

Climate Change and Minnesota Trees

**DNR-MFI Quarterly Meeting
30 April 2013**

Overview

- **Northwoods Climate Change Response Framework**
- **Tree species vulnerability assessments**
 - **Emissions scenarios, GCMs, and downscaling**
 - **Projected changes in climate**
 - **Modeling impacts to tree species**
 - **Tree Atlas results**

Northwoods Climate Change Response Framework

A collaborative approach among scientists, managers, and landowners to incorporate climate change considerations into forest management



Stephen Handler and Chris Swanston

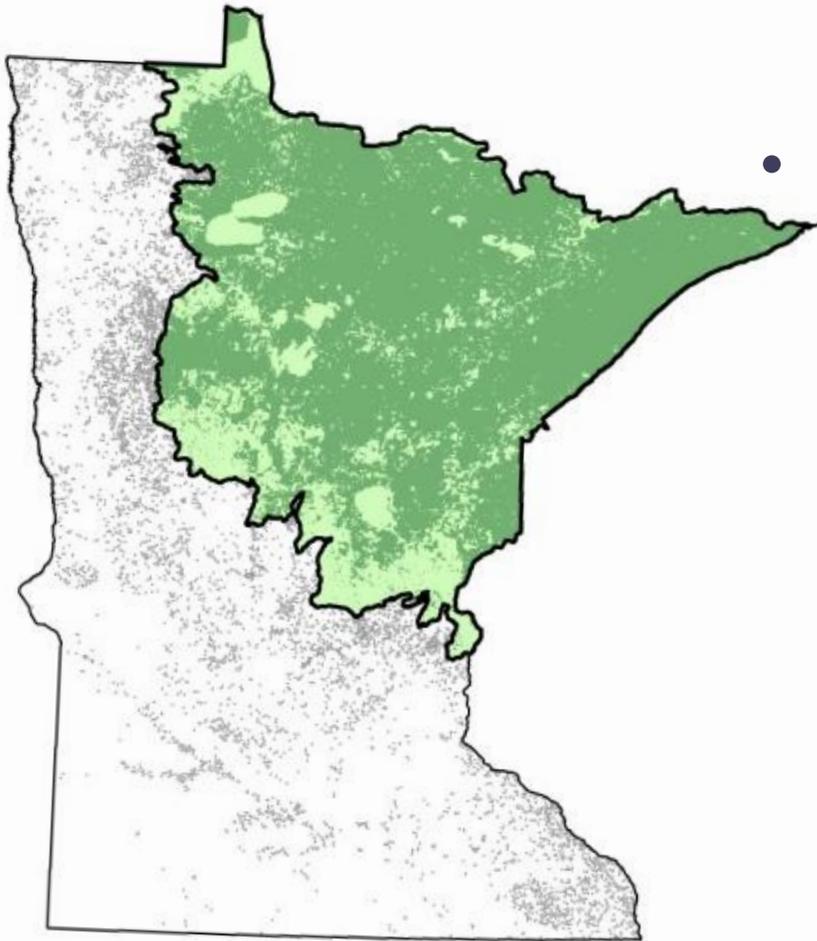
Northern Institute on Applied Climate Sciences
Northern Research Station, US Forest Service

Participants: MFRC, Superior and Chippewa NFs,
DNR wildlife & forestry, UofM, NRRI, Tribes, TNC,
PSU, Private landowners

Northwoods CCRF

Objectives:

- Assess the vulnerability of forests in Province 212 to climate change
- Provide advice to forest managers on maintaining forests and the ecosystem services they provide



Northwoods CCRF Products

Forest Ecosystem Vulnerability Assessment and Synthesis

Forest Adaptation Resources: Climate Change Tools and Approaches for Land Managers

An integrated set of tools, partnerships and actions to support **climate smart** conservation and management

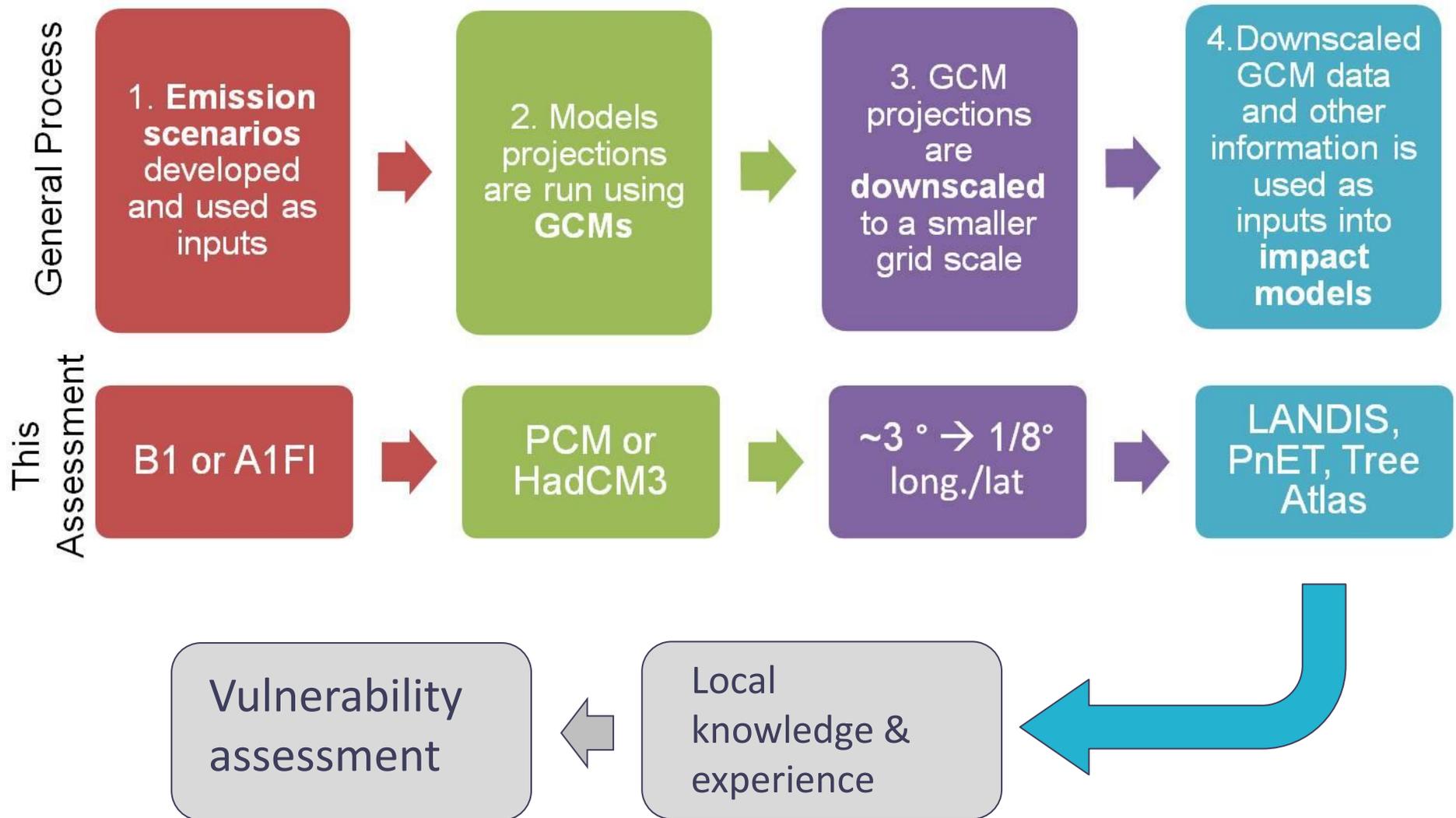
Demonstration Projects

Real-world examples of adaptation forestry
Variety of landowners and objectives

Tree species vulnerability assessments

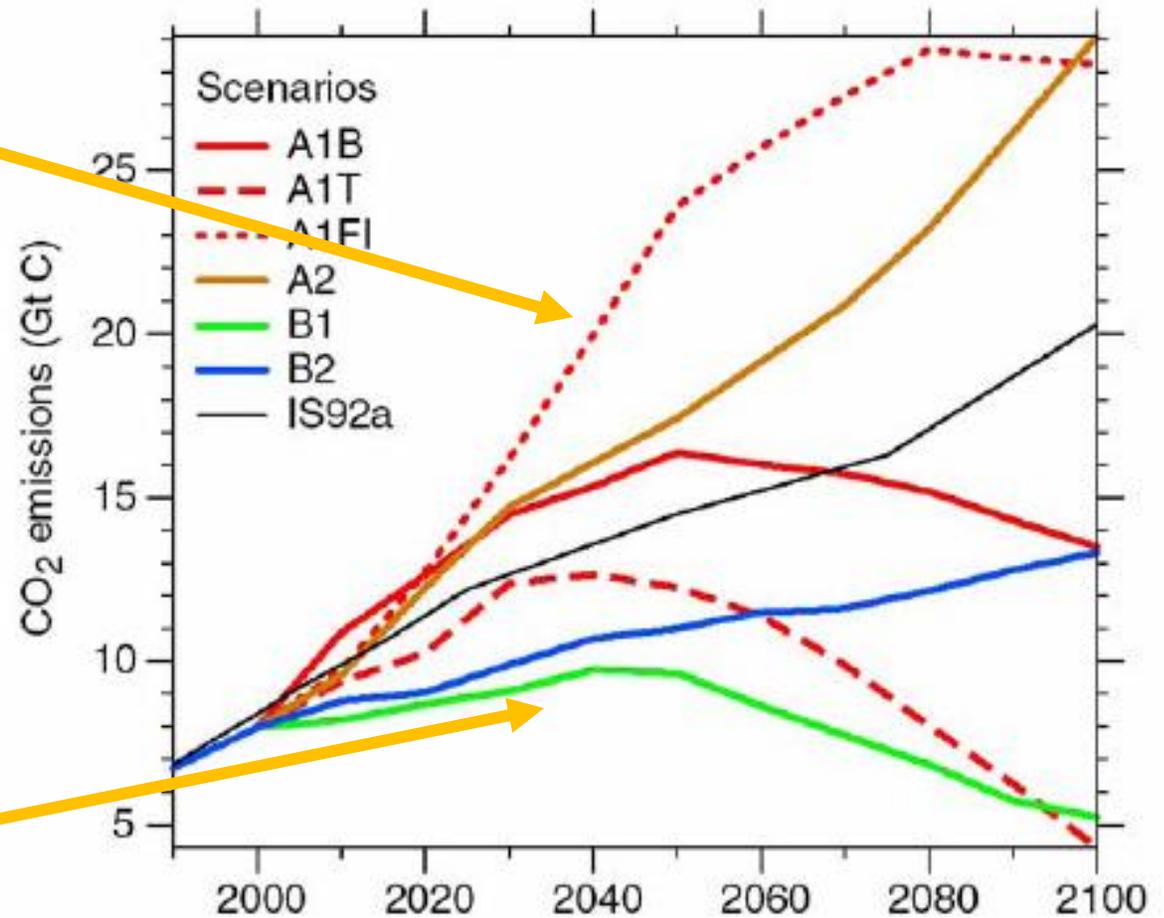
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Northwoods CCRF process for assessing vulnerability

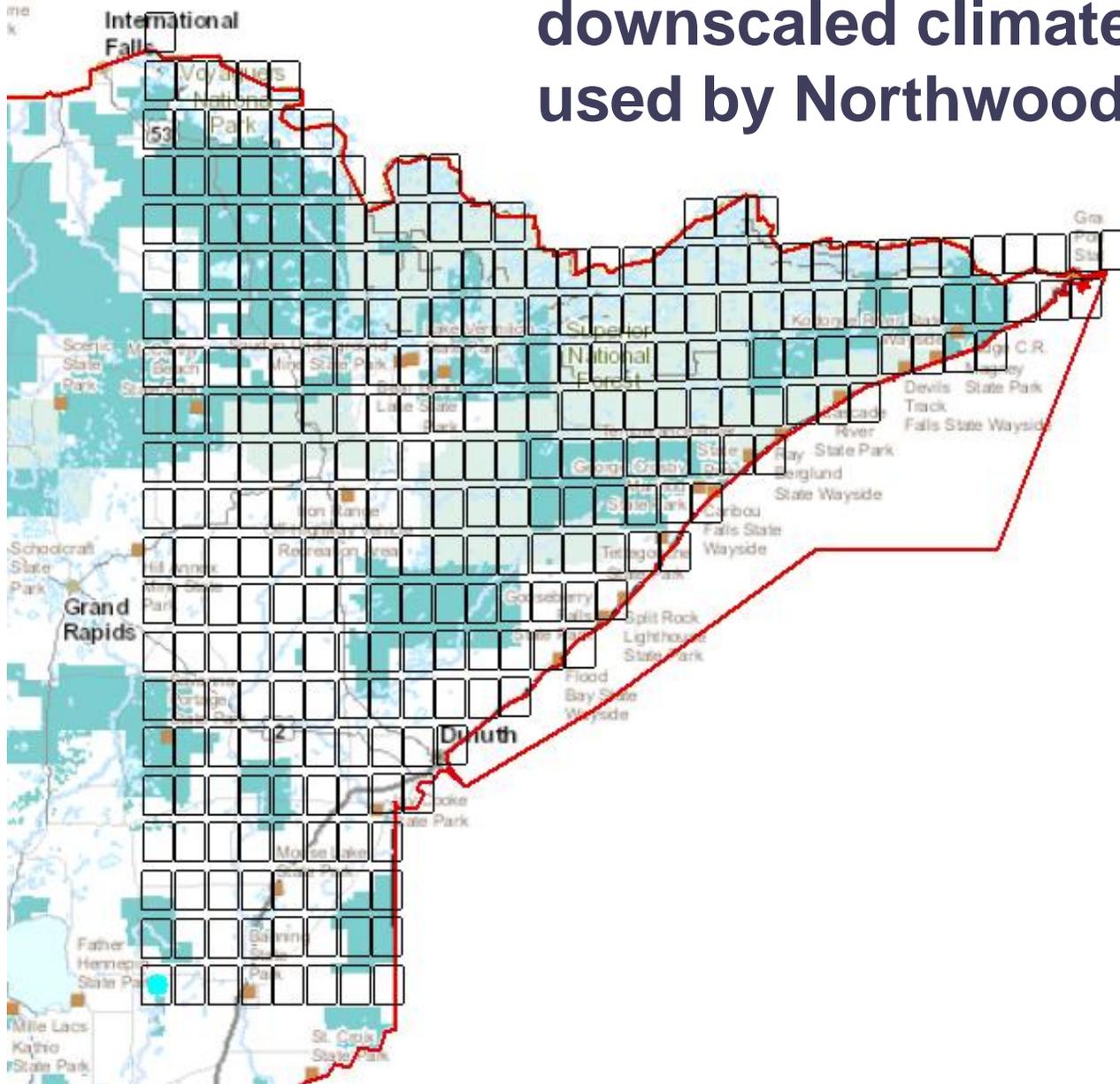


Emissions of CO₂ – range of scenarios over next 100 years

- A1fi (high)-fossil fuel intensive until later century
- B1 (low)-shift to resource efficient technology



Approximate spatial resolution of downscaled climate projections used by Northwoods CCRF

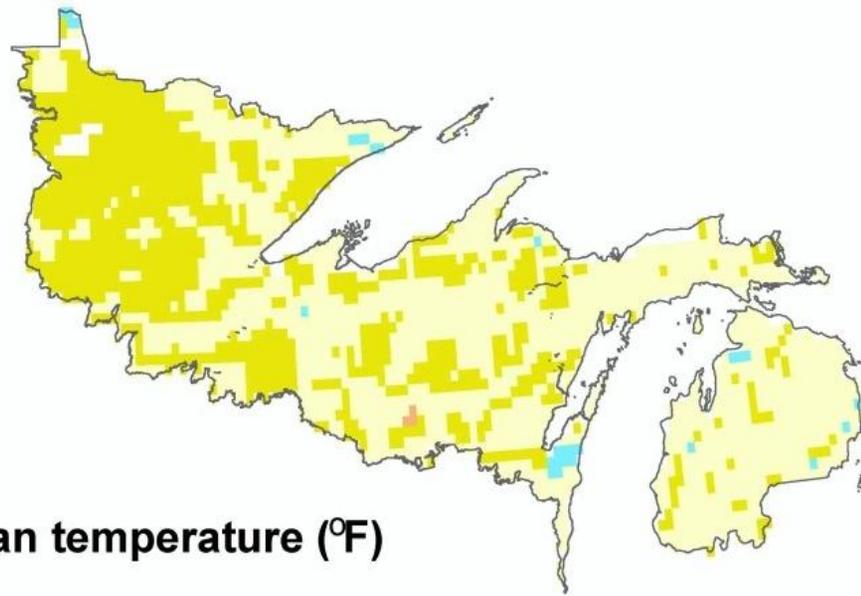


Tree species vulnerability assessments

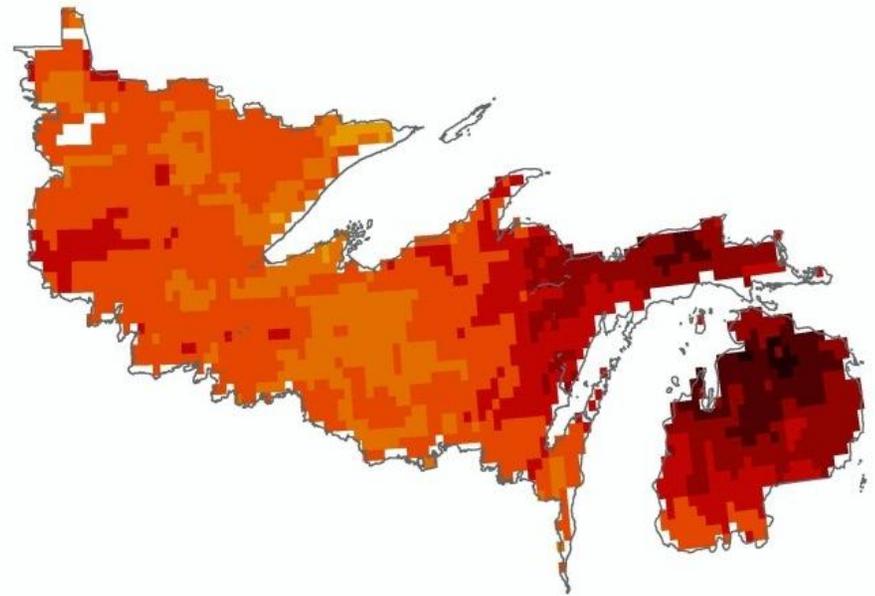
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2070-2100 Projected Annual Temperature Departure from Baseline (°F)

PCM B1



Hadley A1fi

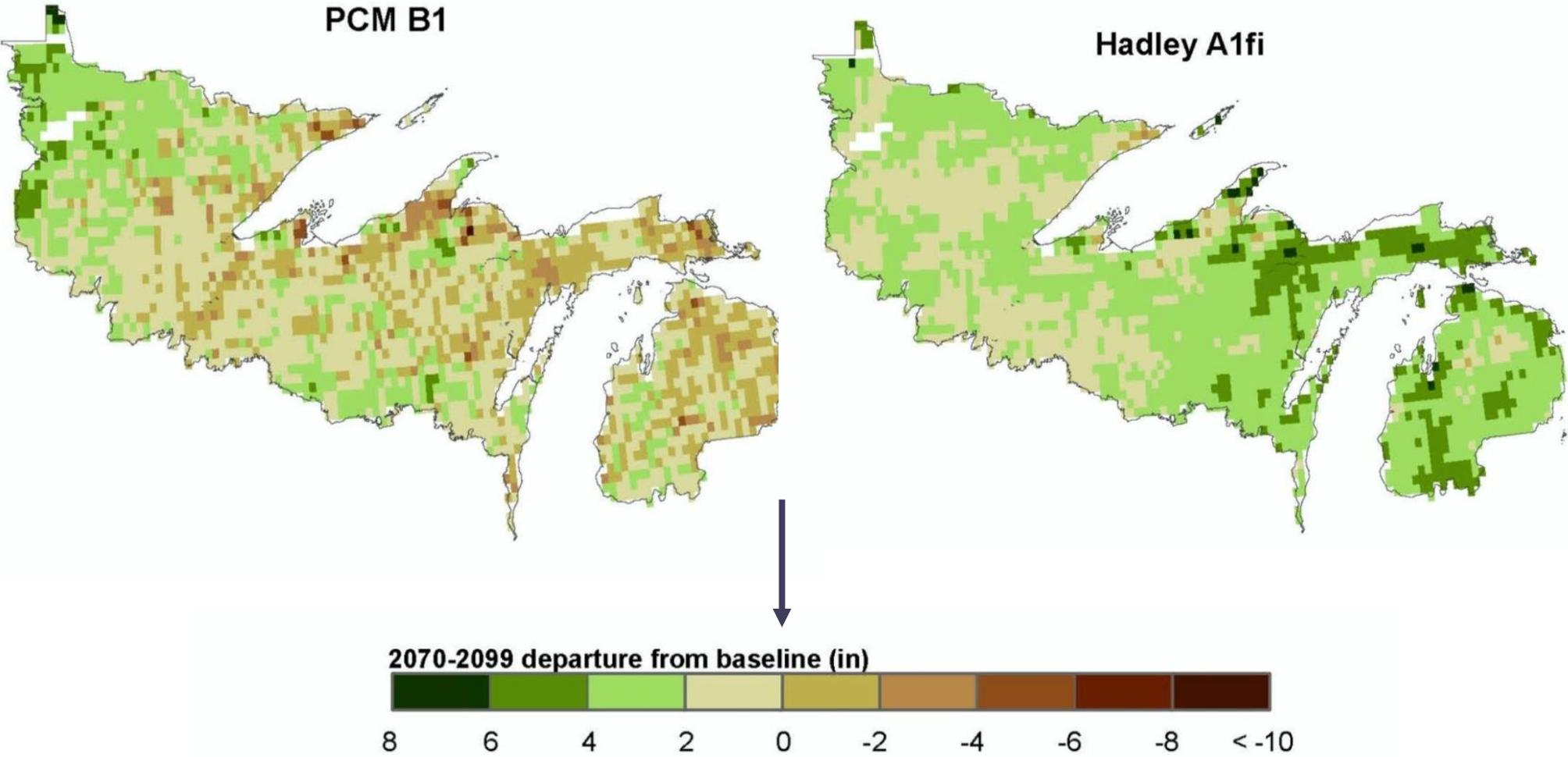


Mean temperature (°F)

2070 - 2099 departure from baseline (°F)



2070-2100 Projected Annual Precipitation Departure from Baseline (in)



Summary of anticipated changes in climate for the Laurentian Forest Province in Minnesota

- Average annual temperature is projected to increase between 2.17 °F to 7.96 °F with winter warming by the end of the century (4.7 °F to 10.6 °F) much more than spring (1.36 °F to 4.51 °F).
- Changes in annual precipitation are less clear. GCM-scenarios combinations suggest an annual increase of as much as 3 inches or a decrease of about 0.5 inches.
- Changes in the seasonal distribution of precipitation in combination with higher temperatures suggest that moisture stress at the end of the growing season may be significant.
- Severe weather will be more frequent and intense.

