Climate Change, Management, and Disturbance in Northern Wisconsin Forests

What do we need to understand to plan and manage for the future?

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Drivers and Stressors

- Changing climate itself
- Fire, wind, insects, deer
  - Other biological drivers
- Current, known drivers
  - Can be new (e.g., gypsy moth)
  - Or changed (e.g., fire)

Management effects

- Historical vs. current
  - Differ both in practices, context
  - Legacy effects of past
- Direct and Indirect
  - Site, landscape, and regional effects

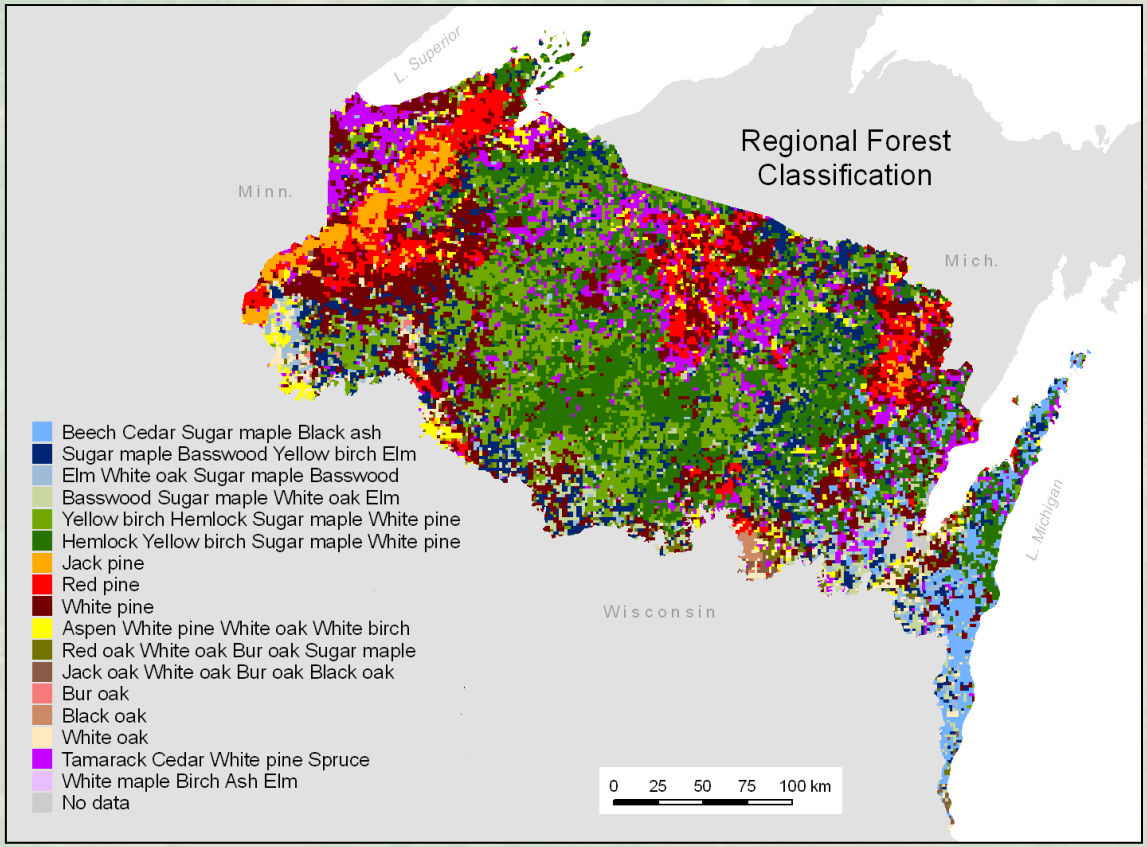
    - cumulative in space and time

      (e.g., silviculture, vs. land use)

Importance in Northern Lake States

- Tree species diversity
  - Integrate biogeographic regions

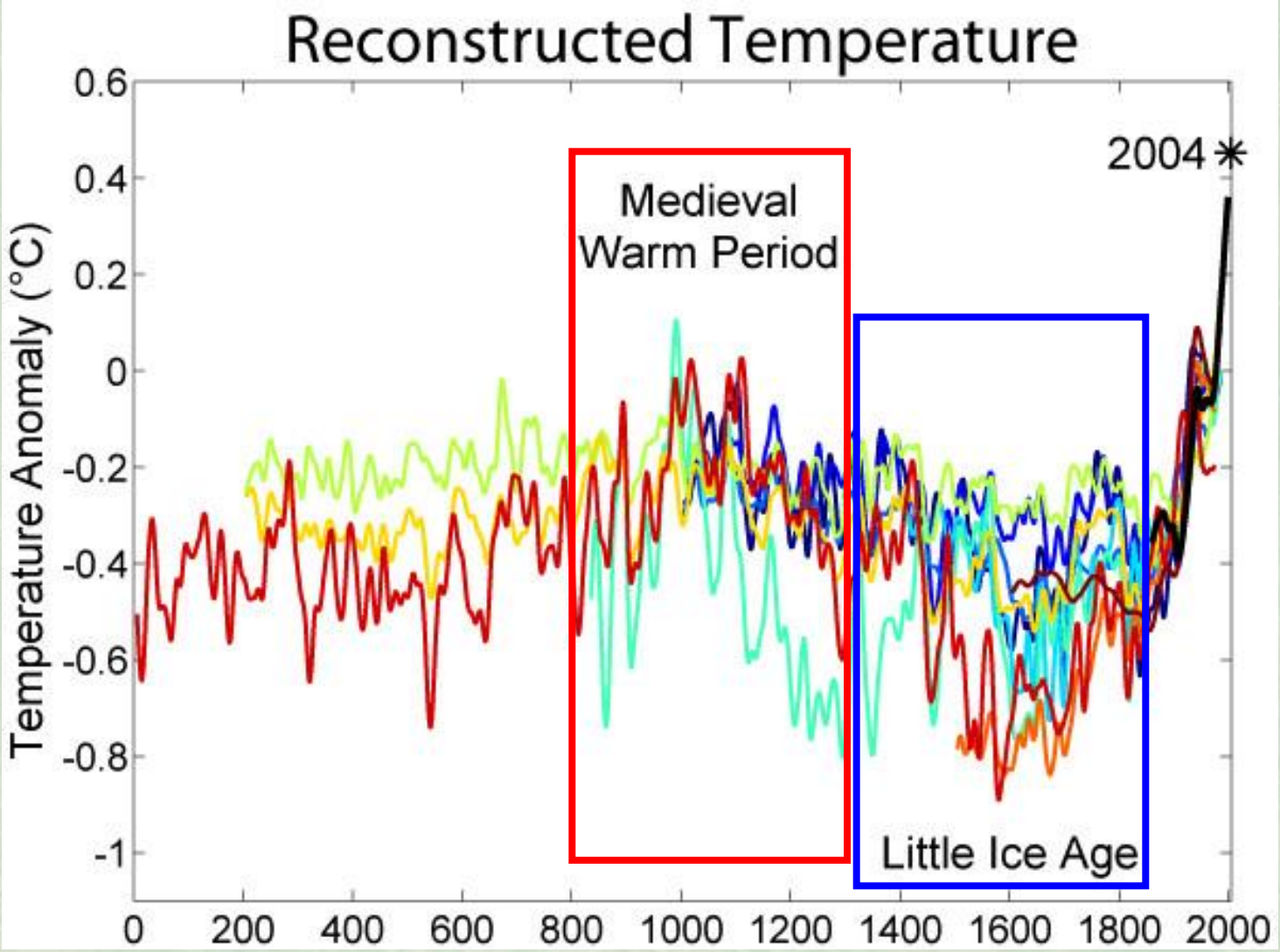
•Boreal conifers
•Eastern deciduous
•Laurentian/Lake States



Importance in Northern Lake States

- Climatic gradients
  - Ecotonal location
  - Potential for change
- Complex interactions among diverse species pool, disturbance and management
  - Potential for significant effect with modest climate change
- Need to understand recent, current, and future dynamics to guide management

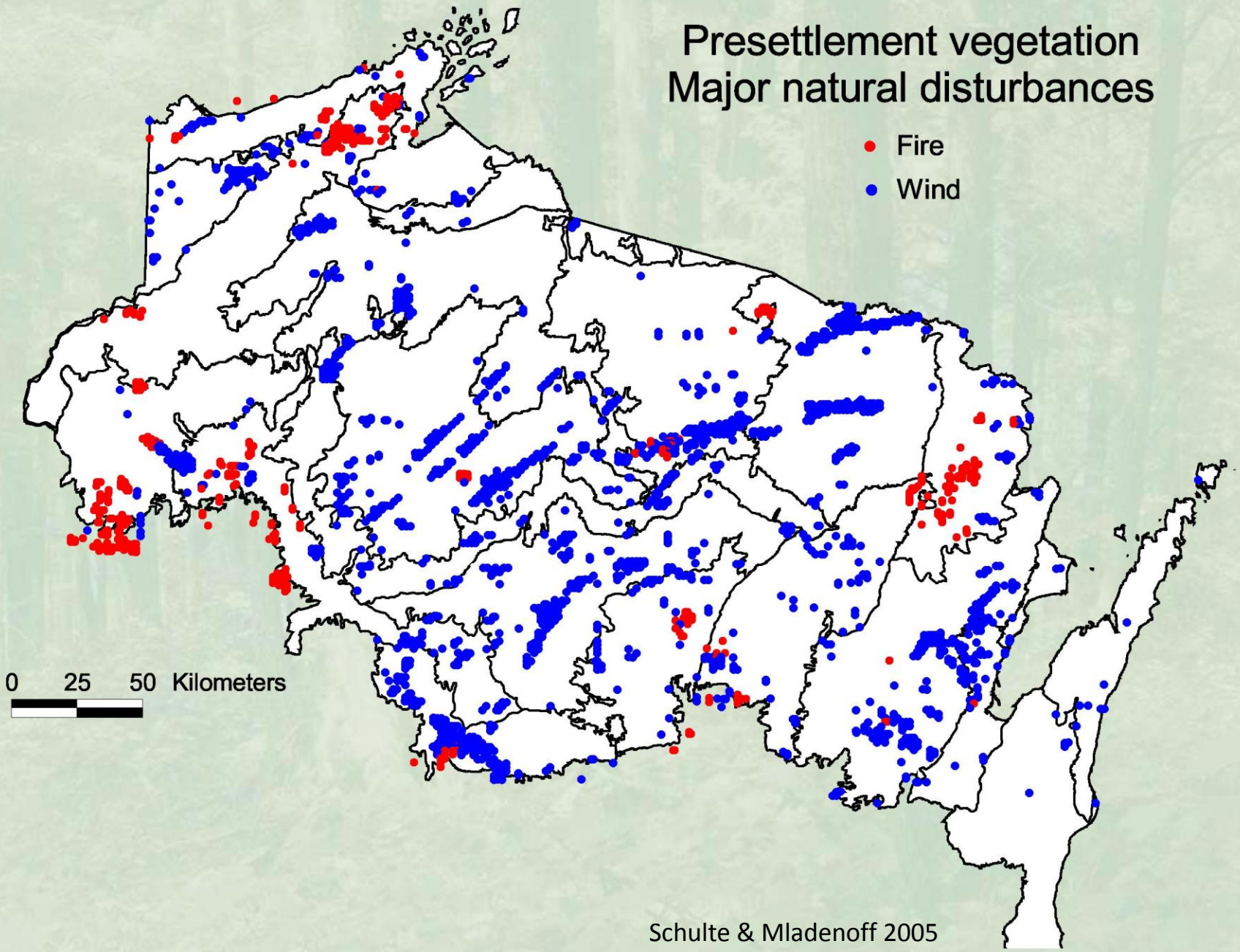
What do we know about past regimes and ecosystems?



C.E.

