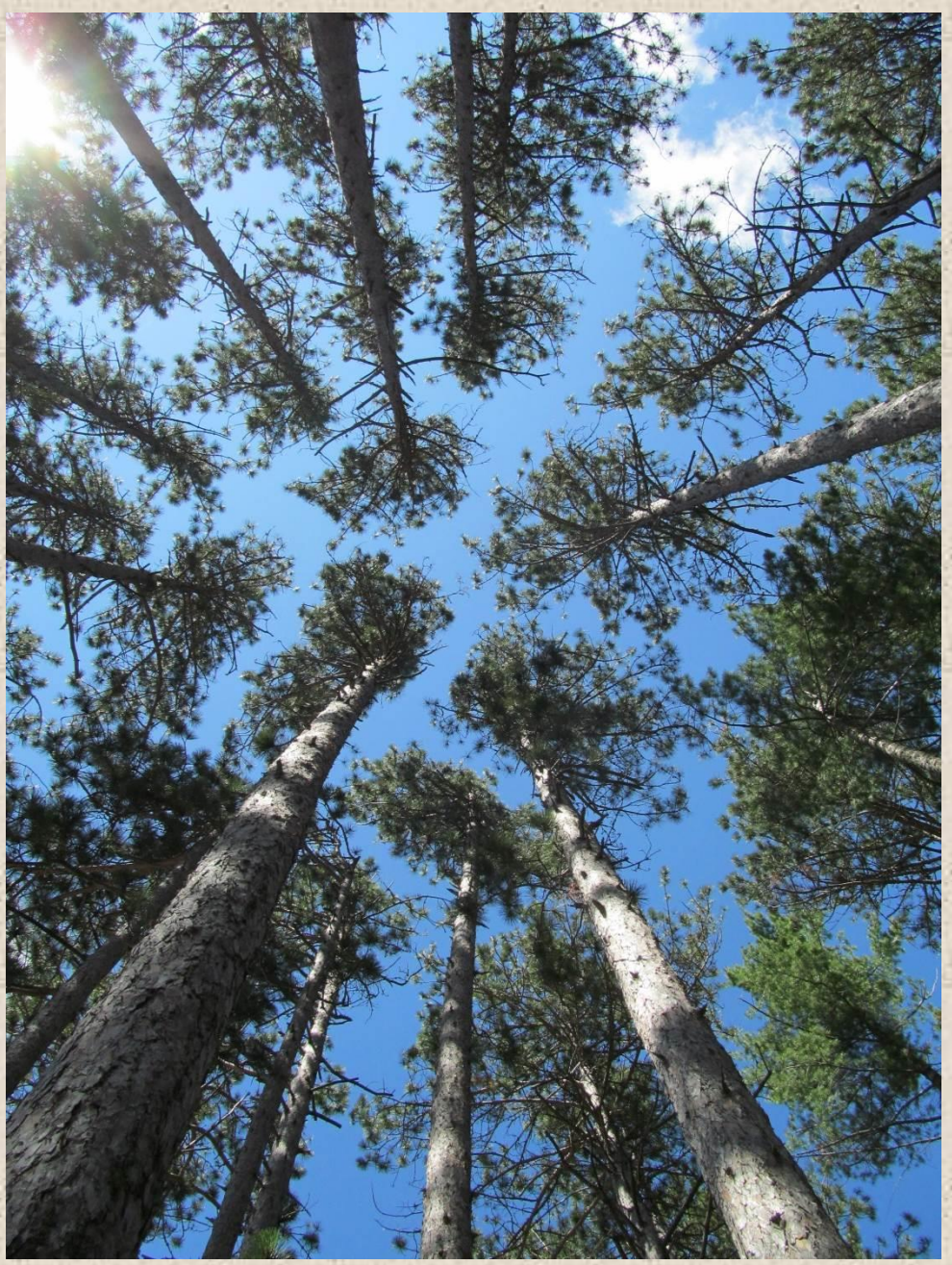
Mission

The National Park Service preserves unimpaired the natural and cultural resources and values of the national park system for the enjoyment, education, and inspiration of this and future generations.



Current Projects

- Traditional Ecological Knowledge
- Park wetlands

- Climate change vulnerability assessment
  - Questions
  - Ecosystems & Scheme
  - Apostle Islands National Lakeshore
    - Context – islands in Lake Superior
    - Abiotic and biotic features and susceptibilities
    - Observed impacts
    - Methods
    - Results

Vulnerability Assessment Objectives

The objectives of this project are to:

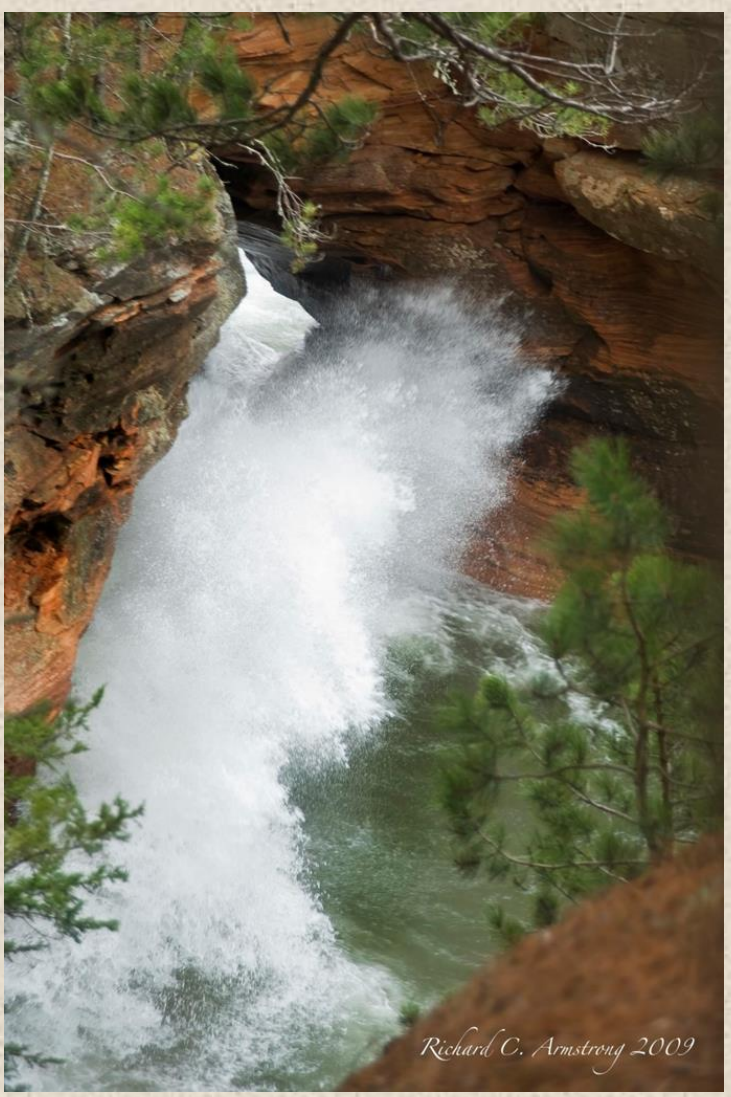
- understand the climate change vulnerabilities of key terrestrial natural plant communities, features, and species,
- incorporate this information into on-the-ground management, and
- increase education about impacts and adaptation of park managers, staff, and visitors to promote behavior change regarding this issue.

