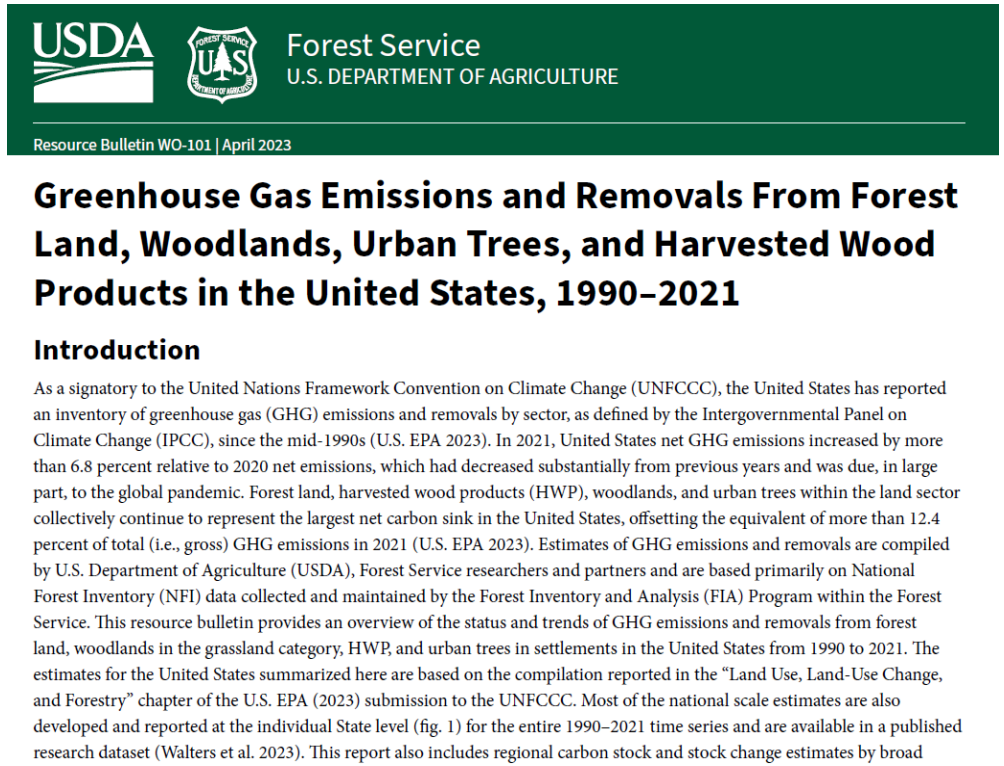
Carbon impacts of thinning and future wildfires

John Coulston
Collaborators
Grant Domke, Evan Brooks, David Walker, Claire O'Dea, et al.

Center for Integrated Forest Science
Southern Research Station

US Background: Status and Trends in Forest Ecosystem Carbon: 1990-2021

- Forest Carbon Stocks have increased ~ 5.5 billion metric tons.
- Our forests are denser: aboveground biomass (Mg C per ha) has increased ~34%.
- ~ 84% of net C sequestration occurs on private forests.
- Public forest account for ~7% of net C sequestration.
- Forest in Rocky Mt., Intermountain, and Southwestern Regions currently a net source of C.
- Net C sequestration (stock change) has generally slowed.
  - 190 MMT C per year (1990)
  - 161 MMT C per year (2021)



USDA Forest Service
U.S. DEPARTMENT OF AGRICULTURE

Resource Bulletin WO-101 | April 2023

Greenhouse Gas Emissions and Removals From Forest Land, Woodlands, Urban Trees, and Harvested Wood Products in the United States, 1990–2021

