Natural Climate Solutions for Maine's Managed Forests

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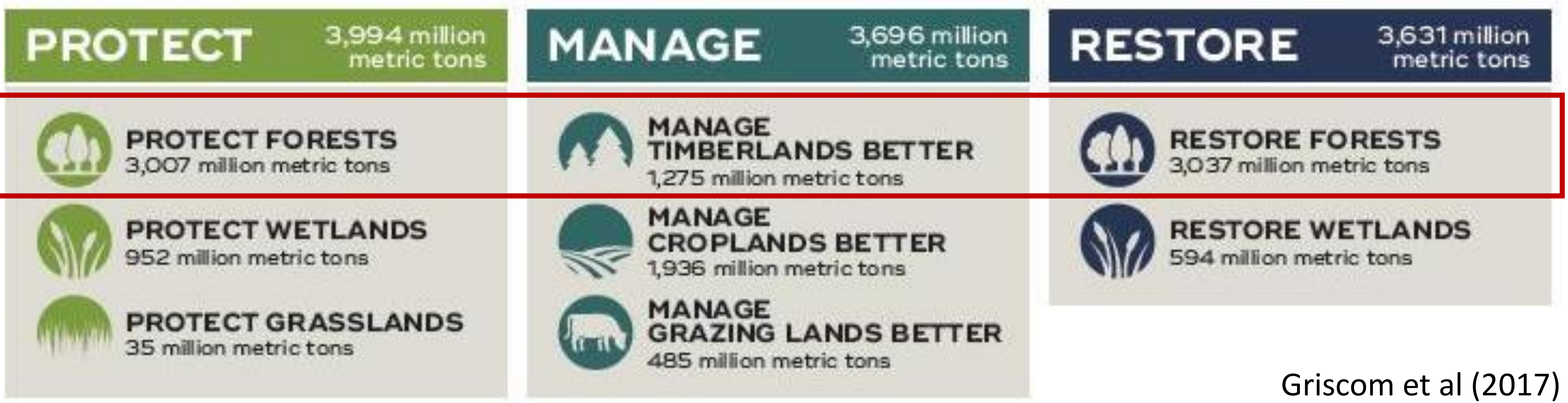
What are "Natural Climate Solutions"?

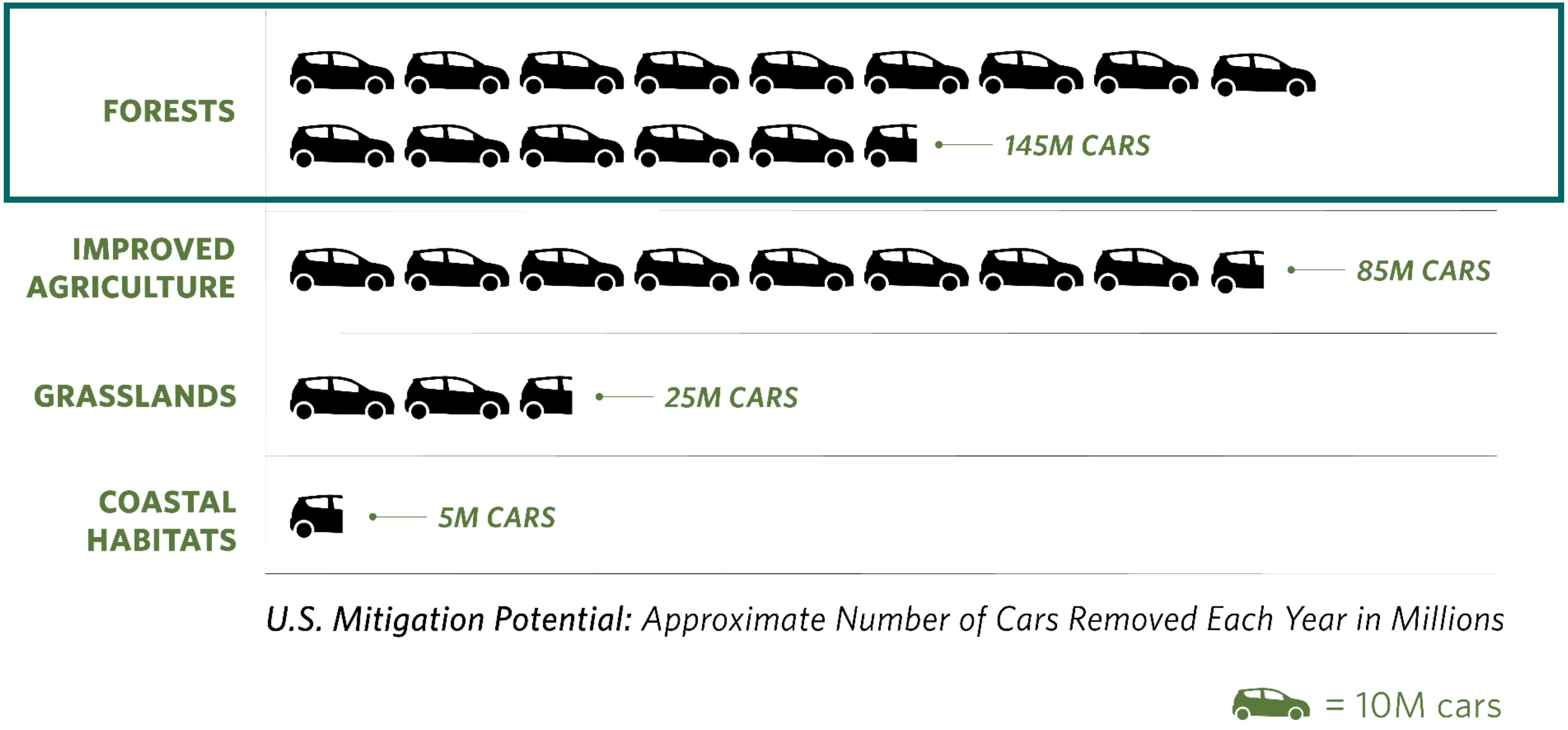
Any action that **conserves**, **restores** or improves the use or **management** of forests, wetlands, grasslands, and agricultural lands, while simultaneously **increasing carbon storage** or **avoiding greenhouse gas emissions**.



Griscom et al (2017)

NATURAL CLIMATE SOLUTIONS

In the U.S., nature has potential to remove **21% of the nation's carbon pollution**—equivalent to removing emissions from **ALL cars and trucks on the road**...and then some.

