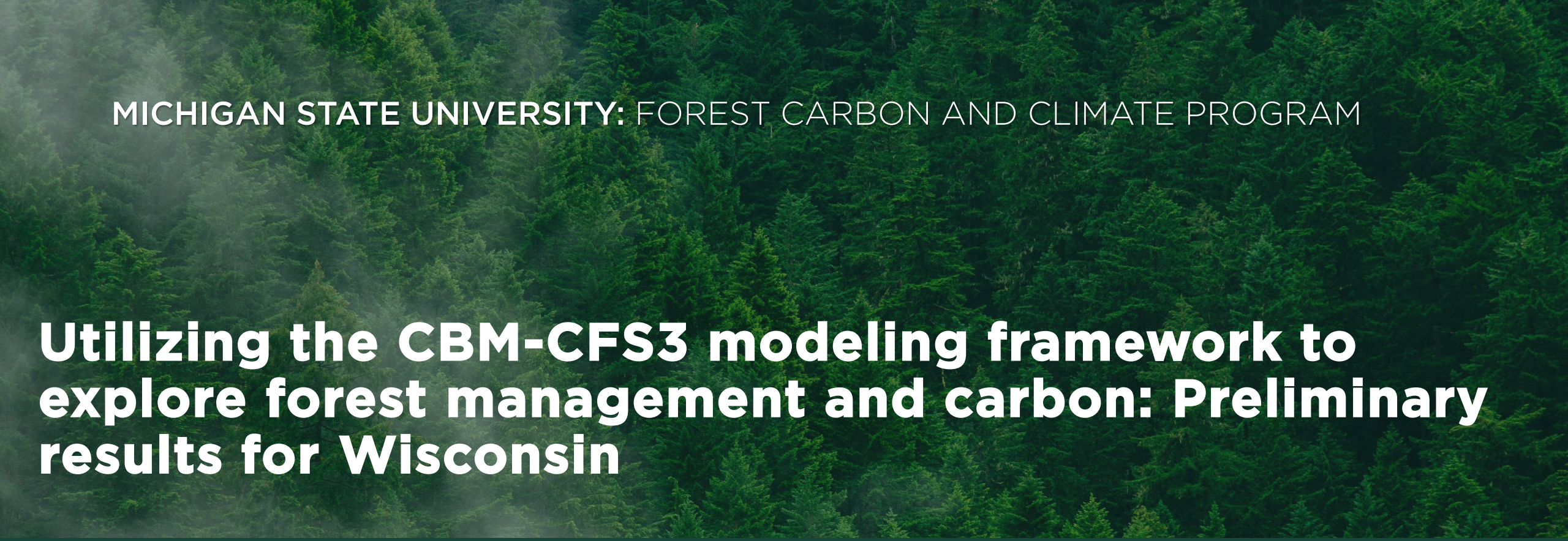

MICHIGAN STATE UNIVERSITY: FOREST CARBON AND CLIMATE PROGRAM

Utilizing the CBM-CFS3 modeling framework to explore forest management and carbon: Preliminary results for Wisconsin

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Wisconsin Governor's Council of Forestry, 11/15/2022

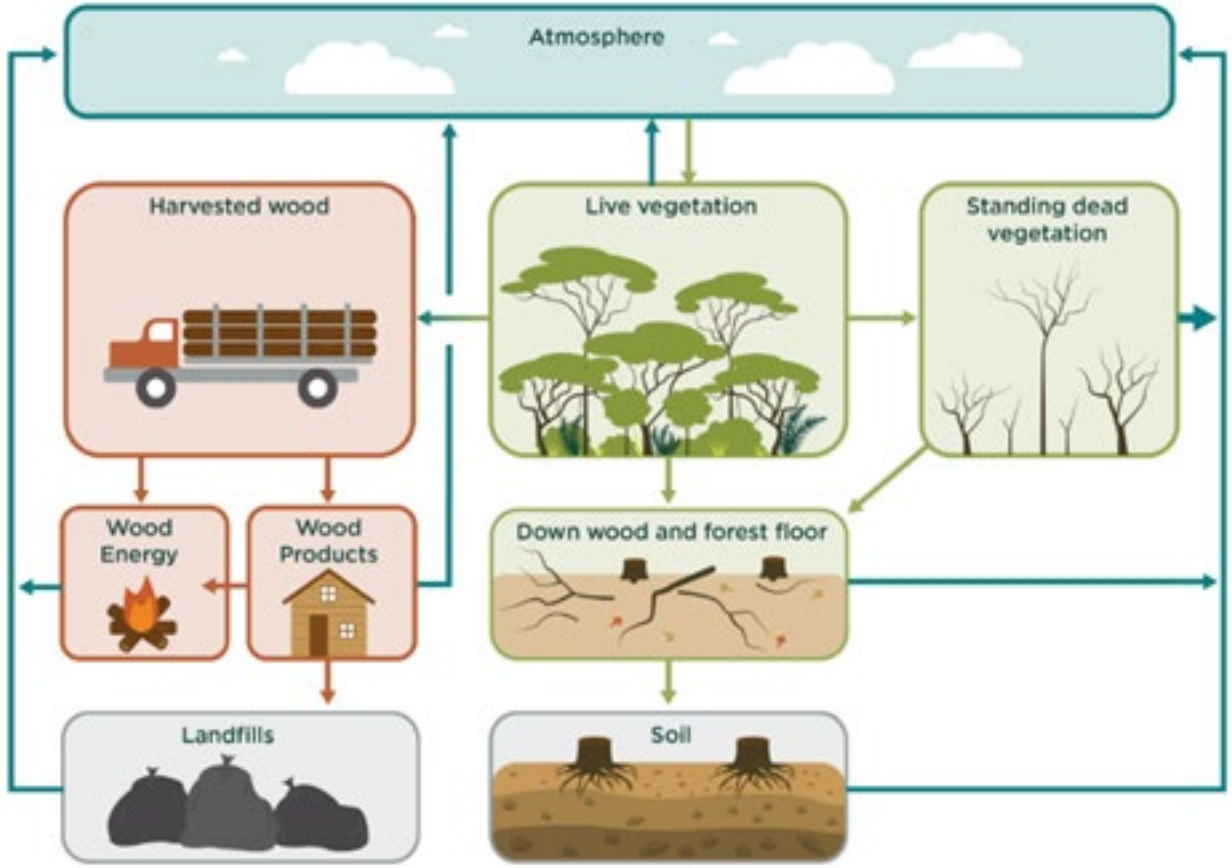
Forest Carbon and Climate Program
Department of Forestry
MICHIGAN STATE UNIVERSITY

Outline

- Introduction / CBM-CFS3
- Model structure and data inputs
- Business-as-Usual Simulation results
  - Disturbance representation
- Scenario Analyses
- CBM-FWHP

Forest Carbon and project future emissions

- Forest play an outsized role in the transfer of energy and mass
- Climate change is global issue
- Forest are seen as a key part of the solution to climate change
- Forests are integral to future state management, climate plans and GHG reductions



1. Insert academic sources

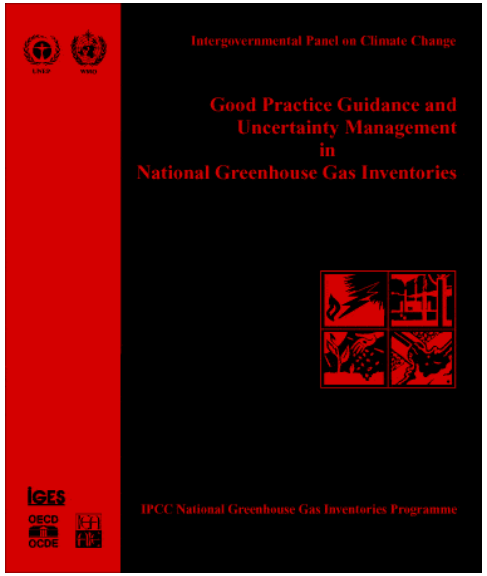
• Insert picture sources

CBM-CFS3: as a tool for state-wide planning and action

Combines strengths of both empirical and process-based modeling approaches

IPCC Compliant: Tier 3 methods:

- "One inventory plus change" method
- The CBM-CFS3 tracks 10 biomass and 11DOMC pools
- Easy aggregation into IPCC pools for reporting
- Ease of data availability with data inputs



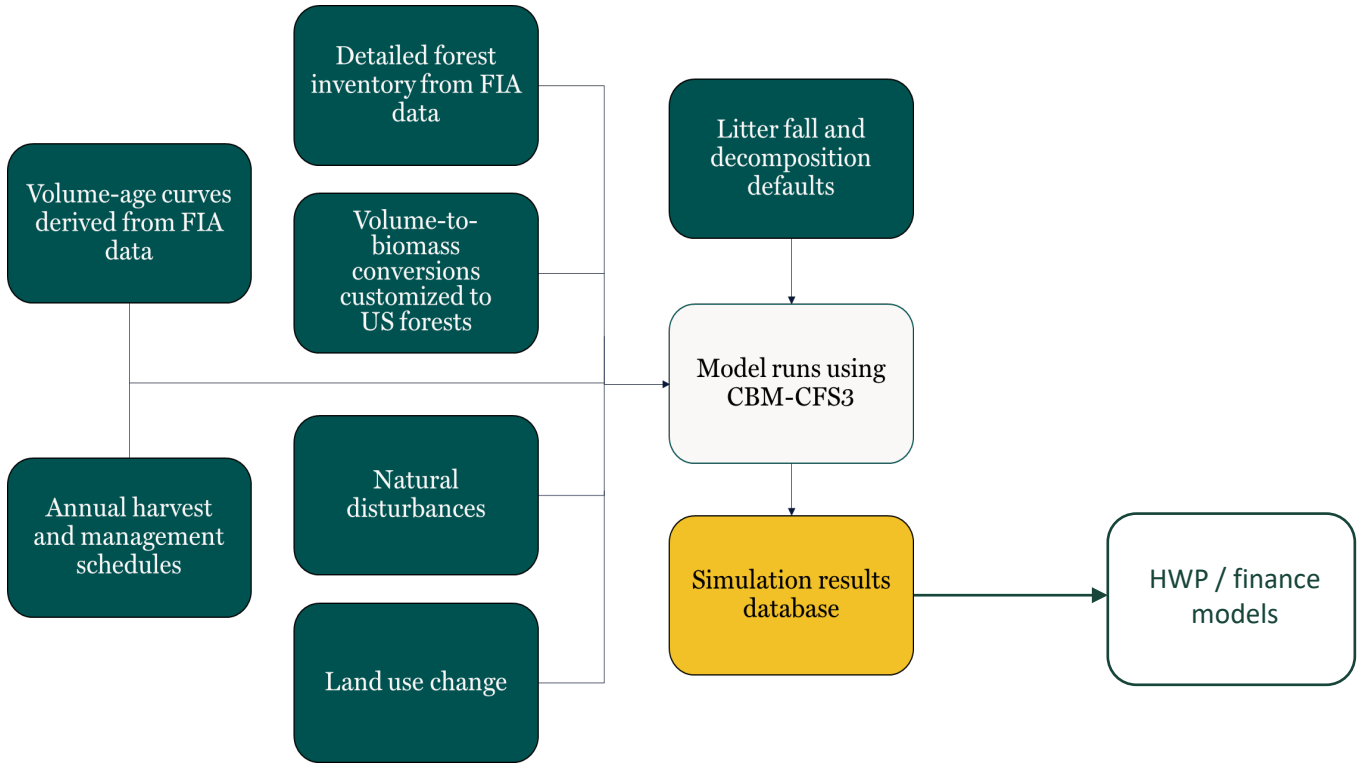
Integration of US based inventory data with the CBM-CFS3: systems-based approach

