Massachusetts Forest Carbon Study:
The Impact of Alternative Land-use Scenarios on Terrestrial Carbon Storage and Sequestration in Massachusetts

March 24, 2025

MA Executive Office of Energy & Environmental Affairs

Agenda

- **Welcome**
- **Presentation (~40 minutes)**
  - Forest Carbon Study’s goals and objectives
  - Modeled Scenarios
  - Key Results
  - Takeaways and Policy Implications
  - EEA’s Next Steps
- **Q&A (~15 minutes)**
- **Wrap Up**

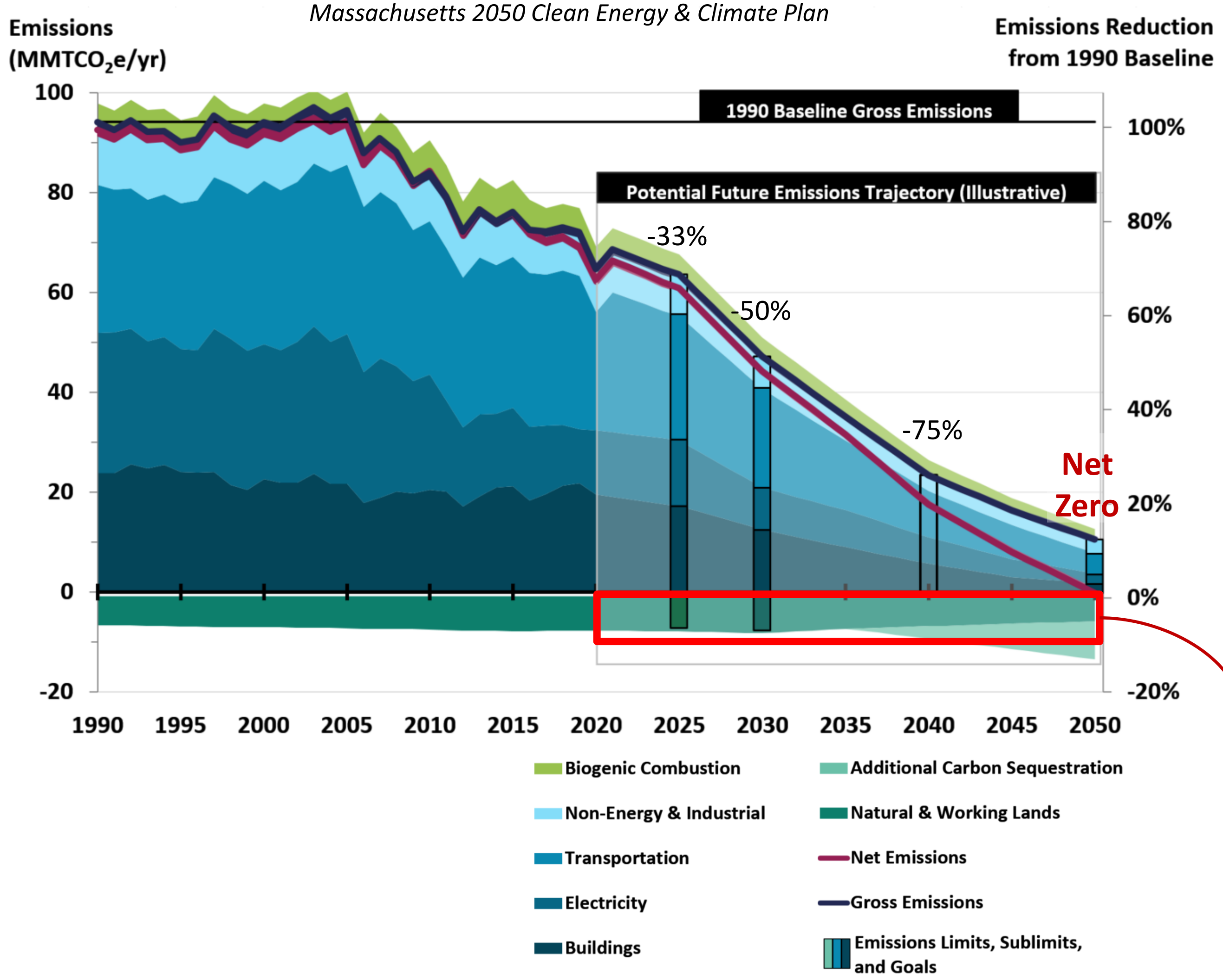
Presenters

- **Dunbar Carpenter,** Manager of Land Carbon Science & Analysis, Exec. Office of Energy and Environmental Affairs
- **Jonathan Thompson,** Research Director & Senior Ecologist, Harvard Forest
  - Meghan Graham MacLean, Senior Lecturer of Quantitative Ecology, University of Massachusetts – Amherst
  - Danelle Laflower, Research Assistant, Harvard Forest
  - Joshua Plisinski, GIS and Research Assistant, Harvard Forest
- **William Van Doren,** Forester, Department of Conservation and Recreation
- **Hong-Hanh Chu,** Policy Advisor for Carbon Sequestration & Storage, Exec. Office of Energy and Environmental Affairs

Background – The Role of Natural & Working Lands in Achieving Net Zero Emissions

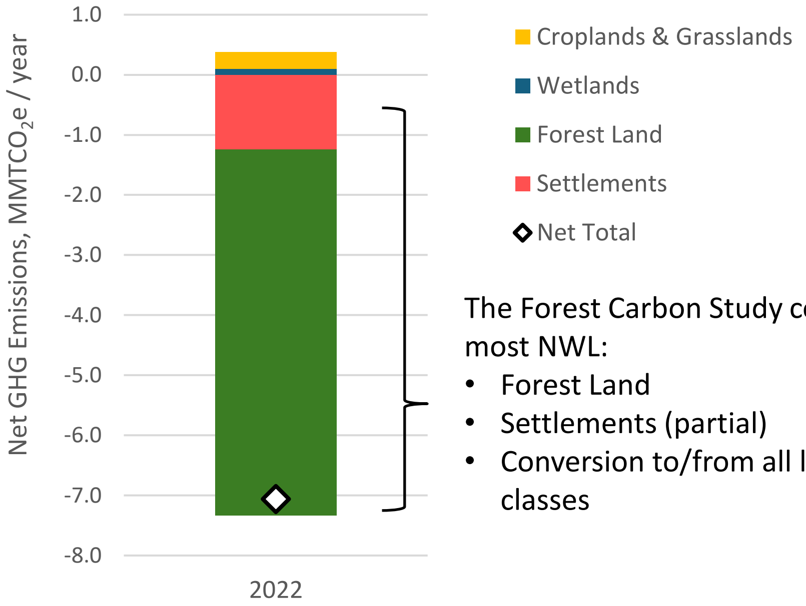
Past and Future Statewide Greenhouse Gas Emissions

Massachusetts 2050 Clean Energy & Climate Plan



Current Natural & Working Lands (NWL) Greenhouse Gas Emissions

Massachusetts NWL GHG Inventory



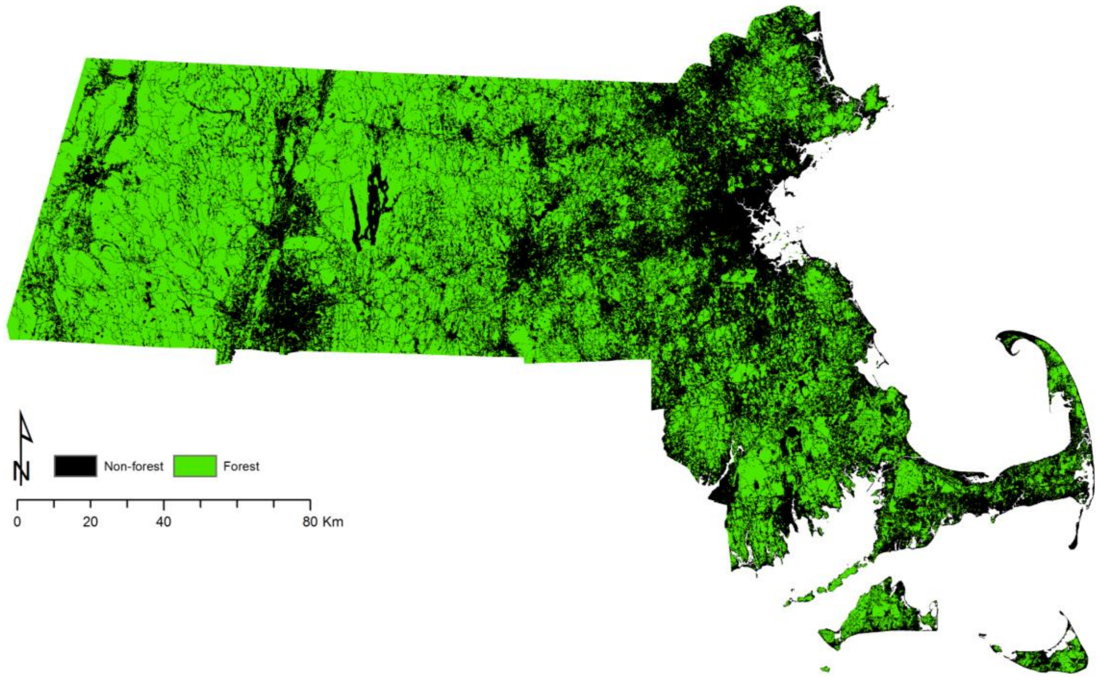
The Forest Carbon Study covers most NWL:

- Forest Land
- Settlements (partial)
- Conversion to/from all land classes

Study Motivation: To better characterize *future* NWL emissions and the potential role of NWL in achieving Net Zero

Background – Study Goals and Scenario-Based Modeling Approach

- **Study Goal:** To better quantify future carbon sequestration and storage potential of Massachusetts forests and NWL, including trends, risks, and opportunities, in the context other land use objectives.
- **Study approach:** Simulate alternative forest and land use scenarios with different combinations of drivers and strategies and assess carbon and other outcomes.



