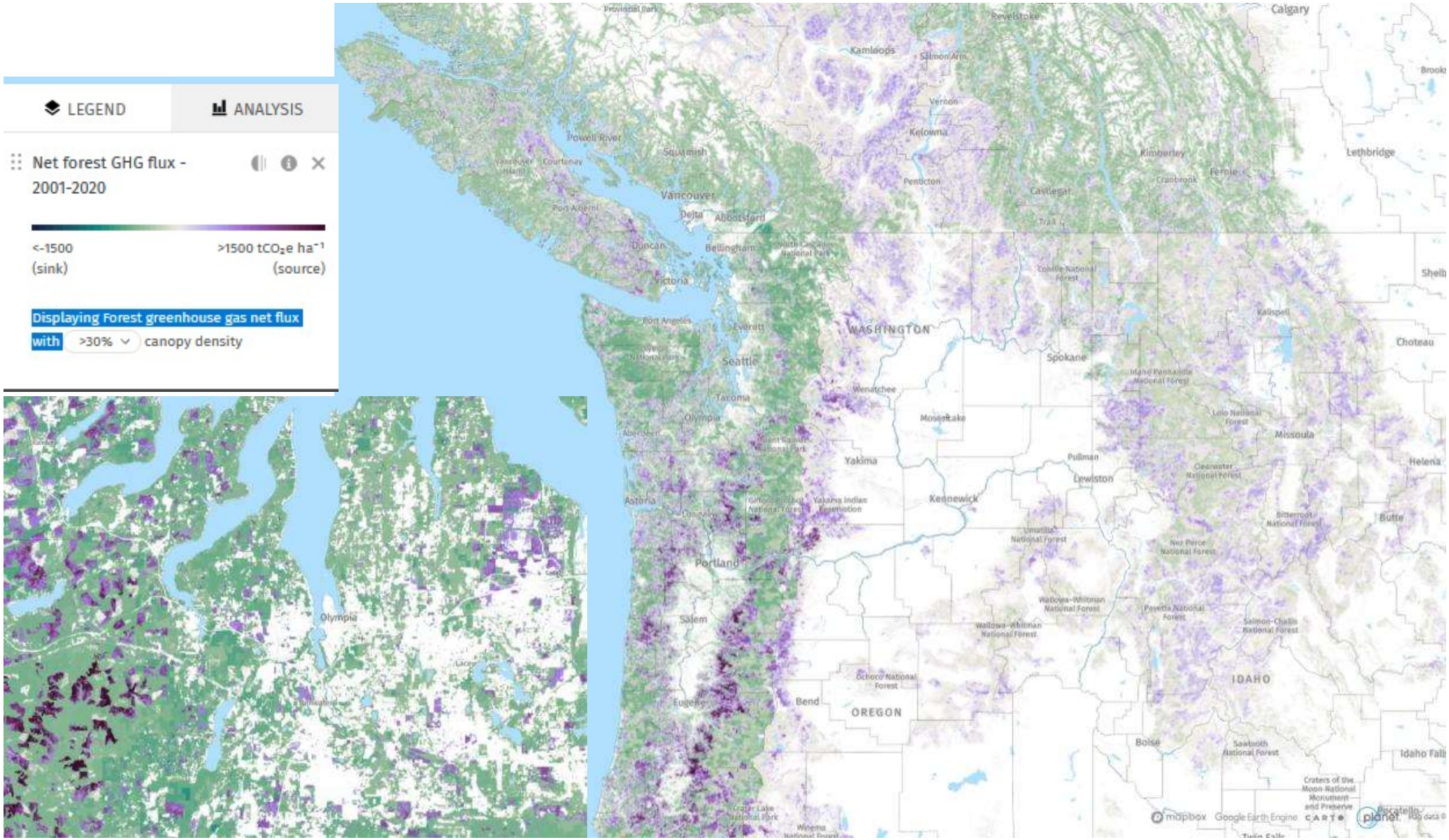
**Innovation in Biological Capture and Storage: Buildings, Forests, Agriculture**



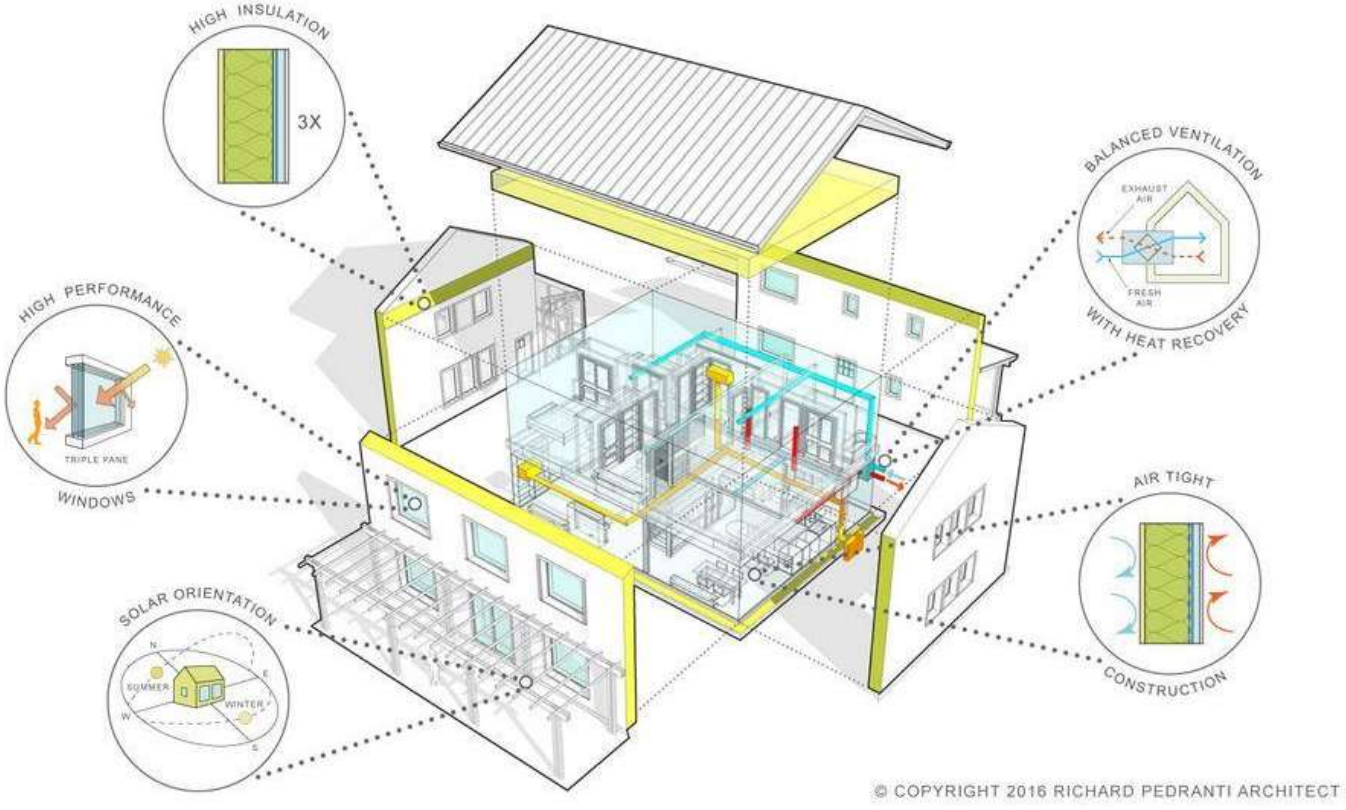



Ecosystem Carbon Dynamic:  Management Goal is Increasing Carbon Sinks

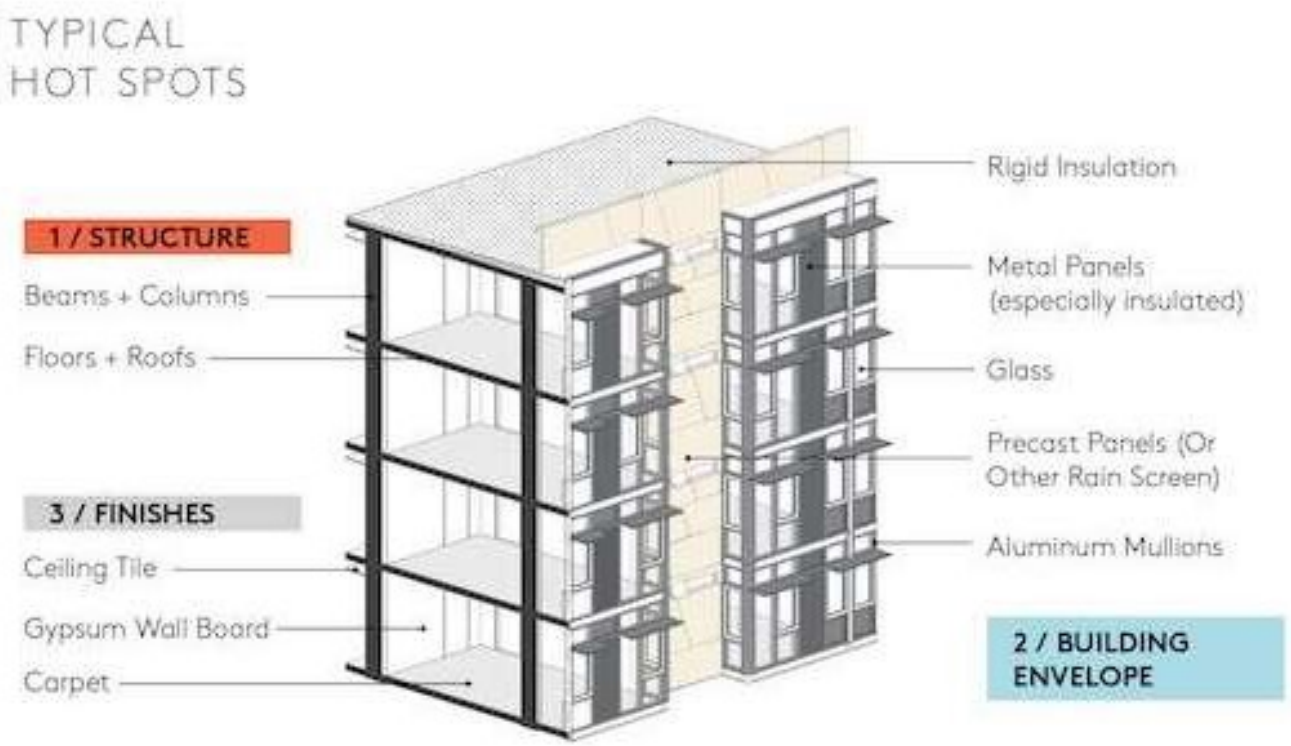



LEGEND
ANALYSIS
Net forest GHG flux - 2001-2020
<-1500 (sink)
>1500 tCO₂e ha⁻¹ (source)
Displaying Forest greenhouse gas net flux
with >30% canopy density
Calgary
Kamloops
Revelstoke
Vernon
Kelowna
Penticton
Kimberley
Cranbrook
Lethbridge
Powell River
Squamish
Vancouver
Abbotsford
Duncan
Victoria
Bellingham
Port Angeles
Everett
Seattle
Tacoma
Olympia
WASHINGTON
Spokane
Wenatchee
Moses Lake
Yakima
Pullman
Lewiston
Kennewick
Missoula
Helena
Butte
Portland
Salem
Eugene
Bend
OREGON
IDAHO
Boise
Olympia
mapbox
Google Earth Engine
CARTO
planet.

