Using Multiple Lines of Evidence to Prioritize Assisted Migration of Both Rare and Common Species

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Chicago Botanic Garden

Assisted Migration: Generally thought of in the context of climate change

Native Species | **People**

Assisted Migration: Generally thought of in the context of climate change

Native Species **People**

- In Situ Adaptation

Assisted Migration: Generally thought of in the context of climate change

Native Species **People**

- In Situ Adaptation
- Local Extirpation

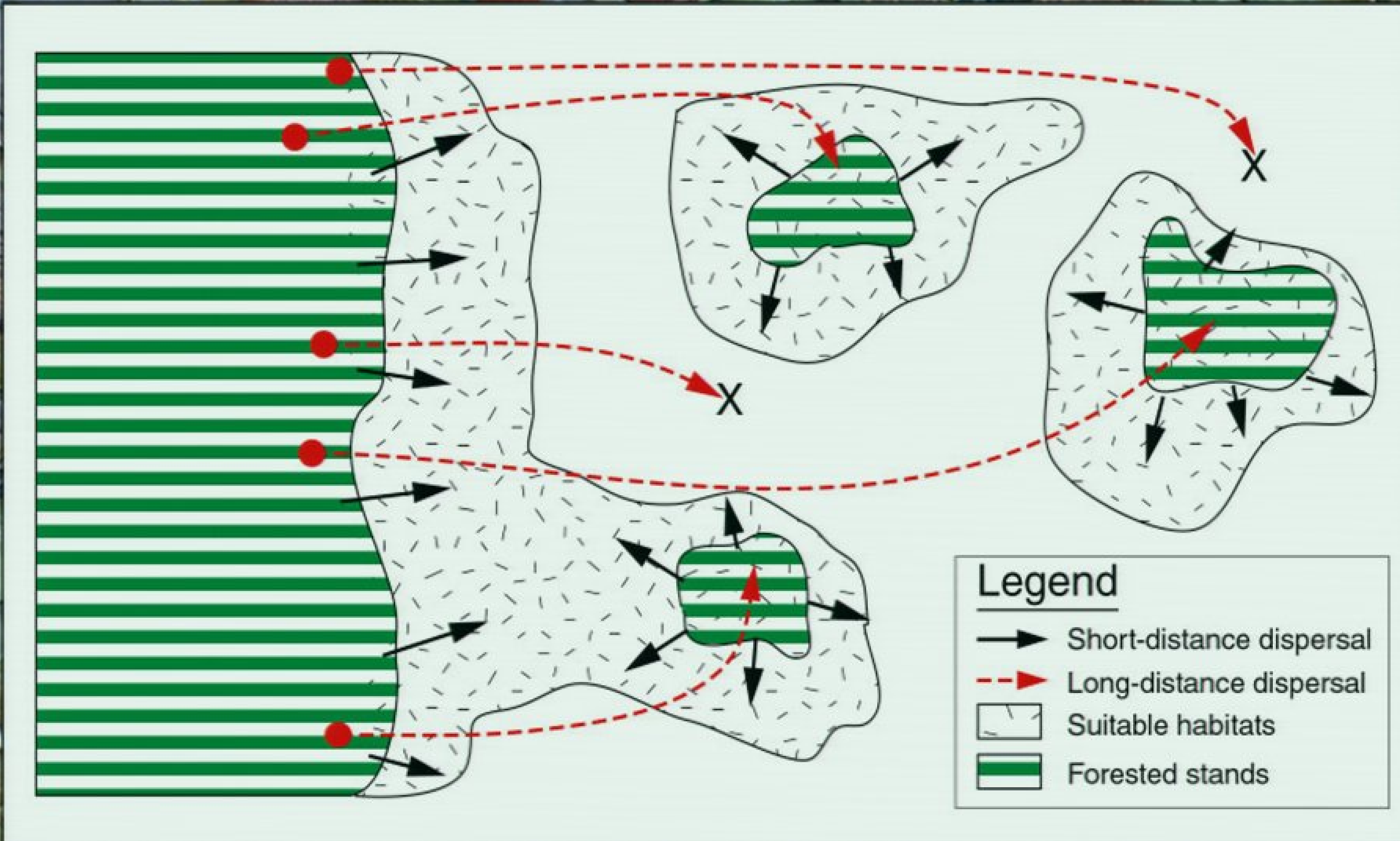
Assisted Migration: Generally thought of in the context of climate change

Native Species

- In Situ Adaptation
- Local Extirpation
- Natural Migration
- Extinction

People

- In Situ Conservation
- Ex situ Conservation
- Assisted Migration
- Acceptance

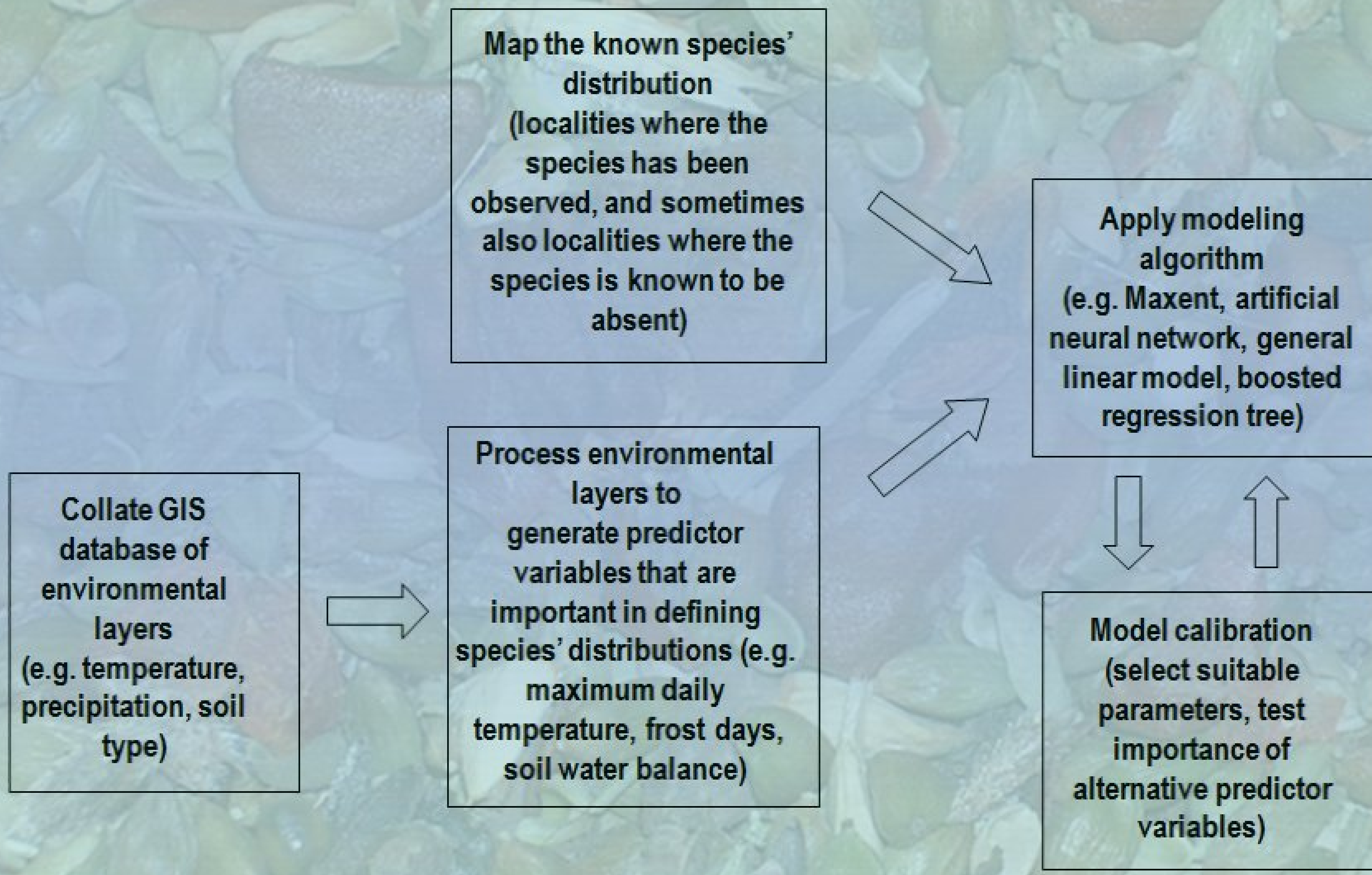


Stochastic long-distance dispersal Liske, 1999

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, my graduate students and PostDoc Shannon Still, have shown that MaxEnt outperforms many other modeling approaches… and..
- It's FREE!