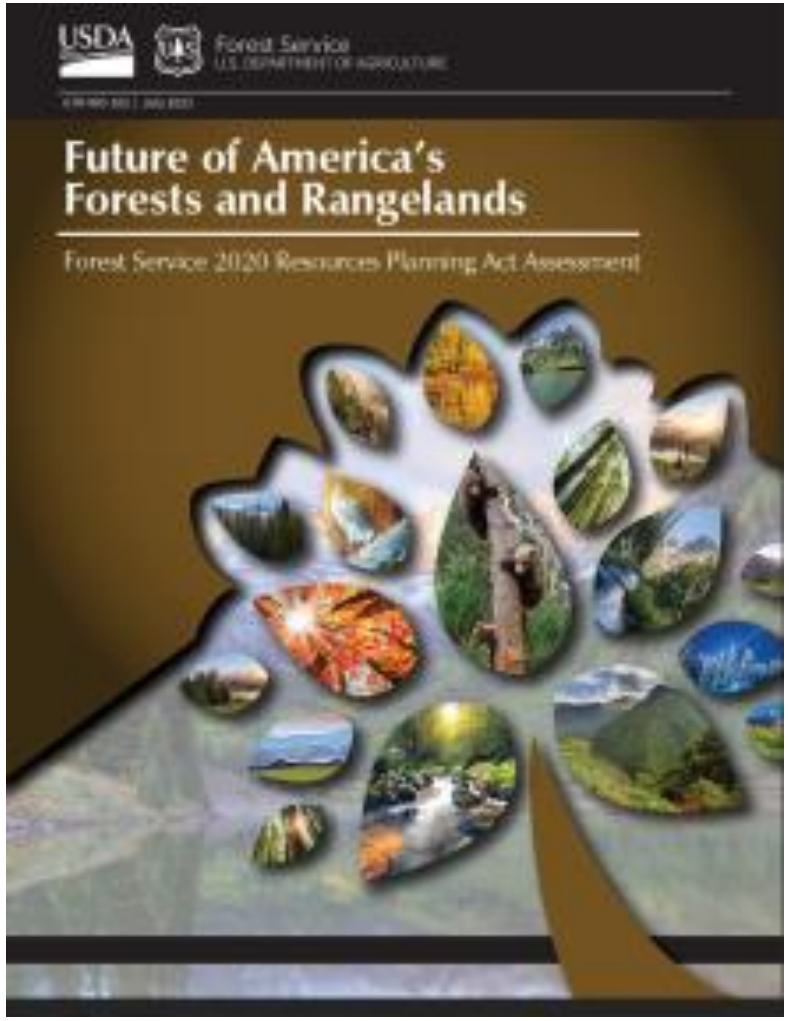
Introduction

As a signatory to the United Nations Framework Convention on Climate Change (UNFCCC), the United States has reported an inventory of greenhouse gas (GHG) emissions and removals by sector, as defined by the Intergovernmental Panel on Climate Change (IPCC), since the mid-1990s (U.S. EPA 2023). In 2021, United States net GHG emissions increased by more than 6.8 percent relative to 2020 net emissions, which had decreased substantially from previous years and was due, in large part, to the global pandemic. Forest land, harvested wood products (HWP), woodlands, and urban trees within the land sector collectively continue to represent the largest net carbon sink in the United States, offsetting the equivalent of more than 12.4 percent of total (i.e., gross) GHG emissions in 2021 (U.S. EPA 2023). Estimates of GHG emissions and removals are compiled by U.S. Department of Agriculture (USDA), Forest Service researchers and partners and are based primarily on National Forest Inventory (NFI) data collected and maintained by the Forest Inventory and Analysis (FIA) Program within the Forest Service. This resource bulletin provides an overview of the status and trends of GHG emissions and removals from forest land, woodlands in the grassland category, HWP, and urban trees in settlements in the United States from 1990 to 2021. The estimates for the United States summarized here are based on the compilation reported in the "Land Use, Land-Use Change, and Forestry" chapter of the U.S. EPA (2023) submission to the UNFCCC. Most of the national scale estimates are also developed and reported at the individual State level (fig. 1) for the entire 1990–2021 time series and are available in a published research dataset (Walters et al. 2023). This report also includes regional carbon stock and stock change estimates by broad

https://www.fs.usda.gov/research/treesearch/66035

US Background: Forest Ecosystem Carbon Projections: 2020-2070

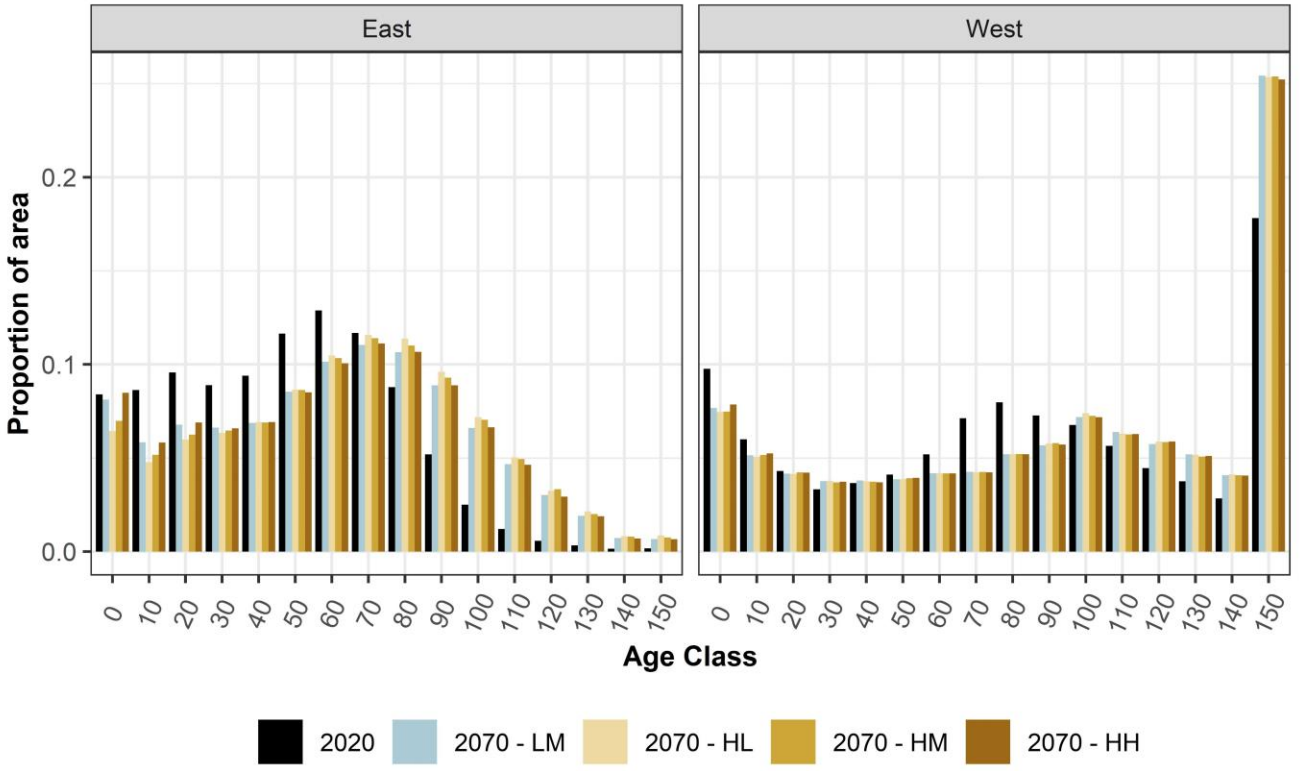
- CONUS Forest Carbon Stocks 2.5-4.3 billion metric tons.
- Our forests continue to become denser: 17%-25% increase in aboveground biomass density (Mg C per ha).
- Carbon stocks increase at a decreasing rate suggesting carbon saturation (ie slowing growth and less stock change per year).
- Stock change relatively stable over next decade but decreases significantly by 2050 across scenarios.
- Forest in Rocky Mt., Intermountain, and Southwestern Regions projected to remain a net source of C.
- Other regions of projected to decrease in sink strength across scenarios.



https://www.fs.usda.gov/research/inventory/rpaa/2020

What's driving projection results?