- **Scenarios are illustrative** – represent alternative futures intended for learning, not specific policies under consideration.
- **Scenarios based on:**
  - Scientific understanding of risks and opportunities for Massachusetts forest and land carbon
  - Clean Energy & Climate Plan NWL strategies (Protect, Manage, Restore, Sustainable Resource Utilization)
  - Stakeholder, agency, and administration input, via internal consultations and stakeholder workshops
- **Limitations:** Focus on biophysical systems; results based on many (informed) assumptions; not all social, economic, or environmental factors necessary for setting policy were considered.
- **Study Application:** Guide the Commonwealth’s climate mitigation strategies and goals for NWL and for achieving Net Zero. One of many sources informing state-scale land use and management policy.

Background – Forest Carbon Study Scope

	Forest Carbon Study (2025)	Land Sector Report (2020)
Timeframe	80 years (2020-2100) and 30 year (2020-2050)	30 years (2020-2050)
Environmental Drivers	**Forest Ecosystem Dynamics:** growth, mortality, regeneration	(same)
	Climate Change: projected temperature, precipitation, CO_2 (RCP 8.5, CCSM4)	Historic and projected temperature, precipitation, CO_2 (RCP 8.5, HADGE)
	Natural Disturbances: Hurricanes, forest insect pests, climate-intensified generic disturbances	Generic disturbances
Human Drivers	**Forest Management:** Climate-oriented forestry, expanded forest reserves, increased local wood production	Recent and improved forest harvesting practices; constant area and volume
	Wood utilization: Improved wood utilization, salvage	Recent trends
	NWL Conversion: building development, solar development; low-, moderate-/recent trends-, and high-impact siting	Generic development; recent trends, sprawl
	Reforestation & tree-planting: varying levels	N/A
Carbon Pools	• Live trees (above- & below-ground) • Dead wood • Wood products	• Live trees (above- & below-ground) • Harvested wood/products • Soils (partial)
Primary Outputs:	• Cumulative carbon sequestration/emissions (changes in pools) • Annual carbon sequestration/emissions rate (5-yr increments) • Indicators of forest ecosystem resilience and health	• Cumulative carbon sequestration/emissions (changes in pools)

Background – Forest Carbon Study Scenario Framework

Focus Scenarios: to assess the specific effects of individual drivers in isolation:

- Total land use effect
- Building development
- Solar development
- Reforestation & tree-planting

Integrated Scenarios: to assess combinations of drivers and define a plausible range of future forest carbon outcomes.

		Forest Management Regimes			
		Recent Trends	*Reserves Emphasis*	*Local Wood Emphasis*	*Reserves & Local Wood Emphasis*
		Current harvest practices and levels, current reserves	Climate-oriented forestry, current harvest levels , expanded reserves	Climate-oriented forestry, increased harvest levels, current reserves	Climate-oriented forestry, increased harvest levels, expanded reserves
Land Disturbance Regimes	High levels of forest disturbance and NWL loss	***1. Recent Trends Harvest + High Disturbance/ Development***	***2. Reserves Emphasis + High Disturbance/ Development***	***3. Local Wood Emphasis + High Disturbance/ Development***	***4. Combined Emphasis + High Disturbance/ Development***
Land Disturbance Regimes	High levels of forest disturbance and NWL loss	***5. Recent Trends Harvest + Low Disturbance/ Development***	***6. Reserve Emphasis + Low Disturbance/ Development***	***7. Local Wood Emphasis + Low Disturbance / Development***	***8. Combined Emphasis + Low Disturbance/ Development***
Wood Utilization		Variants for all scenarios: (a) *Recent trends wood utilization* (b) *Improved wood utilization*			

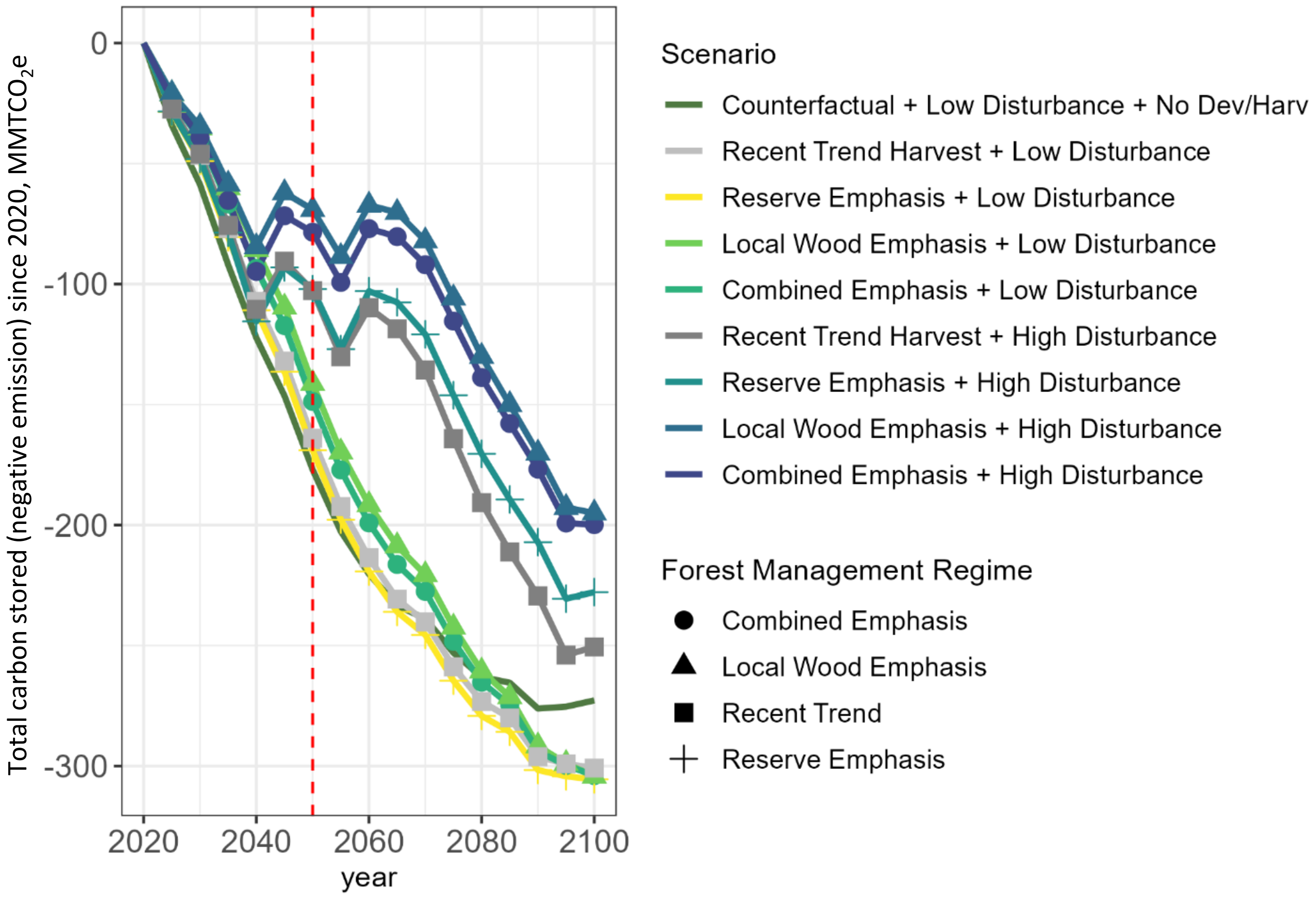
Overview of Key Findings

- **Massachusetts' forests are expected to continue serving as a long-term net sink of atmospheric carbon over the course of the 21st Century, but this forest carbon sink is vulnerable to natural and human disturbances.**
  - Hurricanes pose the largest risk to forest carbon and could temporarily weaken or reverse the net removal of carbon by the state's forests.
  - In the absence of hurricanes, the annual rate of forest carbon removal is expected to remain relatively steady through mid-century, then decline later in the century.
- **Conversion of NWL to developed uses will modestly increase emissions through 2050, but most of these emissions could be avoided with less land-consumptive development patterns, while still meeting clean energy and building development needs.**
- **Different harvesting levels and approaches to forest management come with tradeoffs, but do not generally lead to large differences in carbon sequestration in Massachusetts relative to other factors.**
  - Considerations include annual carbon sequestration rates v. long-term cumulative carbon storage, out-of-state leakage, and non-carbon ecosystem services.
  - Active forest management can improve indicators of forest resilience and climate adaptability, including landscape-scale tree species and structural diversity and regeneration of important tree species.
- **Other forest and land use strategies have more limited carbon sequestration potential:**
  - Reforestation and tree planting.
  - Improved utilization of wood generated by harvesting, disturbances, and land clearing in durable products.

