

# Vermont House Committee on Environment and Energy William R Moomaw Testimony

Professor Emeritus of International Environmental Policy Tufts University

Visiting Scientist Woodwell Climate research Center

January 18, 2023

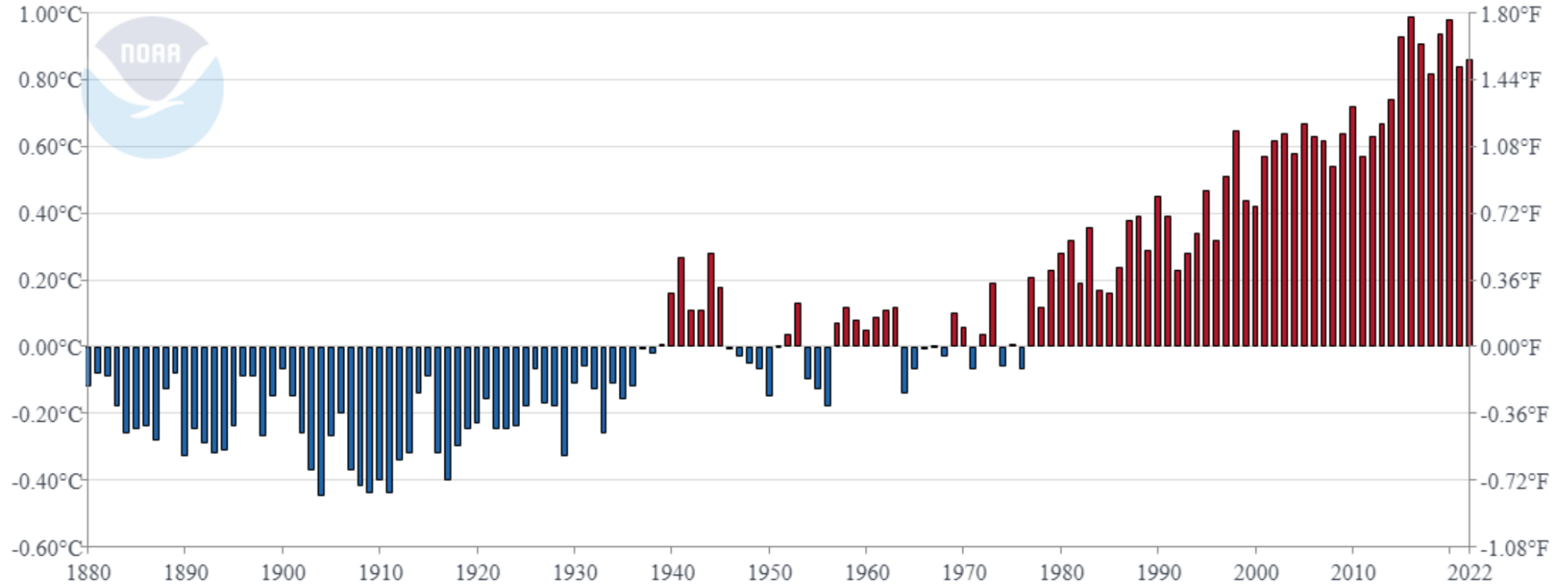
# The Climate Has Already Changed!



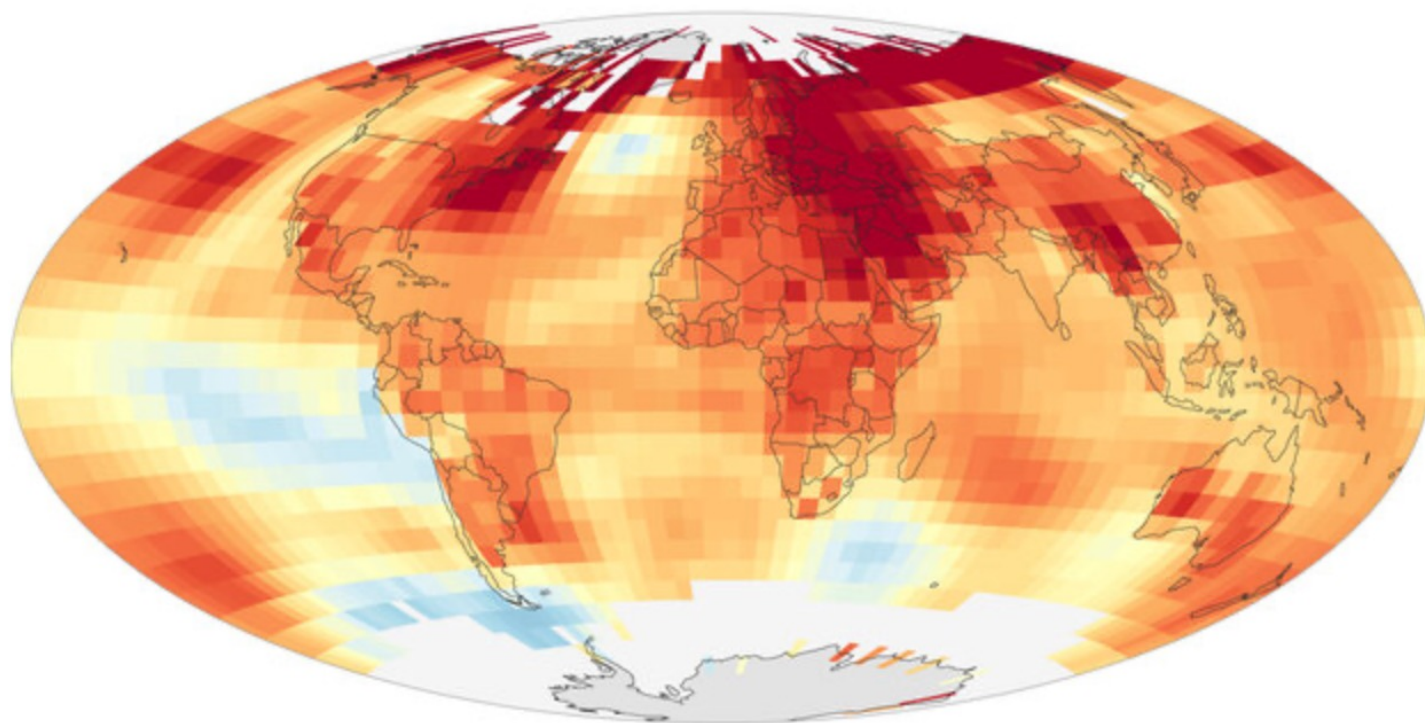
# Global average land and ocean temperature

## Global Land and Ocean

January-December Temperature Anomalies



## RECENT TEMPERATURE TRENDS (1990-2021)



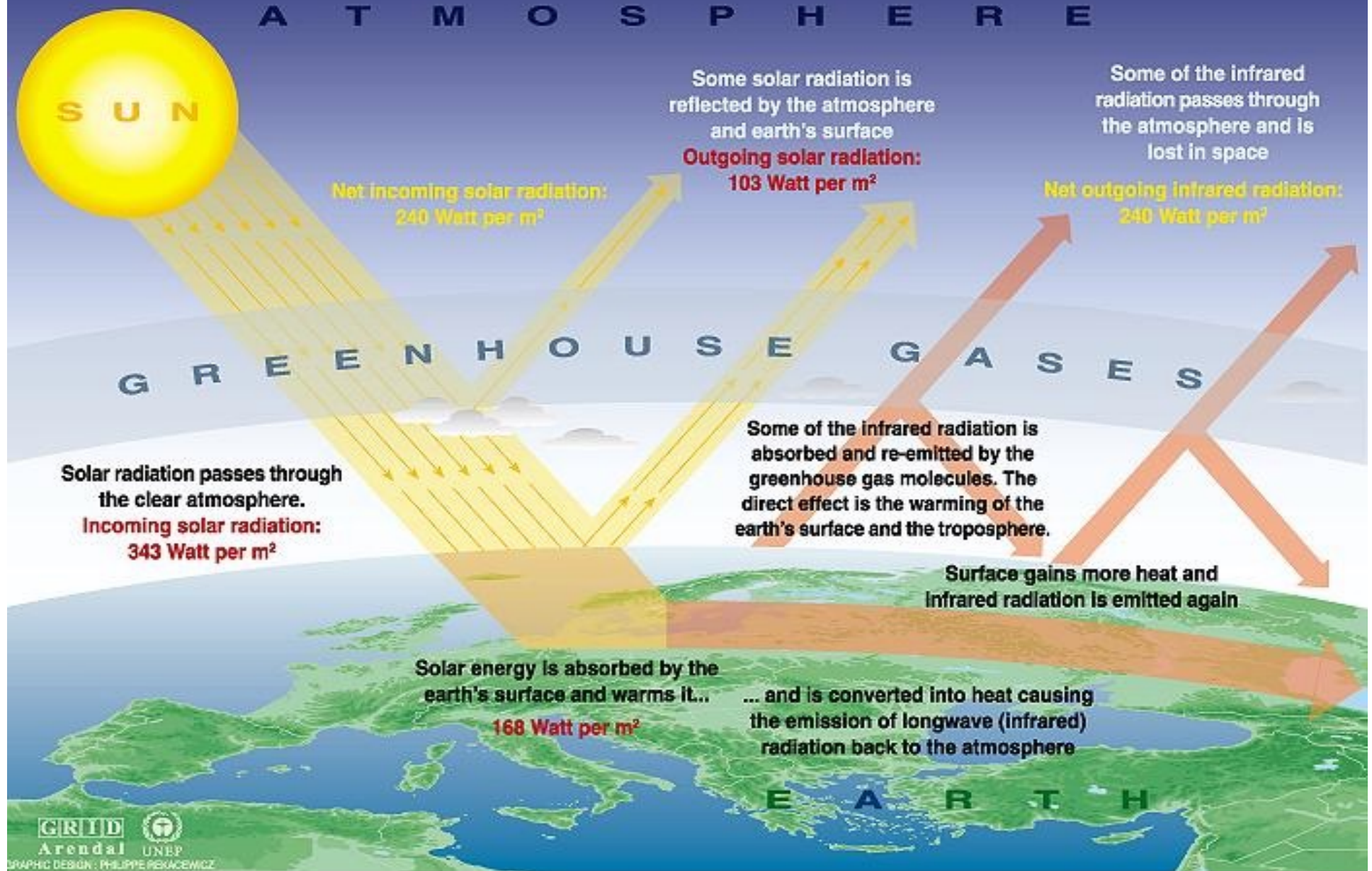
1990-2021

Change in temperature ( $^{\circ}\text{F}/\text{decade}$ )



