Greenhouse gas emissions from forest management – Life Cycle Assessment as a tool

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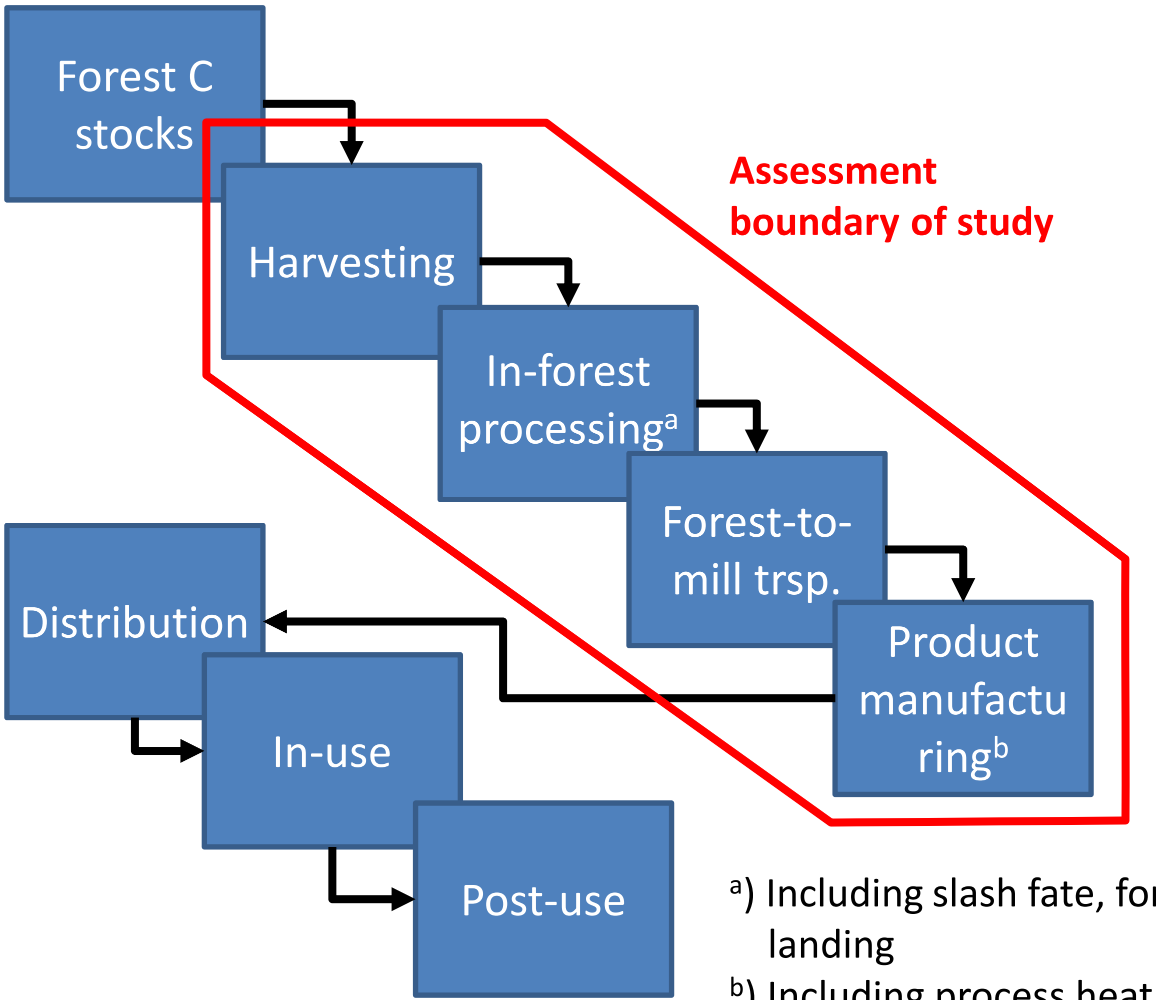
Spatial Informatics Group

Life cycle assessment (LCA)

- Comparative LCA:
  - Compare two scenarios on outcomes
  - Use a unifying metric (Metric tonnes of carbon dioxide equivalents – Mg CO_2e)
- Define scenarios
- Define boundaries:
  - Spatial/accounting elements
  - Temporal: Measure impact over how many years?
- Applied examples:
  - Carbon offset markets (baseline vs. project)
  - Carbon footprint wood building vs. steel/concrete