Data Inputs

- Detailed forest inventory
- Empirically-derived growth-yield relations
- Harvest scheduling / volumetric removals
- Disturbance representation
  - Harvest / management information
  - Natural disturbances
  - Land-use change

Model structure

- Volume to biomass conversions
- Process-based models for turnover
  - Climate / soil dependent



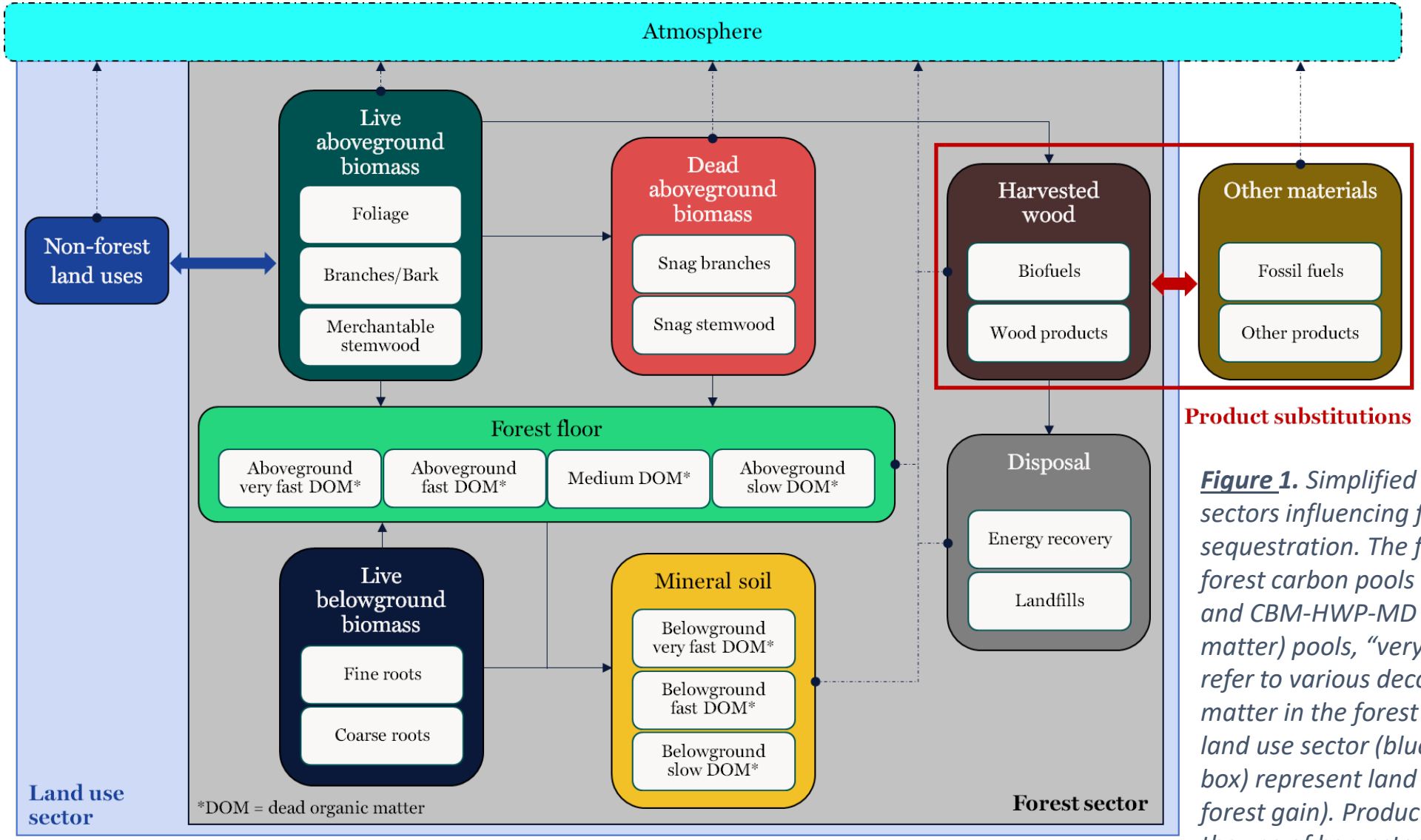


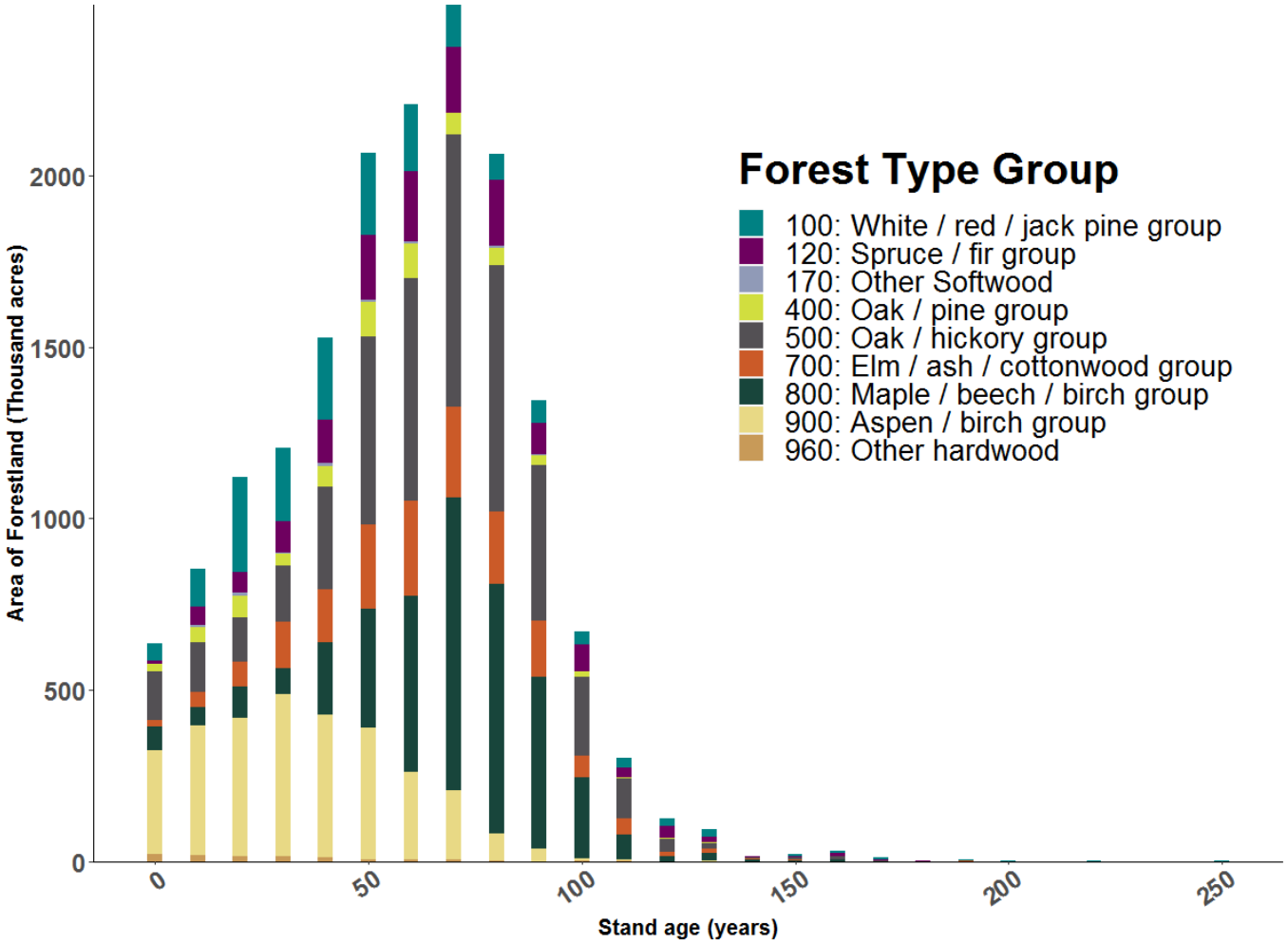
Figure 1. *Simplified systems view of land uses and sectors influencing forest carbon stocks and sequestration. The forest sector (gray box) shows the forest carbon pools and transfers used in the CBM-CFS3 and CBM-HWP-MD models. For DOM (dead organic matter) pools, "very fast", "fast", "medium", and "slow" refer to various decomposition rates of dead organic matter in the forest ecosystem. Transfers between the land use sector (blue box) and the forest sector (gray box) represent land use changes (either forest loss or forest gain). Product substitutions (red outline) represent the use of harvested wood in place of other materials in the economy. Adapted from Kull et al. 2019 and Nabuurs et al. 2007.*