Tree species vulnerability assessments

- Emissions scenarios, GCMs, and downscaling
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Comparison of impact models

Feature	Model		
	Tree Atlas	LANDIS-II	PnET-CN
Description	Statistical niche model (Species distribution model)	Spatially explicit, dynamic process model	Ecosystem-level carbon, water, and nitrogen process model
Primary outputs	Maps of suitable habitat and relative importance values by species	Biomass and distribution maps by species	Productivity, transpiration and runoff, N mineralization, etc.
Migration	Yes	Yes	No
Competition, survival, and reproduction	No (implied via historic pattern)	Yes	No
BAU and new management scenarios	No	Yes	No
Disturbances	Yes (via modifying factors)	Yes (harvest, fire, wind)	Yes (harvest, fire, wind)
Tree physiology feedbacks	No	No	Yes
Succession or ecosystem shifts	No (implied via historic pattern)	Yes	No
Ozone, N-deposition, CO2 fertilization	No	No	Yes
Confidence estimates	Yes	Yes	Yes

Tree Atlas approach

- **Describe the habitat of individual tree species using statistical models; identify where those habitats occur under future climate conditions.**
- **Predict how much of the future habitat will be occupied by those species.**
- **Account for other factors known to influence species success.**

Factors used to describe the current habitat and locate future habitat of individual tree species (20 km cells)

Climate

Mean annual temperature
Mean January temperature
Mean July temperature
Mean May-September temperature
Mean May-September precipitation
Annual precipitation
Difference temperature (January-July)

Elevation

Elevation coefficient of variation
Maximum elevation
Average elevation
Minimum elevation
Range of elevation

Land Use and Fragmentation

Percent cropland
Percent forestland
Fragmentation index
Percent non-forestland

Soil Order and Soil Properties

% Alfisol, Aridisol, etc.
Soil bulk density
Percent clay
Soil erodibility
Percent coarse soil
Percent fine soil
Organic matter content
Potential soil productivity
Soil permeability
Soil pH
Depth to bedrock
Percent weight of rock fragments
Soil slope
Total available water capacity

Factors used to predict how much of the future habitat will be occupied by those species (over 100 year period).

Current abundance in surrounding cells

Habitat quality

Distance

Factors known to influence species success.

Biological

Fire regeneration

Dispersal ability

Water use efficiency

Productivity

Shade tolerance

Edaphic specificity

Vegetative regeneration

Seedling establishment

Environmental habitat specificity

Disturbance

Drought

Flood

Browse

Pollution

Ice

Fire topkill

Harvest

Invasive plants

Insect

Wind

Disease

Temperature gradients

Tree species vulnerability assessments

- **Emissions scenarios, GCMs, and downscaling**
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In the following slides:

Current and future habitat is measured by Importance Value (IV).

For current conditions, IVs are calculated from FIA data.

$$IV(x) = 50 * BA(x) / BA \text{ (all species)} + 50 * NS(x) / NS(\text{all species})$$

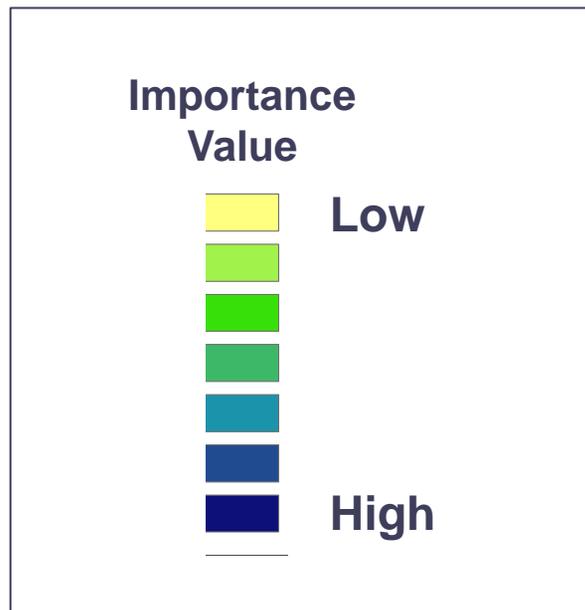
For future conditions, IV is predicted based on relationships between current IVs and environmental variables quantified via regression analysis.

In the following slides

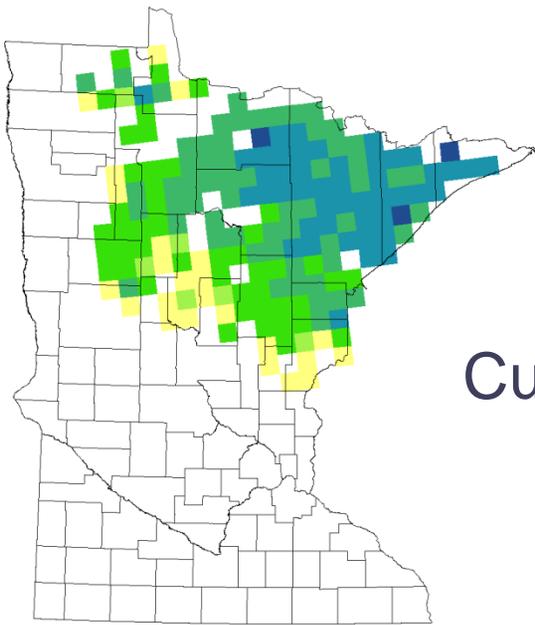
IVs tend to be lower in the future than the present.

IVs between 0 and 1 were rounded to 1.

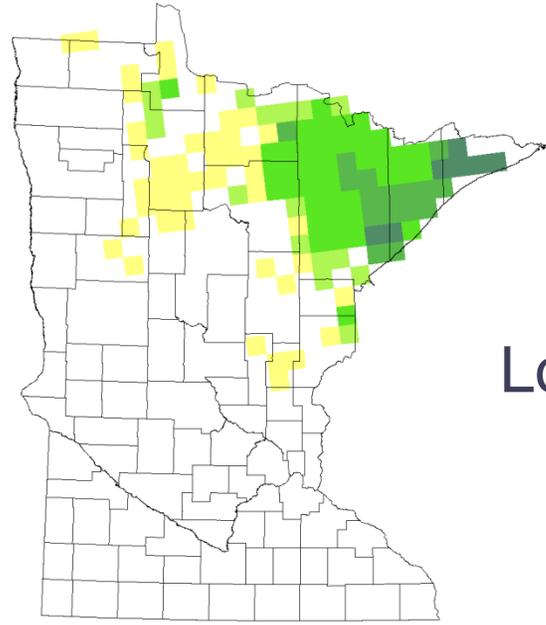
A single color scheme was used for all species to allow comparison between species.



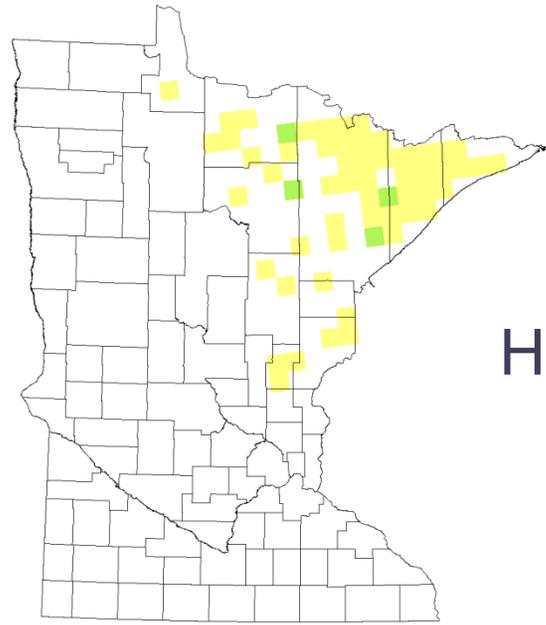
Balsam fir



Current

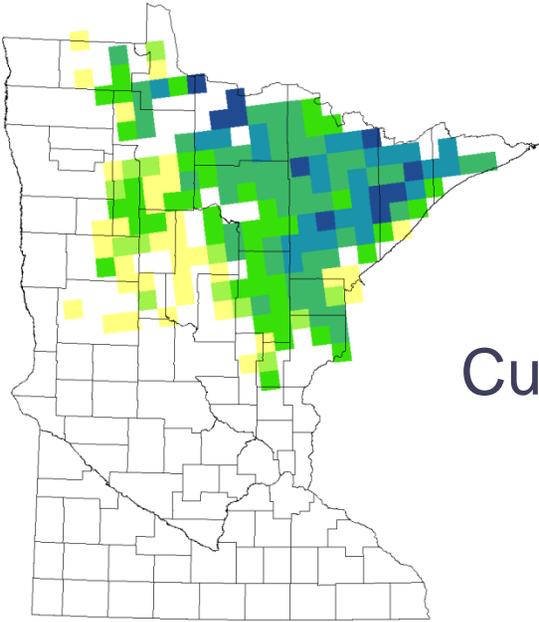


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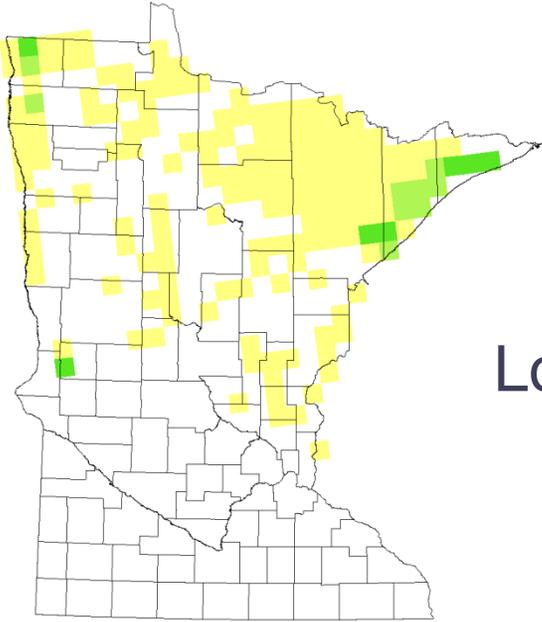


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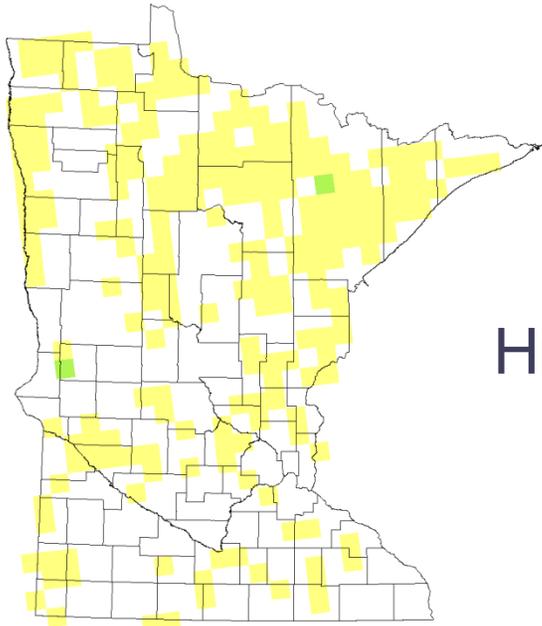
White spruce



Current

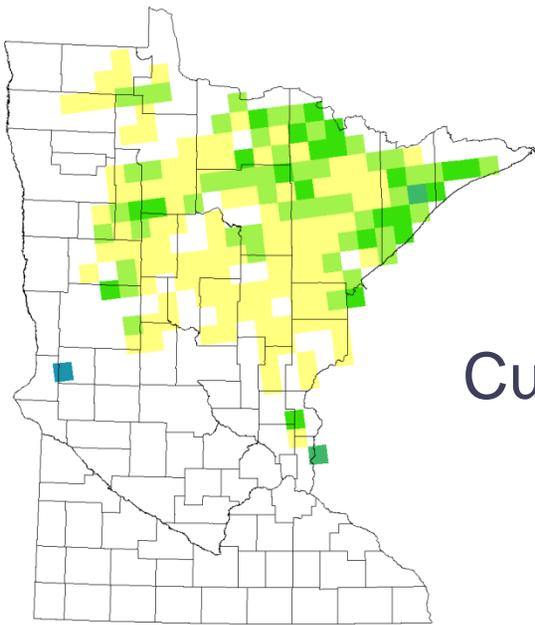


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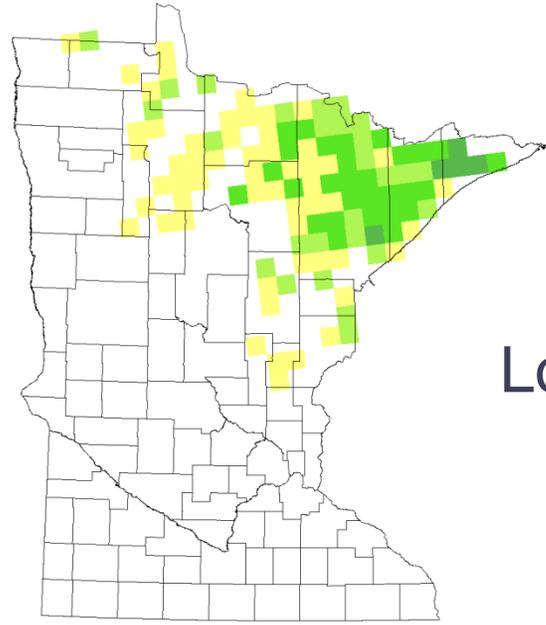


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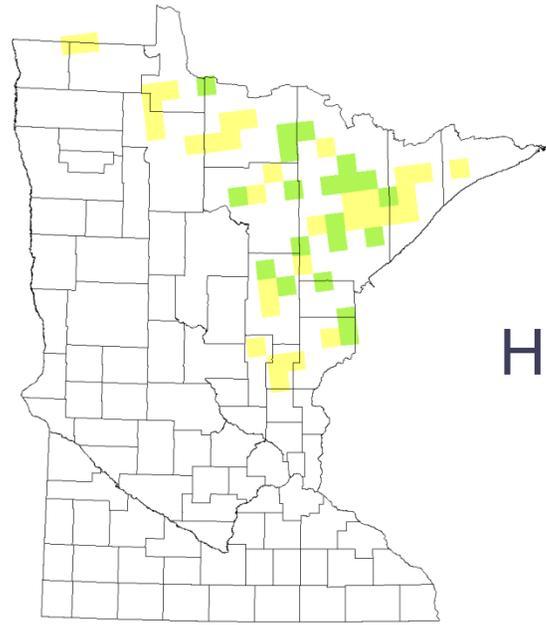
Black spruce



Current

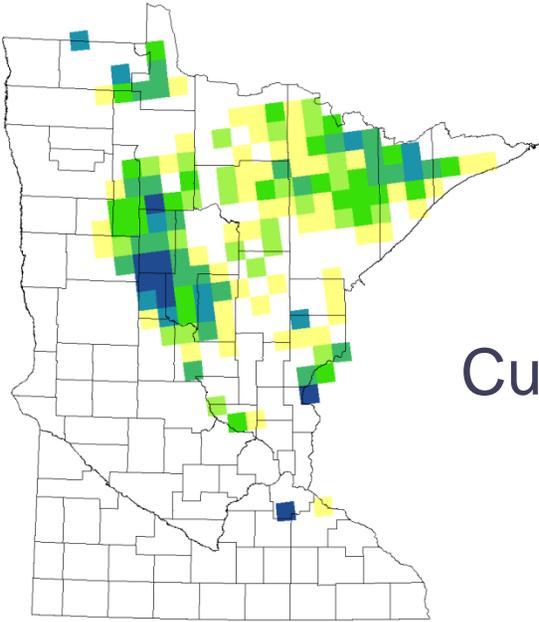


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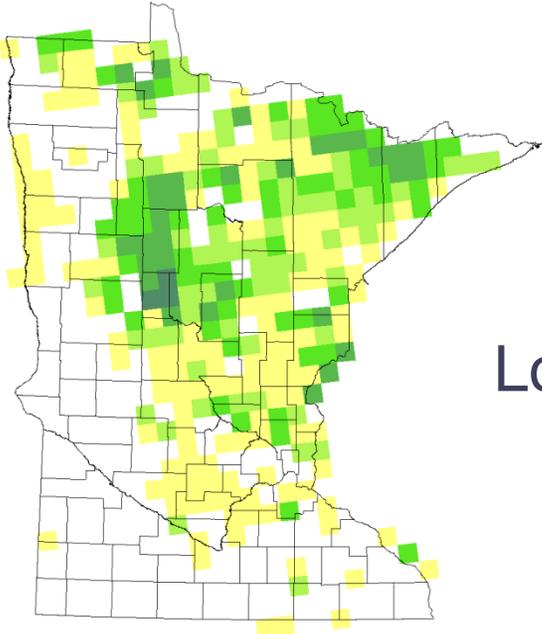


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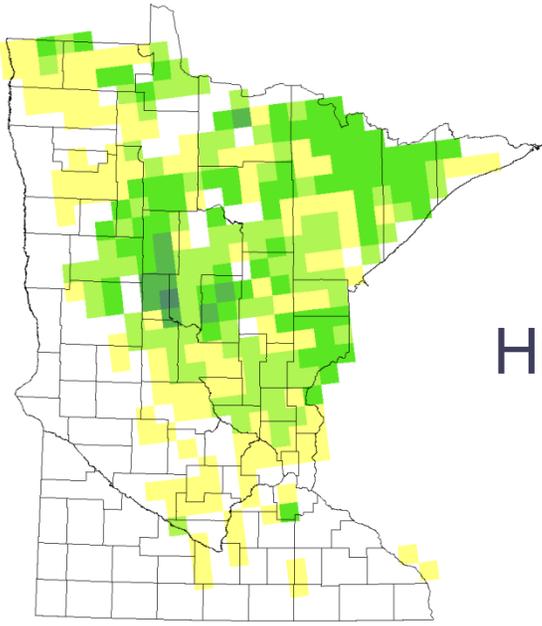
Jack pine



