Filling the Carbon Sequestration Gap: Expanding the Role of Forests and Wetlands

Ecological Society of America
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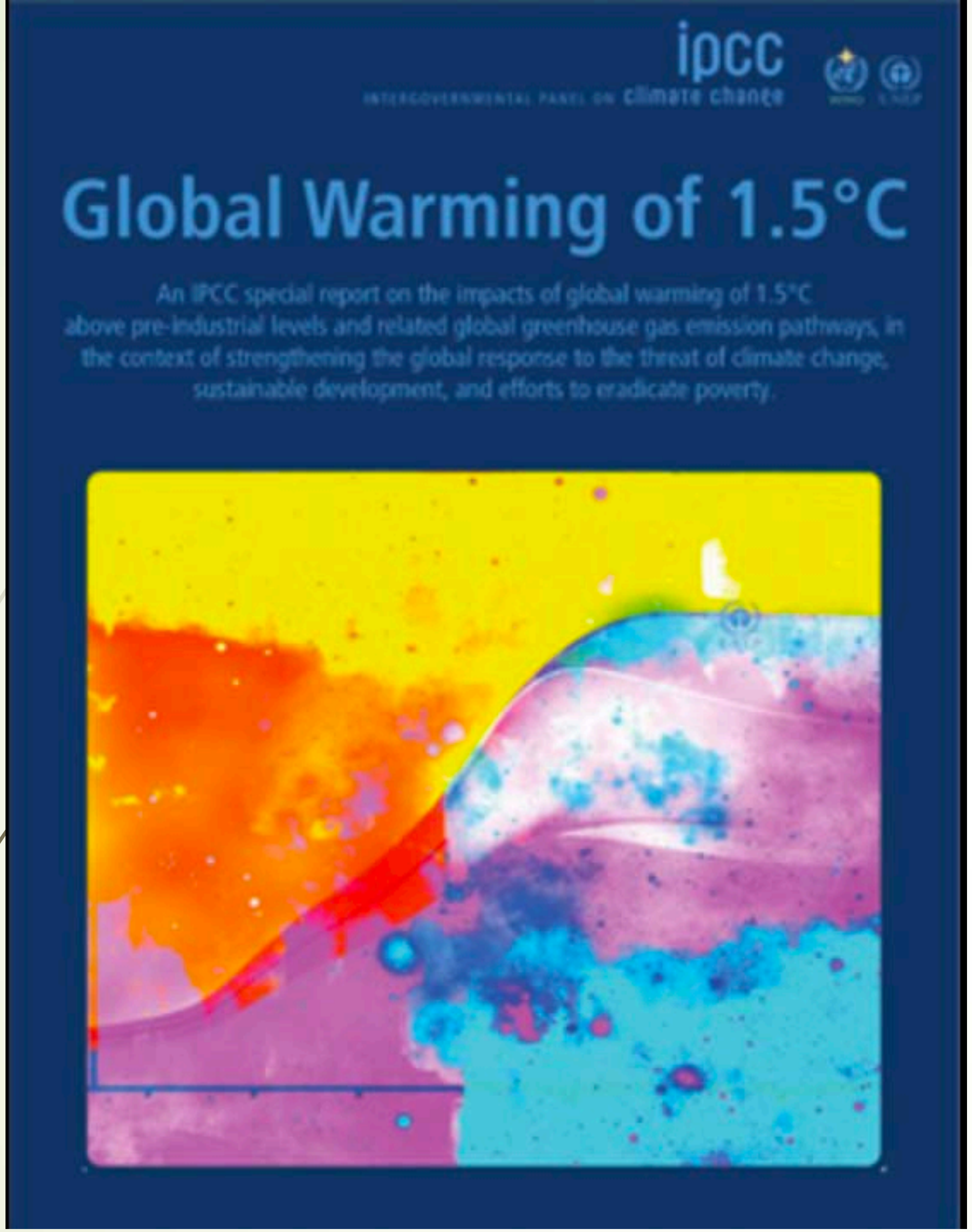


Intergovernmental Panel on Climate Change Special Report
Global Warming of 1.5° C

It was prepared by the Panel at the request of the United Nations following the 2015 Paris Climate Agreement that called for limiting temperature increases to 2.0° C and to make every effort to limit to 1.5° C above preindustrial temperatures by 2100.

Released on October 8, 2018

- "In model pathways with no or limited overshoot of 1.5°C, global ***net*** anthropogenic CO2 emissions decline by about 45% from 2010 levels by 2030 … reaching ***net*** zero around 2050 … ."
- The challenge of avoiding "dangerous anthropogenic interference with the climate system" requires ***simultaneously*** **reducing emissions and increasing removal rates** of atmospheric greenhouse gases

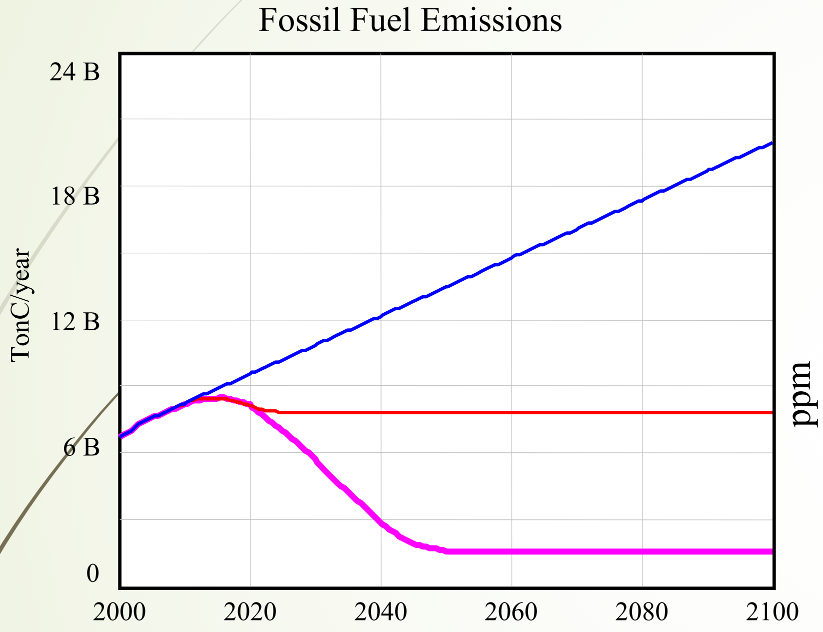
Global Warming of 1.5°C

IPCC Report October 2018

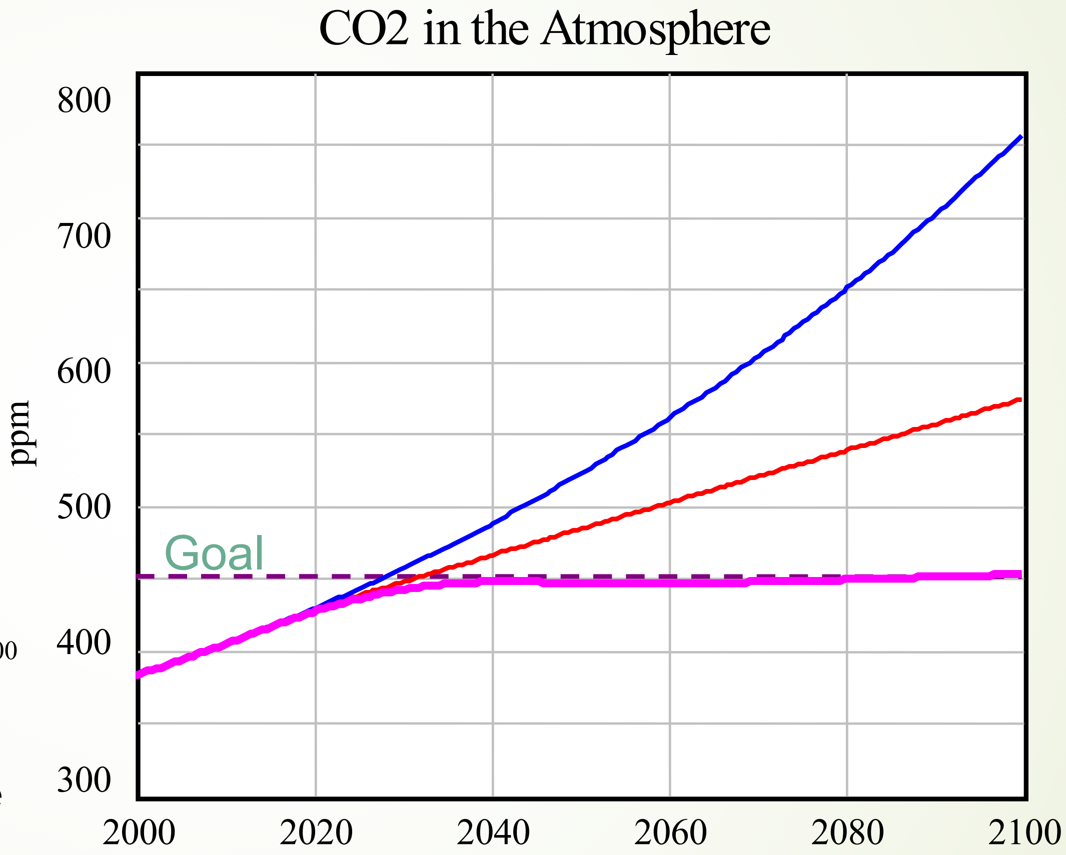
Effective means to enhance carbon sequestration by terrestrial ecosystems

- Existing forests, soils and wetlands can sequester substantially more carbon dioxide than they currently do
- The most effective means for sequestering more CO_2 in the immediate future is to alter management practices to allow some forests to continue growing to meet their biological growth potential – a management practice we term **Proforestation.**

What is needed to stabilize CO_2 concentrations in the atmosphere?

