

# Closing the Carbon Sequestration Gap: Proforestation in Primary and Secondary Forests

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"All the News  
That's Fit to Print"

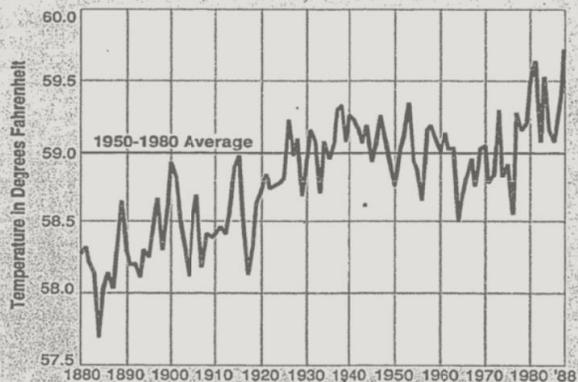
# The New York

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NEW YORK, FRIDAY, JUNE 24, 1988

JUNE 24, 1988

## Global Warming Has Begun, Expert Tells Senate



### Global Warming: Greenhouse Effect?

Average global temperatures through the first five months of 1988. As a baseline, scientists use the global average from 1950 to 1980.

Source: James E. Hansen and Sergej Lebedeff

The New York Times/June 24, 1988

## Drought Raising Food Prices; Inflation Effect Seems Minor

By **ROBERT D. HERSHEY JR.**  
Special to The New York Times

WASHINGTON, June 23 — The severe drought gripping the farm belt has begun to raise the supermarket price of such items as cereal, mayonnaise and spaghetti, and the list of affected products will inevitably broaden to include such items as pickles and canned peas in coming weeks, according to industry officials and Government and private analysts.

At this stage, however, it appears that crop shortages will not raise food prices enough to have a major effect on

Other analysts, however, do not entirely accept official reassurances. They worry that the jolt could be great. Two major unknown factors are to what extent food processors will engage in anticipatory buying of raw materials and to what extent consumers will stock up on certain products. Both factors could heighten demand.

"I'm apprehensive," said Harold Breimyer, professor emeritus of agricultural economics at the University of

## Sharp Cut in Burning of Fossil Fuels Is Urged to Battle Shift in Climate

By **PHILIP SHABECOFF**  
Special to The New York Times

WASHINGTON, June 23 — The earth has been warmer in the first five months of this year than in any comparable period since measurements began 130 years ago, and the higher temperatures can now be attributed to a long-expected global warming trend linked to pollution, a space agency scientist reported today.

Until now, scientists have been cautious about attributing rising global temperatures of recent years to the predicted global warming caused by pollutants in the atmosphere, known as the "greenhouse effect." But today Dr. James E. Hansen of the National Aeronautics and Space Administration told a Congressional committee that it was 99 percent certain that the warming trend was not a natural variation but was caused by a buildup of carbon dioxide and other artificial gases in the atmosphere.

### An Impact Lasting Centuries

Dr. Hansen, a leading expert on climate change, said in an interview that there was no "magic number" that showed when the greenhouse effect was actually starting to cause changes in climate and weather. But he added, "It is time to stop waffling so much and say that the evidence is pretty strong that the greenhouse effect is here."

If Dr. Hansen and other scientists are correct, then humans, by burning of fossil fuels and other activities, have altered the global climate in a manner that will affect life on earth for centuries to come.

Dr. Hansen, director of NASA's Institute for Space Studies in Manhattan, testified before the Senate Energy and Natural Resources Committee.

