

# Climate Change, Seed Banking and Assisted Migration – the long shadows of humanity

**Dixon National Tallgrass Prairie Seed Bank Staff  
Dave Sollenberger, Pati Vitt, and Emily Yates**



# Responses to Climate Change

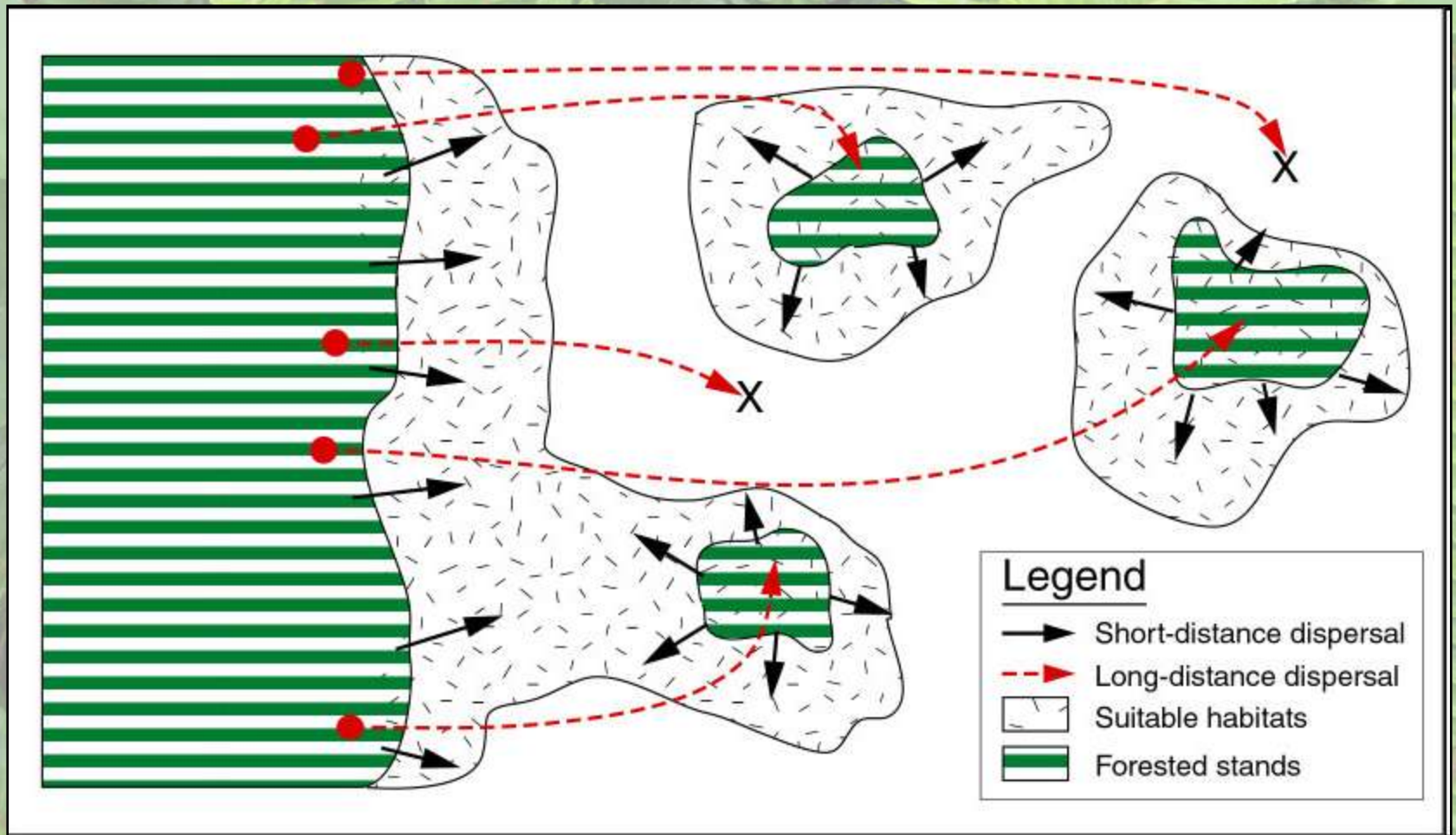
## Native Species

- **Adaptation**
- **Migration**
- **Local Extirpation**
- **Extinction**

## People

- **Focused Conservation**
- **Seed Banking**
- **Assisted Migration**
- **Acceptance**

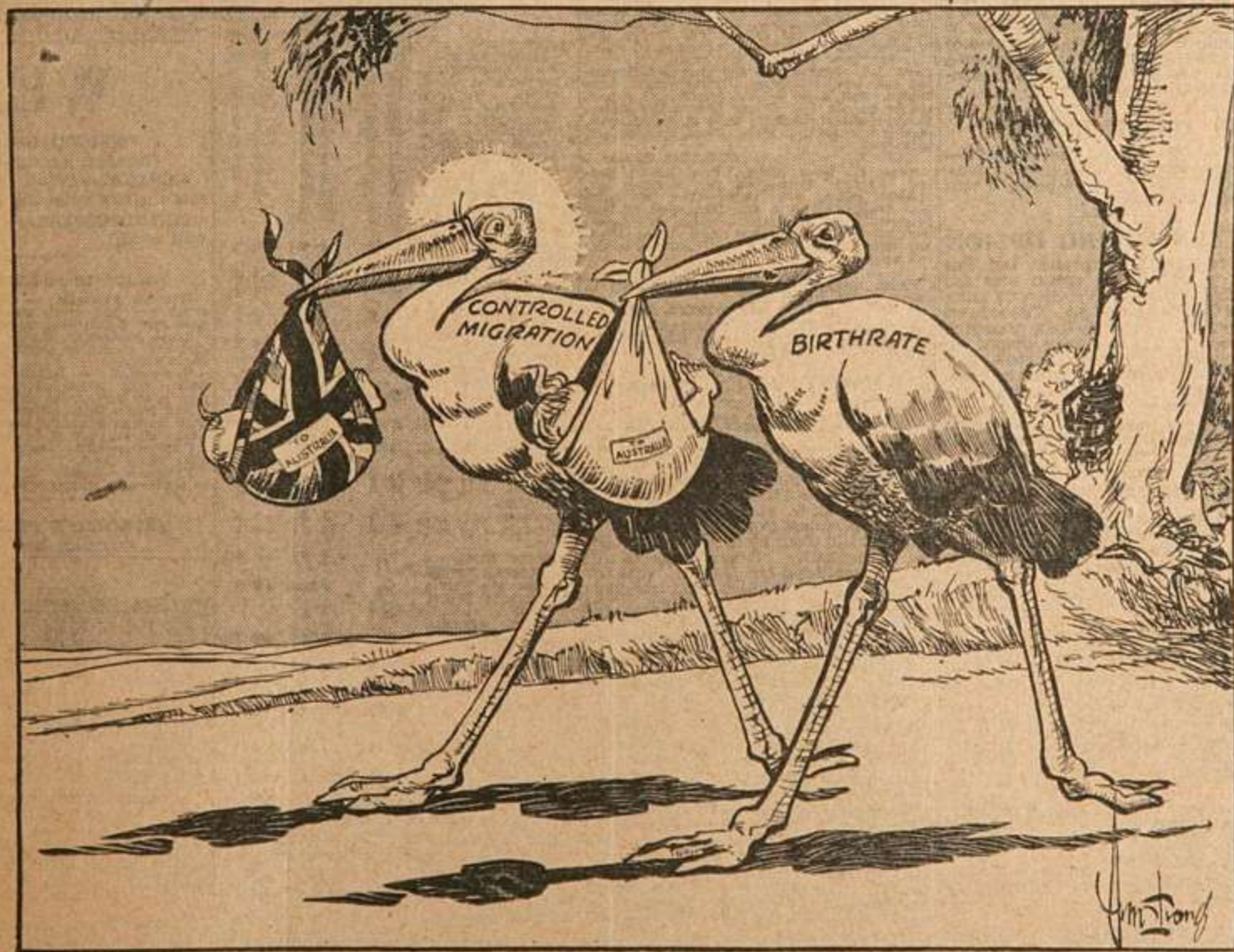




Stochastic long-distance dispersal

Liske, 1999

118 / "A SISTER TO ASSIST HER!"