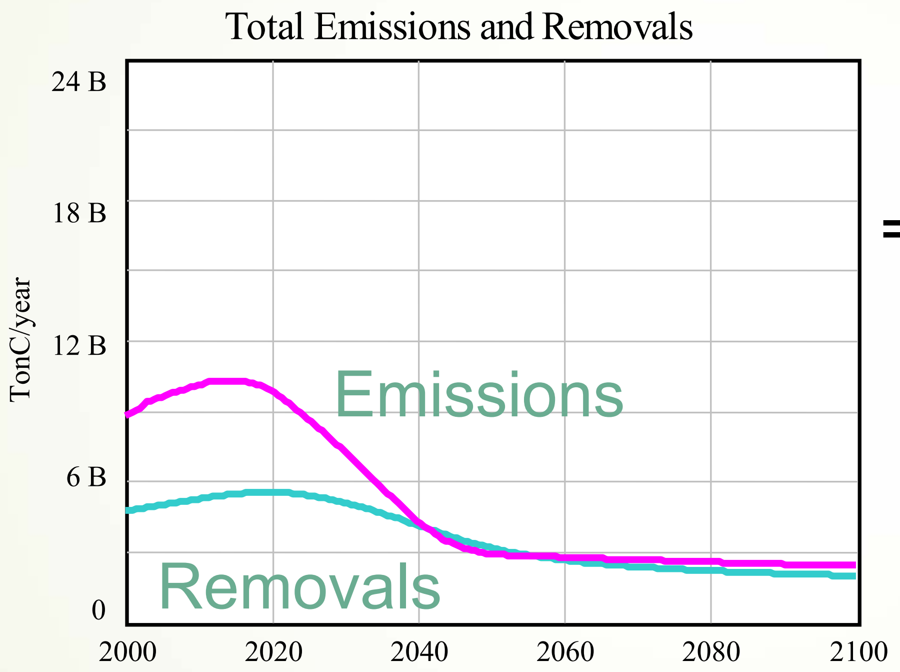


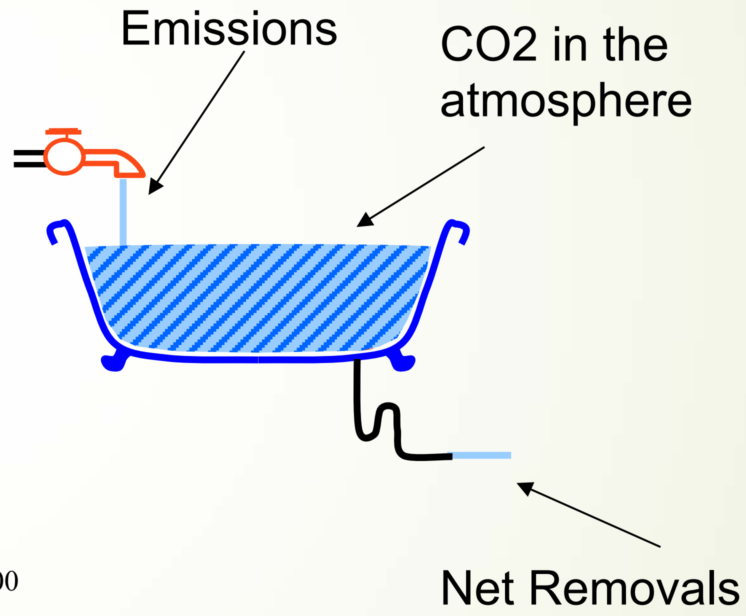
Simulation by Climate Interactive



What stabilized atmospheric concentrations of CO_2?

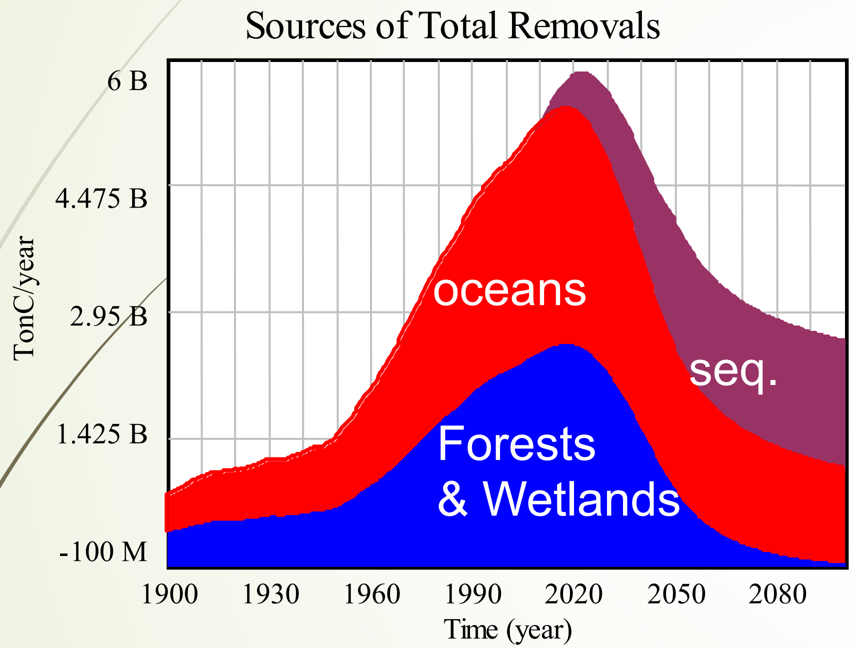
80% Reduction In Emission Rate Equals Removal Rate

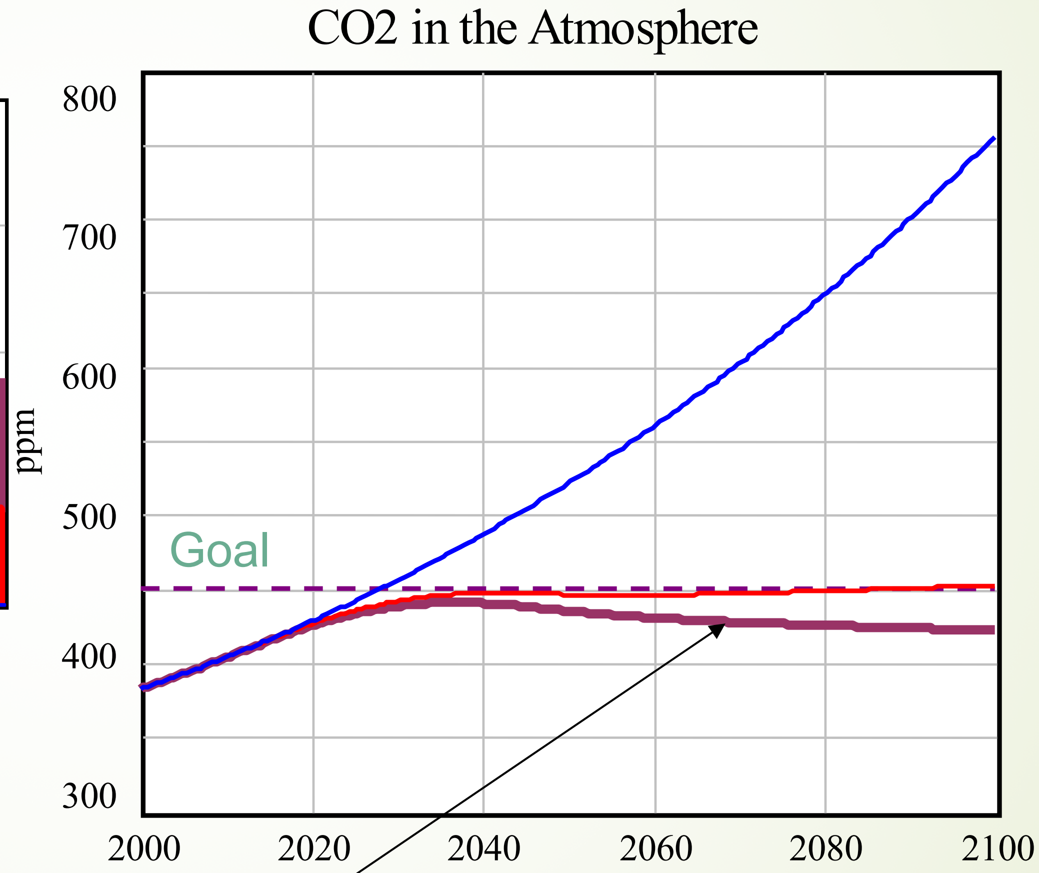




So levels of CO2 in the atmosphere stabilizes.