Inventory

FIADB, estimated using the 2013-2019 inventory window

<u>Classifiers:</u>

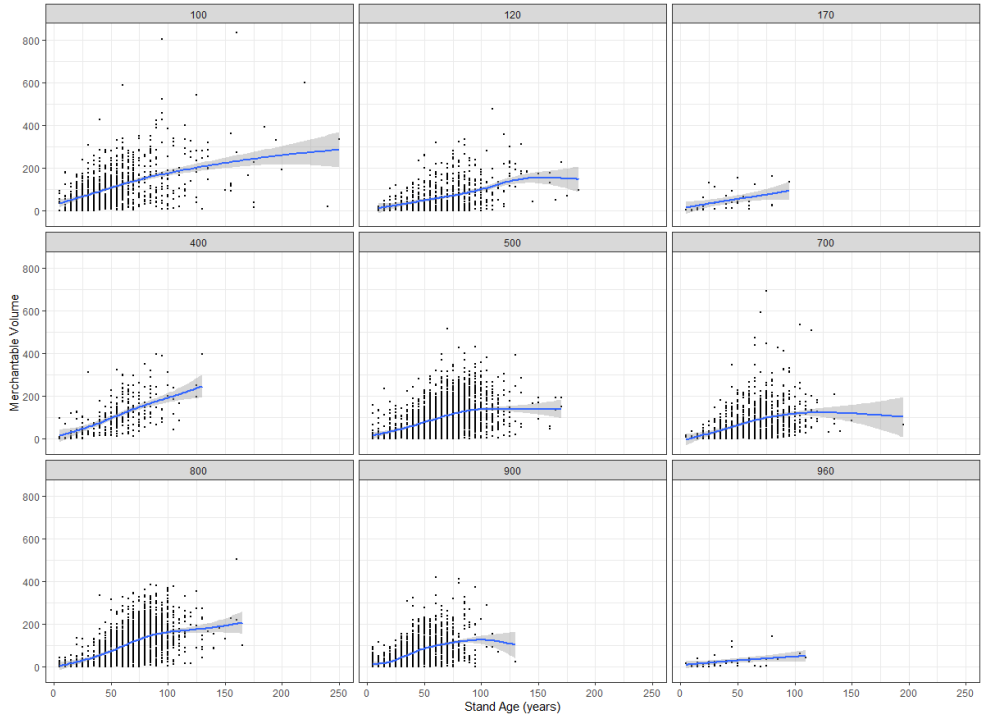
- Eco section
- Ownership
- Forest Type
- Forest Type Group
- Site Class

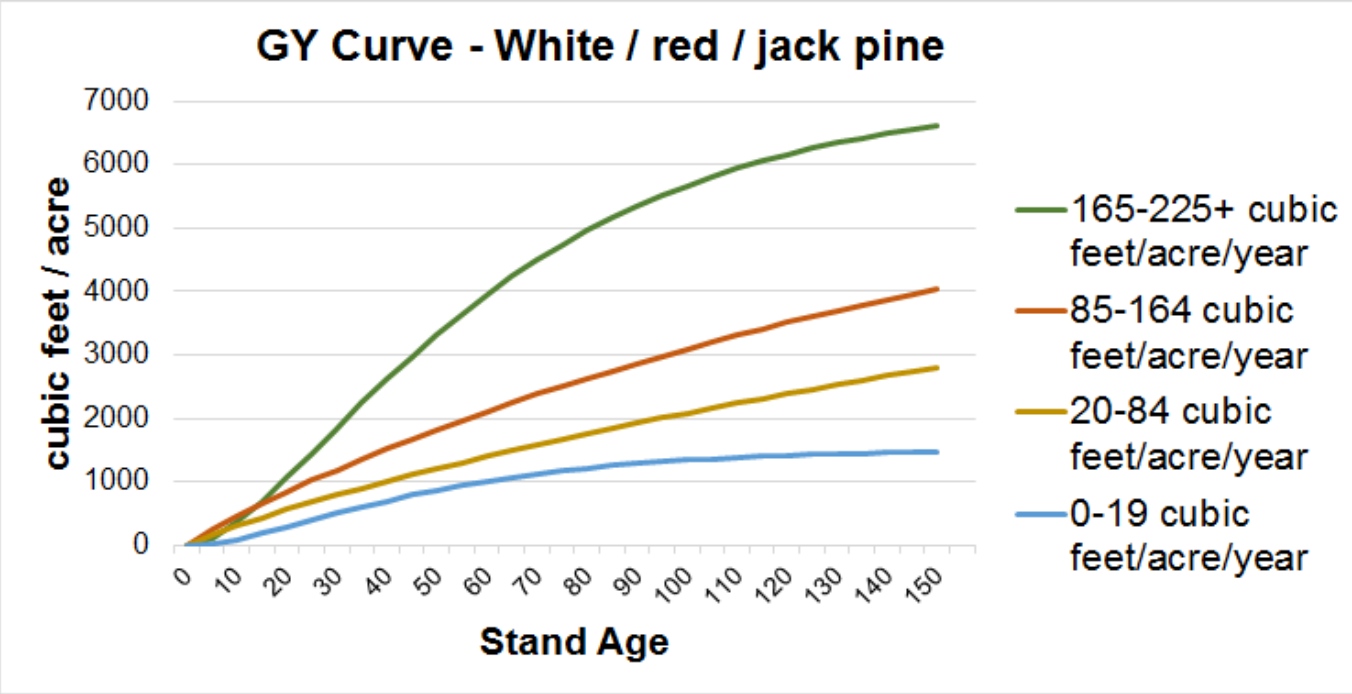


Growth-Yield

- Chapman-Richards function to predict merchantable volume using stand-age and site class

$$vol \sim b0*(1 - exp(-b1*AGE))^{b2}$$





Business-as-usual simulation

- Harvest rates / schedules
- Land-Use Change (LUC)
- Disturbance representation
  - Disease/Insect
  - Abiotic disturbance

Harvest schedule

- Estimated from FIADB using classifiers (including midpoint age)
- Age-based prescription by removals
- Crosswalk midpoint age from WI silvicultural handbook to prescribe harvest

1. Commercial thinnings
2. Clearcut
3. Coppice Cut
4. Shelterwood
5. Overstory removal

Ownership	Vol (m^3)	Carb (tonnes)
10: USFS	220,691.8	46705.28
20: Other Fed	41,872.1	9098.662
30: State/Local	2,043,140.0	452577
40: Private/Tribal	4,923,893.4	1143852

Forest Type Group	Vol (m^3)	Carb (tonnes)
100: White / red / jack pine	1,185,331	235,425.7
120: Spruce / fir	102,555.7	18,275.43
400: Oak / pine	194,413.5	45,909.75
500: Oak / hickory	1,897,086	499,948.6
700: Elm / ash / cottonwood	259,936.9	58,047.15
800: Maple / beech / birch	1,860,355	449,126.9
900: Aspen / birch	1,579,929	307,910.7
960: Other HW	80,613.7	21,143.49
999: Nonstocked	69,377.26	16,445.81

$$\text{Carbon} = Volume * (Prop_{SW} + SG_{SW}) + (Prop_{HW} + SG_{HW}) * CF$$

Land-use Change

- Remote-sensing derived LUC
  - NLCD from-to-change
  - Afforestation in agreeance with FIA, RS estimates high deforestation rates than FIA
- Inputted by forest type, randomly applied spatially

Ownership	Afforestation	Deforestation	Net Change
10: USFS	122	92	+30
20: Other Fed	161	401	-240
30: State/Local	2452	3796	-1344
40: Private/Tribal	16600	27418	-10818

Fire Disturbances

- WI dashboard for prescribed fire
- Used FIADB for wildfire
- Split into severity
  - Rx
  - Low
  - Medium
  - High

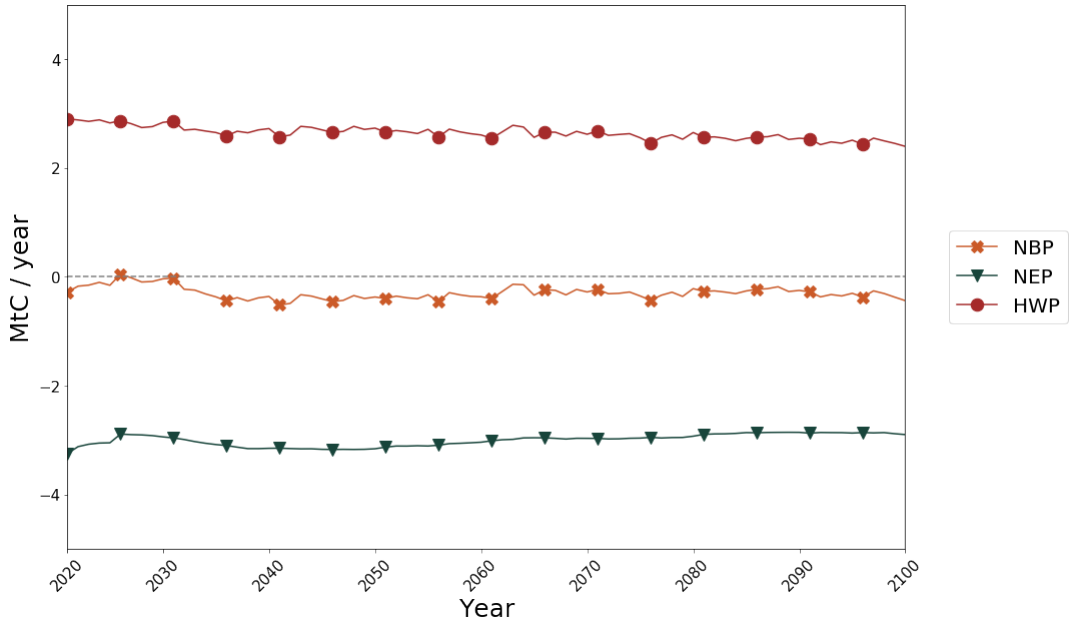
Severity	Area (ha)
Rx	2805.7
Low	79.7
Medium	808.1
High	391.4