- Land use change: Loss of forest area on private lands.
- Maturing forests with passive or no management (only 23% of owners have a management plan).
- Disturbance mortality and climate driven disturbance shifts (fire, insects, diseases, etc.)
- Leads to gradual maturing forest land base with
  - slower growth rates (less net carbon sequestration).
  - Uncaptured mortality through harvest for products.
  - Less resilience to disturbance.

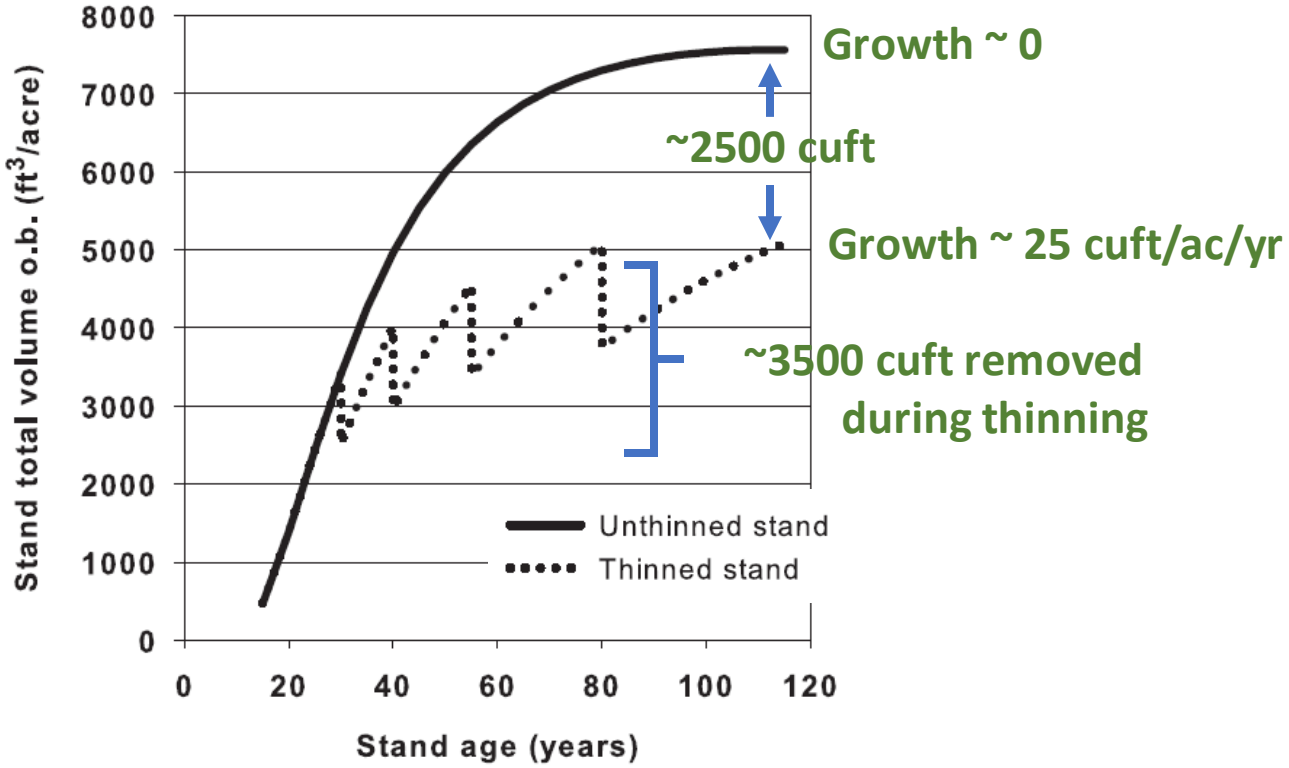


Approaches to increase current and future sink strength

- Traditional forest management
- Other measures that fall under natural climate solutions (NCS)
- Recent US policy provides funding for management actions that fall under NCS – US Forest Service Implementation plan:
  - Fuel reduction treatments (50 million ac)
    - Thinning
    - Removal of dead material
  - Reforestation of perpetually non-stocked forest (4 million ac on Forest Service lands).
  - Goal – protect people and property; increase forest resilience.
- With over 620 million acres of persistent forest – management actions will need to affect significant acreage to shift carbon futures.