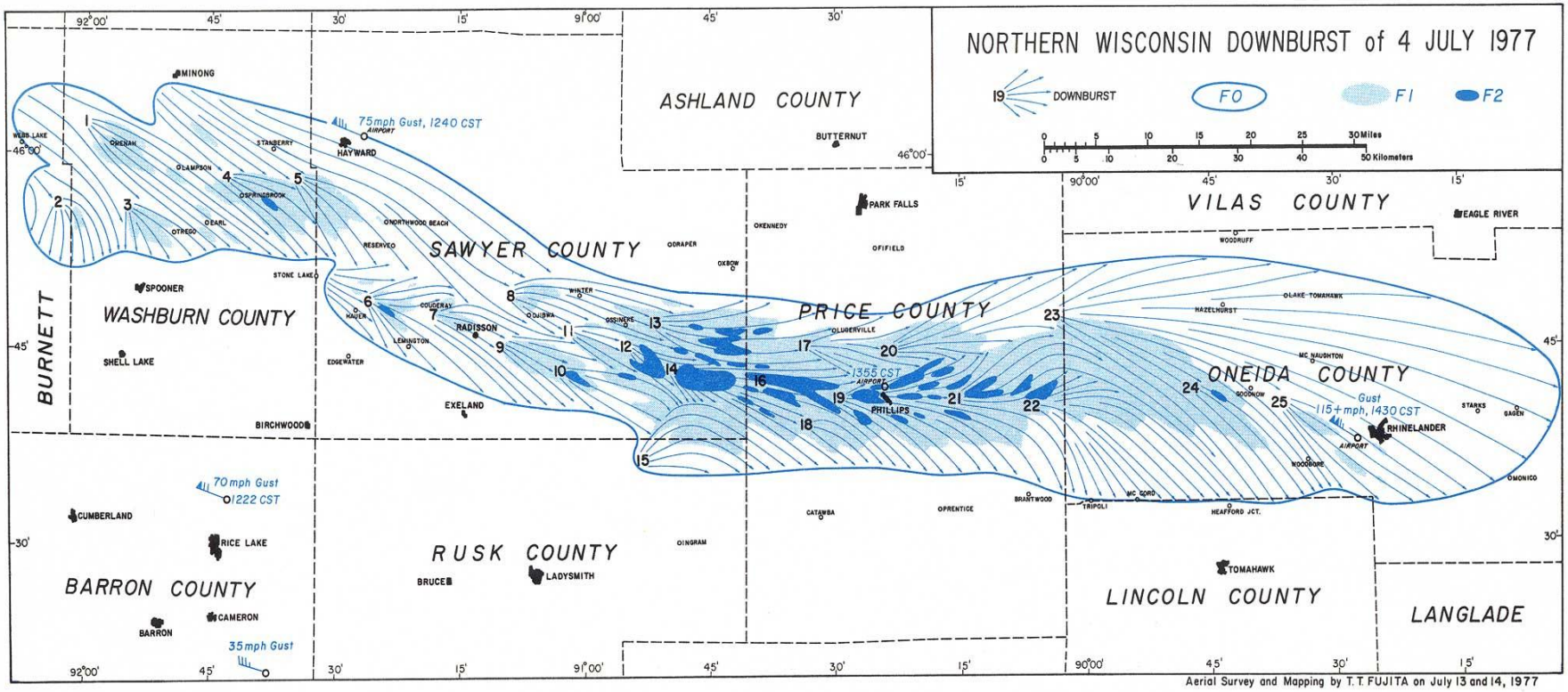
2000 1200 700 80 0 cal yr BP

http://www.globalwarmingart.com/wiki/Image:1000_Year_Temperature_Comparison_png
Jones et al. 1998, Mann et al. 1999, Crowley et al. 2000, Briffa et al. 2001, Esper et al. 2002, Mann & Jones 2003, Jones & Mann 2004, Huang 2004, Moberg et al. 2005, Oerlemans 2005.



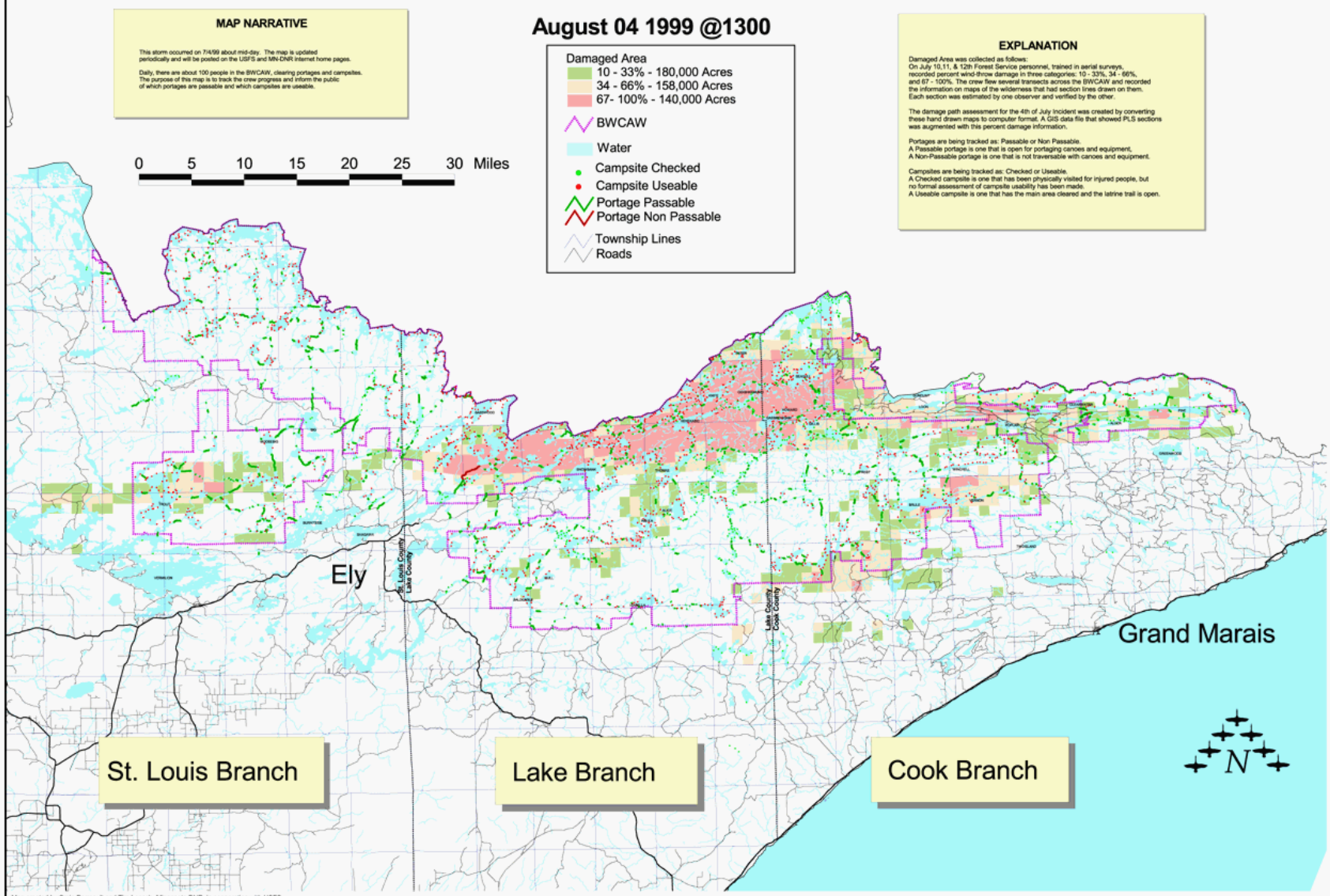
Schulte & Mladenoff 2005

Flambeau Blowdown 4 July 1977



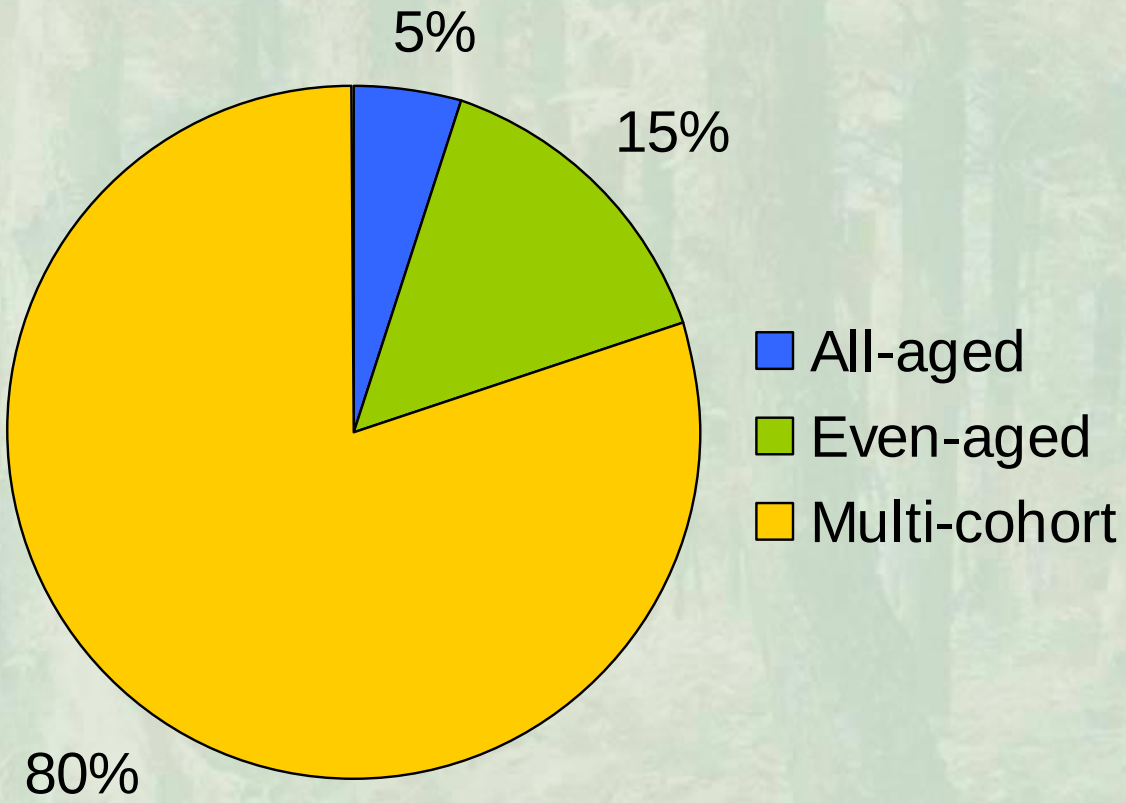
Map 4. Twenty-five downbursts on Independence Day in Northern Wisconsin left behind a damage swath 166-miles long and 17-miles wide. No evidence of a tornado was found anywhere.