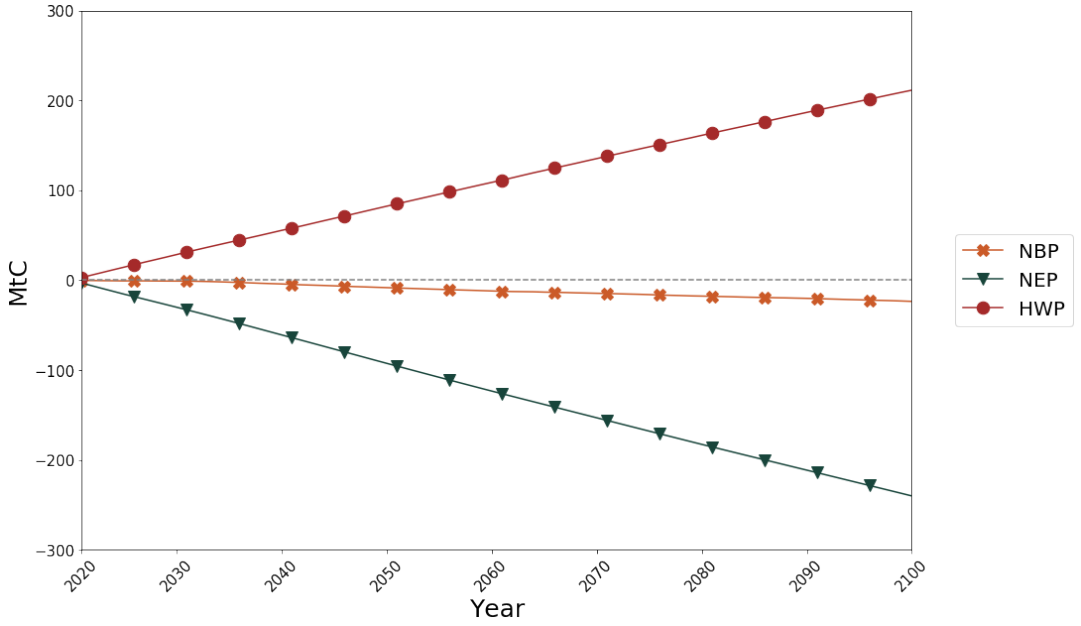
Other natural disturbances

- RS based metrics:
  - Defoliator / Mortality events
  - Abiotic (wind, animal)

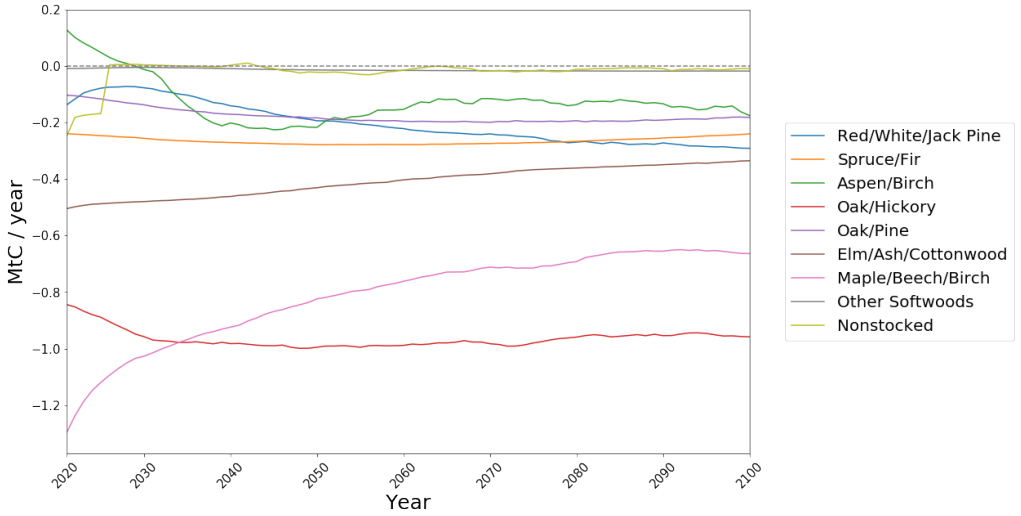
Disturbance	Severity	Area (ha)
Defoliator	Light (<10%)	10,001.5
	Moderate (10-15%)	2,436
	Severe (>50%)	14,039.2
Mortality	Light (<10%)	31,987.3
	Moderate (10-15%)	15,770.9
	Severe (>50%)	740.3
Abiotic	Light (10%)	123,710.6
	Severe (>10%)	3623.9

