Utilizing Climate Change Refugia for Climate Change Adaptation and Management in the Northeast

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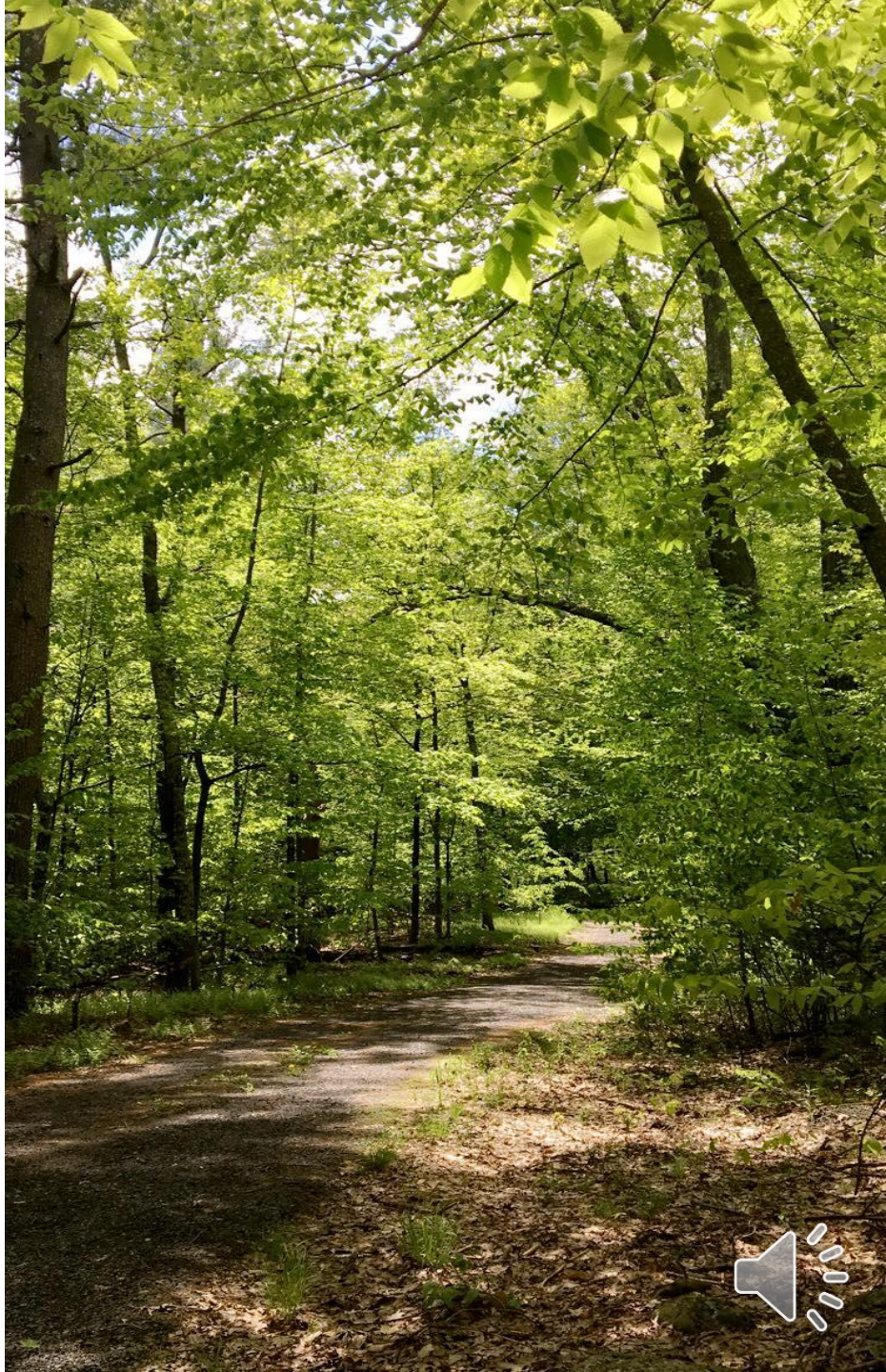
Background

- An increase in frequency of heat waves, droughts, winter temperatures, severe precipitation events, rise in sea levels

- Climate change will have impacts on biodiversity.

(Horton et al. 2014, Meehl & Tebaldi 2004, Alexander et al. 2006, Sillmann et al. 2013, Staudinger et al. 2015).



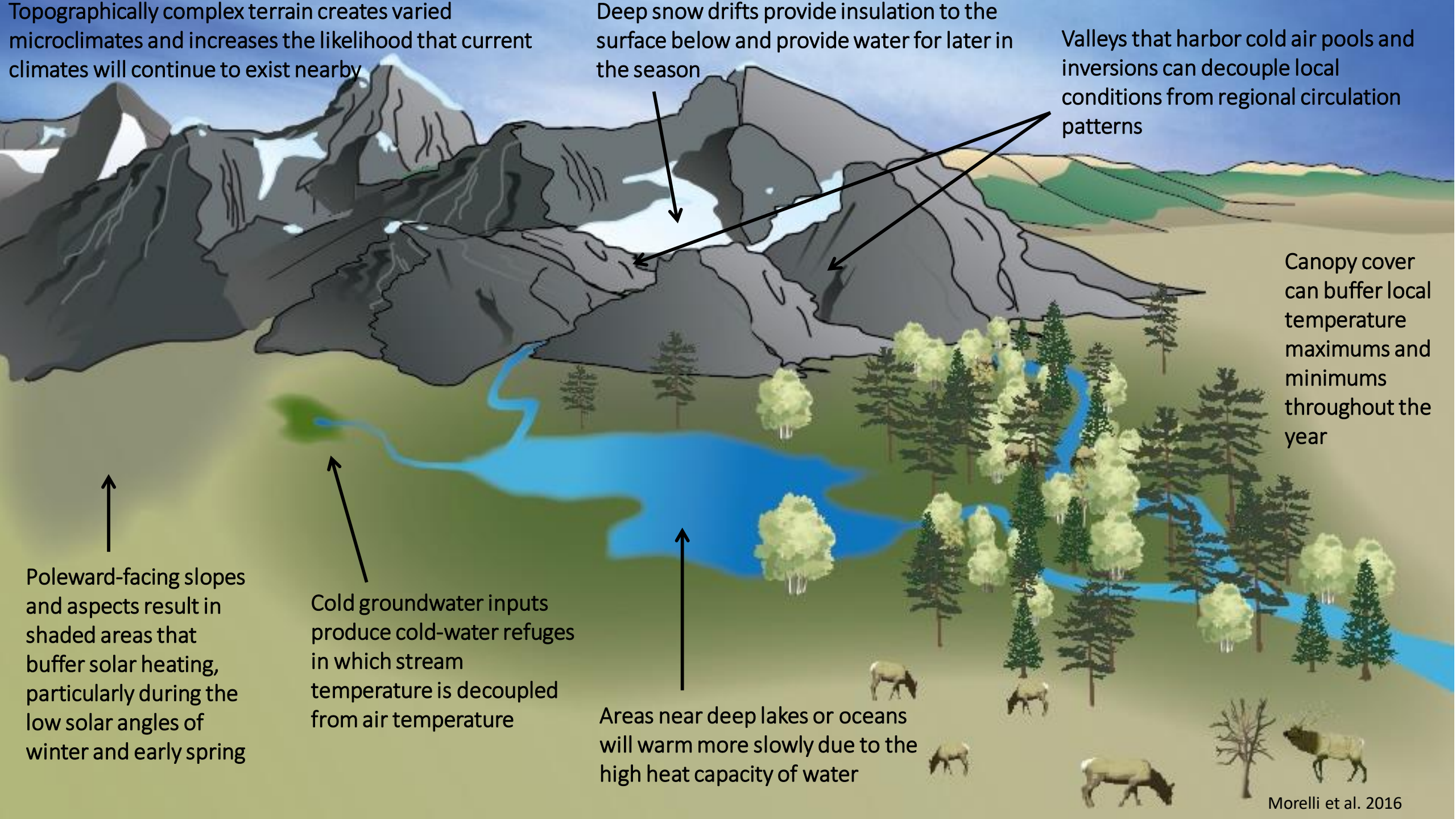
Climate Change Adaptation as a Solution

- Management plans need to adapt to these changing environments

- Refugia could be used in management plans

Refugia are areas buffered by climate change that enable the persistence of valued physical, ecological and cultural resources.

Image from Toni Lyn Morelli


Topographically complex terrain creates varied microclimates and increases the likelihood that current climates will continue to exist nearby
Deep snow drifts provide insulation to the surface below and provide water for later in the season
Valleys that harbor cold air pools and inversions can decouple local conditions from regional circulation patterns
Canopy cover can buffer local temperature maximums and minimums throughout the year
Poleward-facing slopes and aspects result in shaded areas that buffer solar heating, particularly during the low solar angles of winter and early spring
Cold groundwater inputs produce cold-water refuges in which stream temperature is decoupled from air temperature
Areas near deep lakes or oceans will warm more slowly due to the high heat capacity of water
Morelli et al. 2016

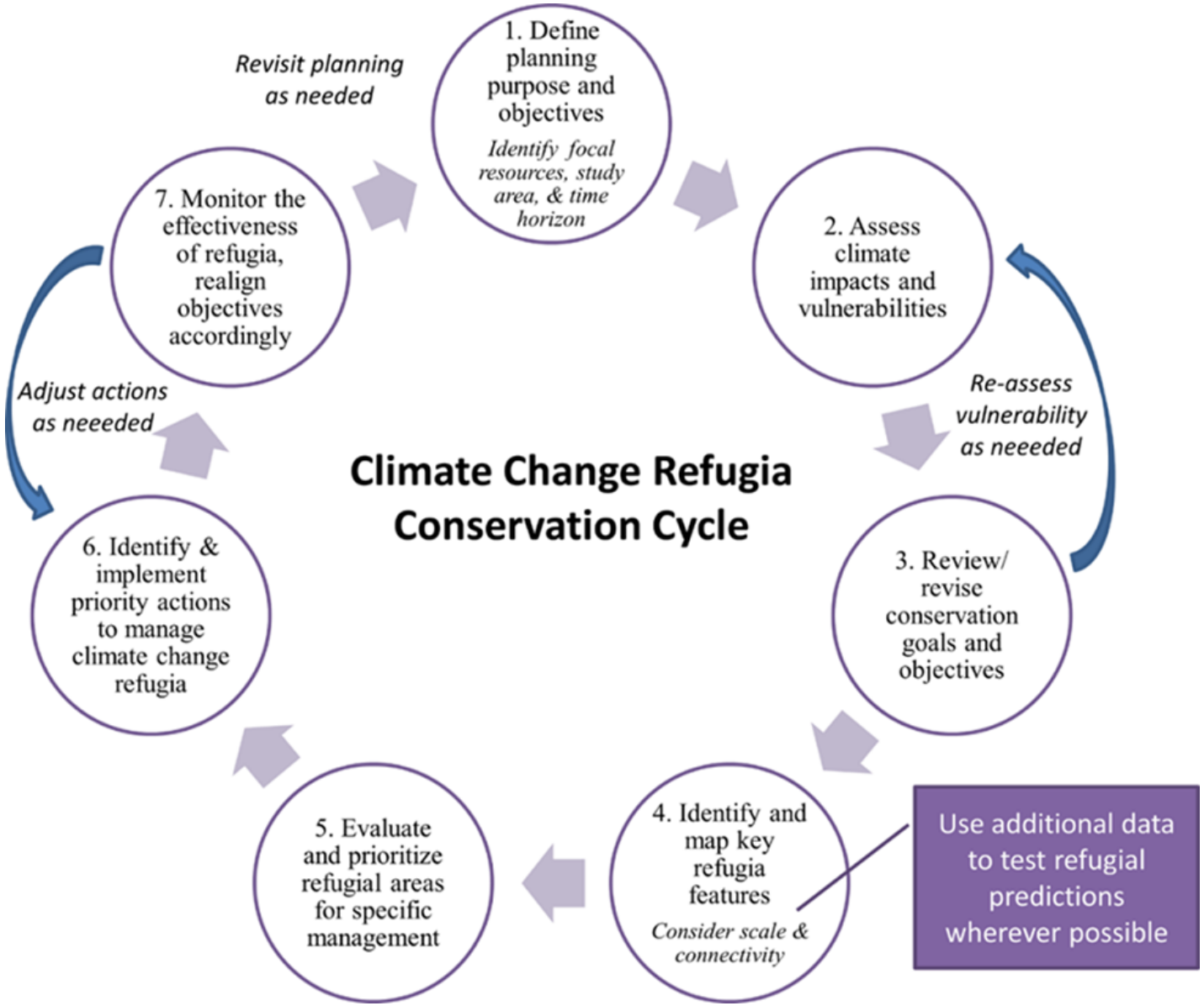
Translational Ecology

"is an approach in which ecologists, stakeholders, and decision makers work together to develop research that addresses the sociological, ecological, and political contexts of an environmental problem" (Enquist et al. 2017).

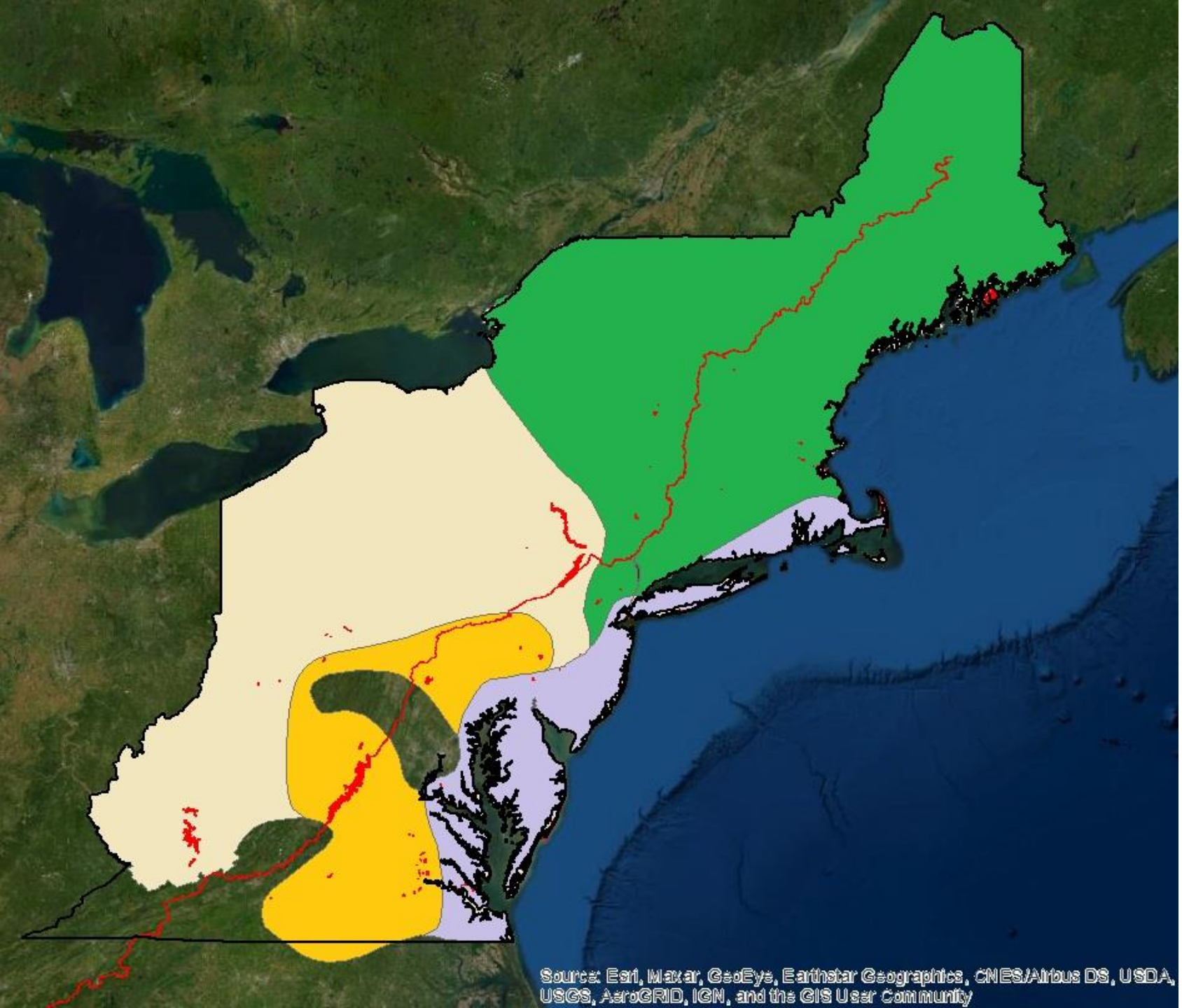
(Enquist et al. 2017).