NOAA Climate.gov  
Data: NCEI

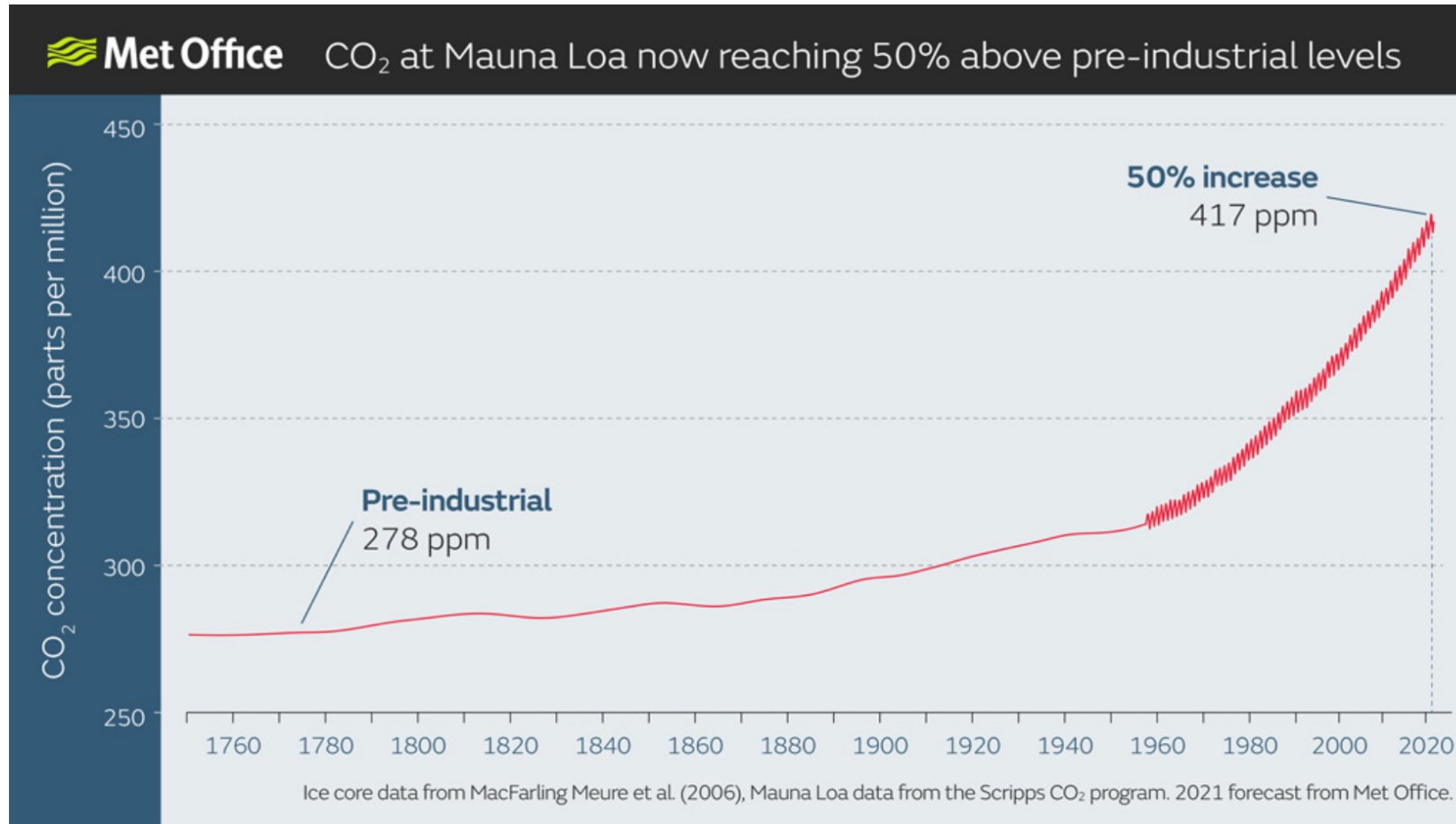
# TRAPPING HEAT AND WARMING THE EARTH



Sources: Okanagan university college in Canada, Department of geography, University of Oxford, school of geography; United States Environmental Protection Agency (EPA), Washington; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge university press, 1996.

# 50% CO<sub>2</sub> increase in the atmosphere since 1750

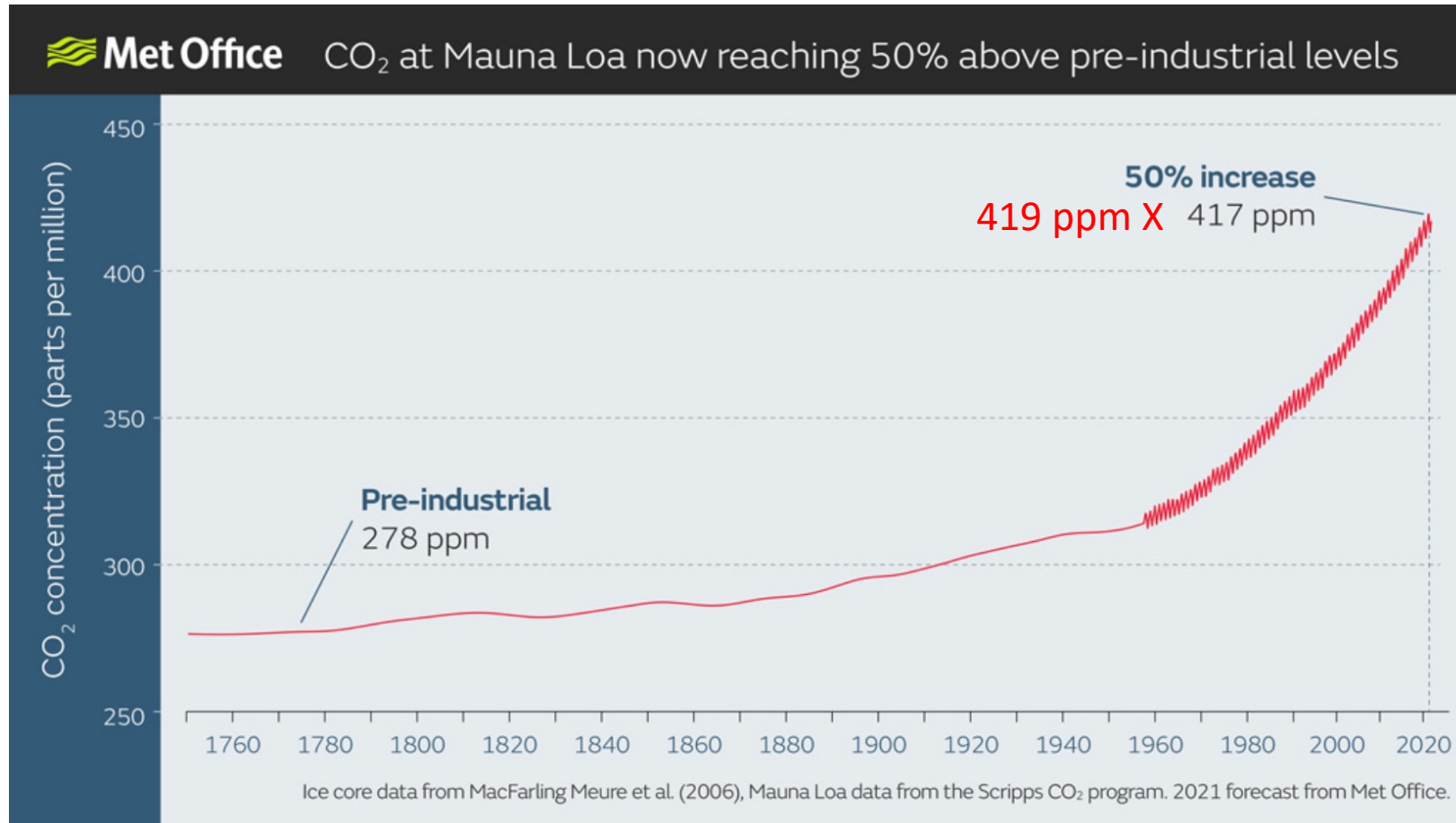
30% of this addition is from deforestation and soils degradation



Global atmospheric CO<sub>2</sub> concentrations from 1700 to 2021. Credit: [Met Office](#).

