Considering Landscape Resilience

TNC's Resilient and Connected Network

Matt Dallman

Forestry for Birds in a Changing Climate

October 18th, 2023

10:00-10:20

The Nature Conservancy

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Conservation Planning

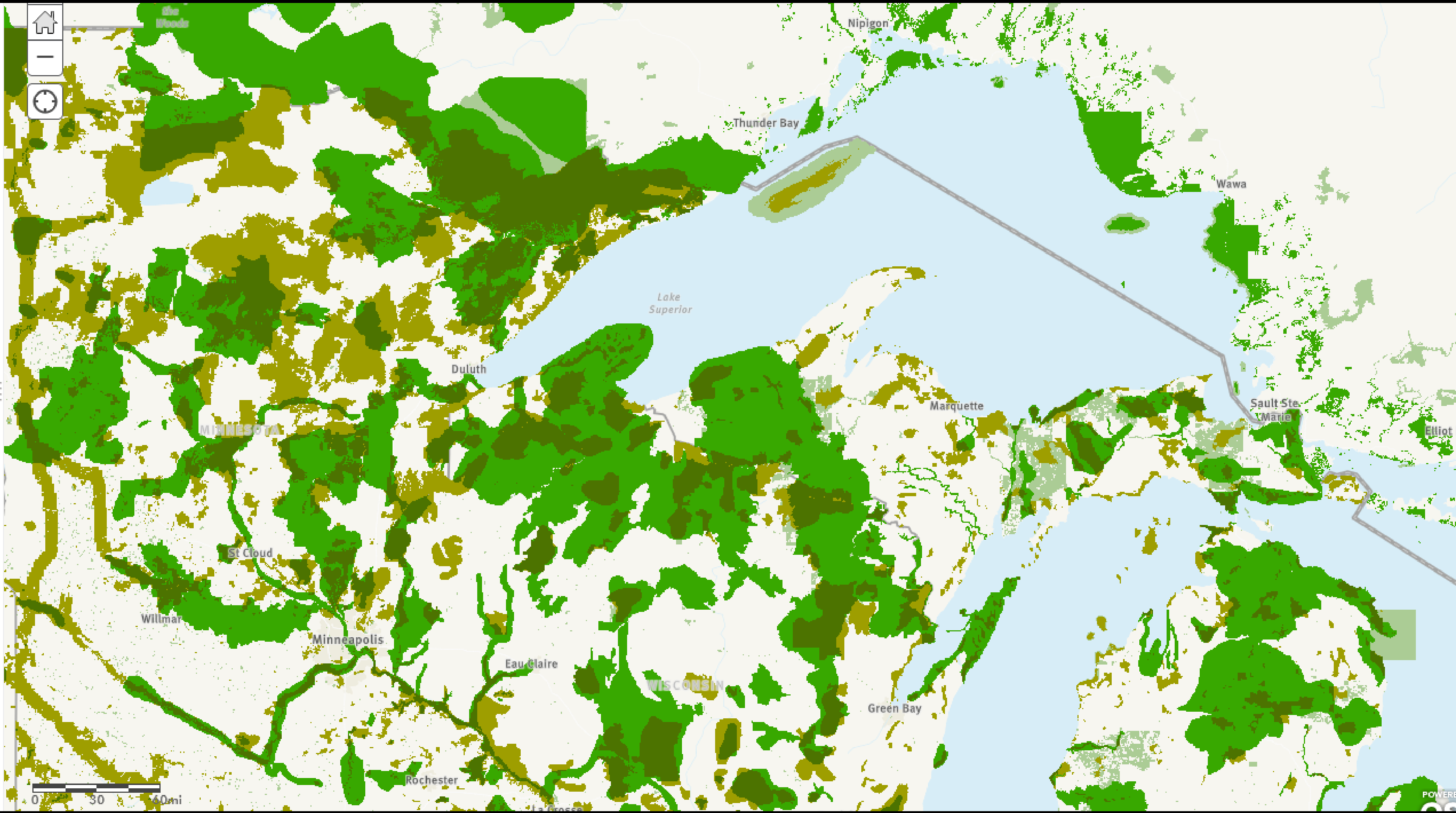
Contents

Recognized Biodiversity Value

Recognized Biodiversity Value

- Ecoregion and State-based
- Ecoregion-based
- State-based
- Additional Habitat and Species

TNC Light Map



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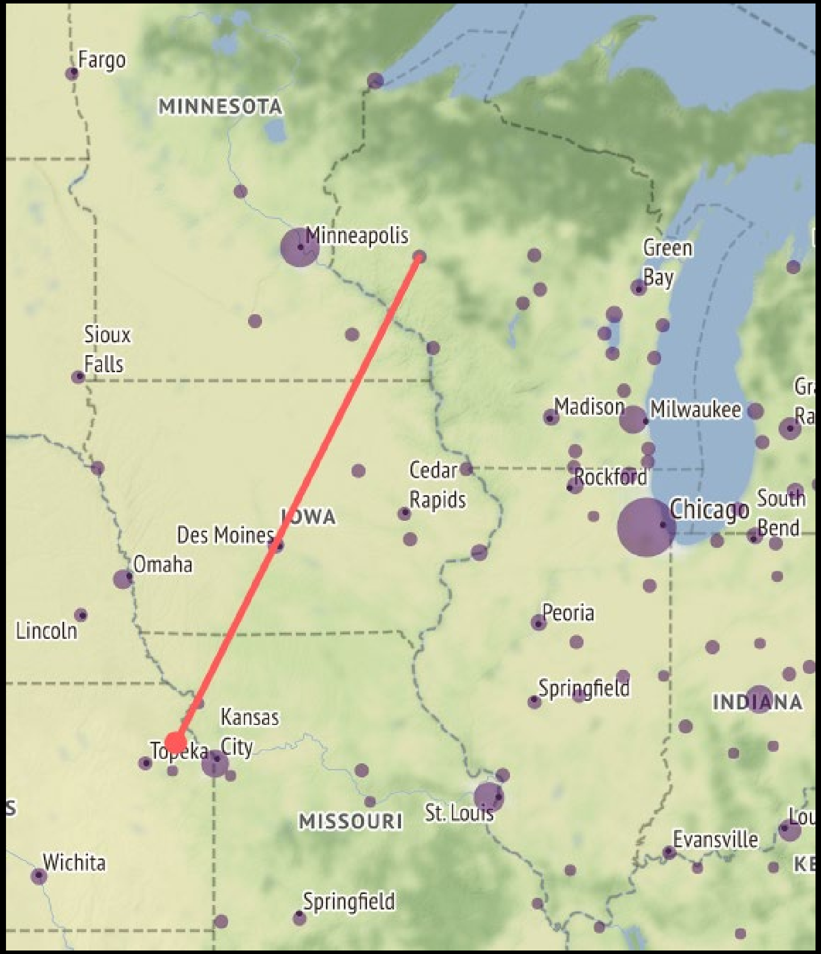
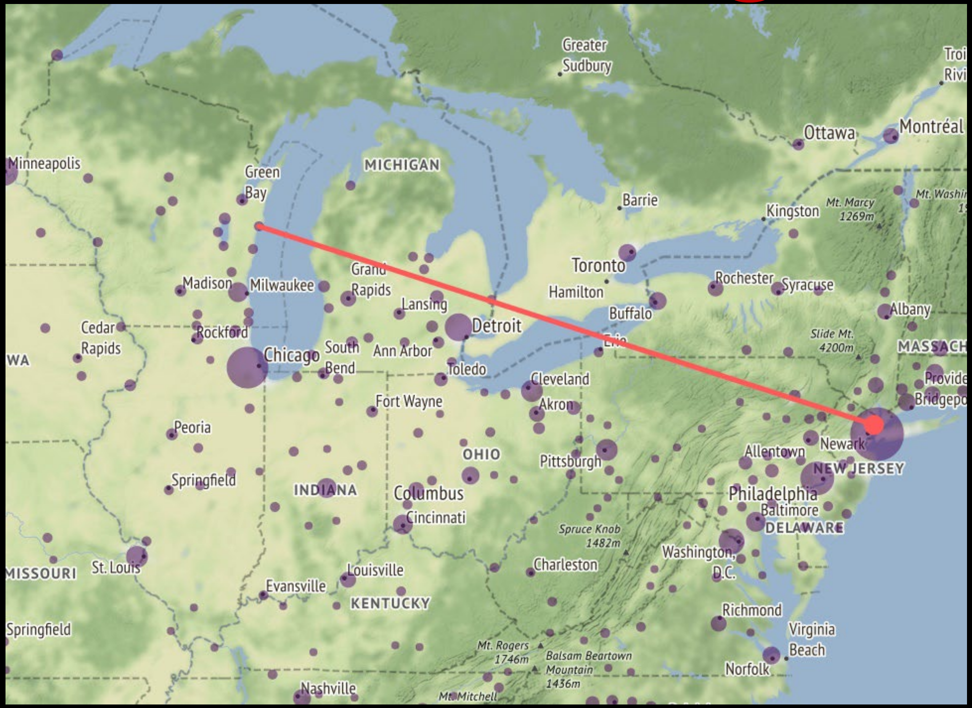
Conservation Planning ***with Climate Change***