Flow diagram detailing the main steps required for building and validating a correlative species distribution model: PART 1



Slides borrowed liberally from Richard G. Pearson's course on SDM's
http://biodiversityinformatics.amnh.org/index.php?section=sdm

Flow diagram detailing the main steps required for building and validating a correlative species distribution model: PART 2

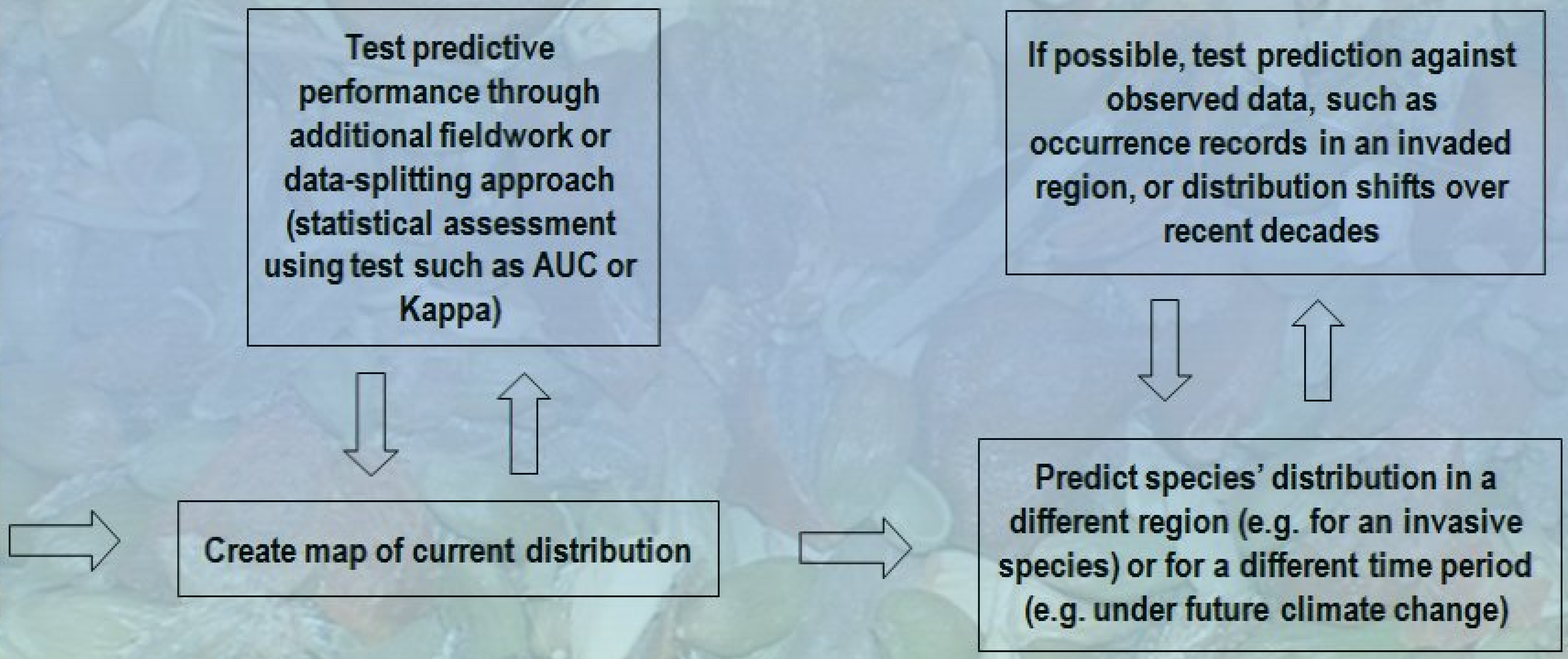


Diagram illustrating the relationship between species' position in geographical space and environmental space

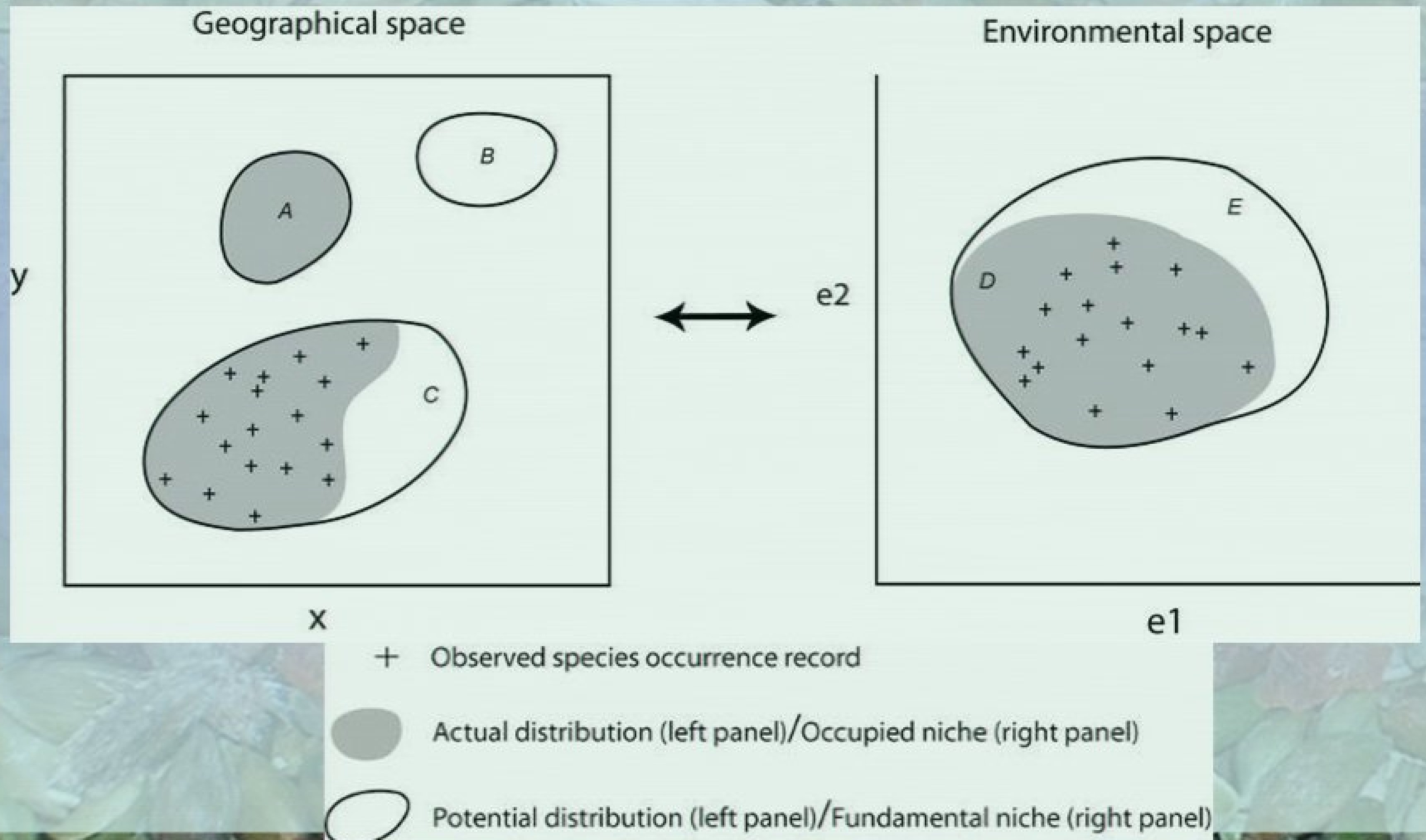
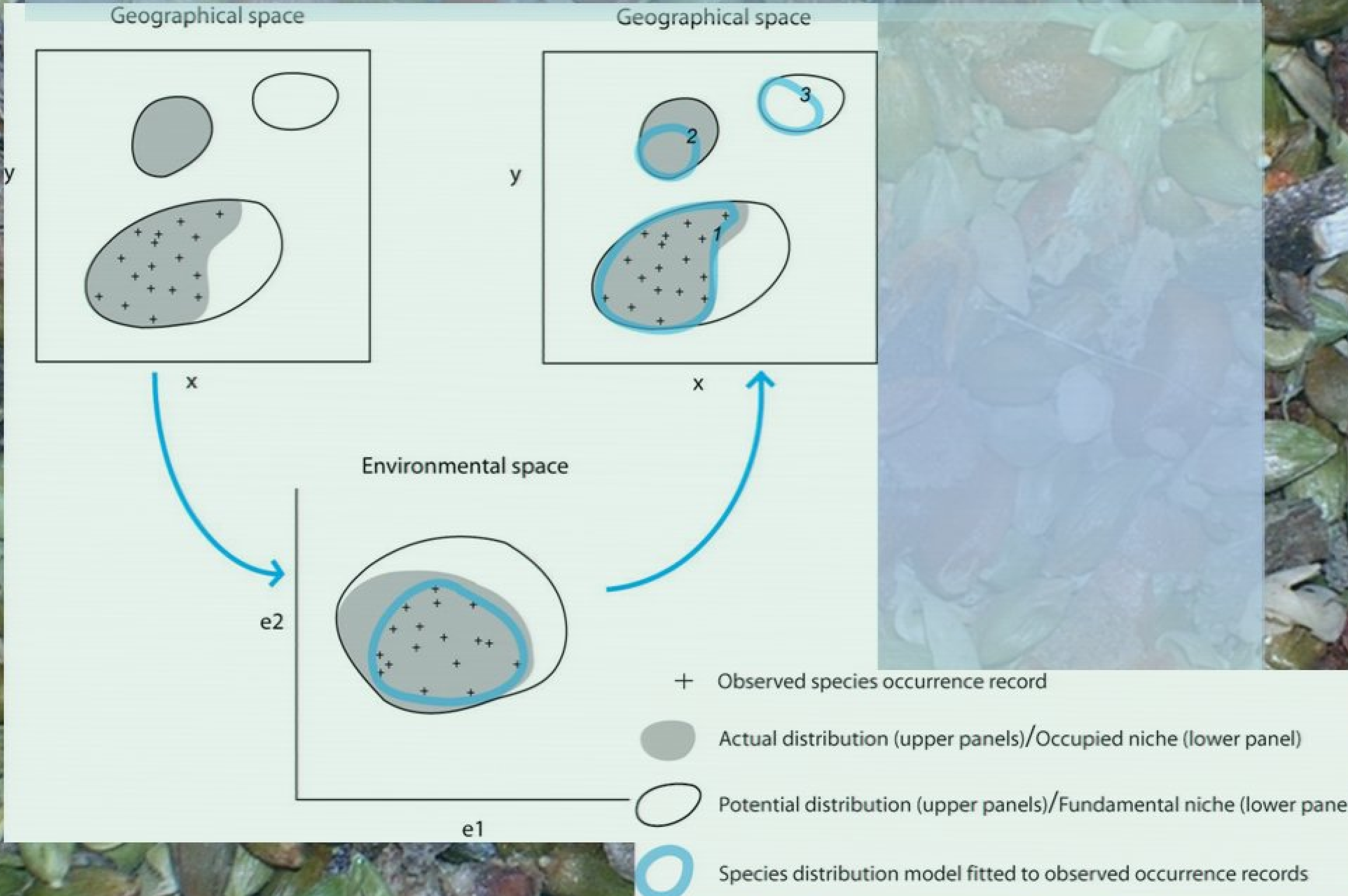


Illustration of the general species' distribution modeling approach



Examining current range of species

- models and ground-truthing

Examining future range of species

- models for 3 time periods in the future
  - 2020s, 2050s, 2080s, low and high emissions
- range changes on public lands

Examining methods

- to improve modeling for current and future

Define current suitability range

- **Model**
  - Complete current suitability models
- **Test**
  - ground-truth to test the model
- **Model again**
  - incorporate new occurrences and absences
- **Test new model**
  - ground-truth to test the model
- **Model again**

WHY GROUND-TRUTHING IS NEEDED

- Rare plants are often under-surveyed
- Rare plants can be difficult to find
- We want more occurrences
  - positive and **negative** occurrences

FINDING PLANTS CAN BE DIFFICULT

do you see the cactus?