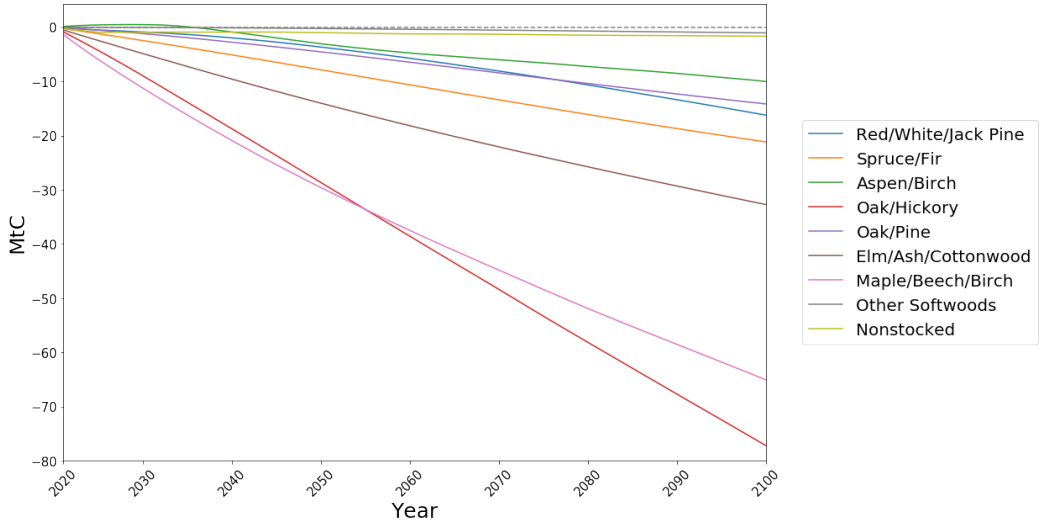
Forest ecosystem emissions and removals



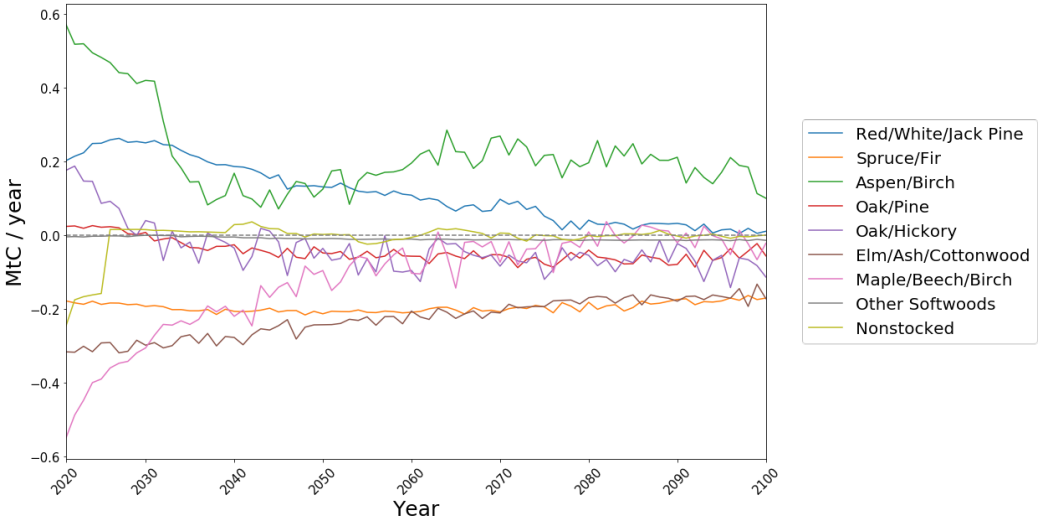


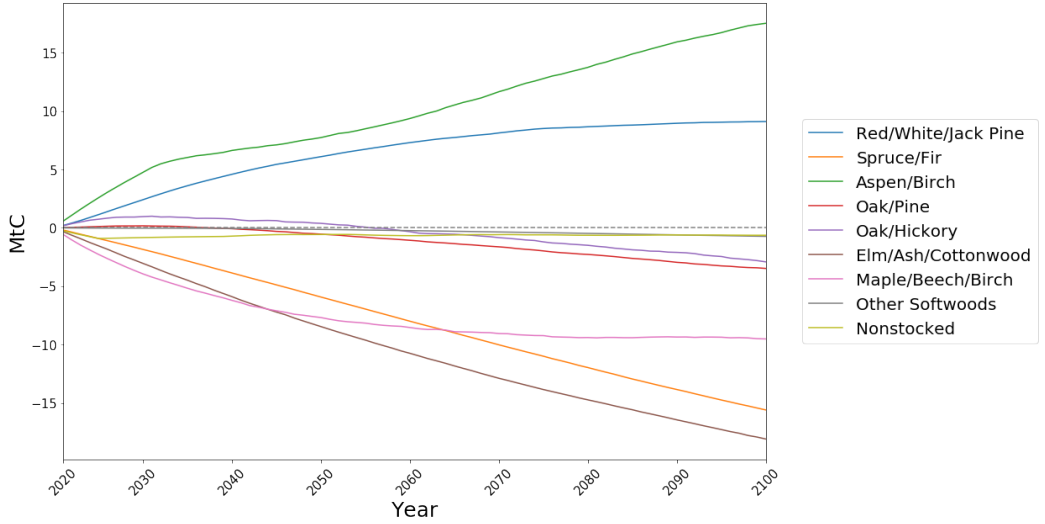
Fluxes by Forest Type





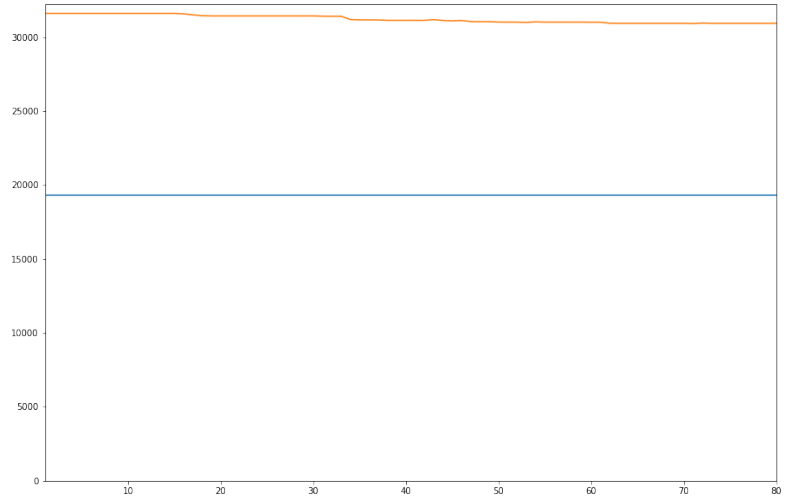
Net Ecosystem Productivity

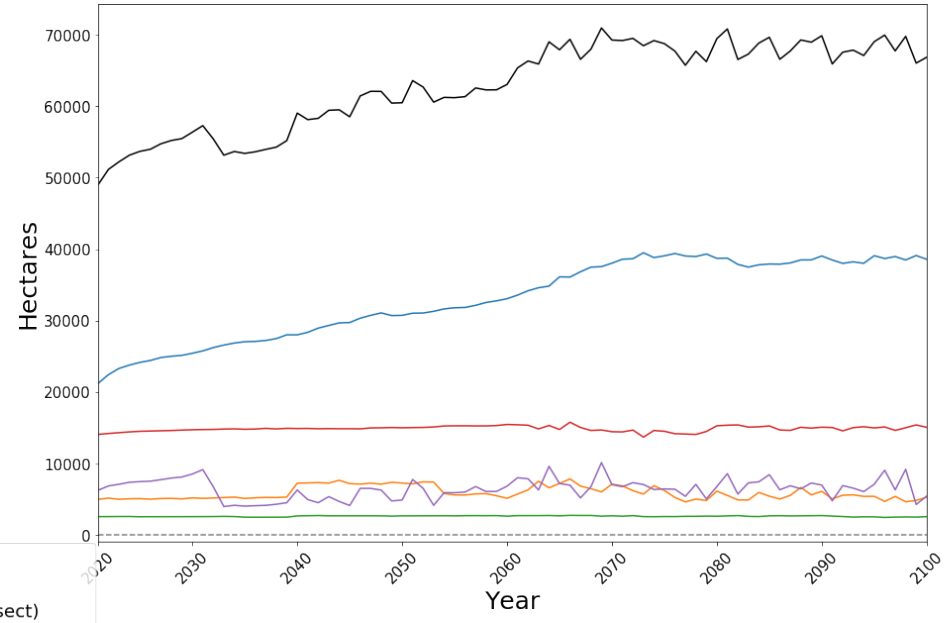


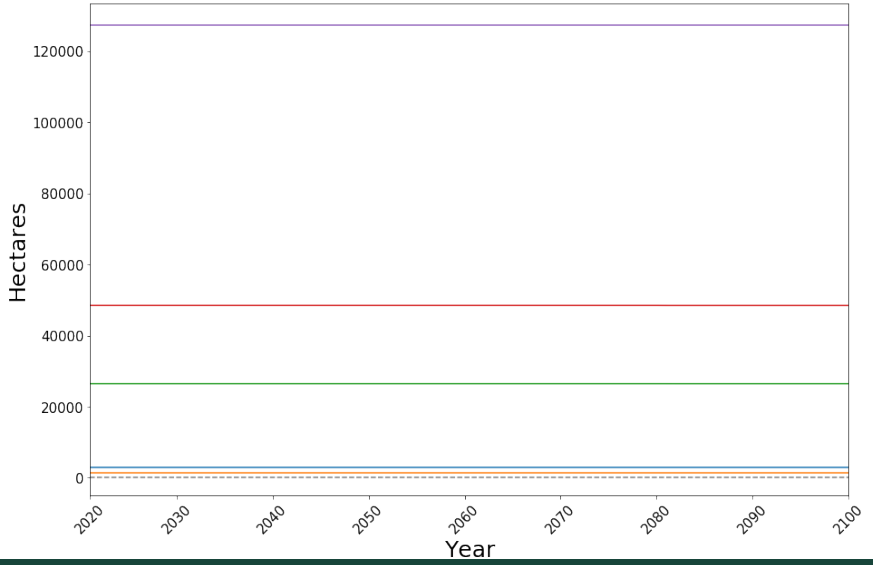


Net Biome Productivity

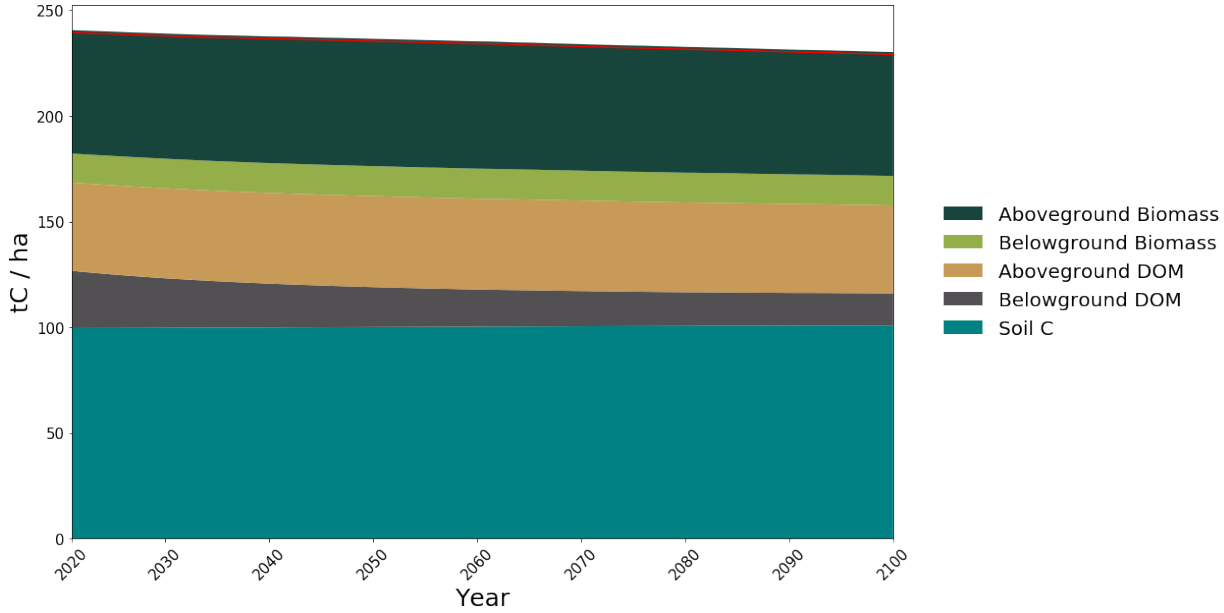
Disturbance

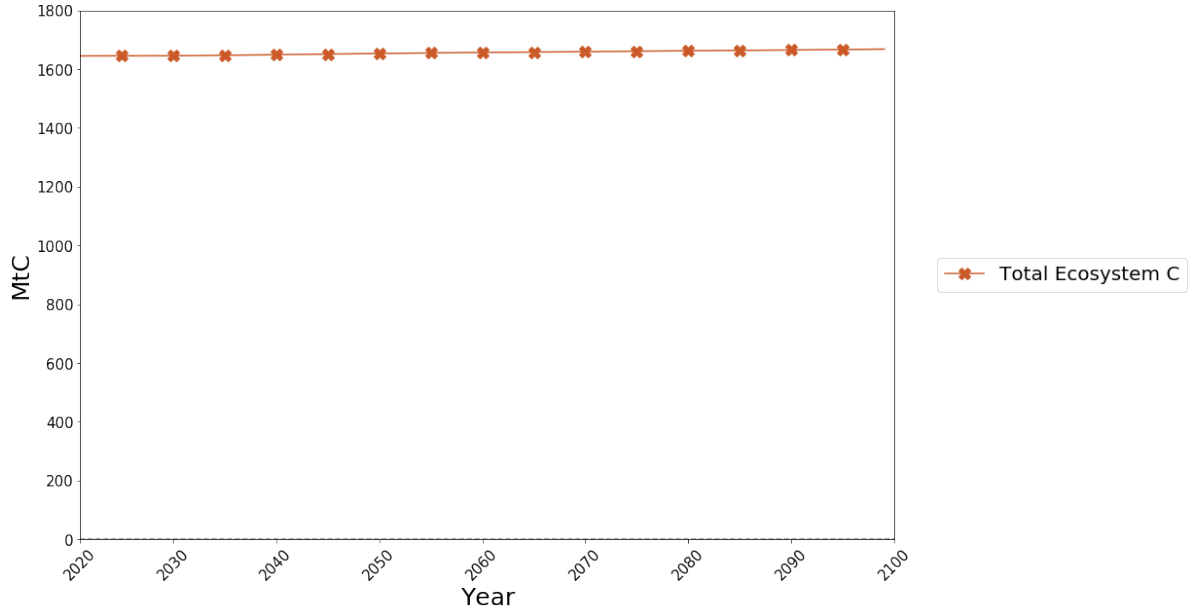




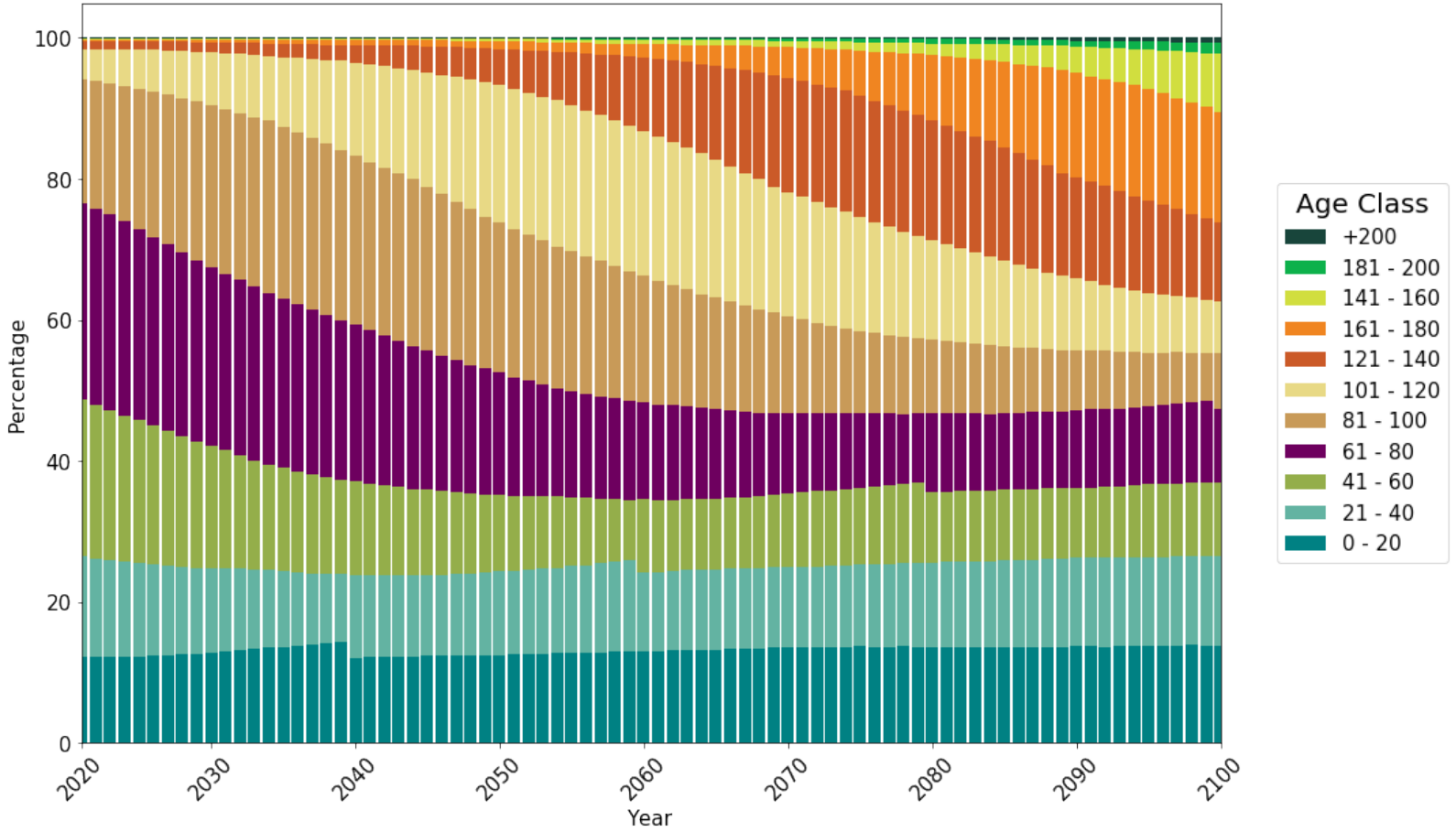


Carbon density and stocks





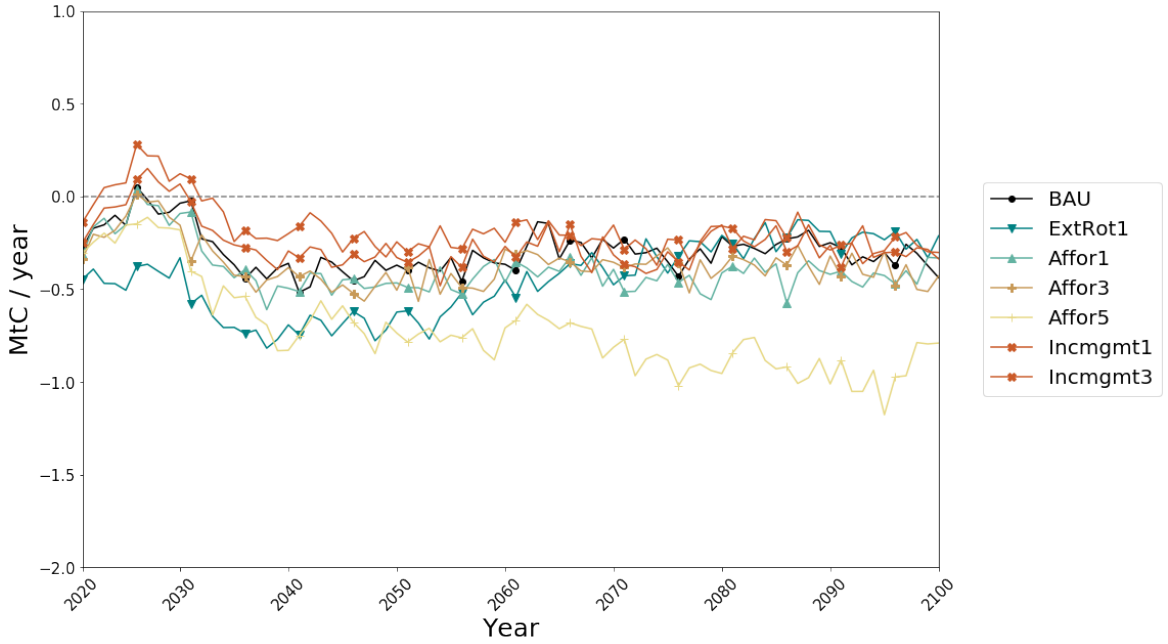
Age demographics

