

Climate Change & Land Conservation

Jeff Walk

The Nature
Conservancy



Protecting nature. Preserving life.™

The Greenhouse Effect

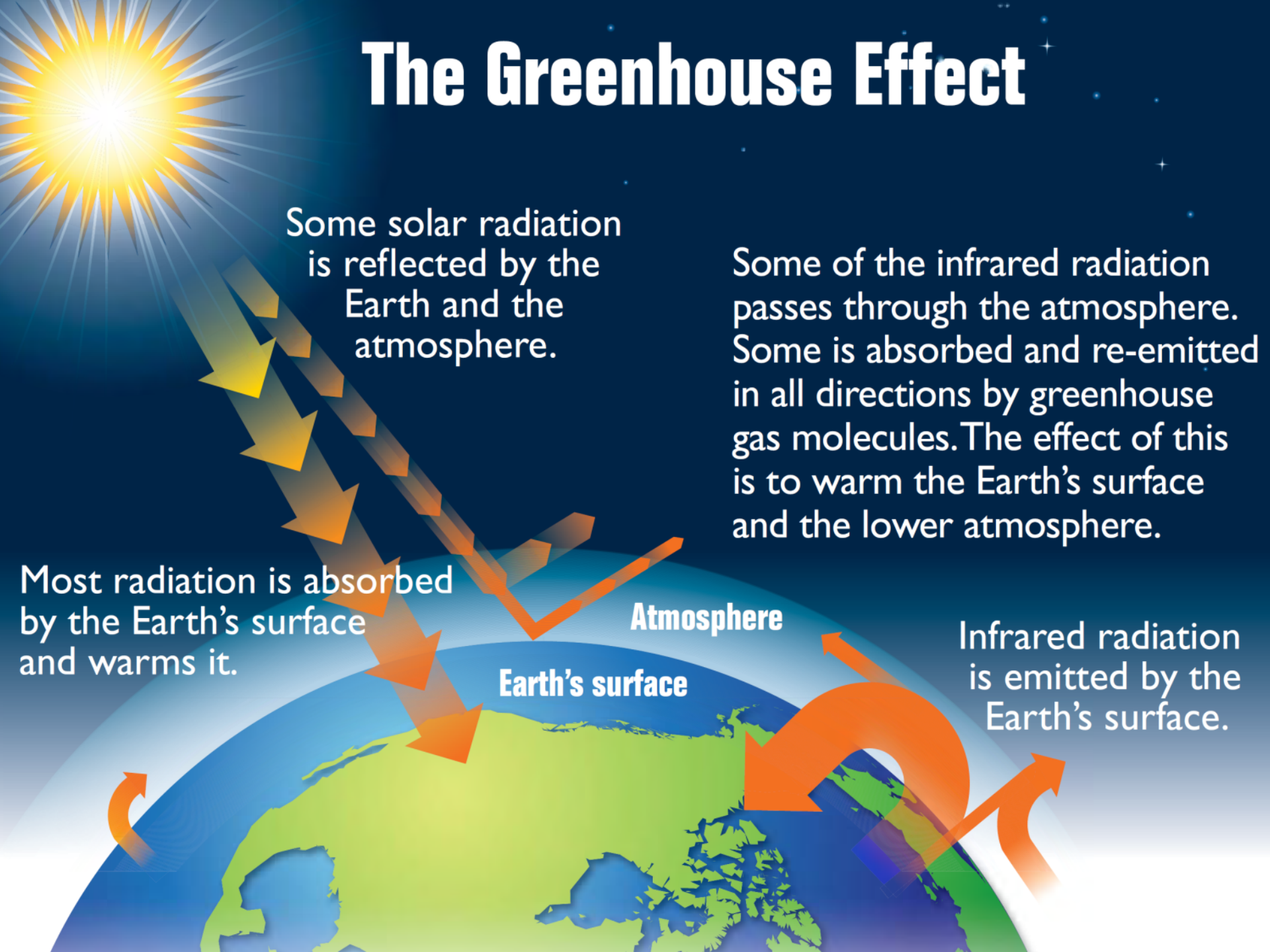
Some solar radiation is reflected by the Earth and the atmosphere.

Some of the infrared radiation passes through the atmosphere. Some is absorbed and re-emitted in all directions by greenhouse gas molecules. The effect of this is to warm the Earth's surface and the lower atmosphere.

Most radiation is absorbed by the Earth's surface and warms it.

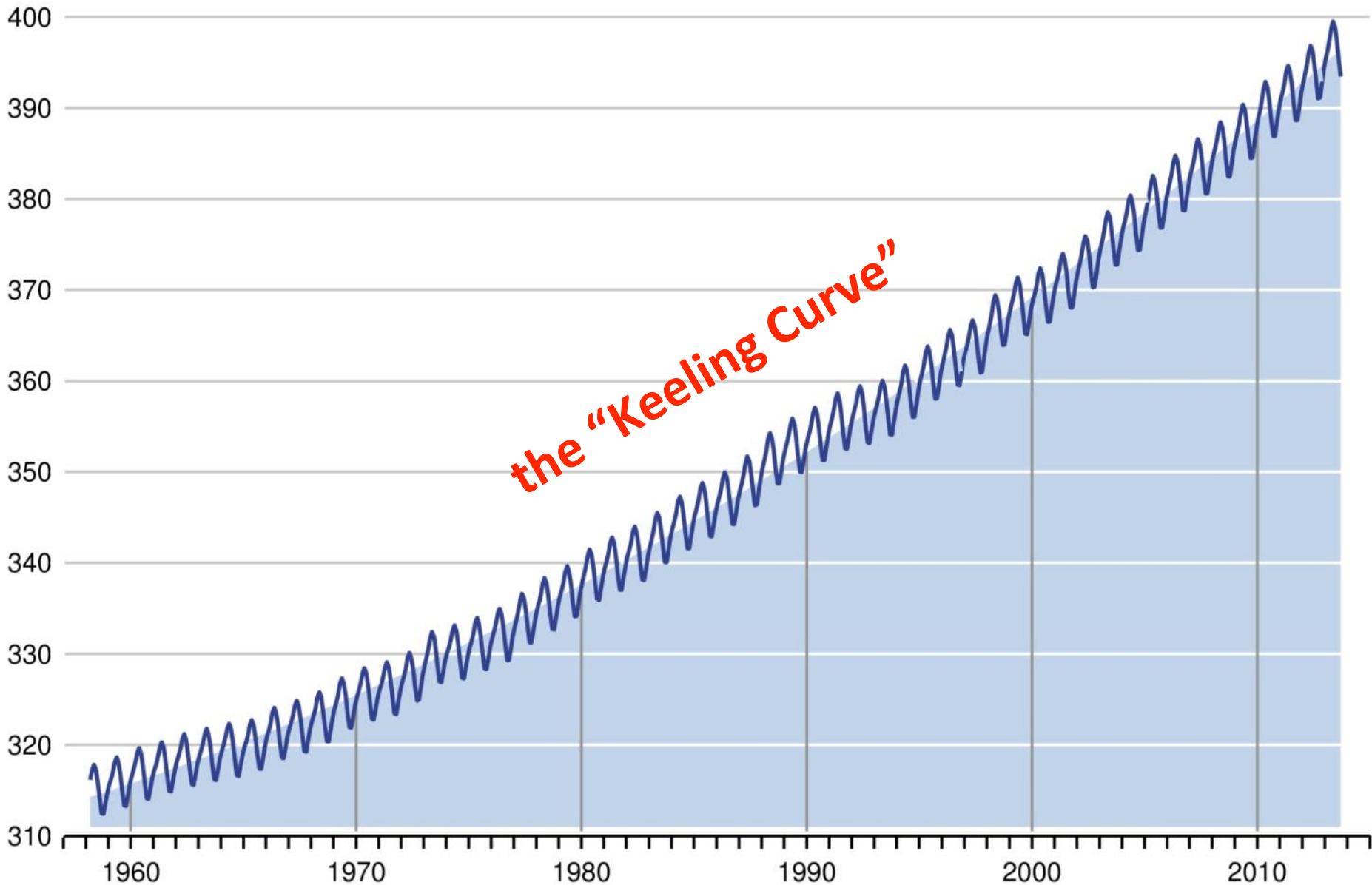
Infrared radiation is emitted by the Earth's surface.

Atmosphere
Earth's surface



Monthly CO₂ Concentration, Mona Loa, Hawaii

parts per million

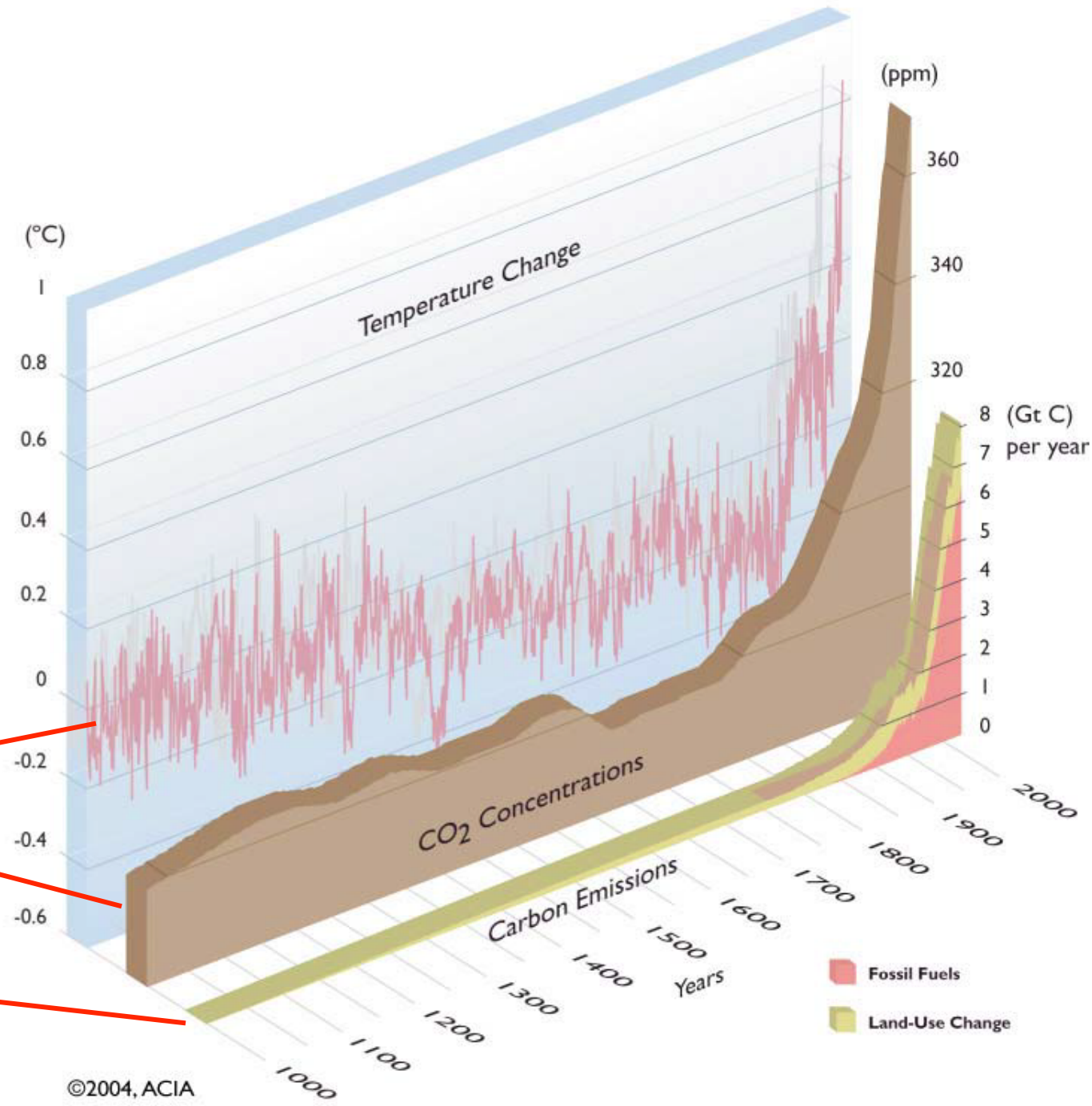


Strong Correlation!