FINDING PLANTS CAN BE DIFFICULT

do you see the cactus?

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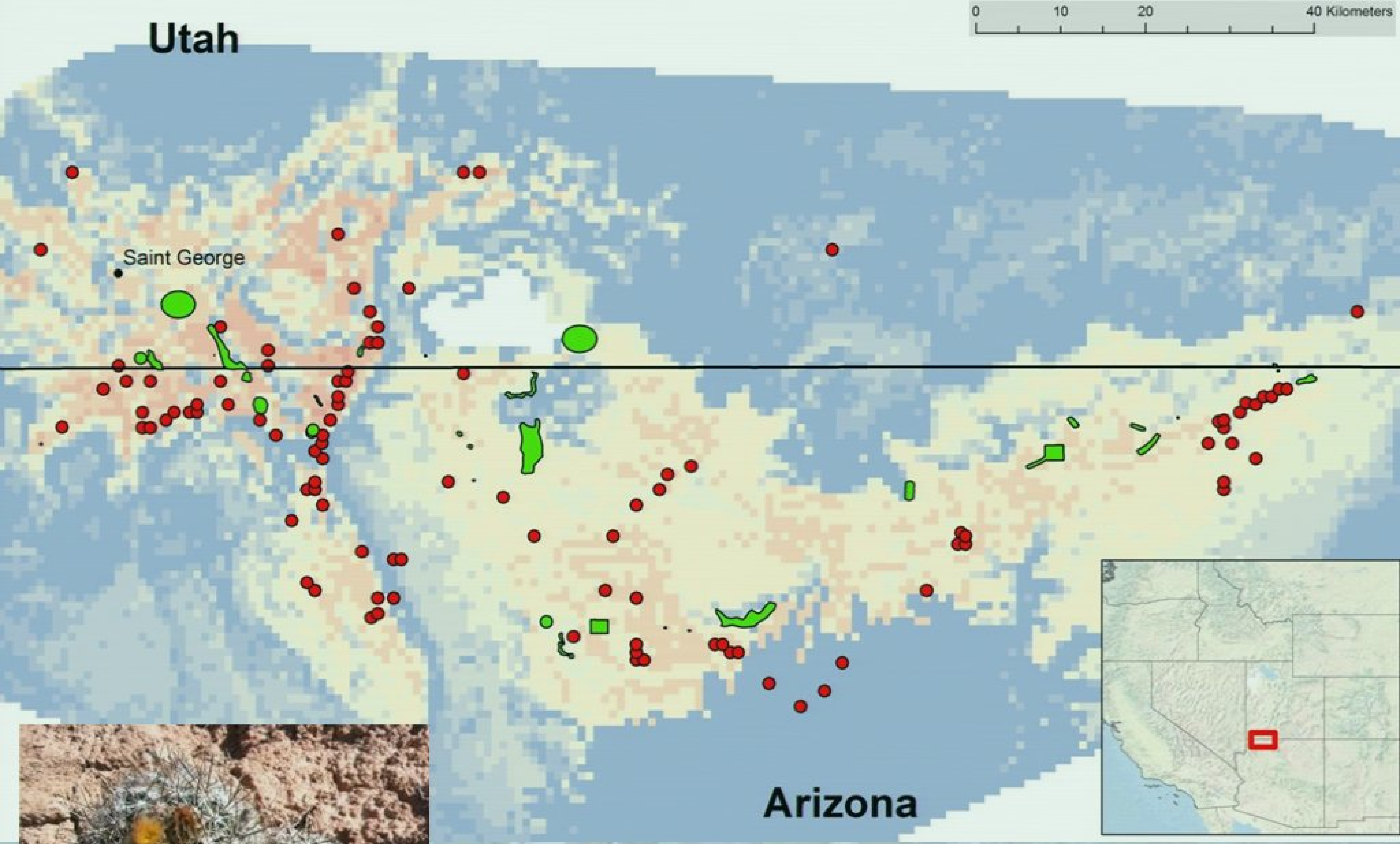
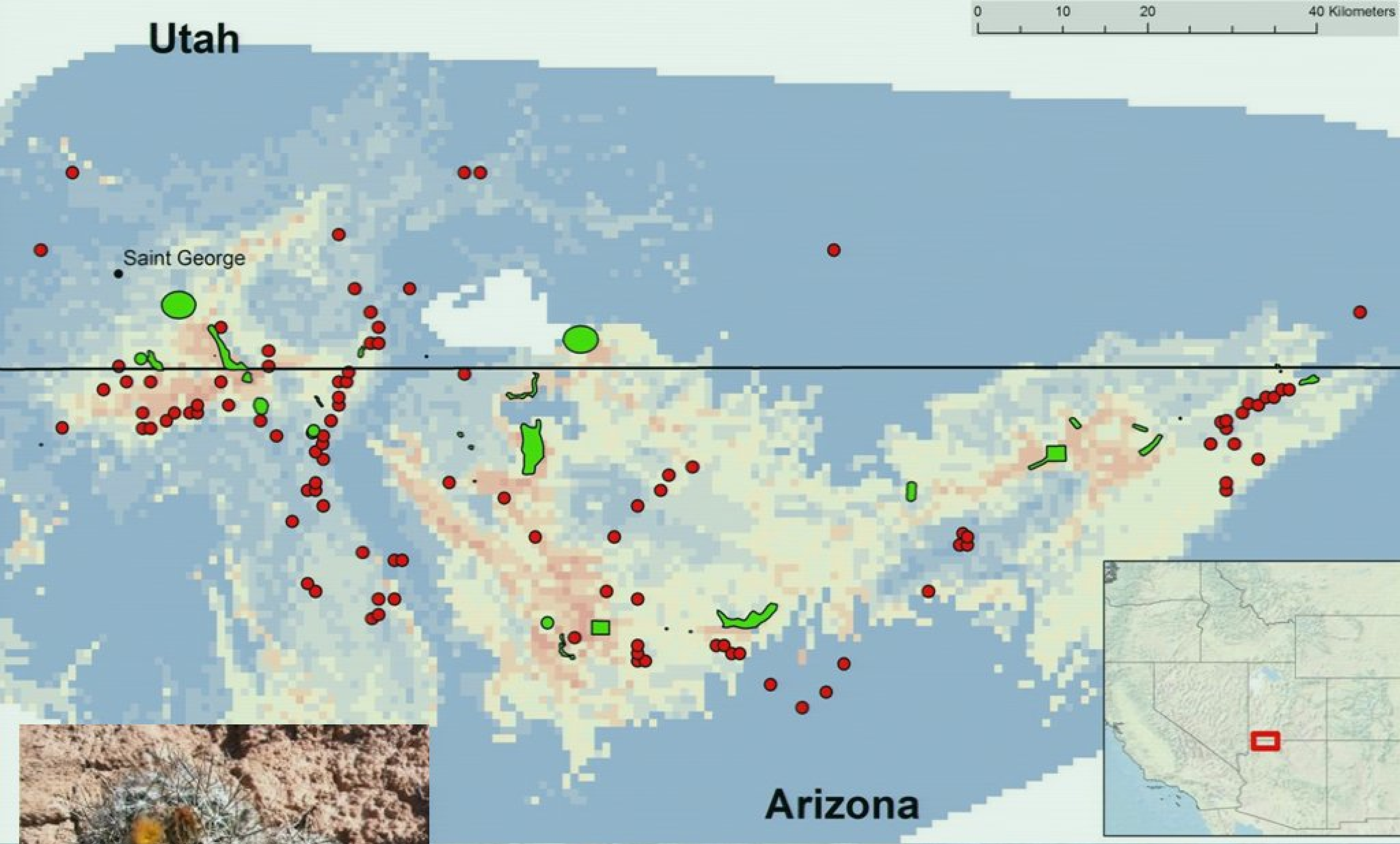
do you see the cactus?