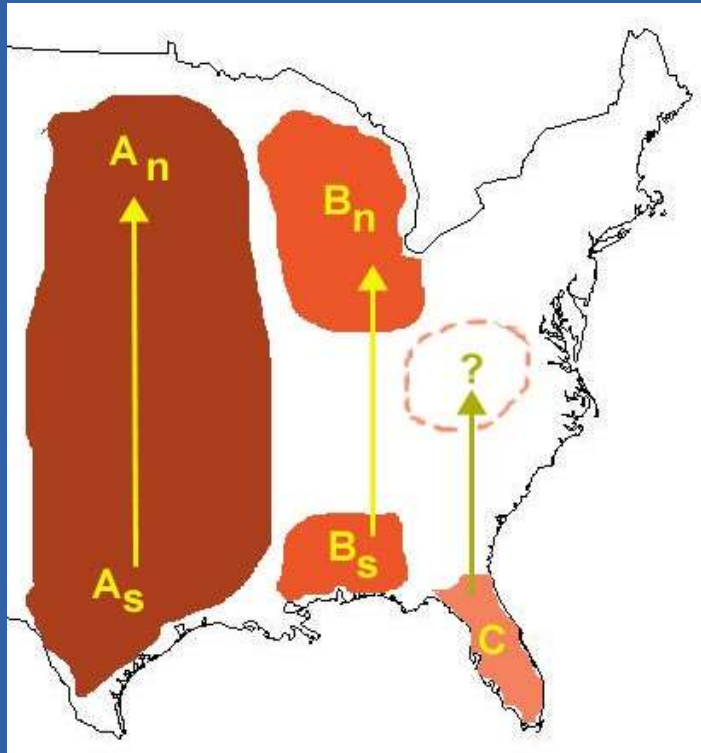
Concerned by the decline in the birth rate in Australia, the Lyons Ministry plans the resumption of assisted migration of British stock, and an increase in the scope of the maternity allowance.

# **Assisted Migration (Managed Relocation, Assisted Colonization)**

The purposeful movement of species to facilitate or mimic natural range expansion, as a direct management response to climate change. Vitt et al, 2010 Bio Cons

Assisted migration/managed relocation usually defined as movement outside of known historic range.

# Scenarios for Assisted Migration



A: Movement to increase potential adaptation to climate change. When resulting in purposeful introgression = “Facilitated Adaption”

B: Natural dispersal that has been disrupted by loss of habitat connectivity restored through assisted migration.

C: Translocation outside of historic range (as far as we can tell).

# Species Distribution Modeling

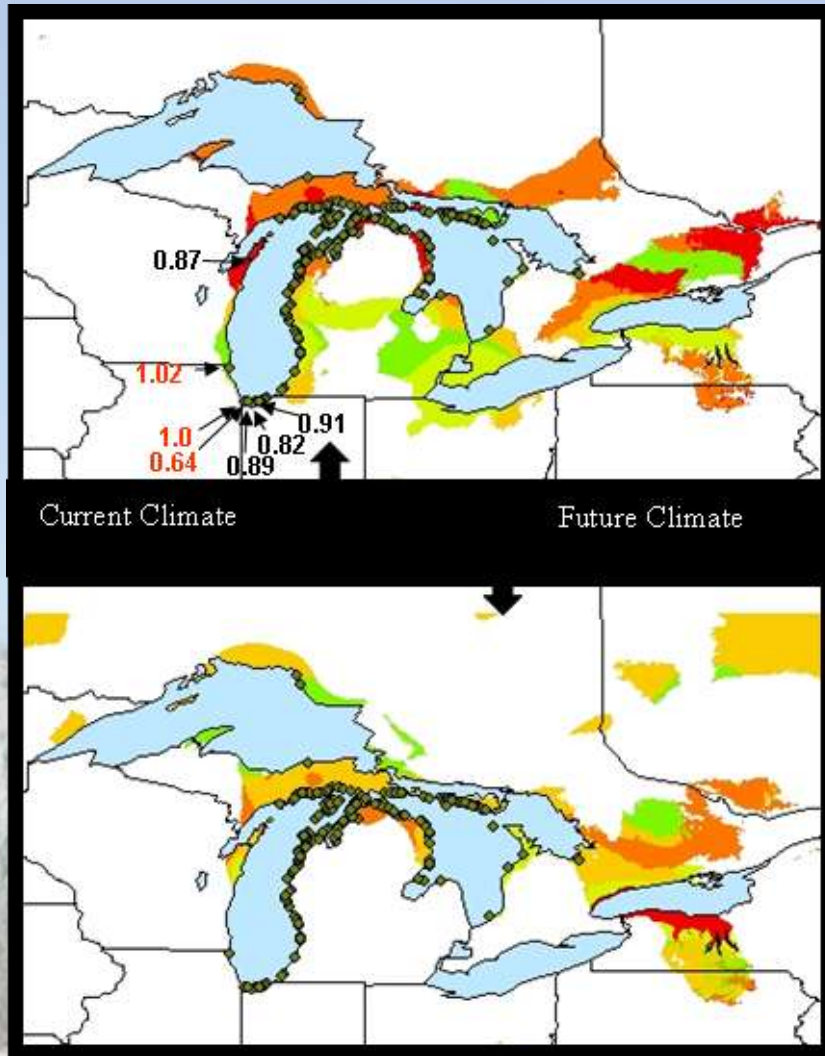
- Essentially model the realized niche of a species
- Use locality data and environmental layers (including climate variables)
- Several studies, including my own and one of my graduate students, have shown that MaxEnt outperforms many other modeling approaches...and..
- It's FREE!

# Climate Variables Used

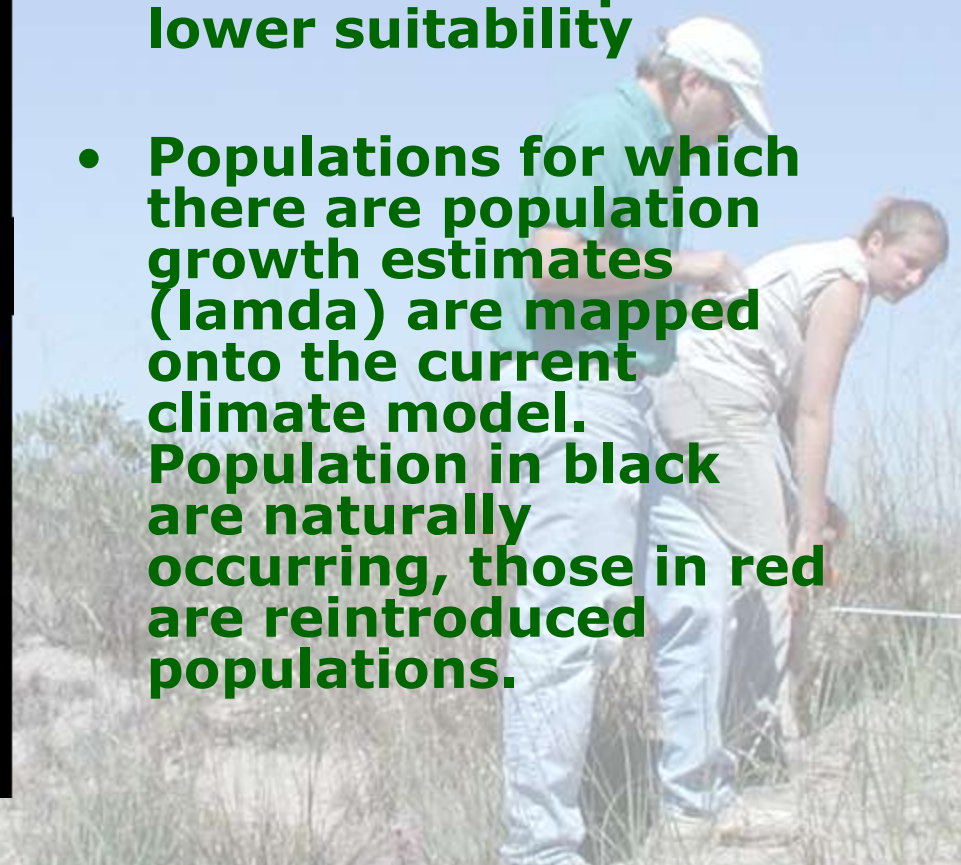
Mean Annual Temp	Mean Monthly Temp Range	Isothermality
Temperature Seasonality	Max Temp Warmest Month	Min Temp Coldest Month
Temp Annual Range	Mean Temp Warmest Quarter	Mean Temp Driest Quarter
Mean Temp Warmest Quarter	Mean Temp Coldest Quarter	Annual Precipitation
Precip Wettest month	Precip Driest Month	Precip Seasonality
Precip Wettest Quarter	Precip Driest Quarter	Precip Warmest Quarter
Precip Coldest Quarter	Altitude (Elevation)	

