

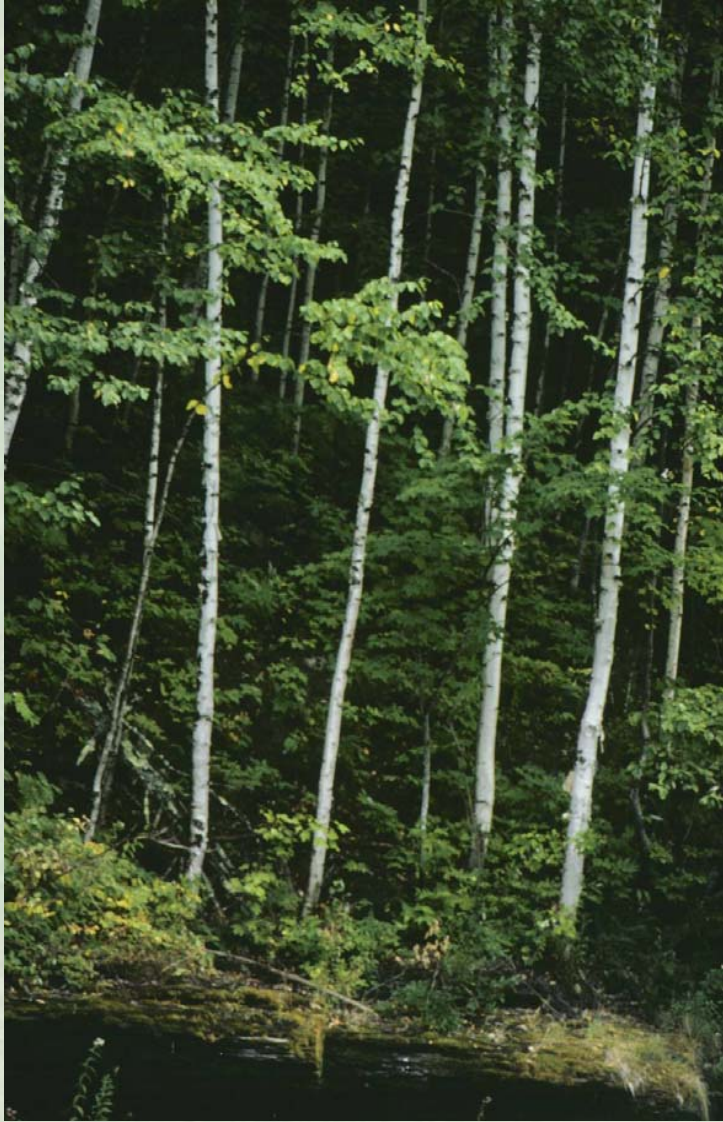
# Forest change due to climate warming in the upper Midwest

David Mladenoff  
and  
Robert Scheller

Dept of Forest and Wildlife Ecology  
Forest Landscape Ecology Lab  
<http://landscape.forest.wisc.edu>





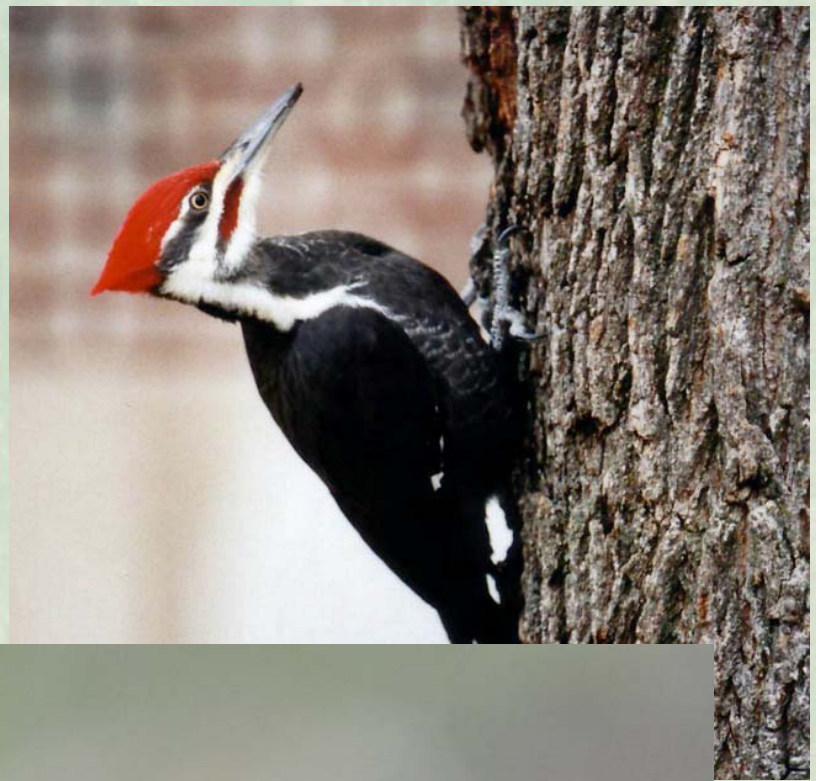






© 2000 W. Steve Sherman, Lone Wolf Photography







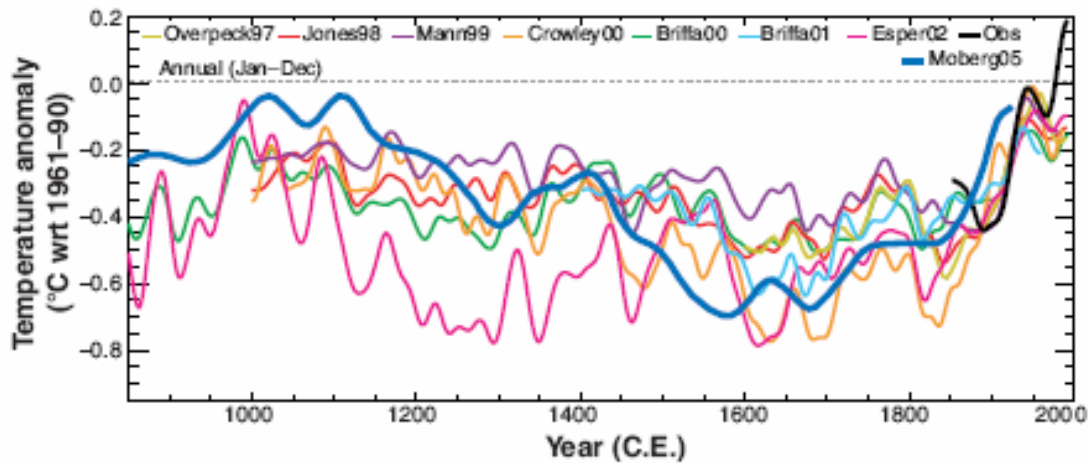
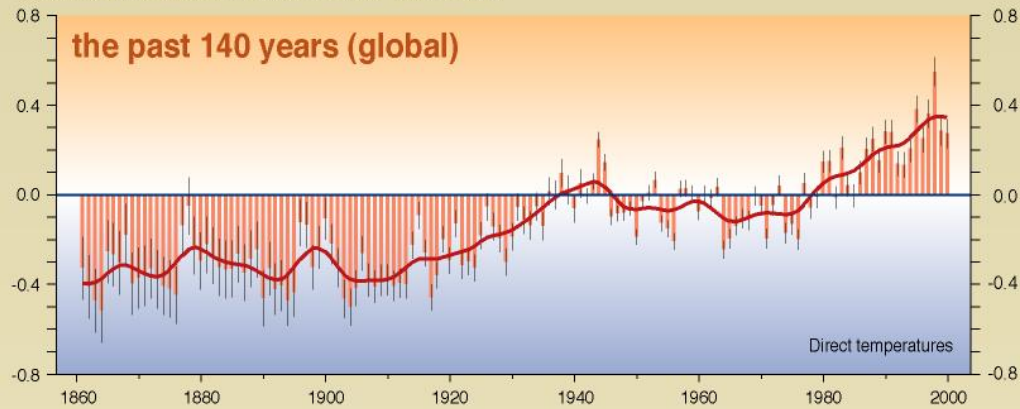






## Variations of the Earth's surface temperature for...

Departures in temperature in °C (from the 1961-1990 average)



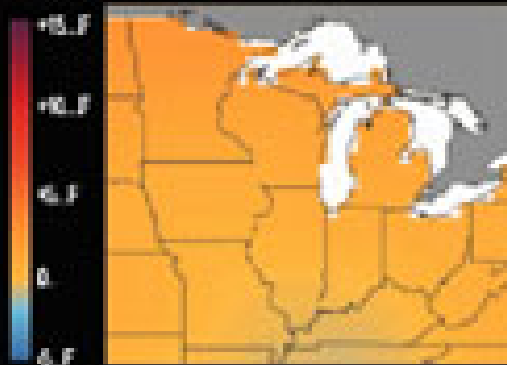
**Still no equal.** Temperature records recovered from tree rings and other proxies broadly agree that no time in the past millennium has been as warm as recent decades (black).