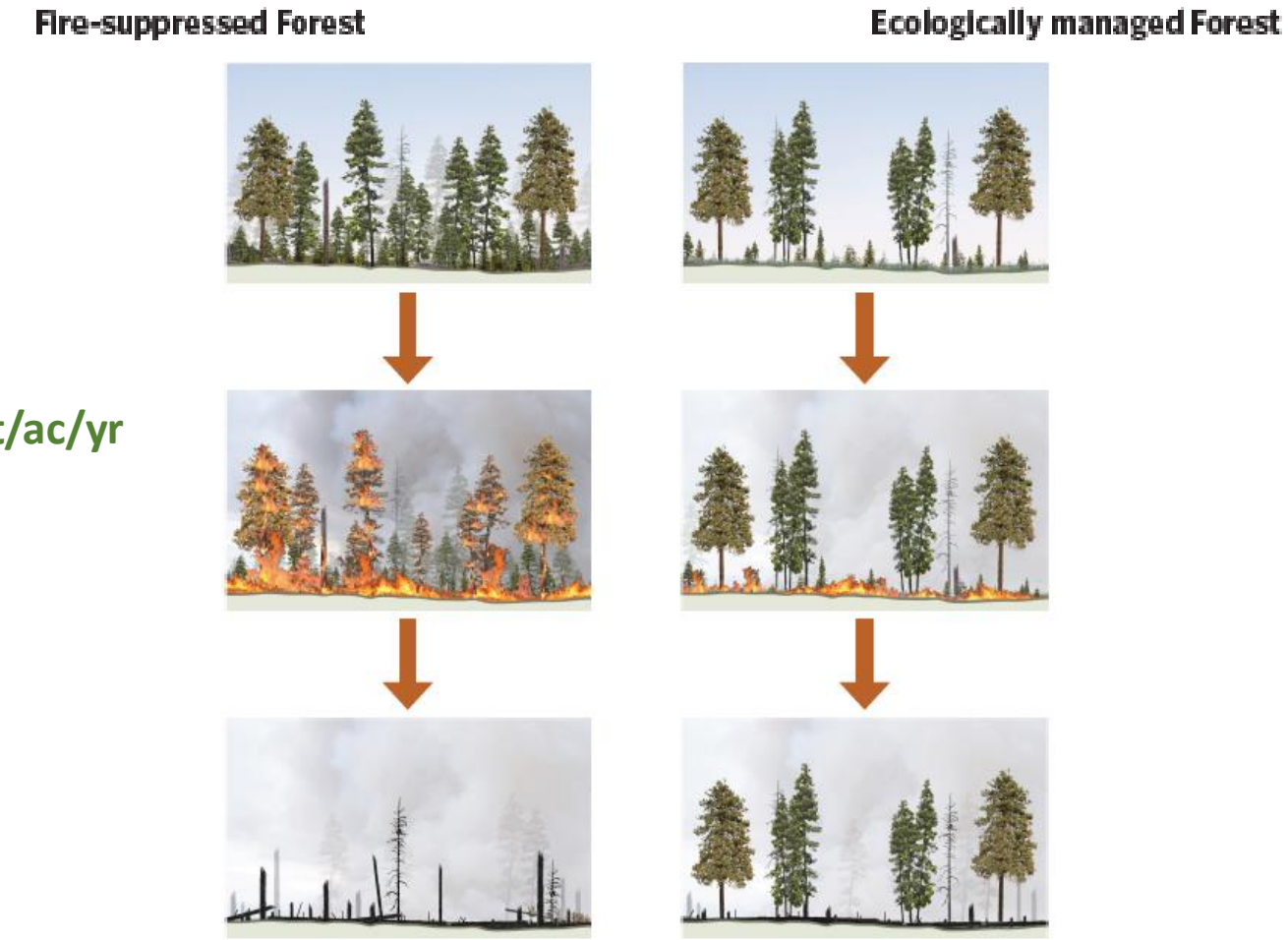
Potential forest production and ecological effects of thinning

Forest Production: example Longleaf Pine in Alabama



https://doi.org/10.2737/RDS-2022-0034

Ecological



https://www.nature.org/content/dam/tnc/nature/en/documents/FINALwildfireresilienceinsurance6.27.21.pdf

Other effect of fuel treatment

- Goal of fuel treatment is to reduce forest carbon
  - Above ground live
  - Dead pool carbon
- Literature suggests
  - Decrease in soil C.
  - Decrease in belowground live C
  - Amount depends on forest type and stand characteristics.

https://northernwoodlands.org/articles/article/dead-wood

Policy Analysis: Potential effects of implementation plan

- 2022 Forest Service strategy to combat the wildfire crisis offers implementation plan
  - Conduct fuel treatments on 20 million acres of National Forest Systems Land
  - Conduct fuel treatment on an additional 30 million acres of other federal and private land.
  - Reforest 4 million acres of National Forest Systems land
  - 10-year implementation schedule

PNAS Nexus

PNAS Nexus, 2023, **2**, 1–4
https://doi.org/10.1093/pnasnexus/pgad345
Advance access publication 21 November 2023
Brief Report

Near-term investments in forest management support long-term carbon sequestration capacity in forests of the United States

John W. Coulston[a,*], Grant M. Domke[b], David M. Walker[c], Evan B. Brooks[d] and Claire B. O'Dea[e]

[a]USDA Forest Service, Southern Research Station, 1650 Research Center Dr, Blacksburg, VA 24060, USA
[b]USDA Forest Service, Northern Research Station, 1992 Folwell Ave, St Paul, MN 55108, USA
[c]USDA Forest Service, Southern Research Station through Oak Ridge Institute for Science Education, 1650 Research Center Dr, Blacksburg, VA 24060, USA
[d]Department of Forest Resources and Environmental Conservation, Virginia Tech, 1650 Research Center Dr, Blacksburg, VA 24060, USA
[e]USDA Forest Service, Southern Research Station, Washington Office, 201 14th St SW, Washington, DC 20227, USA
*To whom correspondence should be addressed: Email: john.coulston@usda.gov
Edited By: Yannis Yortsos

Abstract

The forest carbon sink of the United States offsets emissions in other sectors. Recently passed US laws include important climate legislation for wildfire reduction, forest restoration, and forest planting. In this study, we examine how wildfire reduction strategies and planting might alter the forest carbon sink. Our results suggest that wildfire reduction strategies reduce carbon sequestration potential in the near term but provide a longer term benefit. Planting initiatives increase carbon sequestration but at levels that do not offset lost sequestration from wildfire reduction strategies. We conclude that recent legislation may increase near-term carbon emissions due to fuel treatments and reduced wildfire frequency and intensity, and expand long-term US carbon sink strength.