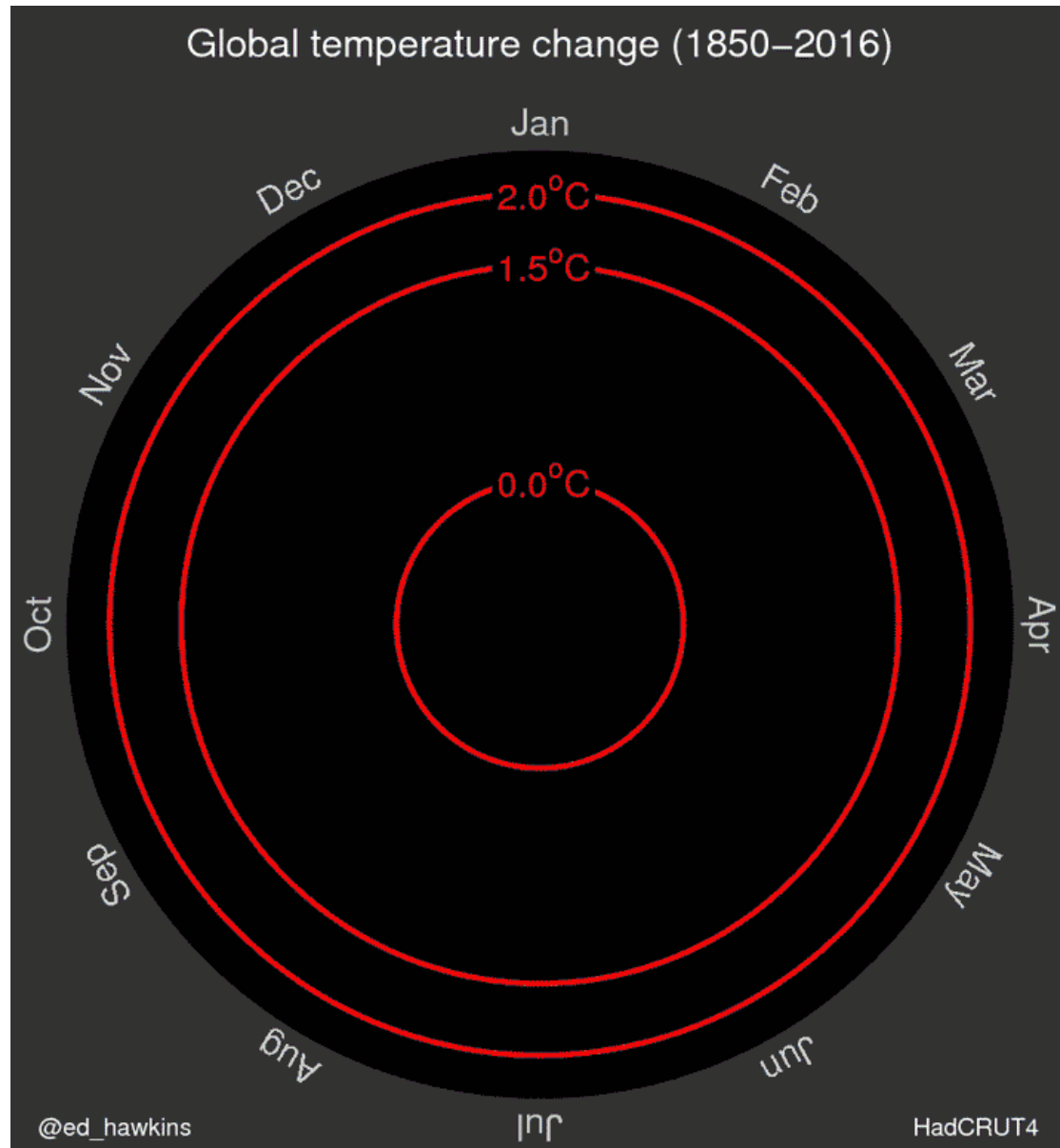
global temperature

atmospheric CO₂

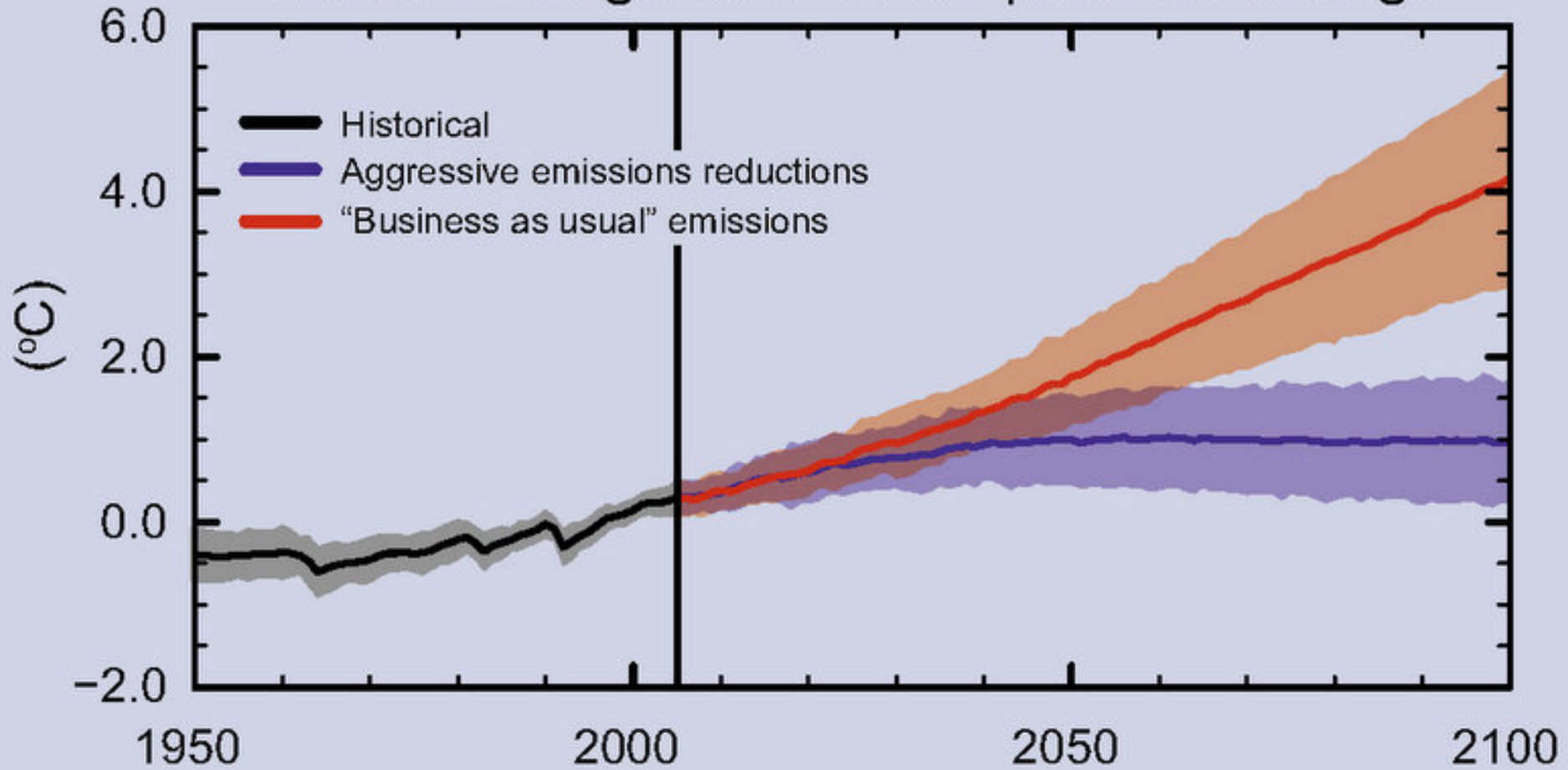
GHG emissions



See Earth's Temperature Spiral Toward 2°C

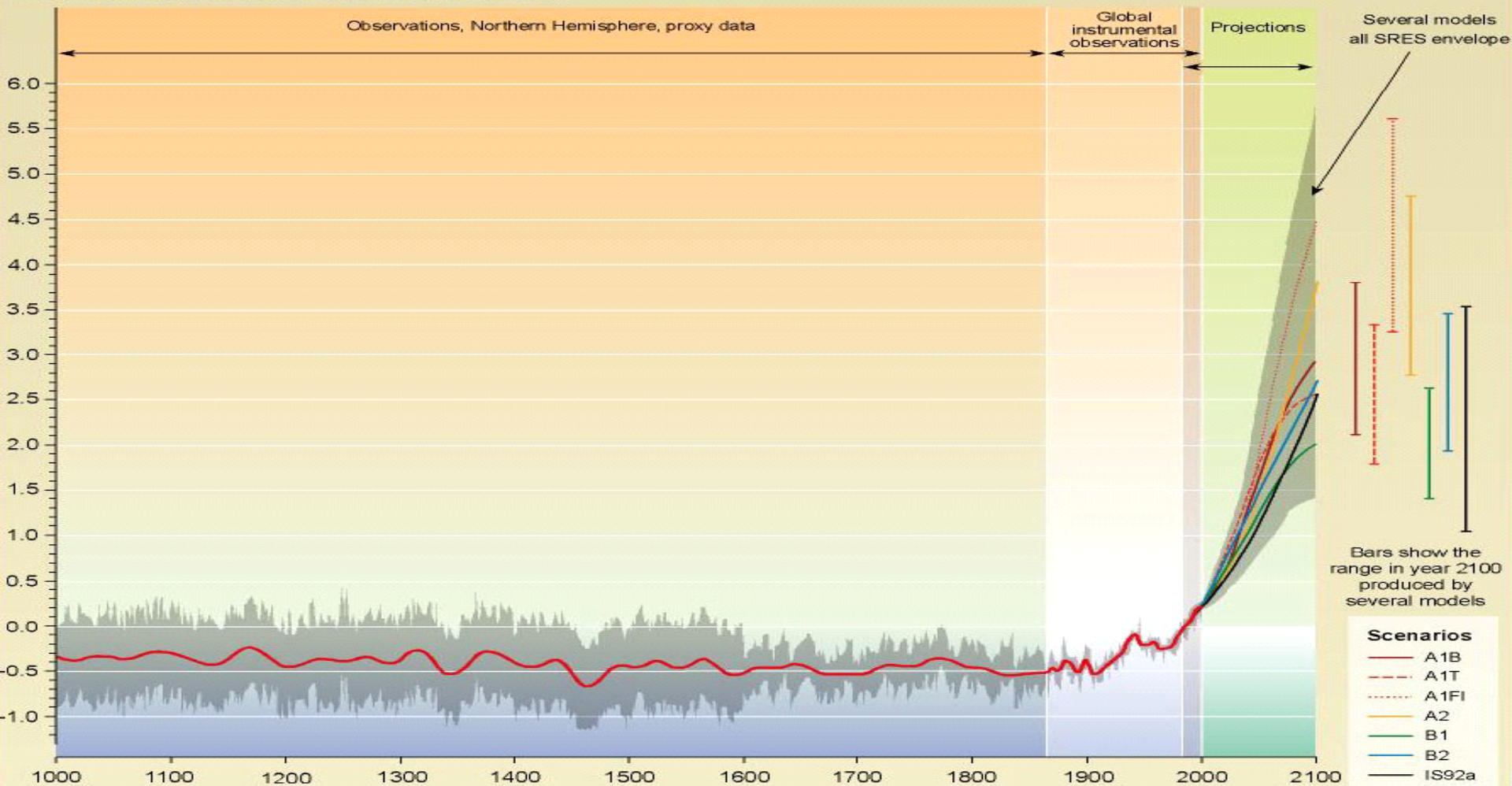


Global average surface temperature change



Variations of the Earth's surface temperature: year 1000 to year 2100

Departures in temperature in °C (from the 1990 value)



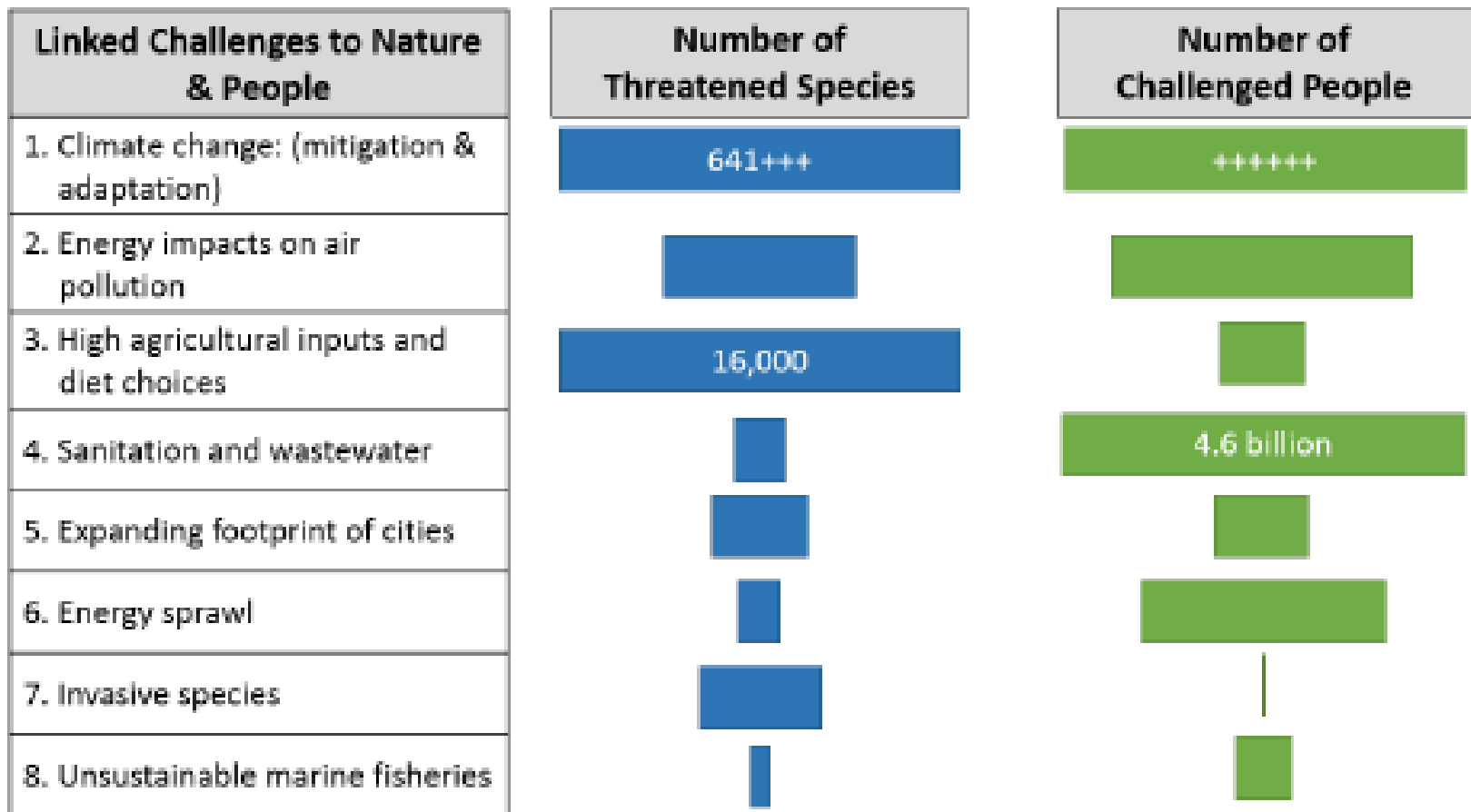
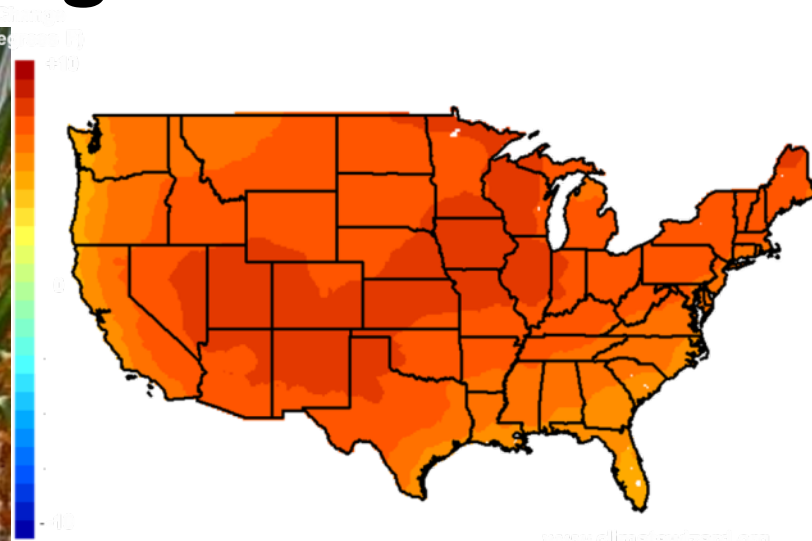


Figure 5. Global Challenges and associated species in decline and people at risk. All species bars are