SYR - FIGURE 2-3



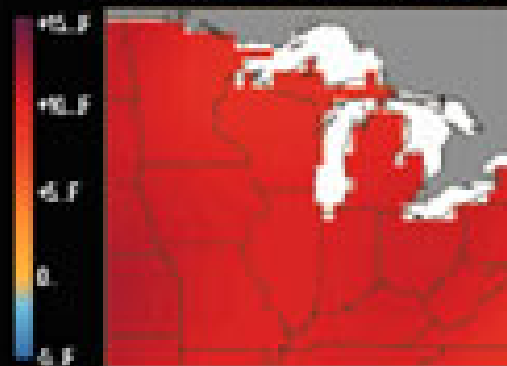
## Temperature Change - 20th & 21st Centuries

### Observed 20th

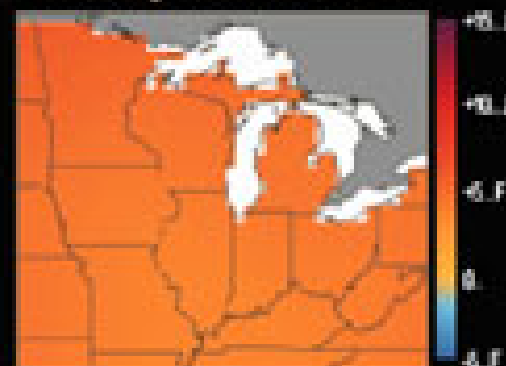


Temperatures in the Midwest have increased, with the largest observed changes for the region in Minnesota and the Upper Peninsula of Michigan. Model scenarios suggest further increases over the 21st century from near 5...F (Hadley model) to more than 10...F (Canadian model).

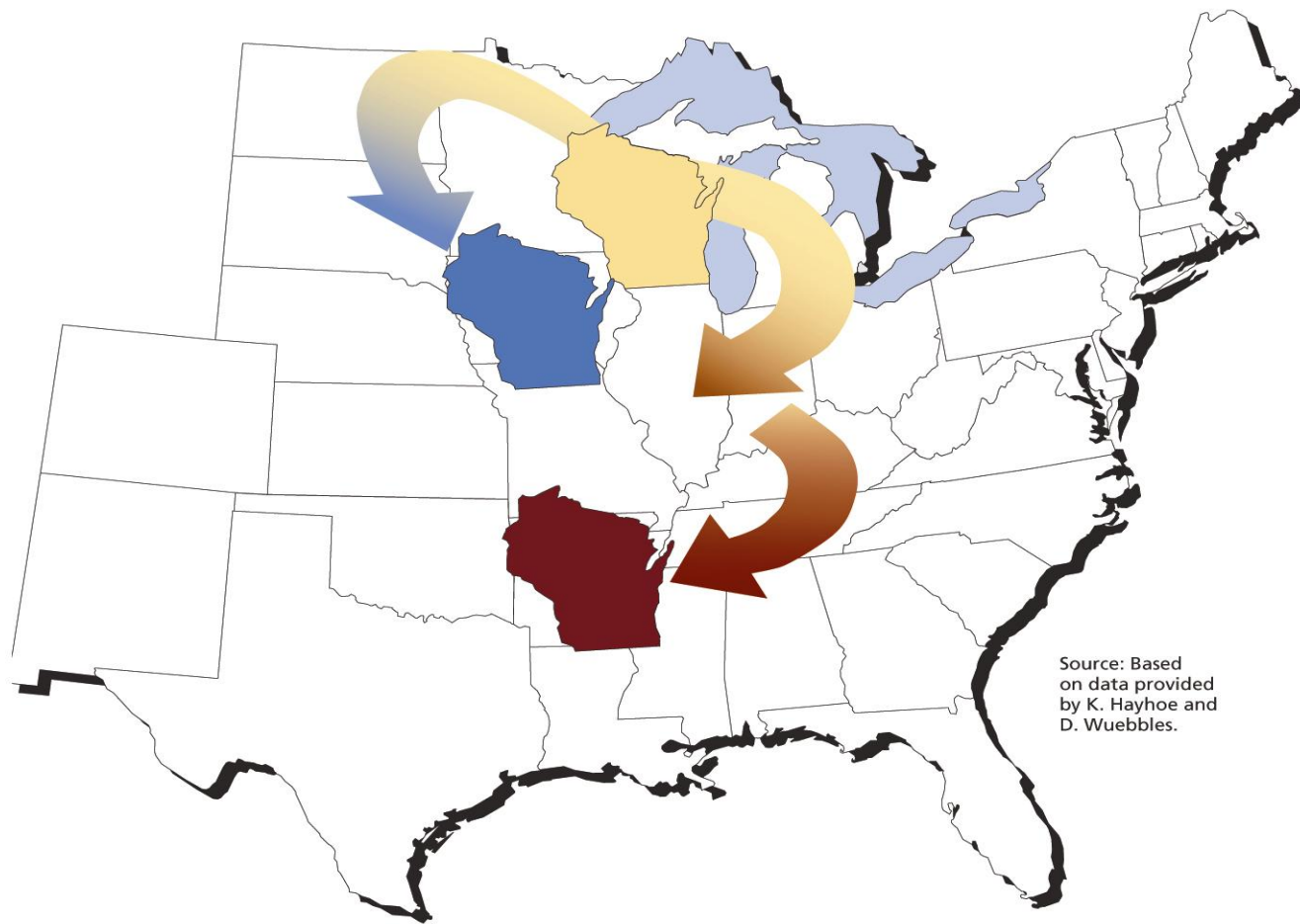
### Canadian Model 21st



### Hadley Model 21st







Source: Based on data provided by K. Hayhoe and D. Wuebbles.

Current

By 2030  
Summer

By 2095  
Summer

Winter  
Changes  
Over the 21st  
Century

By 2095  
Winter



# How will climate change alter forest composition and biomass in northern Wisconsin?

Climate change is only one of many important drivers of forest change.

Harvesting is currently the most important disturbance.