Current

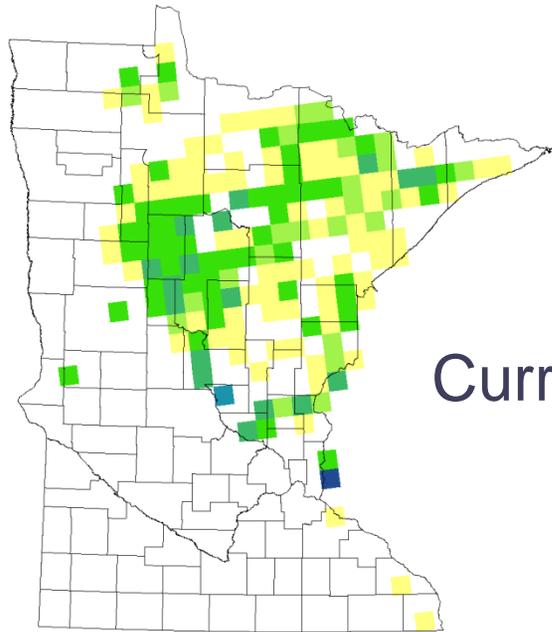


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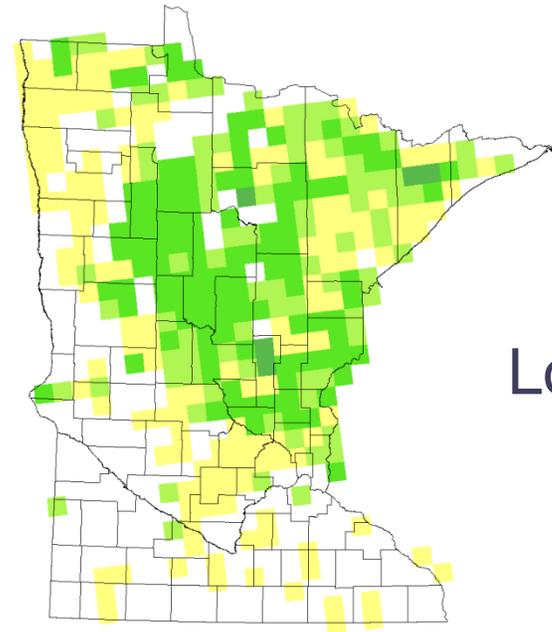


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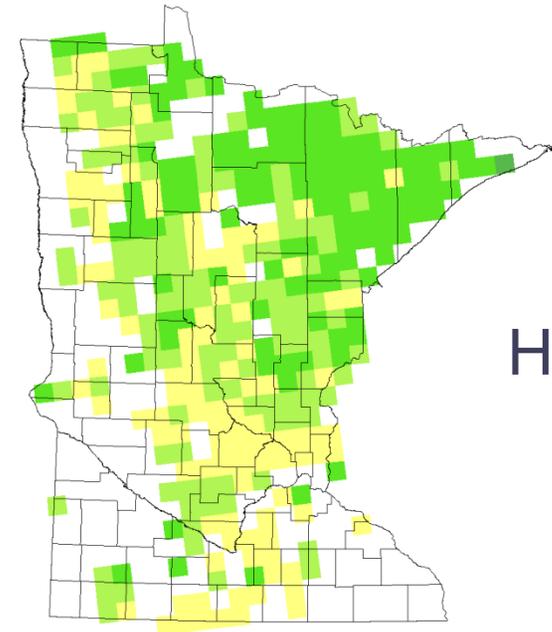
Red pine



Current

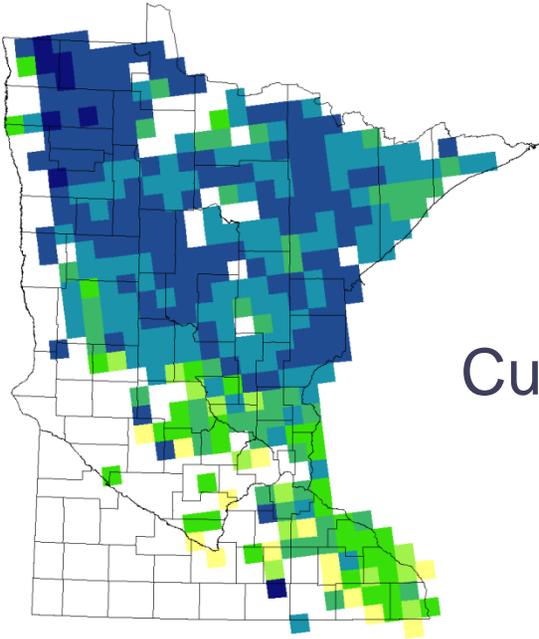


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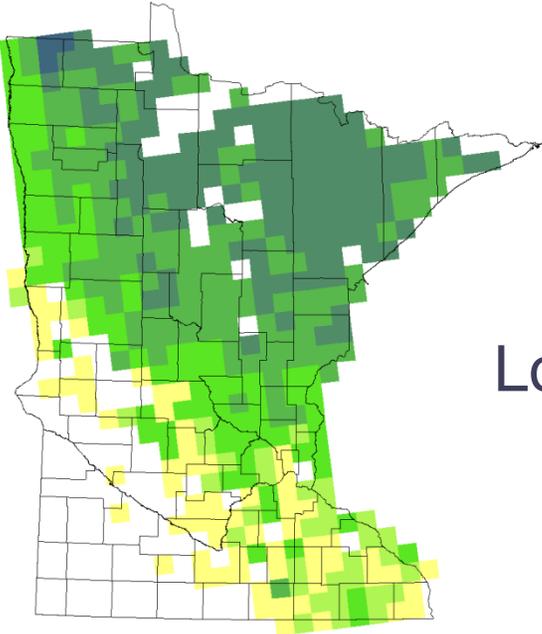


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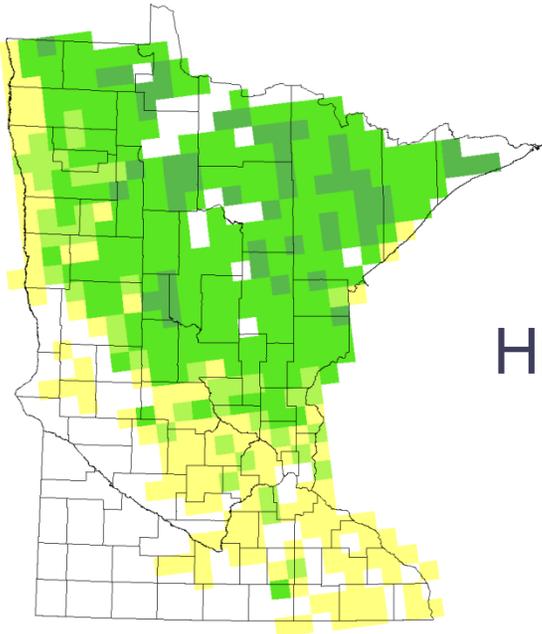
Quaking aspen



Current

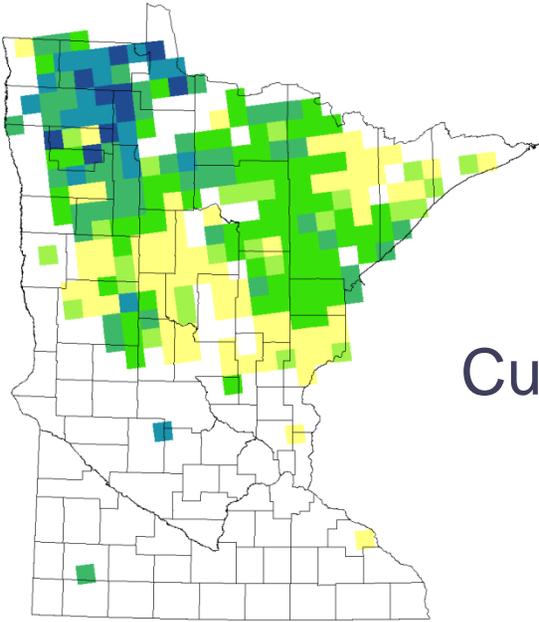


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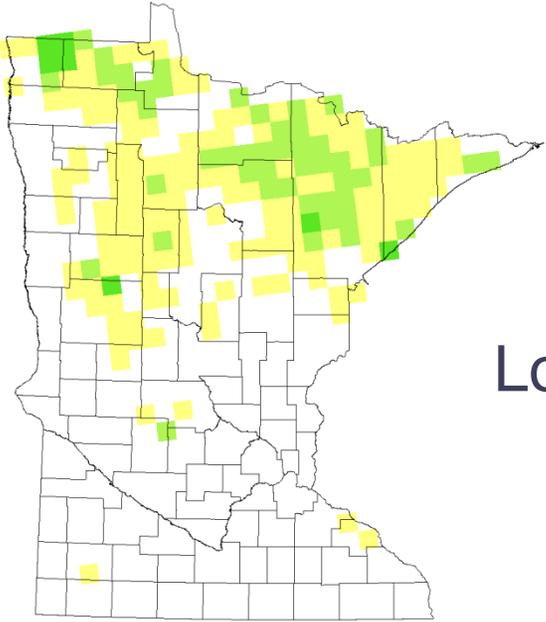


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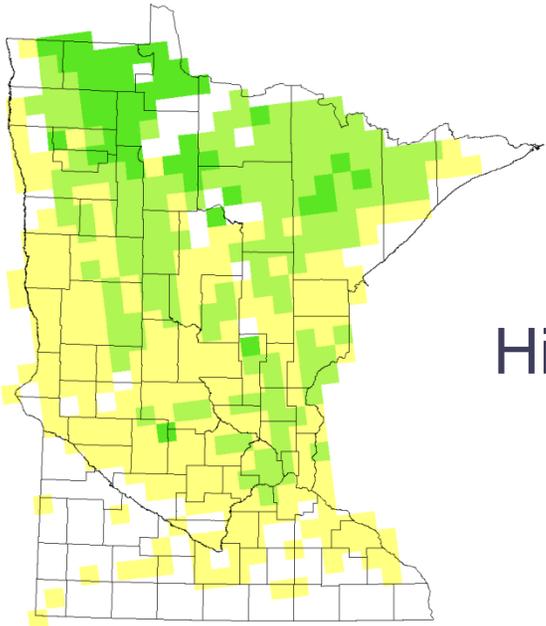
Balsam poplar



Current

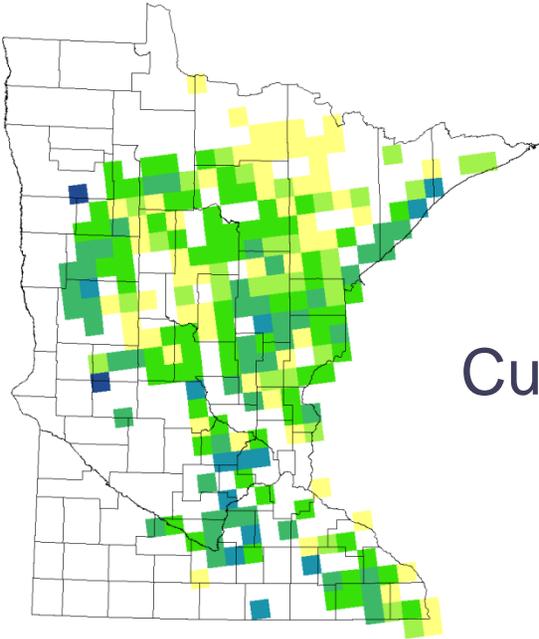


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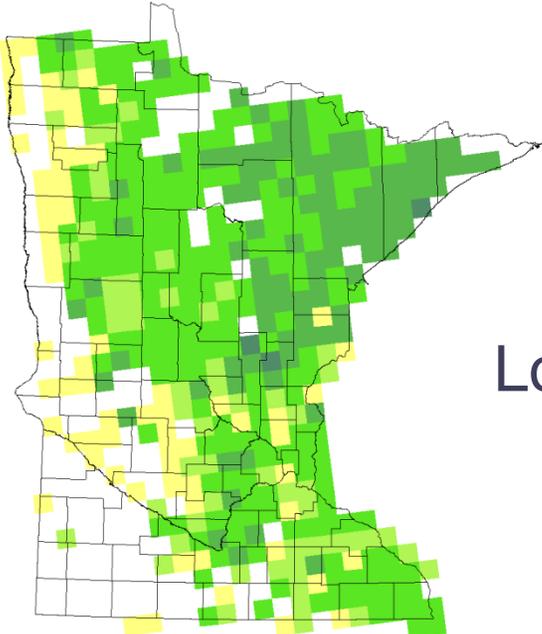


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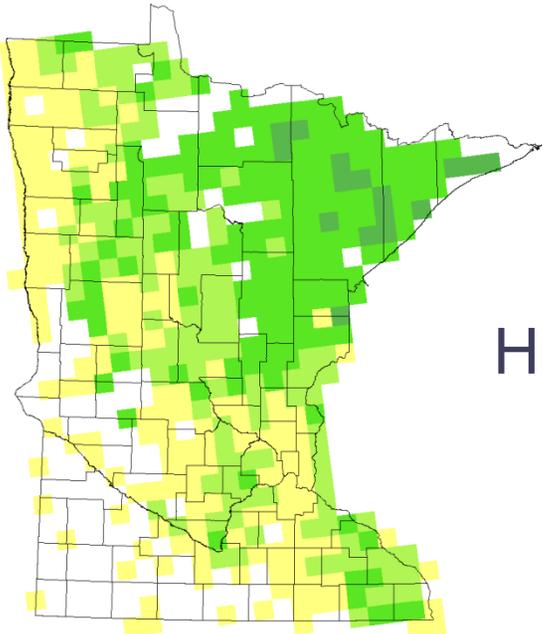
Sugar maple



Current

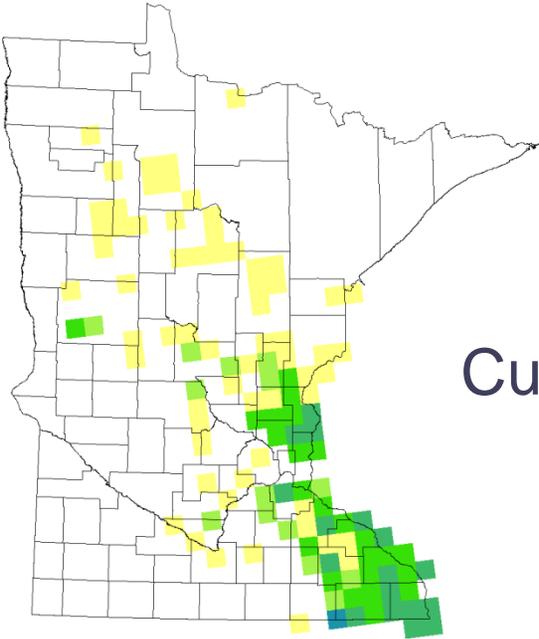


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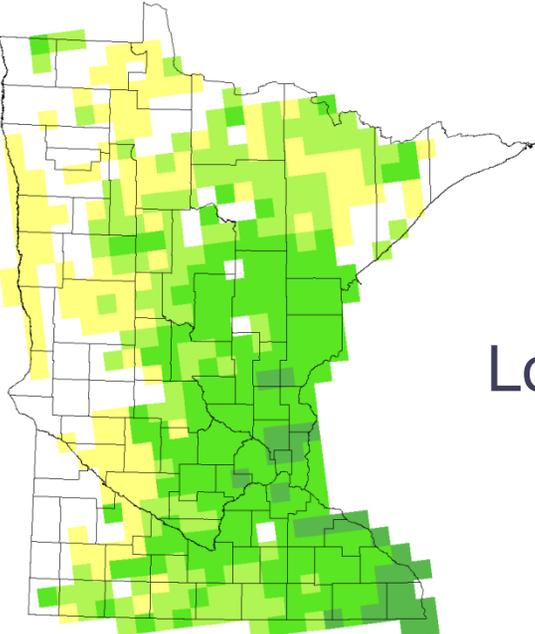


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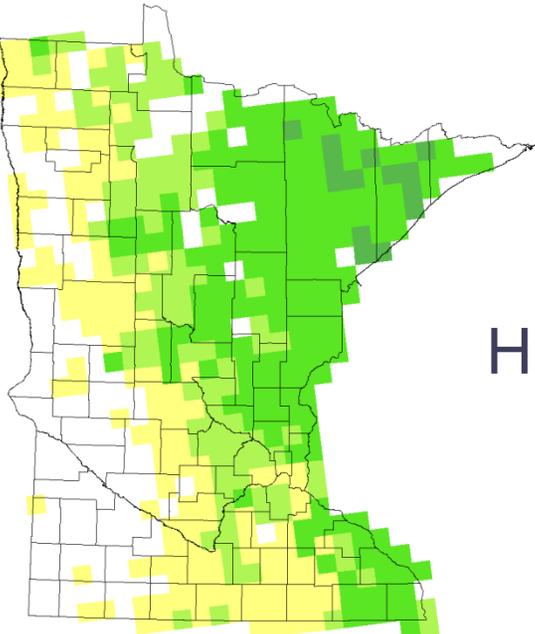
White oak



Current



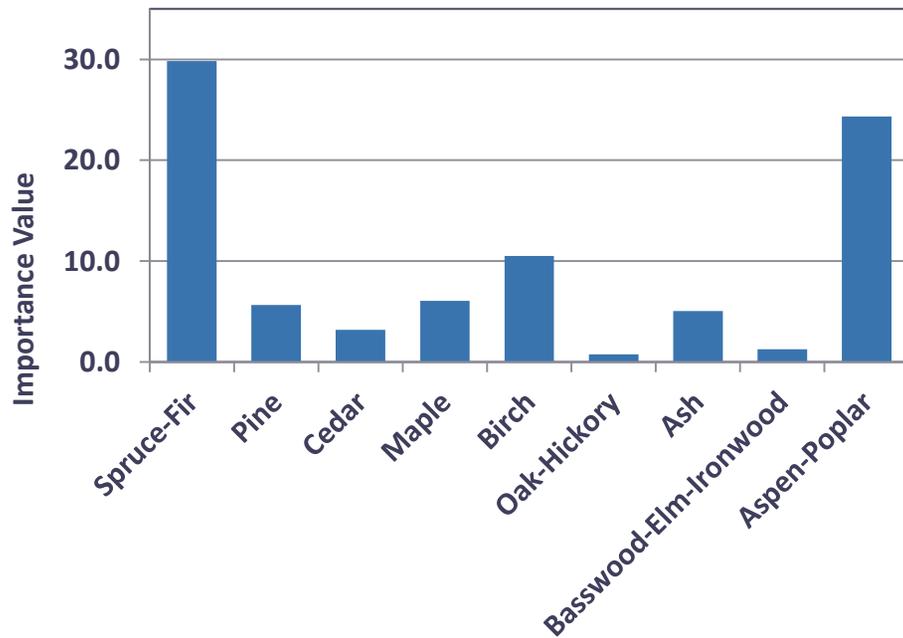
Low



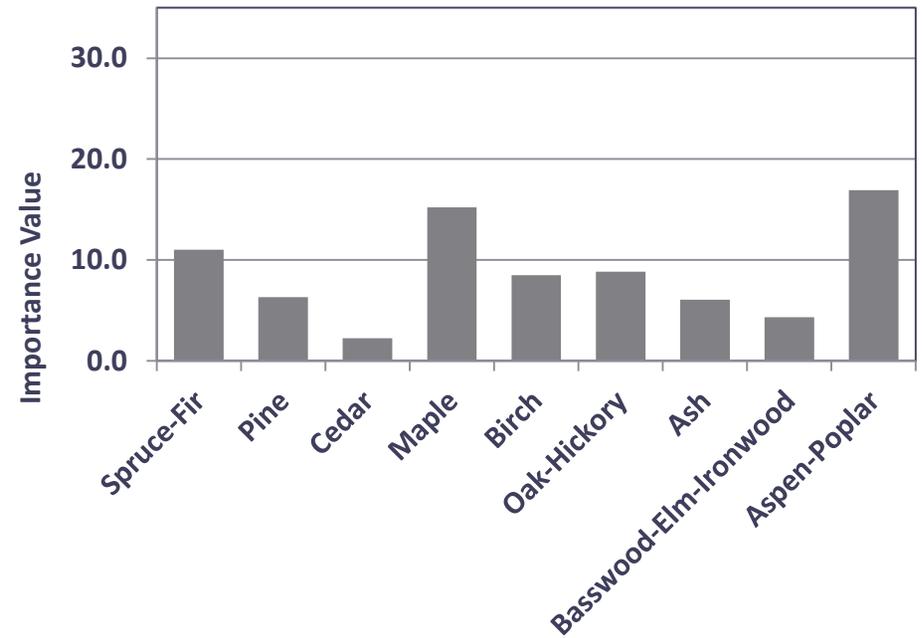
High

Current and projected tree species habitat in the MFRC Northeast Landscape

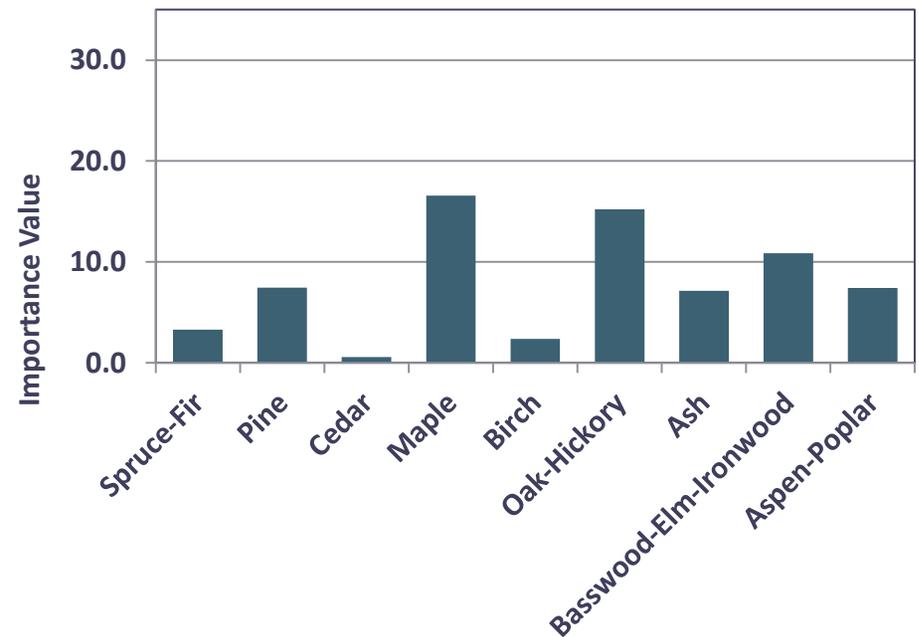
Current FIA



2070-2100 Low



2070-2100 High



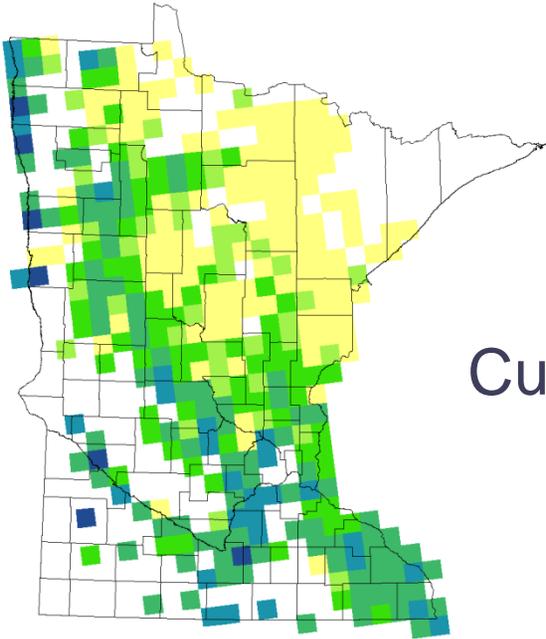
Questions?