**Current Climate Data: WorldClim, version 1.3, October 2004. Future Climate Data: (2xCO<sub>2</sub> climate conditions, CCM3 model) B. Govindasamy, P.B. Duffy, J. Coguand, 2003. High-resolution simulations of global climate, part 2: effects of increased greenhouse cases. Climate Dynamics 21: 391–404**

# Predicted *Cirsium pitcheri* Distribution using MaxEnt



- **Climate suitability response:** warmer tones indicate higher bioclimatic suitability, cooler tones represent lower suitability
- **Populations for which there are population growth estimates ( $\lambda$ ) are mapped onto the current climate model. Population in black are naturally occurring, those in red are reintroduced populations.**





Indiana Dunes State Park



Indiana Dunes National Lkshr



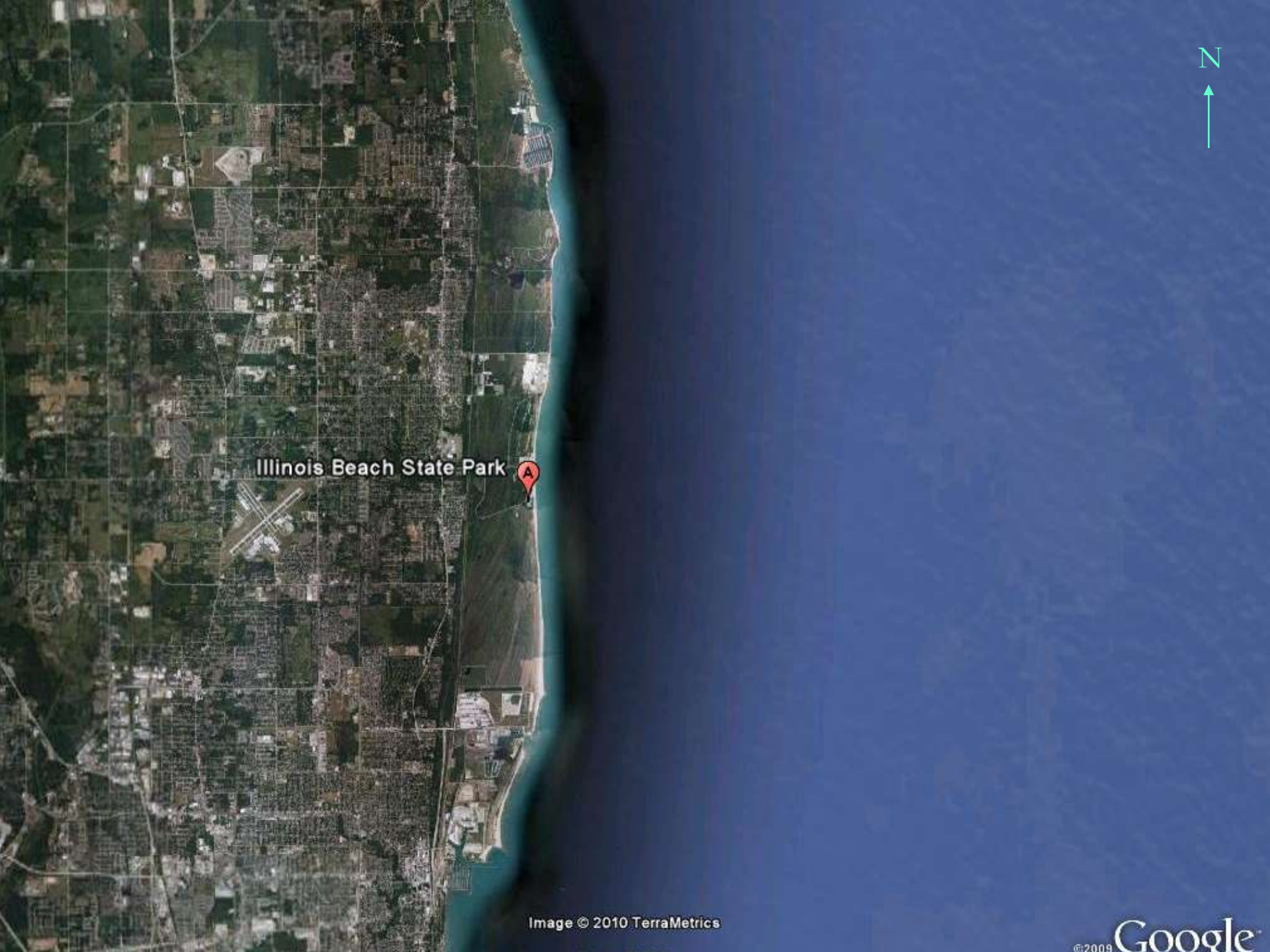
Indiana Dunes National Lakeshore



Indiana Dunes Natl Lakeshore



Dunes Learning Center



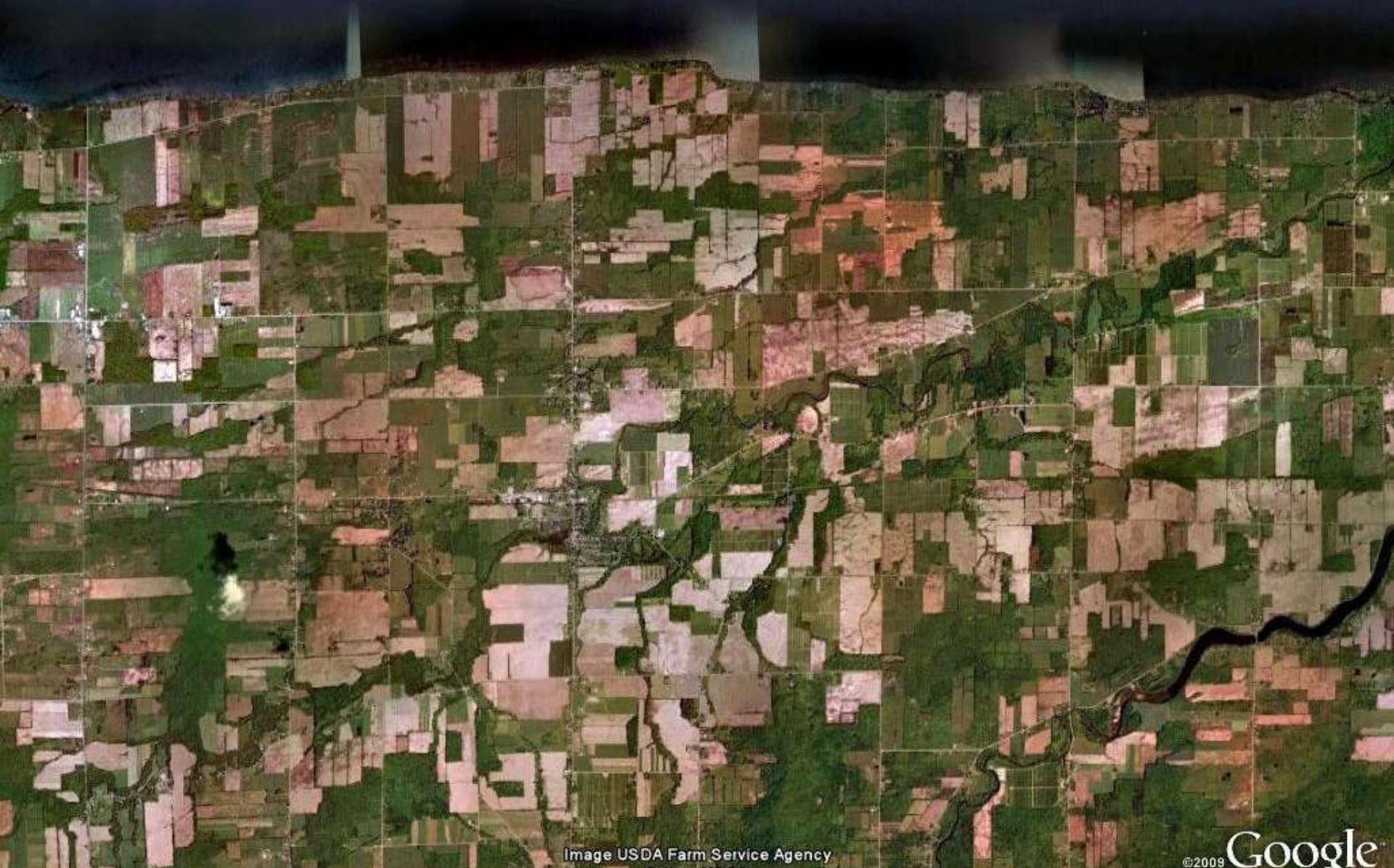
Illinois Beach State Park



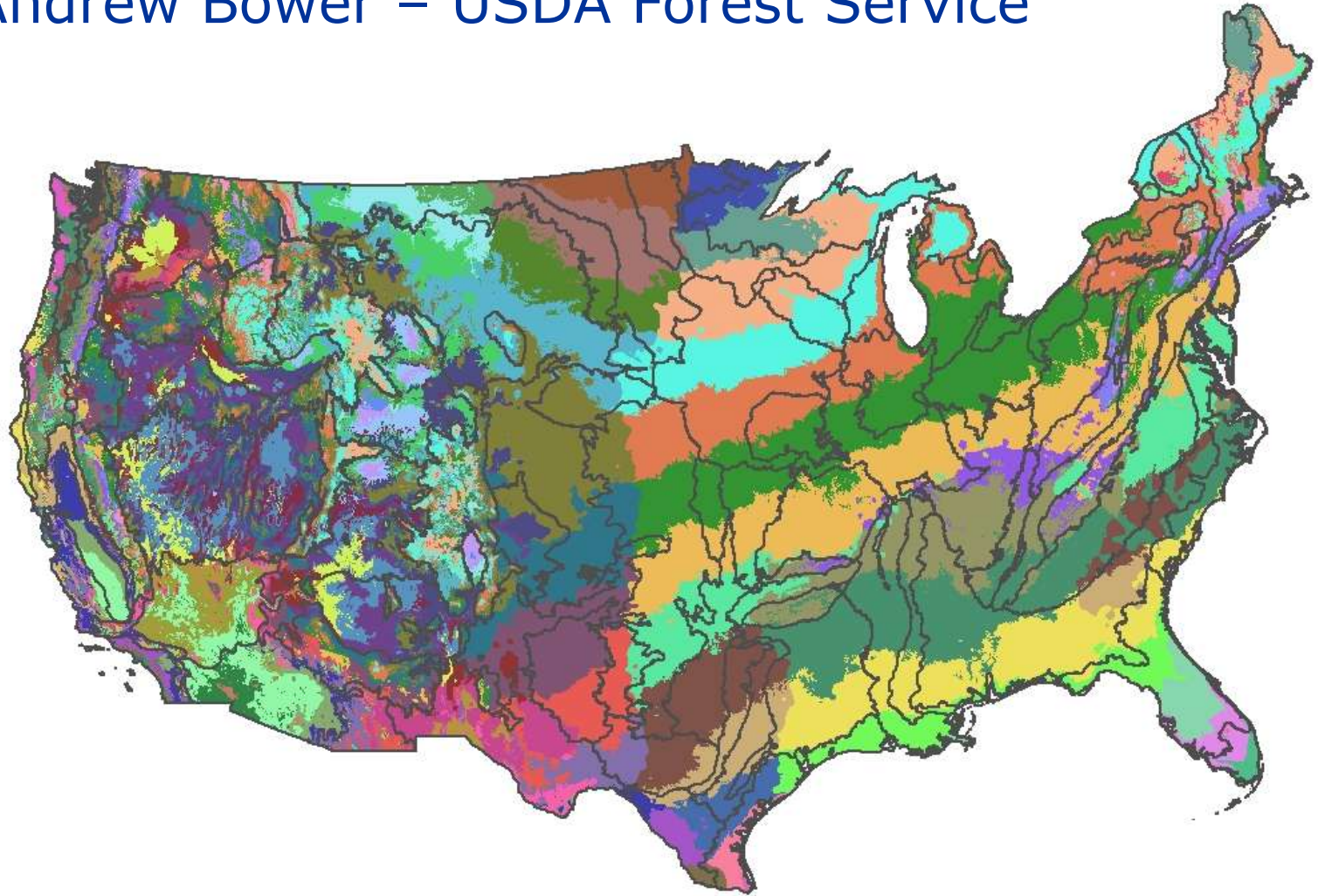


# Southern Shore of Lake Ontario

(~ 11 miles in length)