Some Dispute Link



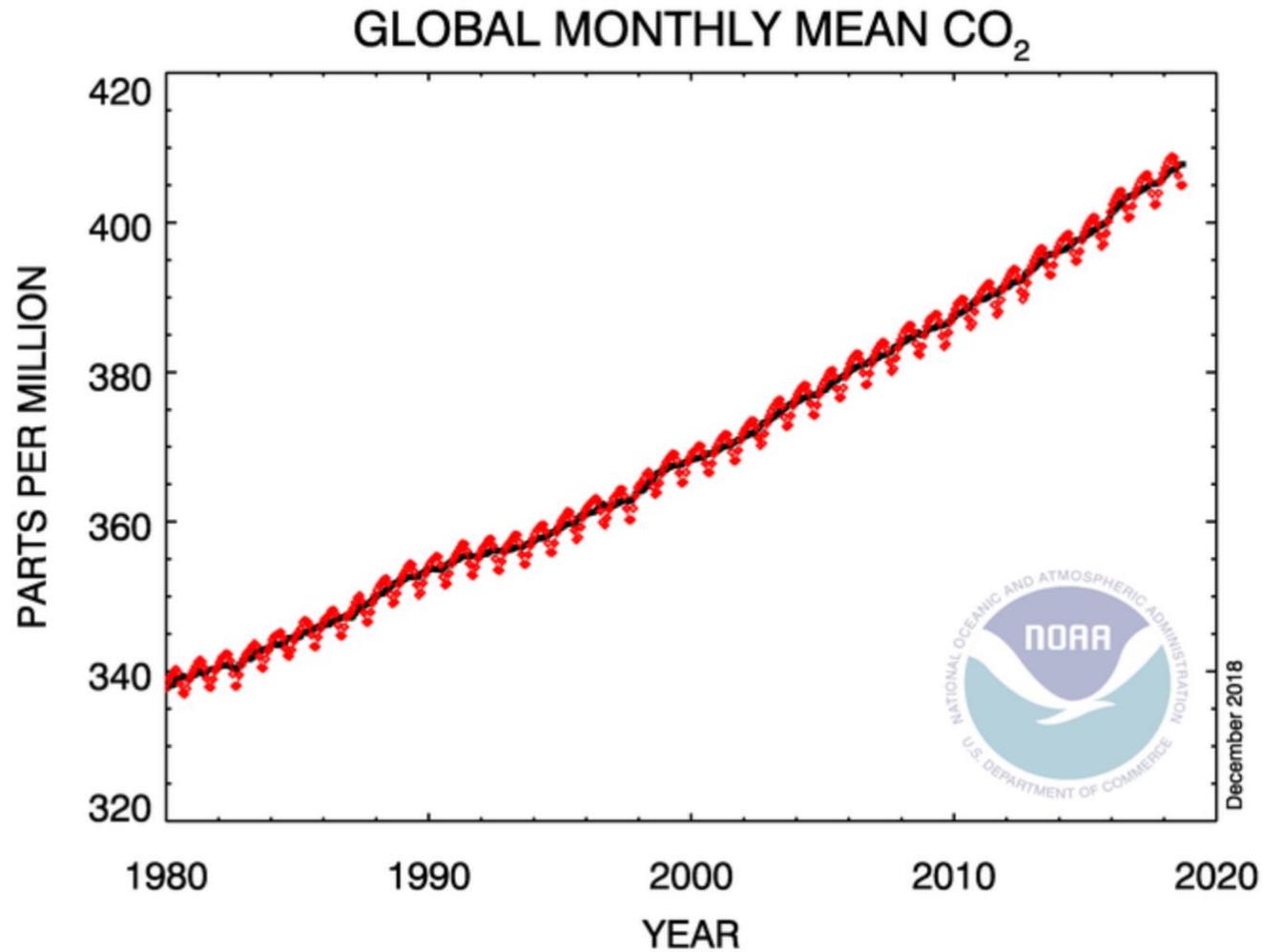
Cañon Zapata in Tijuana

## High Court C Not to Reve

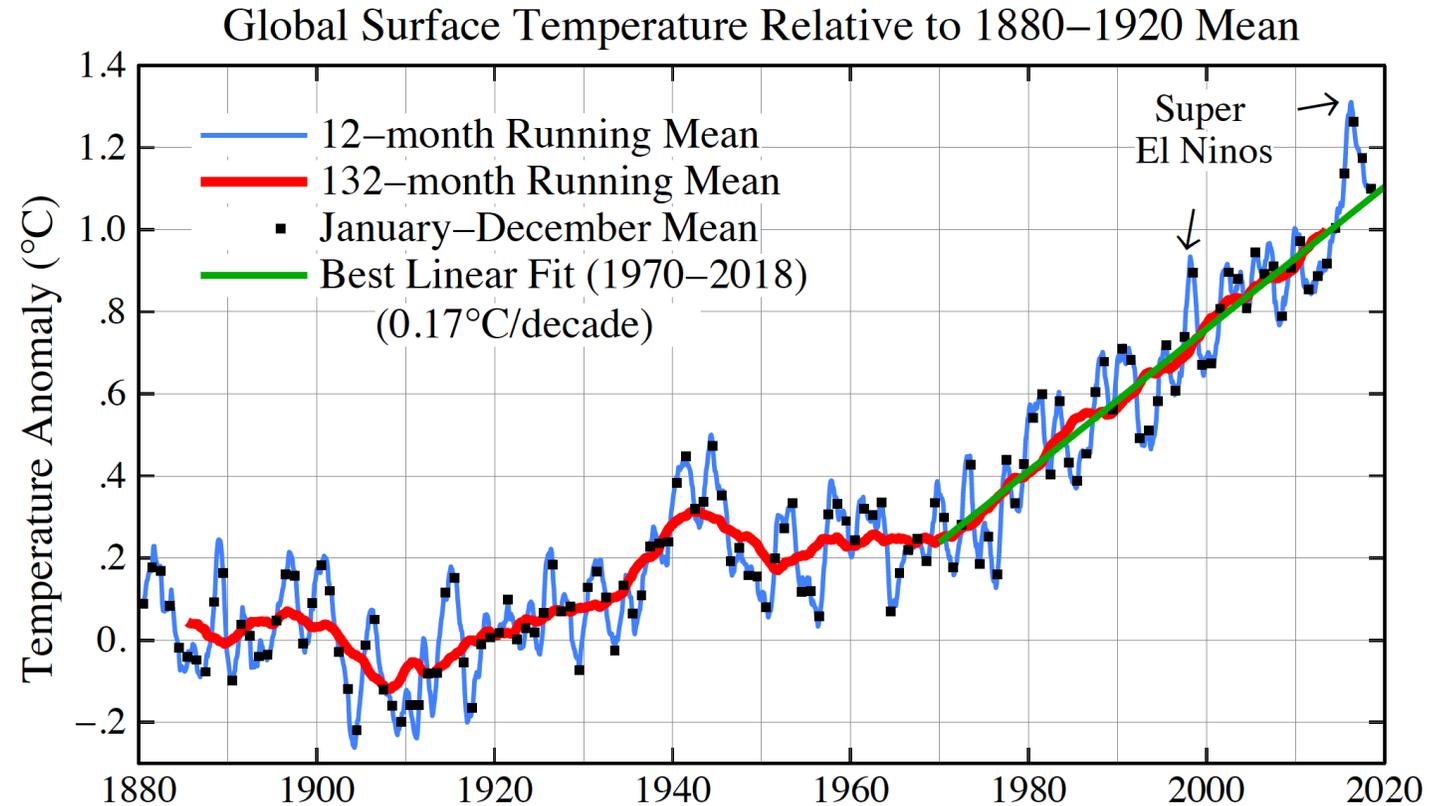
WASHINGTON, June 23 — An extraordinary massing of political prestige, 60 senators, 4 attorneys general, the American Bar Association, prominent histo

Concern over  
climate change is  
not a new topic!

# CO<sub>2</sub> emissions continue to increase

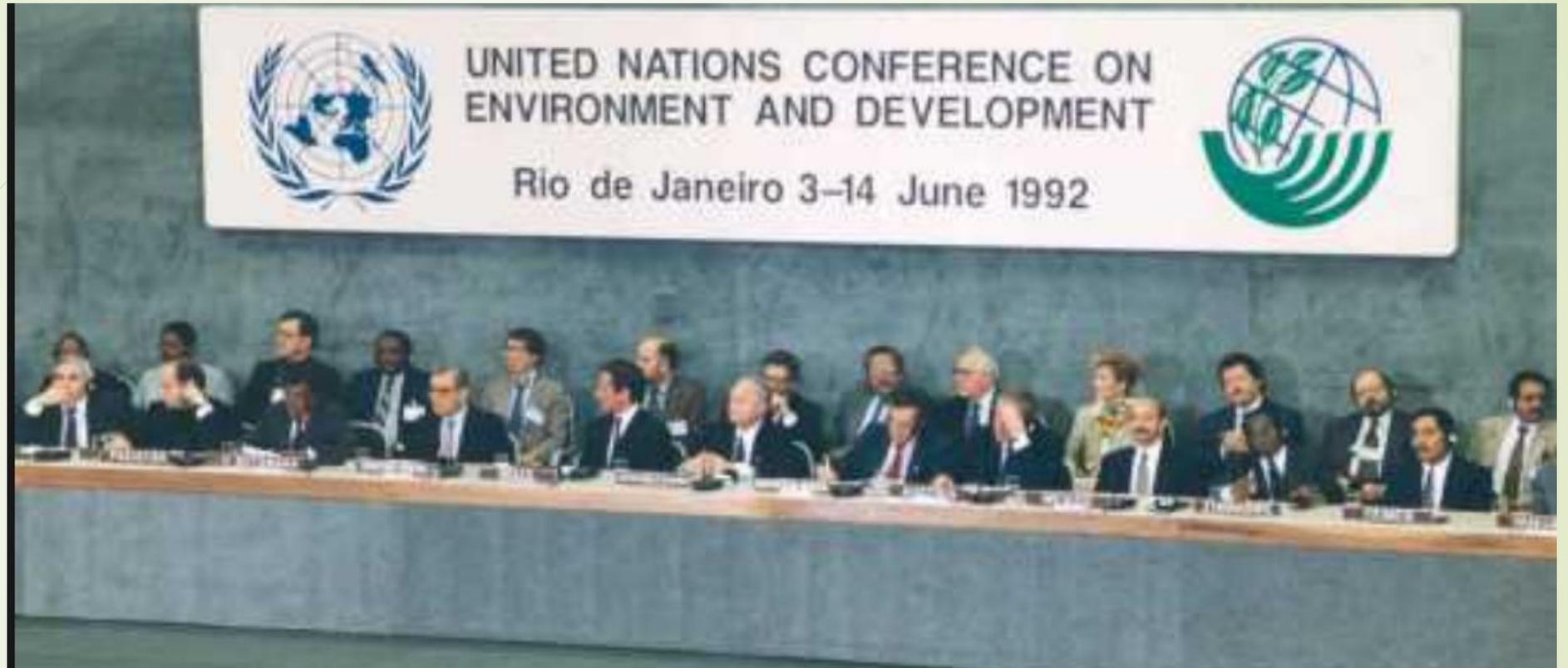


# Global temperatures continue to rise



NASA February 2019





## International Climate Goals 1992

“The ultimate objective of this Convention...is to achieve...stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.”

