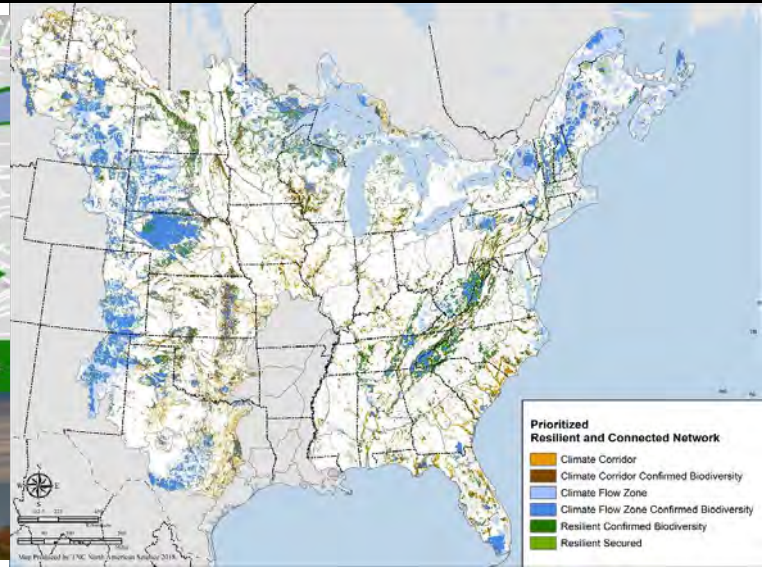
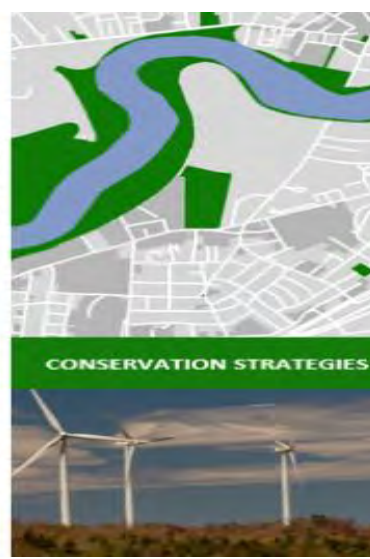
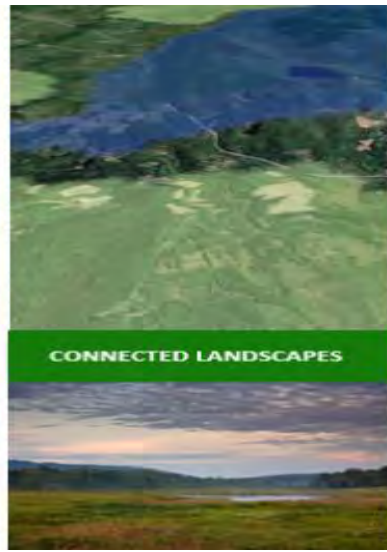


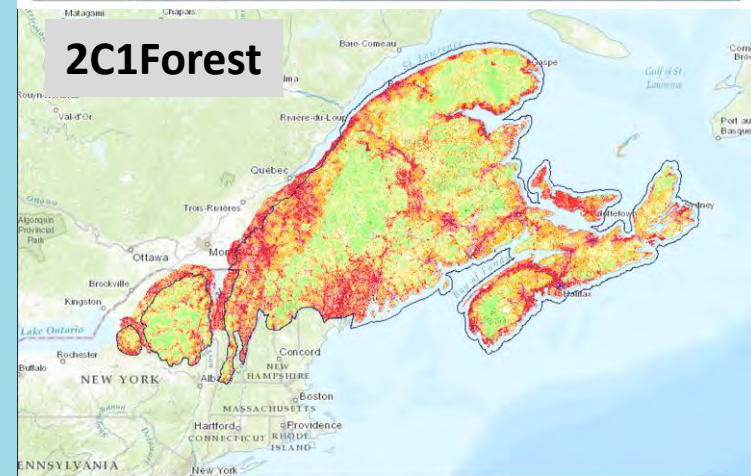
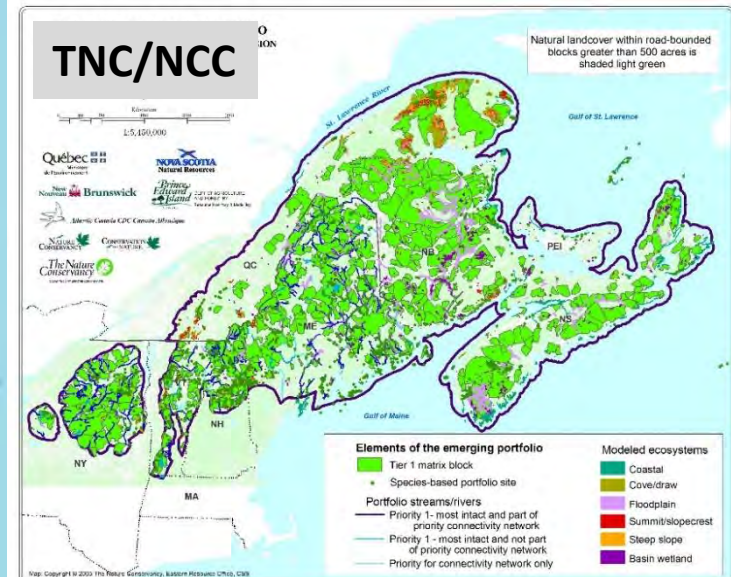
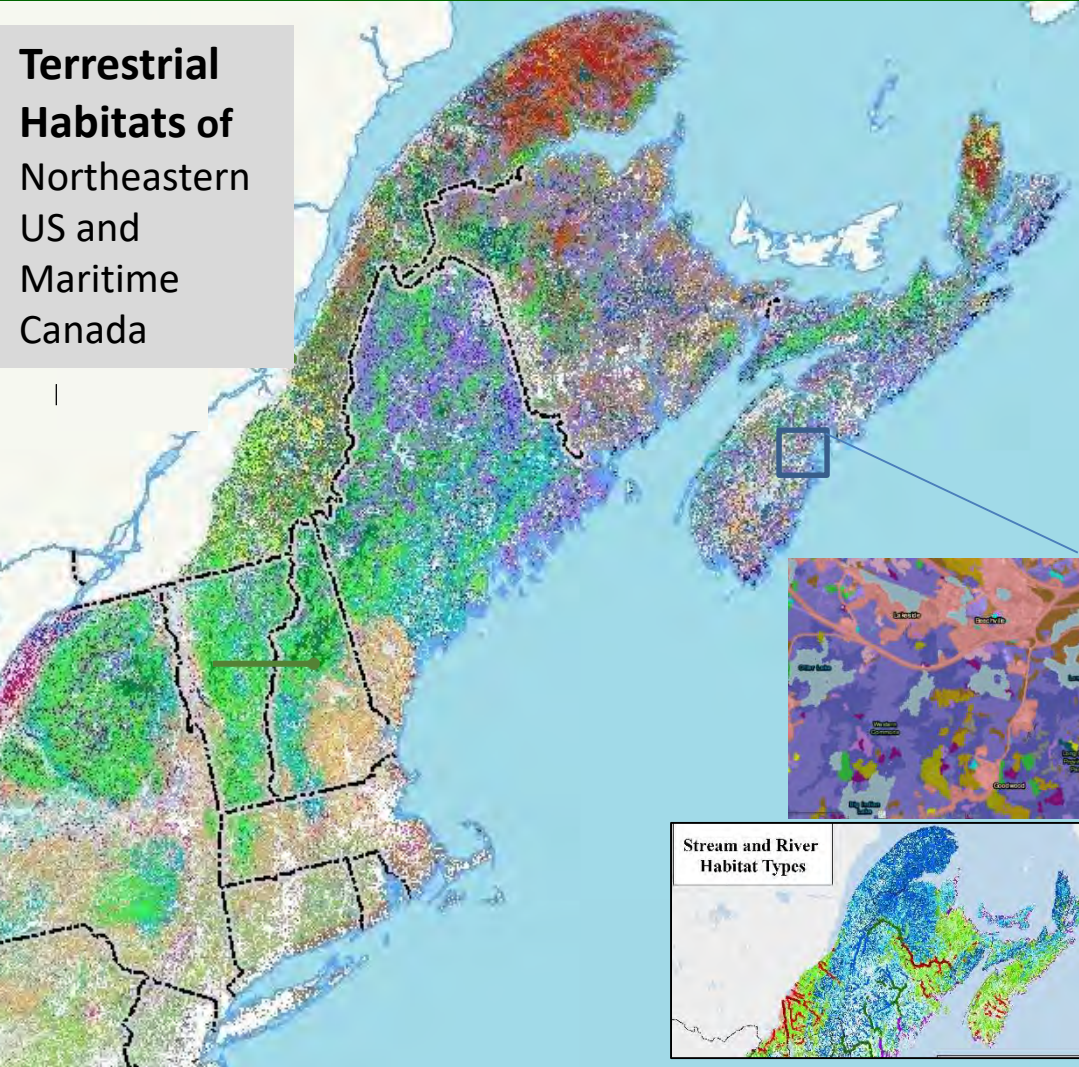
# Resilient and Connected Landscapes

## *to Sustain Diversity under Climate Change*



# A Productive Partnership

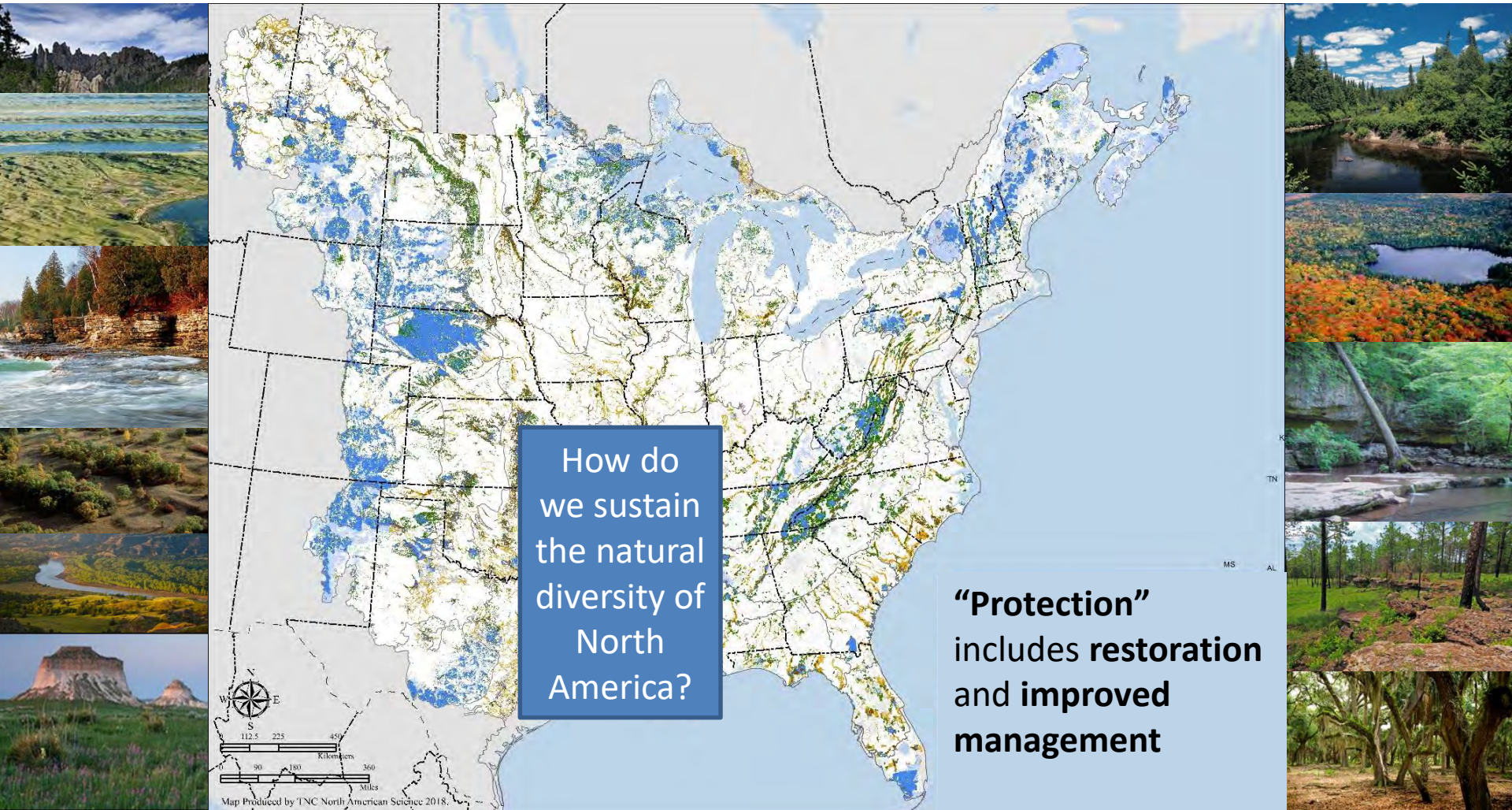
## Terrestrial Habitats of Northeastern US and Maritime Canada



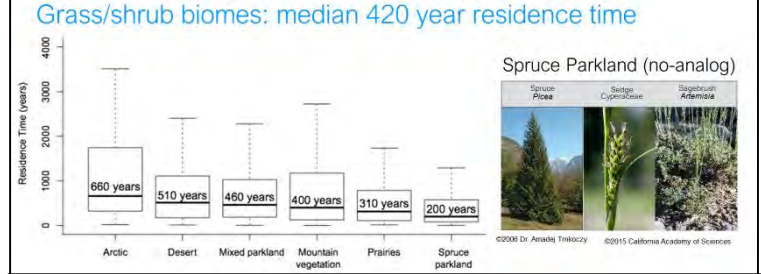
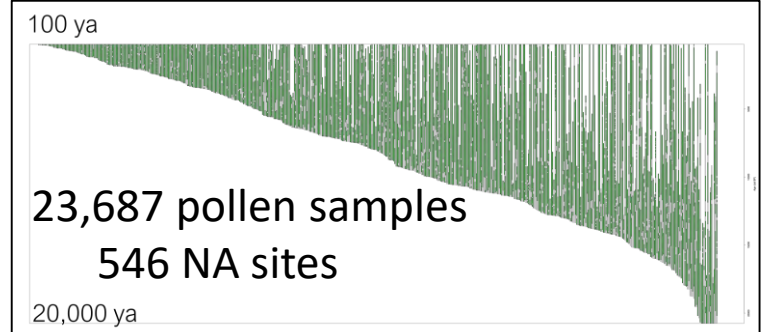
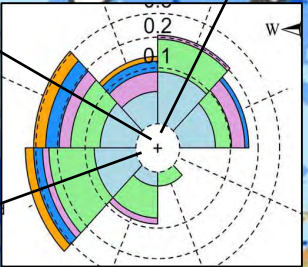
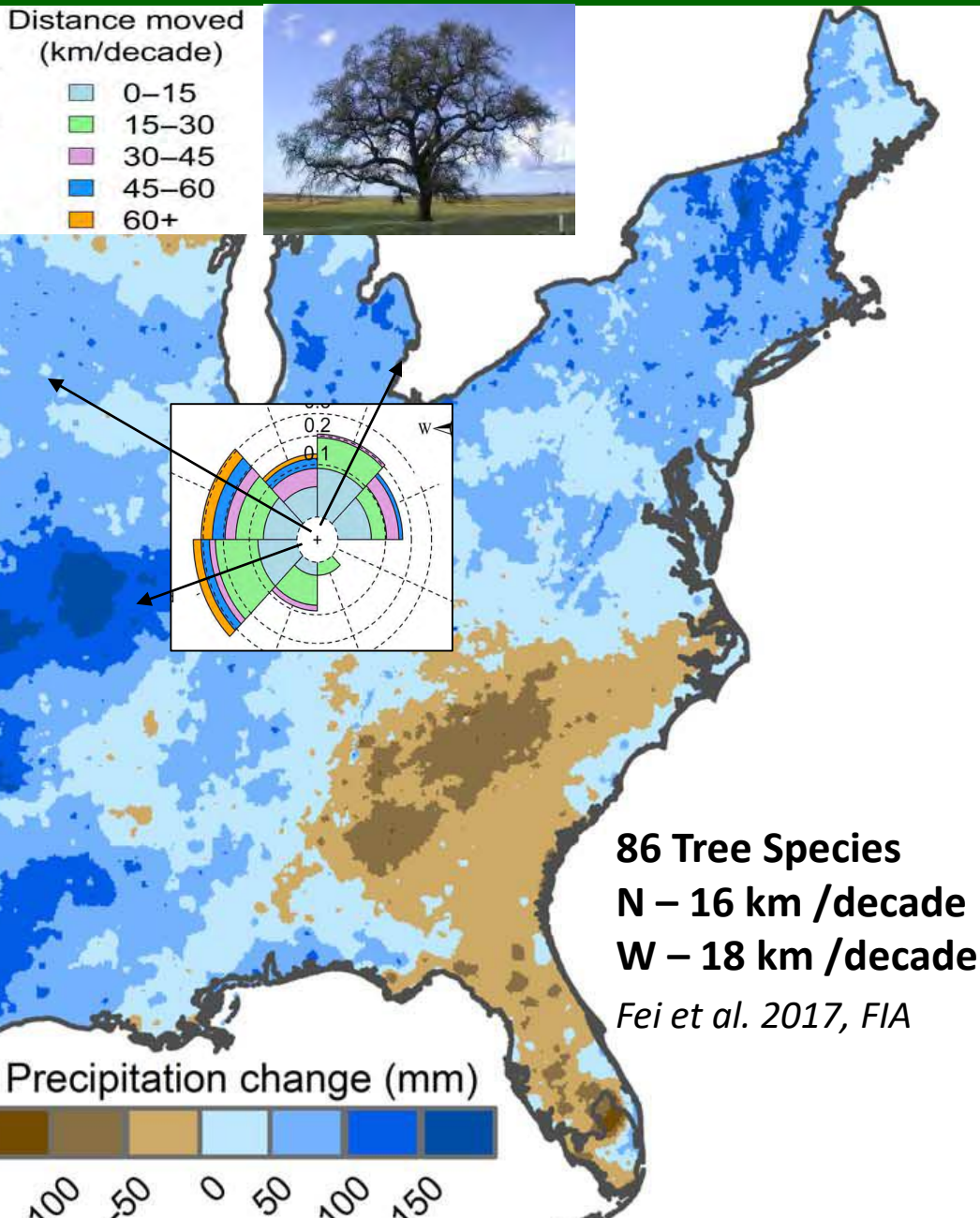
# Protect Land and Water Priority

TNC North America

**Conserve** a network of resilient sites and connecting corridors that will sustain North America's natural diversity by allowing species to adapt to climate impacts and thrive.

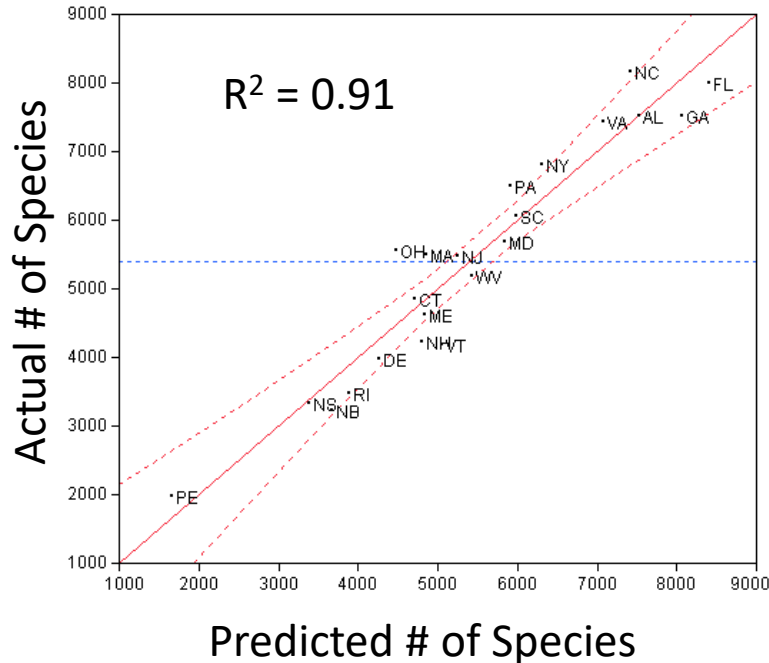
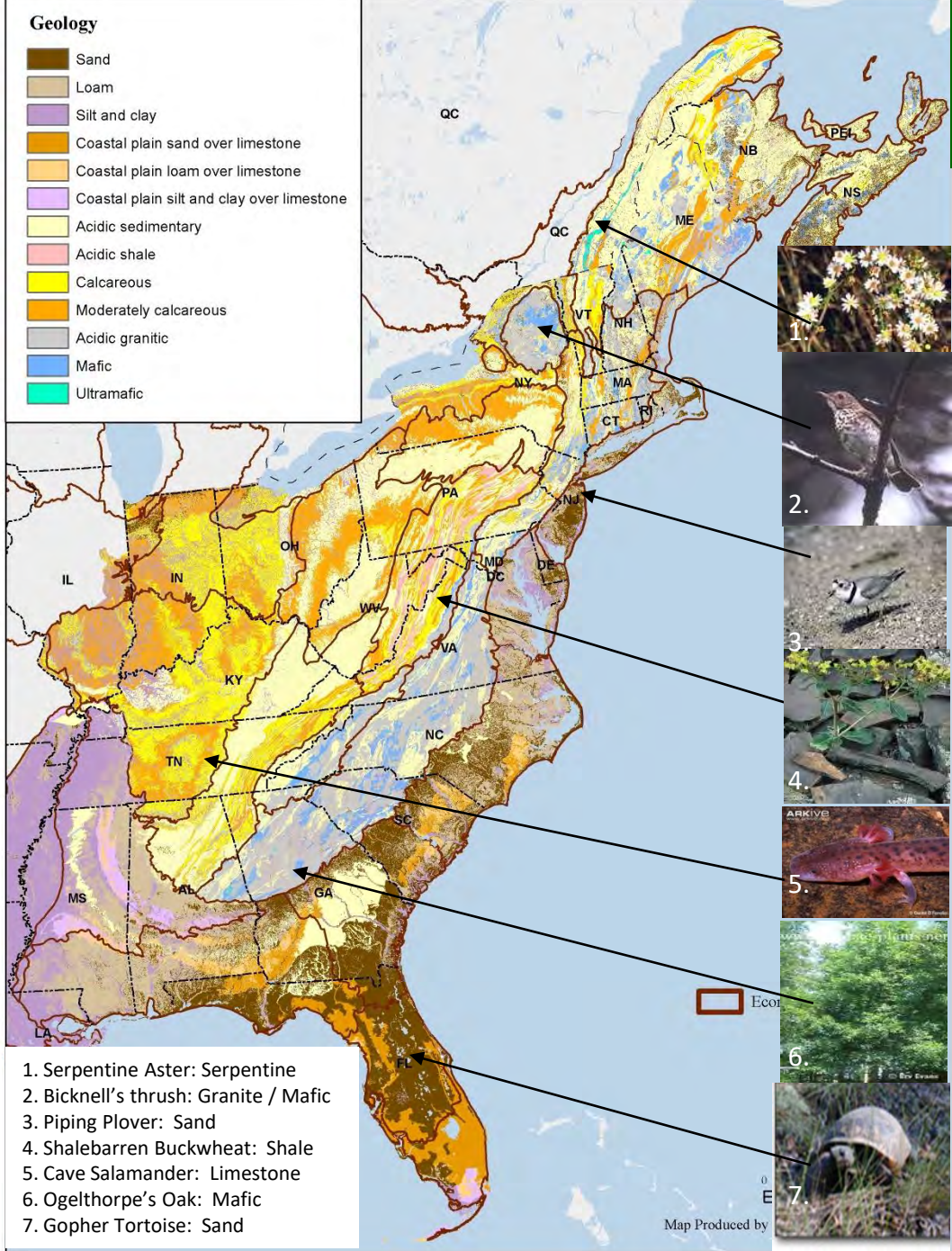


# Nature is Dynamic

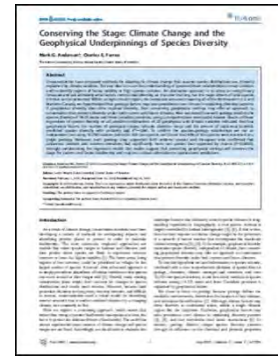


Median residence times range from **200-700 years** (overall **500 years**) and are shorter during times of warming *McGuire et al. in prep*

# Representation Conserving Nature's Stage



Biological diversity is highly correlated with **Ecoregions and Land Properties (Geology, Soil, Topography)**



# Site Resilience

**Resilient sites** = sites that continue to support biological diversity, productivity and ecological function even as they change in response to climate change.

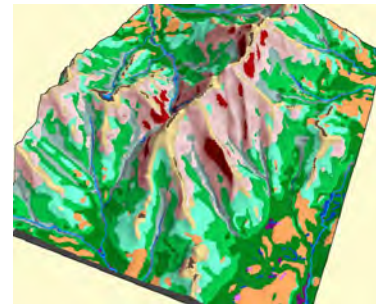
Choose among options based on:

**Many  
Microclimates**

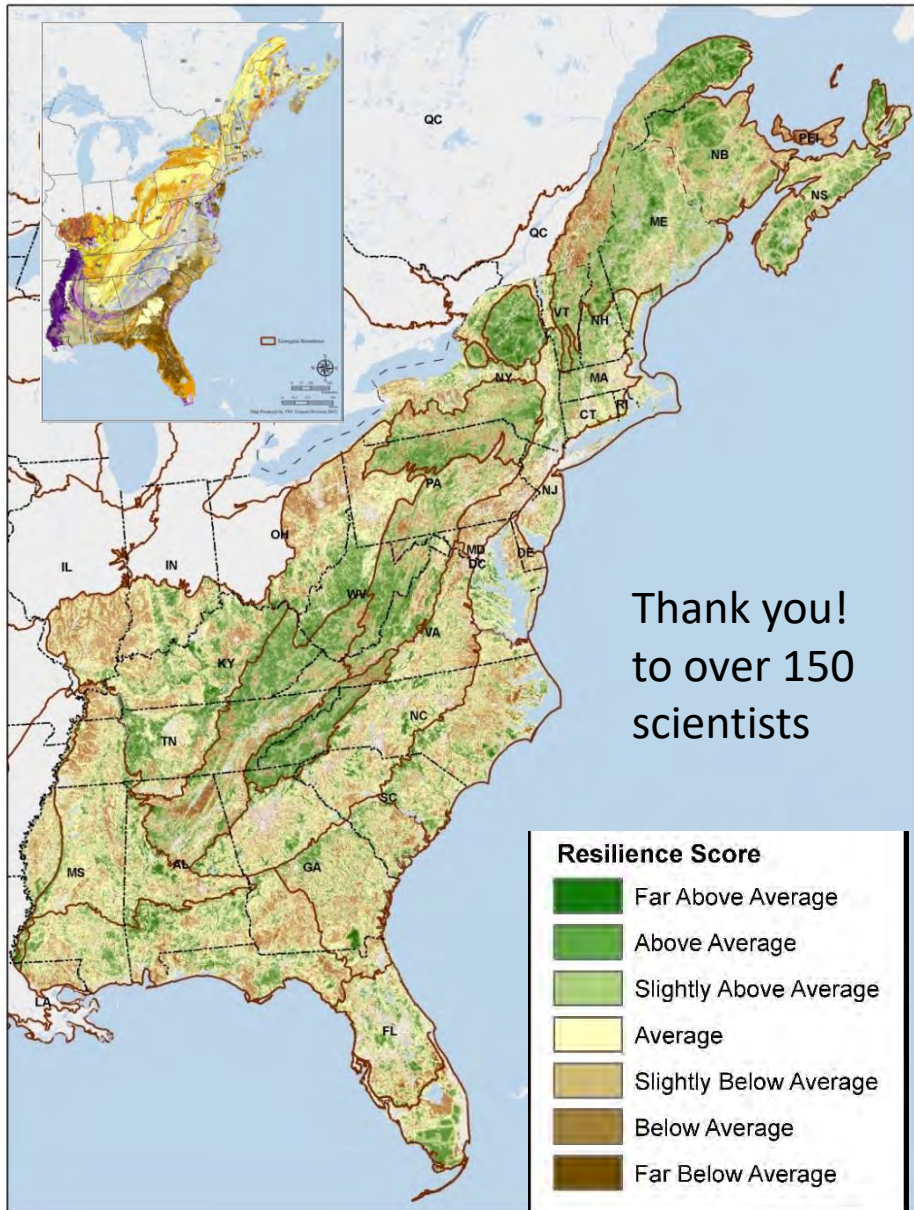
Create climate options

**Locally  
Connected**

Allows species to move



Thank you!  
to over 150  
scientists

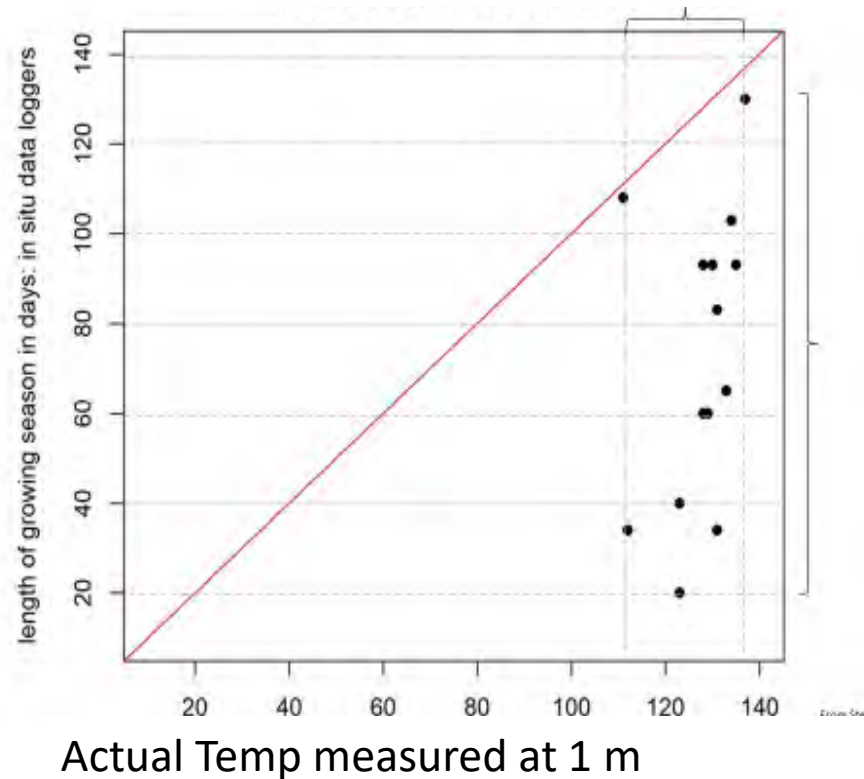


# Resilience / Microclimates

Topography and Moisture create Species-relevant Microclimates



Temp from 4 km Climate Model

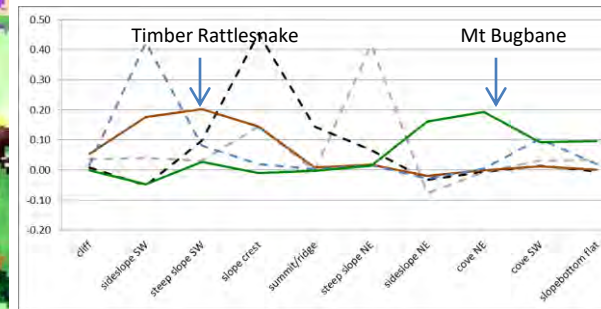
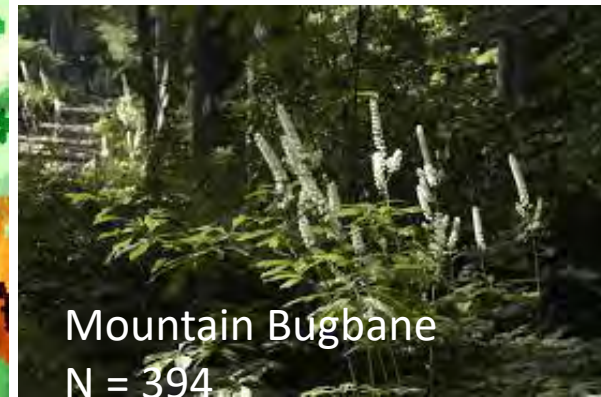
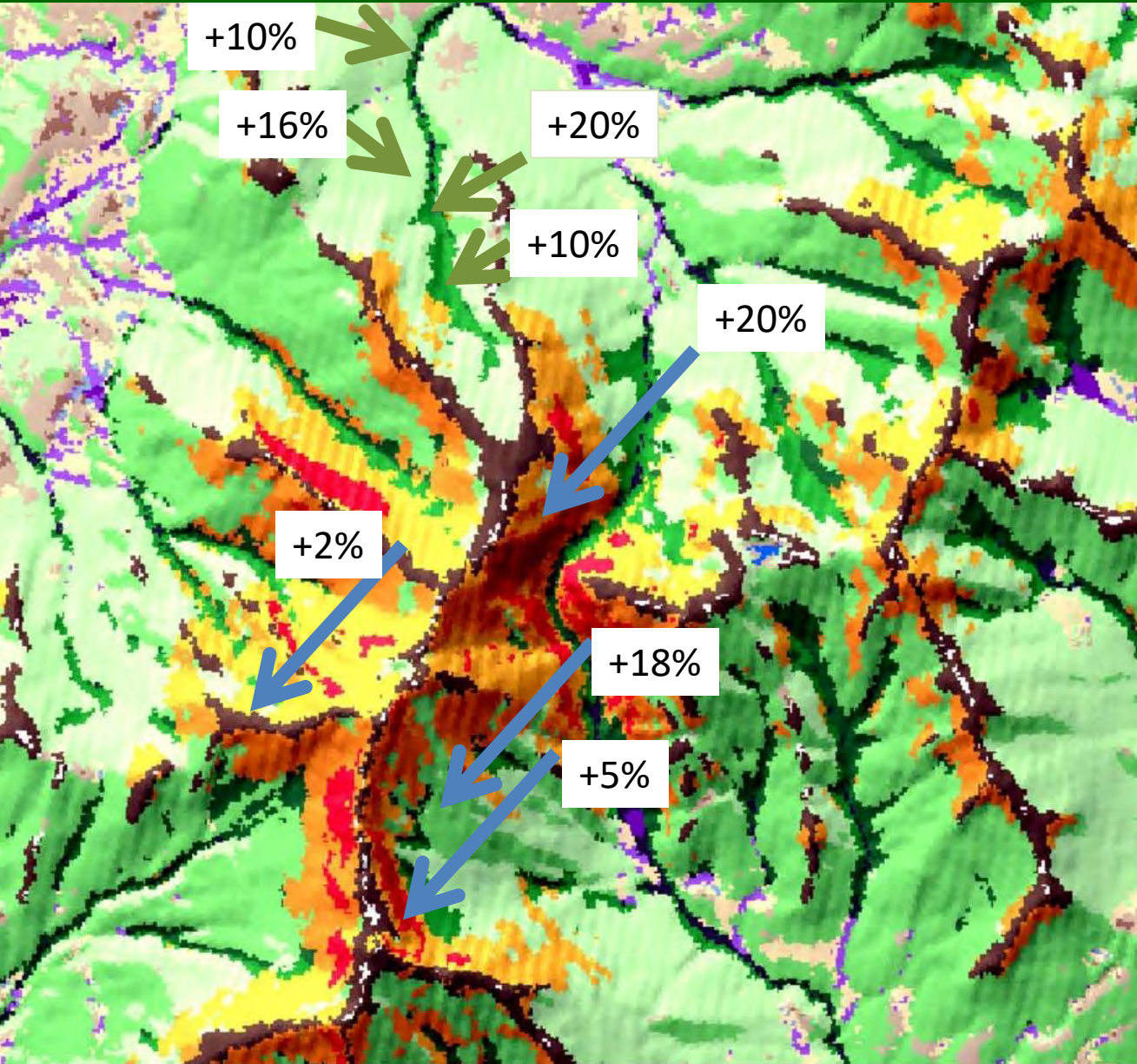