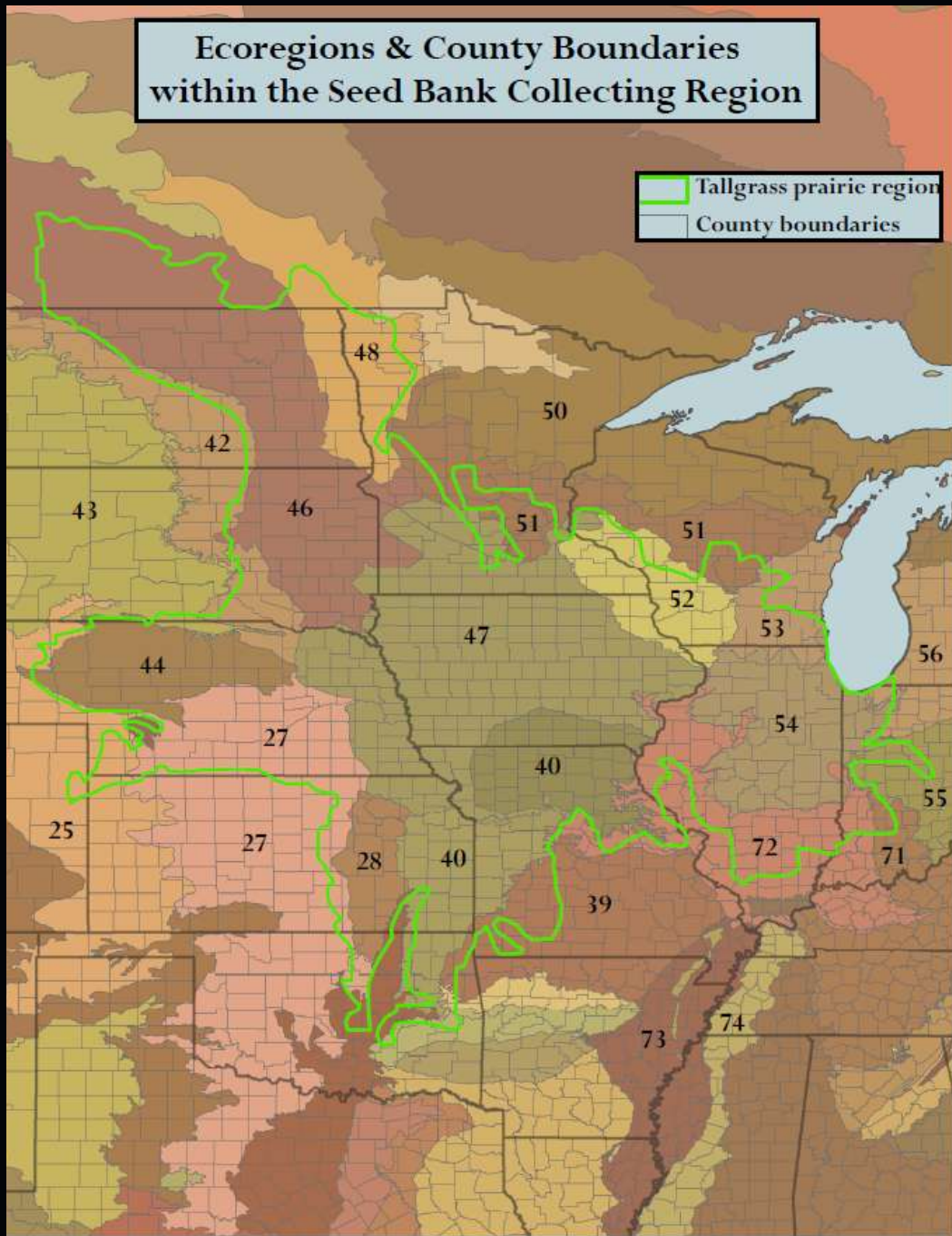


# Minimum Temps/Omernik Ecoregion Level III Andrew Bower – USDA Forest Service



# Ecoregions & County Boundaries within the Seed Bank Collecting Region

Tallgrass prairie region  
County boundaries



**Compile a comprehensive species list – Nature Serve**



**Perform literature search to determine overall importance of each taxa in plant communities**



**Eliminate non-native taxa**



**Eliminate hybrid taxa**

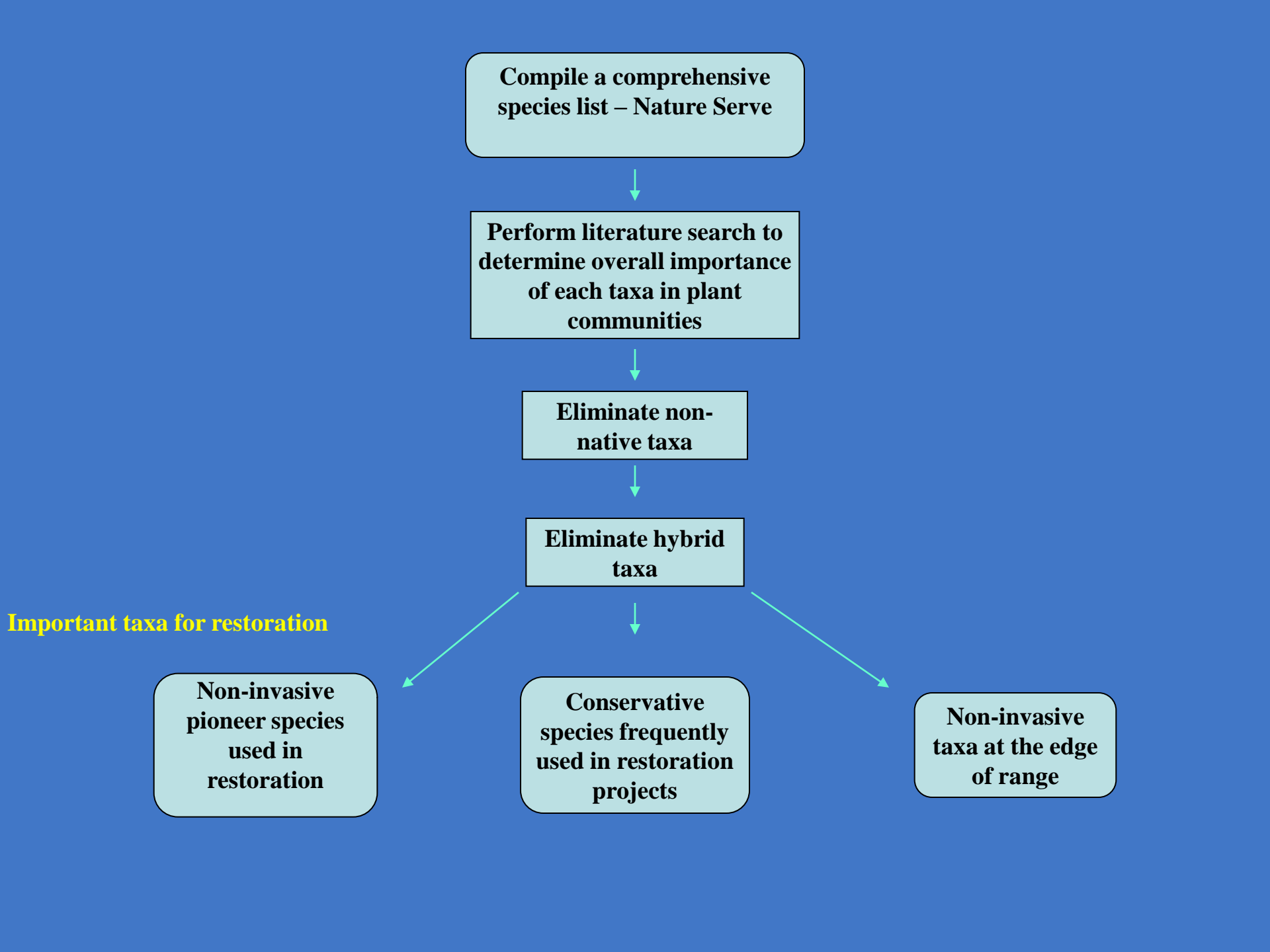