UN Framework Convention on Climate Change, Article 2

# International Climate Goals 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.”
- ▶ Calls for increasing **forest sinks** specifically in developing countries

▶ Paris Climate Agreement Articles 2 & 5 (2015)



And no planet “B”  
Ban Ki-moon Secretary General United Nations



French President Francois Hollande, right, French Foreign Minister and president of the COP21 Laurent Fabius, second, right, United Nations climate chief Christiana Figueres and United Nations Secretary General Ban Ki-moon applaud after the final conference at the COP21, the United Nations conference on climate change, in Le Bourget, north of Paris, Saturday, December 12, 2015.

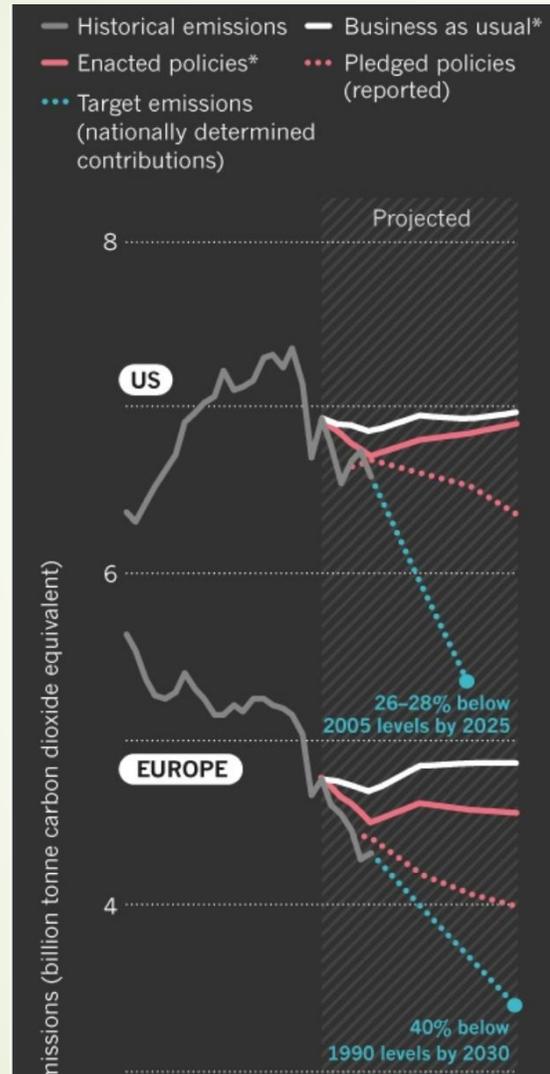
Celebration at the unanimous acceptance of Paris Agreement

# REALITY CHECK



## Falling short in EU and US

Trends from 1990 -2030



“No major advanced industrialized country is on track to meet its pledges to control the greenhouse-gas emissions that cause climate change.”

“Wishful thinking and bravado are eclipsing reality.”

D. Victor et al, *Nature* 2017

Intergovernmental Panel on Climate  
Change Special Report  
*6Global Warming of 1.5°C*  
October 8, 2018

To keep temperatures from rising excessively  
“... global **net** anthropogenic carbon dioxide  
emissions (must) decline by about 45% from  
2010 levels by 2030 ... reaching **net** zero around  
2050 ...”

**Must simultaneously reduce  
emissions and increase removal of  
atmospheric CO<sub>2</sub> by forest growth**



# Emissions Gap Report 2018

## UN Environmental Program

27 November 2018



**“...if countries do not scale up their ambitions before 2030, exceeding the 1.5° C goal can no longer be avoided.”**

“if nothing changes the world will see global warming of about 3°C by 2100, with warming continuing afterwards.”



# Closing the Carbon Dioxide Sequestration Gap IPCC 1.5° C Report

- To achieve a limited rise of 1.5° C by 2100, emissions must decline rapidly **and** additional CO<sub>2</sub> must be removed from the atmosphere (Carbon Dioxide Removal or CDR)
- “Existing and potential CDR measures include **afforestation and reforestation, land restoration and soil carbon sequestration, bioenergy with carbon capture and storage (BECCS)**, direct air carbon capture and storage (DACCS), enhanced weathering and ocean alkalization.”



Today eleven machines are removing CO<sub>2</sub> directly from the air – just 4000 tons of CO<sub>2</sub> are removed annually  
Cost of Direct Air Capture is 10 times CCS stack removal



# Issues With IPCC Forest Recommendations

- *Afforestation* and *Reforestation* are good actions to take, but neither will sequester much additional carbon between now and 2050 when it is needed to avoid exceeding global average temperature goals
- They will have their greatest benefit 75-200 years from now
- Afforestation and BECCS compete with other land uses