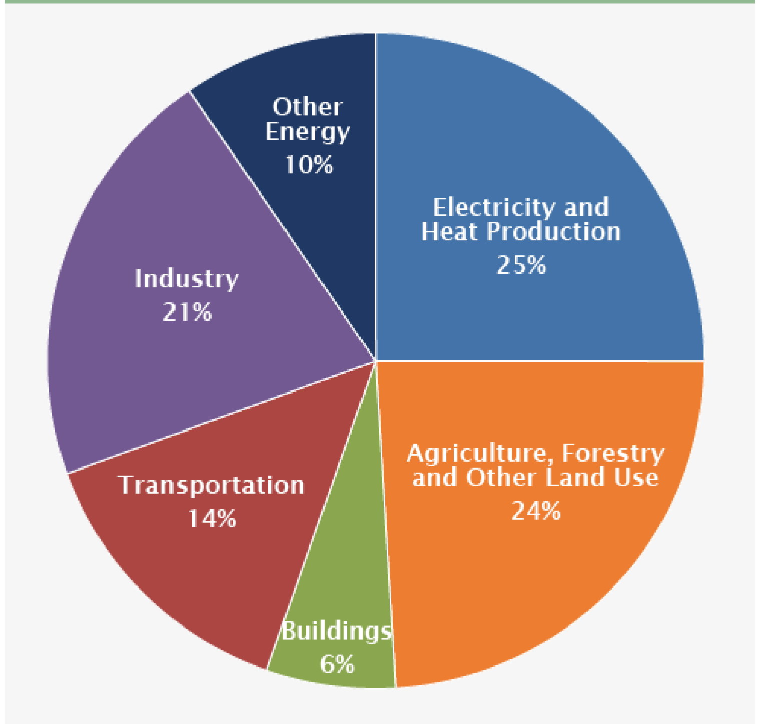


56% of total NCS

Source: Fargione et al (2018)

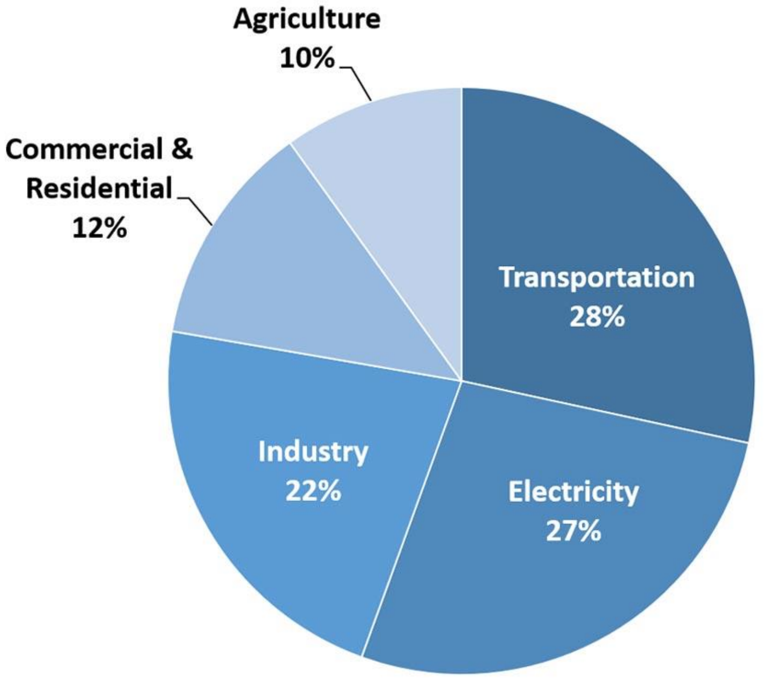
But, agriculture, forest and other land use greenhouse gas (GHG) emissions vary depending on where and what you measure…

Total Global GHG Emissions by Economic Sector in 2014



Global Ag & Forest: +24% total GHGs

Total Global GHG Emissions by Economic Sector in 2018



US Forests: -11%

Total Maine GHG Emissions by Source Category in 2017

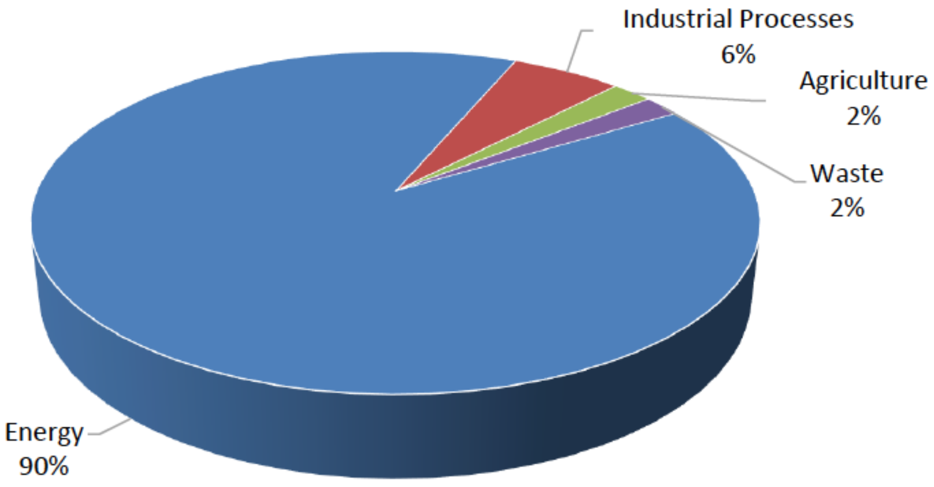
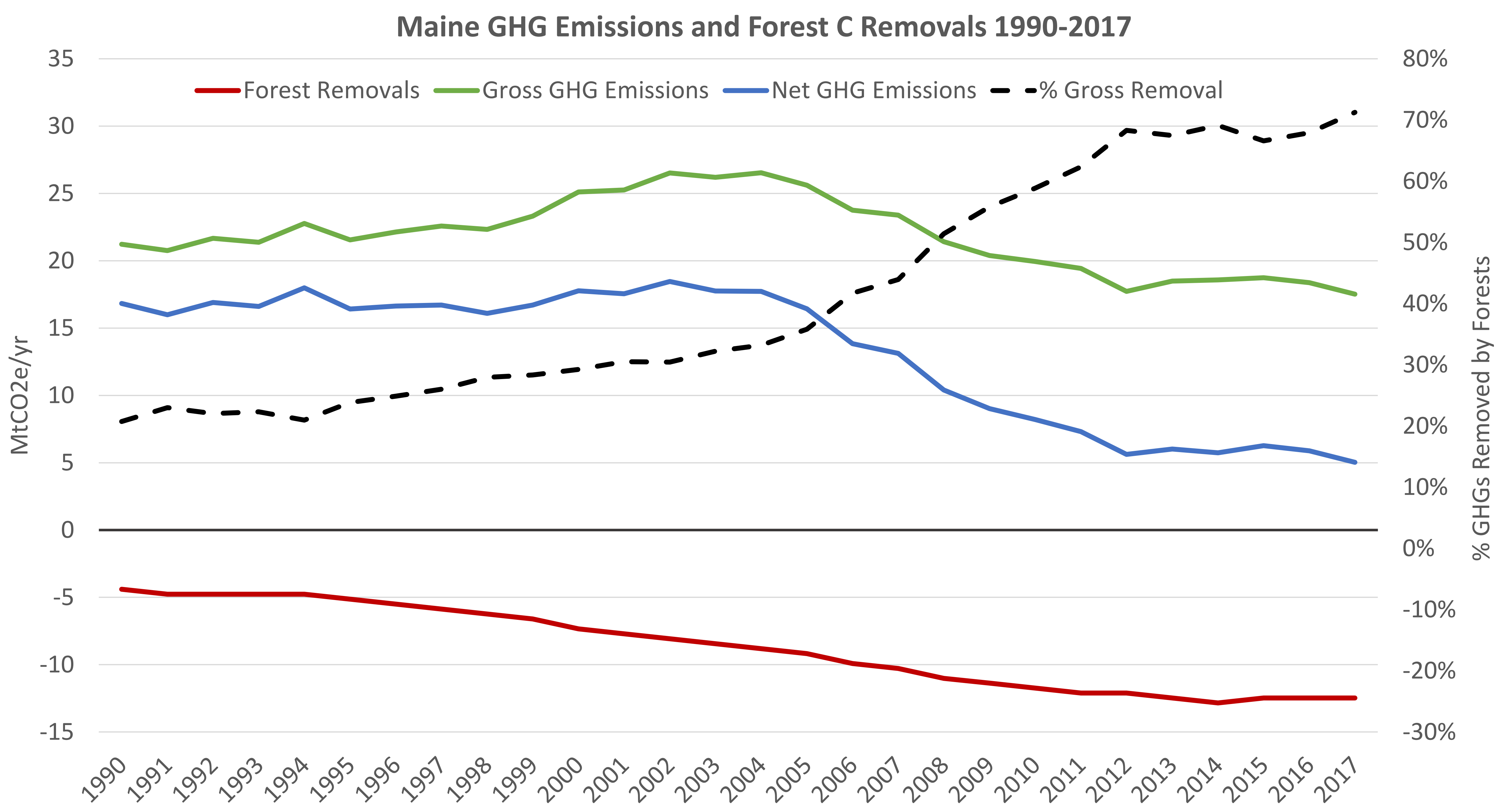