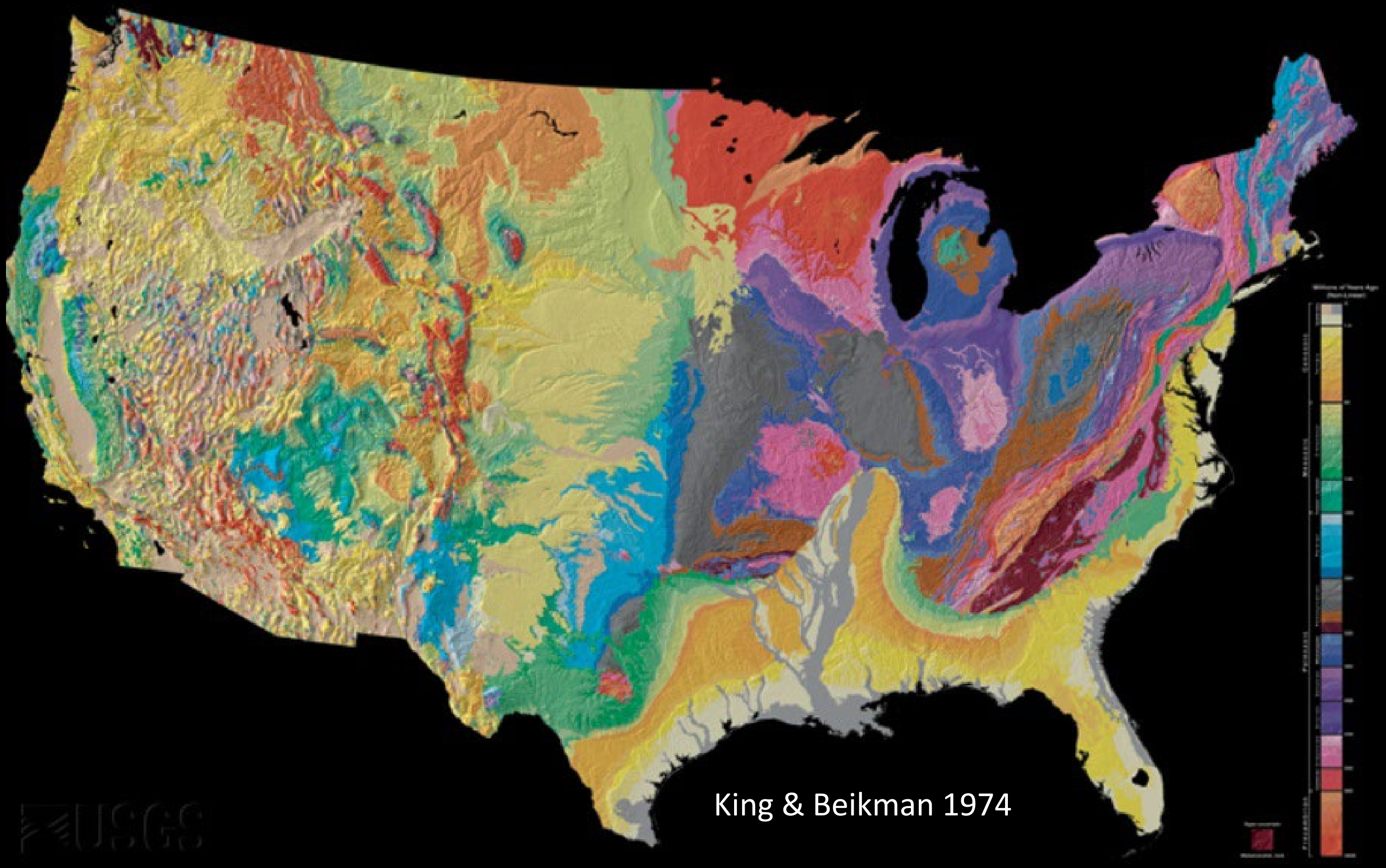




Source: University of Maryland, www.WICCI.org

“Geodiversity…. drives patterns of biodiversity.”