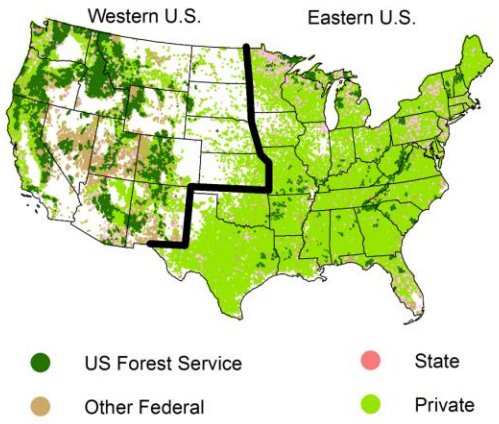
Keywords: natural climate solutions, climate mitigation, forest carbon projections, climate legislation

Significance Statement

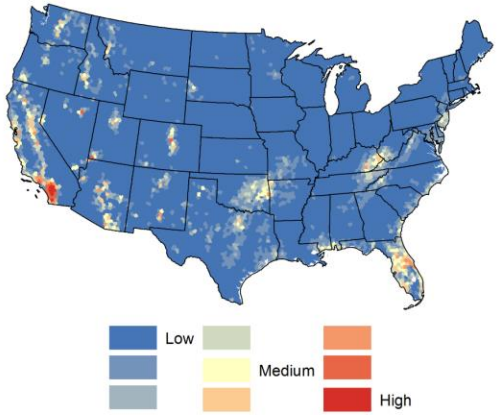
Nature based climate solutions and investments in forest management can help protect communities, improve forest resilience, and improve forest carbon sequestration rates. However, the scope, scale, and timing of the management actions have different carbon consequences in the near-term versus longer-term. Our results suggest that nature based climate solutions can increase forest carbon

Methods

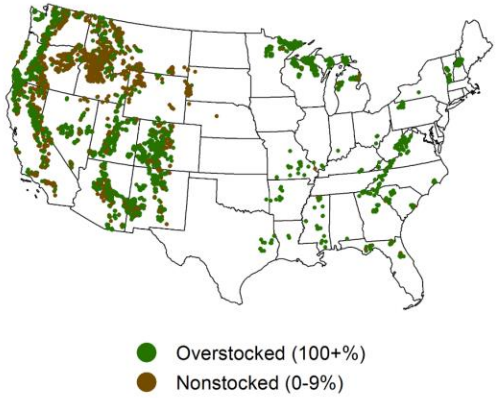
A



B



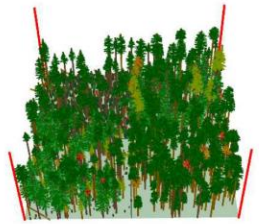
C



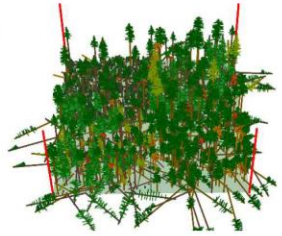
D

Fire Fuel High Treatment (FHT) 2022-2032	Fire Fuel Low Treatment (FLT) 2022-2032	Planting	Shared Socioeconomic Pathway 2: U.S. characteristics	Representative Concentration Pathway 8.5 climate models and U.S. classification
Remove 10-50% of the live basal area and/or 90% of the dead fuel weight.	Remove 10-25% of the live basal area and/or 90% of the dead fuel weight.	Reforestation of 1.6 million ha of non-stocked USFS land.	Medium U.S. population growth	CNRM-CM5 (Wet)
			Medium U.S. economic growth rate	IPSL-CM5A-MR (Dry)
Treat 8.1 and 12.1 million ha of USFS and other forest land respectively based on fireshed priority areas.	Treat 8.1 and 12.1 million ha of USFS and other forest land respectively based on fireshed priority areas.		Medium bioenergy demand	HadGEM2-ES (Hot)
			Mixed focus on renewables and fossil fuels for energy	MRI-CGCM3 (Least warm)
			Medium trade openness	NorESM1-M (Middle)