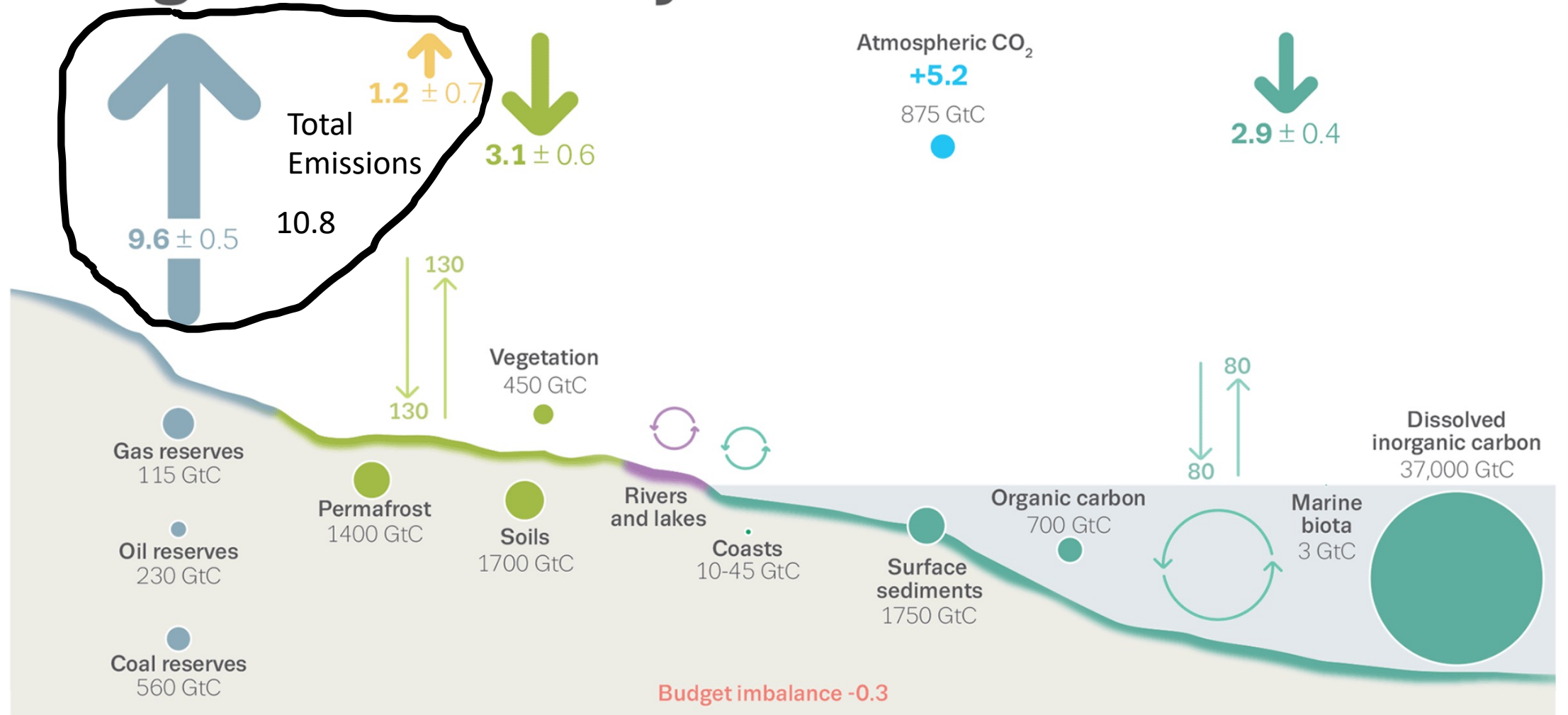
What would happen if 30% additional CO<sub>2</sub> was added each year for 50 years?

542 ppm X 



Global atmospheric CO<sub>2</sub> concentrations from 1700 to 2021. Credit: [Met Office](#).

# The global carbon cycle



Anthropogenic fluxes 2012-2021 average GtC per year

↑ Fossil CO<sub>2</sub> E<sub>FOS</sub>  
 ↓ Land uptake S<sub>LAND</sub>

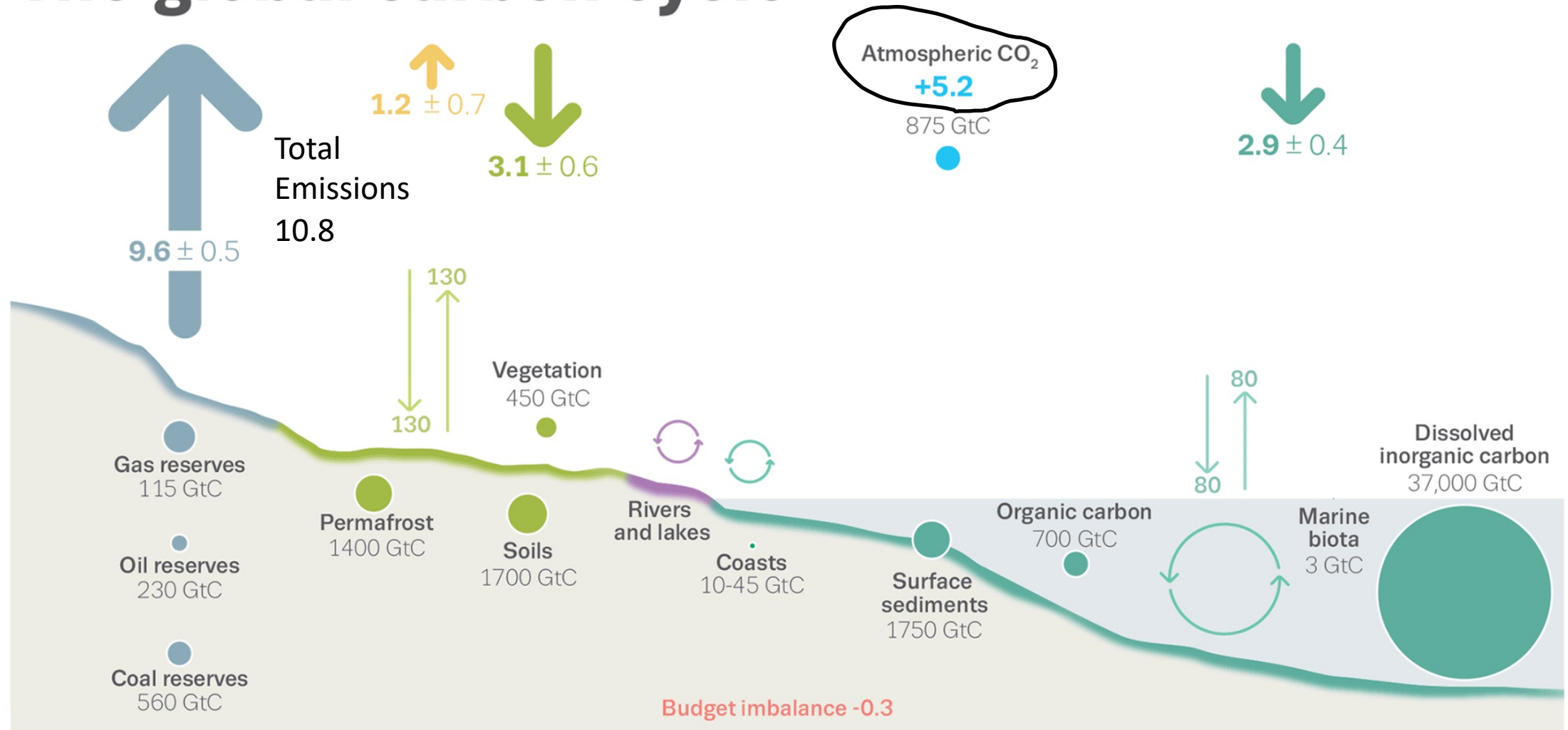
↑ Land-use change E<sub>LUC</sub>  
 ↓ Ocean uptake S<sub>OCEAN</sub>

↑ Carbon cycling GtC per year  
 ● Stocks GtC

+ Atmospheric increase G<sub>ATM</sub>  
 ■ Budget Imbalance B<sub>IM</sub>



# The global carbon cycle



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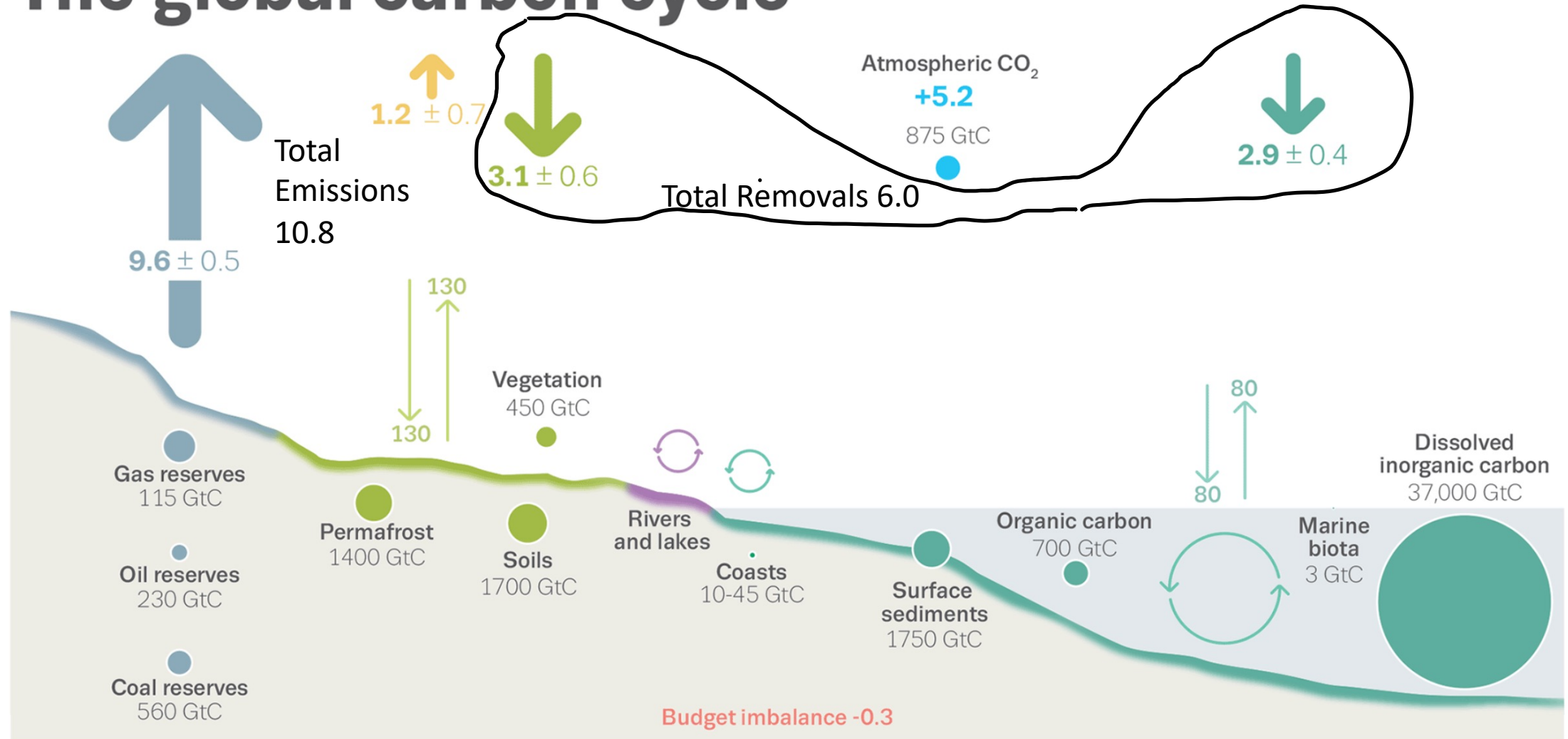
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# The global carbon cycle