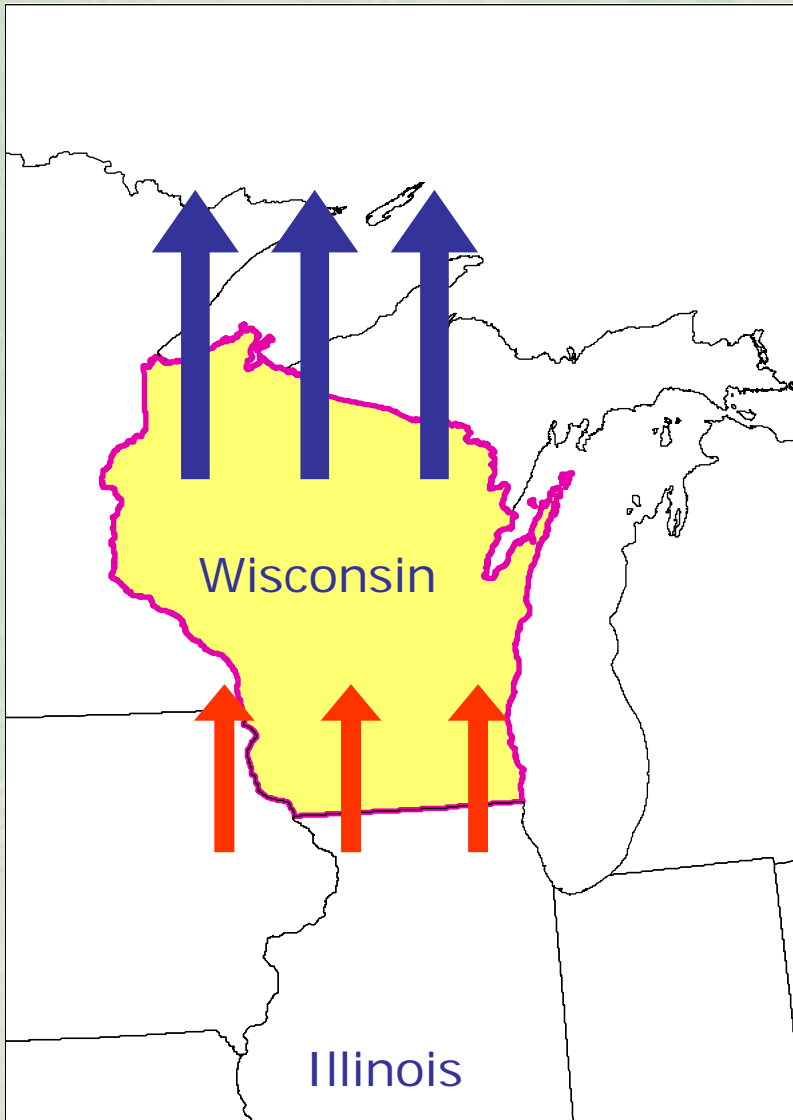
- *Hypotheses:*

Tree species will migrate into and out of northern Wisconsin.

Disturbance and fragmentation will alter how quickly tree species migrate north.



# What Effect Fragmentation?



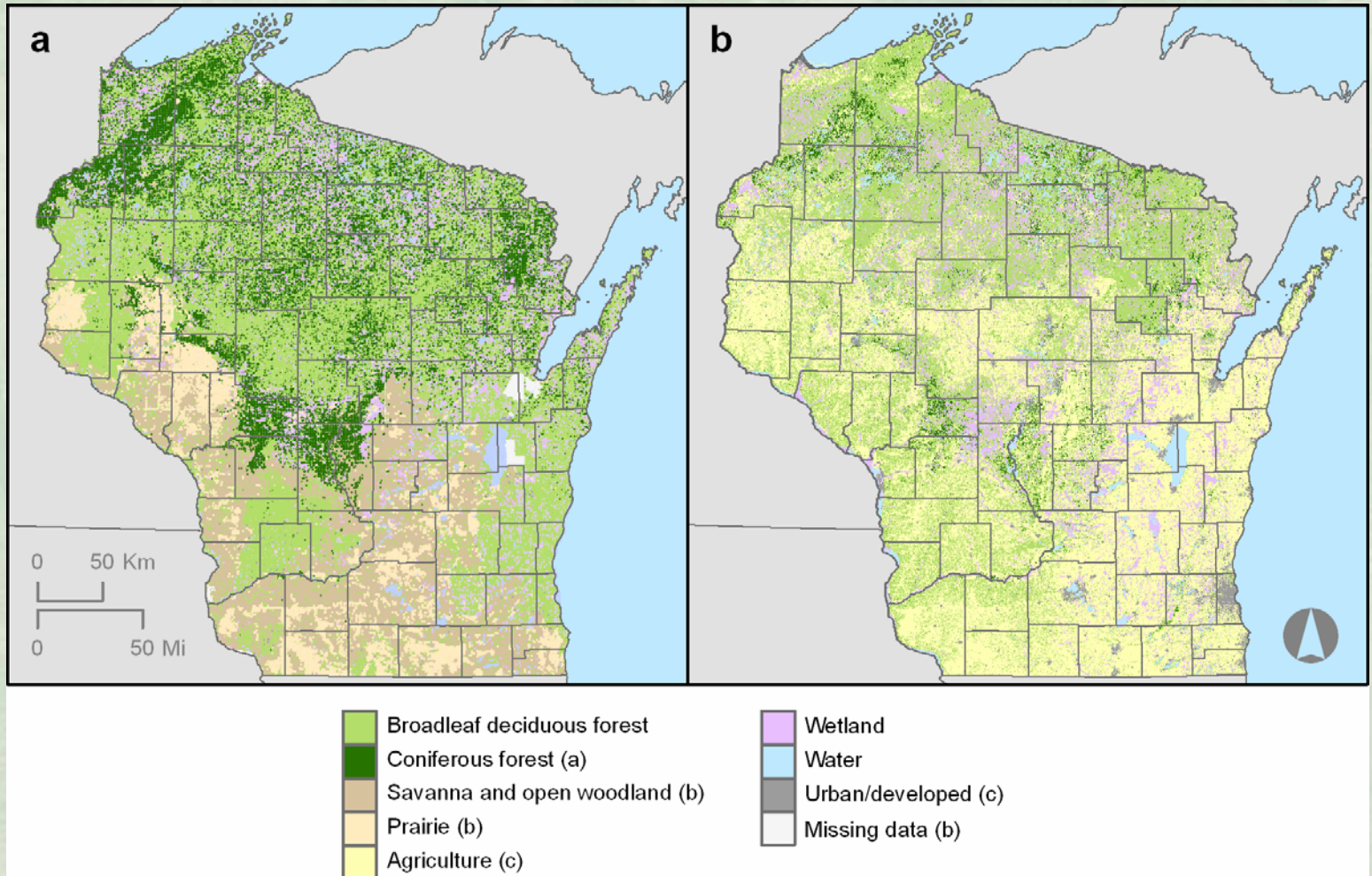
Tree species migration north may be limited by:

- distance-limited seed dispersal
- competition from existing species
- generational lags
- **FRAGMENTATION**
  - *less suitable habitat*
  - *fewer seed sources*

First: Where are we now?

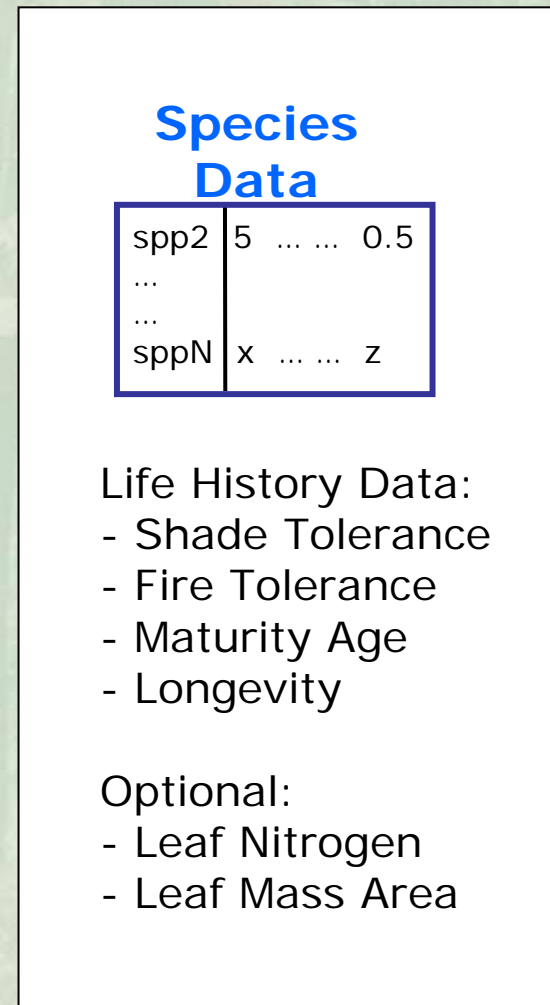
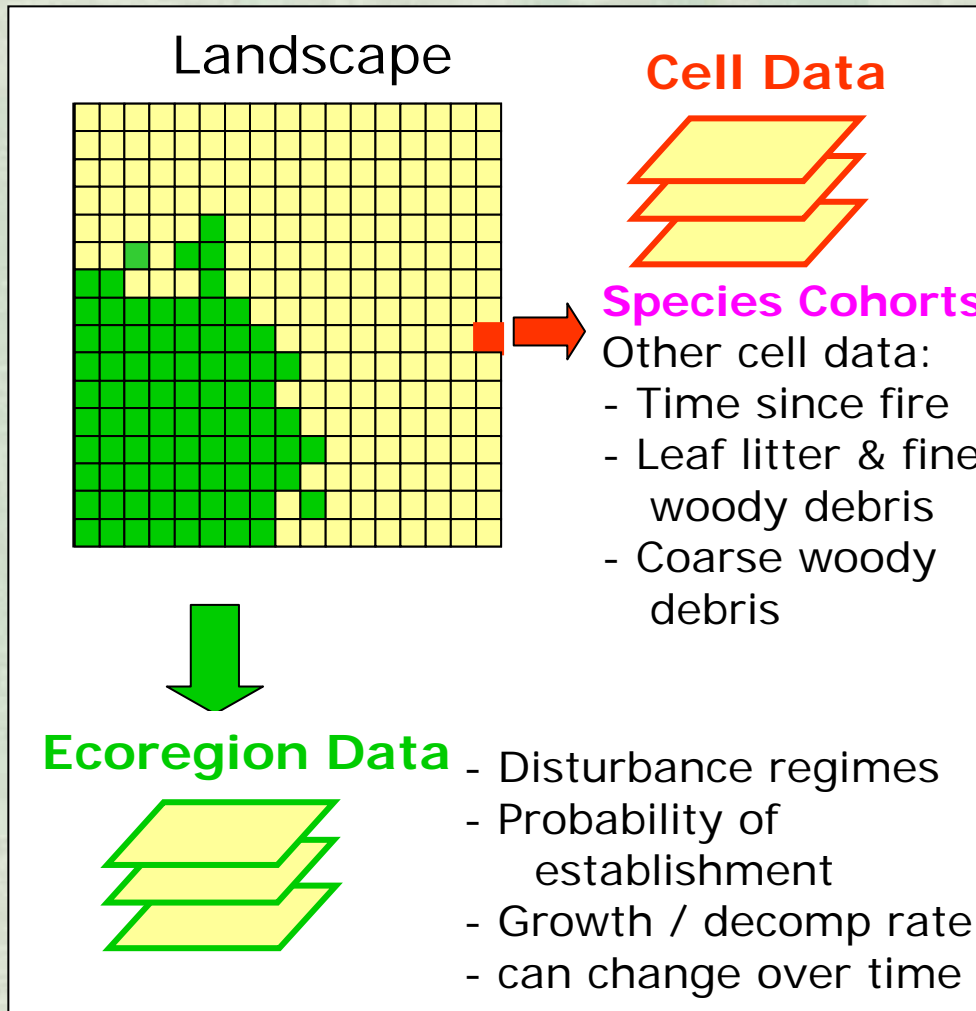
Before European  
Settlement