Objectives

- Identify climate-vulnerable species within the Northeast NPS Region
- Map climate change refugia for those priority NPS species
- Calculate percentage of refugia for each park unit
- Map transition areas for species
- Coproduce climate adaptation actions



Climate change refugia conservation cycle (Morelli et al. 2016).



I&M Network:

- Northeast Temperate
- Northeast Coastal & Barrier
- Eastern Rivers & Mountains
- Mid-Atlantic

- Northeast National Park Units

Eliciting Stakeholder Feedback

1. Define planning purpose and objectives

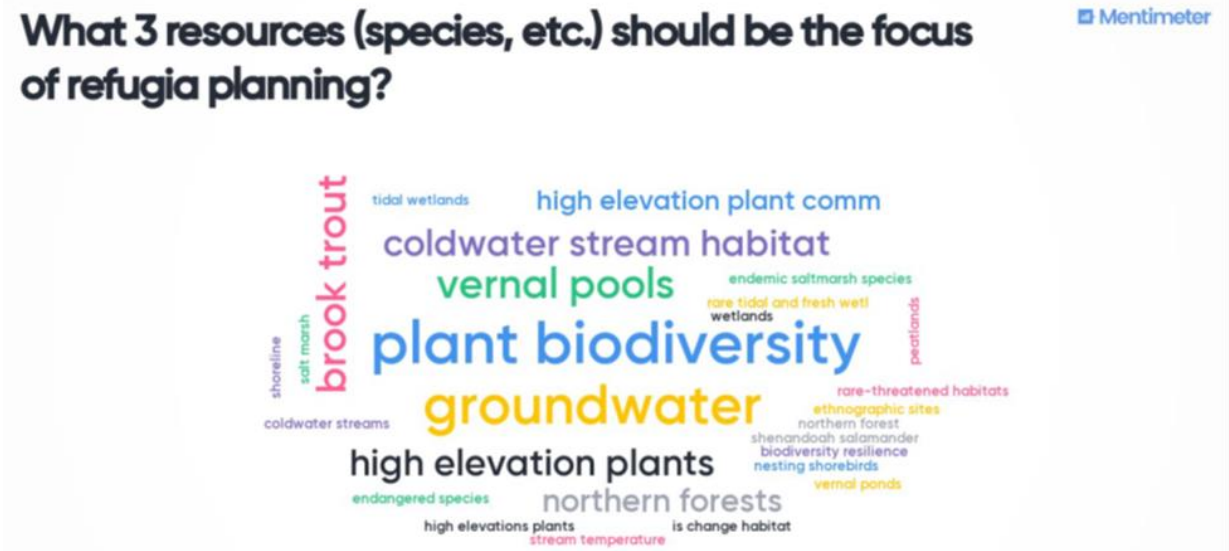
Identify focal resources, study area, & time horizon

“What should we map refugia for?”

Northern NER

March 16, 2020 Zoom meeting. Source: Mentimeter.

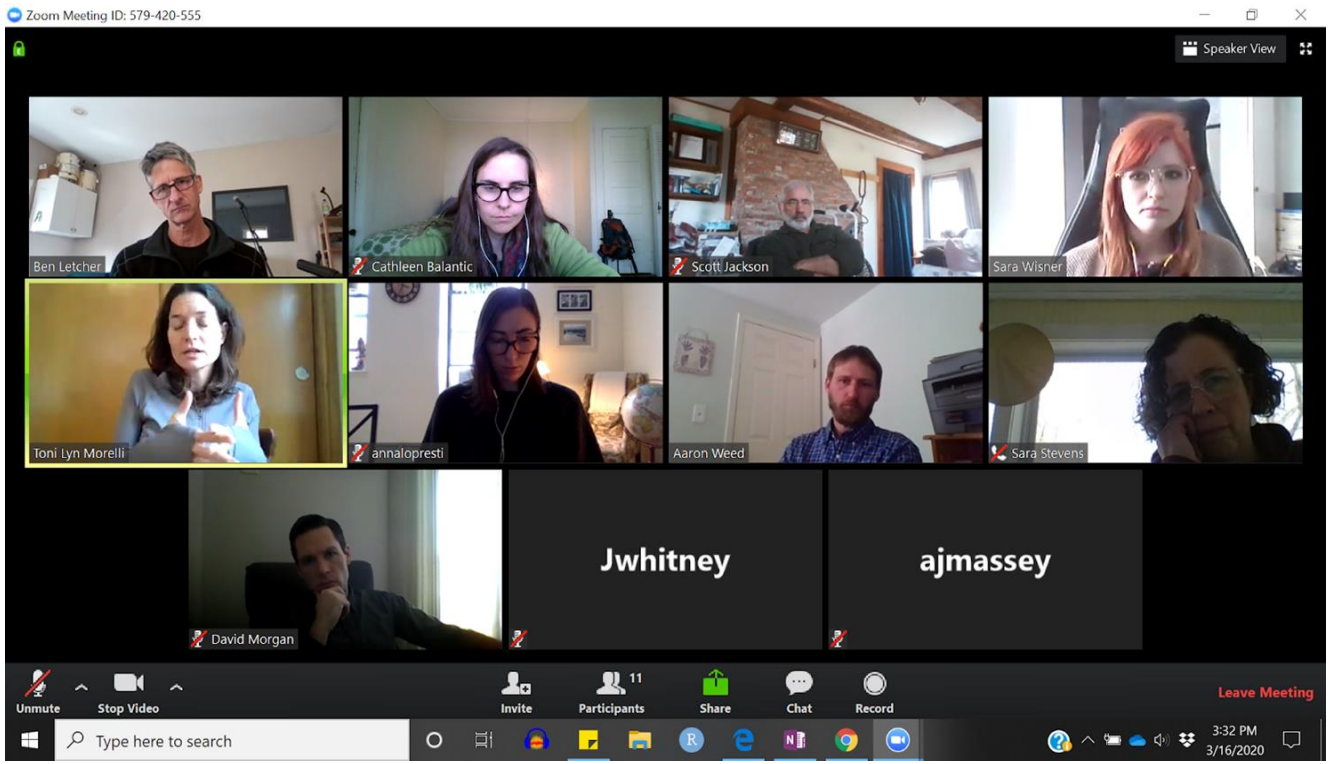
Southern NER



March 19, 2020 Zoom meeting. Source: Mentimeter.

2. Assess climate impacts and vulnerabilities

- “What is the specific focus?”
- “How to apply climate change refugia results to ongoing or future management actions?”
- “What data and partnerships are available?”



Source: Cathleen Balantic

March 16, 2020 Workshop Focal Resources:

- Estuarine Marsh
- Submerged Marine (including Seagrasses)
- Coldwater Streams
- Northern Forest Types
- Cultural Resources
- Freshwater Wetlands

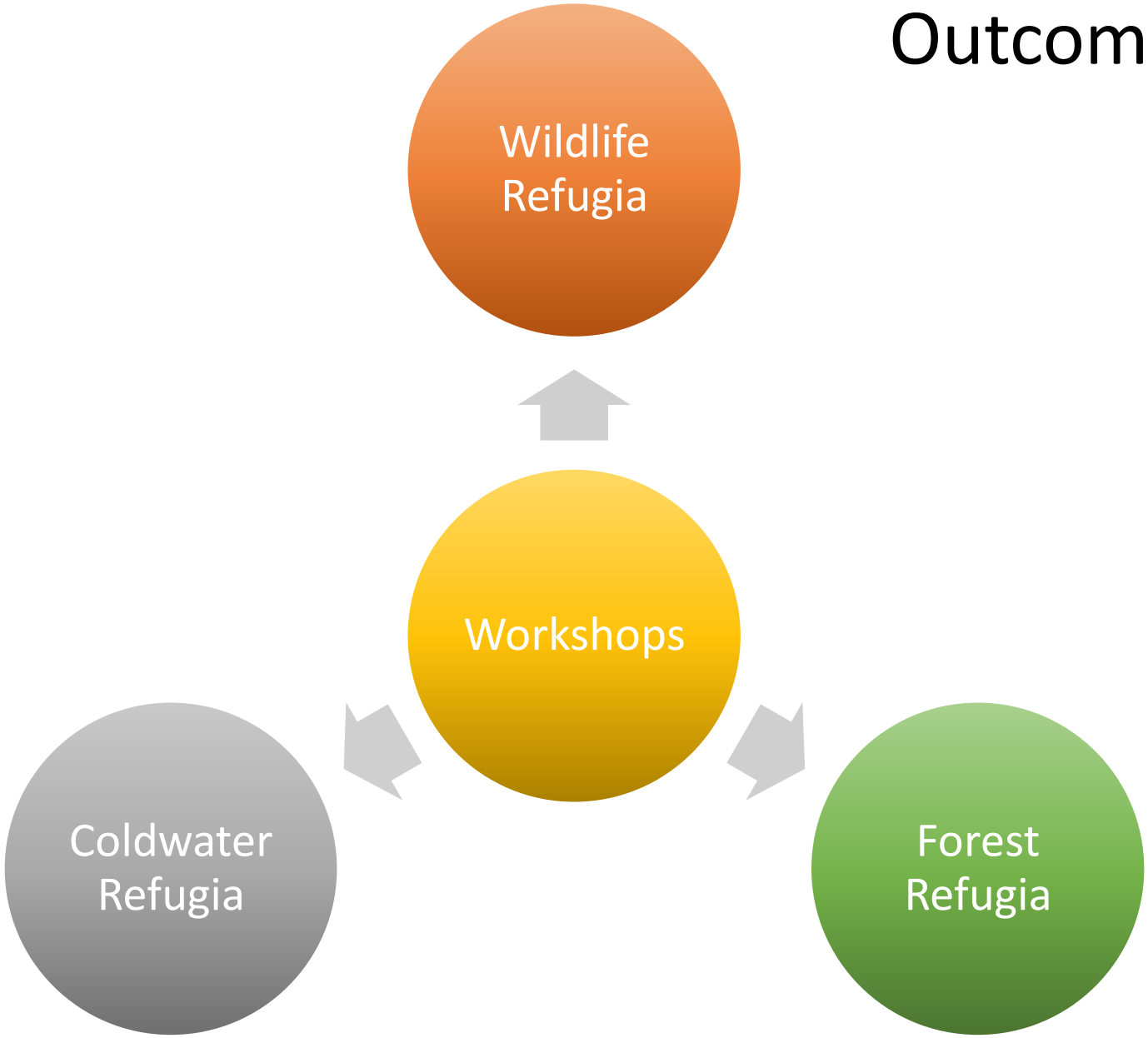
March 19, 2020 Workshop Focal Resources:

- Coldwater Streams
- High Elevation Plants
- Salt marsh / Intertidal
- Boreal Communities
- *Plant Diversity* (this topic was agreed to be considered under the other categories)

Outcomes

4. Identify and map key refugia features

Consider scale & connectivity



- List of priority species identified
- Accumulated data, partnerships and available resources

Priority Species

- Black-throated green warbler (*Setophaga virens*)
- Grasshopper Sparrow (*Ammodramus savannarum*)

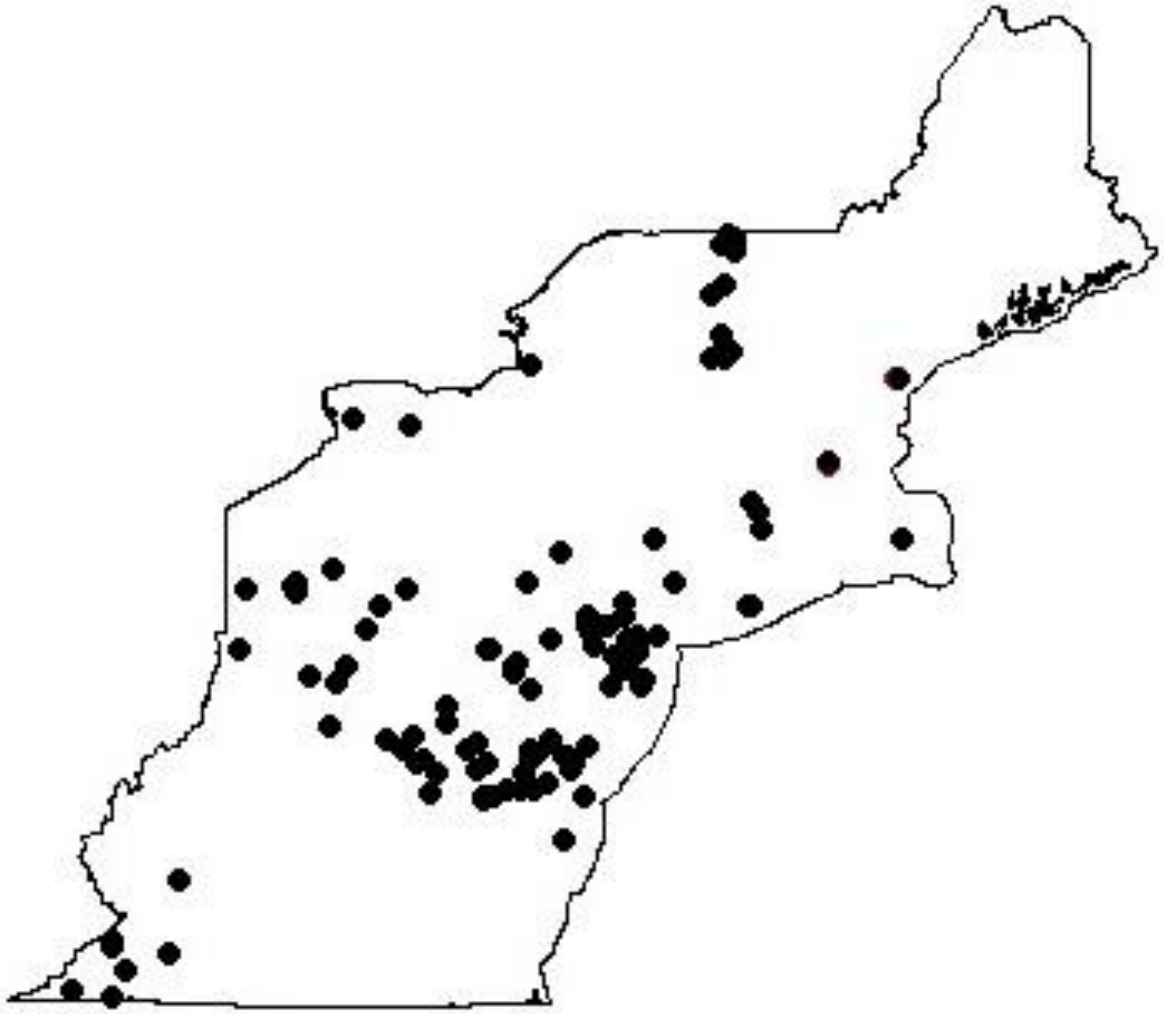
- Blue-spotted salamander (*Ambystoma laterale*)
- Marbled salamander (*Ambystoma opacum*)
- Jefferson salamander (*Ambystoma jeffersonianum*)

- Shrubby five-fingers (*Sibbaldiopsis tridentata*)
- Common bearberry (*Arctostaphylos uva-ursi*)
- Highland rush (*Juncus trifidus*)
- Bebb's sedge (*Carex bebbii*)