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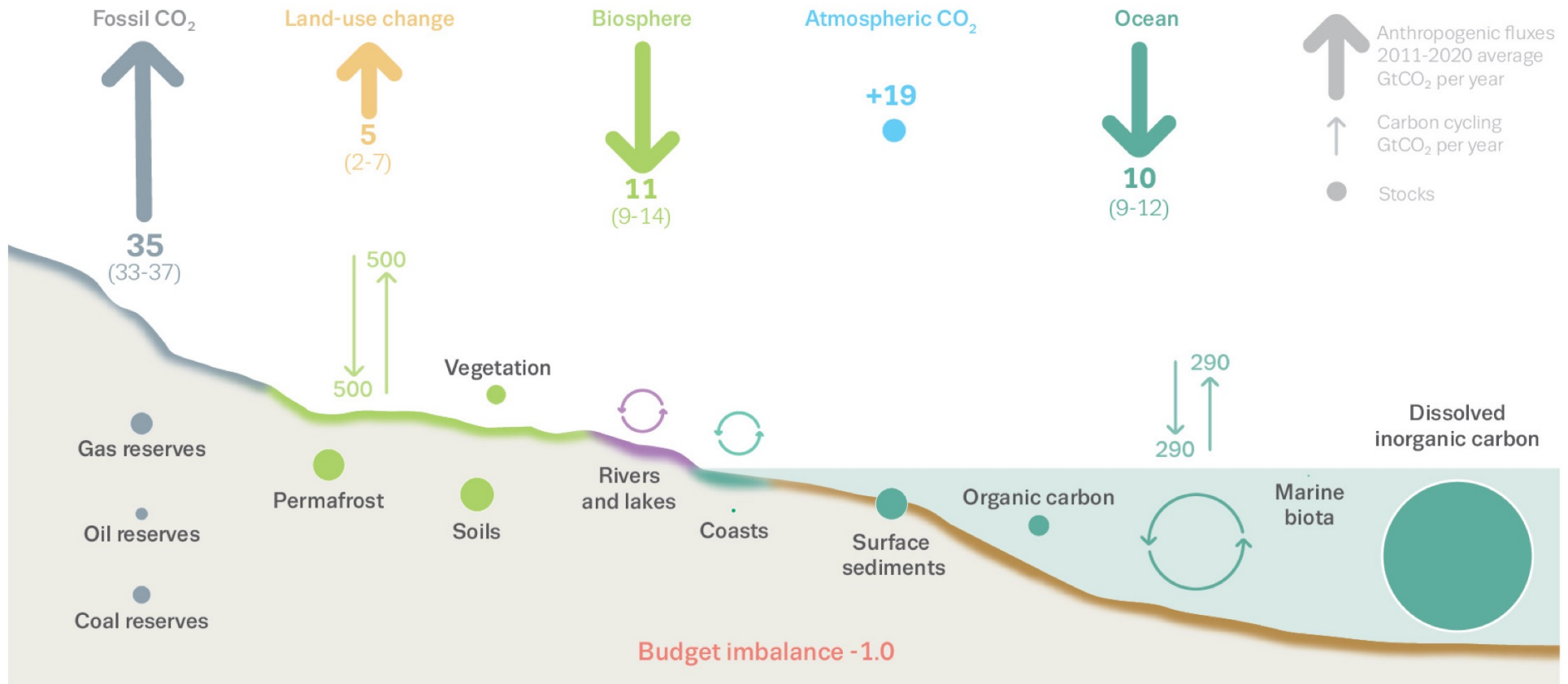
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# Anthropogenic perturbation of the global carbon cycle

global annual average for the decade 2012–2021 (GtCO<sub>2</sub>/yr)



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

Source: [NOAA-ESRL](#); [Friedlingstein et al 2022](#); [Canadell et al 2021 \(IPCC AR6 WG1 Chapter 5\)](#); [Global Carbon Project 2022](#)

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



IPCC Special Report *Global Warming of 1.5°C* (2.7°F) 2018

To achieve 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” ...and net negative beyond 2100

**Must simultaneously reduce carbon dioxide emissions and increase its removal from the atmosphere**

**Global average temperature has risen by 1.2°C (WMO 2022)**

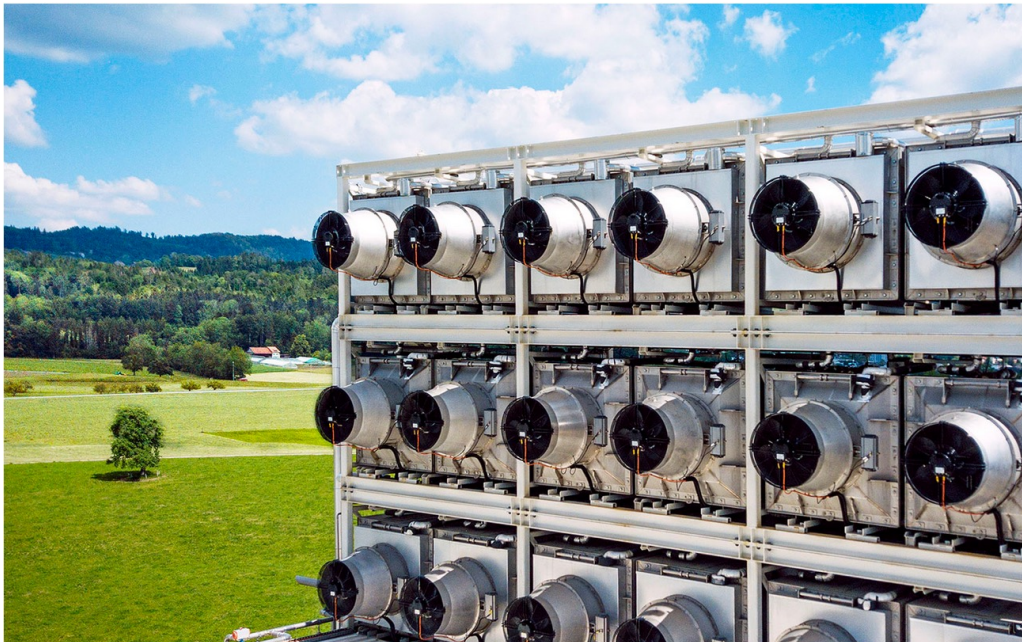
# Lowering carbon dioxide additions to the atmosphere and eventually decreasing concentrations

- **Improve energy productivity** (efficiency) to reduce emissions for energy services provided to fossil fuel emitting sources
- **Rapidly transition** from fossil and wood fuels to **zero carbon energy** such as wind, solar geothermal and some hydro
- **Capture and store carbon dioxide** from fossil fuel and wood combustion and from concrete and steel production
- **Remove Additional** carbon dioxide from the atmosphere and store it
  - Technological solutions – Direct air capture
  - **Natural Climate Solutions by forests, grasslands, wetlands and oceans**
- **Removal is the most effective action!**

# How do we remove more atmospheric carbon?

**19 direct air capture systems remove  
10,000 tons CO<sub>2</sub>/y**

Equal to annual emissions of 1600 EU citizens/year



(IEA 9/22)

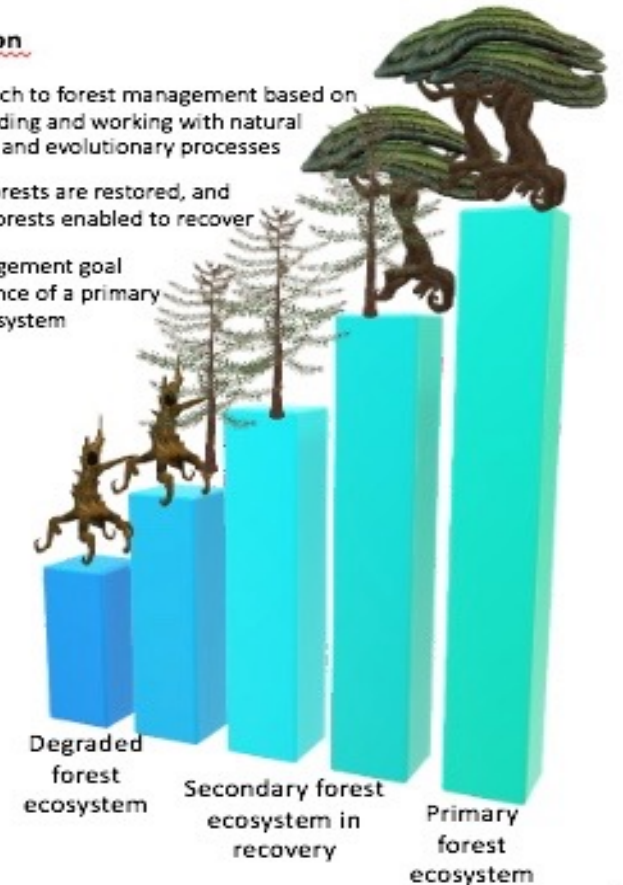
**Nature's Solution removes 11,000,000,000 tons**

Equal to annual emissions of 1.8 billion EU citizens –  
3.8 x EU population

## 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

The largest 1% of trees in a mature multiage forest hold half the carbon!



