

Forest Bioenergy and Climate Goals

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Presentation at Yale School of Forestry

February 22, 2022




Climate Goals



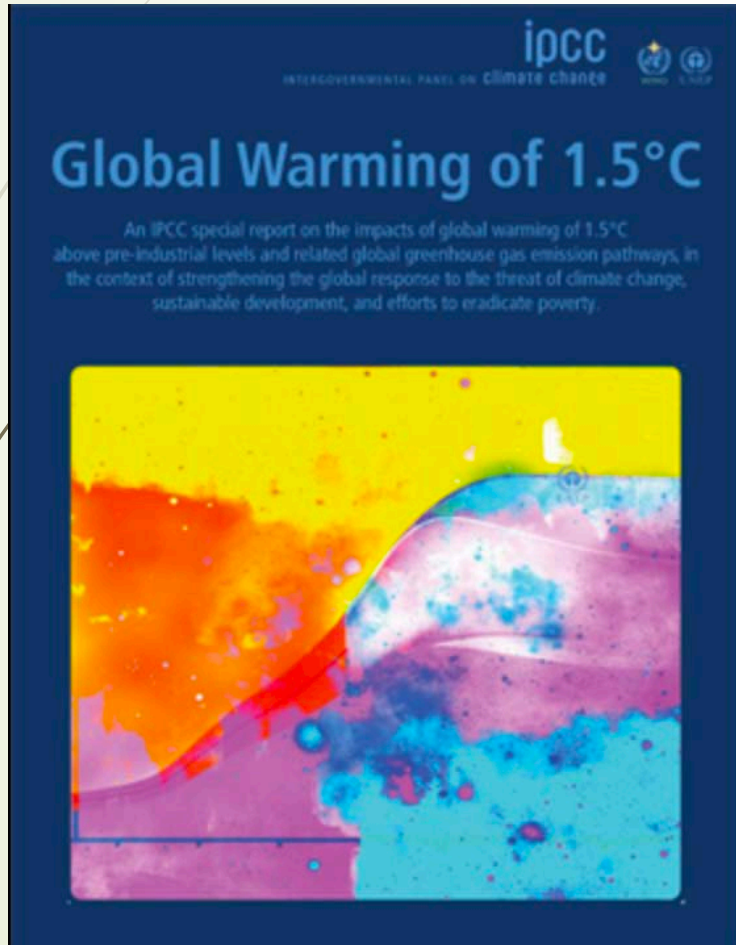
- 1992 – UN Framework Convention on Climate Change
 - “The goal of this convention ... is to achieve ... a concentration of greenhouse gases in the atmosphere that will avoid dangerous anthropogenic interference in the climate system.”
- Paris Climate Agreement 2015
 - “This Agreement ... aims to strengthen the global response to the threat of climate change ... by holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels.” - Article 2
 - “Parties should take action to conserve and enhance, as appropriate, sinks and reservoirs of greenhouse gases ... including forests.” Article 5
- 2018 Intergovernmental Panel on Climate Change 1.5°C Report



Test for Whether Forest Bioenergy is Helping or Hurting Climate Change

- ▶ The important metric is the amount of CO₂ and other greenhouse gases in the atmosphere
 - ▶ How rapidly we *achieve a safe concentration of greenhouse gases in the atmosphere* is important
 - ▶ If we do not act sufficiently rapidly, amplifying feedback loops will make it impossible to “avoid dangerous ... interference with the climate system!”
- 

Climate Change: How to meet the 1.5° C goal?



IPCC Special Report Global Warming of 1.5°C (2.7°F) October 8, 2018

To keep temperatures from rising excessively

“... global net anthropogenic carbon dioxide emissions (must) decline by about 45% from 2005 levels by 2030 ... reaching net zero around 2050 ...”

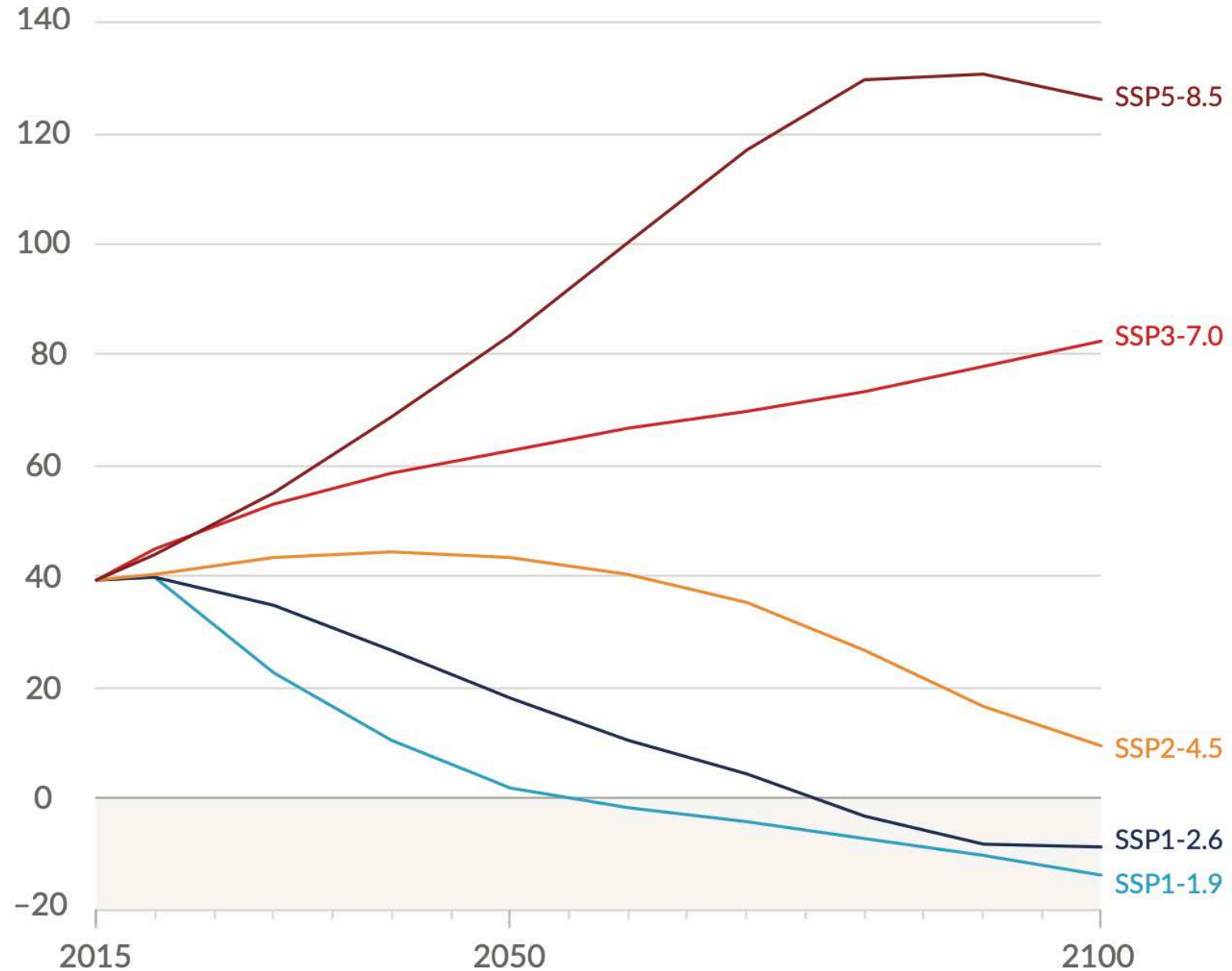
Must simultaneously reduce CO₂ emissions and increase its removal from the atmosphere



What is Zero Carbon, Net Zero Carbon, Negative Carbon and Carbon Neutrality

- Zero Carbon means that no CO₂ is emitted from producing energy or a product
- Net Zero Carbon means the difference between CO₂ emitted and removed is zero
 - Sustainable forest management is Net Zero Carbon if accomplished each year
- Carbon Neutral is sometimes interchangeable with Zero Net Carbon, but increasingly means there is an offset somewhere else
- Carbon Negative is removing more Carbon than is being emitted

Carbon dioxide (GtCO₂/yr)