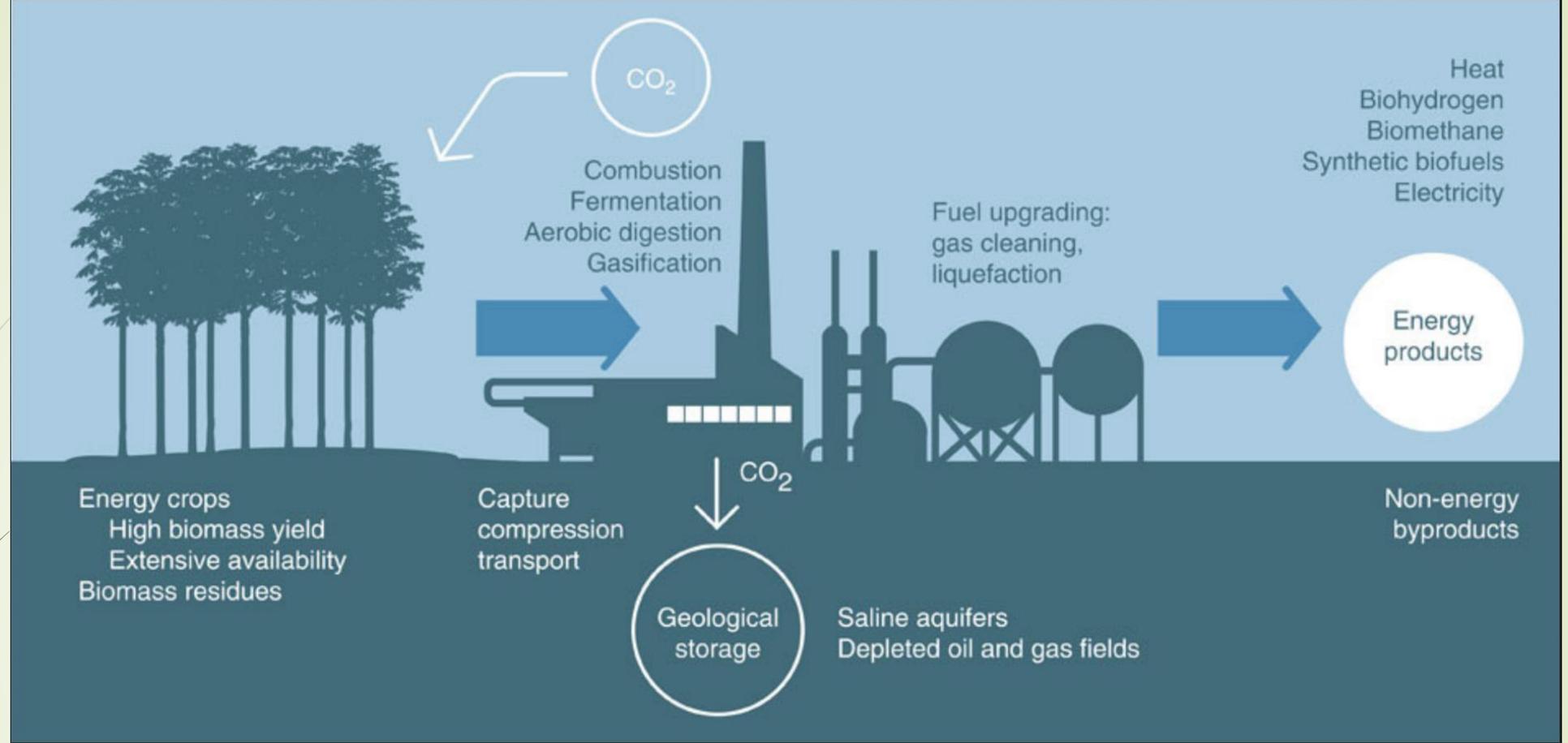
## Afforestation for Sequestration

Afforestation requires 9.9 million km<sup>2</sup> additional area to stay within 1.5°C

This is the area of Canada

IPCC 1.5 Degree Report





## Bioenergy Carbon Capture and Storage (BECCS)

Exists only as a demonstration, is inefficient and requires a very large dedicated area for sustainably harvested plantations

## Bioenergy for Carbon Capture and Storage

BECCS would require a forest plantation area of 7.7 million km<sup>2</sup>

This is the area of Australia

IPCC 1.5 Degree Report

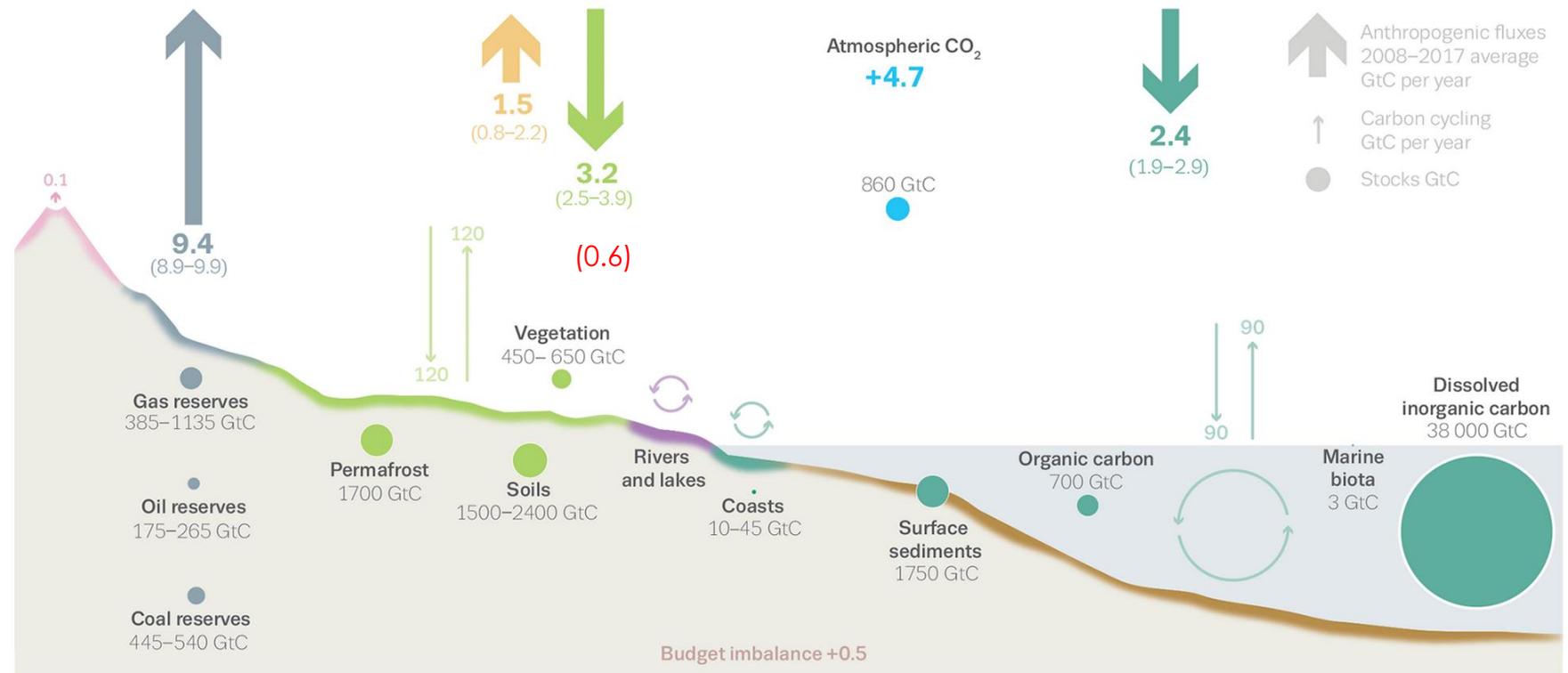




# An overlooked option: Proforestation

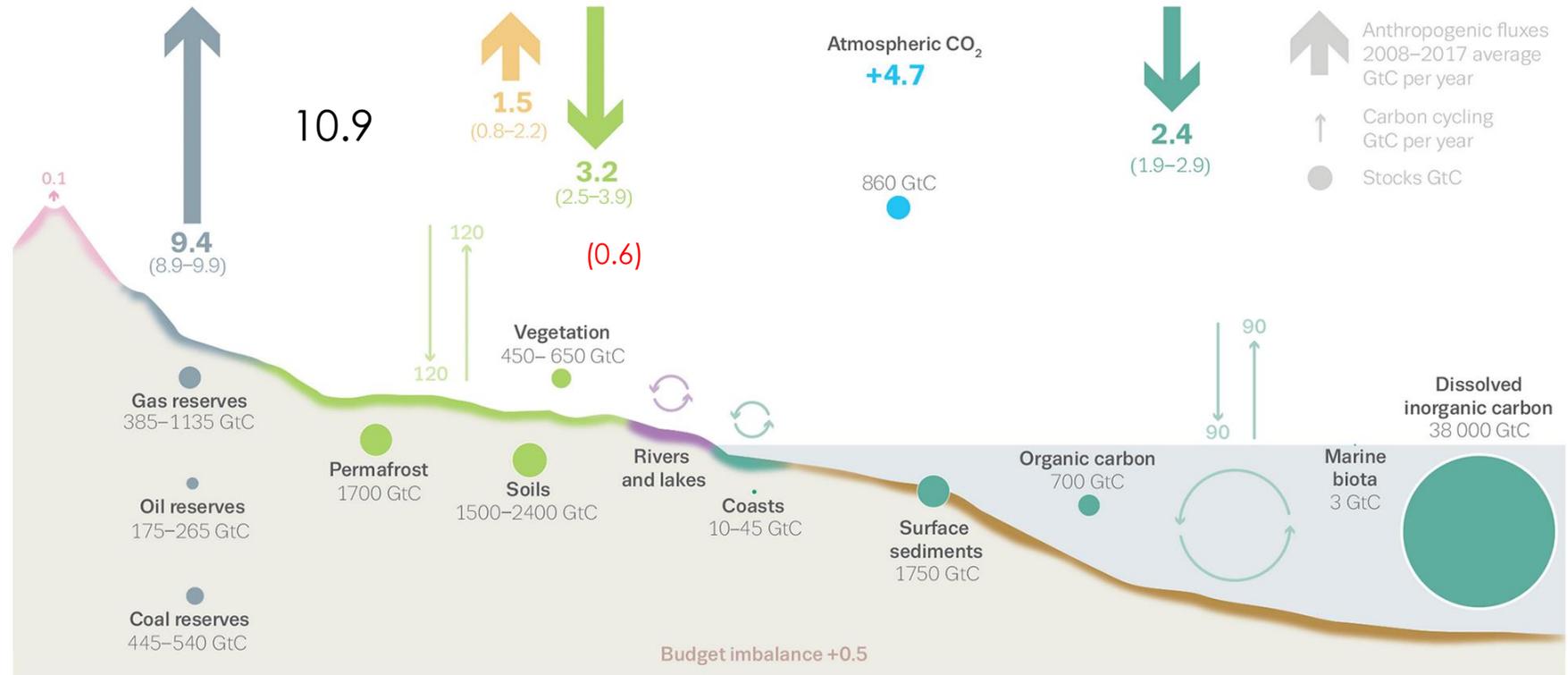
- ▶ Proforestation identifies those intact secondary forests likely to sequester the most carbon in the next 50 years and insures that they continue to grow
  - ▶ Proforestation protects existing primary and older forests with large carbon stocks
  - ▶ These primary forests become the core for forest restoration and connectivity
  - ▶ **This does not require additional land and additional growth occurs immediately**
- 