**Non-invasive pioneer species used in restoration**

**Conservative species frequently used in restoration projects**

**Non-invasive taxa at the edge of range**

**Important taxa for restoration**

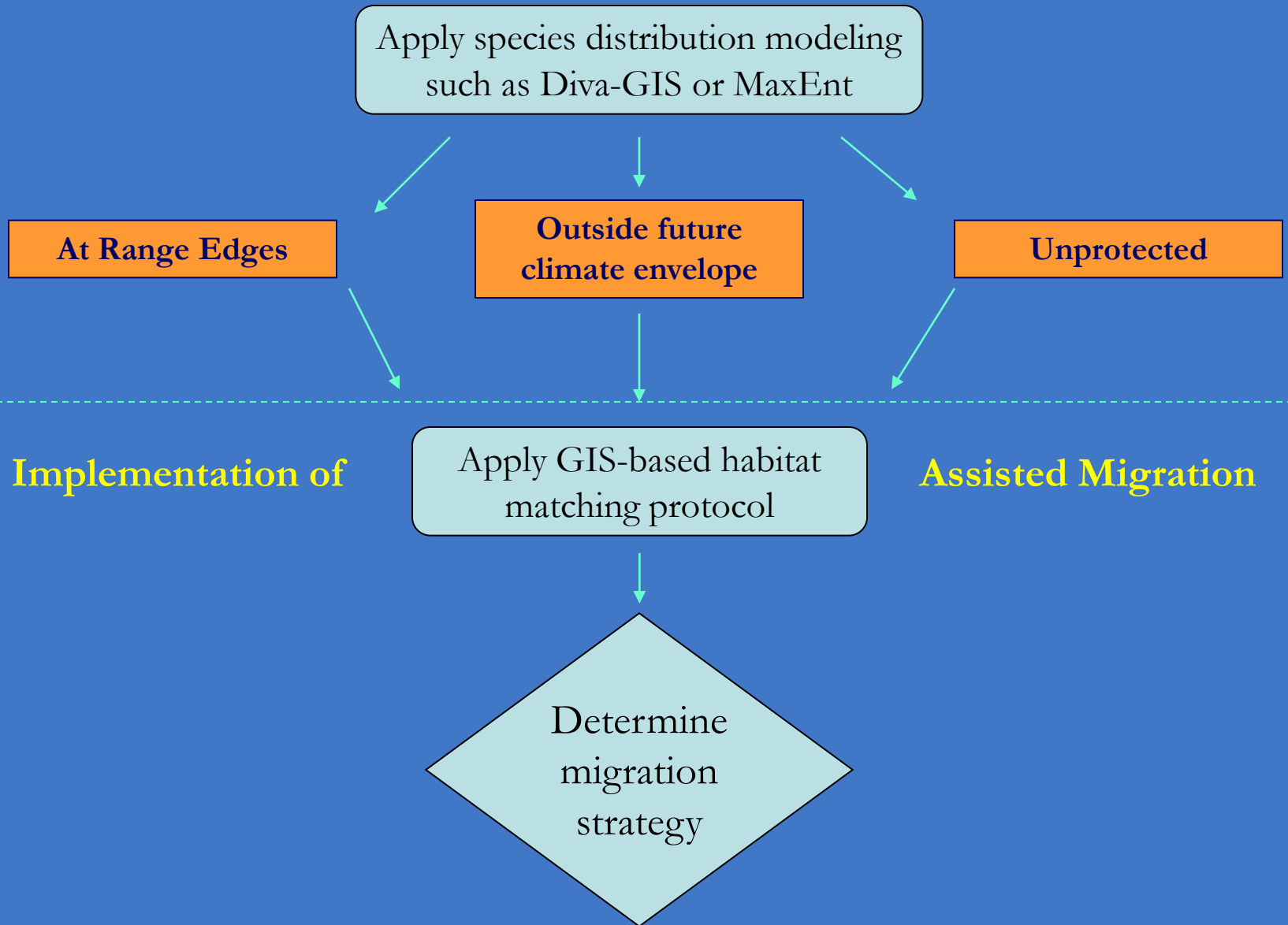


## Important taxa for assisted migration (Collection Priority)

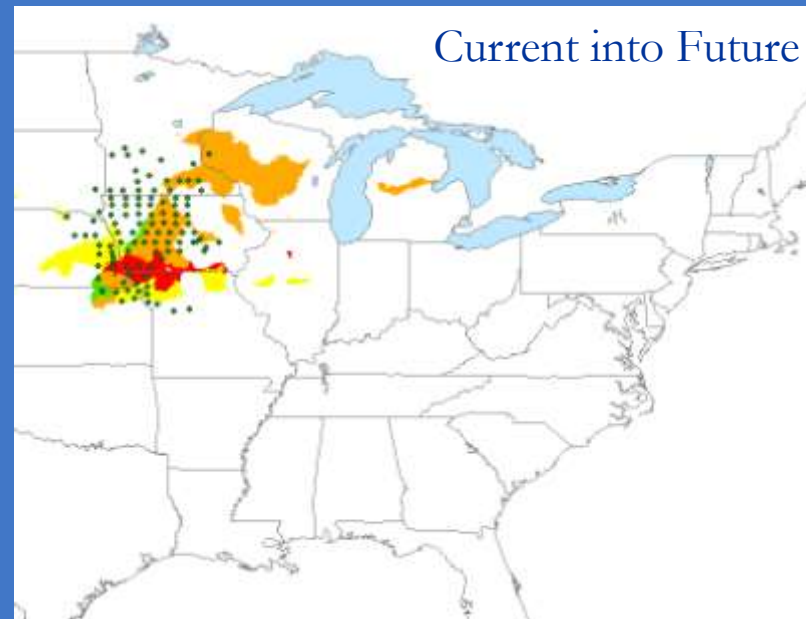
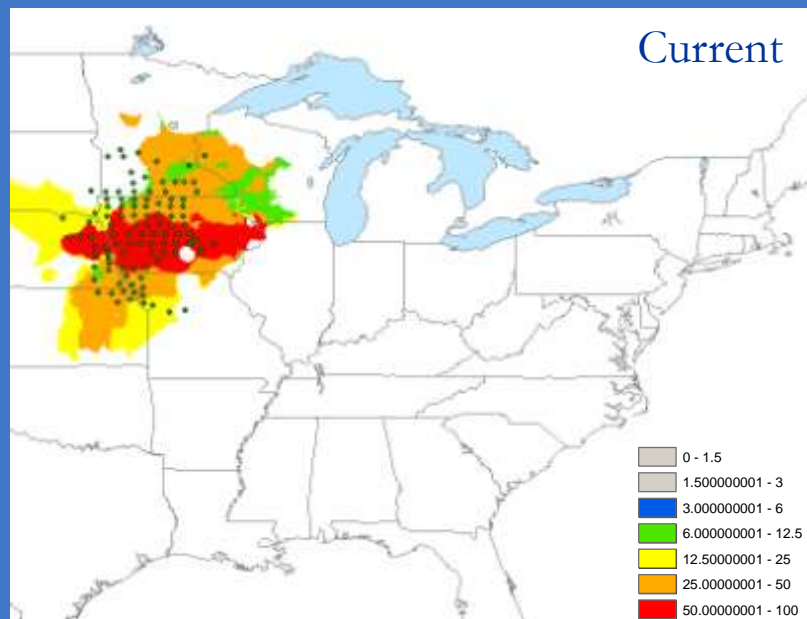
- Taxa with patchy distribution or only locally abundant