Results – Future Forest Carbon Storage Trajectories

- **Massachusetts forests will continue to accumulate carbon through 2100**
- **Cumulative carbon storage is influenced most strongly by forest growth and next by major hurricanes,** which can cause temporary reversals in net carbon sequestration (i.e. net emissions)
- **Alternative forest management regimes can also change future carbon storage, but these effects are smaller and more context-dependent**

Cumulative carbon stored in forests & wood products, 2020-2100 (excluding soil carbon, development emissions, reforestation)

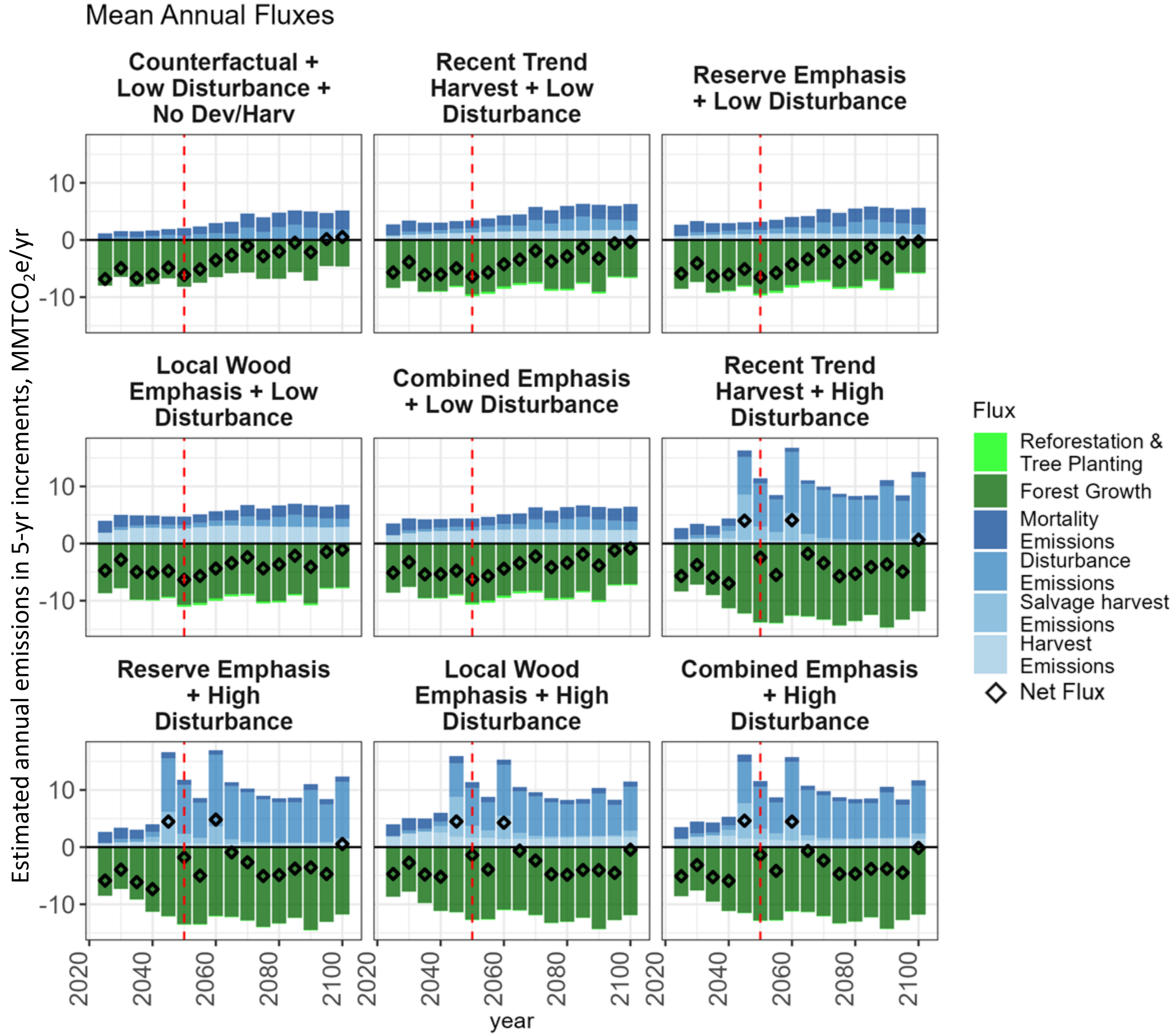


This figure does not include the impacts of land cover change

Results – Future Forest Carbon Sequestration Rates

- **Decline in rate of net carbon sequestration expected under low disturbance scenarios** due to a combination of declining growth, increased mortality, and/or disturbance emissions.
  - In the higher disturbance scenarios, net sequestration rates remain relatively strong with pulses of net emissions when a hurricane is modeled.
- **Strong temporal variation in net sequestration,** particularly mid-century, contingent on major disturbance activity.

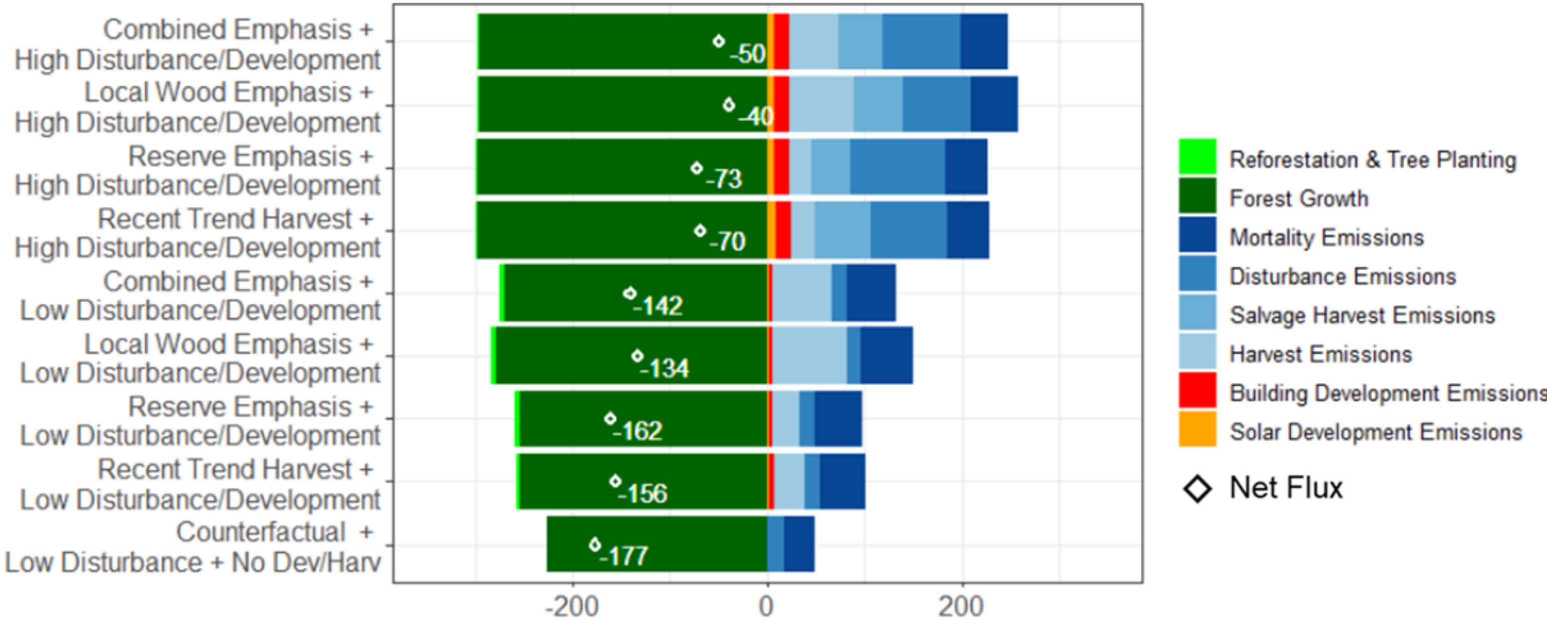
These figures do not include the impacts of land cover change



Results – Attribution of Mid-Century Forest Carbon Emissions

- **Net sequestration between 2020 and 2050 is the balance of forest growth (sequestration) and mortality, disturbance, and harvest (emissions)**
- **Reforestation and less land-consumptive development practices can slightly increase forest carbon sequestration**
- **By 2050, management regimes emphasizing reserves or following recent trends result in slightly higher net cumulative sequestration than those emphasizing local wood production or a combination of local wood and reserves**

Cumulative carbon sequestration and emissions, 2020-2050



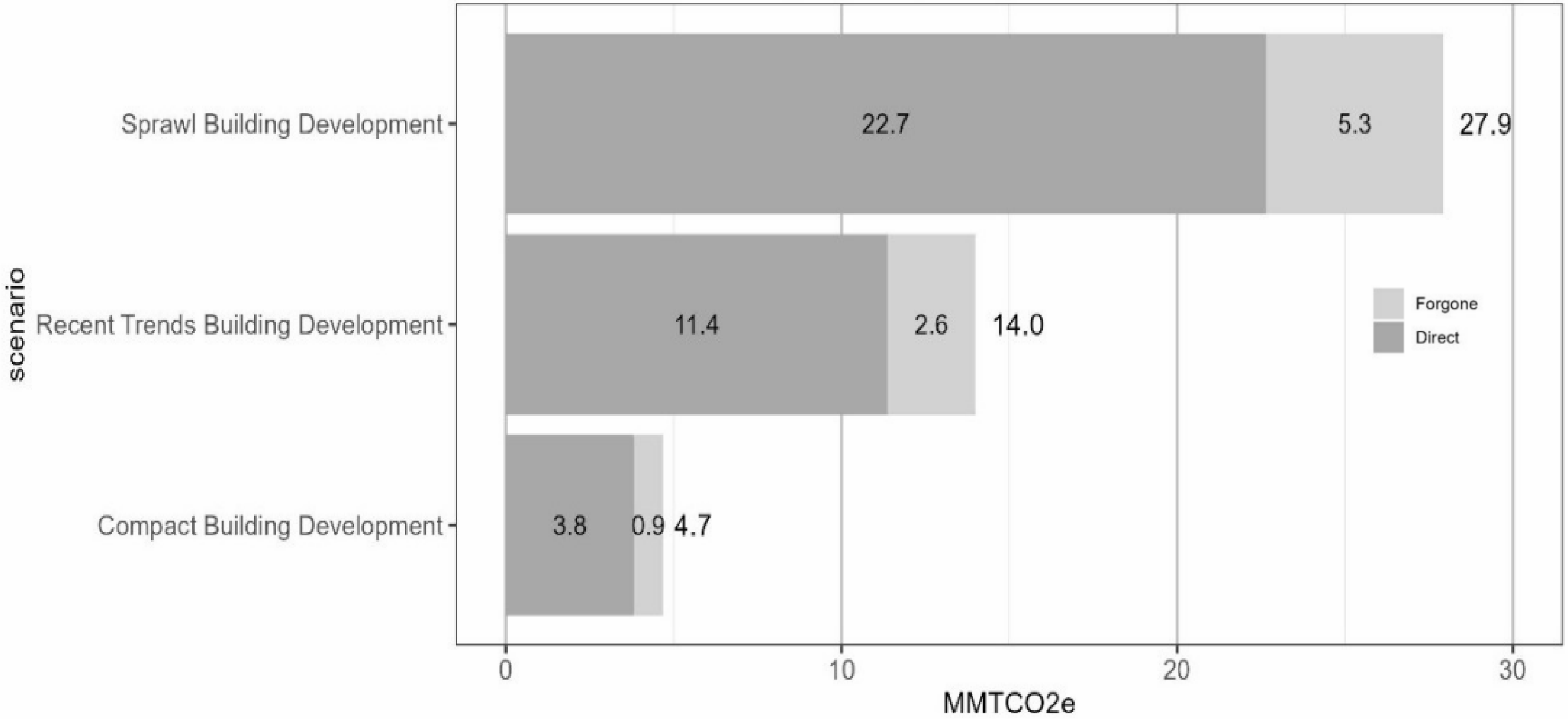
Total carbon sequestered (-) or emitted (+) 2020-2050, $MMTCO_2e$

Soil carbon was not modeled. Therefore, estimated emissions from forest loss and the carbon accrual from reforestation are likely underestimates.