Now





# LANDIS-II Brief Overview



## Species Cohorts

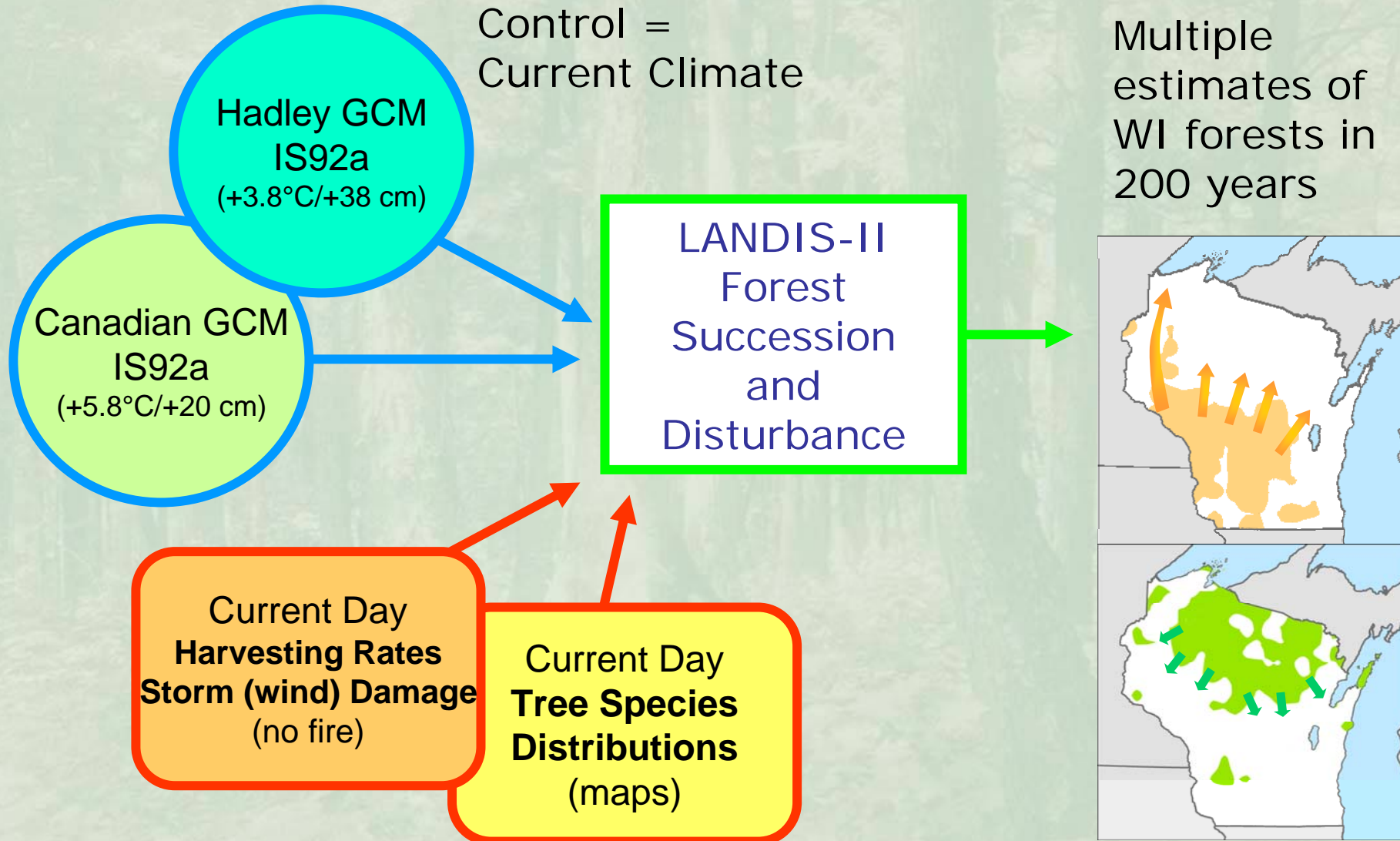
Minimally Includes: **Species ID** and **Age**

Can Include: **Aboveground Live Biomass, Density, Diameter, etc.**

# Simulation of Climate Change Effects

Control =  
Current Climate

Multiple  
estimates of  
WI forests in  
200 years



Control = No Disturbance



# Results: Biomass and Species Composition

Climate change and disturbance interact and have large effects on aboveground biomass and tree species composition.