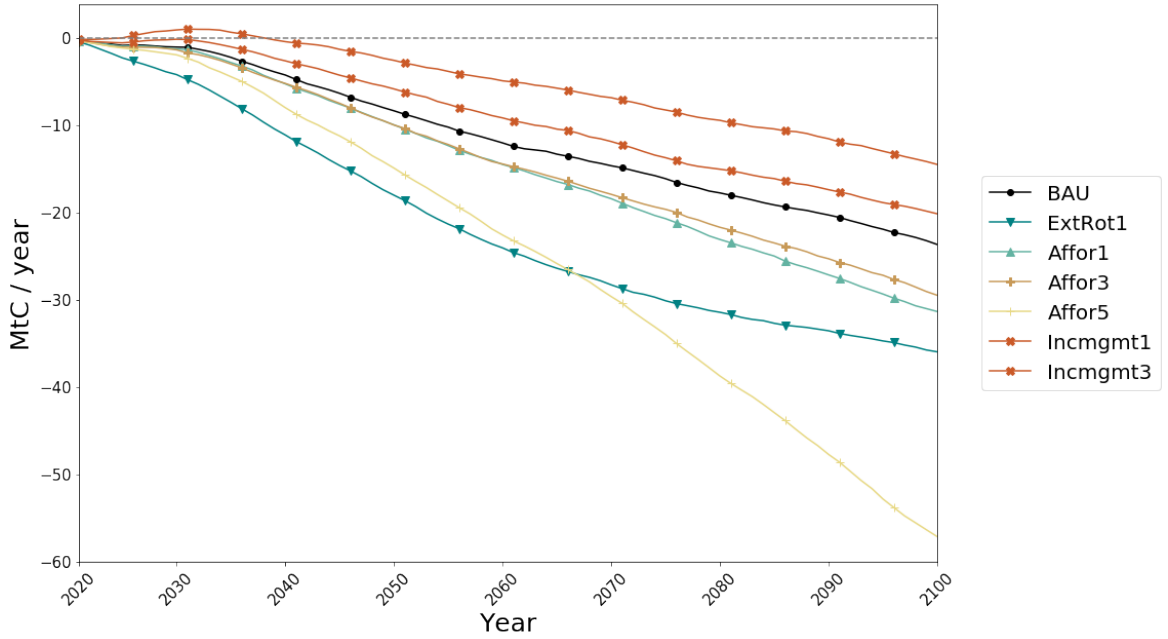


Alternate management scenarios

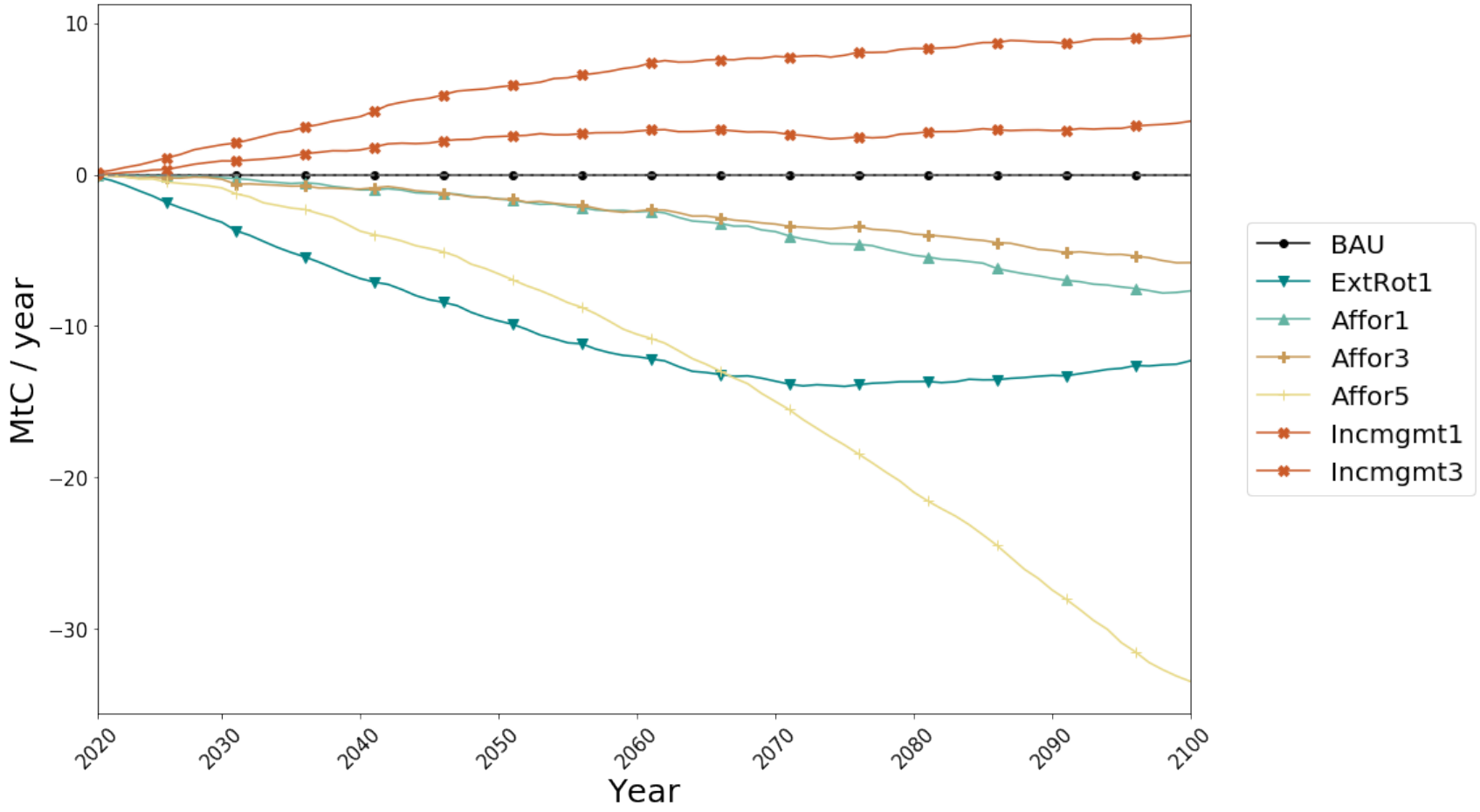
1. Extended Rotations
   - Red Pine, White Pine, Oak, Northern Hardwoods
2. Increased Reserved patch size
   - All lands
3. Increase Afforestation
   - Using percentage of available lands
4. Restocking
   - underplanting / regen cuts
5. Increased management
   - Increased mature harvest rates
   - All lands
6. Forest Type Conversion
   - Focus on Aspen
7. Oak Maintenance
   - Increased acres by oak type
8. Enhance course woody debris
   - Increase snags and CWD left on site