4th of July Storm Recovery



From http://www.ra.dnr.state.mn.us/bwca/maps/

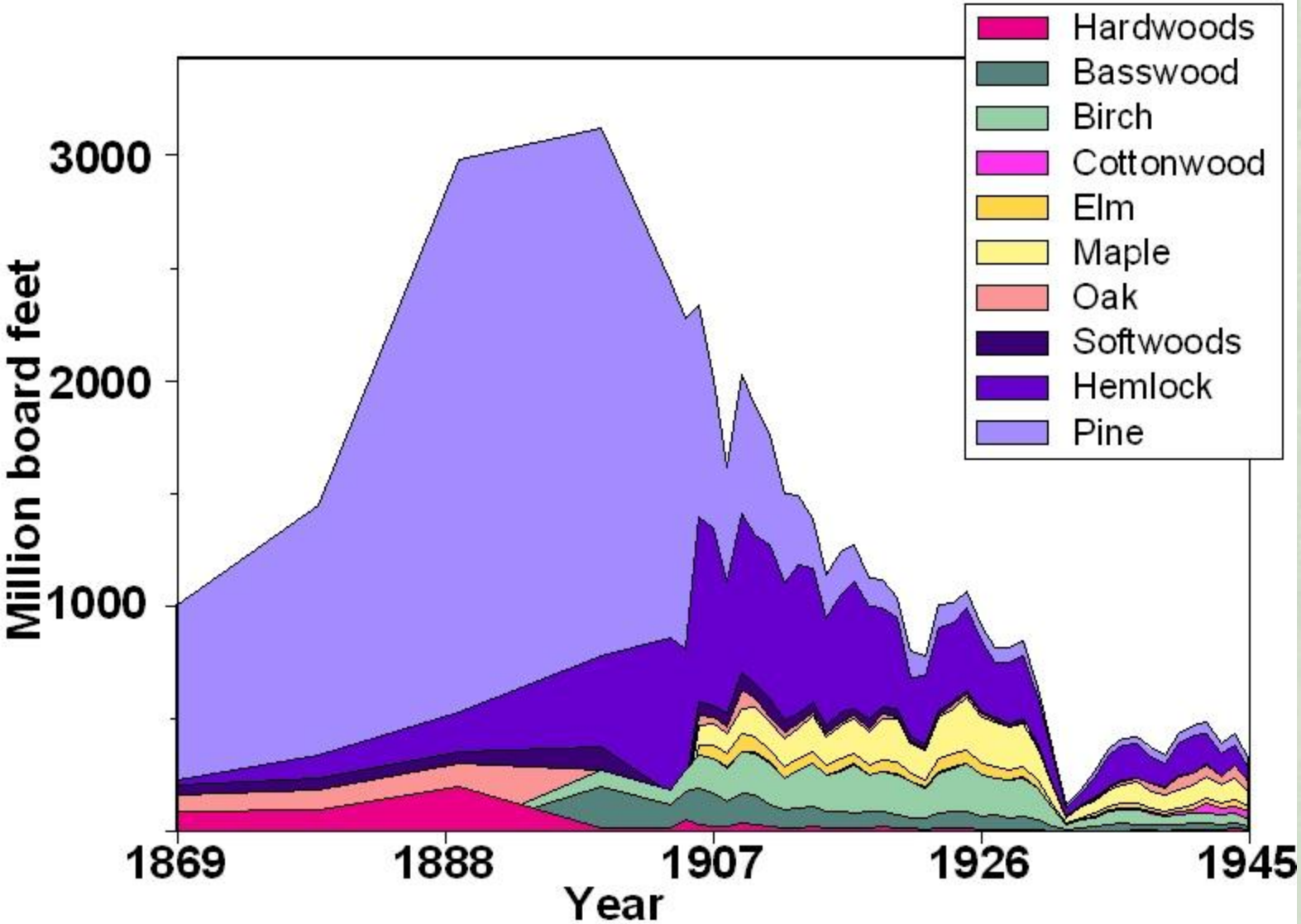
Result……



Composition of presettlement northern hardwood forest landscape

Courtesy J. Hanson; based on Hanson, Lorimer, Dahir, Frelich

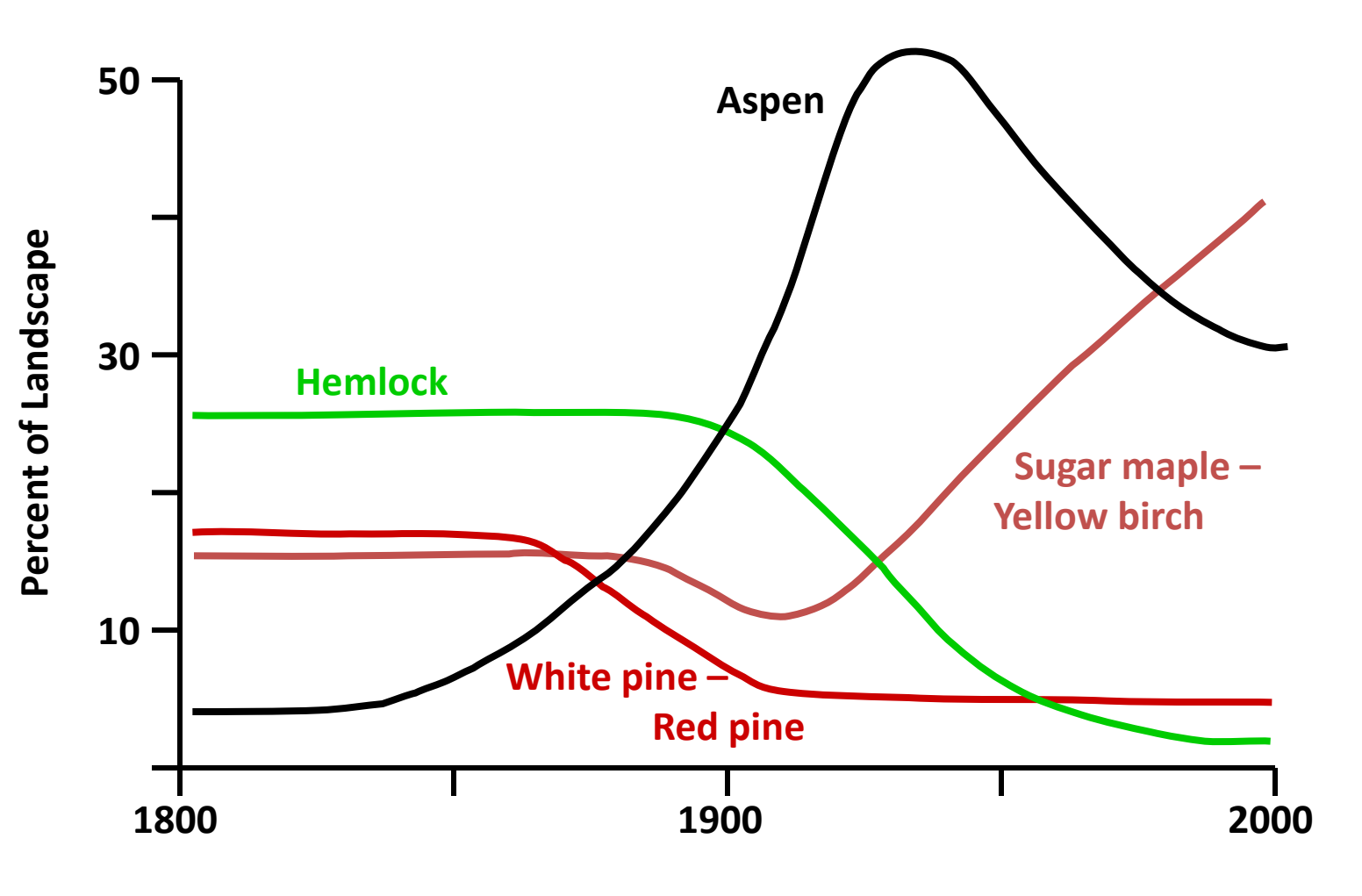
Historical Lumber Production in Wisconsin by Species



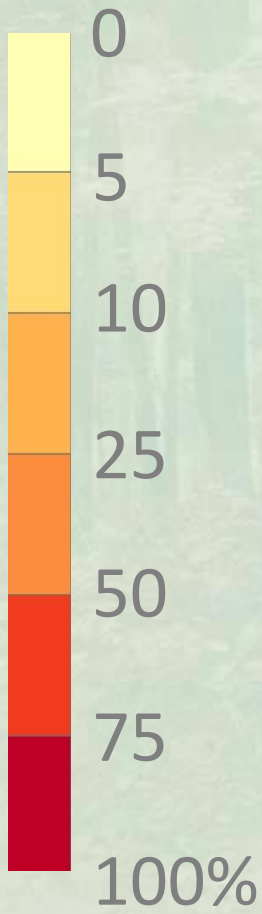
From Steer 1948

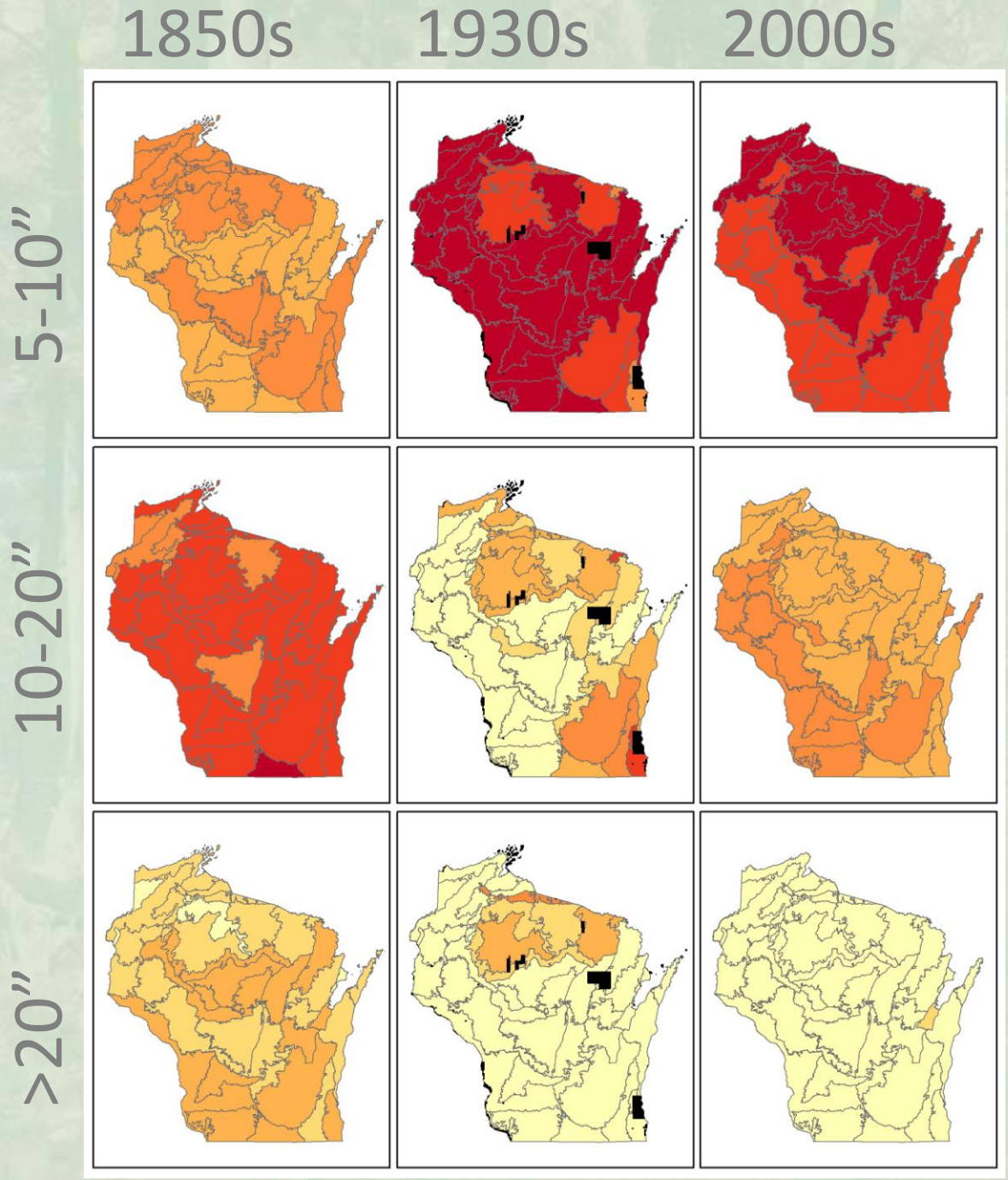
Historical Disturbance

Approximate Trends in Northern Wisconsin Forest Types



Proportion of trees by DBH Class





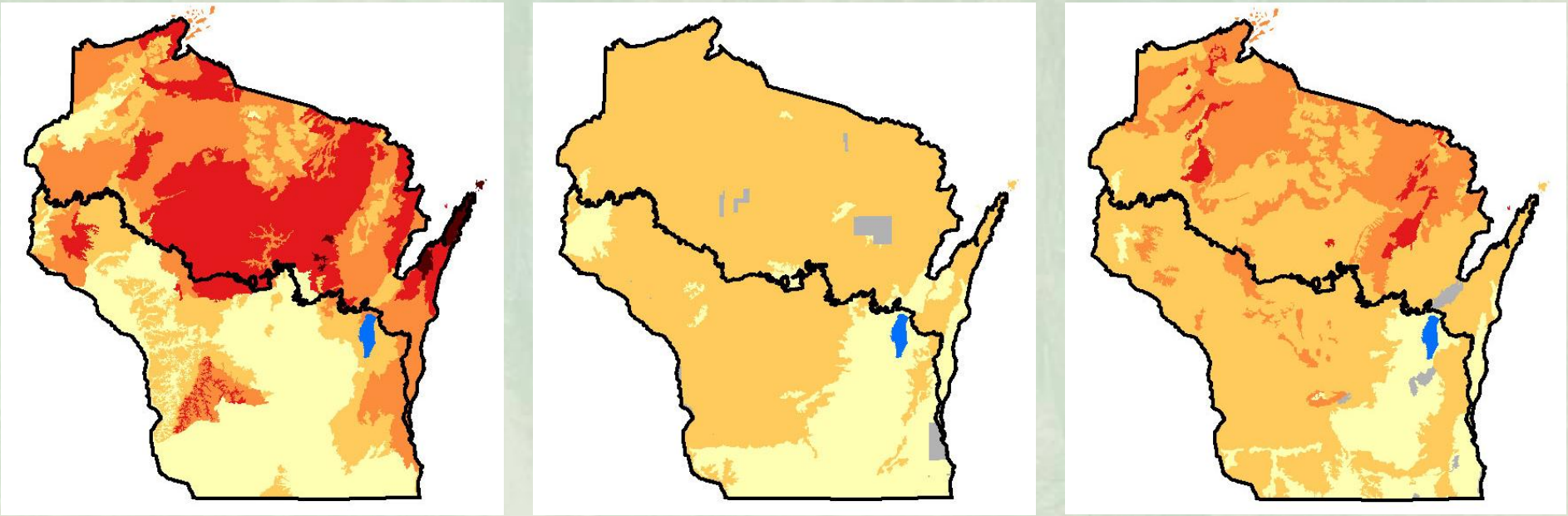
Rhemtulla et al. 2009a

Forest Carbon (Aboveground Live, Median)

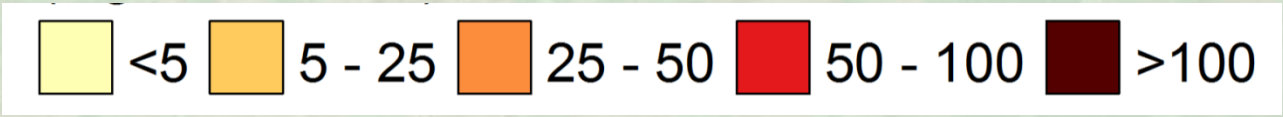
mid-1800s (pre-settlement)

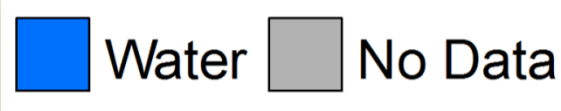
1930s (peak ag)