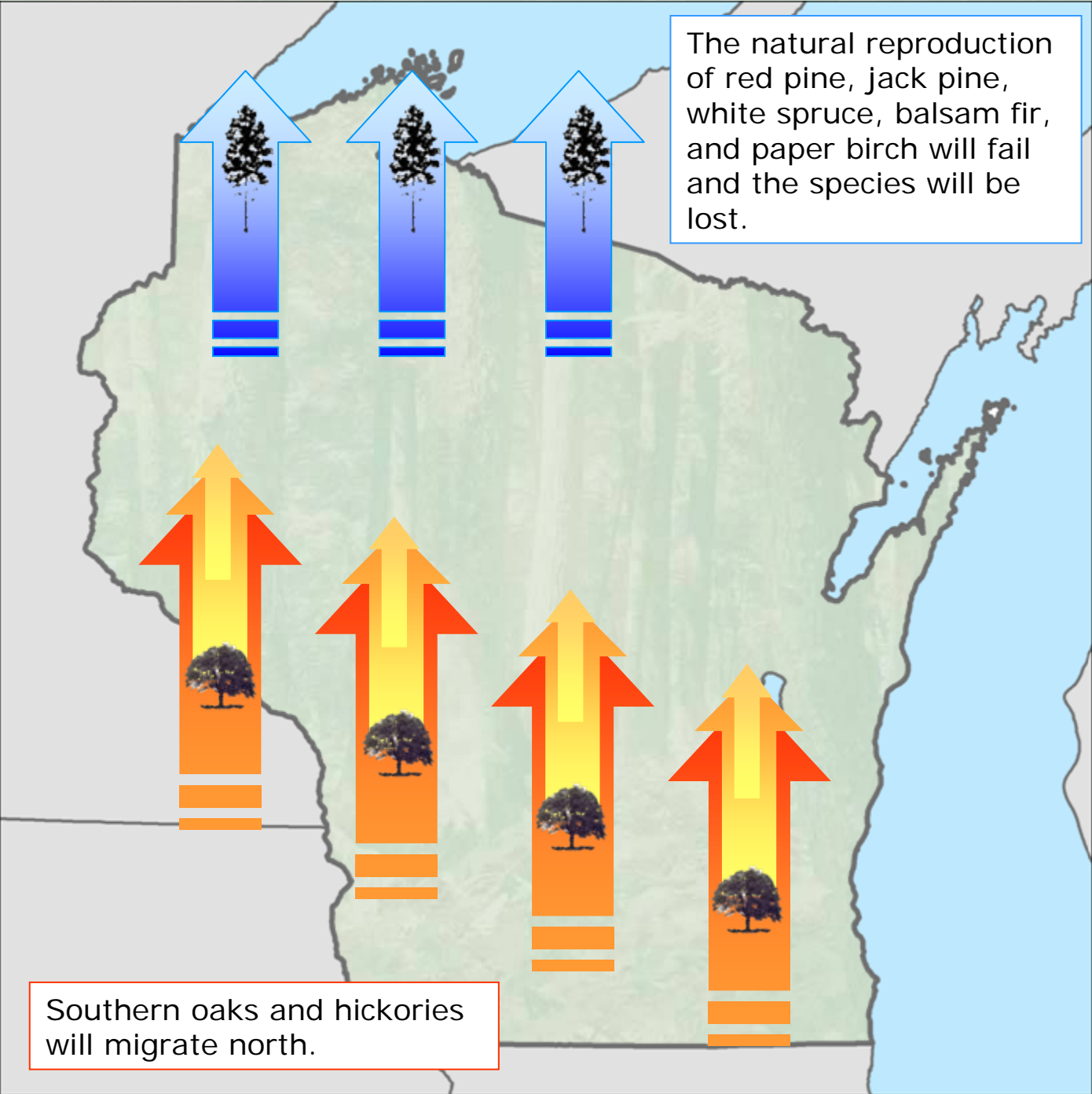
Many tree species will likely be locally extirpated due to climate change.

Decline in tree species richness.

# Results: Species Composition

	<b>Northern</b>	<b>Southern</b>
<b>Dry Sites</b>	- jack pine, red pine, paper birch+ oaks	- red pine, aspen? + oaks, hickory
<b>Moist Sites</b>	- balsam fir, white spruce + maples, white pine	- aspen? + maples, white pine



A map of the eastern United States showing the migration of tree species. Three blue arrows point north from the northern part of the map, each containing a tree icon. Four orange arrows point north from the southern part of the map, each containing a tree icon. The background is a light green map of the eastern US with a grey border. A blue box is in the top right, and a white box with a red border is in the bottom left.

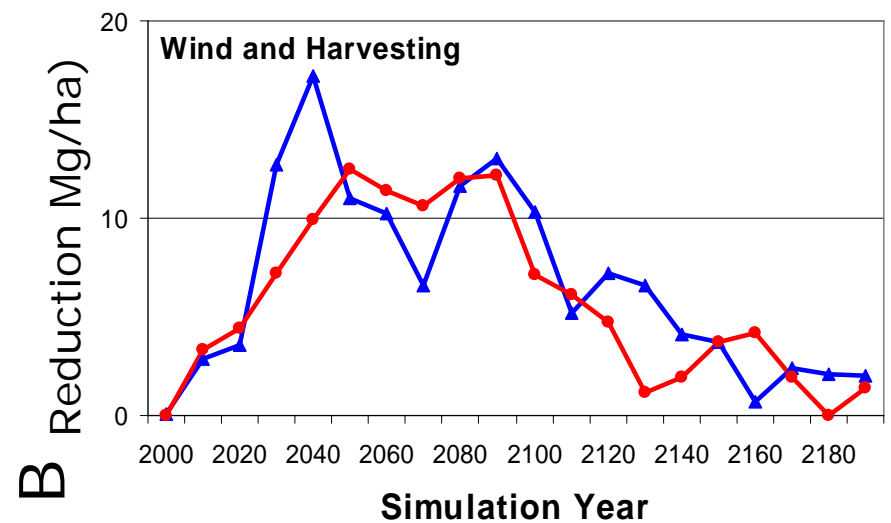
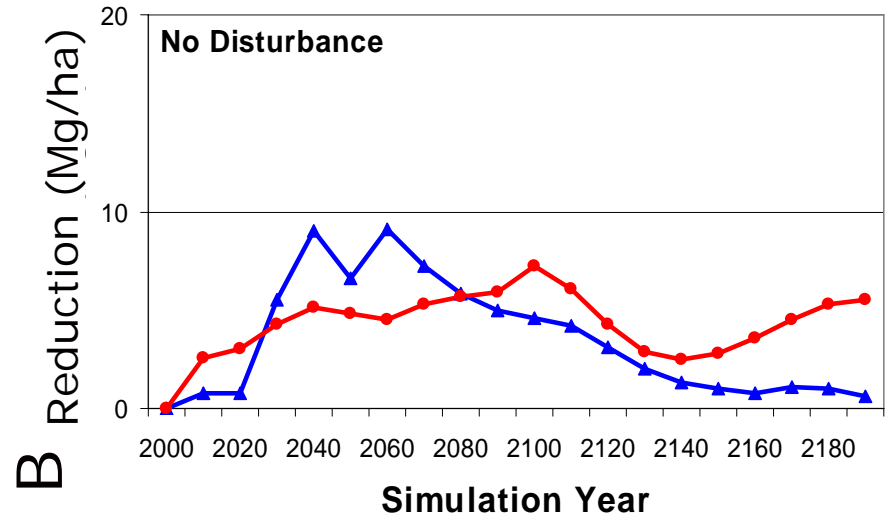
The natural reproduction of red pine, jack pine, white spruce, balsam fir, and paper birch will fail and the species will be lost.

Southern oaks and hickories will migrate north.

# The Reduction of Aboveground Biomass Due to Migration Limitations

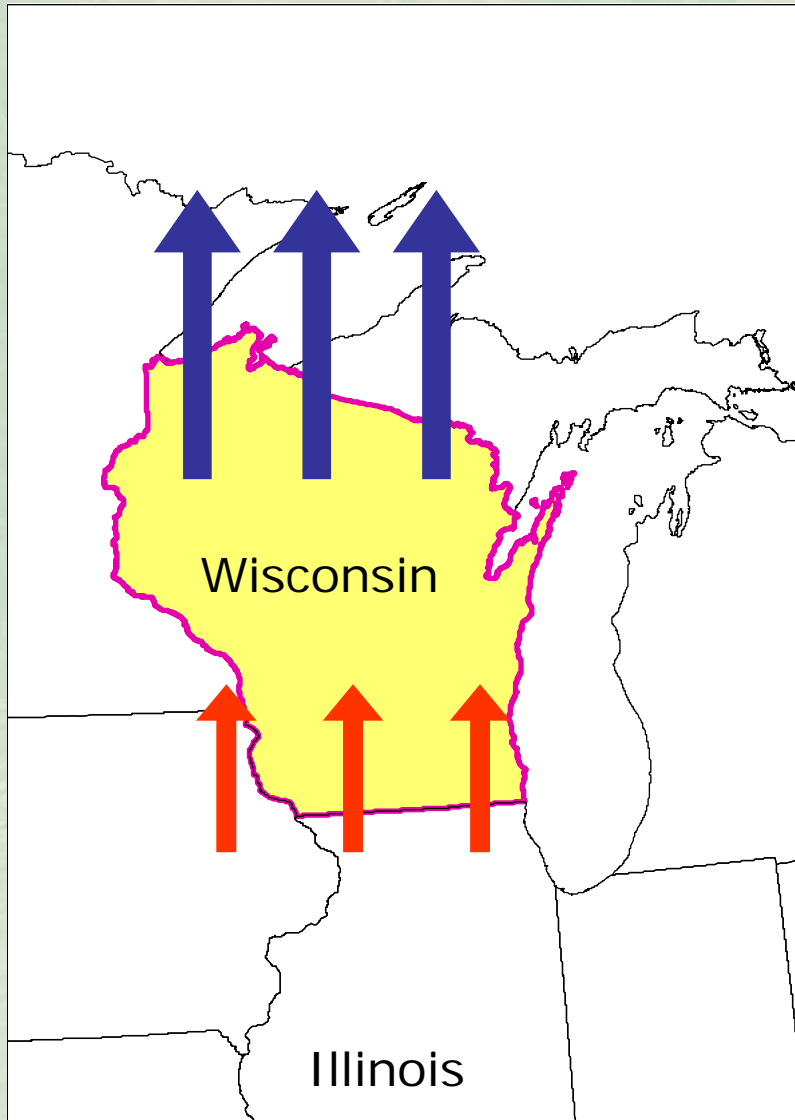
Temporal Change of  $B_{\text{MIGRATION EFFECT}}$