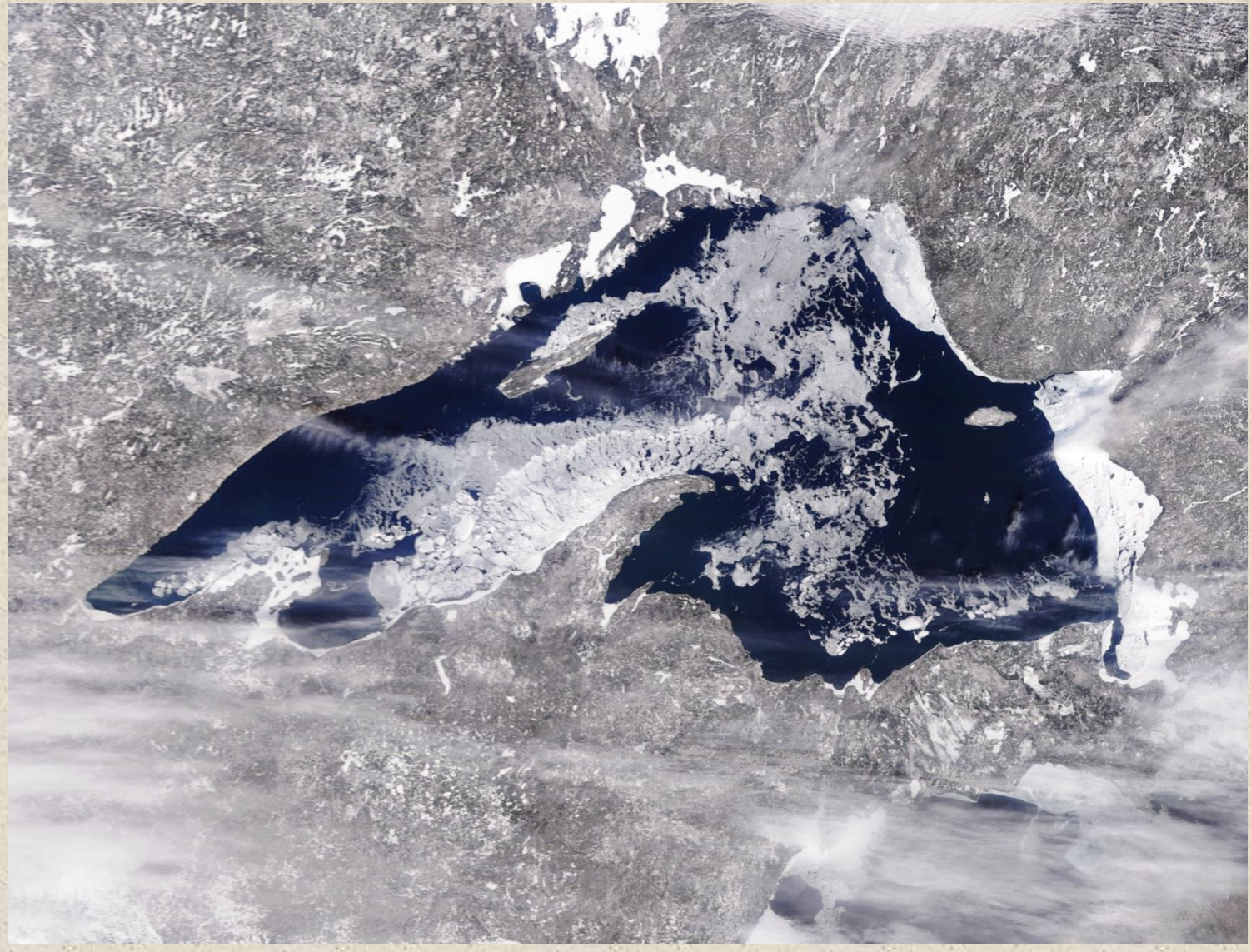
Park Specific Questions

- How are rare and character-defining terrestrial features and natural communities of the park – specifically sandscapes and boreal, krummholz, and old-growth forests – and associated species including hemlock, yellow birch, northern white cedar, and Canada yew, vulnerable to climate change? And how does the park's island setting influence these vulnerabilities?
- Could the park serve as important refugia (Morelli et al., 2016) for some terrestrial vegetation species or community types?
- Will Lake Superior function as a barrier to northward migration of species, and what are the implications?
- How will increasing lake temperatures and wind speeds alter the natural disturbance regimes in the park? What are the implications for both wind and fire processes?

Apostle Islands National Lakeshore

- Context – islands in Lake Superior
- Abiotic and biotic features and susceptibilities
- Disturbance processes
- Observed impacts





Scale - 42,160 Park acres/20,364,800 Lake acres = .002070

Fetch - Northeast - 200 miles

Fetch

South – 25 miles; Northwest – 30 miles

21 Islands

<u>Natural features</u>

Elevation

Geology

Landforms

Soils

Natural disturbances

Vegetation

Wildlife

<u>Cultural History</u>

Native Americans

Fires

Quarries

Logging

Fishing

Farming

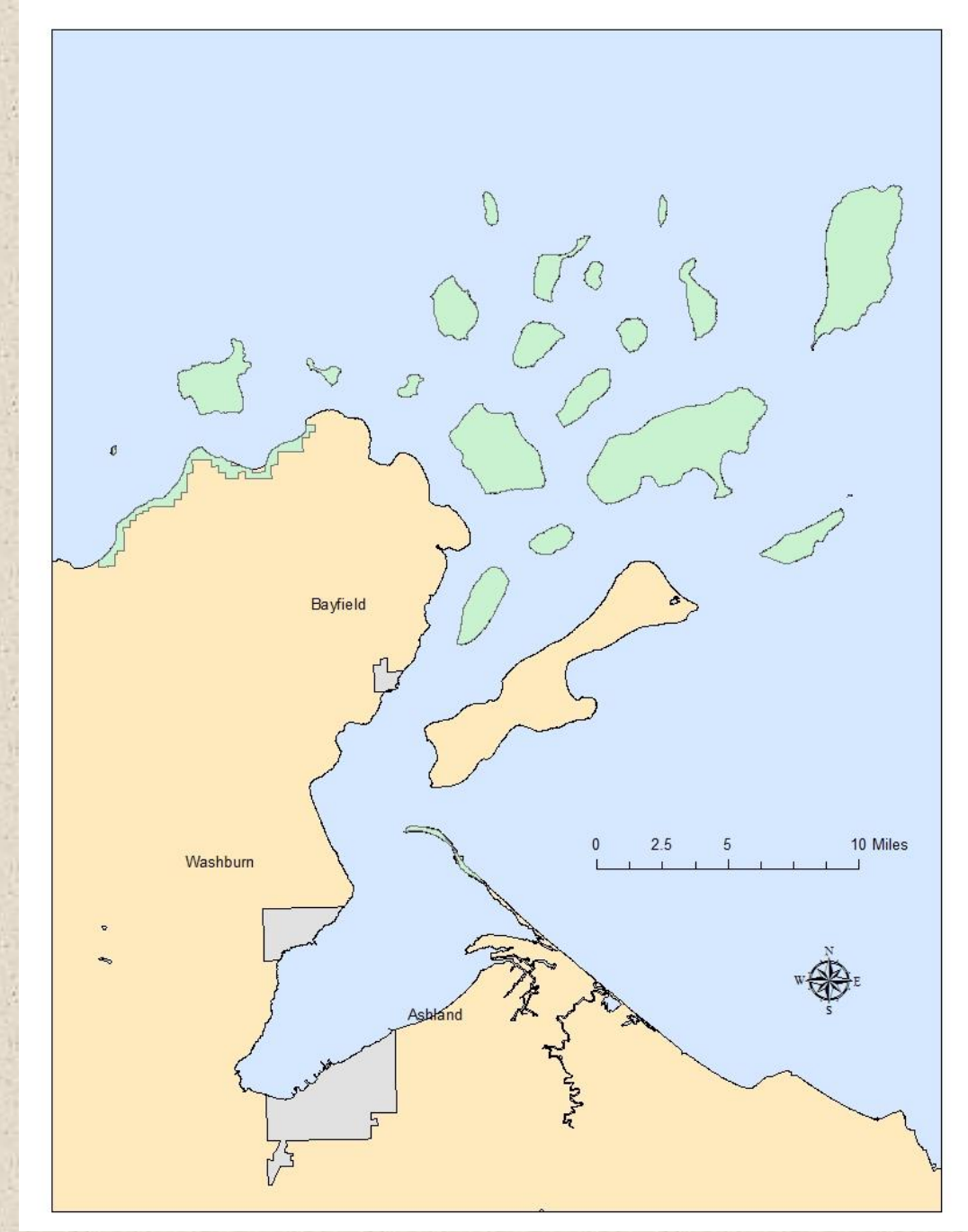
Recreation

Deer

21 Islands

- Covering about 450 mile^2 area
- 160 miles of coastline
- Islands range
  - 1-15 miles from Mainland
  - 2 – 10,000 acres in size