Increase Removal Rates by Forests and Wetlands to Decrease CO_2 Concentrations





Results with 80% reduction in fossil fuel emissions plus 1.6 GTC/year in additional removal by 2050

August 8, 2019

ipcc

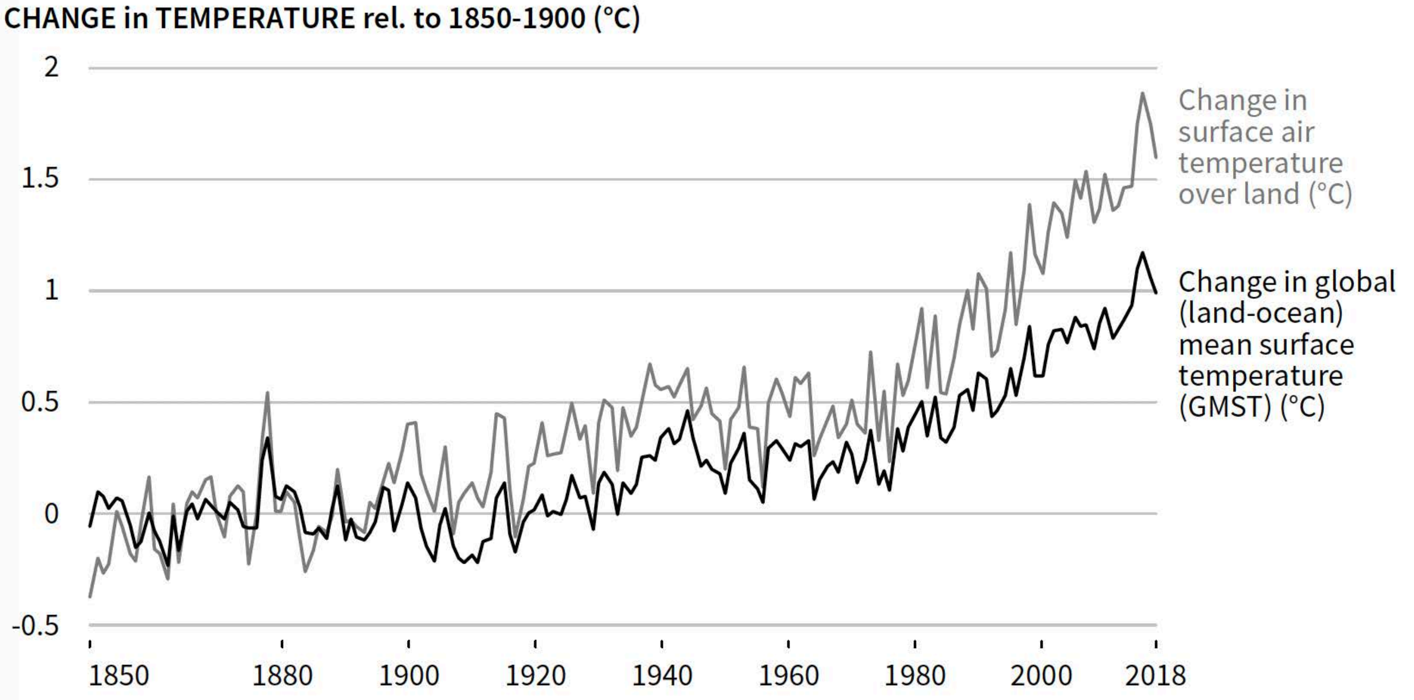
INTERGOVERNMENTAL PANEL ON climate change

Climate Change and Land

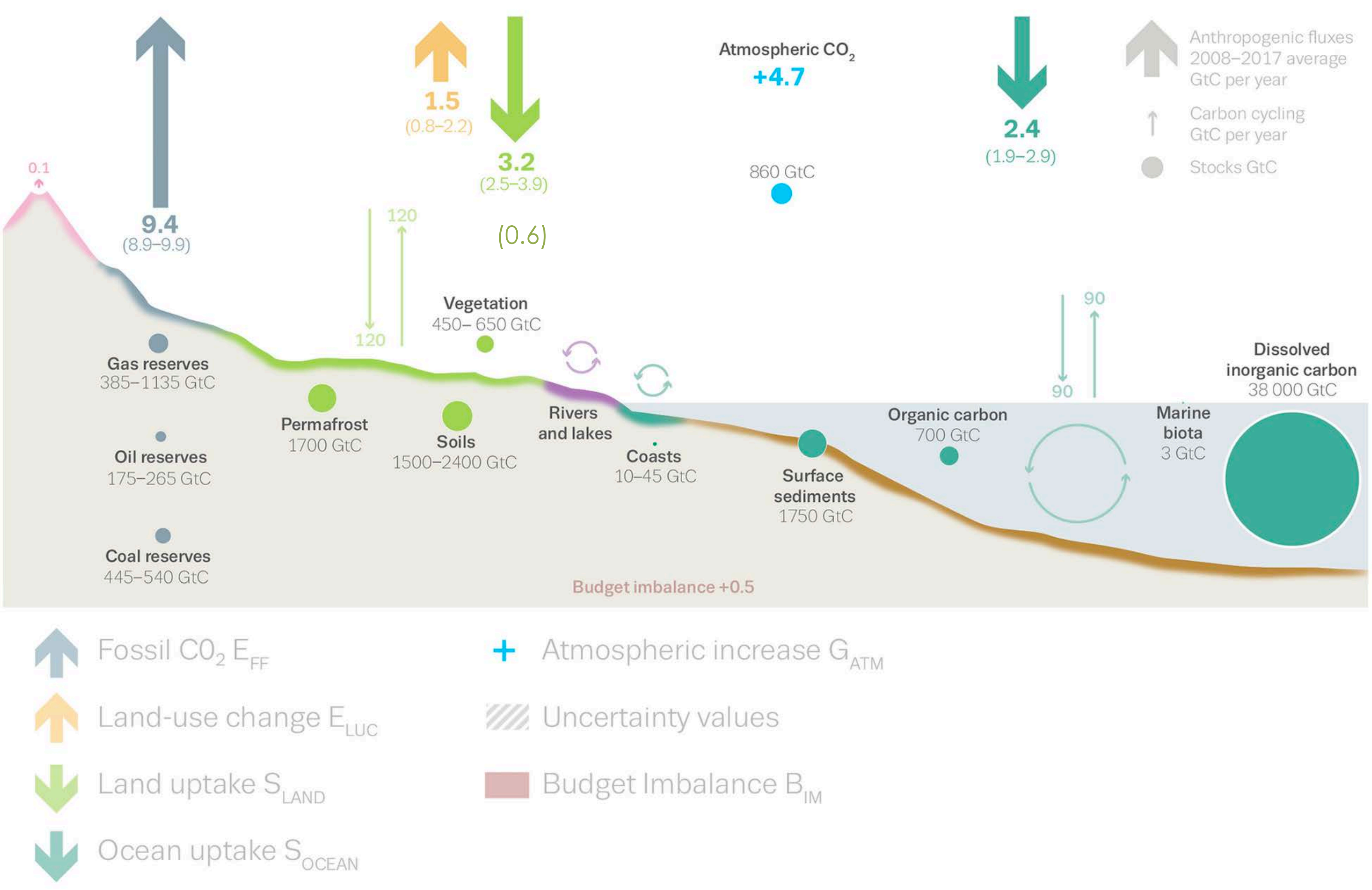
An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems

A. Observed temperature change relative to 1850-1900

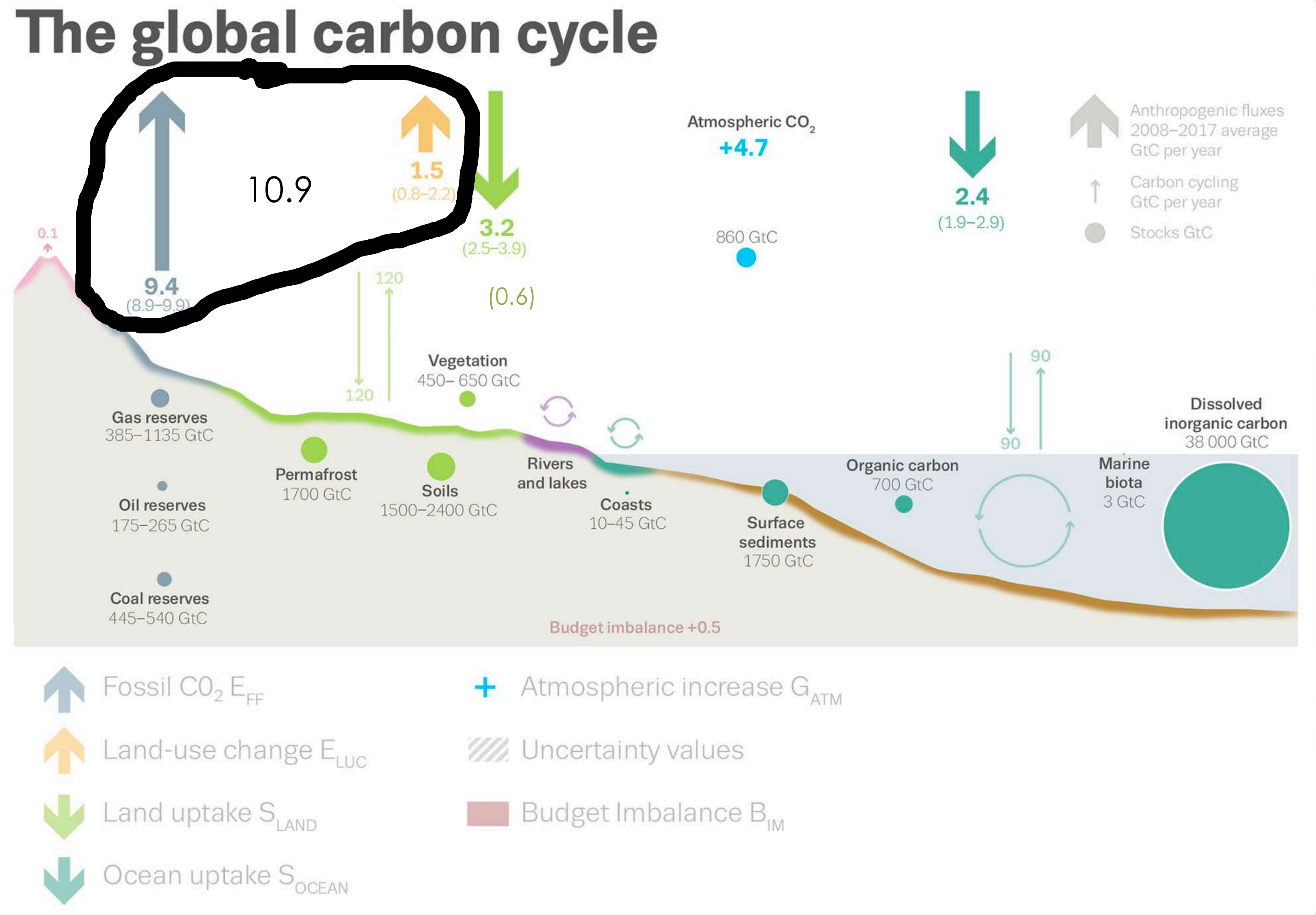
Since the pre-industrial period (1850-1900) the observed mean land surface air temperature has risen considerably more than the global mean surface (land and ocean) temperature (GMST).