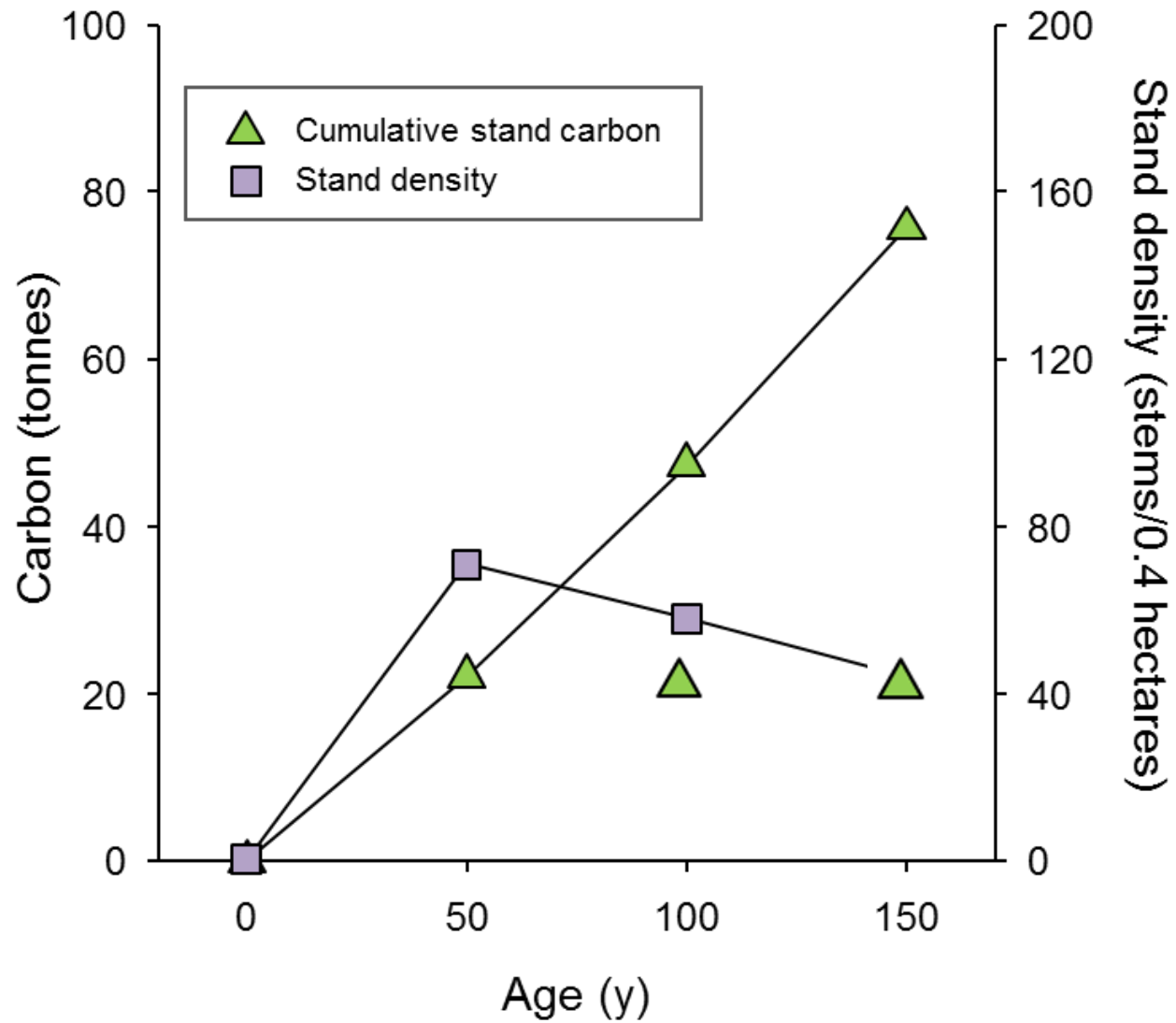


50% Carbon

How do we get big trees?  
Let more of them grow!

**Proforestation Management**  
growing forests without harvest to  
**reach their potential for**  
**biodiversity and carbon**  
**accumulation** in trees and soils

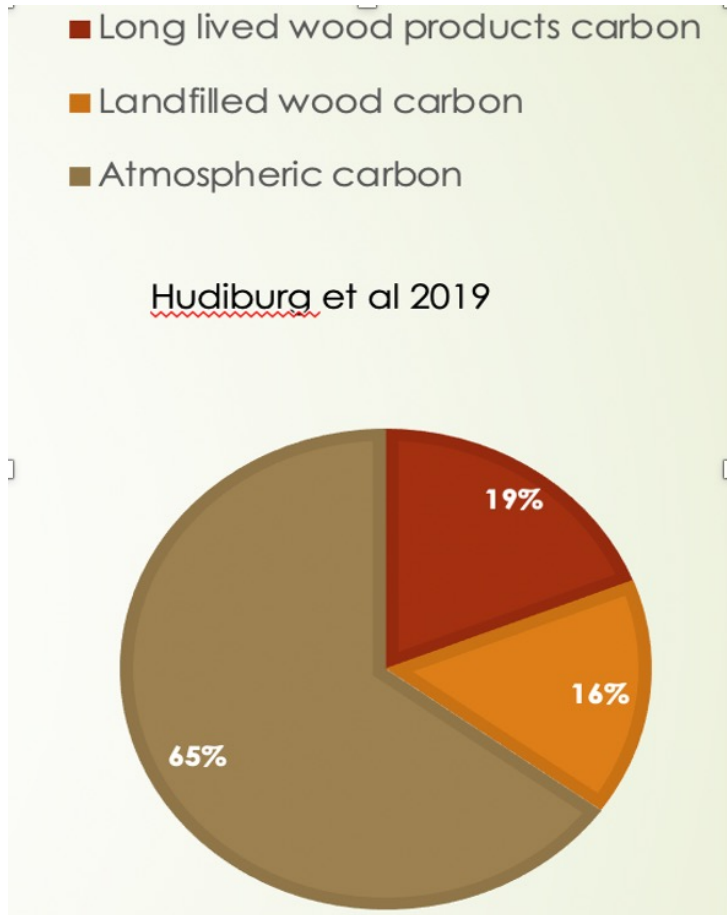
**Larger trees in older and growing**  
**forests accumulate the most**  
**atmospheric carbon over time,**  
and store it in the wood of their  
trunk and limbs and in soils



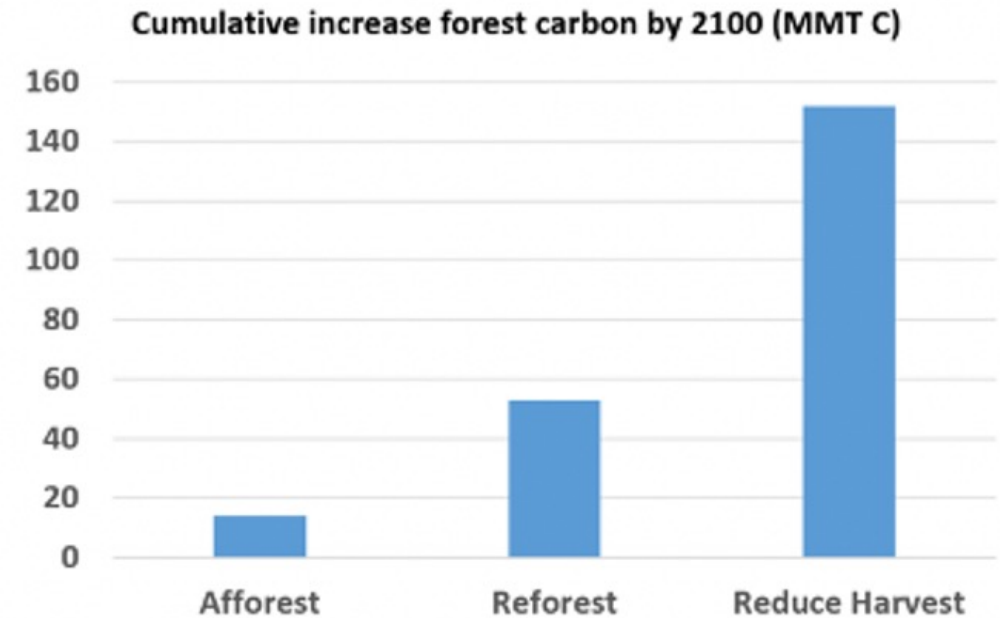
150 year old stand of white continue to accumulate carbon (Leverett et al. 2021)



# Fate of harvested carbon in California, Oregon And Washington 1900-2015



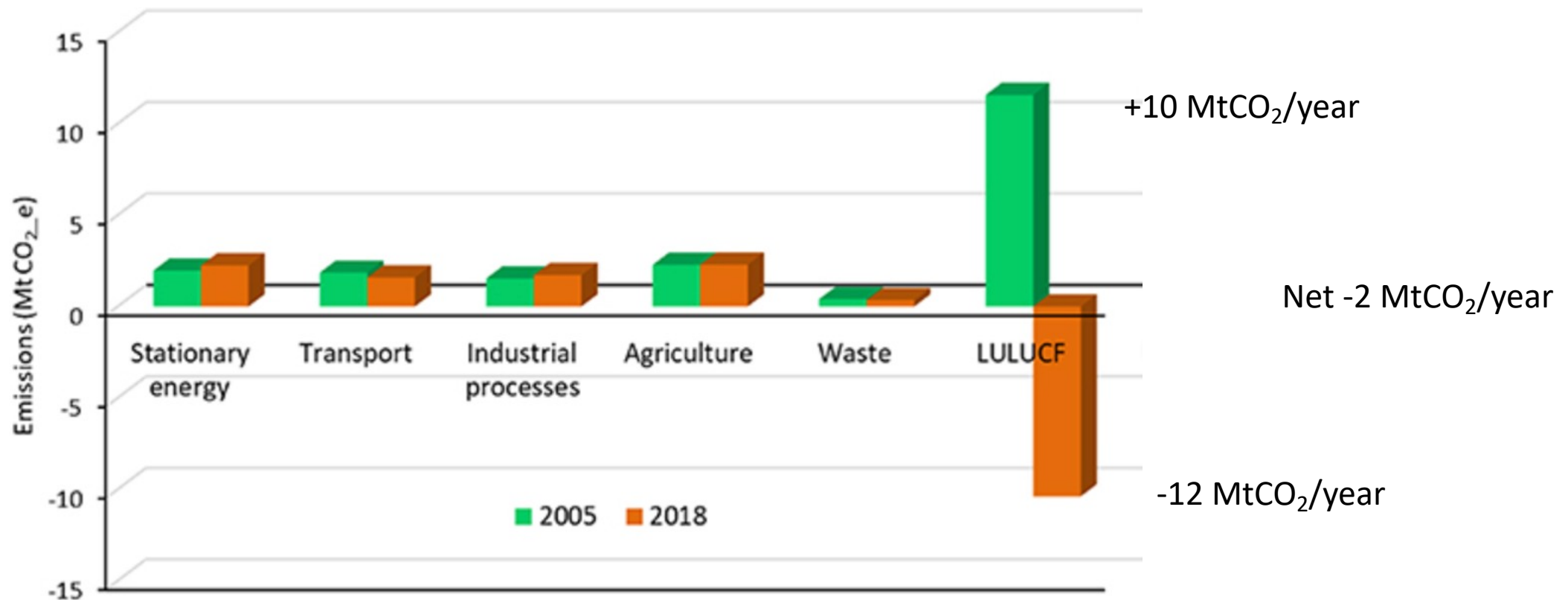
# Projected cumulative carbon in Oregon forests by 2100 MMT C