**Strategies to Reduce Operating Energy**
**Passive House, Net Zero**



## Highest Embodied Carbon Materials: Concrete, Steel, Aluminum

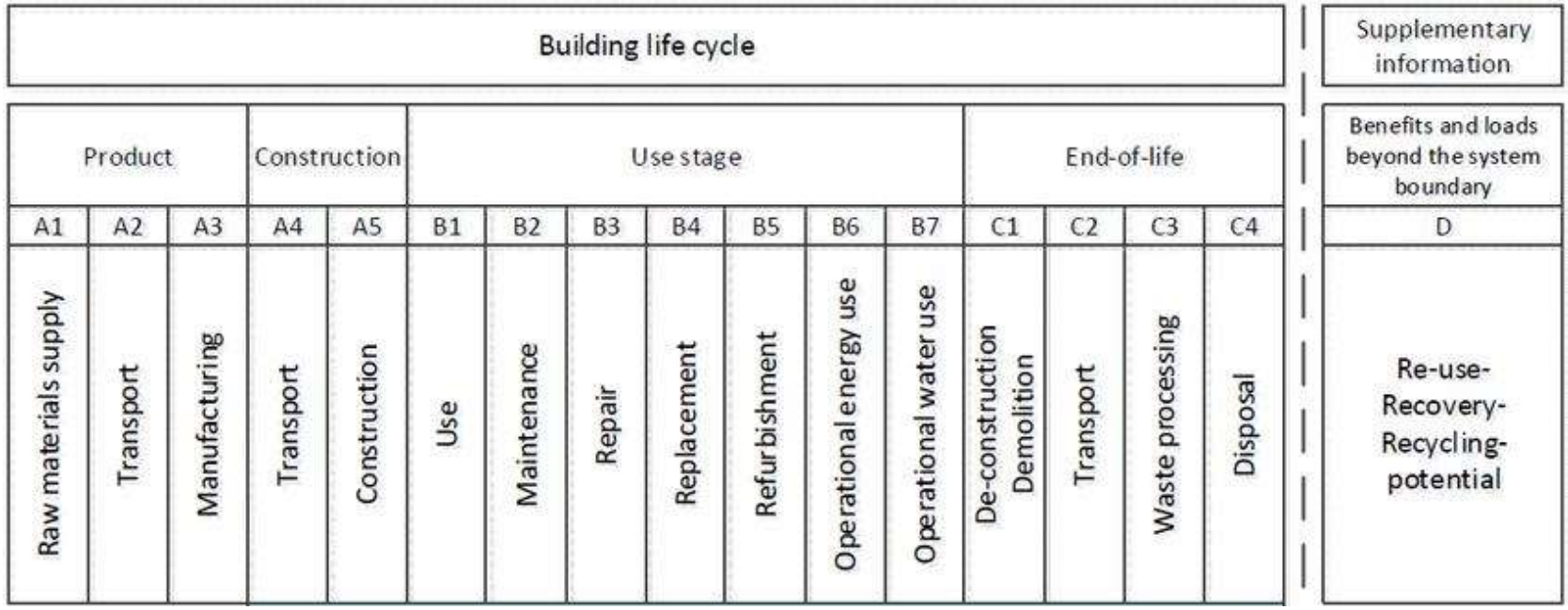



https://www.buildinggreen.com/feature/urgency-embodied-carbon-and-what-you-can-do-about-it