- How does the marine context effect:
  - Islands
  - Geological features



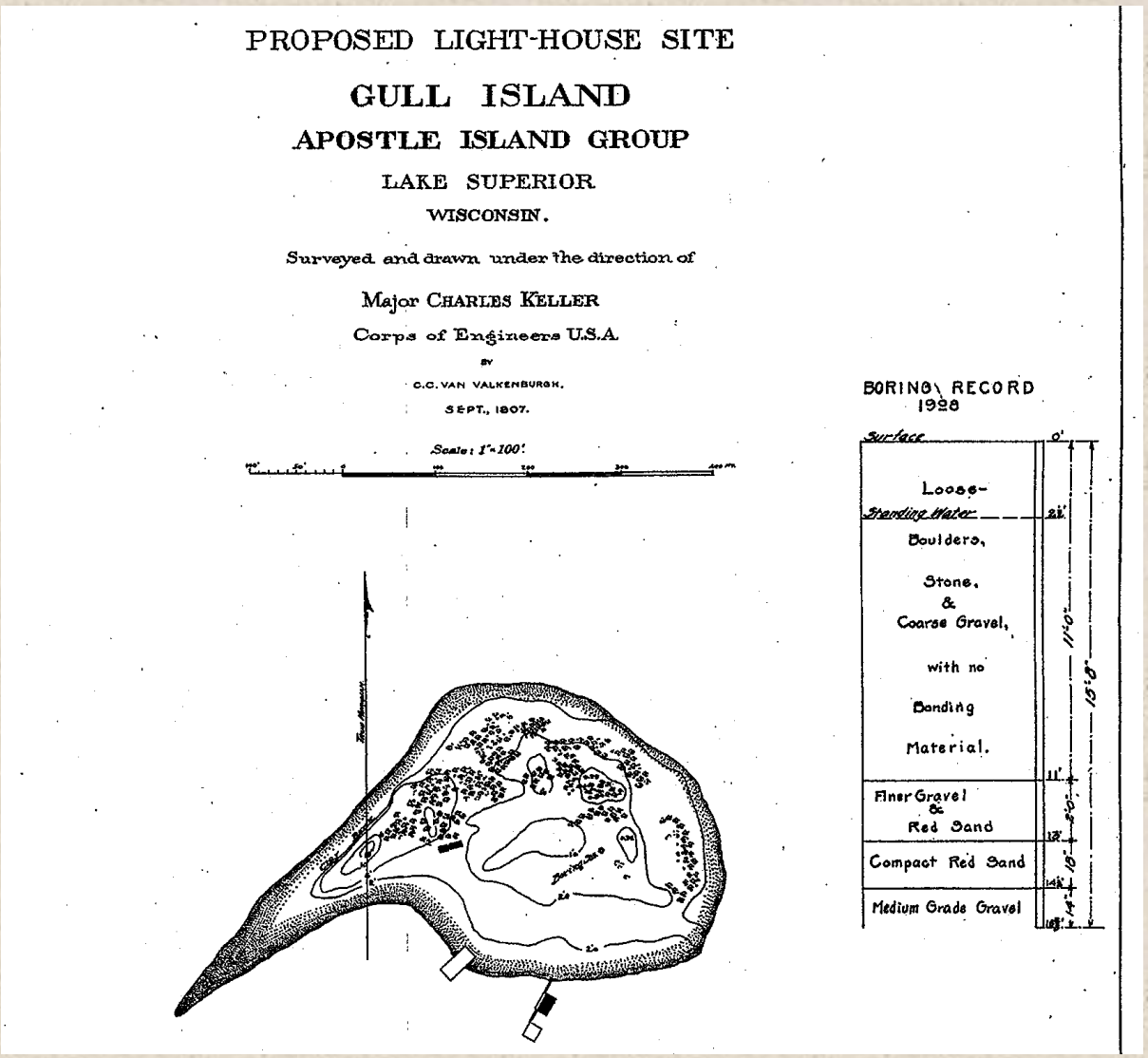
Little Steamboat Island

- Present during GLO surveys 1857
- Photo – 1888, island 20-25 feet tall
- Entire island lost in a storm in 1901

Steamboat Island.—Plate XVIII.

Gull Island - 1857

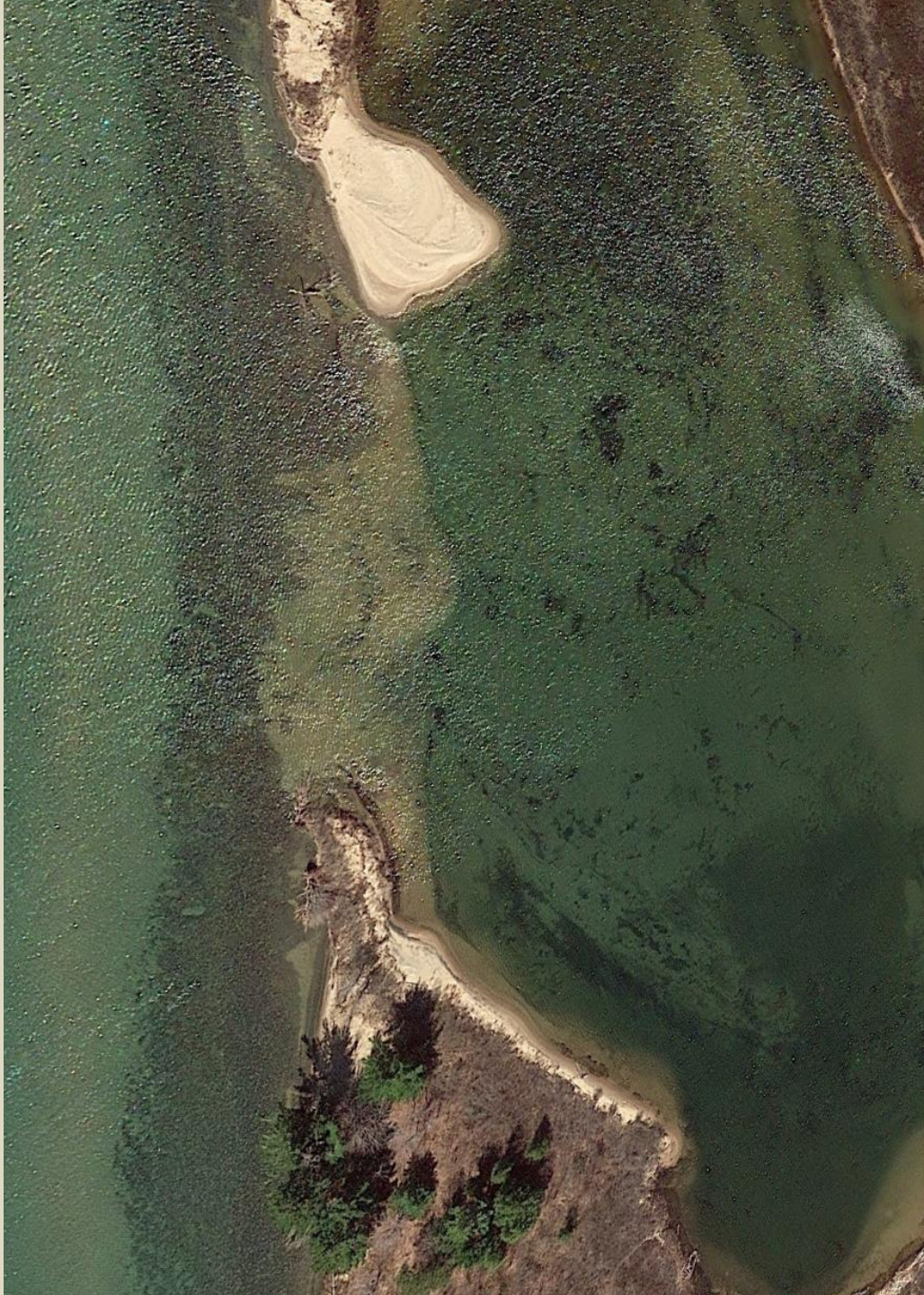
"Clay bluffs 10 to 15 feet high with boulders at the foot. Not much timber on the island. Undergrowth balsam, spruce, & birch."