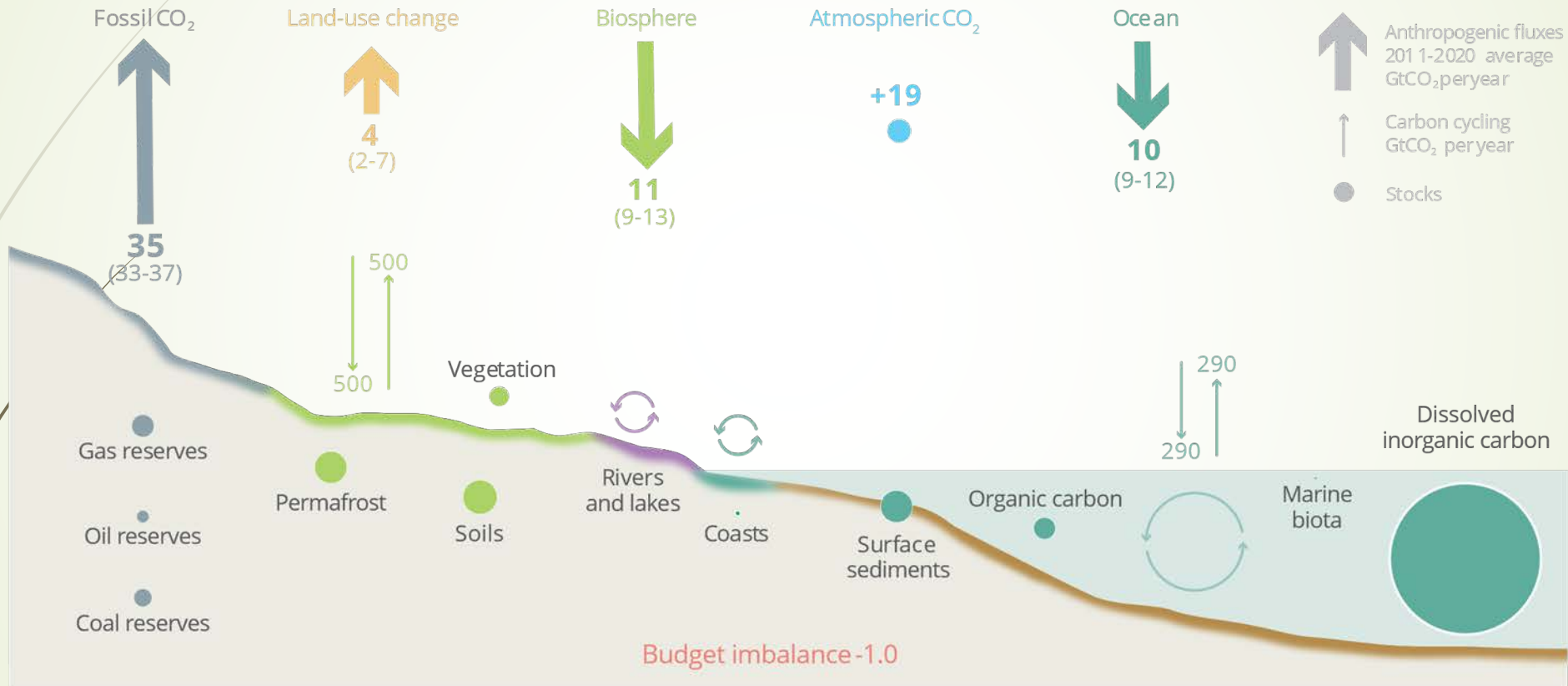


5 scenarios
IPCC AR6
2021

Absolute
Negative
Emissions

Anthropogenic perturbation of the global carbon cycle

Perturbation of the global carbon cycle caused by anthropogenic activities, global annual average for the decade 2011–2020 (GtCO₂/yr)



The budget imbalance is the difference between the estimated emissions and sinks.

Source: [NOAA-ESRL](#); [Friedlingstein et al 2021](#); [Canadell et al 2021 \(IPCC AR6 WG1 Chapter 5\)](#); [Global Carbon Project 2021](#)

global annual average for the decade 2011–2020 (GtCO₂/yr)

Anthropogenic fluxes (2011–2020 average):

- Fossil CO₂: 35 (33–37) GtCO₂/yr
- Land-use change: 4 (2–7) GtCO₂/yr
- 39 total** GtCO₂/yr

Carbon cycling (GtCO₂ per year):

- Biosphere: 11 (9–13) GtCO₂/yr
- Atmospheric CO₂: +19 GtCO₂/yr
- Ocean: 10 (9–12) GtCO₂/yr

Carbon Stocks (GtC):

- Gas reserves
- Oil reserves
- Coal reserves
- Permafrost
- Vegetation
- Soils
- Rivers and lakes
- Coasts
- Surface sediments
- Organic carbon
- Marine biota
- Dissolved inorganic carbon

Fluxes between stocks:

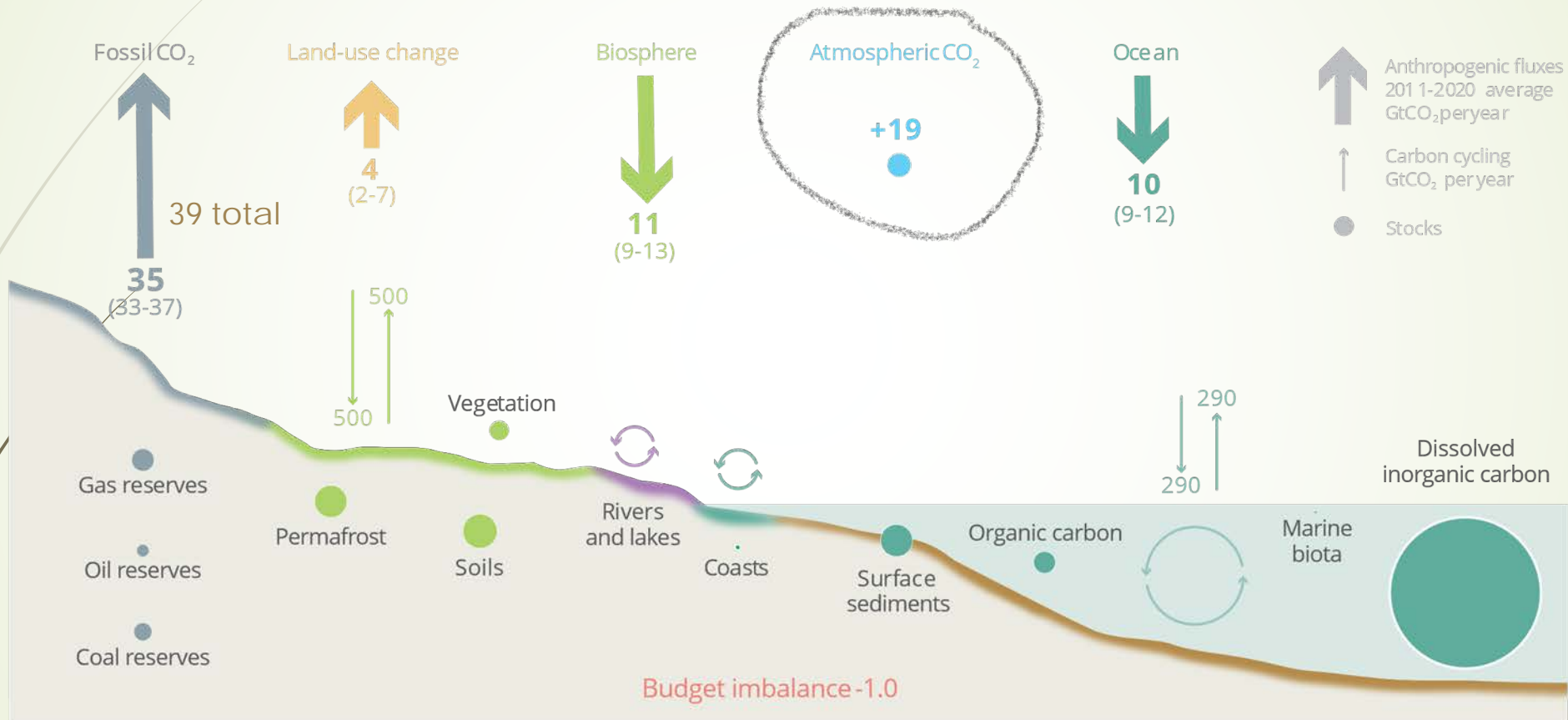
- Vegetation to Soils: 500 GtC/yr
- Soils to Vegetation: 500 GtC/yr
- Coasts to Rivers and lakes: 290 GtC/yr
- Rivers and lakes to Coasts: 290 GtC/yr
- Surface sediments to Organic carbon: 290 GtC/yr
- Organic carbon to Surface sediments: 290 GtC/yr
- Marine biota to Dissolved inorganic carbon: 290 GtC/yr
- Dissolved inorganic carbon to Marine biota: 290 GtC/yr

Budget imbalance: -1.0 GtCO₂/yr

Source: NOAA-ESRL; Friedlingstein et al 2021; Canadell et al 2021 (IPCC AR6 WG1 Chapter 5); Global Carbon Project 2021

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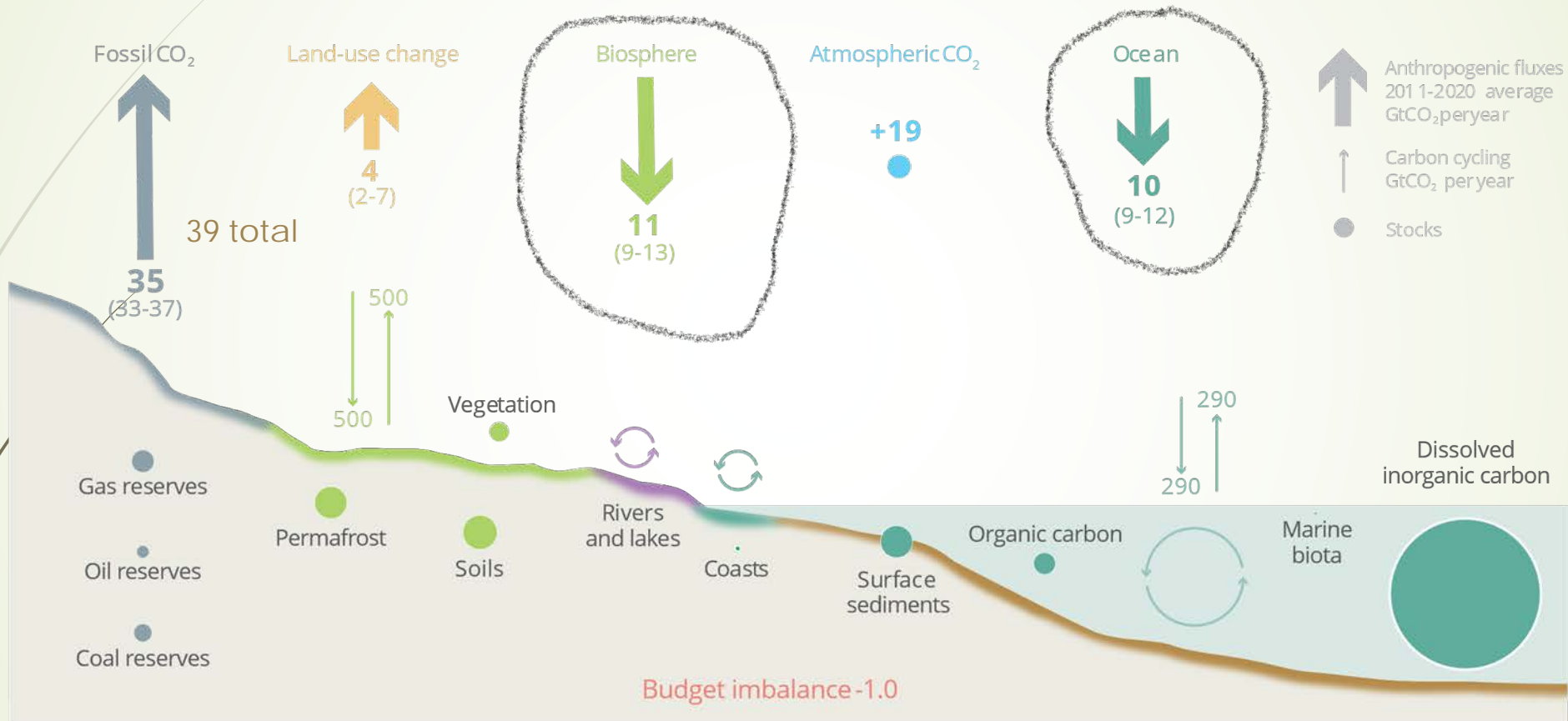


The budget imbalance is the difference between the estimated emissions and sinks.