LCA example: setting boundaries



[a]) Including slash fate, forwarding, landing

[b]) Including process heat and electricity production & consumption

The Key: Scenario assumptions – Example: NE Wood pellet production

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Greenhouse gas emissions of local wood pellet heat from northeastern US forests

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The Key: Scenario assumptions – Example: NE Wood pellet production

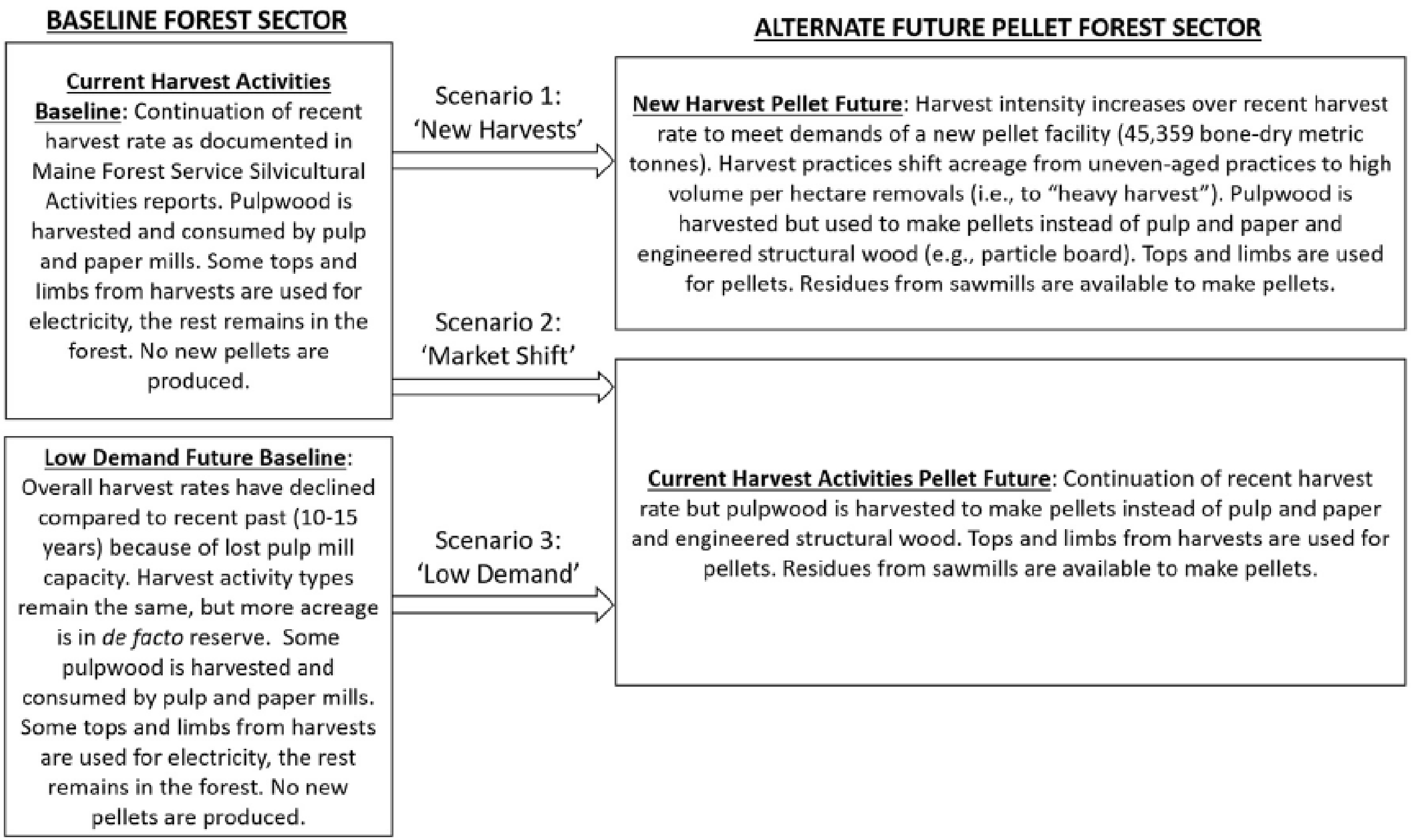


Fig. 1. Forest sector market comparison pathways.