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)

# Proforestation carbon benefits in Australia

- Tasmania halted harvesting half its forests and between reduced emissions from harvest and 7 years of growth, became **net negative**



# CARBON ROCK STARS: LARGE, OLDER TREES AND FORESTS

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

Robert Leverett 2021



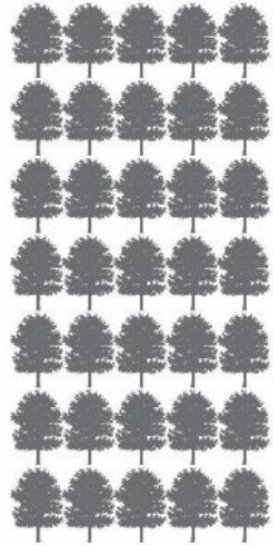
150 years

**1**

**Mature  
Canopy Tree**

*100' tall x 54" dia*

OR



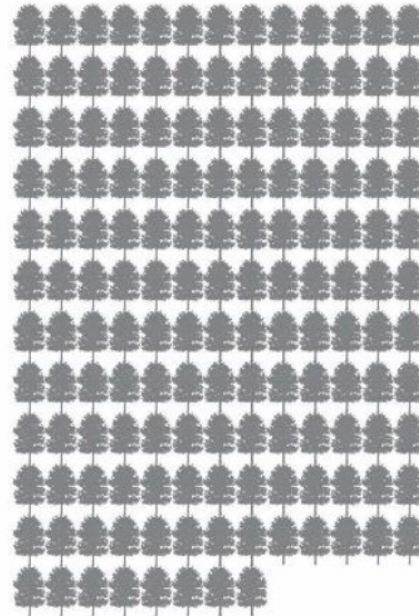
29 years

**35**

**Young  
Canopy Trees**

*50' tall x 12" dia*

OR



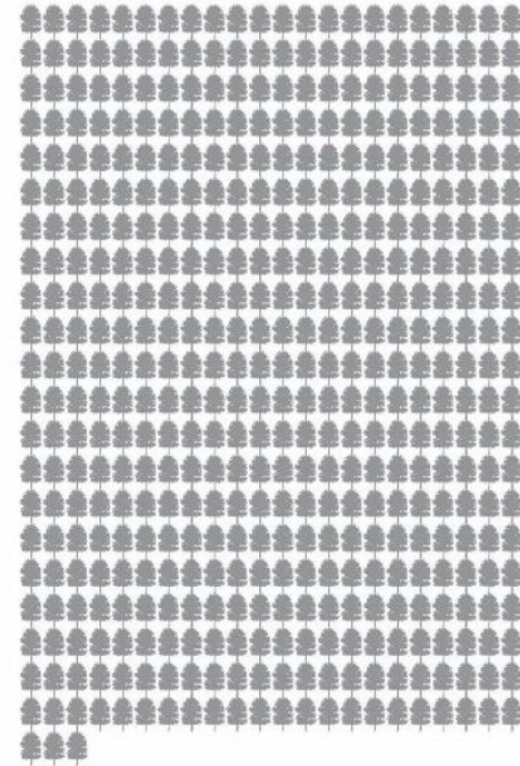
16 years

**151**

**Typical  
Street Trees**

*40' tall x 6" dia*

OR



10 years

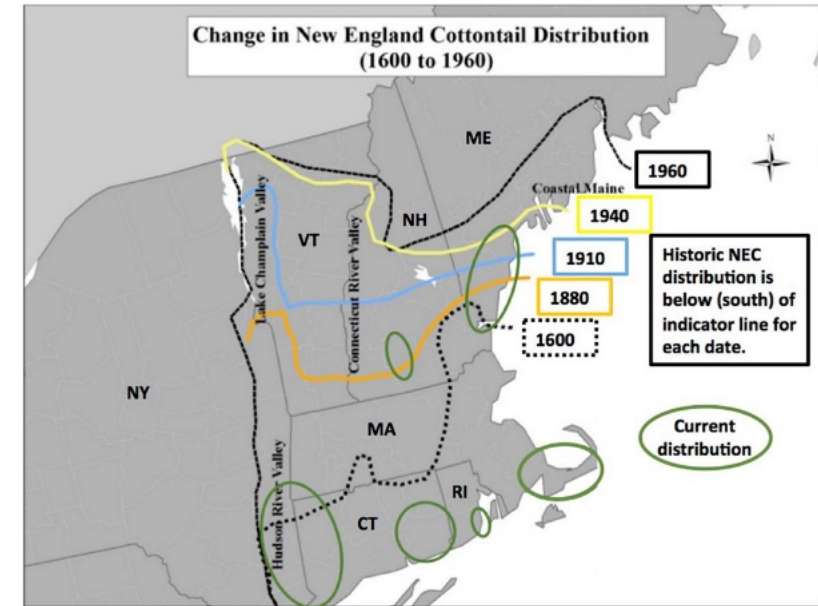
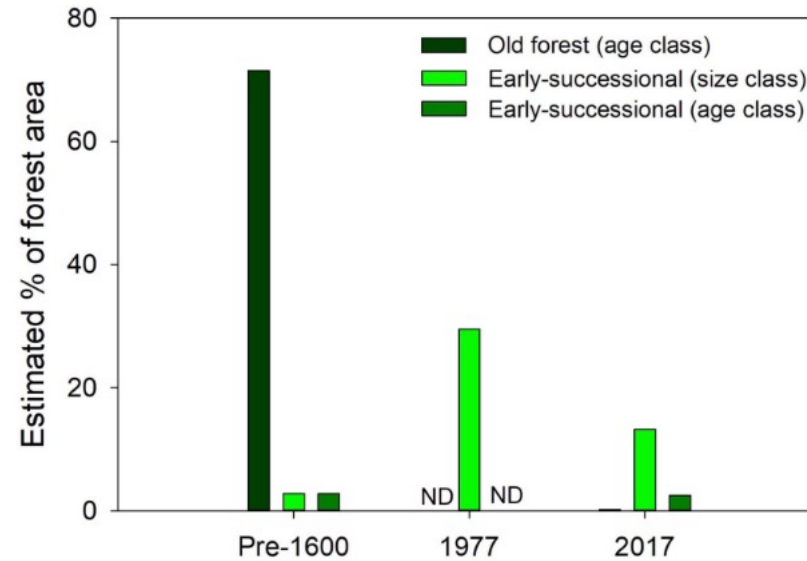
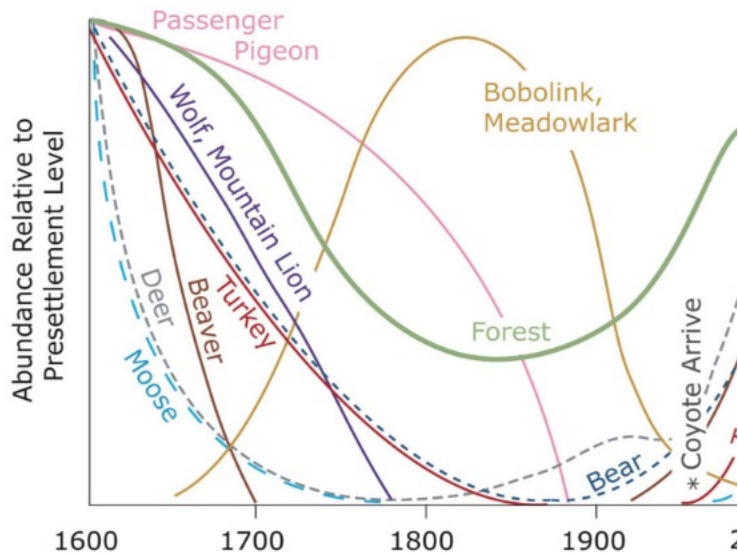
**465**

**New Large  
Landscape Trees**

*25' tall x 4" dia*

# It is seldom necessary to create Early Successional Habitat – nature is doing that now!

Figure 1



# A New Framing of two Emergencies

Linking biodiversity and climate change as a single problem that requires an integrated approach

The natural world removes 56% of annual emissions from the atmosphere

Forests host 80% of the world's land based biodiversity

**“Only by considering climate and biodiversity as parts of the same complex problem, which also includes the actions and motivations and aspirations of people, can solutions be developed that avoid maladaptation and maximize the beneficial outcomes.”**



Intergovernmental Platform for Biodiversity and  
Ecosystem Services 2021

[https://ipbes.net/sites/default/files/2021-06/20210609\\_workshop\\_report\\_embargo\\_3pm\\_CEST\\_10\\_june\\_0.pdf](https://ipbes.net/sites/default/files/2021-06/20210609_workshop_report_embargo_3pm_CEST_10_june_0.pdf)