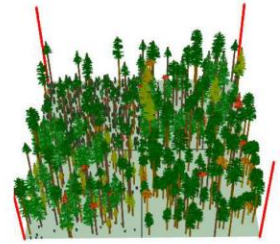
E



F

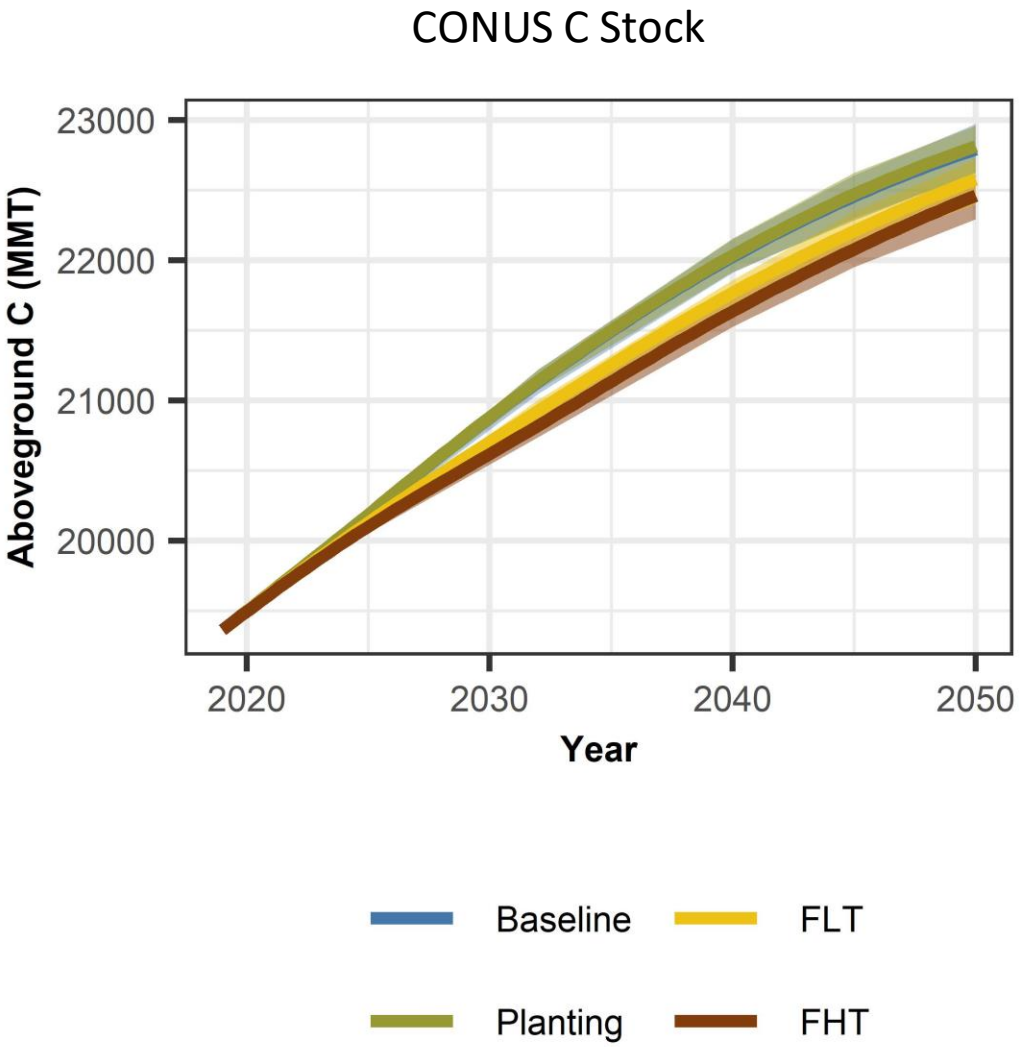


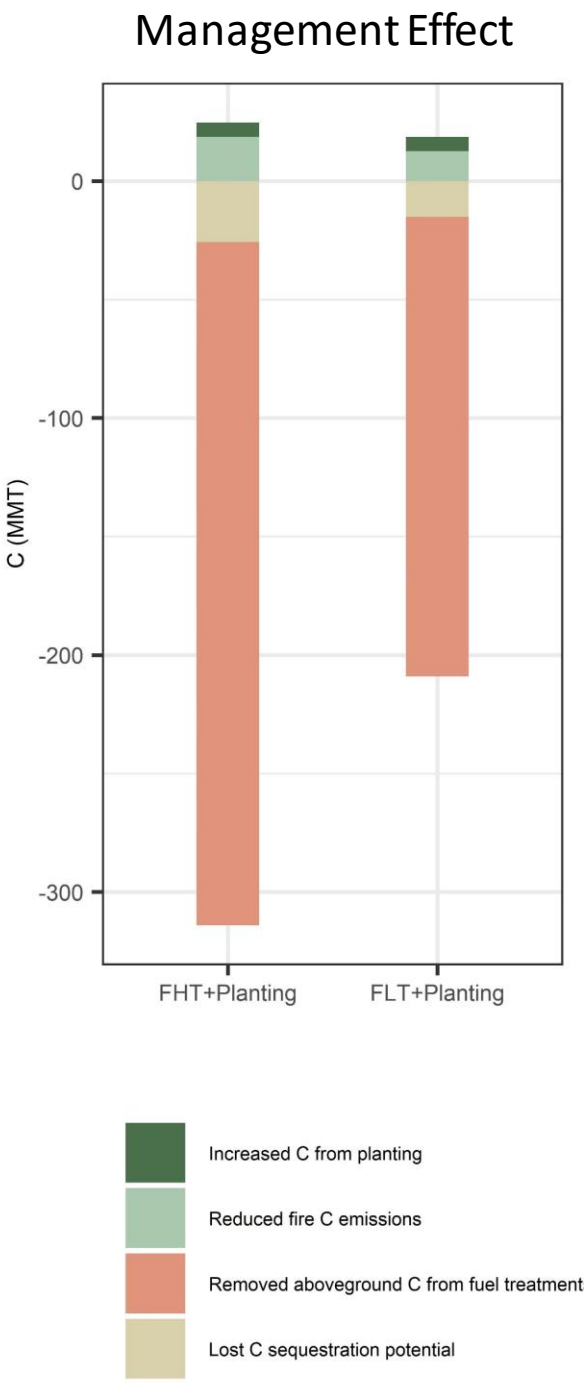
G



Results: effect on C stocks

- Only aboveground carbon examined: live biomass, deadwood, and litter.
- Continental US forests store 19,362 MMT carbon.
- Fuel treatments remove carbon from the forest landscape.
- Depending on assumption:
  - High treatment level removes 288 MMT C 2022-2032 from aboveground stock.
  - Low treatment level 194 MMT C.
- From 2022-2032 stocks also decrease from baseline because of live tree removal (ie trees that were removed would have sequestered some carbon).
- Carbon removals from treatments and lost sequestration are partially offset by reduced wildfire emission and planting