Forest product carbon pools

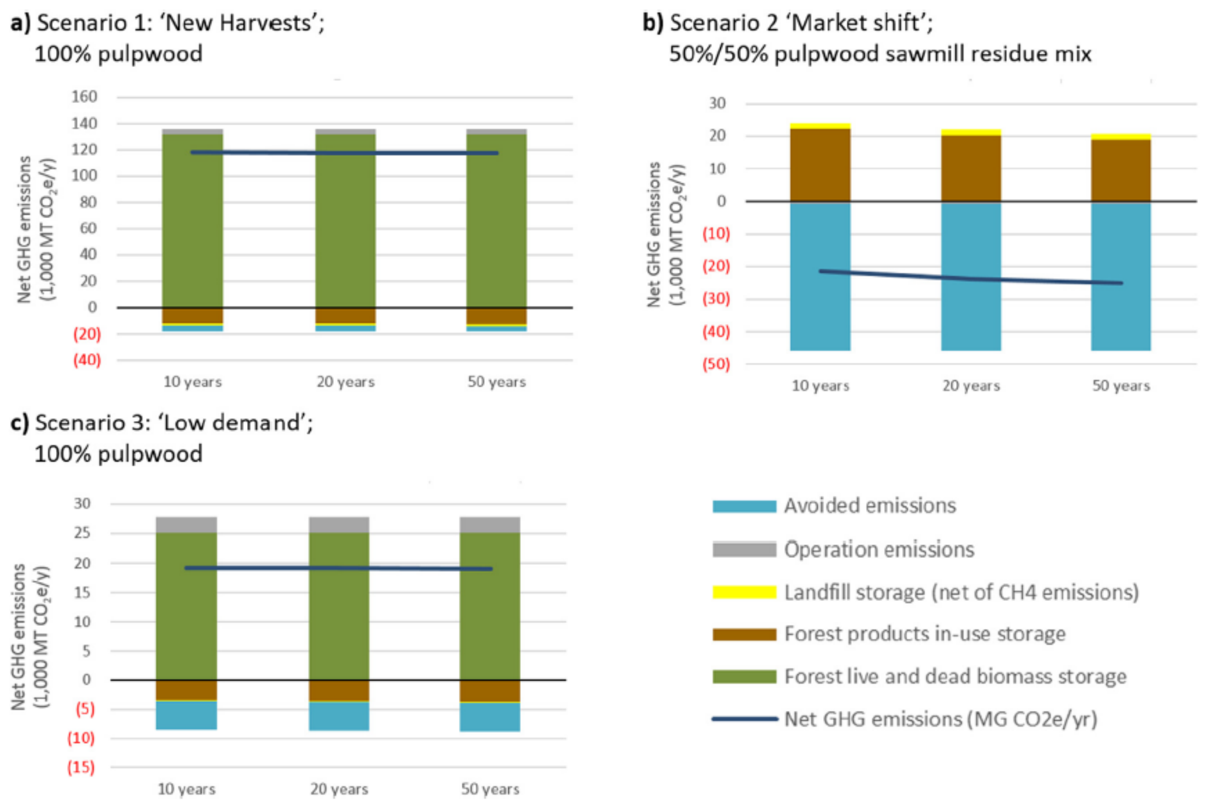


Fig. 2. Net GHG emissions across a representative wood supply area in the northeastern US by carbon accounting category and timescale with example feedstock mixes for each economic scenario. All scenarios assume that 50% of the feedstock is derived from sawmill residues while the remaining 50% are sourced from forest operations. Pellets from new harvests in addition to current harvest activities (Figure 2a) as well as pellets derived from harvests that would have not been executed due to the closing of pulp mills (Figure 2c) result in a net GHG increase mostly driven by net GHG emissions occurring in forest carbon pools (green). Pellets derived from harvests that would have occurred anyway to supply (now closed) pulp mills (Figure 2b) result in a net GHG decrease mostly driven by reduced avoided fossil fuel emissions from both pulp manufacturing and fossil-fuel based heat. See Fig. 1 for an explanation on the three forest sector market scenarios. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Sourcing of biomass

Table 3
GHG emissions by economic scenario and timescale when displacing home heating oil with regionally sourced wood pellets in the Northern Forest. Net GHG emissions (MT CO_2e/y) are across the wood supply area and inclusive of upstream and downstream forest sector emissions. Green and red shading indicate positive and negative climate benefits, respectively. Plant size was scaled for 45,359 MT of annual pellet production and partly limited by scenario-specific wood supply area forest growth limits.