Scenario analysis





Scenario Analysis



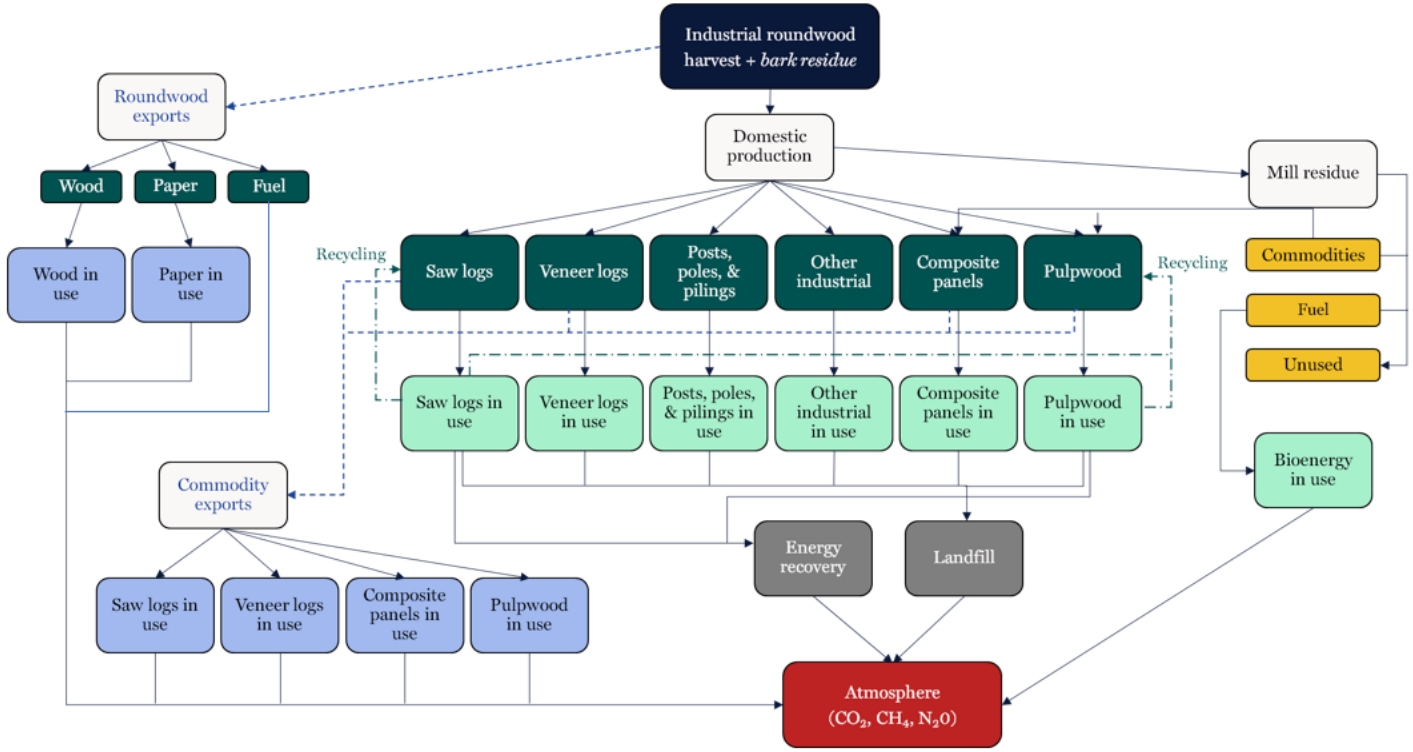
Linkages to HWP

- ANSE modeling framework adapted to and parameterized with US data
  - TPO survey, RPA assessments, US commodity flow surveys, US trade export data, FAOSTATE, GTR-343, other published literature / data
- Ecosystem model outputs aggregated by softwood / hardwood components by forest type
  - Then partitioned in HWP streams, exports, energy

Potential considerations for:

- Substitution, leakage, transportation emissions, harvest emissions

Final models?



Thanks! Questions?

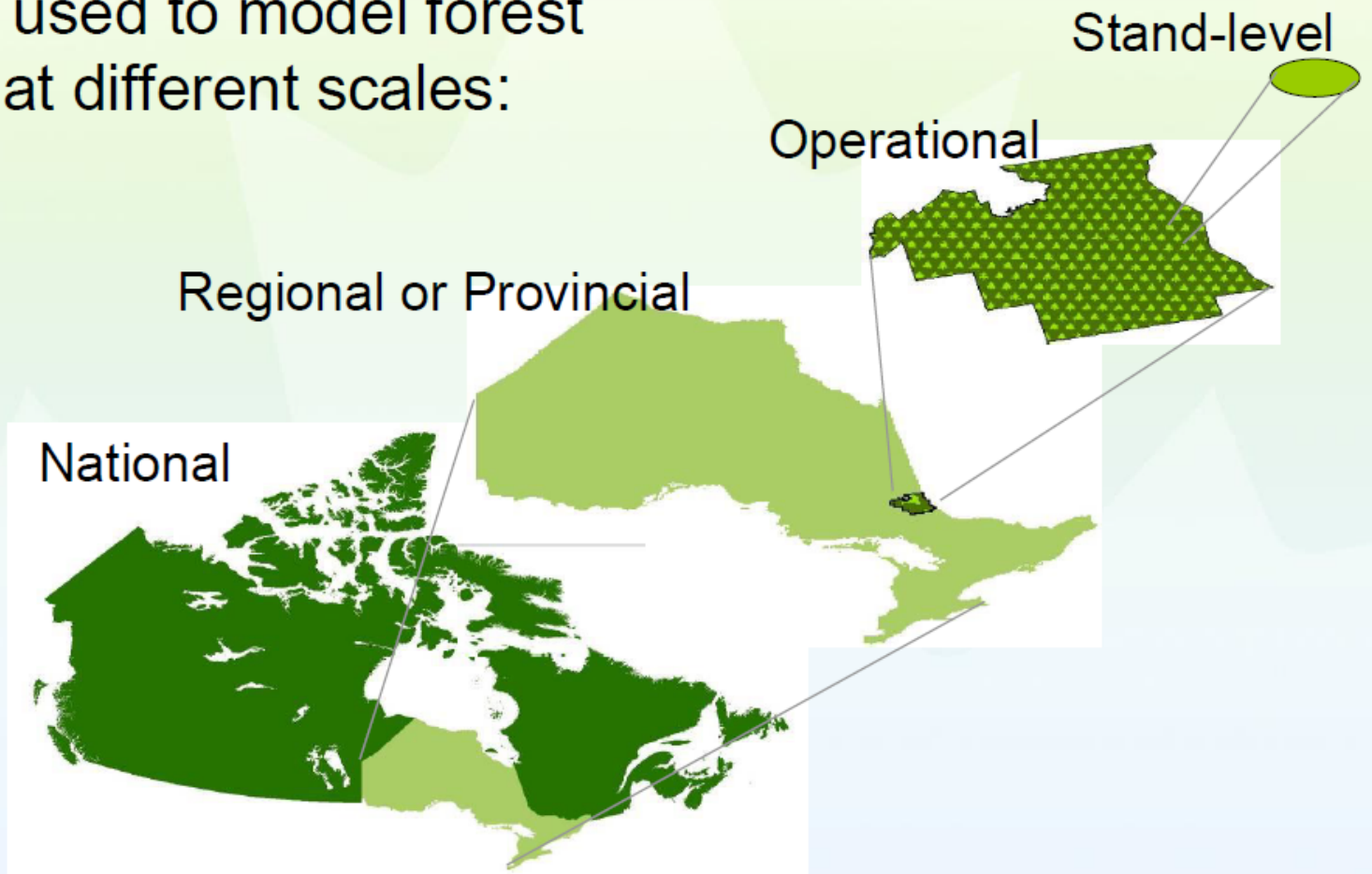
Contact: papachad@msu.edu

Acknowledgements: Werner Kurz, Michael Magnan, Eric Neilson, Scott Morken, Stephen Kull

Huge thanks to state partners!