*Other species were modeled by collaborators

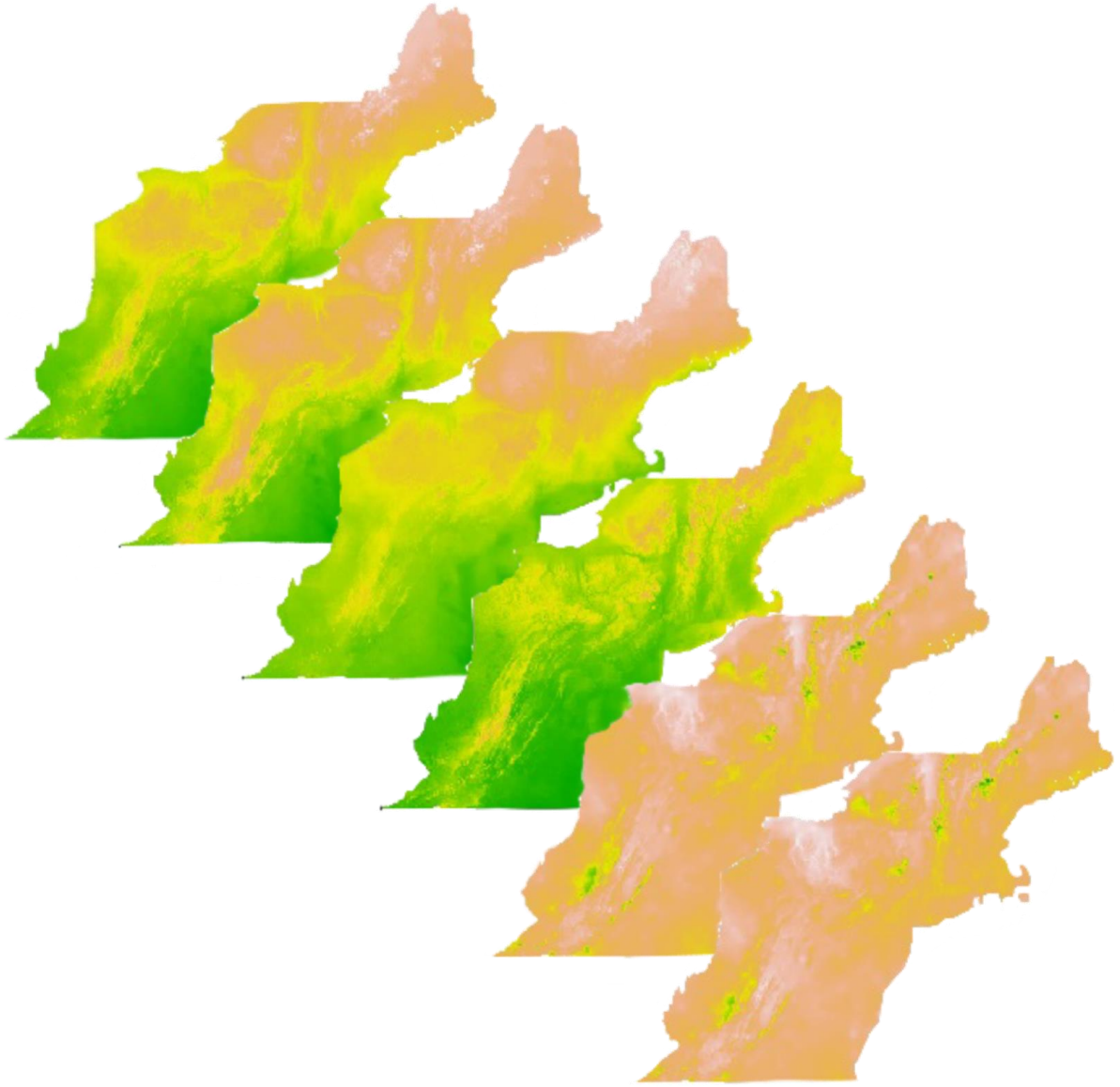
Occurrence Data

- Data from iNaturalist and GBIF
- For bird species only observations between May – September, to omit winter migration
- Collected from the years 2000 to 2020
- Research grade observations
  - Spatial accuracy of up to 800m
- Generated pseudo-absences during SDM modeling



Predictor Variables - Climate data

Annual Precipitation	Total precipitation for the year. The sum of the daily values across all days. mm/year * 100. Note the “delta” in this case is actually a ratio.	precip
Growing Season Precipitation	Sum of daily precipitation for days in May through September mm/year * 100. The “delta” is a ratio.	precipgs
Average annual temperature	Mean of daily min and max for every day of the year.	temp
Mean Minimum Winter Temperature	Mean of the daily minimum temperatures for everyday in December, January, and February.	tmin
Mean Maximum Summer Temperature	The mean of the daily maximum temperature for June, July and August.	tmax
Growing Degree Days	The sum across days of the number of degrees by which the mean daily temperature exceeds a threshold of 10 deg C. Where mean temperature is the mean of the min and max temp for the day. For prism data this is calculated from the 30 year mean temperature for each month by multiplying the exceedance by the number of days in the month.	gdd



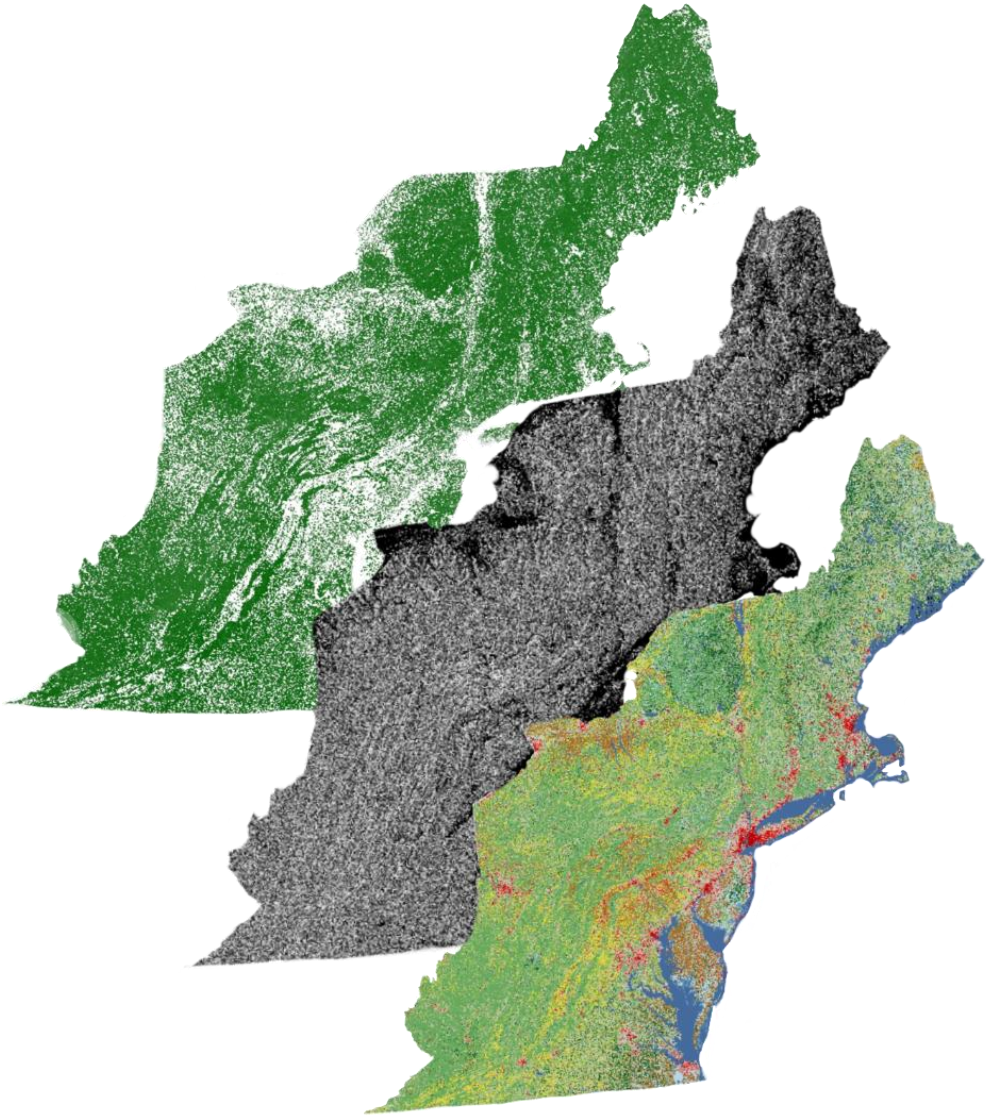
(McGarigal et al. 2017b).

Predictor Variables – Non-Climate Environmental Data

- National Land Cover Data (NLCD)
- Aspect
- Tree canopy

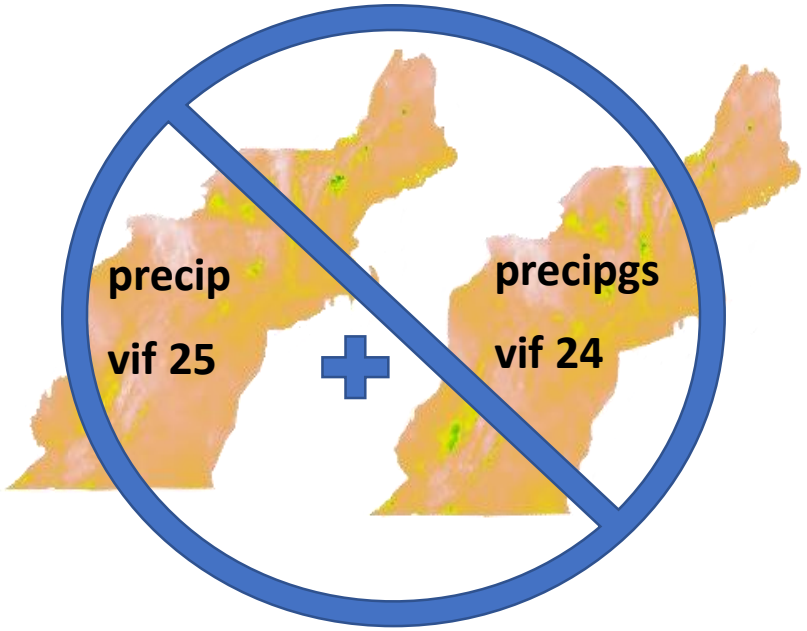
Plant species:

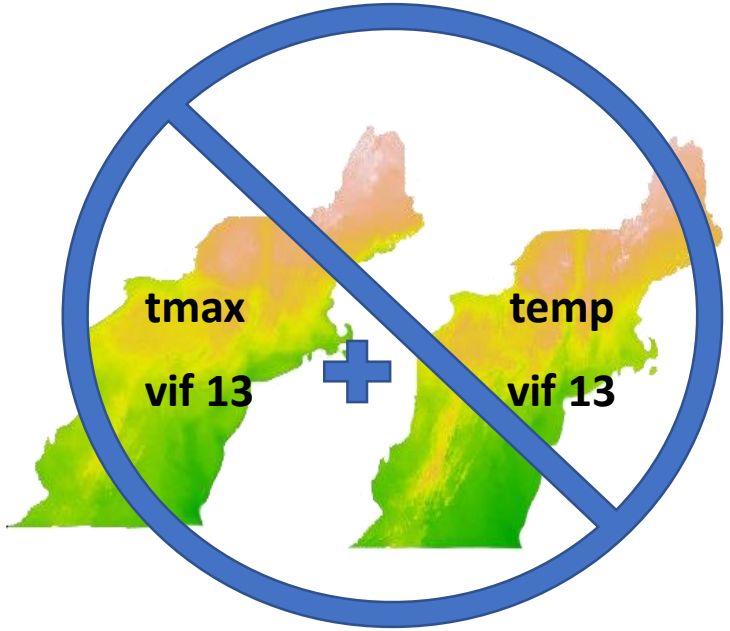
- Soil pH
- Available water supply
- Depth to water table
- Soil drainage
- Soil organic matter
- Depth to resistant layer (bedrock)

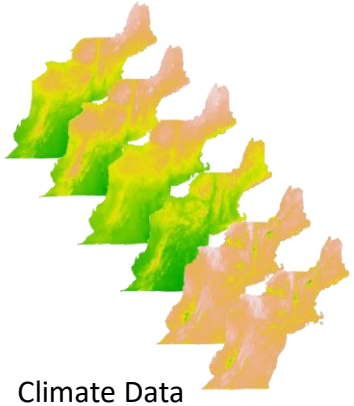


Model Fitting

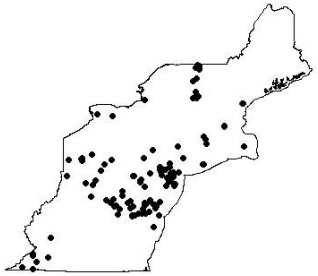
- To model relationship between occupancy and the predictor variables I used glms
- Checked the variance inflation factor for collinearity
- Used a backwards stepwise selection step()
- Compared the resulting models AIC to find the best models for each species