Pediocactus despainii

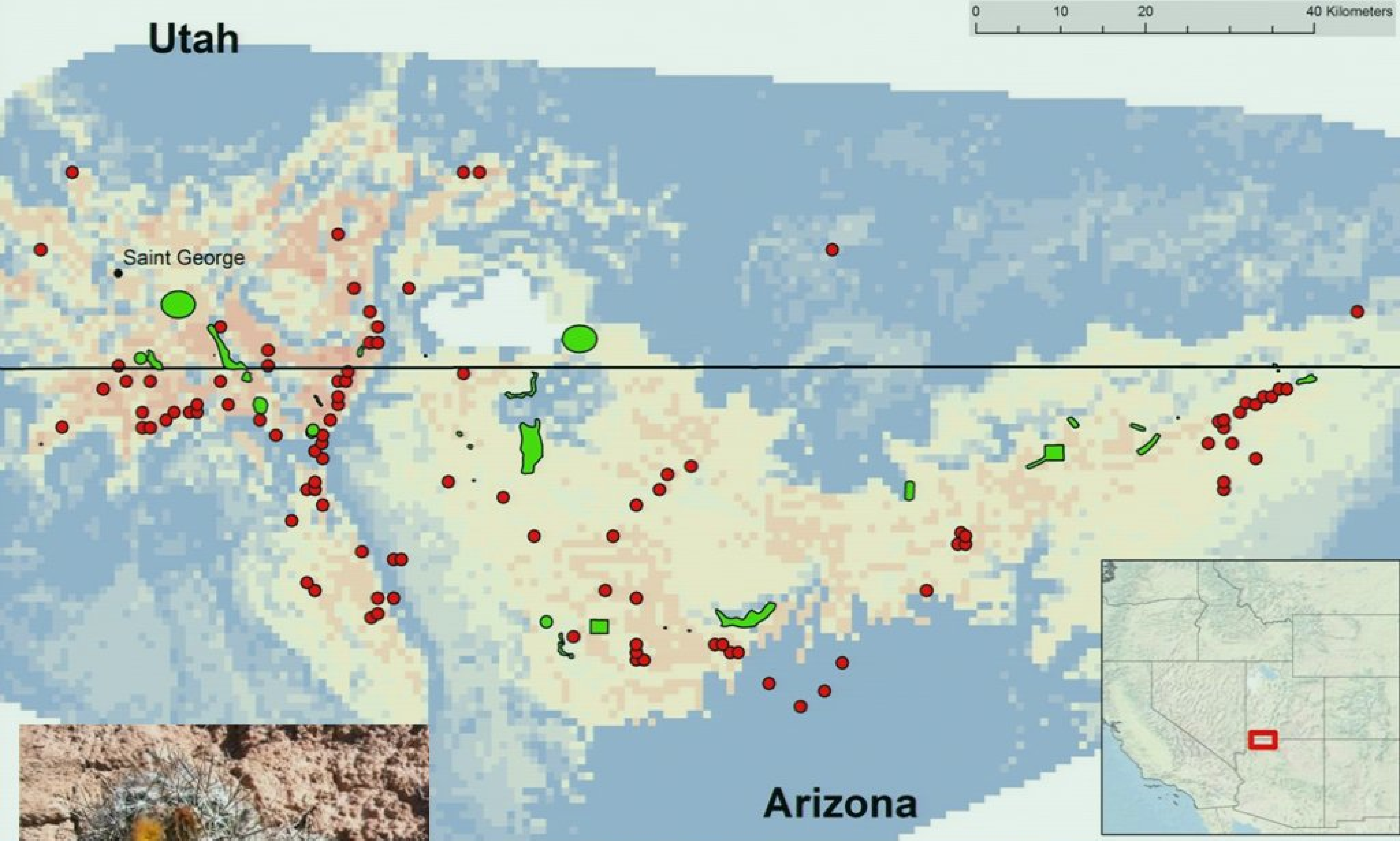


Predicted suitable habitat in April
(before groundtruthing)



Predicted suitable habitat in September (after groundtruthing)

Incorporating new occurrence information.



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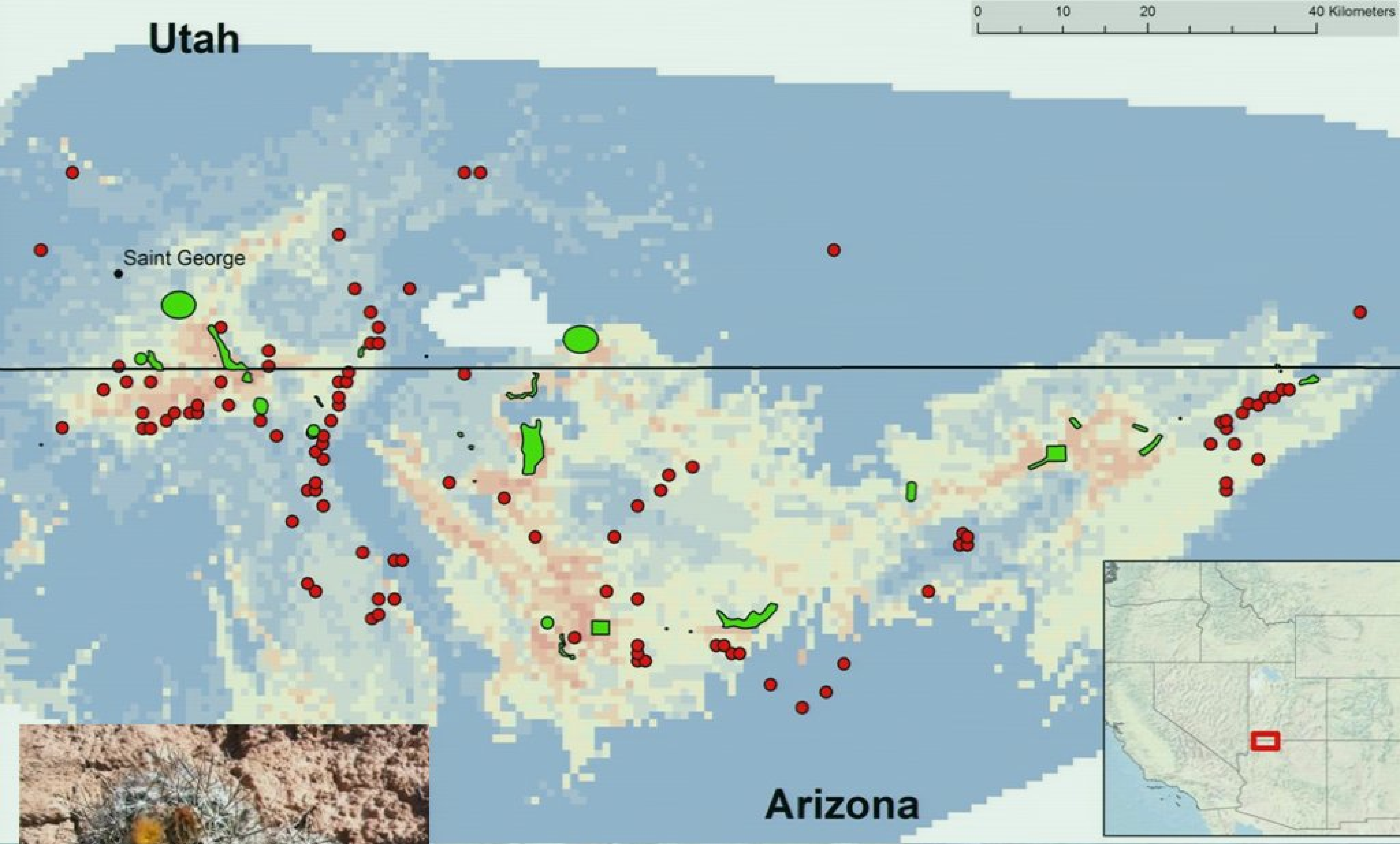


Predicted suitable habitat in September (after groundtruthing)

Incorporating new occurrence information.

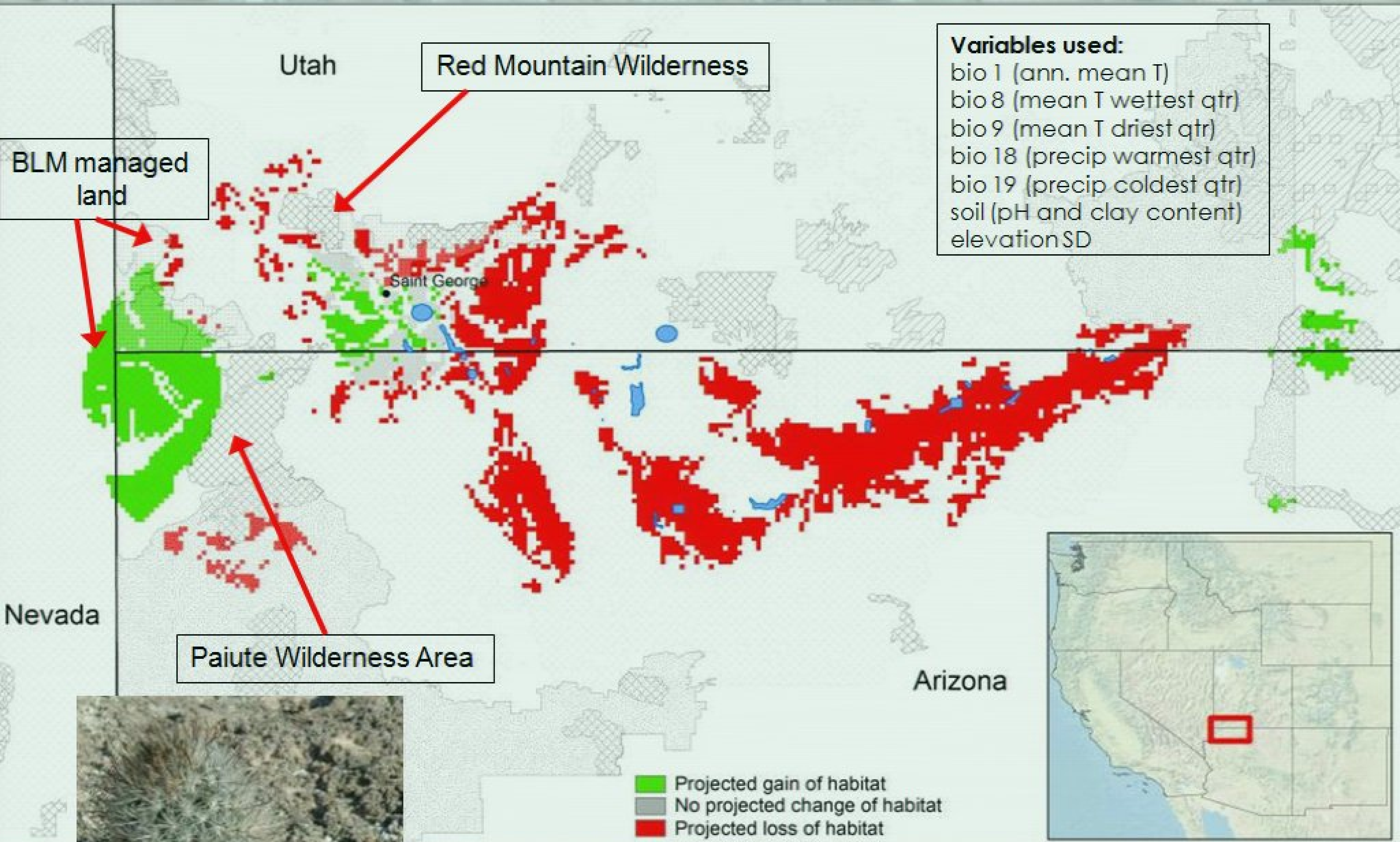
FIELD RESULTS: PEDIOCACTUS SILERI

Pediocactus sileri		high	medium	low	NA	total
targeted	**searched**	**14**	**8**	**2**	**0**	**24**
	found	0	0	0	0	0
	%	0	0	0	0	0
	mean dist. (km)	-	-	-	-	-
	not found	14	8	2	0	24
	%	100	100	100	0	100
	mean dist. (km)	*6.95*	*8.83*	*9.21*	-	*7.77*

		high	medium	low	NA	total
visited	**searched**	**59**	**31**	**9**	**6**	**105**
	found	2	2	0	0	4
	%	3	6	0	0	4
	mean dist. (km)	*2.21*	*3.8*	-	-	3
	not found	57	29	9	6	101
	%	97	94	100	100	96
	mean dist. (km)	*6.65*	*8.72*	*9.65*	*9.65*	*7.69*