MITHŪN

## Quantifying Embodied Carbon of a Building Material

## Life Cycle Analysis

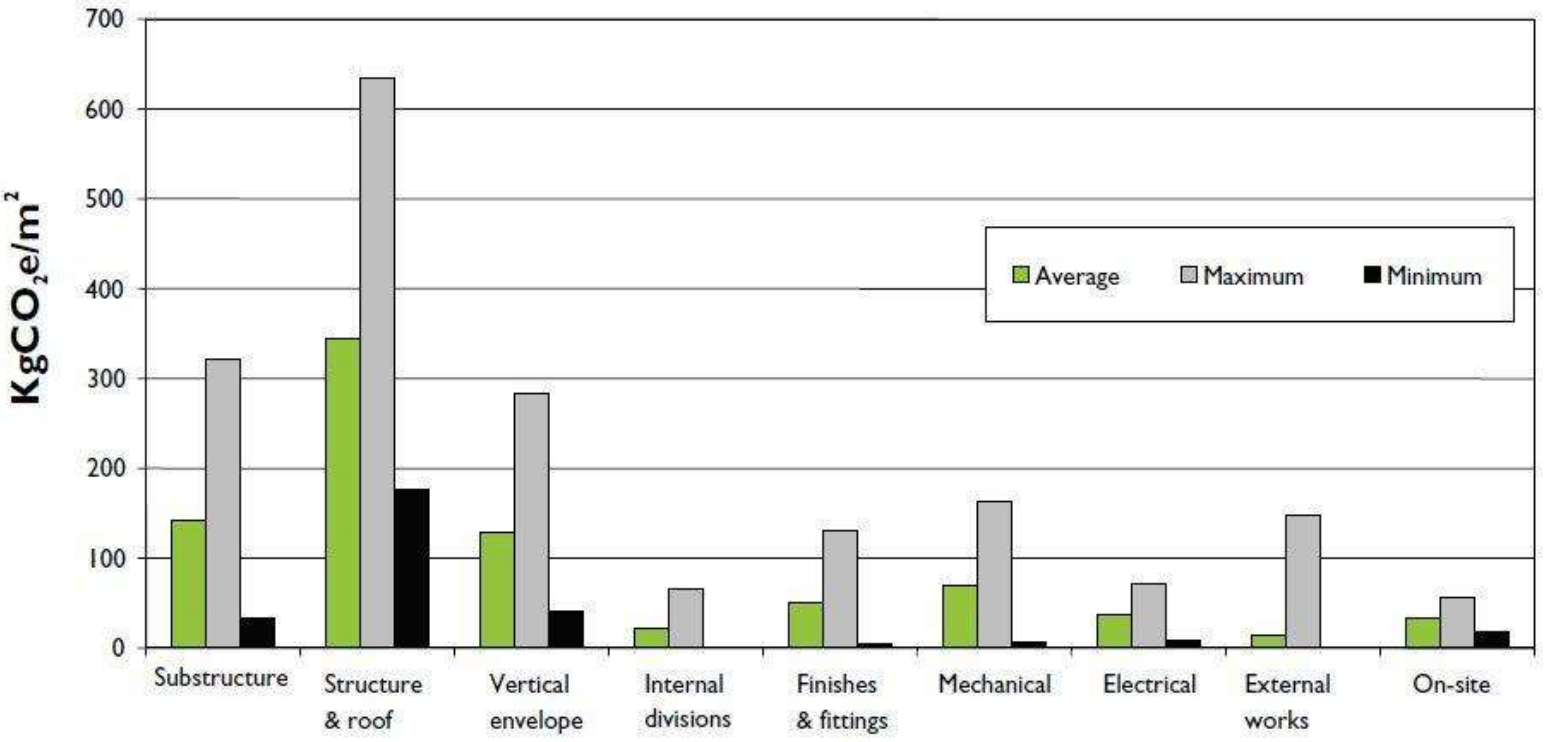



Cradle to Gate

Cradle to Grave

Cradle to Cradle

**Figure 7:** Embodied carbon of commercial offices.

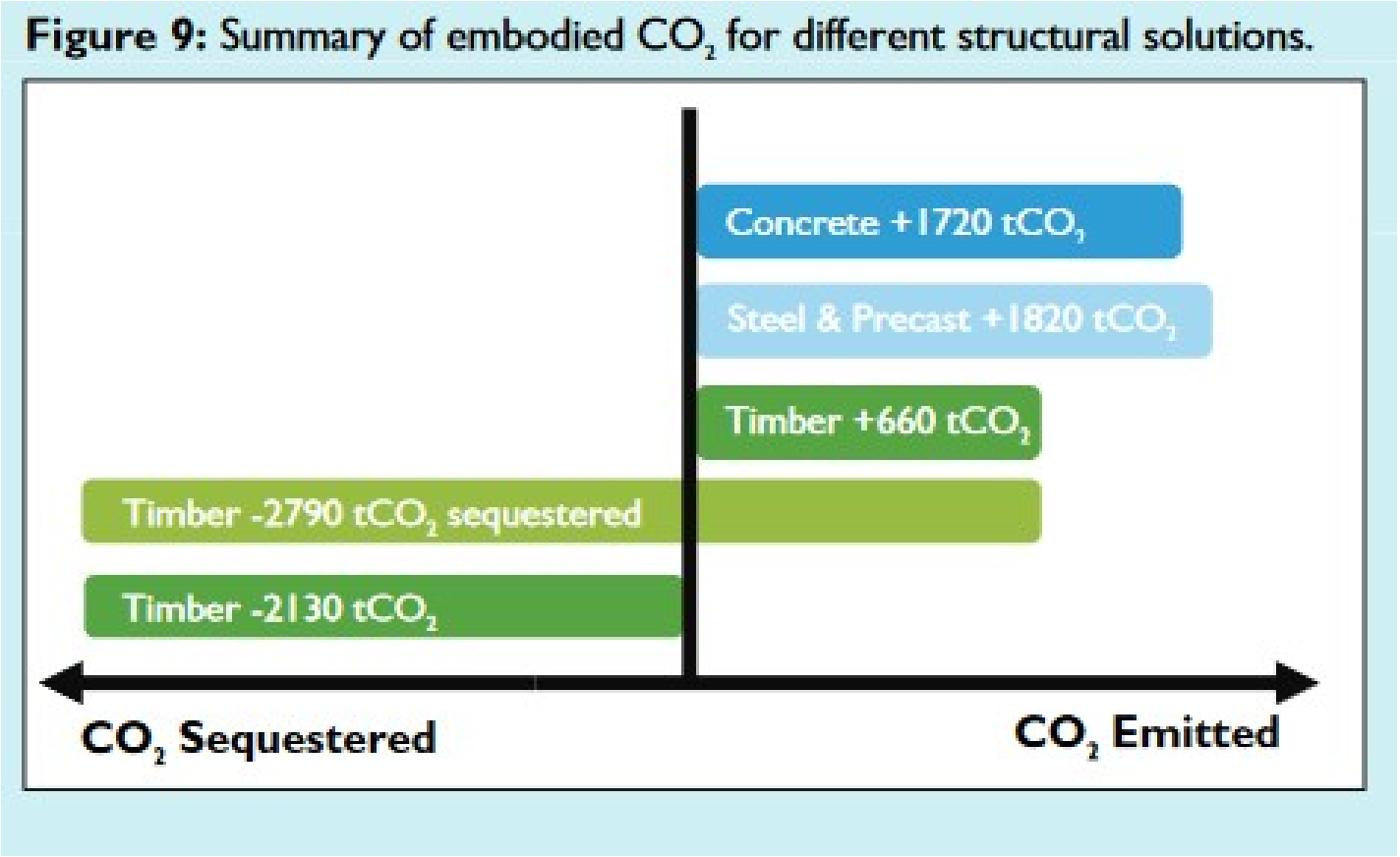



Davis Langdon AECOM

Analysis of 29 buildings different materials England

https://greenbuildingencyclopaedia.uk/wp-content/uploads/2014/07/Full-BSRIA-ICE-guide.pdf

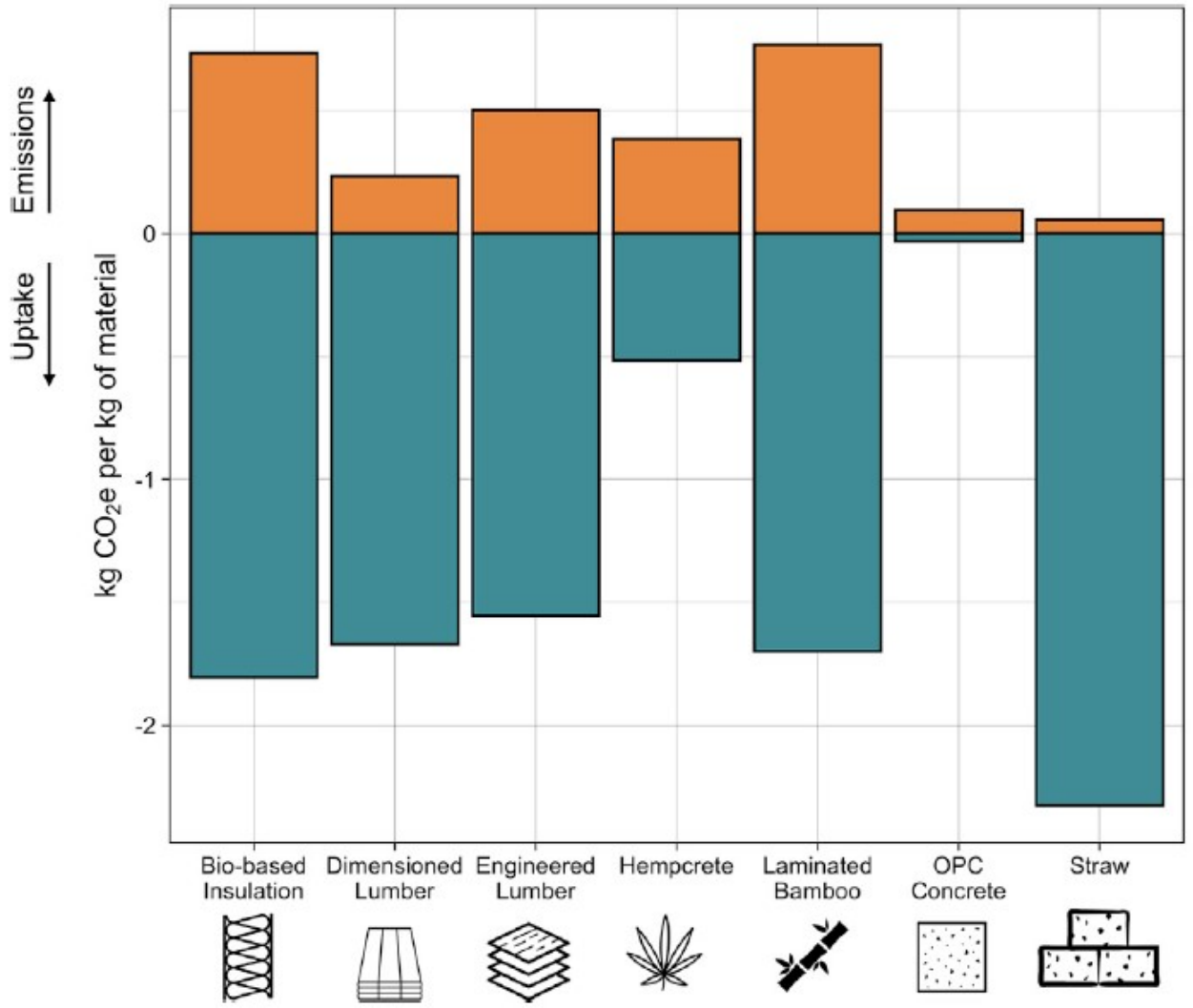
**Mass Timber Building, Norwich, England**




Ramboll

Oliver Neve,
Gavin White

https://greenbuildingencyclopaedia.uk/wp-content/uploads/2014/07/Full-BSRIA-ICE-guide.pdf




Potential net-carbon storage of biogenic materials

https://www.sciencedirect.com/science/article/pii/S2590332220303626

## ModCell  Modular Wall Panels – Straw, Timber, Wood Fiber

**Sequestered Carbon:**
Typical 100 m2 BaleHaus
43 tons of atmospheric $CO_2e$
(converted: 390 kg/m2 $CO_2e$)

Average whole building
200 to 800 kg/m2 $CO_2e$

https://www.modcell.com/technical/

# Expanding LCA Boundary to Include Ecosystem Carbon Balance of Farm or Forest

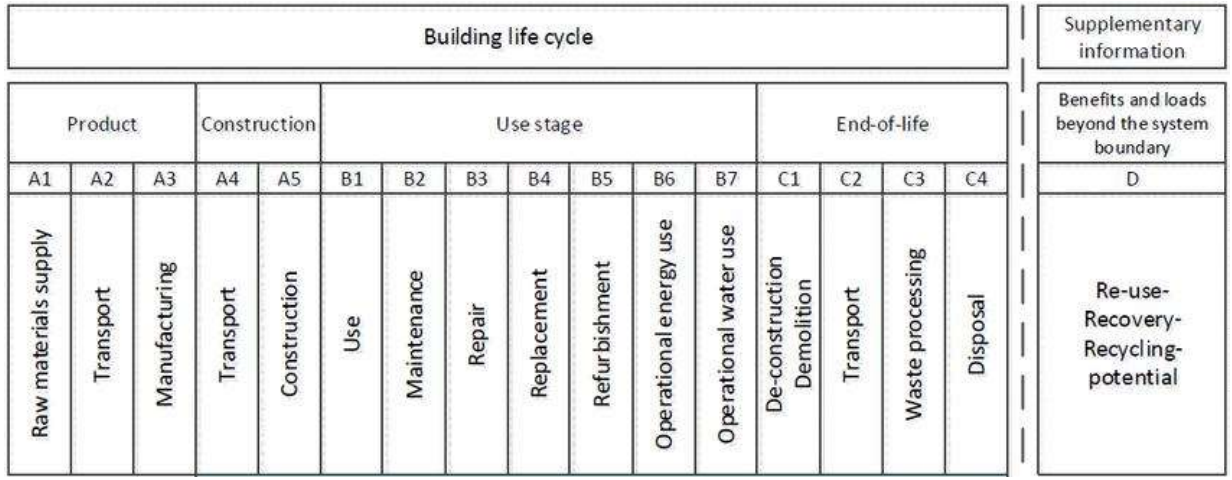
Forest or farm ecosystem:
Biogenic carbon source