# The global carbon cycle



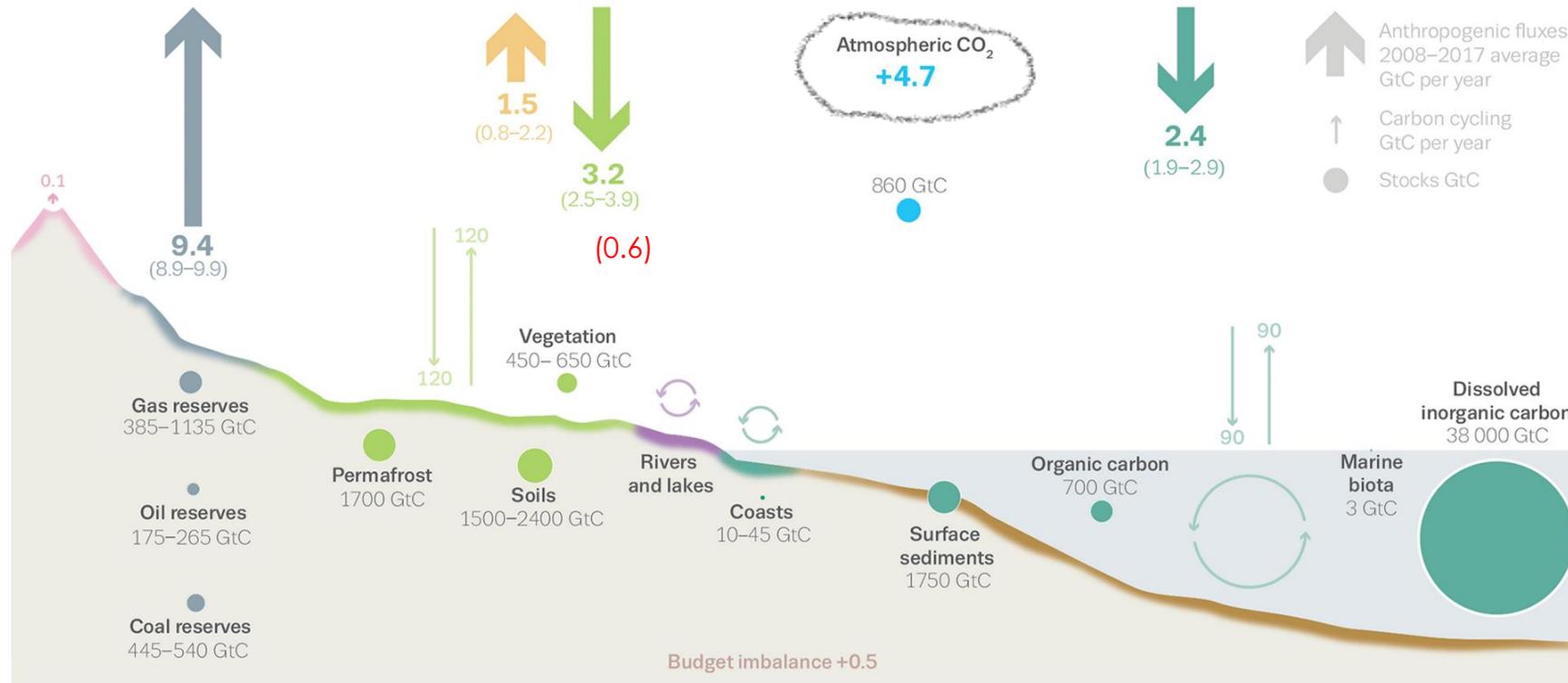
- Fossil CO<sub>2</sub> E<sub>FF</sub>
- Land-use change E<sub>LUC</sub>
- Land uptake S<sub>LAND</sub>
- Ocean uptake S<sub>OCEAN</sub>
- Atmospheric increase G<sub>ATM</sub>
- Uncertainty values
- Budget Imbalance B<sub>IM</sub>

# The global carbon cycle



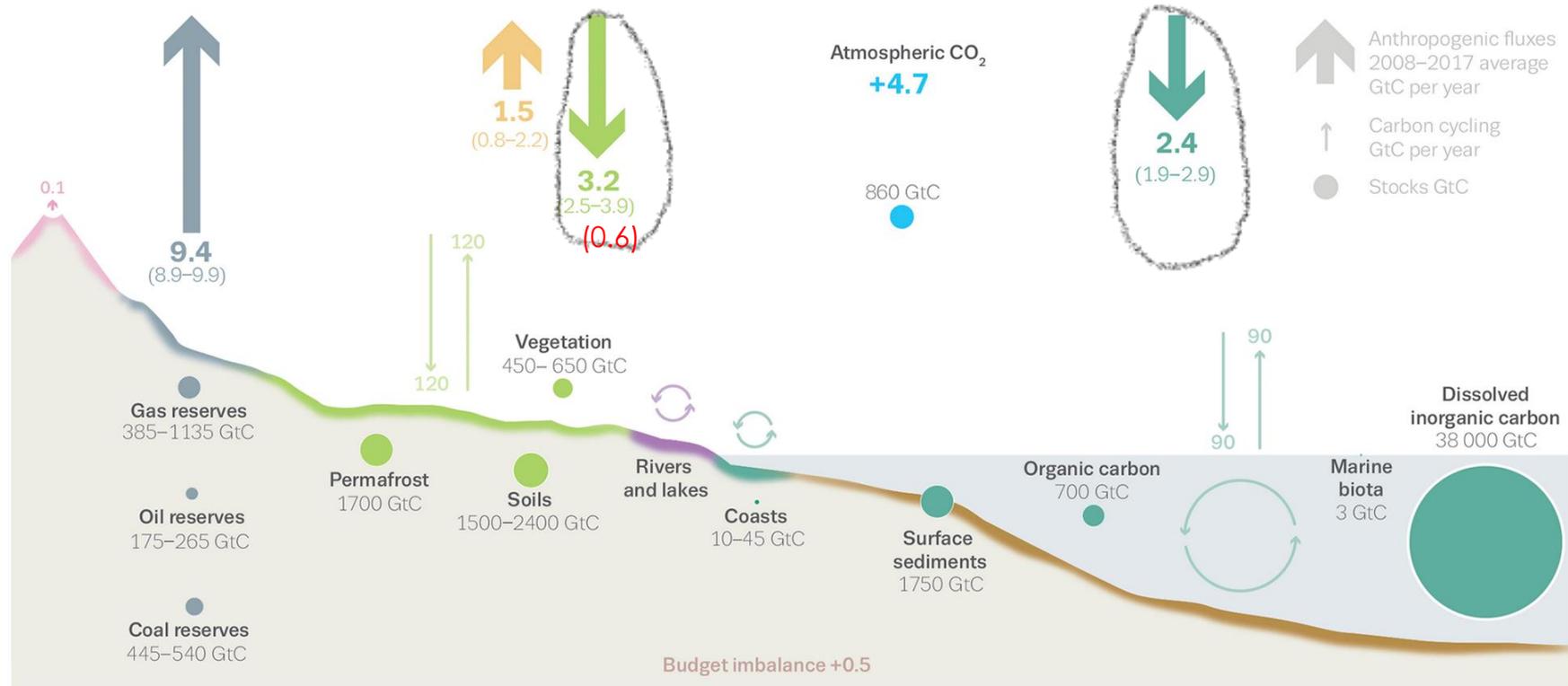
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# The global carbon cycle