The global carbon cycle



https://www.earth-syst-sci-data.net/10/2141/2018/ Le Quere et al, 2018



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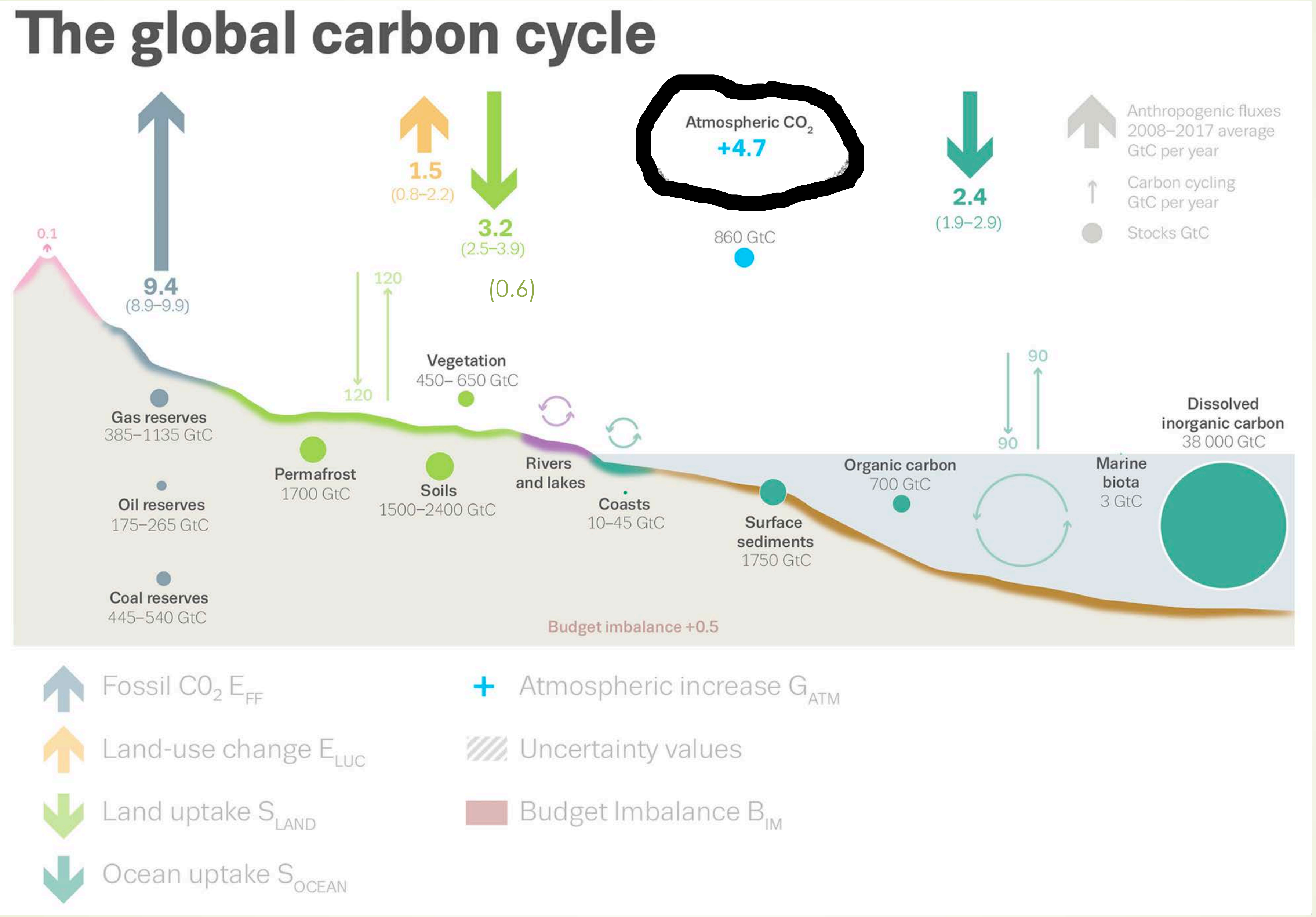

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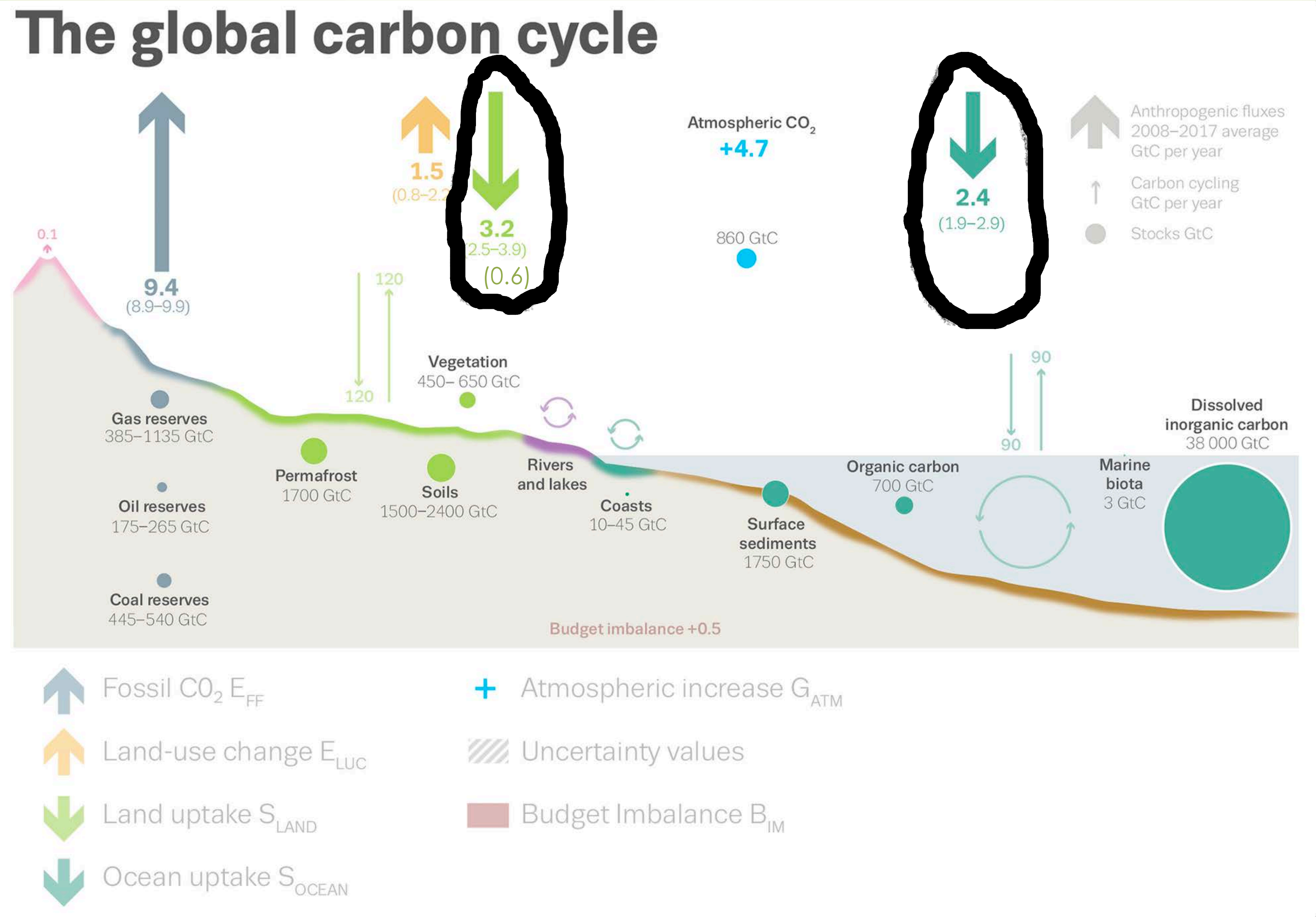


https://www.earth-syst-sci-data.net/10/2141/2018/ Le Quere et al, 2018

Recent proposals for increasing CO_2 sequestration by terrestrial ecosystems

- "Existing and potential C(arbon) D(ioxide) R(emoval) 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." *(IPCC 1.5 Degree Report 2018)*
- Global afforestation and reforestation could remove between 0.5 and 1.5 GtC/y but would require between 50 and 500 million ha of land (*NAS 2019*)
- Afforestation/reforestation – "there is room for an extra 0.9 billion hectares of canopy cover, which could store 205 gigatonnes of carbon in areas that would naturally support woodlands and forests. … Of course, the carbon capture associated with global restoration could not be instantaneous because it would take several decades for forests to reach maturity." (Bastin et al 2019)
- **There is a missing option!**

How much carbon are forests sequestering?