A0

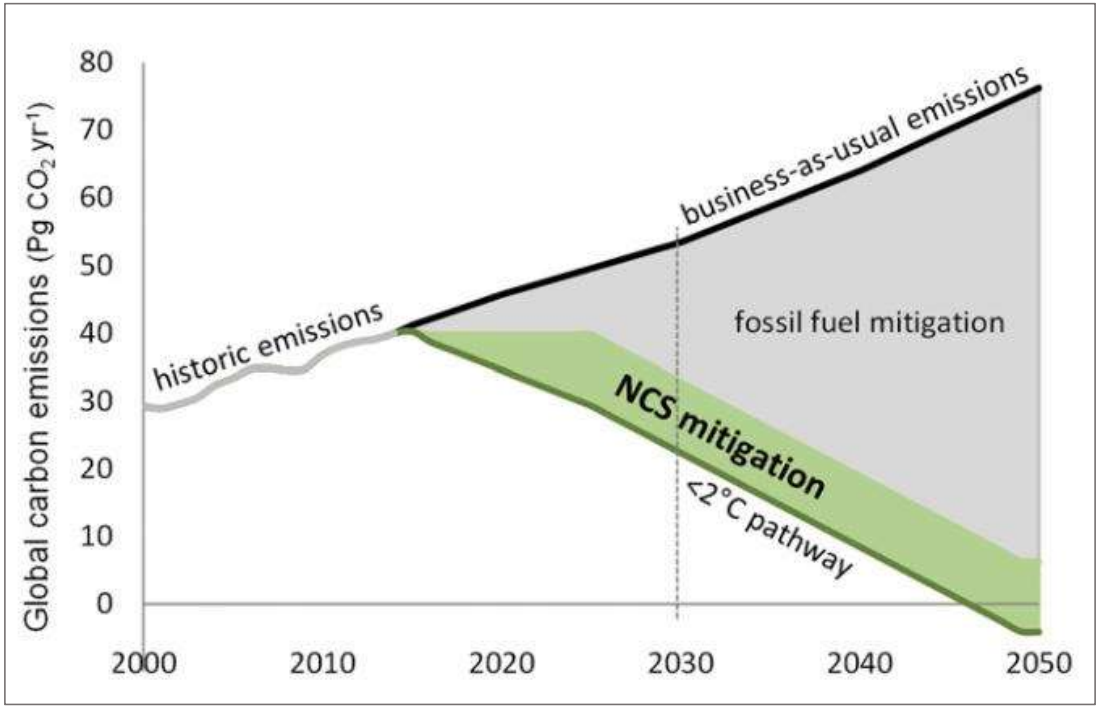
Measure: The net carbon emissions and sequestration by the plant biomass and soils in the farm or forest.

Biodiversity conservation impact

Benefits to rural communities



**Natural Climate Solutions Bends Emissions Down While Clean Tech Energy & Geoengineering Scale Up**




Business Model?

Waiting for carbon market for forestry

Investors interested in Natural Climate Solutions businesses – but few ready

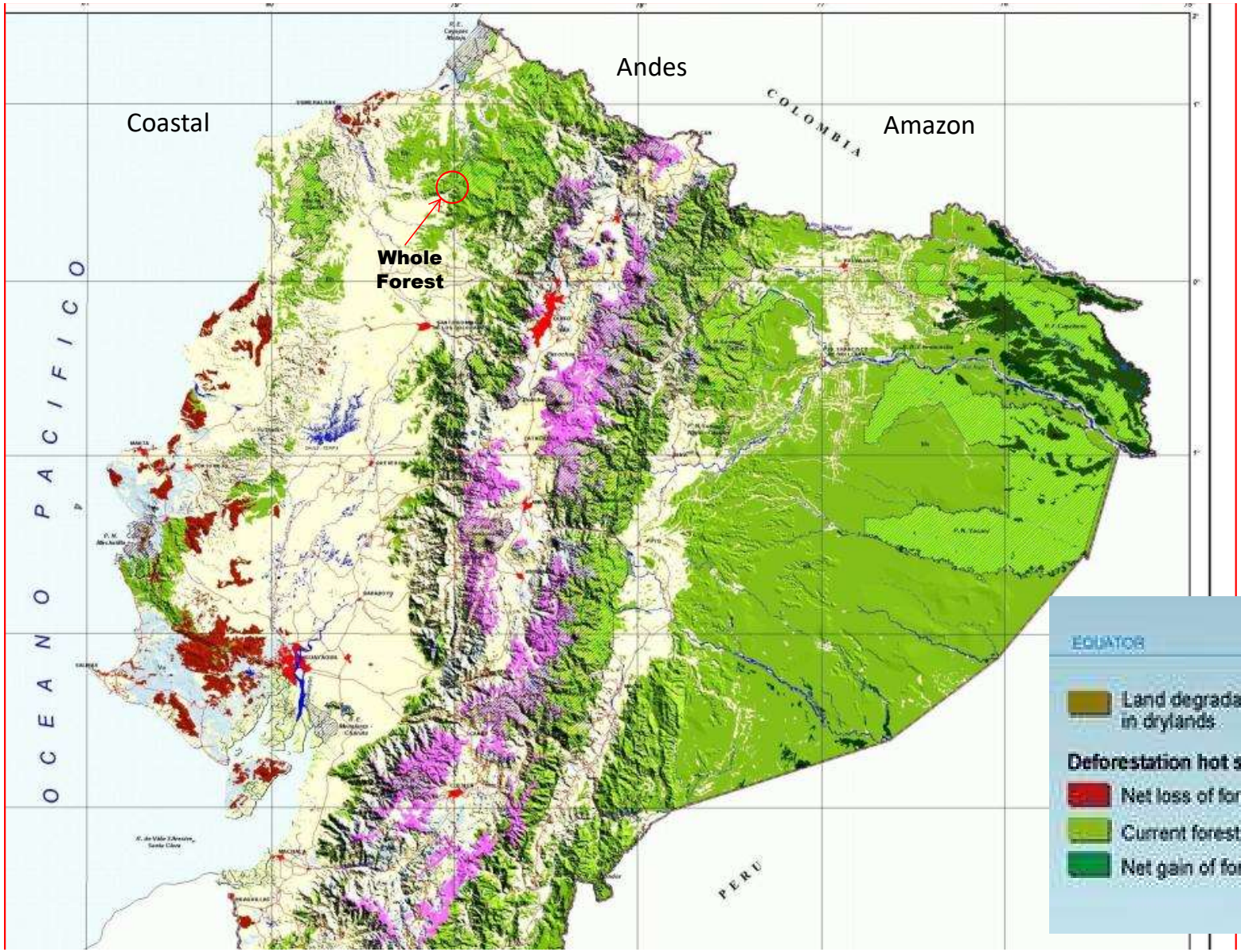
Opportunity: Old school – Sustainable forestry, wood products, sales to green construction markets, with added carbon reduction benefit.

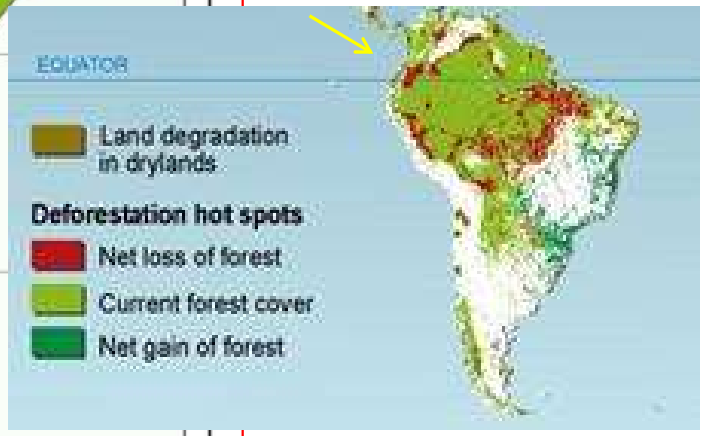
WholeForest™

Case Study

Developing a Community Forest Economy in Ecuador

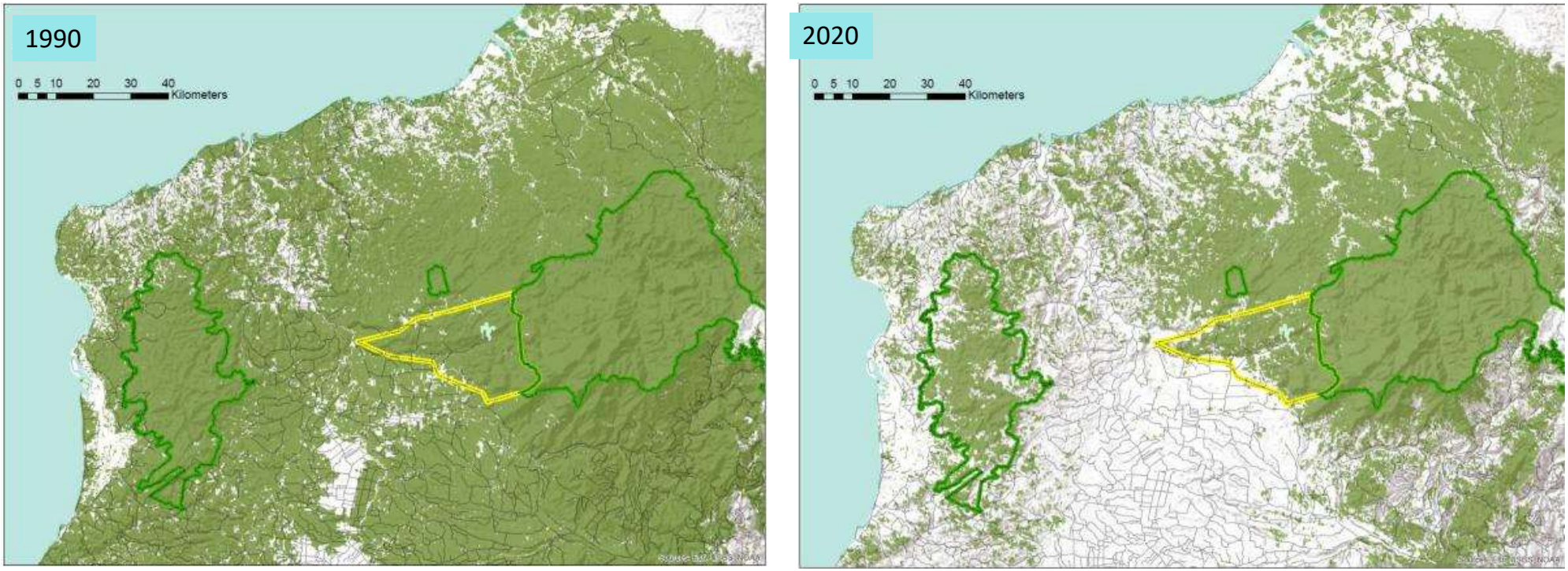
Designing Negative Carbon Hardwood Products


Andes
Coastal
Amazon
COLOMBIA
Whole Forest
OCEANO PACIFICO
PERU


EQUATOR
Land degradation in drylands
Deforestation hot spots
Net loss of forest
Current forest cover
Net gain of forest

**Deforestation in Chocó Coastal Rainforests in Ecuador**

50,000 hectare conservation project (yellow)