2000s



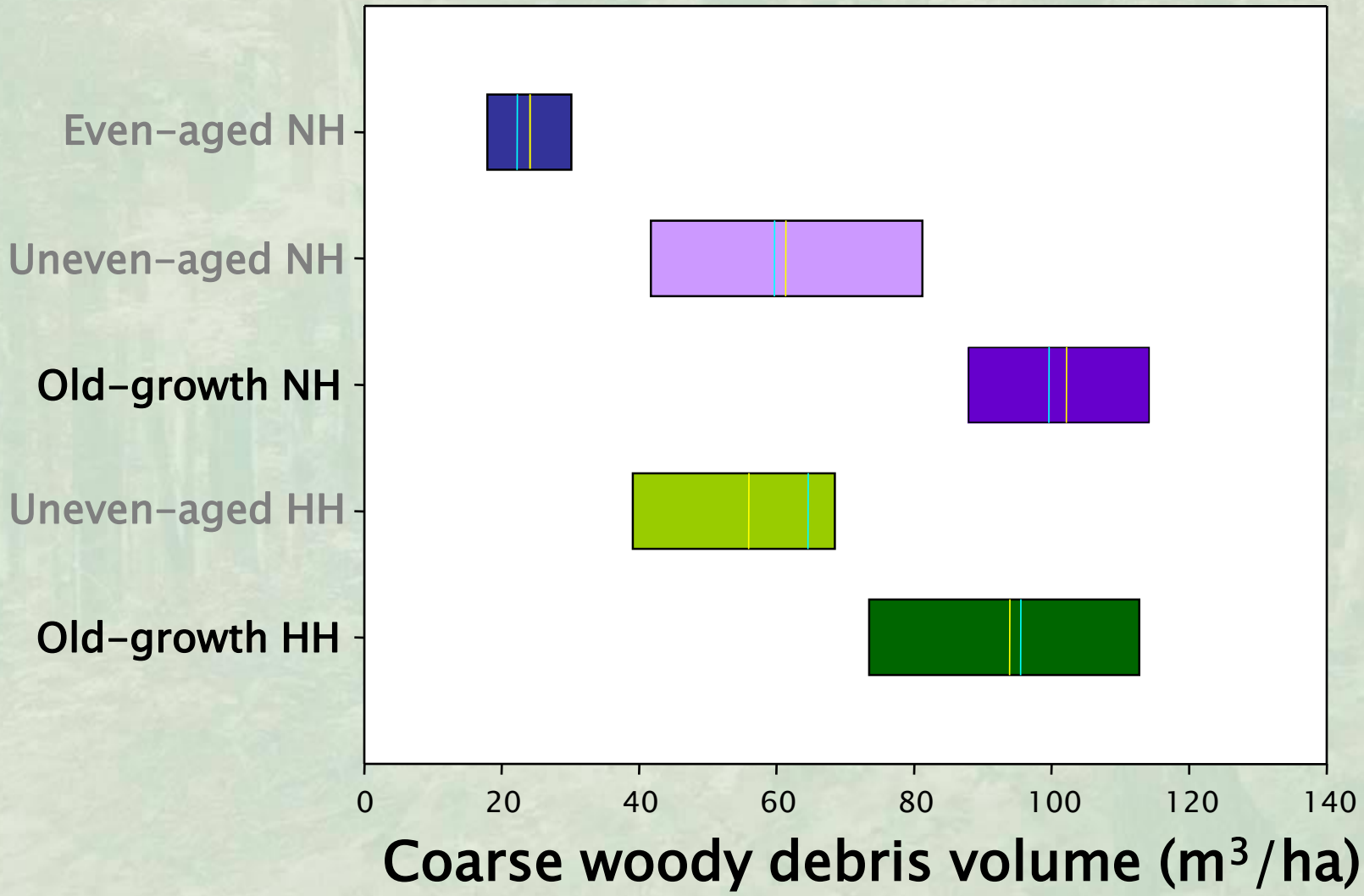
Carbon (MgC/ha)





Rhemtulla et al. 2009b

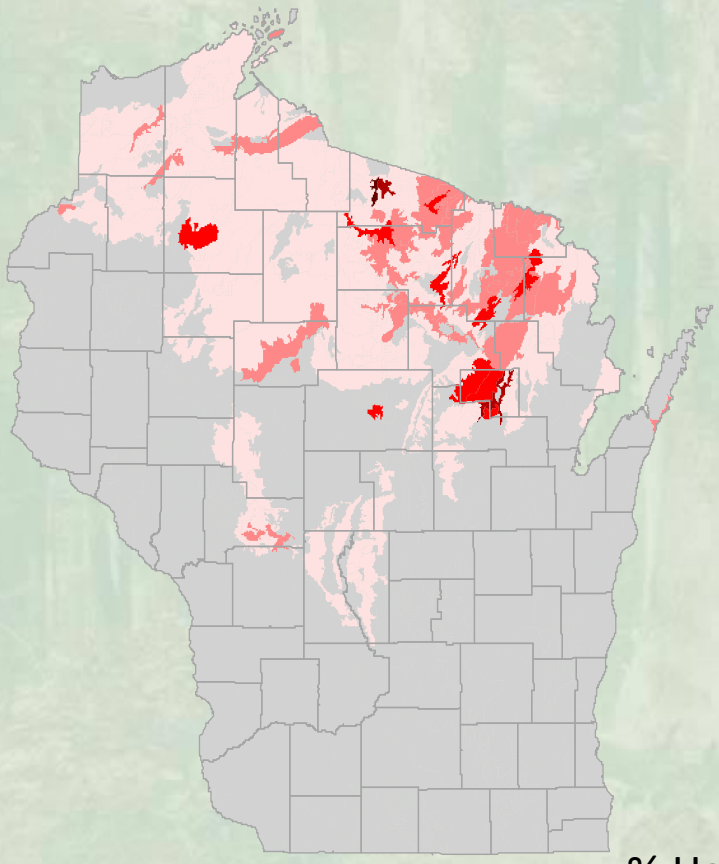
Downed coarse woody debris volume



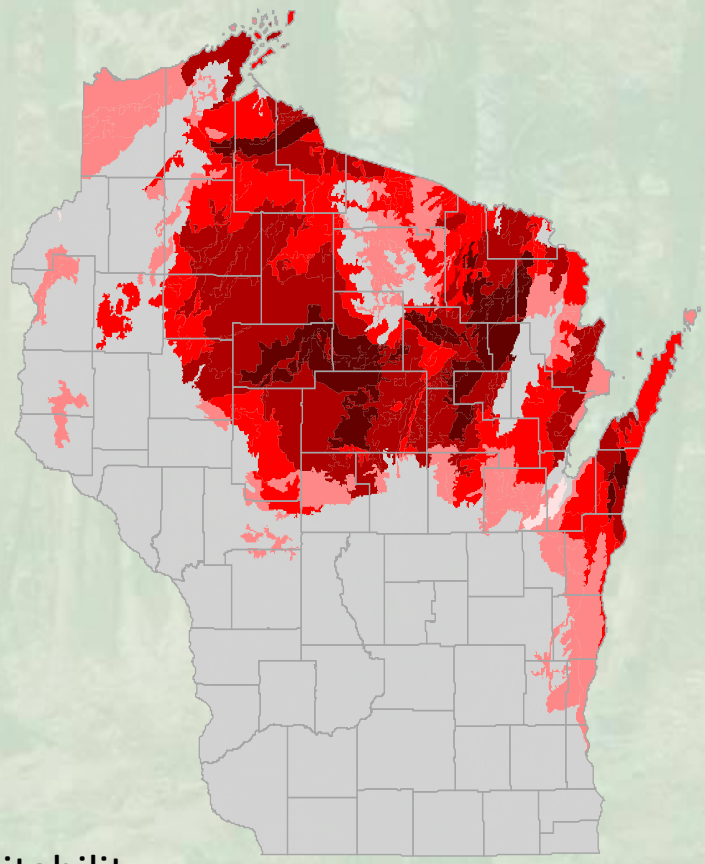
Goodburn & Lorimer 1998

Black-throated Green Warbler

Current Habitat Dist. Model



Presettlement Dist. Model



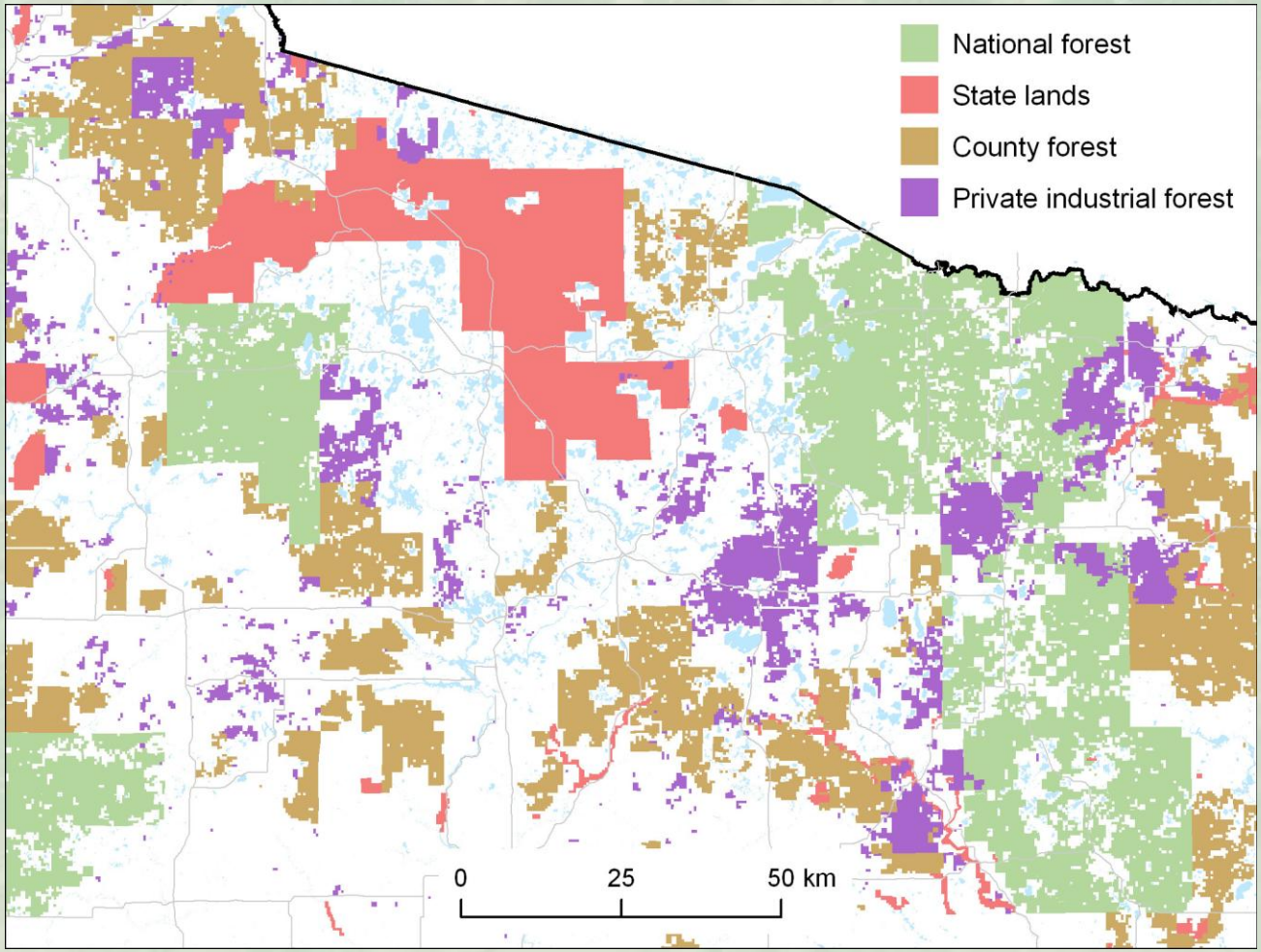
% Habitat Suitability

0
1 - 20
20 - 40
40 - 60
60 - 80
80 - 100

Schulte et al. 2005

Variable Land Management

Major Forest Land Ownership



Source: Wisconsin Department of Natural Resources

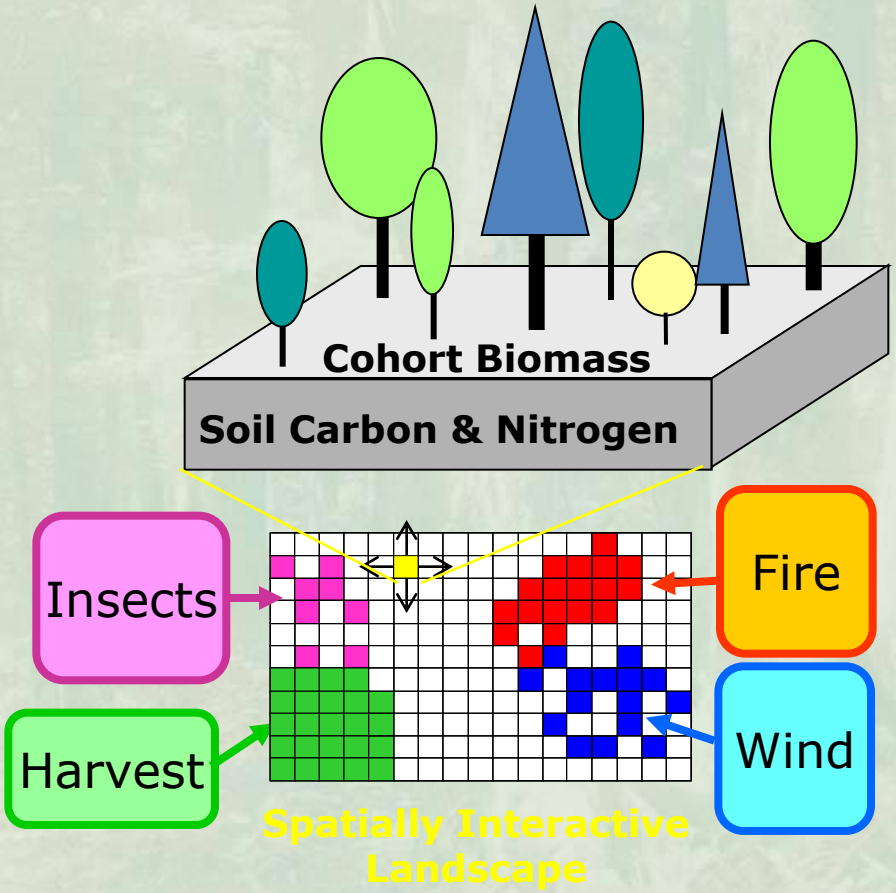
Complex Dynamics and Change- How Can we Guide Management?