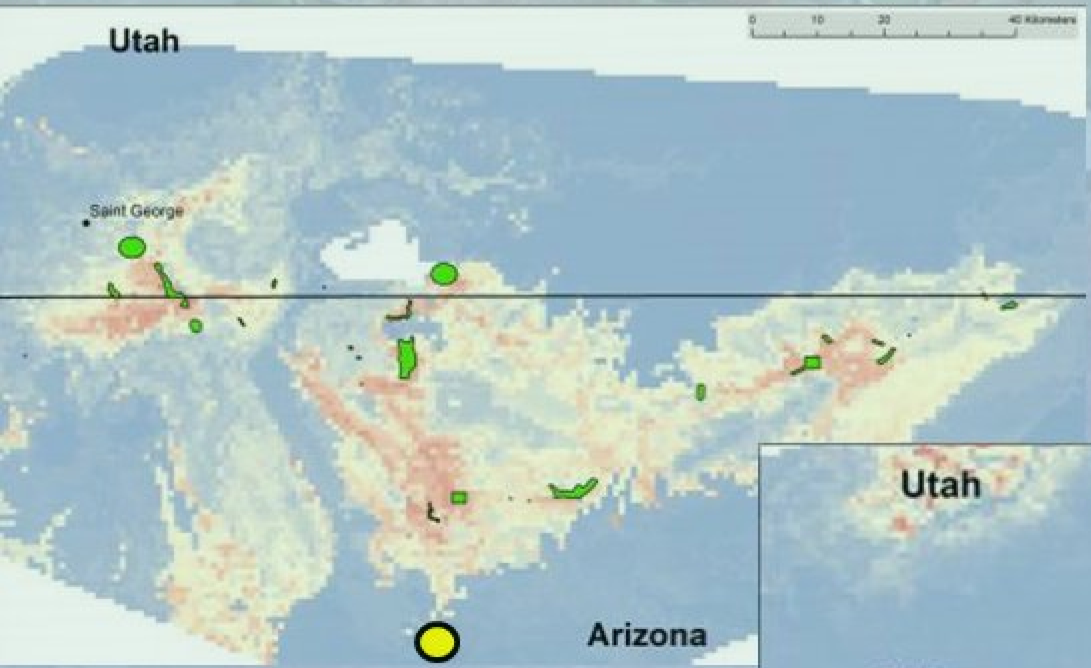
HOW ASSESS VULNERABILITY: OVERALL LOSS OF SUITABLE HABITAT

- Threshold suitable habitat
- Use testing data to evaluate the modeled distribution and then set a likelihood value above which plants are likely to be found



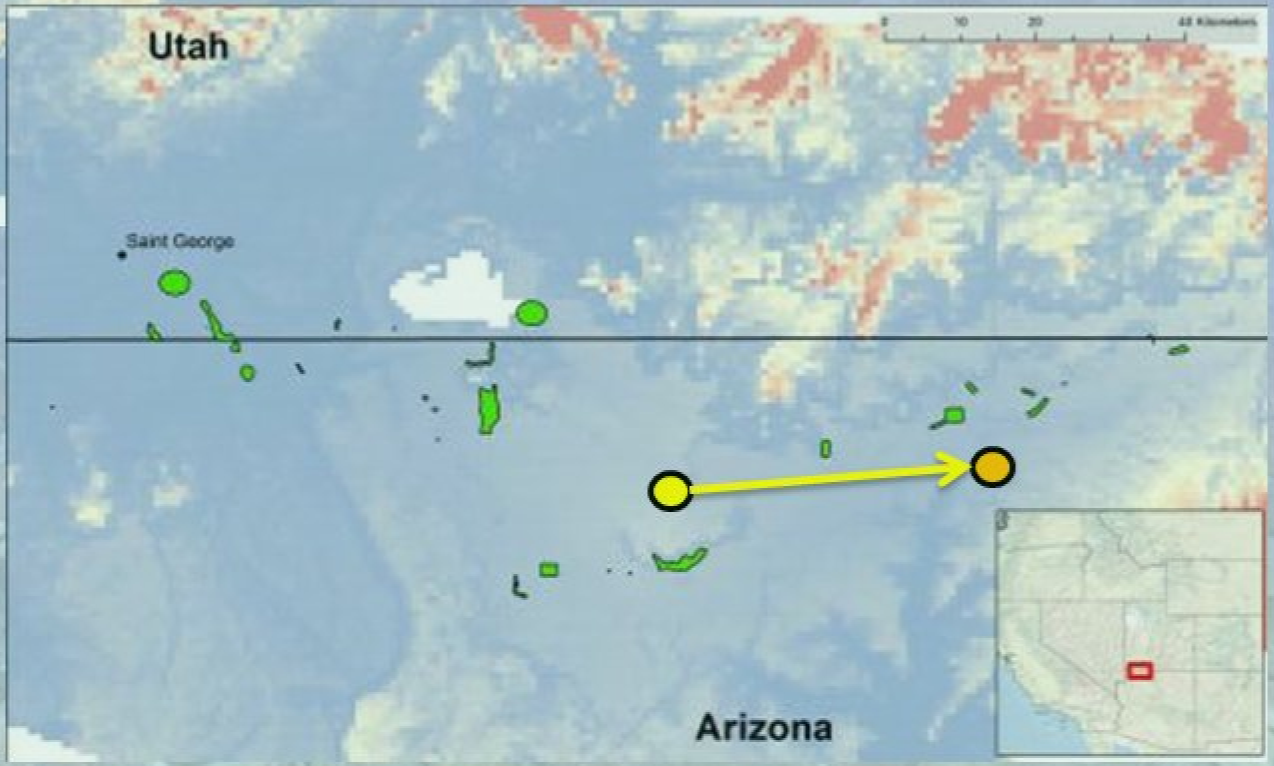
Predicted change in suitable habitat for *Pediocactus sileri* between now and 2050s.

ASSESS VULNERABILITY: CHANGE IN CENTER OF DISTRIBUTION

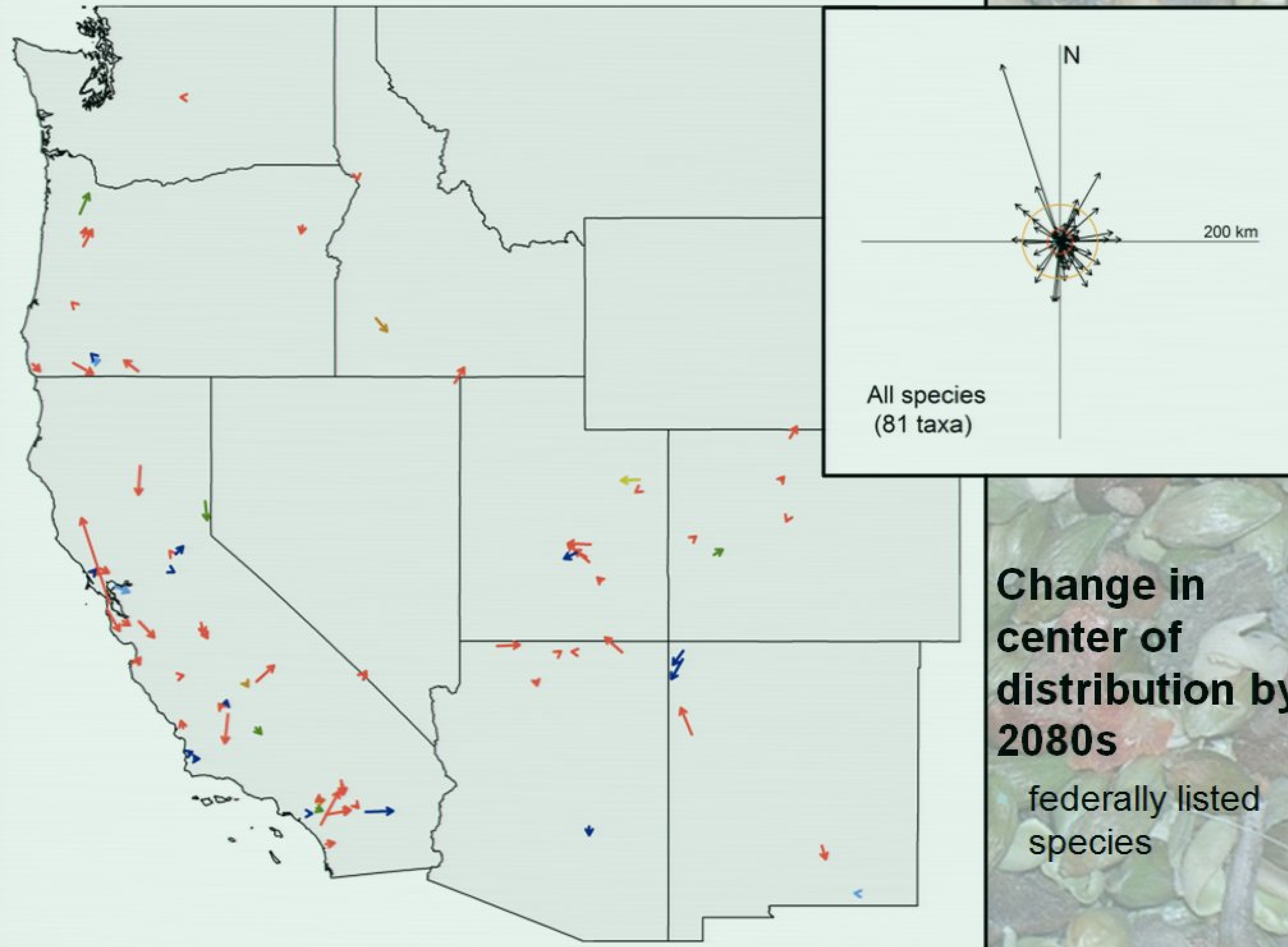


current

2080s



Pediocactus sileri



Change in center of distribution by 2080s

- federally listed species

- Compare suitability between current and future climates for currently known locations
  - for each location, is suitability getting better or worse
    - mean of suitability of current and future distributions for each species.