- An amount equal to 29% of annual anthropogenic CO_2 emissions is removed from the atmosphere each year by terrestrial ecosystems (IPCC 2019)
- Forests are not simply a fixed carbon stock, but even primary forests continue to sequester increasing amounts of carbon in new growth and in forest soils (Köhl et al. 2017, Mackey et al 2015)
- Forests and grasslands could sequester twice as much CO_2 annually as they do now (Erb et al 2018)
- Allowing secondary forests to continue growing will sequester an additional 2.8 GtC/yr and halting land use change will sequester an additional 1.5 GtC/yr or 4.3 of the 4.7 GtC/yr gap between emissions and removal rates (Houghton and Nassikas 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)
- Afforestation and reforestation are great for 75-200 years from now, but proforestation sequesters more additional carbon in the coming decades when it is most needed.

Proforestation

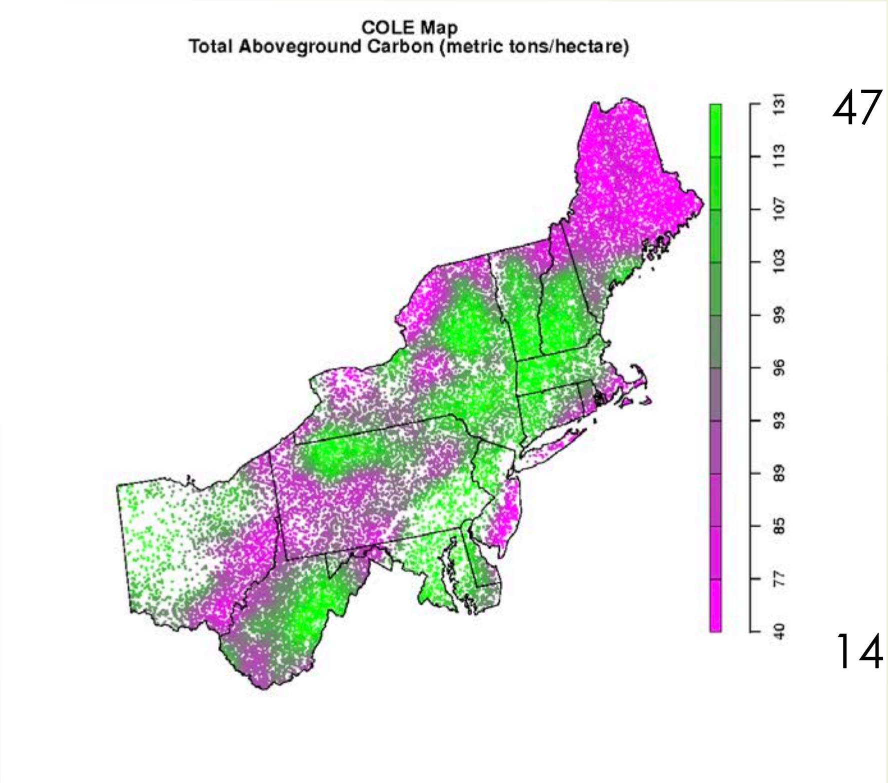
Management that allows trees to reach their biological potential for carbon storage

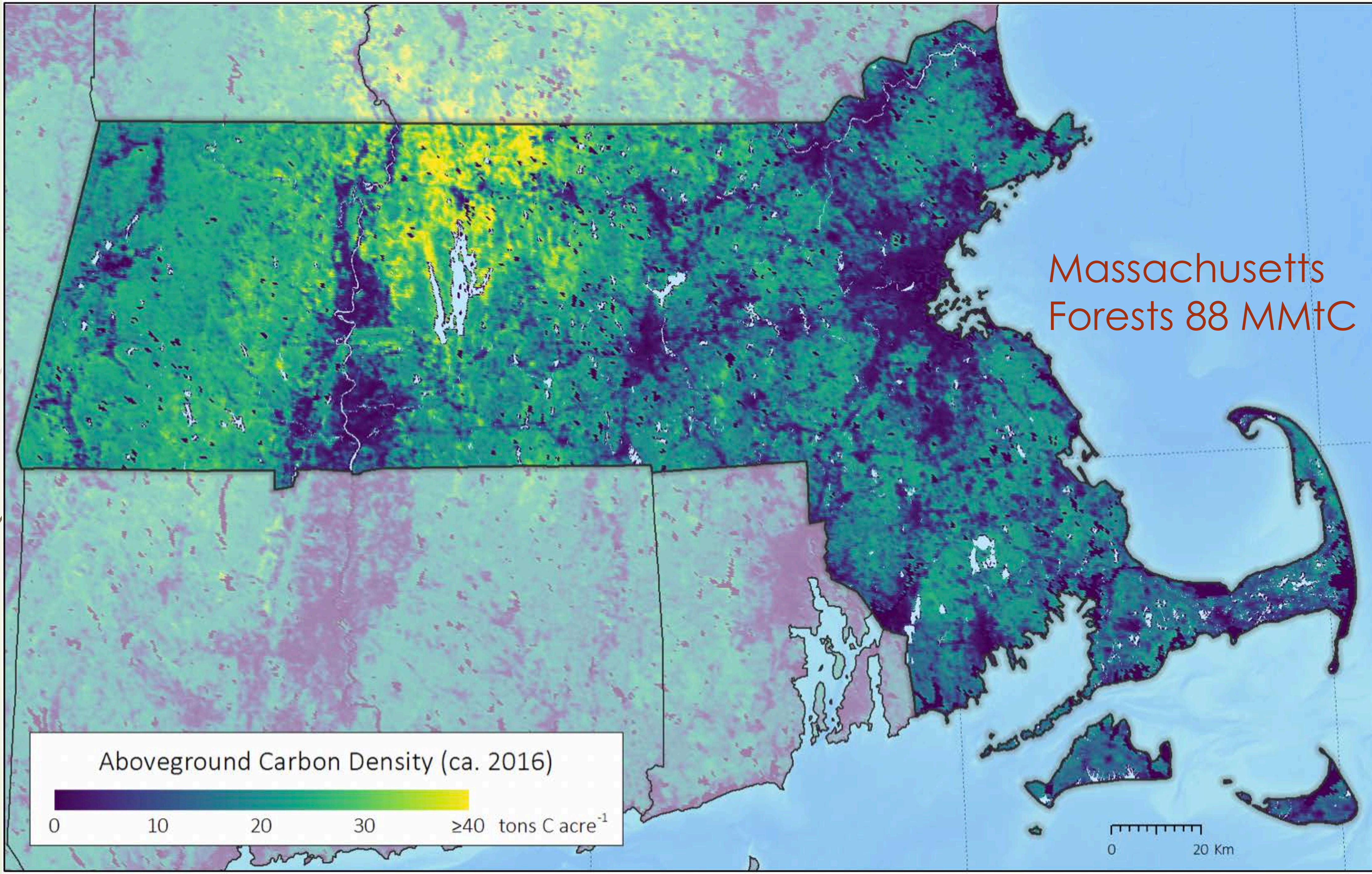
Larger trees in their prime growth period remove the most atmospheric carbon each year, and store the carbon in the wood of their trunk and limbs