Direct Climate Change Effects

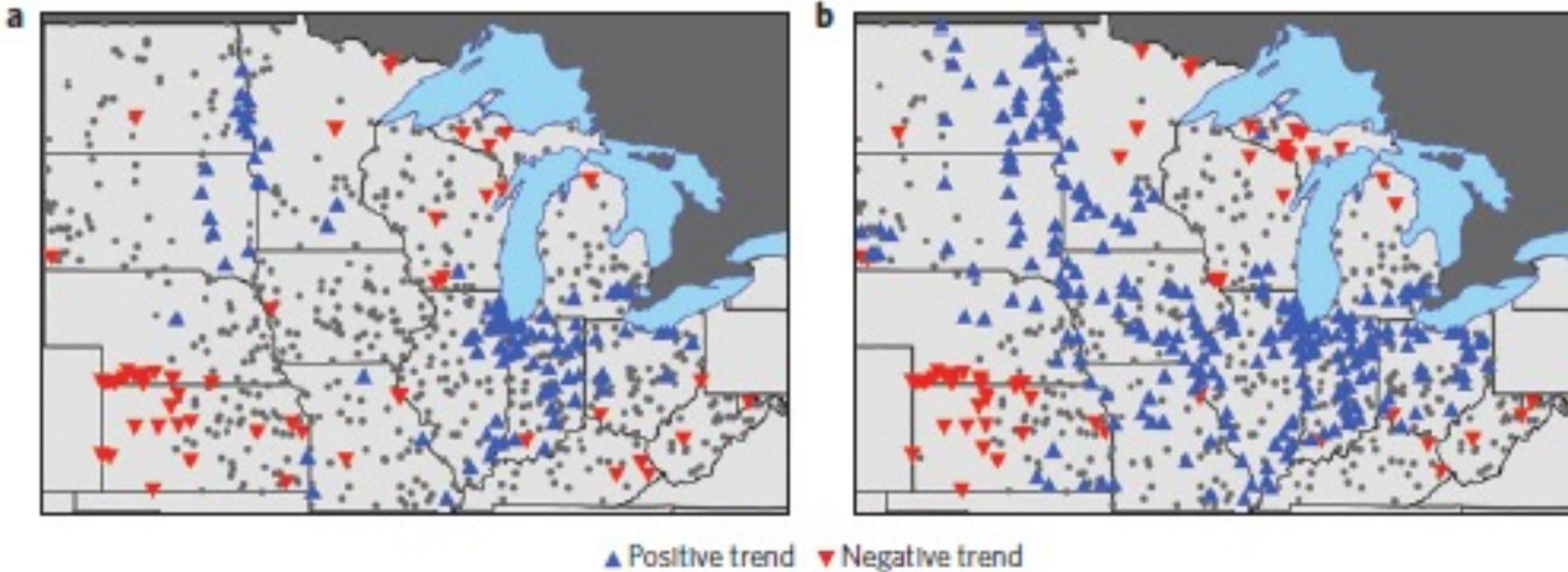


Louisville, IL, July 2012
Robert Ray/Assoc Press



near Havana, IL, April 2013
K. Doug Blodgett, TNC

50-Year Changes in Flooding in the Central US



Higher Flood Magnitude

And Especially Flood Frequency

Mallakpour and Villarini 2015

Indirect Climate Change Effects



Energy Law Wisconsin



S. Long, Univ IL

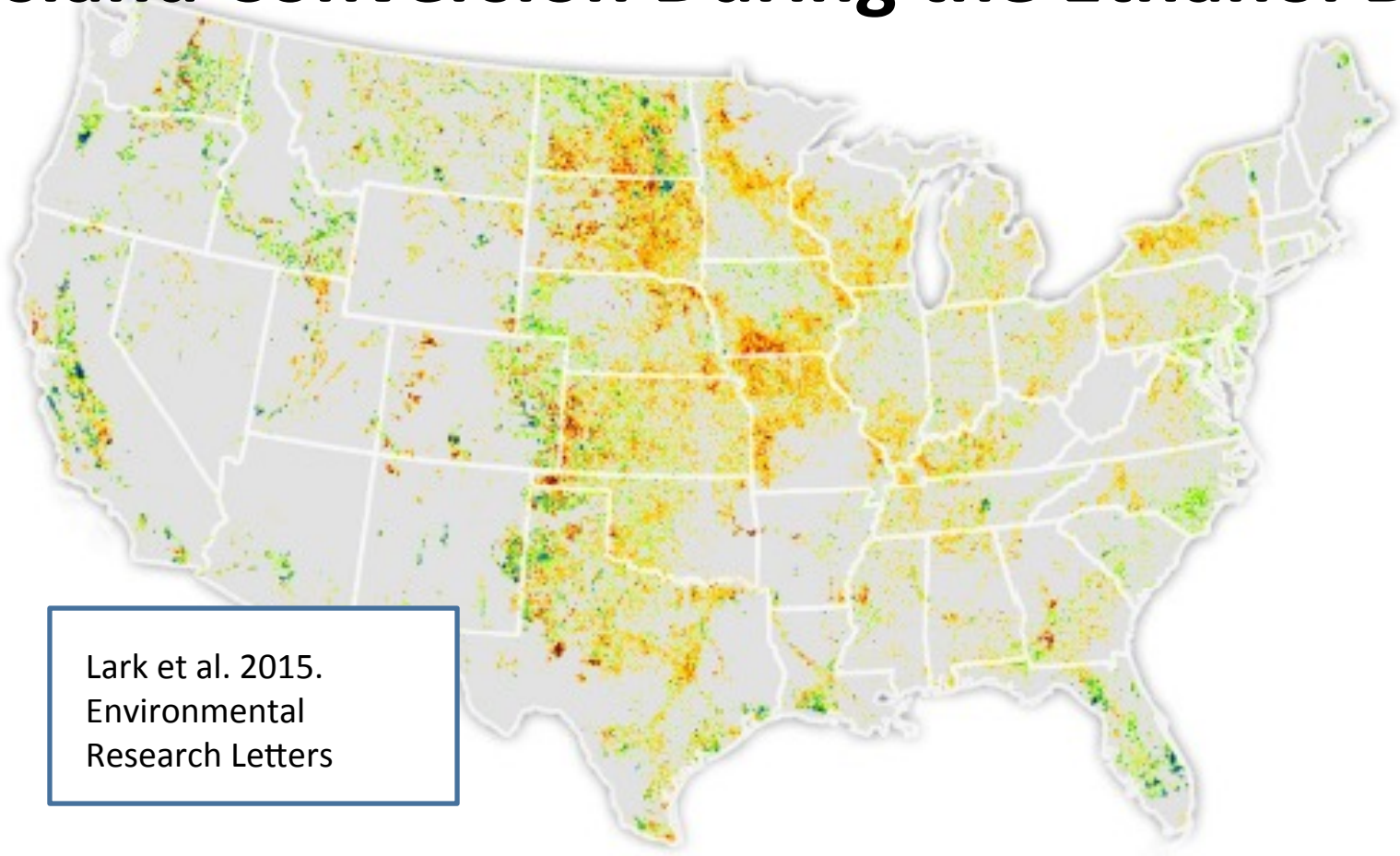


tlirr.com



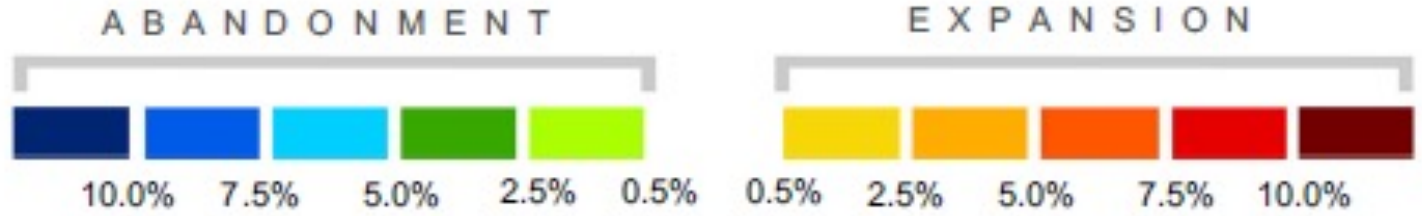
P. Aronsson

Grassland Conversion During the Ethanol Boom



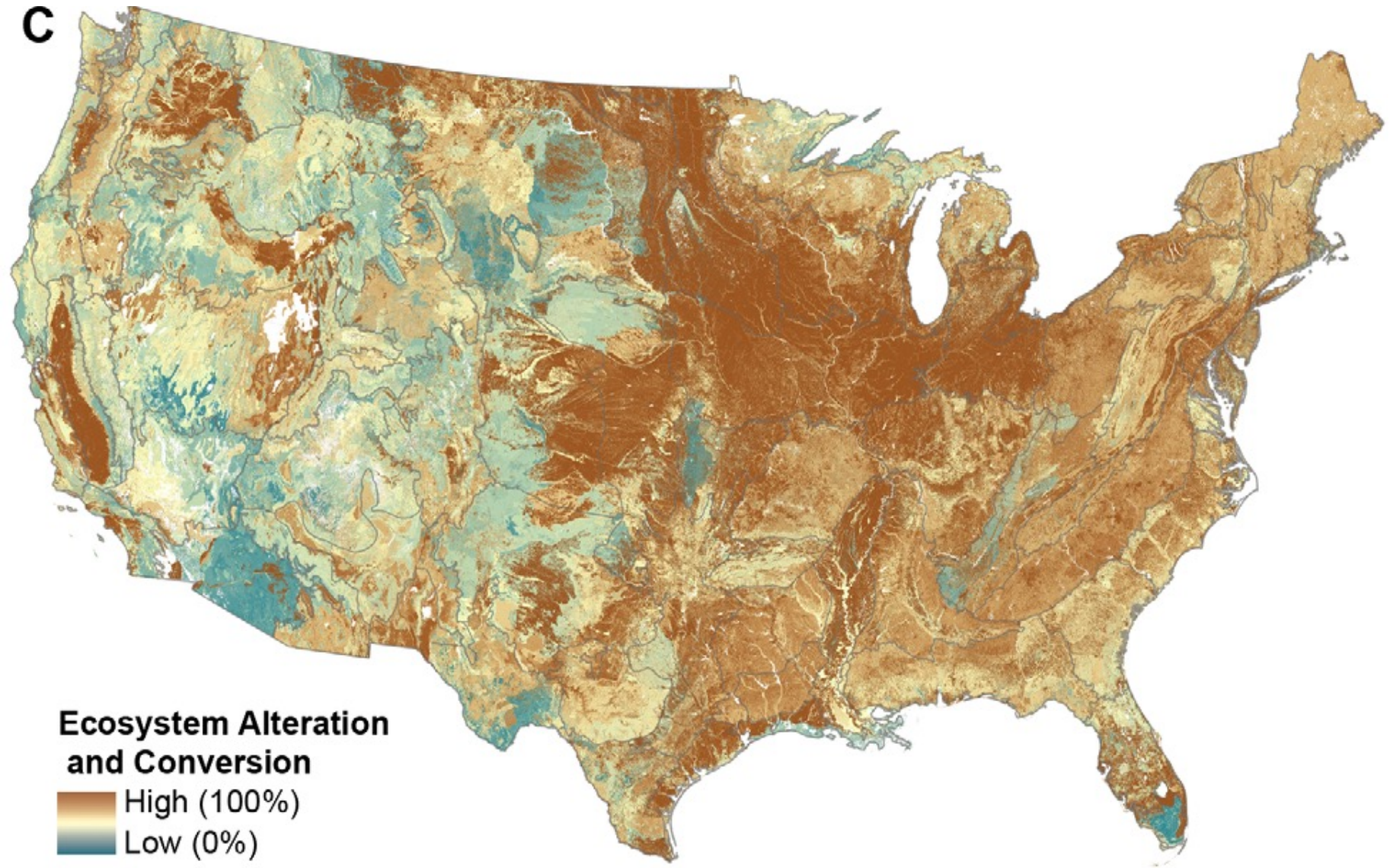
Lark et al. 2015.
Environmental
Research Letters

NET CONVERSION



A Challenging Region, on the Land...

C

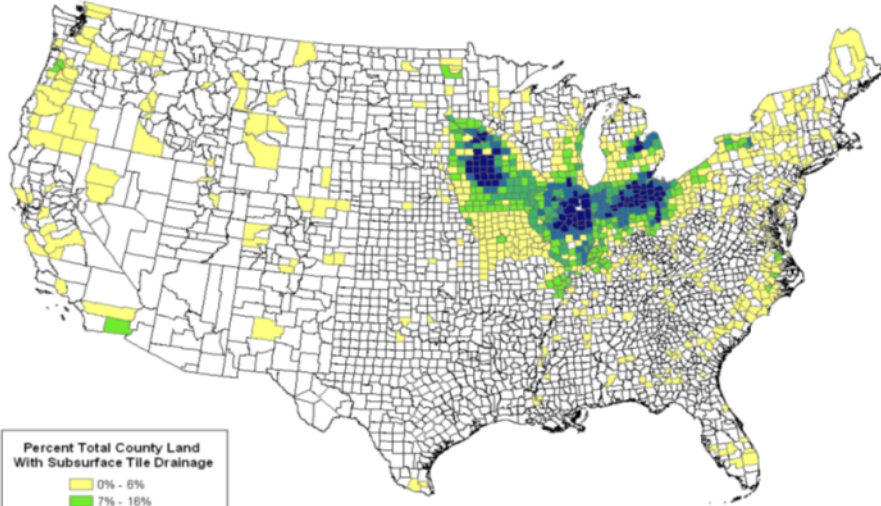


**Ecosystem Alteration
and Conversion**

High (100%)
Low (0%)

...Under the Land...

Subsurface Tile Drainage

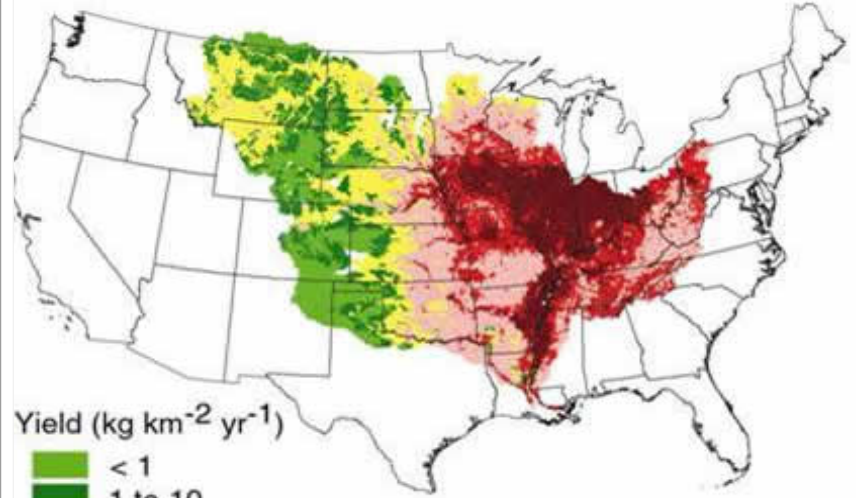


Percent Total County Land With Subsurface Tile Drainage

| |
|-----------|
| 0% - 6% |
| 7% - 16% |
| 17% - 32% |
| 33% - 51% |
| 52% - 82% |

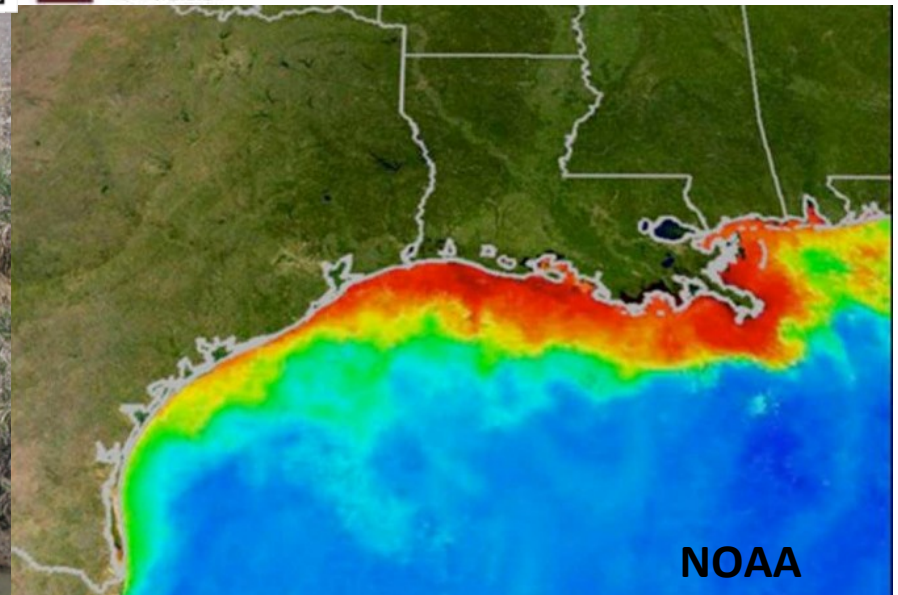
Sources: 1992 National Resources Inventory and World Resources Institute

Total Nitrogen



Yield ($\text{kg km}^{-2} \text{ yr}^{-1}$)

| |
|-------------|
| < 1 |
| 1 to 10 |
| 10 to 100 |
| 100 to 500 |
| 500 to 1000 |
| > 1000 |



NOAA

...And in the Water



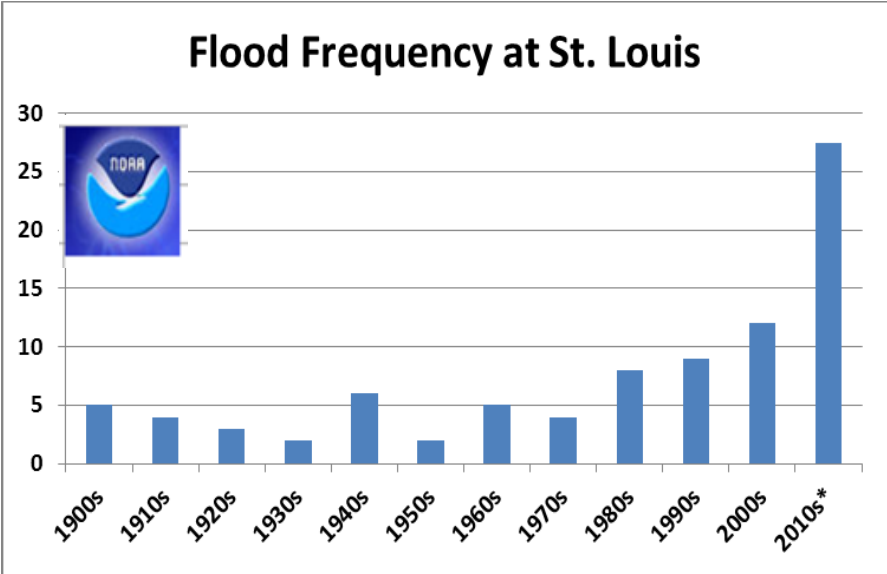
Lock & Dam #7 La Crescent MN;
mvp.usace.army.mil



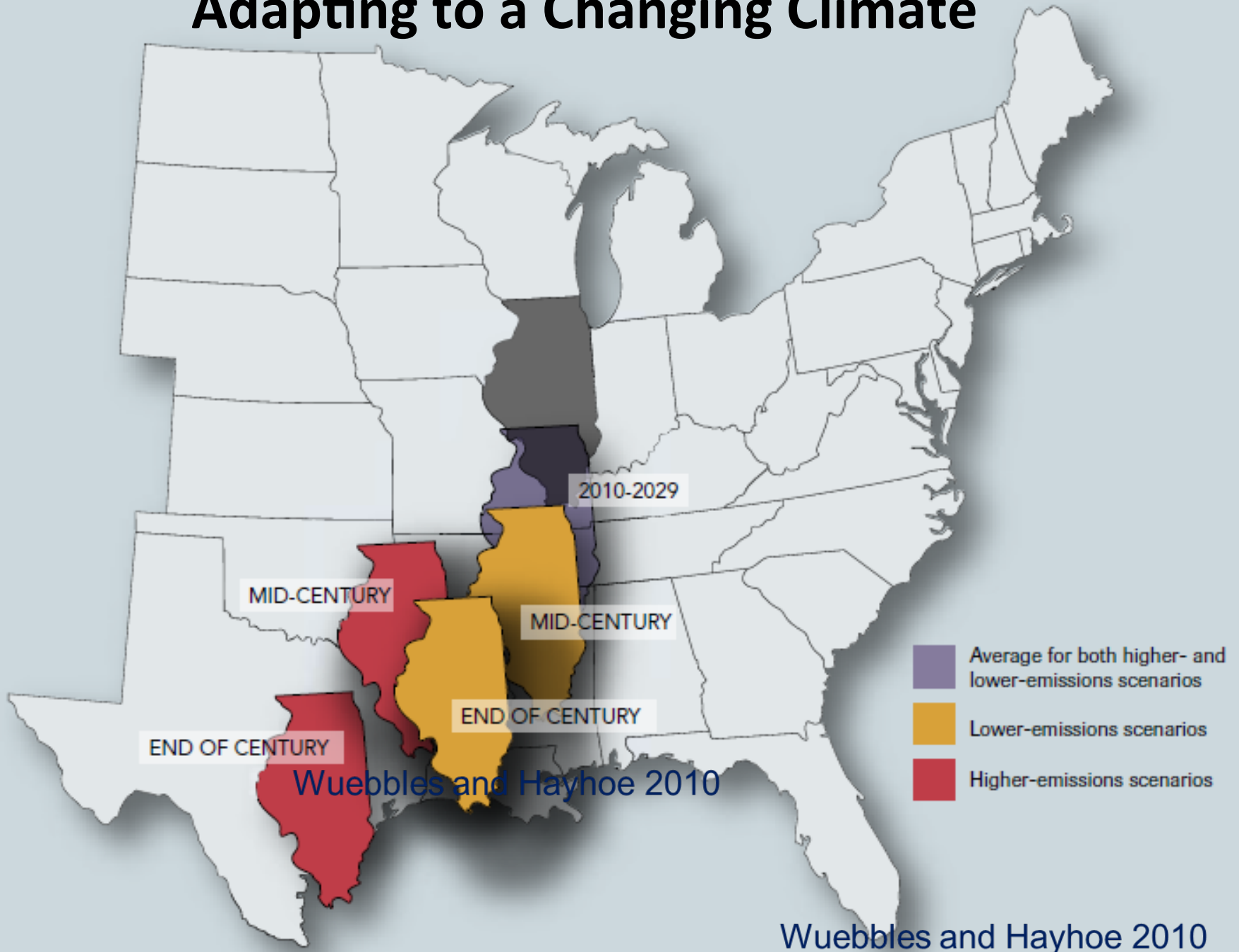
Illinois River sediment;
dnr.illinois.gov