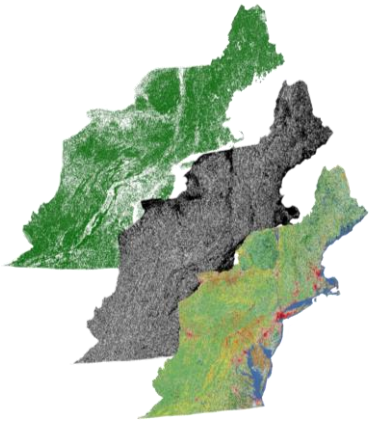




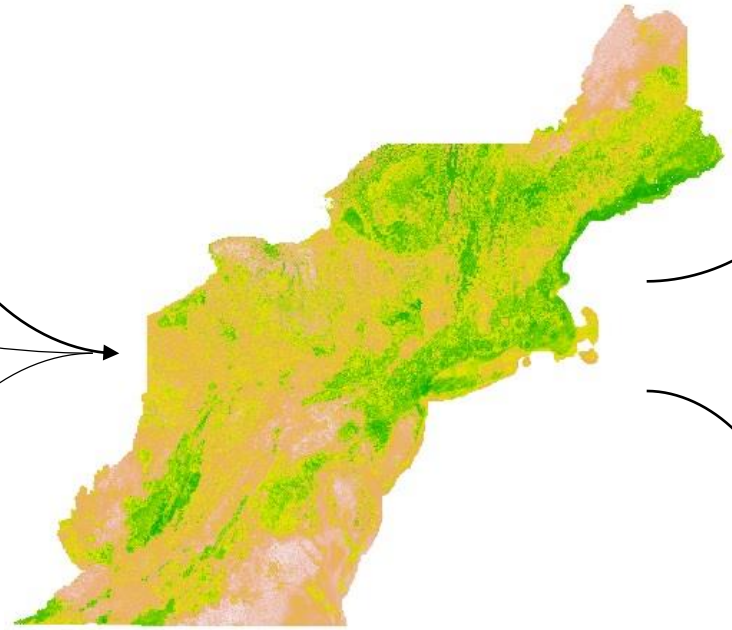
Climate Data



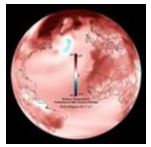
Occurrence Data



Non-Climate Environmental Data



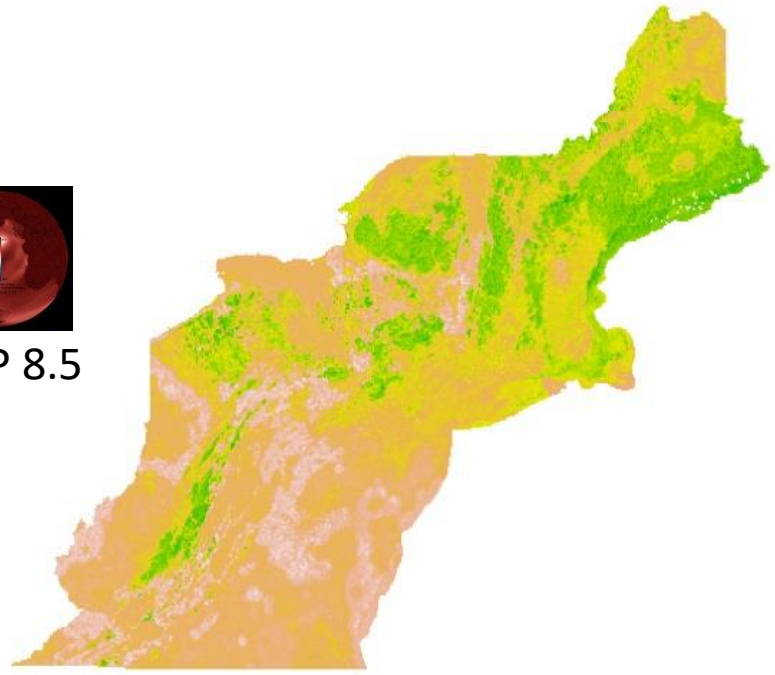
2010 Habitat Suitability



RCP 4.5

2080 Habitat Suitability

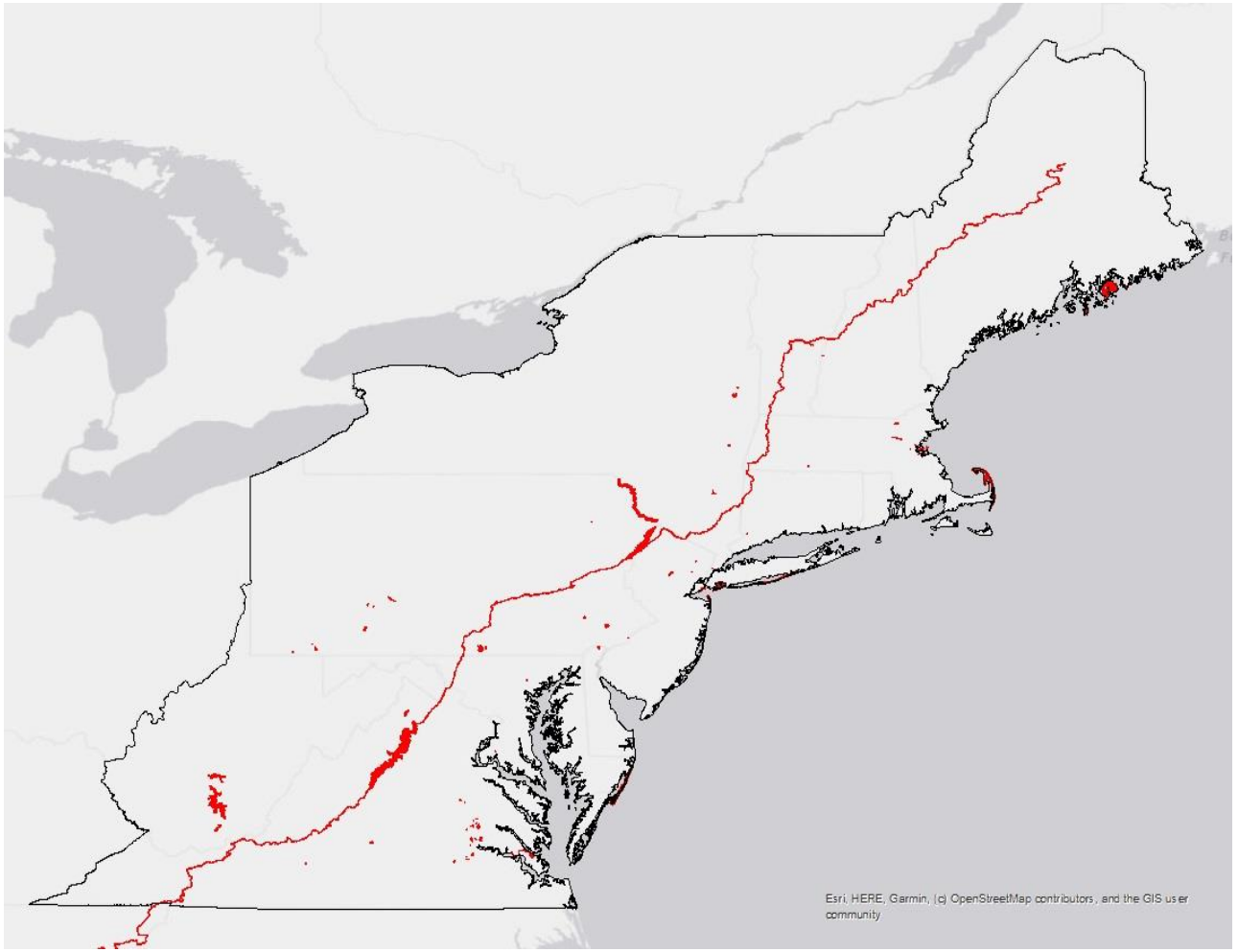
RCP 8.5



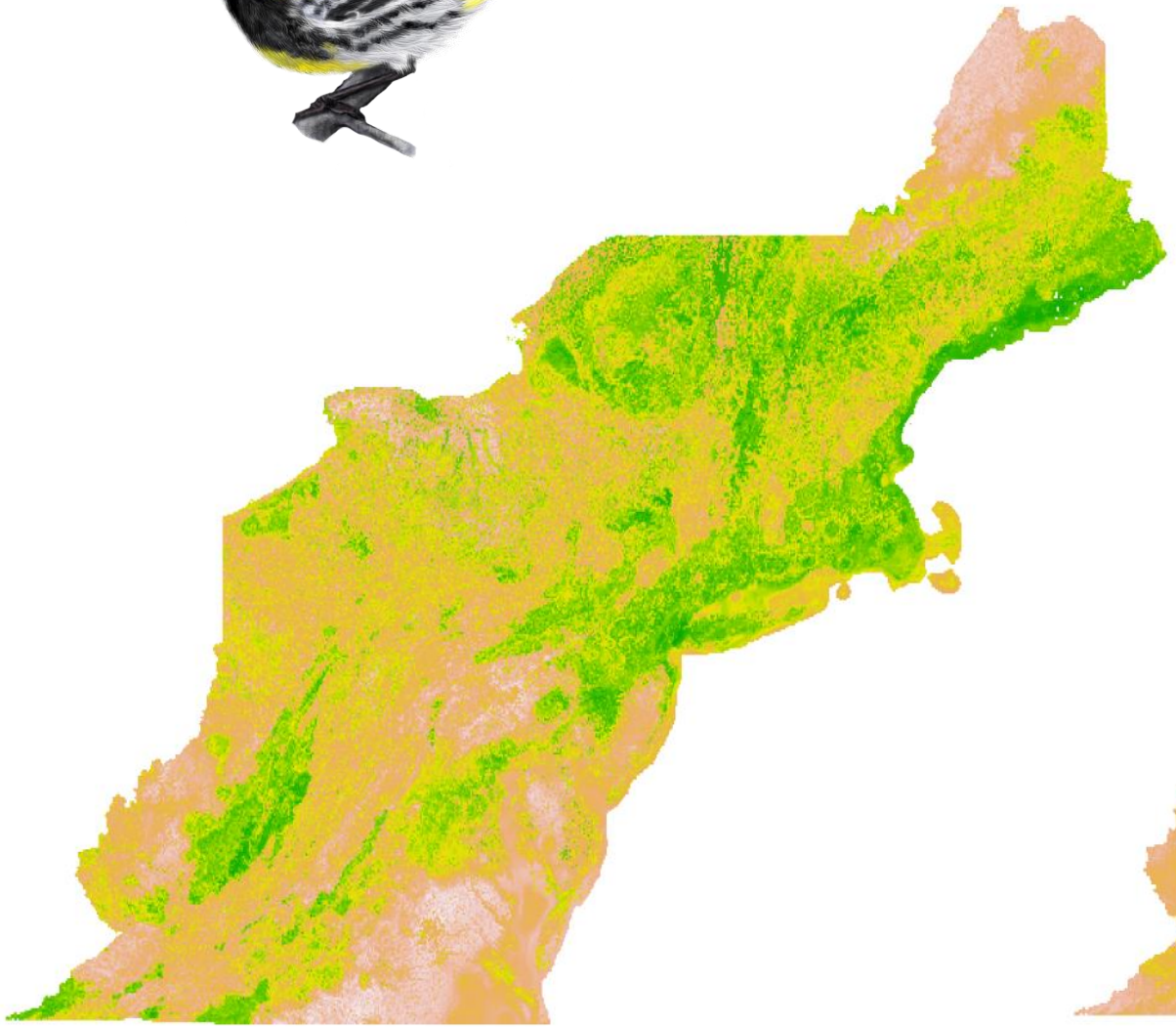
2080 Habitat Suitability

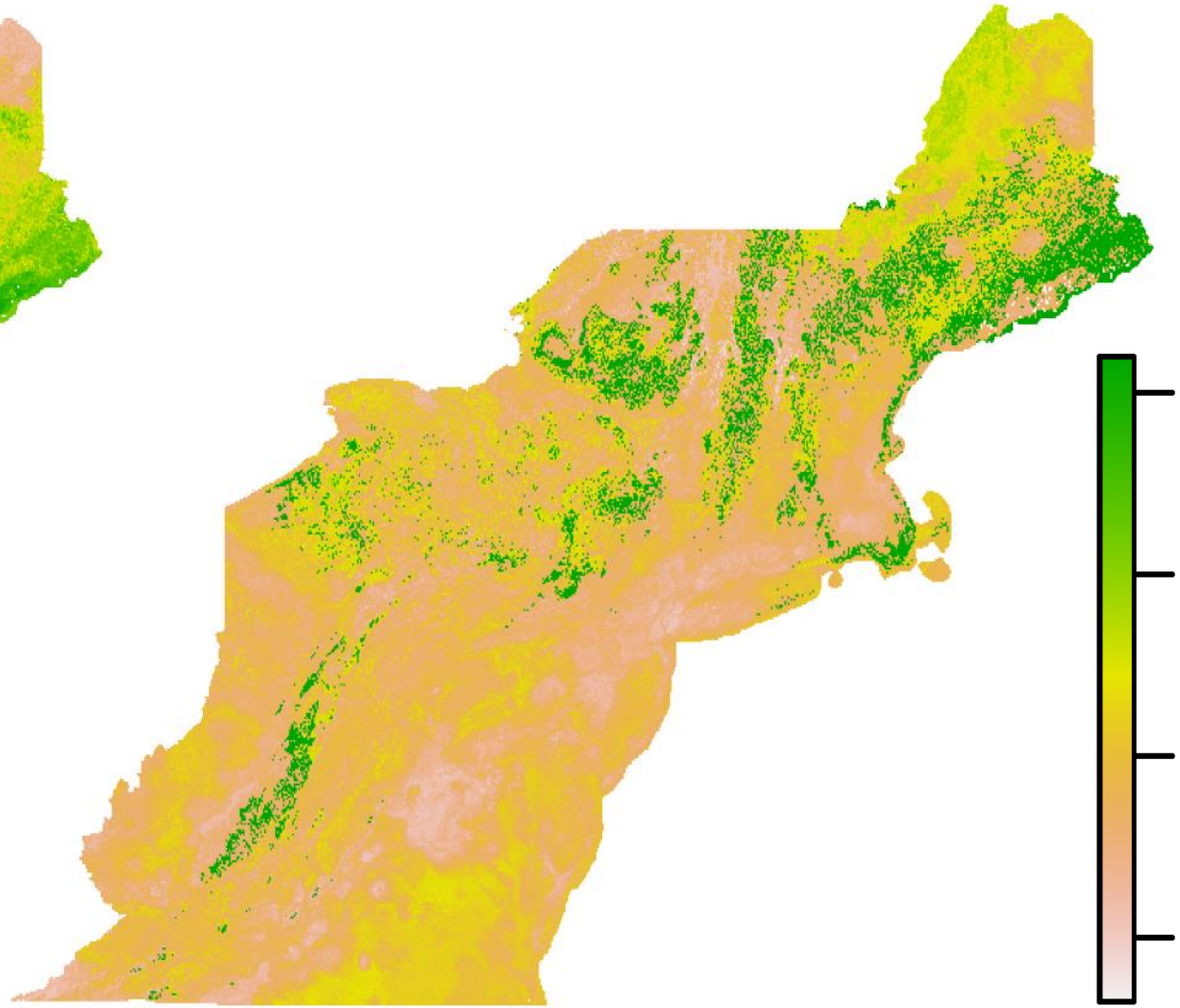
Climate change refugia in NPS units

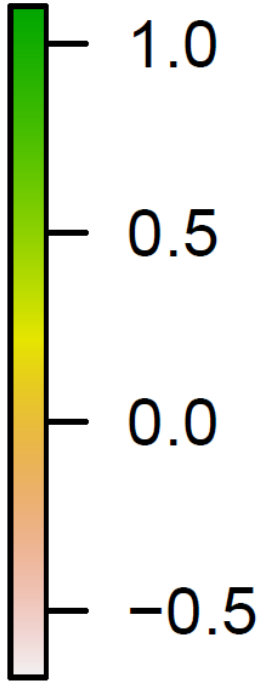
- 77 park units
- The Appalachian trail is broken down into HUC units.
- Mapped refugia for each of these NPS units
- Calculated the % of refugia