Figure 2. Emissions by source category for 2017 (data in Appendix A)

ME Forests: -70%



ME DEP (2020); USFS (2020)

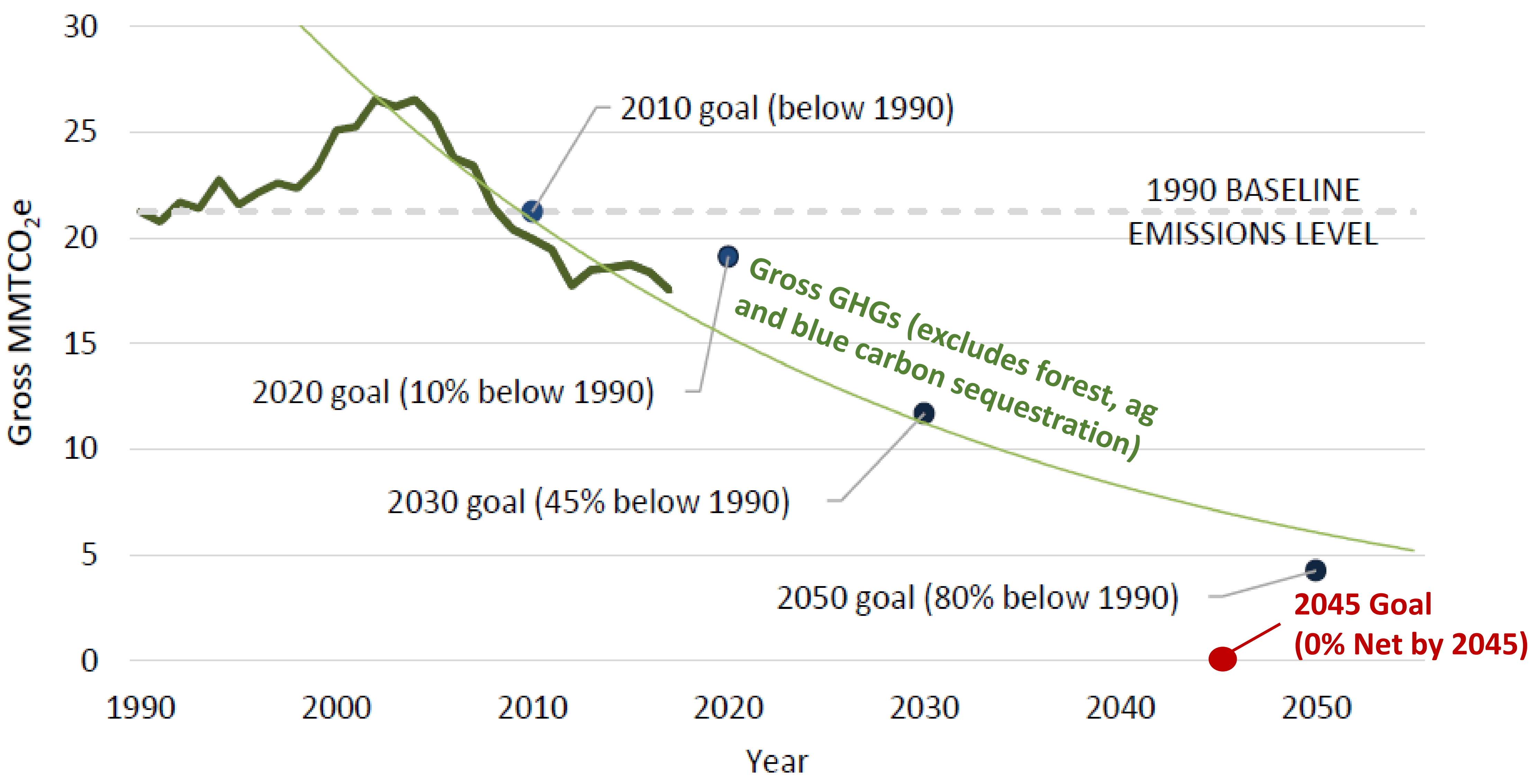


Figure 11. Maine's greenhouse gas emissions 1990-2017 with 2020, 2030, and 2050 reduction and emissions goals

Source: ME DEP (2020)

How do we estimate NCS mitigation benefits and costs?

1. Define ‘baseline’ or ‘business as usual’ pathway

2. Establish list of acceptable mitigation practices

3. Estimate ‘cost’ and ‘effectiveness’ of implementing practices

Estimating Costs and Benefits

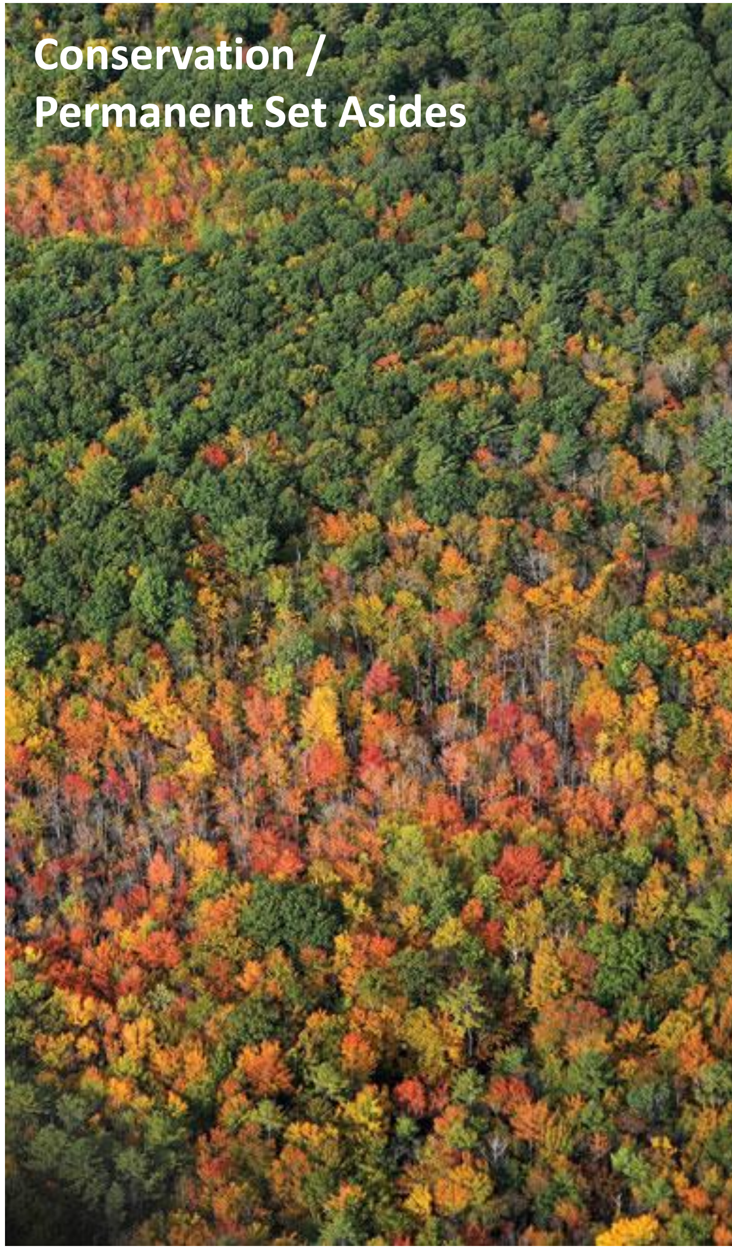
Costs

- Opportunity
  - Yield reductions
  - Harvestable area
- Capital/equipment
- Labor
- Maintenance
- Other environmental costs?