Results – Building Development

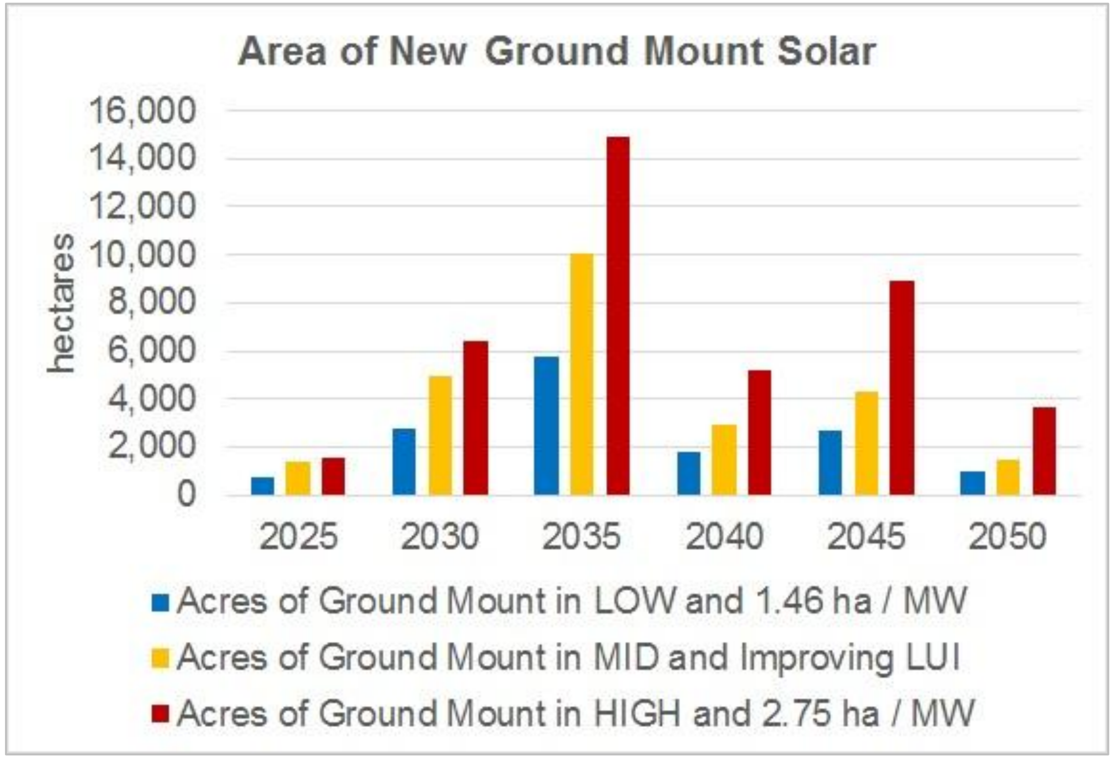
- **Less land-consumptive building development practices could reduce carbon emissions from land conversion by up to two-thirds**
- **More sprawl-oriented building development patterns could increase emissions by up to 50%**

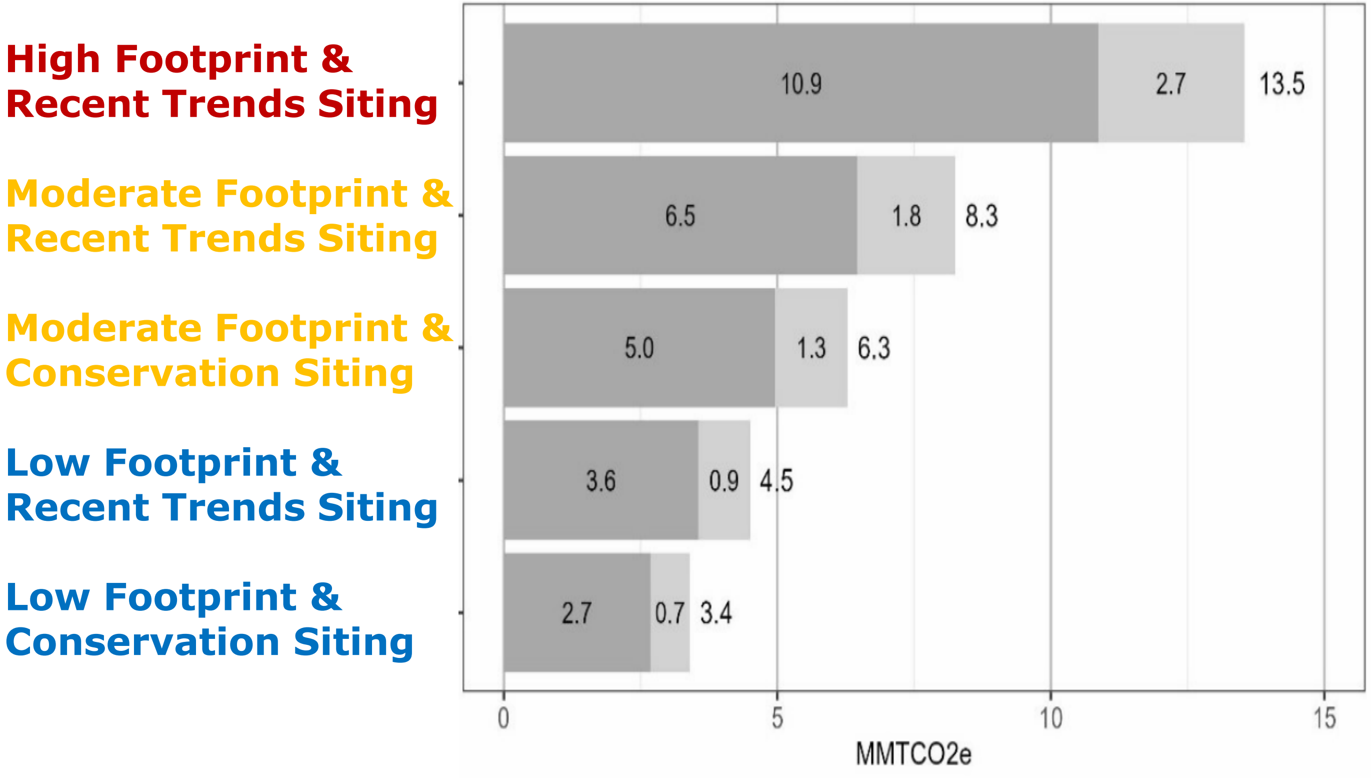
Scenario	**Greenfield development, 2020-2050** (area, growth from 2020 developed area)	**Development rate multiple** (relative to reference scenario)
Sprawl building development	204K acres, +15.9%	2.00 (2x Recent Trends development rate)
Recent trends building development	102K acres, +7.9%	1.00
Compact building development	34K acres, +2.6%	0.33 (1/3 Recent Trends development rate)



Results – Solar Development

- Solar capacity growth follows the timeline of the "Phased" pathway from analysis for the 2050 CECP
- **LOW**, **MID**, and **HIGH** scenarios all hit 27 GWAC
- Differences in:
  - Ratio of ground mount to rooftop/brownfield
  - Land Use Intensity (ac/MW)
  - Siting restrictions