- ▲ Hadley GCM
- Canadian GCM





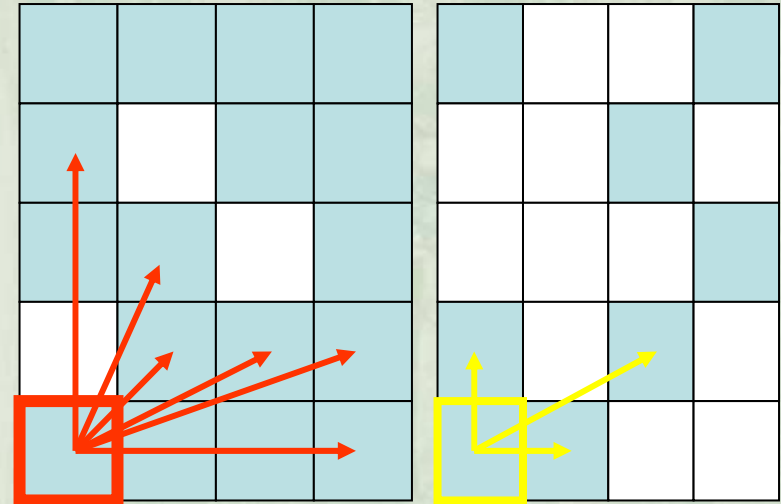
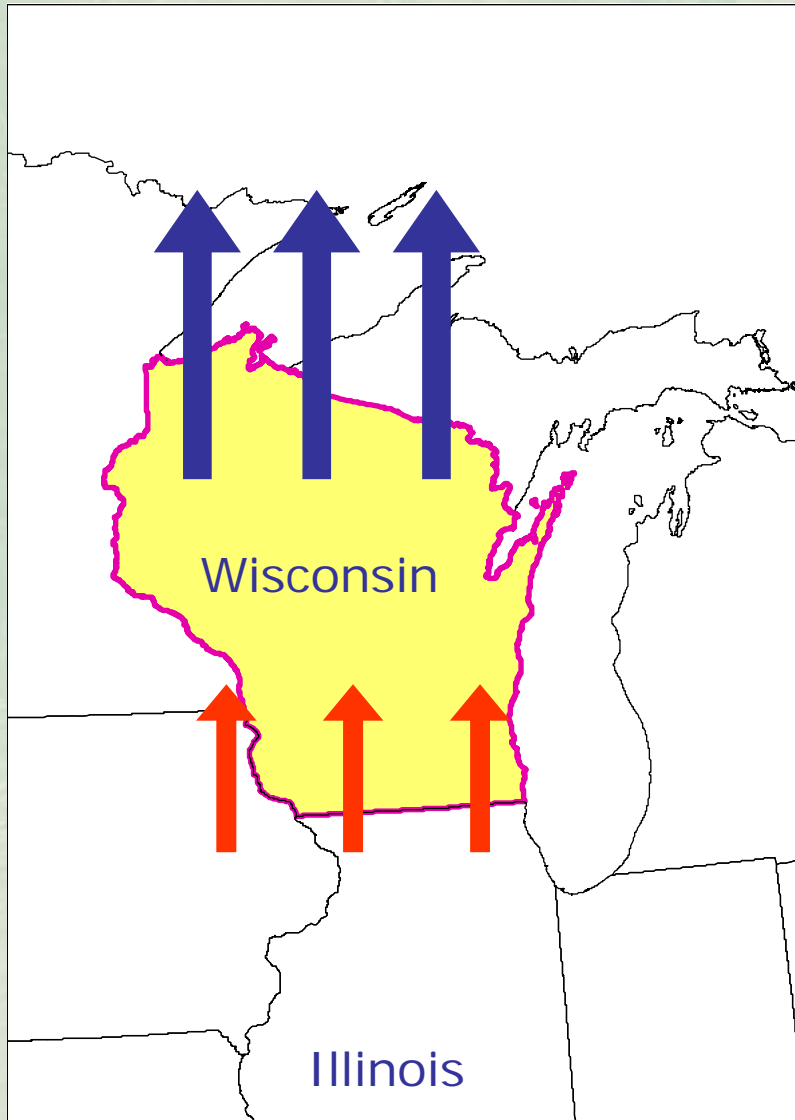
# Interactions between climate change, migration, and fragmentation



Tree species migration north limited by:

- distance-limited seed dispersal
- the priority effect - occupancy by current species
- disturbance
- generational lags

# Interactions between climate change, migration, and fragmentation



Fragmentation reduces migration:

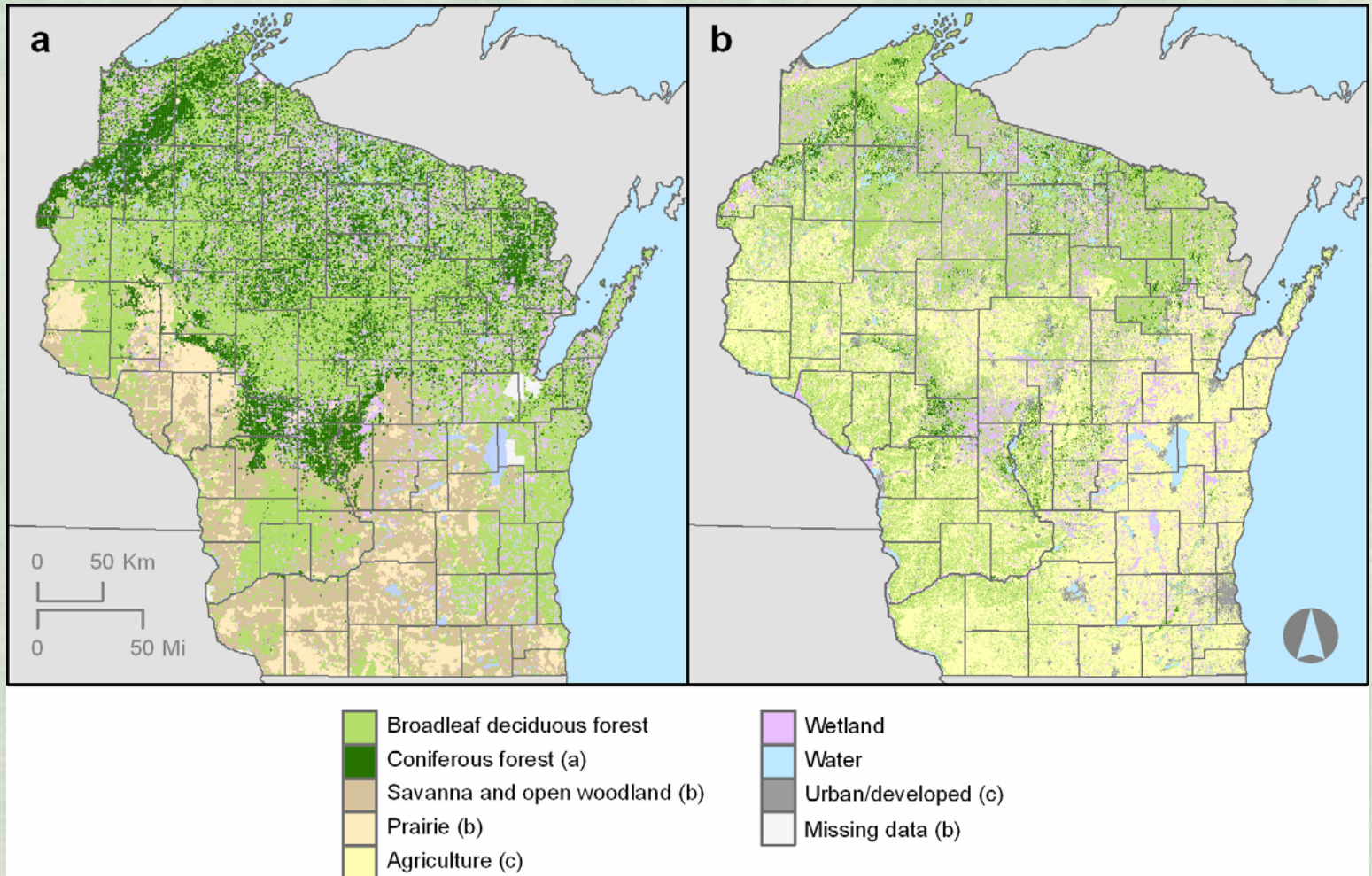
- fewer available colonization sites
- fewer seed sources