Source: [NOAA-ESRL](#); [Friedlingstein et al 2021](#); [Canadell et al 2021 \(IPCC AR6 WG1 Chapter 5\)](#); [Global Carbon Project 2021](#)

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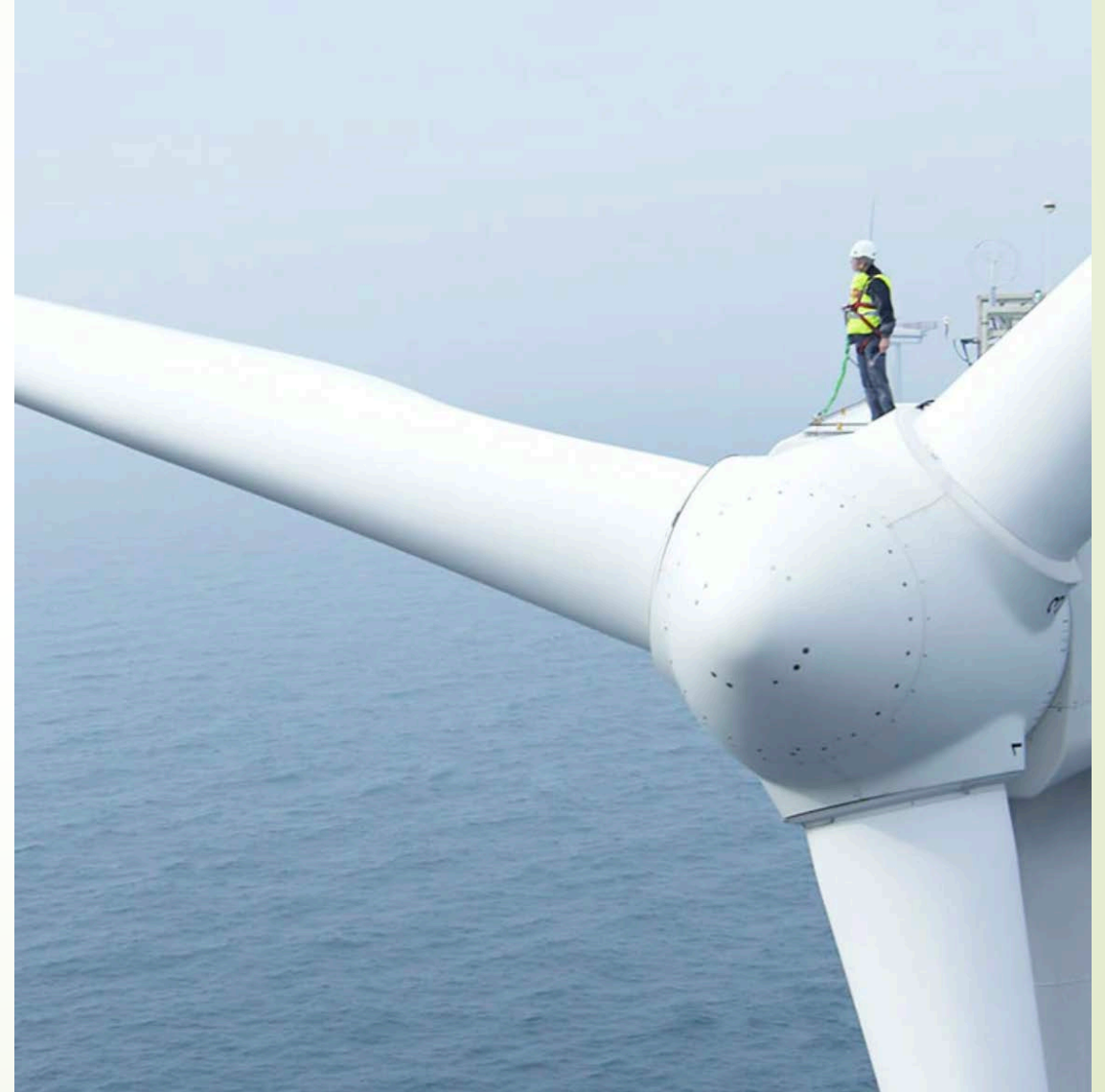


Terrestrial Biosphere and oceans remove ~60% of annual emissions

The budget imbalance is the difference between the estimated emissions and sinks.

Source: [NOAA-ESRL](#); [Friedlingstein et al 2021](#); [Canadell et al 2021 \(IPCC AR6 WG1 Chapter 5\)](#); [Global Carbon Project 2021](#)

Reducing fossil fuel emissions with greater energy efficiency and zero carbon alternatives





2022 = year 15

84% less energy for heat and hot water than code
Grid connected - Net electricity exported
Annual net zero energy met by solar panels
Import from zero carbon sources

Electric Vehicle and
More solar panels added later
charging 7000 miles/year

Total negative CO₂ emissions

Global Scale Forest Bioenergy

UK replacing coal with wood pellets



All wood is imported

Subsidized at \$1.1 billion per year

© PUBLICITY PICTURE

2,600 MW biomass-fueled power plant uses 7+ million tons of wood pellets annually and 1,300 MW 2.5 tons coal



Claims by Drax the world's largest single user of forest bioenergy

- “Our industry is a critical part of maintaining healthy forests.”
- “The world's leading authority on climate science is the United Nations Intergovernmental Panel on Climate Change, or IPCC. The IPCC explicitly recognizes bioenergy as a renewable energy source that is a critical to our low-carbon future.” – Drax



Here is what IPCC states about GHG emission estimates AR5 2013 WG 3 section 11.13.4

- "The neutrality perception is linked to a misunderstanding of the guidelines for GHG inventories,"
- "IPCC — Land Use, Land-Use Change and Forestry (2000) states "Biomass fuels are included in the national energy and carbon dioxide emissions accounts for informational purposes only."
- *"Within the energy module biomass consumption is assumed to equal its regrowth. Any departures from this hypothesis are counted within the Land Use Change and Forestry Model."*
- Interpretation:
 - Fossil fuel emissions are counted in Energy Sector
 - Bioenergy emissions are counted as forest loss in Land Use Sector and noted, but not counted in Energy Sector



Drax removed from green company market index

- “Drax has been booted from an investment index of clean energy companies as doubts over the sustainability of its wood-burning power plant begin to mount within the financial sector.”
- “We argue that bioenergy production is not carbon neutral, in almost all instances. This casts doubt on whether bioenergy with carbon capture and storage (BECCS) is a net-negative emissions technology. The widespread deployment of BECCS looks challenging,” – Jefferies Financial LLC

■ The Guardian 10/19/21



CLAIM 1 - To address climate change, it is necessary to replace fossil fuels with renewable energy

COUNTER CLAIM - The goal is to eliminate emissions of carbon dioxide and other heat trapping gases

- Wood is more carbon intensive than coal, oil or gas and electricity conversion is less efficient

- Natural gas: 117.8 lb CO₂/mmbtu
- Bituminous coal: 205.3 lb CO₂/mmbtu
- Wood: 213 lb CO₂/mmbtu (bone dry)

- Utility-scale biomass boiler: 24%
- Average efficiency US coal fleet: 33%
- Average gas plant: 43%



CLAIM 2 - Wood bioenergy is renewable energy



Counterclaim - Burning wood is instantaneous: Growing it back is a slowly renewable process