Clarence Turner
clarence.turner@state.mn.us
651-259-5291

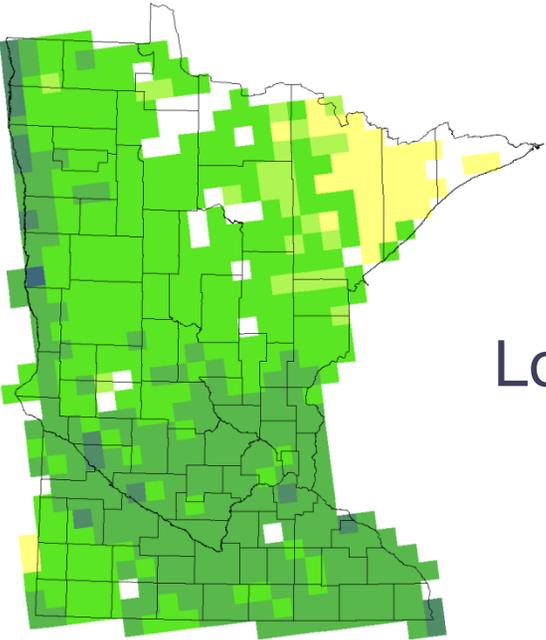
Summary of potential changes in tree species habitat in the NE landscape

Species group	Area-weighted mean IVs in NE landscape			Change	
	Current	Hadley High	PCM Low	Hadley High	PCM Low
Spruce-Fir	29.8	3.3	11.0	Large decrease	Large decrease
Pine	5.6	7.5	6.3	Increase	Increase
Cedar	3.2	0.6	2.3	Large decrease	Decrease
Maple	6.1	16.6	15.2	Large increase	Large increase
Birch	10.5	2.4	8.5	Large decrease	Decrease
Oak-Hickory	0.8	15.2	8.8	Large increase	Large increase
Ash	5.1	7.2	6.1	Increase	Increase
Basswood-Elm-Ironwood	1.3	10.9	4.3	Large increase	Large increase
Aspen-Poplar	24.4	7.4	16.9	Decrease	Decrease

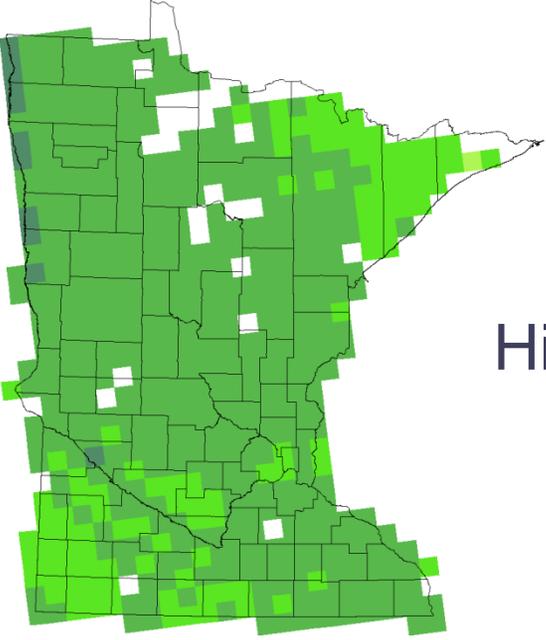
American elm



Current

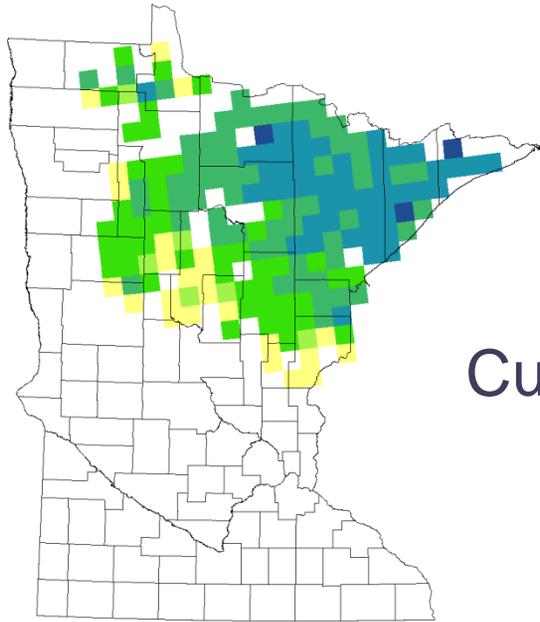


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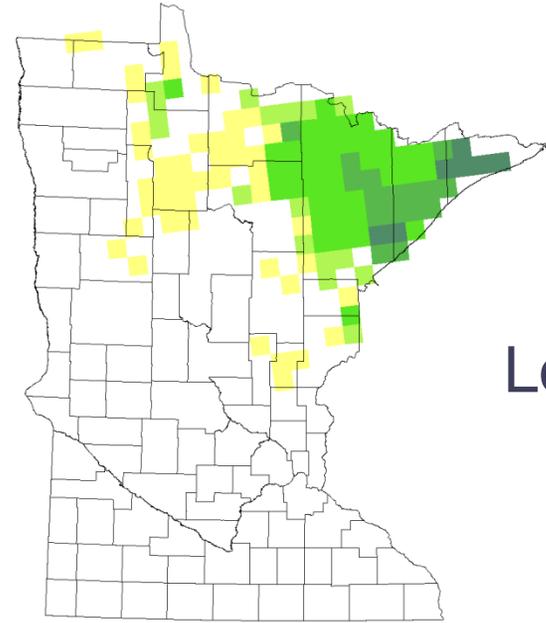


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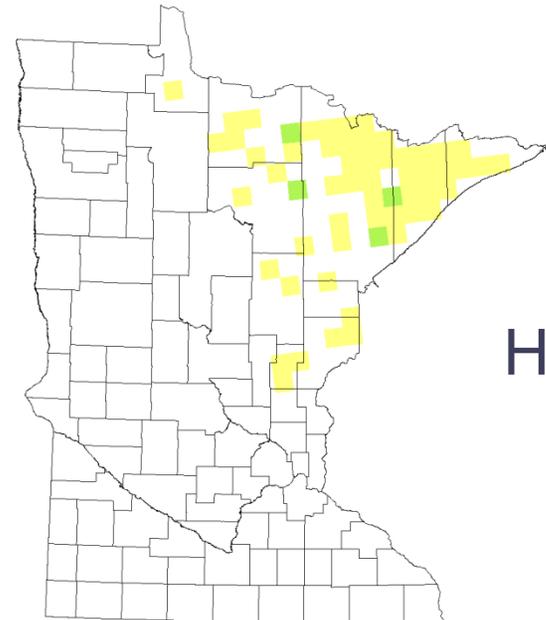
Balsam fir



Current

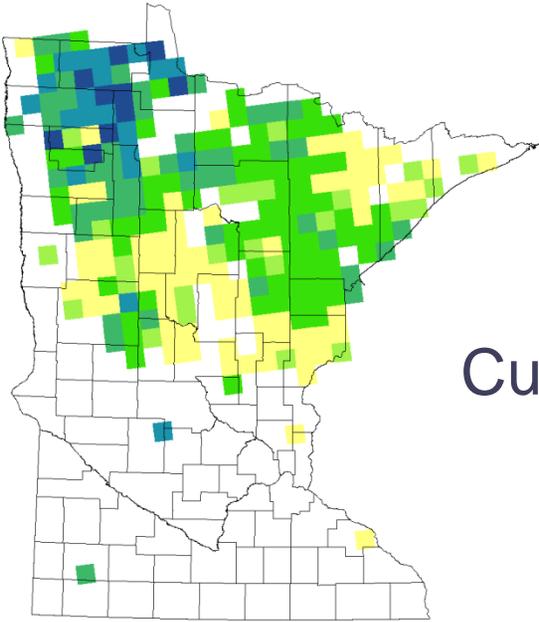


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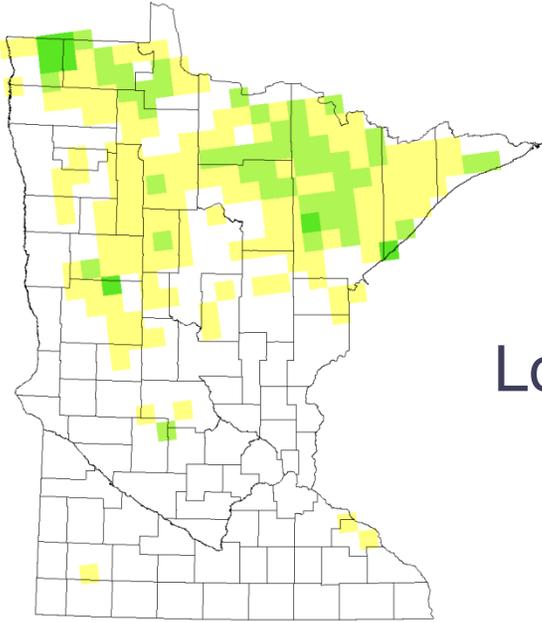


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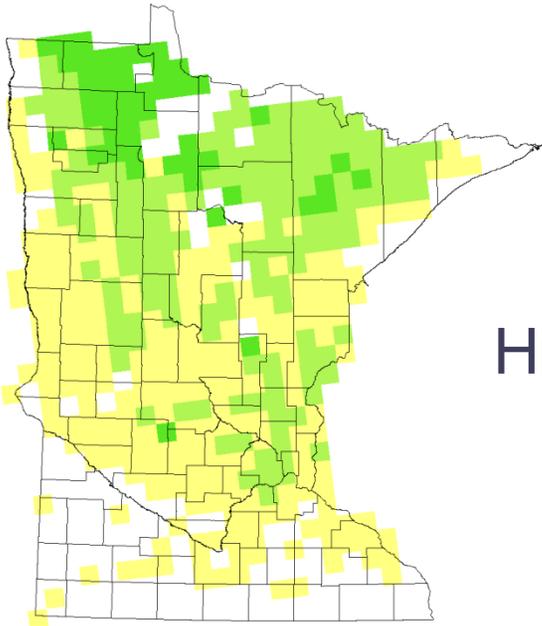
Balsam poplar



Current

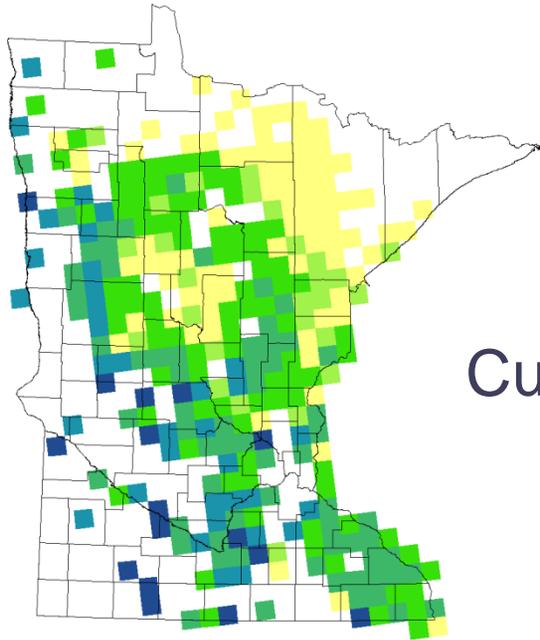


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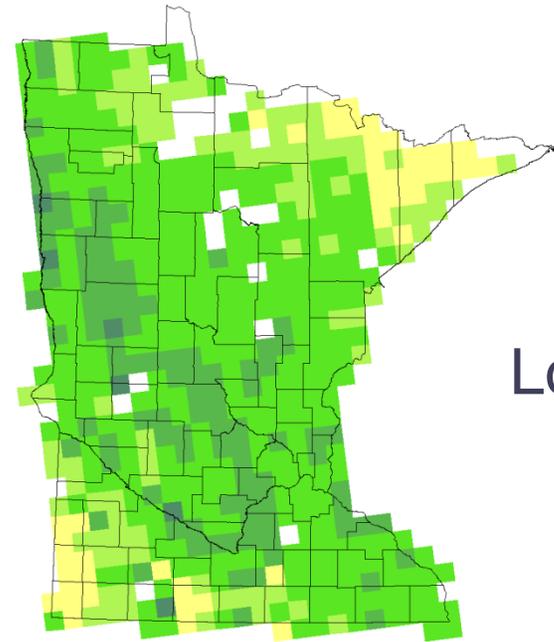


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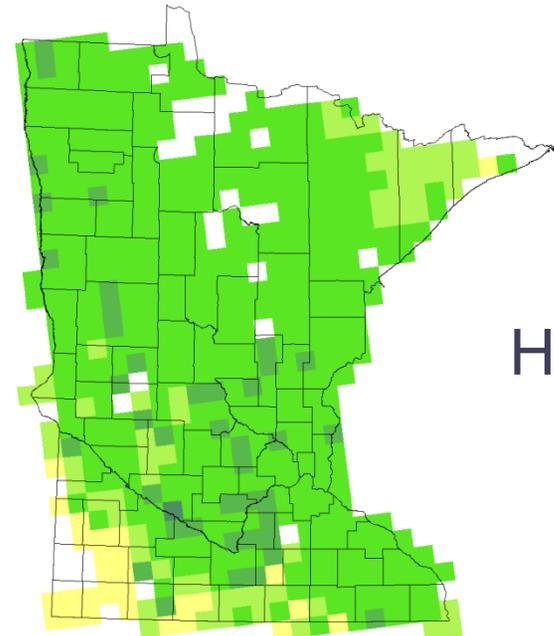
Basswood



Current

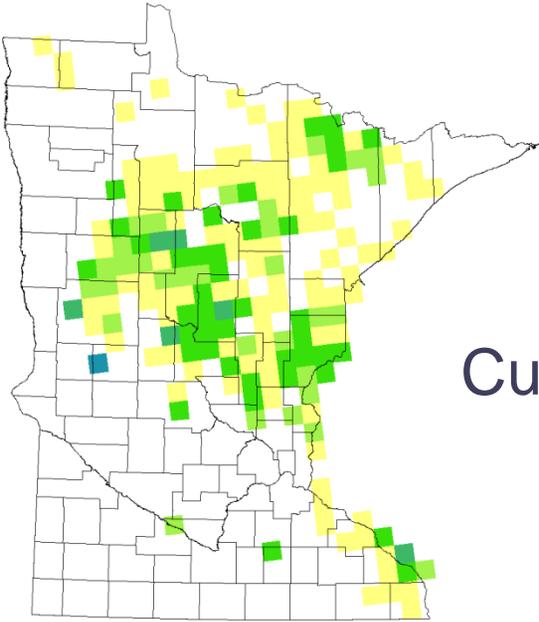


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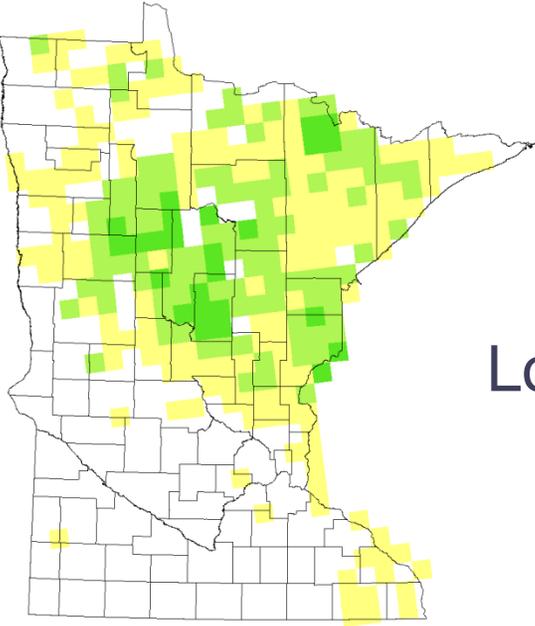


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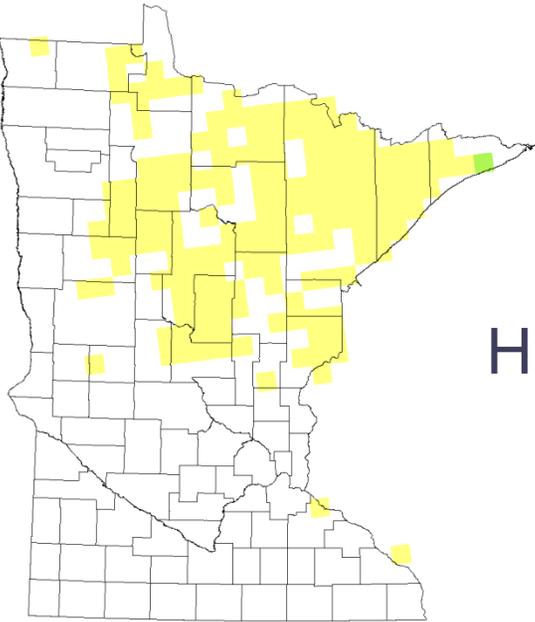
Big-toothed aspen



Current

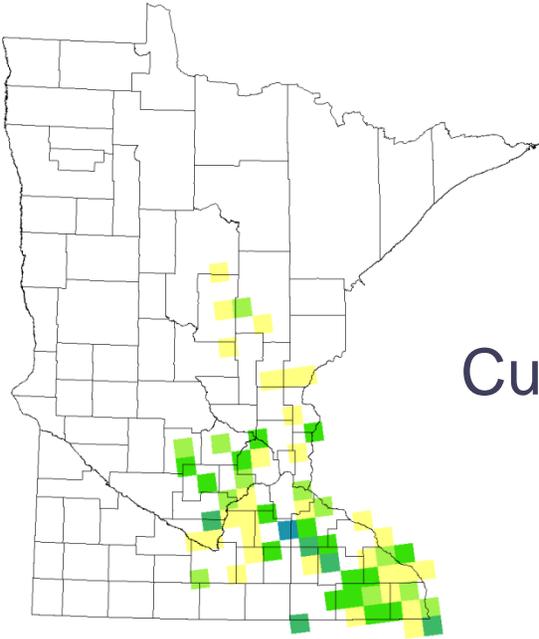


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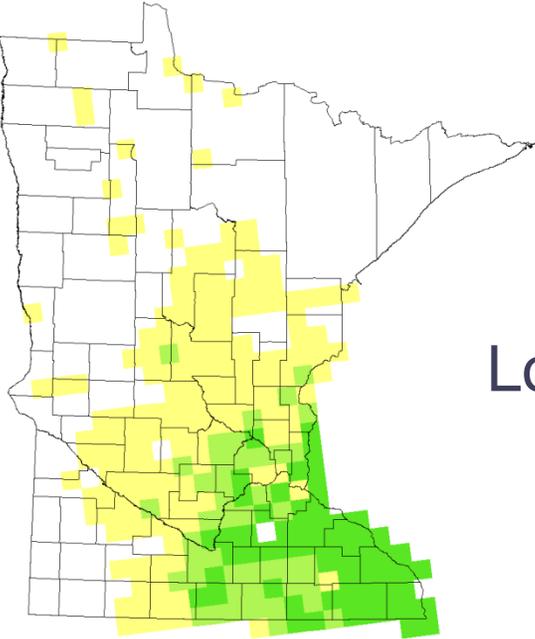