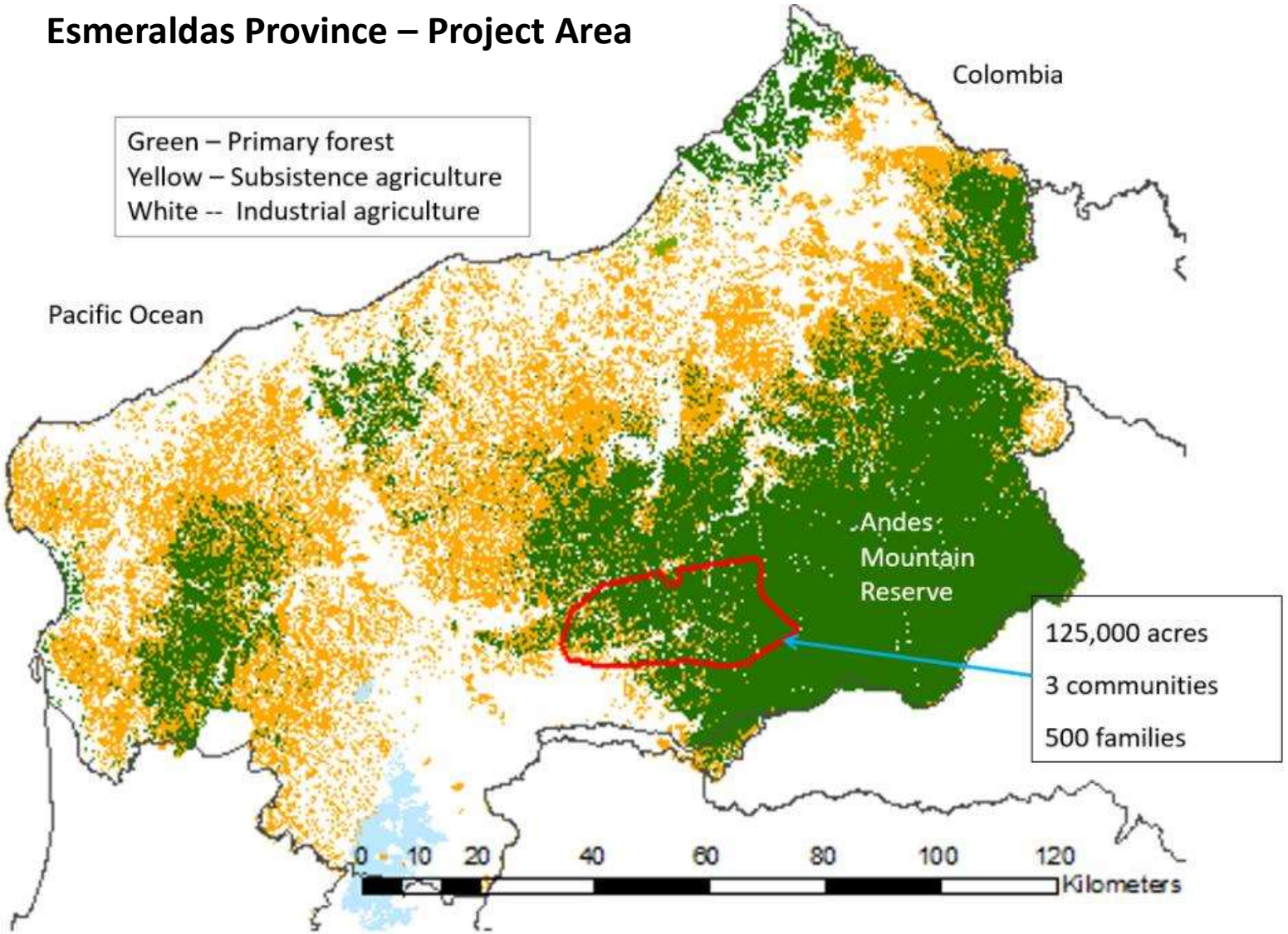



Estimated deforestation impact over 30 years: 1 million hectares cleared @ 300 tons of $CO_2$ per hectare

Goal: Reverse deforestation and restore degraded forests

**Ecuador: Clearing Native Rainforest for Commercial Oil Palm Plantations**

## Esmeraldas Province – Project Area



**Deforestation Cycle From Forest to Agriculture**

Logging road opens native forest to illegal logging and international crop markets.

Clearing for cattle and commodity crops, African Oil Palm.

2008:  Founded Community Forestry Enterprise

Mission:  Replace deforestation with a sustainable forest products economy

Two Businesses: 1) Balsa Tree Plantations on Deforested Land and Balsa Wood Laminates.
2)Sustainable Management of Native Forests and Hardwood Products

Markets:
China
Europe
USA

**Developing the Social and Business Infrastructure for Climate Smart Forestry**

20-year contracts with local landowners to allow sustainable forestry and forest restoration.

Hire locally for forestry, harvesting and manufacturing.

**Management goals: Protect and expand carbon and biodiversity. Provide wood for local manufacturing.**

No roads built to open forest to crop markets. Cable transport milled lumber.

Harvest 5 to 8 trees per hectare with 20-year harvest cycle.

Protect endangered biodiversity

Monitoring forest carbon and habitat

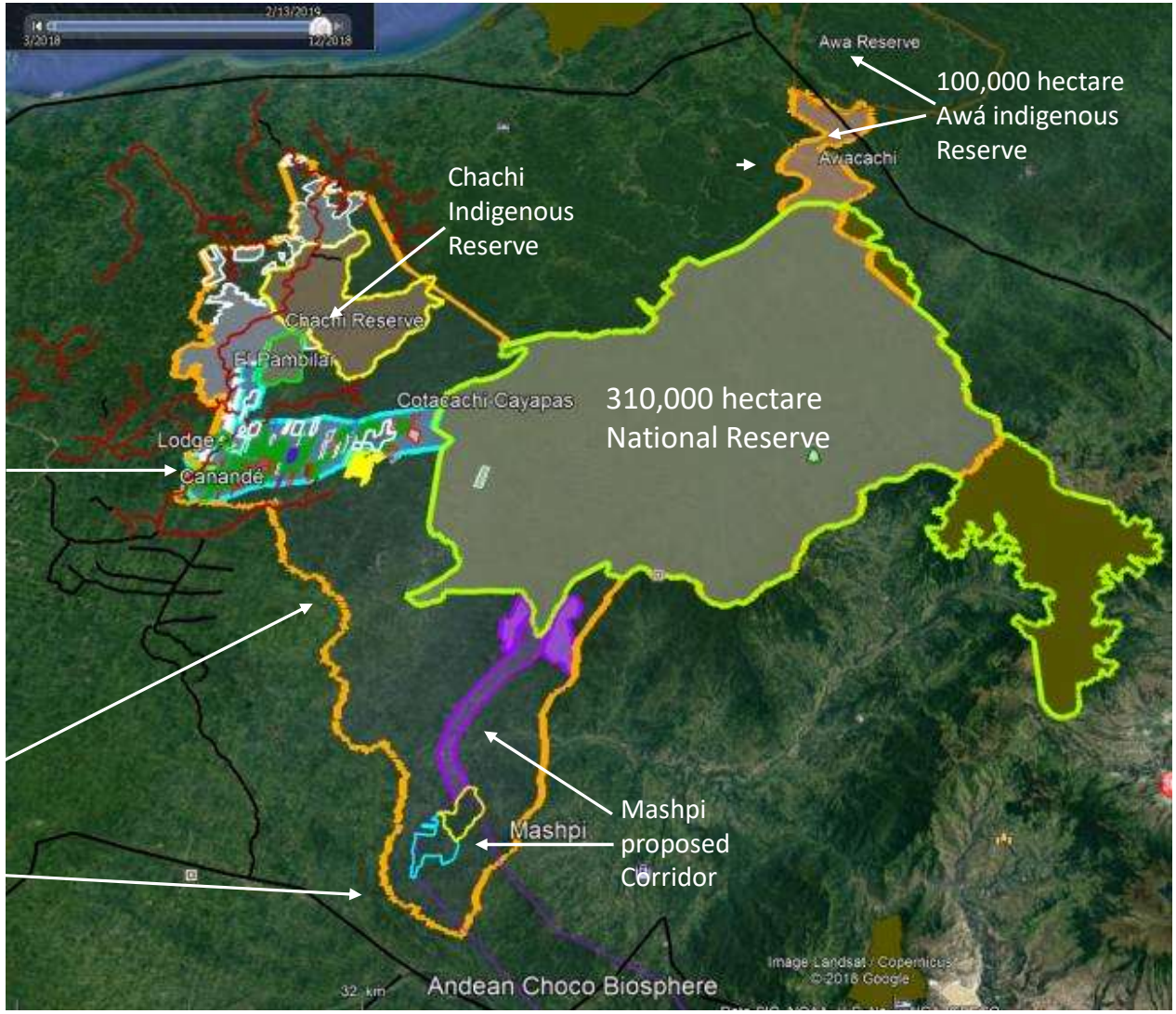
Biodiversity Conservation

**Whole Forest Design Challenge: Informed by Forest Diversity**

- Coastal rainforests: 300 tree species, 5 have good markets
- Design strategy: Products that integrate many species to raise the forest value.
- Intensive R&D in wood properties, design, manufacturing, gluing, finishes.


**Multiple species products.  Biophilic Designs.**

## Whole Forest, Two Bird Conservation NGOs, and Ecuadorian Government Conservation Target




Whole Forest community forestry projet 50,000 ha.