Scenario Title	Feedstock (0% – Source – 100%: Pulpwood / Sawmill Residues)	Pellet Net GHG emissions: MT CO_2e/Y 10 y	MT CO_2e/Y 20 y	MT CO_2e/Y 50 y	% Change 10 y	% Change 20 y	% Change 50 y	MT CO_2e/MT Pellets 10 y	MT CO_2e/MT Pellets 20 y	MT CO_2e/MT Pellets 50 y	Results Category
1 'New harvests'		27,240	29,886	31,474	3%	4%	4%	0.6	0.7	0.7	Climate Neutral
1 'New harvests'		57,361	59,030	60,032	7%	8%	8%	1.3	1.4	1.4	Climate Negative
1 'New harvests'		87,553	88,245	88,660	11%	11%	12%	2.1	2.1	2.1	Climate Negative
1 'New harvests'		117,813	117,527	117,356	15%	15%	15%	2.8	2.8	2.8	Climate Negative
2 'Market shift'	*Harvest Residues*	20,665	2,231	-21,292	2%	0%	-3%	0.5	0.0	-0.5	Climate Neutral
2 'Market shift'		-85,185	-85,185	-85,185	-11%	-11%	-11%	-1.9	-1.9	-1.9	Climate Beneficial
2 'Market shift'		-53,411	-54,452	-55,077	-7%	-7%	-7%	-1.2	-1.2	-1.2	Climate Beneficial
2 'Market shift'		-21,558	-23,640	-24,889	-3%	-3%	-3%	-0.5	-0.5	-0.5	Climate Neutral
2 'Market shift'		10,376	7,253	5,379	1%	1%	1%	0.2	0.2	0.1	Climate Neutral
2 'Market shift'		42,388	38,224	35,725	5%	5%	5%	0.9	0.8	0.8	Climate Negative
3 'Low demand'		-76,441	-73,437	-71,635	-10%	-9%	-9%	-1.7	-1.6	-1.6	Climate Beneficial
3 'Low demand'		-44,604	-42,641	-41,463	-6%	-5%	-5%	-1.0	-0.9	-0.9	Climate Beneficial
3 'Low demand'		-12,674	-11,752	-11,199	-2%	-2%	-1%	-0.3	-0.3	-0.2	Climate Neutral
3 'Low demand'		19,343	19,224	19,153	2%	2%	3%	0.4	0.4	0.4	Climate Neutral