N=178

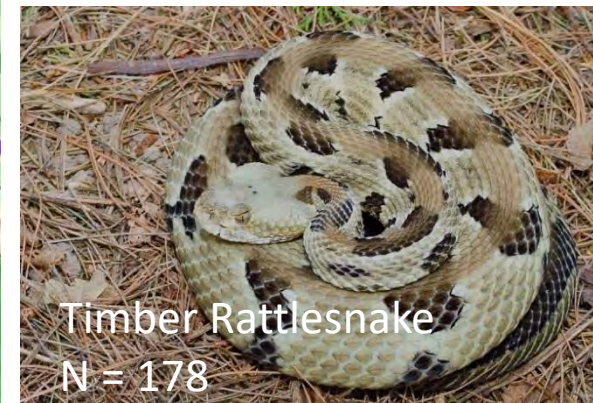
*Langdon in prep 2018.  
(PRISM 4 km gridded data) and temperatures  
measured at 1 m above the ground in peatlands in the  
Adirondacks*

# Species Relevant Micro-Climates

%AE – Percent Above Expected based on known locations in Northeast

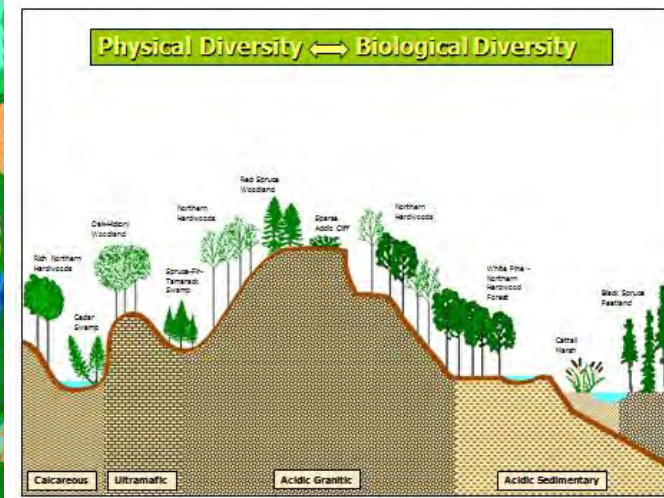
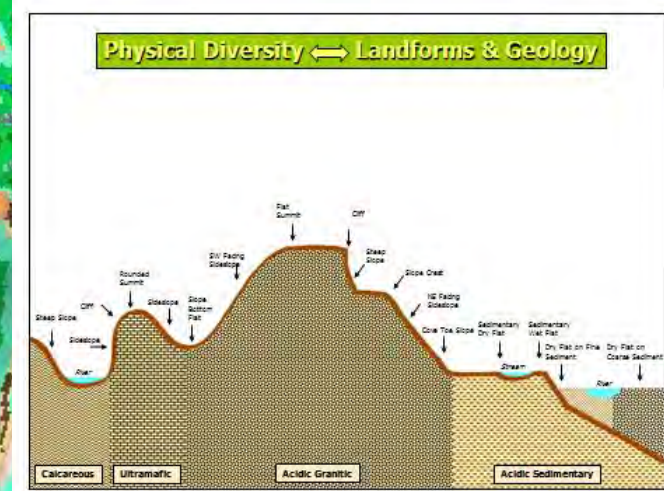
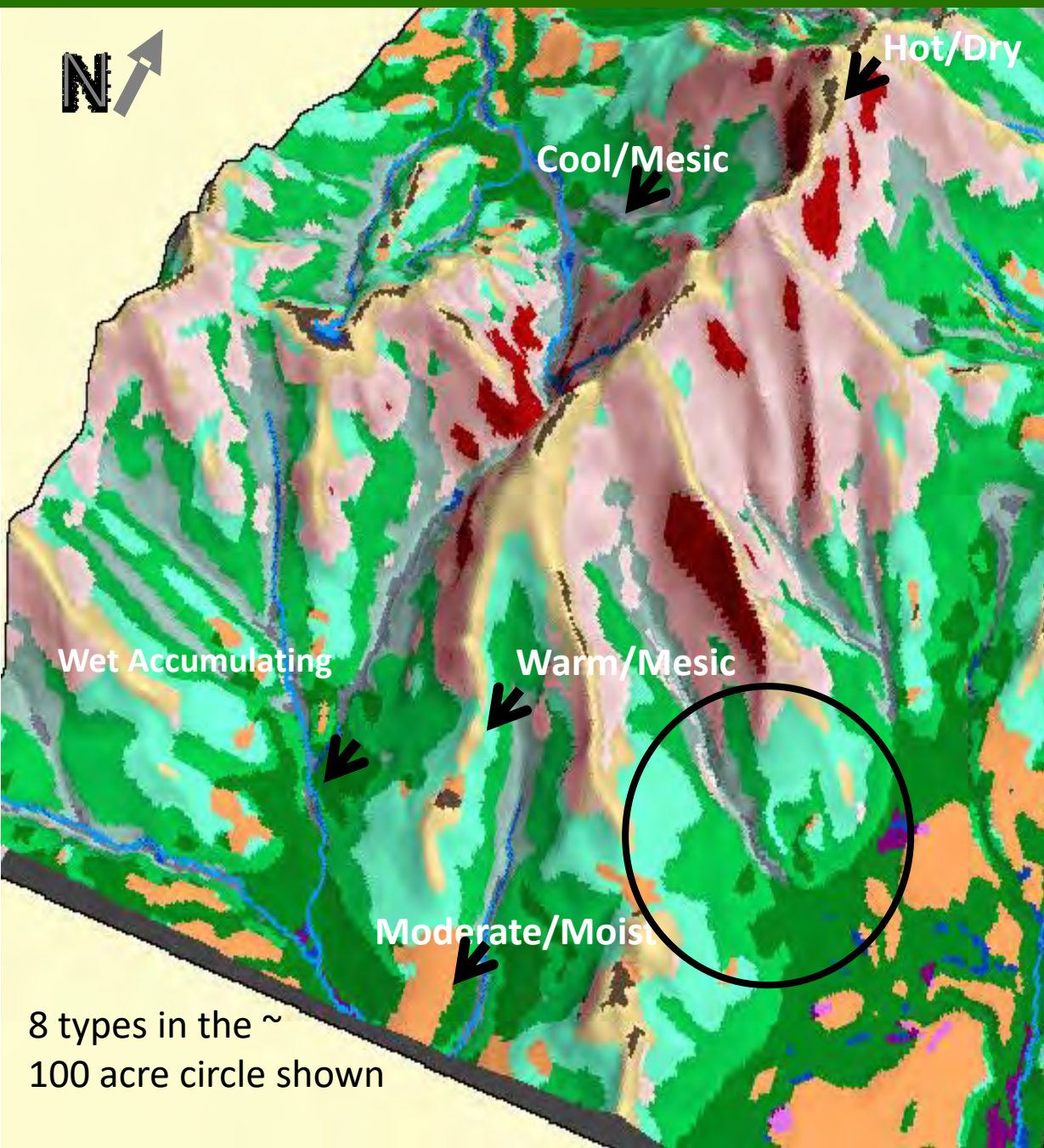


Thank You NHP!



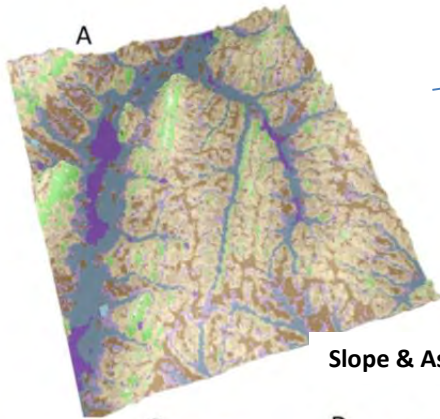
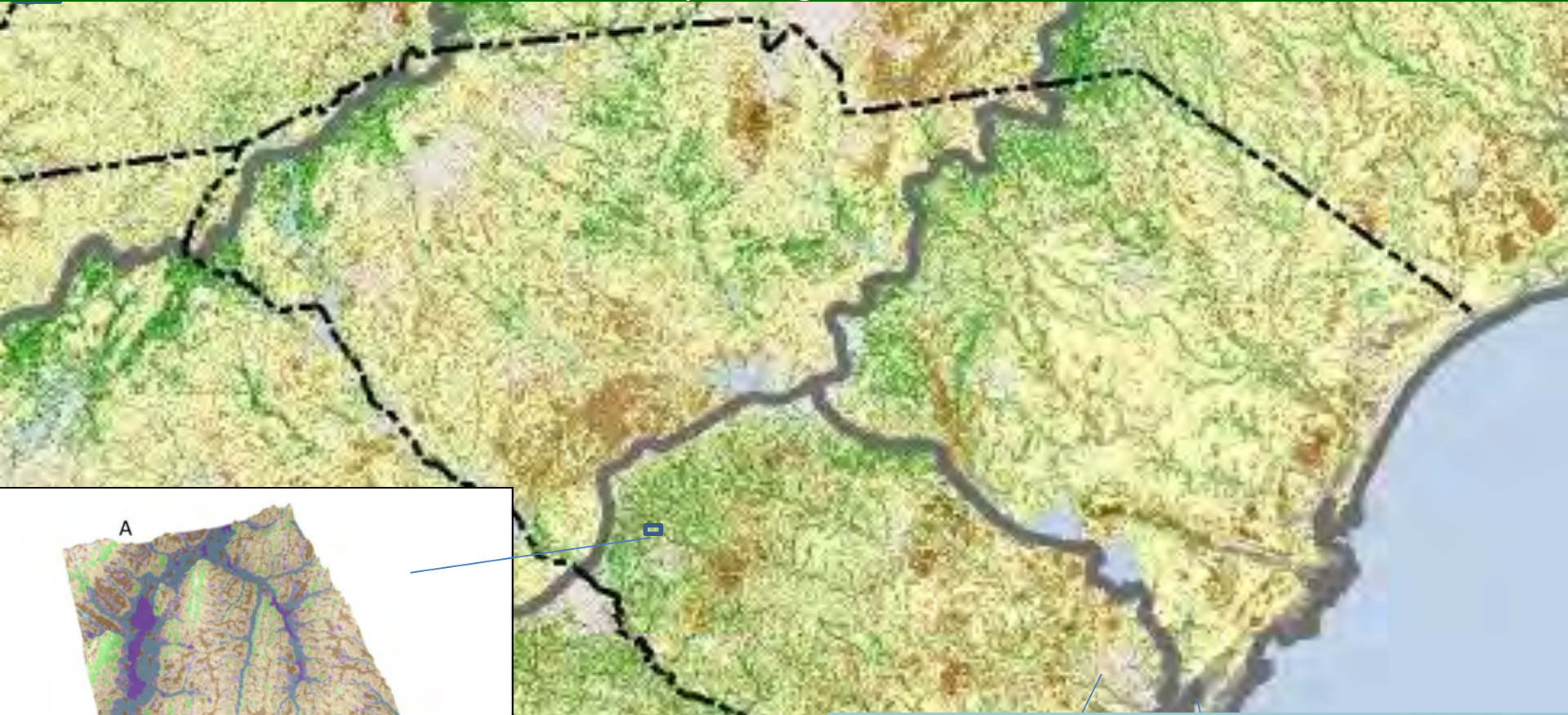


# Estimating Microclimates: 11 topo-climatic environments



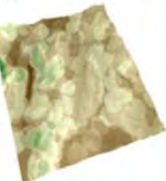
# Landscape Diversity – Microclimates

By Ecoregion



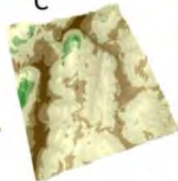
Slope & Aspect

B



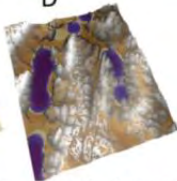
Landform Variety

C



Elevation Range

D



Wetland Density

nature  
climate change

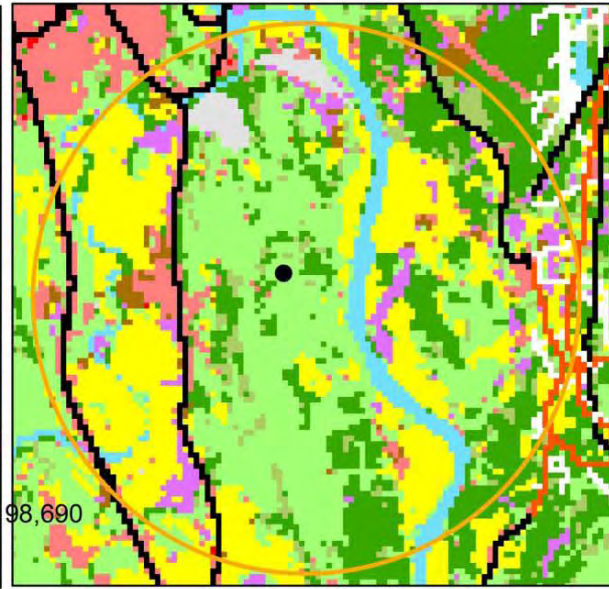
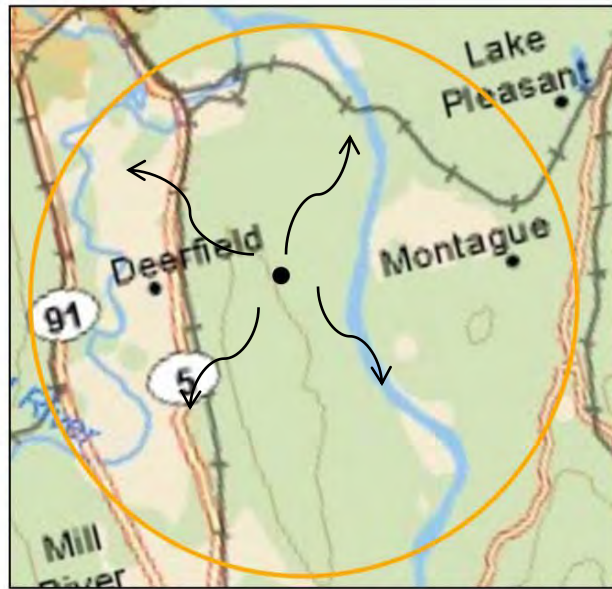
LETTERS

<https://doi.org/10.1038/s41558-018-0231-9>

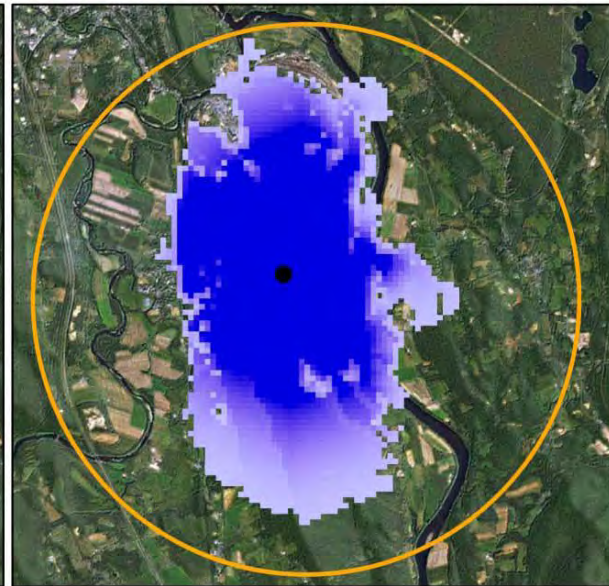
## Extinction risk from climate change is reduced by microclimatic buffering

Andrew J. Suggitt<sup>1,2\*</sup>, Robert J. Wilson<sup>3\*</sup>, Nick J. B. Isaac<sup>4</sup>, Colin M. Beale<sup>5,2</sup>, Alistair G. Auffret<sup>5,6</sup>, Tom August<sup>4</sup>, Jonathan J. Bennie<sup>1</sup>, Humphrey Q. P. Crick<sup>7</sup>, Simon Duffield<sup>7</sup>, Richard Fox<sup>8</sup>, John J. Hopkins<sup>1</sup>, Nicholas A. Macgregor<sup>7,9</sup>, Mike D. Morecroft<sup>7</sup>, Kevin J. Walker<sup>10</sup> and Ilya M. D. Maclean<sup>1\*</sup> 5 million, 430 sp

# Local Connectedness



**Highly Permeable** areas offer many options and alternatives for movement and reorganization



We used a resistant kernel model based on weights assigned to roads, development and agriculture



**Category** **Weight**

**Developed**

- Low intensity 8
- Mid intensity 9
- High intensity 20
- Mine 9

**Roads/Linear**

- Major 20
- Minor 10
- Unpaved +1
- Transmission 9
- Pipelines 9
- Railroads 9

**Agriculture**

- Corn/Soy 9
- Other Ag 7
- Hay Pasture 3
- Forestry (indust.) 4

**Energy**

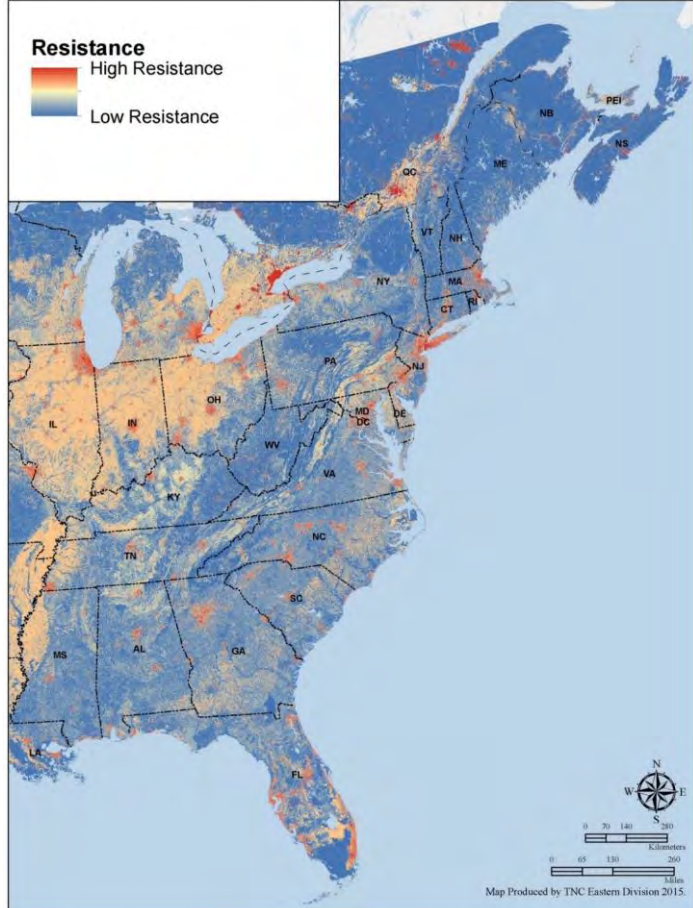
- Oil & Gas 7+
- Wind +1

**Local Connectedness**

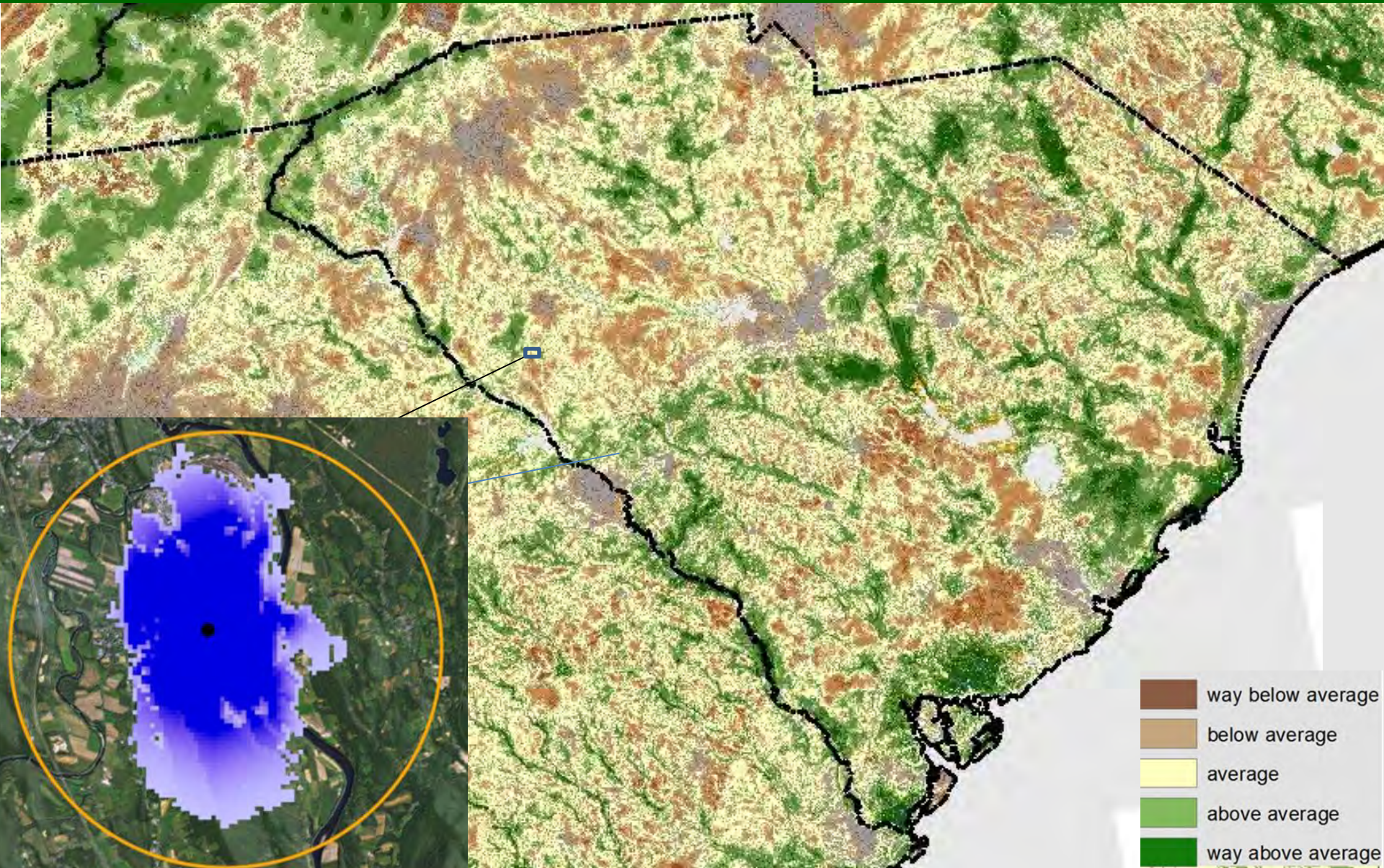
**Resistance Grid**



- Natural** **Weight**
- All Vegetation Types 1
  - Barrens 1
  - Water (by size) 1-3\*



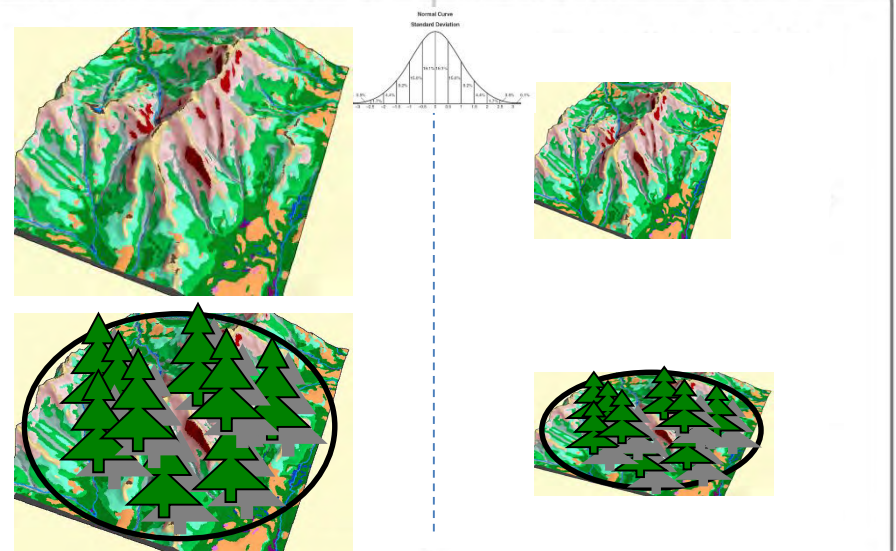
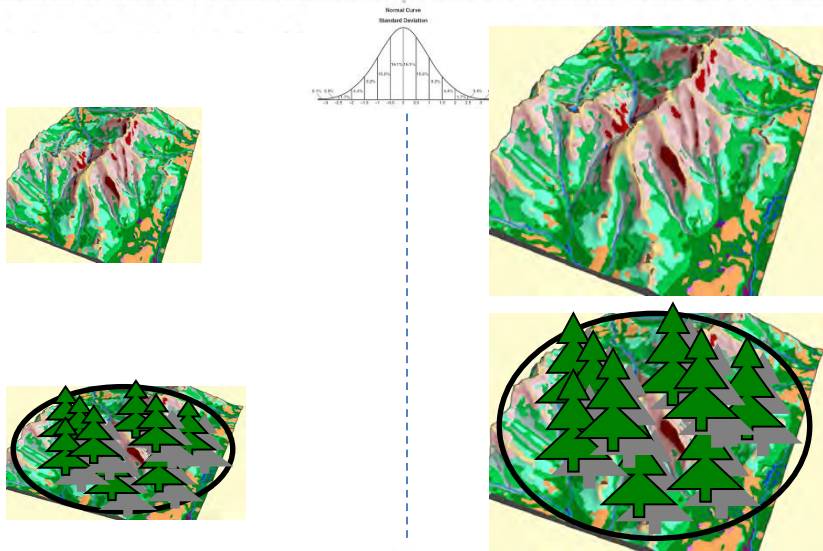
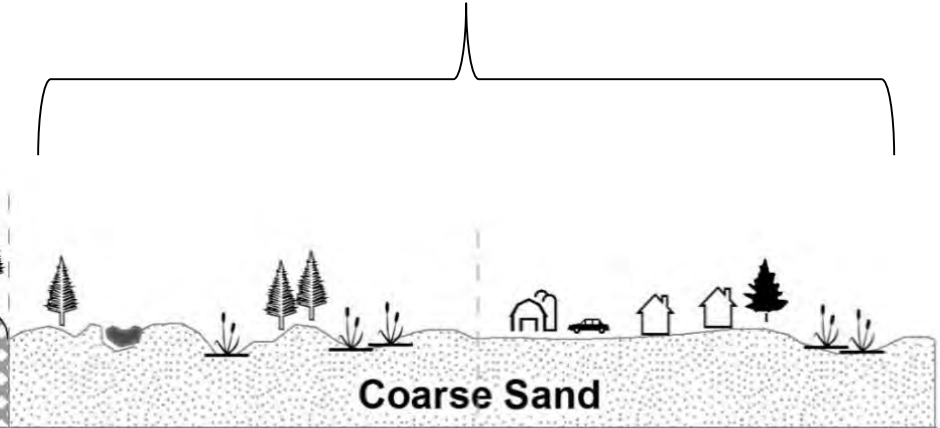
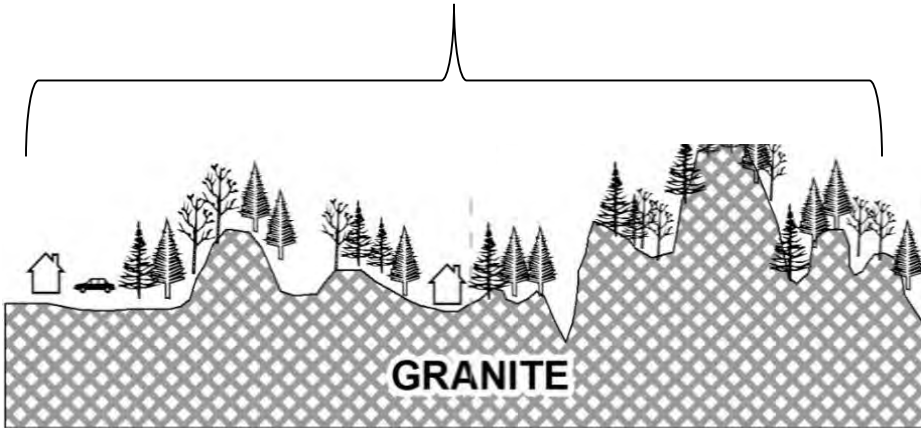
# Local Connectedness (by ecoregion)



# Climatic Species Pool

Granite to Granite

Sand to Sand



richness many species

# Representation & Resilience

About 33% of each Geophysical Environment in each Ecoregion



Mafic



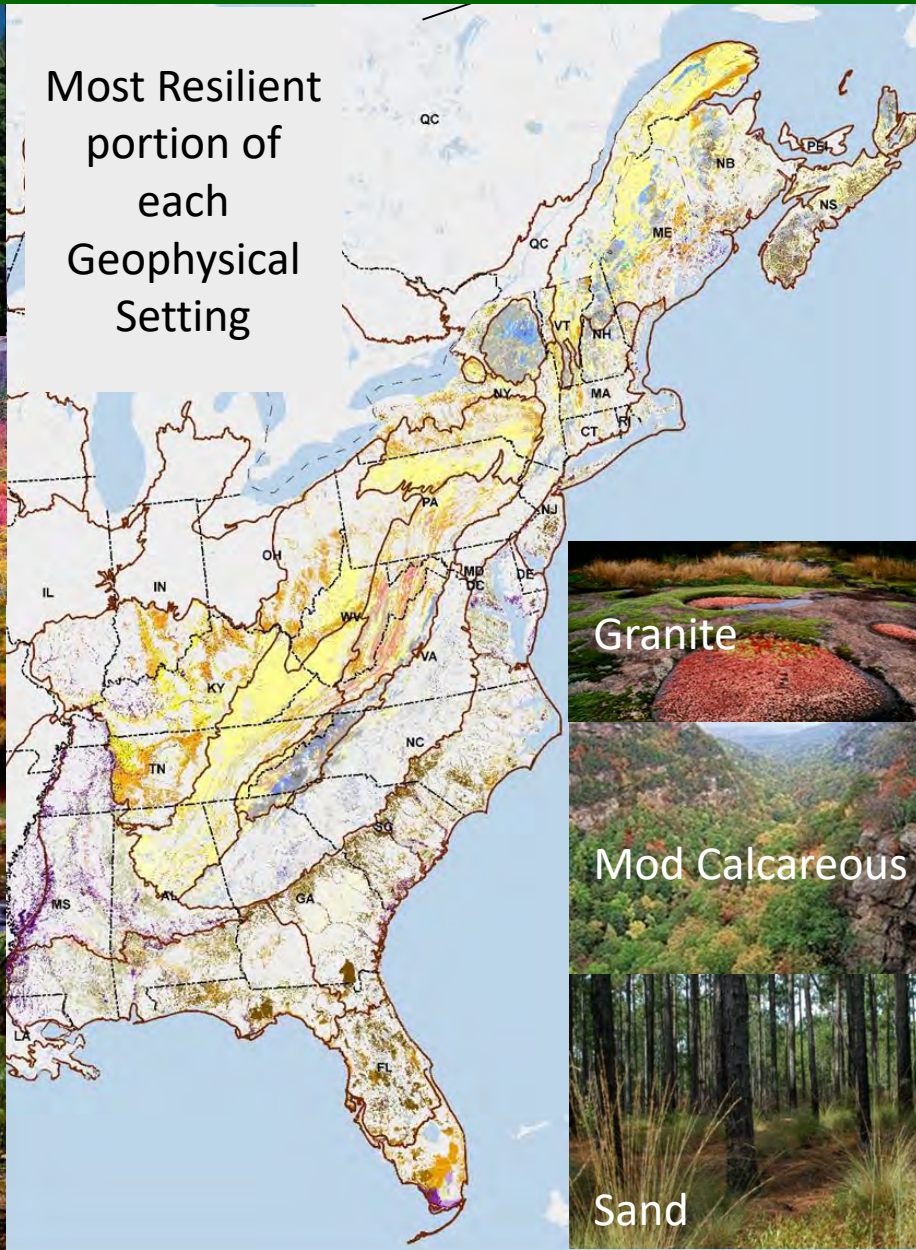
Calcareous



Mod Calc



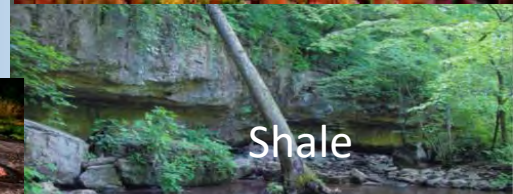
Sand



Granitic



Sedimentary



Shale



Granite



Mod Calcareous



Sedimentary



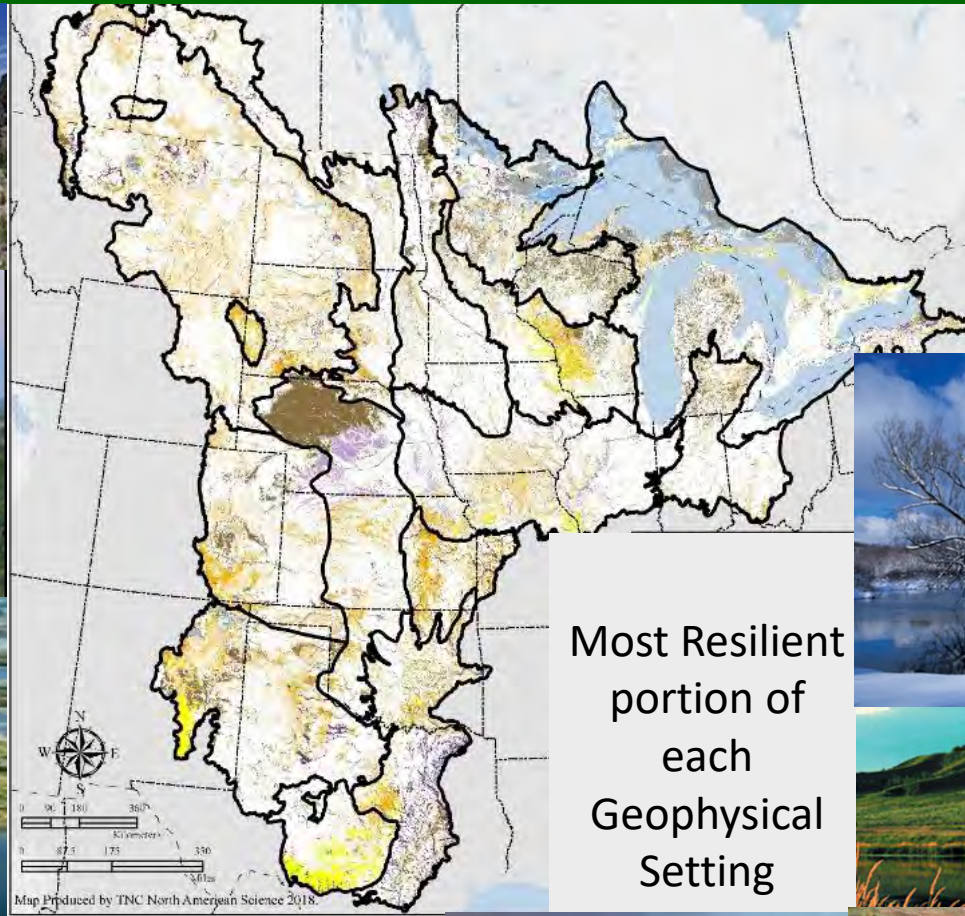
Sand



Silt

# Representation & Resilience

About 33% of each Geophysical Environment in each Ecoregion





# Resilient Land Map

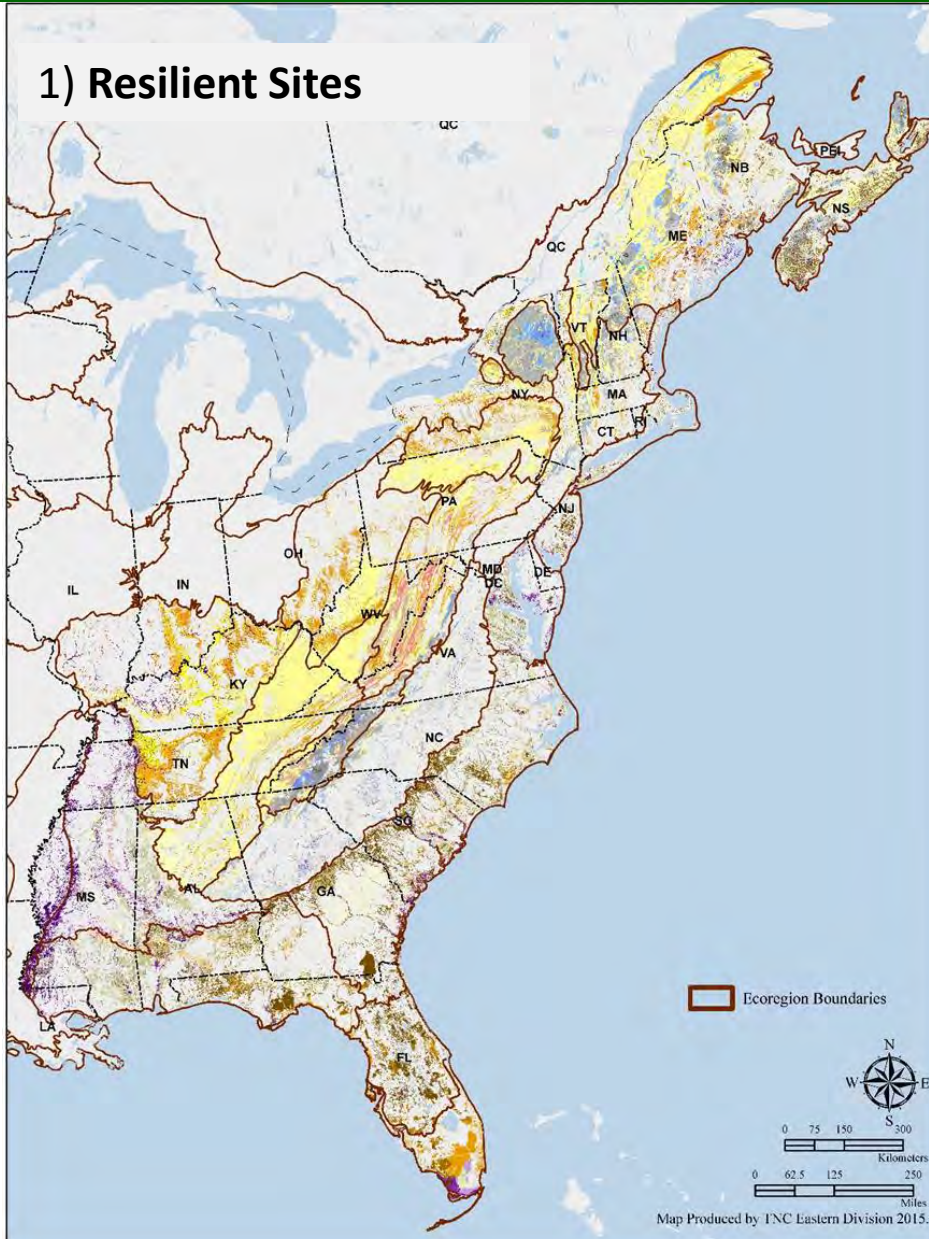
10 years, Over 120 Scientists and Planners, Slated to be completed by July 2019



# Creating a Network

Connectivity for What?