—Mark Anderson, The Nature Conservancy, Eastern Division



King & Beikman 1974

Conserving Nature's Stage: *Resilience*

<u>Concept 1</u>

The Stages






Conserving Nature's Stage: *Resilience*

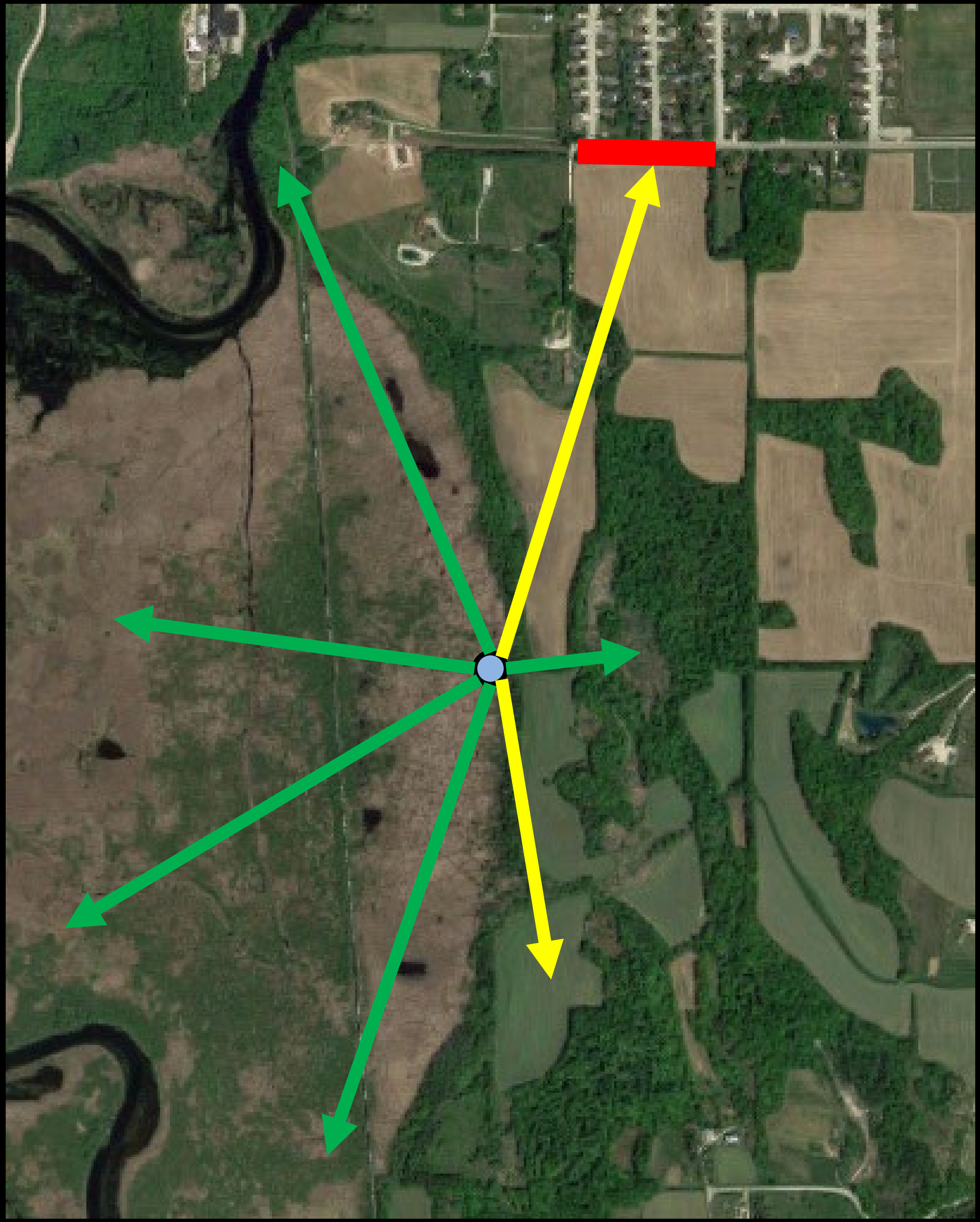
Concept 2

Niches

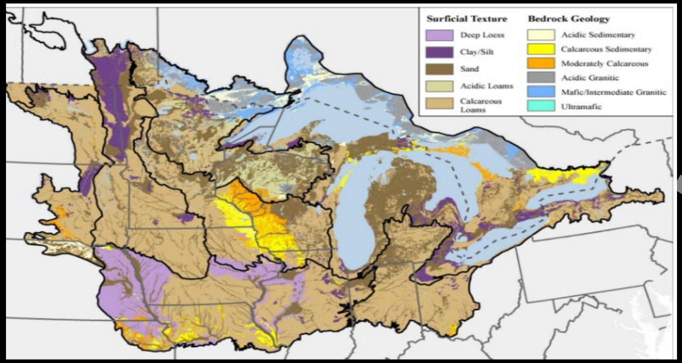
Conserving Nature's Stage: *Resilience*

<u>Concept 3</u>

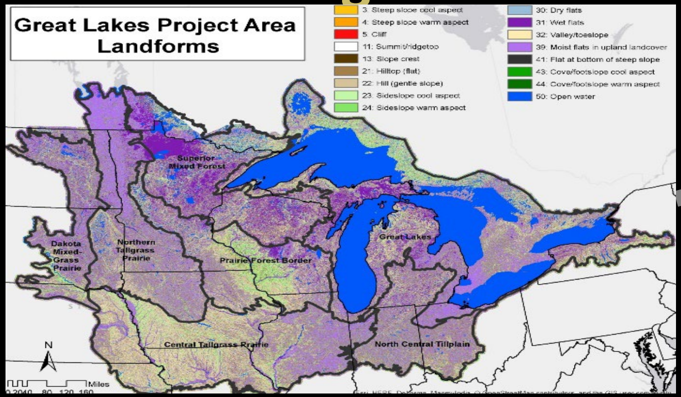
Local Connectivity



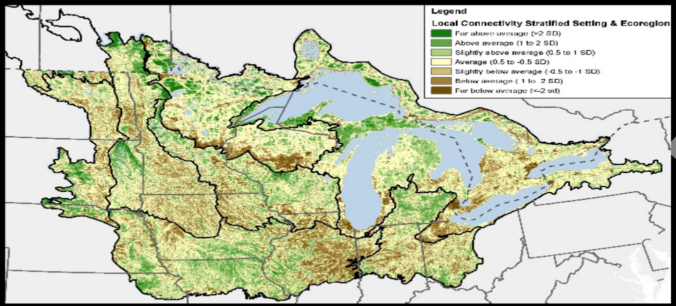
Conserving Nature’s Stage: *Resilience*



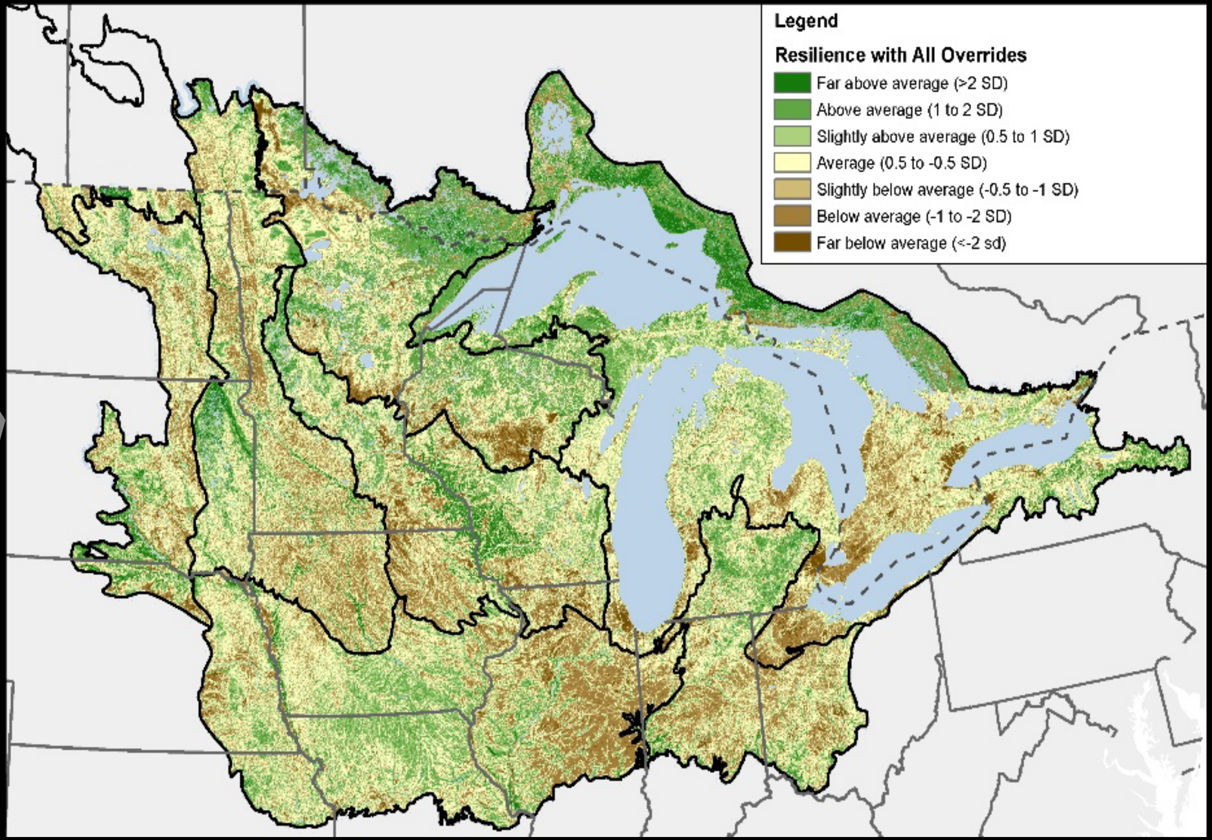
Stages



Niches

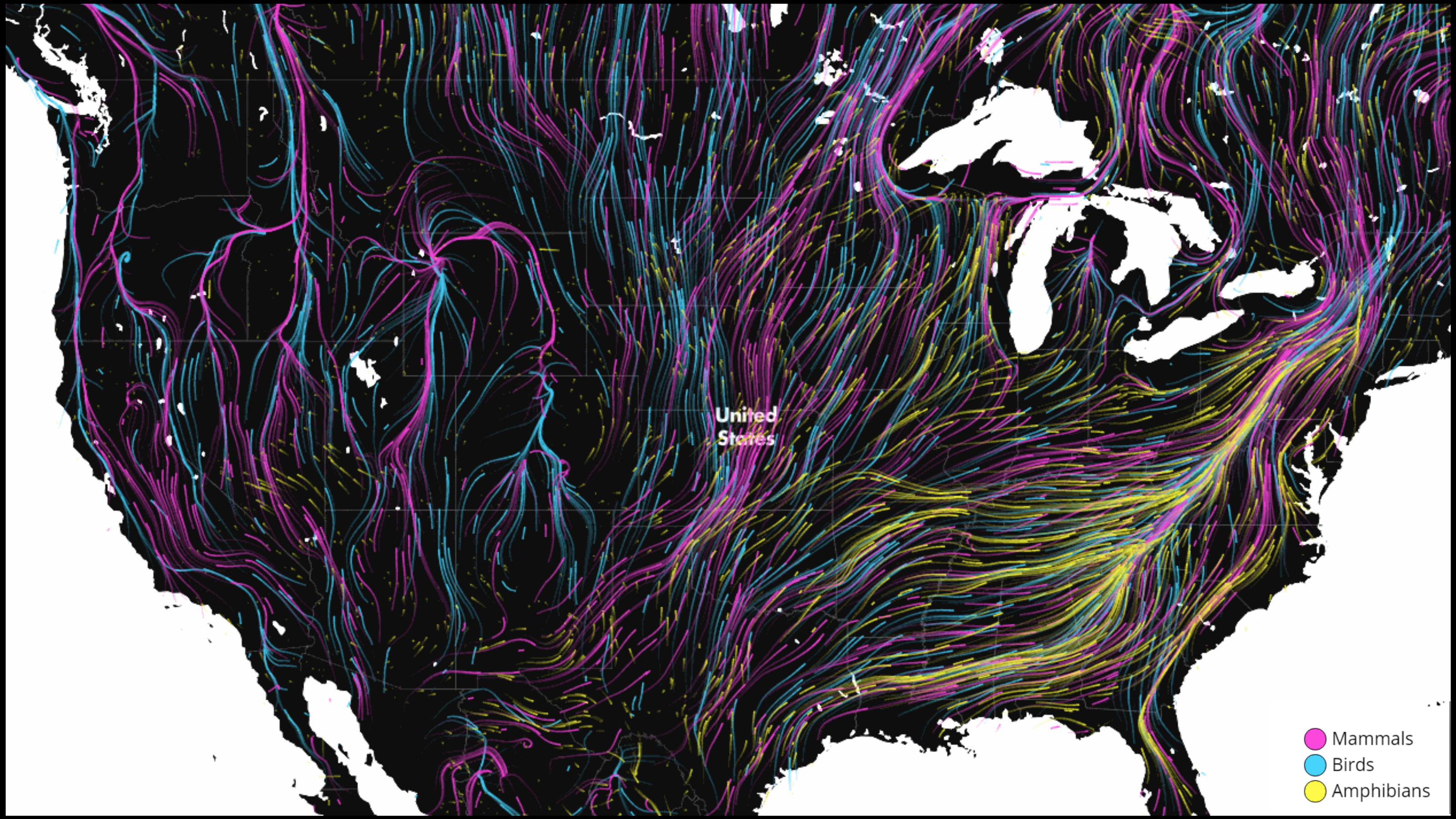


Local Connectivity



Resilience

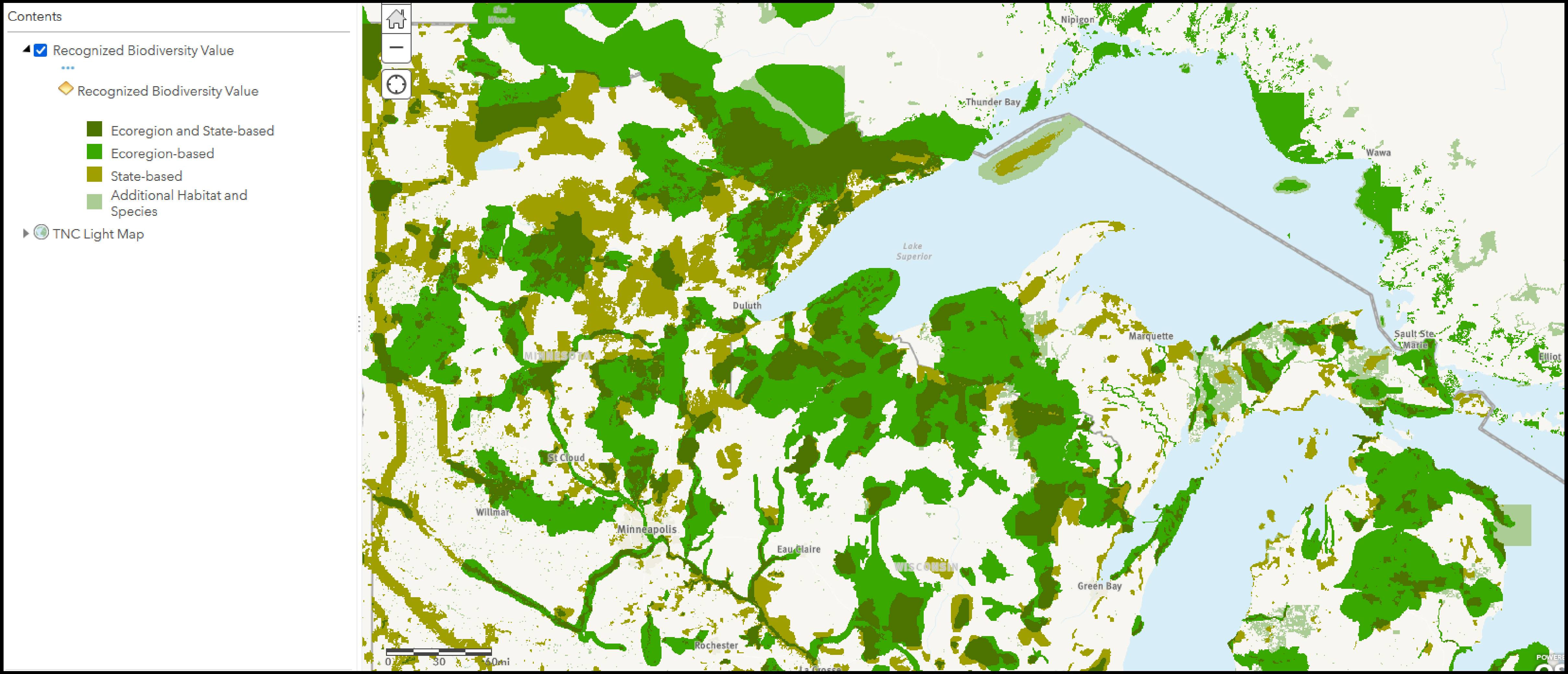
Conserving Nature's Stage: *Resilient & Connected Network*