Benefits

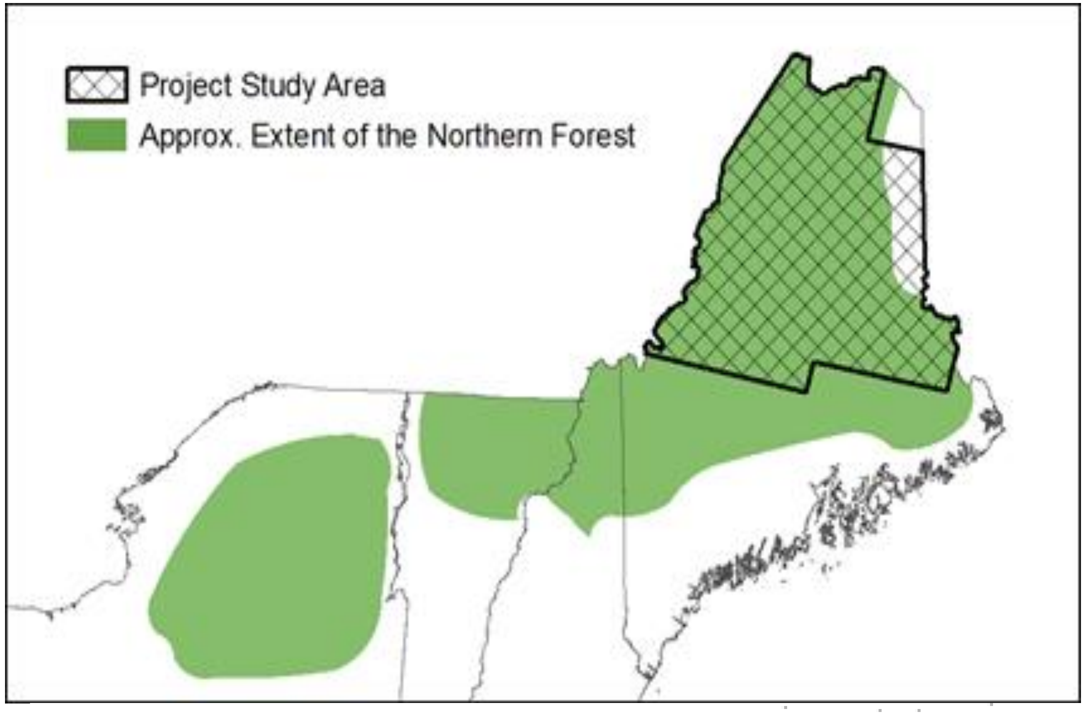
- Increased C sequestration
- Yield improvements
- Diversified income stream
- Cost-savings
- Other environmental co-benefits?

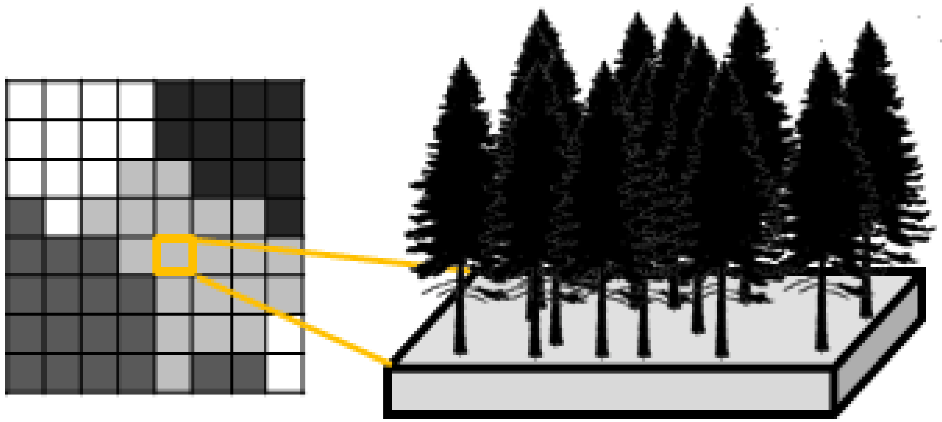
Some forestry practices to consider…



Methods

- Model: LANDIS-II forest landscape model
- Geography: 9.1 million acres, 30m resolution
- Timespan: 2020 to 2100
- Climate: RCP 2.6 (low climate change) and RCP 8.5 (high climate change)
- Mitigation practices:
  - extend rotation
  - partial/clearcut harvest distribution
  - tree planting
  - set-asides
  - mix of above