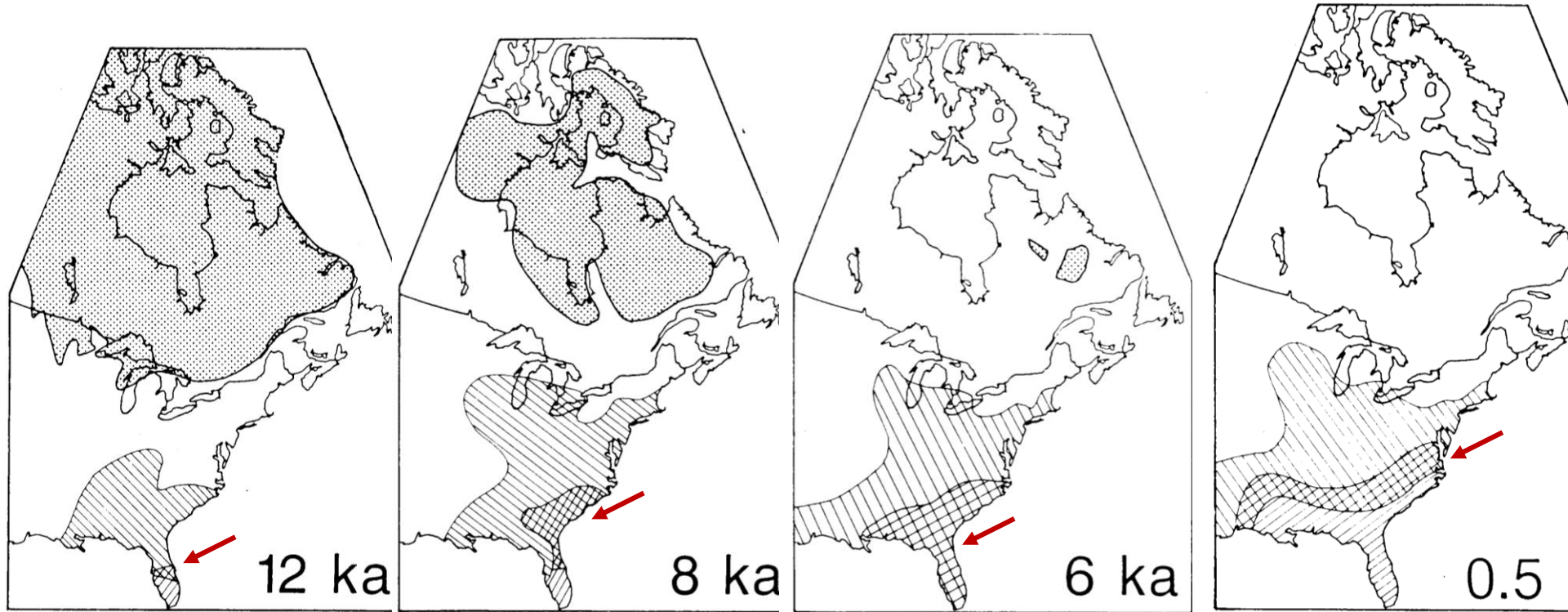
## 1) Resilient Sites



## 2) A Resilient and Connected Network of Sites to sustain diversity



# Range Shifts in Response to Climate

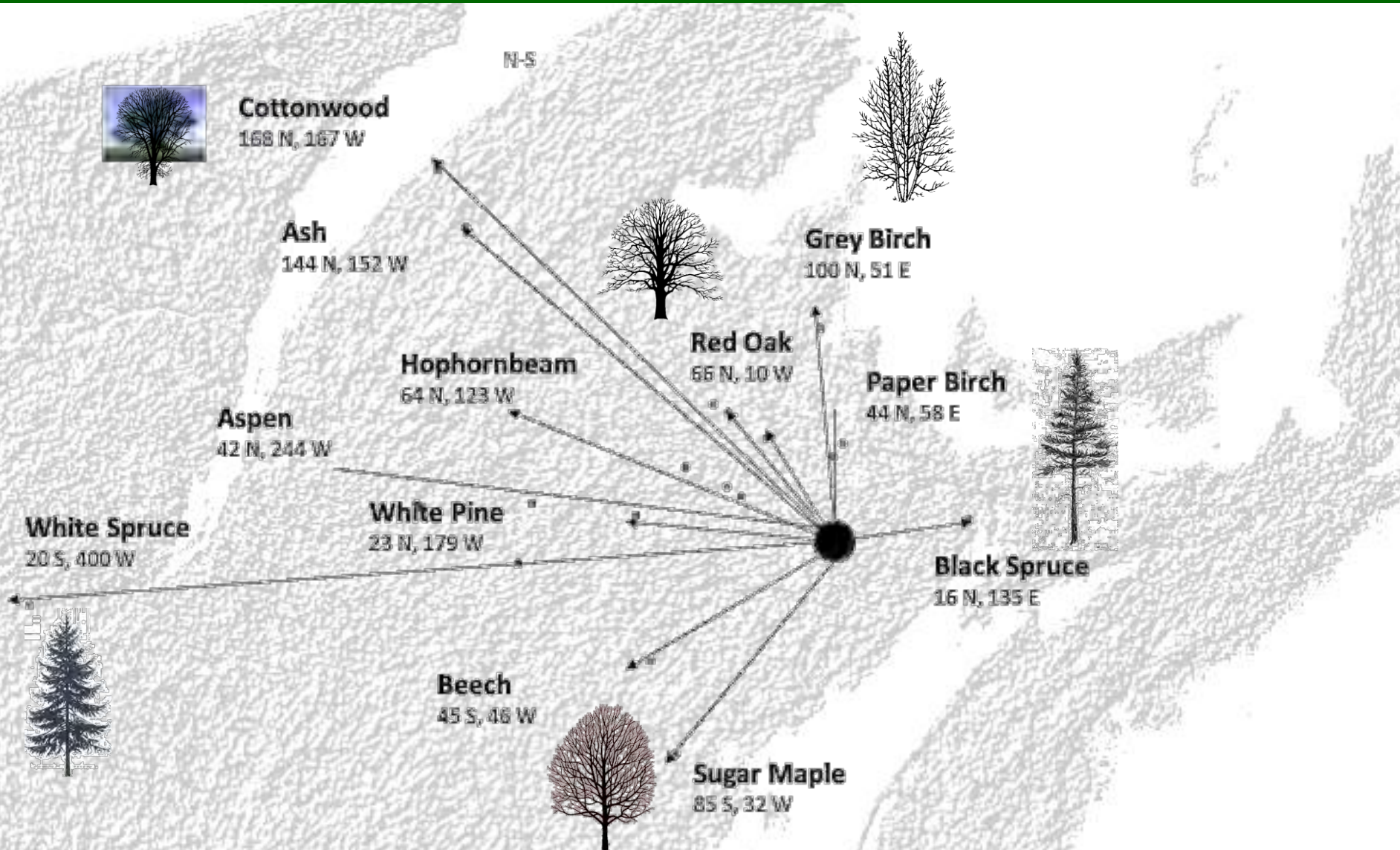


Southern Pine and Oak,  
(from Hunter et al 1988)

**Quaternary conundrum:** “during the recent ice ages surprisingly few species became extinct.” — Botkin et al. 2009

# Tree Range Shifts over 40 Years

US results superimposed on Maritime Canada for Scale

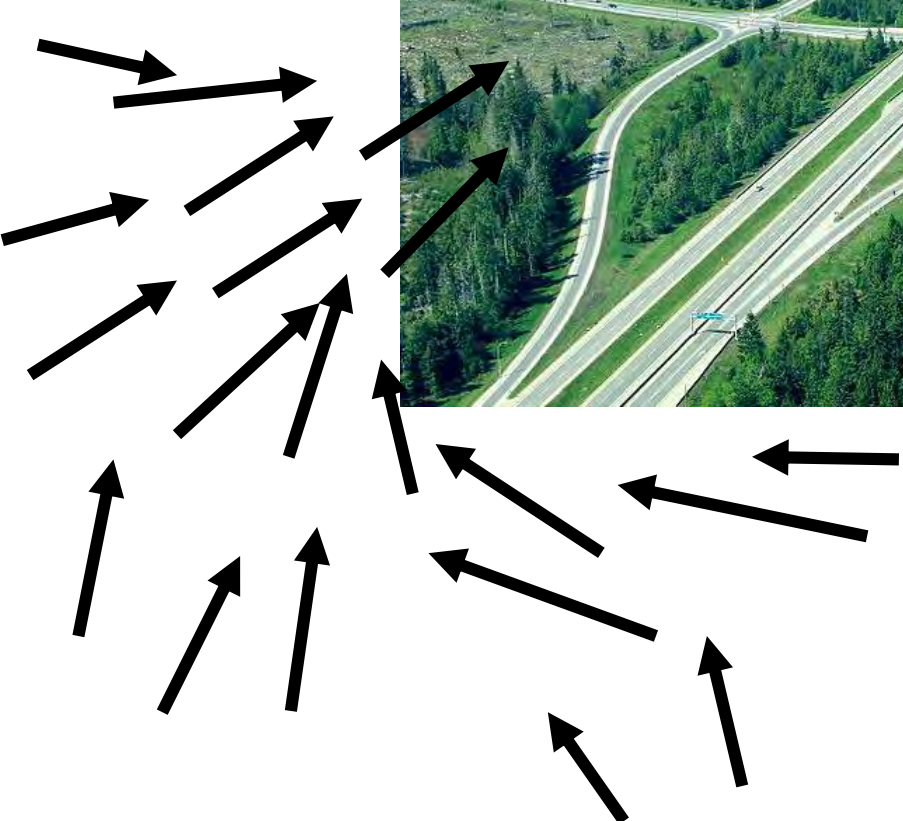




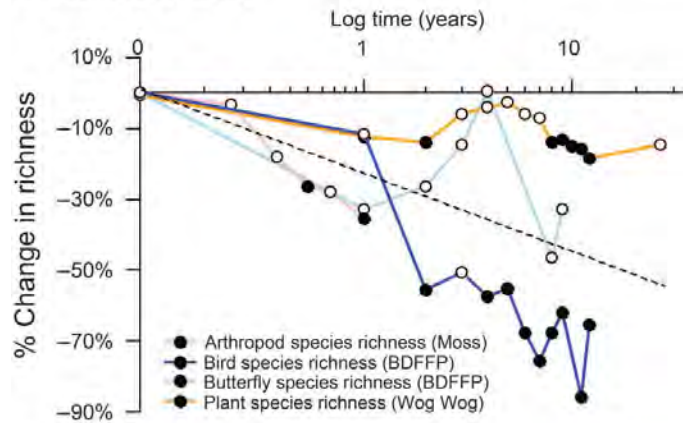
The Bad News  
Not the same landscape



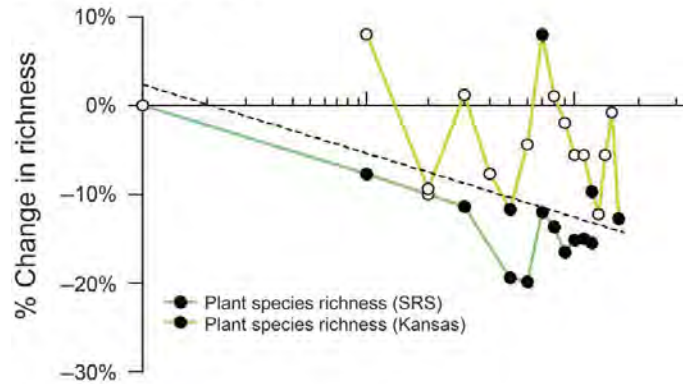
3 M miles road  
144 M people



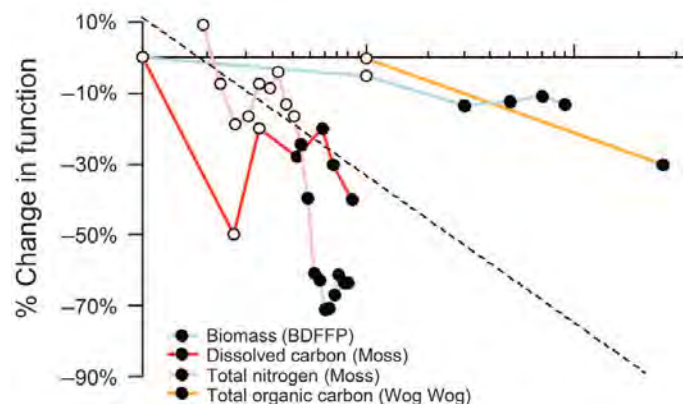
### A Extinction debt



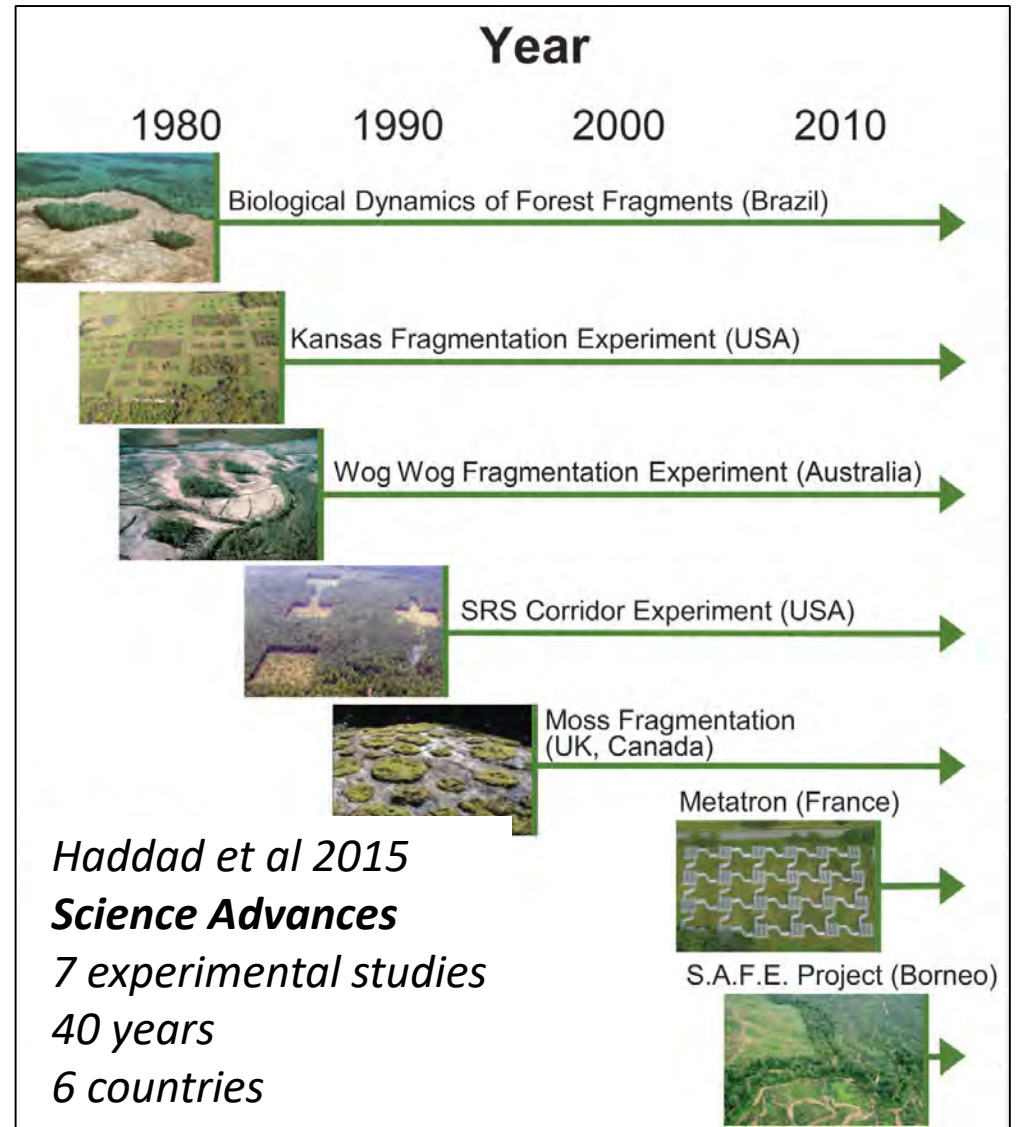
### B Immigration lag



### C Ecosystem function debt



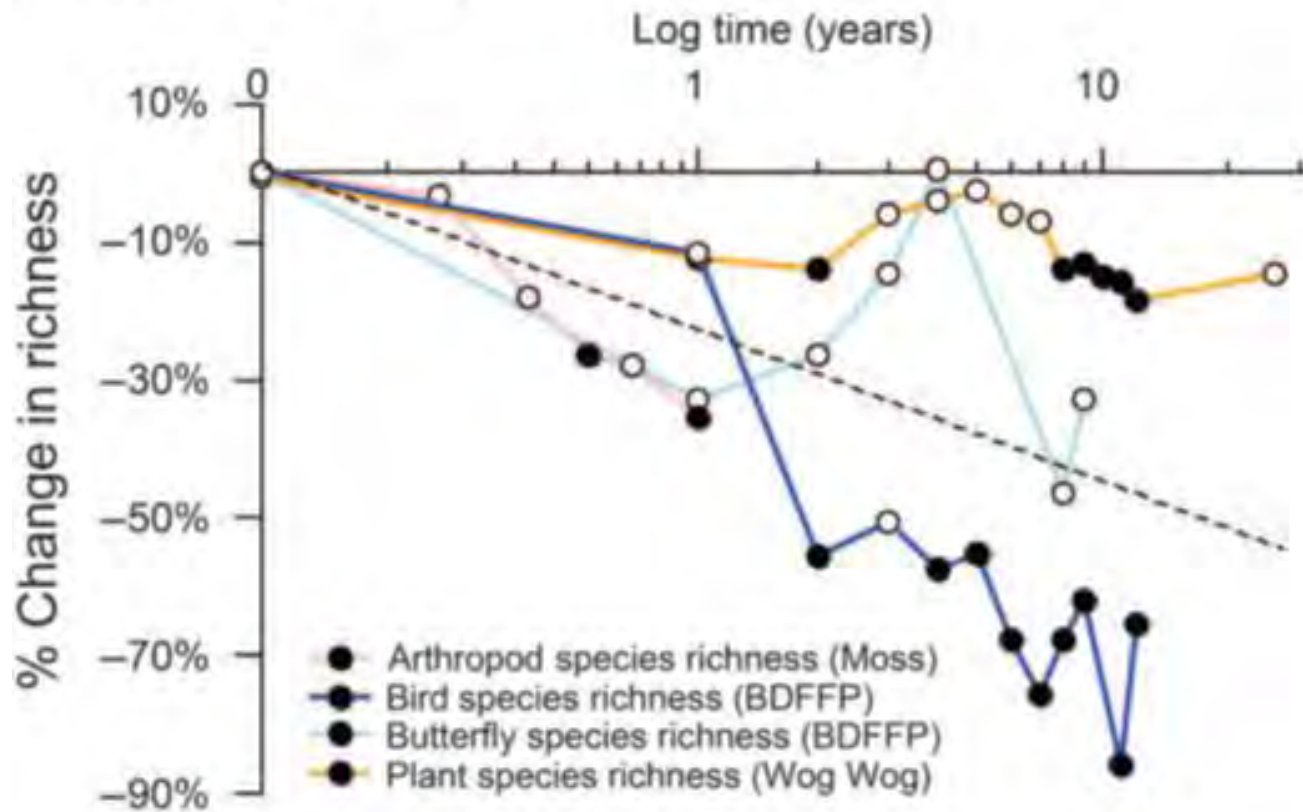
# Effects of Fragmentation Strong, Consistent, and Accumulating



# Species

Variation around the Decline

## A Extinction debt

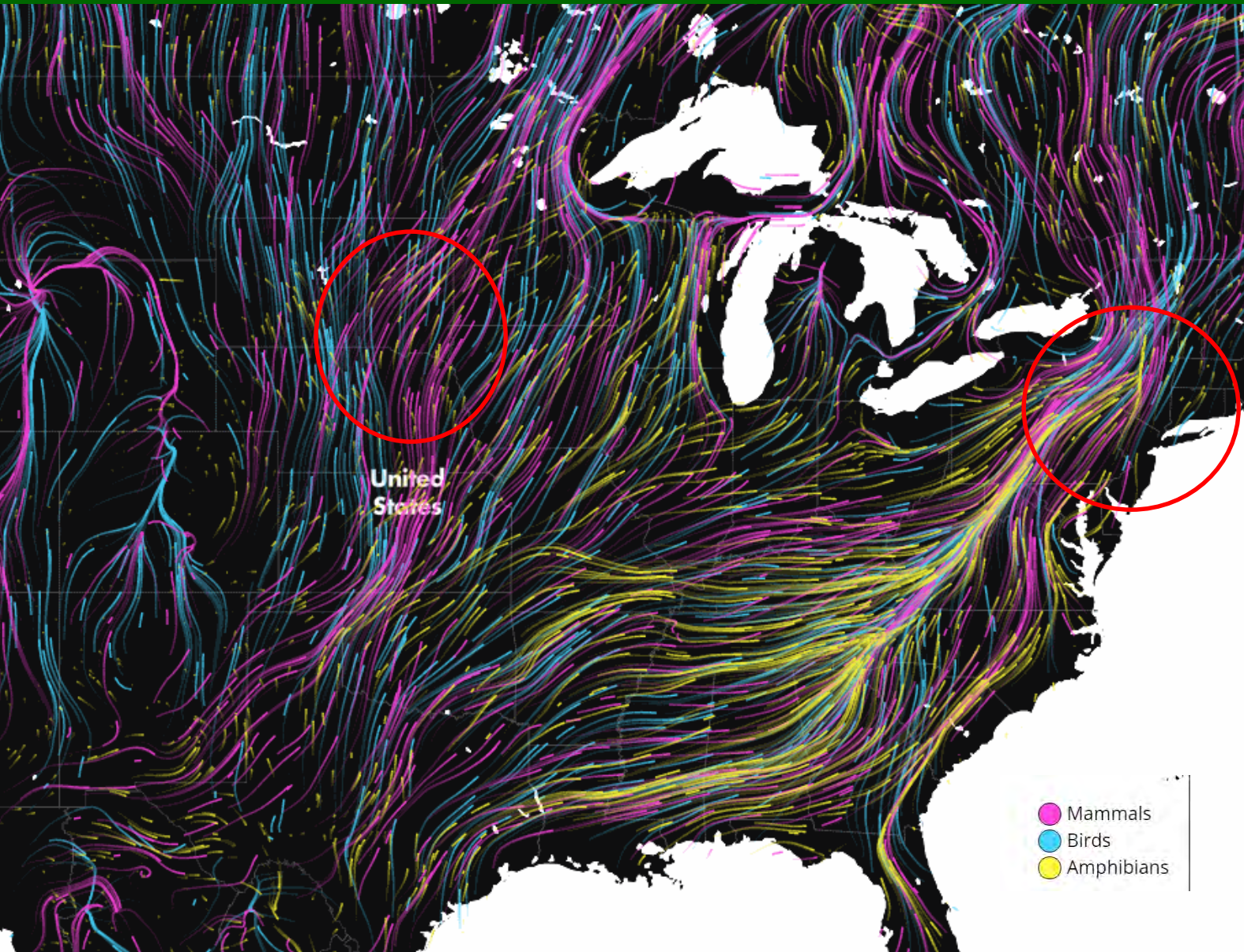


Reversibility



# Migrations in Motion

## Natural Flow Patterns



The gradual movement of populations across the landscape in response to climate change

**Current Rates**  
**11 mile per decade North**

**36 feet per decade Upslope**

Lawler et al 2015.

Animation thanks to Dan Majka

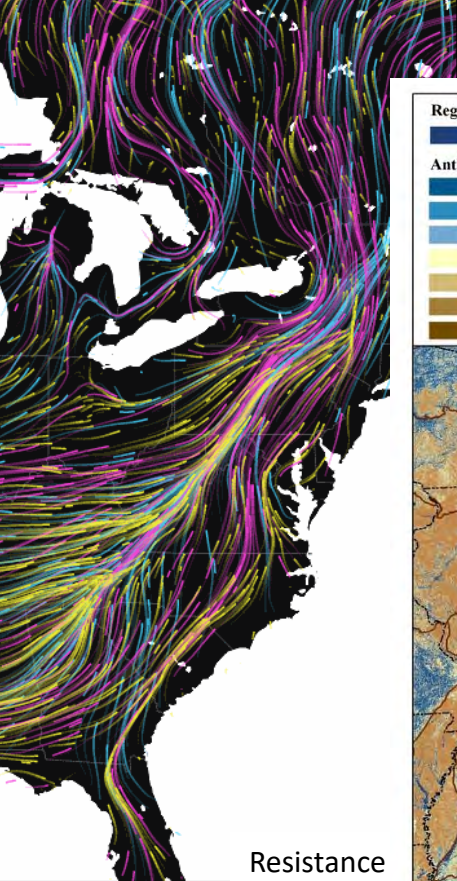


# Climate Flow

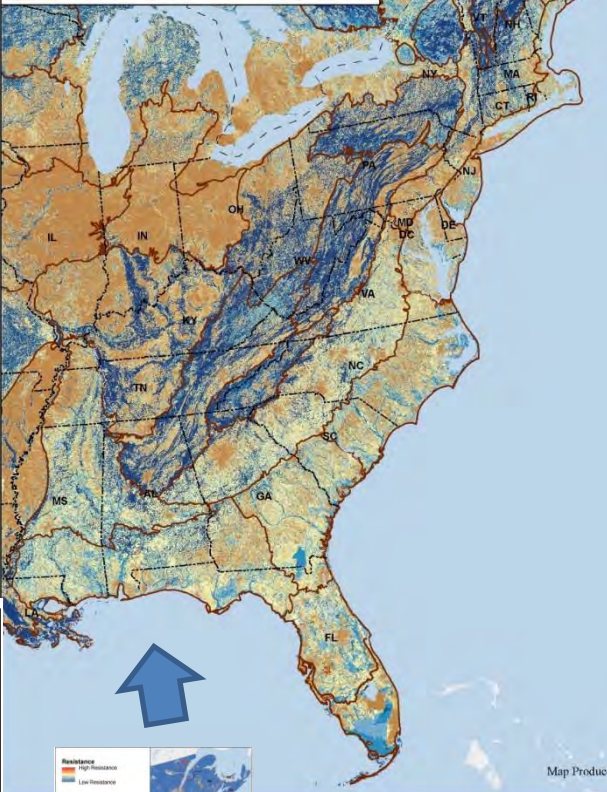
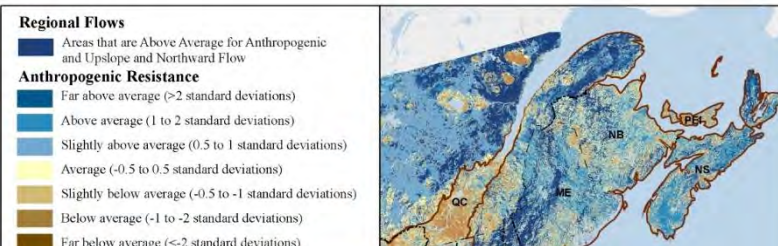
(wall to wall Circuitscape)



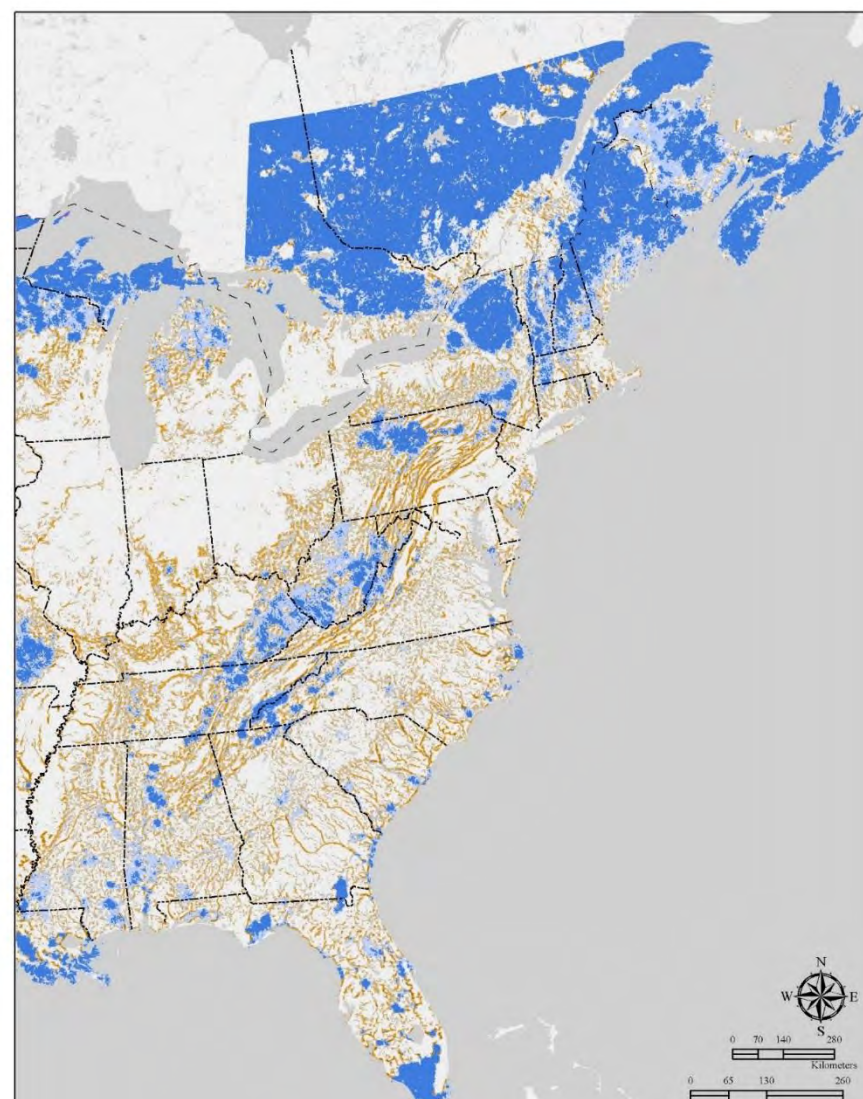
Thanks to  
Brad McRae



Resistance  
Grid



Based on same  
Resistance Grid as  
Local Connectedness



Category	Weight
<b>Developed</b>	
-Low intensity	8
-Mid intensity	9
-High intensity	20
-Mine	9
<b>Roads/Linear</b>	
-Major	20
-Minor	10
-Unpaved	+1
-Transmission	9
-Pipelines	9
-Railroads	9
<b>Agriculture</b>	
-Corn/Soy	9
-Other Ag	7
-Hay Pasture	3
-Forestry (indust.)	4
<b>Energy</b>	
-Oil & Gas	7+
-Wind	+1

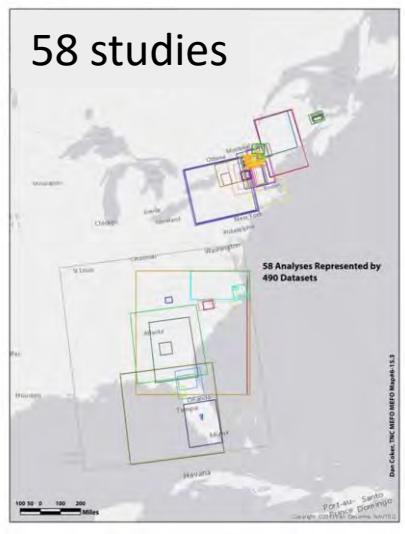
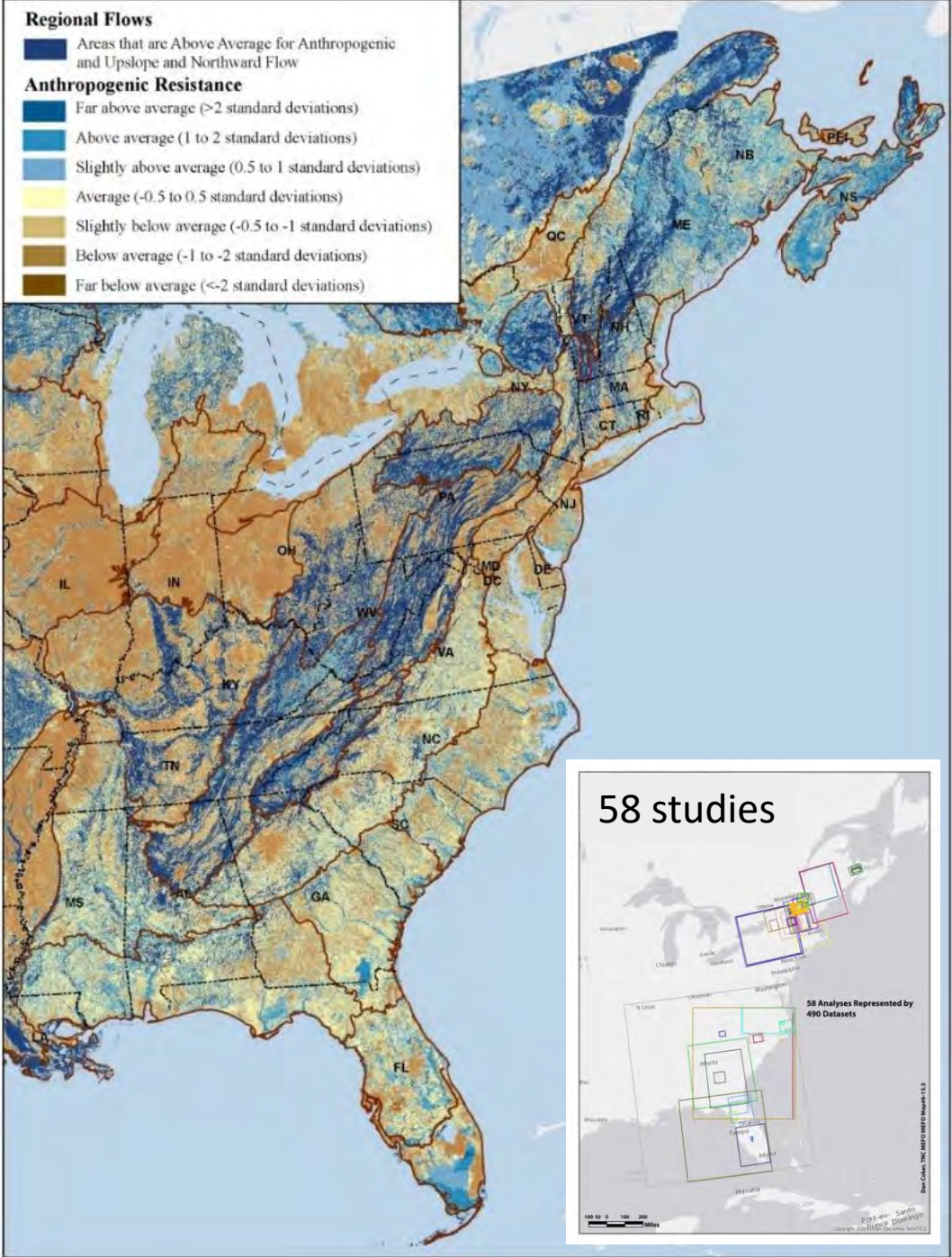