GHG impact: Residential heating

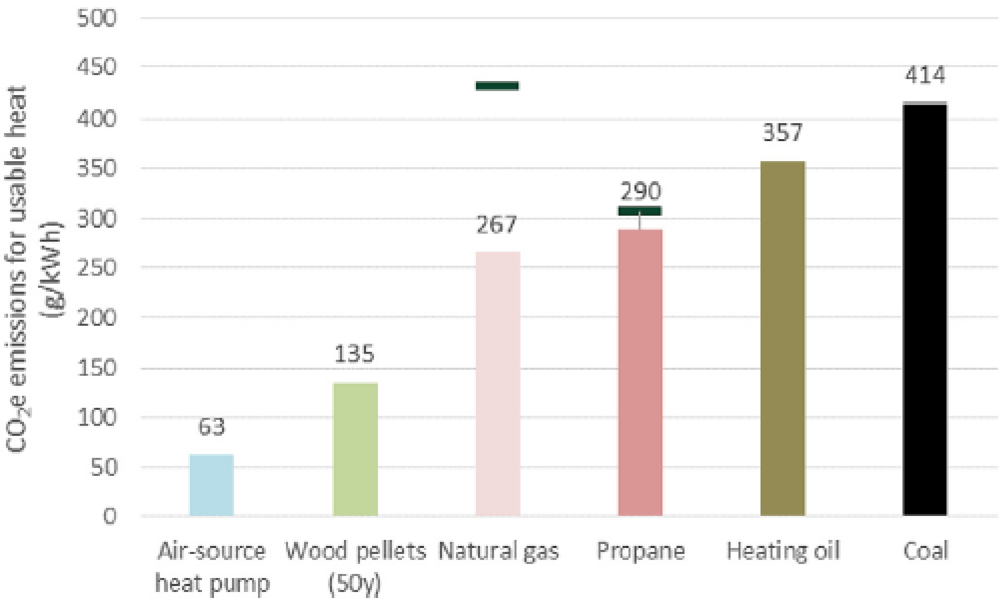


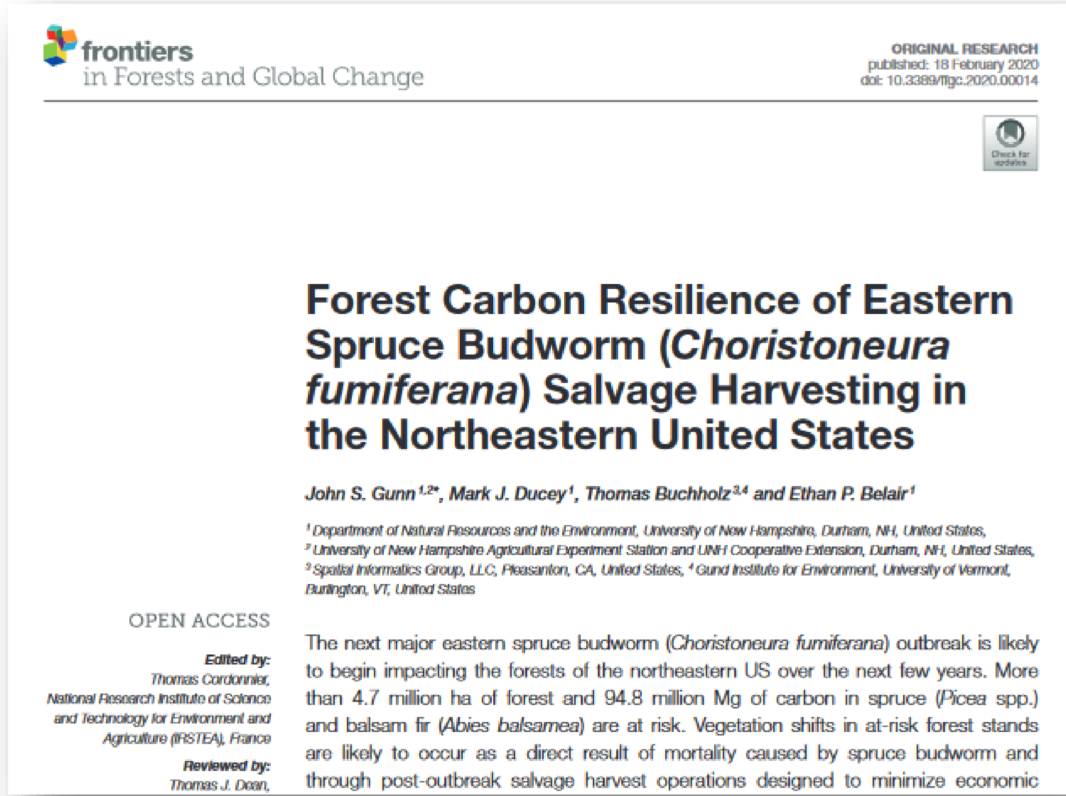
Fig. 3. Net GHG emissions for residential heat from heat of pellets vs. other heating alternatives in the Northern Forest for pellet Scenario 2 'Market Shift' and a feedstock mix of 50% sawmill residue, 50% pulpwood. While this metric suggests a strong impact of heating alternative, wood supply area analysis suggests only a muted impact of heating alternative on GHG emissions. Black bars for natural gas and propane present potential net GHG emissions for these fuels when including methane distribution losses of 2.4% natural gas [28] and 0.24% for propane.

LCA: Forest C modeling

- 'Level 1' - Standard LCA: Forest C dynamics excluded (e.g. ISO standard of LCAs: focus on fossil fuels)
- 'Level 2' - Include Forest C dynamics: Growth and yield (can include climate change projections)
- 'Level 3' - Include stochastic events with probability discounting; examples:
  - Wildfire
  - Drought
  - Insects

LCA example: Salvage harvest

- Climate impact of salvage harvest
- "A benchmark scenario without timber harvesting or the occurrence of a spruce budworm outbreak had the greatest net carbon sequestration profile after 40 years compared to all other scenarios."



frontiers in Forests and Global Change

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Forest Carbon Resilience of Eastern Spruce Budworm (*Choristoneura fumiferana*) Salvage Harvesting in the Northeastern United States