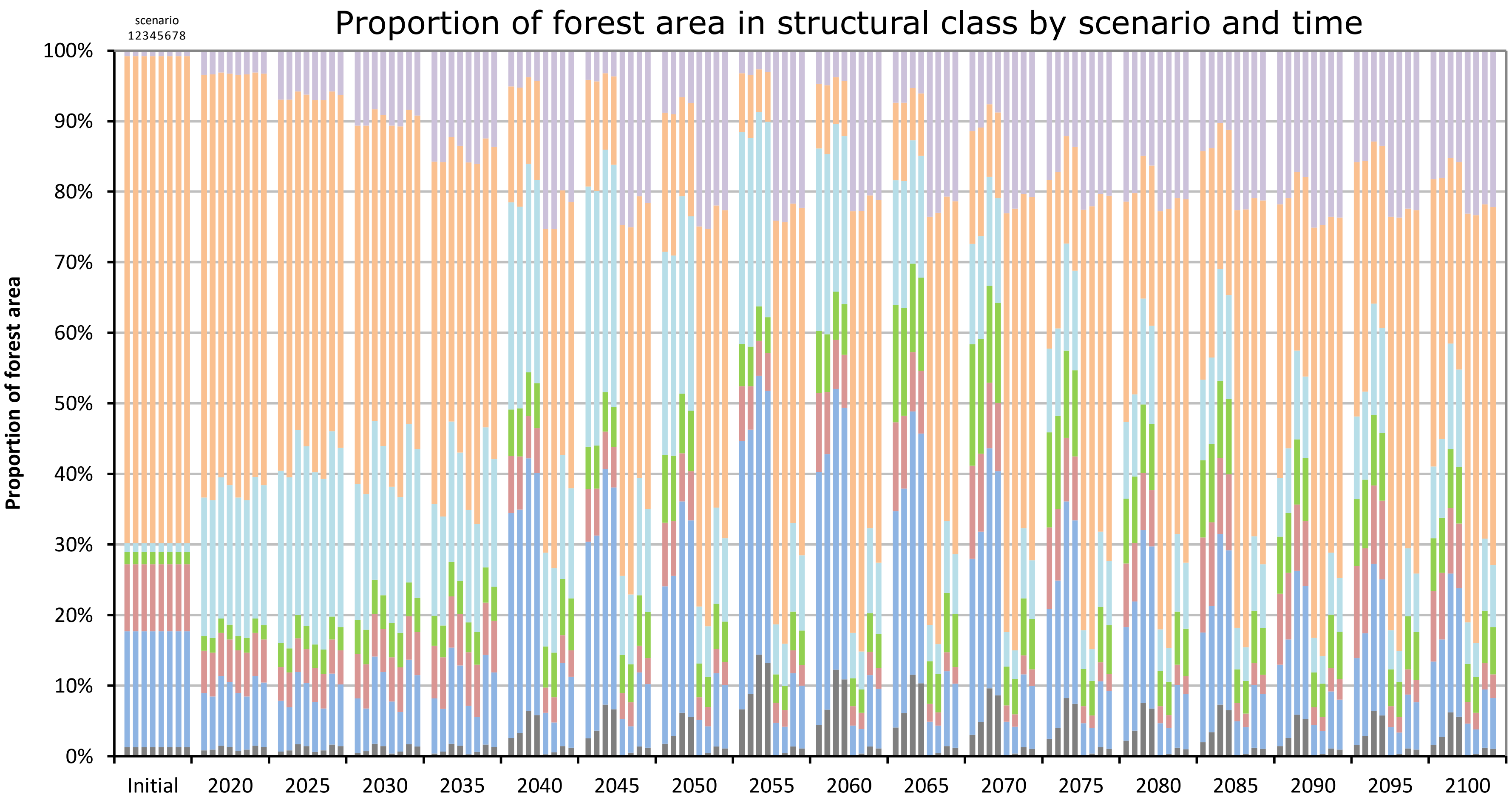




- **Less land-consumptive solar development practices could reduce emissions by up to two-thirds by 2050**

Results – Resilience: Forest Structure

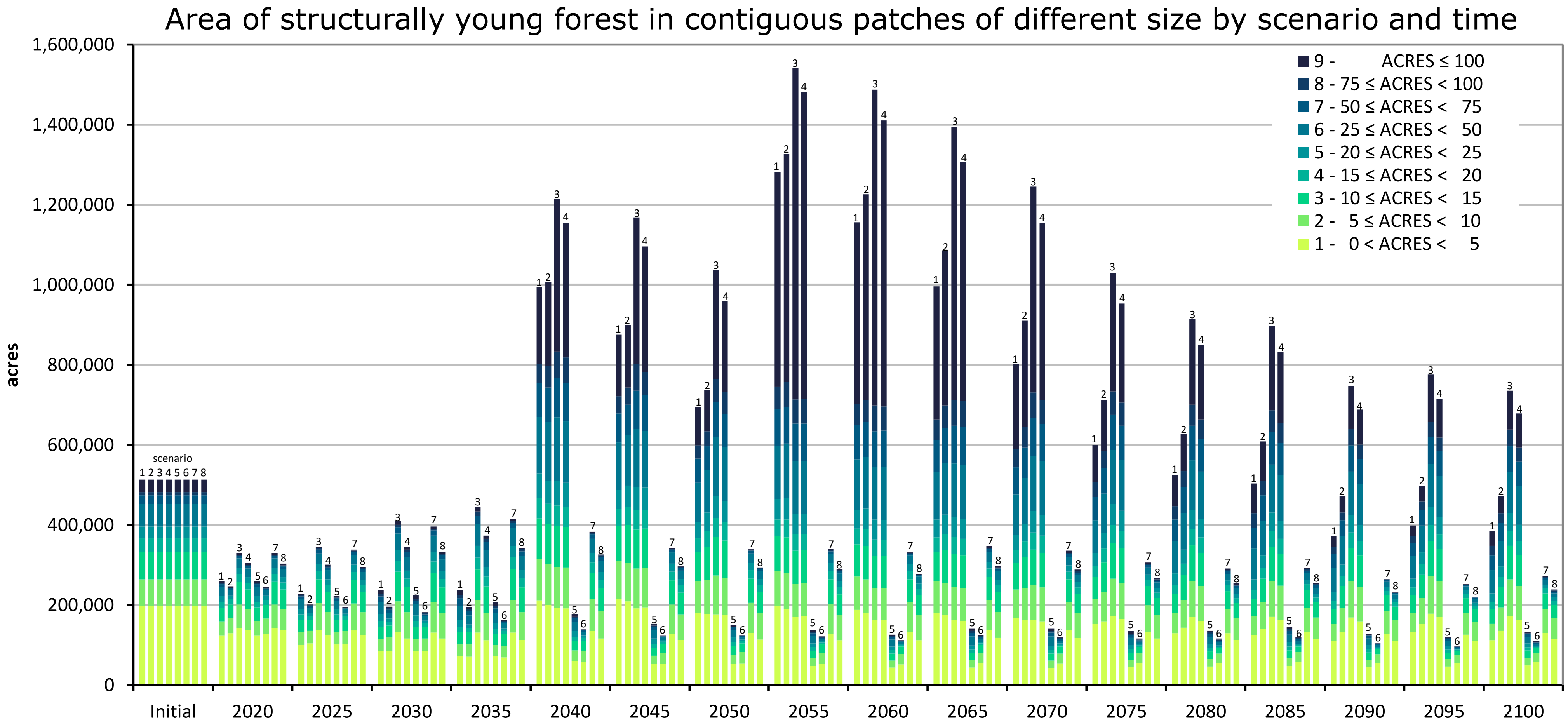
- **Structural composition strongly influenced by disturbance and management regime**



		Recent trends	Reserves	Local wood	Combined
Disturbance	Hi	1	2	3	4
	Lo	5	6	7	8

Results – Resilience: Forest Structure

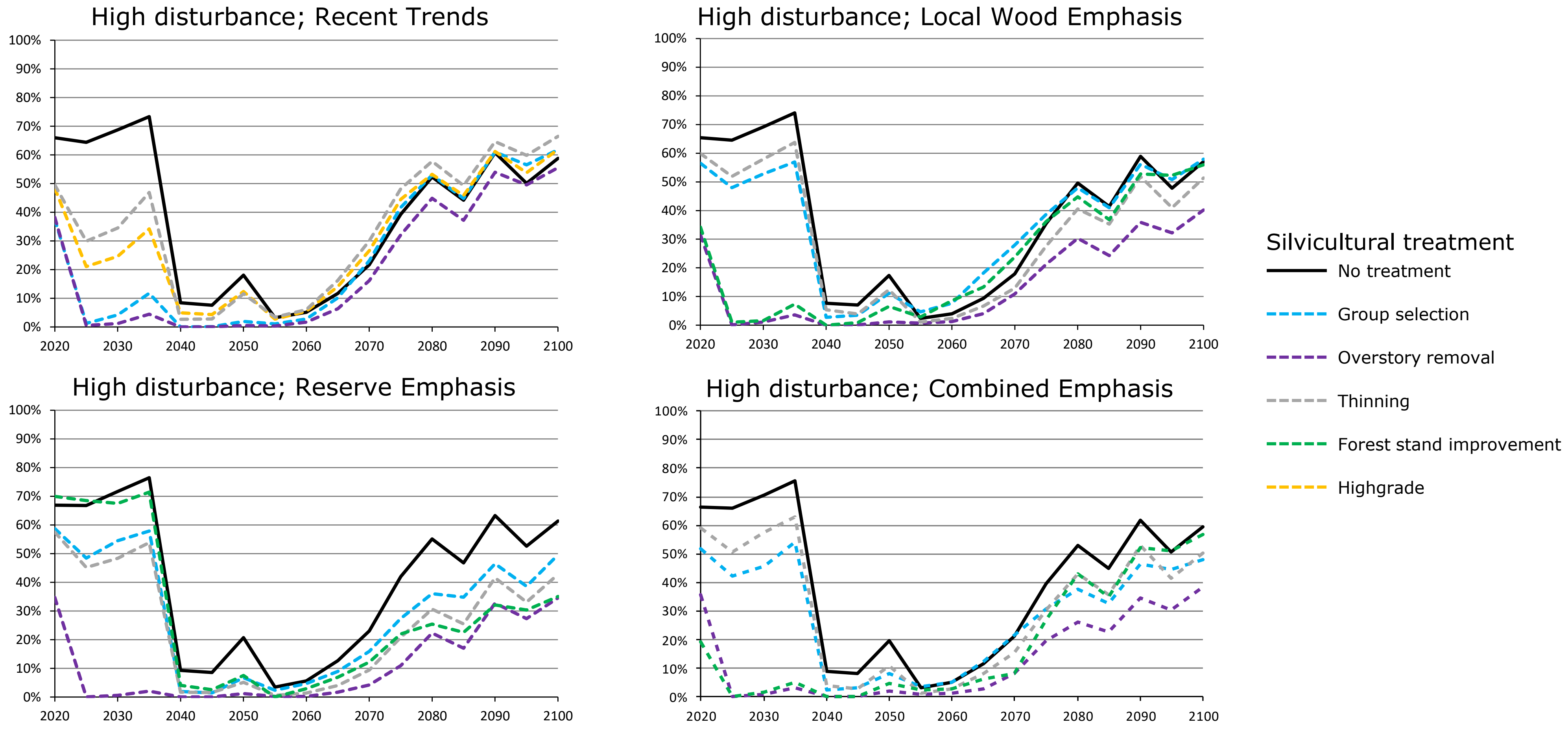
- **Structural composition strongly influenced by disturbance and management regime**
- **Management provides for stability of structural classes**