Total potential biosphere reserve 1.1 million hectares (orange outline)


Registered REDD+ project with Ecuador to meet their pledge to the UN to control deforestation


Working towards FSC Chain of Custody certification by year end


Working towards VCS forest carbon certification by Spring 2022


Next steps:  LCA and EPDs for each product

**Certified Carbon Benefit Whole Forest Hardwoods**

**Lu Pinchot – Whole Forest Floor**

Communities increase forest carbon storage → Gain certification of carbon credit → Manufacture wood products locally → Deliver carbon credit with wood products

Certification: 23 tons of forest carbon protected per acre → 30 tons forest carbon credit per 1,000 sf of flooring → Cradle to gate LCA 2 tons per 1,000 sf → Embodied carbon ($CO_2e$) reduction = 28 tons per 1,000 sf of flooring

## Embodied Carbon: Fossil Fuel Emissions from Building Materials


Emissions sources: Mining raw materials, manufacturing products, and transporting materials and products

# Biogenic Carbon Building Products

CARBON SMART MATERIALS PALETTE™


BAMBOO


HEMPCRETE


SHEEP'S WOOL


STRAW-BALE


WOOD

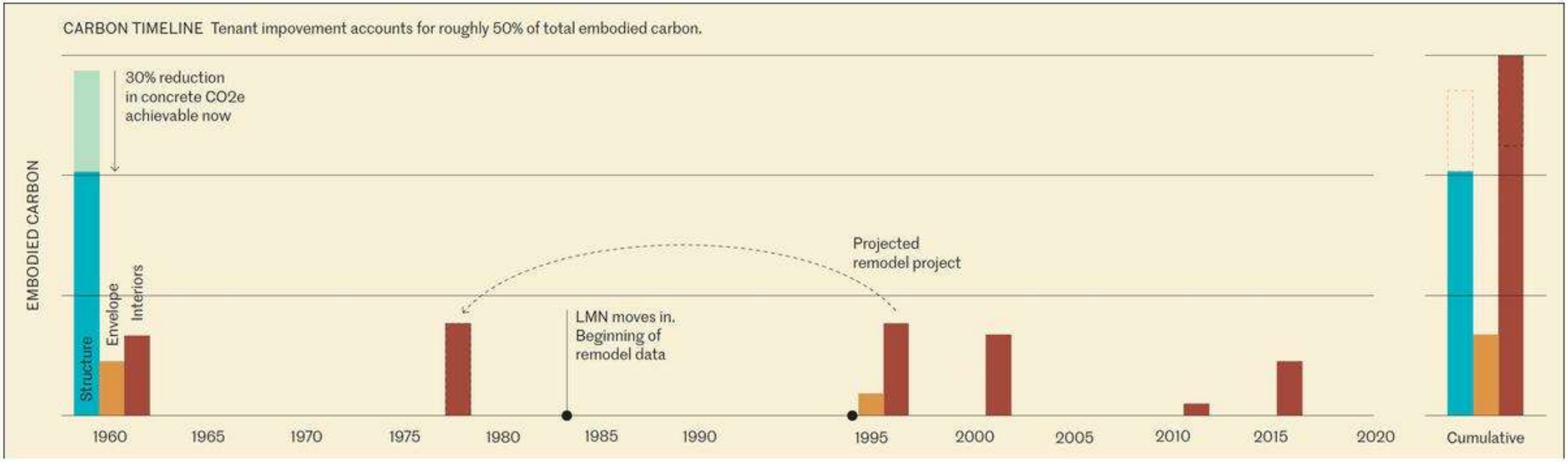
https://materialspalette.org/palette/

Biogenic carbon is not a fungible commodity. It matters where it comes from. The primary actor in carbon capture and storage is photosynthesis in forest or agricultural vegetation. If the farm or forest is losing carbon from its sinks, there should be no harvest. Management should focus on raising the biomass and soil carbon to mitigate climate change. It should take into account impacts on biodiversity and on rural populations.

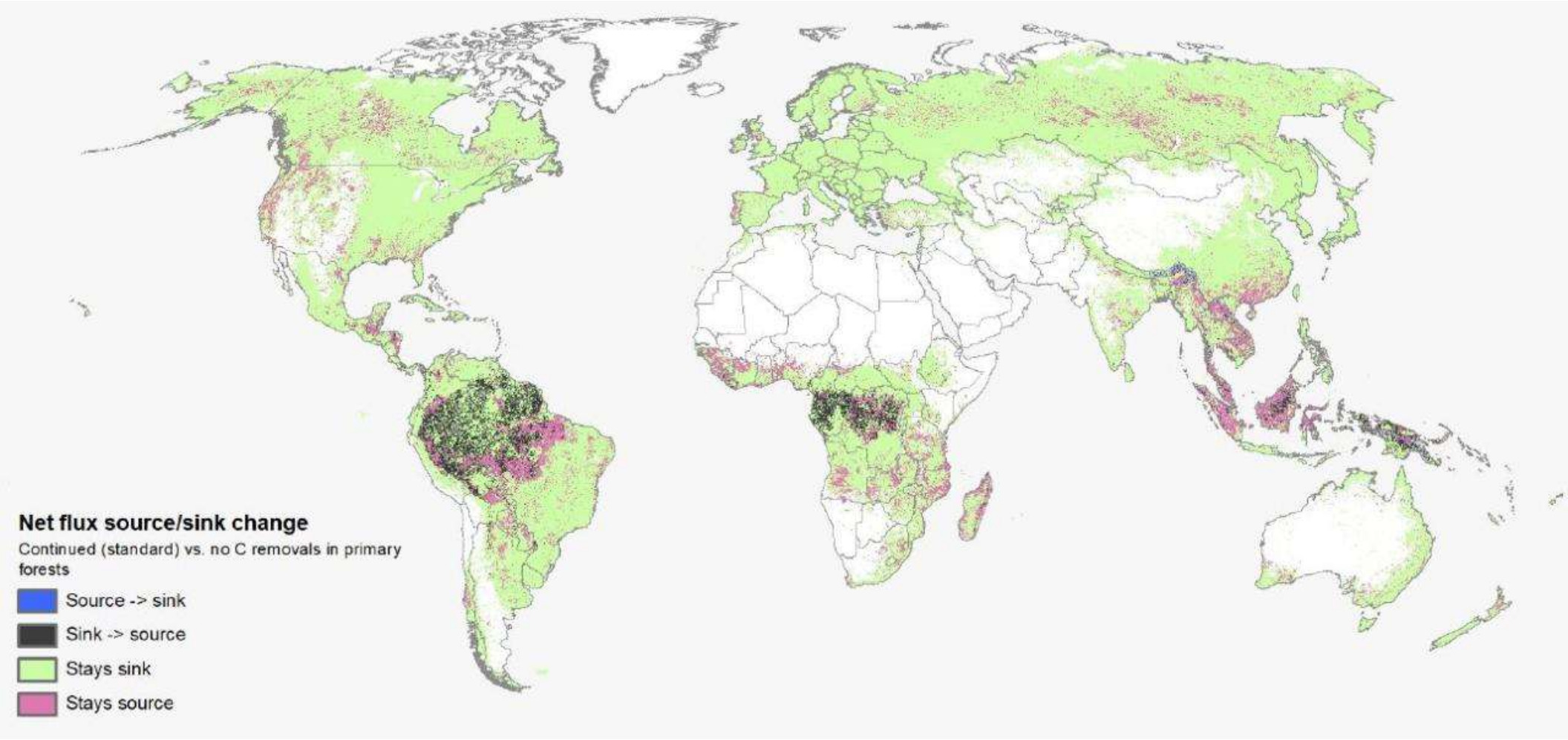
This suggests a agricultural product certification program analogous to Forest Stewardship Council certification for forestry and timber products. To claim a climate impact in a building material, the raw material provider (forest, farm) should be certified and demonstrate a positive carbon impact.

I am not suggesting producers wait for certification before providing biogenic carbon building materials. Cleary, using products made from agricultural residuals can have strong substitution impact for synthetic based products with a much higher carbon impact. But rather, there is no guarantee that there is a sustainable biogenic carbon impact until the land ecosystem dynamics of the source of the materials are measured and certified.
Include biodiversity, food security, and rural communities impacts if relevant.

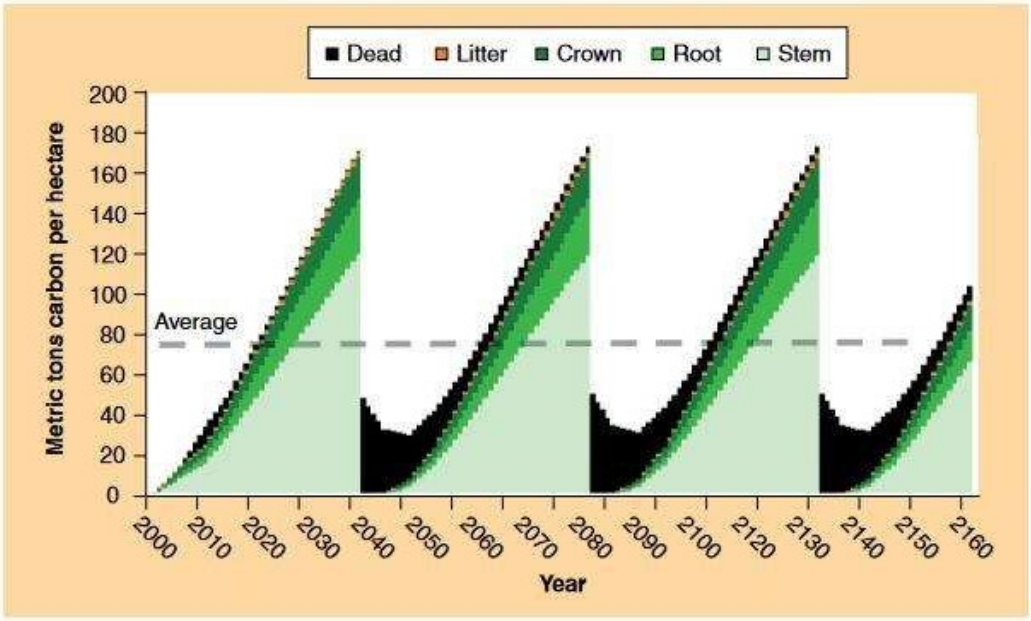
**Rethinking Embodied Carbon: The Impact of Interior Renovations**