Concept 4

Regional Connectivity

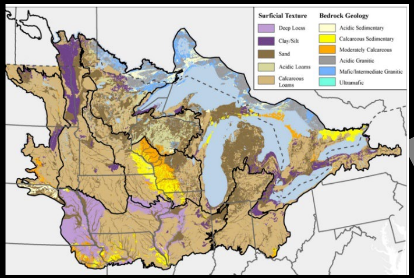
Conserving Nature's Stage: *Resilient & Connected Network*



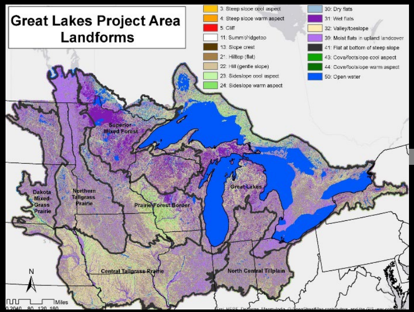
Concept 5

Recognized Biodiversity

Conserving Nature's Stage: *Resilient and Connected Network*



Stages



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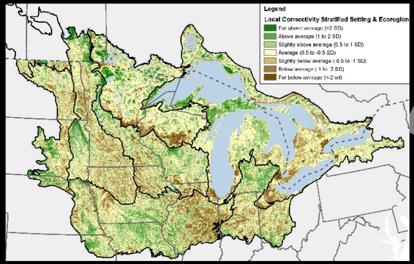
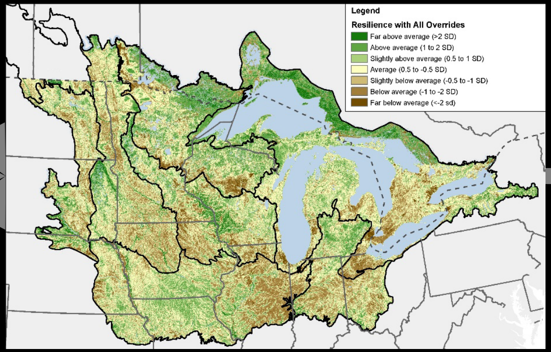
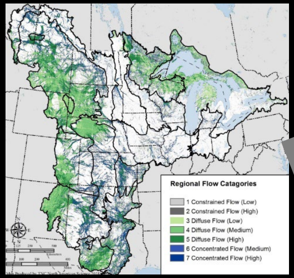


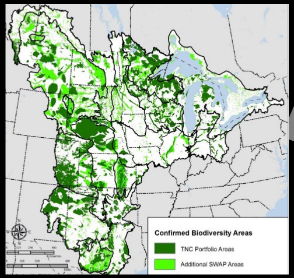
Local Connectivity



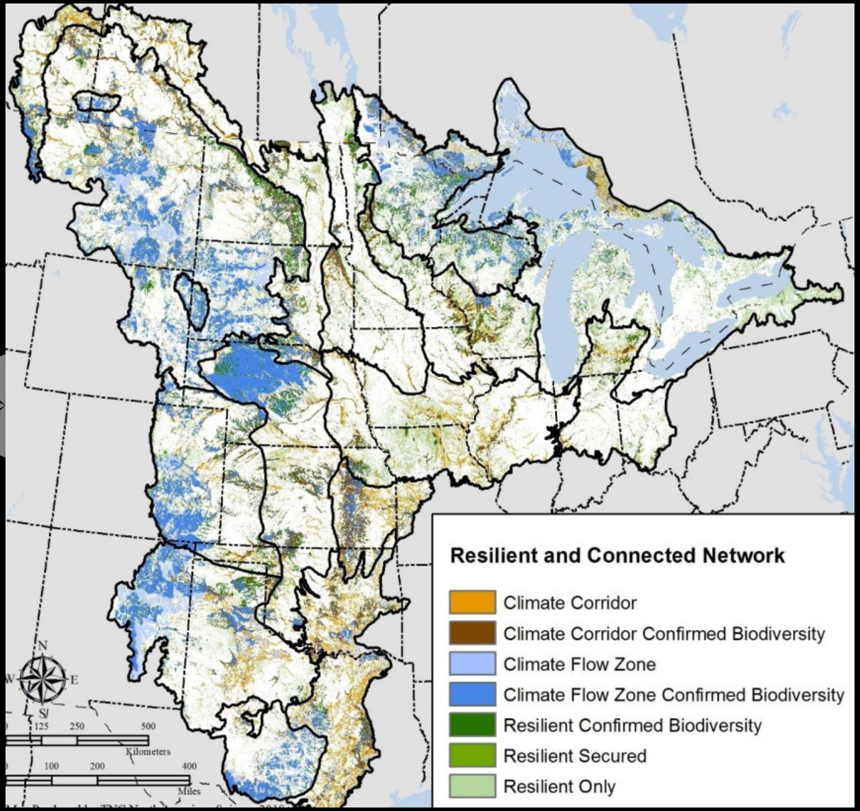
Resilience



Regional Connectivity

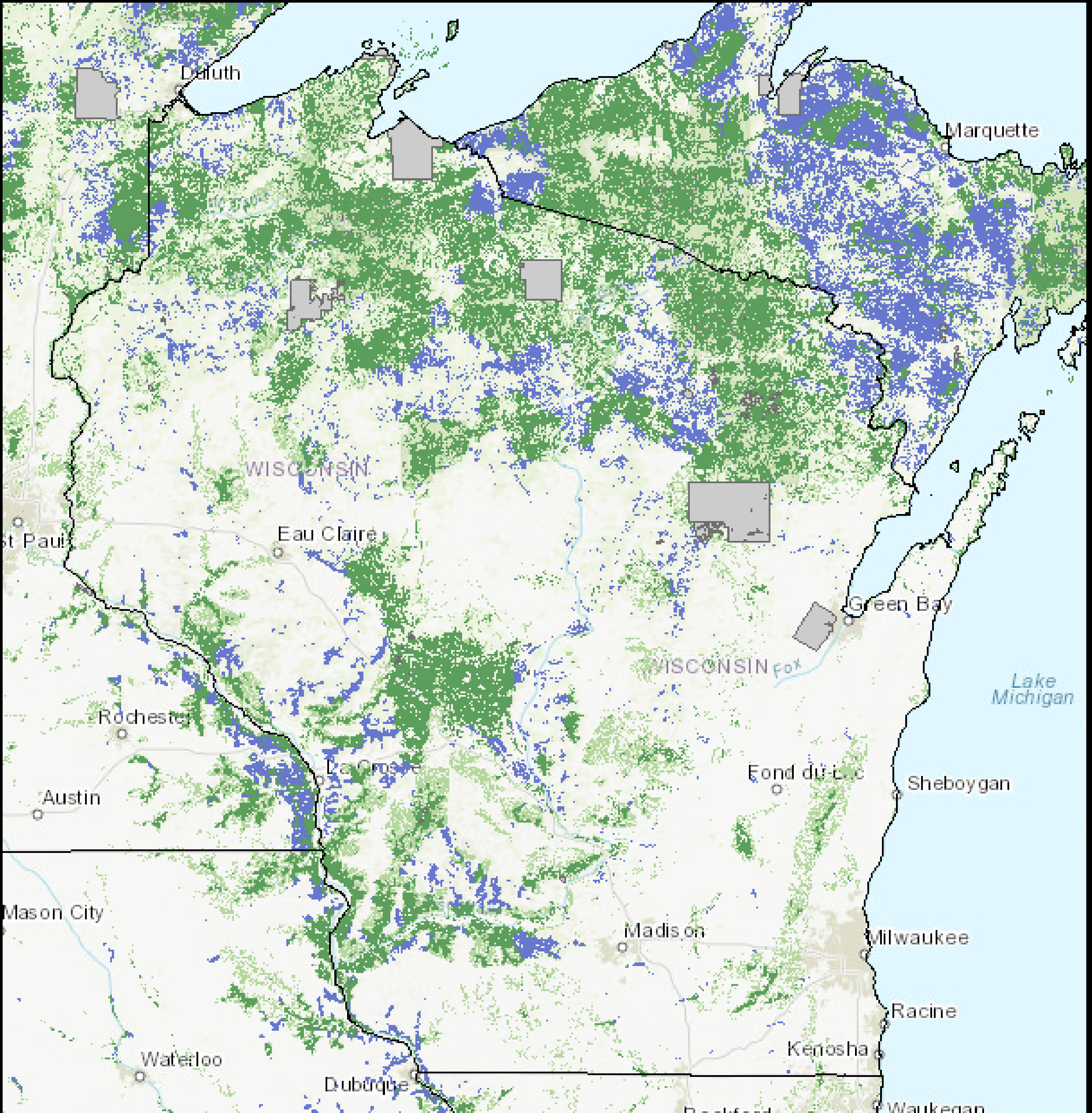


Biodiversity



Resilient and Connected Network

How is it being used?