### Regional Flows

Areas that are Above Average for Anthropogenic and Upslope and Northward Flow

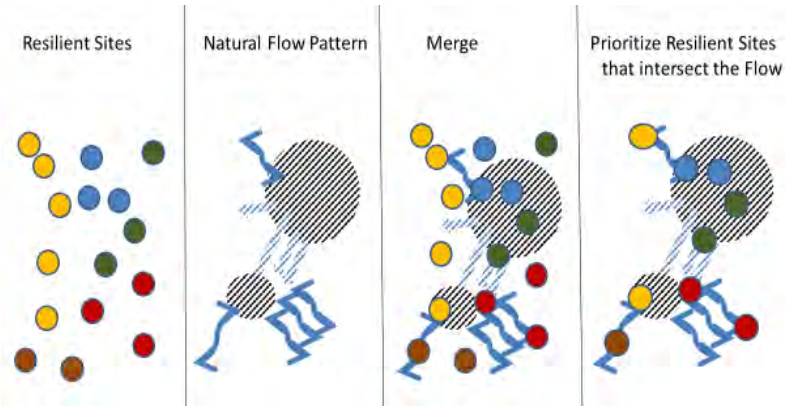
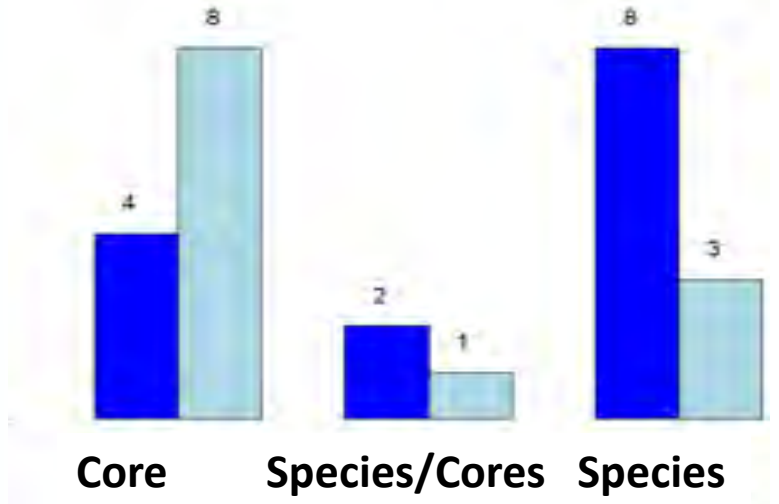
### Anthropogenic Resistance

- Far above average (>2 standard deviations)
- Above average (1 to 2 standard deviations)
- Slightly above average (0.5 to 1 standard deviations)
- Average (-0.5 to 0.5 standard deviations)
- Slightly below average (-0.5 to -1 standard deviations)
- Below average (-1 to -2 standard deviations)
- Far below average (<-2 standard deviations)

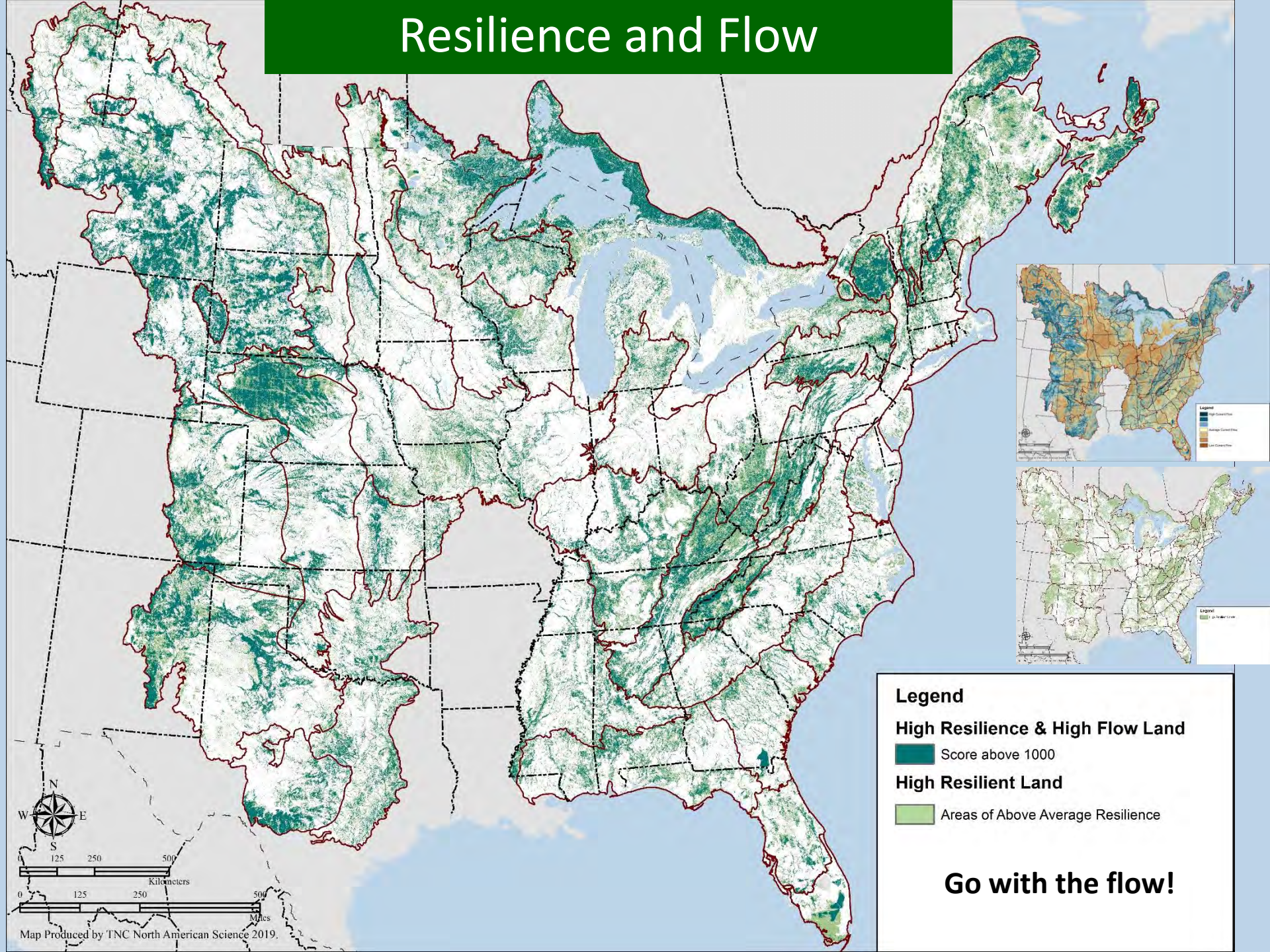


# Testing the Flow Data

- Good Agreement
- Moderate Agreement

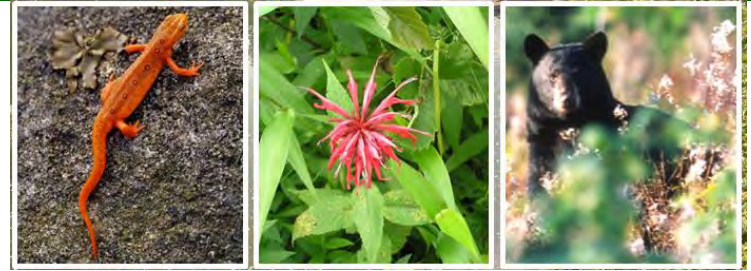
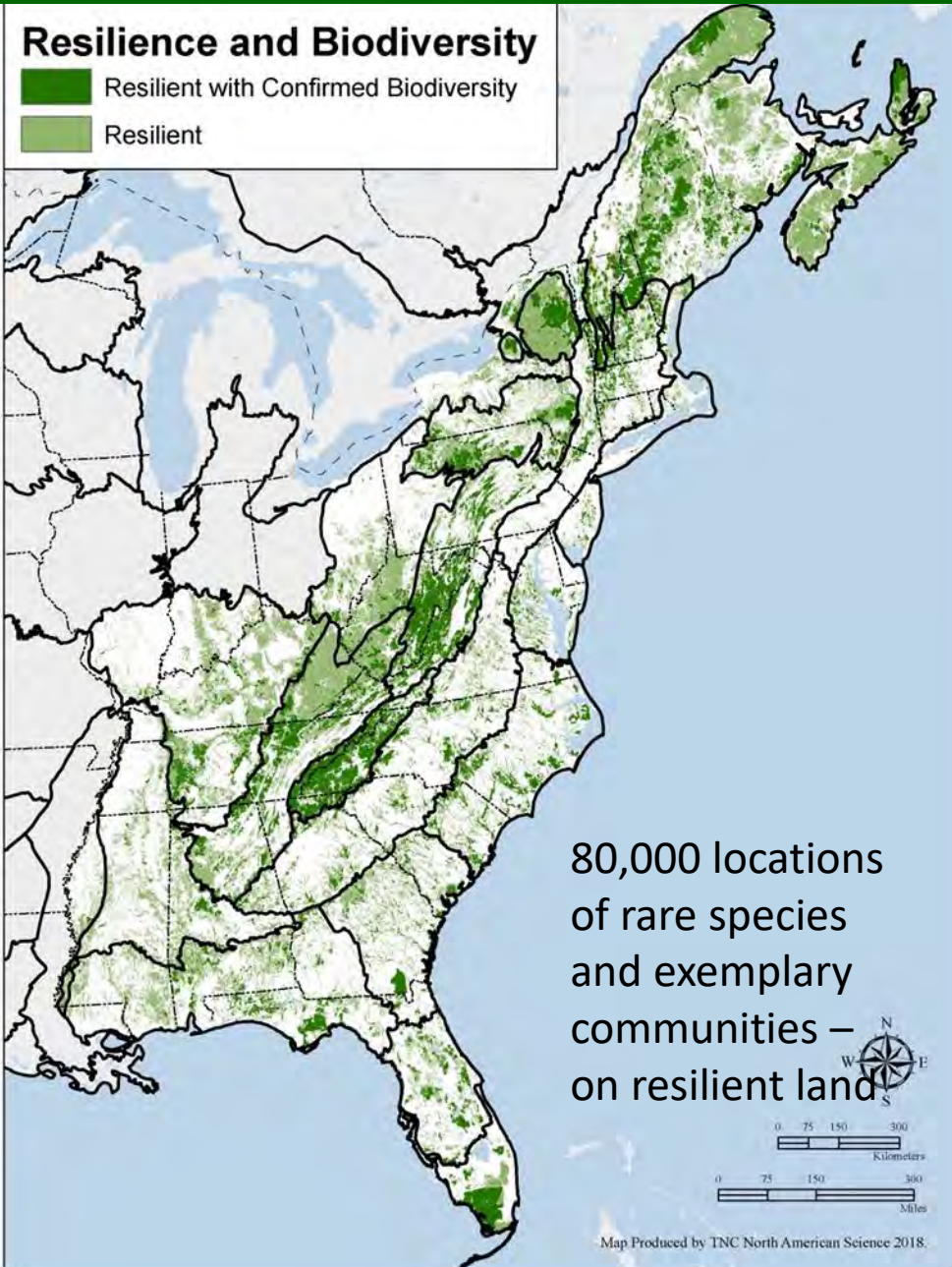


# Resilience and Flow



**Go with the flow!**

# Confirmed Biodiversity: Dispersal Pressure

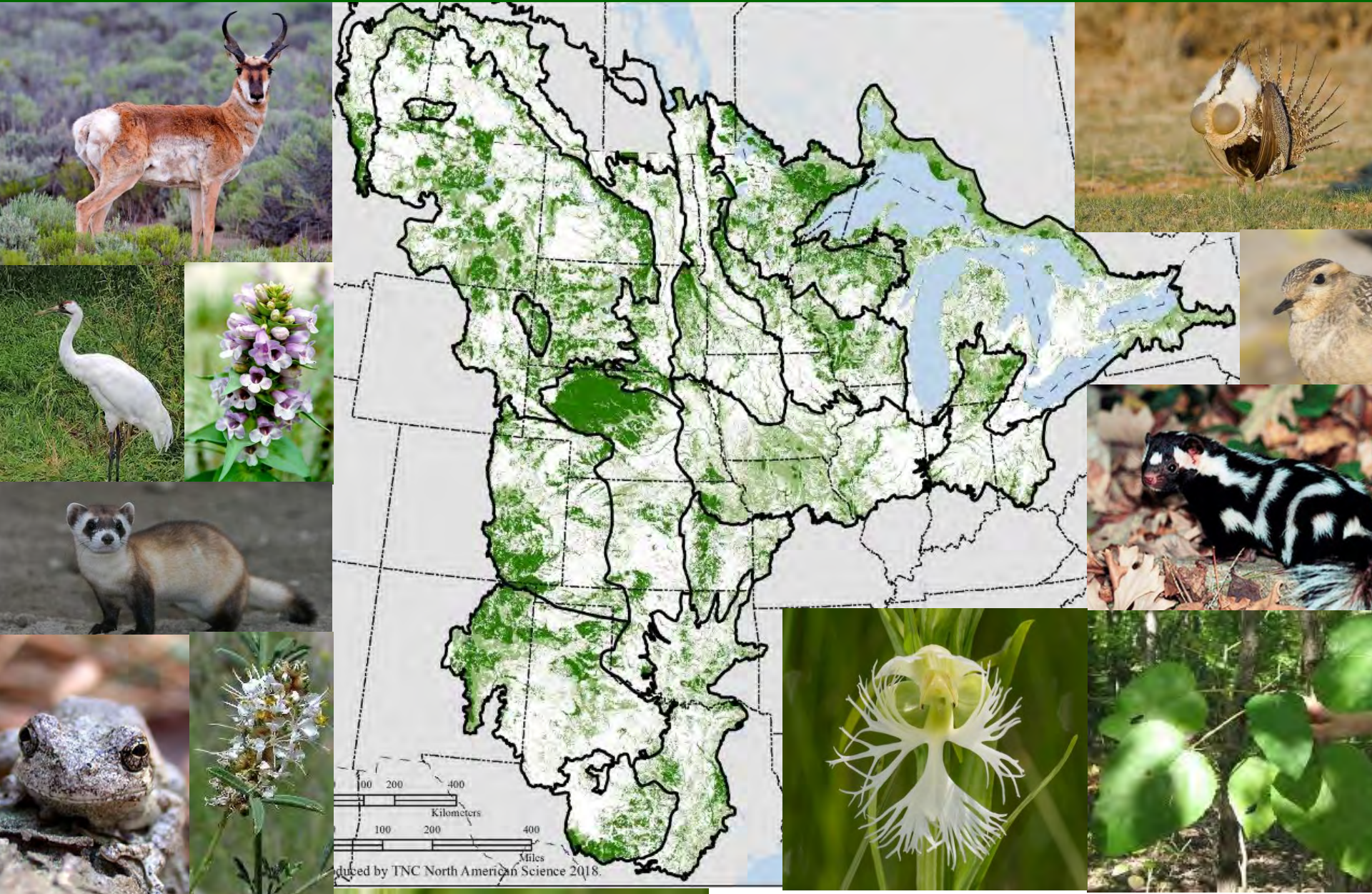


Rare species and exemplary example of unique communities ensure that the network is seeded with robust populations providing the raw material for change and adaptation.

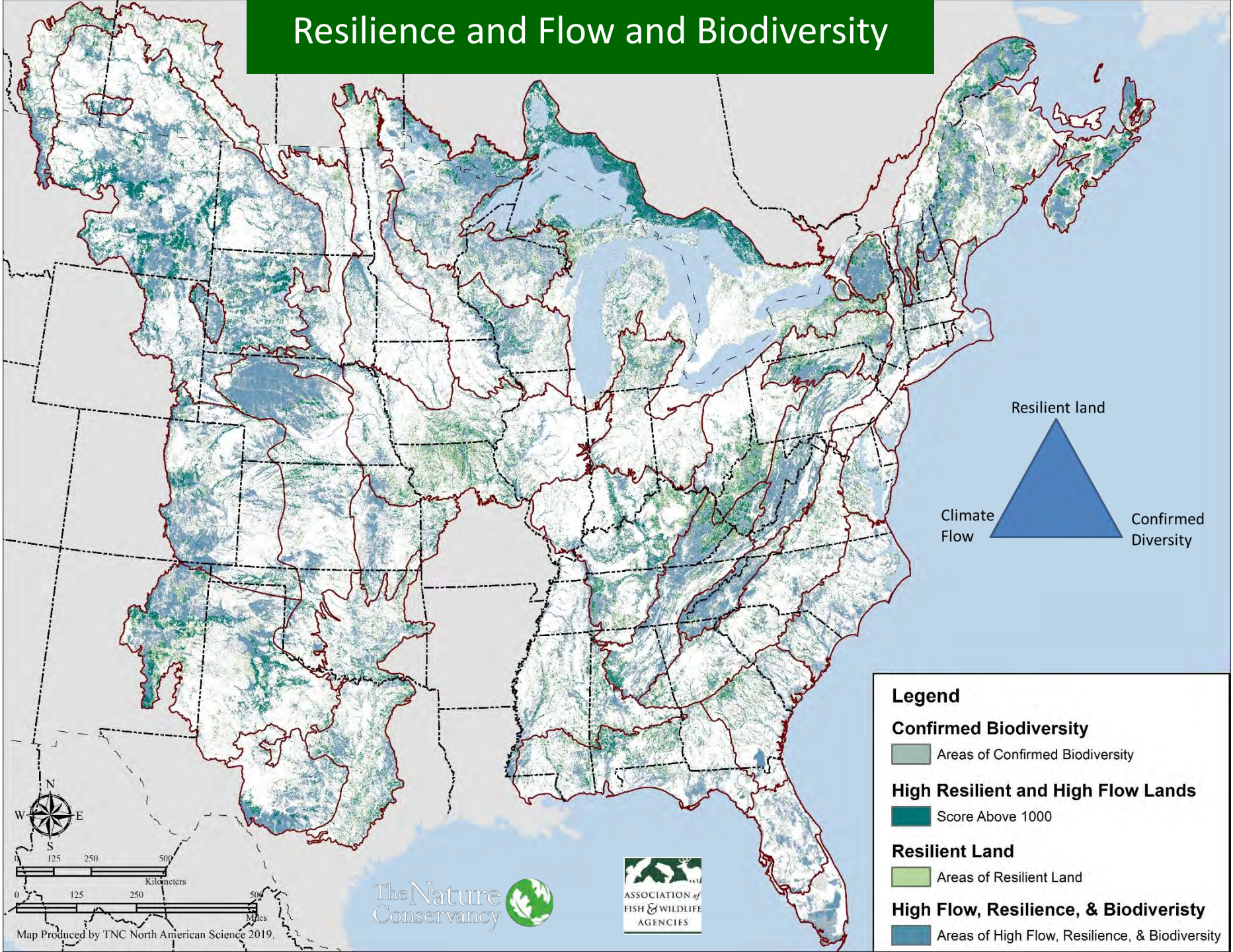


# Confirmed Biodiversity

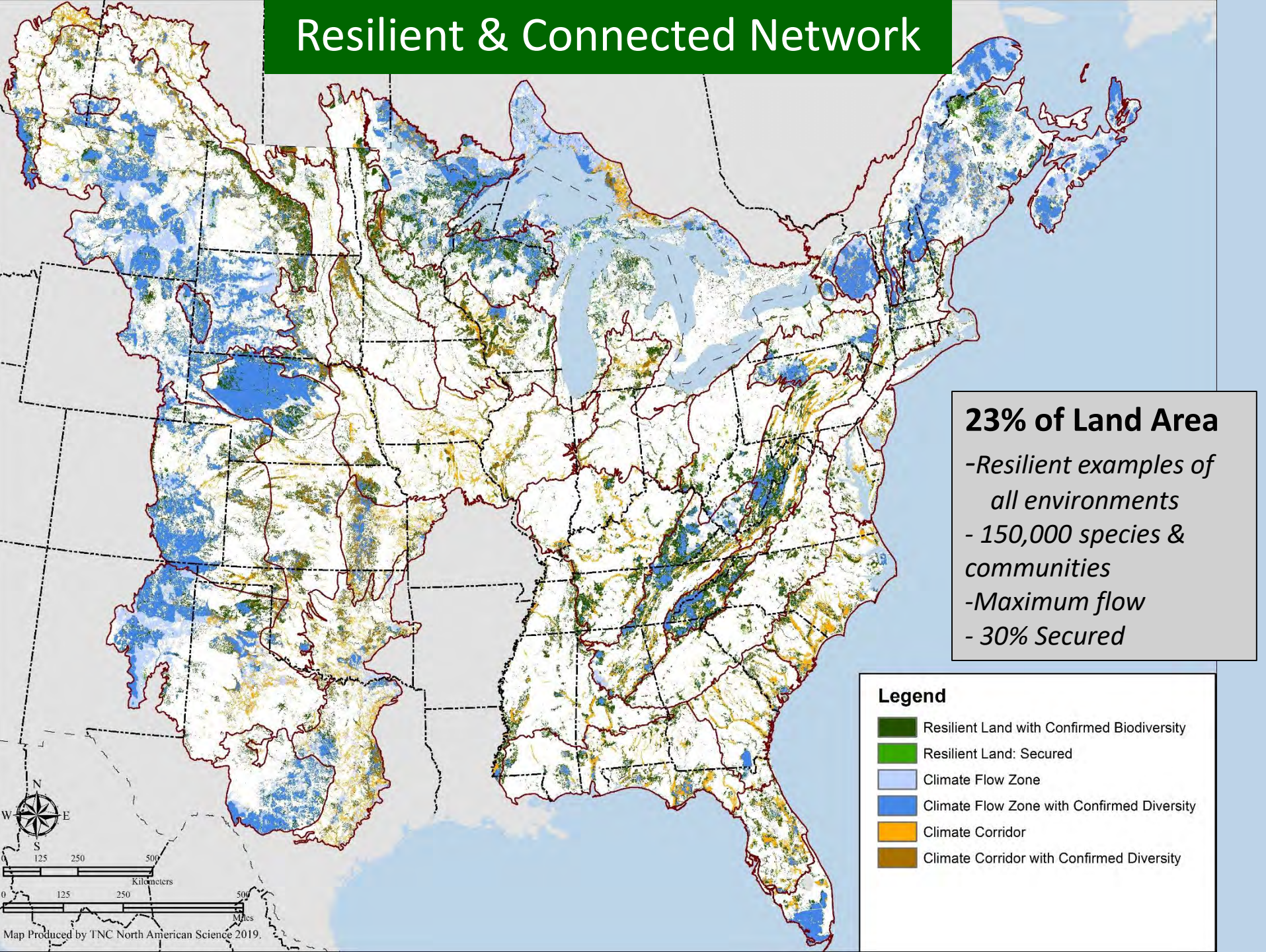
TNC Portfolio, State Wildlife Action Plans, Rare Species and Communities (50% of Resilience)



# Resilience and Flow and Biodiversity



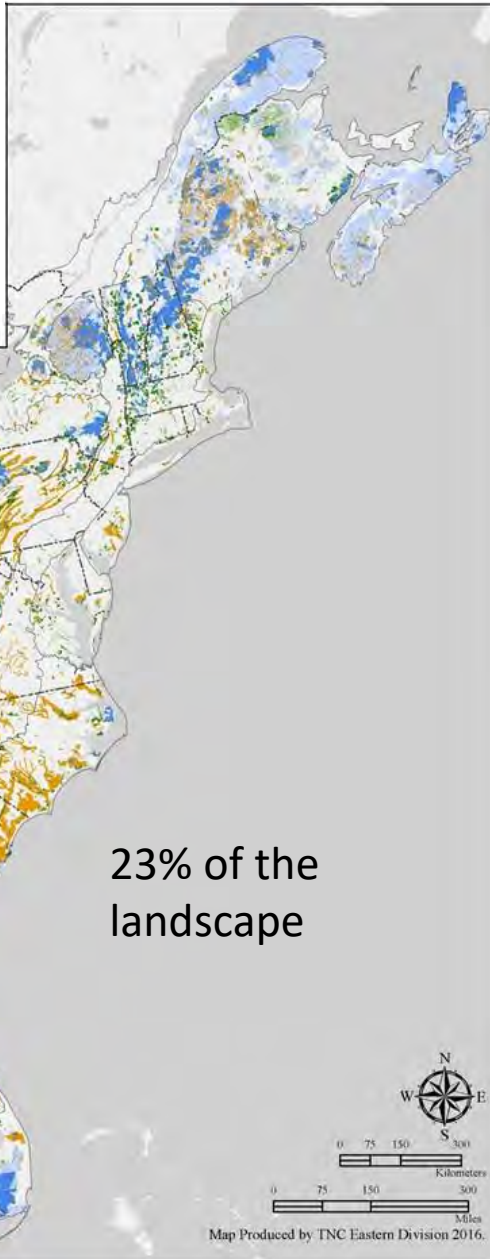
# Resilient & Connected Network



# Multiple Benefits

## Multiple Benefits

Designed to sustain natural diversity but has huge benefits for people



**56% of all Above-Ground Carbon**  
(3.9 B tons)



**75% of High Value Source Water**  
(66+ M acres)



**O<sub>2</sub> for 1.8 Billion People**



**Mitigates 1.3 M Tons of Pollution**  
(\$913 M)

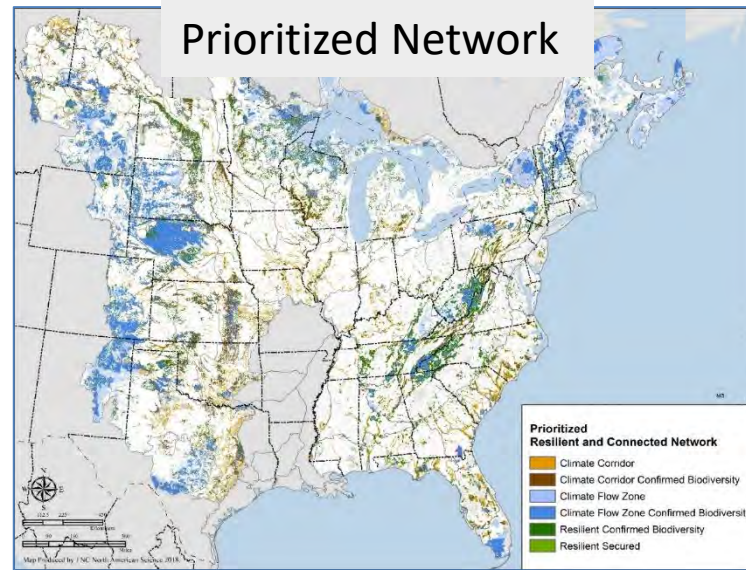
**Generates ~\$25 Billion - Recreation**



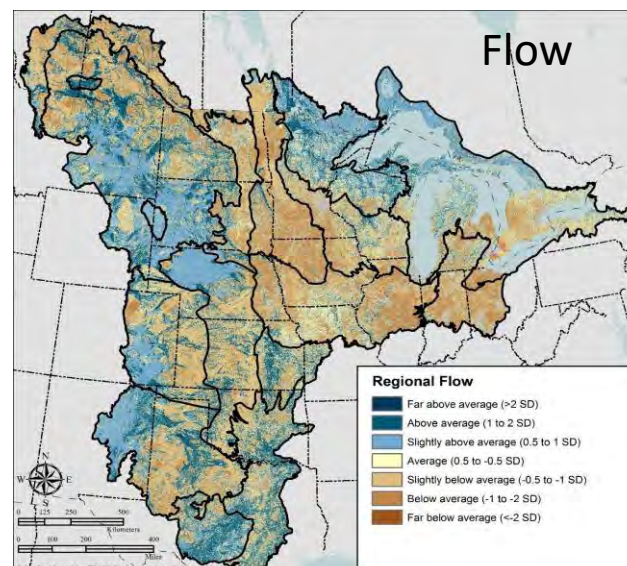
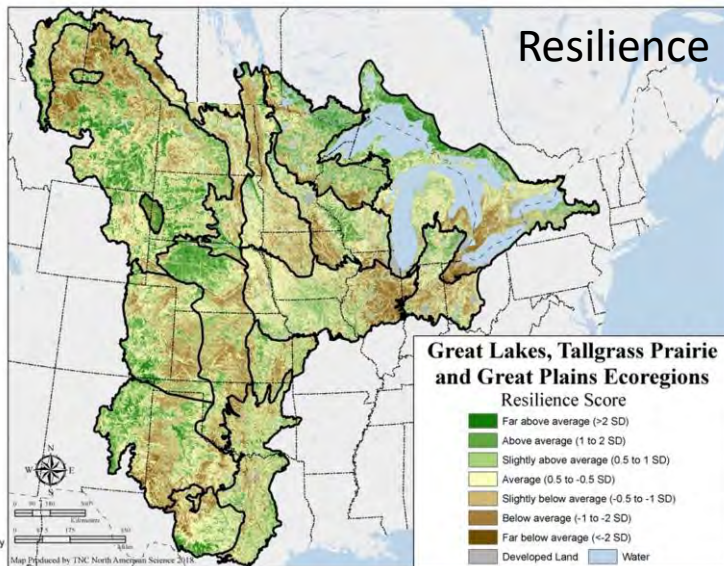
# Resources: Conservation Gateway

## Web Tools and Story Maps

## Papers and Reports



## Continuous Datasets:



# Resilient Land Tool



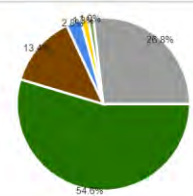
Over 12,000 visits in the last 6 months

## Resilient Land Summary

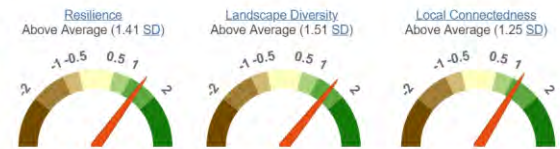
Total area: 31,097 acres

### Resilient and Connected Network Results

Resilient Area with Confirmed Diversity: 16,981.8 Acres  
Climate Corridor with Confirmed Diversity: 4,179.7 Acres  
Climate Flow Zone with Confirmed Diversity: 861.3 Acres  
Climate Corridor: 417 Acres  
Resilient Only (Secured): 313.6 Acres  
Outside Prioritized Network: 8,343.6 Acres

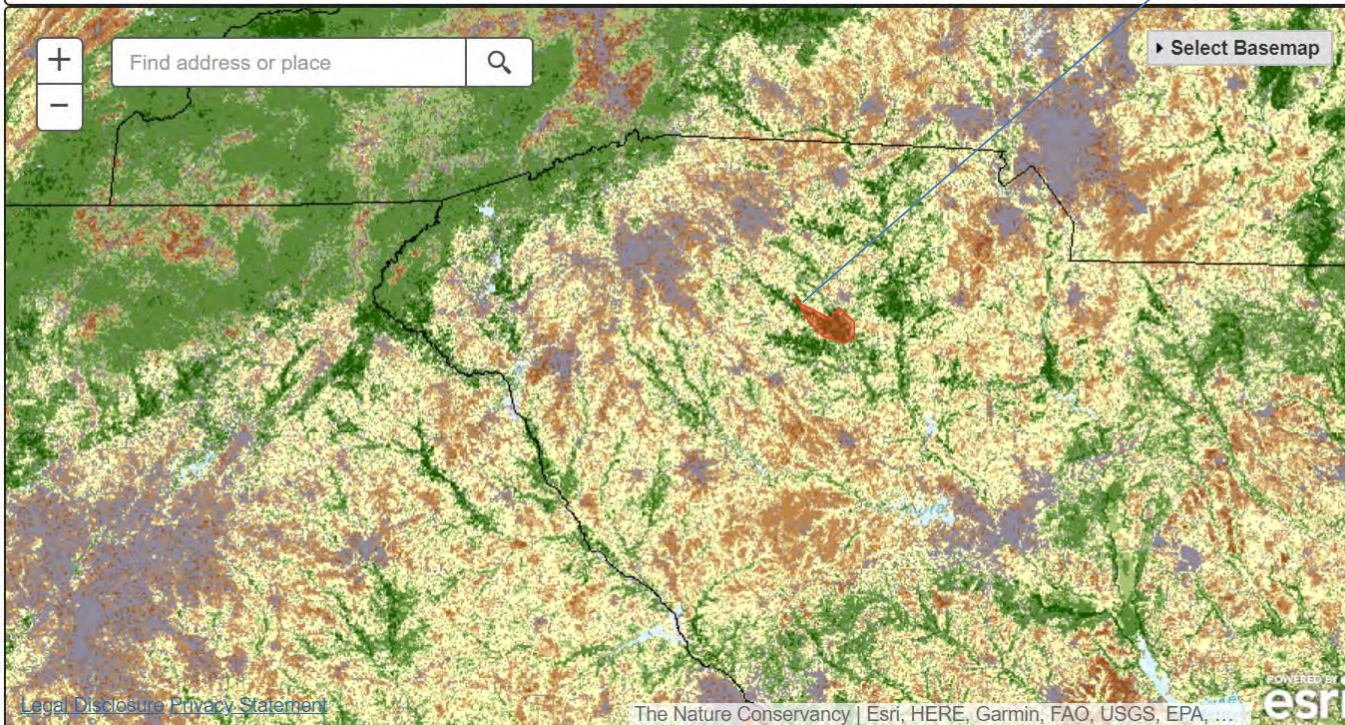


### Terrestrial Resilience



## The Nature Conservancy Resilient Land Mapping Tool

Learn more about the TNC resilient land project and download data [here](#)  
Get a quick primer on the [Core Concepts](#)



Enter a printout title [Print]

### Analyze

Get resilience statistics for a parcel or other polygon.

**Upload Zipped SHP**

OR

**Sketch a Polygon**

**Open Last Results** **Clear Old Polygon**

Reprojecting data...