- ↑ Fossil CO<sub>2</sub> E<sub>FF</sub>
- ↑ Land-use change E<sub>LUC</sub>
- ↓ Land uptake S<sub>LAND</sub>
- ↓ Ocean uptake S<sub>OCEAN</sub>
- + Atmospheric increase G<sub>ATM</sub>
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# The global carbon cycle



- Fossil CO<sub>2</sub> E<sub>FF</sub>
- Land-use change E<sub>LUC</sub>
- Land uptake S<sub>LAND</sub>
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# What is the justification for proforestation?

- ▶ Allowing secondary forests to continue growing will sequester an additional 2.8 GtC/y and halting land use change will sequester an additional 1.5 GtC/y (Houghton and Nassikas, 2018)
- ▶ One-third of annual fossil fuel CO<sub>2</sub> emissions is removed each year by terrestrial ecosystems (Le Quere et al, 2018)
- ▶ Terrestrial ecosystems currently remove only half as much CO<sub>2</sub> annually as they are capable (Erb et al, 2018)
- ▶ Half of all carbon in above-ground living forest biomass is in the largest 1% diameter trees (Lutz, 2018)
- ▶ “Rate of carbon accumulation increases continuously with tree size.” Each year a single tree that is 100 cm in diameter adds the equivalent biomass of an entire 10–20 cm diameter tree, further underscoring the role of large trees (Stephenson et al, 2014)
- ▶ Primary forests store more than twice as much carbon as do sustainably managed rotationally harvested forests and much more than plantations (Harmon, 1990)

Figure 1

Harmon, Ferrell and Franklin (1990)



Source: Harmon, Mark E., William K. Ferrell, and Jerry F. Franklin. "Effects on Carbon Storage of Conversion of Old-Growth Forests to Young Forests." *Science*, 9 February 1990: Vol. 247, pp 699–702

All forests are not equal in terms of carbon storage or ecosystem integrity

Old growth forests hold far more carbon than sustainably managed forests



Forest cover in  
Northeast U.S.



## US Forest Service Carbon Online Estimator

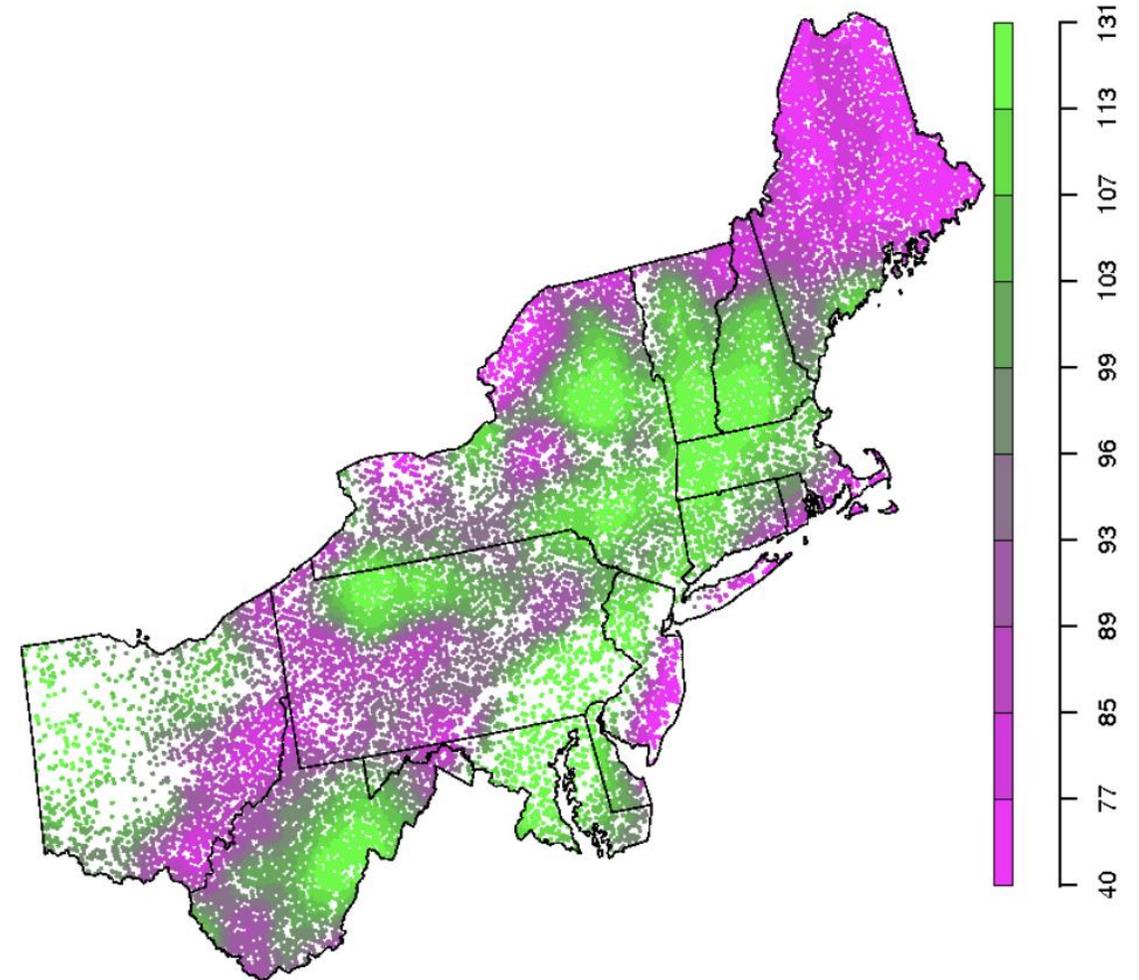
Western New England is the center of high carbon dense temperate forests

The Adirondack region of New York contains primary forest

Maine carbon density is less than one-third that of Western Massachusetts, southern Vermont and New Hampshire