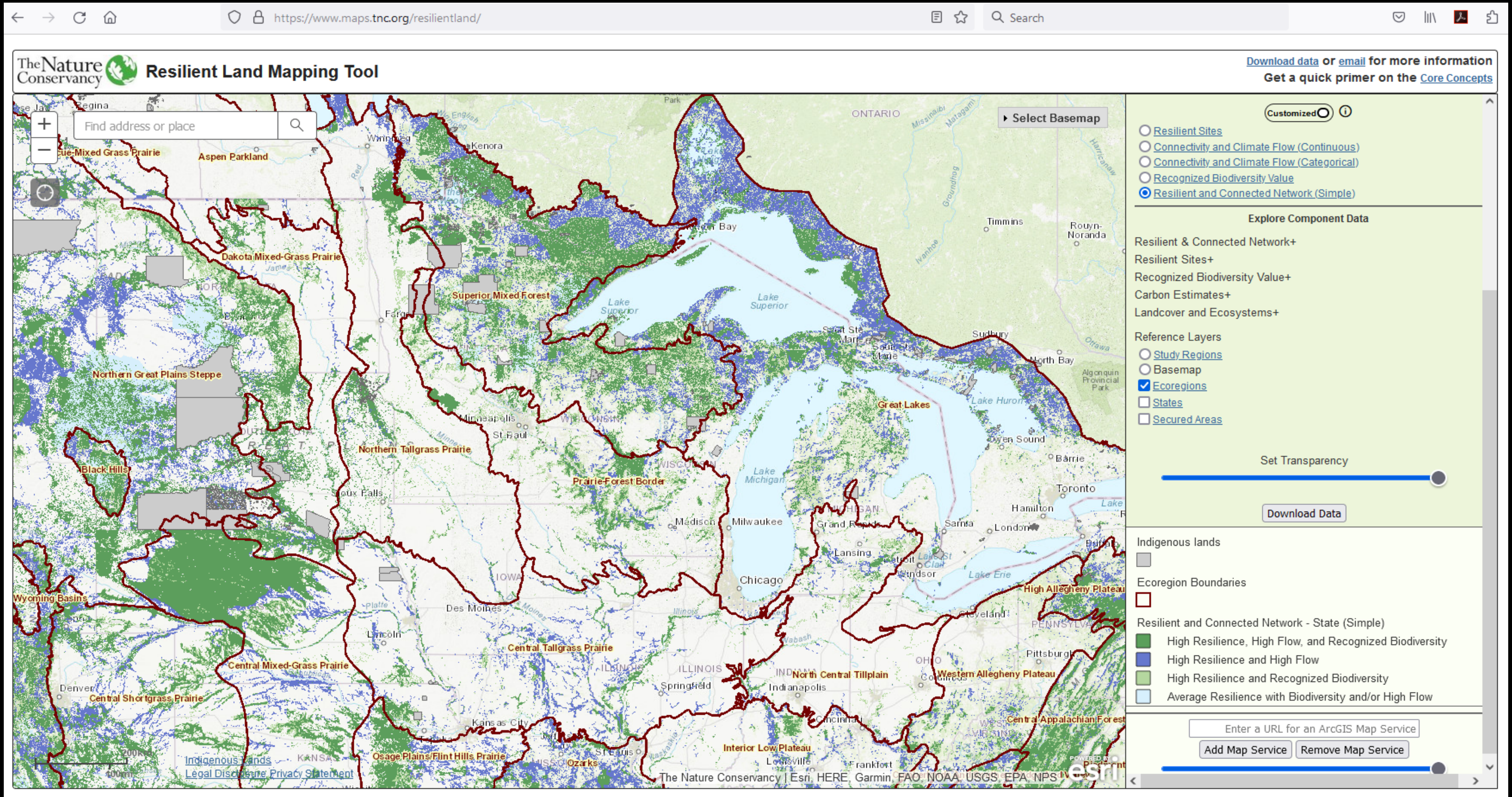


- Inform land-acquisition and management decisions
- State and federal agencies, land trusts, some foundations and other funding sources

How can I access the data?

https://www.maps.tnc.org/resilientland/

Key words: resilient connected network



Applying Adaptation Principles:
A Case Study from Caroline Lake

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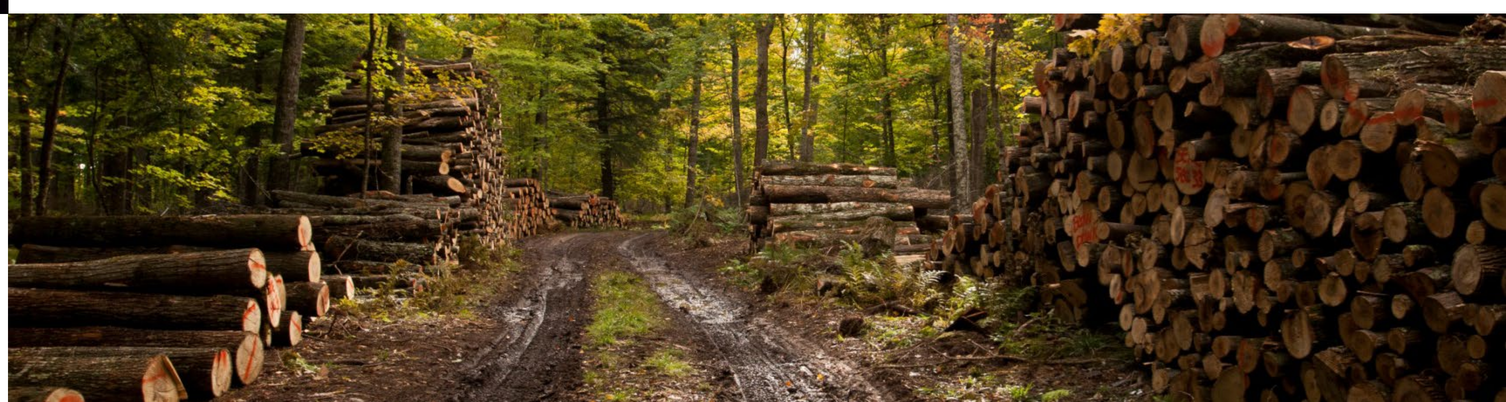

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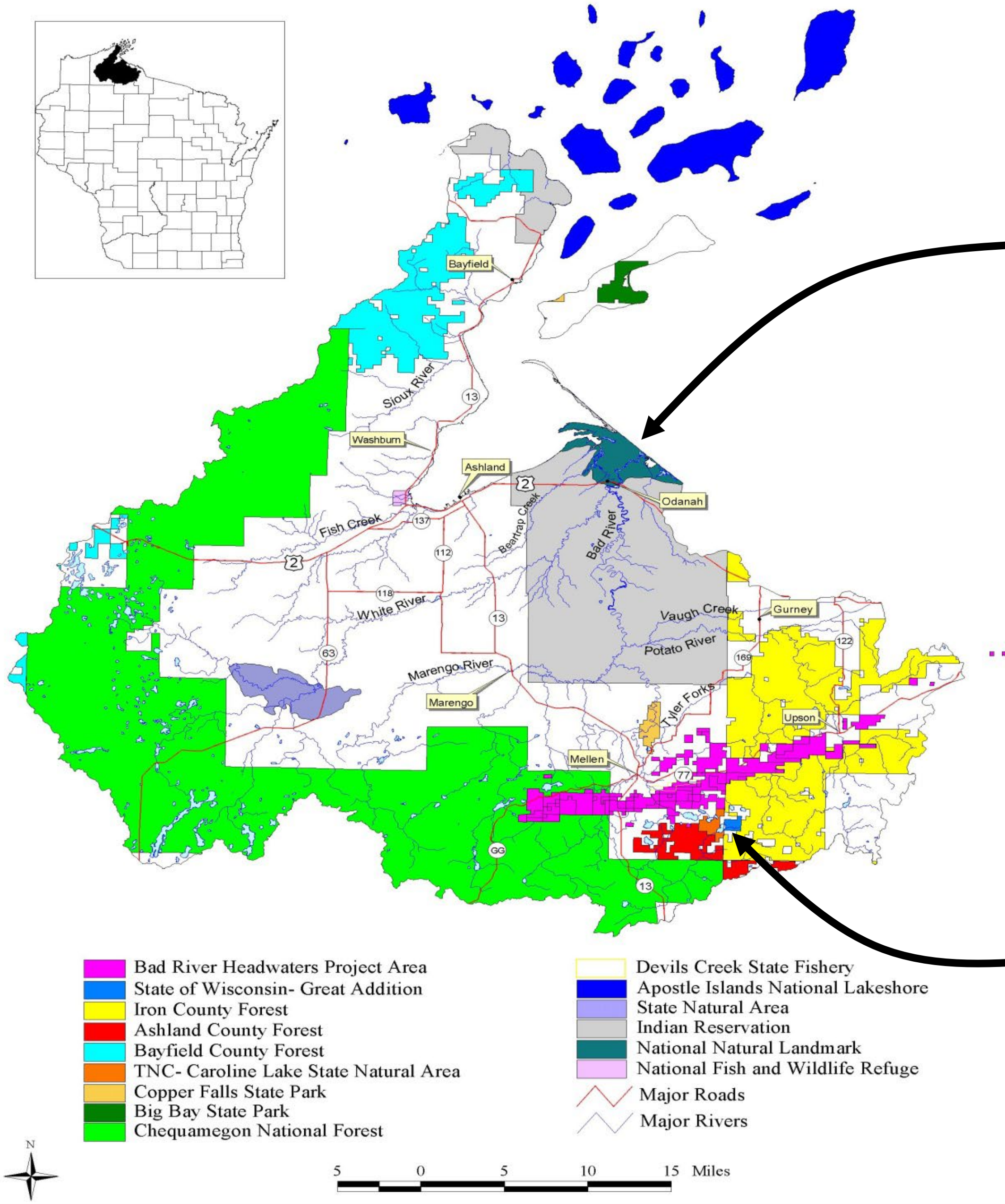
Chequamegon Bay Watershed