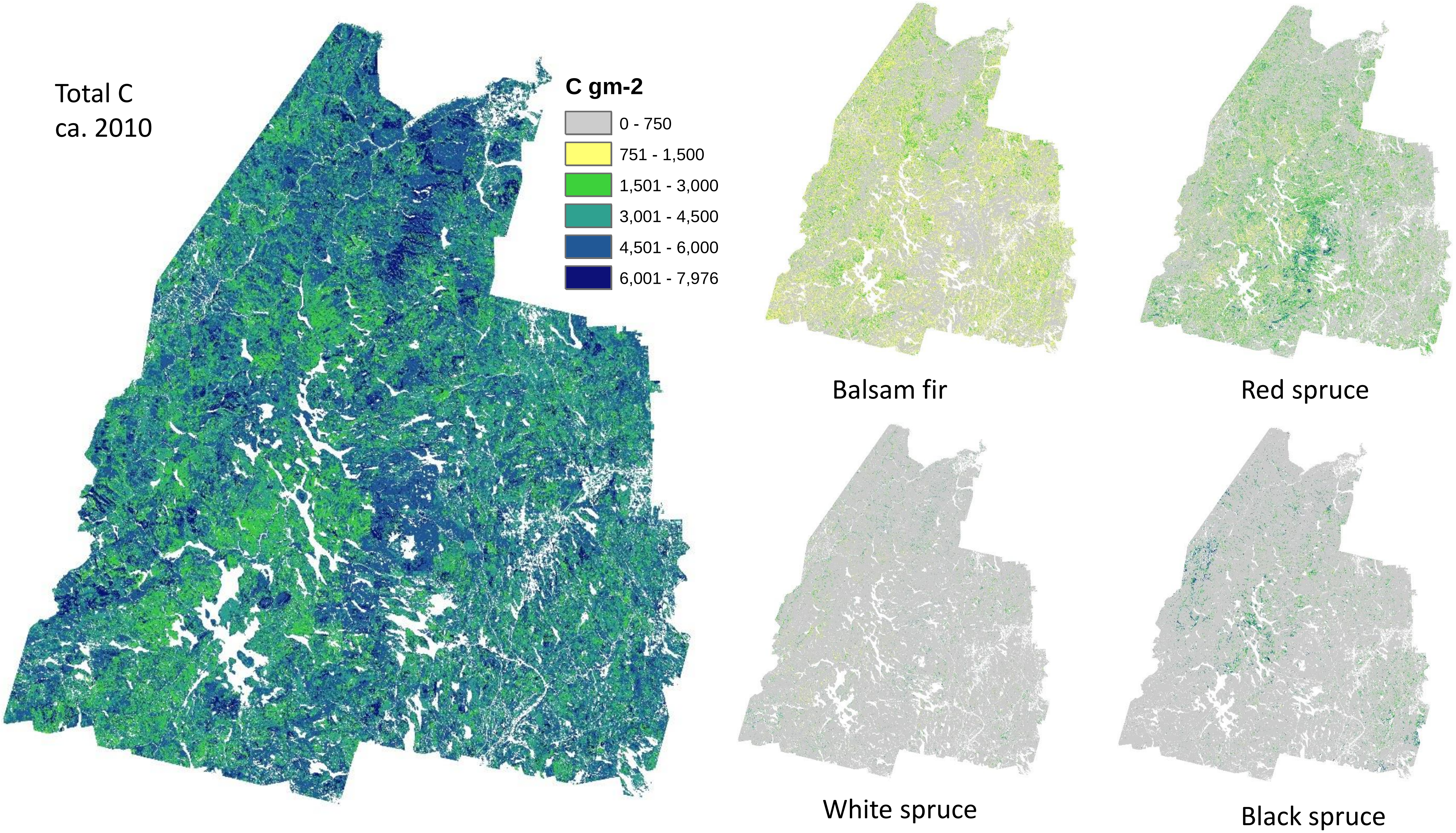




Figurative example of the cell-based system used by LANDIS-II to represent a single species (e.g., Red spruce) even-aged area of forest. Stands are formed by groups of like cells.

Baseline/Business as Usual (BAU) Scenario

- Emulated the average rate of harvesting in the study area from 2000-2010
- Harvest practice: 90% partial removal, 10% clearcut
- Timber removal: ~50% of biomass from combo of harvest trails and group selection.
- Minimum mean stand age eligible for harvest: 50 years.
- Supply target: maintain 2010 total harvest levels


Total C
ca. 2010
C gm-2
0 - 750
751 - 1,500
1,501 - 3,000
3,001 - 4,500
4,501 - 6,000
6,001 - 7,976
Balsam fir
Red spruce
White spruce
Black spruce

Forest NCS Practices Modeled

1. ***Extended Rotation**:* increased minimum stand age eligible for harvest (from 50 year to 70, 85, or 100 years).
2. **Clearcut/Partial harvest distribution***:* increased % of the harvest (from 10% to 30% or 40%). Wood supply was held constant by reducing overall harvest footprint.
3. ***Planting:*** added planting (or artificial regeneration) after clearcut with a 700 tree per acre mix of red and white spruce.
4. ***Set-aside:*** Reserved 10% or 20% of land, which is permanently removed from harvest.
5. ***Triad***: Mix of set asides, clearcut+plant, and BAU harvest/rotation
6. ***Avoided Forest Conversion:*** Hold 2010 forest area constant via renting land at cost of highest and best use if converted.
7. ***Afforestation:*** Plant trees in eligible areas not forested since at least 1990.

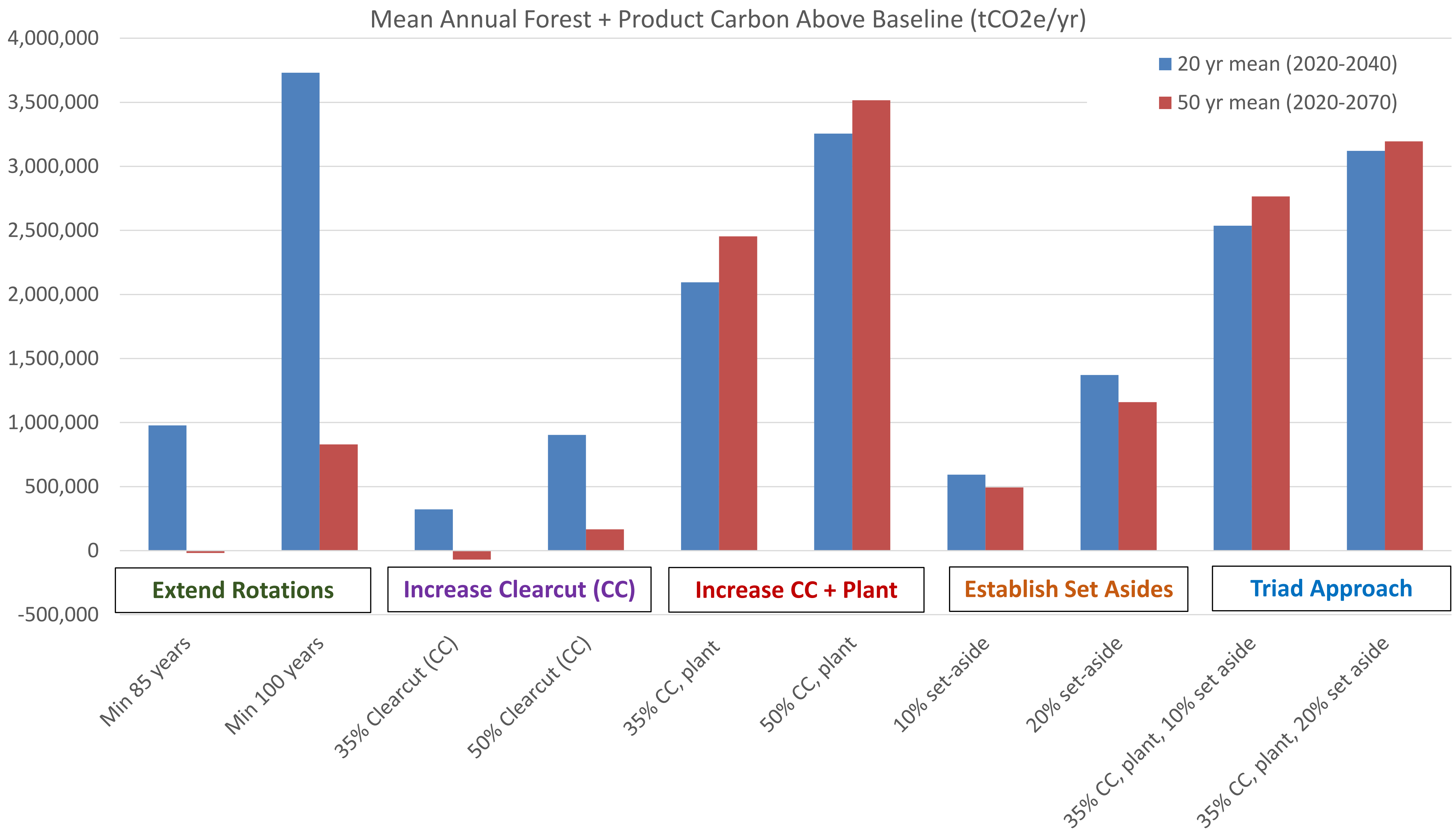
Forest Carbon + Cost Estimation

- *Forest Carbon Sequestration Components*
  - **Forest C**: Annual change in aboveground growing stock
  - **Harvest C**: Removal timber stored in harvested wood products & landfills (~20% removals)