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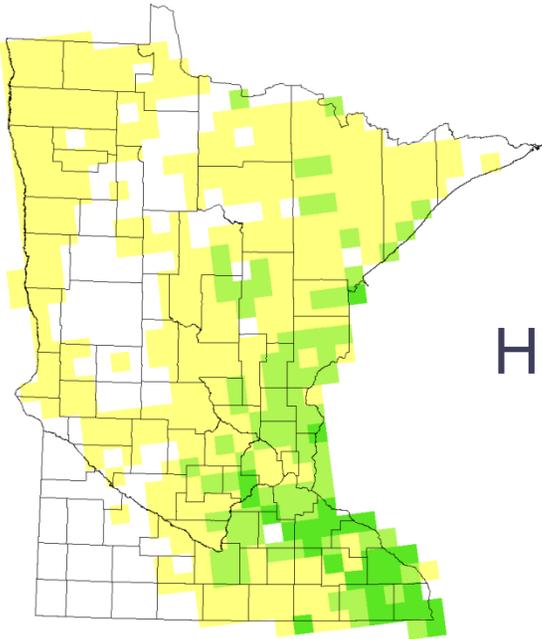
Bitternut hickory



Current

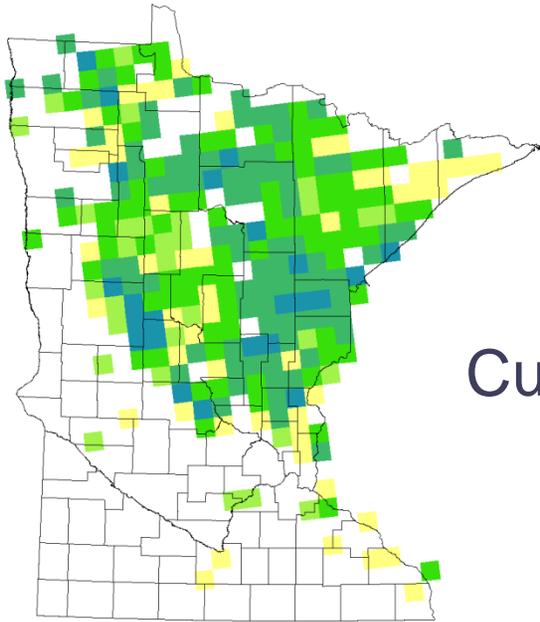


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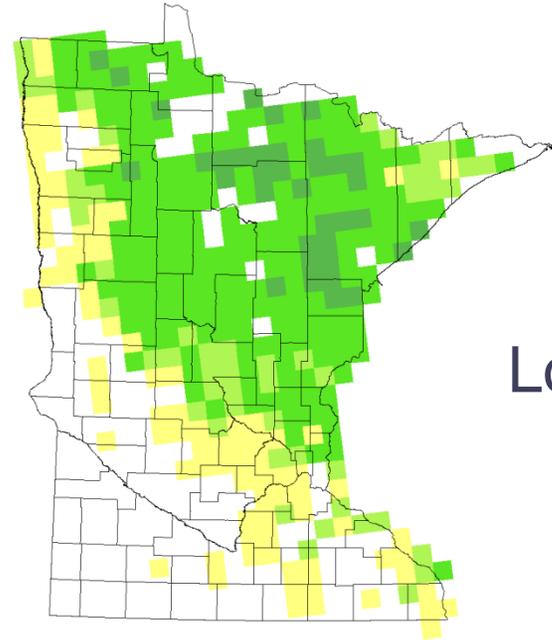


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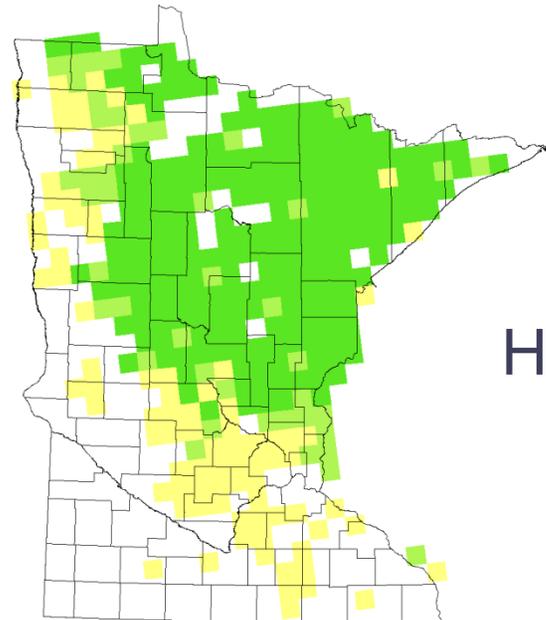
Black ash



Current

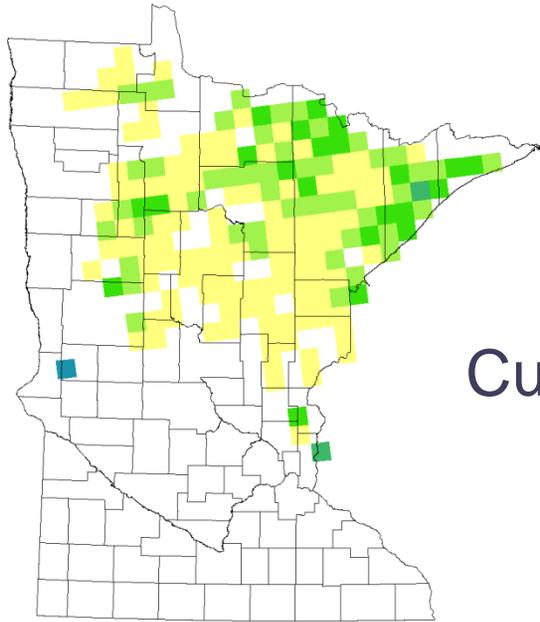


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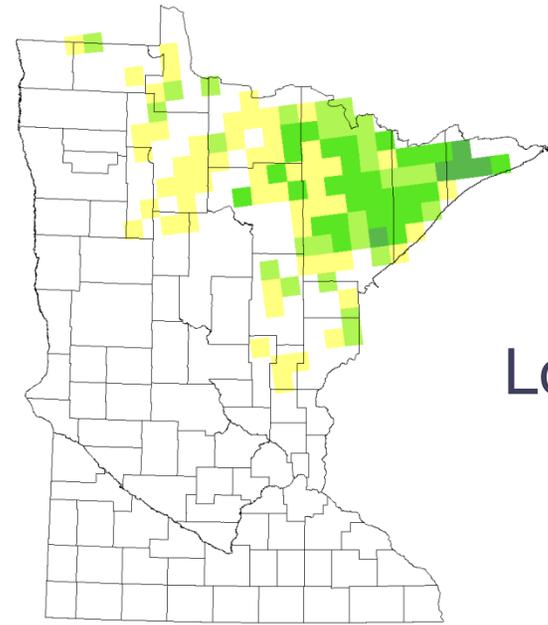


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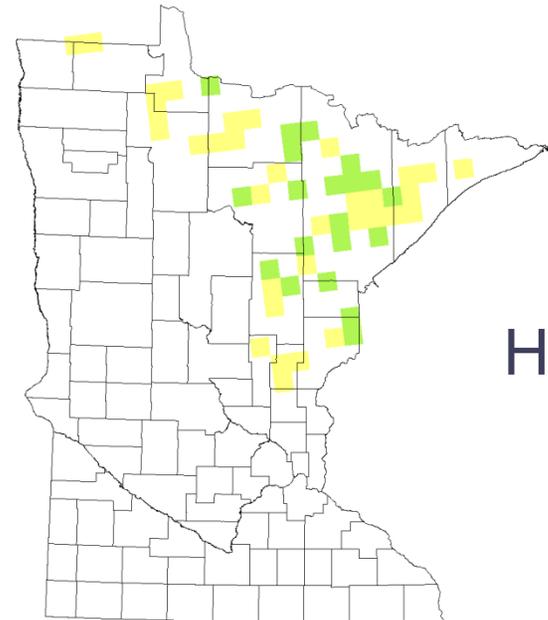
Black spruce



Current

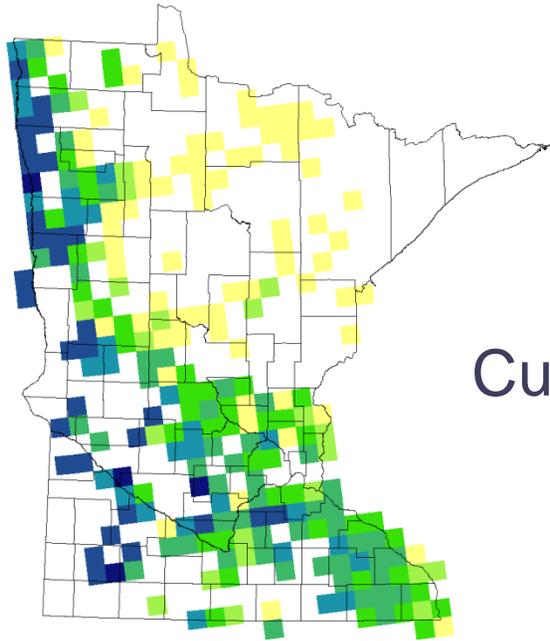


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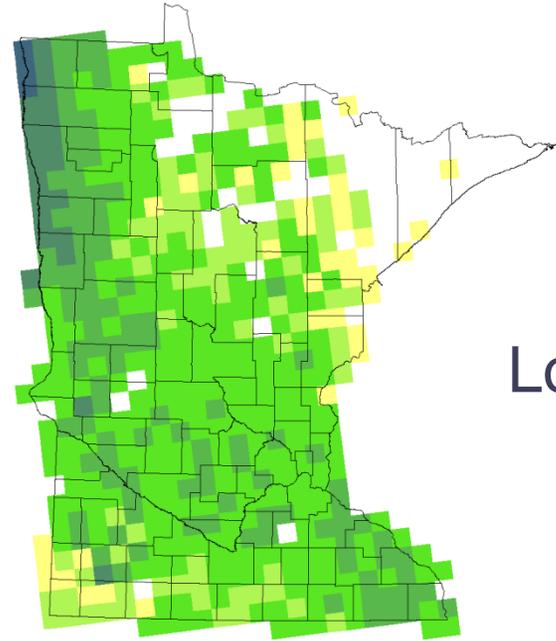


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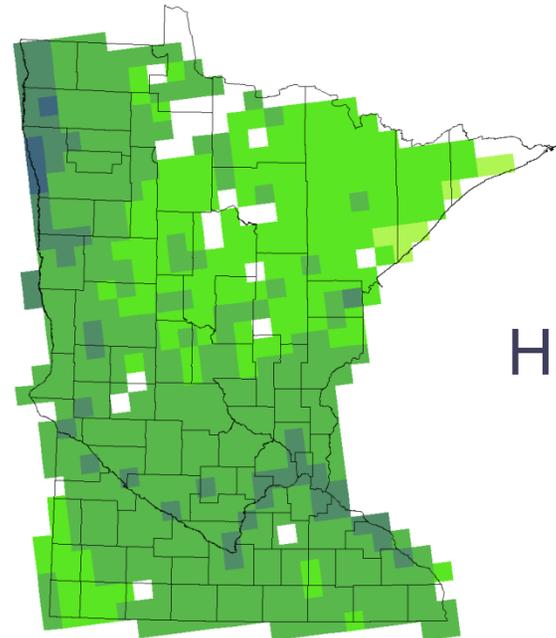
Boxelder



Current

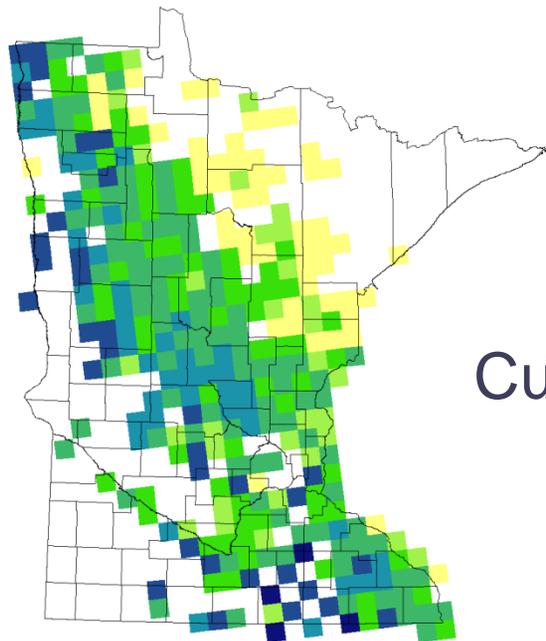


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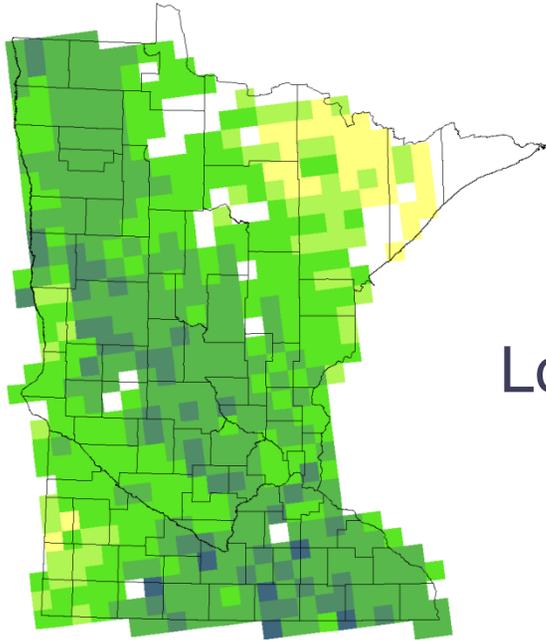


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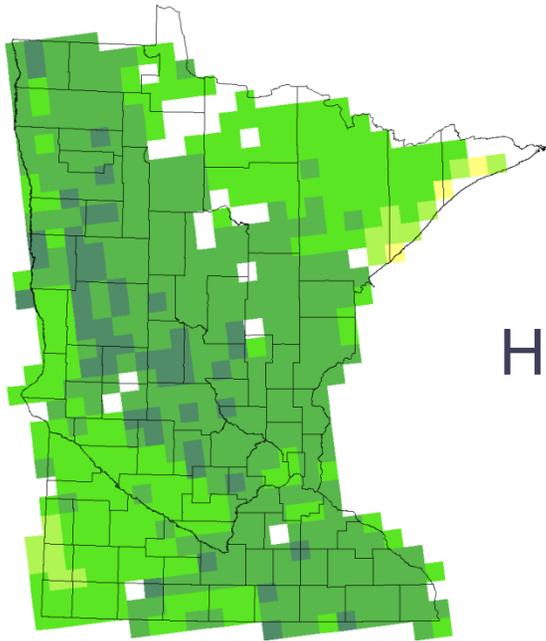
Bur oak



Current

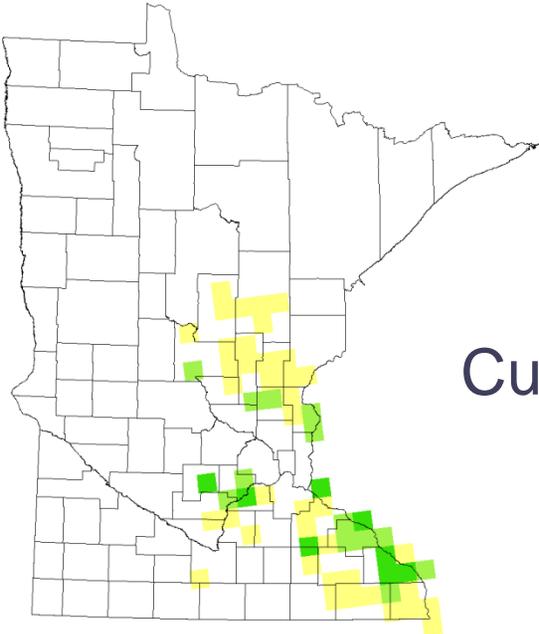


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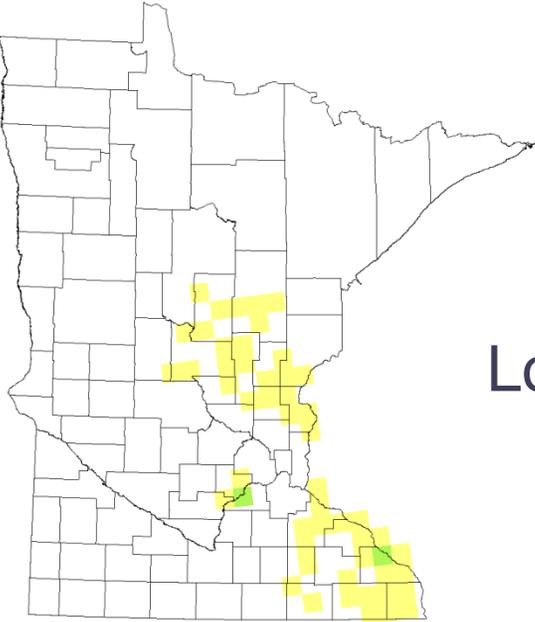


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Butternut



Current

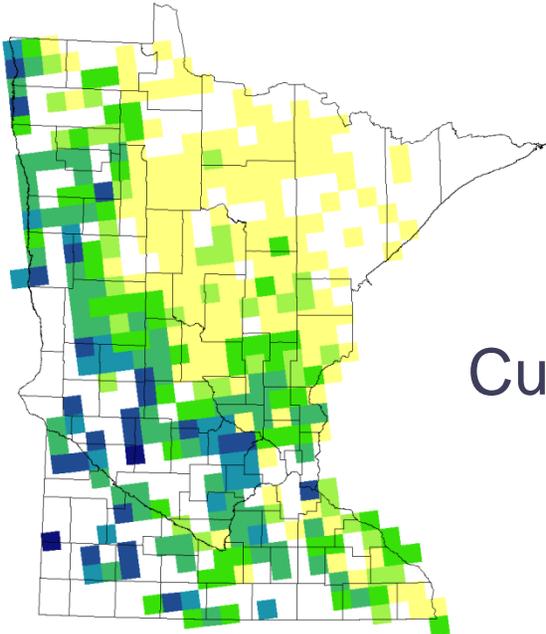


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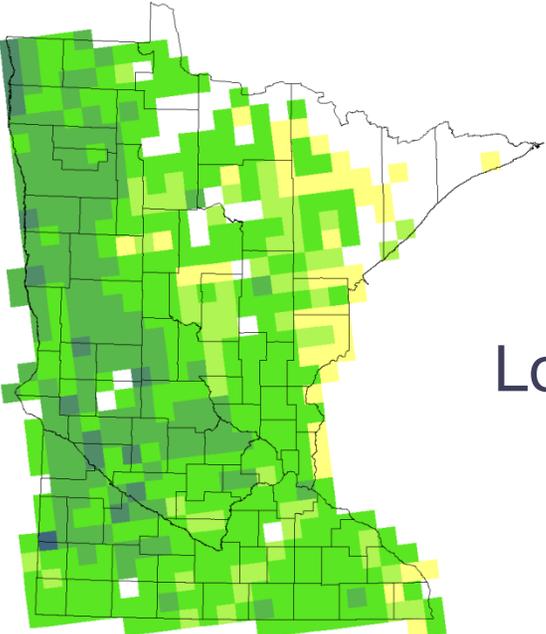