Black-throated green warbler





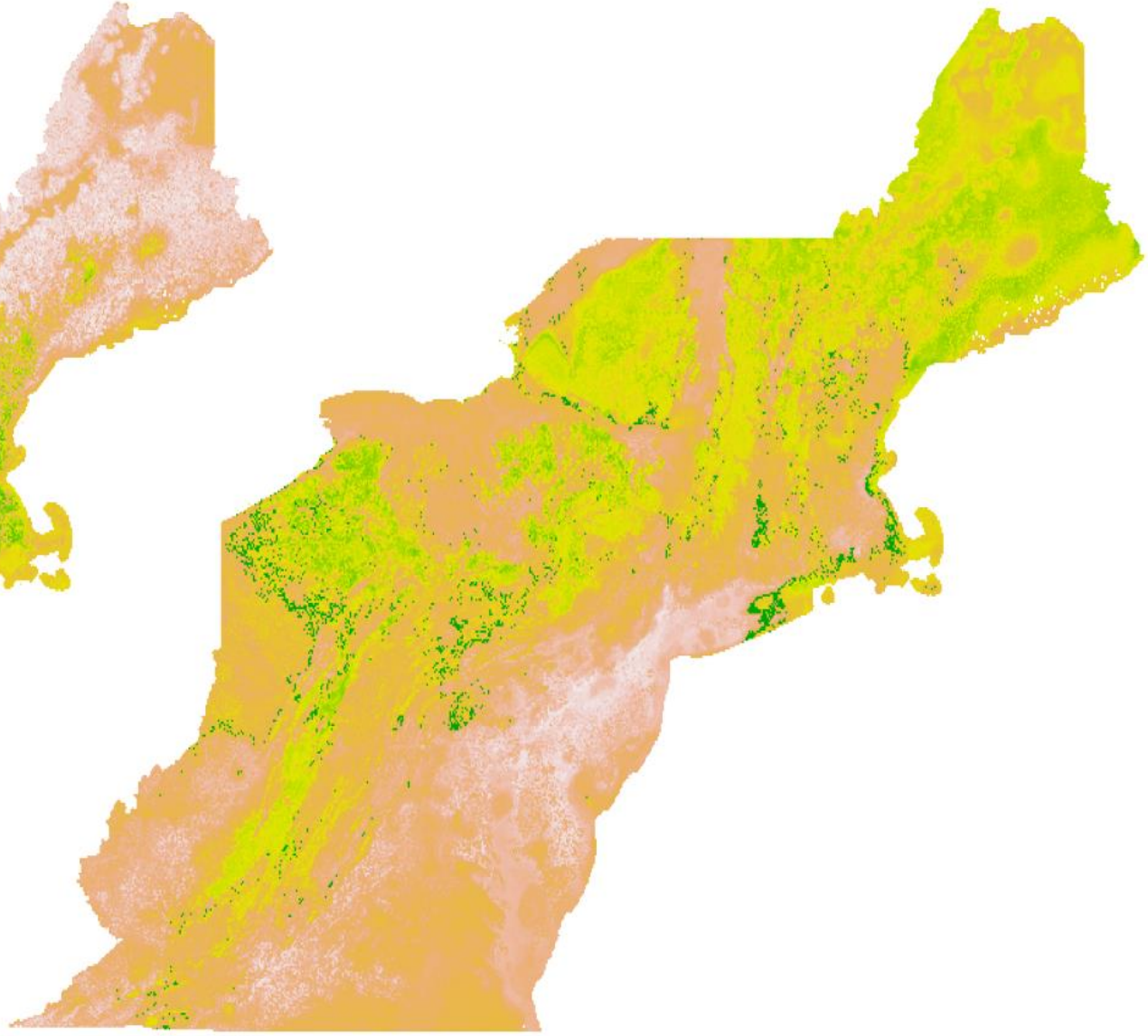


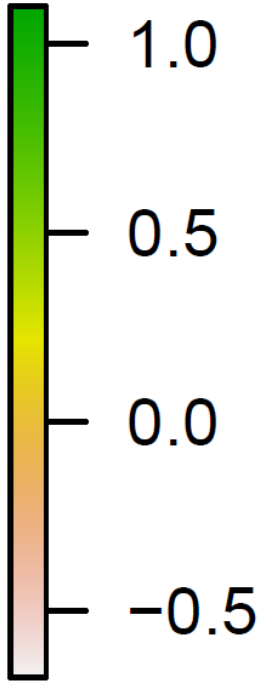
2010 Habitat Suitability

2080 RCP 8.5 Climate Change Refugia

Black-throated green warbler

Grasshopper sparrow





2010 Habitat Suitability

2080 RCP 8.5 Climate Change Refugia

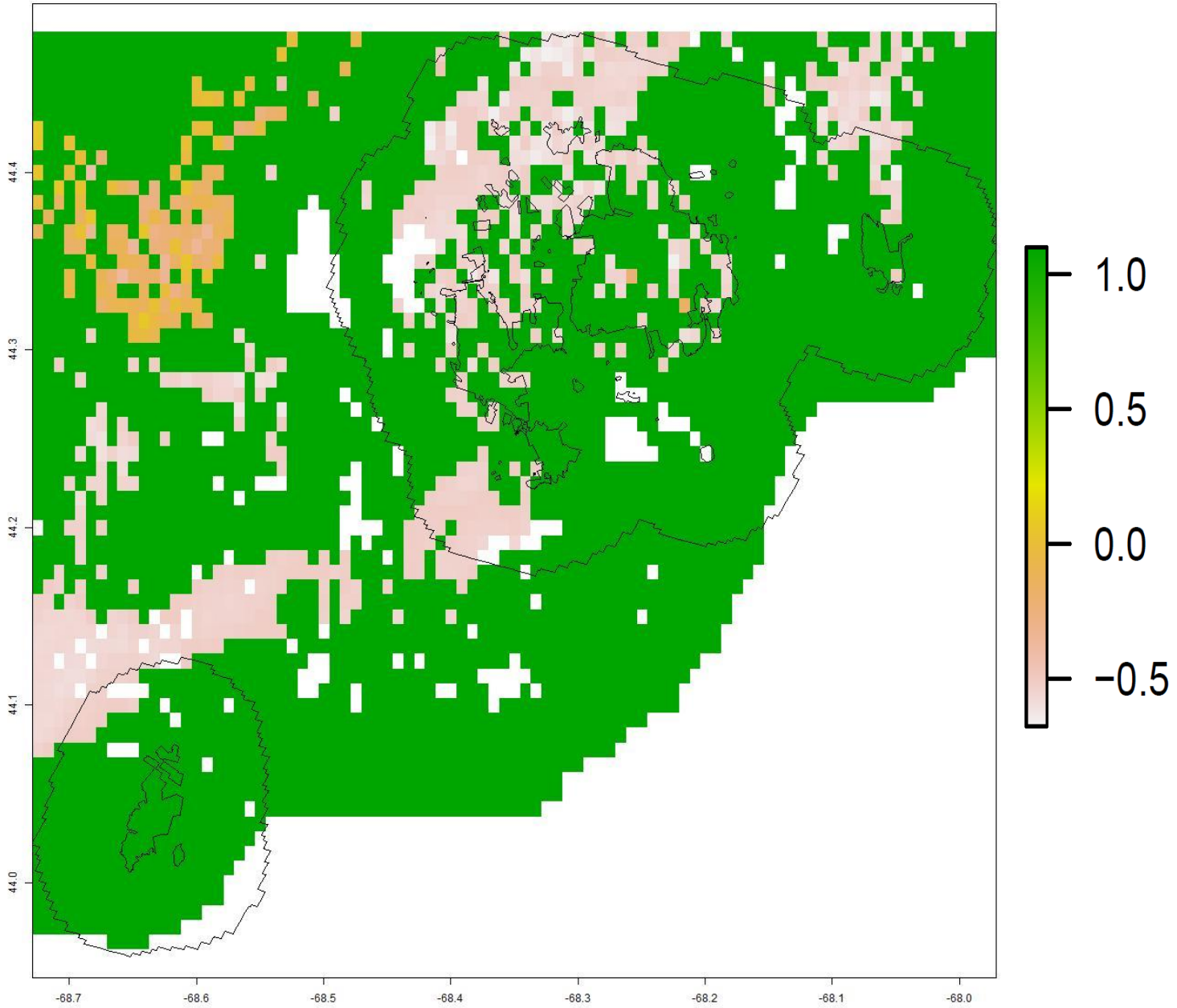
Grasshopper sparrow

Highest percentage of refugia

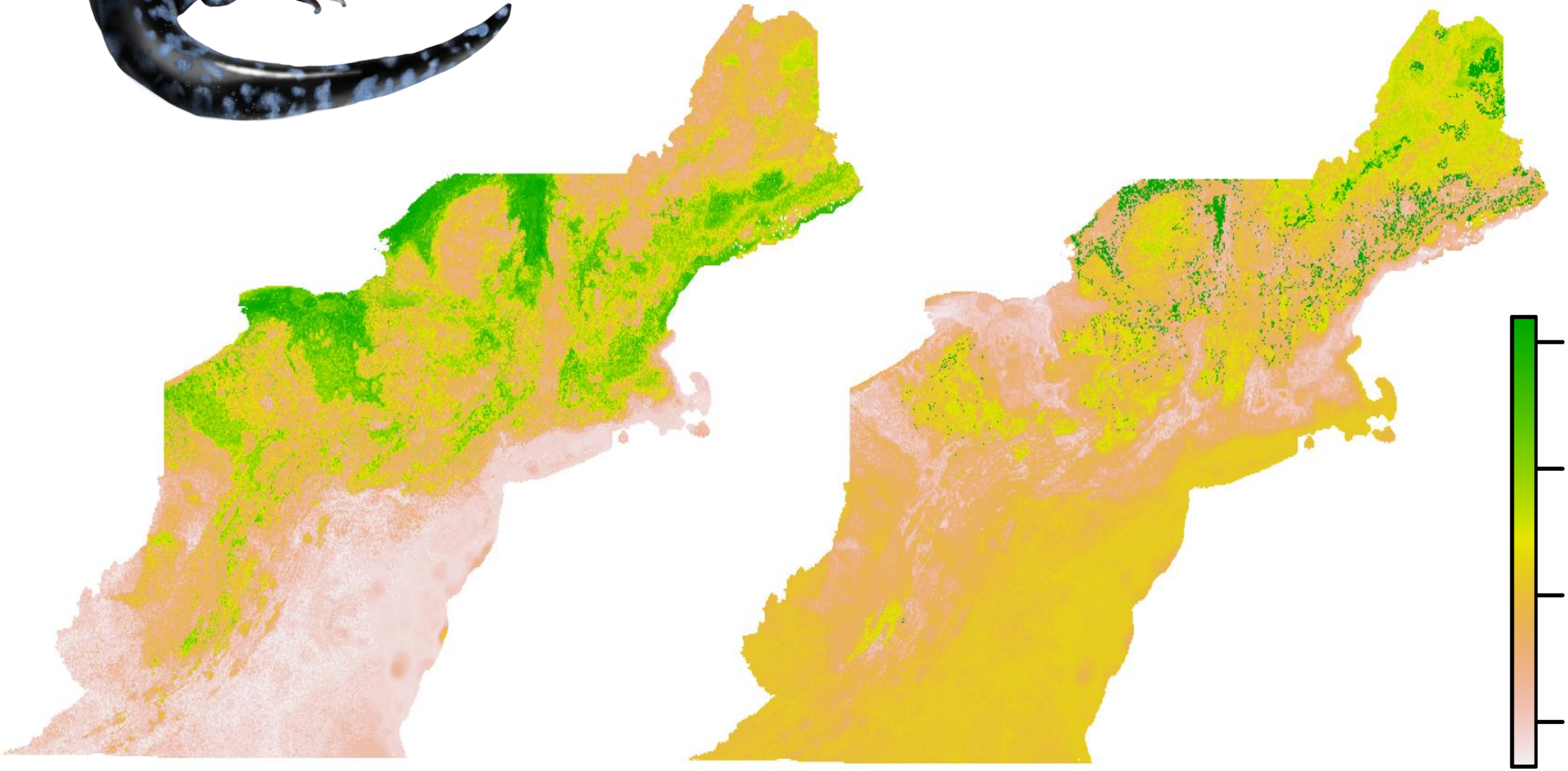
- Grasshopper sparrow had the highest refugia in Delaware Water Gap National Recreation Area (DEWA).

- Black-throated green warbler had the highest refugia in Acadia National Park (ACAD).