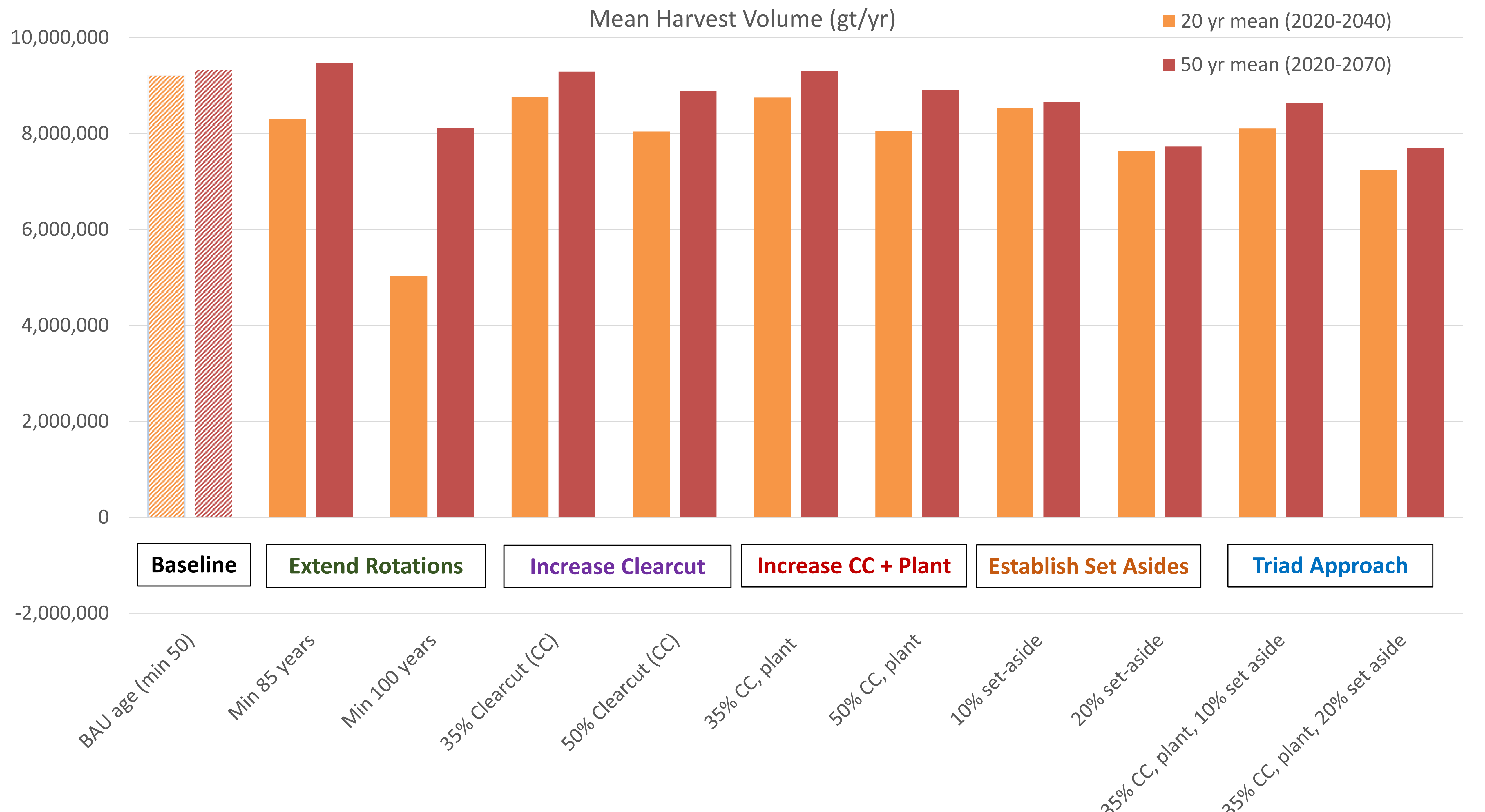
Total C = Forest C + Harvest C

- *Economic Costs and Benefits Components*
  - **Harvest value**: Harvest x state mean stumpage price (by product)
  - **Opportunity cost**: Change in harvest revenue relative to BAU (can be positive)
  - **Planting cost**: seedling ($0.37/plant), site prep + spraying ($250/ac) = $509/ac
  - **Land Cost/Rent**: varies by current or highest and best use

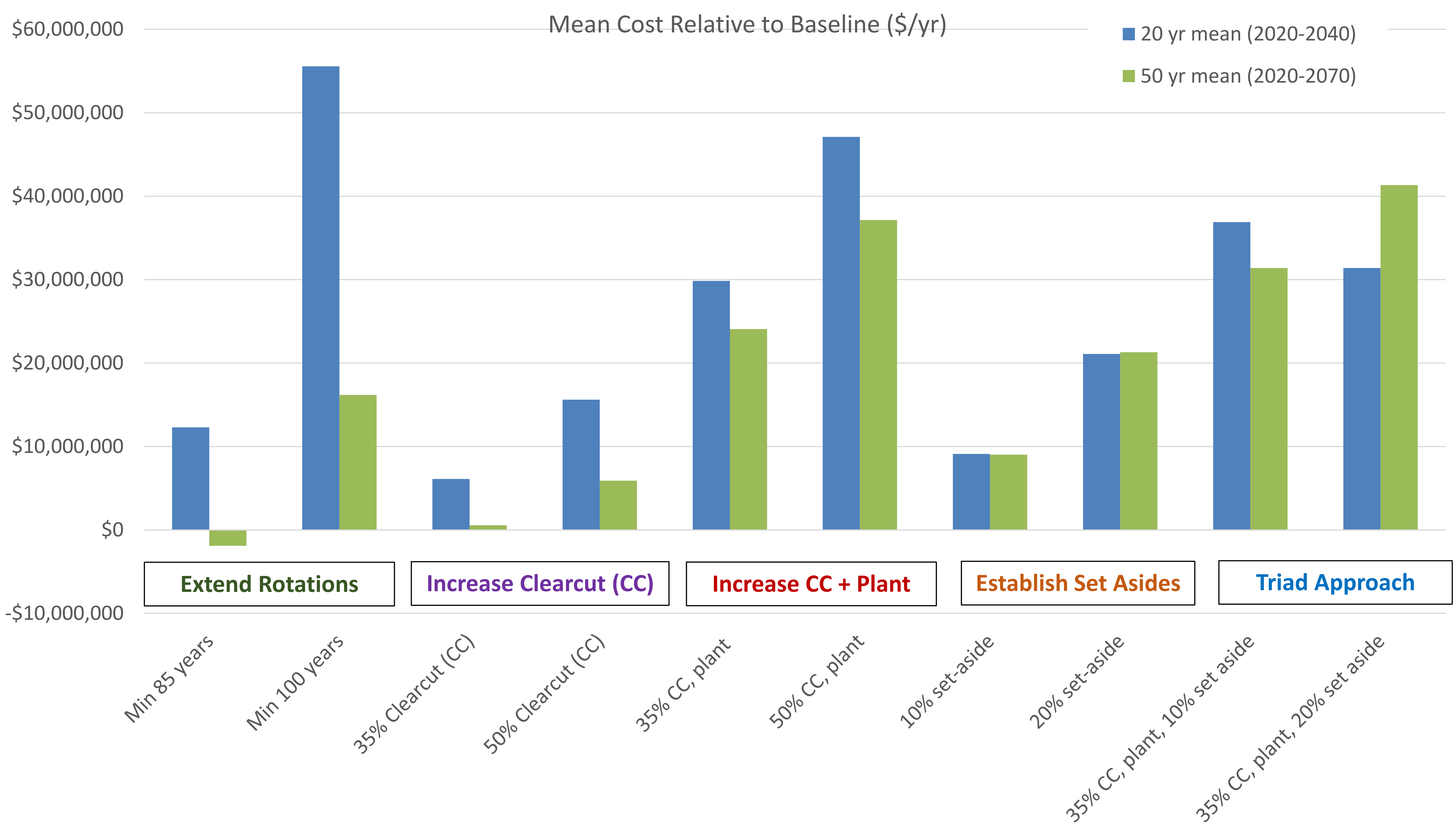
Total Cost = Opportunity + Planting Cost + Land Cost