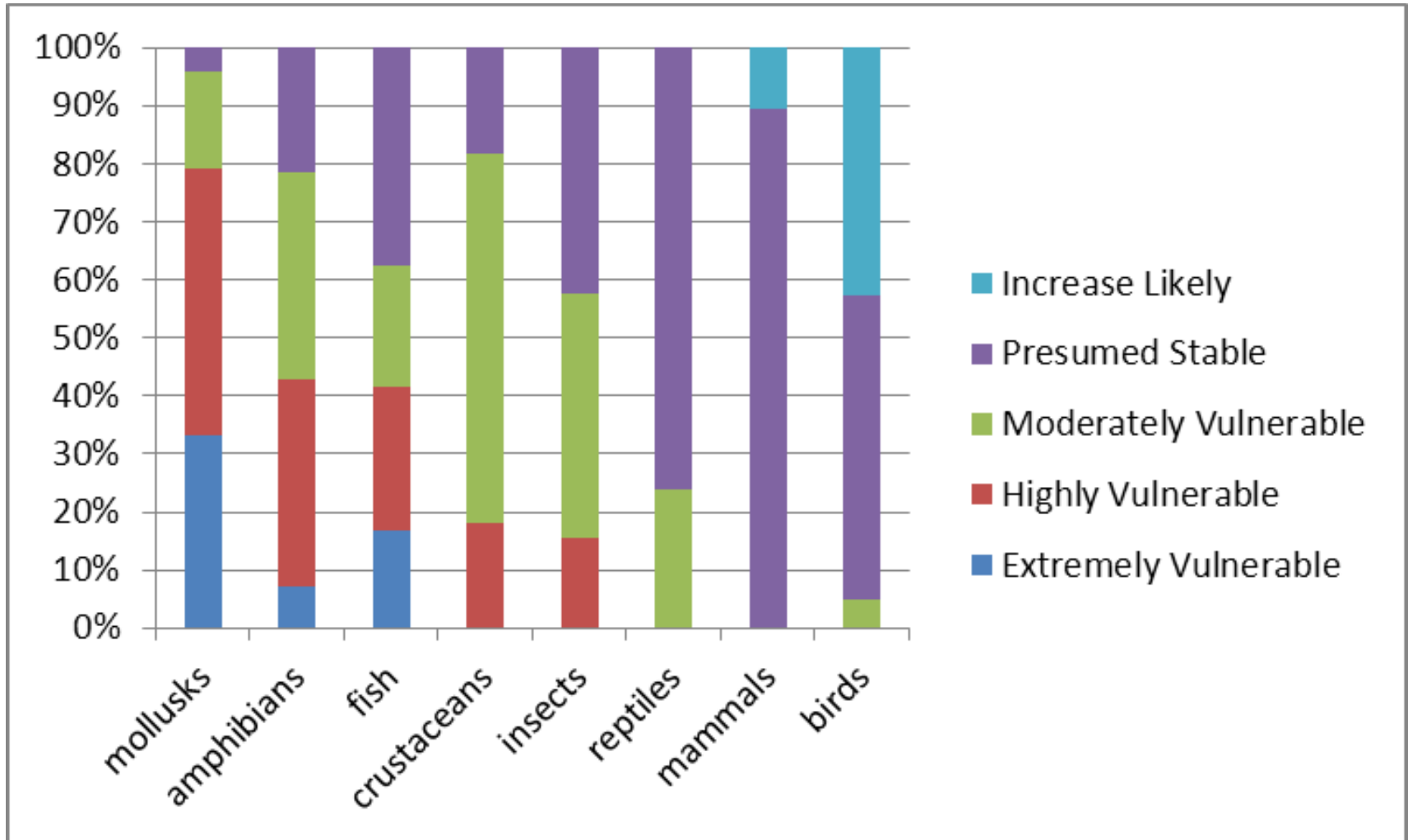
Winchester Dam, Monroe,
MI



Adapting to a Changing Climate

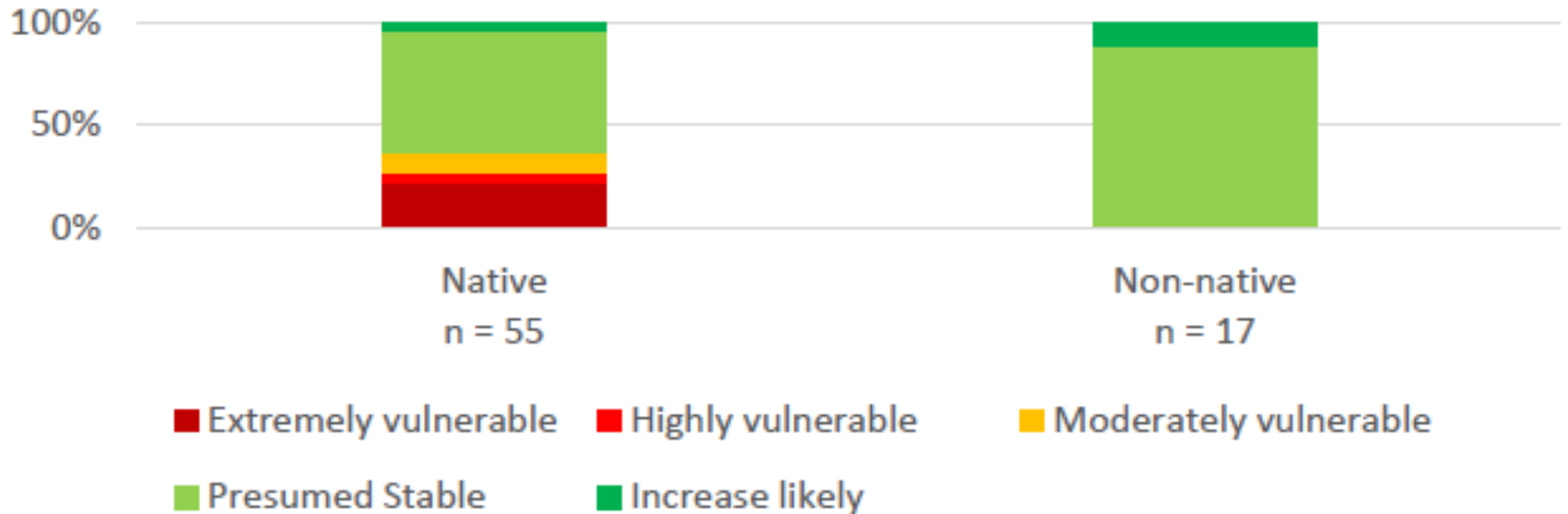


Aquatic Wildlife Are More Vulnerable to Climate Change



Native Plants are More Vulnerable than Non-Native Plants

CCVI score by species' geographic origins



Adaptation Strategies

RESISTANCE
to change

RESILIENCE
of current system

TRANSFORMATION
to new state

30-Year Trend

**Familiar Results,
Difficult to Sustain**

**Uncertain
Results,
More Sustainable**

Modified from Heller and Zavaleta 2009



Adaptation Strategies

RESISTANCE
to change

RESILIENCE
of current system

TRANSFORMATION
to new state

25-Year Trend

**Familiar Results,
Difficult to Sustain**

**Uncertain
Results,
More Sustainable**

Modified from Heller and Zavaleta 2009

Improving Resilience

- Enhance connectivity, reduce fragmentation
- Restore natural processes
- Reduce pollution, invasive species, other stressors
- Increase population size



Illinois Fire Needs Assessment

| Survey Respondents | Water, parks, crops | Degraded/ Unburnable | Burn-Worthy | Burned June 2014- May 2015 |
|--|---------------------|-------------------------|---------------|----------------------------|
| 1,049,573 acres managed; 25 organizations | 256,379 acres | 210,533 acres | 582,661 acres | 50,789 acres |
| 100% | 24% | 20% | 56% | 5% (9% of burn-worthy) |

- We need to burn more area
- With higher frequency
- Far too many ecologically degraded acres cannot recover with fire alone



Adaptation Strategies

RESISTANCE
to change

RESILIENCE
of current system

TRANSFORMATION
to new state

25-Year Trend

**Familiar Results,
Difficult to Sustain**

**Uncertain
Results,
More Sustainable**

Modified from Heller and Zavaleta 2009

Conserving Nature's Stage

Create arenas for evolution not museums of the past



Sedimentary



Granite



Coarse Sand



Limestone



Fine Silt/Organic



Mafic



Moderately Calcareous



Granite

Conserving Nature's Stage



“Geodiversity... drives patterns of biodiversity.”

—Mark Anderson, Director of Conservation Science, Eastern Division



**Primary Funder:
Doris Duke Charitable Foundation**

A Well-Established Approach



Special Section: Conserving Nature's Stage

Conservation Biology

Volume 29, Number 3, June 2015

Resilient Sites for

Conserving the Stage of Geophysical Underpinning

Mark G. Anderson*, Charles E. Ferris

Abstract

Conservationists have proposed methods for identifying resilient sites to conserve biological diversity under a changing climate. We developed and tested such a method for northeastern forest reserves that can be based on physical features associated with ecological diversity and site resilience to climate change. We comprehensively mapped 30 distinct geophysical settings based on geology and elevation. Within each geophysical setting, we identified sites that have both contained or sustained forest and that had relatively more microclimate buffered by diverse topography and elevation gradients. We did this by scoring every 50-ft by 50-ft cell in the region for these two characteristics and selecting those that scored 10 or above the mean combined score for each setting. We hypothesized that these high-scoring sites had the greatest resilience to climate change, and we compared them with sites selected by the Nature Conservancy for their high-quality rare species systems and natural community occurrence. High-scoring sites captured significantly more of the biodiversity sites than expected by chance ($p < 0.0001$). 75% of the 414 target species, 49% of the 4532 target species locations, and 51% of the 2179 target community locations. Calamity oak, chestnut, and blue-stem were scored markedly lower for estimated resilience and had no levels of potential land protection (average 7%). Because our method identifies... for every geophysical setting... sites that are the most likely to retain species and functions longer under a changing climate, it reveals natural corridors for future conservation that would also conserve natural setting biodiversity and correct the bias to current natural lands.

Introduction

As a result of climate change, conservation scientists are developing a variety of methods for identifying resilient sites. Many have focused on either... methods that rate species ranges to isolate and characterize... or have the highest stability [1]. The latter... of the network could be practical to identify... large number of species. A second, site advanced approach to... to understand the resilience of natural corridors... can more easily be their range [2]. Overall, many... methods have been used to identify resilient sites... and study land resilience. However, these... methods have not been used to identify resilient sites... and in some, conservationists used a naive model for... to assess resilience to natural natural threats [3]. In... climate, we research in this.

Here, we explore a consistent, mapping approach, which... rather than trying to predict biodiversity conservation... a large to present for sites and diverse of biodiversity. The... about regional-scale means of climate change and... impact are not fixed. Accordingly, we should look to...

Keywords: biodiversity, climate change, conservation, conservation planning, fragmentation, geology, North America, protected areas.

Identificación de Sitios Resilientes para la Conservación de la Diversidad del Paisaje y las Comunidades Locales por Sus Características de Biopersistencia al Cambio Climático

Resumen: Los conservacionistas buscan un método mediante el cual poder conservar la diversidad biológica mediante criterios que las especies y las comunidades se resquebrajan con respecto al clima cambiante. Desarrollamos y probamos un método, el cual basamos en características físicas asociadas con la diversidad ecológica y la resiliencia al cambio climático, en el nordeste de Norteamérica. Mapeamos exhaustivamente 30 escenarios geofísicos distintos basados en la geología y la elevación. Dentro de cada escenario geofísico, identificamos sitios que habían contenido o sostenido bosques naturales y que tenían relativamente más microclimas bufferados por la topografía diversa y los gradientes de elevación. Hicimos esto al puntuar cada celda 50 por 50 metros del paisaje con dos características: 1) el número de especies y 2) el número de especies locales. Seleccionamos aquellos sitios que obtuvieron una puntuación combinada de 10 o superior. Hipotetizamos que estos sitios de alta puntuación tenían la mayor resiliencia al cambio climático, y los comparamos con los sitios seleccionados por el Nature Conservancy por sus producciones de alta calidad de especies raras y sus ocurrencias de comunidades naturales. Los sitios con alta puntuación capturaron significativamente más de la biodiversidad que se esperaba por casualidad ($p < 0.0001$). 75% de las 414 especies objetivo, 49% de las 4532 localidades de especies objetivo y 51%

- Theory
- Ecosystem services
- Evidence in past
- Current protection
- Surrogate for diversity
- Approaches
- Management implications

<http://maps.tnc.org/resilientland/>

Two Main Concepts

Geodiversity



Sedimentary (sandstone)



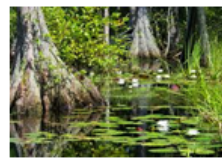
Granite



Coastal Sand



Limestone



Fine Silt/Organic



Mafic (amphibolite)