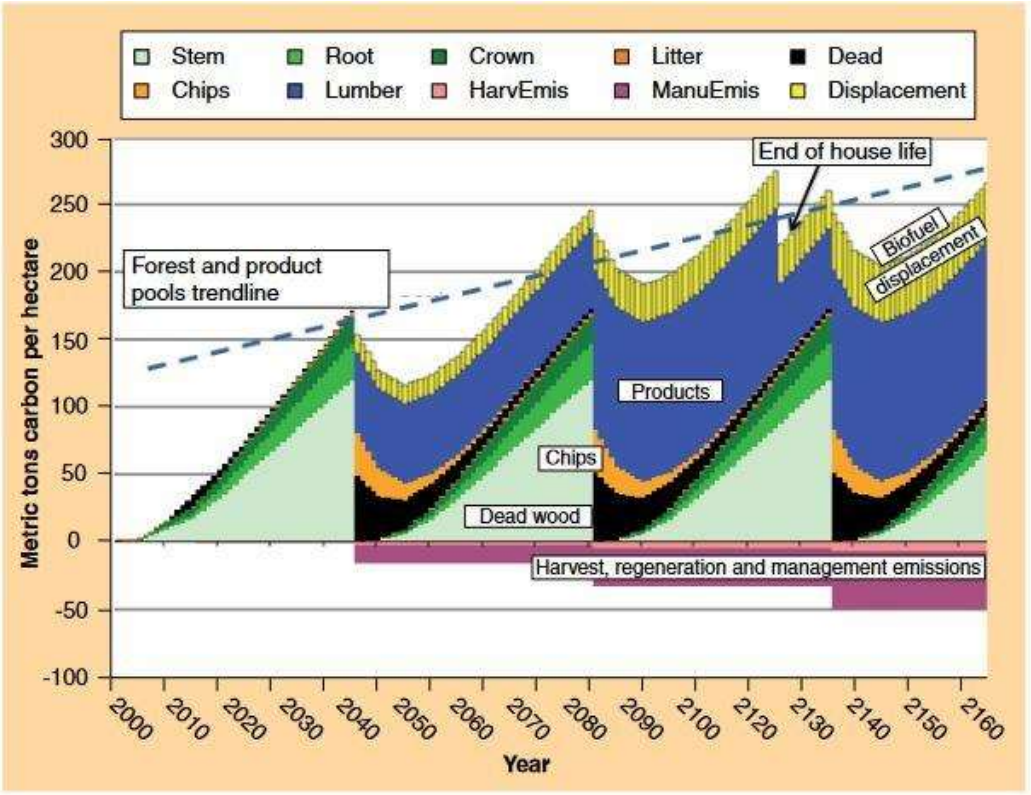



LMN Architects: Study of Embodied Carbon from a Series of Interior Renovations


Net flux source/sink change
Continued (standard) vs. no C removals in primary forests
Source -> sink
Sink -> source
Stays sink
Stays source

**Pacific Northwest Conifer 45 Year Plantation Rotation – Wood Frame or Mass Timber**
**Life Cycle Analysis of Forests and Products**



Two Big Emerging Climate Change Challenges:
Embodied Carbon of Industrial Building Materials
Land Use Emissions – Deforestation and Industrial Agriculture

Opportunity:  New Supply Chain Linking Sustainable Land Use and Biogenic Carbon Building Materials

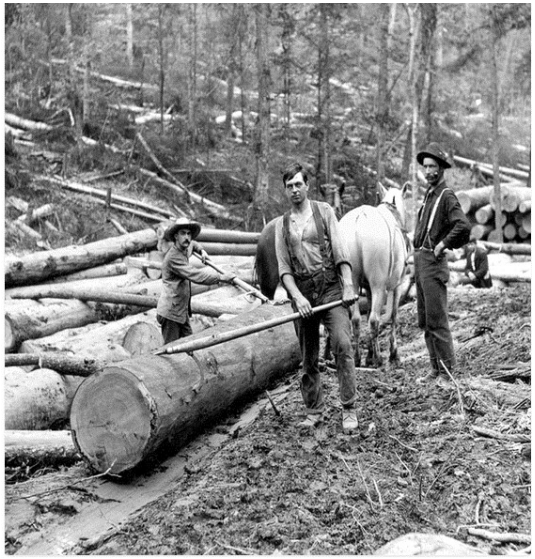
**Indigenous Day October 11, 2021**

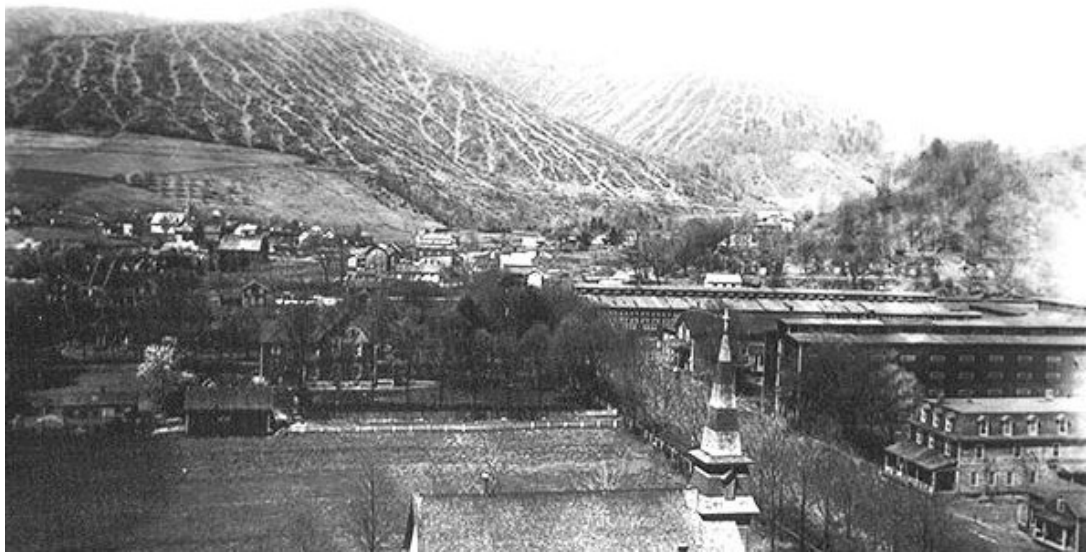
Act 2: Colonial settlement, land theft, forced western migration, pre-European settlement