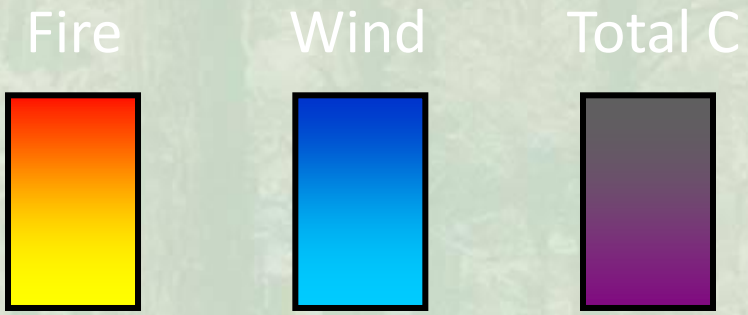
- Can we really model all these interacting drivers, under future change, with confidence?
- We can estimate relative importance of drivers in simulation scenarios
- Suite of models
  - Statistical- Tree Atlas, FVS
  - Simulation-
    - PnET-CN, LANDIS II, Biome-BGC
- Questions, scale drive needs

LANDIS-II Modeling

- Two brief examples illustrating spatially dynamic simulation
  - Tree species
  - Heterogeneous disturbance and management
  - Climate change
  - Local and regional effects

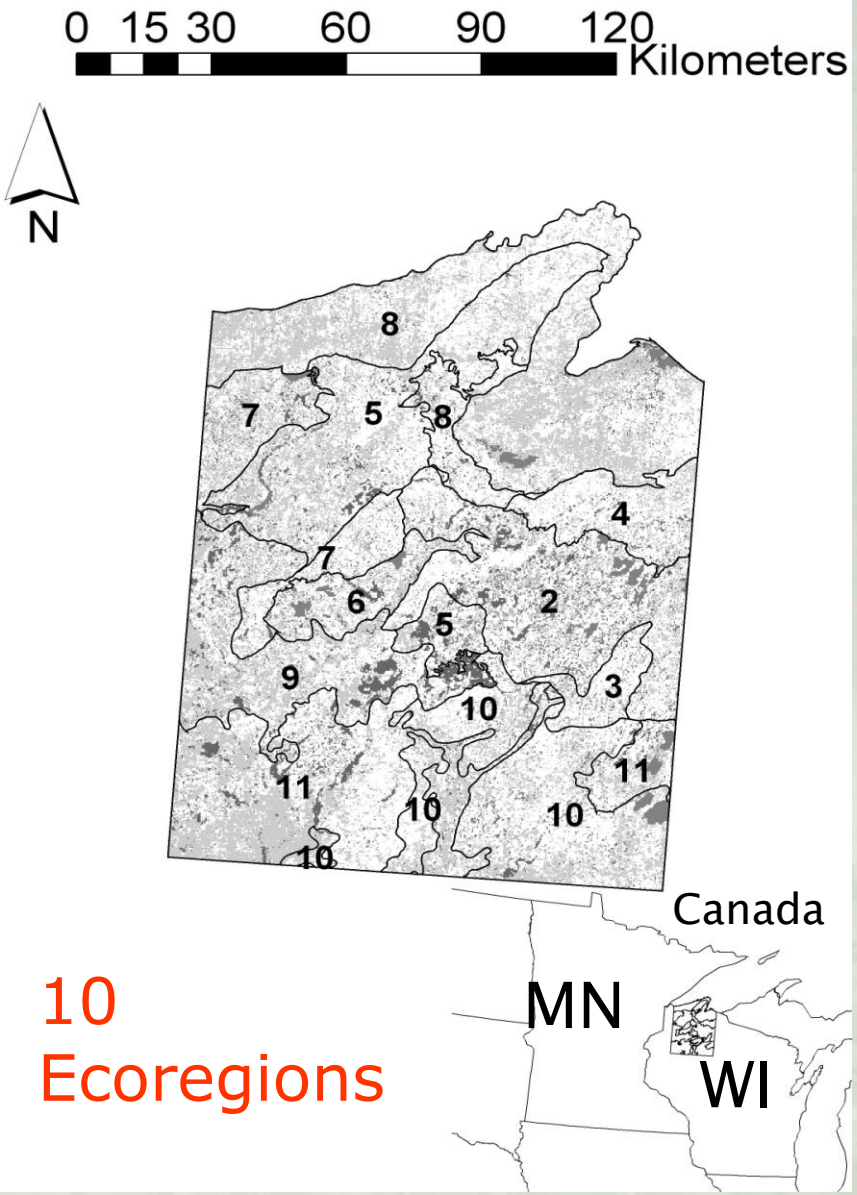
LANDIS-II





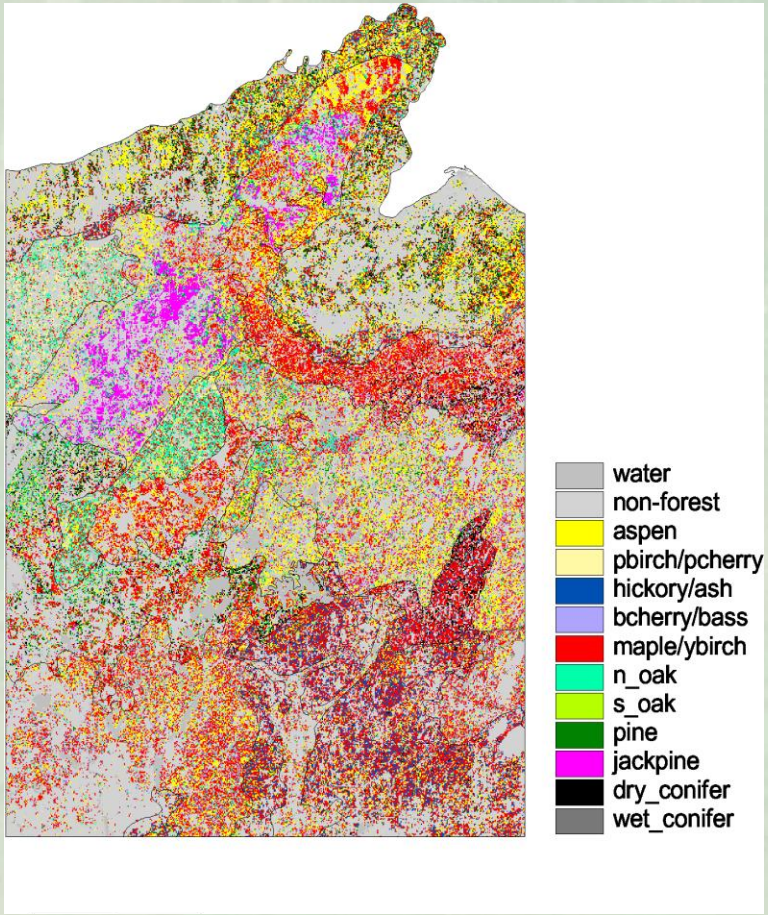
For Illustration ONLY

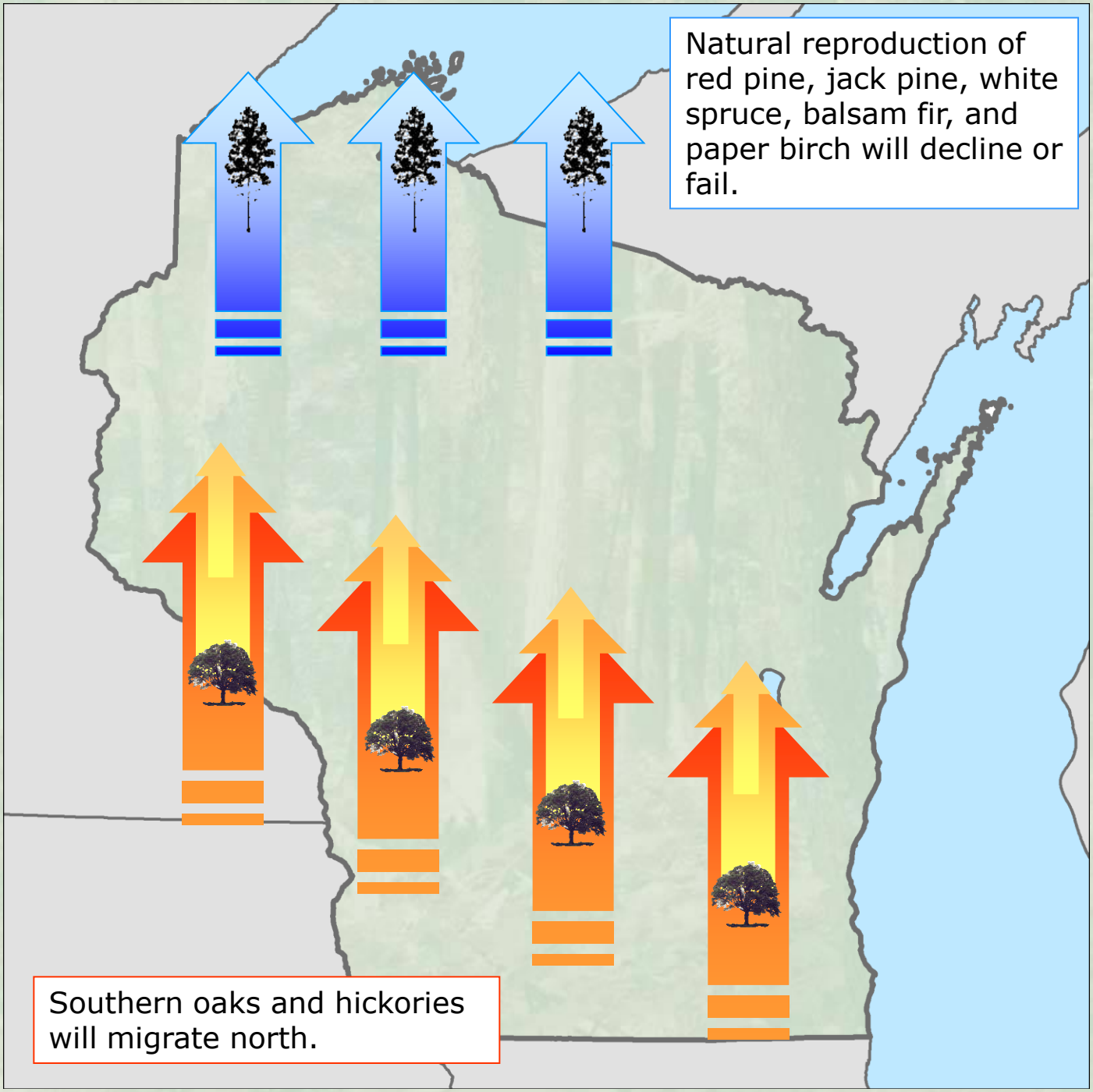
Climate Change: Study Area



10 Ecoregions

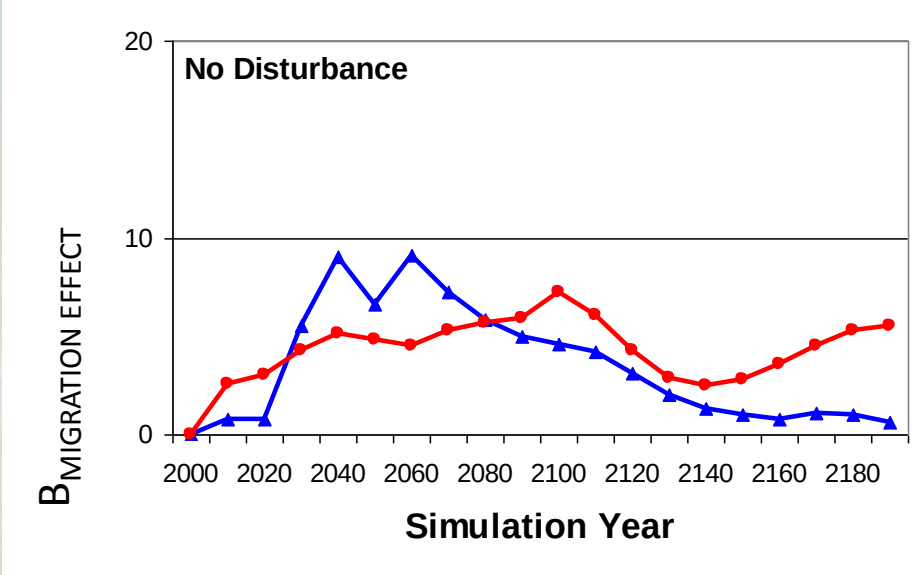
Divided into 10 ecoregions with homogeneous soils