Moderately Calcareous

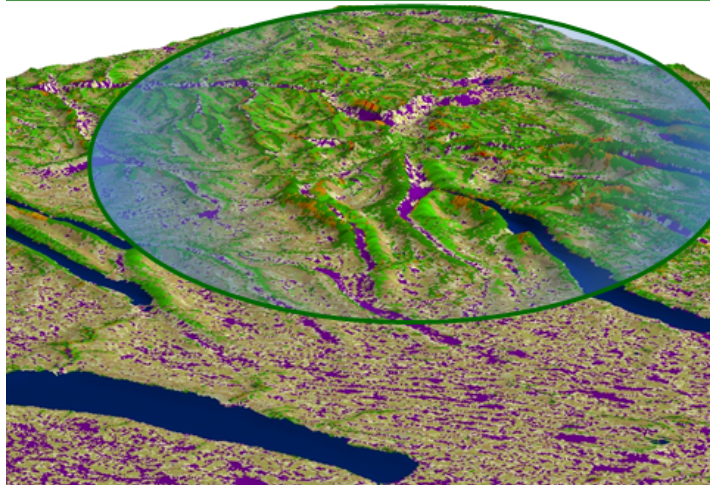


Coarse Sand

1. Geodiversity

Conserve examples of different physical environments

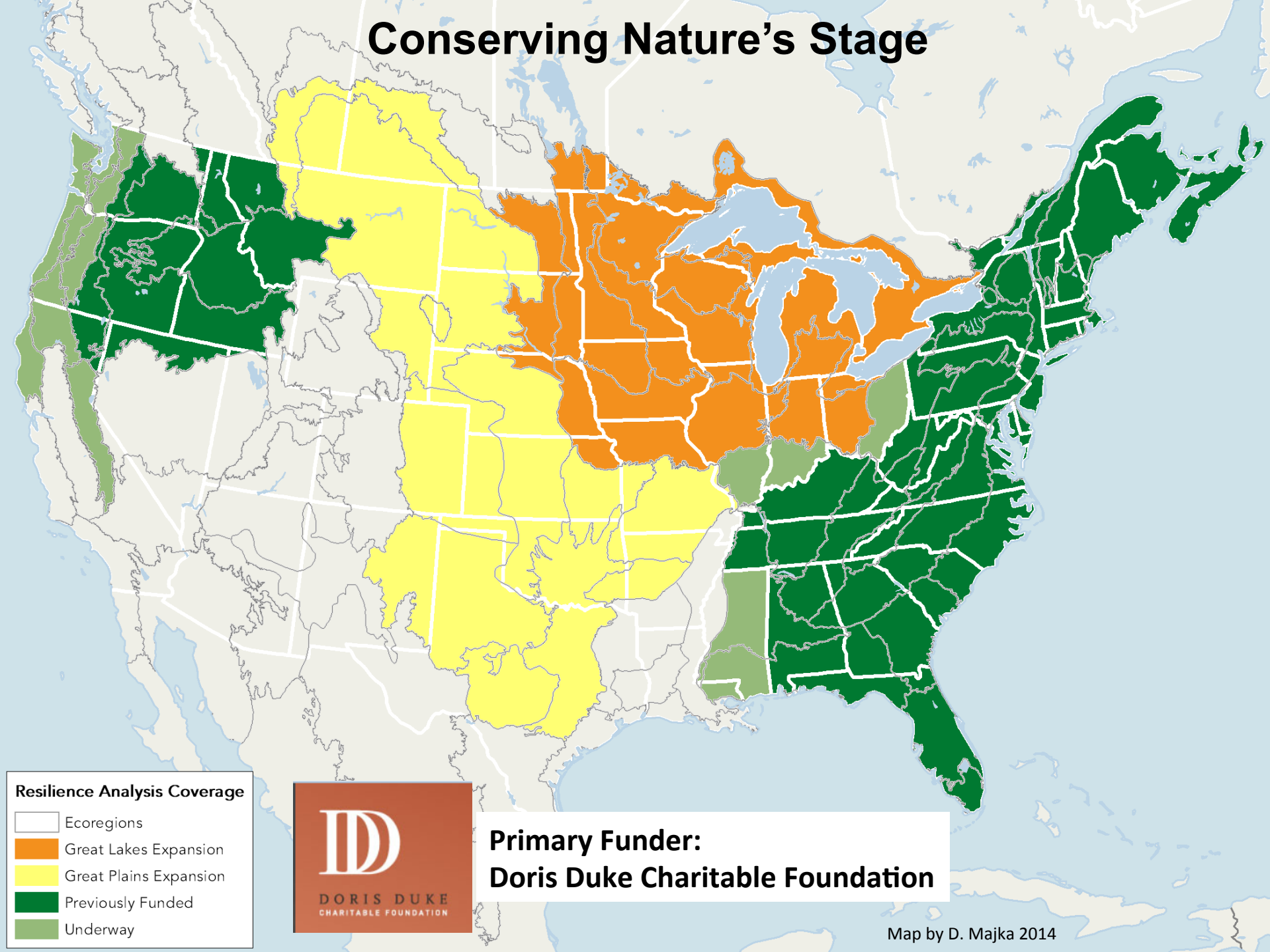
Complex and Connected = Many Options



2. Climate-Resilient Sites

Focus conservation on natural climate strongholds

Conserving Nature's Stage



Resilience Analysis Coverage

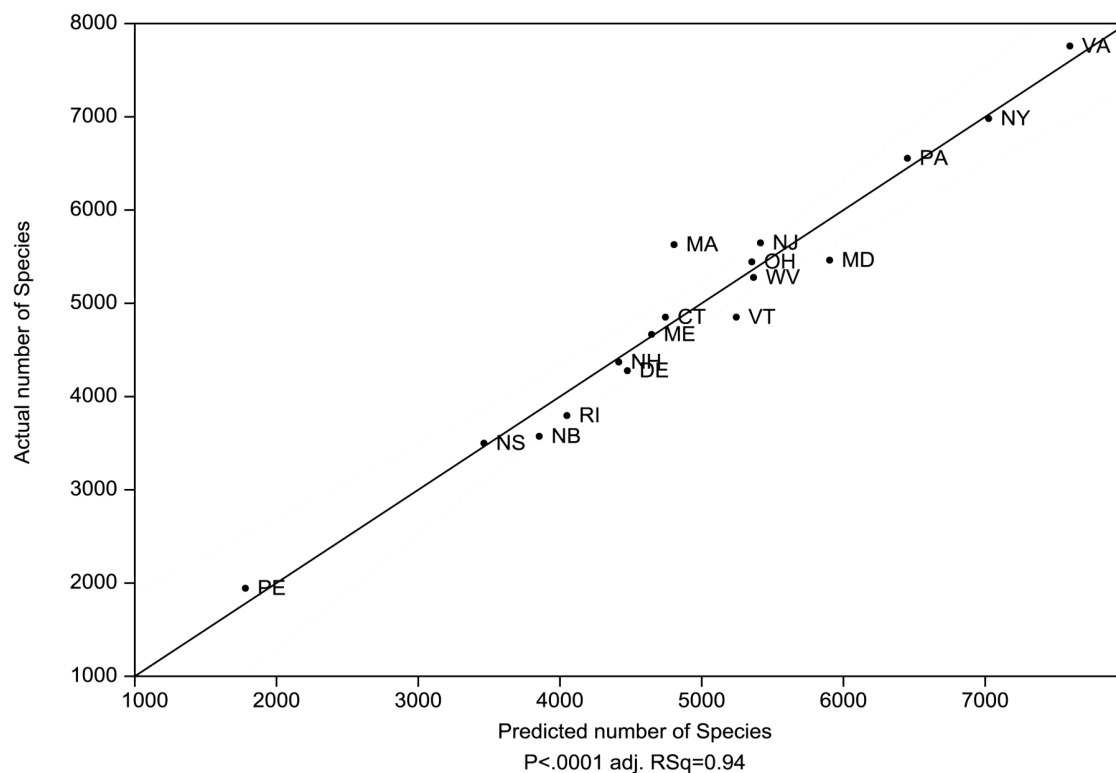
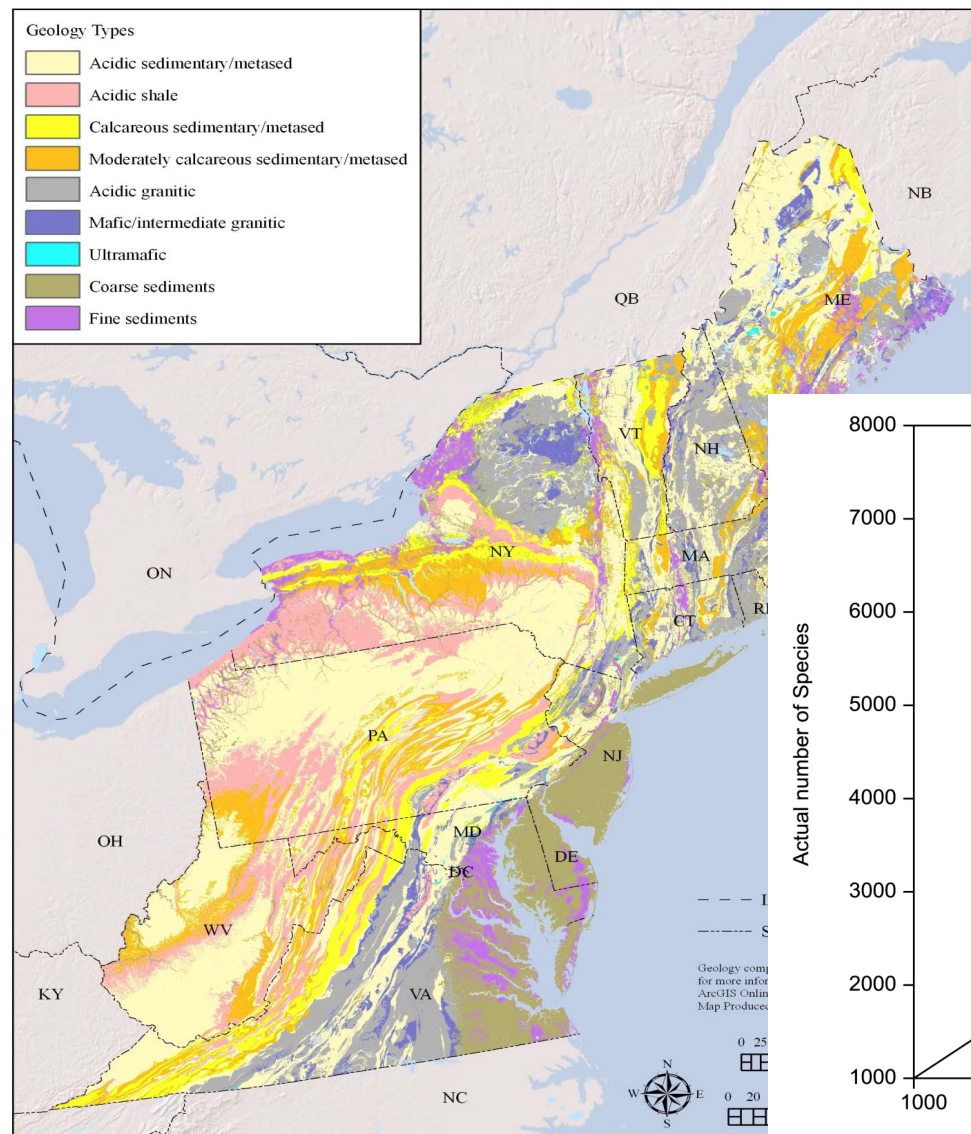
-  Ecoregions
-  Great Lakes Expansion
-  Great Plains Expansion
-  Previously Funded
-  Underway



Primary Funder:
Doris Duke Charitable Foundation

1. Species as Actors on the Geophysical Stage

- Latitude
- Elevation
- Bedrock

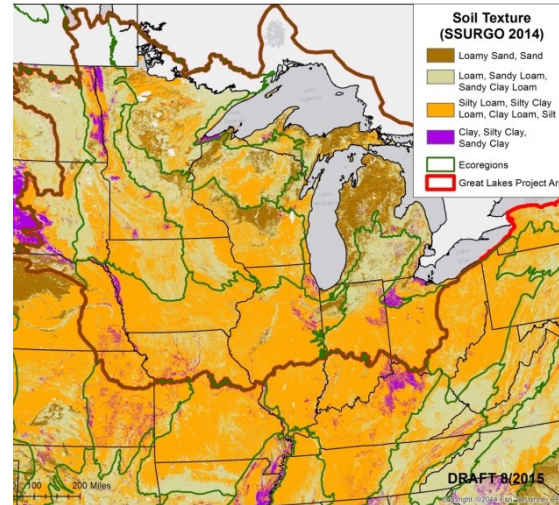


Large Scale Factors for Stratification

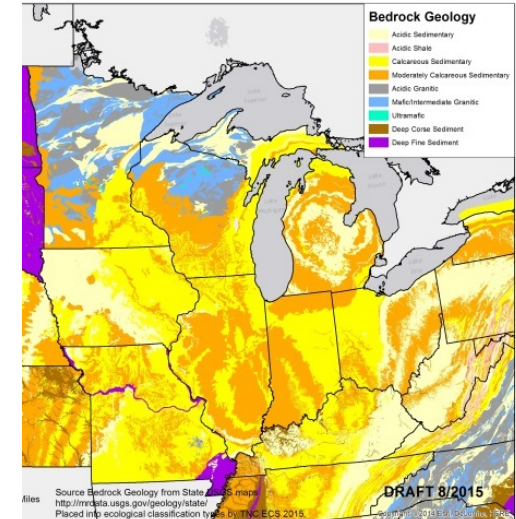
Survey

| Factor | ON | MB | All/ NRCS | GL | MN | MO | IA | IL | OH | MI | WI |
|--|----|----|--------------|----|----|----|----|----|----|----|----|
| Soil Type | | | ✓ | | | ✓ | ✓ | ✓ | | ✓ | ✓ |
| Great Lakes "Effect" | ✓ | | ✓ | ✓ | | | | ✓ | | ✓ | |
| Geology/Parent Material | ✓ | ✓ | ✓ | | | | | | ✓ | ✓ | |
| Glaciated vs. unglaciated | | | | | | | ✓ | ✓ | ✓ | | |
| Hydrology | ✓ | | ✓ | | | | | | | ✓ | ✓ |
| North-South Gradient | | | | | | | ✓ | | | ✓ | ✓ |
| East-West Gradient | | | | | ✓ | | | | | | ✓ |
| Glacial Landforms | | | | | ✓ | | | ✓ | | | |
| Mississippi R. Drainage (historical connections) | ✓ | | | | | | | | | | |

Soil Texture



Bedrock/Parent Material



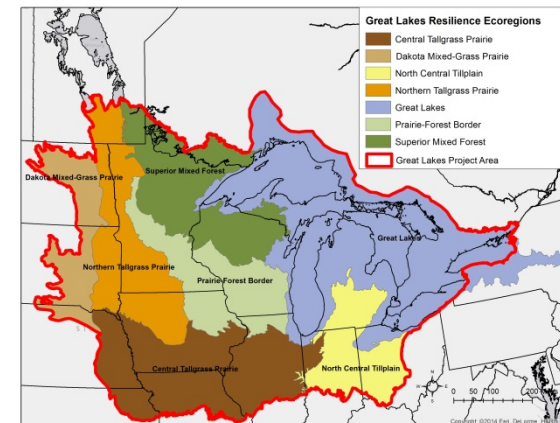
Glacial Boundary




Lake Effect

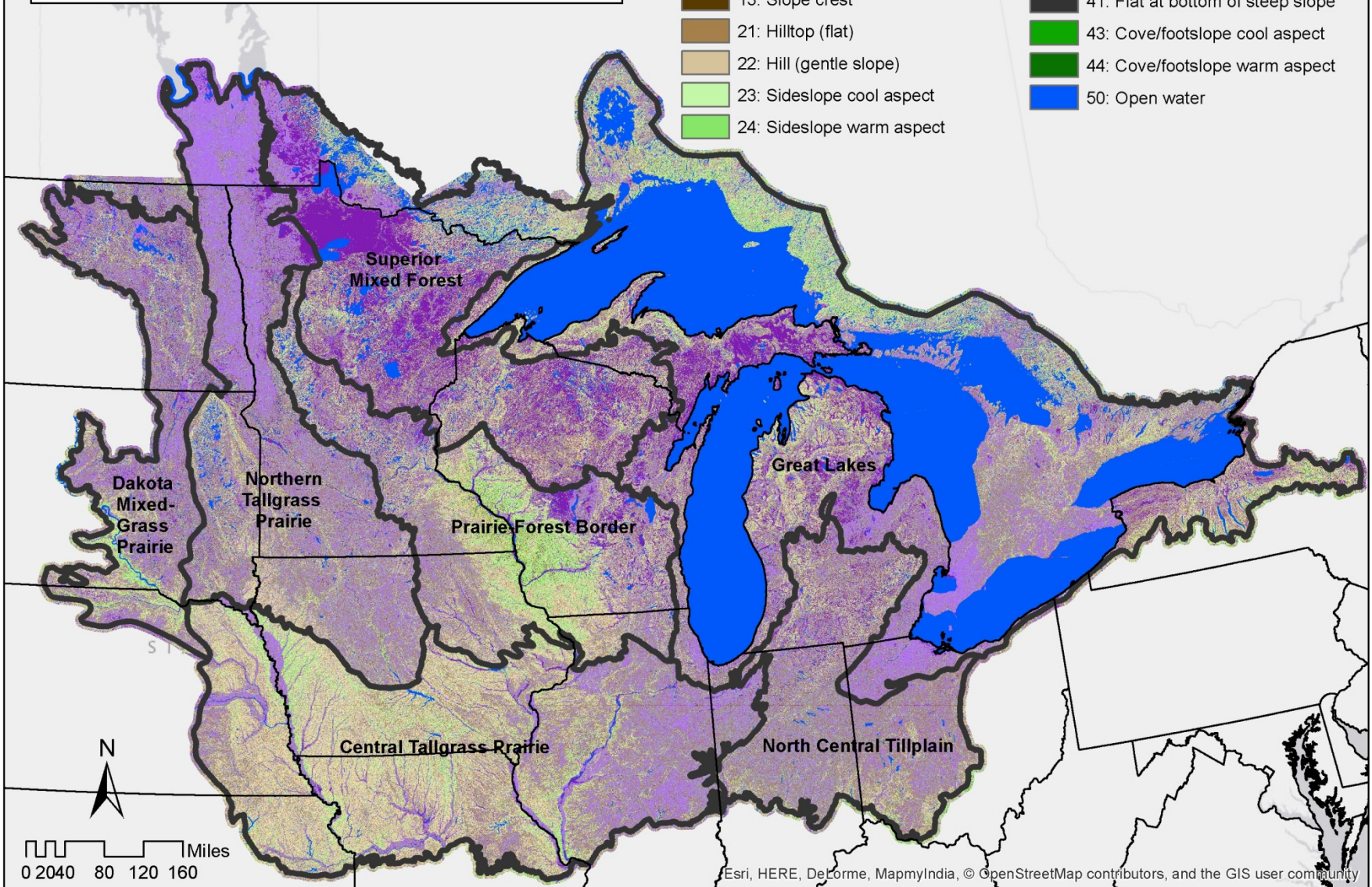


Ecoregion (EW, NS)