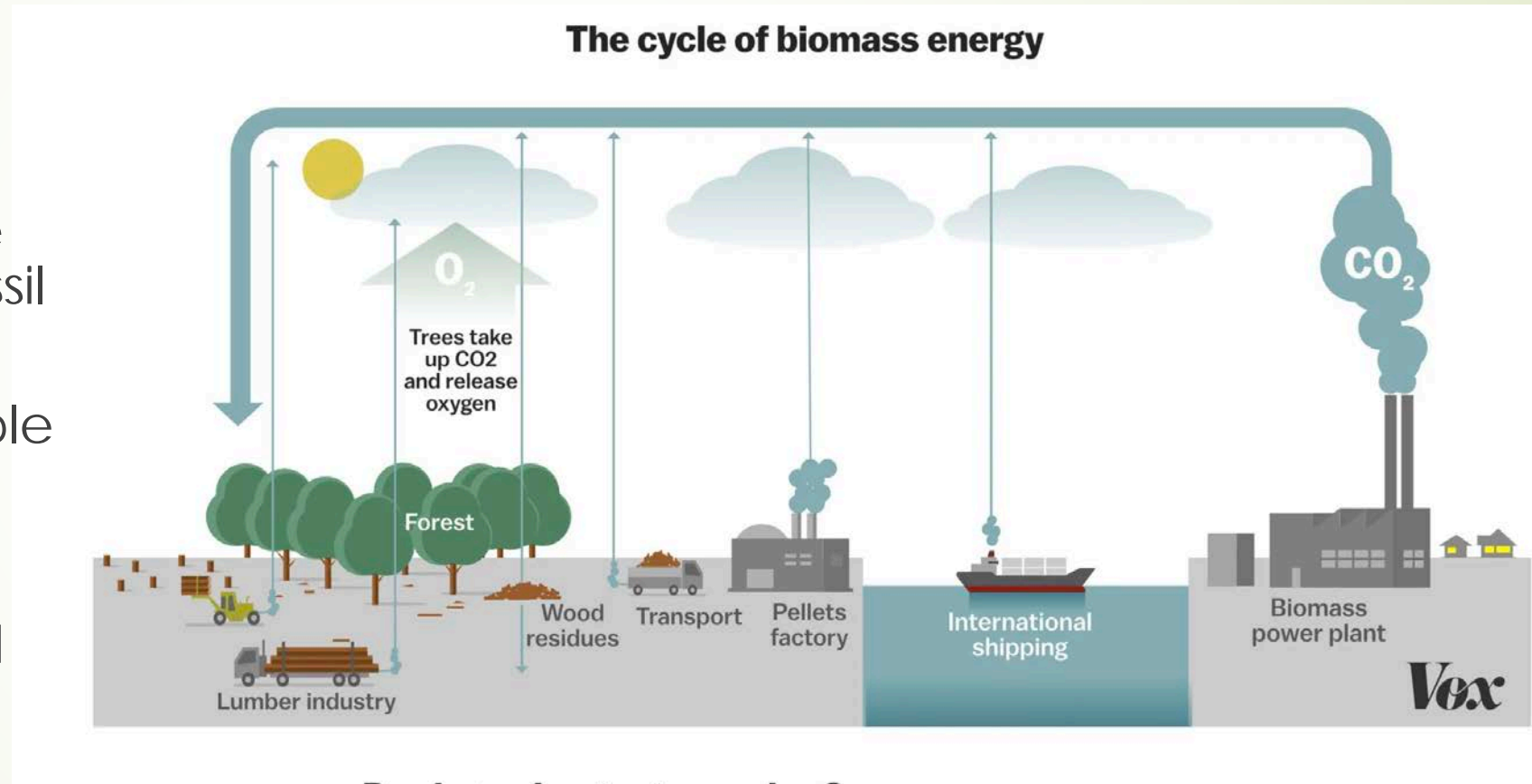
European Union Commitment is to renewables rather than CO₂ reduction


- ▶ “Well, that’s the prime objective, to go to full renewables. But simply looking at how fast we need to do that, we just can’t reach the levels of renewables we would need to have to stop burning fossil fuels and meet E.U. energy needs to completely exclude biomass.”
 - ▶ Frans Timmermans Vice President European Commission, COP 26

Assumptions for Claim that burning wood is net zero and renewable

Assumption

- We must eliminate coal and other fossil fuels
- Trees are renewable and Grow Back
- So let's burn wood to replace coal!





CLAIM 3- Wood bioenergy is carbon neutral.
Carbon that is emitted now and reabsorbed later
has no impact on the climate

COUNTER CLAIM - Emissions from burning wood are comparable to burning coal. Burning it now and removing the CO₂ later causes changes that are not reversed when trees grow back.

Added CO₂ from burning wood traps additional heat throughout regrowth period melting glaciers and sea ice, raising sea level, releasing additional methane from permafrost.

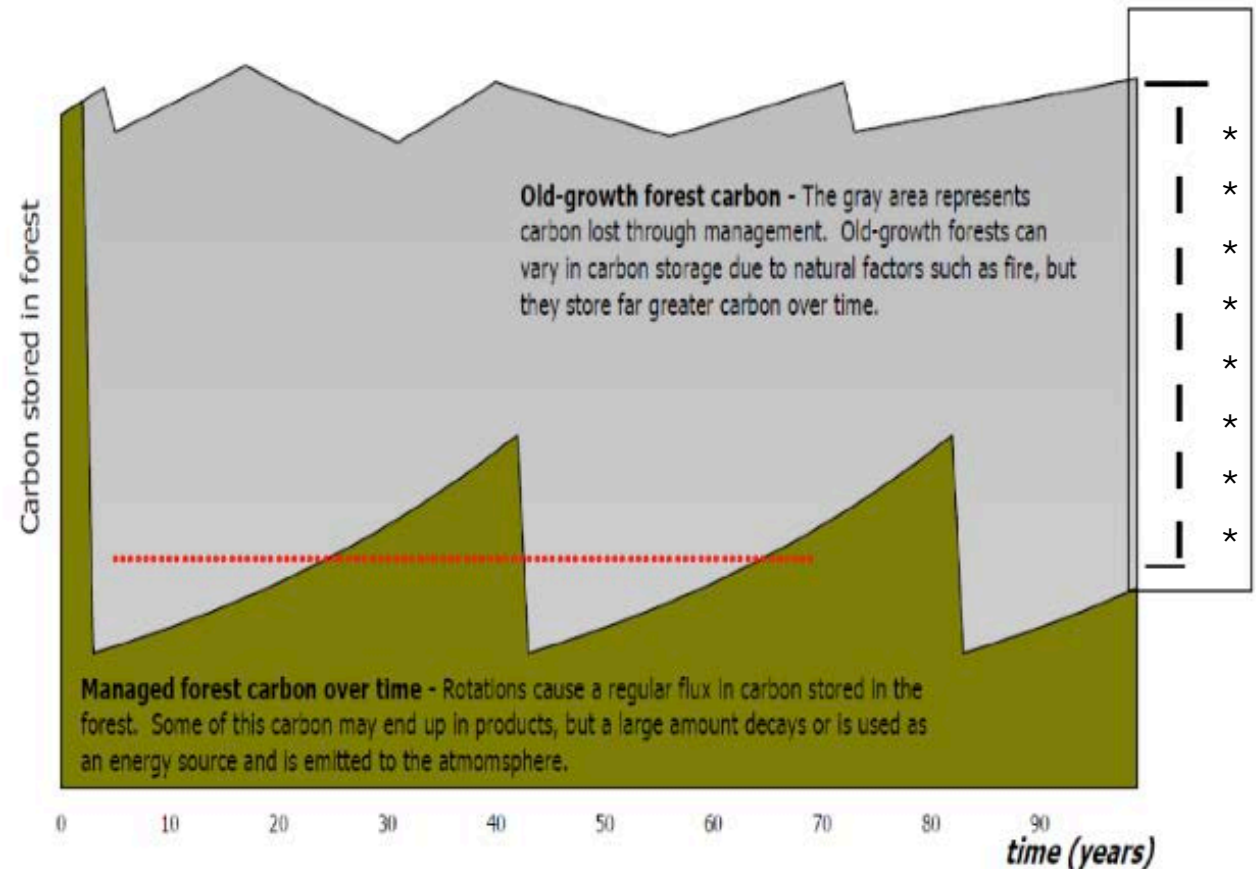
These are not restored to their previous condition when trees grow back

EVENTUAL CARBON NEUTRALITY IS NOT CLIMATE NEUTRALITY!

US law defines sustainably managed forest bioenergy as carbon neutral

"... the carbon neutrality of biomass harvested from sustainably managed forests has been recognized repeatedly by numerous studies, agencies, institutions, and rules around the world ..."
Senator Collins on the amendment to Energy Policy Modernization Act, S. 2102 in 2016.

Carbon Loss from Old-Growth or Mature Natural Forest Logging (model)



Harmon and Franklin 1990

* Extra atmospheric carbon



CLAIM 4 - Young trees grow faster than older trees. We should harvest older trees for bioenergy, and replace them with faster growing younger trees

COUNTER CLAIM –

- The goal is to accumulate the most carbon out of the atmosphere by any given date in the future.
- Young trees hold very little carbon
- They can never accumulate more carbon than older trees until after those older trees die
- We do not have time to wait for regrowth

CARBON ROCK STARS: LARGE, OLDER TREES AND FORESTS

How many oak trees does it take to store 8 tons of carbon?