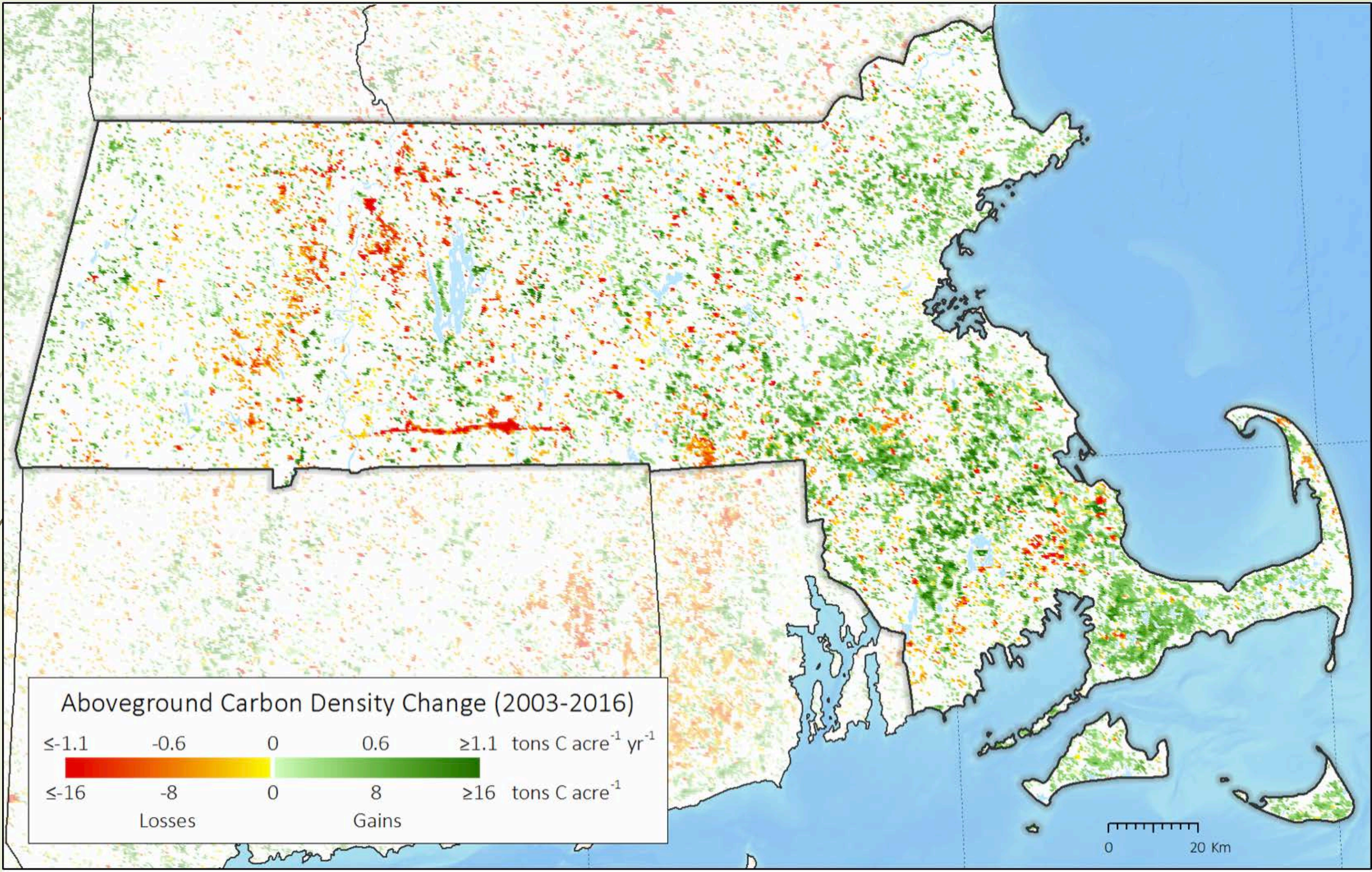
Forest Cover and Carbon Density

Forest cover in NE

Carbon density in NE




Massachusetts
Forests 88 MMtC
Aboveground Carbon Density (ca. 2016)
0
10
20
30
≥40
tons C acre-1
0
20 Km


Aboveground Carbon Density Change (2003-2016)
≤-1.1 -0.6 0 0.6 ≥1.1 tons C acre^{-1} yr^{-1}
≤-16 -8 0 8 ≥16 tons C acre^{-1}
Losses
Gains
0
20 Km

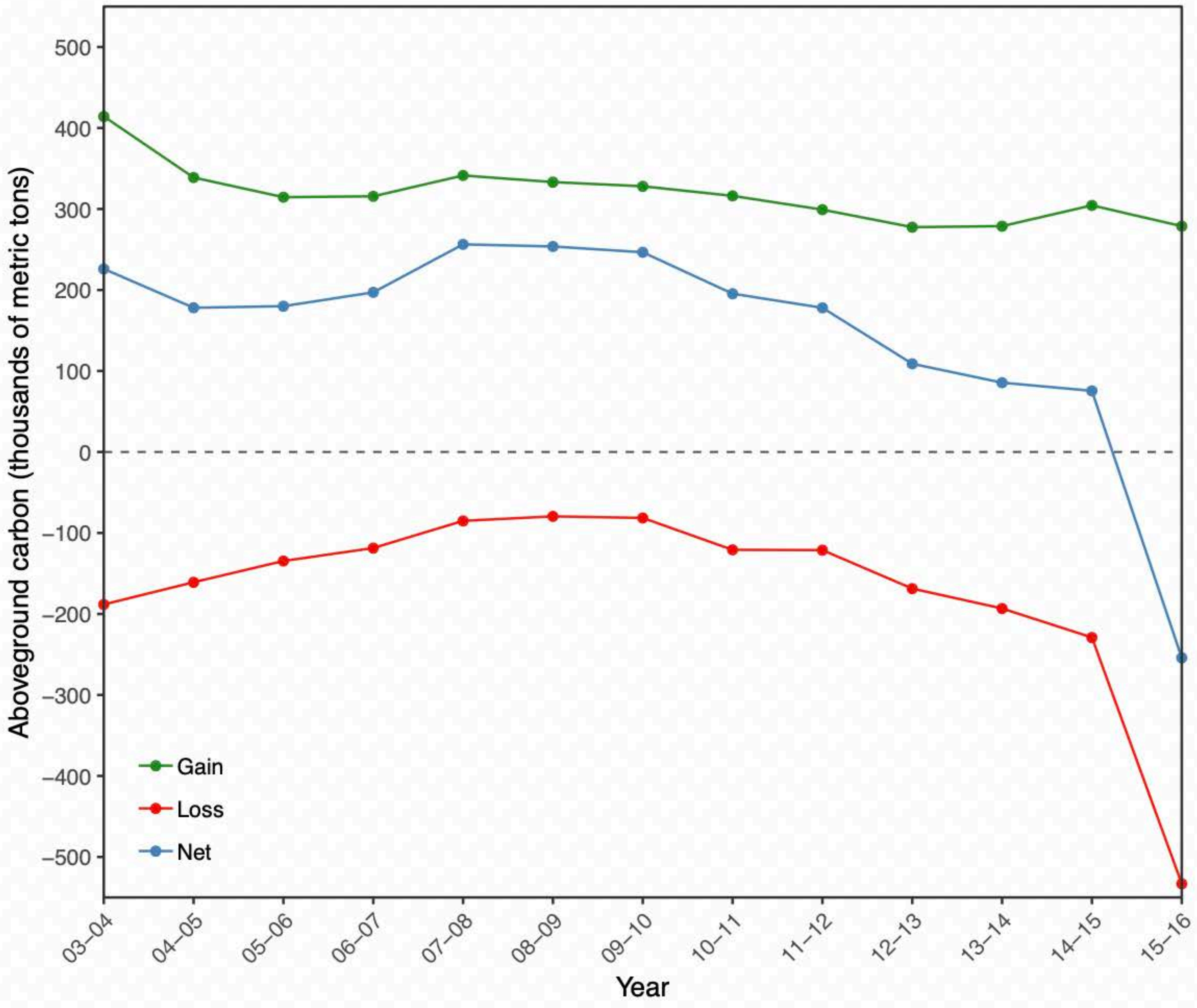
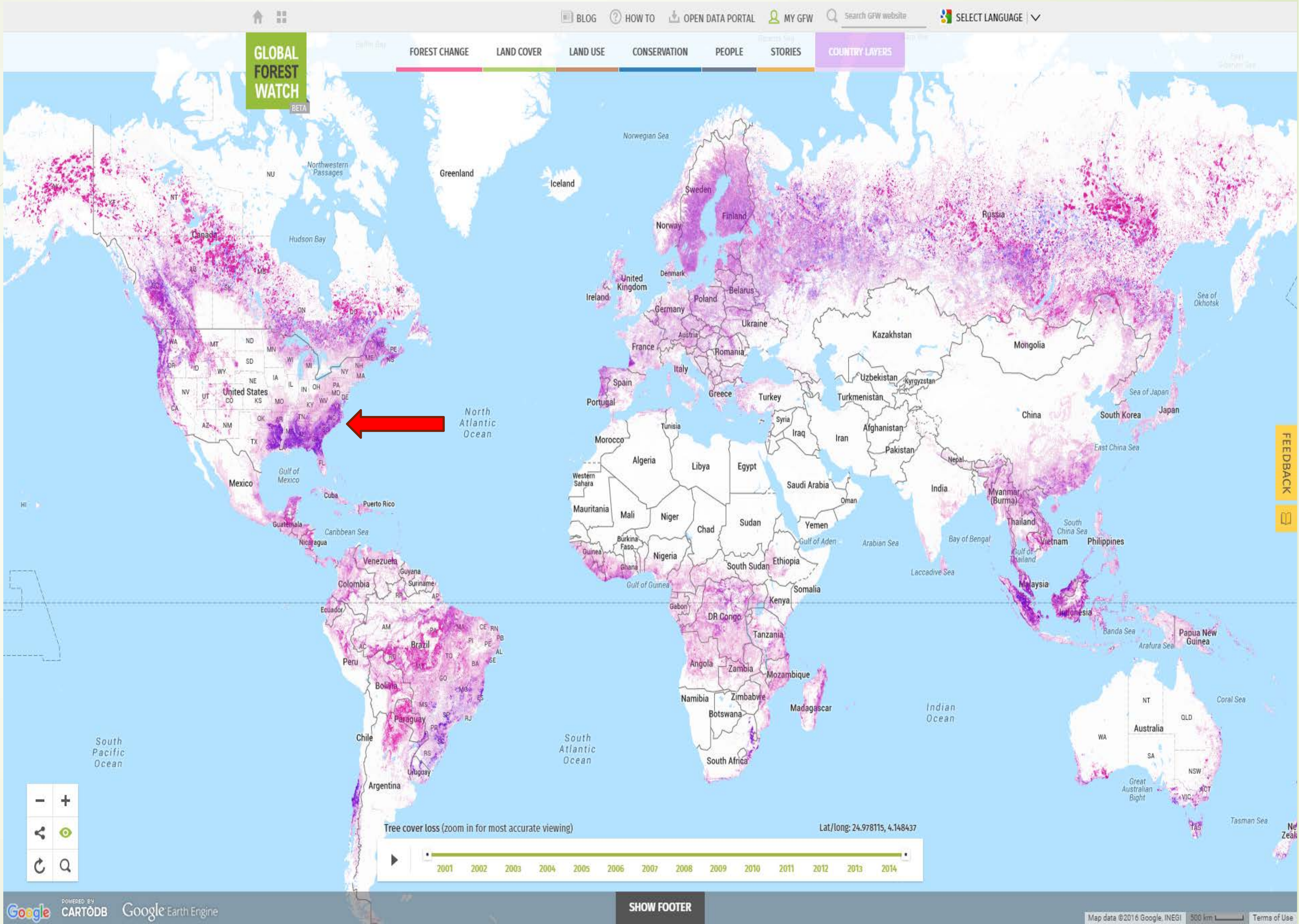


Figure 1: Annual (2003-2016) gain, loss, and net change in aboveground carbon storage across the Massachusetts.