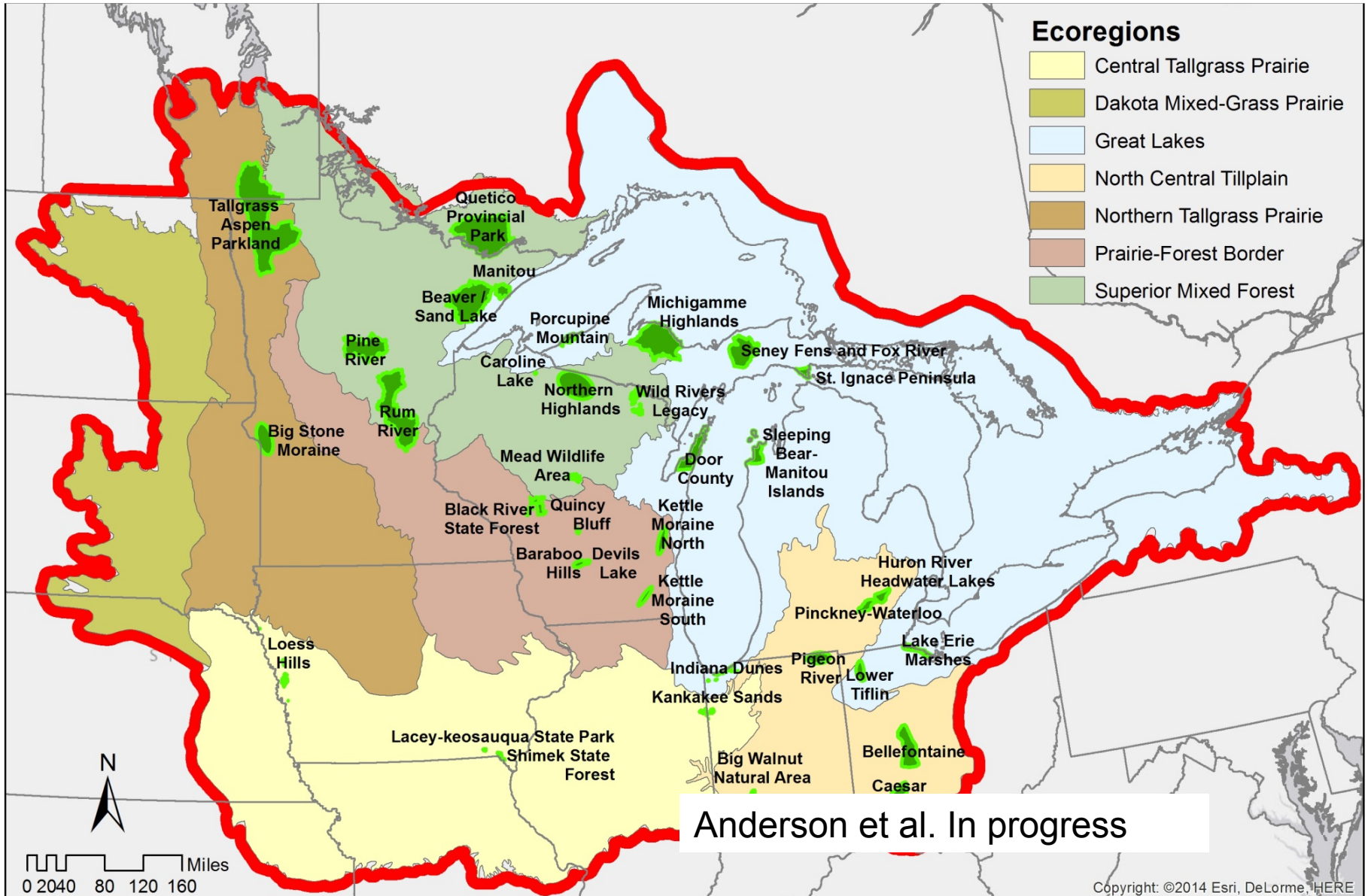


Great Lakes Project Area Landforms

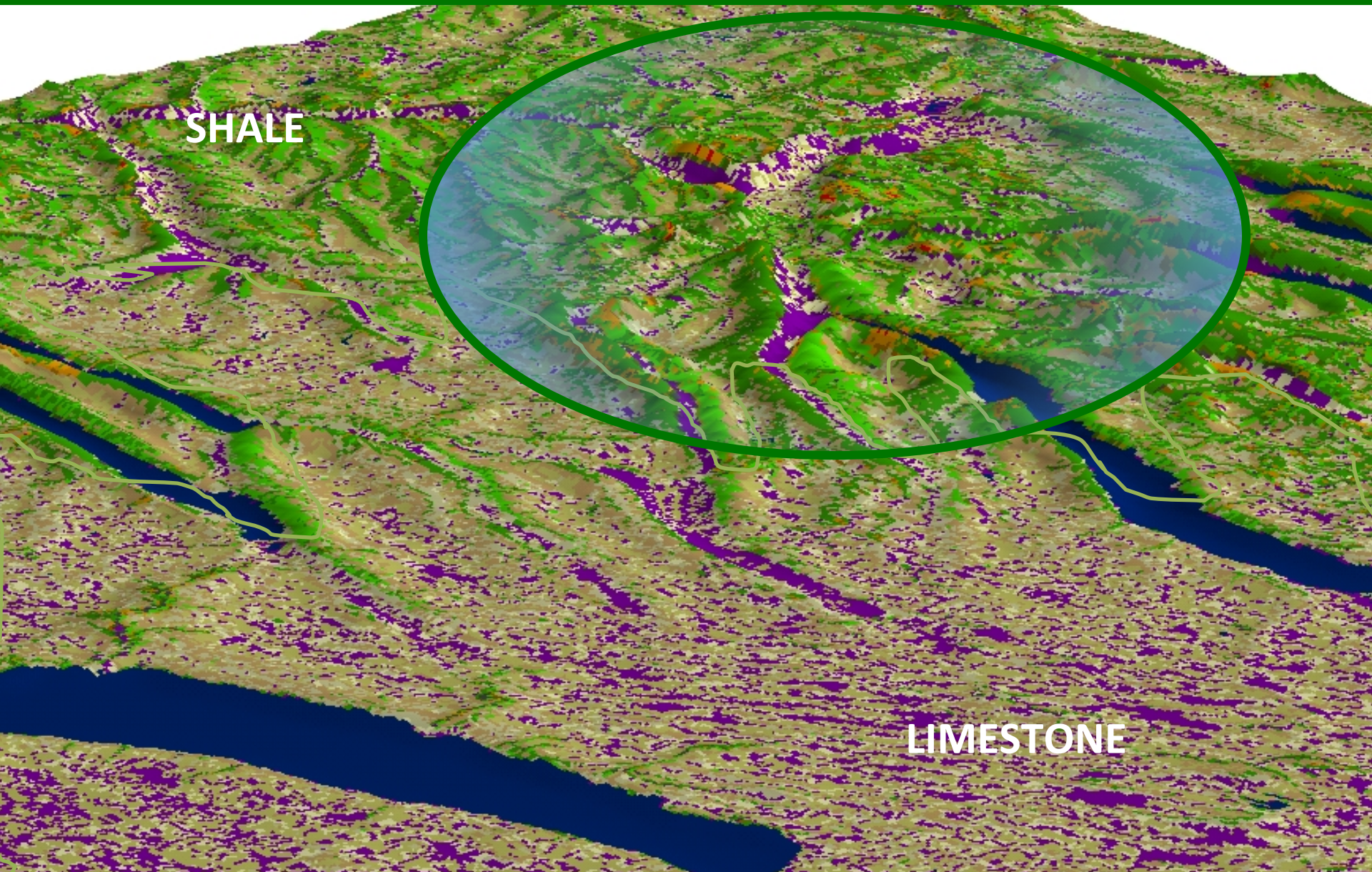
- | | |
|---|---|
|  3: Steep slope cool aspect |  30: Dry flats |
|  4: Steep slope warm aspect |  31: Wet flats |
|  5: Cliff |  32: Valley/toeslope |
|  11: Summit/ridgetop |  39: Moist flats in upland landcover |
|  13: Slope crest |  41: Flat at bottom of steep slope |
|  21: Hilltop (flat) |  43: Cove/footslope cool aspect |
|  22: Hill (gentle slope) |  44: Cove/footslope warm aspect |
|  23: Sideslope cool aspect |  50: Open water |
|  24: Sideslope warm aspect | |



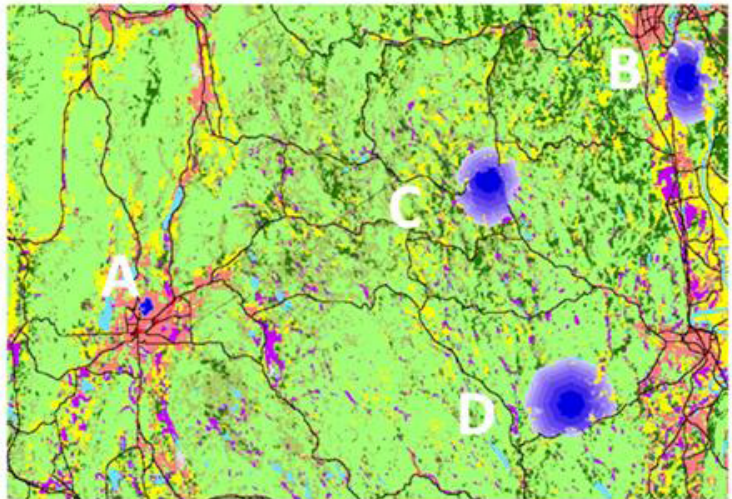
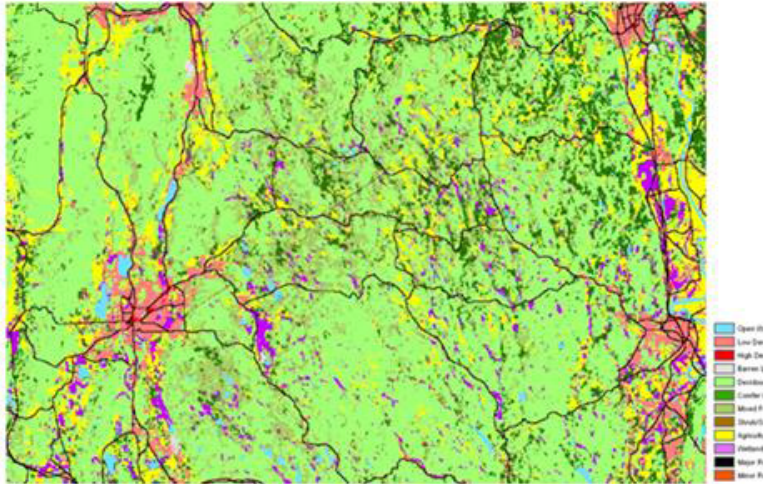
Conserving Nature's Stage: Test Sites for Great Lakes



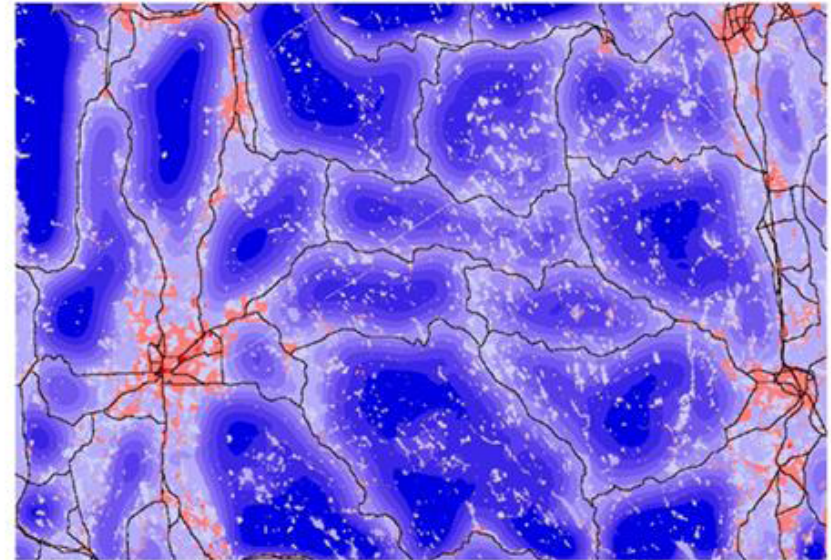
2. Resilient Sites are Complex and Connected = Many Options



Local Connectedness

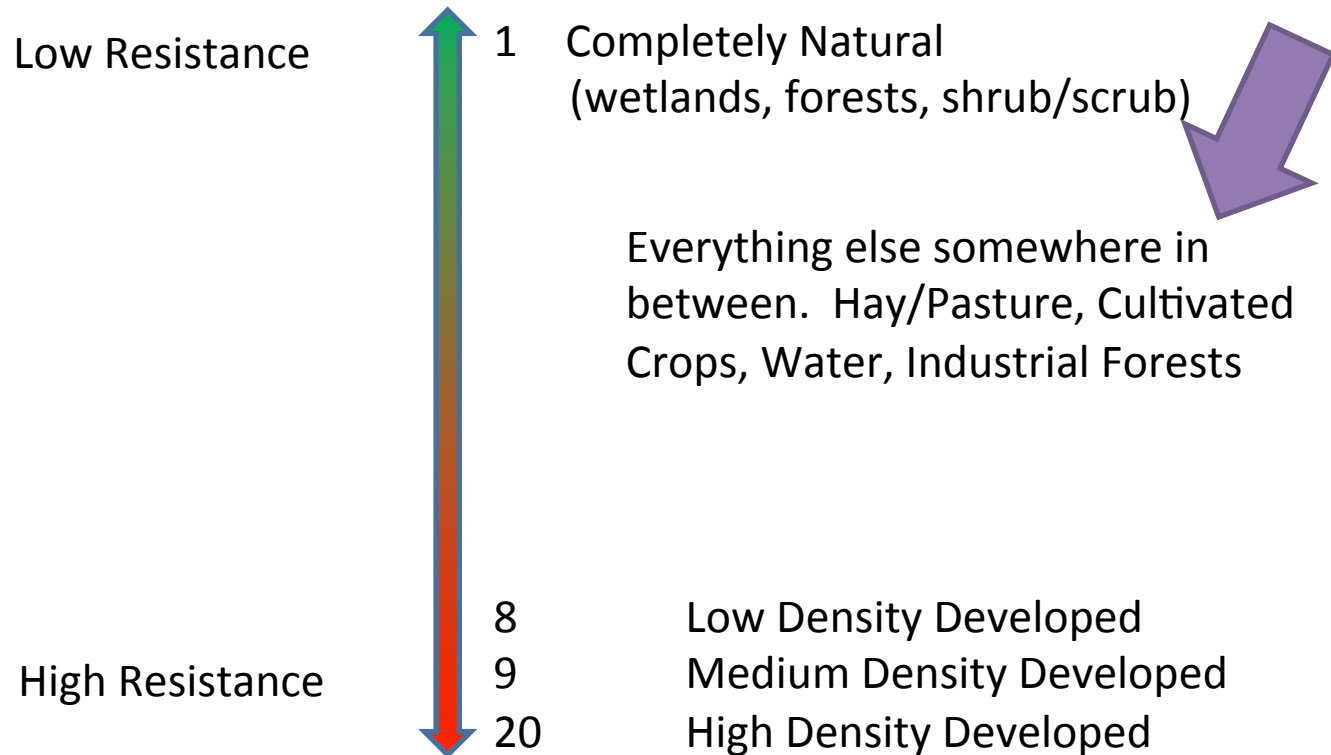


Going from points to a continuous surface



Calibrating the Resistance Grid

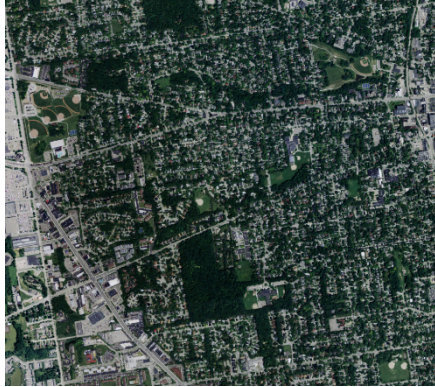
Settings used in Eastern Region (log scale)