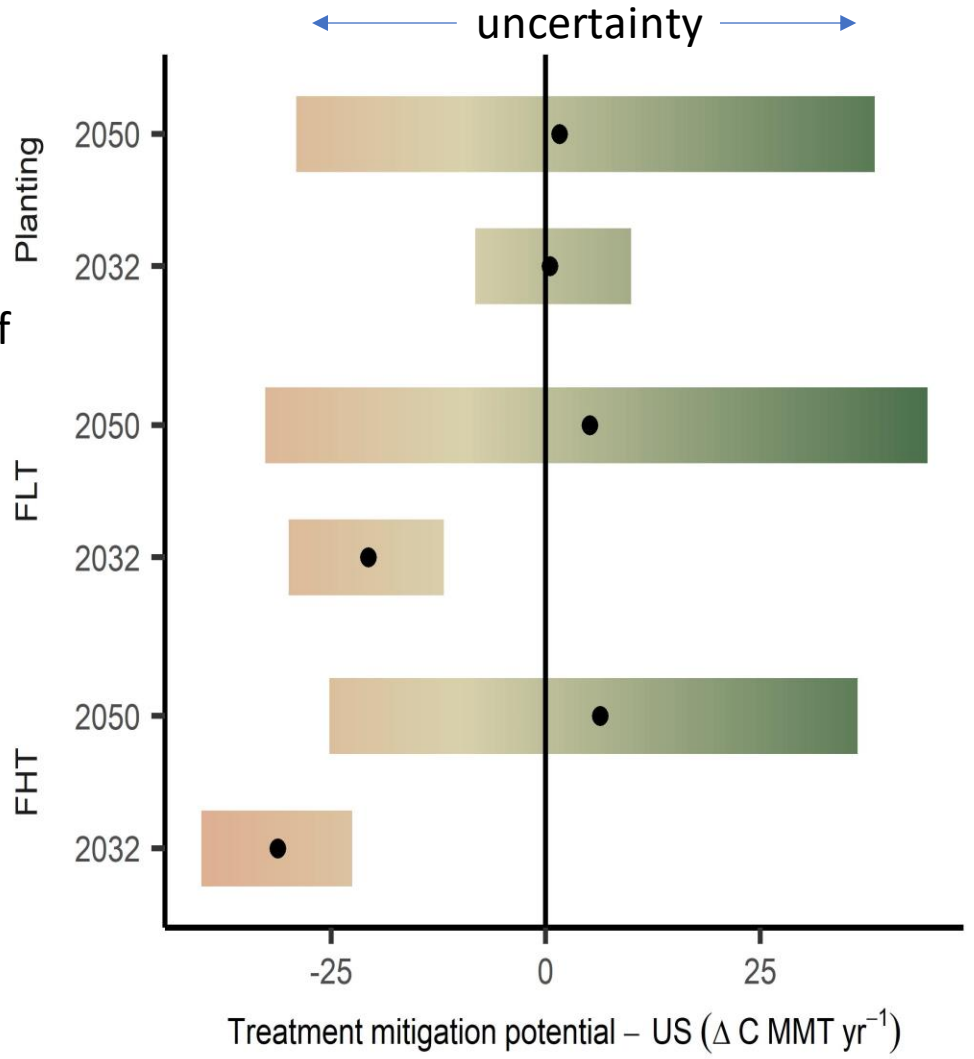




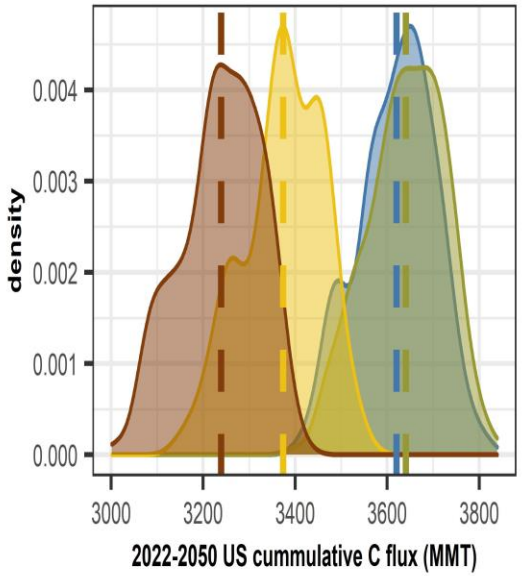
Results: Mitigation Potential

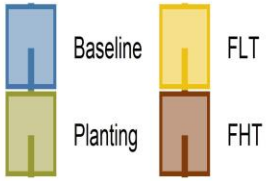
- Mitigation potential = baseline – scenario
- Forest Service model is stochastic: range of results presented.
- Reforestation is positive for mitigation potential in 2032 and 2050.
- Fuel treatments: under both FLT and FHT 2032 results suggest decreased annual stock change due to biomass removal.
- By 2050 both FHT and FLT suggest positive mitigation potential.
  - Note uncertainty and that only one stand entry modeled.
- From 2022-2050 perspective less cumulative C sequestered under FLT and FHT.