Gull Island - 2015

Outer Island Lagoon

- Storm – September 2014
- 280 feet long breach



Outer Sandspit

Devils Island

- Highly exposed edges
- Sea caves formed over time

Clay Bluffs – Over Half of Park's Coastline

Clay Bluffs

Erosion

Outer Island 2007

Erosion

Stockton Presque Isle 5-15


Erosion
Long Island 9-14

Additions of Woody Debris

Additions of Sand

Additions of Sand

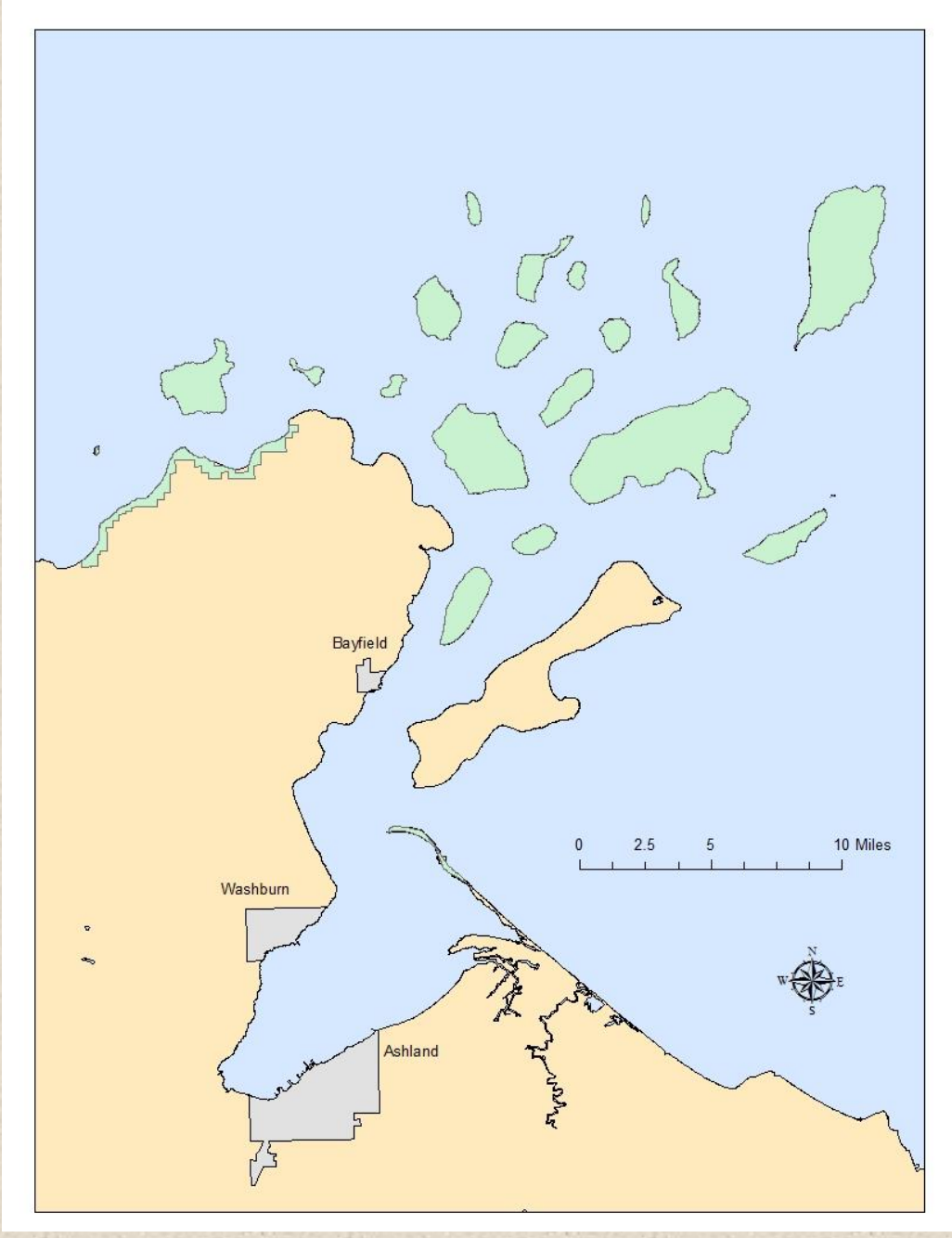
Stockton Island

Rocky Island - Hadlund

21 Islands

- Covering about 450 mile^2 area
- 160 miles of coastline
- Islands range
  - 1-15 miles from Mainland
  - 2 – 10,000 acres in size

- How do these factors influence:
  - Natural disturbance regimes
    - Fire
    - Wind
  - Vegetation
  - Plant dispersal



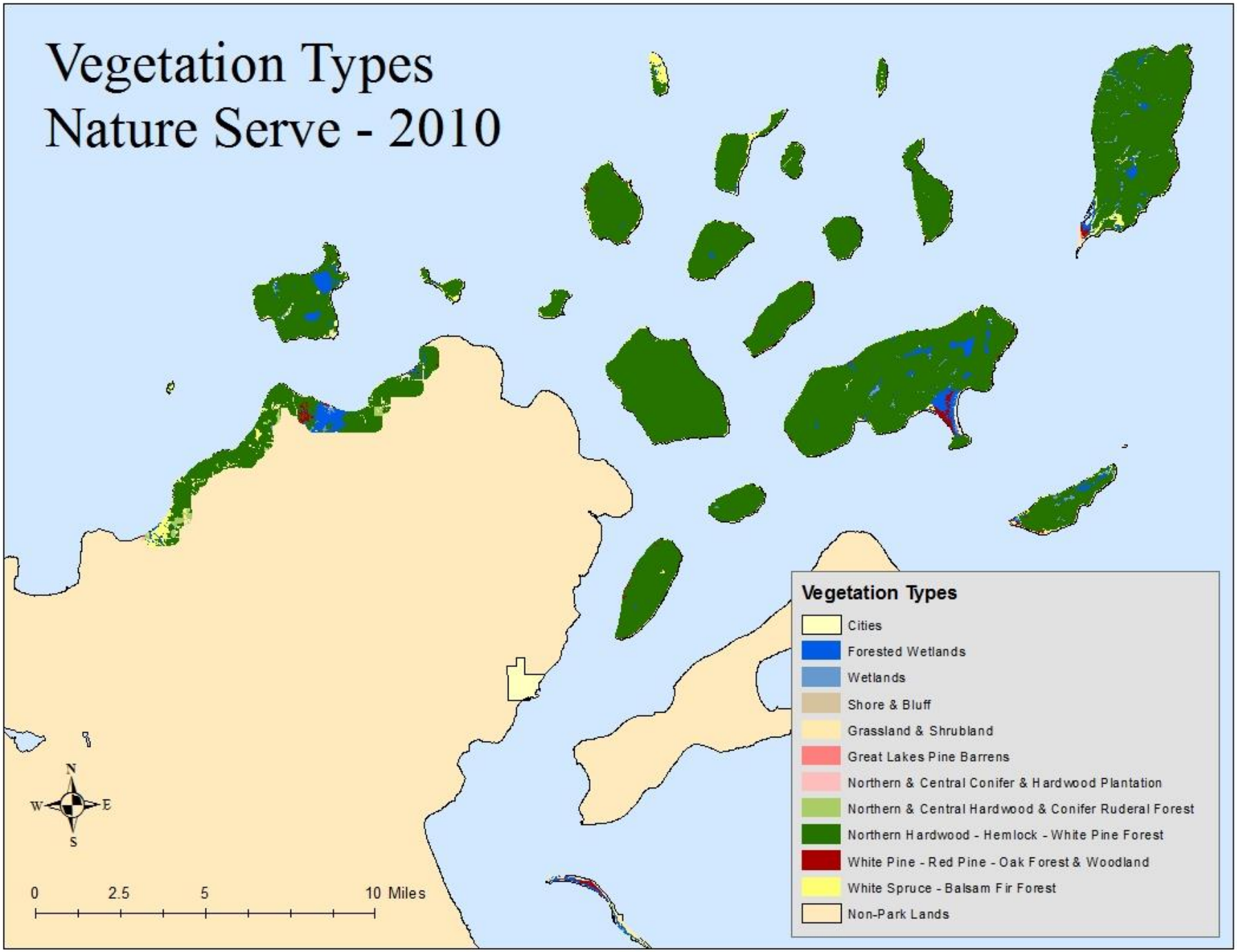
Natural Disturbance Regimes

Fire

- Frequency and spread influenced by:
  - Marine and island context
  - Vegetation type