Caroline Lake: Adaptation Demonstration

1,100 acres of working forest

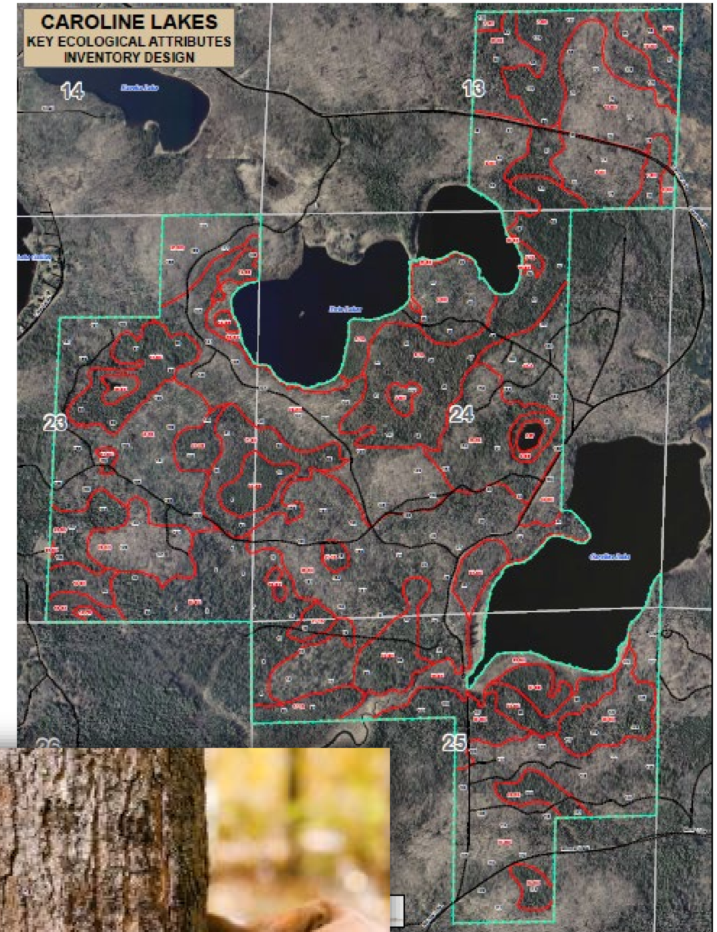
- Owned by TNC since 1997
- Commitment to working forest conservation

Management Goal

Maintain and enhance biodiversity, water quality and ecological integrity through long-team sustainable management

Caroline Lake: Adaptation Demonstration

- Initially, management was focused on restoration to historic conditions
- Robust inventory was developed to provide a starting point



Climate-Informed Metrics

Stand Inventory Needed

- Total Stocking (1)
- Tree Species Diversity
  - Richness (2)
  - Evenness (3)
- Large Coarse Woody Debris (4)
- Regeneration
  - Saplings (5)
  - Seedlings (6)

New Risk Metrics

- Risk of Decline
  - Trees (7)
  - Saplings (8)
  - Seedlings (9)

Leveraging Forest Inventory Data

How can we better use forest inventory data to tell us:

1) *Are forests **at risk** from climate change?*

2) *Are management actions **reducing risk**?*

Risk Metrics

Northern Hardwood Stand:

Species	Basal Area	Stems Per Acre	Freq. (%)	Proportion of Stand (IV %)
Sugar maple	79.0	117.1	100.0	40.8
White ash	33.1	30.7	96.2	17.9
American basswood	18.5	23.7	73.1	12.3
Yellow birch	7.7	12.4	53.8	7.0
Bigtooth aspen	10.0	16.1	15.4	5.5
Red maple	4.2	8.6	42.3	5.0
Northern red oak	1.5	0.7	42.3	3.2
American elm	0.4	0.4	34.6	2.4
Paper birch	1.9	5.3	11.5	2.0
Black ash	1.5	2.6	7.7	1.2
Black cherry	0.4	0.2	15.4	1.1
Eastern hemlock	1.2	1.9	3.8	0.8
Quaking aspen	0.8	0.6	7.7	0.8
Total	**160.2**	**220.3**		**100.0**

Risk Metrics

Northern Hardwood Stand:

Low (PCM B1)

Species	Basal Area	Stems Per Acre	Freq. (%)	Proportion of Stand (IV %)	Future: Current Habitat	Change Class	At-risk Proportion of Stand (%)
Sugar maple	79.0	117.1	100.0	40.8	0.8	No Change	0.0
White ash	33.1	30.7	96.2	17.9	1.6	Increase	0.0
American basswood	18.5	23.7	73.1	12.3	1.1	No Change	0.0
Yellow birch	7.7	12.4	53.8	7.0	0.8	Decrease	7.0
Bigtooth aspen	10.0	16.1	15.4	5.5	1.0	No Change	0.0
Red maple	4.2	8.6	42.3	5.0	1.0	No Change	0.0
Northern red oak	1.5	0.7	42.3	3.2	1.3	Increase	0.0
American elm	0.4	0.4	34.6	2.4	2.3	Increase	0.0
Paper birch	1.9	5.3	11.5	2.0	0.7	Decrease	2.0
Black ash	1.5	2.6	7.7	1.2	0.7	Decrease	1.2
Black cherry	0.4	0.2	15.4	1.1	2.4	Large Increase	0.0
Eastern hemlock	1.2	1.9	3.8	0.8	1.2	Increase	0.0
Quaking aspen	0.8	0.6	7.7	0.8	0.6	Decrease	0.8
Total	**160.2**	**220.3**		**100.0**		***Proportion at-risk:***	***11.0***

Risk Metrics

Northern Hardwood Stand:

Species	Basal Area	Stems Per Acre	Freq. (%)	Proportion of Stand (IV %)	Low (PCM B1) Future: Current Habitat	Low (PCM B1) Change Class	Low (PCM B1) At-risk Proportion of Stand (%)	High (GFDL A1F1) Future: Current Habitat	High (GFDL A1F1) Change Class	High (GFDL A1F1) At-risk Proportion of Stand (%)
Sugar maple	79.0	117.1	100.0	40.8	0.8	No Change	0.0	0.3	Large Decrease	40.8
White ash	33.1	30.7	96.2	17.9	1.6	Increase	0.0	1.9	Increase	0.0
American basswood	18.5	23.7	73.1	12.3	1.1	No Change	0.0	1.4	Increase	0.0
Yellow birch	7.7	12.4	53.8	7.0	0.8	Decrease	7.0	0.2	Large Decrease	7.0
Bigtooth aspen	10.0	16.1	15.4	5.5	1.0	No Change	0.0	0.4	Large Decrease	5.5
Red maple	4.2	8.6	42.3	5.0	1.0	No Change	0.0	0.6	Decrease	5.0
Northern red oak	1.5	0.7	42.3	3.2	1.3	Increase	0.0	1.1	No Change	0.0
American elm	0.4	0.4	34.6	2.4	2.3	Increase	0.0	3.2	Large Increase	0.0
Paper birch	1.9	5.3	11.5	2.0	0.7	Decrease	2.0	0.2	Large Decrease	2.0
Black ash	1.5	2.6	7.7	1.2	0.7	Decrease	1.2	0.6	Decrease	1.2
Black cherry	0.4	0.2	15.4	1.1	2.4	Large Increase	0.0	1.4	Increase	0.0
Eastern hemlock	1.2	1.9	3.8	0.8	1.2	Increase	0.0	0.4	Large Decrease	0.8
Quaking aspen	0.8	0.6	7.7	0.8	0.6	Decrease	0.8	0.2	Large Decrease	0.8
Total	**160.2**	**220.3**		**100.0**		***Proportion at-risk:***	***11.0***		***Proportion at-risk:***	***63.0***

https://forestadaptation.org/learn/resource-finder/tree-species-projections-ecological-sections-northern-wisconsin

CLIMATE CHANGE PROJECTIONS FOR INDIVIDUAL TREE SPECIES

SOUTHERN SUPERIOR UPLANDS (SECTION 212J)

Wisconsin's forests will be affected by a changing climate and other stressors during this century. A team of managers and researchers created an assessment that describes the vulnerability of forests in Northern Wisconsin (Janowiak et al. 2014). This report includes information on observed and future climate trends, and also summarizes key vulnerabilities for forested natural communities. The Landscape Change Research Group recently updated the Climate Change Tree Atlas, and this handout summarizes that information. Full Tree Atlas results are available online at www.fs.fed.us/nrs/atlas/. Two climate scenarios are presented to "bracket" a range of possible futures. These future climate projections (2070 to 2099) provide information about how individual tree species may respond to a changing climate. Results for "low" and "high" emissions scenarios can be compared on the reverse side of this handout.