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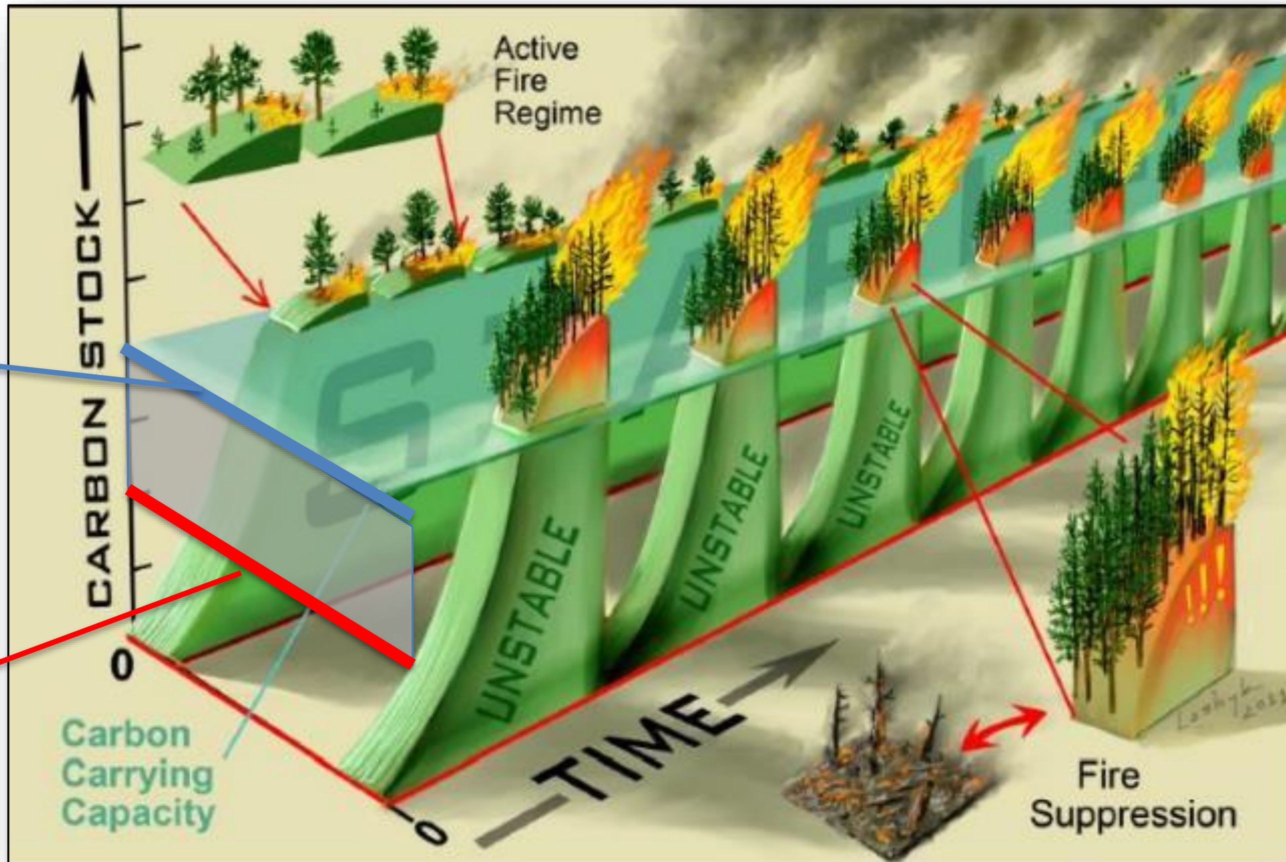
The next major eastern spruce budworm (*Choristoneura fumiferana*) outbreak is likely to begin impacting the forests of the northeastern US over the next few years. More than 4.7 million ha of forest and 94.8 million Mg of carbon in spruce (*Picea* spp.) and balsam fir (*Abies balsamea*) are at risk. Vegetation shifts in at-risk forest stands are likely to occur as a direct result of mortality caused by spruce budworm and through post-outbreak salvage harvest operations designed to minimize economic