Forest Type	Percent of Park Acreage	Return Interval (years)
Mesic	72	350-1,000
Wet mesic	17	350-1,000
Wet	1	350-1,000
Dry mesic	5	5-15 (maintenance) 30-75 (pine - replacement) 75-350 (oak – replacement)

Dickmann & Cleland 2002


Vegetation Types
Nature Serve - 2010
Vegetation Types
Cities
Forested Wetlands
Wetlands
Shore & Bluff
Grassland & Shrubland
Great Lakes Pine Barrens
Northern & Central Conifer & Hardwood Plantation
Northern & Central Hardwood & Conifer Ruderal Forest
Northern Hardwood - Hemlock - White Pine Forest
White Pine - Red Pine - Oak Forest & Woodland
White Spruce - Balsam Fir Forest
Non-Park Lands
N
W
E
S
0
2.5
5
10 Miles

Fire history

Park-wide

- Between 1936-2014
  - Lightning (25) – between 0.1-8 acres (0.76 mean)
  - Human (20) – 0.1-3,983 acres (200 mean)
- All islands but Eagle & Gull

Stockton, Others

- Native American use especially on the Stockton tombolo

North Twin, Raspberry, Sand, York Islands (Martin & Johnson, 2018)

- Charcoal samples – 269 to 2,227 years ago
- Fires were variable
- Many during & after 1600's & likely started by people

Natural Disturbance Regimes

Wind

- Chronic wind
  - Thigmomorphogenesis
    - Above and below ground
  - Evapotranspiration rates
  - Photosynthesis
- Sub-lethal
- Lethal

Natural Disturbance Regimes

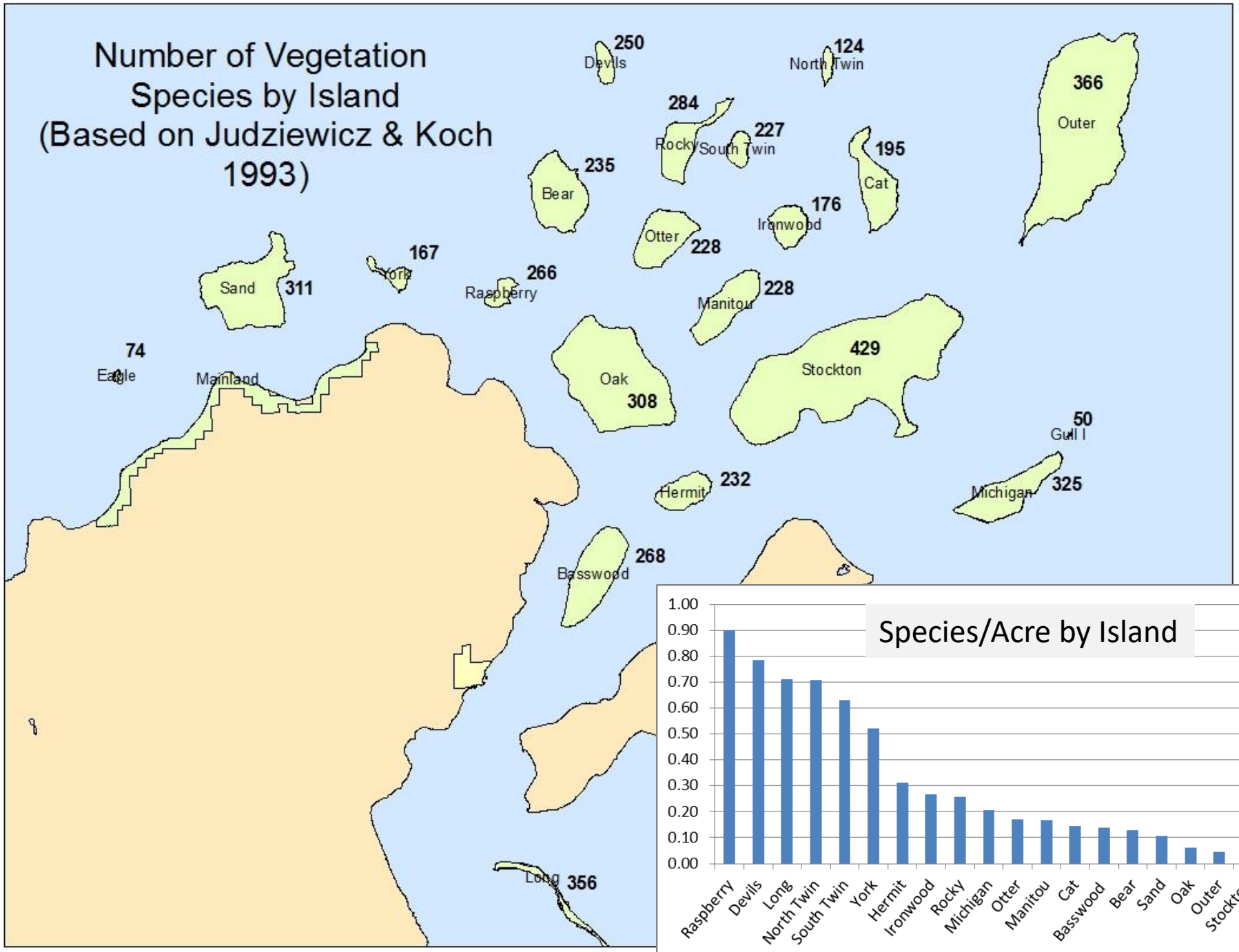
Known

- Wind speeds over western Lake Superior have increased 5% per decade since 1984 (Desai et al. 2009)
- Winds are stronger at higher levels

Unknown

- Are there interactions of island height and wind that create greater edge effect?
- Will the edge zone increase over time and interact with narrow areas or small island size?
- Will more woody debris result and increase fire frequency?

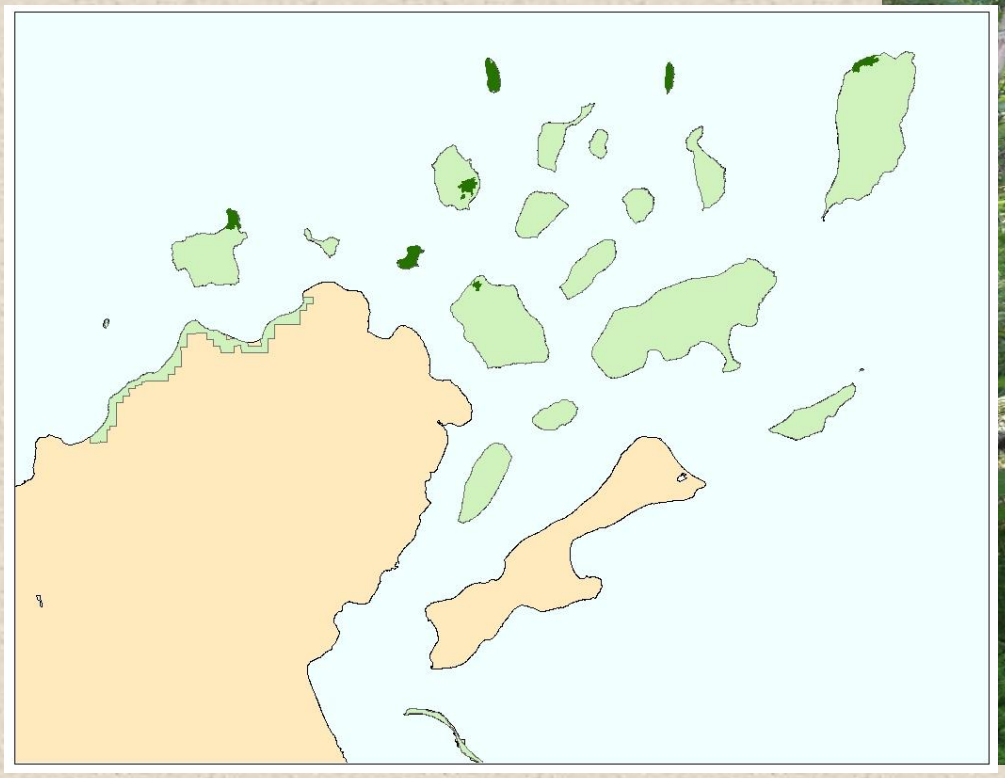
Number of Vegetation Species by Island (Based on Judziewicz & Koch 1993)