The updated Tree Atlas presents additional information helpful to interpret tree species changes:

- Suitable habitat - calculated based on 39 variables that explain where optimum conditions exist for a species, including soils, landforms, and climate variables.
- Adaptability - based on life-history traits that might increase or decrease tolerance of expected changes, such as the ability to withstand different forms of disturbance.
- Capability - a rating of the species' ability to cope or persist with climate change in this region based on suitable habitat change (statistical modeling), adaptability (literature review and expert opinion), and abundance (FIA data). The capability rating is modified by abundance information; ratings are downgraded for rare species and upgraded for abundant species.
- Migration Potential Model - when combined with habitat suitability, an estimate of a species' colonization likelihood for new habitats. This rating can be helpful for assisted migration or focused management (see the table section: "New Habitat with Migration Potential").

Remember that models are just tools, and they're not perfect. Model projections can't account for all factors that influence future species success. If a species is rare or confined to a small area, model results may be less reliable. These factors, and others, could cause a particular species to perform better or worse than a model projects. Human choices will also continue to influence forest distribution, especially for tree species that are projected to increase. Planting programs may assist the movement of future-adapted species, but this will depend on management decisions. Despite these limits, models provide useful information about future expectations. It's perhaps best to think of these projections as indicators of possibility and potential change.

SOURCE: This handout summarizes model results for the Southern Superior Uplands (Section 212J). Download the Climate Change Field Guide for Northern Wisconsin Forests and handouts for other Ecological Sections in northern Wisconsin at www.forestadaptation.org/northern_WI_fieldguide. A full description of the models and variables are provided in Iverson et al. 2019 (www.nrs.fs.fed.us/pubs/57857 and www.nrs.fs.fed.us/pubs/59105) and Peters et al. 2019 (www.nrs.fs.fed.us/pubs/58353).

CLIMATE CHANGE CAPABILITY

POOR CAPABILITY	
Balsam poplar	White spruce
Black spruce	
FAIR CAPABILITY	
Balsam fir	Red pine
Black ash	Tamarack (native)
Eastern hemlock	Yellow birch
GOOD CAPABILITY	
American elm	Northern red oak
Bigtooth aspen	Northern white-cedar
Black cherry	Paper birch
Eastern white pine	Quaking aspen
Green ash	Red maple
Ironwood	Sugar maple
Jackpine	White ash
Northern pin oak	
MIXED RESULTS	
American basswood	Silver maple
NEW HABITAT WITH MIGRATION POTENTIAL	
American beech	Hackberry
Bitternut hickory	Sassafras
Black locust	Shagbark hickory
Black oak	Slippery elm
Black walnut	Swamp white oak
Eastern cottonwood	White oak
Eastern redcedar	

NIACS Northern Institute of Applied Climate Science

www.forestadaptation.org

ADAPTABILITY: Life-history factors, such as the ability to respond favorably to disturbance, that are not included in the Tree Atlas model and may make a species more or less able to adapt to future stressors.

- \+ HIGH *Species may perform better than modeled*
- • MEDIUM
- – LOW *Species may perform worse than modeled*

HABITAT CHANGE: Projected change in suitable habitat between current and potential future conditions.

- ▲ INCREASE *Projected increase of >20% by 2100*
- ● NO CHANGE *Projected change of <20% by 2100*
- ▼ DECREASE *Projected decrease of >20% by 2100*
- ★ NEW HABITAT *Tree Atlas projects new habitat for species not currently present*

ABUNDANCE: Based on Forest Inventory Analysis (FIA) summed Importance Value data, calibrated to a standard geographic area.

- \+ ABUNDANT
- • COMMON
- – RARE

CAPABILITY: An overall rating that describes a species' ability to cope or persist with climate change based on suitable habitat change class (statistical modeling), adaptability (literature review and expert opinion), and abundance within this region.

- △ GOOD *Increasing suitable habitat, medium or high adaptability, and common or abundant*
- ○ FAIR *Mixed combinations, such as a rare species with increasing suitable habitat and medium adaptability*
- ▽ POOR *Decreasing suitable habitat, medium or low adaptability, and uncommon or rare*

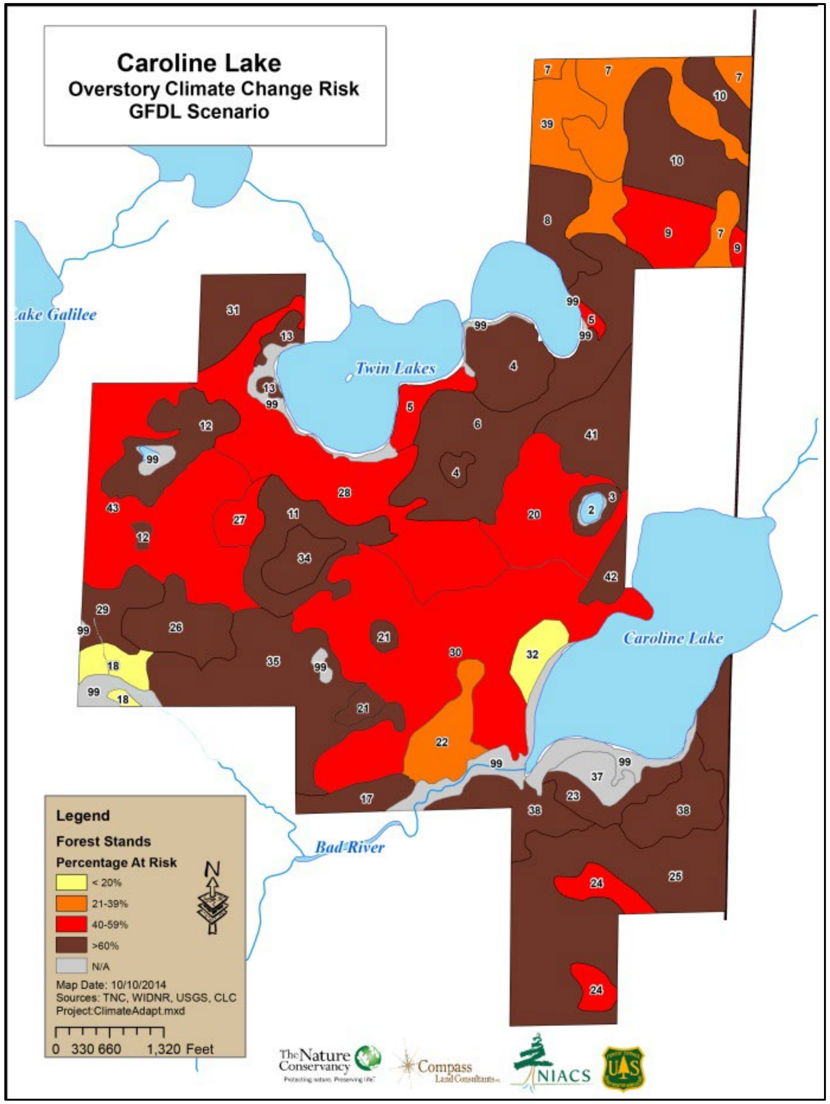
SPECIES	ADAPT	ABUN	LOW CLIMATE CHANGE (RCP4.5) HABITAT CHANGE	LOW CLIMATE CHANGE (RCP4.5) CAPABILITY	HIGH CLIMATE CHANGE (RCP8.5) HABITAT CHANGE	HIGH CLIMATE CHANGE (RCP8.5) CAPABILITY
American basswood	•	•	▲	△	●	○
American beech	•		★		★	
American elm	•	•	▲	△	▲	△
American hornbeam*	•	–	●	▽	●	▽
Balsam fir	–	+	▼	○	▼	○
Balsam poplar	•	–	▼	▽	▼	▽
Bigtooth aspen	•	•	▲	△	▲	△
Bitternut hickory*	+		★		★	
Black ash	–	+	●	○	●	○
Black cherry	–	•	▲	△	▲	△
Black locust*	•		★		★	
Black oak	•		★		★	
Black spruce	•	•	▼	▽	▼	▽
Black walnut*	•		★		★	
Black willow*	–	–	▲	▽	▲	○
Blackgum	+		★		★	
Boxelder*	+	–	▲	△	▲	△
Bur oak	+		★		★	
Cedar elm	–		★		★	
Chestnut oak	+		★		★	
Eastern cottonwood*	•		★		★	
Eastern hemlock	–	+	▼	○	▼	○
Eastern redcedar	•		★		★	
Eastern white pine	–	•	▲	△	▲	△
Flowering dogwood	•				★	
Green ash*	•	–	▲	△	▲	△
Hackberry	+		★		★	
Honeylocust*	+		★		★	
Ironwood*	+	•	▲	△	▲	△
Jack pine	+	•	●	△	●	△
Live oak	•		★		★	