# Intergovernmental Panel on Climate Change 2022

- *“Safeguarding biodiversity and ecosystems is fundamental to climate resilient development, in light of the threats climate change poses to them and their roles in adaptation and mitigation (very high confidence).”*
- *“Recent analyses ... suggest that maintaining the resilience of biodiversity and ecosystem services at a global scale depends on effective and equitable conservation of approximately 30% to 50% of Earth’s land, freshwater and ocean areas, including currently near-natural ecosystems (high confidence).”*  
<https://www.ipcc.ch/report/ar6/wg2/>

To reach Net Zero Carbon by 2050, we need to slow additions by reducing emissions and removing more atmospheric CO<sub>2</sub> as soon as possible

- **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 more forests continue growing** reduces net additions to the atmosphere the most rapidly
- A better economic and climate use for forest residues than burning them is to use fibers to make building insulation to reduce atmospheric additions (Maine)

# GLASGOW LEADERS' DECLARATION ON FORESTS AND LAND USE

## COP 26 NOVEMBER 2021

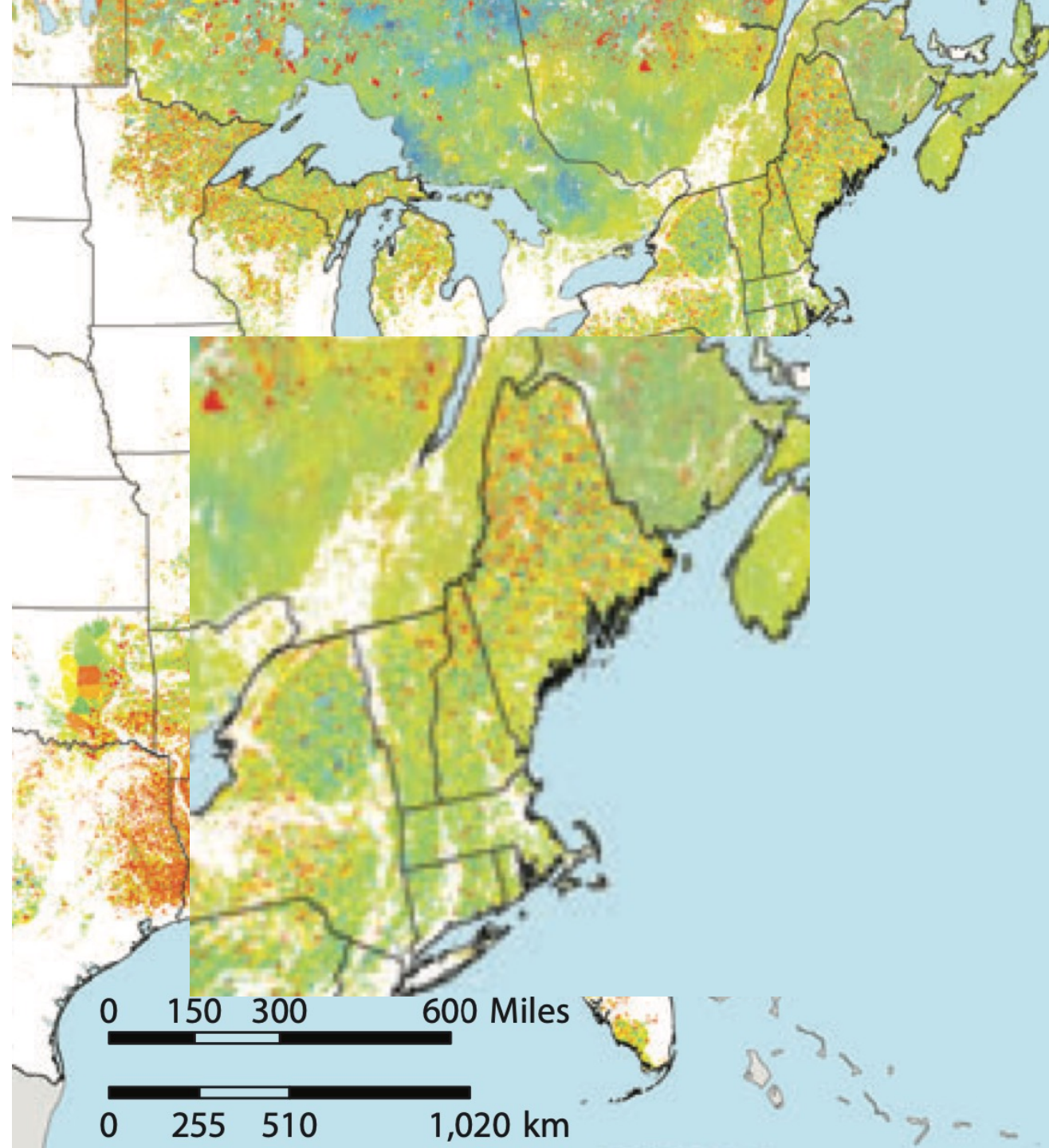
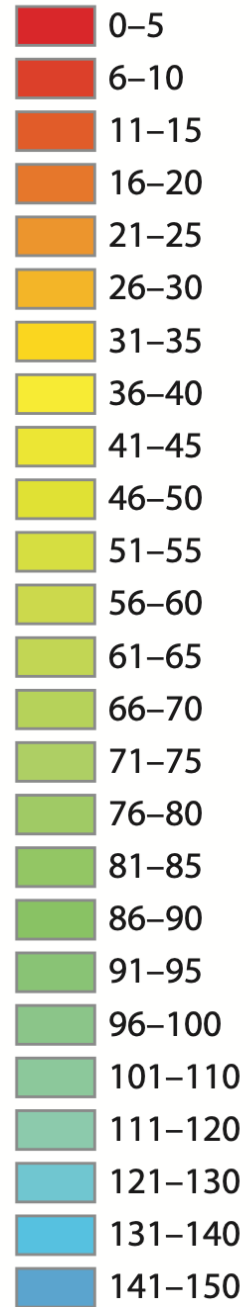
- “We, the leaders of the (145) countries identified below:”
- “Emphasise the critical and interdependent roles of forests of all types, biodiversity and sustainable land use in enabling the world to meet its sustainable development goals; to help achieve a balance between anthropogenic greenhouse gas emissions and removal by sinks; to adapt to climate change; and to maintain other ecosystem services.”
- **“We therefore commit to working collectively to halt and reverse forest loss and land degradation by 2030 while delivering sustainable development and promoting an inclusive rural transformation.”**
- “We will strengthen our shared efforts to conserve forests and other terrestrial ecosystems and accelerate their restoration;”



# Zero action so far by National Governments!

- What can Vermont's forests do for climate and biodiversity?
- Vermont's forests are resilient temperate forest that were established at the end of the Ice Age 10,000 years ago.
- They have withstood intensive clearing, harvesting and returned.
- Selecting at least 30% of those that are already mature or old growth forests for protection now and sufficient younger forests that can become old growth will assure that Vermont makes a strong contribution and will set an example for other states.
- Assuring a strong sustainable forest products industry by effective management of remaining production forests

**Stand age of forest in years:**



# Old Forest Ecologically Significant Treatment Areas in Vermont

Old Forest Ecologically Significant Treatment Areas described on page 34 in the Minimum Standards for Forest Management and Regeneration, effective April 1, 2010 and by authority established by 32 V.S.A. § 3755, are revised to clarify what lands may be eligible for enrollment in this subcategory.

Process for Identifying Old Forests: Land to be enrolled as an ESTA based on its eligibility as old forest, shall be identified and mapped by a plan preparer. These areas shall be included in the forest management plan for approval by the county forester, along with a reasonable justification for the proposed management and appropriate documentation of the forest condition

Old forests exhibit the following characteristics: 1) native tree species characteristic of the forest type or natural community present in multiple ages; and 2) complex stand structures including a broad distribution of tree diameters, multiple vertical vegetative layers, abundant coarse woody material (reflecting the diameters of the standing trees) in all stages of decay, numerous large standing dead trees, and when old forest patches are sufficiently large, natural canopy gaps. Most forest types exhibiting these characteristics will have trees exceeding 150 years old, though some forests may develop these conditions at different times. For instance, they may develop earlier in balsam fir (100 years), or later for Eastern hemlock (200 years)

# Strategies for closing the carbon gap and preventing catastrophic feedback heating

- Prevent deforestation, the draining of wetlands and soil loss
- Create more strategic forest carbon and biodiversity reserves
- Reduce demand for wood and paper products
- Grow more of our forests to become high carbon mature forests
- Massachusetts has become the first jurisdiction to halt the subsidization and use of wood burning for electricity under the Renewable Portfolio Standard!