Mean Annual Forest + Product Carbon Above Baseline (tCO2e/yr)
20 yr mean (2020-2040)
50 yr mean (2020-2070)
4,000,000
3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
-500,000
Extend Rotations
Increase Clearcut (CC)
Increase CC + Plant
Establish Set Asides
Triad Approach
Min 85 years
Min 100 years
35% Clearcut (CC)
50% Clearcut (CC)
35% CC, plant
50% CC, plant
10% set-aside
20% set-aside
35% CC, plant, 10% set aside
35% CC, plant, 20% set aside



Mean Harvest Volume (gt/yr)
20 yr mean (2020-2040)
50 yr mean (2020-2070)
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
-2,000,000
Baseline
Extend Rotations
Increase Clearcut
Increase CC + Plant
Establish Set Asides
Triad Approach
BAU age (min 50)
Min 85 years
Min 100 years
35% Clearcut (CC)
50% Clearcut (CC)
35% CC, plant
50% CC, plant
10% set-aside
20% set-aside
35% CC, plant, 10% set aside
35% CC, plant, 20% set aside


Mean Cost Relative to Baseline ($/yr)
20 yr mean (2020-2040)
50 yr mean (2020-2070)
$60,000,000
$50,000,000
$40,000,000
$30,000,000
$20,000,000
$10,000,000
$0
-$10,000,000
Extend Rotations
Increase Clearcut (CC)
Increase CC + Plant
Establish Set Asides
Triad Approach
Min 85 years
Min 100 years
35% Clearcut (CC)
50% Clearcut (CC)
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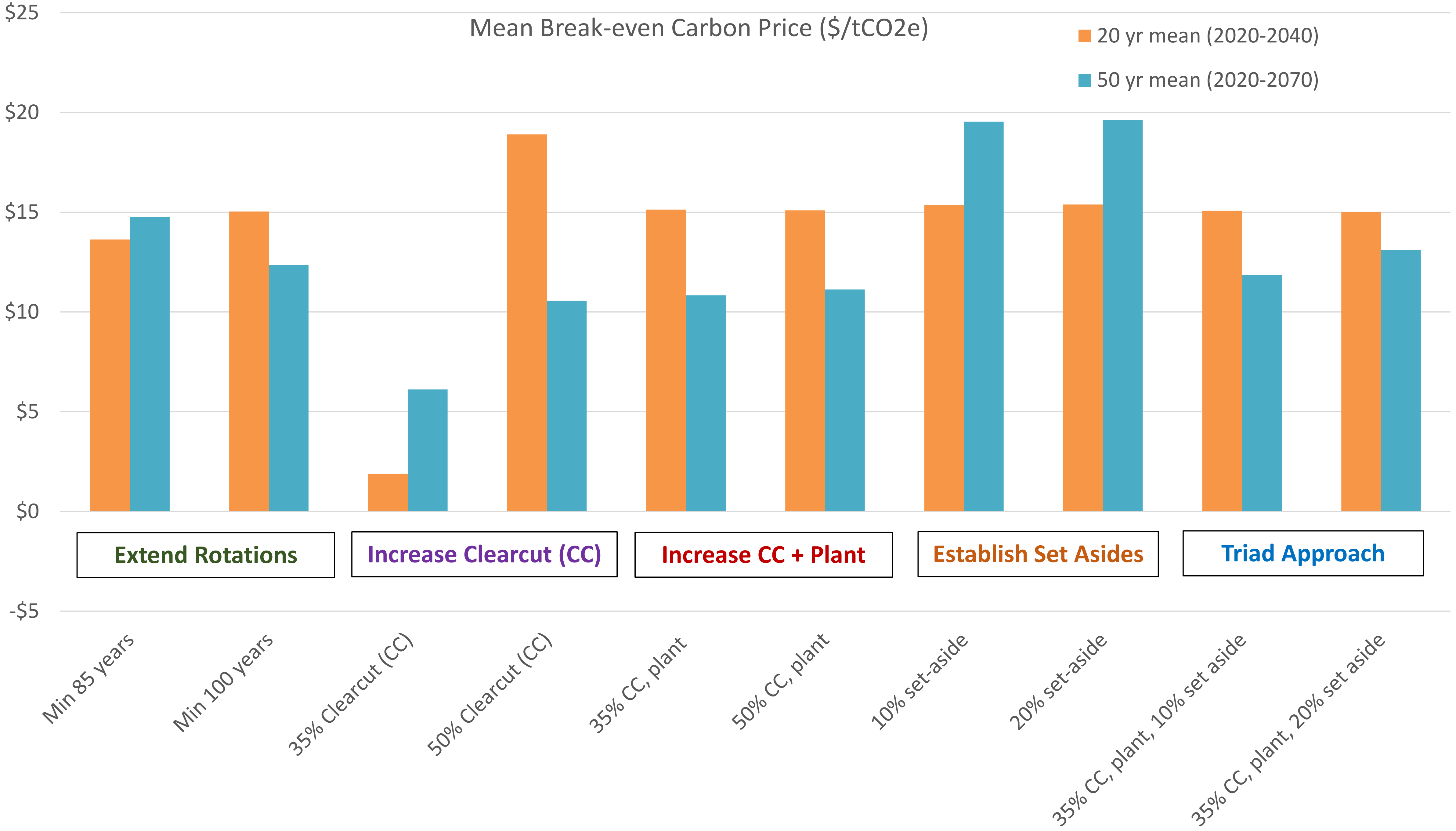