LCA example: Salvage harvest

Carbon carrying capacity high-frequency low-severity fires

Carbon carrying capacity low frequency high-severity fires



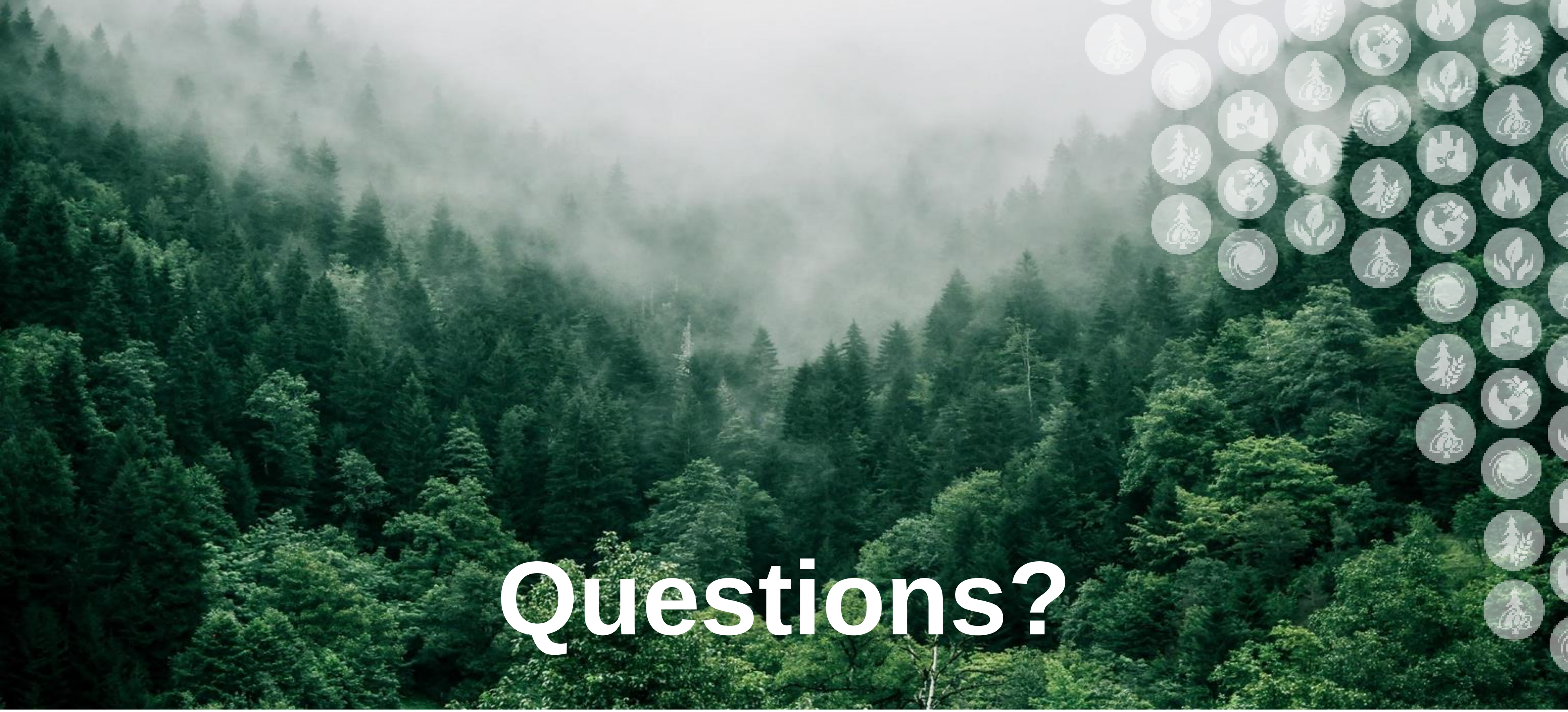
Source: Hurteau 2013

Key considerations

- GHG results for heat applications are ‘better’ than for electricity-only; CHP can be attractive
- Existing biomass power plants might have ‘paid back’ carbon debt
- Baseline and future scenario assumptions drive results
  - Volume of biomass (does current market support demand?)
  - Supply/Demand study to determine ‘risk’ for additional harvests
- Biomass markets rarely drive harvest decisions in the north but can intensify harvests (Buchholz et a. 2019)
- Forest C stock trajectories are uncertain, some harvest activities can stabilize carbon (e.g., beetle risk; Gunn et al. 2020)

Next steps for MN?

- Define future scenarios; important elements:
  - Market shift
  - Climate change
  - New (engineered) wood products
- Include a ‘Let grow’ assumption
- Identify time horizon
- Analyze scenarios:
  - Forest resilience/health
  - Climate impact
  - Socio-economics (jobs, macro-economic impacts etc.)



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