Historical patterns of land use explain much of the difference

COLE Map  
Total Aboveground Carbon (metric tons/hectare)



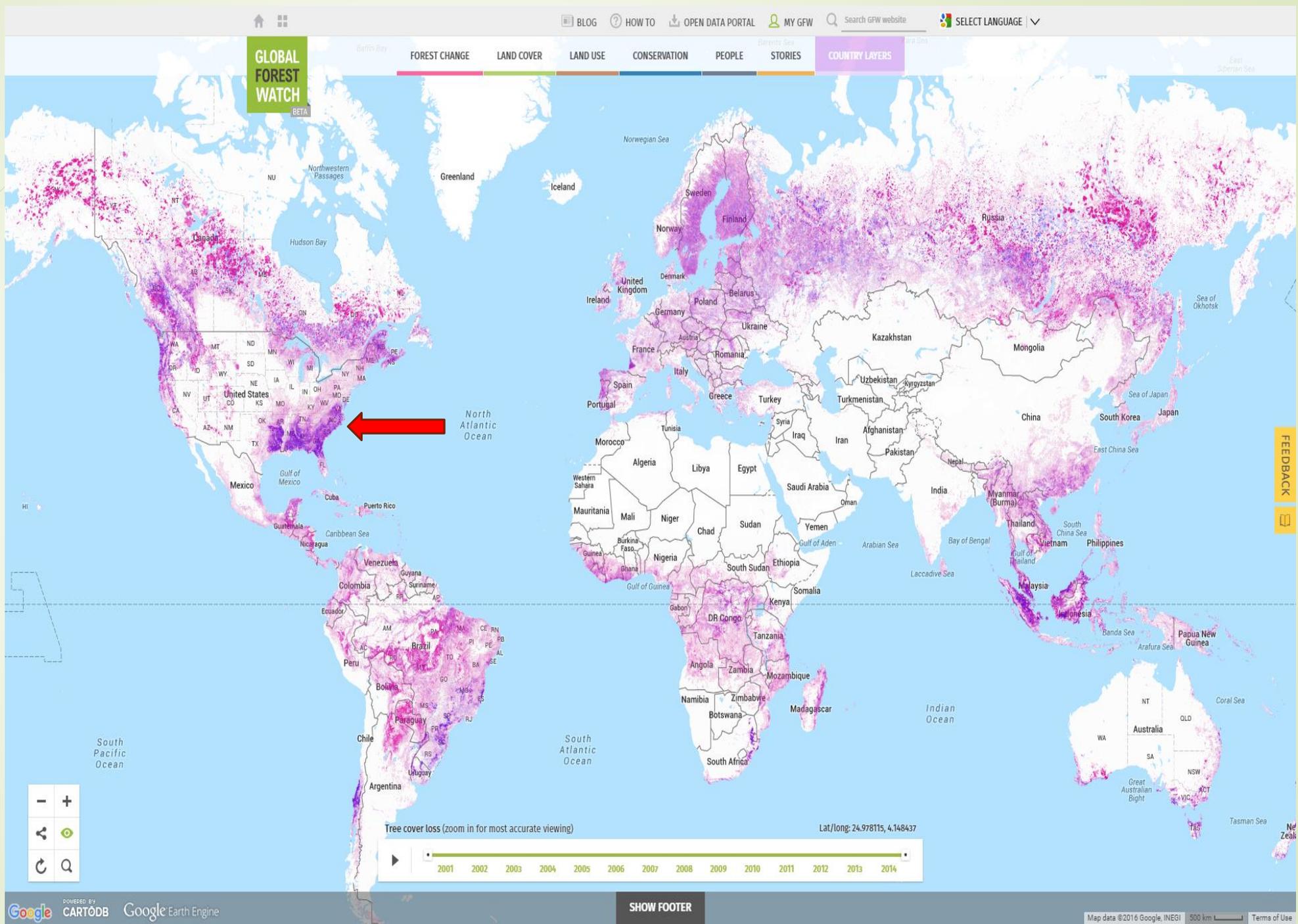
# Where has all the carbon gone globally?

- ▶ One-third of carbon dioxide (CO<sub>2</sub>) added to the atmosphere since 1750 comes from deforestation, wetland destruction and land degradation (IPCC 2013)
- ▶ Clear cut North Carolina wetland forest to produce wood pellets to be sent to Europe and burned to produce “carbon neutral” electricity
- ▶ Major loss of ecosystem and species biodiversity
- ▶ Loss of climate resiliency to flooding



# Tree Cover Loss 2000-2015

World  
Resources  
Institute





## Proforestation

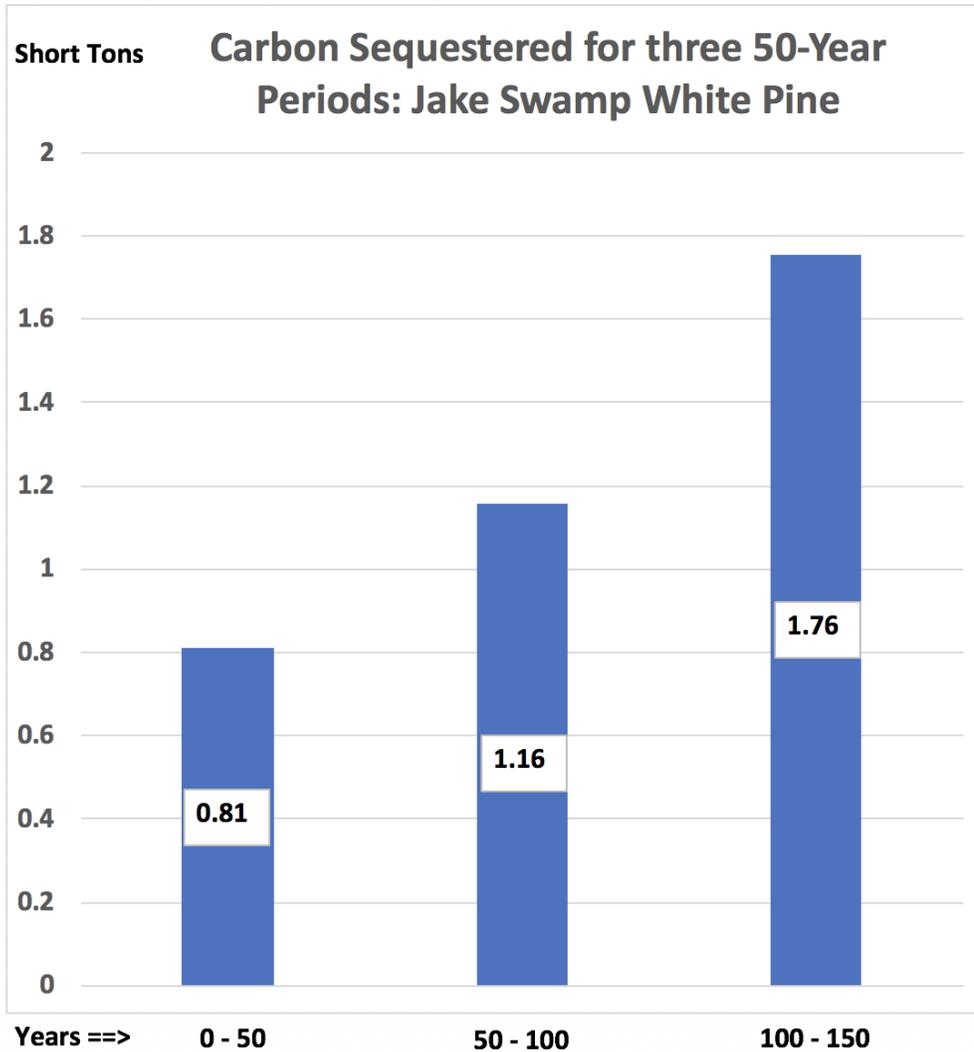
Allowing trees to reach their biological potential for carbon storage