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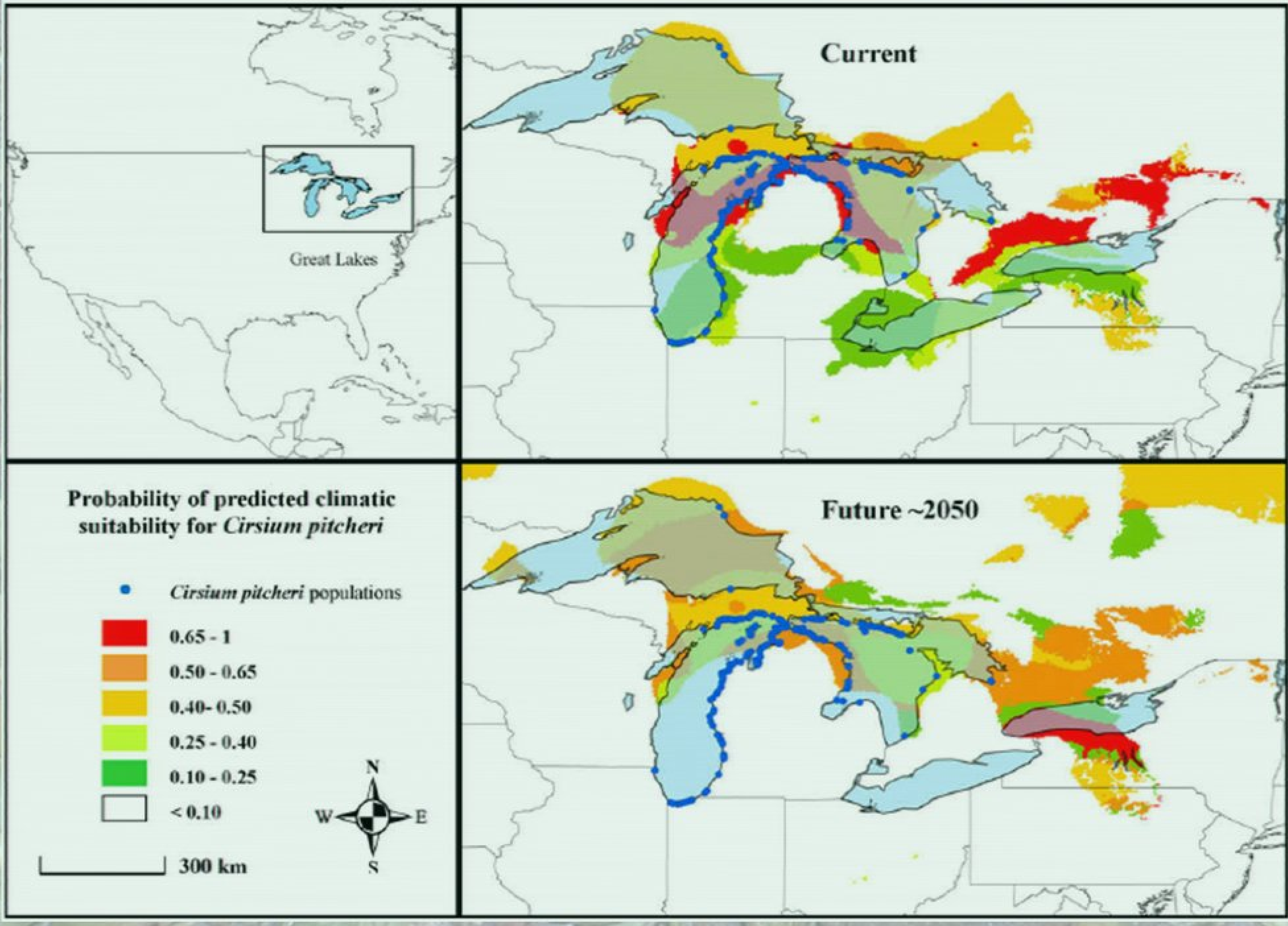
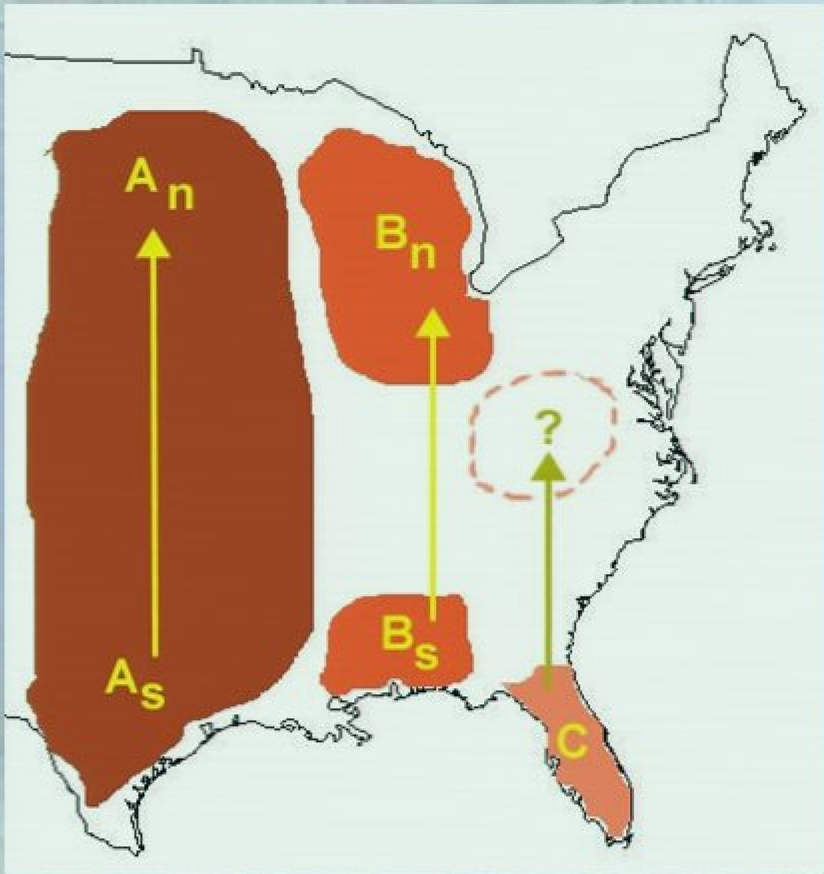
current

Pediocactus sileri

2080s


Great Lakes
Current
Future ~2050
Probability of predicted climatic suitability for Cirsium pitcheri
Cirsium pitcheri populations
0.65 - 1
0.50 - 0.65
0.40- 0.50
0.25 - 0.40
0.10 - 0.25
< 0.10
N
W
E
S
300 km

Scenarios for Assisted Migration



A: Movement to increase potential adaptation to climate change. When resulting in purposeful introgression = "Facilitated Adaption" or augmentation

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

C: Translocation outside of historic range

Assisted Migration: What is it?

➡ Translocating species beyond their historic boundaries

Translocating species within and without historic boundaries (**introduction**)

Translocating species to a previously occupied site (**reintroduction**)

Introduction of individuals into an existing population (**augmentation**)

Translocating groups of species into any site (**restoration**)

Assisted Migration

It's already being done

- Experimental
- Anecdotal – Torreya Guardians
- Active Management – Canadian Forest Service (Black Walnut), Restoration

The best criterion for success has to be naturally reproducing (viable) populations

Placing Forestry in the Assisted Migration Debate

Table 1. Comparison between forestry assisted migration (AM) and species rescue AM.

Topic	Forestry AM	Species rescue AM
Intended outcome	Maintain forest productivity and health under climate change	Avoid extinctions among species threatened by climate change
Target species	Widespread, commercially valuable species	Species of conservation concern
Focal biological unit	Focuses on the movement of populations	Focuses on the movement of species
Movement logistics	Often within the current range of the species or within modest range extensions	Often well outside the current natural range of species
Risks	Limited potential for creating an exotic invasive, limited potential to hybridize with new species, and limited potential to introduce disease to new populations or to other species	Some potential for creating an exotic invasive, some potential to hybridize with new species, and some potential to introduce disease to other species
Feasibility of science-based implementation	Provenance data for many commercial tree species, established seed procurement and storage methods, established best practices around plantation establishment, and autecology often well described	Provenance data not typically available, seeds not typically procured or stored, establishment best practices often not known, and autecology well described for relatively few high-profile and well-studied species
Scope	Potential to be employed across the millions of hectares that are regenerated annually in North America	Likely limited to suitable microsites
Cost	Adds little to existing forest regeneration costs (see the text for caveats)	Costs vary widely with the scope of the initiative
Practice	Already implemented in several regions	Very few known cases being implemented

Pedlar et al 2012 Bioscience 835-842

Torreya taxifolia quick facts.