SPECIES	ADAPT	ABUN	LOW CLIMATE CHANGE (RCP4.5) HABITAT CHANGE	LOW CLIMATE CHANGE (RCP4.5) CAPABILITY	HIGH CLIMATE CHANGE (RCP8.5) HABITAT CHANGE	HIGH CLIMATE CHANGE (RCP8.5) CAPABILITY
Mountain maple*	+	–	▼	▽	▼	▽
Northern pin oak	+	–	▲	△	▲	△
Northern red oak	+	•	▲	△	▲	△
Northern white-cedar	•	+	●	△	●	△
Paper birch	•	•	▲	△	▲	△
Pignut hickory	•		★		★	
Pin cherry*	•	–	▼	▽	▼	▽
Pin oak*	–				★	
Post oak	+		★		★	
Quaking aspen	•	+	●	△	●	△
Red maple	+	+	●	△	●	△
Red pine	–	•	▲	○	▲	○
Red spruce	–		★		★	
Sassafras*	•		★		★	
Scarlet oak	•		★		★	
Serviceberry*	•	–	▼	▽	▼	▽
Shagbark hickory	•		★		★	
Silver maple*	+	–	●	○	▲	△
Slippery elm*	•		★		★	
Sugar maple	+	+	▼	△	▼	△
Sugarberry	•				★	
Swamp white oak*	•		★		★	
Sweet birch	–		★		★	
Sycamore*	•		★		★	
Tamarack (native)	–	•	▲	○	▲	○
White ash	–	•	▲	△	▲	△
White oak	+		★		★	
White spruce	•	•	▼	▽	▼	▽
Yellow birch	•	+	▼	○	▼	○
Yellow-poplar	+		★		★	
Yellow-poplar	+		★		★	

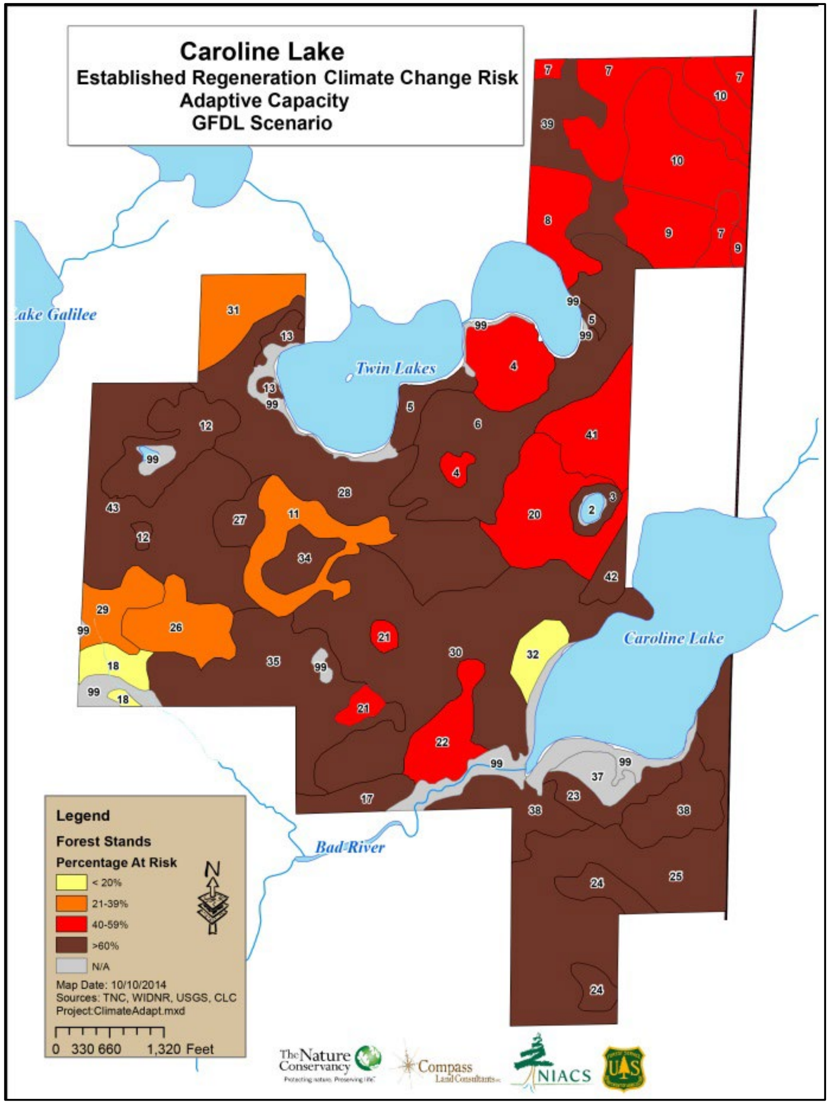
**Species with low model reliability based on five statistical metrics of the habitat models that affect change class. See maps and tables for more information (www.fs.fed.us/nrs/atlas/).*

Established Regen and Overstory under High Emission

Overstory



Established Regen



Adaptation Strategies at Caroline Lake

Strategy 1: Sustain fundamental ecological functions
- 1.1 Reduce impacts to soils and nutrient cycling
- 1.3 Maintain or restore riparian areas

Strategy 2: Reduce the impact of biological stressors
- 2.2 Prevent the introduction and establishment of invasive plant species and remove existing invasive species

Strategy 4: Maintain or create refugia
- 4.2 Prioritize and maintain sensitive or at-risk species or communities

Strategy 5: Maintain and enhance species and structural diversity
- 5.1 Promote diverse age classes
- 5.2 Maintain and restore diversity of native species
- 5.3 Retain biological legacies
- 5.4 Establish reserves to maintain ecosystem diversity

Strategy 6: Increase ecosystem redundancy across the landscape
- 6.2 Expand the boundaries of reserves to increase diversity

Strategy 9: Facilitate community adjustments through species transitions.
- 9.1 Favor or restore native species that are expected to be adapted to future conditions

Strategies Applied at Caroline Lake…

Stand Type	Acres	Initial Management	Adaptation Actions
Northern Hardwoods	643	Single-tree or group selection	• Single-tree with additional use of targeted gaps to maintain or enhance species diversity and age classes • Use large group selection or shelter wood harvests to increase n. red oak where regen is present • Where opportunity exists – promote white pine, black cherry, red oak • Reserve high-quality pockets of hemlock to serve as a refugia for that species

Lessons Learned at Caroline Lake

- Maintain or increase **species diversity** – consider climate adapted species
- Begin by taking **small steps**
- A **thoughtful** and **steady** change in management practices over time will help create lasting resiliency
- Monitor and **eliminate invasive** species
- Work and **learn from**/with others – share findings
- Be creative and **flexible** - ADAPT


Questions

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Menu of Adaptation Strategies and Approaches

Developed for forests

Strategies 1-5

Strategy 1: Sustain fundamental ecological functions.
1.1. Reduce impacts to soils and nutrient cycling.
1.2. Maintain or restore hydrology.
1.3. Maintain or restore riparian areas.
1.4. Reduce competition for moisture, nutrients, and light.
1.5. Restore or maintain fire in fire-adapted ecosystems.

Strategy 2: Reduce the impact of biological stressors.
2.1. Maintain or improve the ability of forests to resist pests and pathogens.
2.2. Prevent the introduction and establishment of invasive plant species and remove existing invasive species.
2.3. Manage herbivory to promote regeneration of desired species.

Strategy 3: Reduce the risk and long-term impacts of severe disturbances.
3.1. Alter forest structure or composition to reduce risk or severity of wildfire.
3.2. Establish fuelbreaks to slow the spread of catastrophic fire.
3.3. Alter forest structure to reduce severity or extent of wind and ice damage.
3.4. Promptly revegetate sites after disturbance.

Strategy 4: Maintain or create refugia.
4.1. Prioritize and maintain unique sites.
4.2. Prioritize and maintain sensitive or at-risk species or communities.
4.3. Establish artificial reserves for at-risk and displaced species.

Strategy 5: Maintain and enhance species and structural diversity.
5.1. Promote diverse age classes.
5.2. Maintain and restore diversity of native species.
5.3. Retain biological legacies.
5.4. Establish reserves to maintain ecosystem diversity.

Menu of Adaptation Strategies and Approaches

Developed for forests

Strategies 6 - 9

Strategy 6: Increase ecosystem redundancy across the landscape.

6.1. Manage habitats over a range of sites and conditions.
6.2. Expand the boundaries of reserves to increase diversity.

Strategy 7: Promote landscape connectivity.

7.1. Reduce landscape fragmentation.
7.2. Maintain and create habitat corridors through reforestation or restoration.

Strategy 8: Maintain and enhance genetic diversity.

8.1. Use seeds, germplasm, and other genetic material from across a greater geographic range.
8.2. Favor existing genotypes that are better adapted to future conditions.

Strategy 9: Facilitate community adjustments through species transitions.

9.1. Favor or restore native species that are expected to be adapted to future conditions.
9.2. Establish or encourage new mixes of native species.
9.3. Guide changes in species composition at early stages of stand development.
9.4. Protect future-adapted seedlings and saplings.
9.5. Disfavor species that are distinctly maladapted.
9.6. Manage for species and genotypes with wide moisture and temperature tolerances.
9.7. Introduce species that are expected to be adapted to future conditions.
9.8. Move at-risk species to locations that are expected to provide habitat.

Strategy 10: Realign ecosystems after disturbance.

10.1 Promptly revegetate sites after disturbance.
10.2. Allow for areas of natural regeneration to test for future-adapted species.
10.3. Realign significantly disrupted ecosystems to meet expected future conditions.

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Inventory Needs

Inventory Metric	**Typical* forest inventory?**	**Normally would be used to…**	**In the context of climate change…**
Tree Species Richness Tree Species Evenness	No: Data collected, but often not evaluated	Give an indication of stand- or forest-level diversity	Higher species evenness and richness may have greater adaptive capacity/ lower risk
Regeneration	Sometimes, but often not	Show effectiveness of regen treatments; inform future actions	Regeneration may be most influenced by climate change; potential early indication of change or future issues

Strategies Applied at Caroline Lake…

Stand Type	Acres	Initial Management	Adaptation Actions
Lowland Hardwoods	78	No harvest – reserve area	• Diversify stands through thinning and group selection • Monitor natural regeneration of desired species. If inadequate, consider experimental plantings of swamp white oak, bur oak, Am. elm as species that are not currently present on the site but may do well in the future