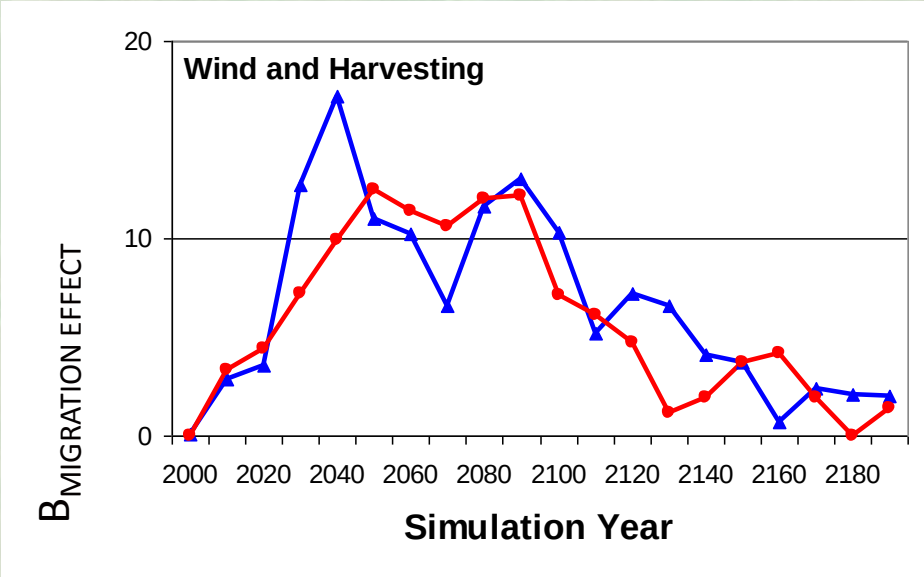



Natural reproduction of red pine, jack pine, white spruce, balsam fir, and paper birch will decline or fail.
Southern oaks and hickories will migrate north.

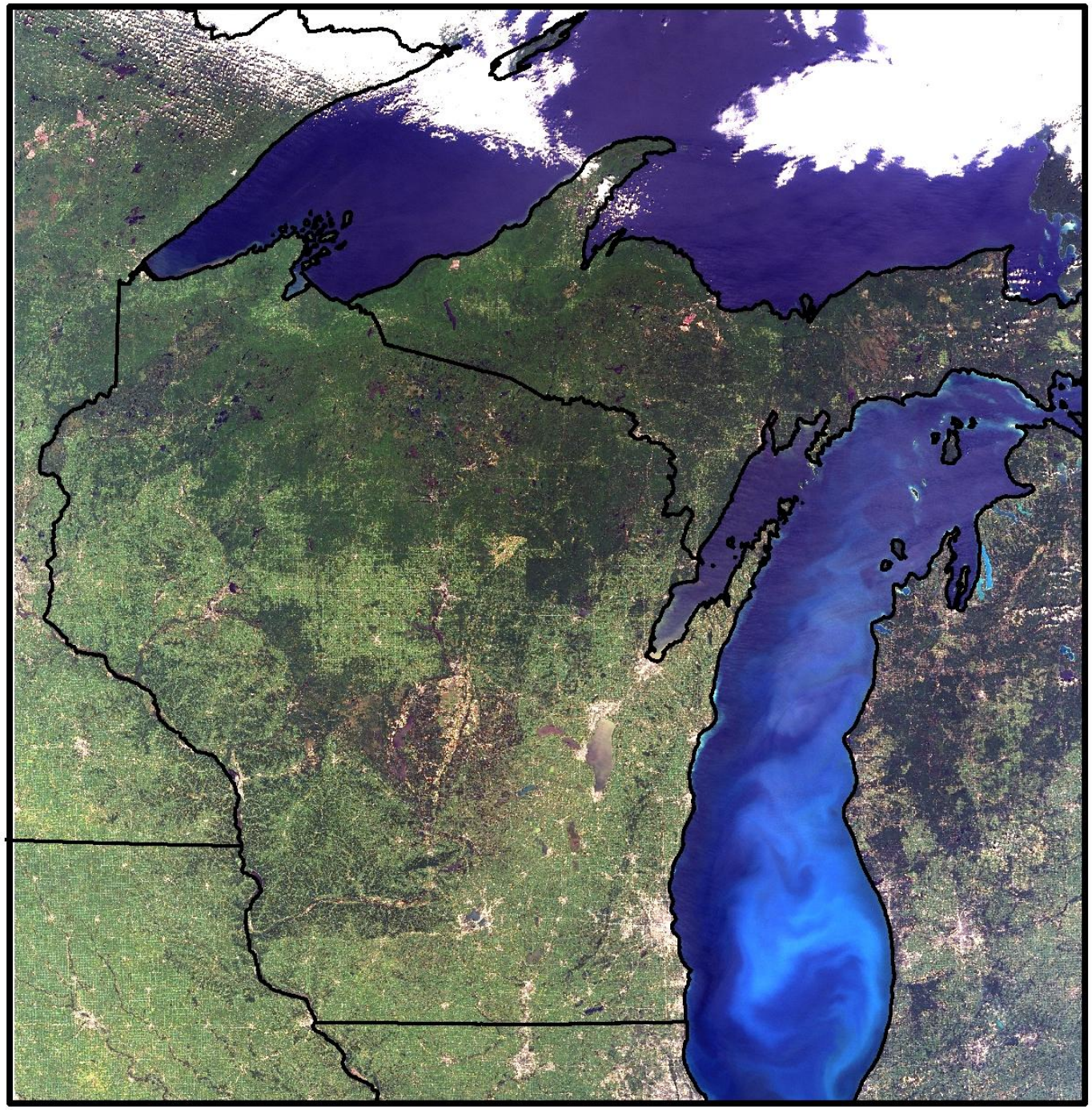
The Reduction of Aboveground Biomass Due to Migration Limitations

Hadley GCM
Canadian GCM





With spatially dynamic processes, management effects interact with landscape fragmentation to limit forest response.

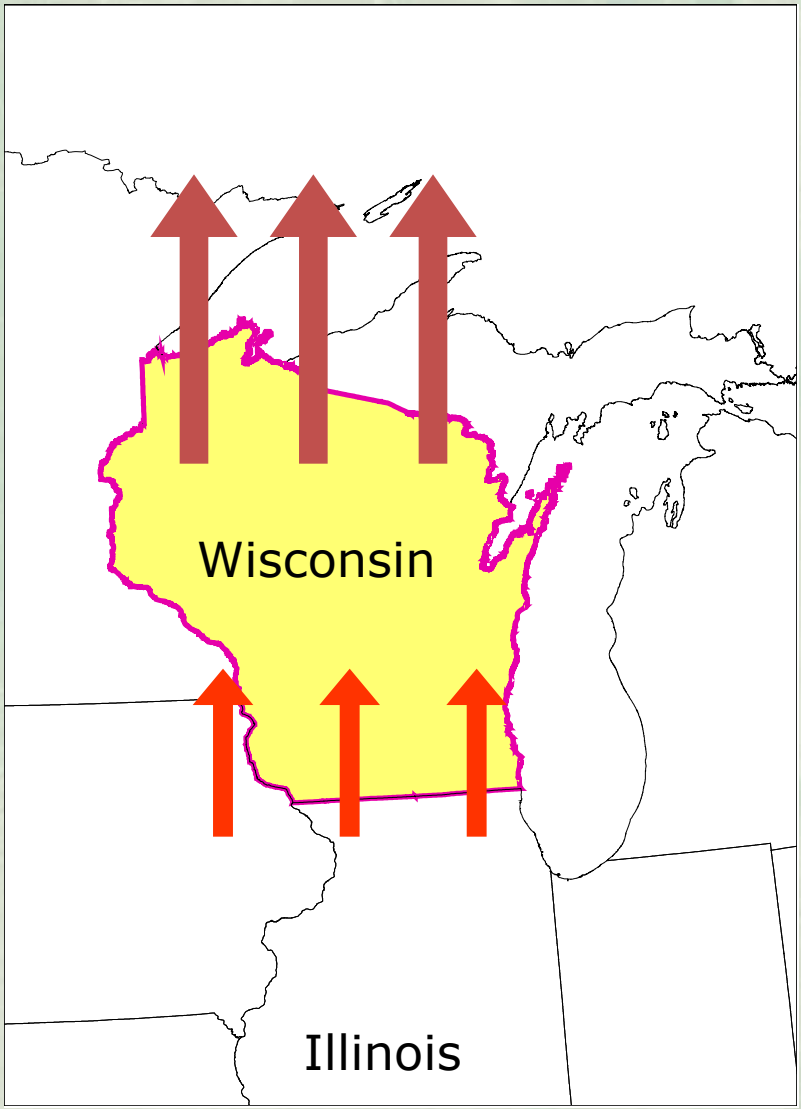


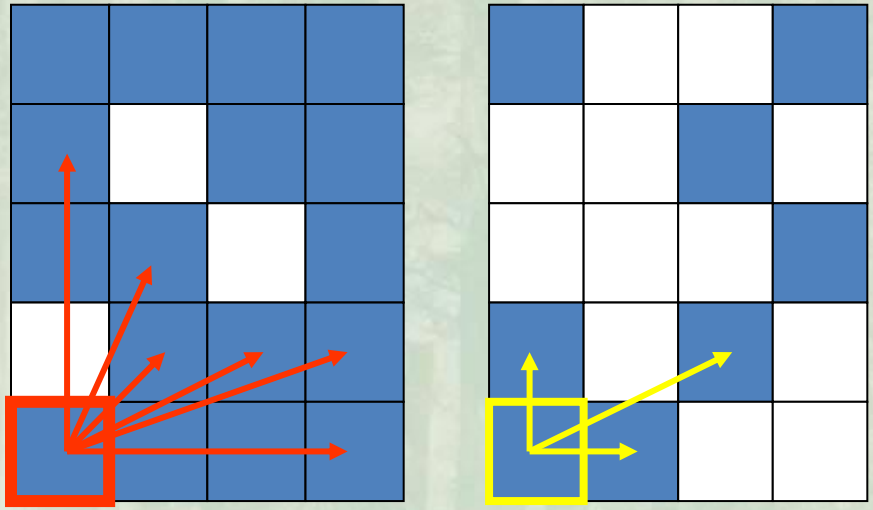
September 3, 2002
MODIS Image from
www.wisconsinview.org

N

50 25 0 50 100
Kilometers

Rapid climate change vs. slow growing trees





Modern, fragmented landscape:

Tree species migration north limited by:

- Seed dispersal
- Sites occupied by current species
- Ambiguous disturbance effects
- Generational lags
- Landscape fragmentation

Results:

Climate change, disturbance (logging, windstorms) and landscape fragmentation interact and have large effects

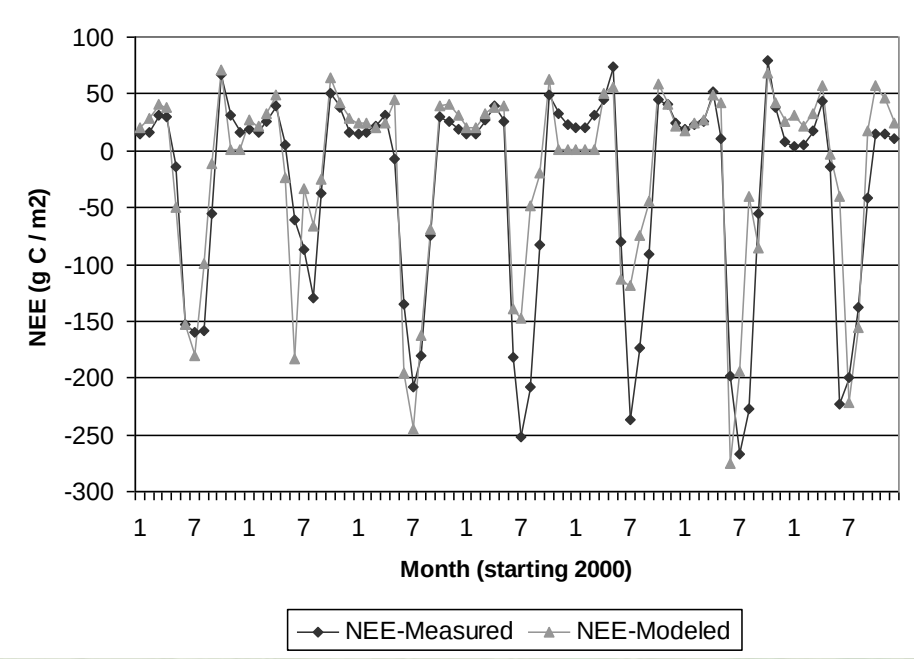
- *Some tree species will decline significantly in abundance and may be extirpated due to climate change*
    - Spruce, red pine, jack pine, paper birch, fir
    - (aspen,…..)