Black-throated green warbler – Acadia National Park

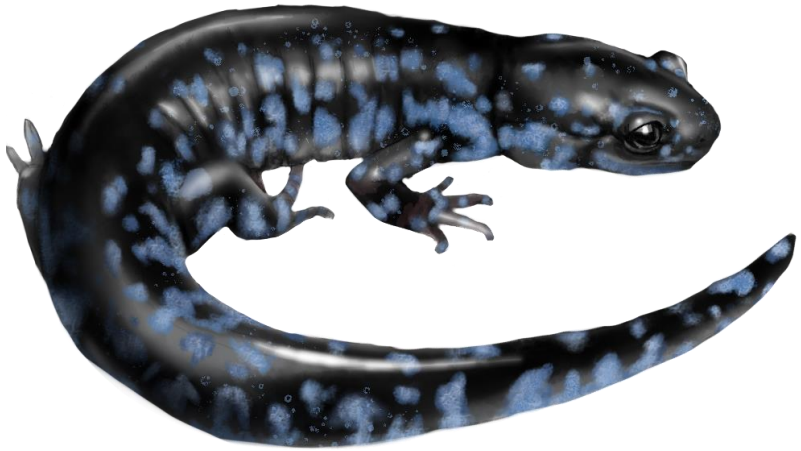


Blue-spotted salamander

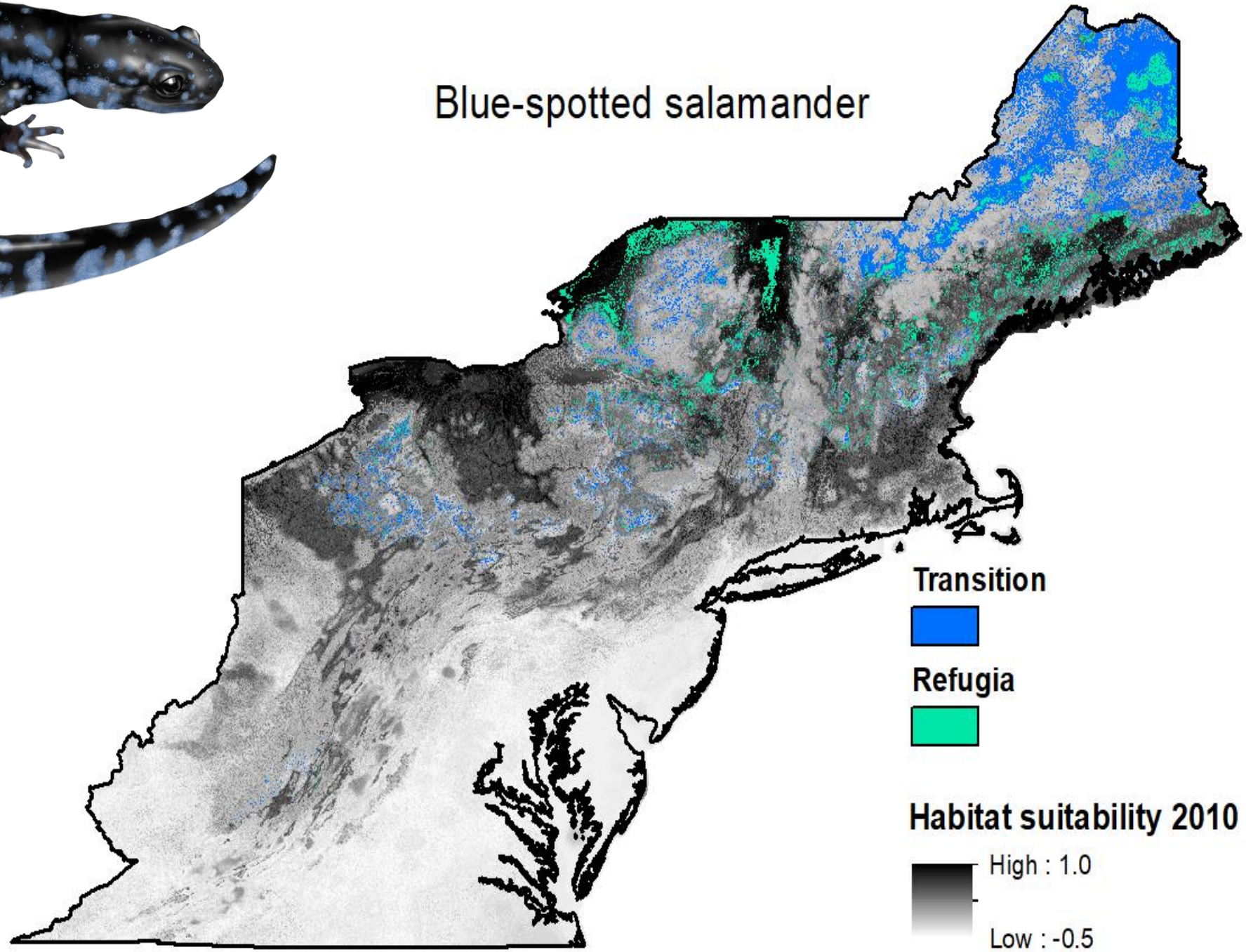


2010 Habitat Suitability

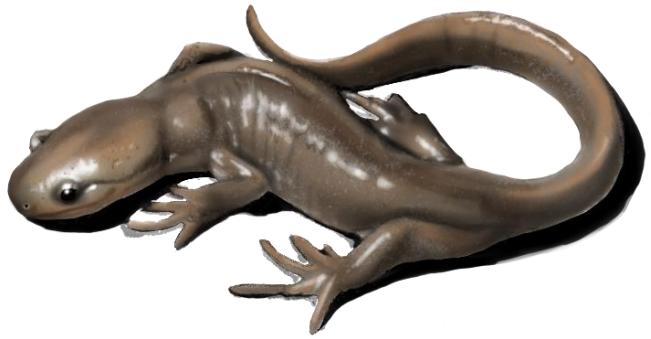
2080 RCP 8.5 Climate Change Refugia



Blue-spotted salamander



Jefferson salamander

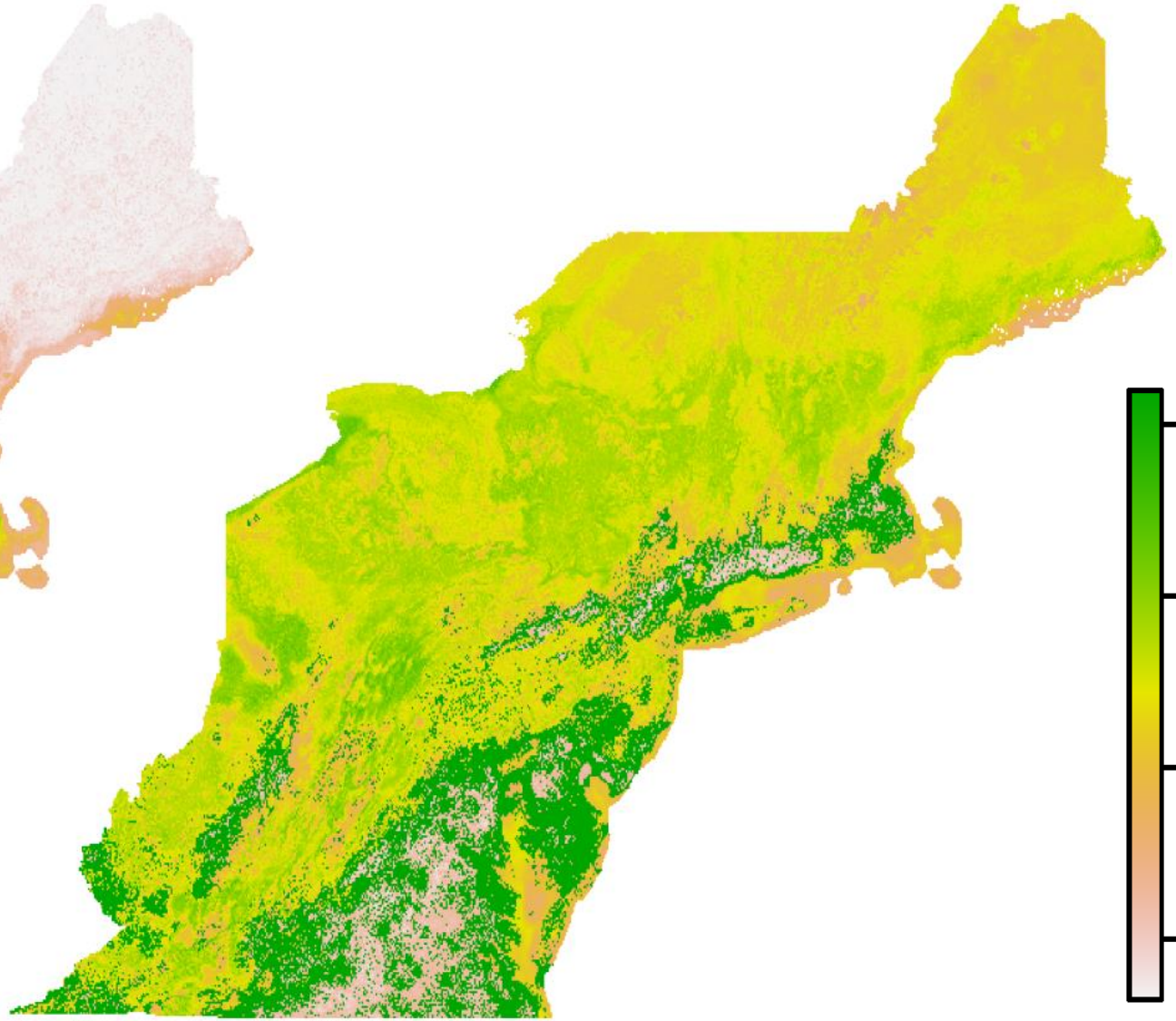


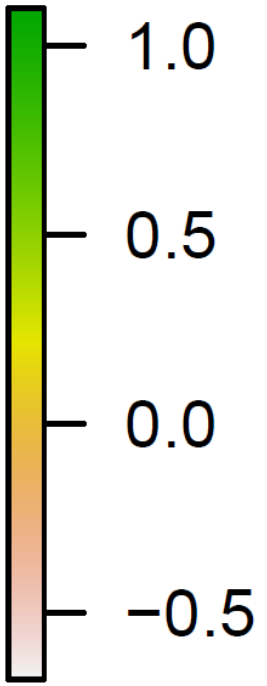
2010 Habitat Suitability

2080 RCP 8.5 Climate Change Refugia

Jefferson salamander

Marbled salamander





2010 Habitat Suitability

2080 RCP 8.5 Climate Change Refugia

Marbled salamander

Transition

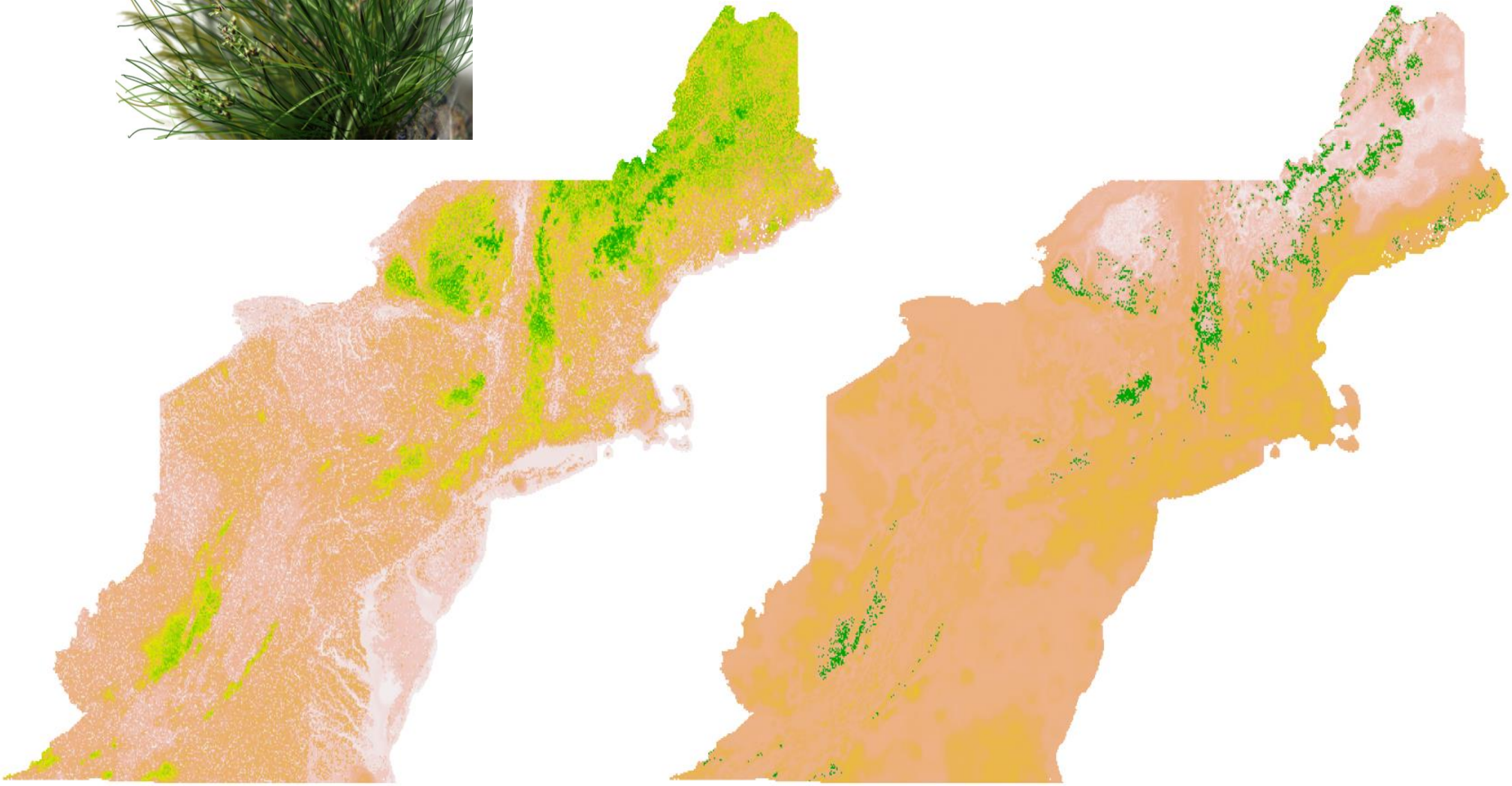
Refugia

Habitat suitability 2010

High :1.0

Low : -0.5

Highland rush



2010 Habitat Suitability

2080 RCP 8.5 Climate Change Refugia

Highland rush

Transition

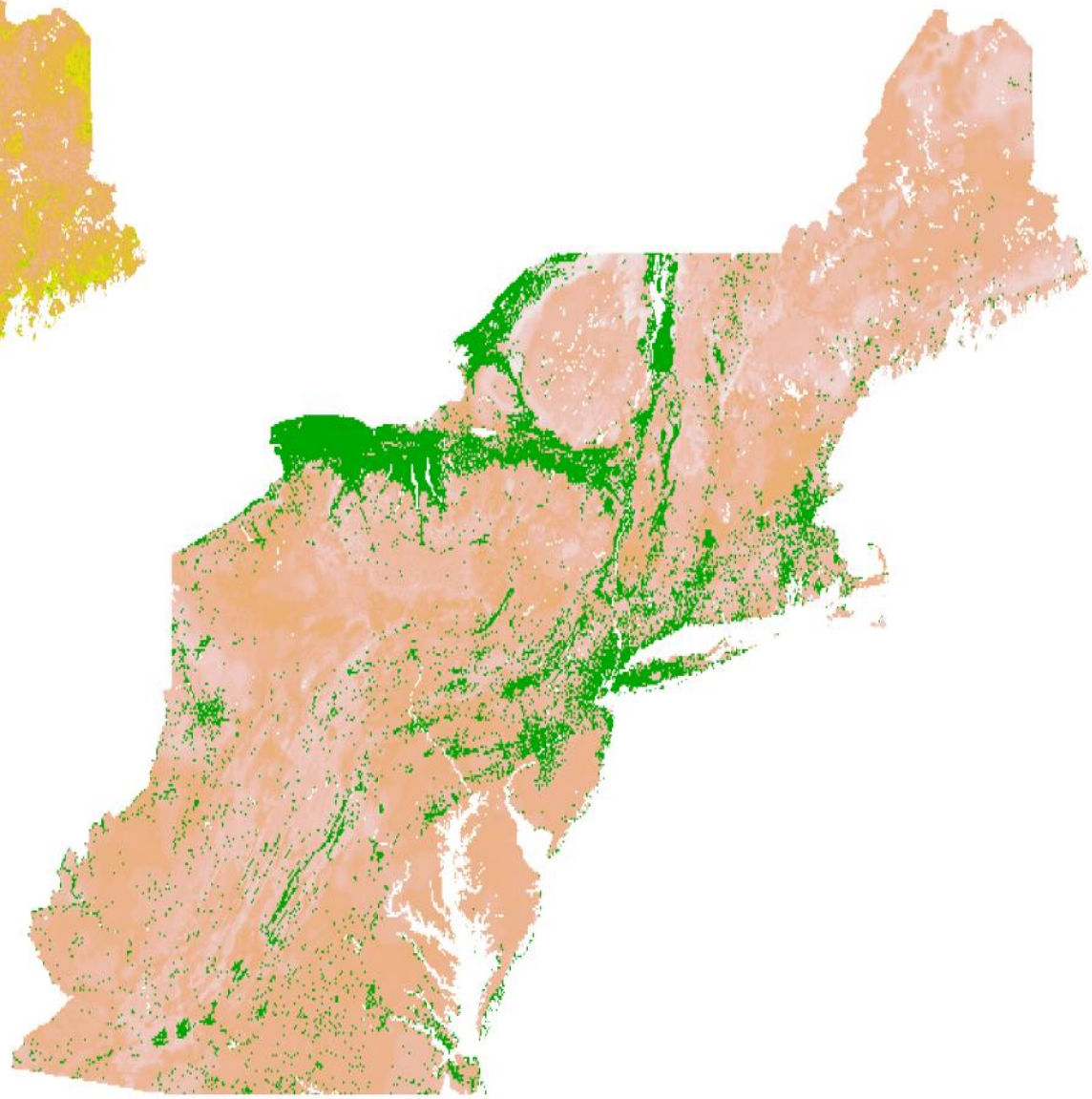
Refugia

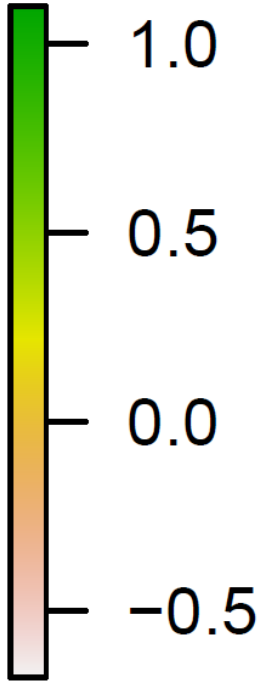
Habitat suitability 2010

High : 1.0

Low : -0.5

Bebb's sedge

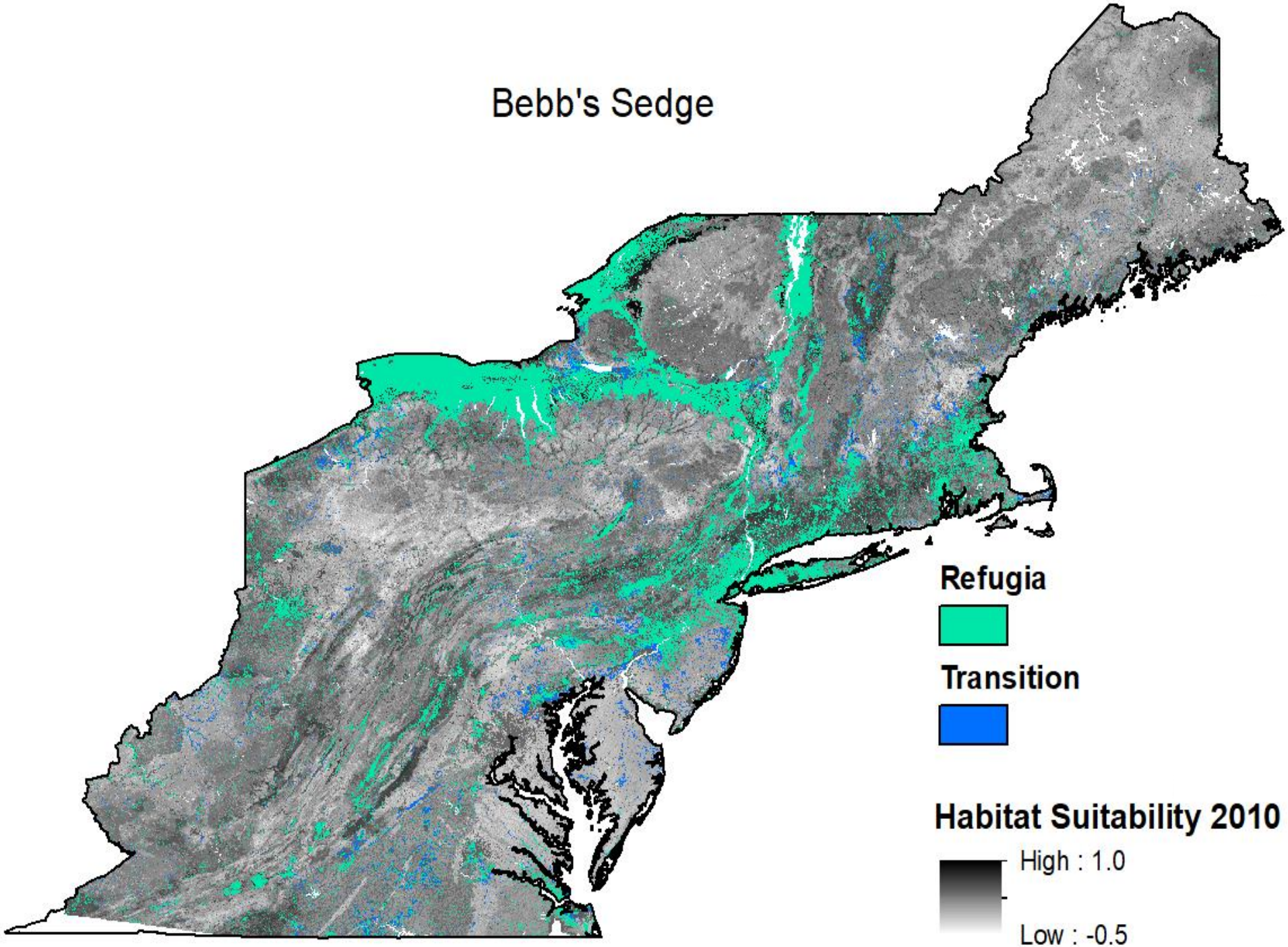




2010 Habitat Suitability

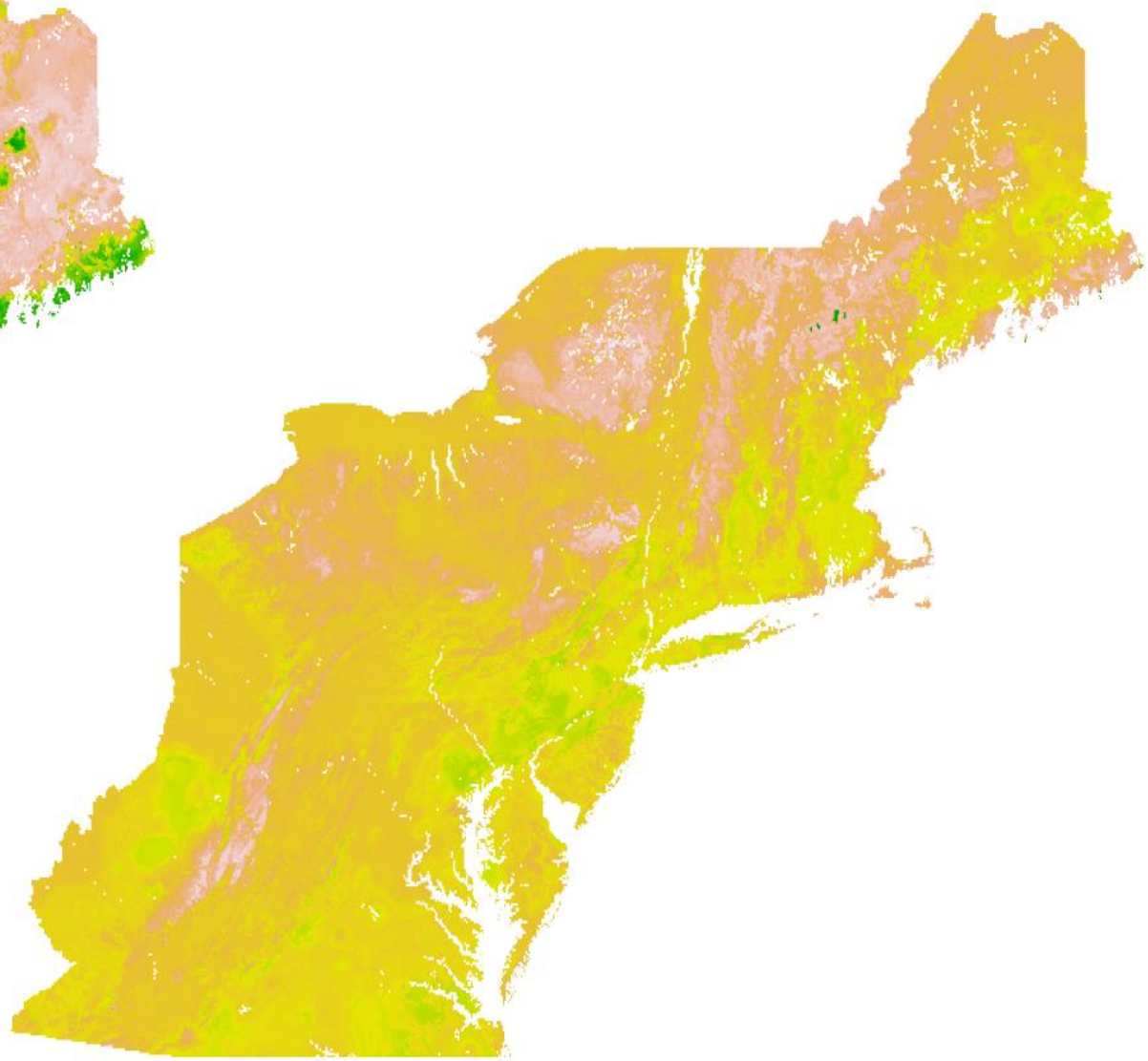