Results – Resilience: Forest Structure

- **Management complements reserve strategies and can promote rapid recovery of an array of structural conditions**

Proportion of area treated in older structural conditions for
high-disturbance scenarios by treatment group and time



Results – Resilience: Forest Structure

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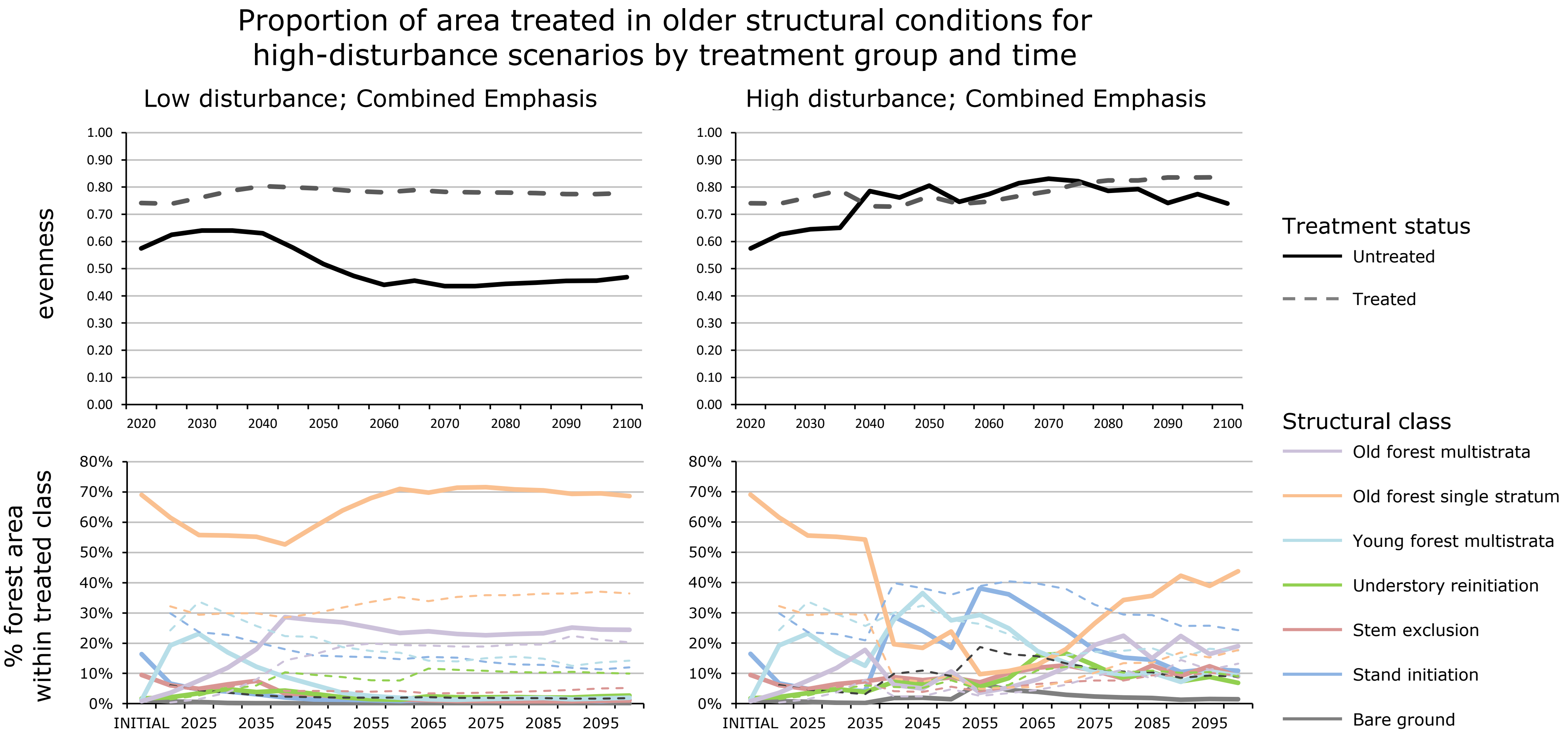
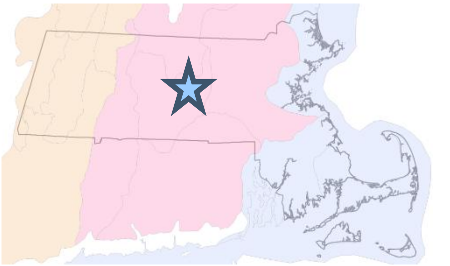


- **Forest management helps maintain the integrity of natural communities in the face of changing disturbance regimes**
  - Example: Oak-hickory communities, central Massachusetts



Percent biomass in oak - hickory species, 0-10 years

	Treated area								Untreated area							
	High Disturbance				Low Disturbance				High Disturbance				Low Disturbance			
	Recent Trends	Reserves	Local Wood	Combined	Recent Trends	Reserves	Local Wood	Combined	Recent Trends	Reserves	Local Wood	Combined	Recent Trends	Reserves	Local Wood	Combined
Acres	1,075	1,123	2,699	2,569	806	1,253	3,061	2,273	26,425	23,955	11,371	14,840	13,535	23,937	11,301	14,795
Pre-treatment	21.9%	32.4%	27.3%	30.7%	19.6%	25.9%	25.1%	29.9%	10.0%	11.2%	9.2%	9.9%	8.9%	11.3%	9.0%	10.1%
Post-treatment	26.6%	33.5%	34.5%	31.5%	25.9%	31.9%	30.5%	30.8%	12.7%	13.8%	11.9%	13.0%	11.9%	14.2%	11.7%	12.8%
Post-10 yr	20.2%	35.2%	39.1%	40.0%	16.4%	34.2%	36.4%	38.7%	6.8%	6.7%	6.5%	6.8%	6.3%	6.9%	5.8%	7.2%
Post-30 yr	36.7%	38.5%	36.3%	39.7%	10.5%	29.6%	31.0%	32.9%	20.7%	19.8%	20.6%	21.1%	4.4%	4.1%	4.3%	4.1%
Post-55 yr	33.4%	37.4%	37.3%	41.1%	19.0%	32.1%	38.2%	34.2%	16.2%	14.6%	18.0%	16.4%	6.6%	5.5%	6.4%	6.1%
Post-75 yr	26.9%	43.2%	39.2%	42.1%	13.8%	39.8%	35.9%	37.1%	13.5%	13.2%	14.9%	14.4%	9.0%	6.5%	9.1%	8.5%

Percent biomass in oak-hickory species, 10-25 years

	Treated area								Untreated area							
	High Disturbance				Low Disturbance				High Disturbance				Low Disturbance			
	Recent Trends	Reserves	Local Wood	Combined	Recent Trends	Reserves	Local Wood	Combined	Recent Trends	Reserves	Local Wood	Combined	Recent Trends	Reserves	Local Wood	Combined
Acres	1,075	1,123	2,699	2,569	806	1,253	3,061	2,273	26,425	23,955	11,371	14,840	13,535	23,937	11,301	14,795
Pre-treatment	1.0%	1.0%	0.4%	0.9%	1.5%	0.9%	0.4%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Post-treatment	7.1%	12.8%	14.3%	15.8%	5.8%	10.9%	9.7%	10.2%	3.1%	3.6%	2.9%	3.2%	2.8%	3.6%	2.8%	3.2%
Post-10 yr	34.2%	38.5%	39.6%	37.6%	29.2%	37.9%	33.9%	35.1%	15.5%	17.2%	14.7%	15.9%	14.3%	17.5%	14.5%	15.7%
Post-30 yr	50.5%	53.8%	54.9%	63.4%	27.3%	50.5%	50.2%	49.7%	36.8%	34.4%	34.7%	35.1%	10.2%	10.2%	9.5%	10.0%
Post-55 yr	45.6%	47.2%	46.4%	40.9%	18.1%	38.7%	50.9%	48.2%	35.9%	35.1%	37.0%	36.2%	7.0%	5.8%	7.1%	6.8%
Post-75 yr	37.5%	41.6%	47.0%	54.4%	22.4%	38.0%	49.5%	42.9%	20.3%	19.2%	21.7%	20.9%	8.8%	7.7%	9.3%	8.6%

Percent biomass in oak-hickory species, 025-999 years

	Treated area								Untreated area							
	High Disturbance				Low Disturbance				High Disturbance				Low Disturbance			
	Recent Trends	Reserves	Local Wood	Combined	Recent Trends	Reserves	Local Wood	Combined	Recent Trends	Reserves	Local Wood	Combined	Recent Trends	Reserves	Local Wood	Combined
Acres	1,075	1,123	2,699	2,569	806	1,253	3,061	2,273	26,425	23,955	11,371	14,840	13,535	23,937	11,301	14,795
Pre-treatment	76.2%	73.6%	74.1%	74.4%	76.2%	74.0%	74.3%	72.6%	82.1%	82.1%	82.1%	82.3%	82.2%	82.1%	82.2%	82.3%
Post-treatment	76.0%	75.6%	78.7%	77.9%	76.2%	77.3%	78.1%	76.8%	82.0%	82.0%	82.1%	82.2%	82.3%	82.0%	82.2%	82.2%
Post-10 yr	76.0%	75.3%	78.8%	77.9%	76.0%	77.5%	78.2%	76.7%	81.7%	81.5%	81.8%	81.8%	82.0%	81.5%	81.9%	81.8%
Post-30 yr	76.2%	77.3%	82.3%	79.1%	75.5%	77.6%	81.5%	78.9%	80.8%	80.4%	81.0%	80.8%	81.5%	80.7%	81.4%	81.2%
Post-55 yr	76.5%	78.2%	81.6%	81.6%	75.6%	79.0%	82.9%	80.3%	79.3%	78.2%	80.0%	79.2%	81.2%	80.0%	81.1%	80.8%
Post-75 yr	76.0%	79.2%	82.8%	82.2%	76.1%	80.4%	85.4%	81.4%	78.4%	77.0%	79.4%	78.4%	80.9%	79.3%	80.8%	80.3%