### Visualize

Resilient and Connected Networks

- Priority Resilient and Connected Landscapes
- Resilient Sites (Terrestrial and Coastal)

Component Data

- Landscape Diversity



*“Health is the capacity of the land for self renewal,  
Conservation is our effort to understand and  
preserve that capacity” Aldo Leopold 1949*

Thank You! This work was funded by the Doris Duke Charitable Foundation, The Gaylord and Dorothy Donnelley Foundation, The USF&W Service, NOAA and The Nature Conservancy



# A brief history of ecological connectivity mapping in the region

Prof. Karen Beazley,  
School for Resource and Environmental Studies  
Dalhousie University

Co-chair, Canadian Maritime Ecological Connectivity Forum  
Halifax, 2019

# Ecological connectivity

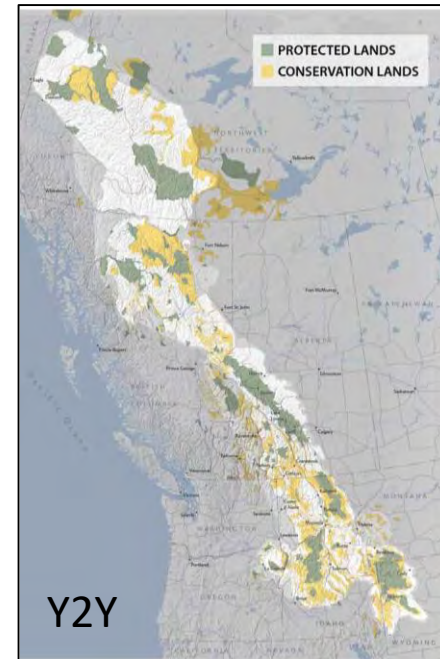


*The degree to which the landscape facilitates or impedes movement or flows of species and processes across space and time.*

- Landscape ecology
- Protected area networks
- Corridors and linkages

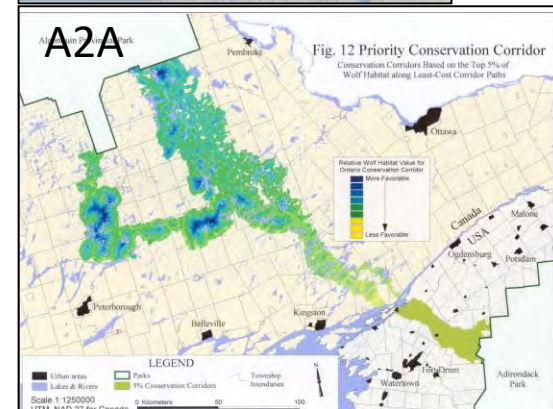


# Continental ecological connectivity

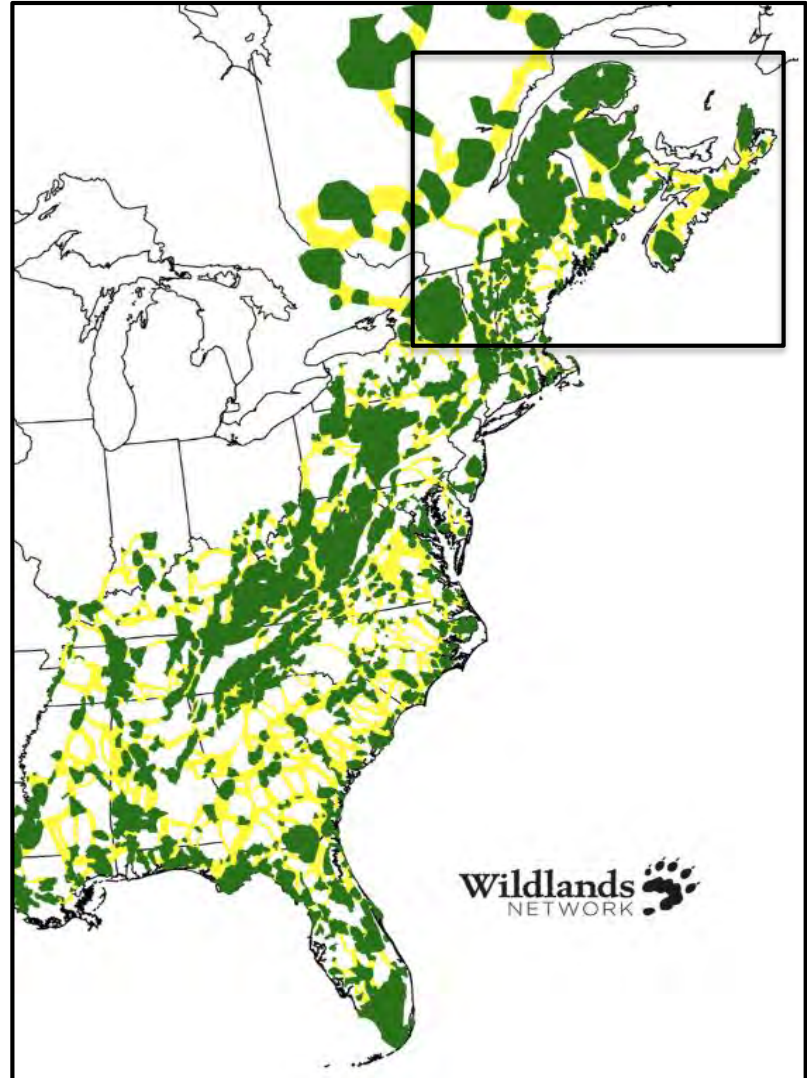


Yellowstone  
to Yukon  
(Y2Y)

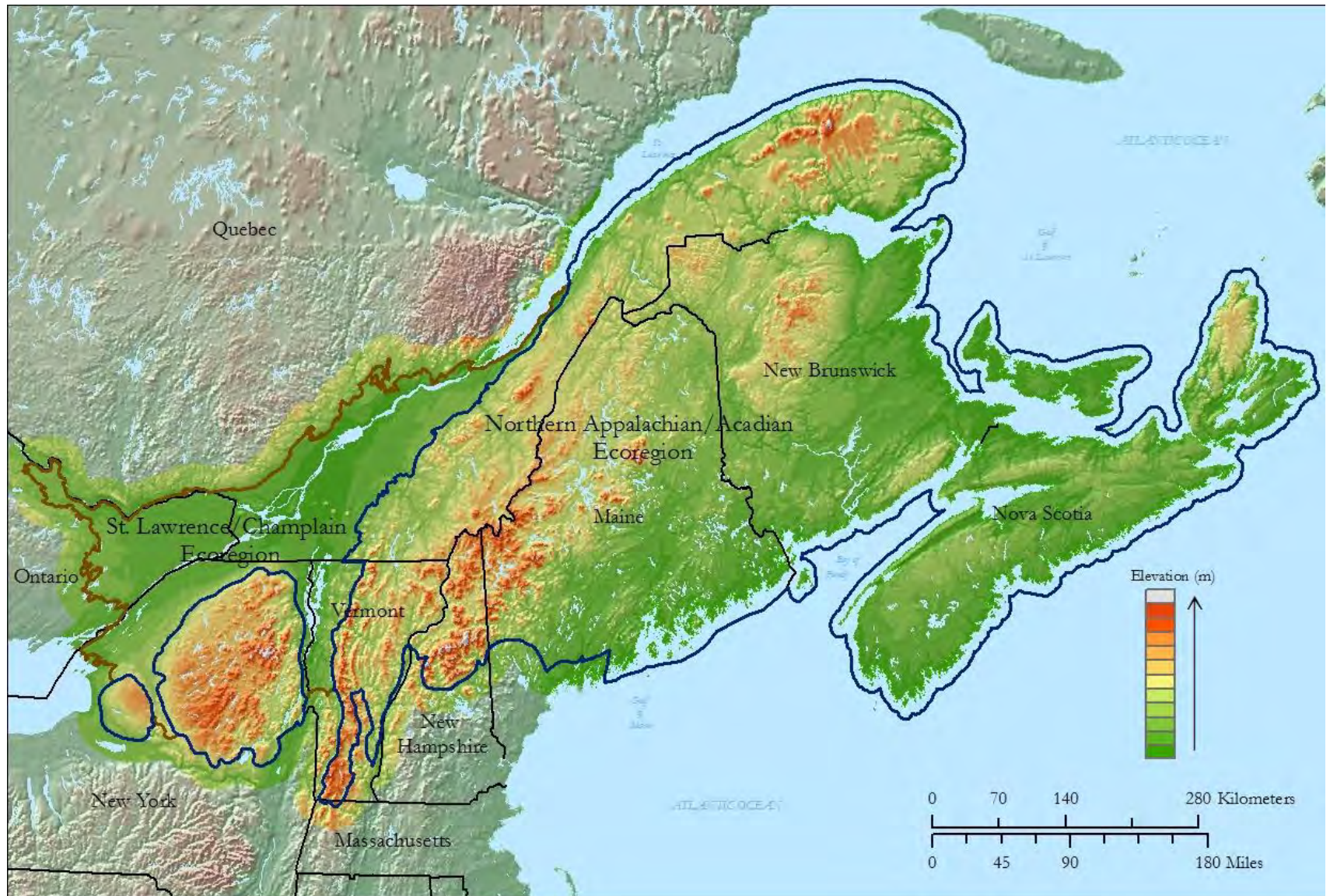
Algonquin to  
Adirondacks  
(A2A)



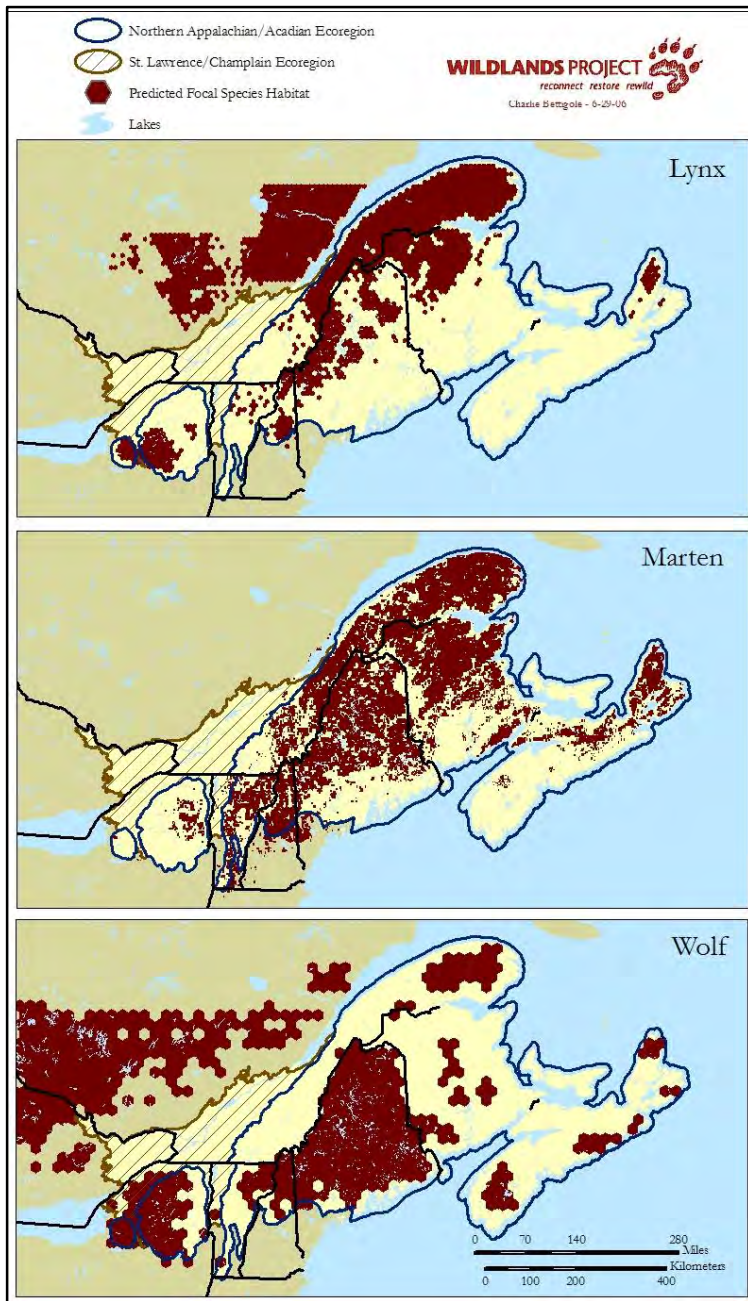
# Eastern Wildways Network



# Northern Appalachian/Acadian Ecoregion







WCS Working Paper No. 15  
June, 2000

Mesocarnivores  
of Northeastern  
North America:  
Status and  
Conservation  
Issues

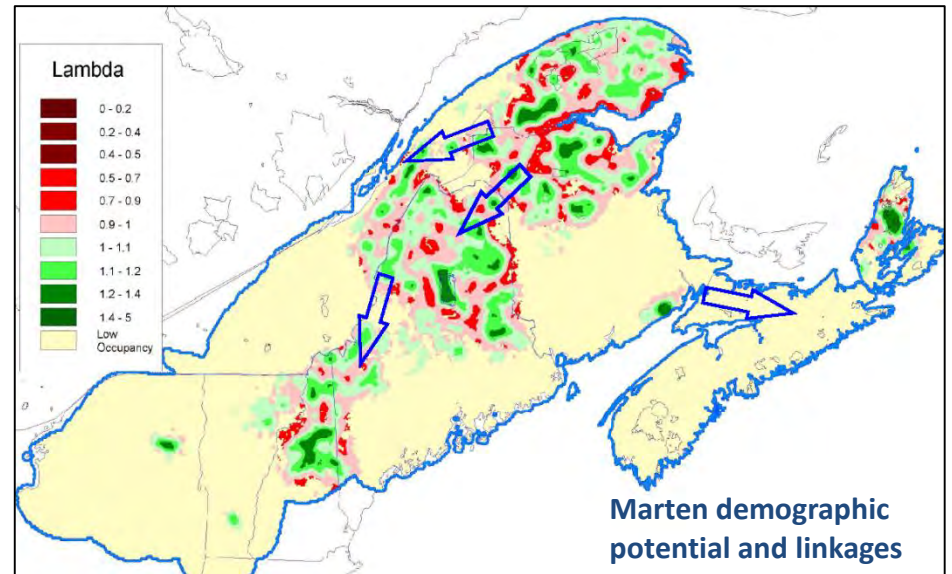
Justina C. Ray

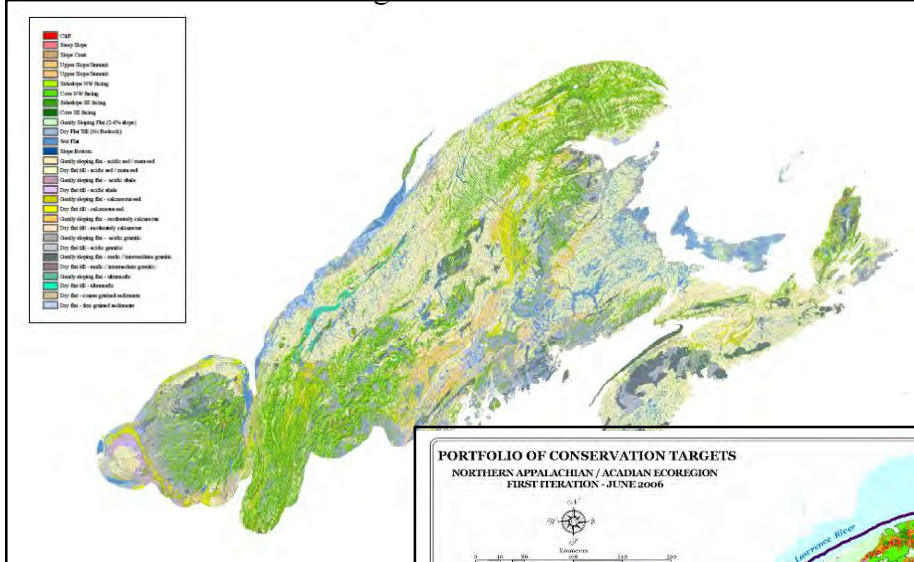


*Wolf Viability in the Northeastern  
U.S. and Southeastern Canada*

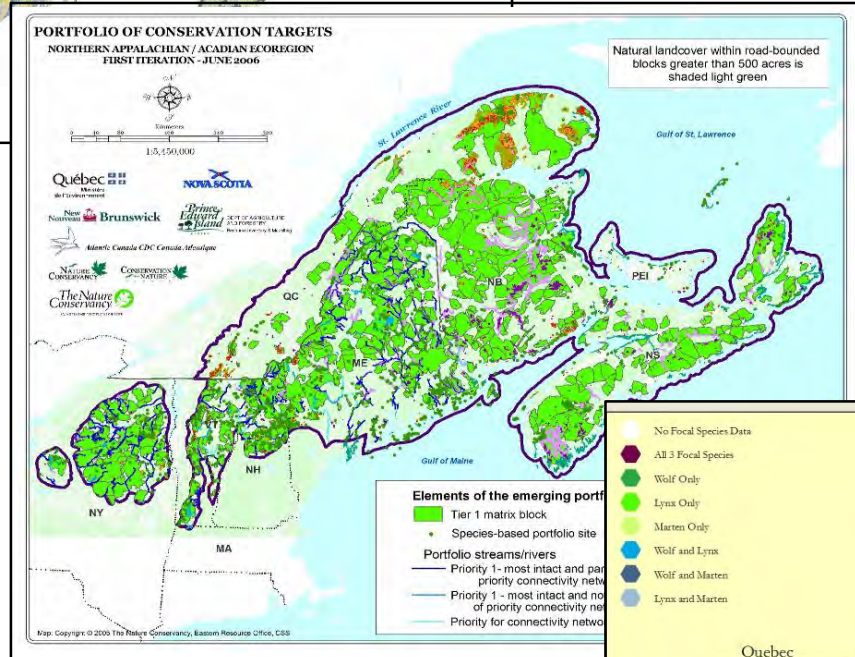
A summary of new research with  
implications for wolf recovery

by Carlos Carroll





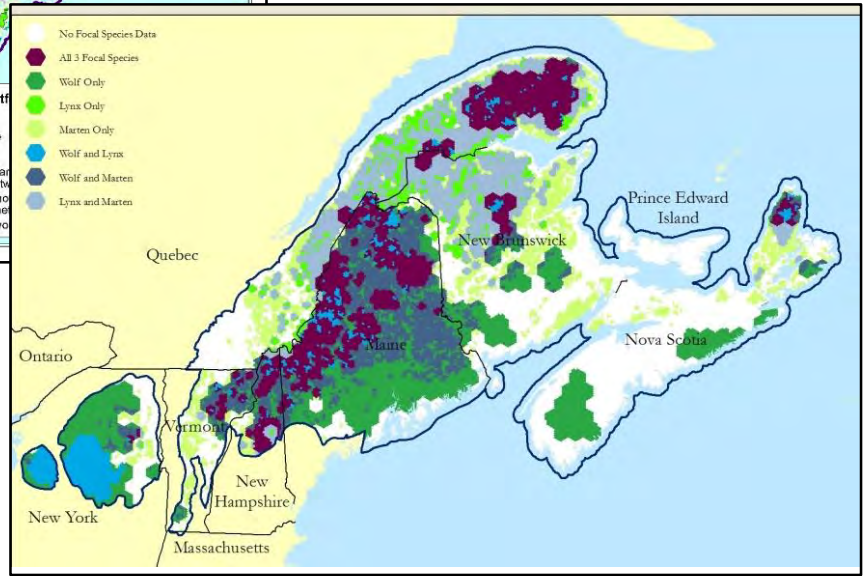
Environmental variation:  
162 ecological land units (TNC)



Special elements (TNC):  
Rare ecological communities  
Tier 1 intact forest blocks

Focal species:  
Source habitat (Carroll 2005)

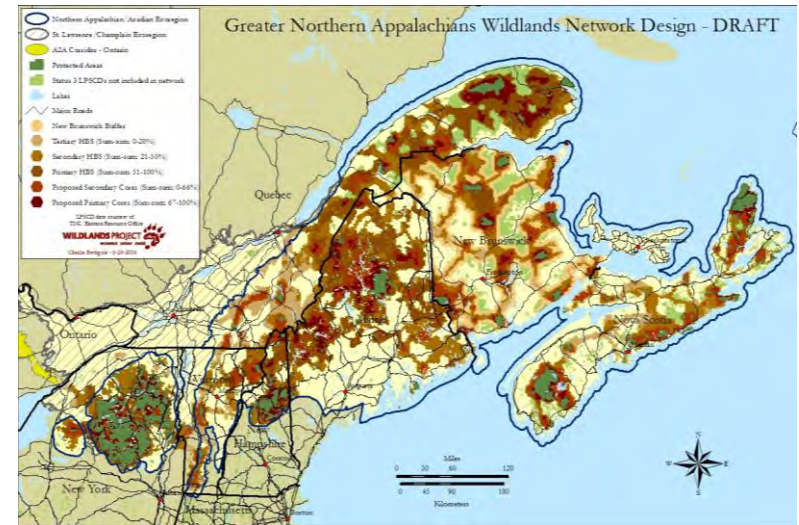
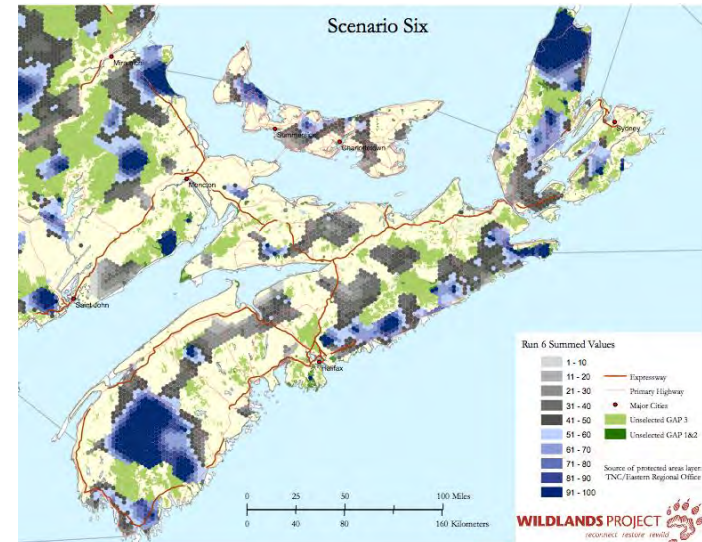
- grey wolf
- Canada lynx
- American marten



# From the Adirondacks to Acadia

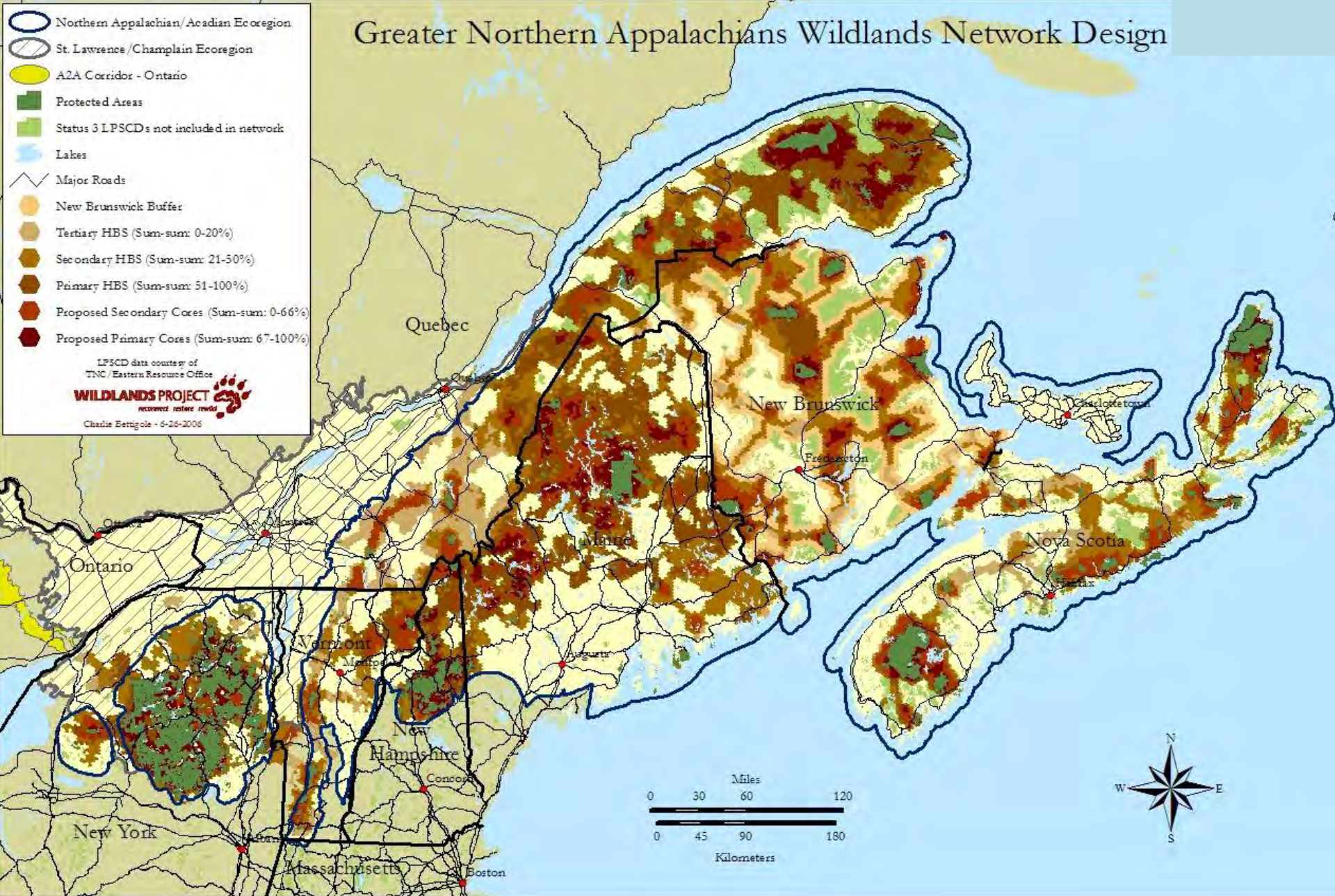
## A Wildlands Network Design for the Greater Northern Appalachians

Conrad Reining, Karen Beazley, Patrick Doran, Charlie Bettigole



A Wildlands network design for the Greater Northern Appalachians  
(Reining et al. 2006)

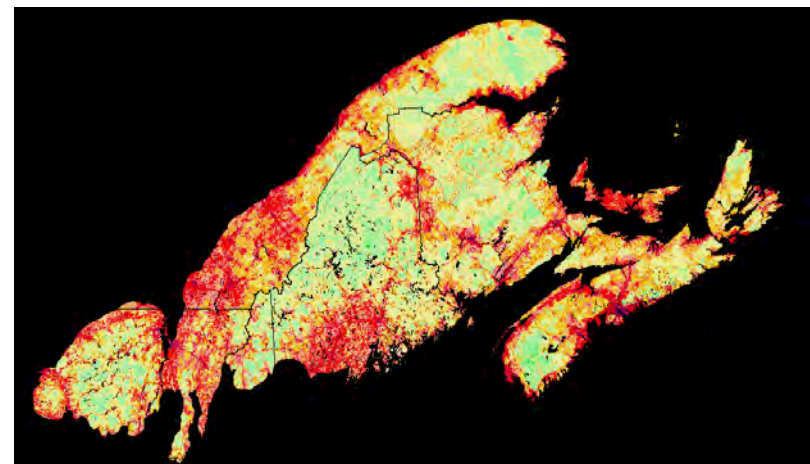
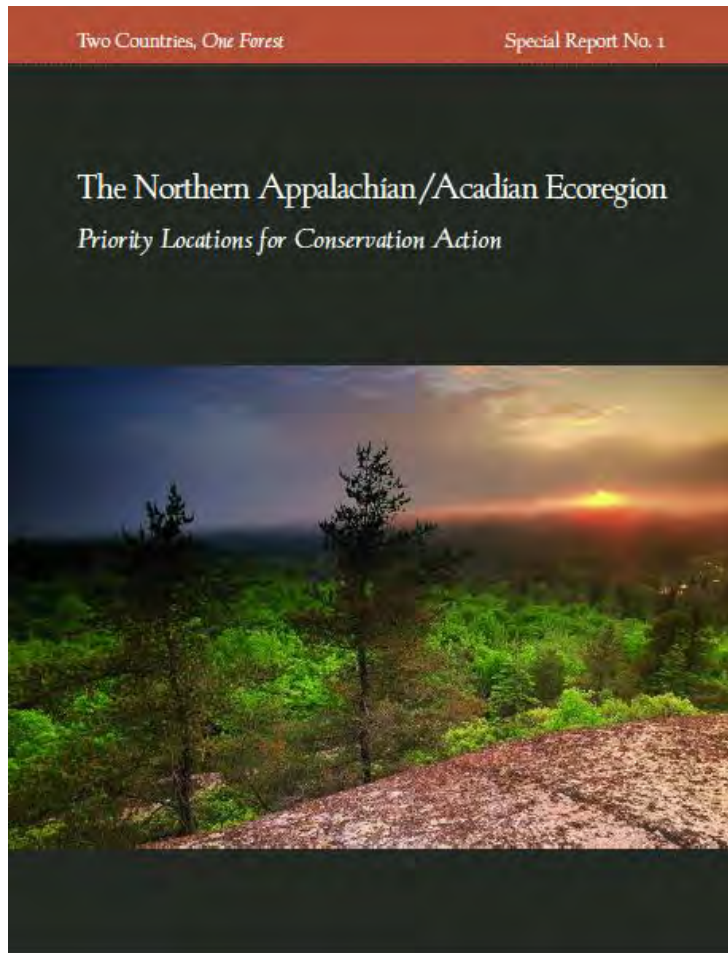
# Greater Northern Appalachians Wildlands Network Design



From the Adirondacks to Acadia (Reining et al. 2006)

# Priority locations for conservation action

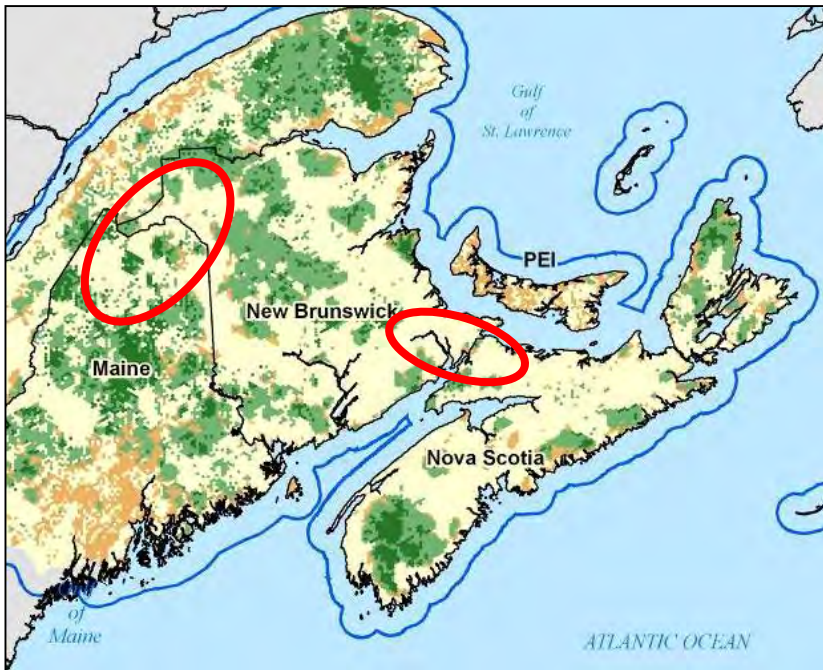
(2C1Forest; Trombulak et al. 2008)



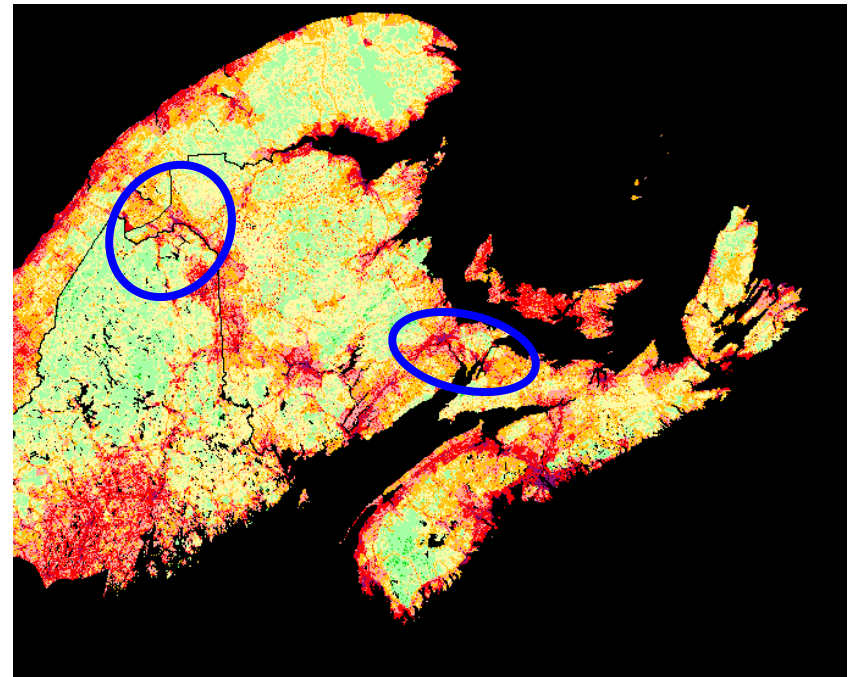
Human footprint (Woolmer et al. 2008)

# Critical linkage areas

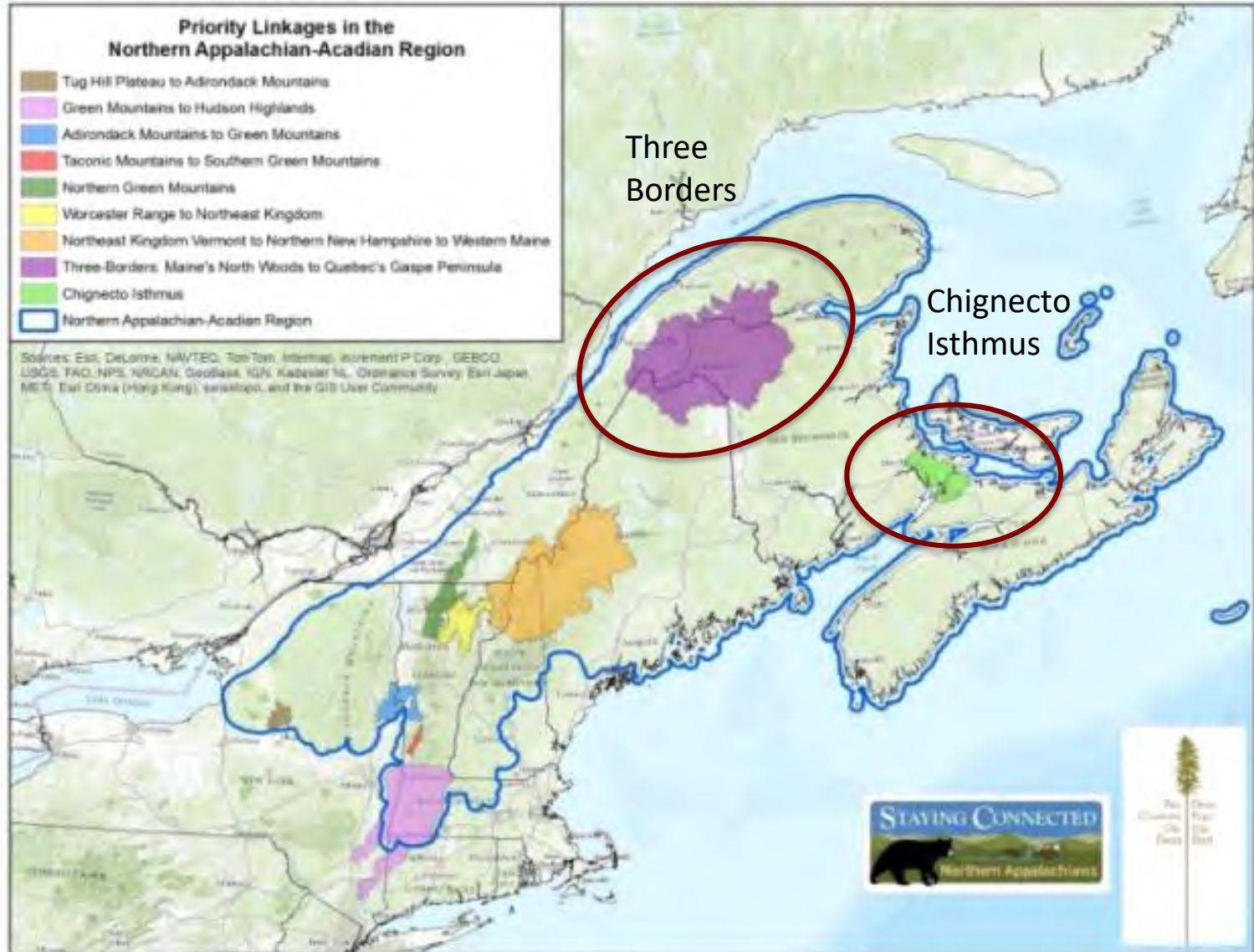
Biodiversity importance



Human footprint



# Priority landscape linkages: Staying Connected Initiative



# Ecological connectivity models

(Perkl and Baldwin 2013; 2C1Forest: Data Basin)

Connectivity scenario:  
Low human footprint



Connectivity scenario:  
Martin source habitat



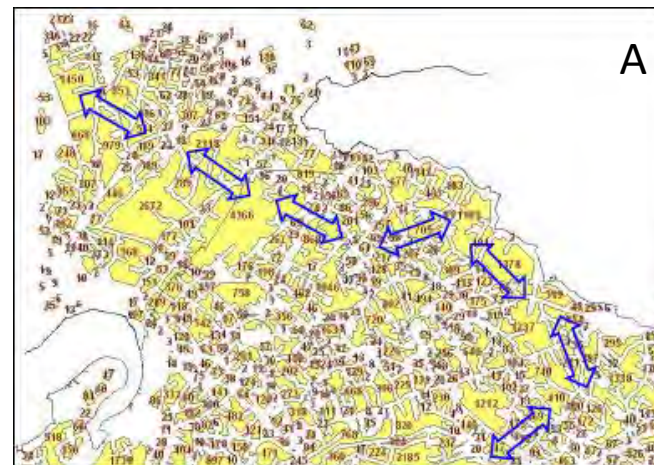


# Natural ecosystem connectivity across the Chignecto Isthmus (MacDonald & Clowater 2005)

High priority areas for facilitating connectivity

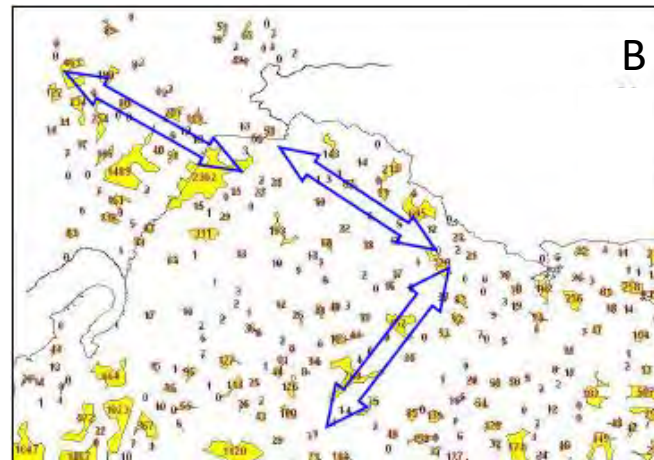


Proposed routes for wildlife connectivity corridors based upon 600m road-buffered patches