Old Growth

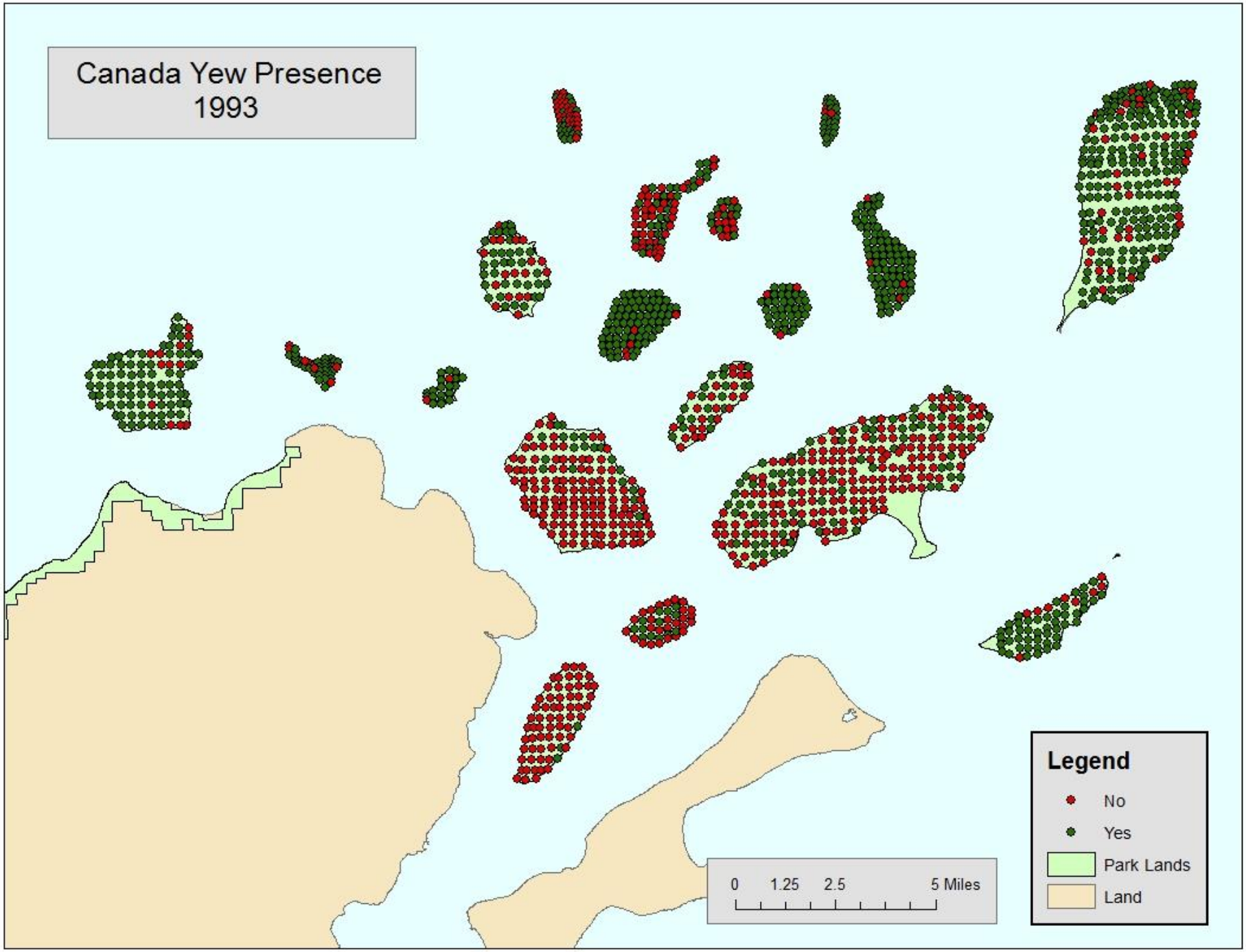
Approximately 1,350 acres
Various species including:

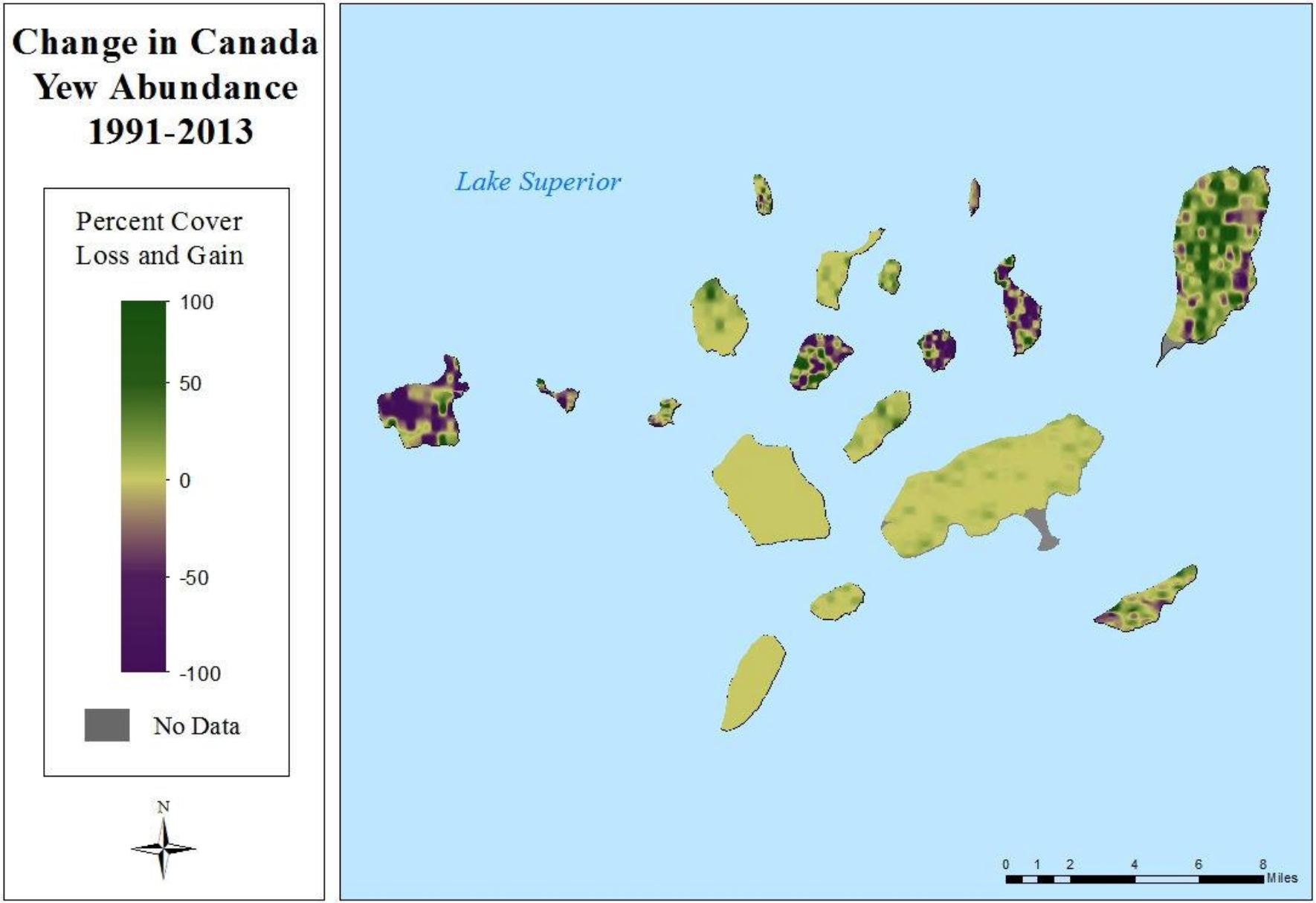
- Hemlock
- Sugar maple
- White cedar
- White pine
- Yellow birch