Robert Leverett 2021



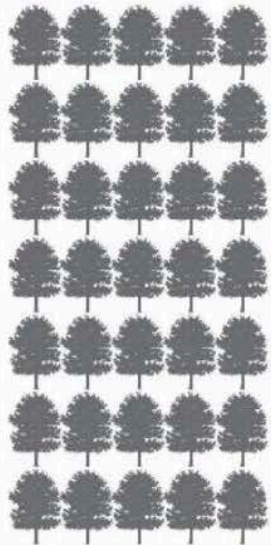
150 years

1

**Mature
Canopy Tree**

100' tall x 54" dia

OR



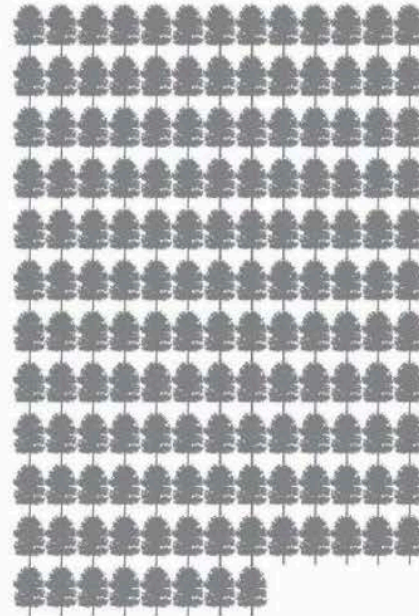
29 years

35

**Young
Canopy Trees**

50' tall x 12" dia

OR



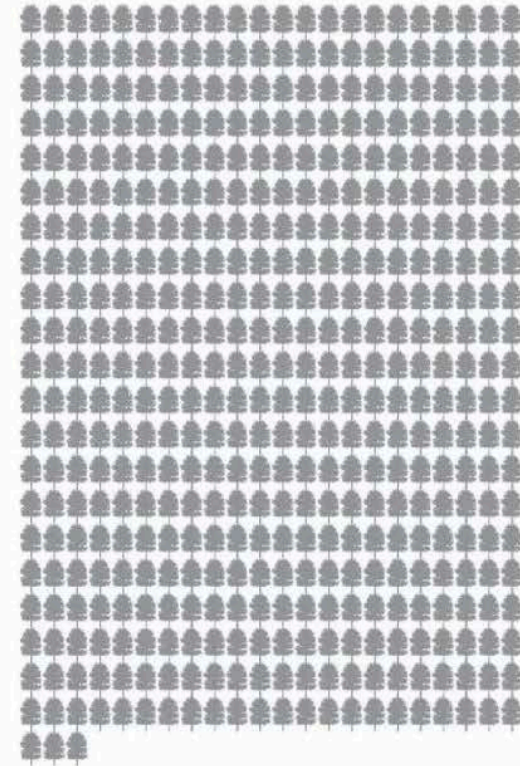
16 years

151

**Typical
Street Trees**

40' tall x 6" dia

OR

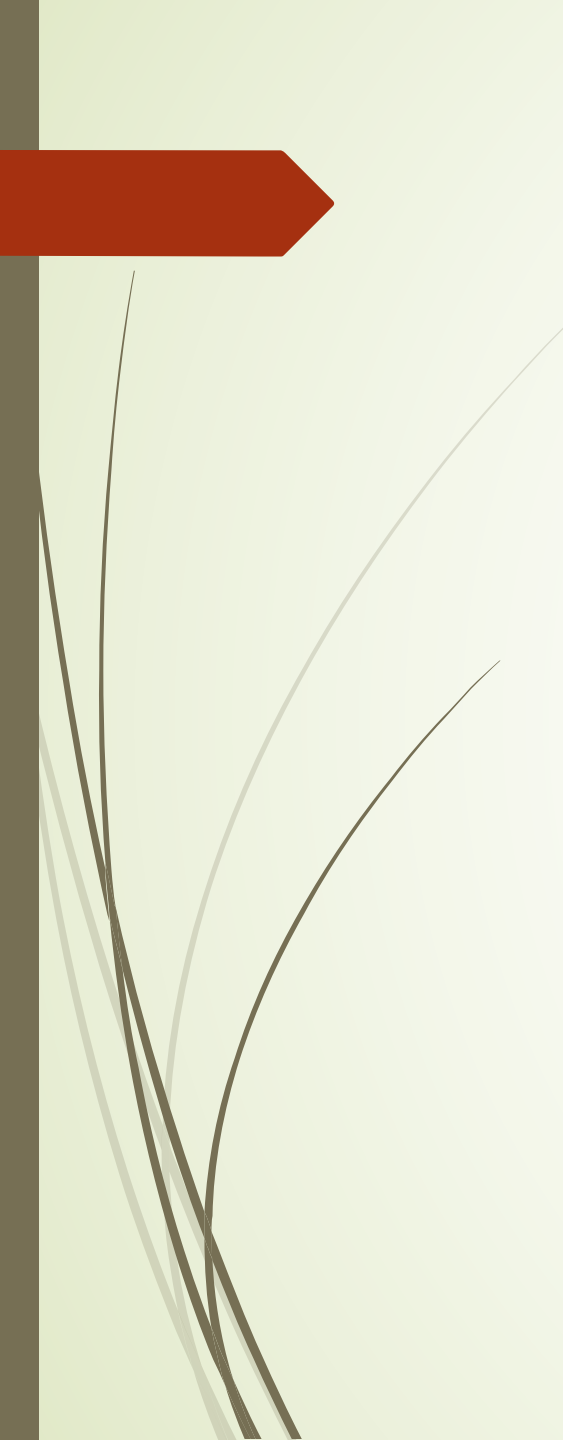


10 years

465

**New Large
Landscape Trees**

25' tall x 4" dia



CLAIM 5 - Wood bioenergy is carbon neutral if only waste wood is burned and this waste would simply rot and release carbon dioxide anyway

COUNTER CLAIM - Waste wood emits just as much CO₂ per pound as does burning whole trees

- Whole trees are a significant portion of forest biofuel
- Logging waste (tops & branches) decays slowly releasing some CO₂, and some wood becomes soil carbon

Wood harvest for bioenergy SE USA


Harvest emissions are counted here in US land sector and not in Europe where the pellets are burned



Harvest sites in North Carolina



Manufacturing sites in North Carolina




CLAIM 6 – As long as there is more carbon removed by forests than is emitted from them, burning wood is immediately carbon neutral

COUNTER CLAIM –

- Forests in aggregate, remove about 25% of human CO₂ emissions from all sources including bioenergy.
- Growing forests do not absorb 100% of the emissions only from wood burning

Natural Climate Solutions

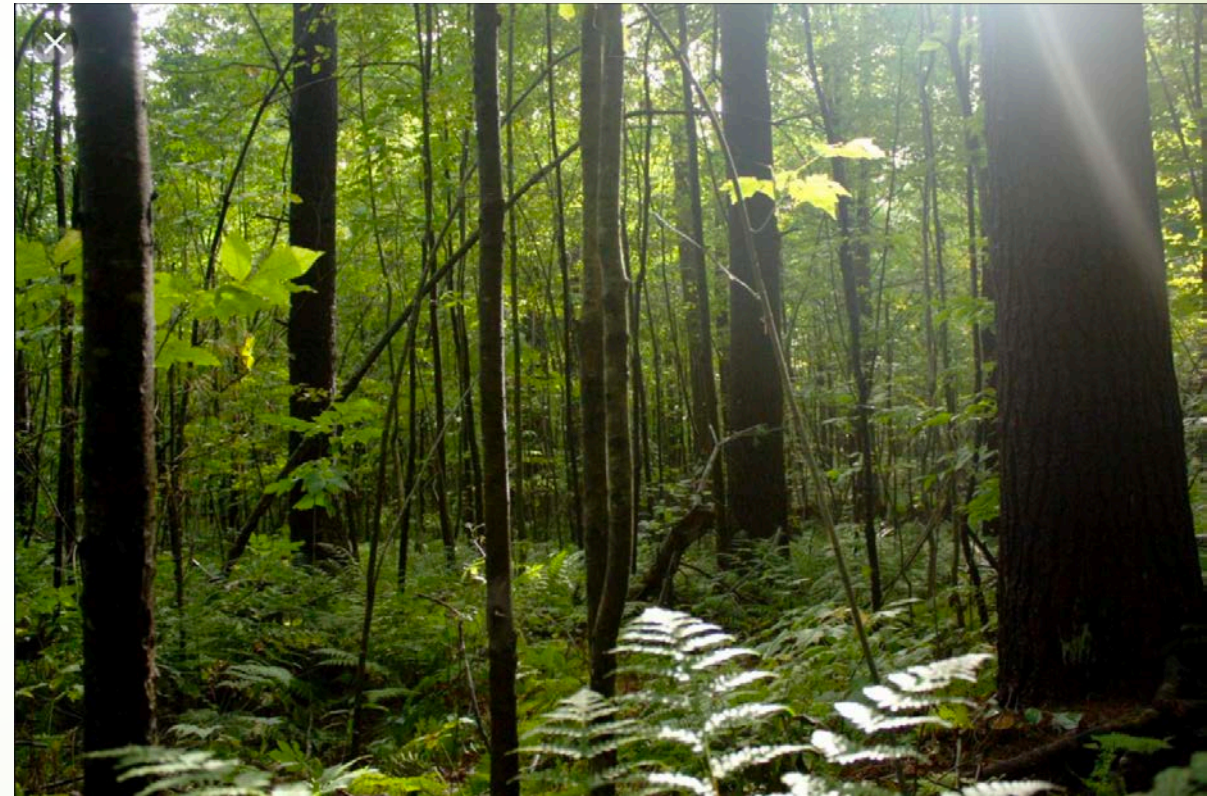


Keeping trees in the ground where they are already growing is an effective low-tech way to slow climate change

February 22, 2021 8:23am EST Updated February 23, 2021 6:12pm EST

Increasing carbon accumulation by forests to meet climate goals

- ▶ "...the largest one percent of trees in mature and older forests comprised 50 percent of forest biomass worldwide" Lutz et al 2018
- ▶ Altering forest management to let more trees grow would allow global forests to accumulate twice as much carbon Erb et al 2018
- ▶ The potential for growing forests to accumulate carbon by natural regrowth is better than active management and has been underestimated by 32% Cook-Patton et al 2020





50% Carbon

Planting trees is good
Letting them grow is better

Proforestation Management
growing forests to reach their
ecological potential for
biodiversity and carbon
accumulation in trees and
soils

Larger trees in older and
growing forests accumulate
the most atmospheric
carbon over time, and store
it in the wood of their trunk
and limbs and in soils

Atmospheric carbon removal

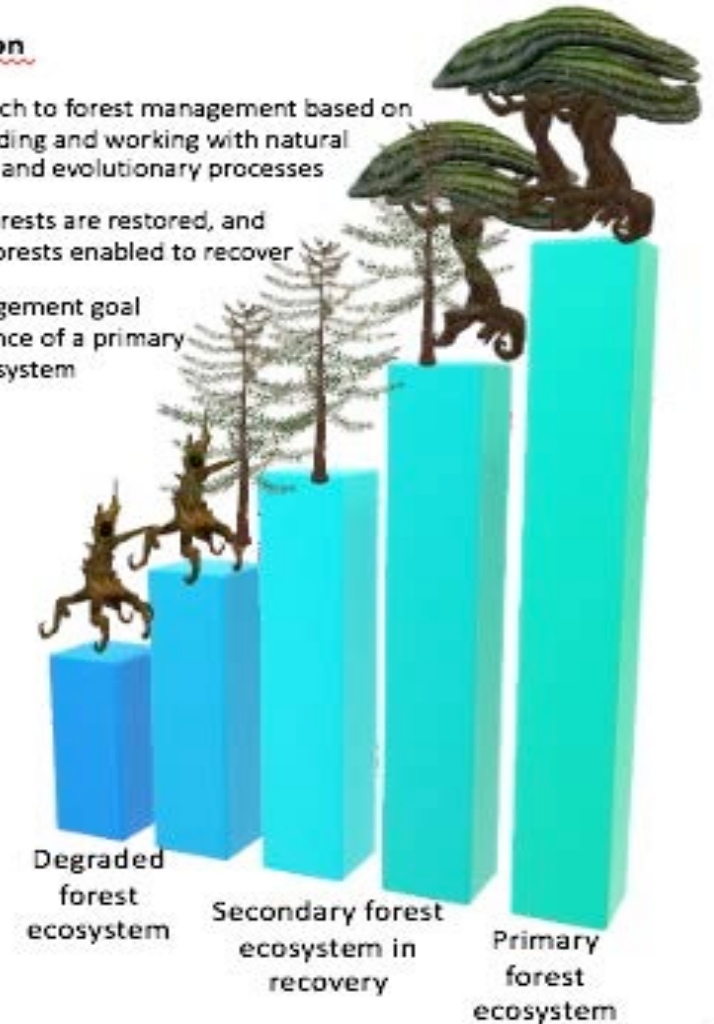
Technology Direct Air
Capture 2000 t CO₂/y