- Dioecious conifer that suffered a disease epidemic that wiped out the adult population in the 1960s.
- Federally listed as *endangered* under the Endangered Species Act.
- There are fewer than 1000 individuals in the wild, all juveniles, and the population is experiencing a slow but steady decline.
- Captive populations of over 150 genotypes exist in more than three botanic gardens in the southeastern United States.
- Several *ex situ* trees produce seed.
- Torreya Guardians released 31 plants from legally obtained material in North Carolina in July of 2008.

Managed relocation release site

Post-Pleistocene historic range

Schwartz et al Bioscience 2012

(Re) Introduction

Plant Reintroduction in a Changing Climate
Center for Plant Conservation

145 projects – various taxa and lifeforms, approximately 90% had survivorship of original propagules or their offspring

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(Re) Introduction: unregulated

Reintroductions are a management option when no others are available

32 countries; earliest record in 1955, but possibly as early as 1783

"…the unregulated use of seed and plant translocations has confused the debate and provided evidence that reintroductions for conservation of threatened plants are prone to failure and a waste of resources." Dalrymple et al 2012

(Re) Introduction

None are a total success – meaning that they resulted in viable populations without need for ongoing intervention and monitoring

Monitoring needs to be long term, as it took more than a decade for biological failure of the annual *Stephanomeria malheurensis* to be apparent

Most reintroductions in the scientific literature have not been monitored long enough to assess their success

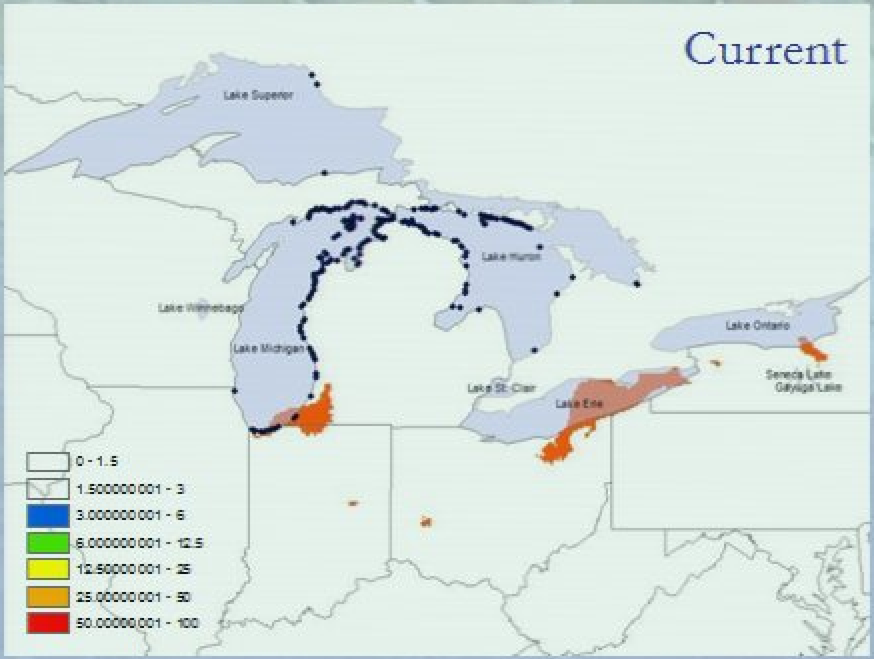
(Re)Introduction – Research Needs

1. Strategies for determining donor and recipient sites
2. Reproductive biology of the species (including pollinators and seed dispersers)
3. Genetic divergence of wild versus ex situ populations, studies of inbreeding and potential for outbreeding depression if mixing sources from 2 or more donor sites

(Re)Introduction- Recomendations

1. Founder sizes greater then 50
2. Use transplants rather than seed for perennials/woodies
3. For annuals introduced by seed, watering is crucial
4. Recruitment limitation a challenge – management
5. Genetic composition, horticultural treatment, competitive and disturbance regimes matter greatly
6. Seed sourcing and habitat matching is critical, and not yet well understood

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



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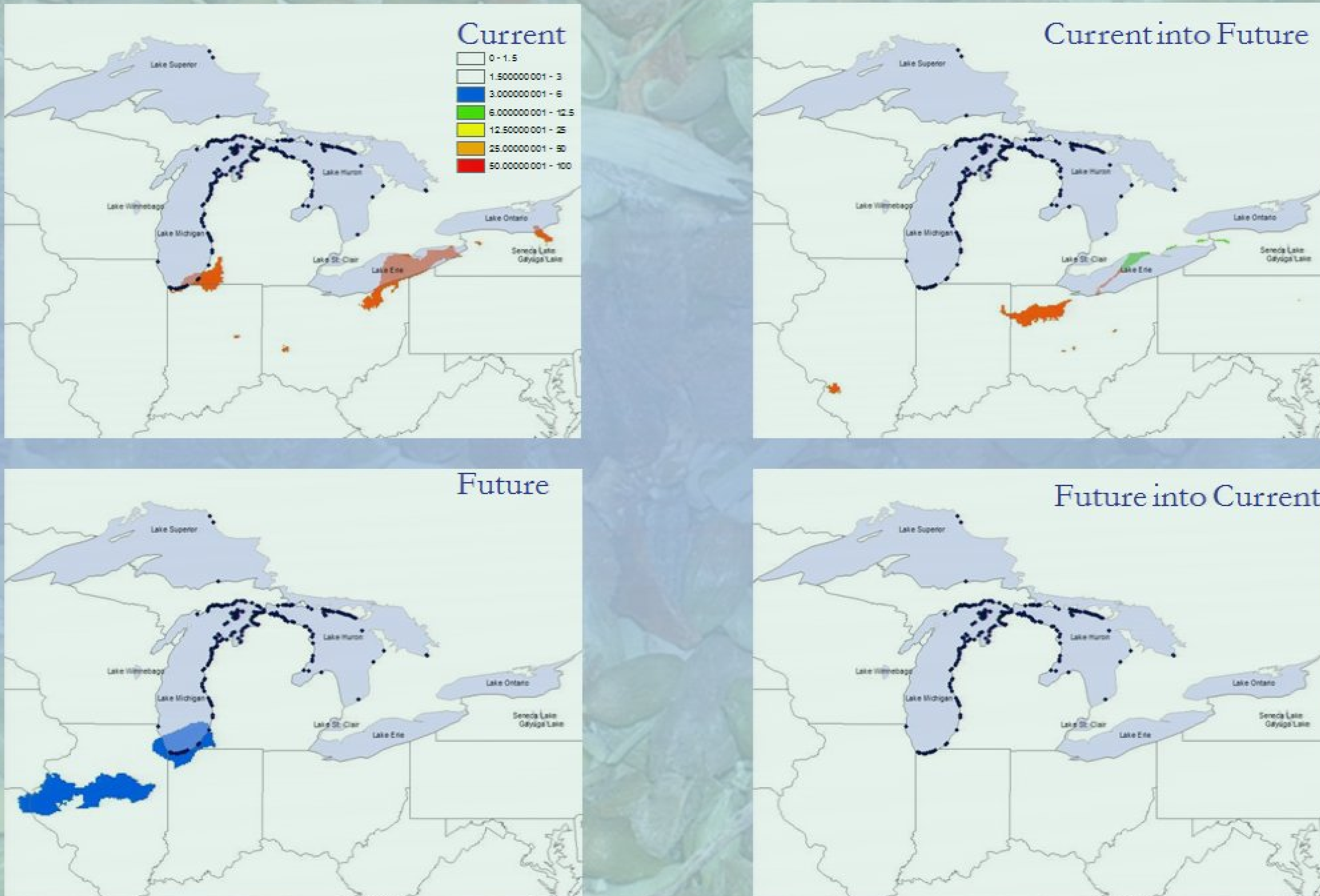
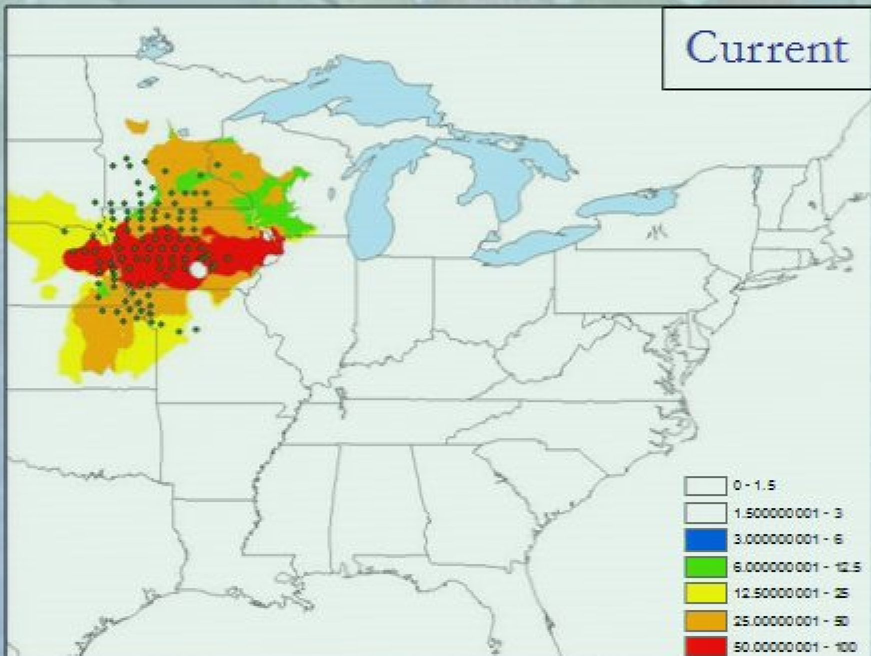
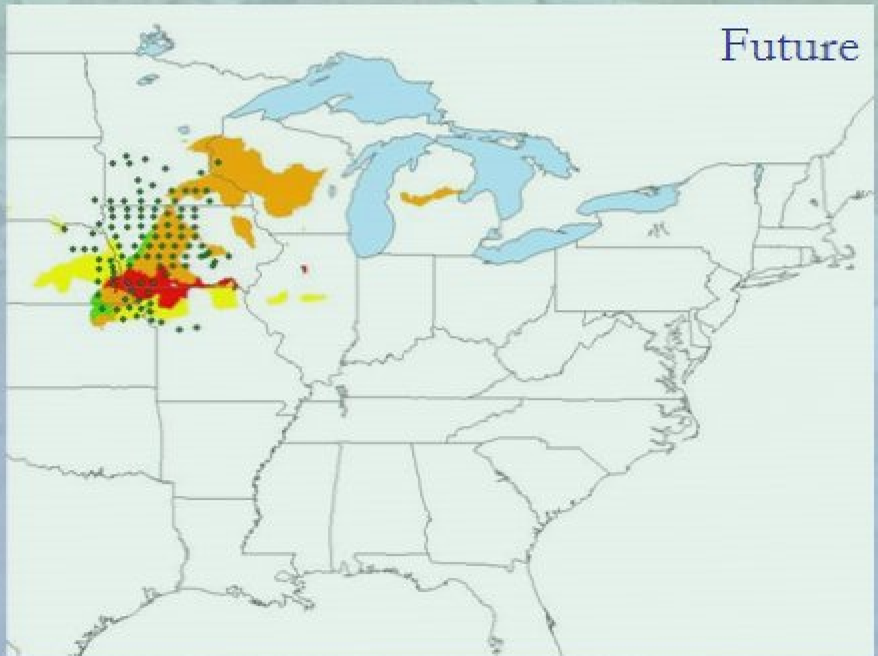
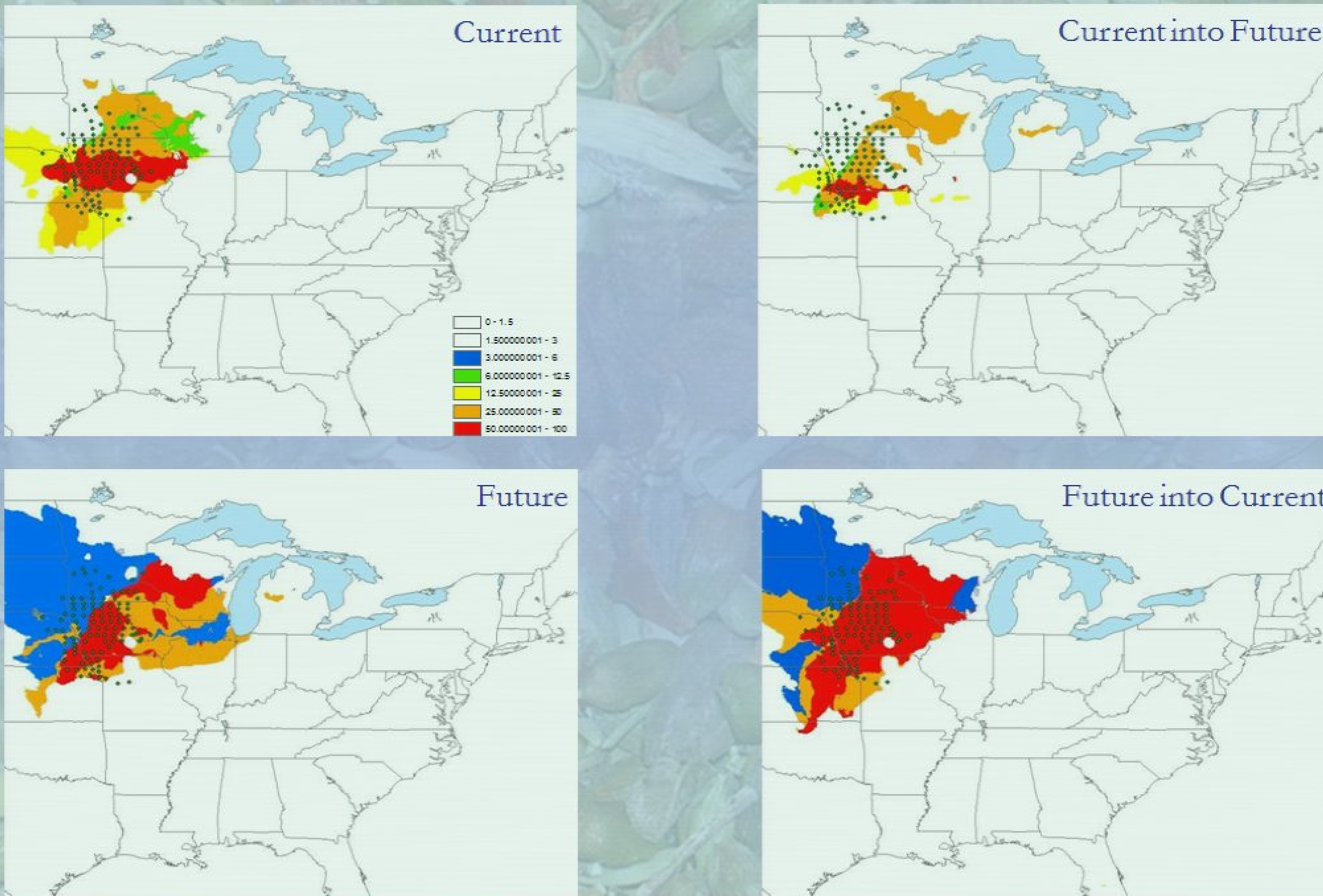