Tree Cover Loss 2000-2015

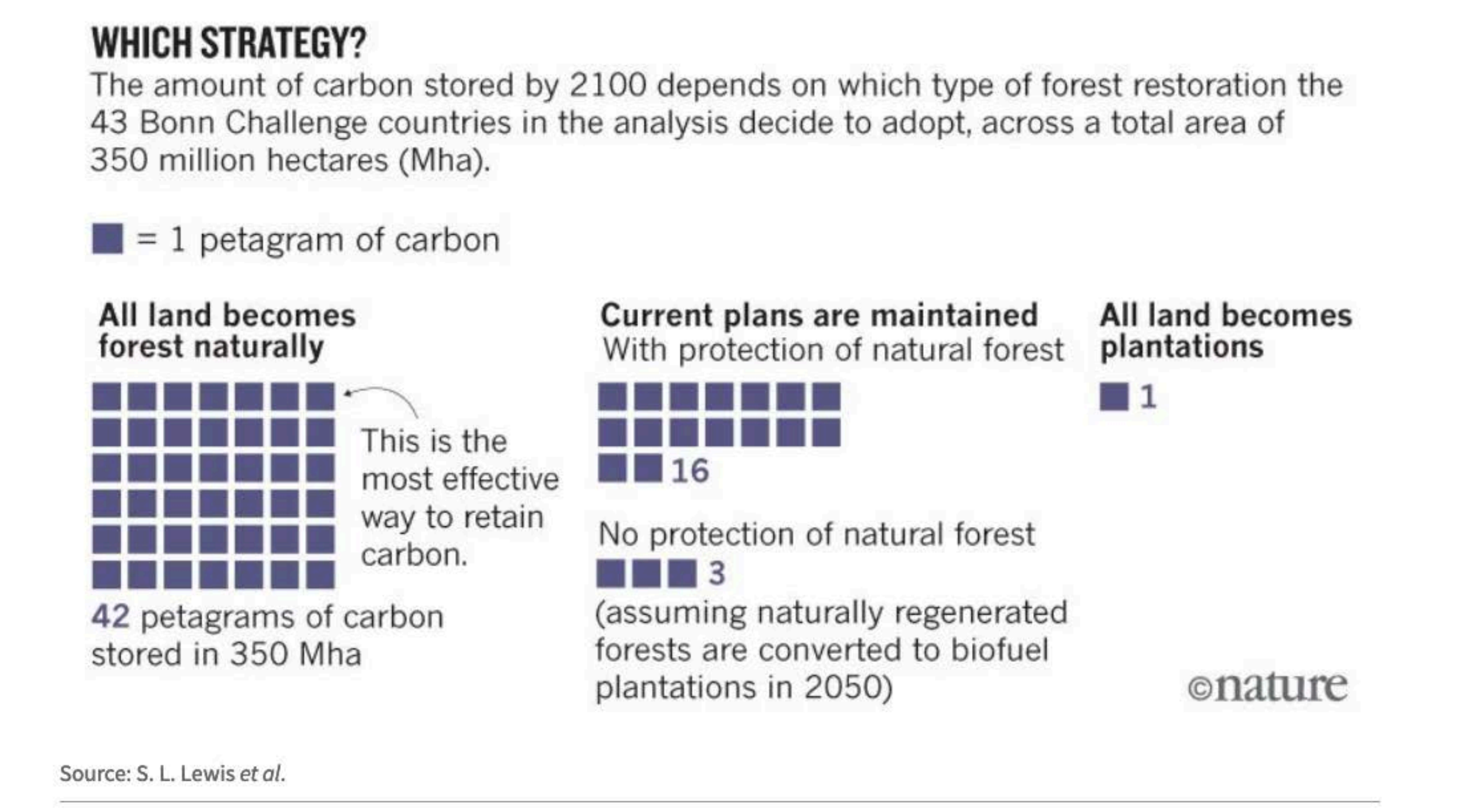
World Resources Institute

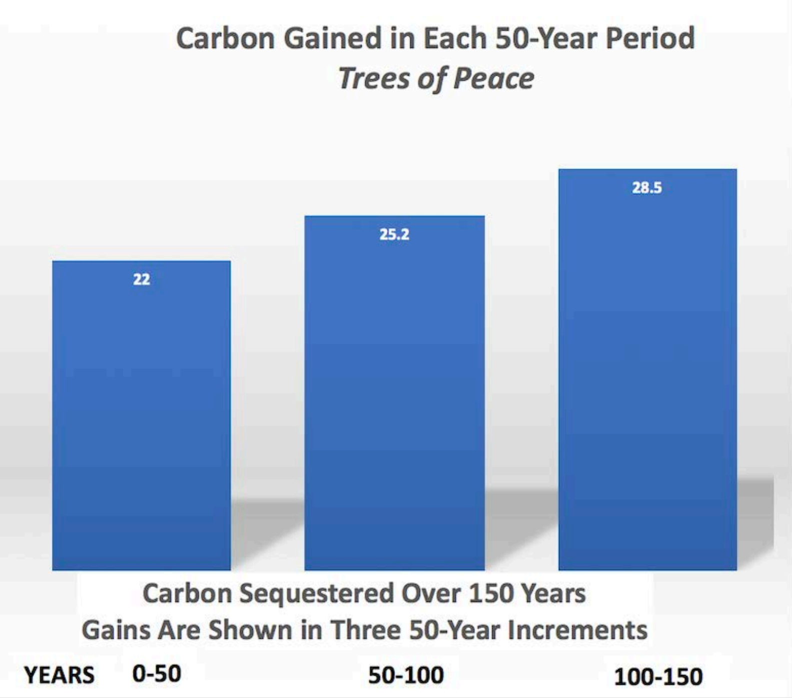


Comparing options for future forests by 2100

Simon L. Lewis,
Charlotte E. Wheeler,
Edward T. A. Mitchard &
Alexander Koch
Nature 2019