1910


2021
Black Hills, South Dakota
(Mt Rushmore)

## Drivers of deforestation





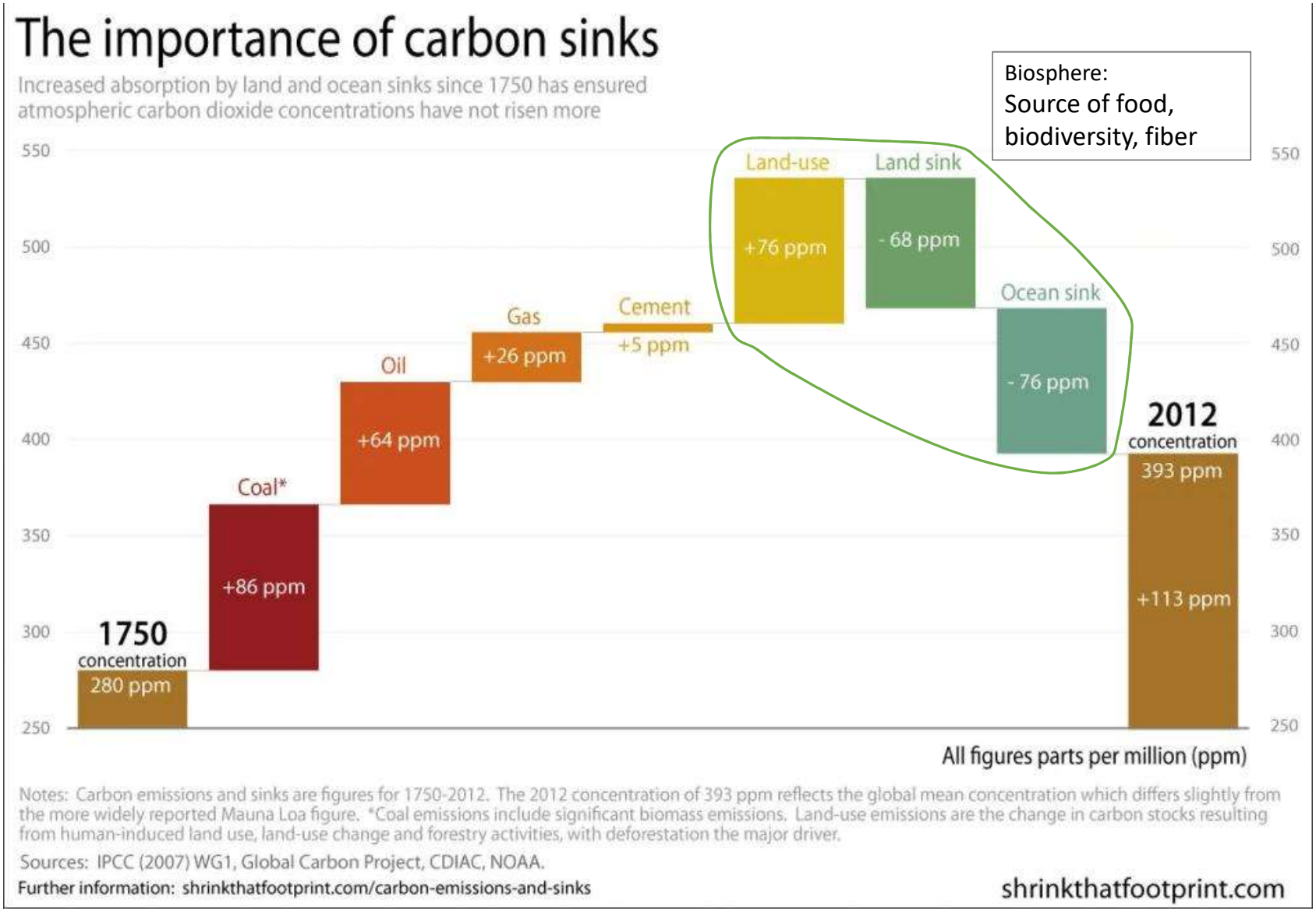
1910, Potter County, PA

Clearing forest for agriculture

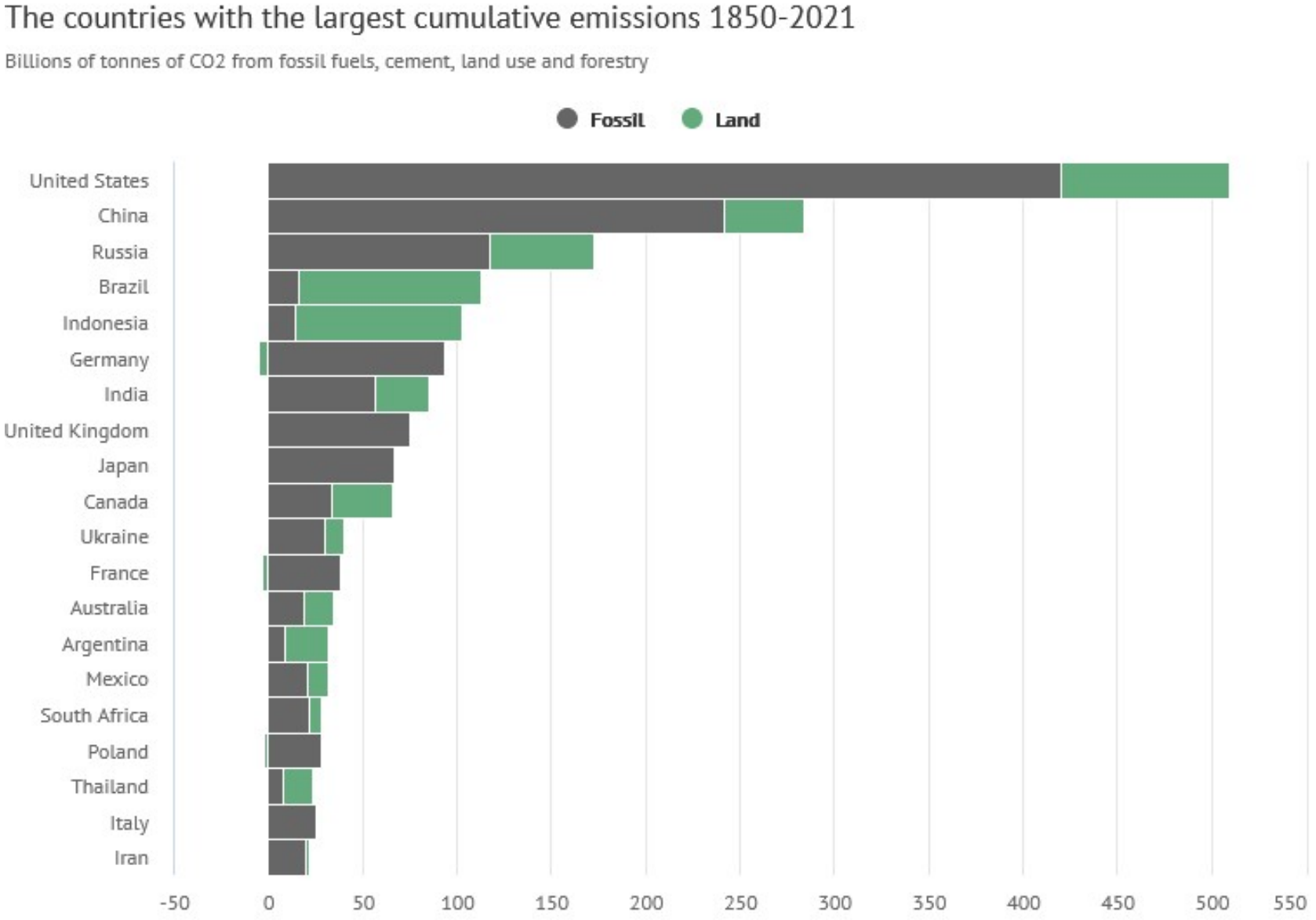
Wood fuel

Timber for construction

Access to markets – rivers, canals, then railroads

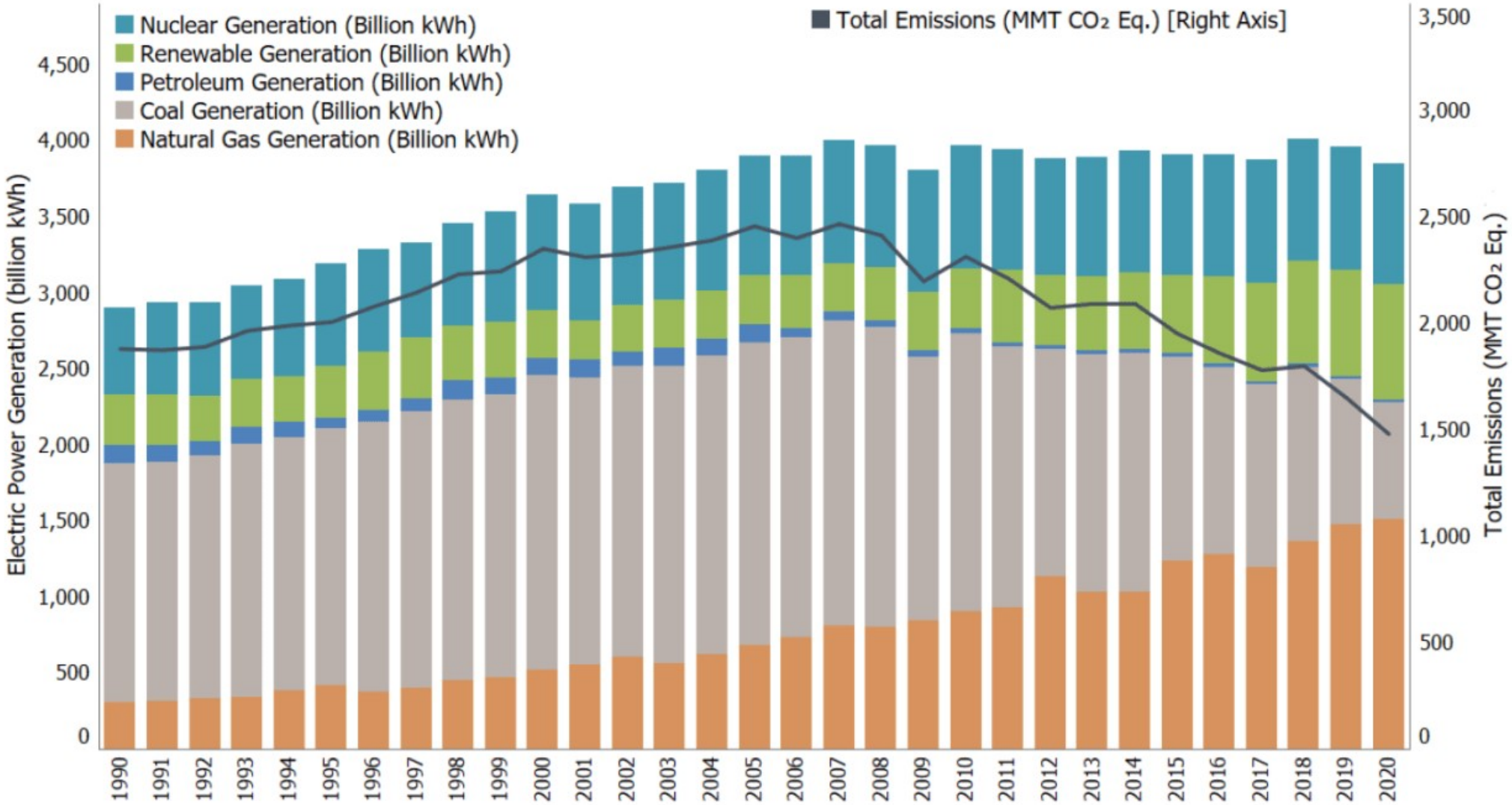

The importance of carbon sinks
Increased absorption by land and ocean sinks since 1750 has ensured atmospheric carbon dioxide concentrations have not risen more
Biosphere:
Source of food, biodiversity, fiber
550
500
450
400
350
300
250
1750
concentration
280 ppm
Coal*
+86 ppm
Oil
+64 ppm
Gas
+26 ppm
Cement
+5 ppm
Land-use
+76 ppm
Land sink
- 68 ppm
Ocean sink
- 76 ppm
2012
concentration
393 ppm
+113 ppm
All figures parts per million (ppm)
Notes: Carbon emissions and sinks are figures for 1750-2012. The 2012 concentration of 393 ppm reflects the global mean concentration which differs slightly from the more widely reported Mauna Loa figure. *Coal emissions include significant biomass emissions. Land-use emissions are the change in carbon stocks resulting from human-induced land use, land-use change and forestry activities, with deforestation the major driver.
Sources: IPCC (2007) WG1, Global Carbon Project, CDIAC, NOAA.
Further information: shrinkthatfootprint.com/carbon-emissions-and-sinks
shrinkthatfootprint.com

419



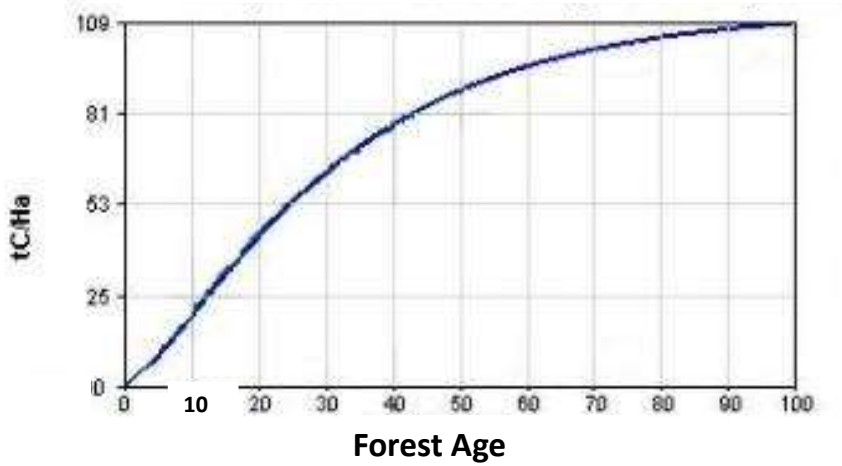

IPCC: 23% of emissions 2007 to 2016: from deforestation and agriculture

## Figure 2-7: Electric Power Generation (Billion kWh) and Emissions



# Reforming Supply Chains to Store Carbon

**Forest plantation carbon storage 100 years**





https://kingstonlim.com/2020/11/01/on-running-a-business-smoothly-wiser-next-week-for-business-3/
https://www.naturefund.de/fileadmin/pdf/Studien/Waelder/Trees-for-carbon-sequestration.pdf


Discussion