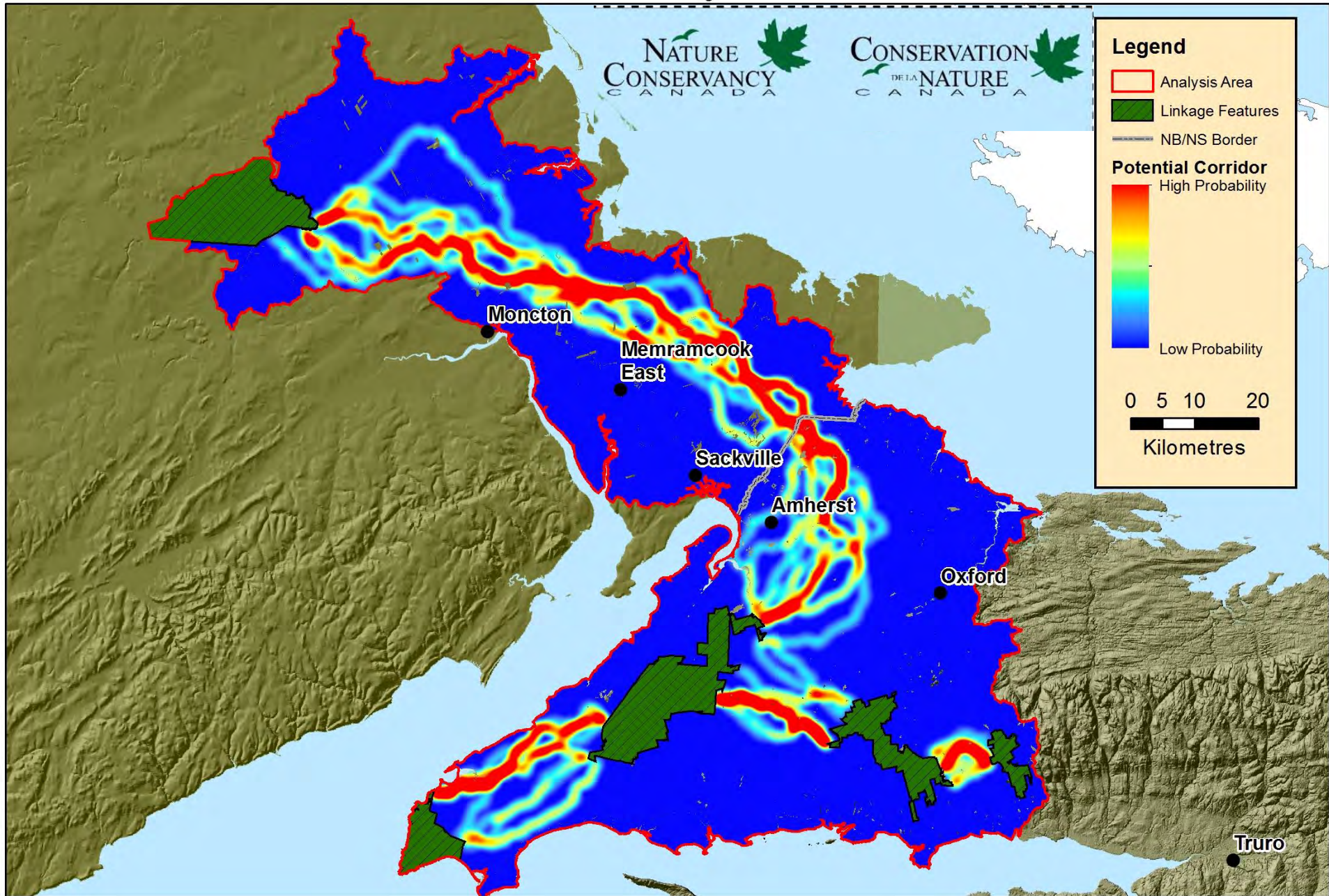


Possible pathways for wildlife connectivity based solely on patch size:

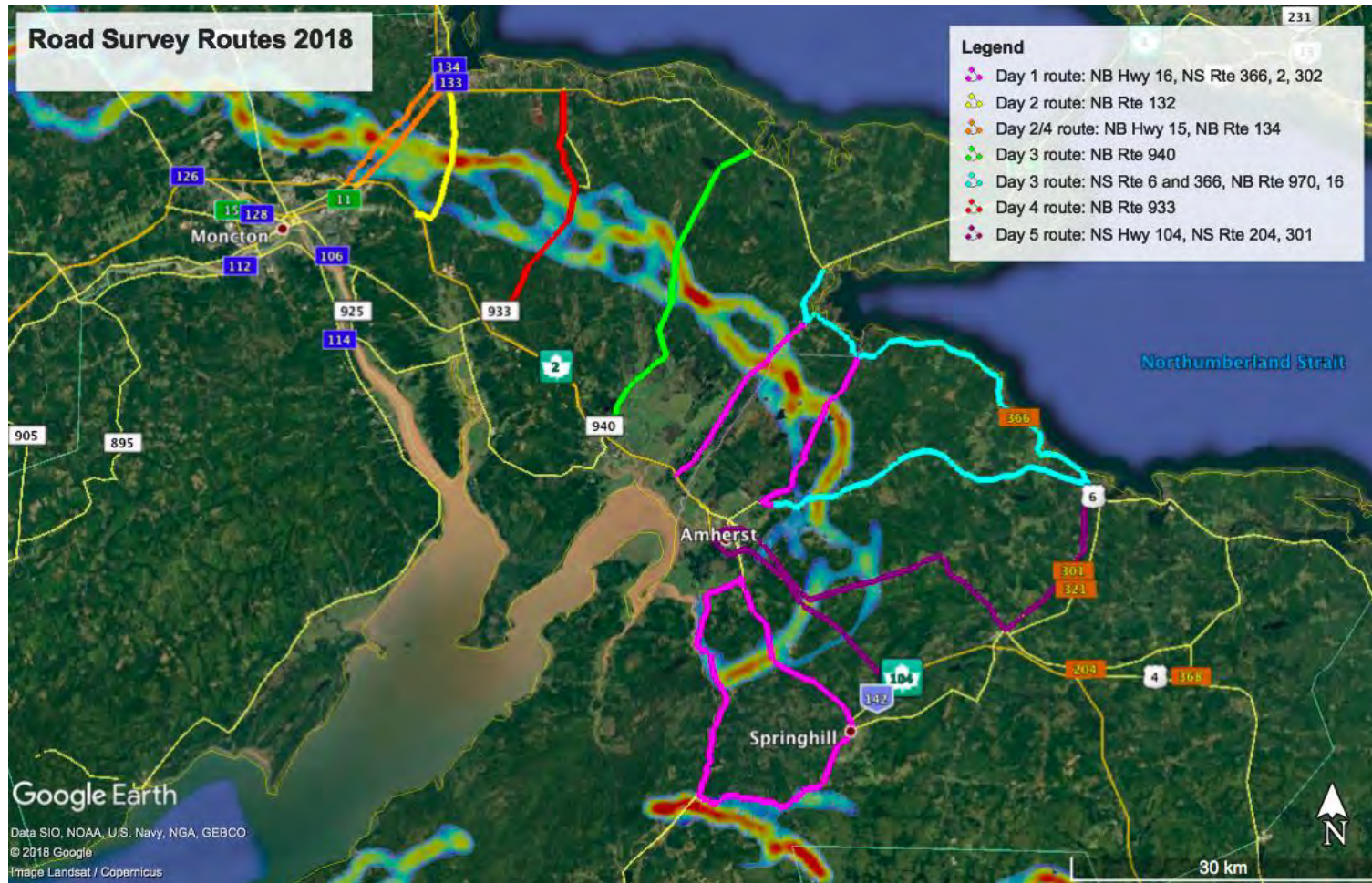
A. 200 m road buffer



B. 600 m road buffer



Wildlife Connectivity Analysis for the Chignecto Isthmus Region  
(Nussy 2016)

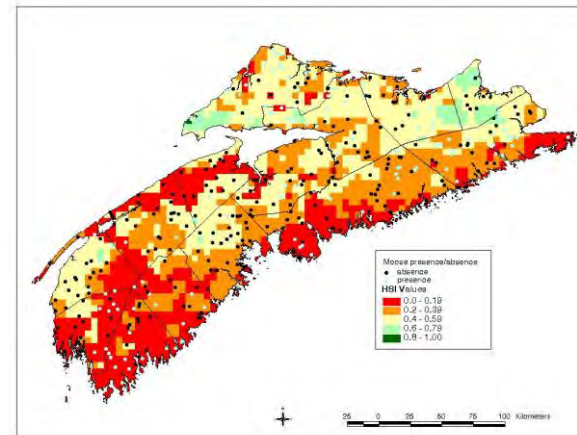
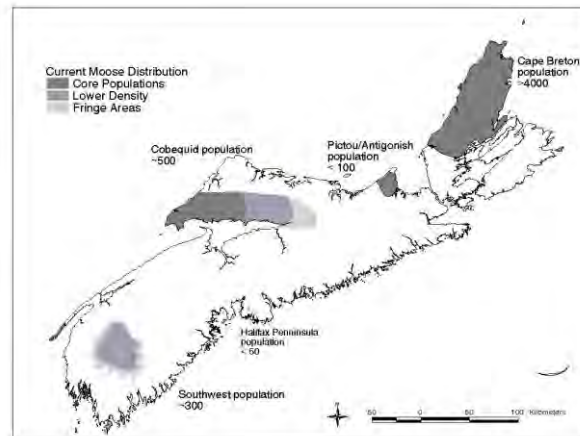


Road survey routes 2018 (A. Barnes)

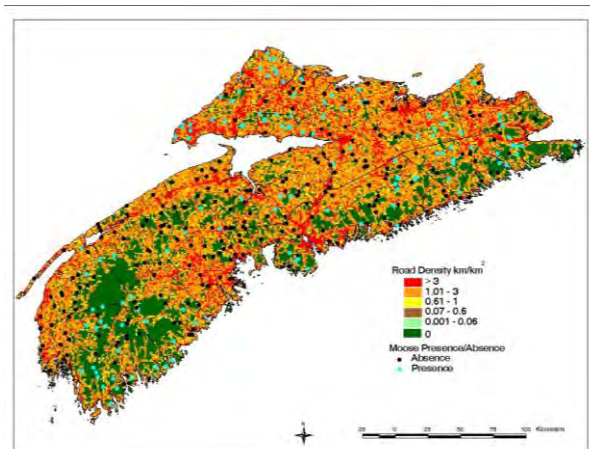


# Connectivity for NS mainland moose

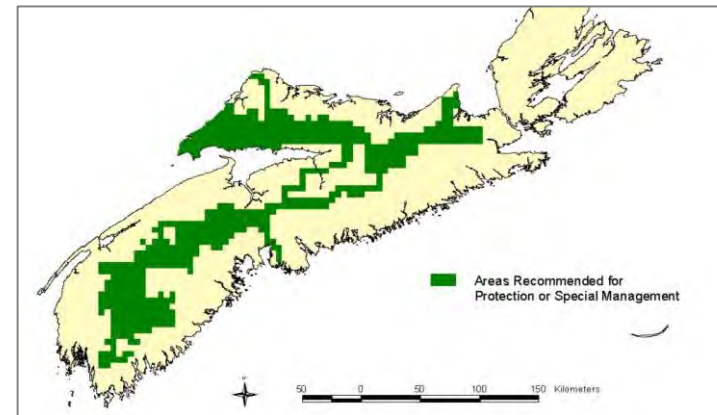
(Snaith and Beazley 2004; Snaith et al. 2004; Beazley et al. 2005)



Moose HSI & pellet presence/absence



Road density & moose pellet data



Minimum critical habitat and connectivity for short-term moose viability (14,000  $\text{km}^2$ )

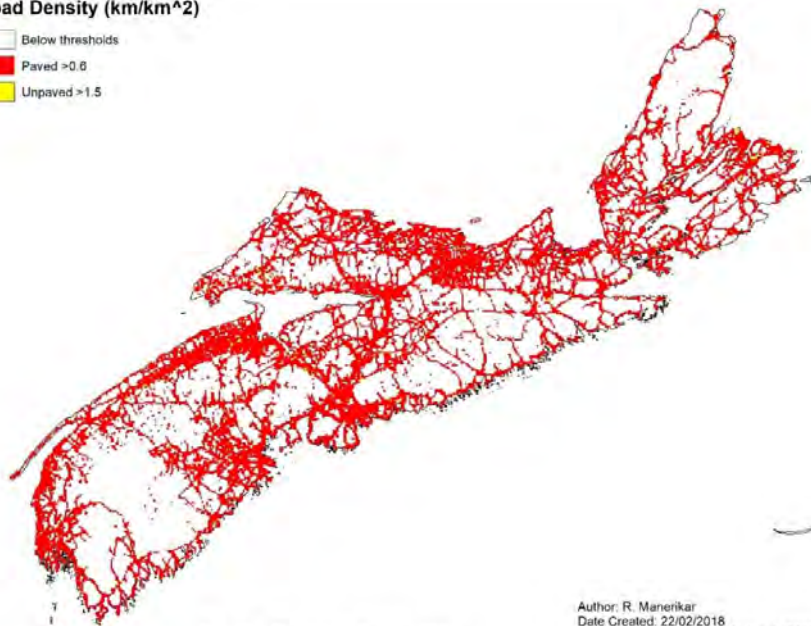
# Influence of roads on effective habitat

Road density (paved)

Road density (paved & unpaved)

Road Density (km/km<sup>2</sup>)

- Below thresholds
- Paved >0.6
- Unpaved >1.5

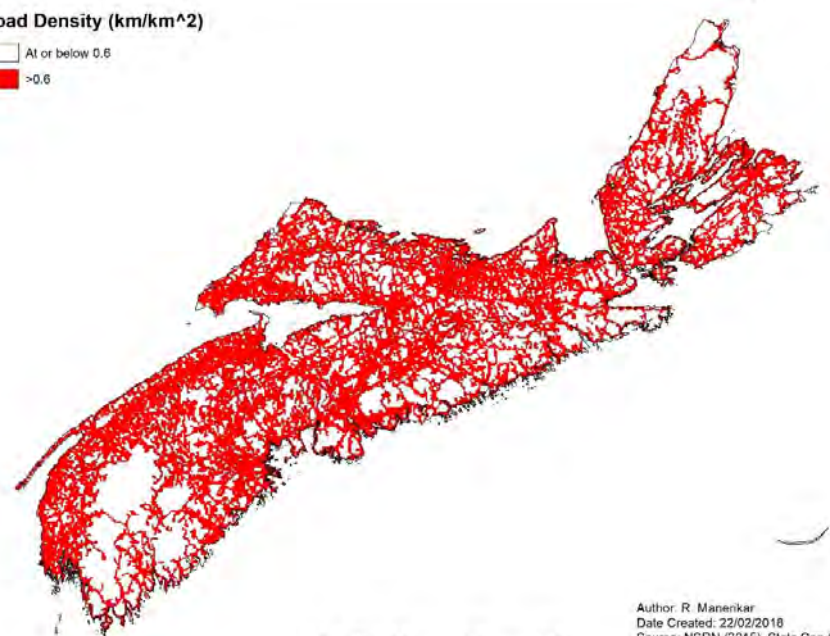


0 25 50 100 150  
Kilometers

Author: R. Manerikar  
Date Created: 22/02/2018  
Source: Nova Scotia Road Network (2015), SI  
Coordinate System: NAD 1983 CSRS UTM Zone 24  
Projection: Transverse Mercator  
Datum: North American 1983 CSRS

Road Density (km/km<sup>2</sup>)

- At or below 0.6
- >0.6



0 25 50 100 150  
Kilometers

Author: R. Manerikar  
Date Created: 22/02/2018  
Source: NSRN (2015), Stats Can (2016)  
Coordinate System: NAD 1983 CSRS UTM Zone 24  
Projection: Transverse Mercator  
Datum: North American 1983 CSRS

(Manerikar & Beazley 2018)

# Habitat suitability (HSI only)

Probability of Suitable Habitat



## Bobcat



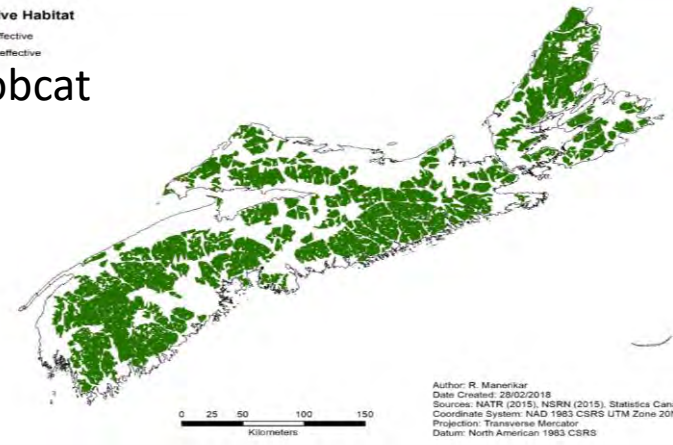
Author: R. Manerikar  
Date Created: 09/02/2018  
Data Source: NATR (2015), Stats Can (2011)  
Coordinate System: NAD 1983 CSRS UTM  
Projection: Transverse Mercator  
Datum: North American 1983 CSRS

# Habitat effectiveness (HSI & road influence buffers)

Effective Habitat



## Bobcat

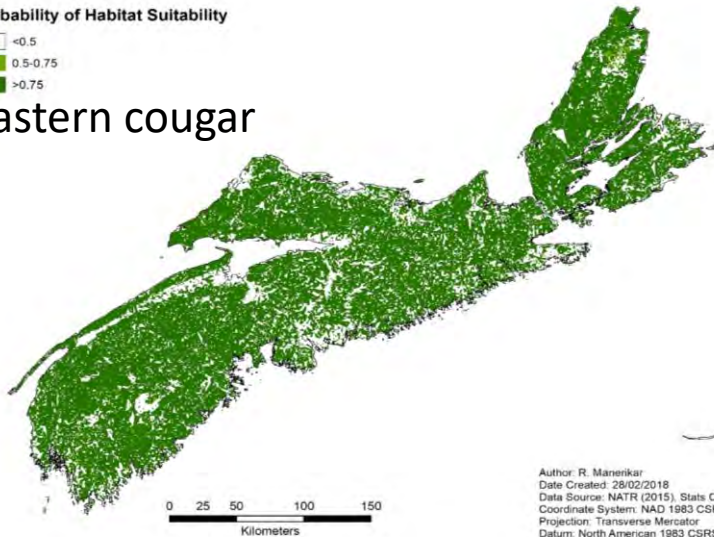


Author: R. Manerikar  
Date Created: 28/02/2018  
Sources: NATR (2015), NSRN (2015), Statistics Canada  
Coordinate System: NAD 1983 CSRS UTM Zone 20N  
Projection: Transverse Mercator  
Datum: North American 1983 CSRS

Probability of Habitat Suitability



## Eastern cougar

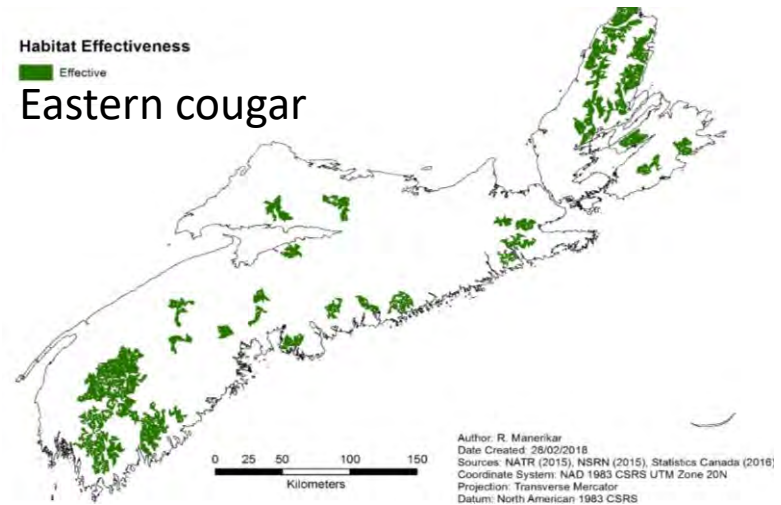


Author: R. Manerikar  
Date Created: 28/02/2018  
Data Source: NATR (2015), Stats Can (2016)  
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Datum: North American 1983 CSRS

Habitat Effectiveness

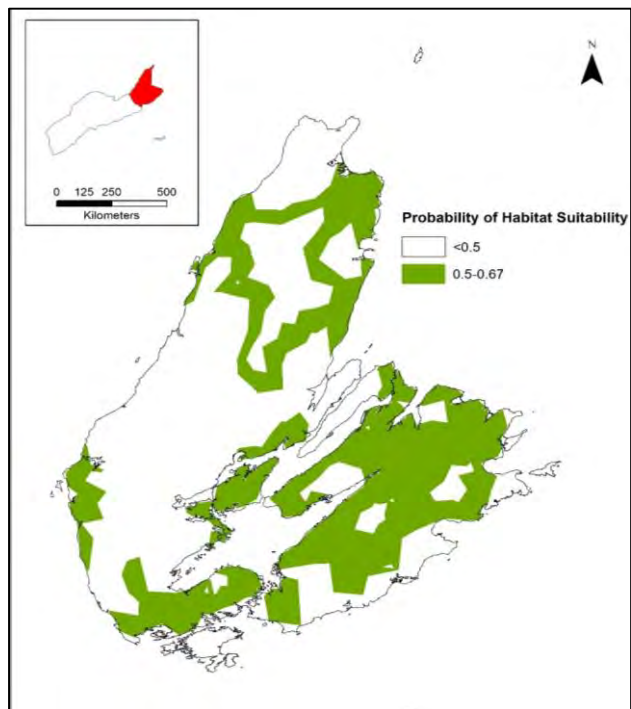


## Eastern cougar



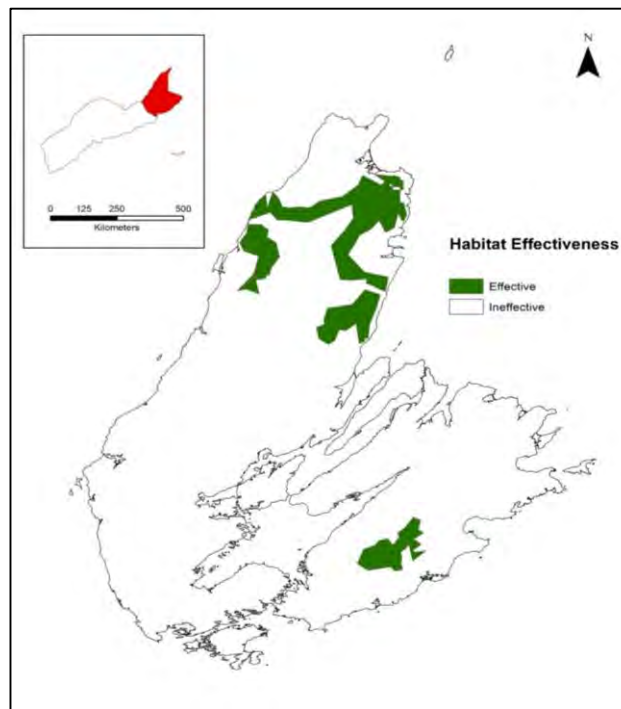
Author: R. Manerikar  
Date Created: 28/02/2018  
Sources: NATR (2015), NSRN (2015), Statistics Canada (2016)  
Coordinate System: NAD 1983 CSRS UTM Zone 20N  
Projection: Transverse Mercator  
Datum: North American 1983 CSRS

## Canada lynx habitat suitability (HSI only)



Cape Breton

## Canada lynx habitat effectiveness (HSI & road influence buffers)



Number of males supported by  
effective habitat: 7  
Number of males required for  
short-term MVP: 154

# Roads, Climate Change and Mainland Moose (*Alces alces americana*) in Nova Scotia

Angie Lynch  
Master of Resource and Environmental Management Candidate



## INTRODUCTION

The natural population of moose in Nova Scotia is limited to approximately 1000 individuals in isolated sub-populations on the Nova Scotia Peninsula (Species at Risk Conservation Plan for Moose, Department of Natural Resources, 2017). This population has declined by 50% over the last 30 years due to climate change, habitat loss, and poaching. The population is currently estimated to be around 500 individuals (Department of Natural Resources, 2017). Although the decline is not fully understood, major threats include climate change and habitat loss (Dunham et al., 2012; Department of Natural Resources, 2017; Lynch et al., 2020).

## HABITAT REQUIREMENTS

Food requirements, snow cover, and precipitation of moose are the most critical components of moose range (Lynch et al., 2020). Climate change is expected to increase winter snow cover and reduce precipitation (Lynch et al., 2020). This is expected to reduce the availability of food and increase the risk of starvation (Lynch et al., 2020). Additionally, increased precipitation is expected to increase the risk of flooding and habitat loss (Lynch et al., 2020).

## RESULTS & CONCLUSIONS

There is a need to address the challenges to the winter range of moose in Nova Scotia. This includes the need to improve habitat quality and connectivity, and to reduce the impact of climate change on the winter range (Lynch et al., 2020). This includes the need to improve habitat quality and connectivity, and to reduce the impact of climate change on the winter range (Lynch et al., 2020).



## CONCLUSION AND DISCUSSION

Mainland moose are currently within their critical habitat range in Nova Scotia. However, climate change is expected to reduce the availability of food and increase the risk of starvation (Lynch et al., 2020). This includes the need to improve habitat quality and connectivity, and to reduce the impact of climate change on the winter range (Lynch et al., 2020).

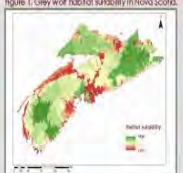
# Grey wolf: A habitat suitability analysis for mainland Nova Scotia

Dr. Karimhos, MREEM Candidate  
You School of Resource and Environmental Studies



## RESULTS AND DISCUSSION

Table 1 outlines the habitat preferences of grey wolves, while Figure 1 demonstrates the habitat suitability for mainland Nova Scotia for grey wolves. Conservation of grey wolf habitat will be most suitable in a grey wolf.



## REFERENCES

David, C., Pelly, S.N., Lavelle, C.A., & Schaller, G.B. (2016). Conservation of the wolf in North America. *Conservation Biology*, 30(1), 1-10.

## METHODS

A literature review was conducted to determine habitat requirements for Mainland Moose and to compare them to Nova Scotia. This included a review of the literature on moose habitat requirements and a review of the literature on climate change impacts on moose habitat requirements.

## RESULTS

The map shows the distribution of moose habitat suitability in Nova Scotia. The map is color-coded by suitability level: High (red), Medium (orange), and Low (green). The map shows that the majority of Nova Scotia is currently within the critical habitat range of moose.

# Effect of the relationship between roads and water temperature on salmonid habitat connectivity in Nova Scotia

By Natalie Secen  
Dalhousie University - School of Resource and Environmental Studies



## INTRODUCTION

The purpose of this study is to determine the relationship between roads and water temperature on salmonid habitat connectivity in Nova Scotia. This includes the need to improve habitat quality and connectivity, and to reduce the impact of climate change on the winter range (Lynch et al., 2020).

## METHODS

The study was conducted using a combination of field observations and laboratory experiments. This included the collection of water temperature data and the measurement of salmonid habitat connectivity.

## RESULTS

The results of the study show that there is a significant relationship between roads and water temperature on salmonid habitat connectivity in Nova Scotia. This includes the need to improve habitat quality and connectivity, and to reduce the impact of climate change on the winter range (Lynch et al., 2020).

## CONCLUSIONS

The study shows that there is a significant relationship between roads and water temperature on salmonid habitat connectivity in Nova Scotia. This includes the need to improve habitat quality and connectivity, and to reduce the impact of climate change on the winter range (Lynch et al., 2020).

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# Wetlands in Watersheds: Conservation System Design Through the Lens of Road Ecology

Method

1. A literature review was performed to determine wetland conservation practices, their habitat wetland value conservation, and the impact of various activity and fragmentation on wetland connectivity.

2. Spatial maps of watersheds in Nova Scotia were compiled for a) total impact (roads, wetlands, and wetland connectivity), b) road density, and c) wetland density.

3. Three geographic regions were selected for further analysis based on the presence of watersheds with lowest road density (0.498 - 1.07 km/km<sup>2</sup>). Significant ecological regions have been observed in watersheds with road densities of 0.6 km/km<sup>2</sup>.

4. Two watersheds of top conservation priority were identified for each region with the lowest road density, lowest total impact ranking, and highest wetland density. Watershed areas of conservation priority were also identified.

## RESULTS

• Watersheds are biologically and ecologically linked within a watershed. Further alterations, such as fragmentation roads, has a cascading negative effect.

• Highly significant impacts (i.e. substantial water quality declines, wetland degradation, and riparian systems impacts) are known to occur at 0.6 km/km<sup>2</sup>.

• However, negative ecological impacts have been observed at a watershed road density of 0.6 km/km<sup>2</sup>.

• Given the importance of watershed connectivity to wetland health, connectivity planning at the watershed level could ensure the conservation of associated wetland resources. This includes the need to improve habitat quality and connectivity, and to reduce the impact of climate change on the winter range (Lynch et al., 2020).

• Riparian fields, meadows, and associated natural areas watershed connectivity planning efforts need to occur to allow for biological watersheds.

• Watersheds with high-intensity (low impact) watersheds within urban areas. These areas also have high wetland density and high ecological connectivity in the context of the watershed.

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# A Habitat Suitability Analysis for Cougars in Nova Scotia

By Katherine Dorey  
Master of Resource & Environmental Management, Dalhousie University, Halifax, N.S.



## Introduction

Cougars are thought to be extirpated from Nova Scotia. However, sightings are reported occasionally.

A viable population of cougars never existed in Nova Scotia but individuals move in from New Brunswick.

Human factors are thought to be the most significant barrier to cougar recovery in Nova Scotia. This includes the need to improve habitat quality and connectivity, and to reduce the impact of climate change on the winter range (Lynch et al., 2020).

Humans have a negative perception of large carnivores because they are considered to be a threat to human safety. For this reason, cougars were once hunted which facilitated their extirpation from the province.



## Methods

A habitat suitability analysis for cougars in Nova Scotia was conducted using criteria outlined in a similar study on habitat suitability in the Adirondack Park, NY.

As cougars are largely extirpated from the east, except for Prince, most theoretical dispersal routes likely derive from western populations.

In ANCOVA, four data types were combined: digital elevation model (DEM), topographic slope, distance to riparian habitat, and human population density. Each cell size represents 0.5 km<sup>2</sup> in Fig. 5.

Table 1. Each parameter was categorized and scored out of the five equal weight to each other through some layers have been than the categories.

Parameter	Score
DEM	1-5
Slope	1-5
Distance to riparian habitat	1-5
Human population density	1-5

## Results

Fig. 1. Lightings by County. Cougars are thought to be extirpated from Nova Scotia. However, sightings are reported occasionally.

Fig. 2. Degree of slope. Cougars are thought to be extirpated from Nova Scotia. However, sightings are reported occasionally.

Fig. 3. Distance to roads. Cougars are thought to be extirpated from Nova Scotia. However, sightings are reported occasionally.

Fig. 4. Land cover. Cougars are thought to be extirpated from Nova Scotia. However, sightings are reported occasionally.

Fig. 5. Population density. Cougars are thought to be extirpated from Nova Scotia. However, sightings are reported occasionally.

Fig. 6. Habitat suitability. Cougars are thought to be extirpated from Nova Scotia. However, sightings are reported occasionally.

Fig. 7. Final habitat suitability. Cougars are thought to be extirpated from Nova Scotia. However, sightings are reported occasionally.

Fig. 8. Final habitat suitability. Cougars are thought to be extirpated from Nova Scotia. However, sightings are reported occasionally.

Fig. 9. Final habitat suitability. Cougars are thought to be extirpated from Nova Scotia. However, sightings are reported occasionally.

Fig. 10. Final habitat suitability. Cougars are thought to be extirpated from Nova Scotia. However, sightings are reported occasionally.

Fig. 11. Final habitat suitability. Cougars are thought to be extirpated from Nova Scotia. However, sightings are reported occasionally.

Fig. 12. Final habitat suitability. Cougars are thought to be extirpated from Nova Scotia. However, sightings are reported occasionally.

Fig. 13. Final habitat suitability. Cougars are thought to be extirpated from Nova Scotia. However, sightings are reported occasionally.

Fig. 14. Final habitat suitability. Cougars are thought to be extirpated from Nova Scotia. However, sightings are reported occasionally.

Fig. 15. Final habitat suitability. Cougars are thought to be extirpated from Nova Scotia. However, sightings are reported occasionally.

Fig. 16. Final habitat suitability. Cougars are thought to be extirpated from Nova Scotia. However, sightings are reported occasionally.

Fig. 17. Final habitat suitability. Cougars are thought to be extirpated from Nova Scotia. However, sightings are reported occasionally.

## Discussion

A study on cougars in the Adirondack Park in 1991 identified the possibility of a small population of cougars based on sightings of adults and kittens.

It is important to maintain connectivity in Nova Scotia landscape for large mammals such as the cougar that act as an umbrella species.

The main areas of concern for maintaining the connectivity of wildlife habitat, as seen in Fig. 5, are road areas leading from Miramichi to Halifax to Truro.

Very small corridors occur in these areas, which should be of focus when considering connectivity of cougars.

Further, these roads are a major obstacle for cougars moving from New Brunswick to reach the southern part of Nova Scotia where there are large areas of suitable habitat.

Table 1. Each parameter was categorized and scored out of the five equal weight to each other through some layers have been than the categories.