Nature's Solution 11x10⁹ tCO₂/y

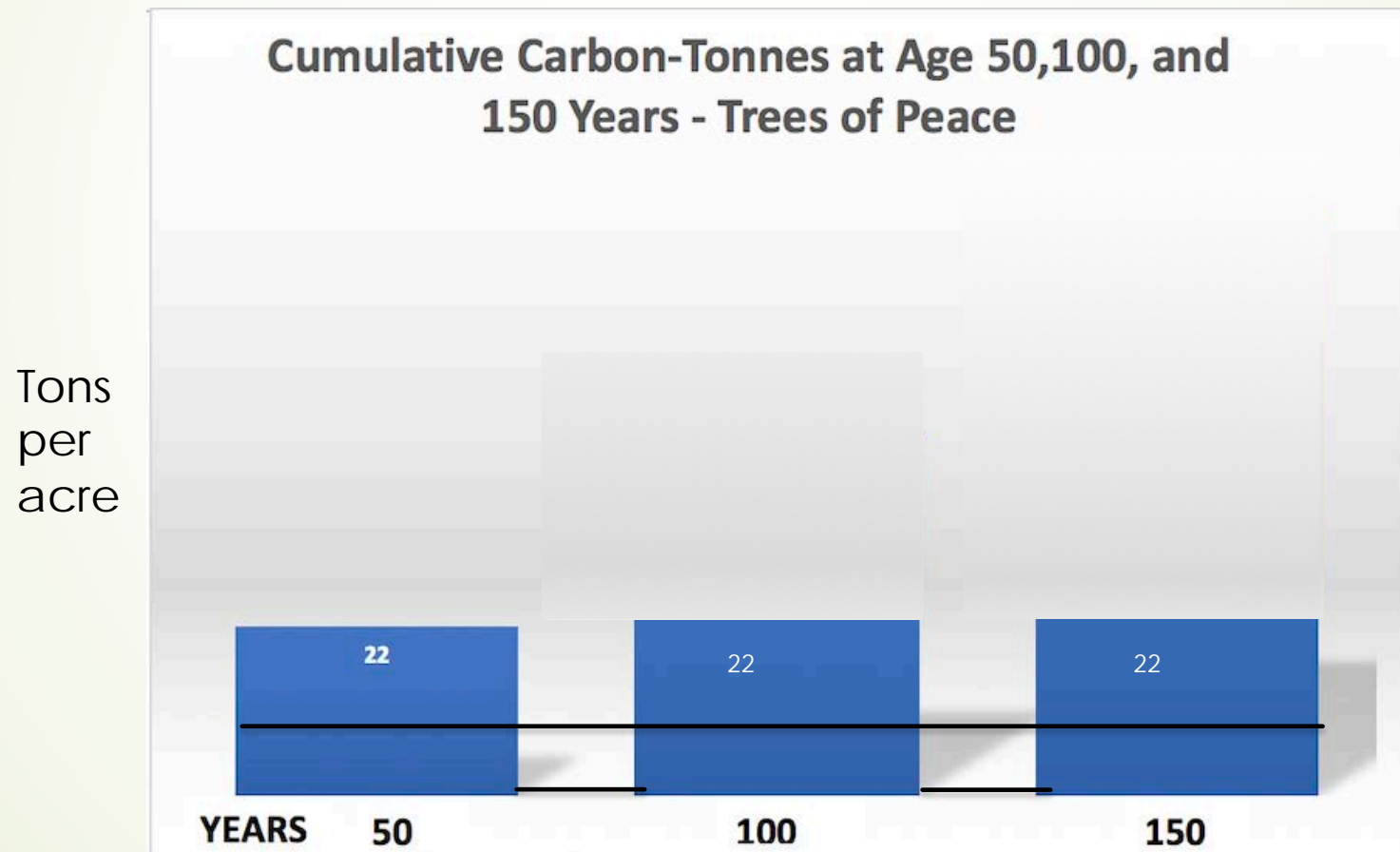
Proforestation

- An approach to forest management based on understanding and working with natural ecological and evolutionary processes
- Degraded forests are restored, and secondary forests enabled to recover
- The management goal is emergence of a primary forest ecosystem



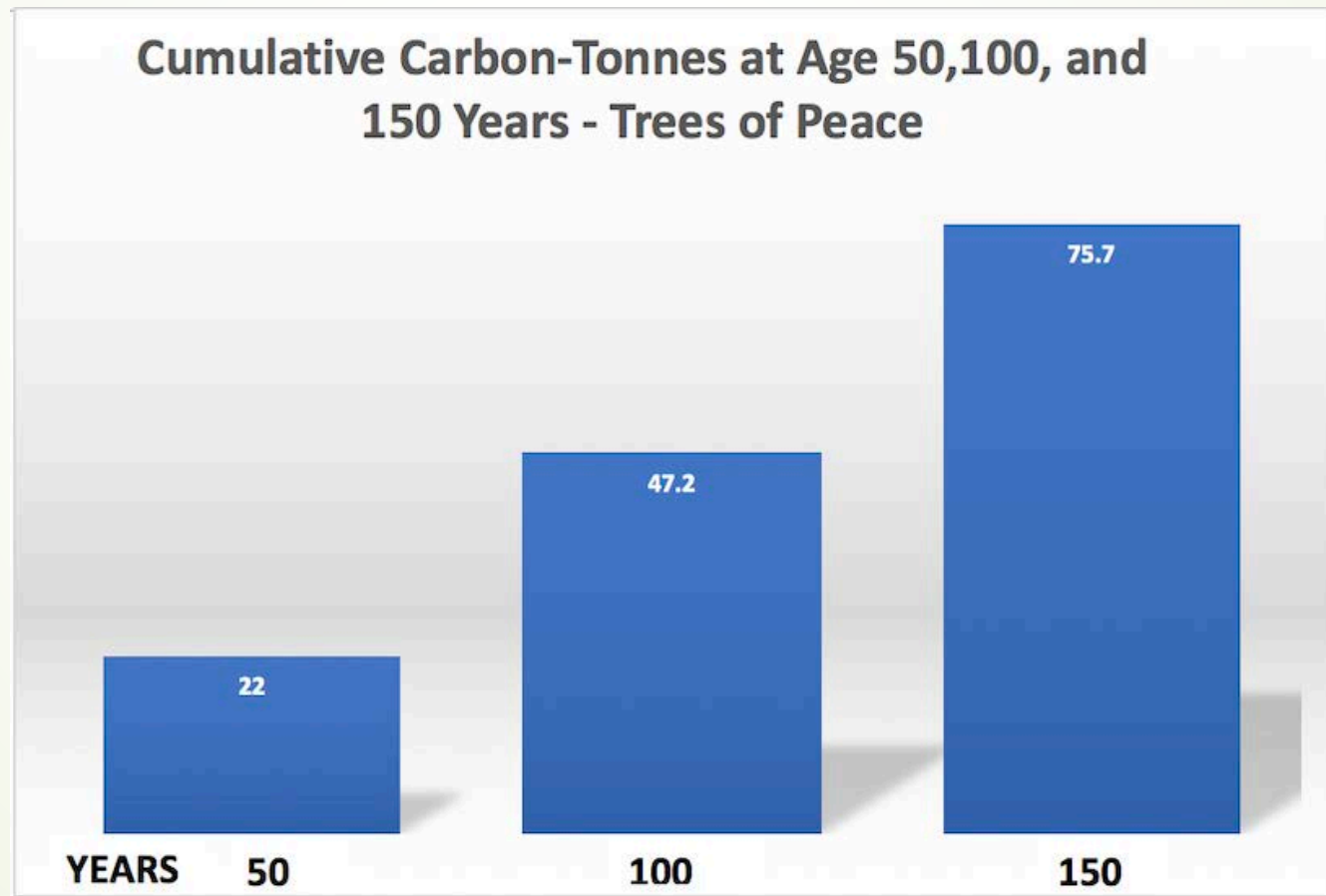
Harvest and Regrowth carbon in a one acre stand of white pine in Northeast United States 150 years