Results – Resilience: Stability of Ecosystem Services

Above ground live tree dry biomass removed per acre by non-hurricane disturbances and EF1 hurricanes, tons per acre

	Treated area								Untreated area							
	High Disturbance				Low Disturbance				High Disturbance				Low Disturbance			
	Recent Trends	Reserves	Local Wood	Combined	Recent Trends	Reserves	Local Wood	Combined	Recent Trends	Reserves	Local Wood	Combined	Recent Trends	Reserves	Local Wood	Combined
2020	0.26	0.18	0.19	0.18	0.20	0.18	0.21	0.21	0.18	0.20	0.20	0.20	0.18	0.20	0.20	0.20
2025	1.55	1.55	1.63	1.56	1.33	1.30	1.35	1.36	1.52	1.61	1.46	1.54	1.25	1.39	1.27	1.33
2030	0.49	0.58	0.48	0.45	0.31	0.39	0.35	0.32	0.70	0.74	0.71	0.72	0.48	0.53	0.50	0.52
2035	0.96	1.10	1.02	1.03	0.64	0.69	0.67	0.62	1.47	1.53	1.44	1.48	0.90	0.99	0.93	0.97
2040	4.06	4.02	4.06	3.82	0.87	0.95	0.83	0.83	4.33	5.77	5.65	5.80	1.12	1.20	1.17	1.18
2045	5.69	5.98	5.53	5.44	0.45	0.50	0.45	0.45	7.24	7.54	7.53	7.52	0.52	0.58	0.56	0.57
2050	1.24	1.26	1.28	1.24	1.09	1.03	1.02	1.00	1.50	1.72	1.57	1.65	1.22	1.34	1.25	1.30
2055	9.25	8.83	6.49	6.66	1.20	1.07	0.93	0.90	9.62	10.37	9.78	10.25	1.39	1.51	1.45	1.48
2060	3.75	3.06	2.61	2.59	0.77	0.66	0.59	0.60	4.40	4.34	4.18	4.21	0.80	0.88	0.83	0.86
2065	5.26	4.22	4.10	3.90	3.16	3.01	2.72	2.64	4.77	5.64	5.00	5.41	3.36	3.71	3.45	3.59
2070	3.11	2.06	2.32	2.14	0.50	0.35	0.37	0.35	3.81	3.95	3.79	3.84	0.47	0.52	0.49	0.50
2075	4.10	3.32	2.94	2.76	2.86	2.35	2.29	2.26	3.97	4.39	3.87	4.17	2.90	3.27	3.01	3.15
2080	5.56	3.94	3.57	3.43	3.13	2.70	2.42	2.33	5.08	5.51	4.92	5.31	3.27	3.60	3.38	3.52
2085	10.84	8.27	7.50	7.28	1.20	1.07	1.02	0.99	12.82	12.58	12.62	12.55	1.31	1.46	1.37	1.44
2090	2.03	1.53	1.45	1.45	1.17	1.05	0.98	1.02	1.95	2.13	1.95	2.06	1.24	1.37	1.27	1.34
2095	10.59	8.79	7.37	7.46	0.90	0.81	0.71	0.69	10.78	10.85	10.49	10.61	0.91	1.03	0.93	0.99
2100	4.77	3.61	3.40	3.30	2.61	2.35	2.20	2.18	4.45	4.82	4.39	4.65	2.70	2.99	2.79	2.92

Above ground live tree dry biomass removed per acre by hurricanes with strength EF2 and greater, tons per acre

	Treated area								Untreated area							
	High Disturbance				Low Disturbance				High Disturbance				Low Disturbance			
	Recent Trends	Reserves	Local Wood	Combined	Recent Trends	Reserves	Local Wood	Combined	Recent Trends	Reserves	Local Wood	Combined	Recent Trends	Reserves	Local Wood	Combined
2020	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2025	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2030	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2035	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2040	25.33	31.24	26.71	26.86	—	—	—	—	40.56	36.49	37.66	36.81	—	—	—	—
2045	1.58	1.33	2.40	2.13	—	—	—	—	4.13	4.17	4.35	4.28	—	—	—	—
2050	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2055	14.22	10.29	10.68	9.85	—	—	—	—	22.95	23.39	23.86	23.43	—	—	—	—
2060	0.00	0.00	0.00	0.00	—	—	—	—	0.00	0.00	0.00	0.00	—	—	—	—
2065	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2070	0.01	0.04	0.04	0.02	—	—	—	—	0.09	0.08	0.10	0.11	—	—	—	—
2075	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2080	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2085	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2090	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2095	3.18	2.25	3.56	2.98	—	—	—	—	7.45	7.45	7.43	7.54	—	—	—	—
2100	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

- **Forest management helps aid in stability of aboveground live tree biomass, and the ecosystem services that stability provides.**

Key Take-Aways: Land Use

- **Avoiding deforestation is critical for "holding the line" on forest carbon sequestration.** Continued permanent forest loss will make achievement of net zero emissions in 2050 even harder.

- **Utilizing cleared trees in durable wood products can help reduce direct emissions from land clearing and provide a local source of wood products.**

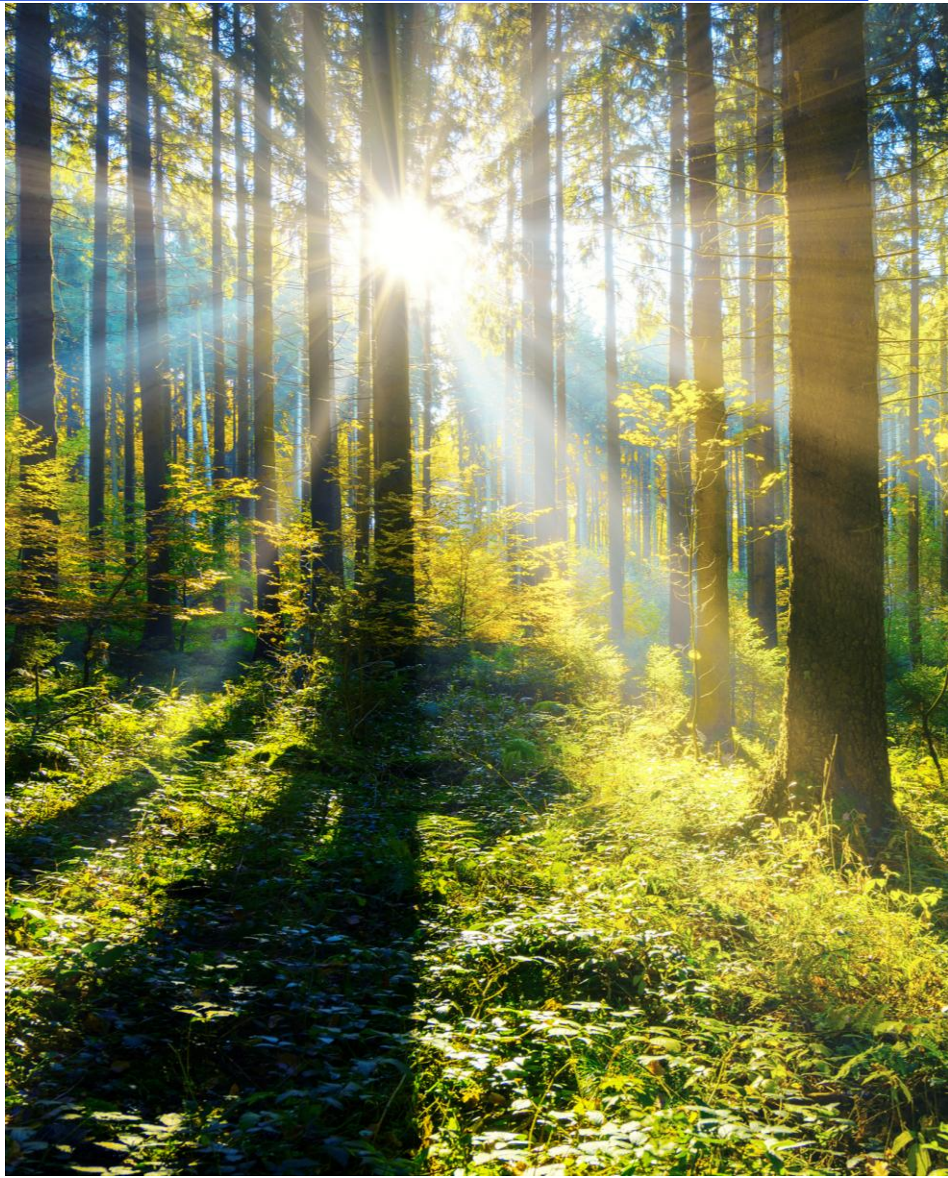
- **The study demonstrates the physical potential to meet the land use needs of solar and building development while minimizing impacts to forest carbon and other ecosystem services.** Realizing this potential will require purposeful and strategic planning, policies, permitting, and incentives.

Key Take-Aways: Forest Management

- **Climate-oriented silvicultural practices and improved wood utilization can help mitigate the short-term carbon emissions from timber harvest while providing a local source of wood products.**

- **Different approaches to forest management are unlikely to significantly increase the level of carbon sequestration by MA forests**.

- **Best to manage forests holistically for long term health, biodiversity, and climate resilience.**
  - The study's landscape-level outputs/results should not dictate site-specific management or conservation decisions.