Examples of Local Connectedness Score

Scores range 0 to 1

Based on Eastern Values: Mean 0.42 and SD 0.25 for the region



RK = 0.017



RK = 0.02



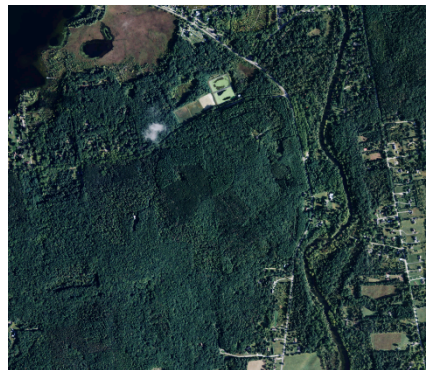
RK = 0.06



RK = 0.21



RK = 0.32



RK = 0.48

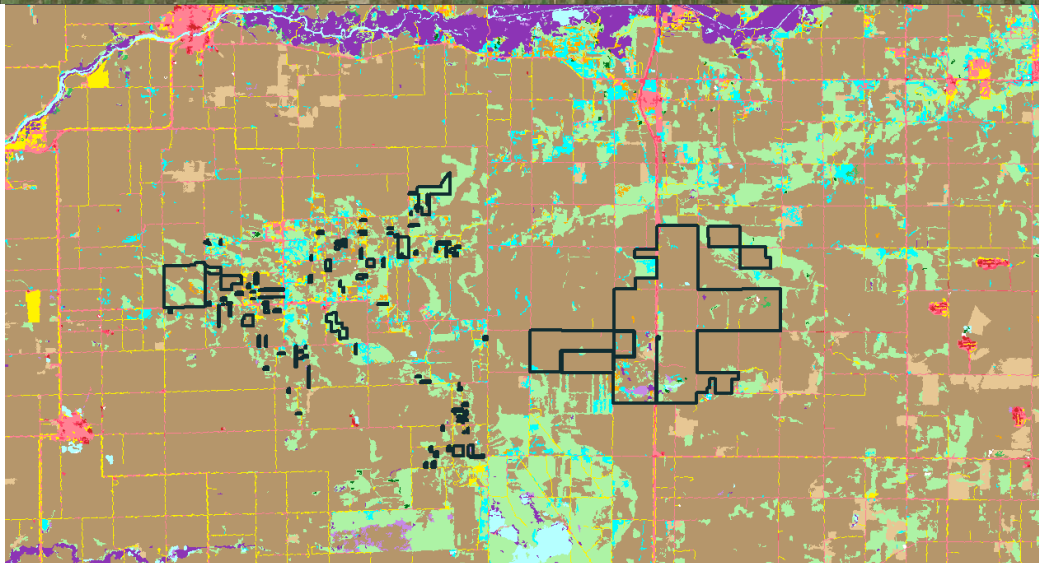
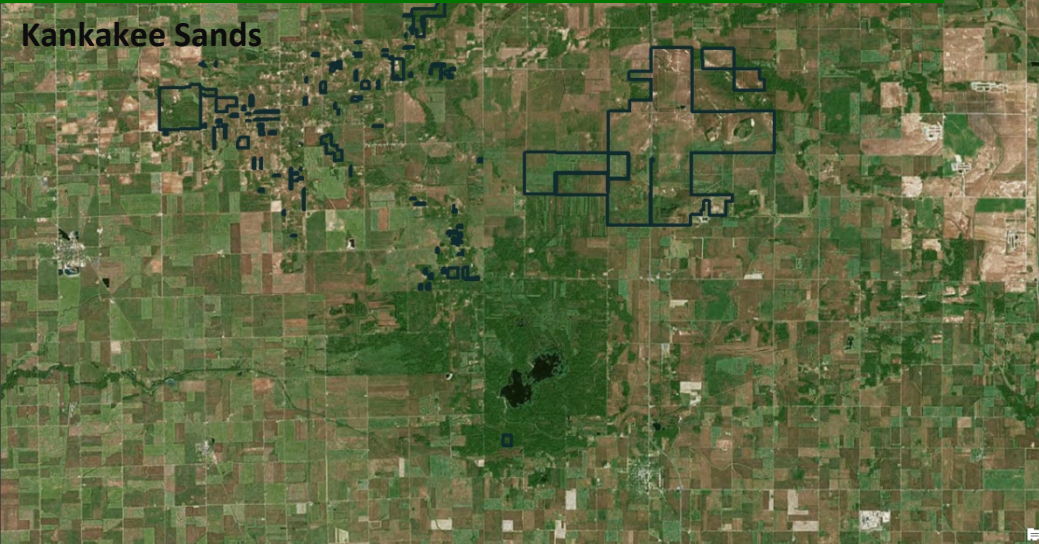


RK = 0.67



RK = 0.80

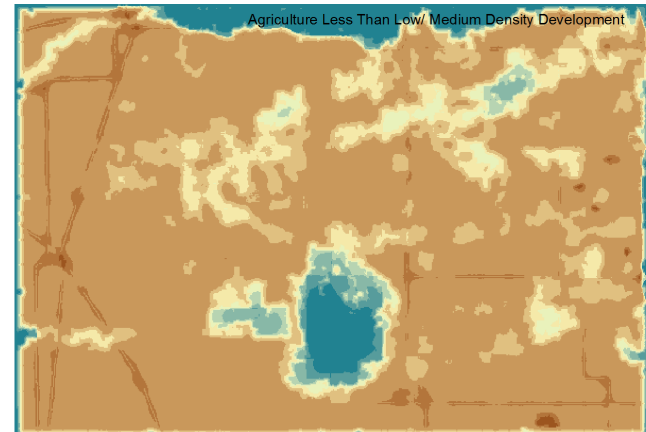
Kankakee Sands



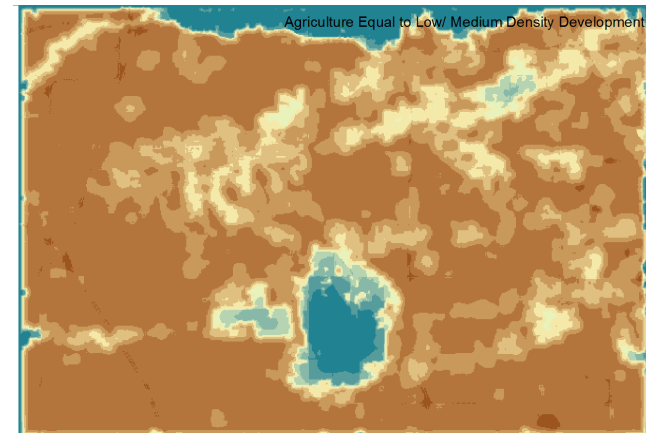
Traverse Value
High : 0.433676 Higher Local Connectivity
Low : 0.00494684 Low Local Connectivity

Agriculture Resistance

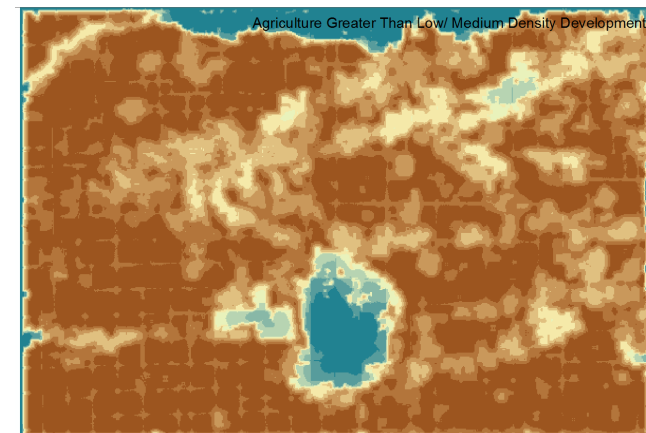
Less than > Development



Equal to = Development



Greater than > Development



3. Who is Using the Results?

Doris Duke Charitable Foundation: \$37M

\$11M in land capital in the East

\$ 6M in land capital in the Pacific Northwest

\$20M revolving loan fund for central Appalachians

LCCs

Conservation Design &
“Resilient Network” multi-LCC
collaboration

State Agencies

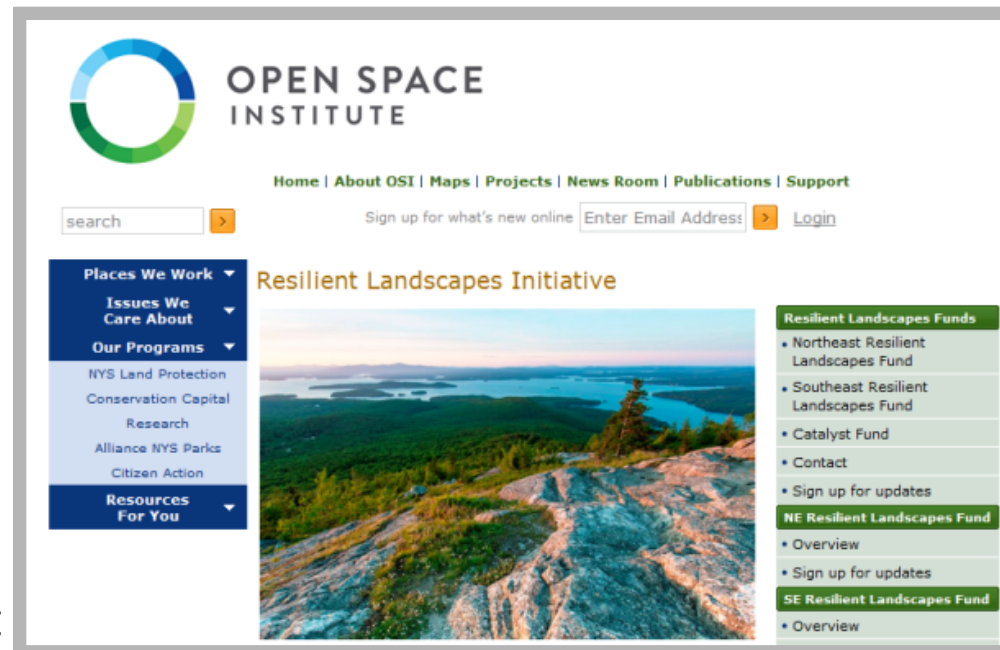
VT DNR BioFinder

MA DEP Landscape Partnership Grant

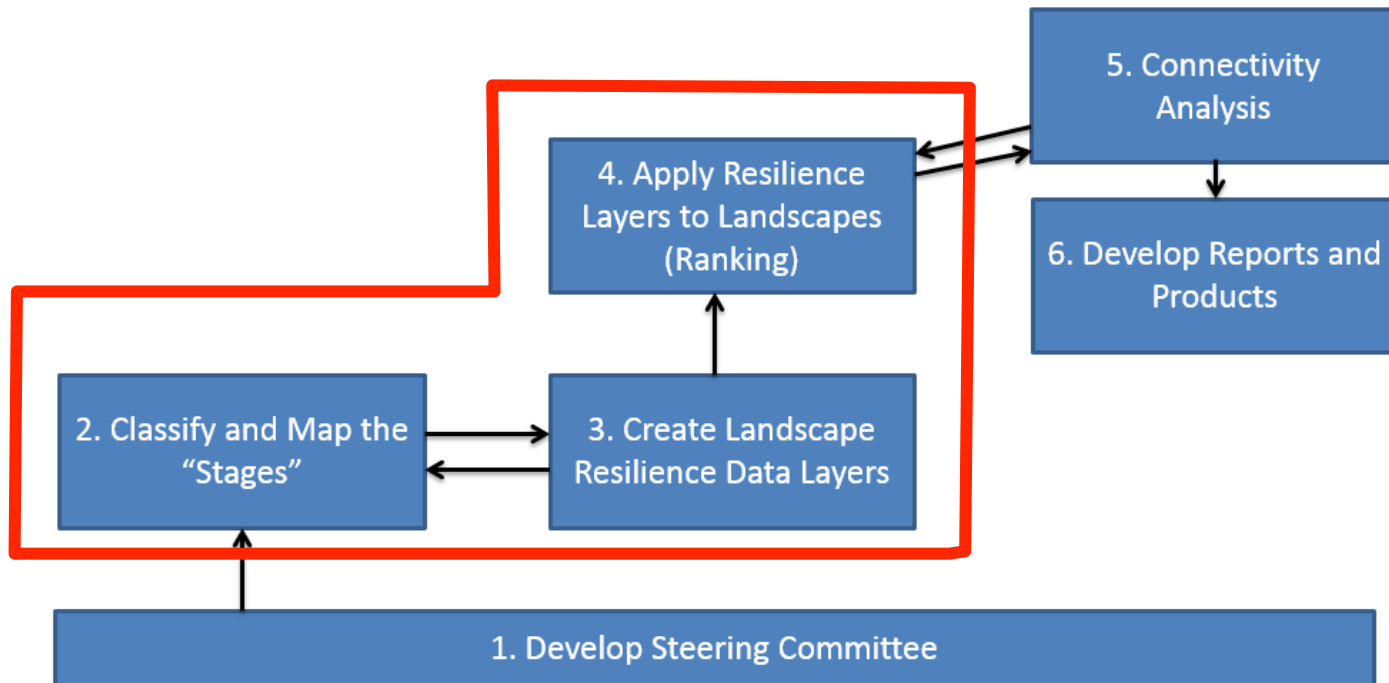
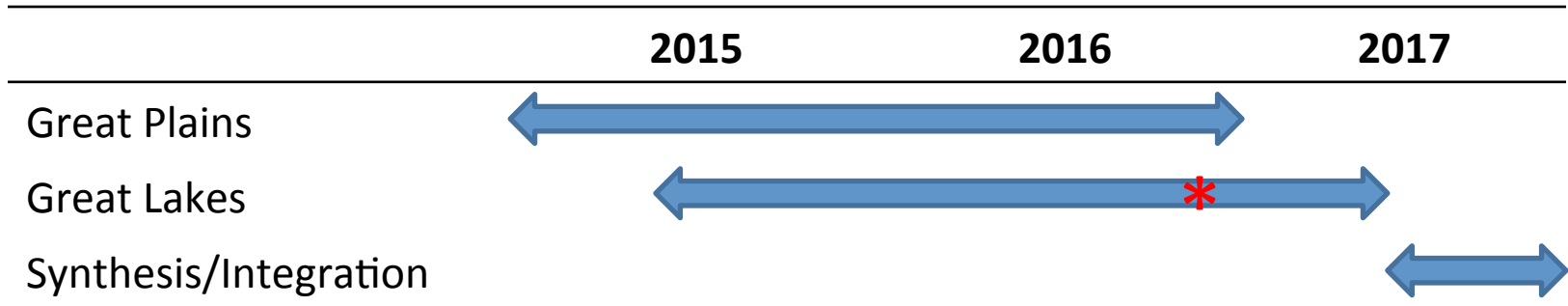
ME NHP Beginning with Habitat

SC DNR Re-evaluate state landholdings

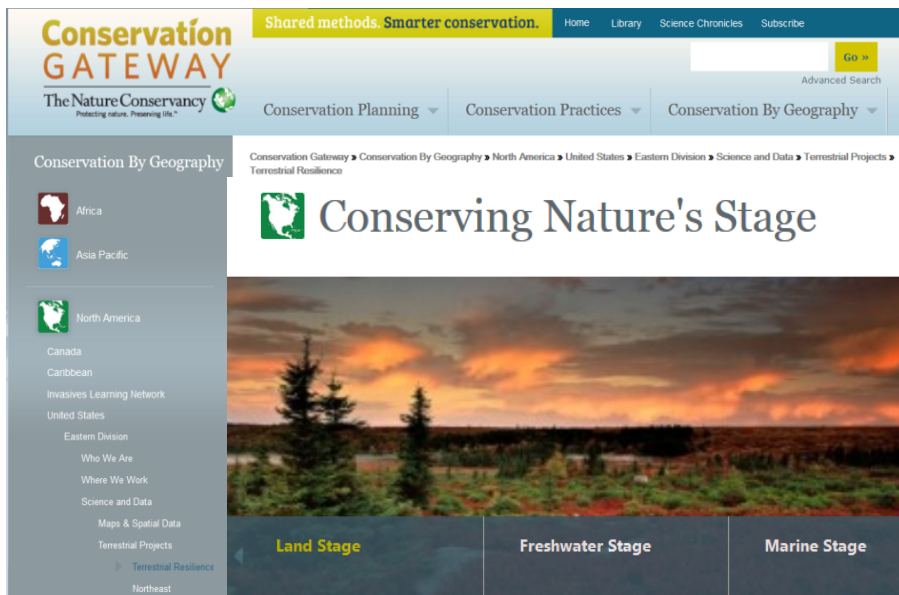
Many State Wildlife Action Plans



Central US: Timeline & Steps



How to Learn More



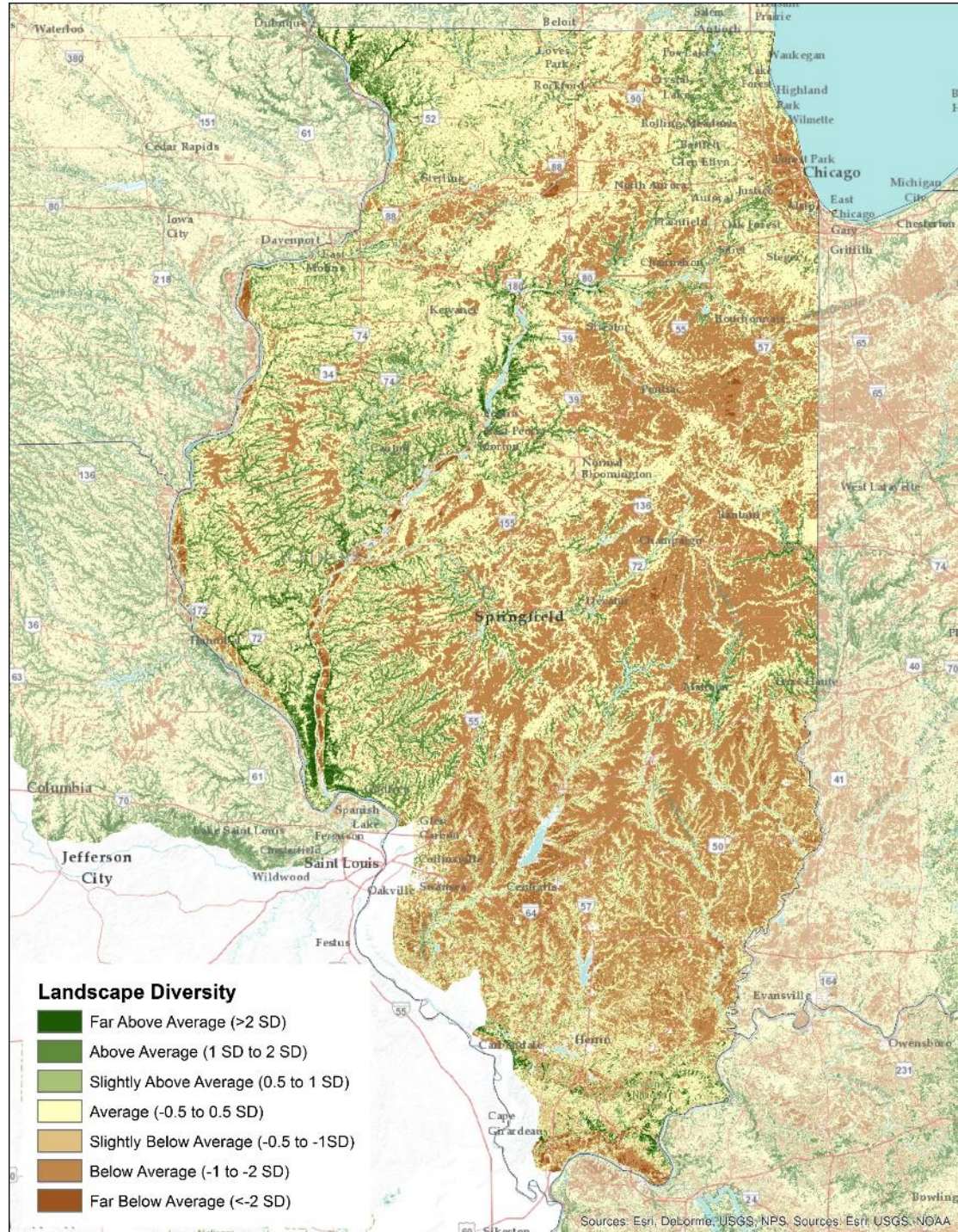
<http://www.nature.ly/TNCresilience>

Special Section: Conserving Nature's Stage

Life is a gloss on geography. And if you dig your fists into the earth and crumble geography, you strike geology. Climate is the wind of mineral earth's rondure, tilt, and orbit modified by local geological conditions. The Pacific Ocean, the Negev Desert, and the rain forest in Brazil are local geological conditions. So are the slow carp pools and splashing trout riffles of any backyard creek. It is all, God help us, a matter of rocks.