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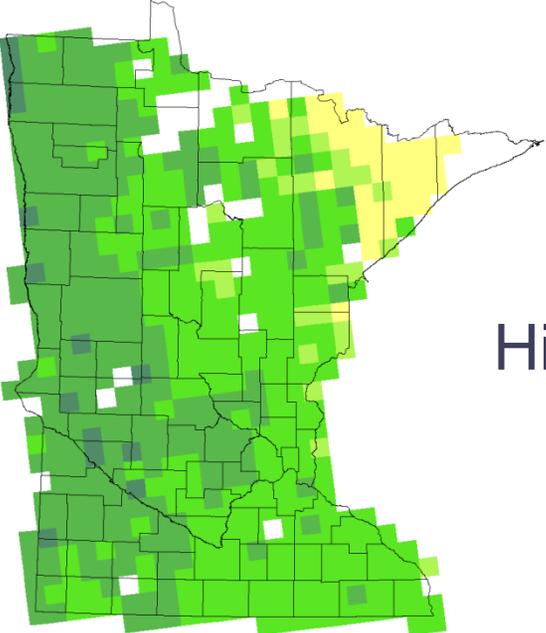
Green ash



Current

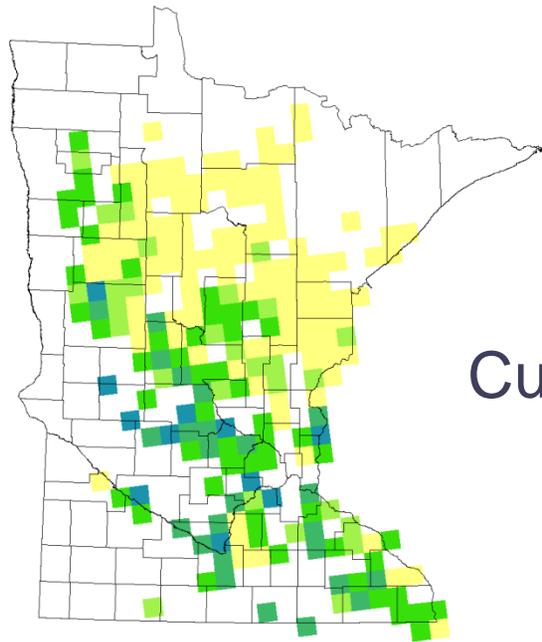


Low

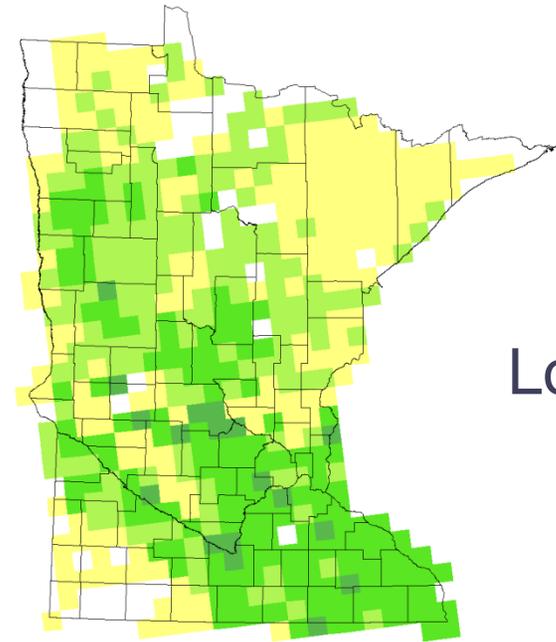


High

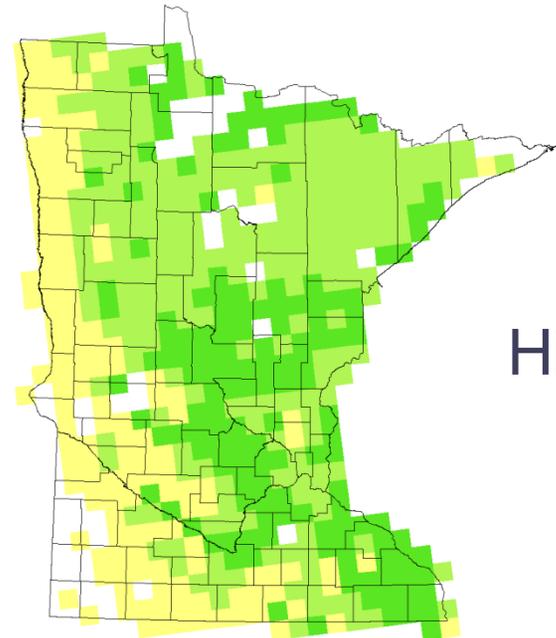
Ironwood



Current

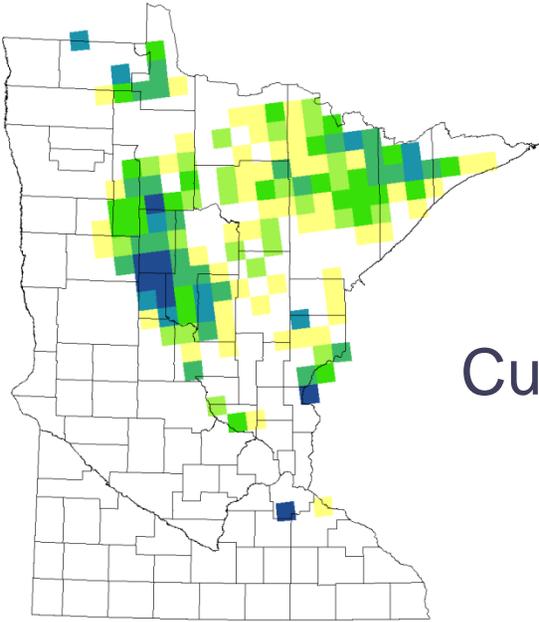


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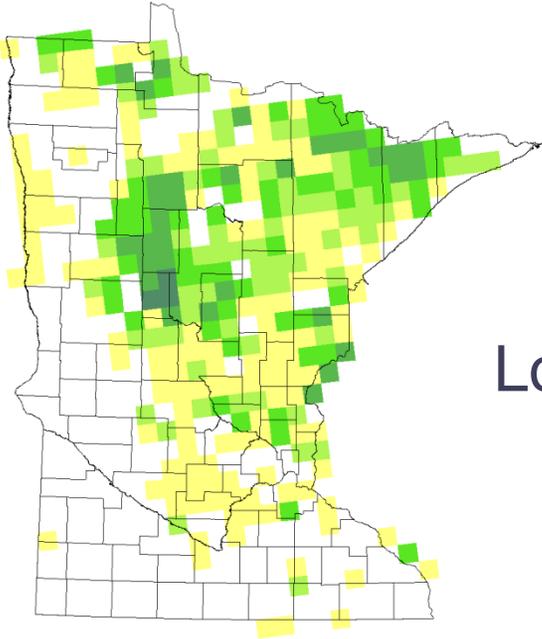


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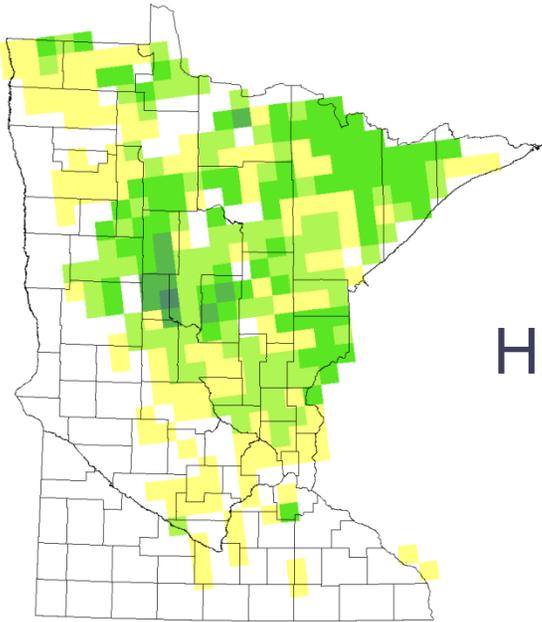
Jack pine



Current

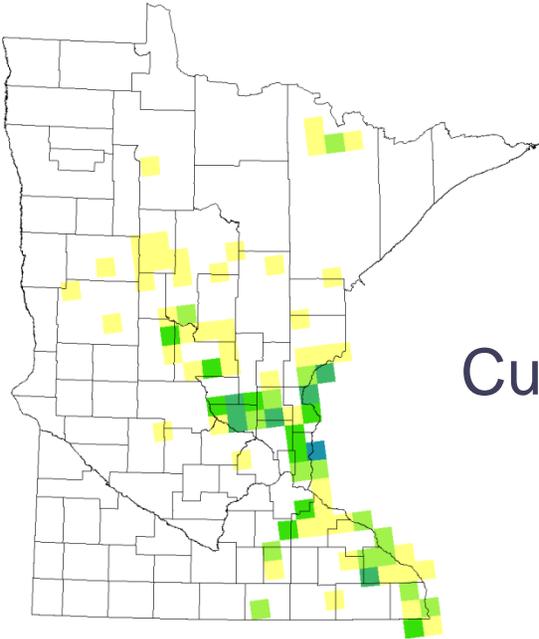


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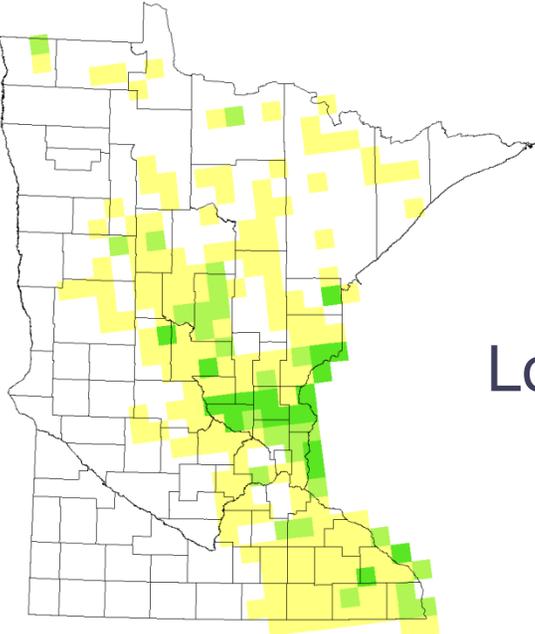


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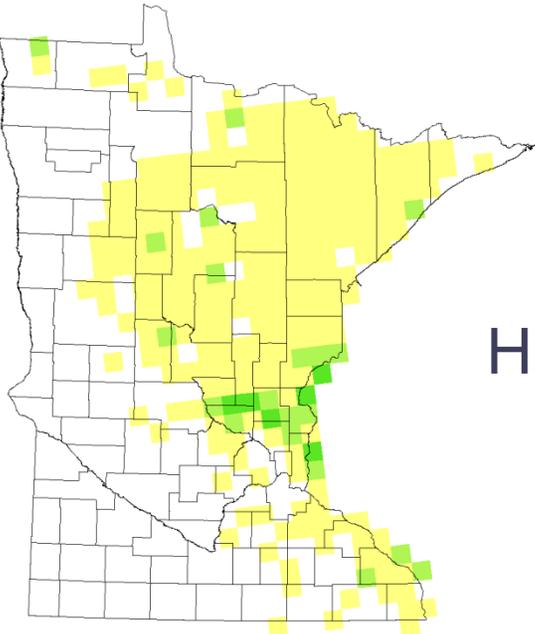
Northern pin oak



Current

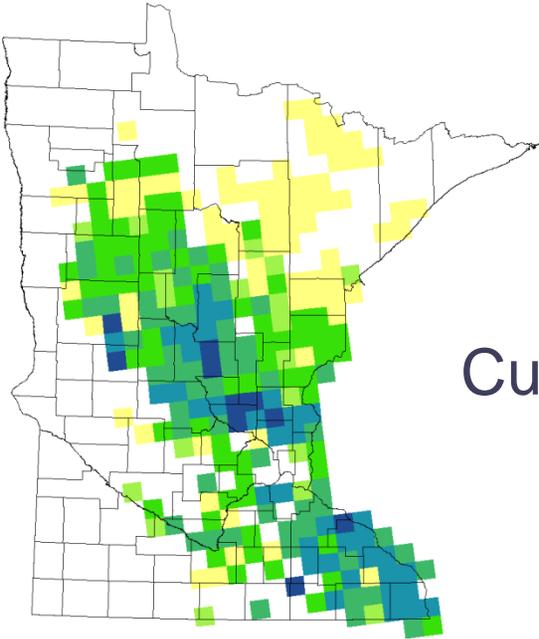


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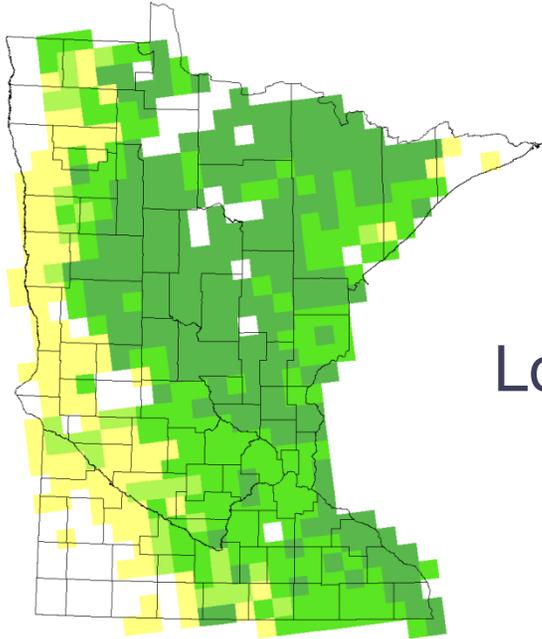


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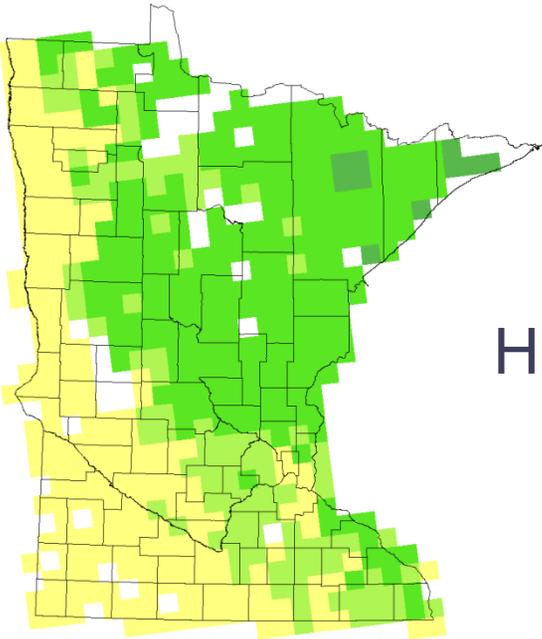
Northern red oak



Current

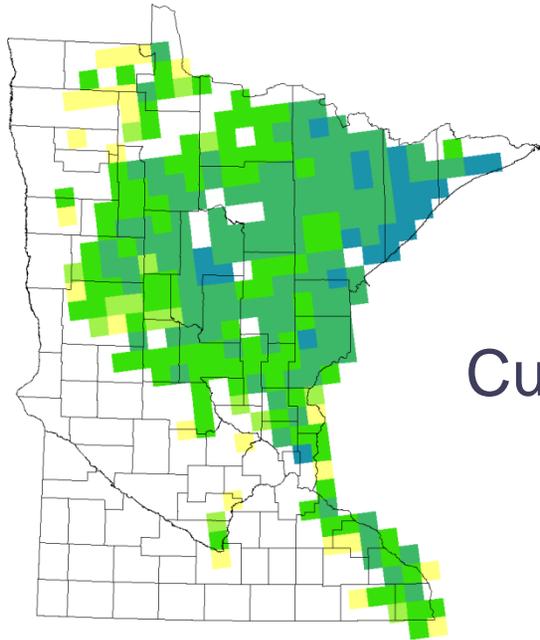


Low

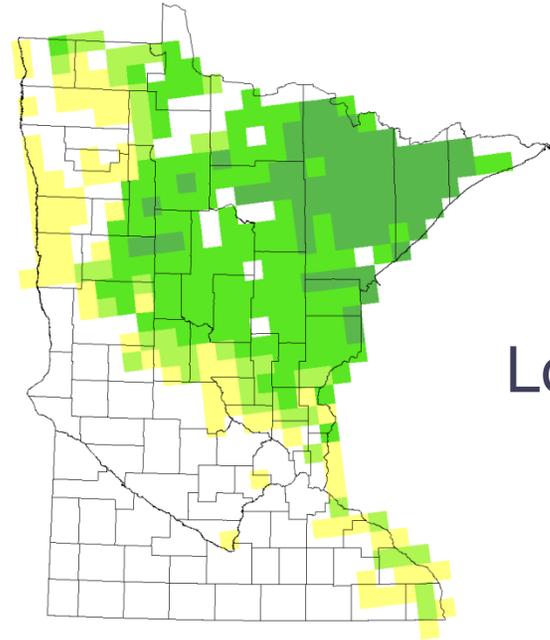


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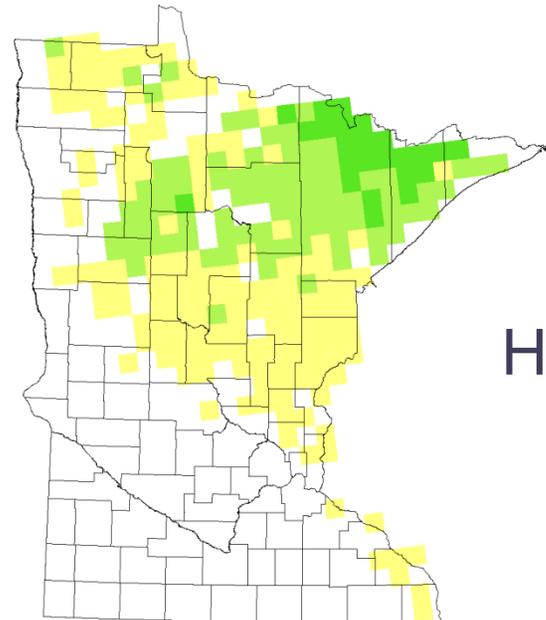
Paper birch



Current

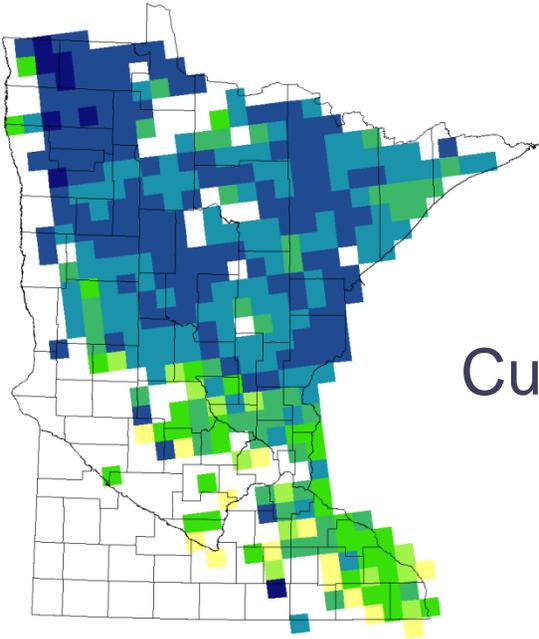


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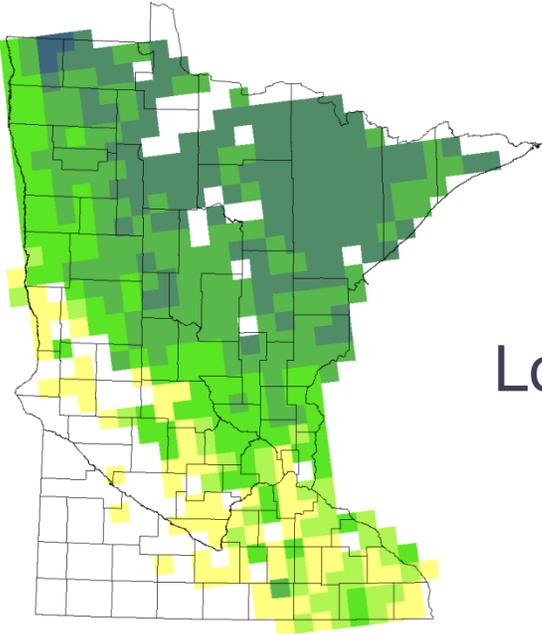


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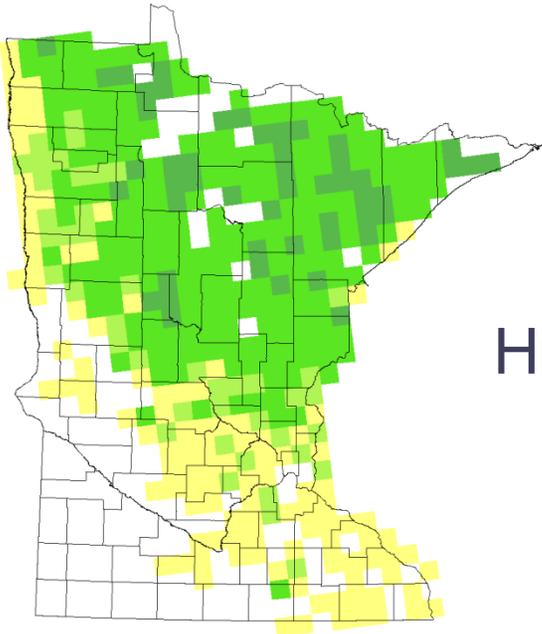
Quaking aspen