If burned, average addition CO₂ to atmosphere is somewhere between 0 and 22 tons

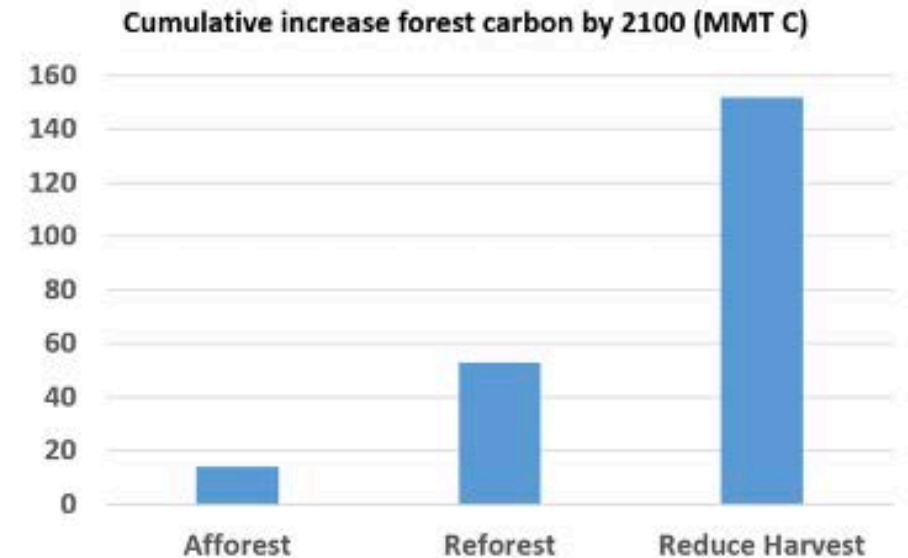
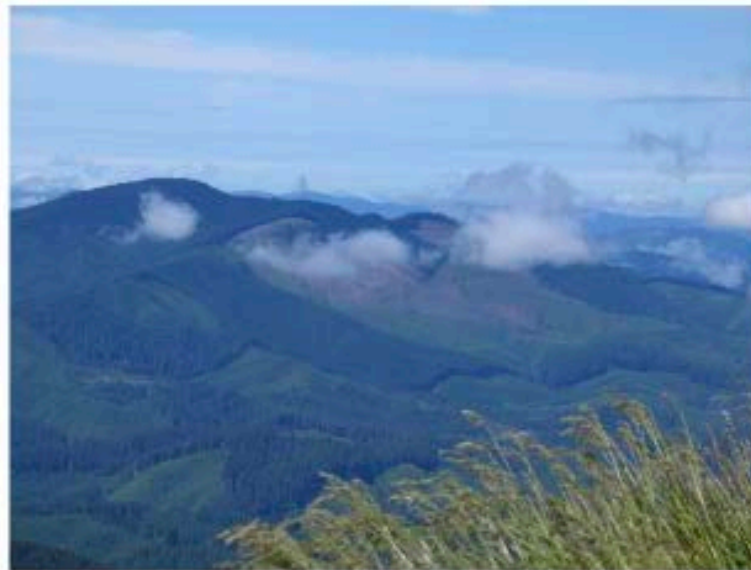


Accumulated carbon in a one acre stand of white pine in Northeast United States

Tons
per
acre



Accumulated carbon stocks in mature and old forests is the most effective forest-related climate mitigation strategy



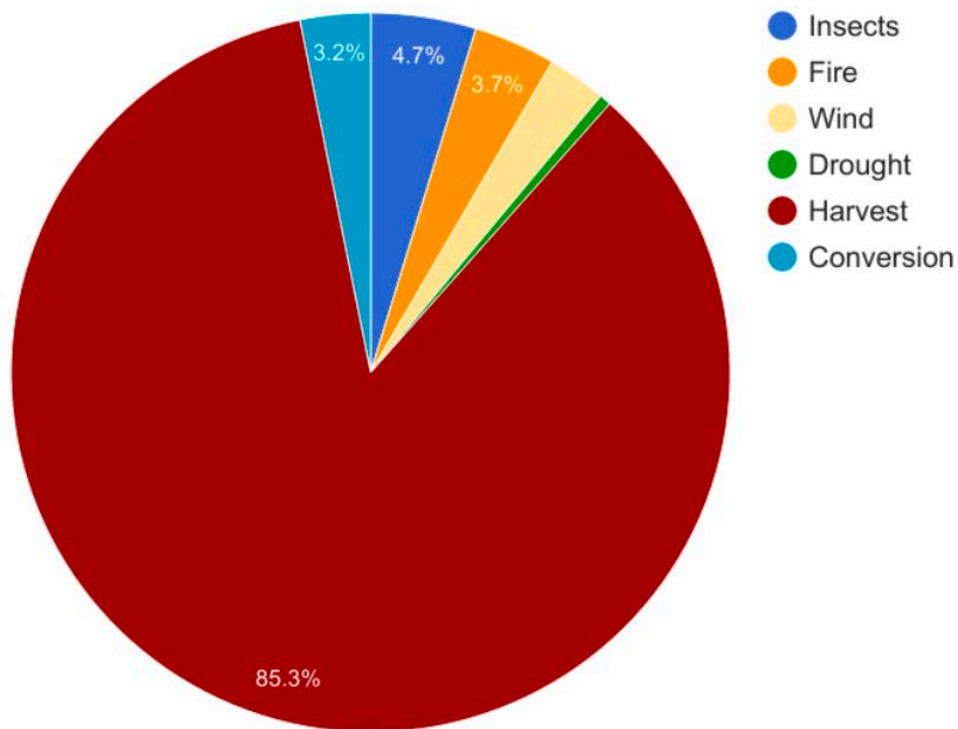
Restricting harvest to half of current rates on public lands and lengthening harvest cycles contributes the most to increasing carbon accumulation compared with business-as-usual management (Law et al. *Proc. Nat. Acad. Sci.* 2018, Luyssaert et al. *Nature* 2008)

Where is the carbon from harvested forests?

US forest harvesting (162 MMtC/y) exceeds US emissions from commercial and residential building sectors (149 MMtC/y) Harris 2016 (USFS)

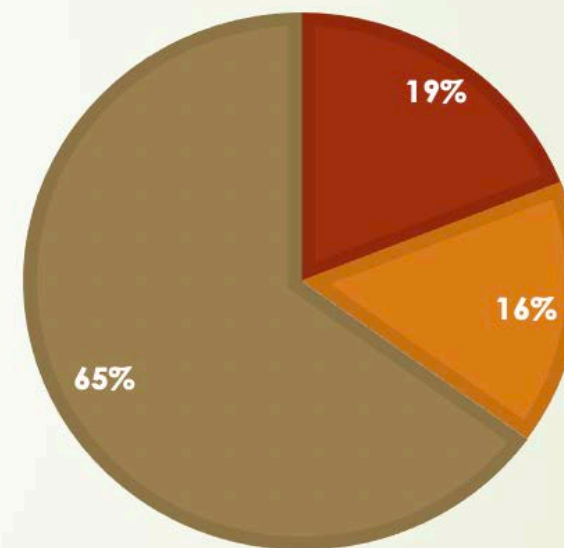
Washington, Oregon, California
TOTAL HARVESTED forest carbon since 1900

Annual forest carbon loss (Tg C) in the US



- Long lived wood products carbon
- Landfilled wood carbon
- Atmospheric carbon

Hudiburg et al 2019



Strategies for closing the carbon gap and preventing catastrophic feedback heating

- Prevent deforestation, the draining of wetlands and soil loss
- Proforestation management for some forests is far more effective than “planting a trillion trees”
- Proforestation management is among the least costly options for removing and storing additional carbon dioxide out of the atmosphere
- Create Strategic Climate and Biodiversity Reserves (Law et al 2022)



Establish two types of forests:



Strategic Climate and
Biodiversity Reserves



Industrial production forests




Urgent need for collaboration among forestry scientists and forest ecosystem and climate scientists

- The Climate Emergency is unfolding extremely rapidly because of amplifying feedbacks from natural systems (13,500 scientists –Ripple et al 2019)
 - Forest, soils and wetland respiration
 - Methane from wetlands and permafrost thaw
 - Increased water vapor from warmer oceans
 - Loss of albedo from ice, snow and declining sea ice cover in Arctic
- There is just a 2 in 3 probability that meeting Net Zero carbon by 2050 scenario will limit global temperature to 1.5° C (2.7° F)



To reach Net Zero Carbon by 2050, we need to slow additions by removing more atmospheric CO₂ today than we are adding