https://www.nature.com/articles/d41586-019-01026-8





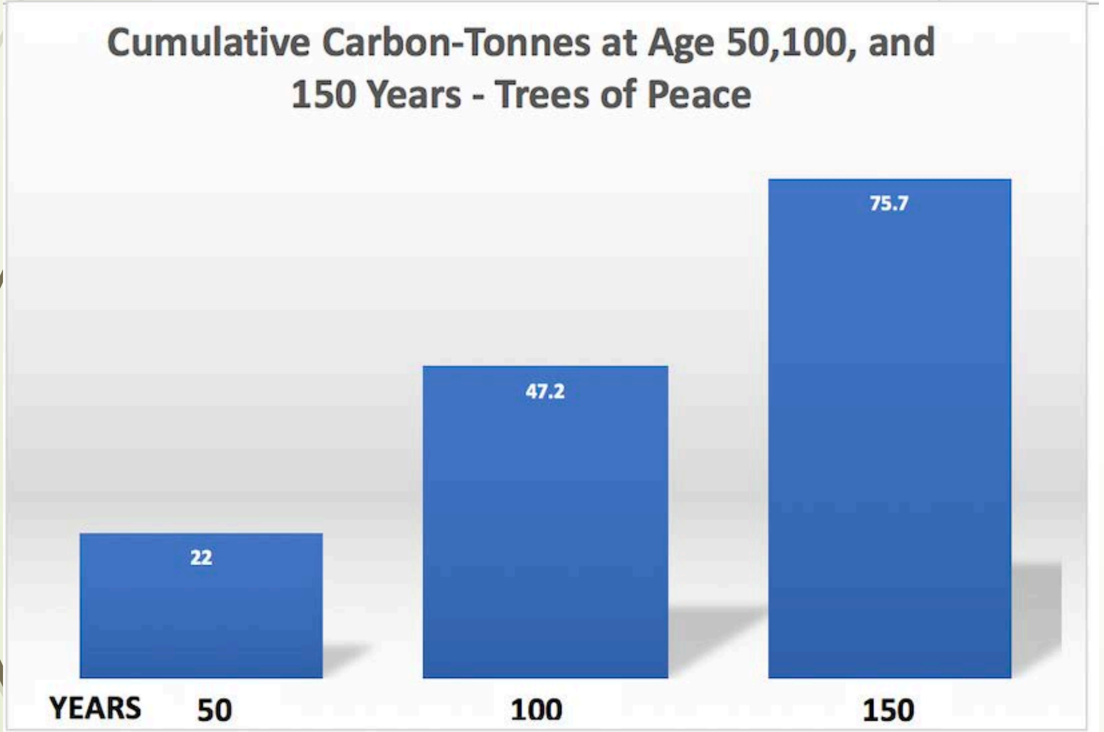
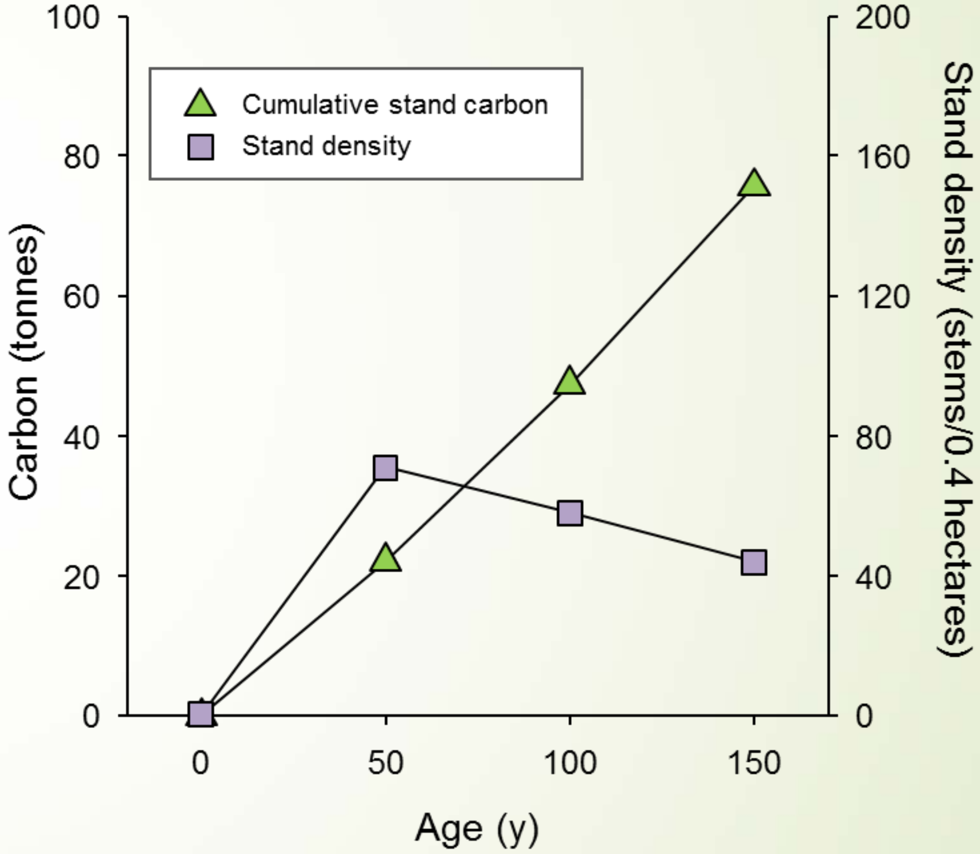


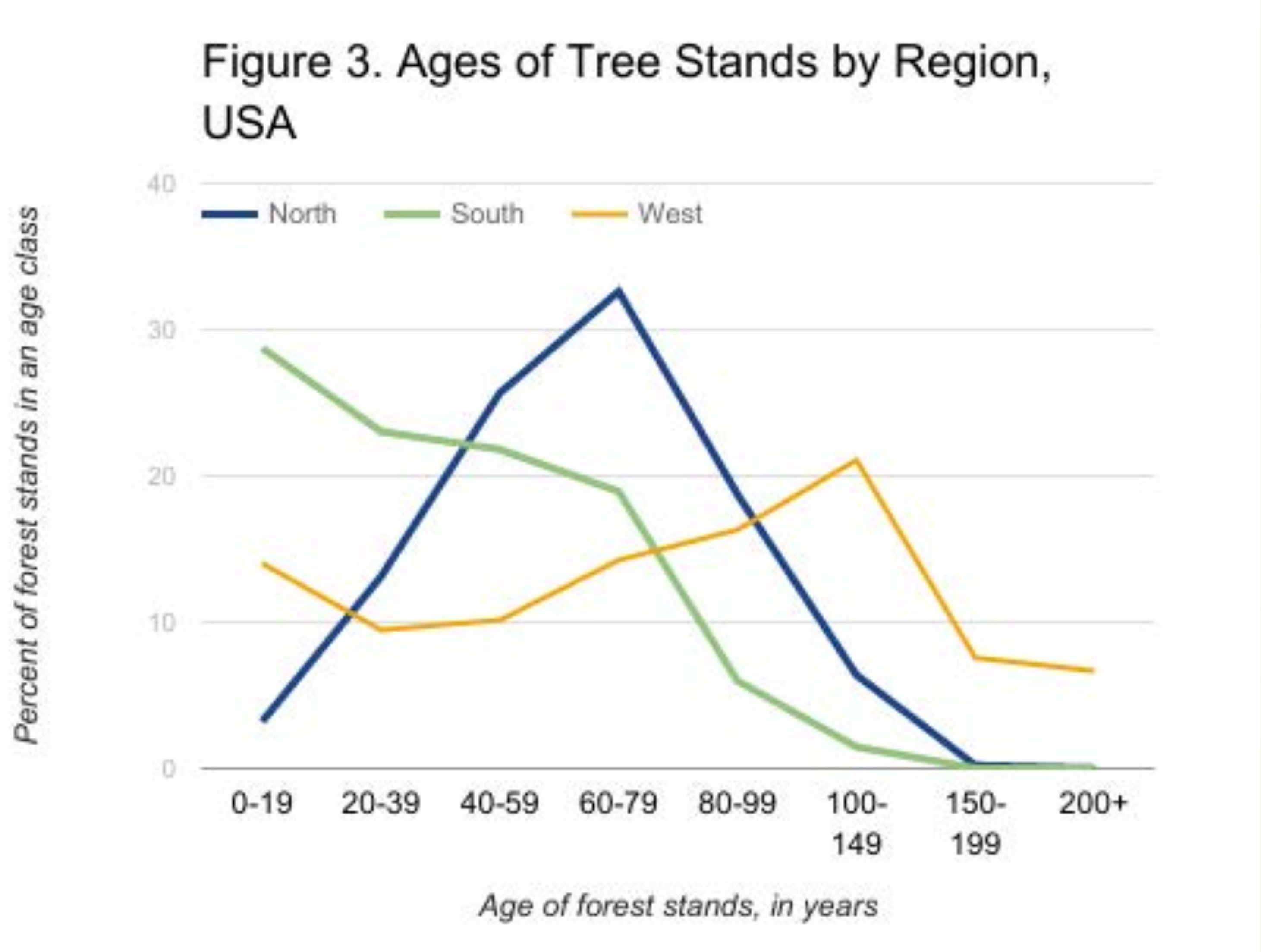
Illustration of Proforestation for a white pine stand in MA



Measurements by Bob Leverett 2018

Median age of NE Forests is 75y

- NE Forests are at age when growth is accelerating making them ideal for proforestation management
- It is also the age when trees are harvested for commercial purposes



Wetlands also have major stores of carbon

Wetlands are only 5-8% of the land area of the U.S. but their soils sequester as much carbon as standing forests

This is the Bay of Fundy with 3 meters of carbon accumulated over the past 3000 years.

Filling and destruction of wetlands release vast amounts of carbon dioxide and methane

Protecting remaining high carbon wetlands is a critical step in enhancing carbon sequestration

High carbon soils in a high altitude fen

- Large quantities of carbon is stored in these soils even though accumulation is relatively slow
- Because of the low average temperature, soil respiration is also very slow allowing carbon to accumulate

Wetland soil core taken from Todd Gulch Fen at 10,000 feet in the Colorado Rockies. The dark, carbon-rich core is about 3 feet long. Living plants at its top provide thermal insulation, keeping the soil cold enough that decomposition by microbes is very slow.

Strategies for closing the sequestration gap

Preventing deforestation and degradation, the draining of wetlands and soil degradation are essential to avoid irreversible and catastrophic climate change

Proforestation management is among the most effective actions and least costly options for removing and storing additional atmospheric CO_2

Thanks to my colleagues who contributed so much to this research

PERSPECTIVE ARTICLE
Front. For. Glob. Change, 11 June 2019 | https://doi.org/10.3389/ffgc.2019.00027

Check for updates

Intact Forests in the United States: Proforestation Mitigates Climate Change and Serves the Greatest Good

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Additional colleagues who are contributing to this work

- Tree measurements, Bob Leverett
- Lidar studies of forest carbon density Wayne Walker and Alessandro Baccini Woods Hole Research Center
- *Wetlands in a Changing Climate: Science, Policy and Management* 2018. Wetlands. William R. Moomaw, G. L. Chmura, Gillian T. Davies, C. M. Finlayson, B. A. Middleton, Susan M. Natali, J. E. Perry, N. Roulet, Ariana E. Sutton-Grier
    - https://link.springer.com/article/10.1007/s13157-018-1023-8


Thank You