Current

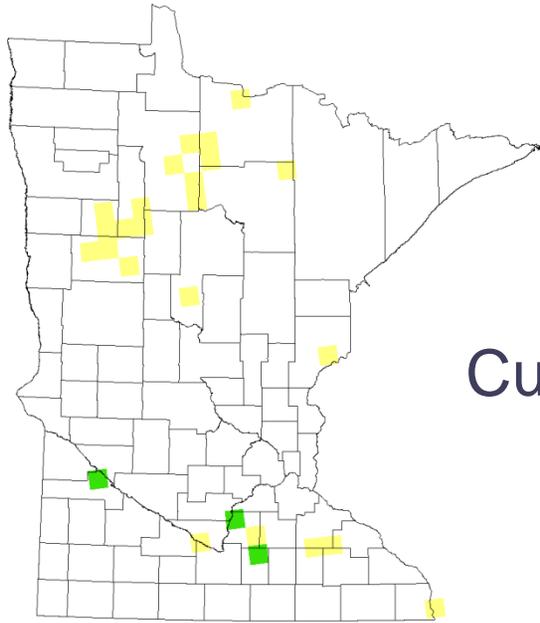


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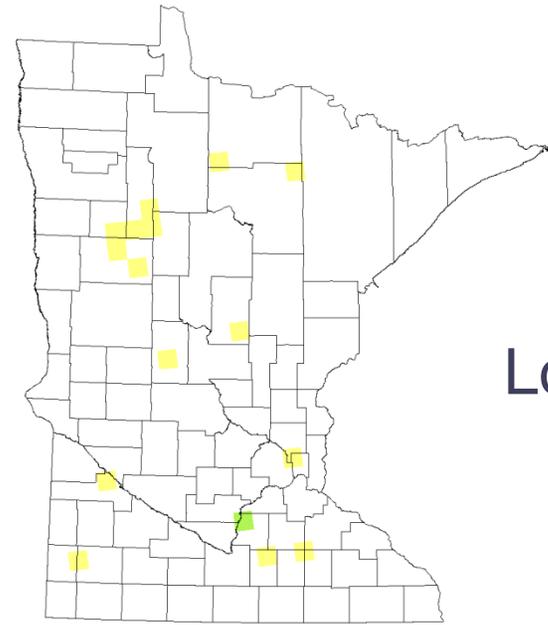


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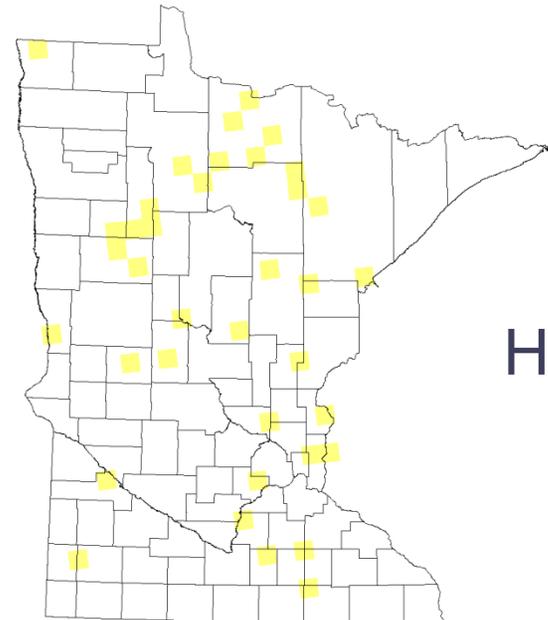
Red elm



Current

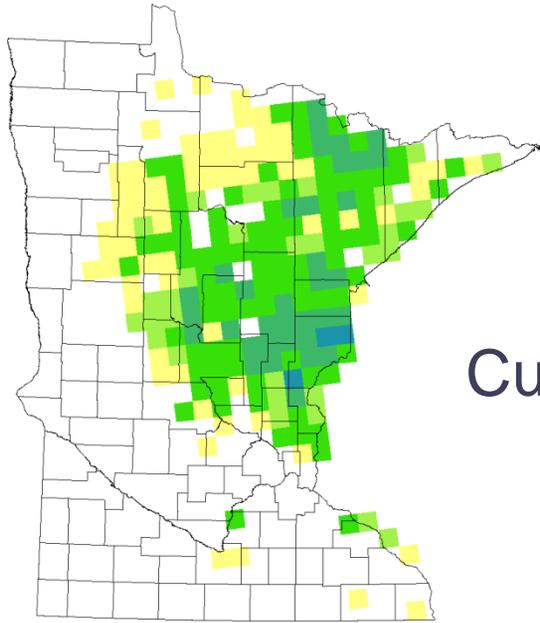


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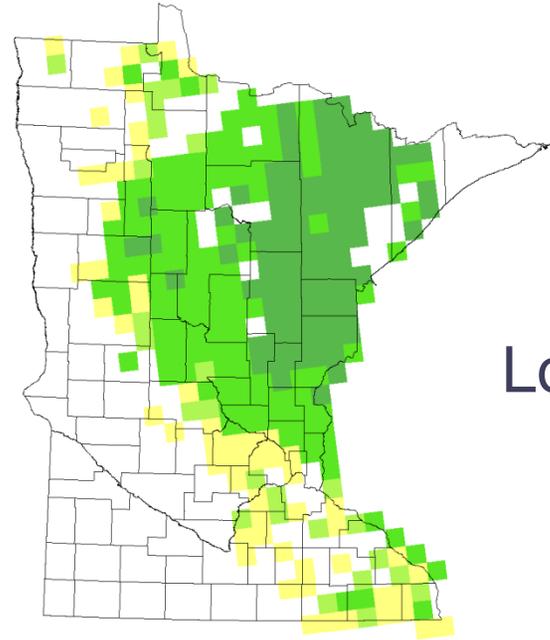


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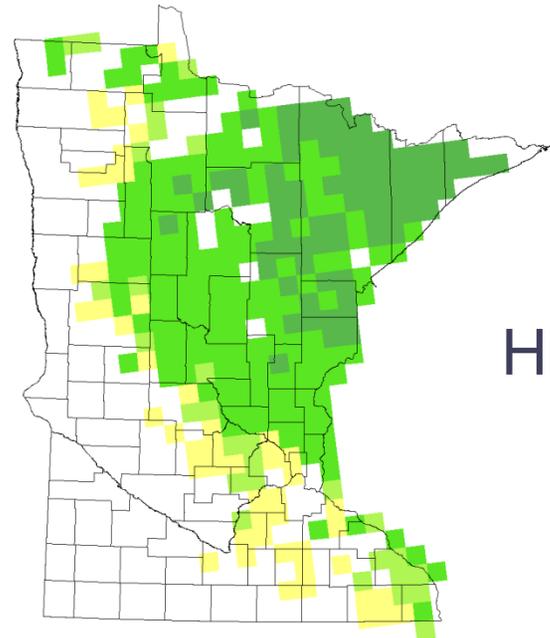
Red maple



Current

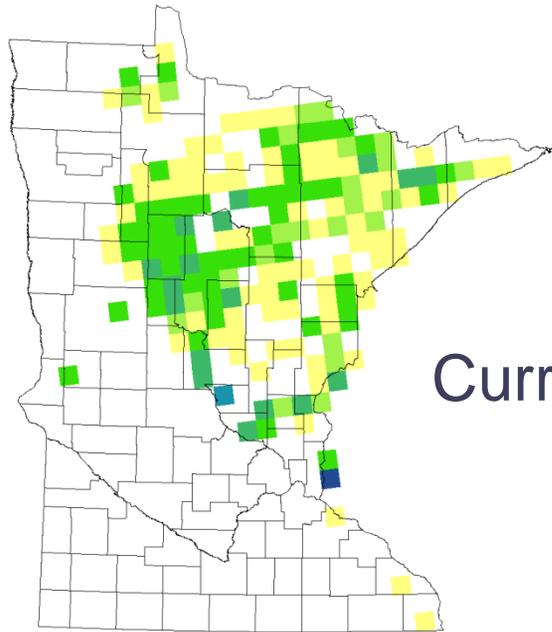


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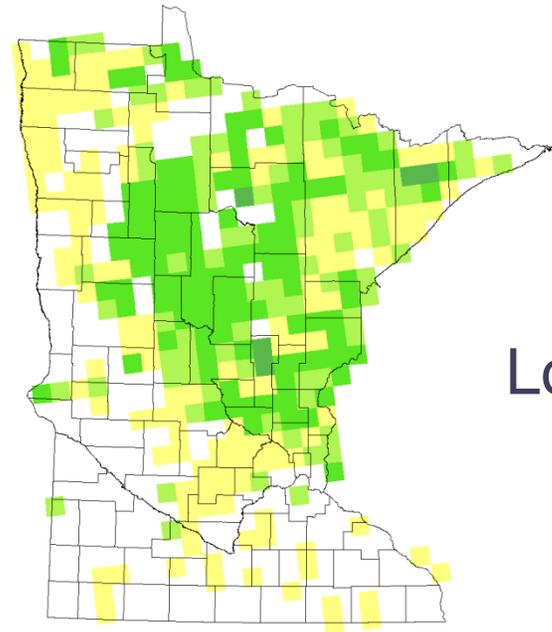


High

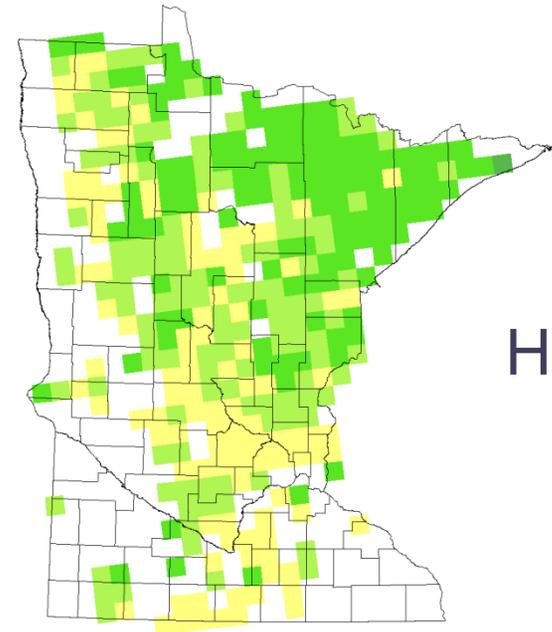
Red pine



Current

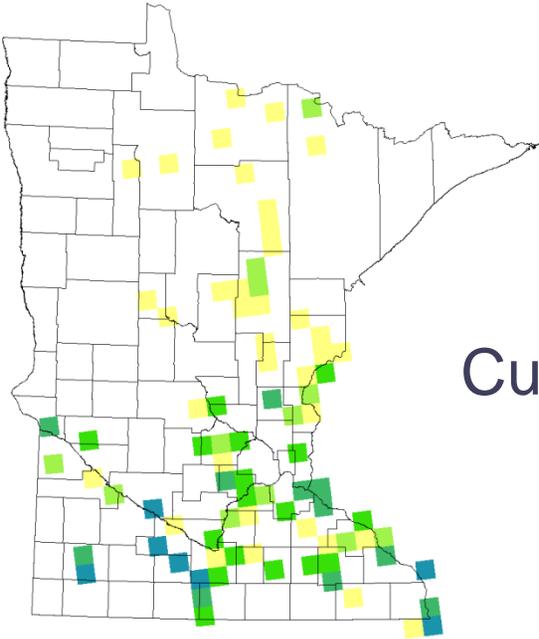


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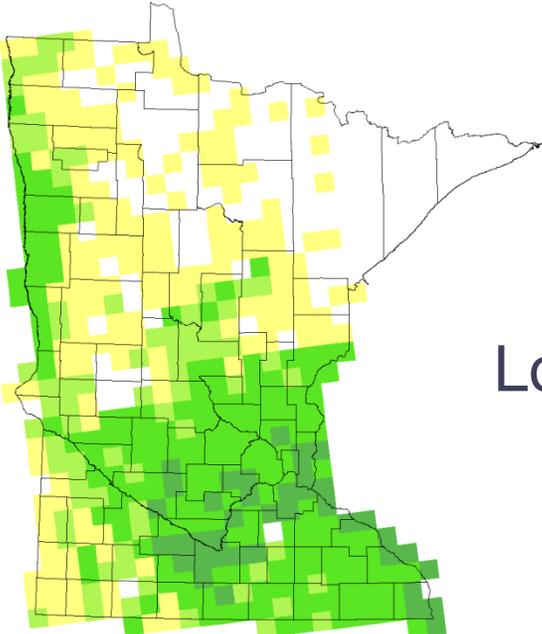


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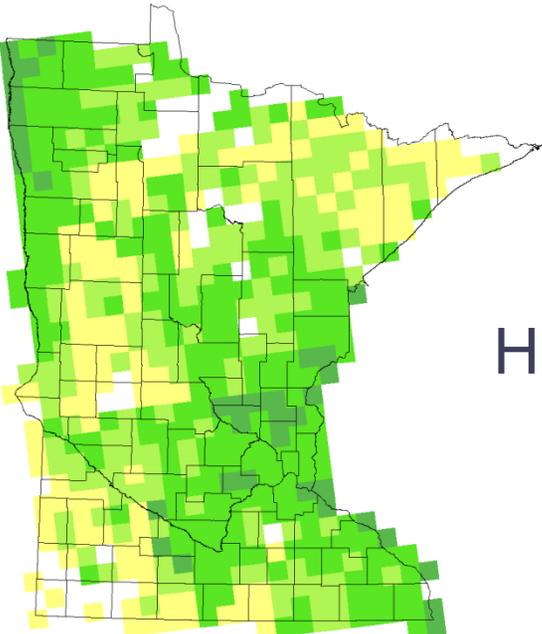
Silver maple



Current

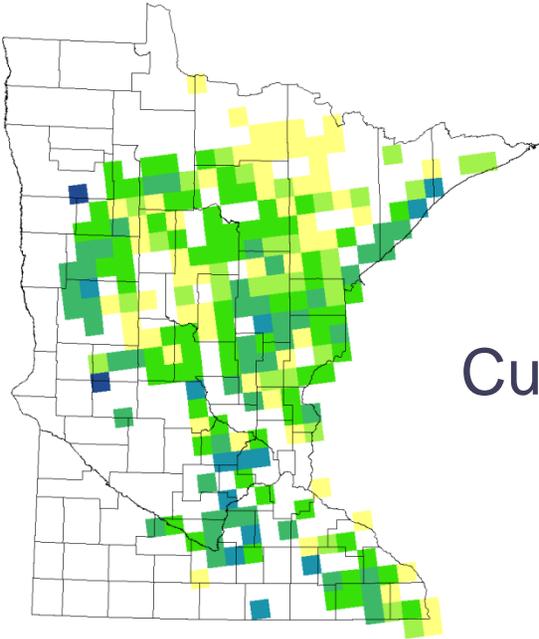


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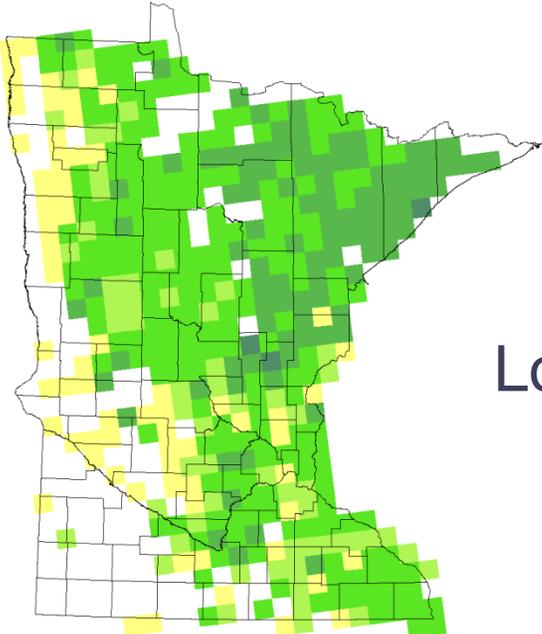


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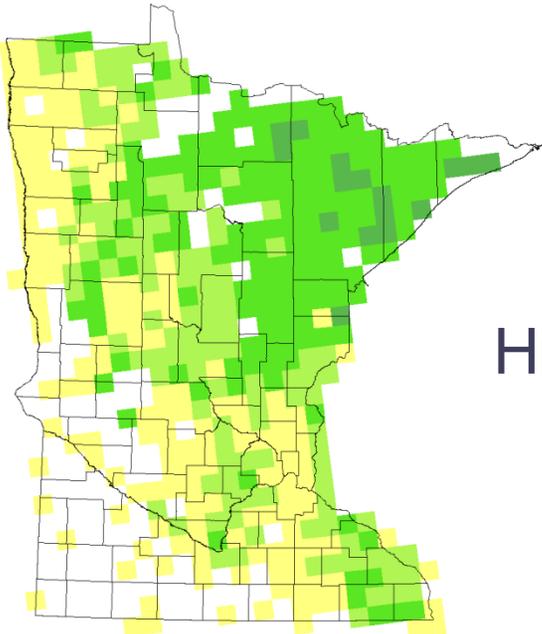
Sugar maple



Current

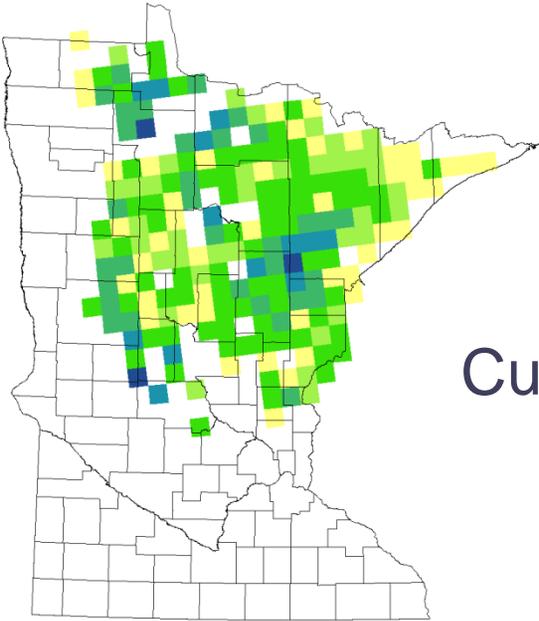


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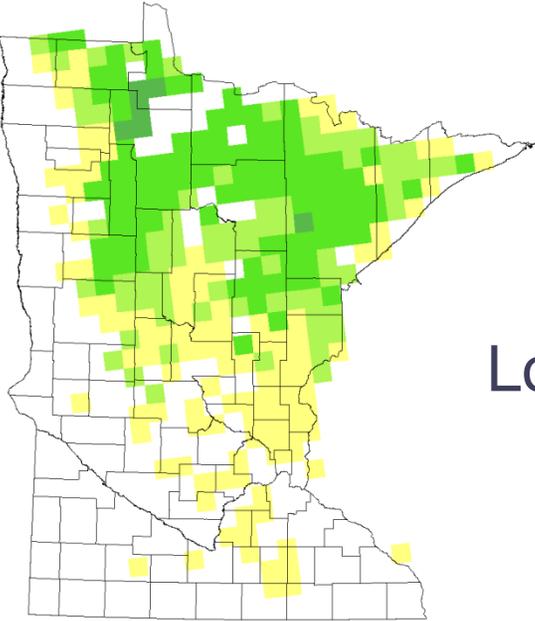


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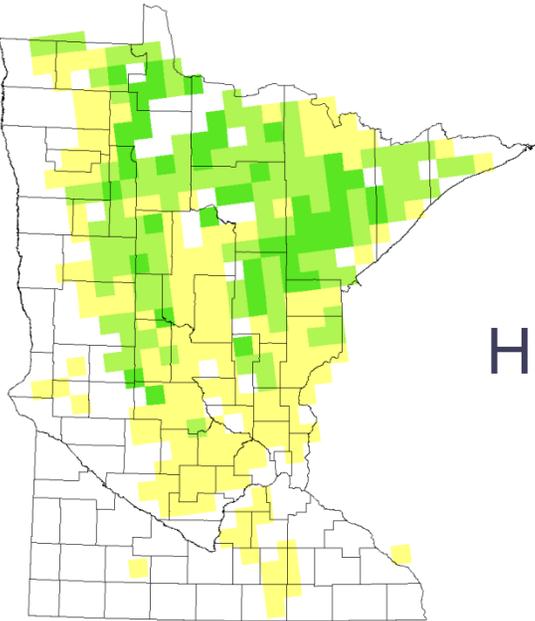
Tamarack