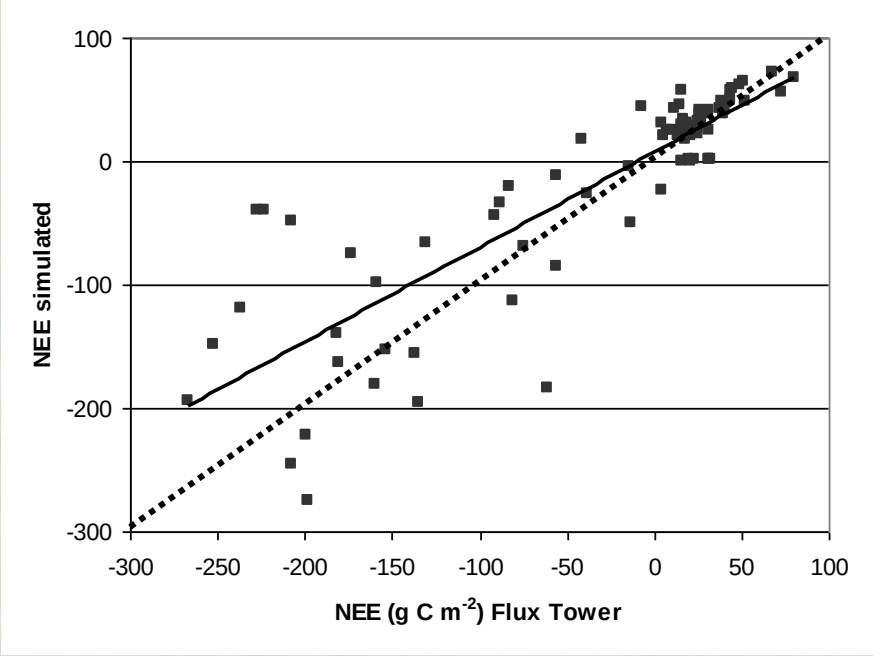
Results:

- Some tree species will experience transitory decline due to habitat/site changes
  - Eventual “escape on the landscape”
  - e.g., possibly sugar maple, white pine
- Southern species slow to arrive
  - Biomass decline under ambient disturbance and management

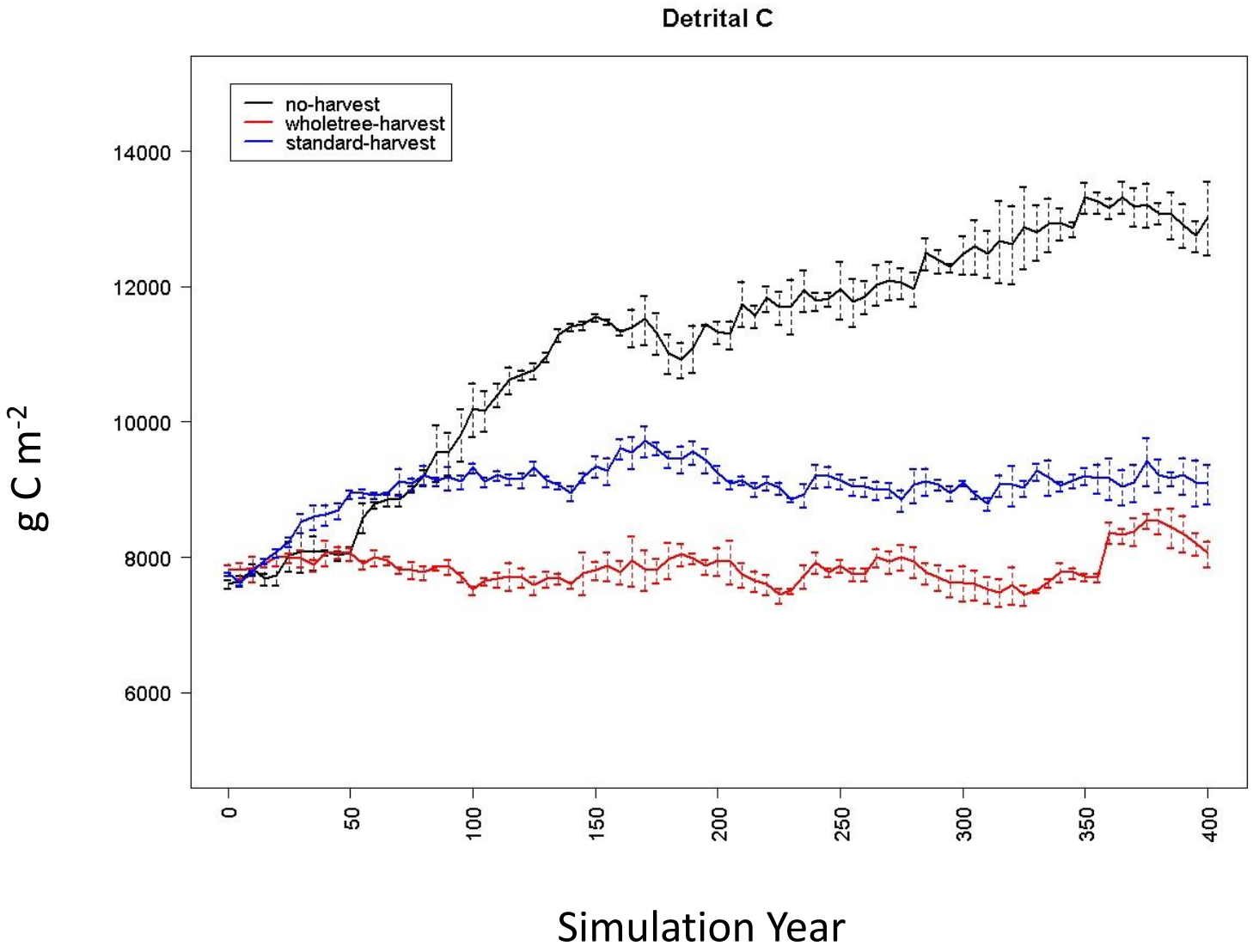
Second simulation
Harvesting and species effects on carbon

- Soil extension was parameterized for Willow Creek Experimental Forest
- Calibrated against flux tower NEE data