Mitigation potential: Annual stock change



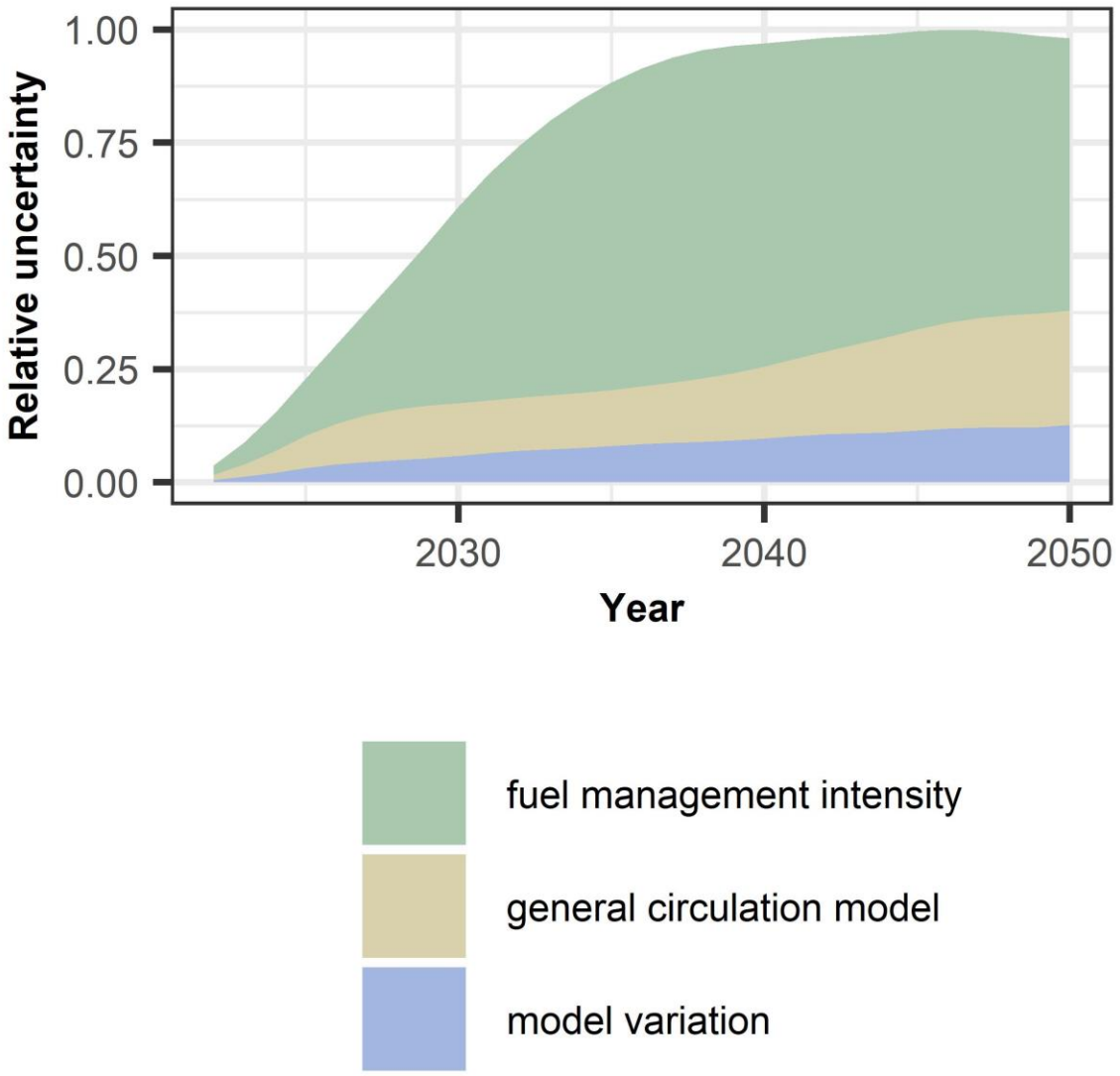
Mitigation potential: Cumulative stock change





Results: Uncertainty Drivers

- Climate variation and model variation important sources of uncertainty
- Yet, lack of foresight on how management activities on the ground is greatest source of uncertainty.
- General results suggest human's ability to manipulate forest conditions outpaces climate shifts.



Assumptions & Conclusions

- Biomass removed during treatments assumed to be an emission
  - Lack of infrastructure / mills and questionable wood quality.
  - Climate smart forestry and market investments (BIL, IRA) may lead to opportunities to use for long lived products (HWP carbon) or offsets in other sectors (bioenergy – domestic pellets)
- Results suggest WCS unlikely to provide carbon sequestration benefit over projection period.
  - Losses in the short run
  - Small increases in annual sequestration in the long run
  - Cumulative sequestration less than baseline
- However, WCS, focuses on protecting communities and improving forest resilience – projections suggest
  - reduction in wildfire area
  - reduced fire mortality volume (~ 10%)
  - Improved growth rates in RMRS (may not be net source by 2050).

Key Points

US Carbon futures

- Projections suggest carbon saturation over next 50-years
- The interaction among aging, disturbance, harvest, and land use change drive the trajectory

2022 IIJA (BIL) and Forest Service Strategies

- CONUS Forest remaining forest landbase ~620 million acres (251 million ha).
- Pace and scale of activities matters (WCS 54 million acres – 21.8 million ha – over 10 years)
- Forestry NCS in many cases take time to offer a benefit.

Observations

- Current approach focuses on less productive lands.
- Mitigation could increase if more productive lands included. Strong markets can help.
- Pace and scale matter. FS policy affect < 10% of forestland in 10 years. Effect is partially a function of scale.
- Forestry NCS, in many cases, take time to offer a benefit-the less productive the land the more time it takes.
- Multiple entries (management actions) are likely needed to sustain benefit.

Thank you for your time

john.coulston@usda.gov