Current

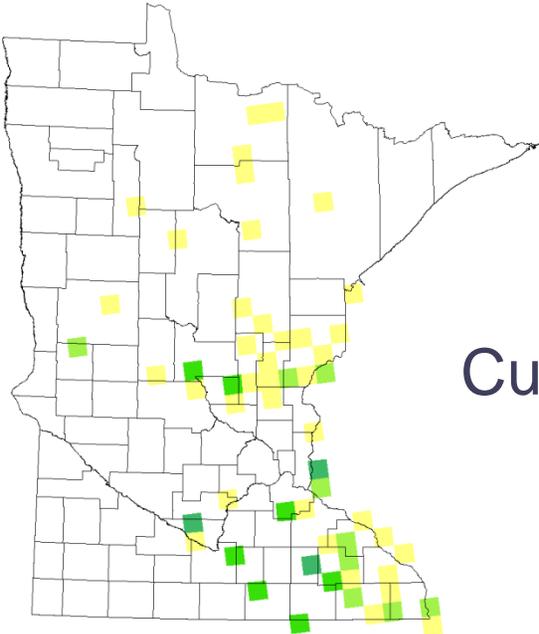


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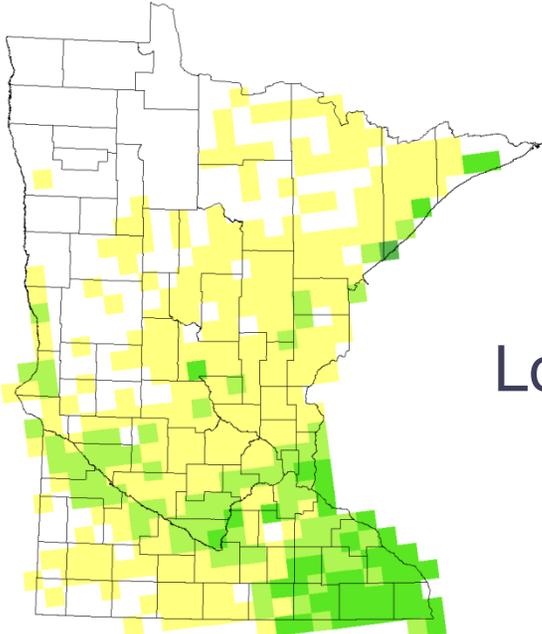


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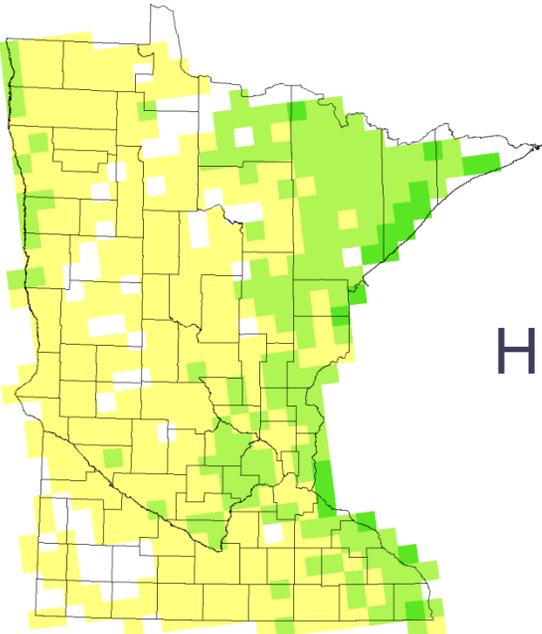
White ash



Current

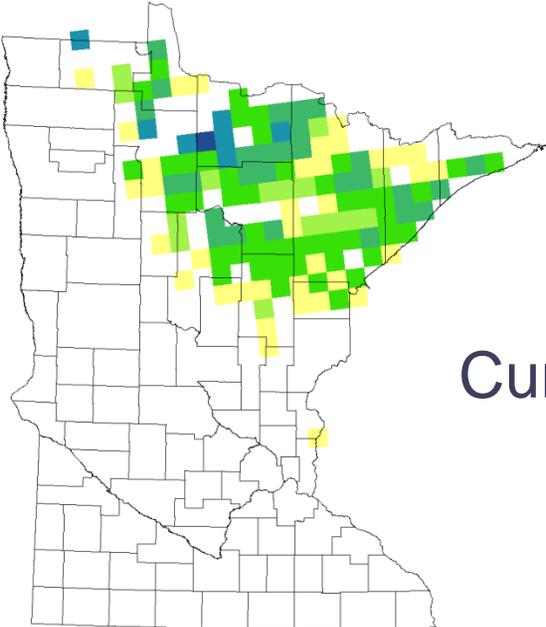


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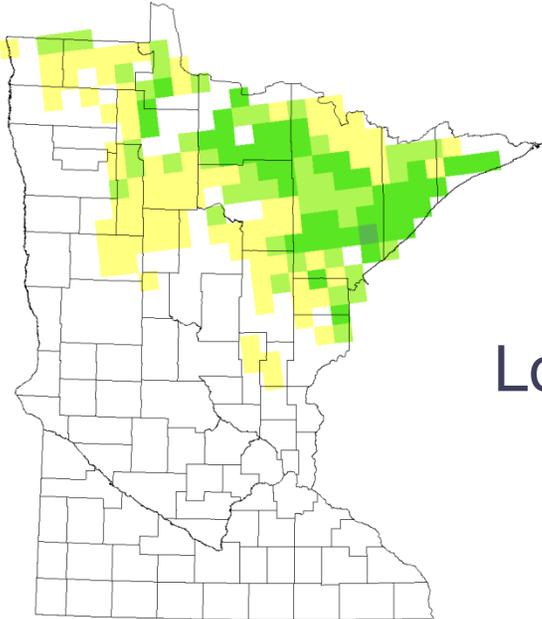


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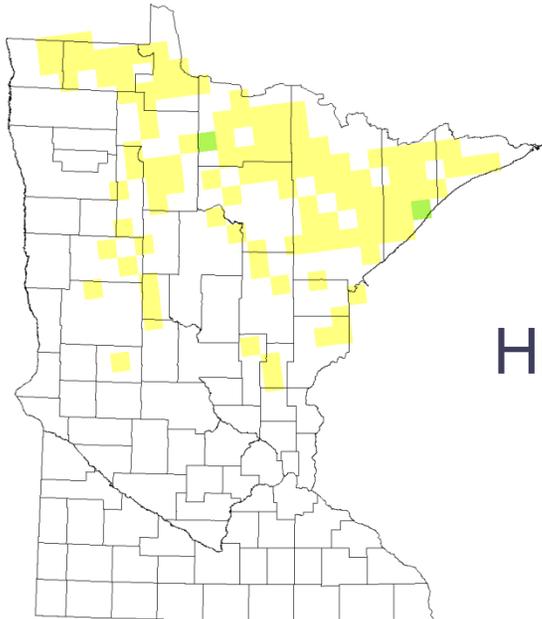
White cedar



Current

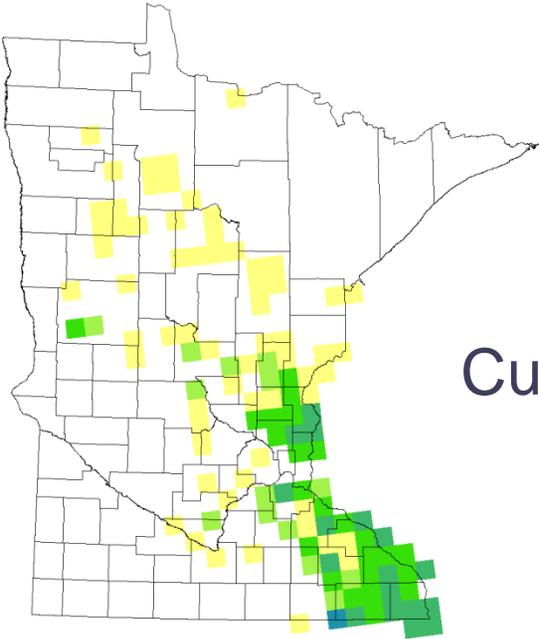


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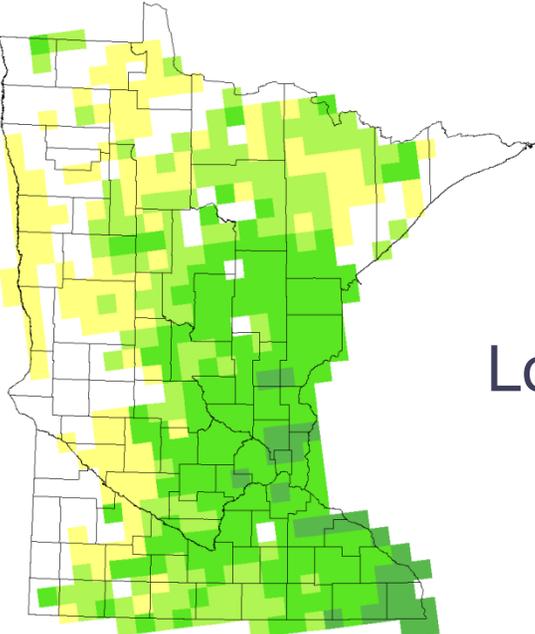


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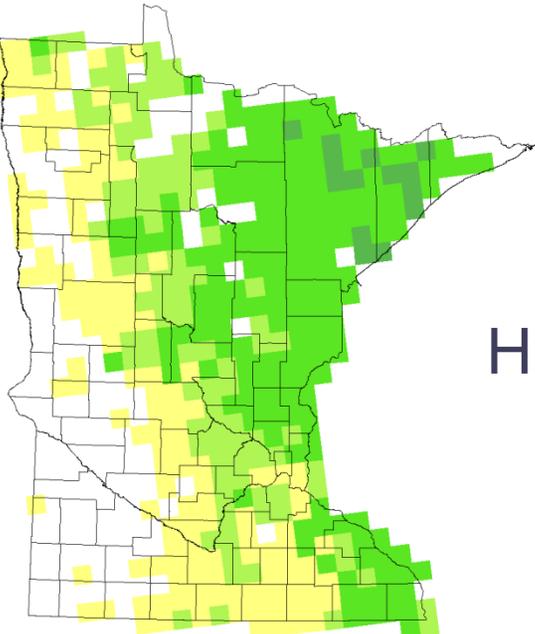
White oak



Current

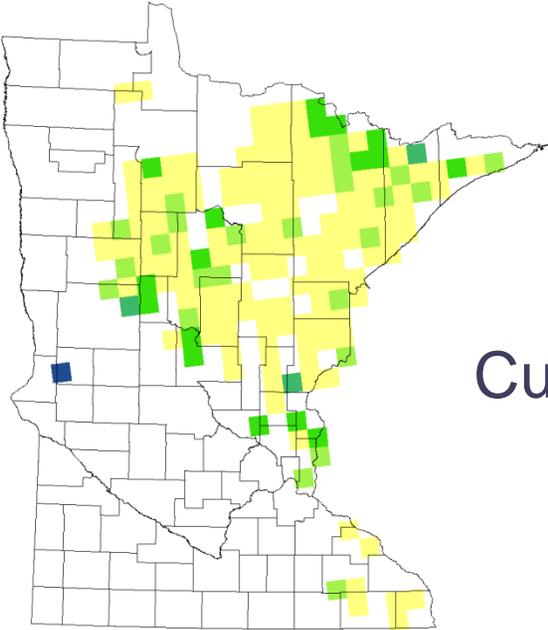


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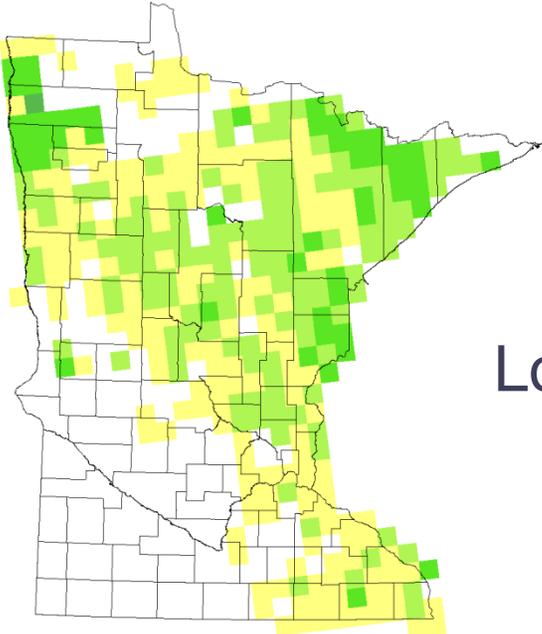


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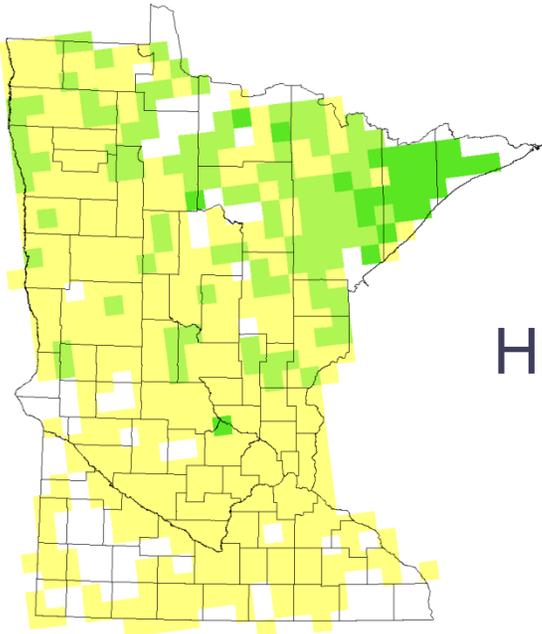
White pine



Current

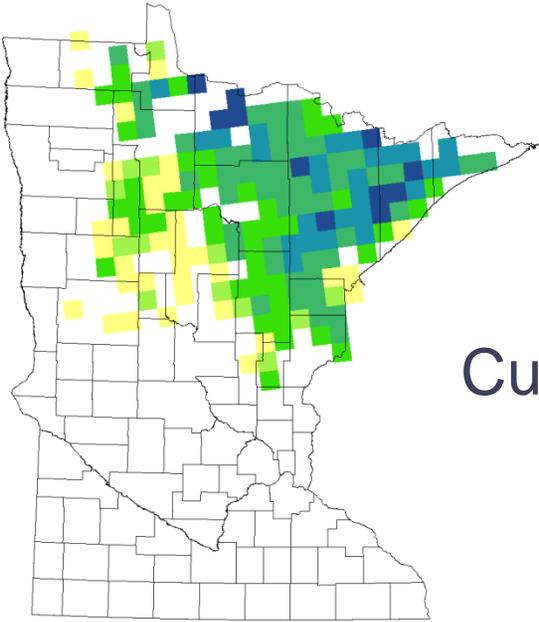


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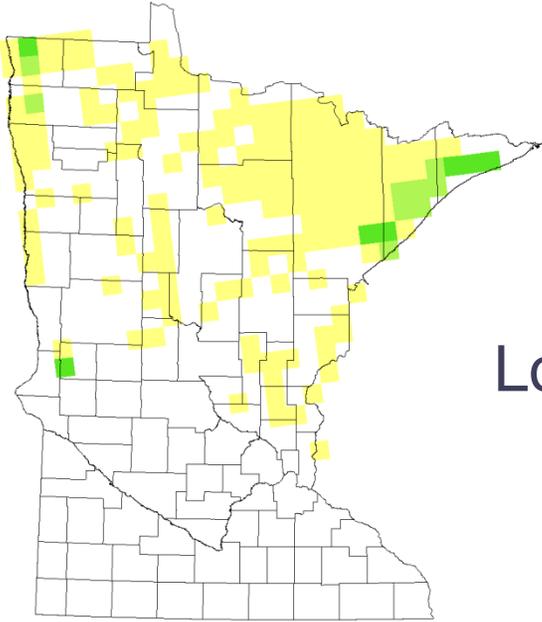


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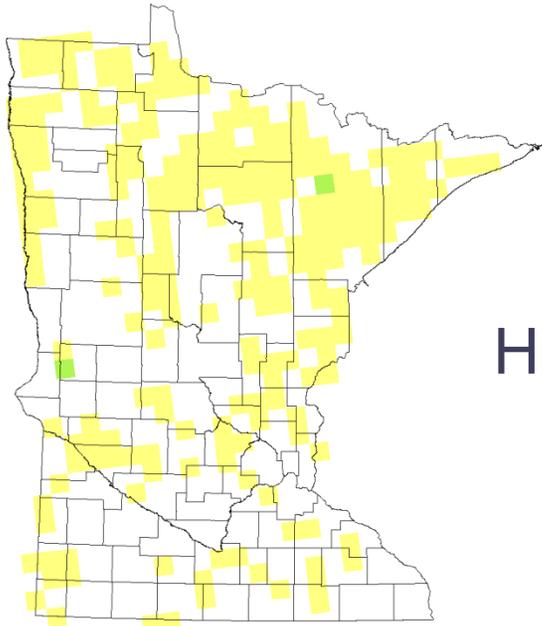
White spruce



Current

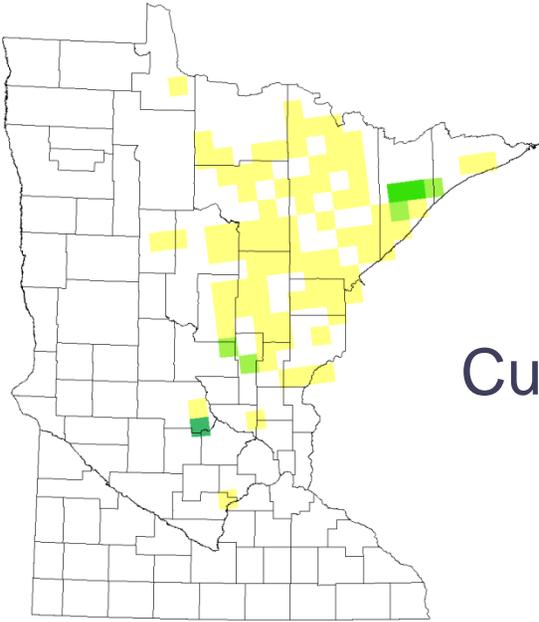


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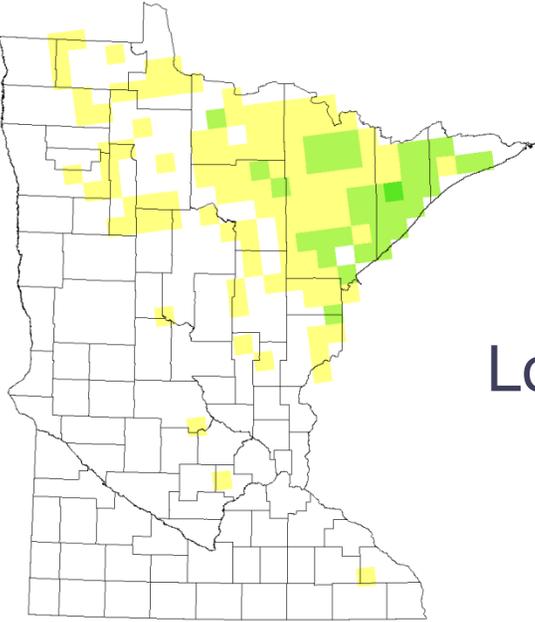


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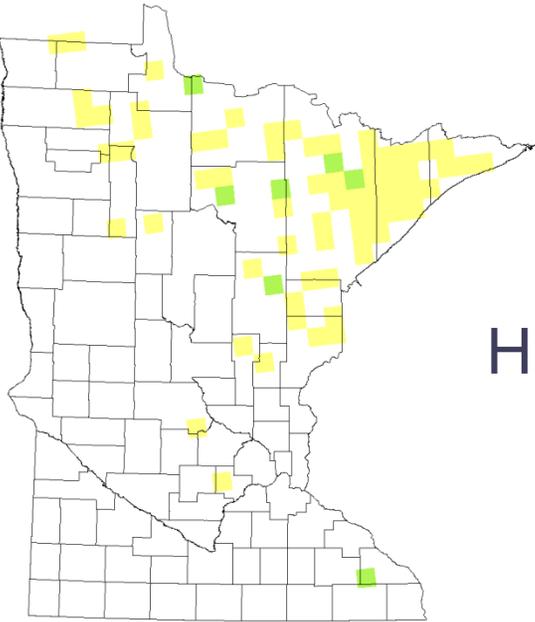
Yellow birch



Current



Low



High

Participants in the Northwood Climate Change Response Framework forest ecosystem vulnerability assessment

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JACK RAJALA is the chief executive officer at Rajala Companies

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JAD DALEY is a program director at the Trust for Public Land

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LUCINDA JOHNSON is a senior research associate at the Natural Resources Research Institute

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