Extra Slides

Can be used to model forest carbon at different scales:



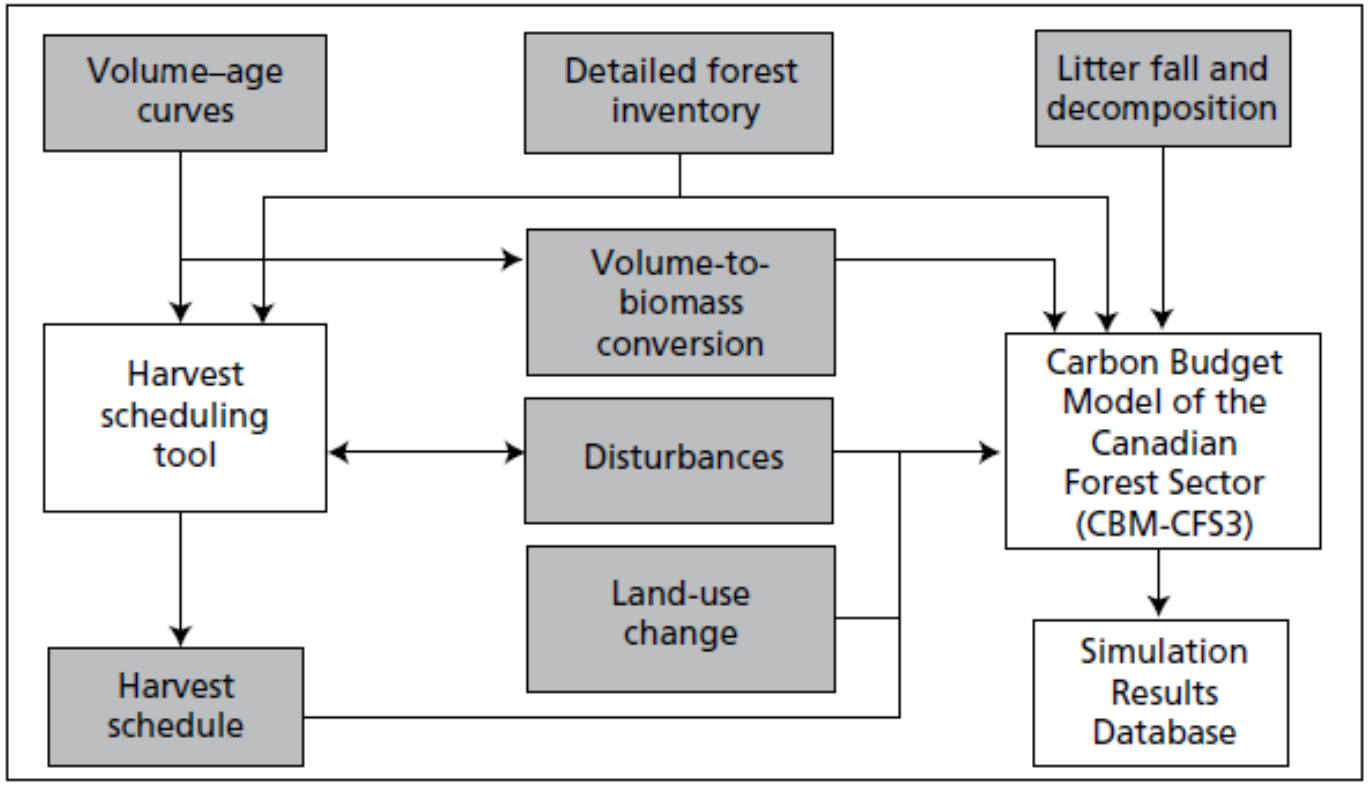


Figure 1-6. Data input (gray boxes) required by the CBM-CFS3.

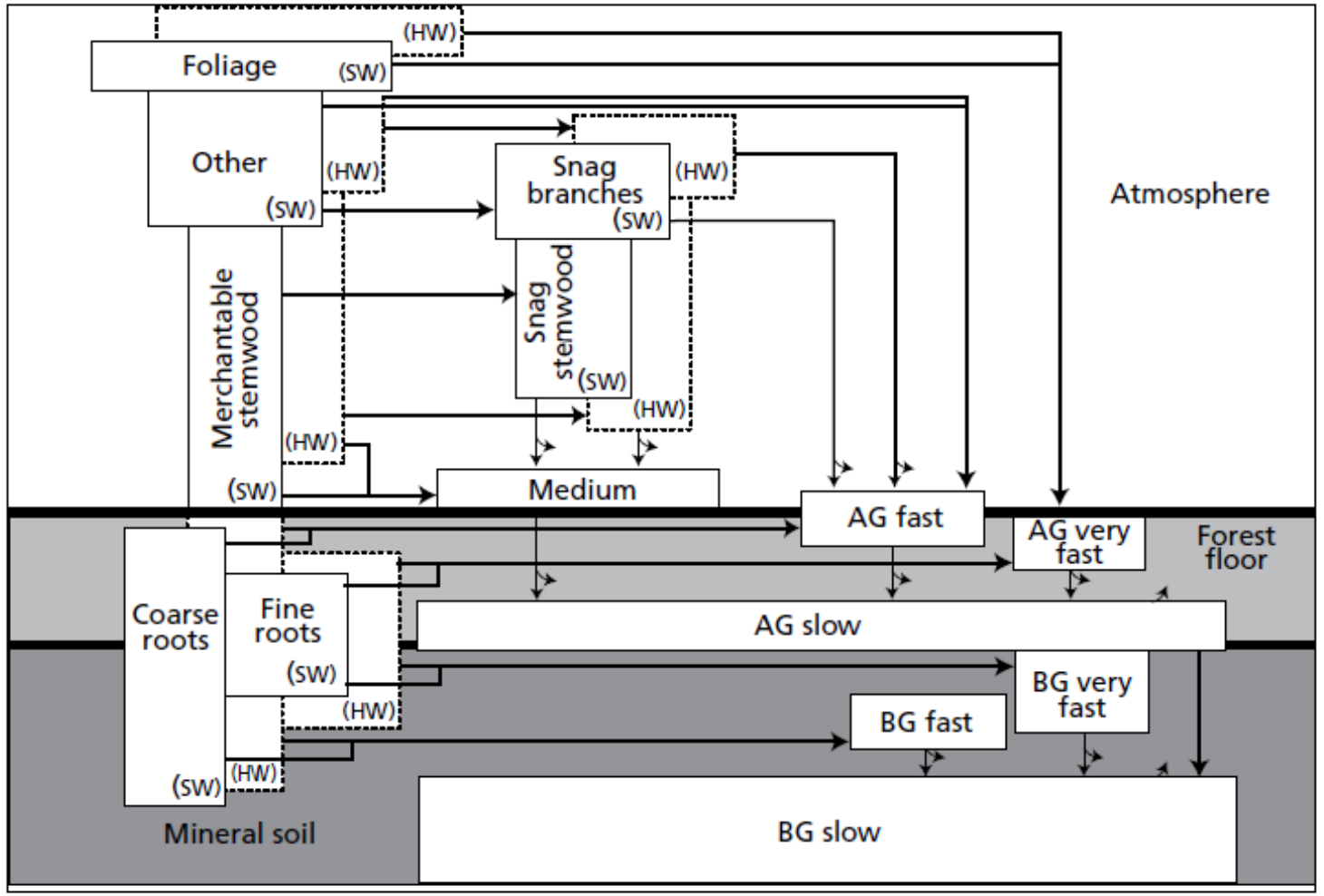
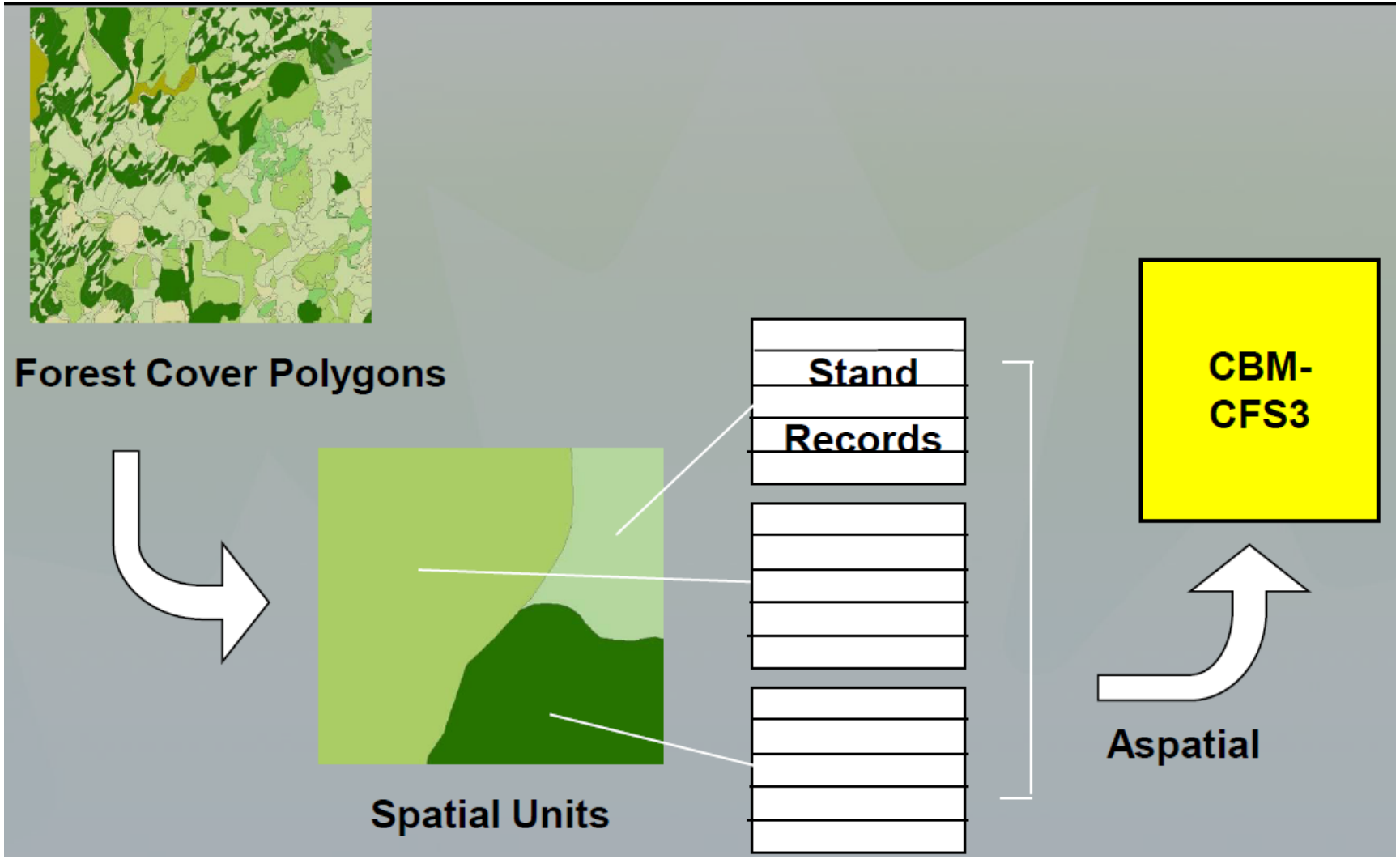


Figure 1-1. The carbon pool structure of the CBM-CFS3. "Very fast," "fast," "medium," and "slow" refer to the relative decay rates for the pools. Curved arrows represent transfers of carbon to the atmosphere, and straight arrows represent transfers from one pool to another. SW = softwood, HW = hardwood, AG = aboveground, BG = belowground.


Forest Cover Polygons
Stand
Records
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Spatial Units
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