Parameter	Score
DEM	1-5
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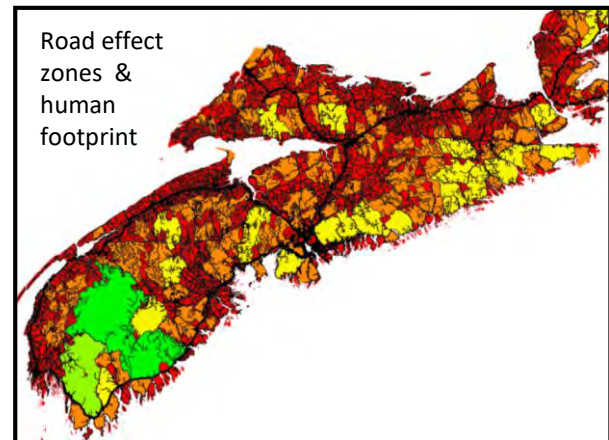
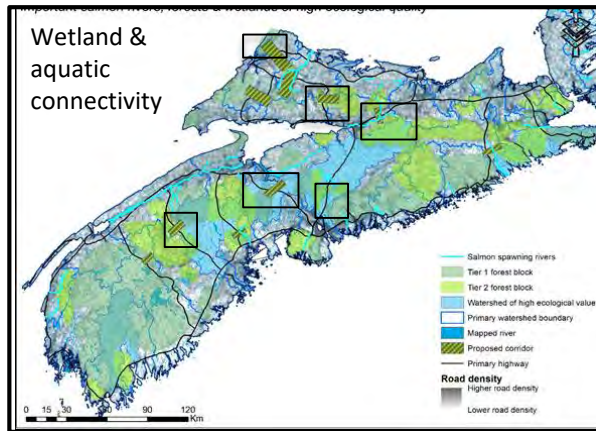
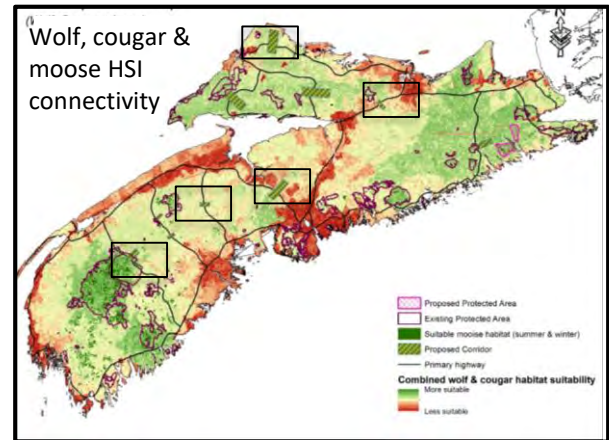
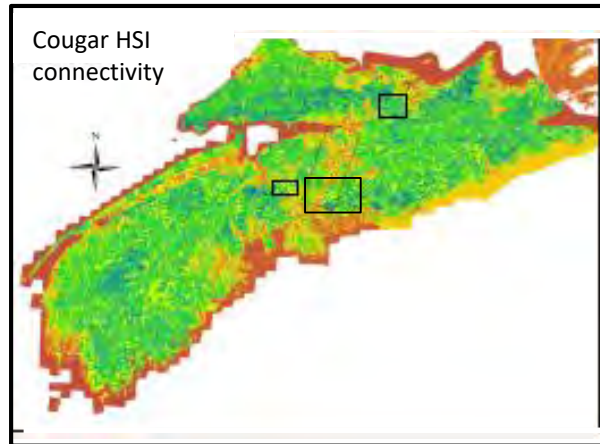
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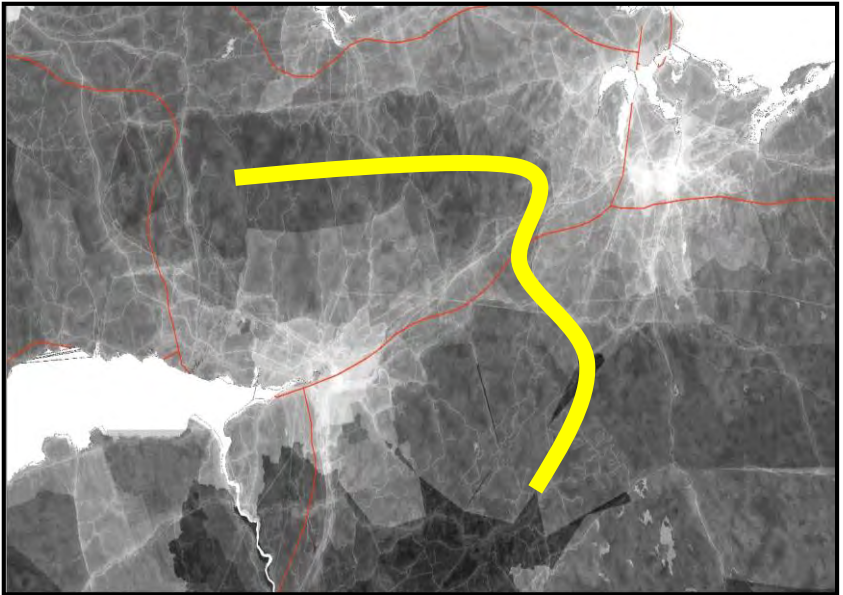
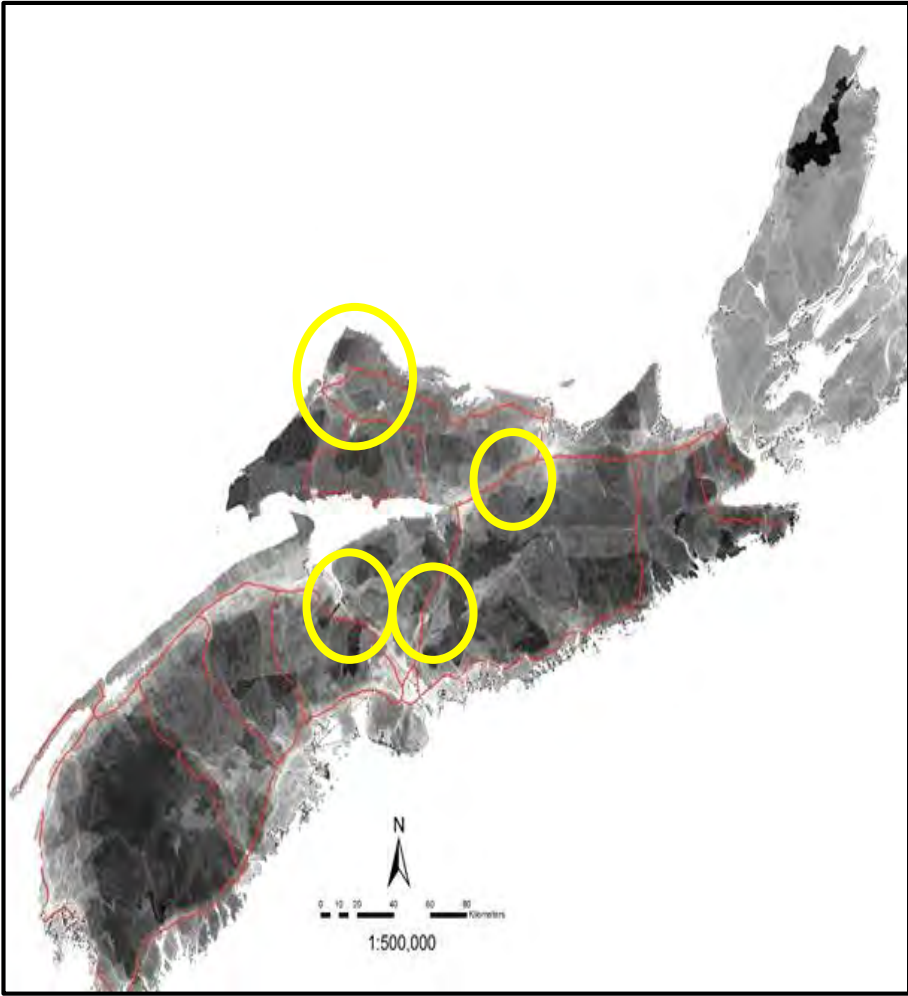
Table 1. Each parameter was categorized and scored out of the five equal weight to each other through some layers have been than the categories.



# Key provincial-scale pinch points of connectivity for various species, ecosystems and processes



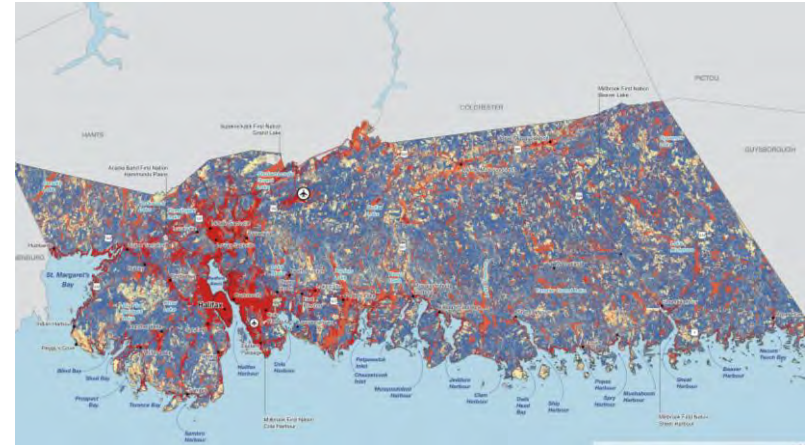
# Key areas for maintaining & restoring connectivity across highways



# Halifax Green Network Plan (2018)



State of the Landscape Report

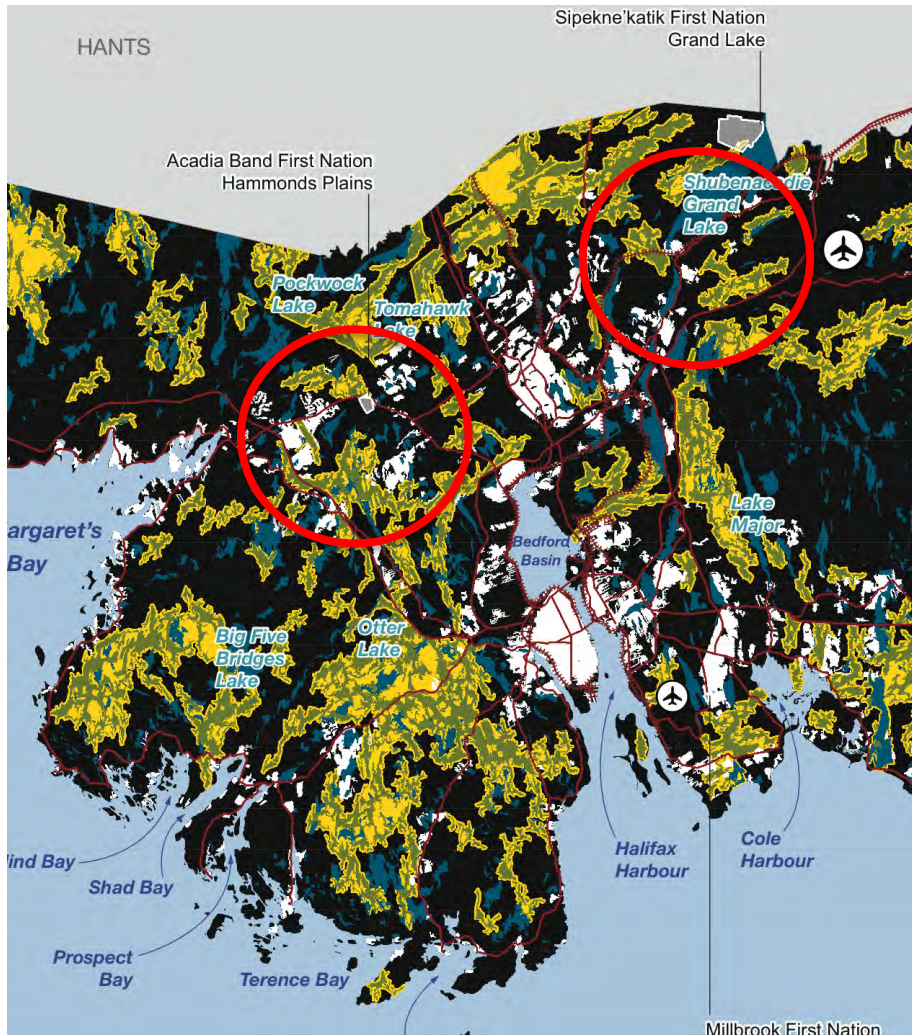


Land cover friction to wildlife movement



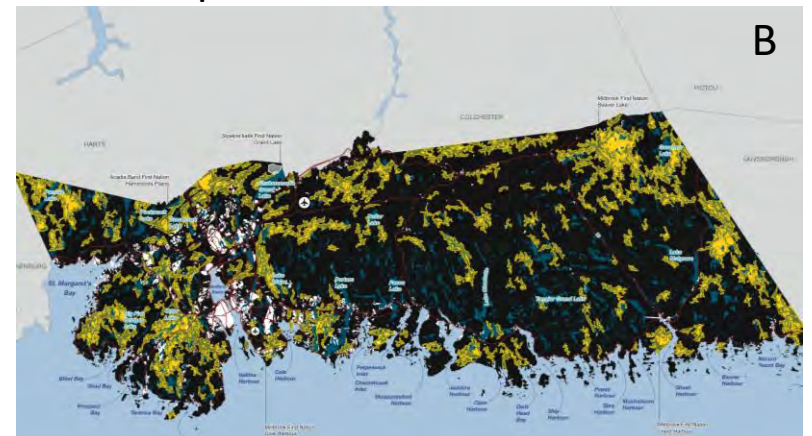
Landscape connectivity

# Generalized connectivity & pinch points to wildlife movement

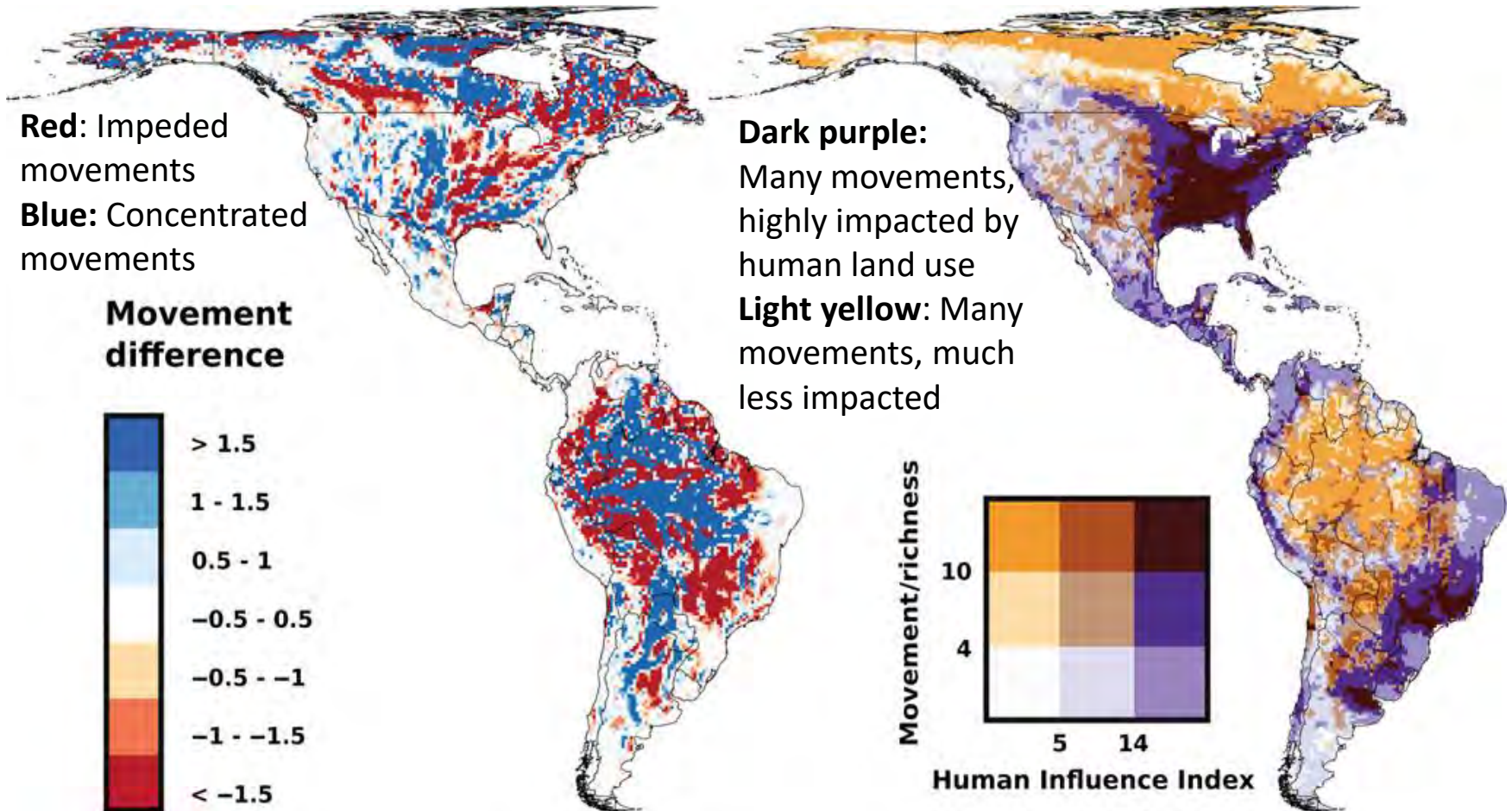


A. Generalized connectivity

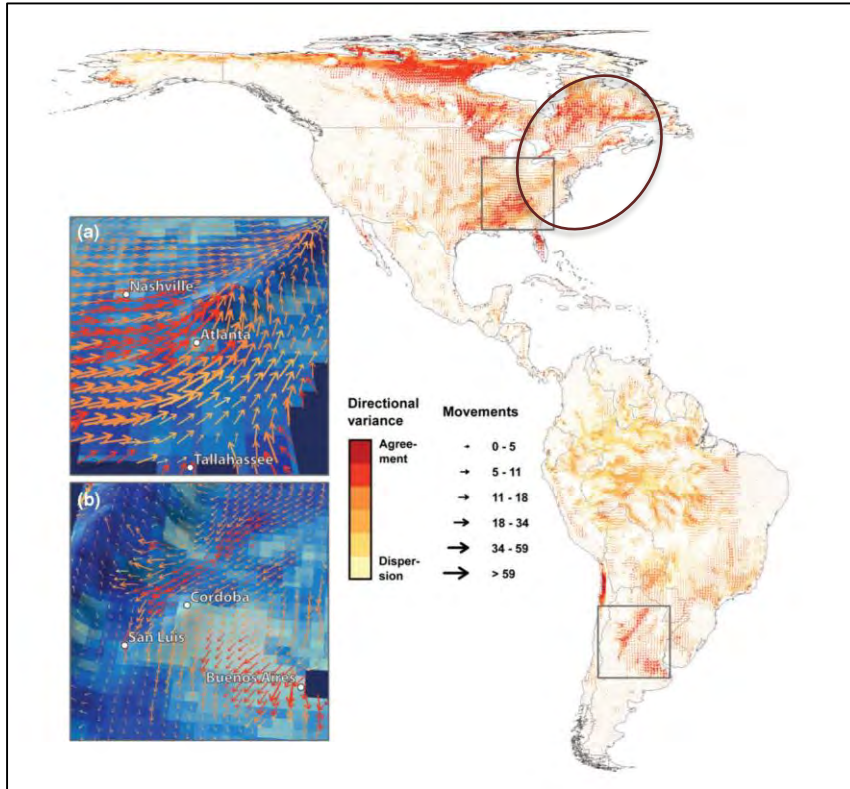
B. Pinch points to wildlife movement



# Climate driven species movements via routes that avoid human land use



(Lawler et al. 2015)



**Cool Green Science**

Smarter By Nature

| CLIMATE CHANGE |

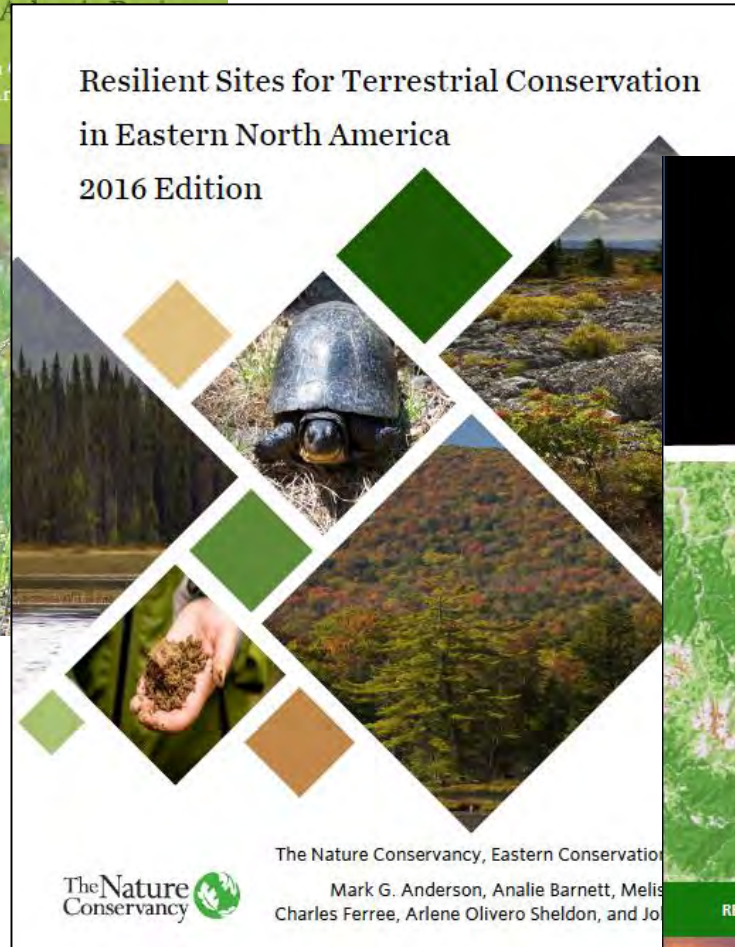
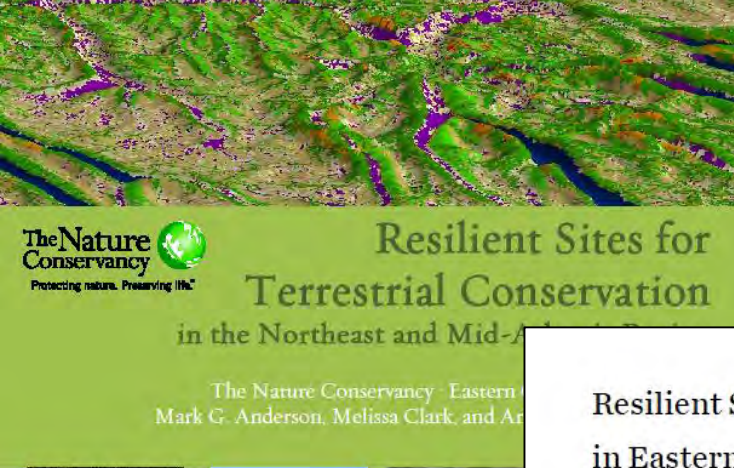
**Migration in Motion: Visualizing Species Movements Due to Climate Change**

BY JUSTINE E. HAUSHEER  
AUGUST 19, 2016 | Follow Justine

<https://blog.nature.org/science/2016/08/19/migration-in-motion-visualizing-species-movements-due-to-climate-change/>

(Lawler et al. 2015)

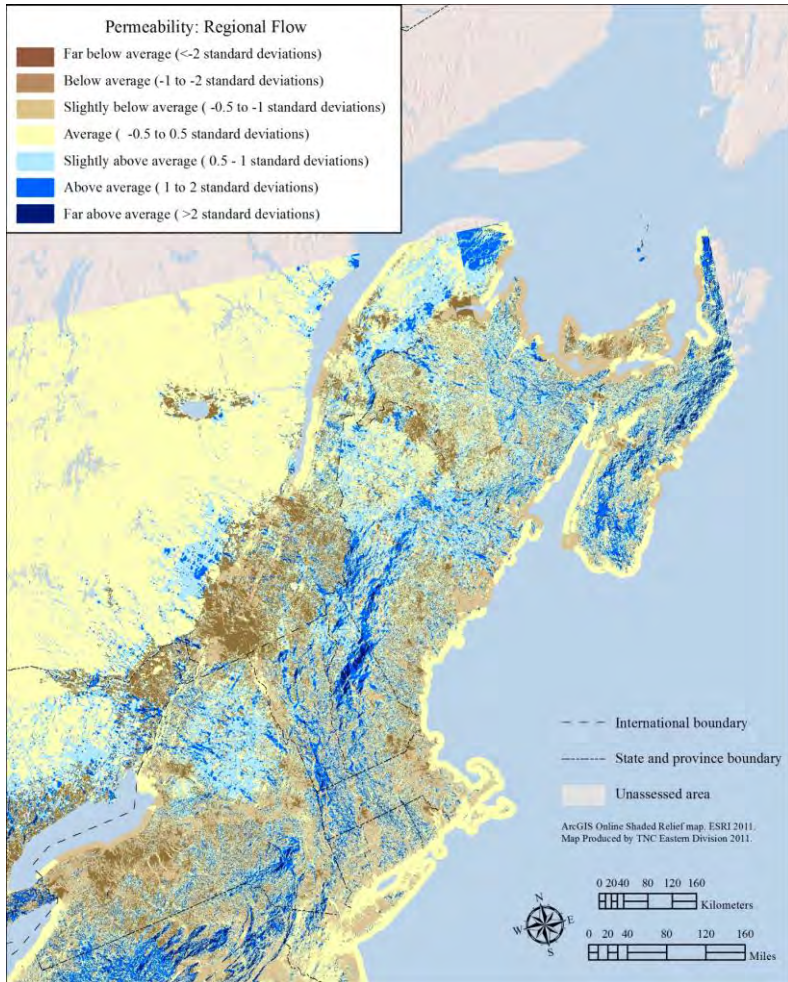
# Resilient sites & Regional flows



(Anderson et al. 2012; 2016a,b)

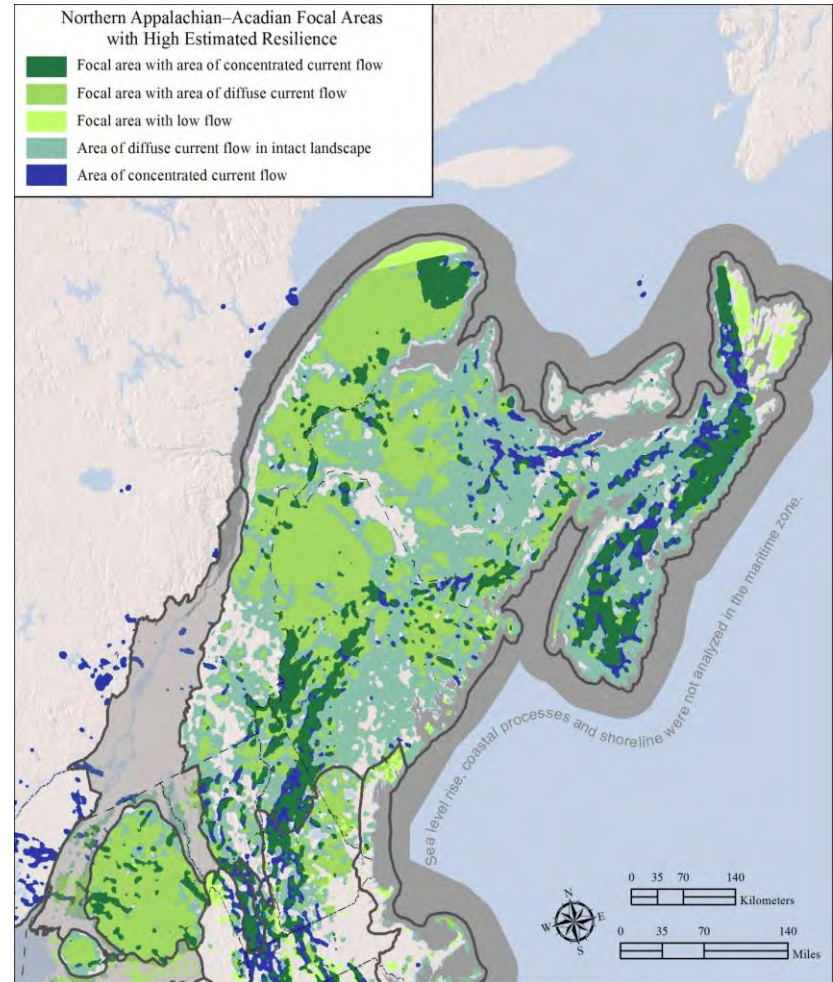
# Regional flows

Anderson et al. 2012



# Resilience and regional flows

Anderson et al. 2012





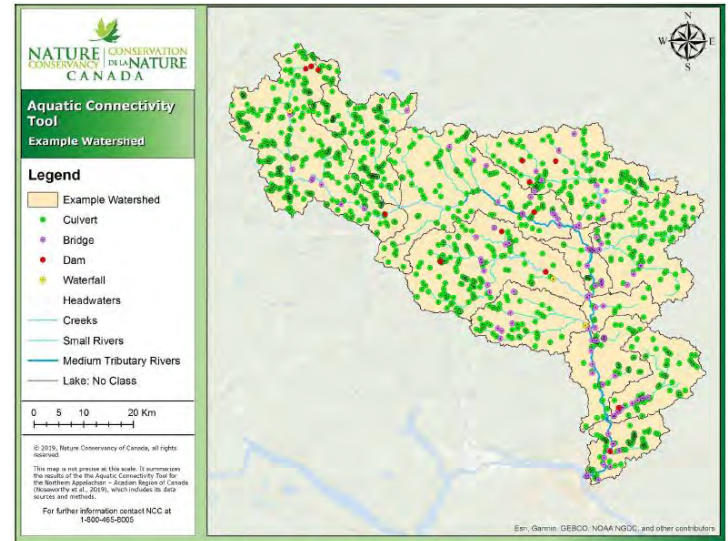
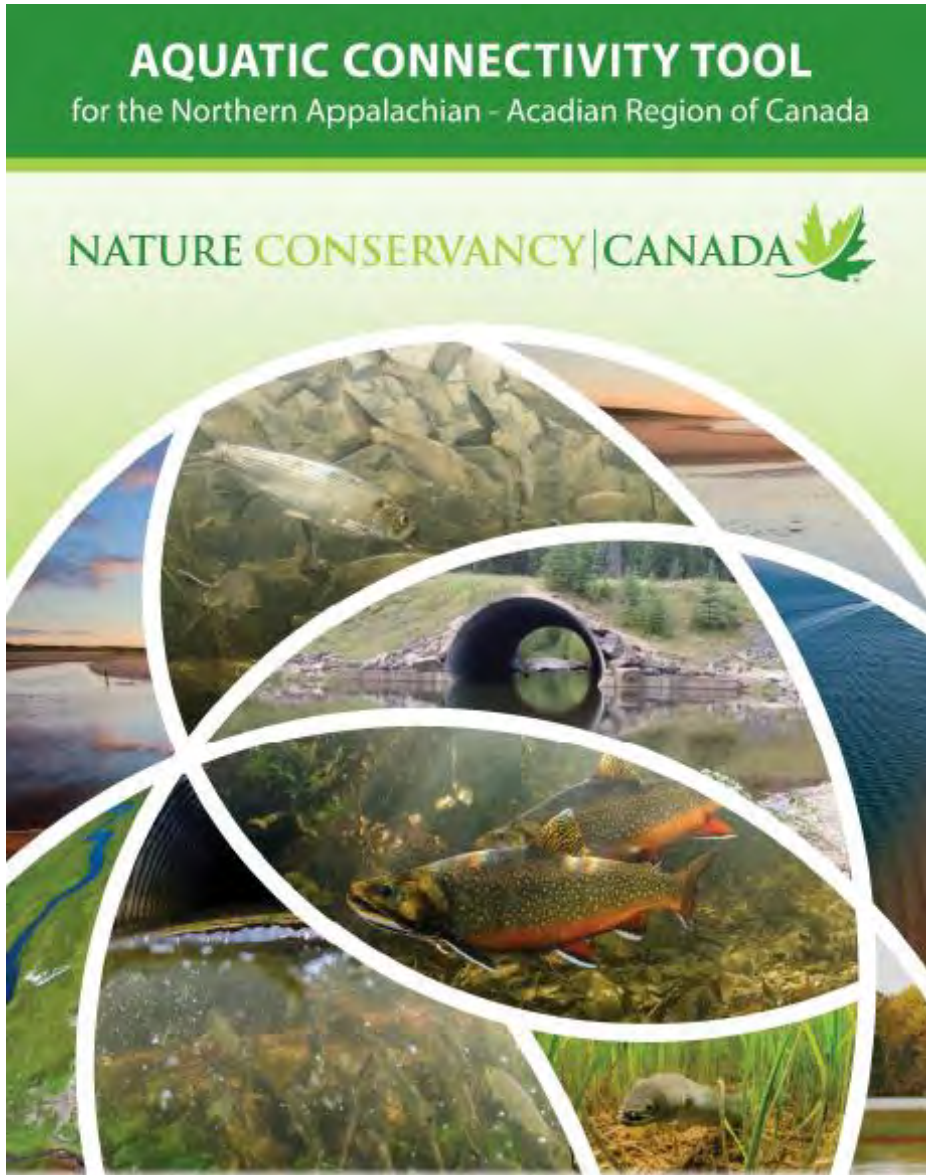
# Prioritized resilient & connected sites

(Anderson et al. 2016)

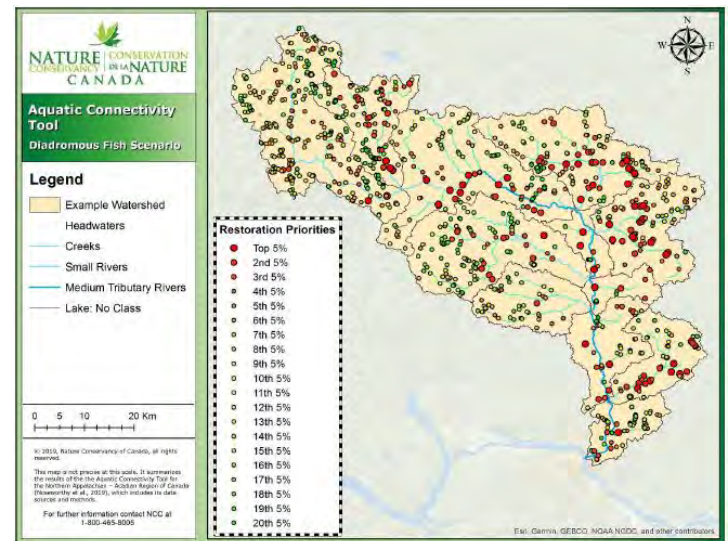


Resilient areas that meet criteria for diversity and permeability, and the linkages between sites that have high flow and connect three or more diversity features





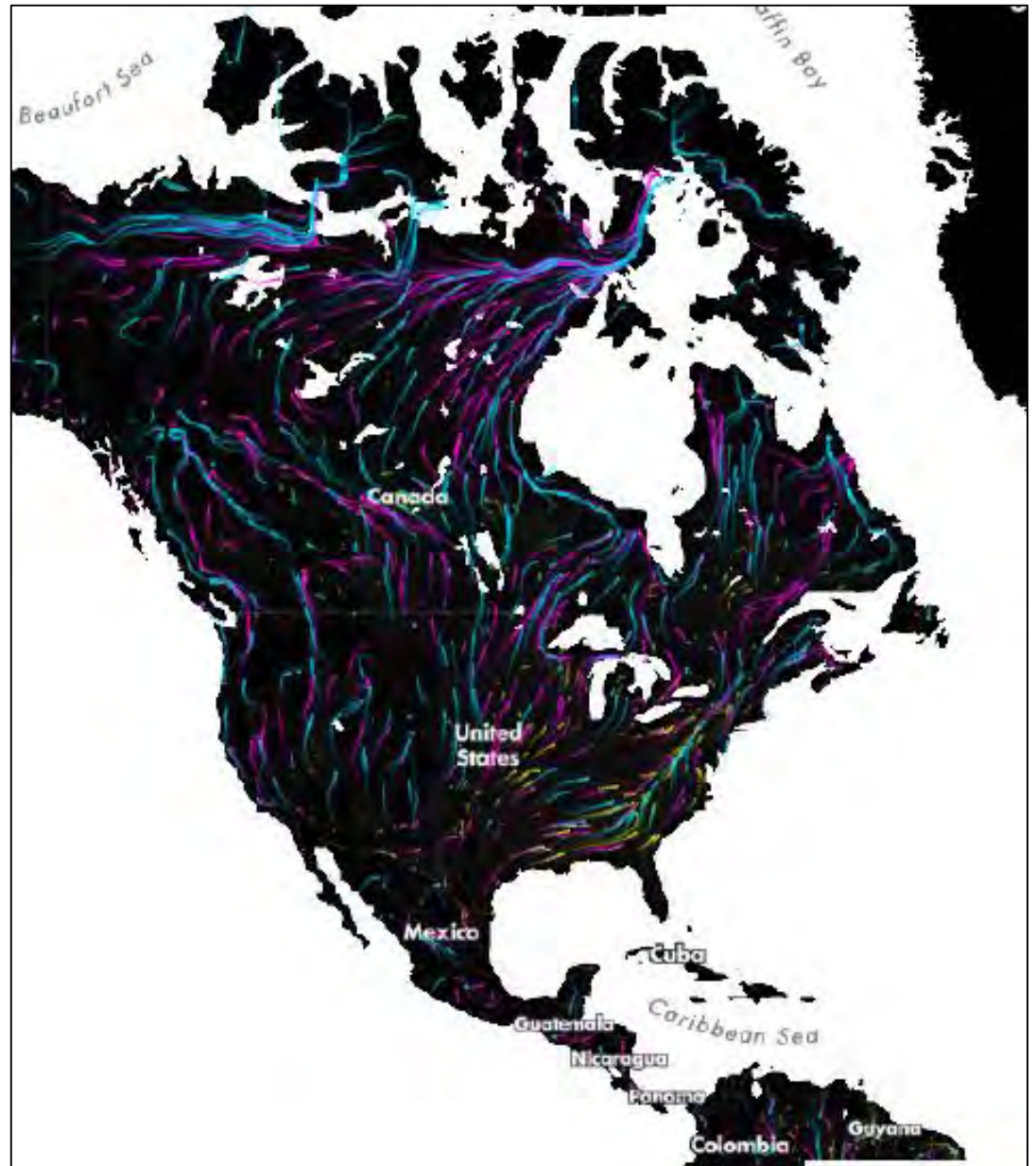
Culverts, dams, bridges, waterfalls



Restoration priorities for diadromous fish

**Migration in motion:  
Visualizing species  
movements due to climate  
change**

<https://blog.nature.org/science/2016/08/19/migration-in-motion-visualizing-species-movements-due-to-climate-change/>





Thank you

[karen.beazley@dal.ca](mailto:karen.beazley@dal.ca)



## Resolution 40-3, A lever to ecological connectivity

M<sup>rs</sup> Danielle St-Pierre, director (Co-chair)

Mr. John Austin, director (Co-Chair)

# Presentation Plan

- ▶ What is the CNEG-ECP ?
- ▶ An overview of connectivity
- ▶ Resolution 40-3
  - Its content
  - The engagements
  - Implementation
- ▶ Working group on the Implementation of Resolution 40-3 (CNEG-ECP)
  - Accomplishments since 2017
  - Goals, Objectives and Actions
  - Uncoming actions
- ▶ Key messages

# R40-3, A lever to ecological connectivity CNEG-ECP

Conference of New England Governors and Eastern Canadian Premiers (NEG-ECP)

- ▶ 5 provinces and 6 states
- ▶ **Promote the participants' interests through cooperation** (public and private sectors)
  - Develop networks and relations
  - Carry out collective actions
  - Support and promote regional initiatives
  - Carry out research projects
  - Heighten public awareness



# R40-3, A lever to ecological connectivity

## CNEG-ECP



Opening session of the 41st CNEG-ECP, August 2017

## Striking achievements

- ▶ 1984: Establishment of the Environment Committee
- ▶ 1988: Adoption of an initial action plan on acid rain
- ▶ 2001: Adoption of the first intergovernmental action plan on climate change
- ▶ 2005: The Climate Group granted the Low Carbon Leaders of the Decade award to the CNEG-ECP
- ▶ 2009: The region attained its first greenhouse gas emission reduction target (return to 1990 levels by 2010)
- ▶ 2009: Recognition of hydroelectricity as a clean, renewable energy source
- ▶ 2013: The Climate Group granted the Leadership Award to the CNEG-ECP
- ▶ 2017: Addition of a B2B linkage program at the annual conference



# R40-3, A lever to ecological connectivity CNEG-ECP



40th Annual Conference of New England Governors and Eastern Canadian Premiers - Boston Massachusetts 2016  
40e Conférence annuelle des gouverneurs de la Nouvelle-Angleterre et des premiers ministres de l'Est du Canada

## **RESOLUTION 40-3**

### **RESOLUTION ON ECOLOGICAL CONNECTIVITY, ADAPTATION TO CLIMATE CHANGE, AND BIODIVERSITY CONSERVATION**

Adopted on August 29, 2016

# R40-3, A lever to ecological connectivity

## What is Ecological Connectivity?

« The degree to which similar facets of the landscape such as habitats or vegetation patches are interconnected to facilitate movements of plants, animals, and the attendant ecological processes »



# R40-3, A lever to ecological connectivity

## Ecological connectivity

Why **it's** important?