# Establish two types of forests (Law, Moomaw, Woodwell 2022)



Strategic Climate and Biodiversity Reserves

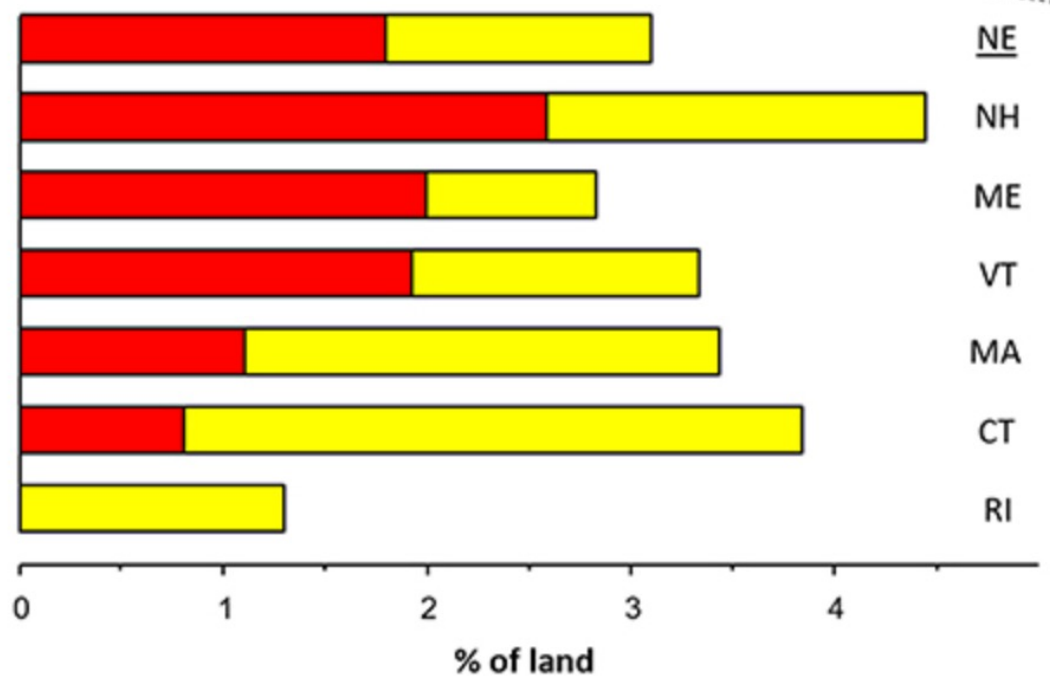
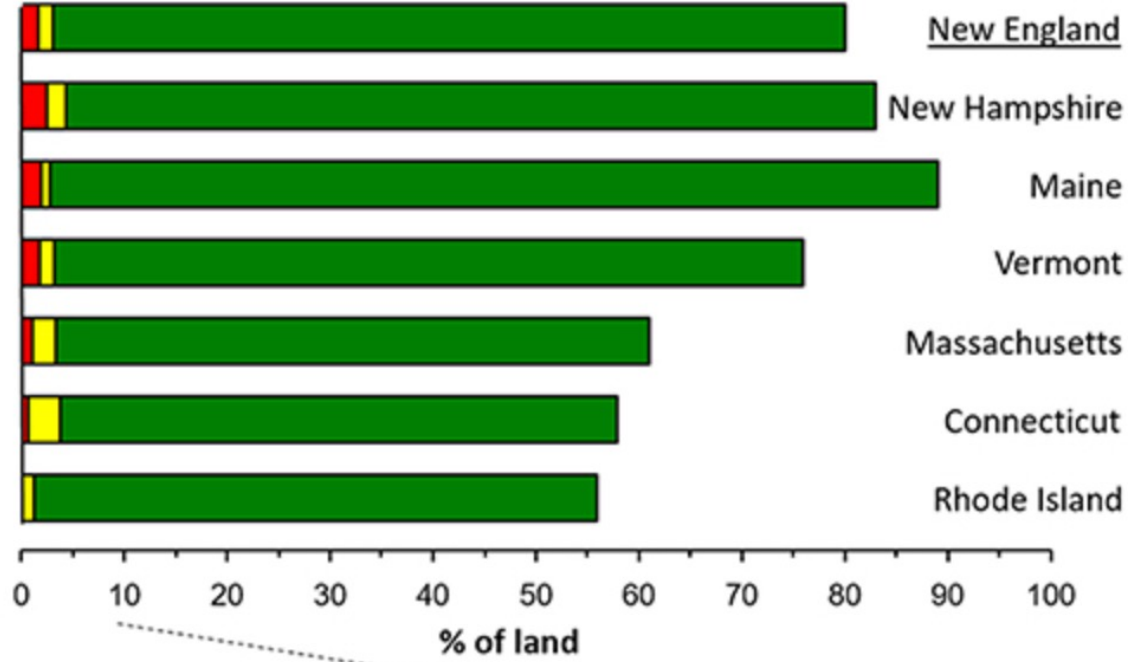
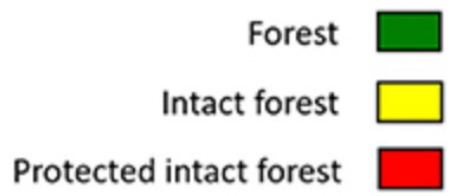
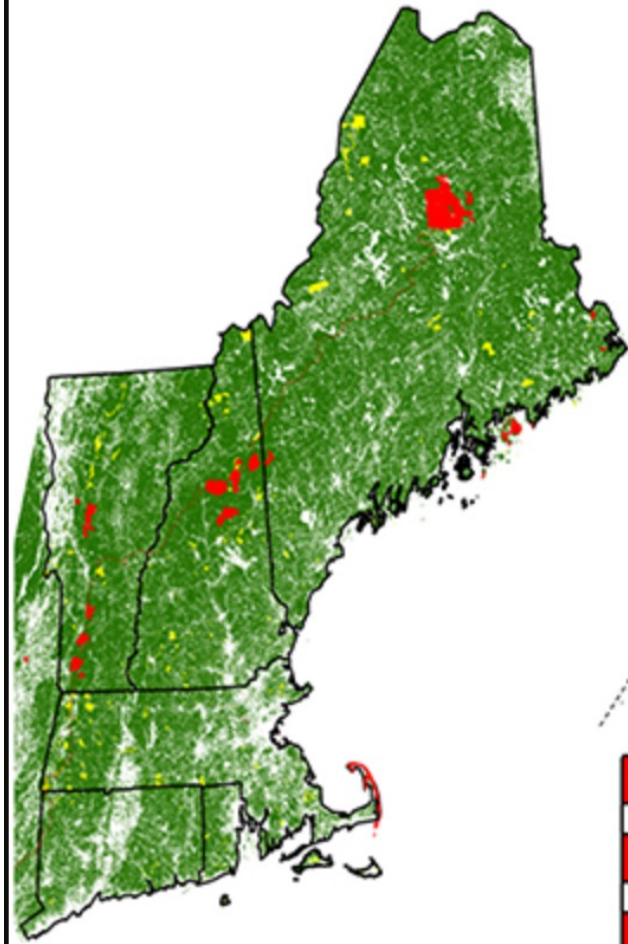


Industrial production forests

# Need More Legally Protected Land in New England

USFS finds that 95% of NE Forests are less than 100 years old

NE Trees live 3x longer





# 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

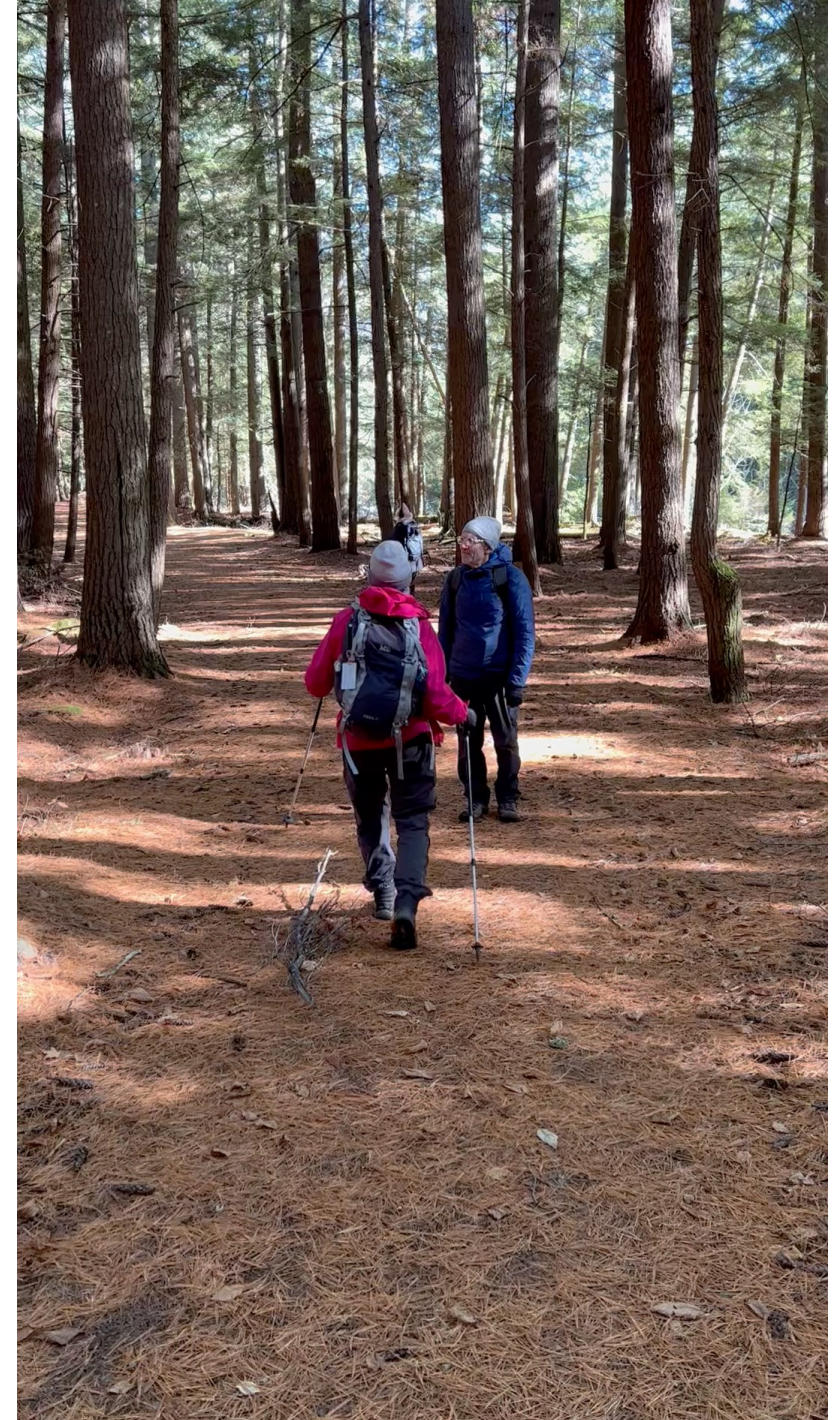


Here is my home where my northern boundary is Pownal Vermont and the Green Mountain National Forest



These people are  
searching for a climate  
solution

If they look up,  
*The Major  
Climate Solution Is  
Growing in Plain Sight*



A photograph of a forest floor. In the center, a large, vibrant red maple leaf with several holes is the focal point. To its left and right are two small, green, five-lobed plants. The ground is covered with dark soil, brown pine needles, small rocks, and other fallen leaves. The text "Thank you" is overlaid in white on the red leaf.

Thank you