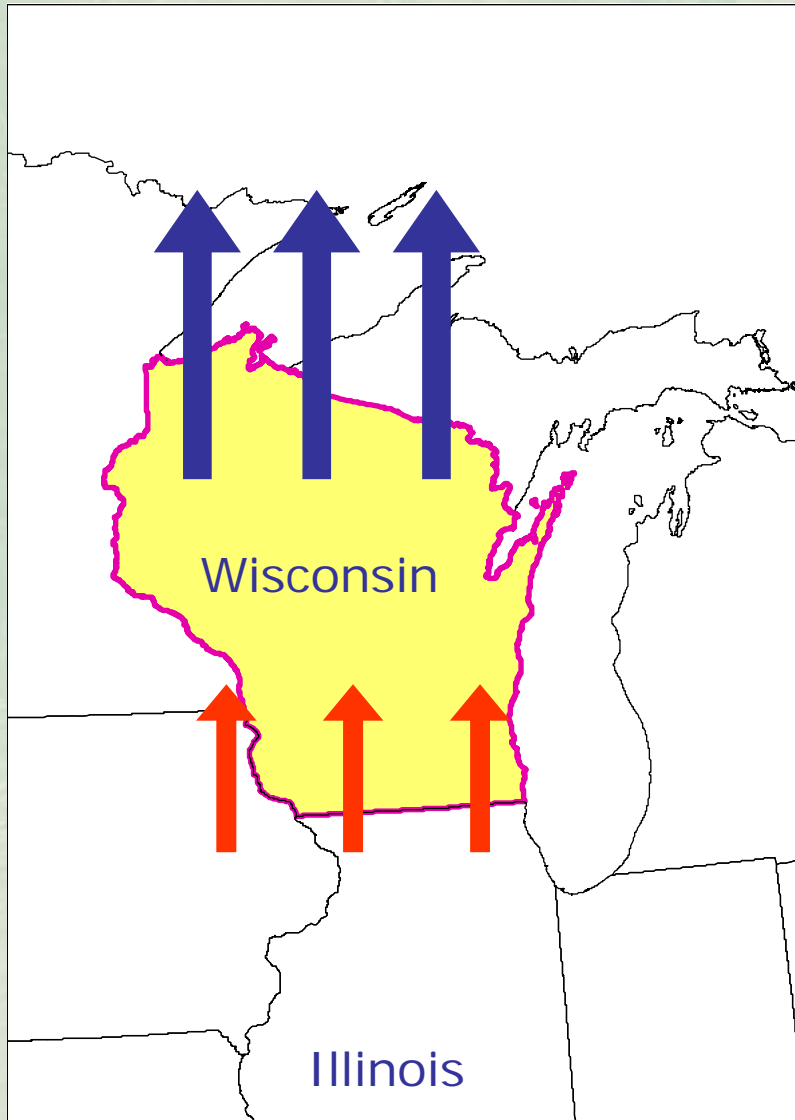
First: Where are we now?

Before European  
Settlement

Now



# Interactions between climate change, migration, and fragmentation



Consequences:

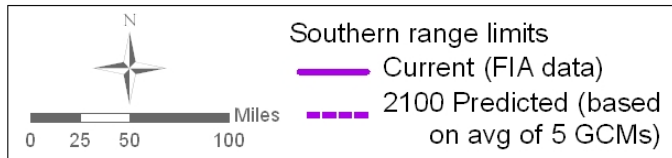
Tree spp richness reduced.

Decline in productivity and **aboveground live biomass.**

Why? Realized niche  $< >$  fundamental niche. The species best adapted to new climate are not widely dispersed.

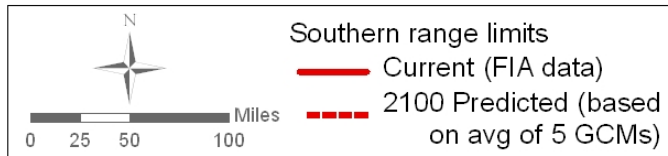
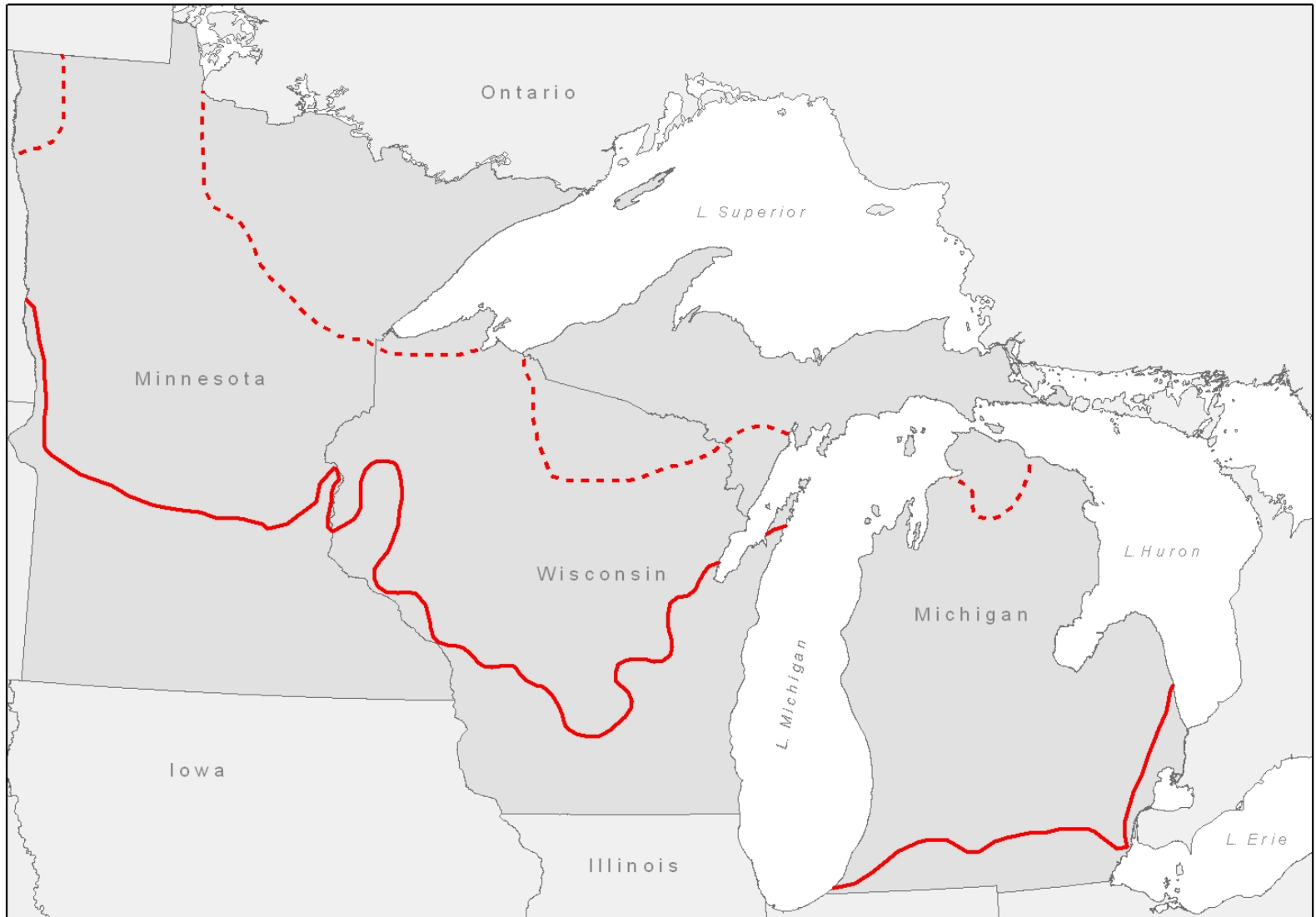