To meet species habitat requirements,  
for population dynamics, for  
maintaining ecological processes

Fragmentation : an issue for  
both terrestrial and aquatic  
ecosystems

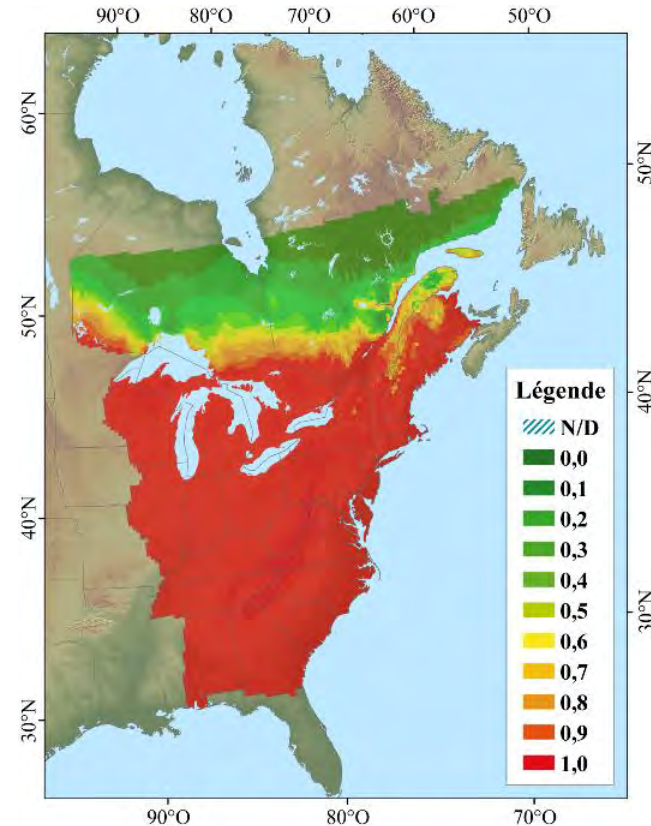


# R40-3, A lever to ecological connectivity

## Ecological connectivity

A specific challenge against a backdrop of climate change

- ▶ Observation: the environment will quickly change ...
- ▶ Species options: adapt or relocate
- ▶ Increase connectivity = one of the main recommendations for biodiversity conservation in the context of climate change



# R40-3, A lever to ecological connectivity

## Resolution: Its content

Recognizes the challenges of maintaining a connected landscape

- ▶ « Maintaining and restoring ecological connectivity is an important strategy for boosting the resilience of the region's native ecosystems »
- ▶ « Connected habitats provide the natural pathways necessary for fish, wildlife and plants to move to meet their life needs and to find suitable habitats as climate conditions change »



# R40-3, A lever to ecological connectivity

## Resolution: Its content

Recognizes the challenges posed by connectivity

- ▶ « Transportation infrastructure can be designed and sited to ensure habitat connectivity ... **significant** public safety, economic and climate resiliency benefits to communities »
- ▶ « Effective action requires collaboration across borders »



## R40-3, A lever to ecological connectivity

Resolution: A call to collaborate throughout the region



« The New England Governors and Eastern Canadian Premiers recognize the importance of ecological connectivity for the adaptability and **resilience of our region's ecosystems, biodiversity,** and human communities facing climate change »

« ...recognize the need to work across borders and landscapes to advance efforts to maintain and restore ecological connectivity »

# R40-3, A lever to ecological connectivity

## Resolution: The engagements



## Conservation

- ▶ « instruct agencies within their jurisdictions to elevate ecological connectivity **...to encourage regional collaboration** »
- ▶ « advise agencies within their jurisdictions to support land protection and planning efforts that maintain and improve connectivity»
- ▶ « to collaborate, where possible, to document the current state of forest and habitat connectedness... »
- ▶ « to pursue collective efforts to control the invasion of exotic species and the spread of wildlife diseases... **to protect the region's biodiversity and preserve the health** »



# R40-3, A lever to ecological connectivity

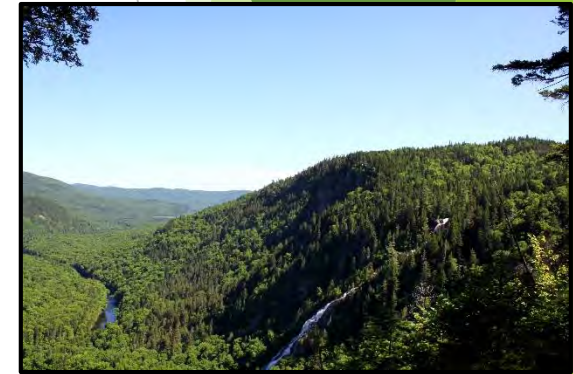
## Resolution: The engagements

### Planning

« Encourage land-use planning bodies at all levels, especially in the municipalities, to include objectives respecting habitat connectivity in their land-use planning policies »

### Development

« Promote the sustainable management of public and private lands and aquatic systems that protect or enhance connectivity »



# R40-3, A lever to ecological connectivity

## Resolution: The engagements

### Transportation



- ▶ « instruct transportation and natural resource agencies to explore opportunities to develop, modify and expand federal, provincial and state programs to enhance transportation in order to improve habitat connectivity »



- ▶ « Collaborate in efforts to determine sound design and proper size of transportation infrastructure to enable species to move about and facilitate adaptation to the anticipated changes in precipitation and peak flow stemming from climate change »



# R40-3, A lever to ecological connectivity

## Resolution: Implementation

### Working Group

- ▶ Co-Chair by Vermont and Québec
- ▶ Each jurisdiction represented by Wildlife agencies
- ▶ Final Implementation plan due 2020



# R40-3, A lever to ecological connectivity

Working group for the Implementation of the Resolution 40-3

## Accomplishments since 2017

- ▶ Developed Working Group administrative structure (e.g., terms of reference)
- ▶ Working group meetings (Sept. 2017, June 2018, April 2019) and regular conference calls
- ▶ Interim report and draft implementation plan (summer 2018)
- ▶ Focusing on assessing current science, sharing information, and creating framework for long-term collaboration

# R40-3, A lever to ecological connectivity

Working group for the Implementation of the Resolution 40-3

## Goals, Objectives and Actions

Goal 1 - Regional and local coordination

At the regional level (Northeast jurisdictions)

- ▶ Connectivity Working Group

At each jurisdiction level

Examples:

- ▶ Interdepartmental Committee
- ▶ Ecological corridors project of the Action-Climate program by NCC

# R40-3, A lever to ecological connectivity

## Working group for the Implementation of the Resolution 40-3

### Goal 2 - Sharing information

#### Information sharing tools

- ▶ Development of a web platform (in progress)

#### Conferences and workshops

- ▶ Conference on road ecology and climate change adaptation (October 2017) - Quebec
- ▶ Northeastern Transportation and Wildlife Conference (sept. 2018) - Massachusetts
- ▶ The Canadian Maritimes Ecological Connectivity Forum (april 2019) - Nova Scotia

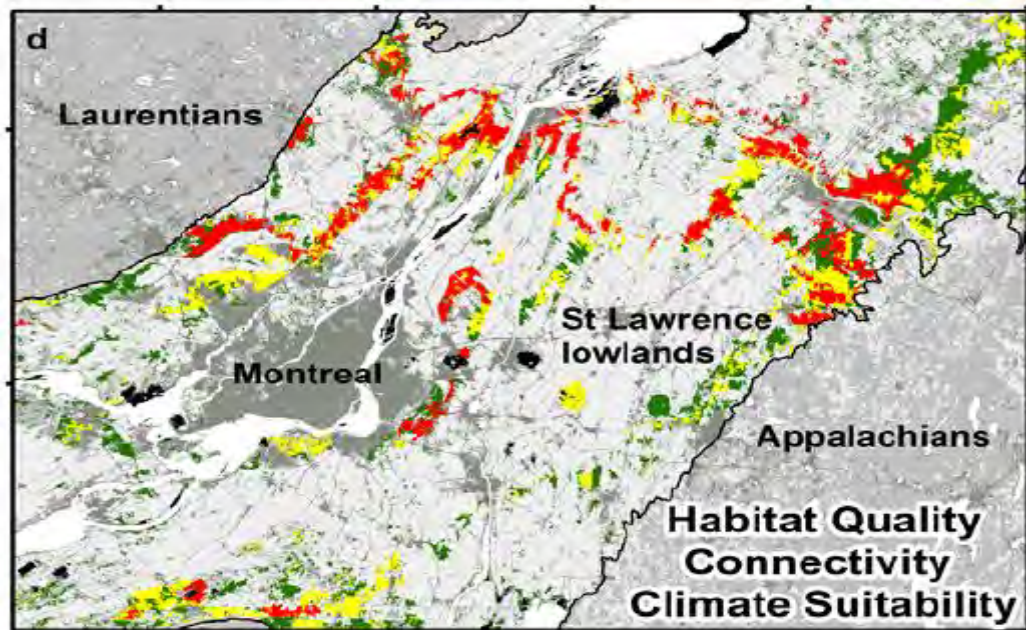


# R40-3, A lever to ecological connectivity

Working group for the Implementation of the Resolution 40-3

## Goal 3 - Assessment of Current Science on Connectivity

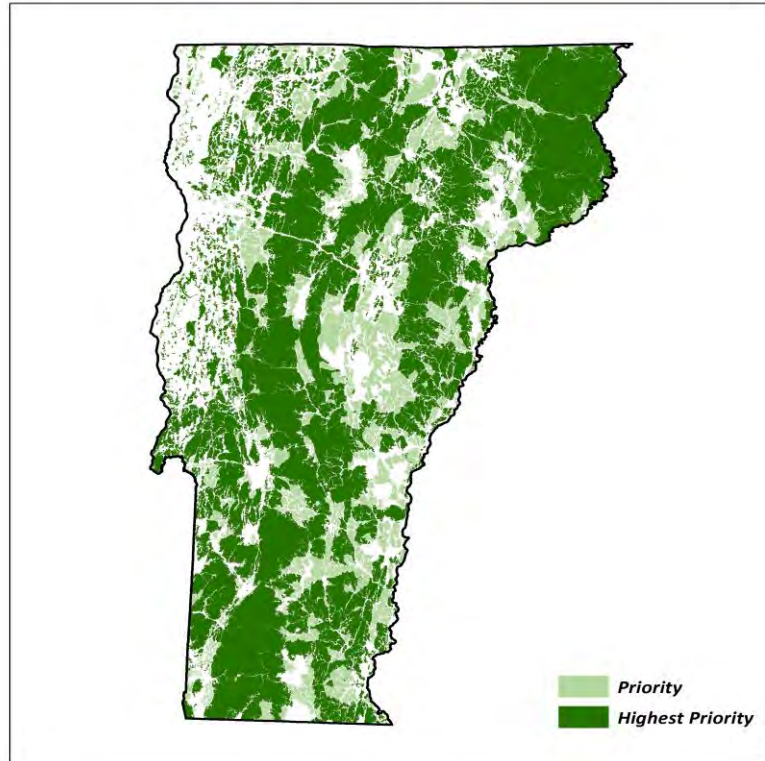
Jurisdiction Report on the Current State of Knowledge



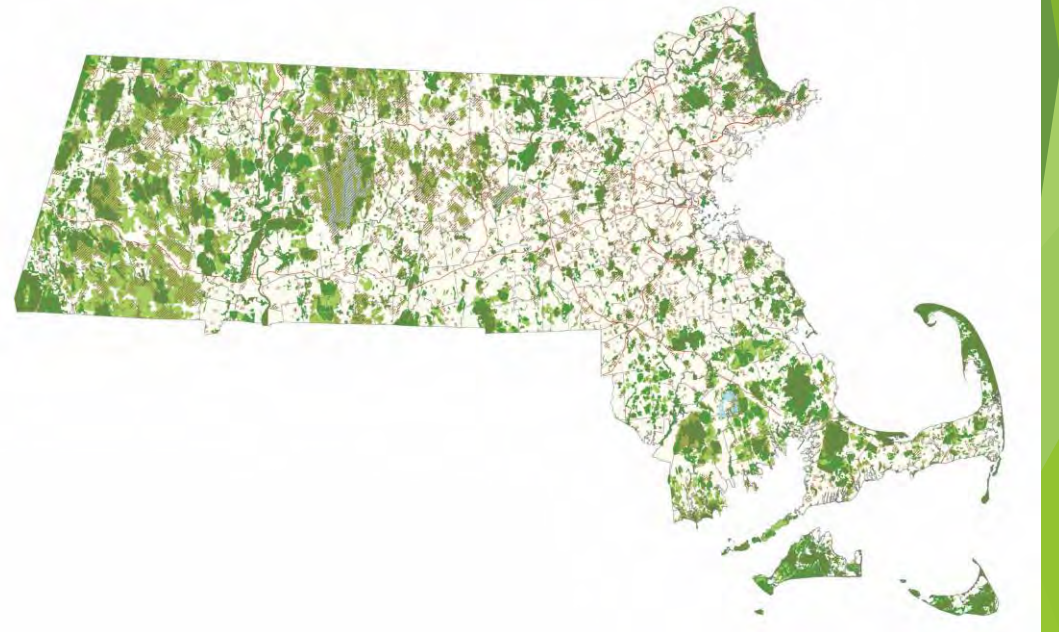
Albert et al. 2017

# Landscape Scale Science

Vermont Conservation Design - Ecological Connectivity Analysis at the State-level



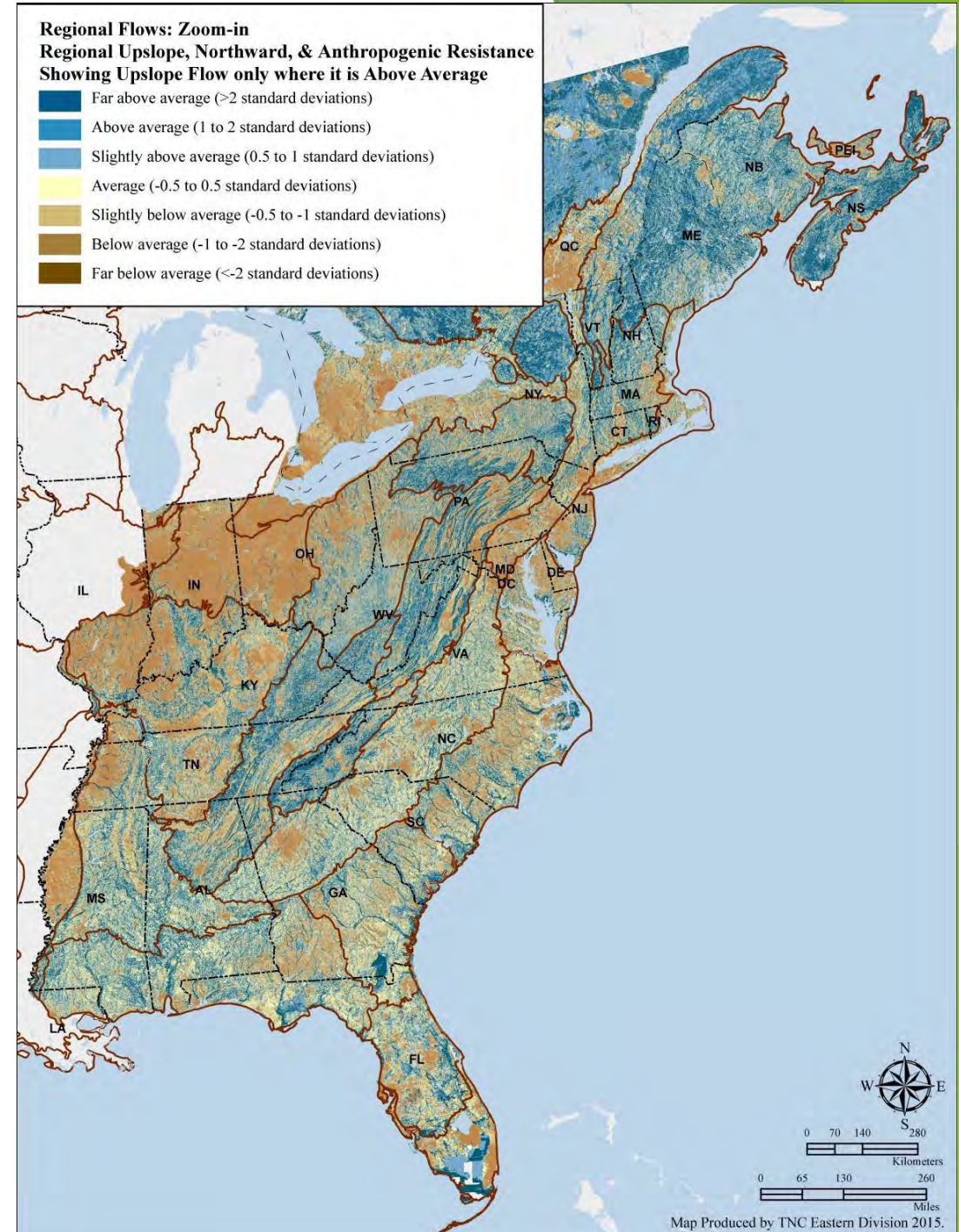
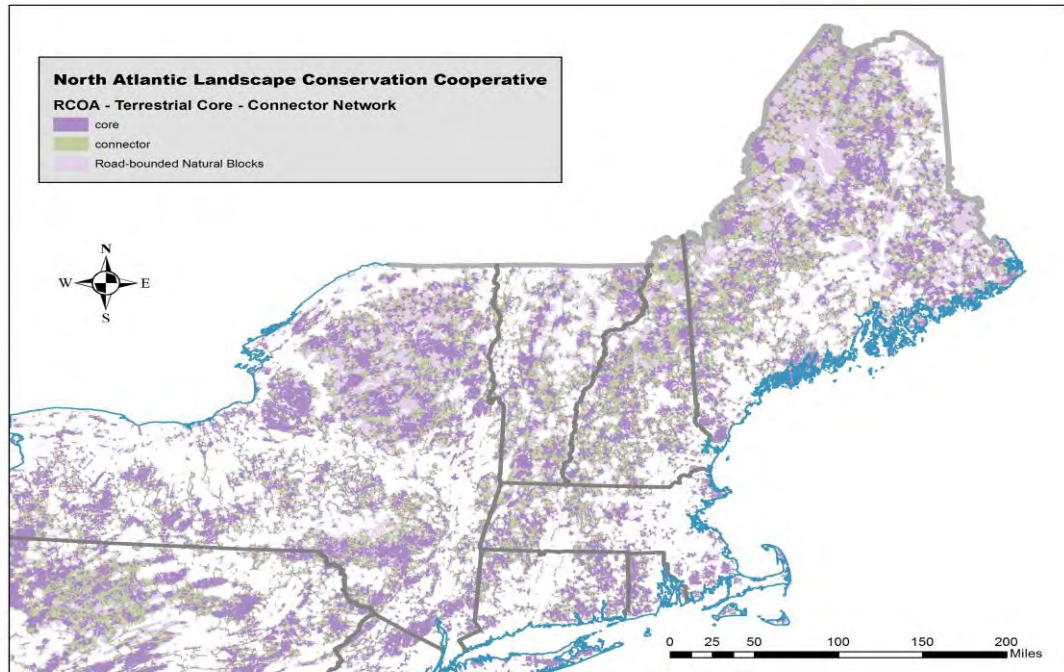
Massachusetts BioMap





# Regional Scale Connectivity Science

The Nature Conservancy  
Resilient and Connected Landscapes  
for Terrestrial Conservation

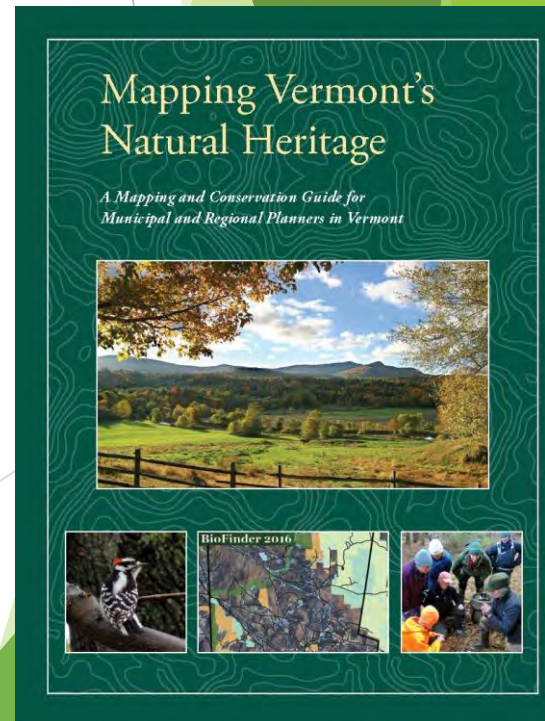
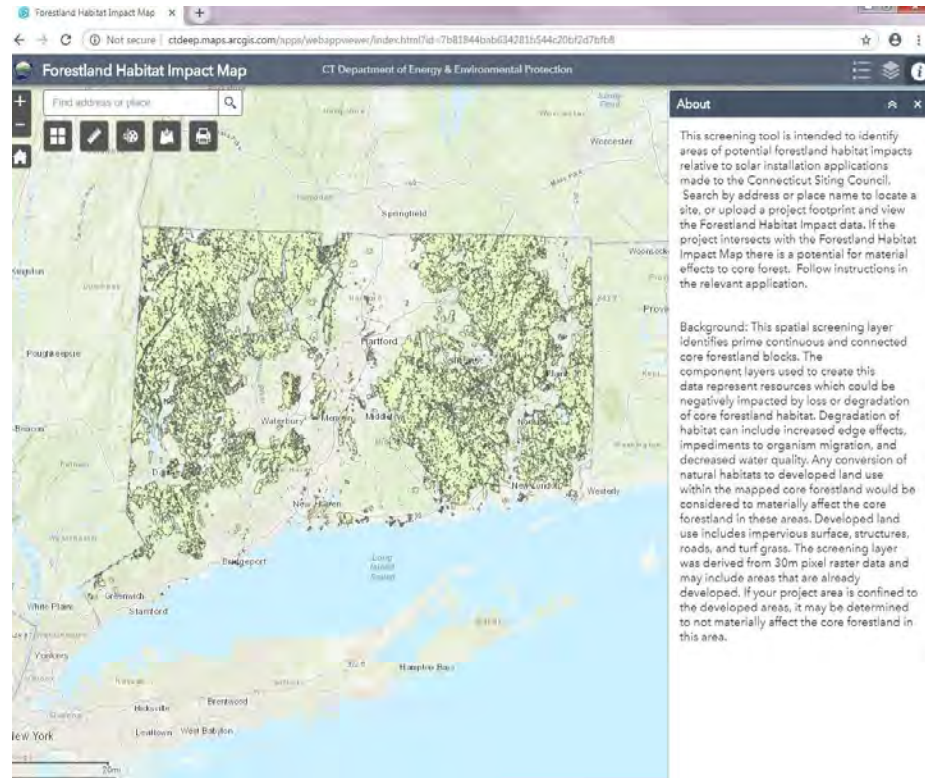


# R40-3, A lever to ecological connectivity

## Working group for the Implementation of the Resolution 40-3

### Goals 4 - Integrate connectivity strategies into land use planning

- ▶ Recognize different legal authority for each jurisdiction
- ▶ Opportunities for sharing information used to guide land use planning and regulation - Build consistency
- ▶ Base guidance on consistent science that illustrates the connected landscape
- ▶ Example - Act 171 in Vermont



## R40-3, A lever to ecological connectivity

### Working group for the Implementation of the Resolution 40-3

- ▶ Goal 7 - Land management and stewardship
  - ▶ In Quebec, government is working to integrate connectivity during forest planning in public forests (ecosystem management in spruce forests, work in progress for fir forests)
  - ▶ NH works with industrial forest landowners to maintain high elevation wildlife corridors in forest management plans



# R40-3, A lever to ecological connectivity

## Working group for the Implementation of the Resolution 40-3

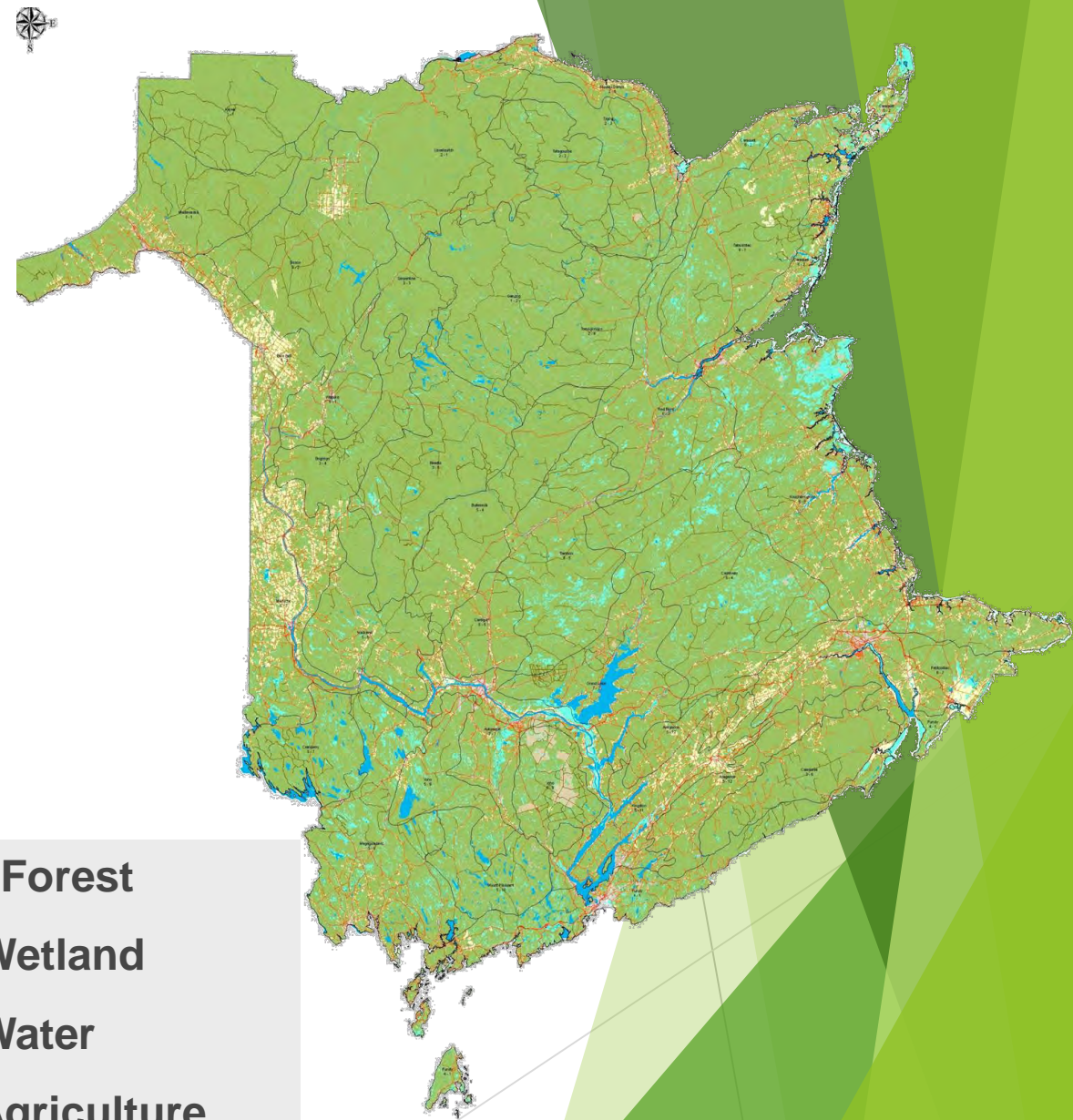
### Goal 5 - Transportation

Establish mechanisms for collaboration between transportation and natural resource agencies



# New Brunswick

- **Protecting Connectivity Corridors** - Chignecto Isthmus and 3-Boarders regions recognized as areas for focused efforts in NB proposal to **Pathway to Canada (Biodiversity) Target 1** (17% protected by 2020).
- **Science and Analysis** - Nature Conservancy Canada (Atlantic Region) proposal to model ecological (structural) connectivity across New Brunswick to aid land-use decisions.
- **Transportation and Infrastructure** – Ongoing efforts to mitigate connectivity issues generated through fencing...



**85% Forest**  
**5% Wetland**  
**2% Water**  
**4% Agriculture**  
**2% Urban & infrastructure**



# Tidal Wetland Restoration Muddy Creek

Route 28 road crossing replacement  
Chatham/Harwich, Cape Cod, MA

Pre-restoration



Post-restoration, 2016



# Goal 6 - Land conservation

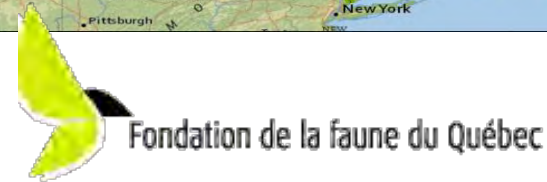
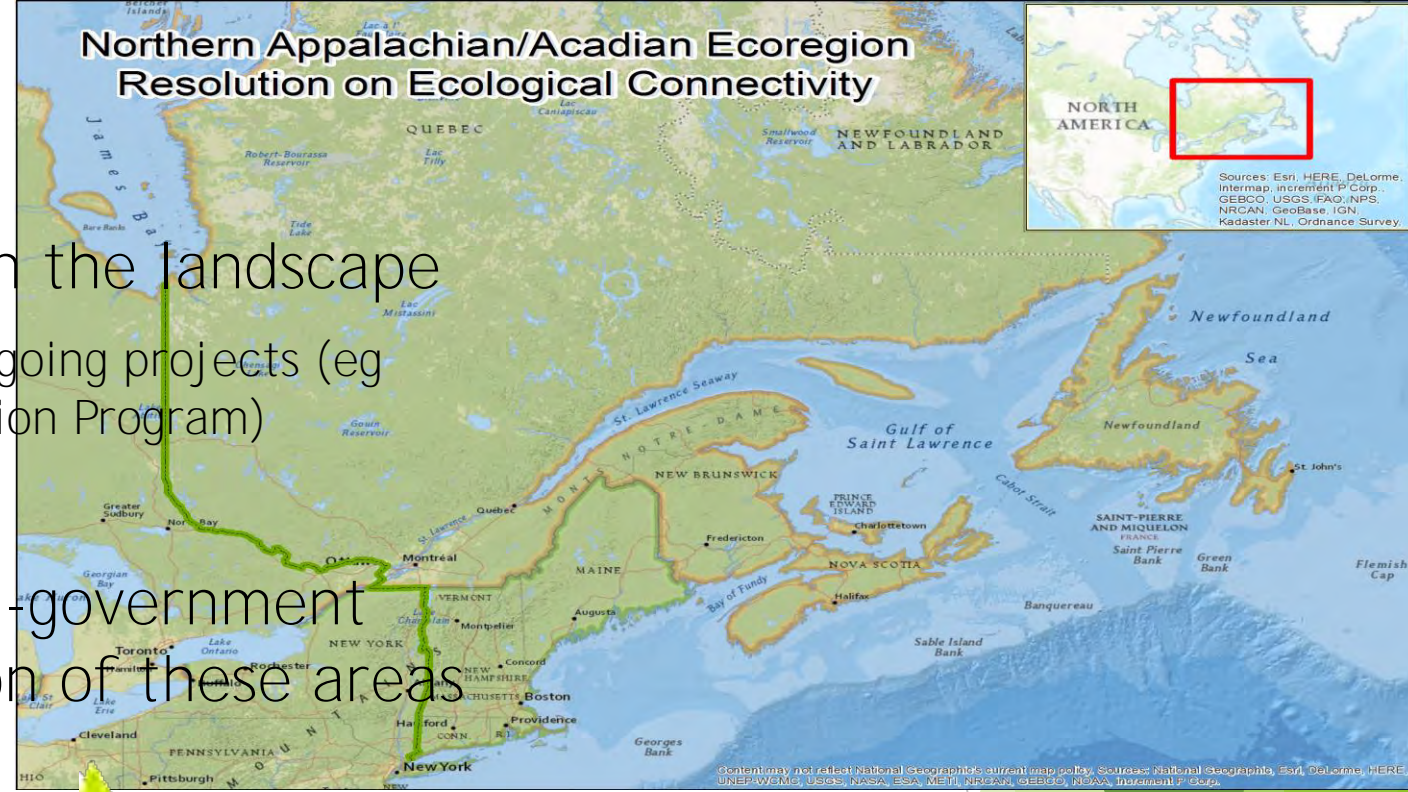
## Identify priority connectivity areas on the landscape

- ▶ Based on Science established in Goal 3 and ongoing projects (eg "Climate Corridors" project of the Climate Action Program)

## Collaboration of government and non-government organizations to promote conservation of these areas

### Examples:

- ▶ Funding to support projects in connectivity
- ▶ Consideration of Connectivity in Financing Programs for Land Acquisition and Restoration



# R40-3, A lever to ecological connectivity

## Key messages

1. Ecological connectivity is essential to the health of our regional environment and to enable effective adaptation to changing climatic conditions
2. Numerous conservation efforts offer opportunities to expand for greater success in the region
3. Resolution 40-3 raises the bar with expectations for success
  - ▶ Ensure collaboration, partnerships and information sharing
  - ▶ Establish a clear vision for a functional, ecologically connected landscape based on science
  - ▶ Promote a coordinated approach to conservation of the connected landscape among all jurisdictions







Resolution 40-3, A lever to  
ecological connectivity

Thank You!

Questions ?

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▶ [John.Austin@vermont.gov](mailto:John.Austin@vermont.gov)