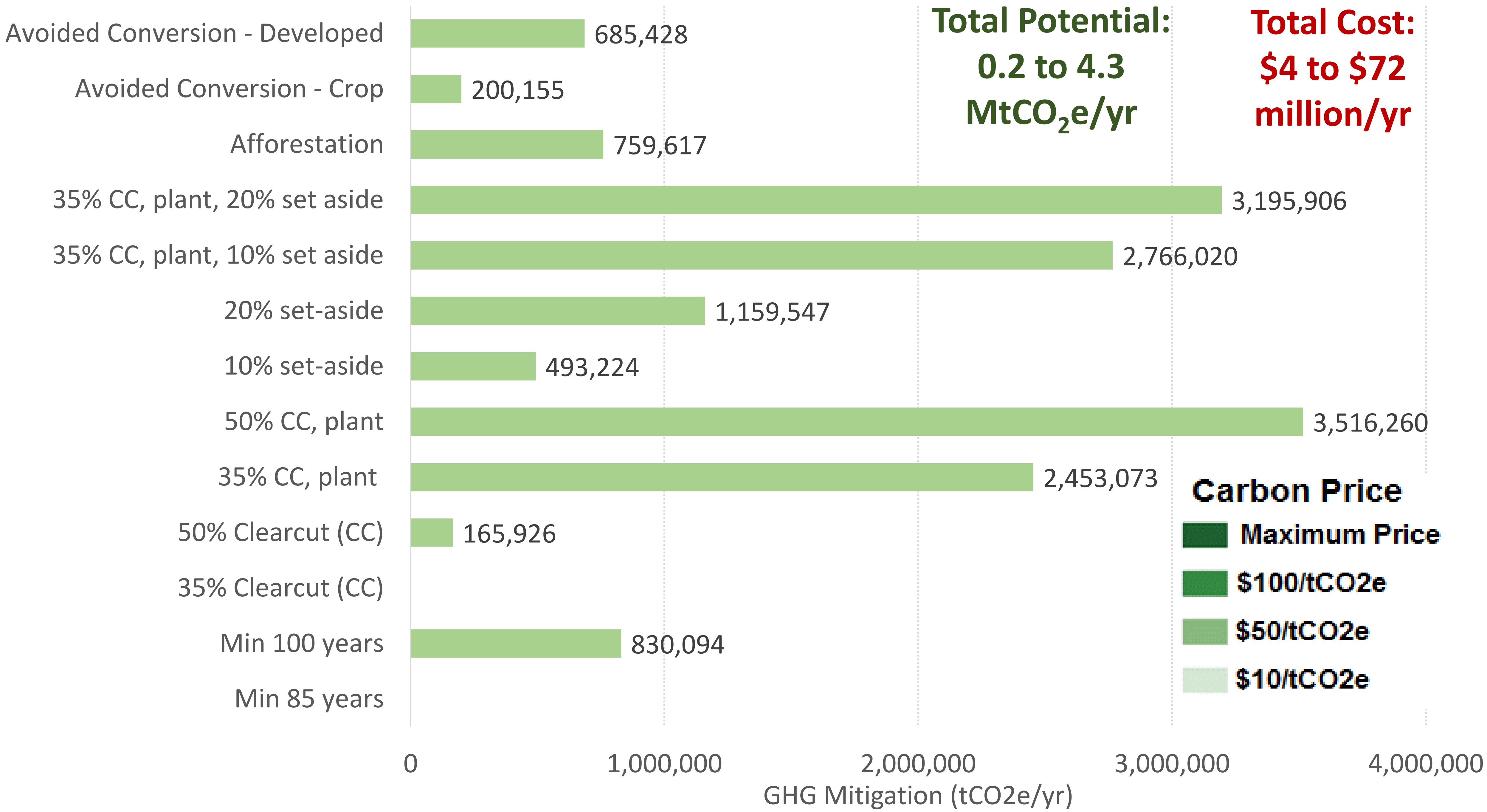
Mean Break-even Carbon Price ($/tCO2e)
20 yr mean (2020-2040)
50 yr mean (2020-2070)
$25
$20
$15
$10
$5
$0
-$5
Extend Rotations
Increase Clearcut (CC)
Increase CC + Plant
Establish Set Asides
Triad Approach
Min 85 years
Min 100 years
35% Clearcut (CC)
50% Clearcut (CC)
35% CC, plant
50% CC, plant
10% set-aside
20% set-aside
35% CC, plant, 10% set aside
35% CC, plant, 20% set aside

Biodiversity & Tradeoffs

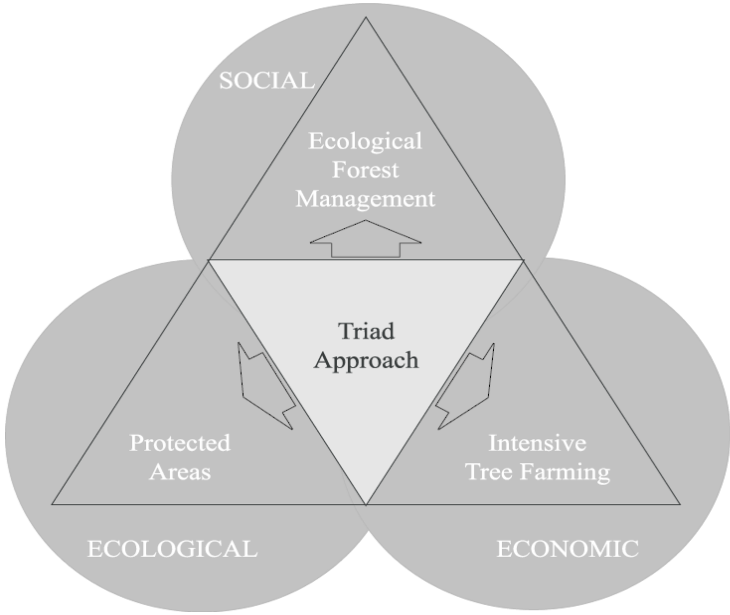
% difference relative to BAU

Scenario	Break even carbon price ($/t$CO_2$e)	Total harvest 2010-2060	Spruce-Fir C	LS forest Change		Lynx habitat Change
				Spruce-Fir	N. Hardwood	
Min 100 years	$12	-13%	33%	-8%	-13%	-25%
10% set-aside	$20	-7%	10%	4%	4%	-3%
35% CC*	$6	-0.4%	-4%	-12%	4%	33%
35% CC* + plant	$14	-0.3%	117%	9%	-7%	487%
35% CC* + plant + 10% set-aside	$12	-8%	118%	-4%	0%	427%

*assumes all clearcuts (CC) target forest with spruce-fir relative abundance >50%


Total Potential: 0.2 to 4.3 $MtCO_2e/yr$
Total Cost: $4 to $72 million/yr
Avoided Conversion - Developed
685,428
Avoided Conversion - Crop
200,155
Afforestation
759,617
35% CC, plant, 20% set aside
3,195,906
35% CC, plant, 10% set aside
2,766,020
20% set-aside
1,159,547
10% set-aside
493,224
50% CC, plant
3,516,260
35% CC, plant
2,453,073
50% Clearcut (CC)
165,926
35% Clearcut (CC)
Min 100 years
830,094
Min 85 years
Carbon Price
Maximum Price
$100/tCO2e
$50/tCO2e
$10/tCO2e
0
1,000,000
2,000,000
3,000,000
4,000,000
GHG Mitigation (tCO2e/yr)

Maine Forest NCS Summary



- Top options by **Mitigation Total** (& mean break-even price):
  1. 50% clearcut area + planting: 3.5 $MtCO_2e/yr$
  2. 20% set aside + 35% clearcut: 3.2 $MtCO_2e/yr$
  3. 10% set aside + 35% clearcut: 2.8 $MtCO_2e/yr$
  4. 35% clearcut + planting: 2.5 $MtCO_2e/yr$
  5. 20% set aside: 1.2 $MtCO_2e/yr$
- Most practices allow **harvests to continue to follow BAU** (exception is scenario with constraint that stands must be at least 100 years old to harvest)
- As harvests close to BAU, **minimal risk of 'leakage'** in most scenarios (ex. 100 yr rot)
- **Habitat tradeoffs** with increased clearcut & planting v. natural regeneration
- **Costs are relatively cheap** compared to typical carbon prices for other sectors of economy & social cost of carbon estimates (often $40+/tCO2e or more)

Thanks to all our collaborators and funders…

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USDA Forest Service — Department of Agriculture

USCA — States United for Climate Action

NSF

Maine Farmland Trust

Forest Climate Change Initiative

School of Forest Resources — forest.umaine.edu

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NASA

Want to know more about Maine's Natural Climate Solutions?

Visit the UMaine Forest Climate Change Initiative's website for full report, fact sheets, and more!

https://crsf.umaine.edu/forest-climate-change-initiative/ncs/

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