Outer Island

Canada Yew

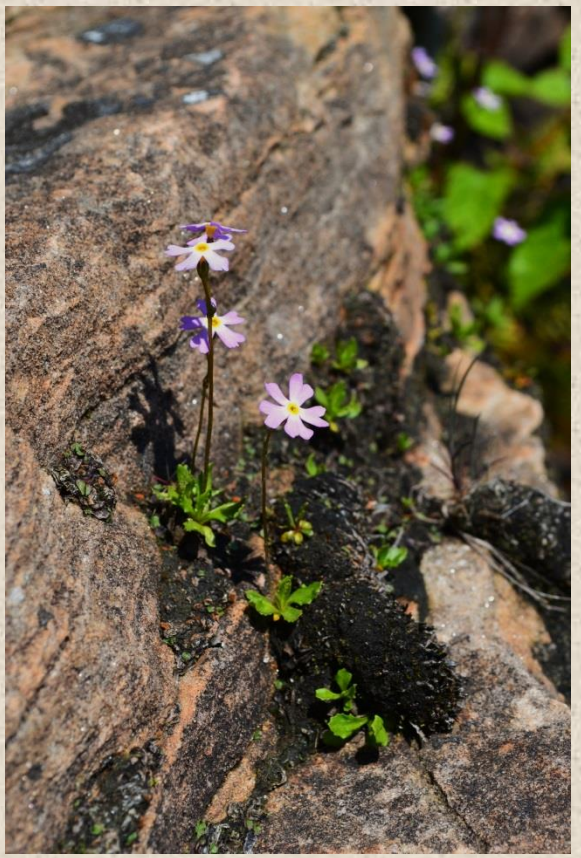

Canada Yew Presence
1993
Legend
No
Yes
Park Lands
Land
0
1.25
2.5
5 Miles



Johnson, et al., 2014

Rare Plants

- 26 species with state classifications
- Present because park provides:
  - rare habitats (cliffs, rock pools, wetlands, ravines)
  - refugia from disturbances



Bird's-eye Primrose – arctic remnant

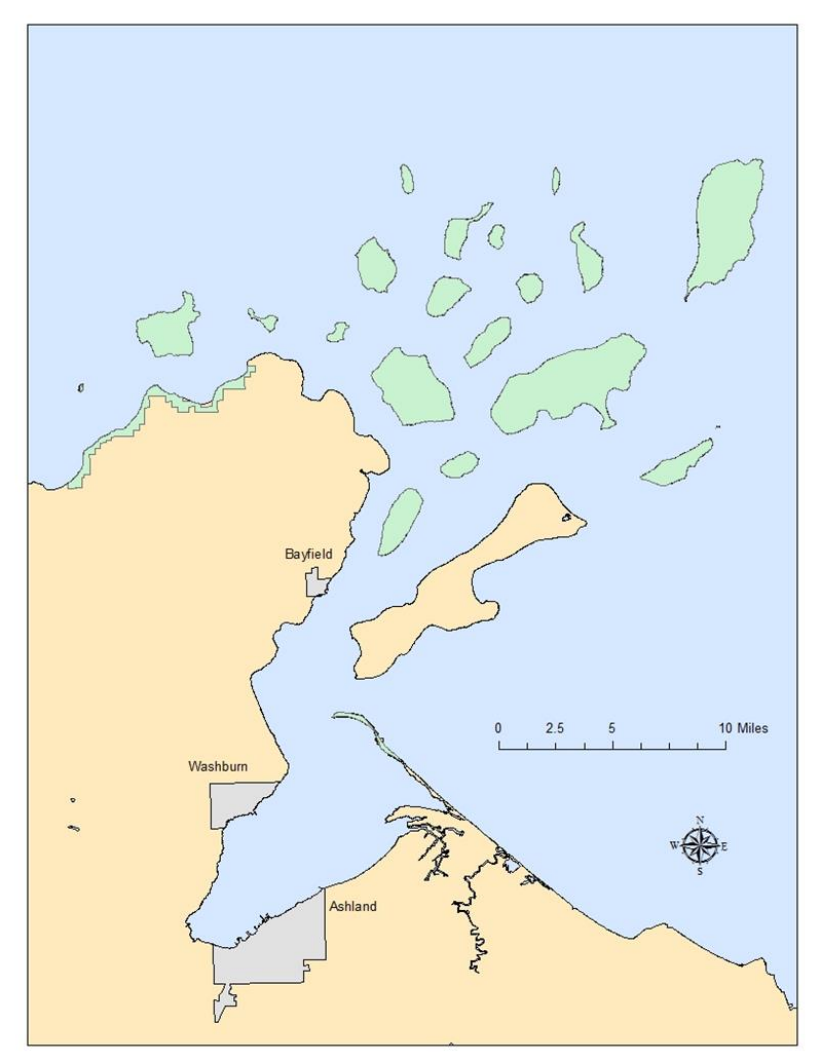
Broad-lipped Twayblade

(*Listera convallarioides*)

State Threatened Species

Seed Dispersal

- Methods – gravity, force, wind, water, animals
- Lake Superior is a barrier
- Distances -
  - From Mainland to various islands: 1 – 15 miles
  - Between various islands: 2 – 40 miles



Key Points

- Island context important:
  - Character defining
    - Various habitats
    - Rare and unique vegetation species and conditions (old growth, krummholz)
  - Contributes to different susceptibilities
    - Abiotic and biotic features
    - Disturbance regimes
    - Seed dispersal
  - Increases vulnerabilities to climate change

Methods

Modeling –

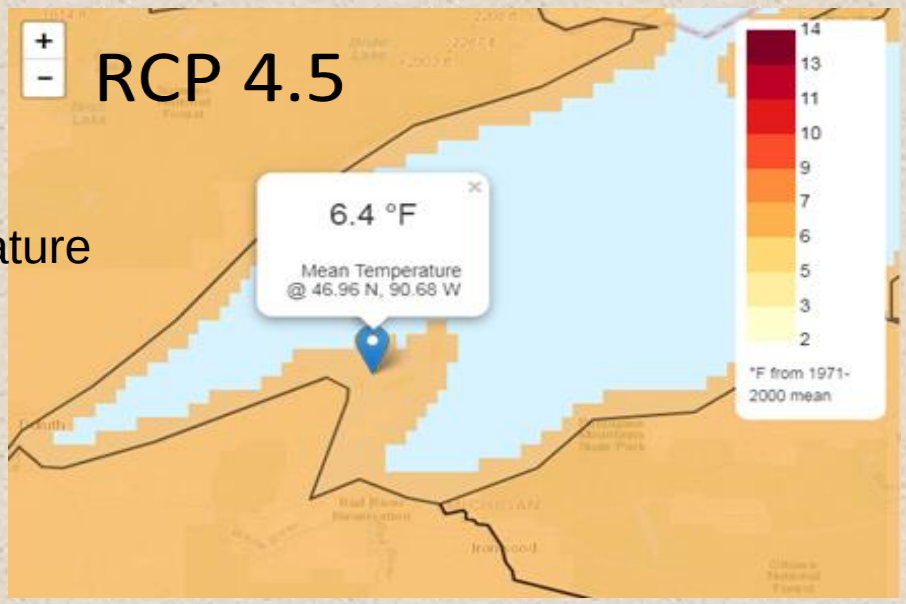
- Used a national statistically downscaled model[2] (RCP 4.5 and 8.5 scenarios) and a regional dynamically downscaled model (RCP 8.5)[3],
- USDA Climate Change Tree Atlas[4], 1 x 1-degree results.