Larger trees in their prime growth period remove the most atmospheric carbon each year, and store the carbon in the wood of their trunk and limbs

Direct measurements demonstrate the great amount of carbon stored in large older trees

Measurements of trees in New England forests show that the amount of carbon sequestered each year increases for at least 200 years for some species





**Total Carbon Sequestered for 1st 150 years**  
**3.7 short tons or 3.4 metric tons**  
**(Currently 4.17 Tons at 160 Years)**

Tallest tree in Northeast US  
 Located in Western Massachusetts  
 160 years old

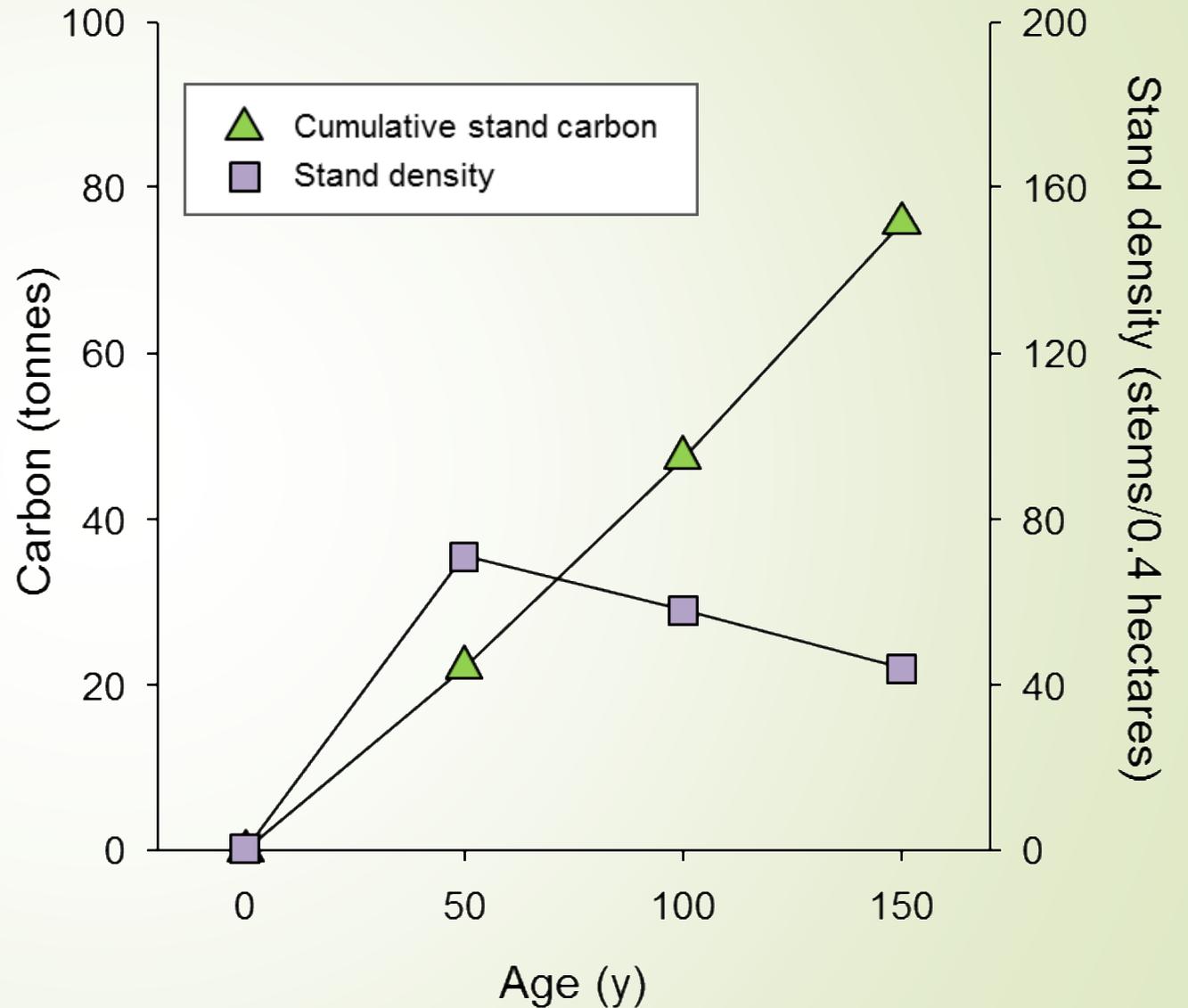
57 meters tall  
 Measurements by  
 Bob Leverett 2018

Trees increase sequestration  
 rates as they age until well  
 into their life cycle

# How much carbon is stored in *stands* of large trees?

Cumulative carbon in stand of white pine and number of stems over 150 years

Measurements by Bob Leverett 2018



“the largest one percent of trees in mature and older forests comprised 50 percent of forest biomass worldwide.”

“Big trees provide functions that cannot be duplicated by small or medium-sized trees.”

“They provide unique habitat, strongly influence the forest around them, and store large amounts of carbon.”

Lutz et al 2018



Large-diameter trees in the Douglas-fir/western hemlock forest of Winder River, Washington, USA Credit: James Lutz/Utah State University

Most of the carbon is stored in the largest trees



# The outcome from Proforestation

- ▶ Stable forests that will maintain or develop multiage, primary forest characteristics of structure and ecosystem integrity
  - ▶ Forests that store more carbon in plants and soils
  - ▶ Biodiverse ecosystems of the full suite of species from plants and animals to fungi and bacteria
  - ▶ Forests that provide a full suite of ecosystem services
  - ▶ Forest ecosystems that resist establishment of invasive species
  - ▶ Forest ecosystems that resist destructive insect invasions and diseases
  - ▶ Forests that are less vulnerable to fire
  - ▶ Forests that are more resilient to climate change
- ▶ Moomaw, Masino and Faison, *Proforestation*, *Front. For. Glob. Change*, 11 June 2019. <https://doi.org/10.3389/ffgc.2019.00027>



# Change in policies needed for carbon accounting and benefits

- ▶ Change **net** accounting to separate accounts for emission reductions and sequestration gains
- ▶ Track total carbon stocks
- ▶ Replace forest area metrics currently used by FAO with forest quality measurements
  - ▶ Carbon density in living biomass
  - ▶ Carbon density in dead biomass and soils
  - ▶ Ecosystem and species diversity of all species
  - ▶ Forest and wetland ecosystem integrity and ecosystem services delivered
- ▶ Change accounting of forest bioenergy to require crediting stack emissions where burned and soil carbon/biomass losses to local land use change
- ▶ Charge forest bioenergy processing and transportation energy to industrial emissions where they occur (If shipped between countries charge to producing country)
- ▶ End subsidies for forest bioenergy **and** fossil fuels and count all carbon emissions
- ▶ Count plantations and associated emissions under agriculture rather than forests in terms of emissions and short-term sequestration



Primary forests continue to sequester carbon in living and dead biomass and soils



Let Forests Grow!