2080 RCP 8.5 Climate Change Refugia

Bebb's Sedge

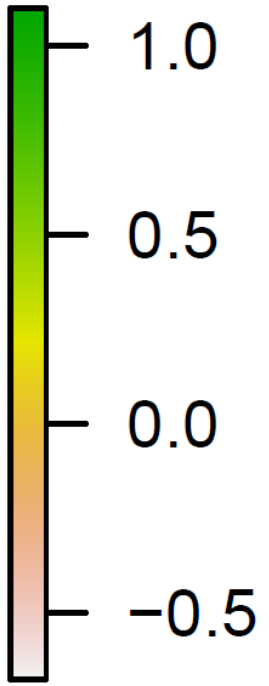

Refugia
Transition
Habitat Suitability 2010
High : 1.0
Low : -0.5

Shrubby five-fingers

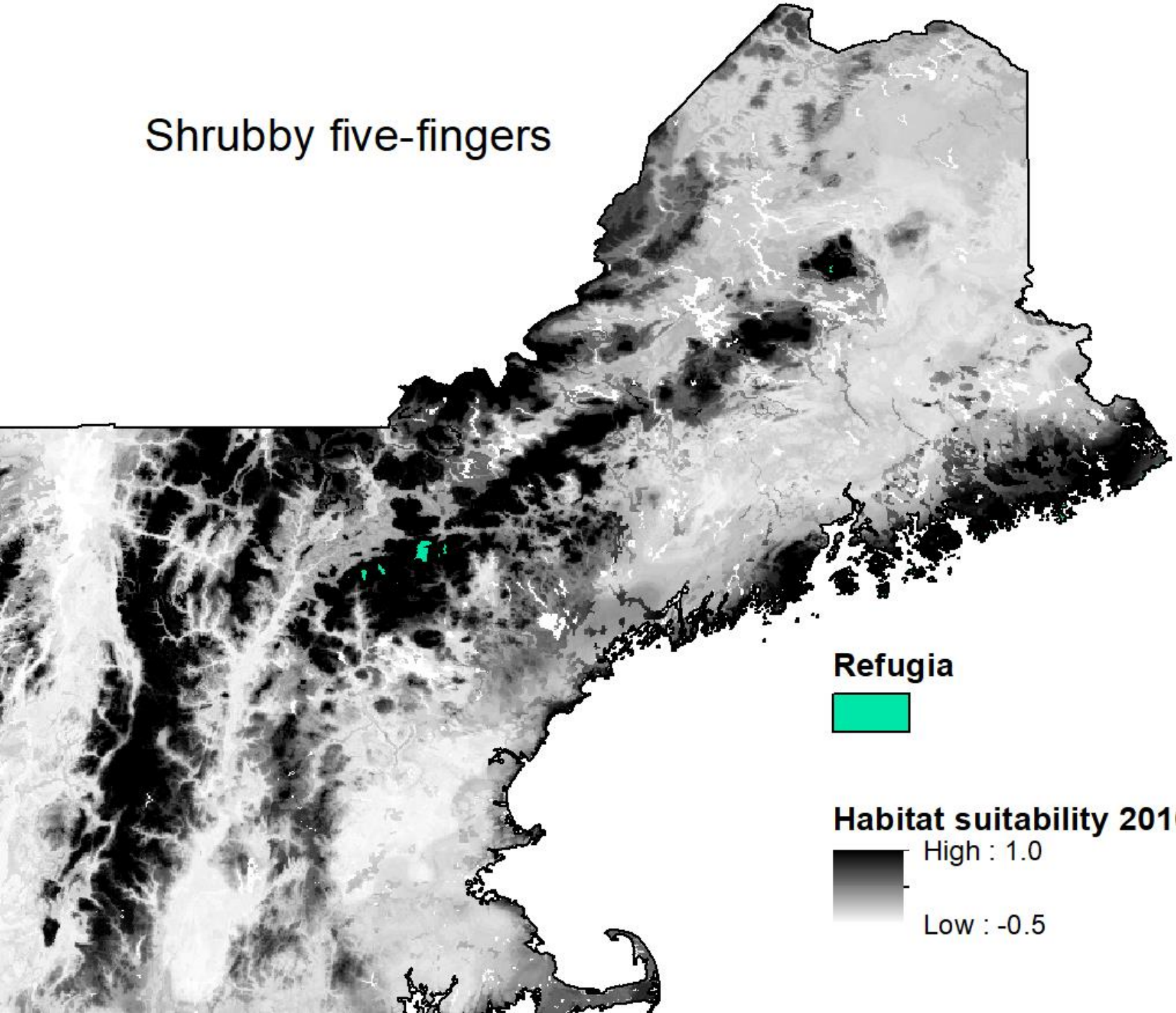
2010 Habitat Suitability



2080 RCP 8.5 Climate Change Refugia



Shrubby five-fingers



Refugia

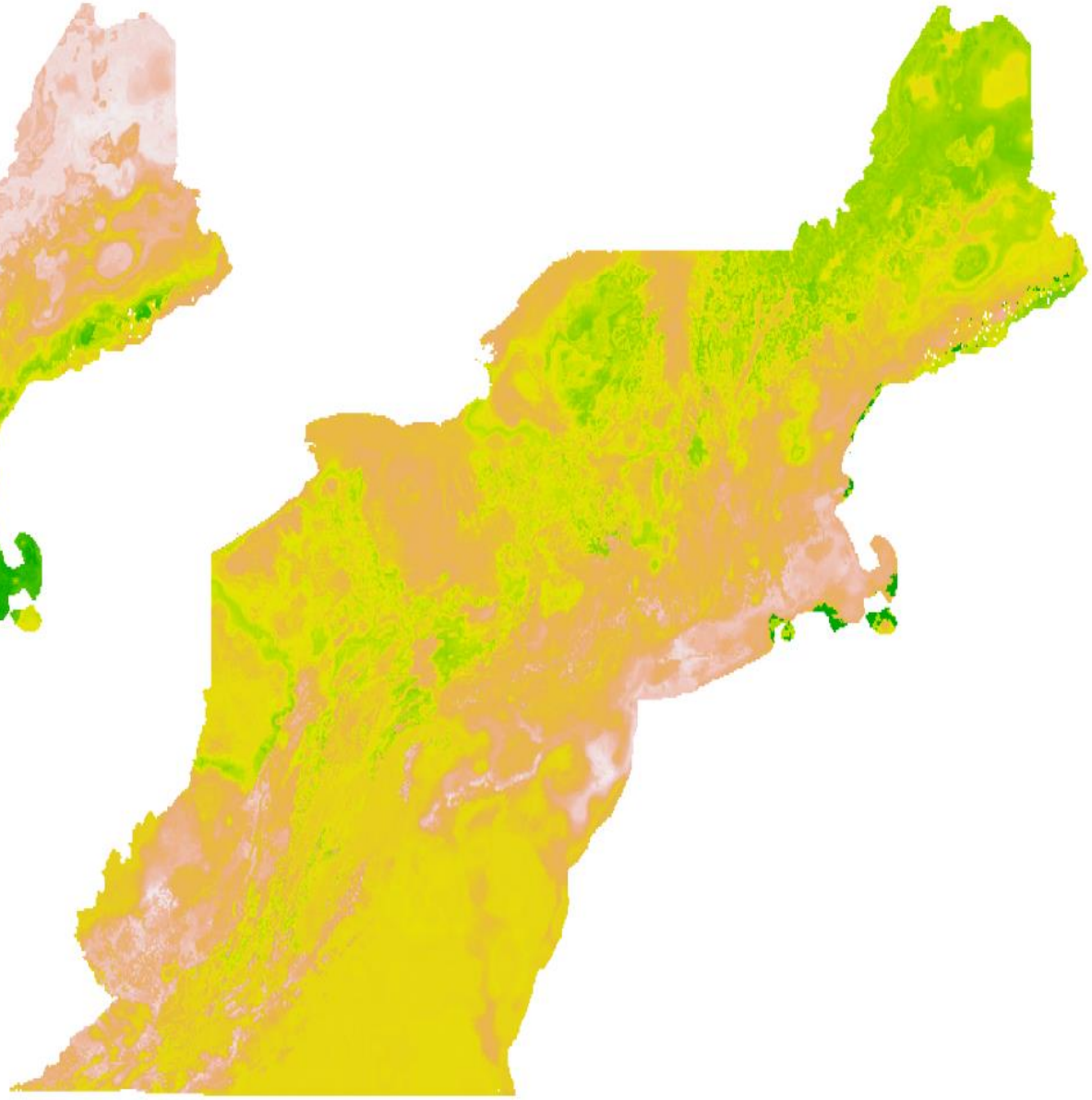
Habitat suitability 2010

High : 1.0

Low : -0.5

Common bearberry

2010 Habitat Suitability



2080 RCP 8.5 Climate Change Refugia

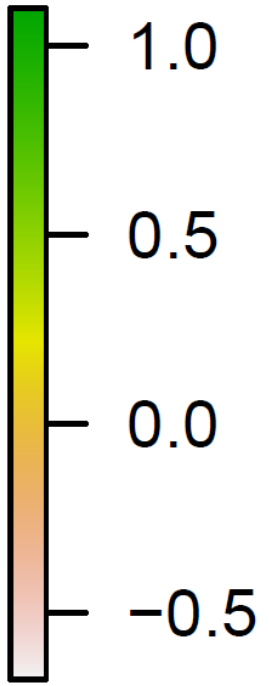
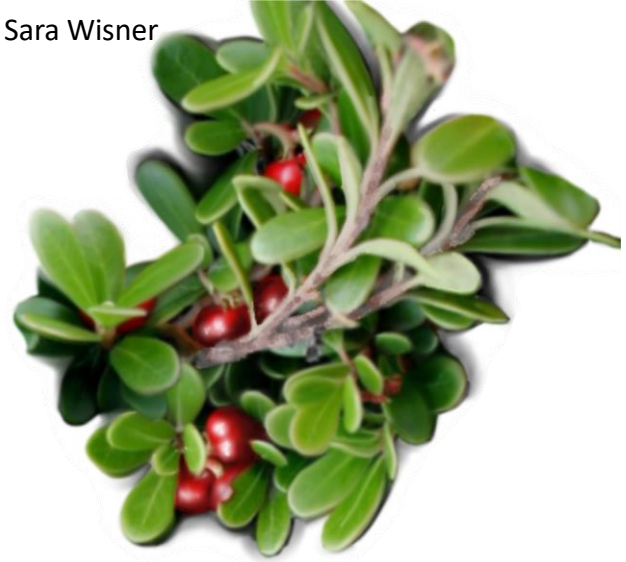


Illustration: Sara Wisner

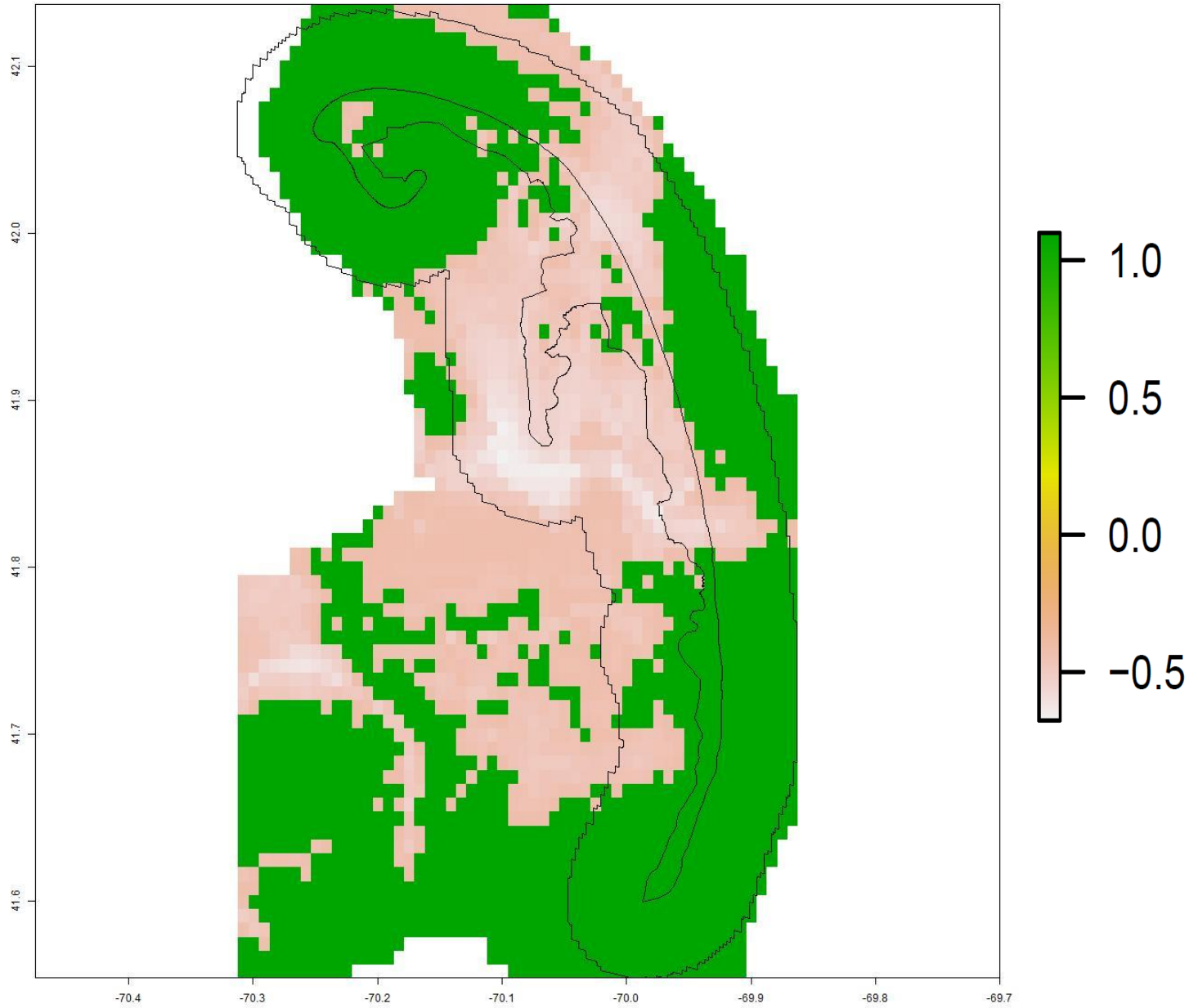


Common bearberry

Highest percentage of refugia

- Common bearberry: Cape Cod National Seashore (CACO)
- Highland rush: Acadia National Park (ACAD) and Shenandoah National Park (SHEN)
- Bebb's sedge: Delaware Water Gap National Recreation Area (DEWA) and Gateway National Recreation Area (GATE).
- Shrubby five-fingers: Only had refugia in Acadia National Park (ACAD)

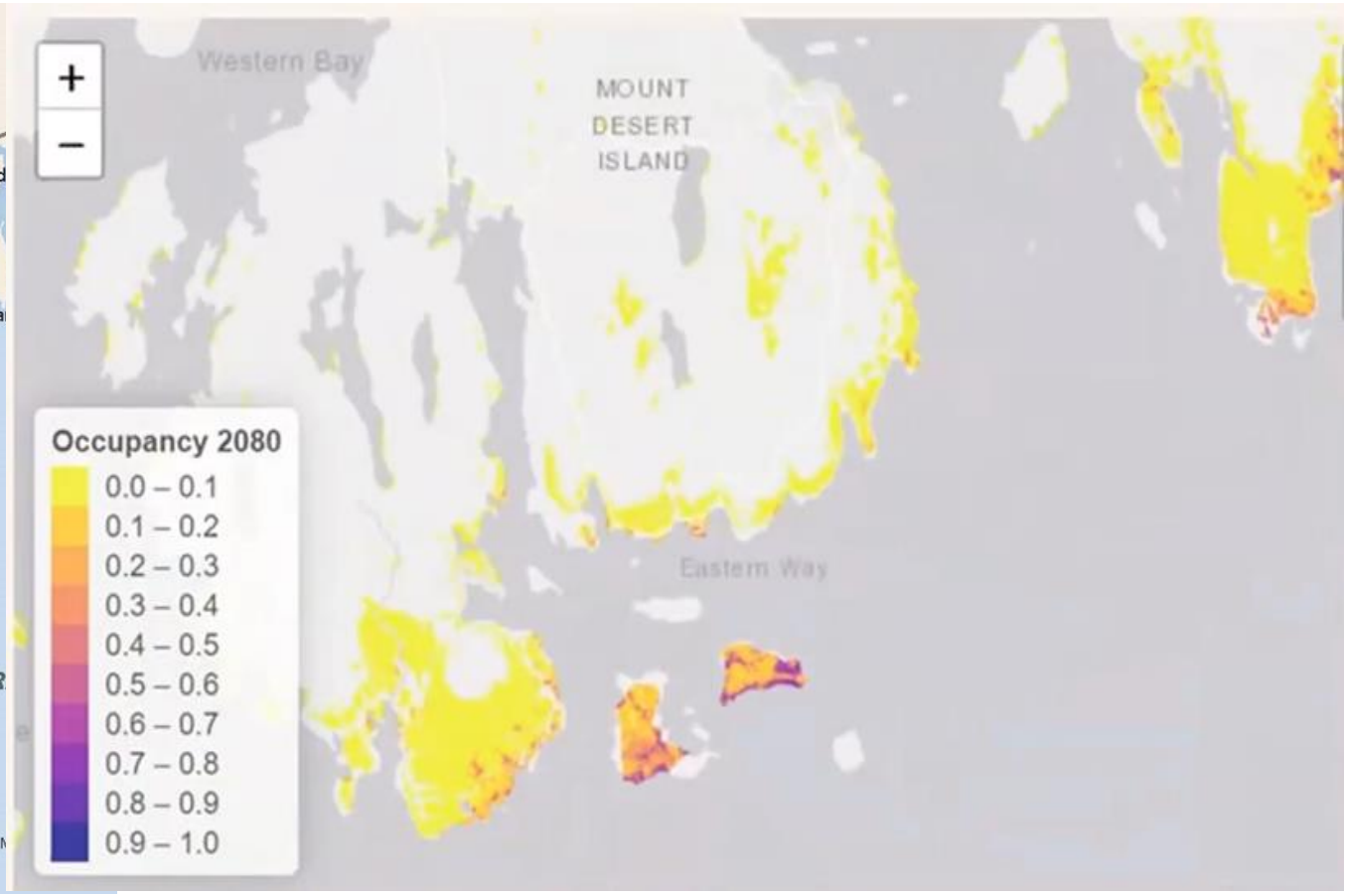
Common bearberry – Cape Cod National Seashore