# Southern Range Limit for White Birch



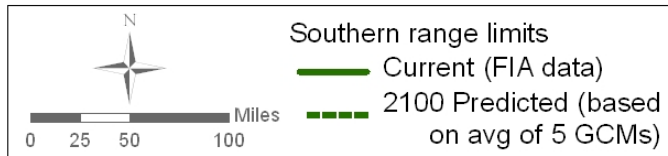
Adapted from Prasad, A. M. and L. R. Iverson. 1999-ongoing.  
<http://www.fs.fed.us/ne/delaware/atlas/index.html>

# Southern Range Limit for Red Pine



Adapted from Prasad, A. M. and L. R. Iverson. 1999-ongoing.  
<http://www.fs.fed.us/ne/delaware/atlas/index.html>

# Southern Range Limit for Balsam Fir



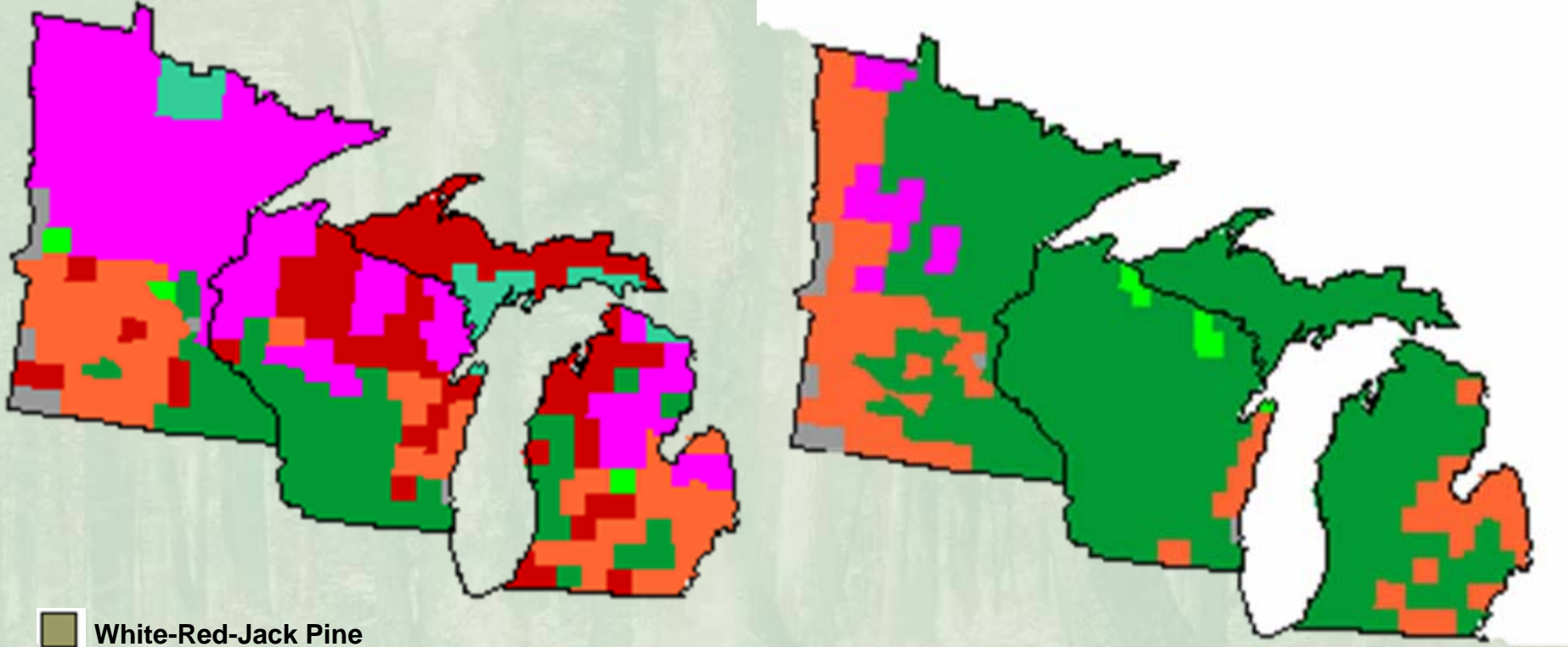
Adapted from Prasad, A. M. and L. R. Iverson. 1999-ongoing.  
<http://www.fs.fed.us/ne/delaware/atlas/index.html>



# Dominant Forest Types

Current (FIA Data)

2100 Predicted (Hadley Scenario)



- White-Red-Jack Pine
- Spruce-Fir
- Oak-Pine
- Oak-Hickory
- Elm-Ash-Cottonwood
- Maple-Beech-Birch
- Aspen-Birch
- No Data

From Prasad, A. M. and L. R. Iverson. 1999-ongoing.  
<http://www.fs.fed.us/ne/delaware/atlas/index.html>

# Summary: Biomass, Tree Species, and Overall Biodiversity

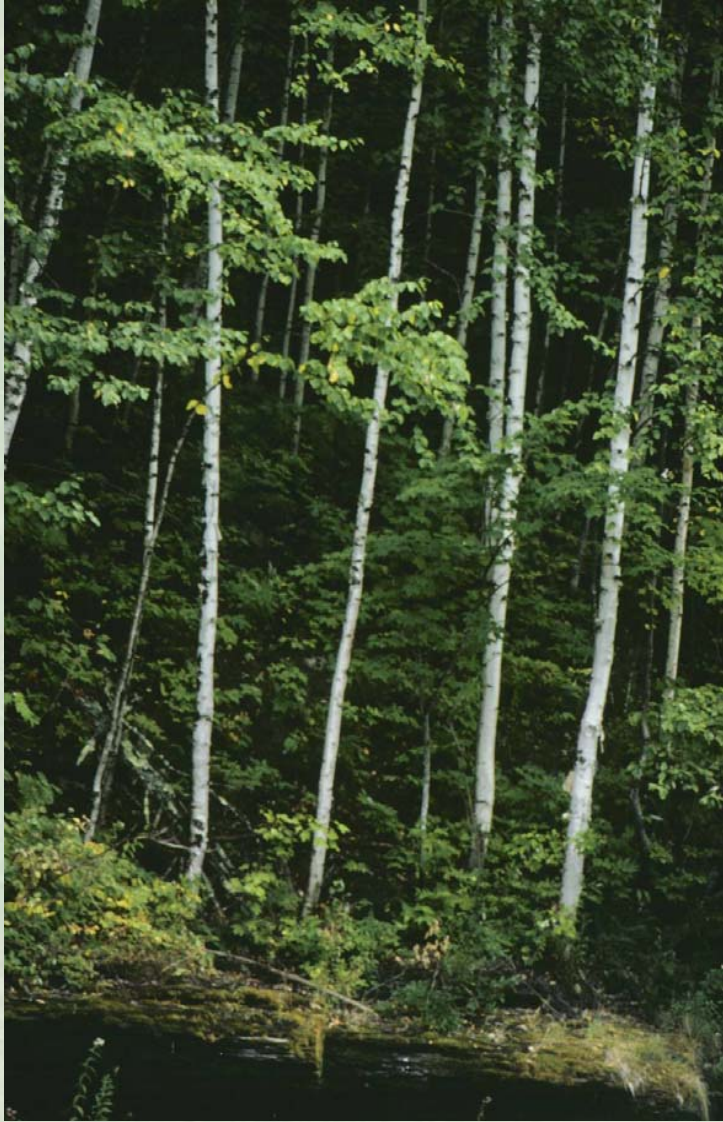
5 tree species (white spruce, balsam fir, red pine, jack pine, paper birch) will likely be extirpated due to climate change.

Fragmentation decreases the ability of tree species to migrate, causing significant reductions in aboveground biomass.

Southern tree species slow to migrate north -> Decline in tree species richness.

- Focus on forest tree species, but effects on habitat and on all species, processes, services







# Acknowledgements

Funding:

US Forest Service, North Central Research Station; NASA; The Nature Conservancy, Wisconsin DNR

<http://landscape.forest.wisc.edu>