Key Take-Aways: Forest Management

- **The findings generally support the recommendations from the Forests as Climate Solutions Initiative,** including:
  - Expanding forest reserves (passive management) on some lands protects existing carbon storage;
  - Climate-oriented active forest management can help balance carbon sequestration, climate resilience, biodiversity, forest health, and other management objectives;
  - Keeping forested land as forests is important for maintaining carbon storage and sequestration, among other benefits.

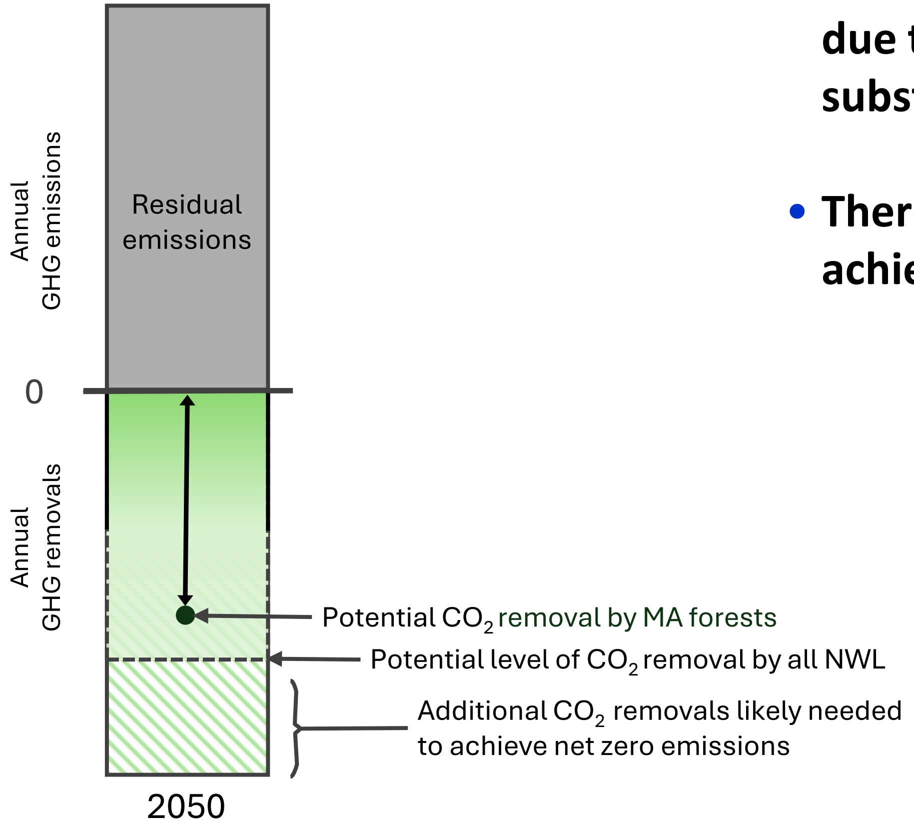
Key Take-Aways: Reforestation & Tree Planting

- **Reforestation and tree planting are long term investments, providing more carbon storage and sequestration (and other benefits) overtime as the planted trees grow.**

- **Important to scale up reforestation and tree planting now to reap their benefits sooner.** Also important is appropriate stewardship to ensure vigor and climate resilience as the planted trees age.

- **However, additional strategies are needed to complement reforestation and tree planting as they have limited potential to significantly increase the statewide carbon sequestration level.**

Key Take-Aways: Supplemental Strategies



- **Forests play an important role in balancing residual GHG emissions in 2050, but an increase in the statewide level of forest carbon sequestration is unlikely due to natural forest processes (i.e. growth and mortality), competing land use, substantial hurricane risks, and other ecological disturbances.**

- **Therefore, a broad range of strategies is needed to offset residual emissions and achieve statewide net zero emissions in 2050:**

  1. In-state natural and working lands (NWL) and hybrid carbon dioxide removal (e.g. biochar, biomass burial)
  2. In-state engineered carbon dioxide removal options
  3. Out-of-state carbon dioxide removal procurement (NWL-based, marine-based, engineered, hybrid)
  4. Further GHG emissions reductions, including waste-based advanced biofuels and other low/zero carbon fuels for hard to decarbonize sectors

EEA’s Next Steps

- **Develop site suitability guidance and Holistic Land Use Strategy/Plan in coordination with other Secretariats to balance the need for clean/renewable energy and infrastructure, housing, and land conservation.**

- **Seek additional and consistent funding to:**
  - Scale up reforestation and tree planting and stewardship, focusing on riparian and urban areas for multiple benefits.
  - Continue enhanced land conservation through implementation of Forests As Climate Solutions Initiative, Resilient Lands Initiative, and Executive Order 618 on Biodiversity Conservation.
  - Continue incentives for climate-oriented forest management and improved wood utilization through implementation of Forests As Climate Solutions Initiative.

- **Continue to explore additional NWL and carbon dioxide removal opportunities to supplement forest carbon sequestration to achieve net zero emissions in 2050.**

- **Revisit existing NWL-related goals and consider developing new goals for the next Clean Energy and Climate Plan.**

Extra Slides

Forest Carbon Study Integrated Scenarios

		I. Forest Management Regimes			
		1. Recent Trends	*2. Reserves Emphasis*	*3. Local Wood Emphasis*	*4. Reserves & Local Wood Emphasis*
	Forestry:	Current forestry practices and harvesting levels	Climate-oriented forestry, current harvest levels (meets ~6% of wood consumption)	Climate-oriented forestry, increased harvest levels to meet 20% of MA wood consumption	Climate-oriented forestry, increased harvest levels to meet 15% of MA wood consumption
	Forest Reserves:	Current forest reserves (3.3% of forests)	Expand forest reserves to 33% of forest land	Current forest reserves	Expand forest reserves to 20% of forest land
II. Land Cover Change & Ecological Disturbance Regimes	*1A. High Ecological Disturbance* *1B. Uncoordinated Land Use/Cover Change*	***Recent Trends Harvest + High Disturbance/ Development Scenario***	***Reserves Emphasis + High Disturbance/ Development Scenario***	***Local Wood + High Disturbance/ Development Scenario***	***Combined Emphasis + High Disturbance/ Development Scenario***
	2A. Low Ecological Disturbances *2B. Coordinated Land Use/Cover Change*	***Recent Trends Harvest + Low Disturbance/ Development Scenario***	***Reserve Emphasis + Low Disturbance/ Development Scenario***	***Local Wood + Low Disturbance / Development Scenario***	***Combined Emphasis + Low Disturbance/ Development Scenario***
III. Wood Utilization		Two variants for all scenarios: (a) *Recent trends wood utilization* (b) *Improved wood utilization*			

Forest Management Regimes: Modeling Details

- **Recent Trends**
  - Current forestry practices and harvesting levels
  - Baseline as point of comparison, illustrates future with minimal change in forest management
  - Initial modeling results shared in FCS Workshop #1

- **Reserves Emphasis**
  - Immediate expansion of reserves to 33% of statewide forest land (up from ~3.5% today)
  - Immediate shift to climate-oriented forestry practices on remaining land
  - Maintain current harvest levels to avoid additional leakage

- **Local Wood Emphasis**
  - Immediate increase in harvest levels to meet 20% of state's current wood consumption from in-state forests (from ~7% today)
  - Immediate shift to climate-oriented forestry practices
  - Maintain existing forest reserves

- **Reserves & Local Wood Emphasis**
  - Immediate expansion of reserves to 20% of statewide forest land (up from ~3.5% today)
  - Immediate shift to climate-oriented forestry practices on remaining land
  - Immediate increase in harvest levels to meet 15% of state's current wood consumption from in-state forests (from ~7% today)

- **Definitions** *(Operational definitions for modeling study purposes; not policy-prescriptive)*
  - Forest Reserves: Areas with no harvesting (wildland definition)
  - Climate-oriented forestry: forestry practices that emphasize forest carbon sequestration and storage, climate adaptation, and disturbance resilience developed by DCR

Disturbance Regimes: Modeling Details

High Disturbance

- A plausible, relatively high-emissions future with increased ecological disturbances and uncoordinated land use change

- ***High Ecological Disturbance***
  - Climate-intensified generic forest disturbances
  - Climate-intensified hurricanes (applied 100yrs after 20th century hurricanes (e.g., 1938 hurricane happens in 2038))
  - Ongoing insect pest outbreaks (EAB, HWA)

- ***Uncoordinated Land Use/Cover Change***
  - Deforestation from building development, following recent trends
  - Deforestation from increasing ground-based solar development
  - No active reforestation

Low Disturbance

- A plausible, relatively low-emissions future with a lower level of ecological disturbances and more coordinated, well-planned land use change

- ***Low Ecological Disturbances***
  - Generic disturbances follow recent trends
  - No hurricanes
  - Ongoing insect pest outbreaks (EAB, HWA)

- ***Coordinated Land Use/Cover Change***
  - Reduced deforestation from building development due to more compact development patterns
  - Reduced deforestation from improved siting of solar development
  - Ambitious afforestation/reforestation

Wood Utilization Variants: Modeling Details

- **Recent Trends in Wood Utilization**
  - Logging and mill efficiencies, and primary product ratios set by 2018 USFS Timber Product Output reports
  - Modest estimate of hurricane salvaging (~25% of larger size classes)

- **Improved Wood Utilization**
  - Changes in logging and milling efficiency, markets for wood products, and post-disturbance salvage logging
    - 5% increase in logging efficiencies for growing stock, 10% increase for non-growing stock (simulating better markets for non-growing stock, e.g., wood-fiber insulation)
    - Modest increases in mill efficiencies (5% reduction in course woody residues, ~1% reduction for other residues)
    - ~10% increase in wood going into longer lived products (e.g., lumber/mass timber) from shorter-term products (e.g., paper)
  - Increase proportions of harvested and disturbance-killed trees converted into long-lived wood products, particularly hemlock (~60% of larger trees into longer-lived products such as CLT)
  - Increase in salvage harvesting following hurricanes (~75% for larger size classes)