The rocks shape life like hands around swelling dough. In Virginia, the salamanders vary from mountain ridge to mountain ridge, so do the fiddle tunes the old men play. All this because it is hard to move from mountain to mountain. These are not merely anomalous details. This is what life is all about: salamanders, fiddle tunes, you and me and things, the split and burr of it all, the fizz into particulars. No mountains and one salamander, one fiddle tune, would be a lesser world. No continents, no fiddlers. No possum, no soup, no taters. The earth without form is void . . .

Annie Dillard (1982)

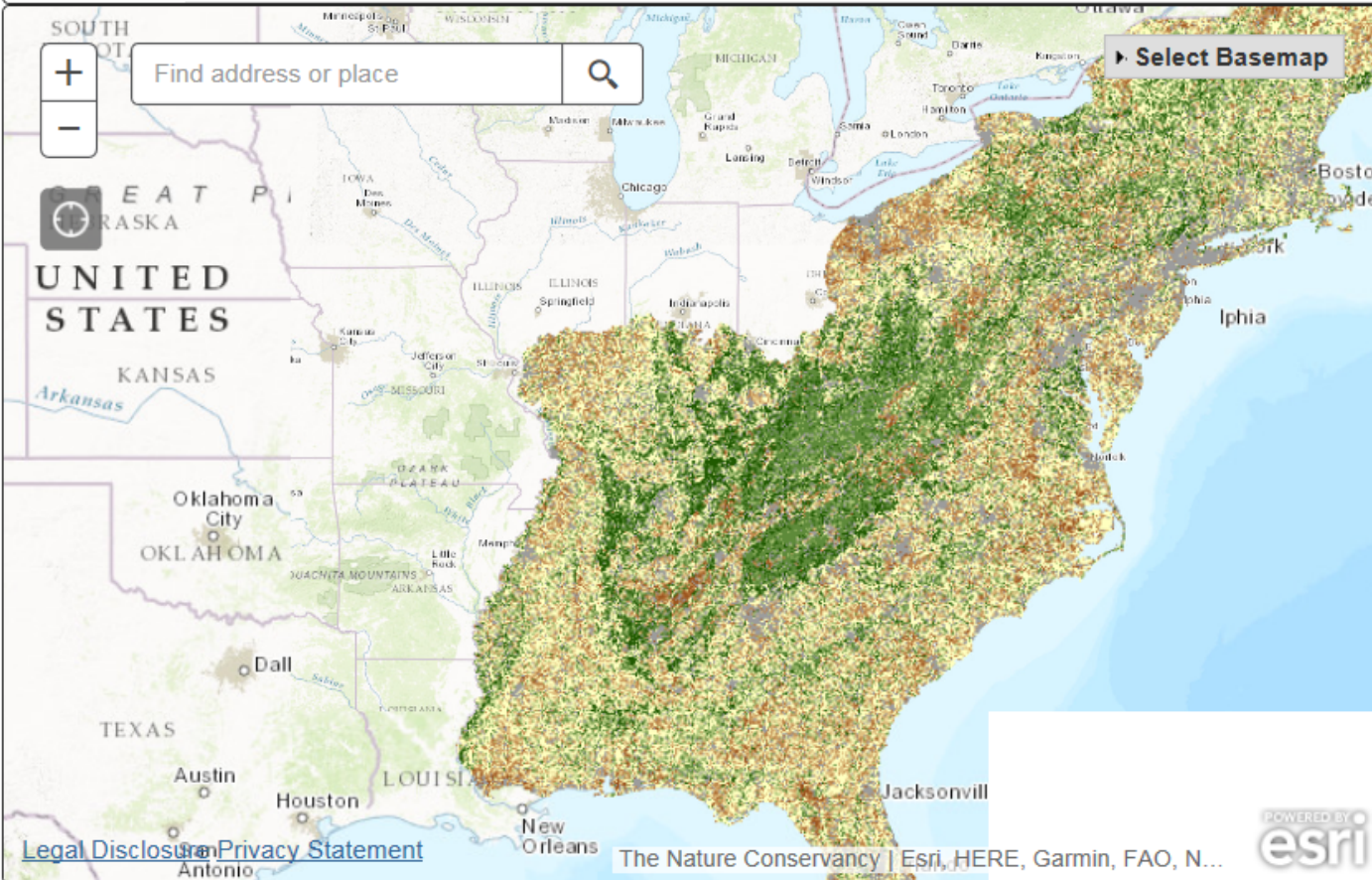


http://maps.tnc.org/resilientland/



Resilient Land Mapping Tool

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



Visualize

Resilience Data

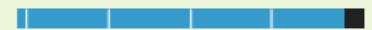
- Resilience
- Landscape Diversity
- Local Connectedness
- Geophysical Setting
- Landforms

Regional Connections

- Regional Flows
- Regional Flows - Description
- Riparian Climate Corridors

- Basemap Only

Set Transparency



Enter a URL for an ArcGIS Map Service

Add Map Service





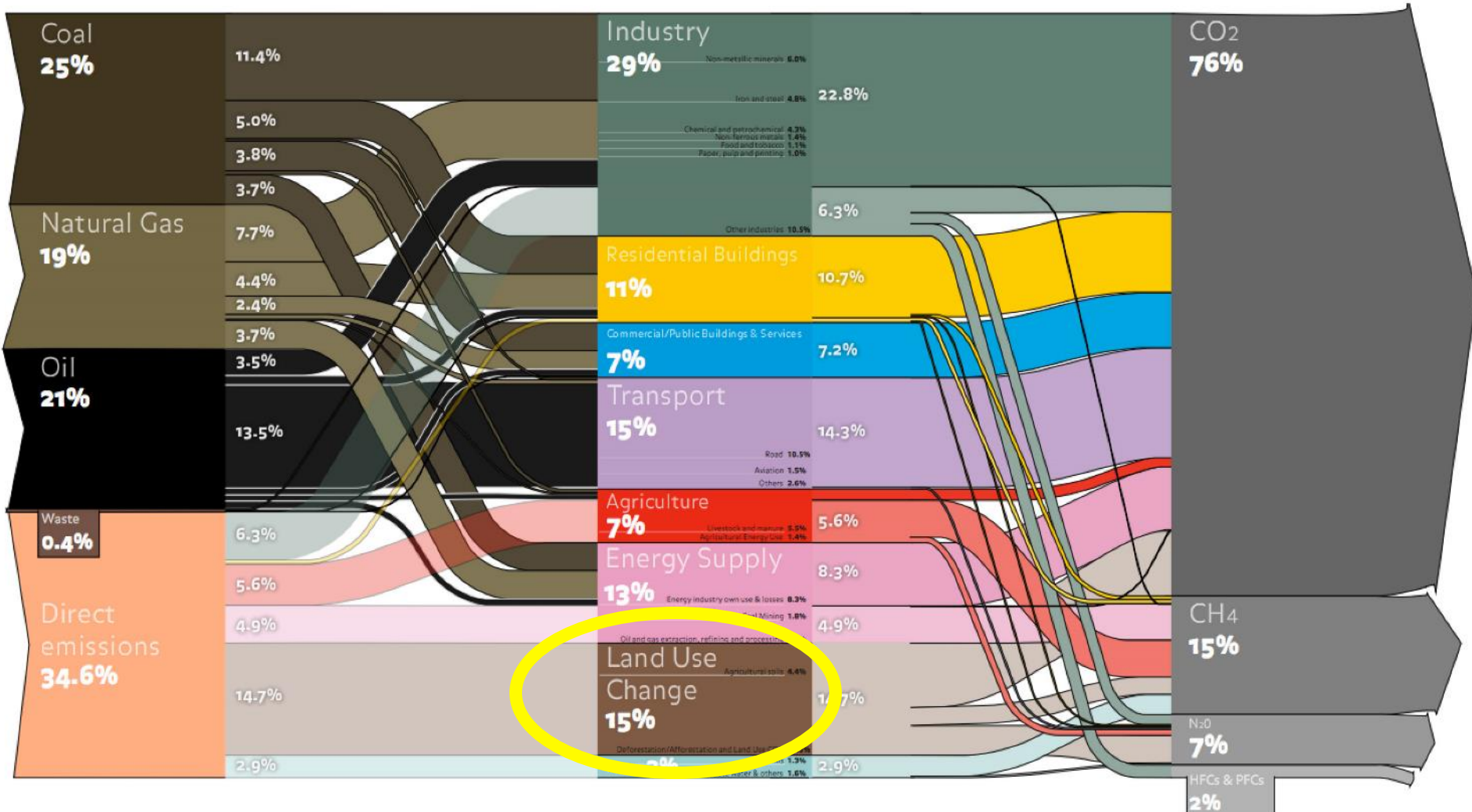
more carbon than contained in remaining oil stocks
double the carbon currently accumulated in atmosphere

**Earth's vegetation & soils currently contain the
equivalent of ~7,500 gigatons of CO²**

WORLD GHG EMISSIONS FLOW CHART 2010

Total emission worldwide (2010)

48 629
MtCO₂ EQ



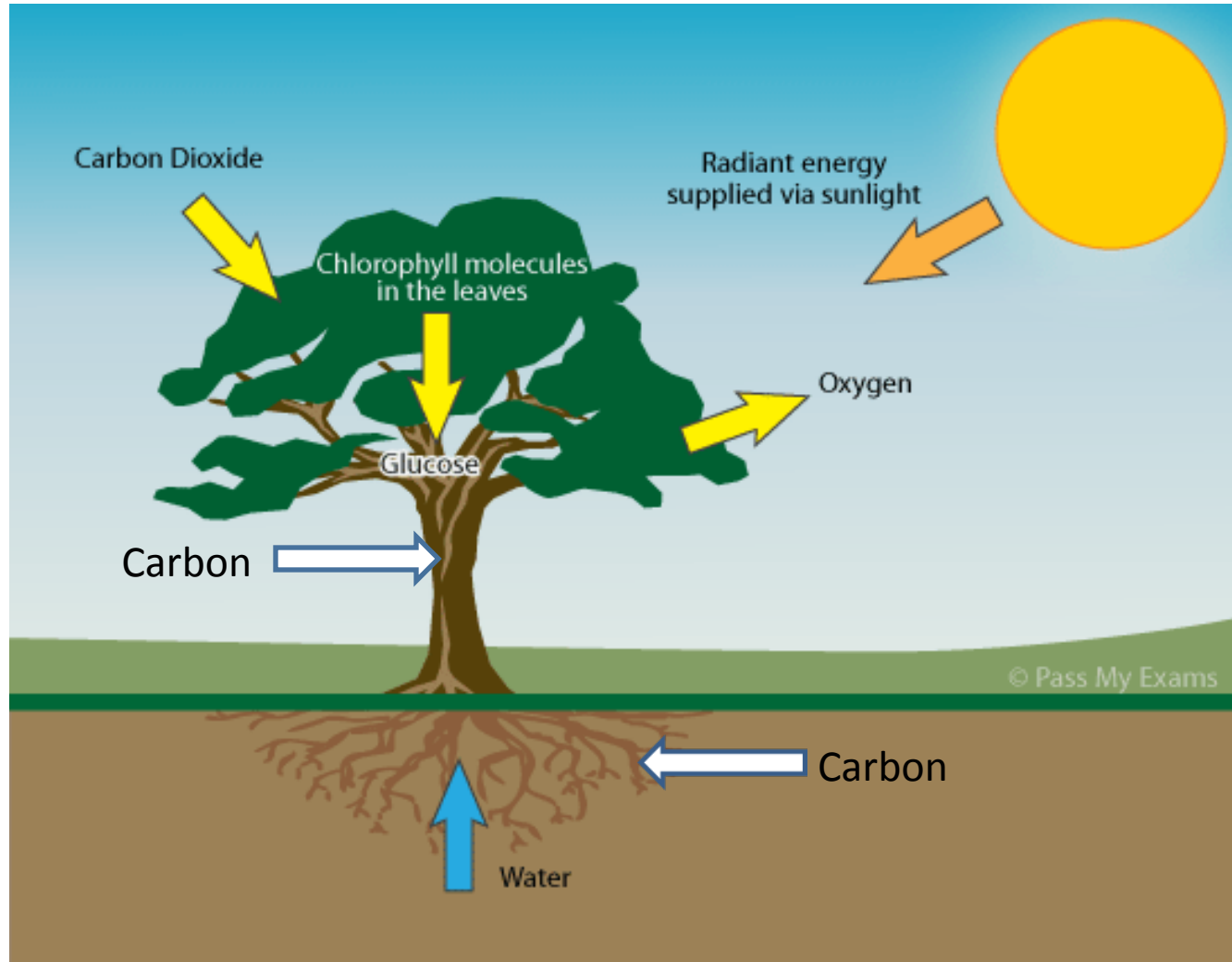
Avoided Conversion



**Chicago
Wilderness:**
Avoided
emission of 53
million tons of
carbon dioxide
into the
atmosphere!

Mitigation By Biosequestration

(Or Photosynthesis is Our Friend)

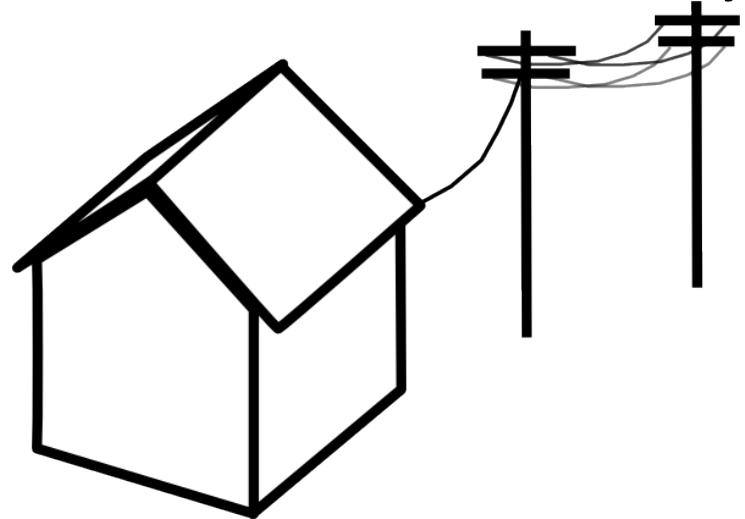


Restoration

Restored Prairie =
~1 ton CO₂ equivalent/acre/yr



Car Emissions = 10.5 tons CO₂/yr



Emissions for Household Electricity = 7.4 tons CO₂/yr

Enhancement and Rehabilitation

healthier soils and larger plants store more carbon



Surprising Strategies...



More and more studies are documenting how “good fire” increases long-term biosequestration

No-till farming and managed grazing can minimize loss of - and even rebuild – soil organic matter