- Highly conservative taxa
- Uncommon to rare taxa
- Taxa with dispersal limitations
- Taxa with life history constraints
- Geographic risk-
  - Narrow endemic
  - Coastal
  - Montane

<http://www.cbgseedbank.org/restorationspecies.html>

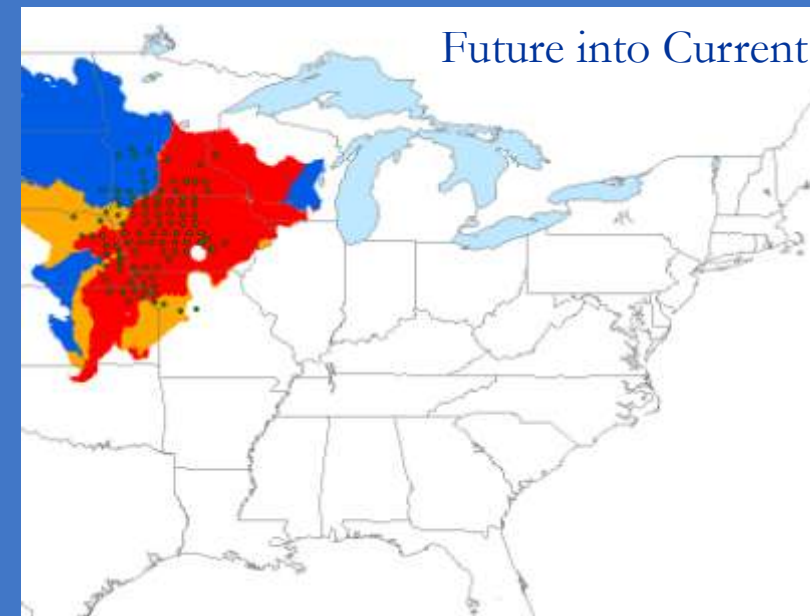
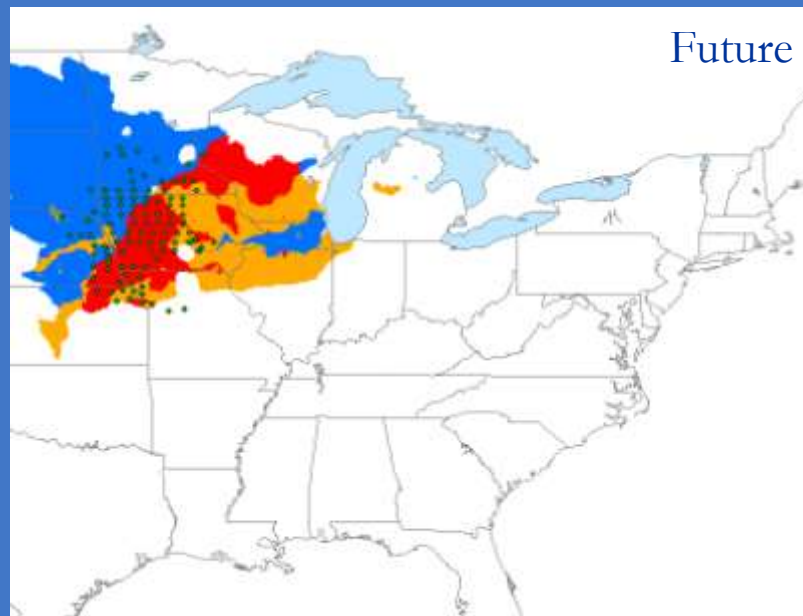
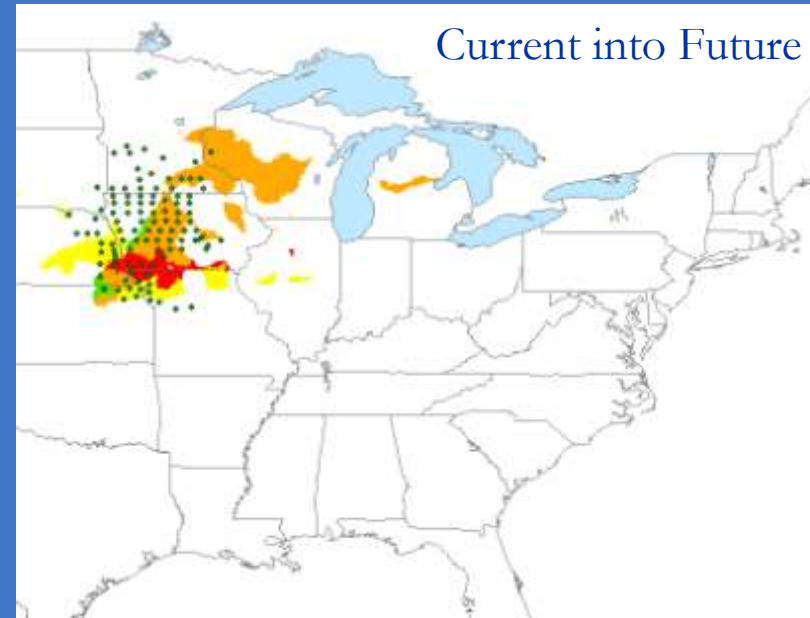
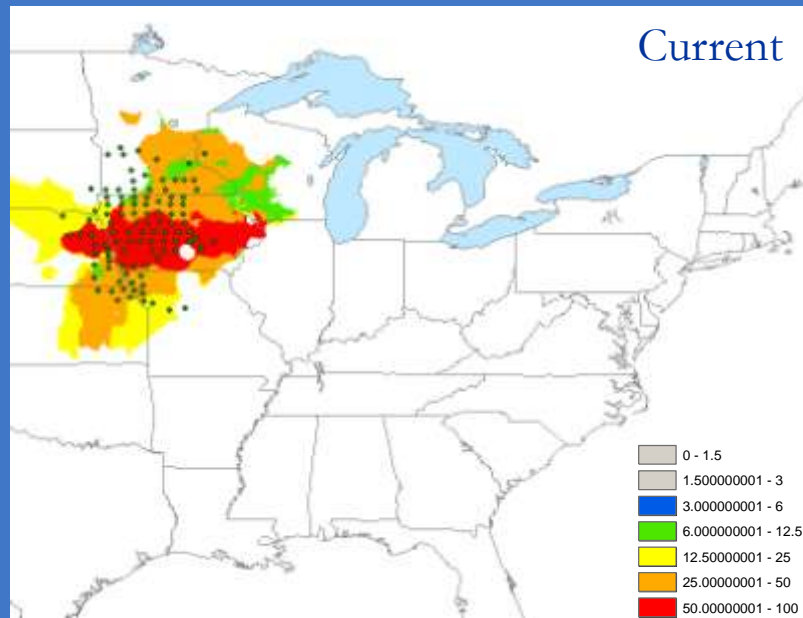
# Determine population level collection priority