Andropogon gerardii Ecoregion 47 Seed Source Model





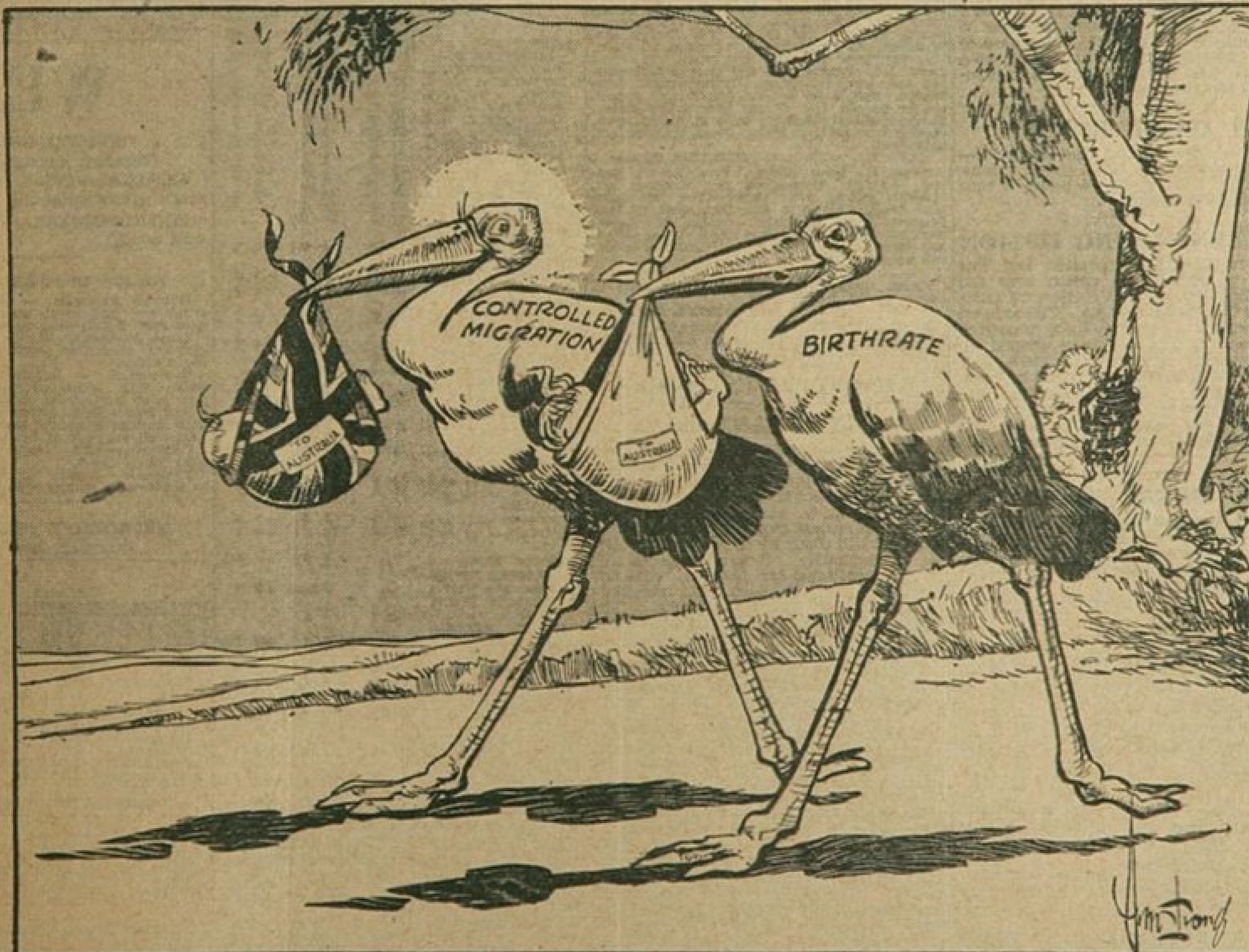
Andropogon gerardii Ecoregion 47 Seed Source Model



Conclusions

- Reintroduction literature has some lessons for AM, as does the larger restoration literature
- Seed sourcing is key, the problem is long-tem – we should be seed banking
- We compared our results with NatureServe, comparable. We know what's in trouble, we need to find the will to triage
- AM may be best undertaken in a restoration or overall management context, else as an experiment
- Resulting outcomes need to be shared – database such as CPC

"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.

For more information, please visit the US Forest Service Reforestation, Nurseries & Genetics Resources website at **http://rngr.net**