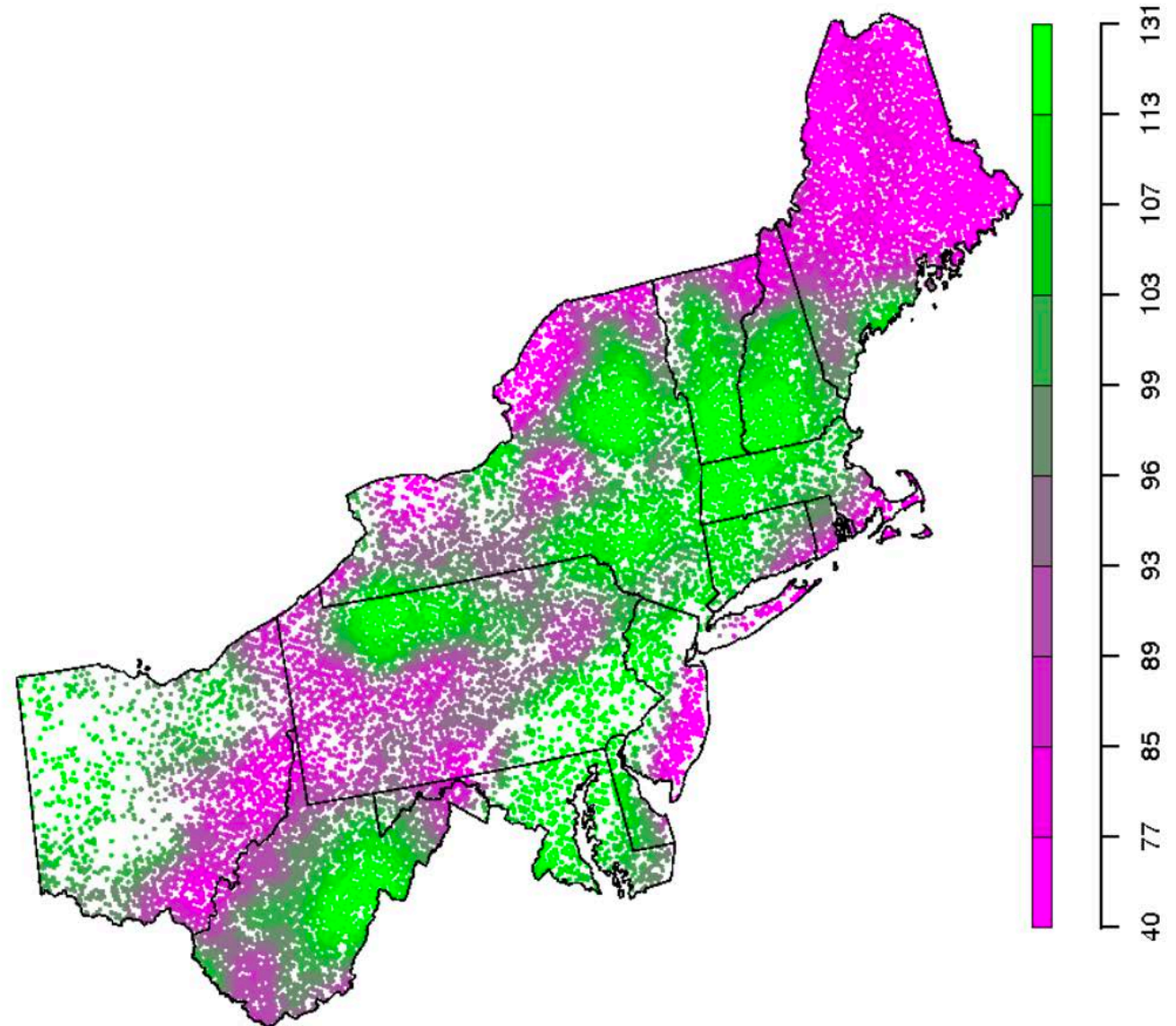
- We do not have enough time for newly planted trees to remove sufficient carbon between now and 2030 or 2050
 - Forest off-sets simply transfer credit, but do not alter atmospheric concentrations
 - Replacing fossil fuels with zero emitting solar and wind and letting some forests continue growing reduces additions to the atmosphere the most rapidly
 - A better economic and climate use for forest residues is to use fibers to make building insulation to reduce atmospheric additions (Maine)
- 

Forest carbon density in N.E. United States

USFS COLE MAP

Note that carbon density is 3x greater in western New England than in Maine

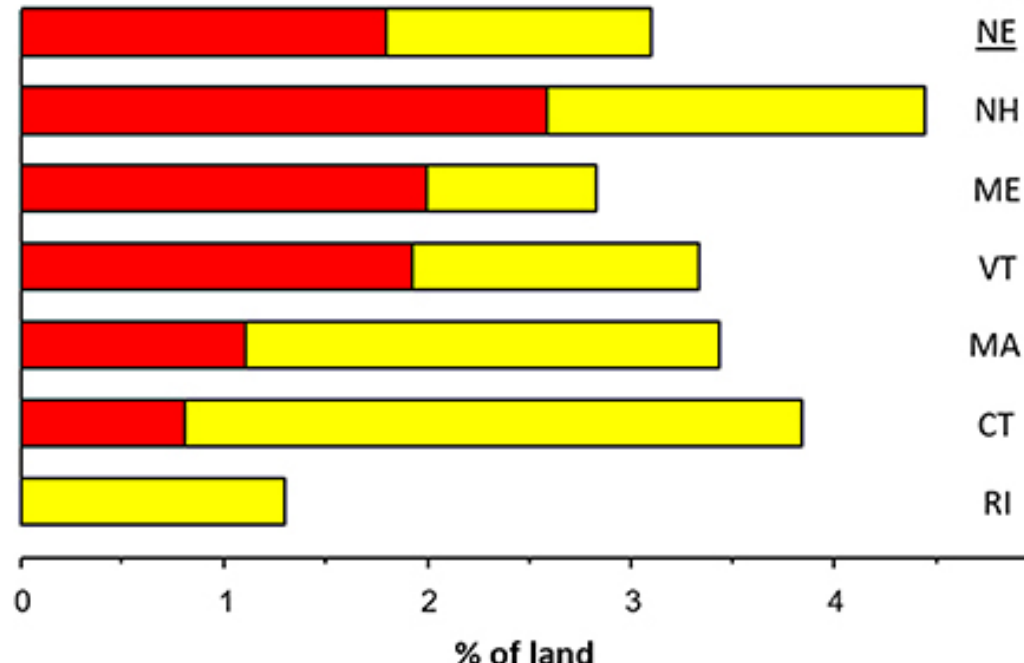
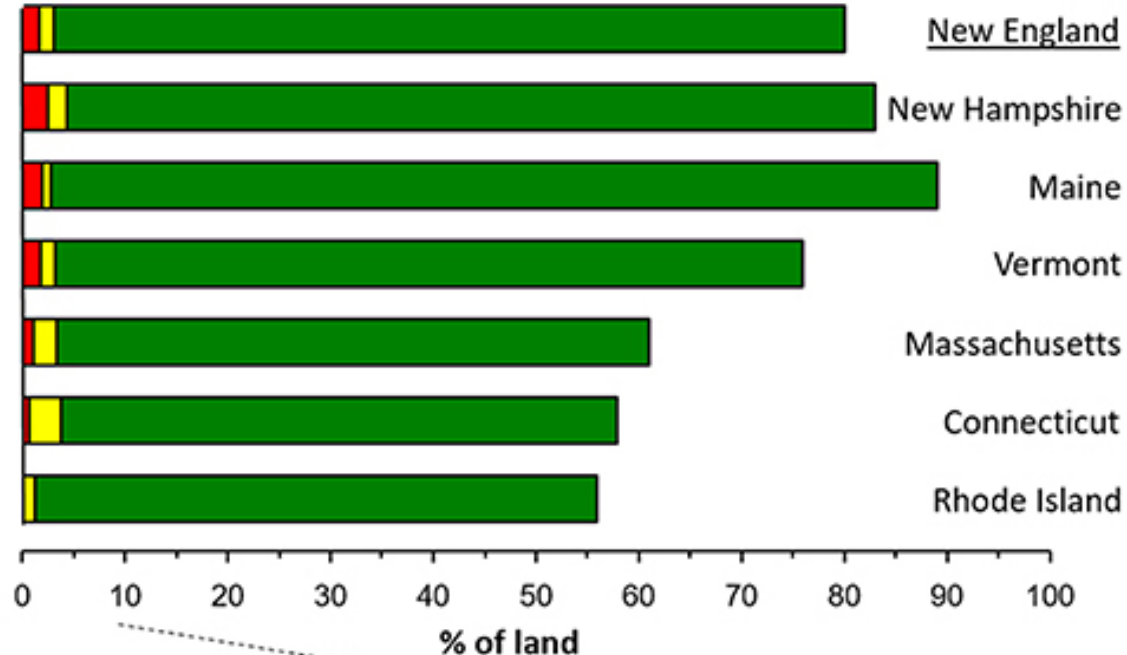
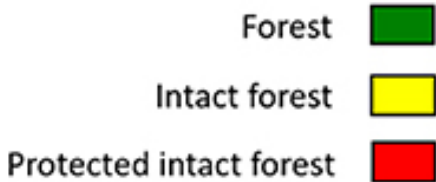
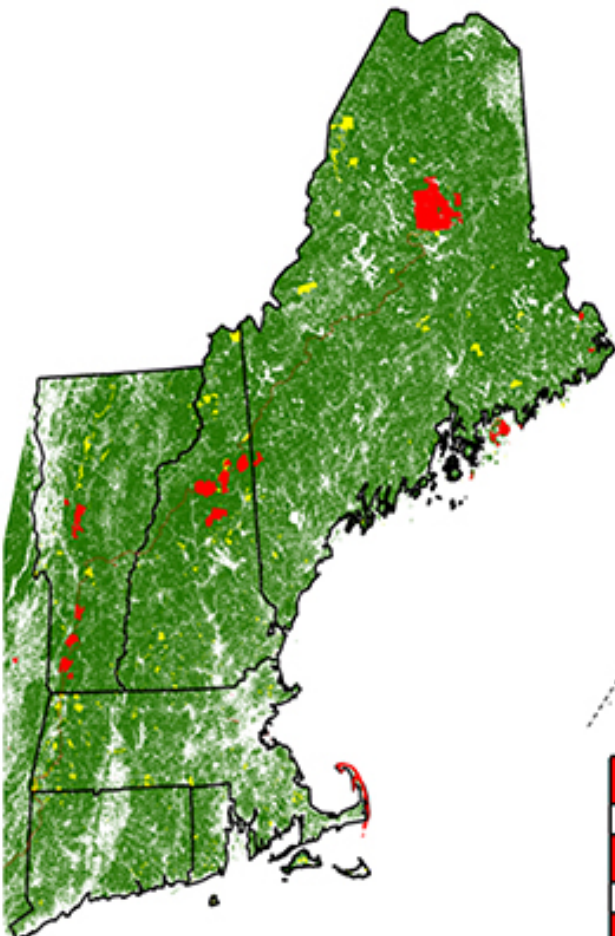
COLE Map
Total Aboveground Carbon (metric tons/hectare)



State of protected Areas in New England

Moomaw et al 2019

Less than 5 per-cent have any regulatory or Statute protection






Nature Needs Half™

Protecting and interconnecting at least half of the planet's land and water is necessary to sustain the health, function, and diversity of all life.

E.O. Wilson co-founder of biodiversity science
10 June 1929- 26 December 2021



That means the other half can provide the resources for the economy if sustainably managed

- Halting climate change meets that criterion!
 - Does burning forests for bioenergy help meet that goal?
- 

A photograph of a forest floor. In the center is a large, vibrant red maple leaf with several small holes and dark spots. To the left and right of the red leaf are two small green plants, each with five rounded leaves. The ground is covered with brown leaves, twigs, and small rocks. The text "Thank you" is written in white across the red leaf.

Thank you