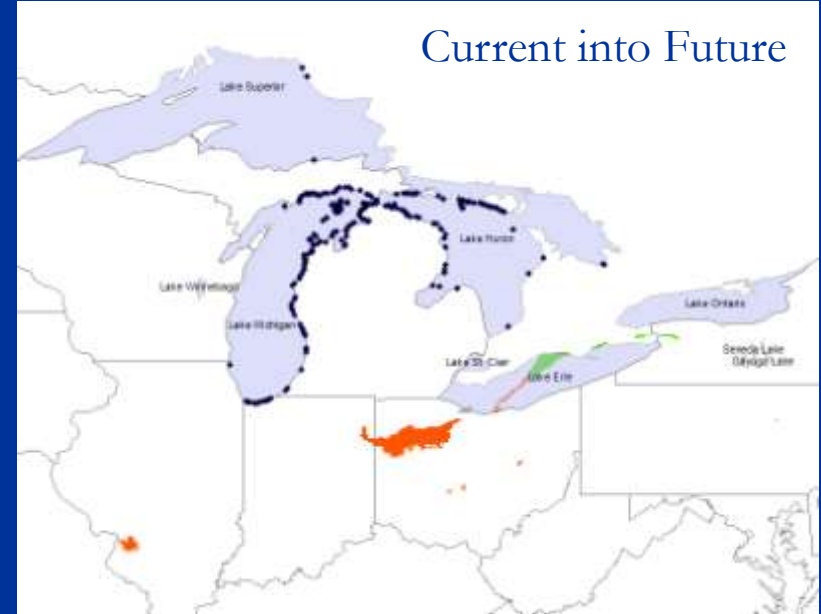
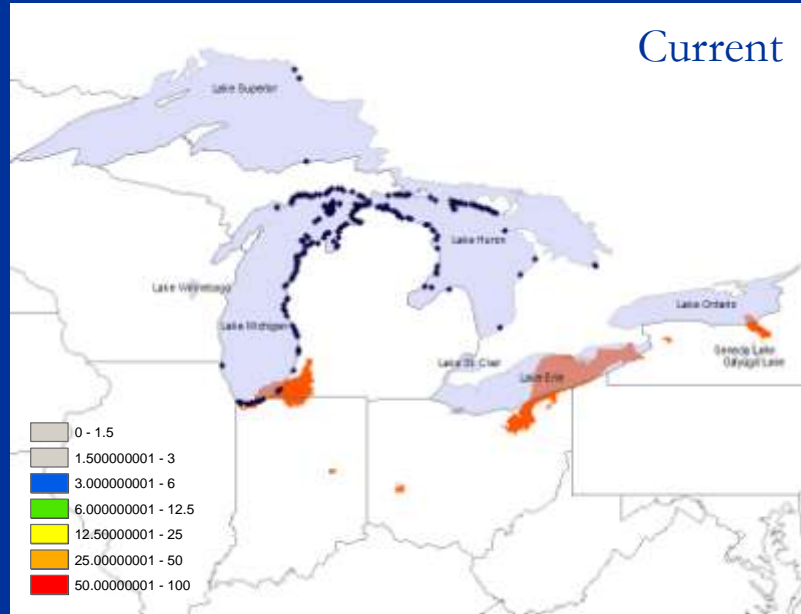
# *Andropogon gerardii* Ecoregion 47 Seed Source Model



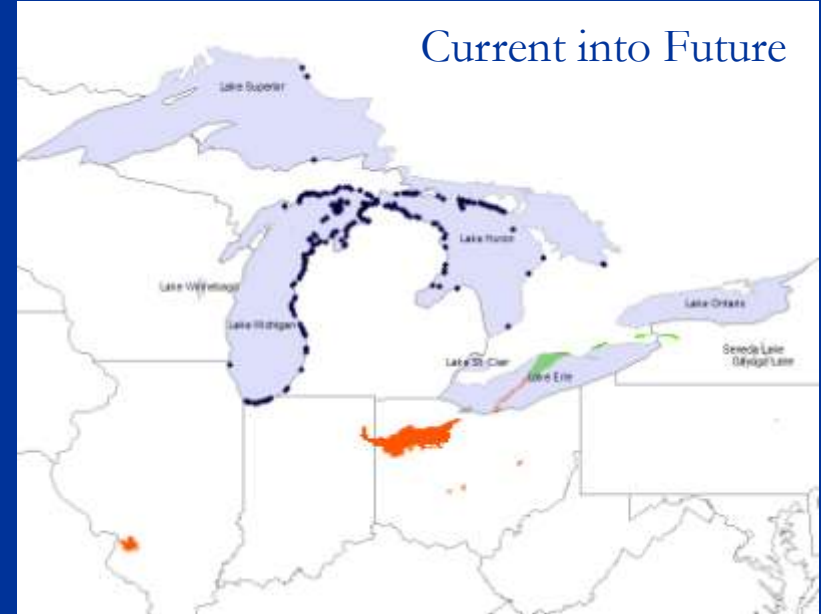
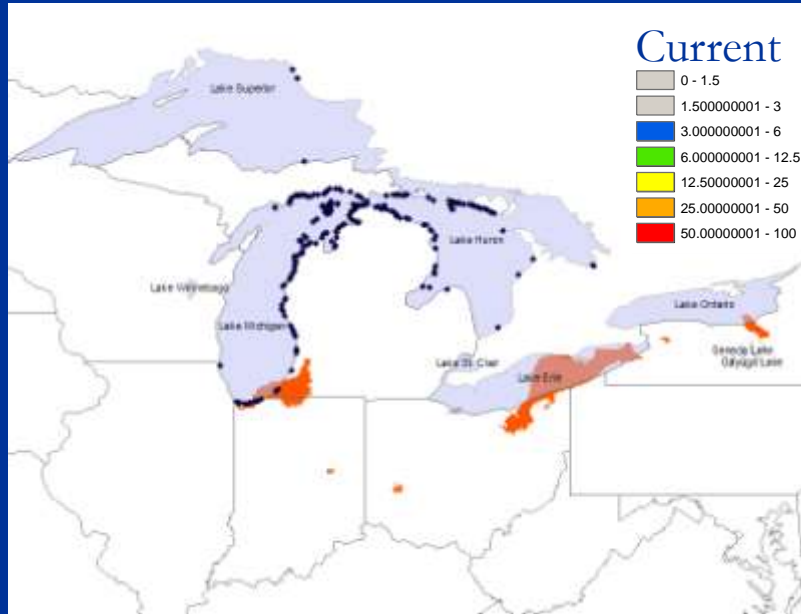
# *Andropogon gerardii* Ecoregion 47 Seed Source Model