Results and Management Plans Workshop

- Presented data results
- Asked how they wanted them presented / packaged for them
- Discussed potential management plans

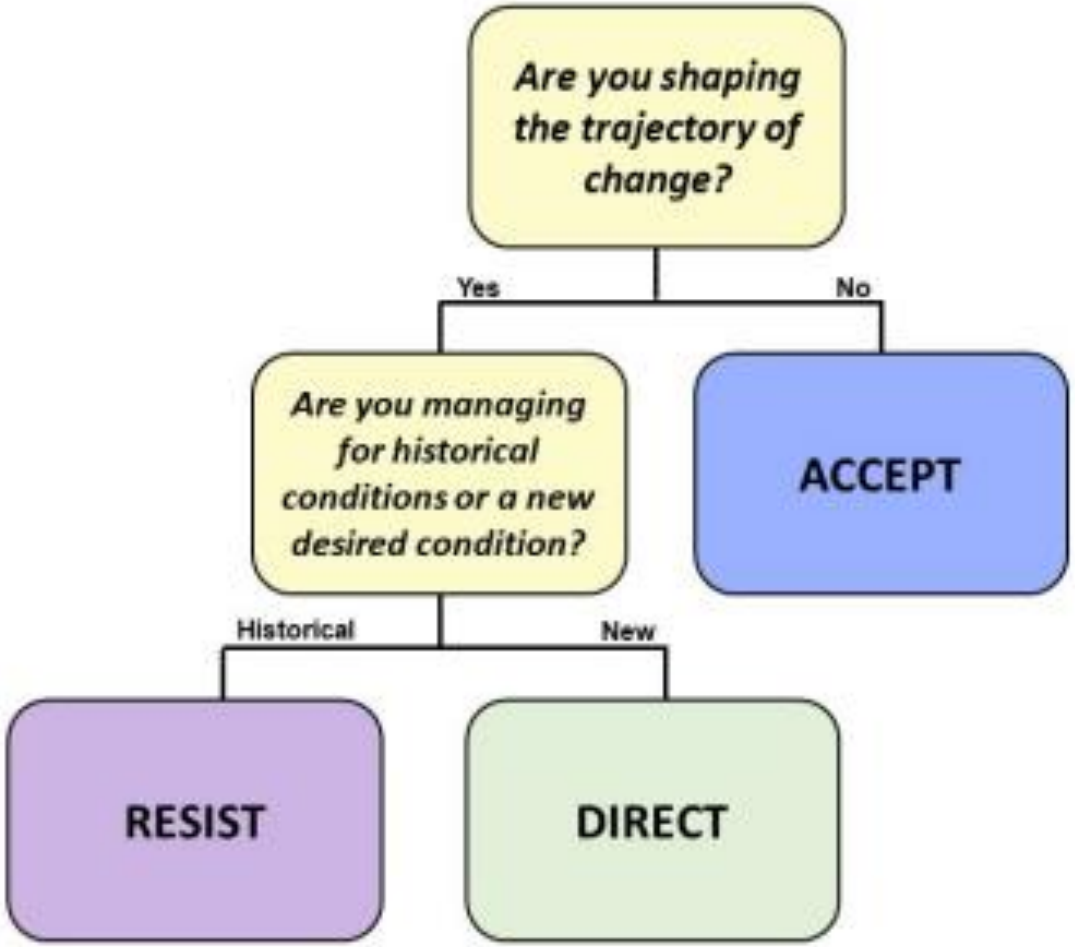
Acadia National Park as a case study



https://www.nps.gov/acad/planyourvisit/maps.htm

Jenny Smetzer, USFWS

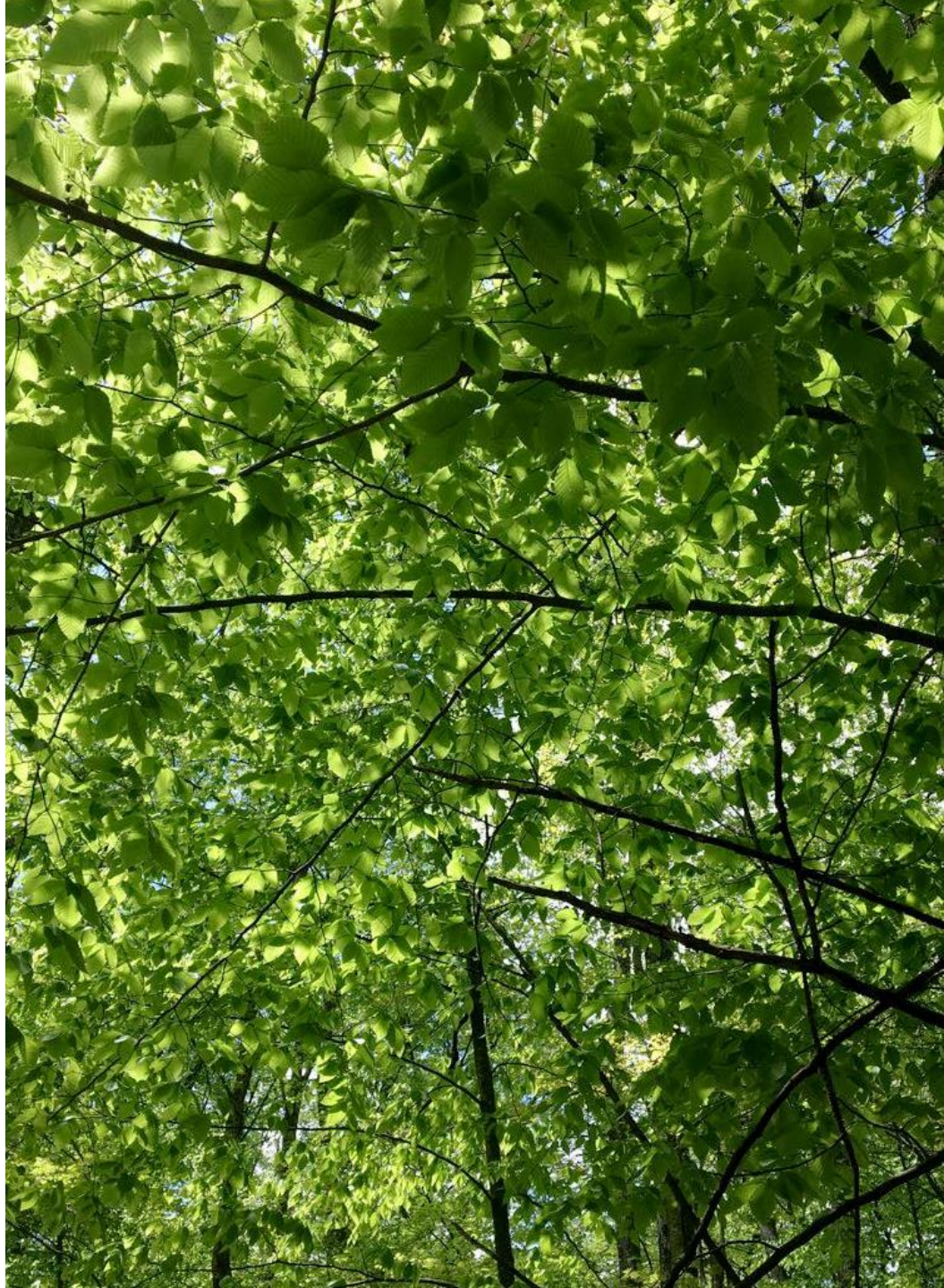
Photo by Abe Miller-Rushing, Acadia NPS



https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/fee.2377

Summary

- The percentage of climate change refugia in each park unit ranges between RCP scenarios.
- Larger park units tended to have more refugia
- Species will experience climate change differently than other species
- Translational ecology could be a vital tool in conservation



Model Limitations

- Doesn’t include biotic interactions
- Doesn’t include land-use, human disturbance, forest succession
- Indirect impacts of climate change
- Occurrence data – survey bias

“Pixel Peeking…”

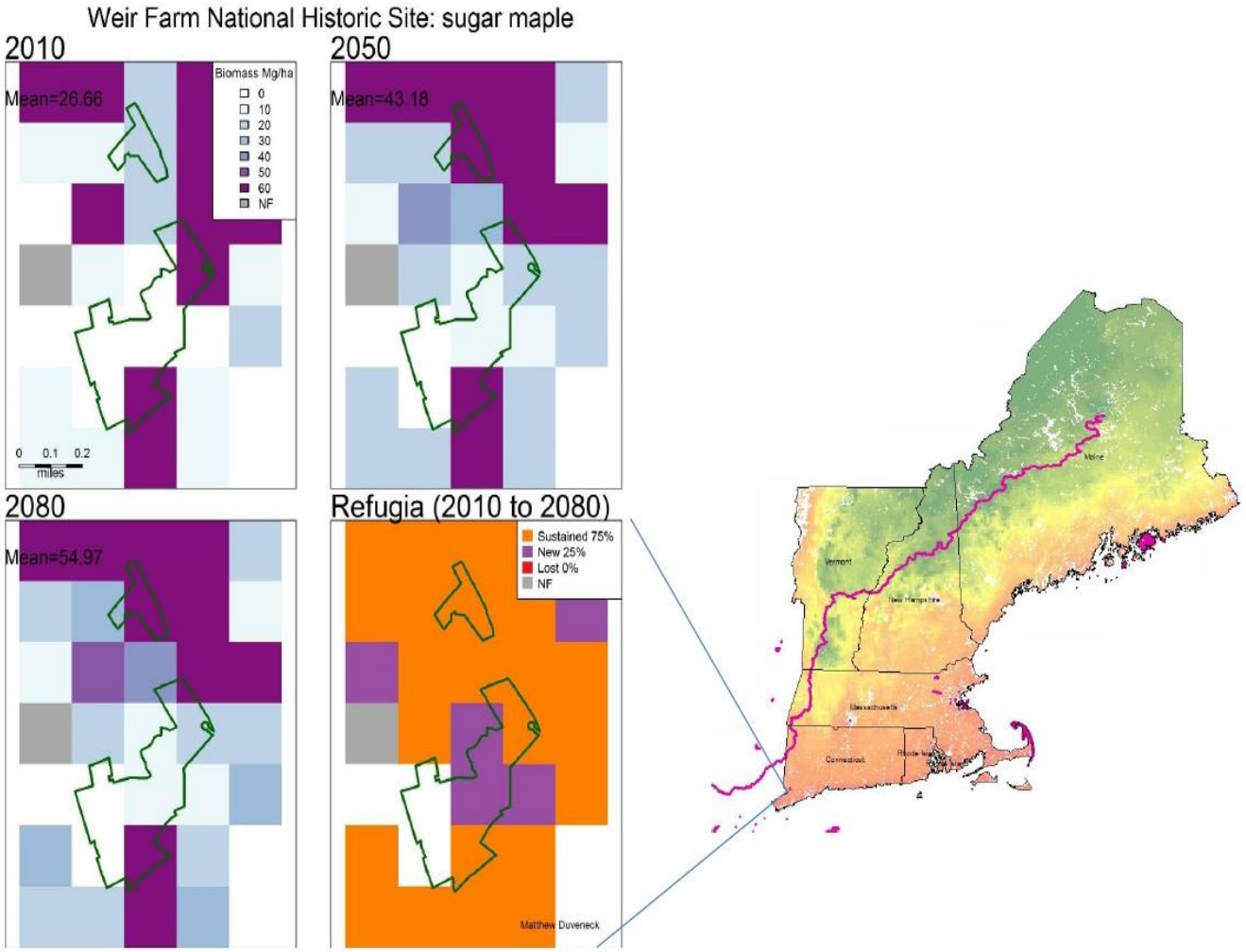
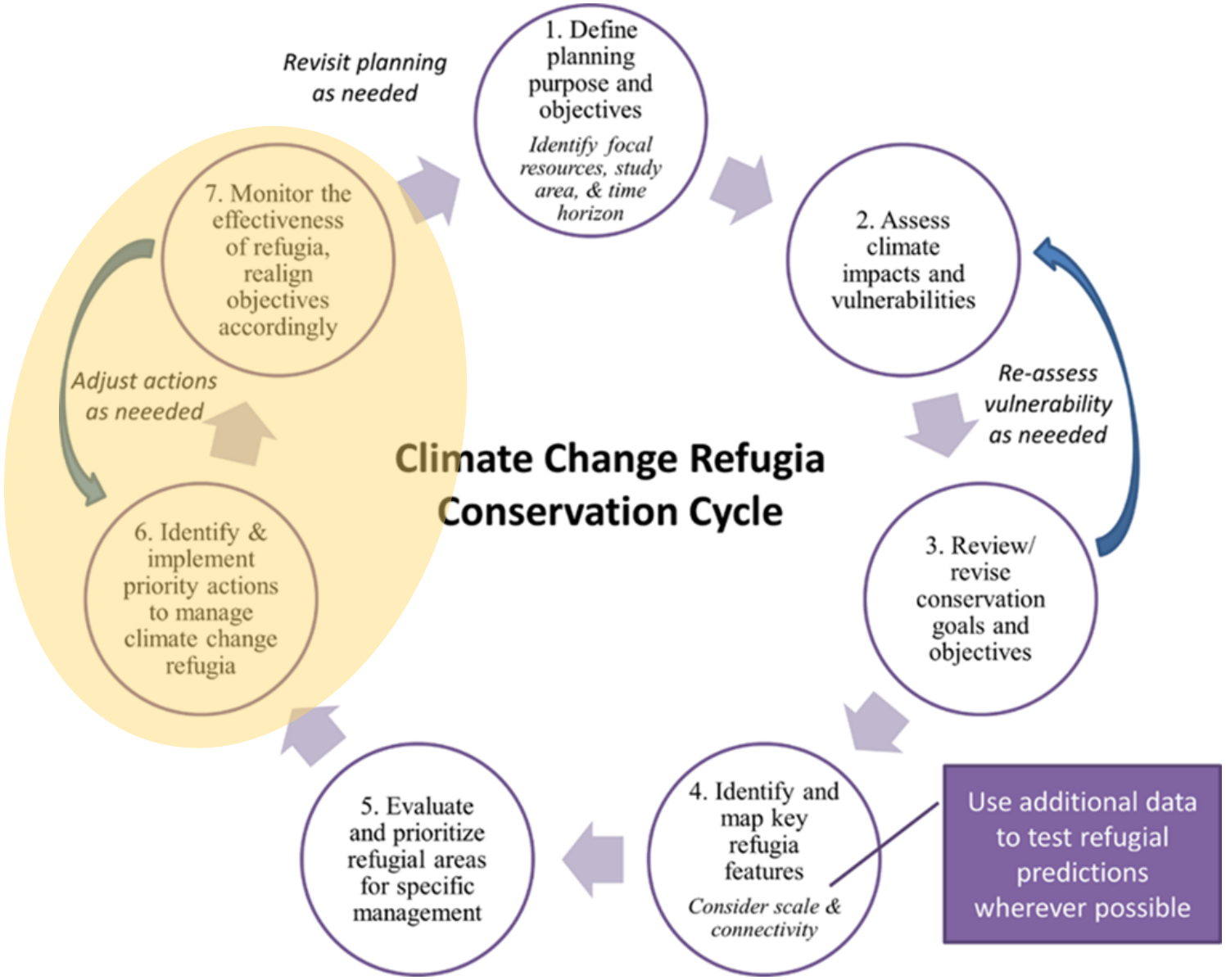


Figure from Matthew Duveneck

Next Steps



Climate change refugia conservation cycle (Morelli et al. 2016).

Conclusion

- Advance climate change adaptation
- Set framework which can be replicated and provide potential future research opportunities.
- Improve mapping, data collection, data analysis, formulating management plans and resource management.
- Set priority for guiding management to protect and preserve climate change vulnerable species.

Illustration: Sara Wisner

Thank you!