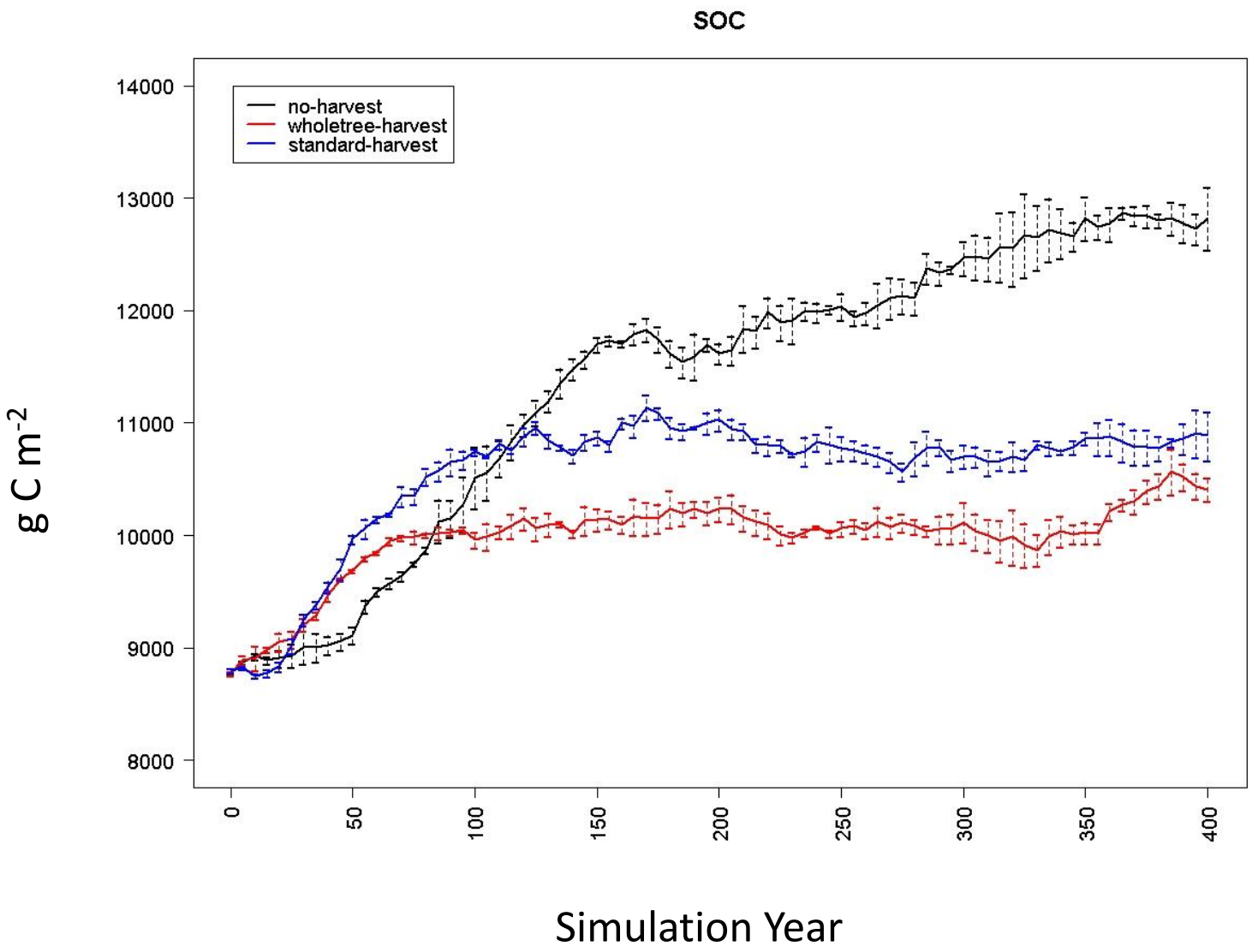




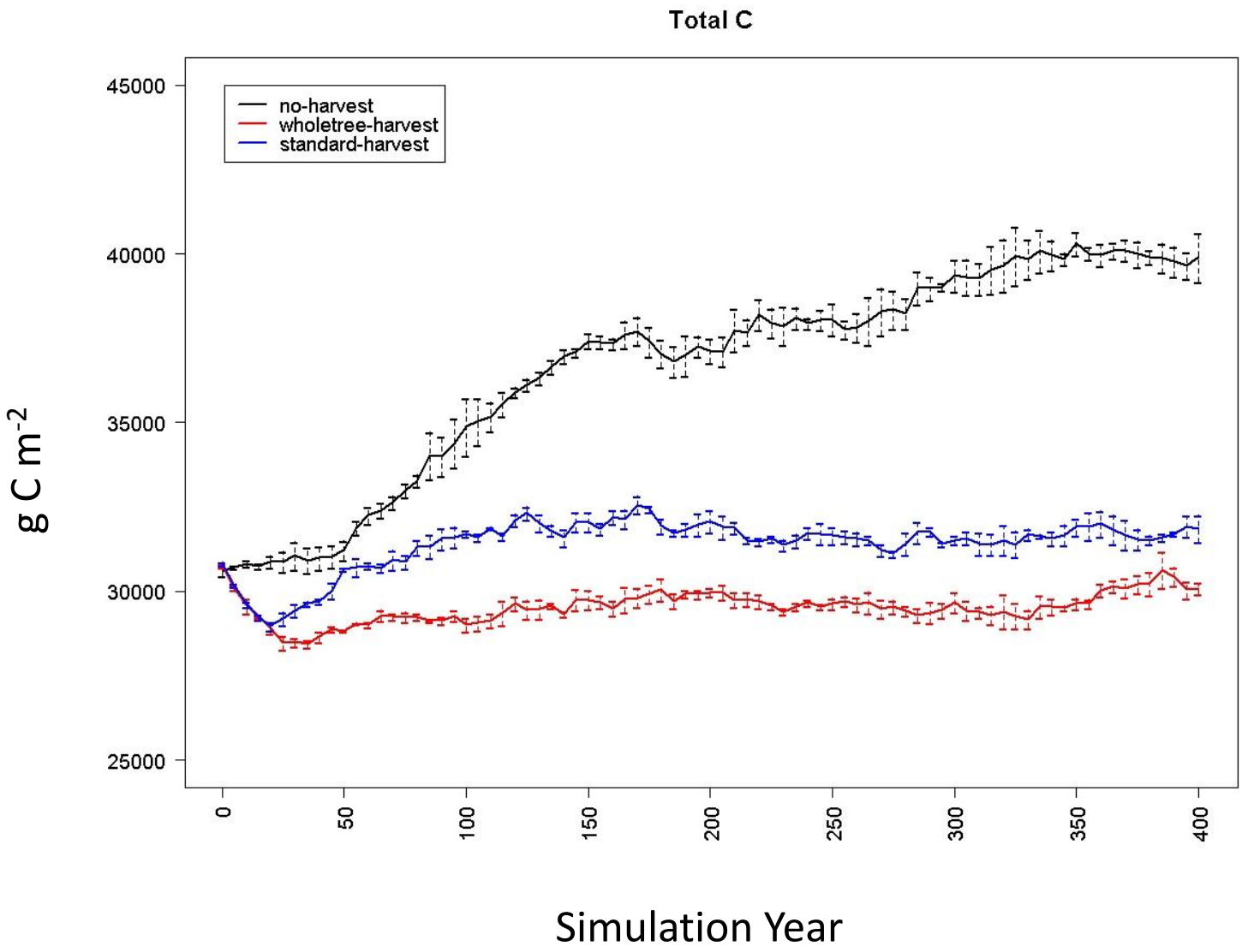
Results: Detritus and Forest Floor C



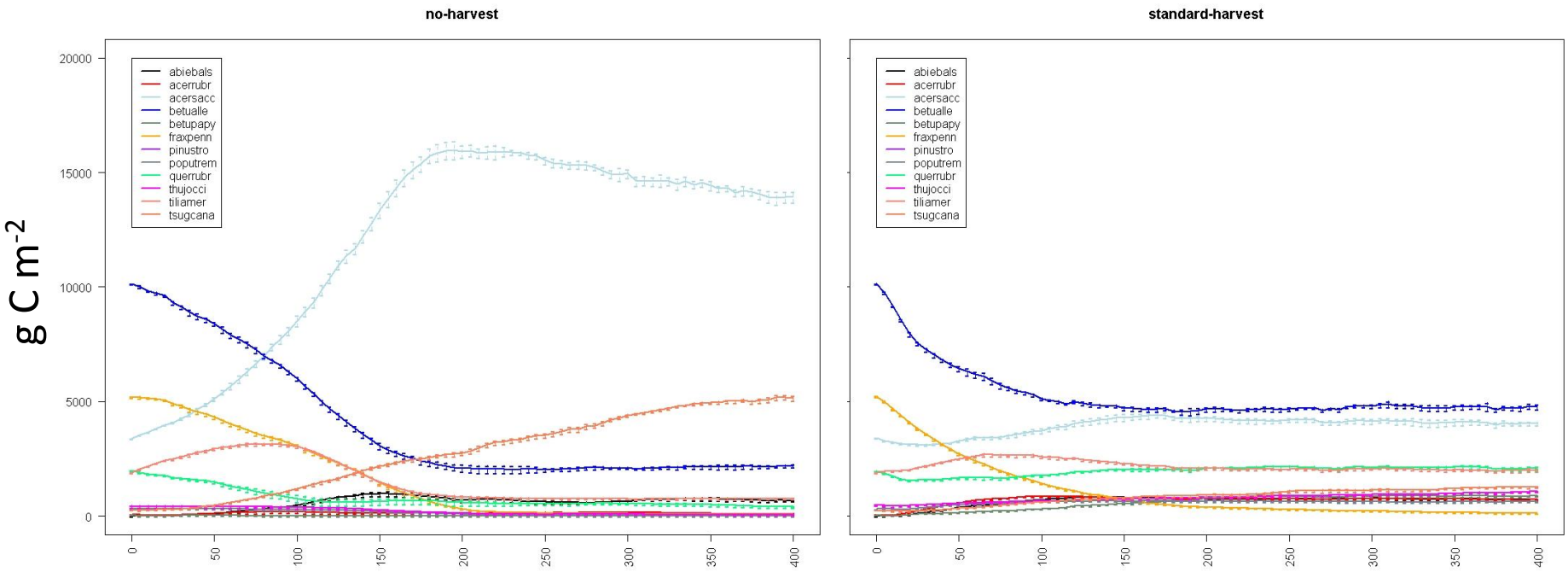
Results: SOC


SOC
no-harvest
wholetree-harvest
standard-harvest
14000
13000
12000
11000
10000
9000
8000
g C m-2
0
50
100
150
200
250
300
350
400
Simulation Year

Results: Total C

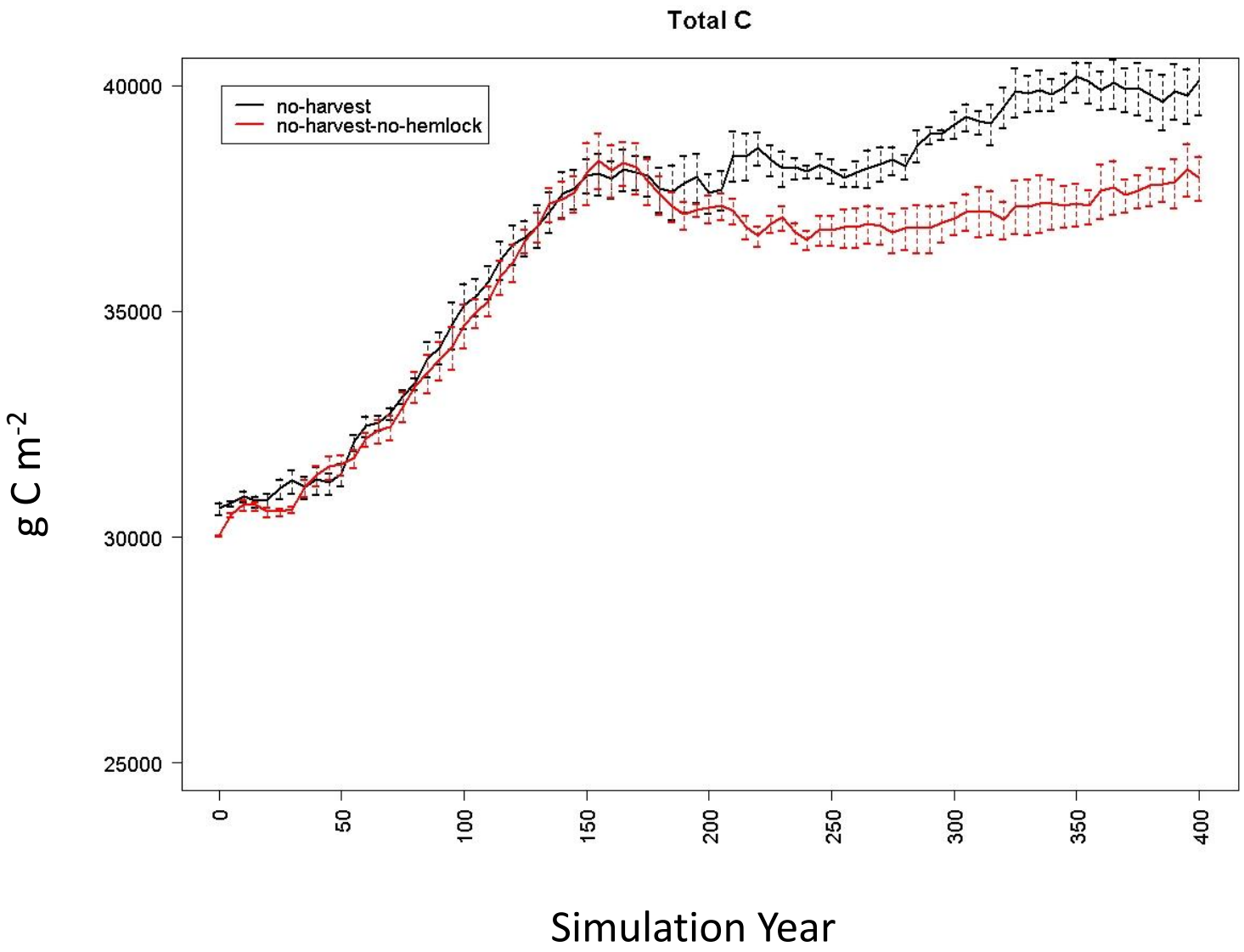


Results: Species Composition



Simulation Year

Results: Total C with and without hemlock



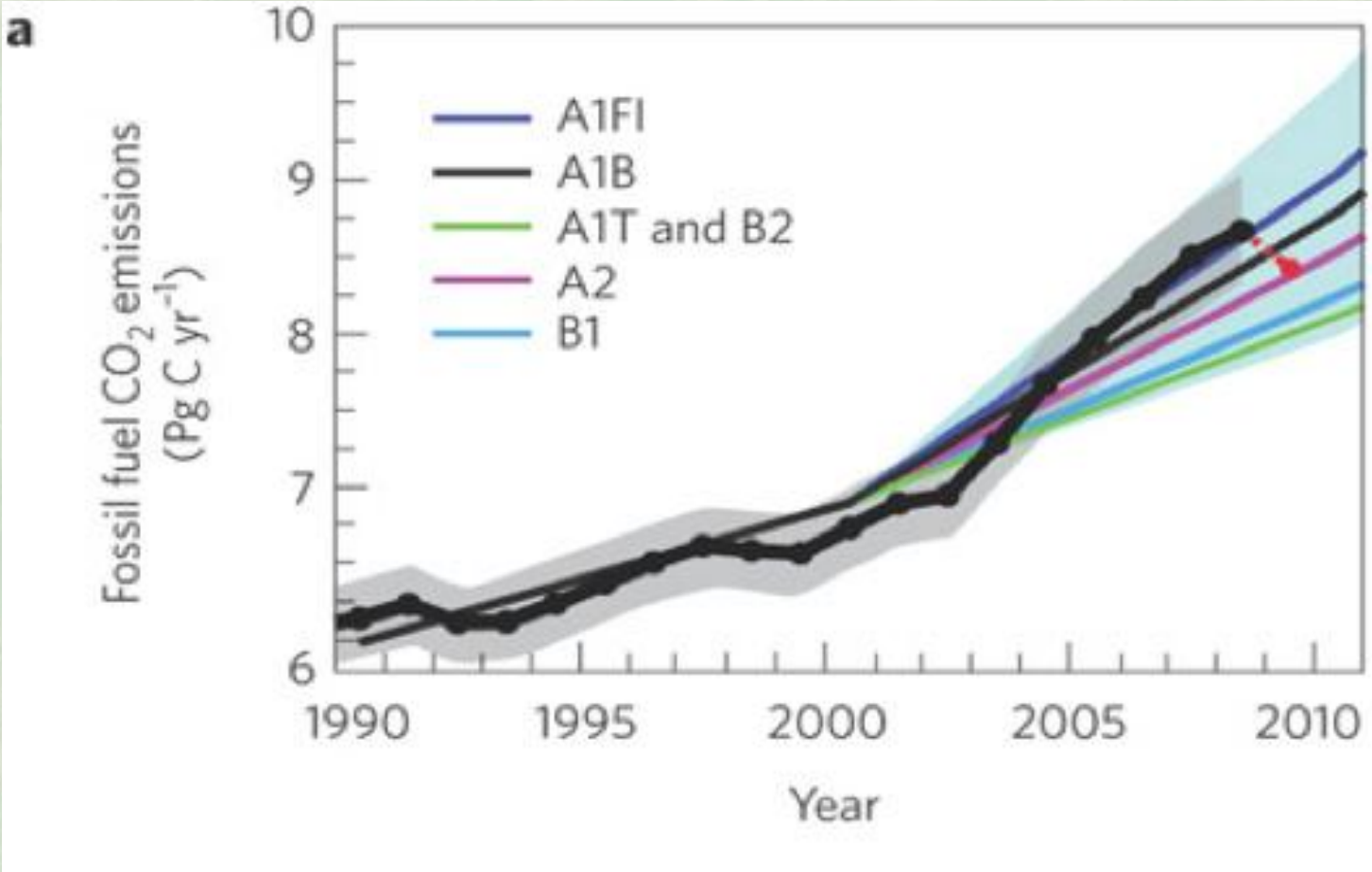
Results: Compared to Literature

- Tang et al. (2009) Upper Penninsula:
  - ~9000 g C m^{-2} in the top 60 cm of soil for 'intermediate aspen' and 'mature hardwoods'.
  - ~10,500 g C m^{-2} at an old-growth forest.

- Johnson and Curtis (2001) meta-analysis:
  - whole-tree SOC and N < 'standard' harvest
  - short-term increase in SOC relative to control

Conclusions

- Harvesting reduces SOC and total C
  - whole tree harvesting > standard
- Detrital amounts and quality control SOC
  - short-term detrital inputs from harvesting < long-term detrital inputs associated with old-growth forests
- Loss of eastern hemlock reduces SOC
  - indicates the importance of maintaining native diversity
  - Simulation benefits from including individual species



Quere et al. 2009

Acknowledgements

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