# *Cirsium pitcheri* – seed source model for Southern Lake Michigan Populations/Sites



# *Cirsium pitcheri* – seed source model for Southern Lake Michigan Populations/Sites



N



Lake Erie – Southern Shore (Approx 11 miles)



Image State of Ohio / OSIP  
Image NOAA  
Image © 2010 TerraMetrics

©2009 Google

Image Dates: Feb 28, 2006 - May 31, 2007

41°25'38.23" N 82°18'36.36" W elev. 0 ft

Eve alt 10.3

# **Cost of Human-Mediated Native Plant Responses to Climate Change**

- **Millennium Seed Bank Project in the UK is collecting seeds from 25% of the world's flora, approximately 60,000 species, at a cost of US\$2000/seed collection (one population per species).**
- **There are approximately 6000 species in the diverse ecosystems that comprise the Midwestern grassland region.**

# Cost of Human-Mediated Native Plant Responses to Climate Change

- **The National Seeds of Success, coordinated by the Bureau of Land Management, estimates that it will cost us\$500M to collect and bank the entire U.S. flora (~14 000 species) and to develop restoration protocols and bulked seed for 1000 species.**
- **The current BLM budget for seed banking and native plant development is us\$7.6M/2011.**

**Surely we can agree that each species, however inconspicuous and humble it may seem to us at this moment, is a masterpiece of biology, and well worth saving. – E.O. Wilson**

# General Seed Collecting Protocols



- Collect from a minimum of 50 maternal lines (if <50, keep separate)
- Collect no more than 20% of available seed on that day
- Collect haphazardly, including small plants
- Collect across environmental gradients
- Collect both within the main portion of the population (where density is highest) and at the edges where density is low

A small yellow and brown bird is perched on a branch of a plant with yellow flowers. The bird is facing left and has a yellow breast and a brown back. The plant has green leaves and yellow flowers. The background is a clear blue sky.

# Seed Handling

- Seed is put into a low-temperature dryer
- Dried to  $>15\%$  humidity
- Seeds are cleaned
- Put into vapor barrier foil envelopes and then into freezer
- Redundant storage at Millennium Seed Bank, or the National Germplasm Repository at Fort Collins

# Collecting Across Time - Seasons

- Peak seed maturity has different paternal patterns than later in the season
- Within inflorescence variation (maternal as well as paternal effects)



# Inadvertent Selection

- Artificial selection for those genotypes that are able to endure the collection and storage protocols
- We don't know what alleles are lost when the small percentage of individuals die in the journey from field to freezer
- Or what selection is operating for those individuals that undergo attrition in the freezer over time
- Also, how do we prevent selection from occurring as we go from freezer to field?



# Where are we now?

- Over 1300 Accessions
- The vast majority are unique taxa
- In most years, we collect approximately 150-200 accessions
- Last two years, with additional full time staff we have collected nearly 300, mostly multiple populations, approximately half of those are held as part of our “restoration” collection



# Problems with this approach

- Millennium Seed Bank targets only one population per species
- Collection protocols are primarily designed to capture easily screened genetic markers (neutral variation), NOT quantitative traits



# Problems Cont'd

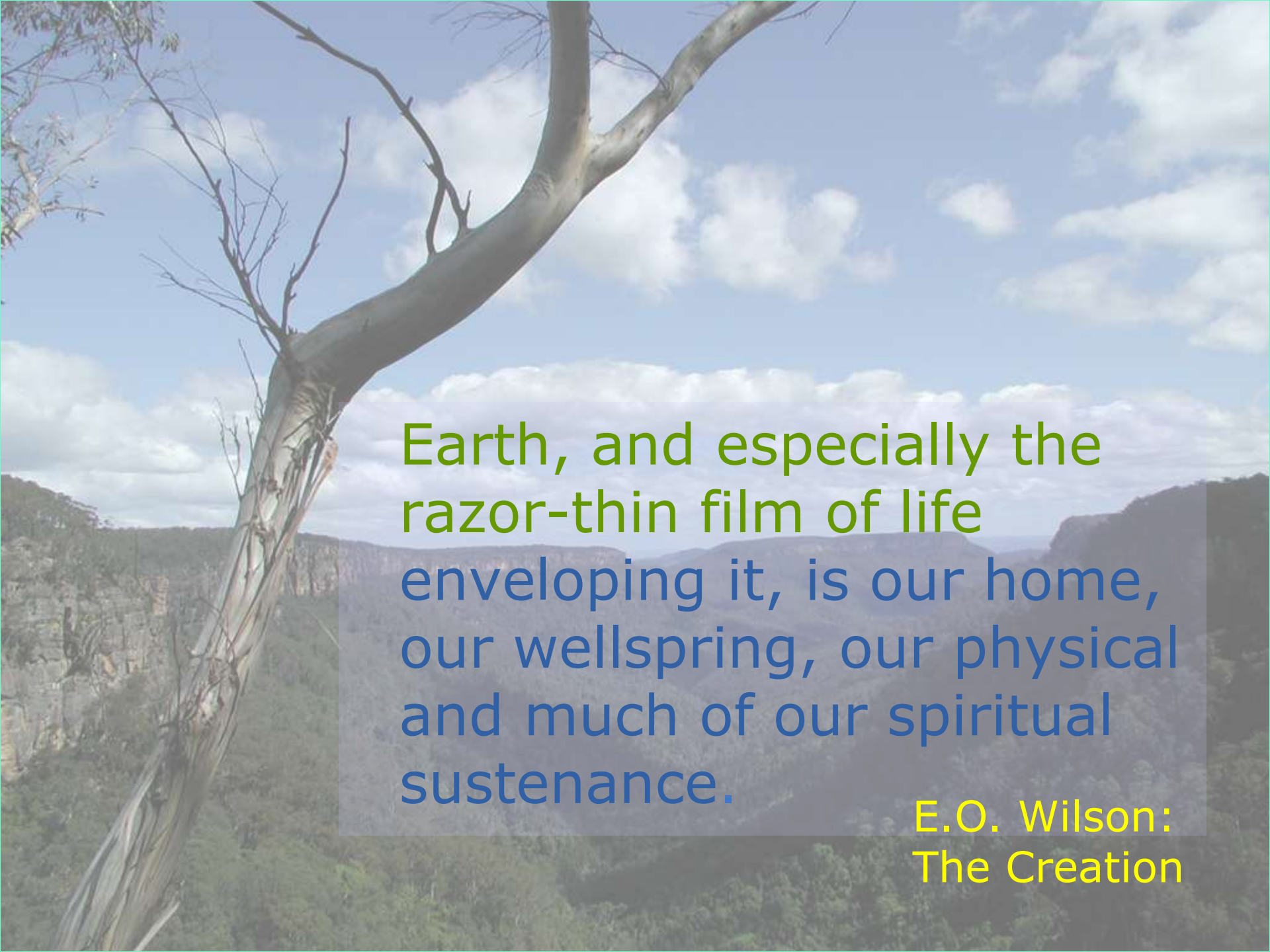
- How is genetic diversity distributed across species ranges?
  - What kind of genetic diversity are we talking about here?
  - And, does it matter?
- Humans are primates – seed collecting as optimal foraging, whether it's across the range or across a population, we have to resist doing it the “easy” way



# Where to from here?

- We are expanding our mission so that it is a true Restoration Collection, with multiple accessions per species
- Spanning as many habitat types as possible (Ecoregion Levels III and IV)
- Spanning as much of the range as possible
- A Minimum of 20 populations across the entire range of a specie, including on in each of the 12 ecoregions of the Tallgrass prairie
- As many local ecotypes as possible





Earth, and especially the razor-thin film of life enveloping it, is our home, our wellspring, our physical and much of our spiritual sustenance.

E.O. Wilson:  
The Creation