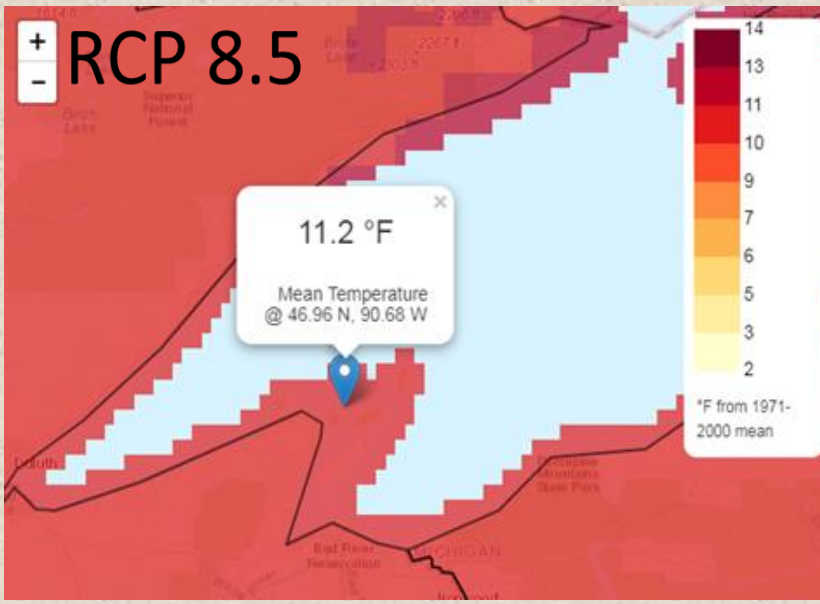
Workshop –

- Worked with subject matter experts to identify 11 Apostle Islands ecosystems.
- Systematically evaluated potential impacts, adaptive capacity, and vulnerability of each ecosystem. Also provided confidence values for conclusions.

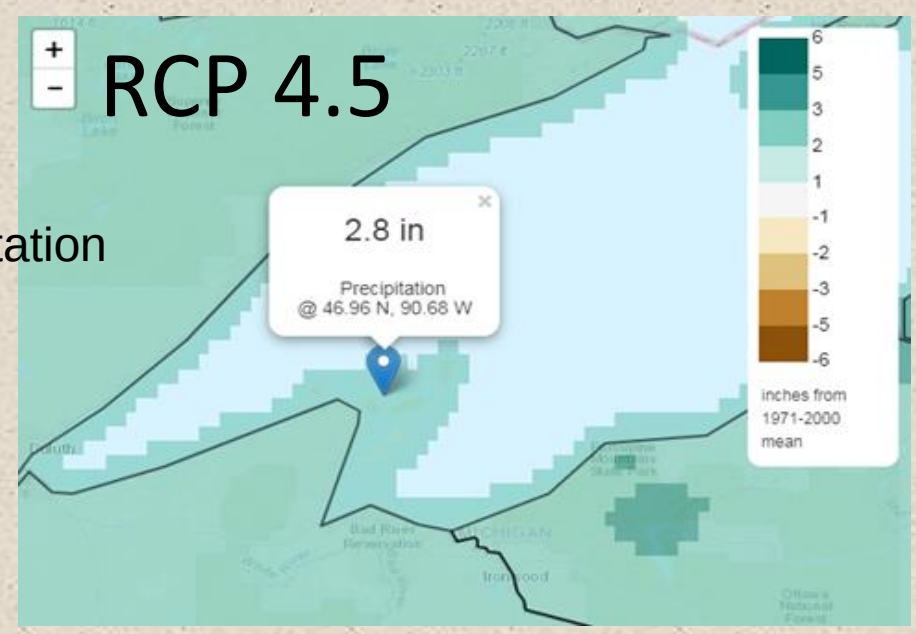
Results - Modeling

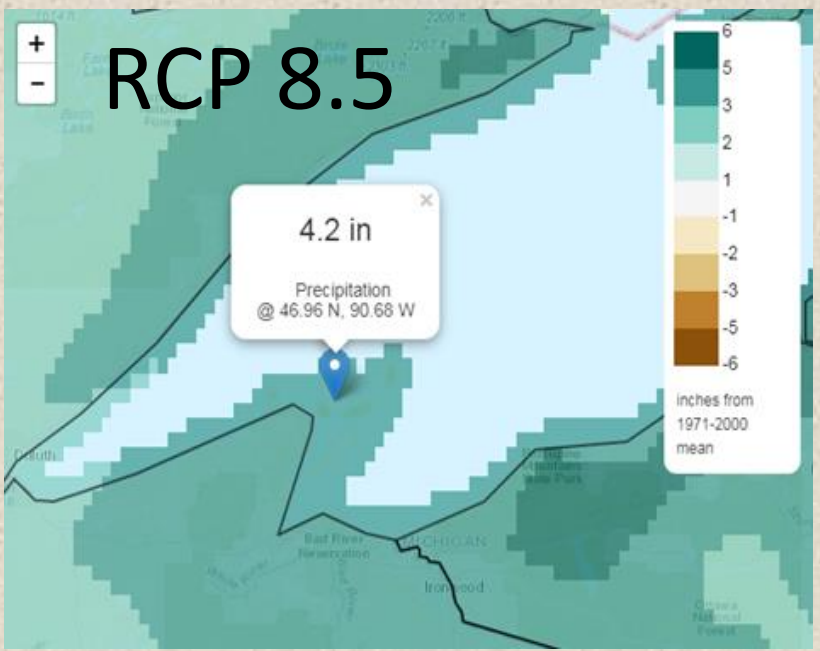
Annual Temperature





Annual Precipitation





Results - Workshop

Ecosystem	Potential Impacts	Adaptive Capacity	Vulnerability
Boreal Forests	Disruptive	Moderate	Moderate-High
Coastal Wetlands	Disruptive	Moderate	Moderate-High
Rock Cliffs	Disruptive-Moderate	Moderate	Moderate-High
Interior Peat Swamps & Bogs	Disruptive-Moderate	High	Moderate
Mixed Conifer Hardwoods (Matrix)	Moderate	Moderate	Moderate
Beaches and Dunes	Moderate	Moderate-High	Low-Moderate
Deep Ravine Forests	Moderate	High	Low-Moderate
Upland Hardwood Forests	Moderate	Moderate-High	Low-Moderate
Erodible Maritime Cliffs	Moderate-Supportive	High	Low
Great Lakes Pine Forests & Barrens	Moderate-Supportive	Moderate-High	Low
Interior Alder Thickets	Moderate-Supportive	High	Low

References

- Desai, A. R., J.A. Austin, V. Bennington, and G.A. McKinley. 2009. Stronger winds over a large lake in response to weakening air-to-lake temperature gradient, Nat. Geosci, 2(12), 855-858, doi:10.1038/ngeo693.
- Dickmann, Donald I. and Cleland, David T. 2002. Fire Return Intervals and Fire Cycles for Historic Fire Regimes in the Great Lakes Region: A Synthesis of the Literature.
- Harper, K., S. MacDonald, P. Burton, J. Chen, K. Brosofske, S. Saunders, E. Euskirchen, D. Roberts, M. Jaiteh, and P. Esseen. 2005. Edge Influence on Forest Structure and Composition in Fragmented Landscapes Volume 19, Issue, 768–782.
- Martin, Jonathan G. and S. E. Johnson. 2018. The legacy of small wide fires for Canada Yew management and future fire risk in the Apostle Islands National Lakeshore. Unpub. Rpt. 61pp.

Other Issues

- Changes in soil moisture
- Interactions between processes and species
- Forest pests and pathogens
  - emerald ash borer
- Exotic plants
  - garlic mustard

Process

Definitions

Timeframe

Ecosystems & Schemes

Wind and Edge

Edge Influence on Forest Structure and Composition in Fragmented Landscapes

Response Type	**Process**	**Structure**	**Composition**
Primary	Tree mortality/damage	Canopy trees Canopy cover Snags and logs	None
Secondary	Recruitment Growth rate Canopy foliage Understory foliage Seedling mortality	Understory tree density Herb cover Shrub cover	Species composition Exotic species Individual species Species diversity

Harper et al., 2005