

Data and Tools for Refining At-Risk Species Distributions



NatureServe.

Healy Hamilton, Ph.D.

Chief Scientist

NatureServe

Where are our target species found? Where is their suitable habitat found?

- Inventory and Monitoring
- Guiding Avoidance and Mitigation Strategies
- Supporting Species Recovery Efforts
- Habitat Conservation Planning
- Informing Listing Decisions
- Focusing Conservation Initiatives
- Finding New Populations
- Climate Change Adaptation
- Ecosystem Management



Texas DOT Projects

planned within the next 4 years

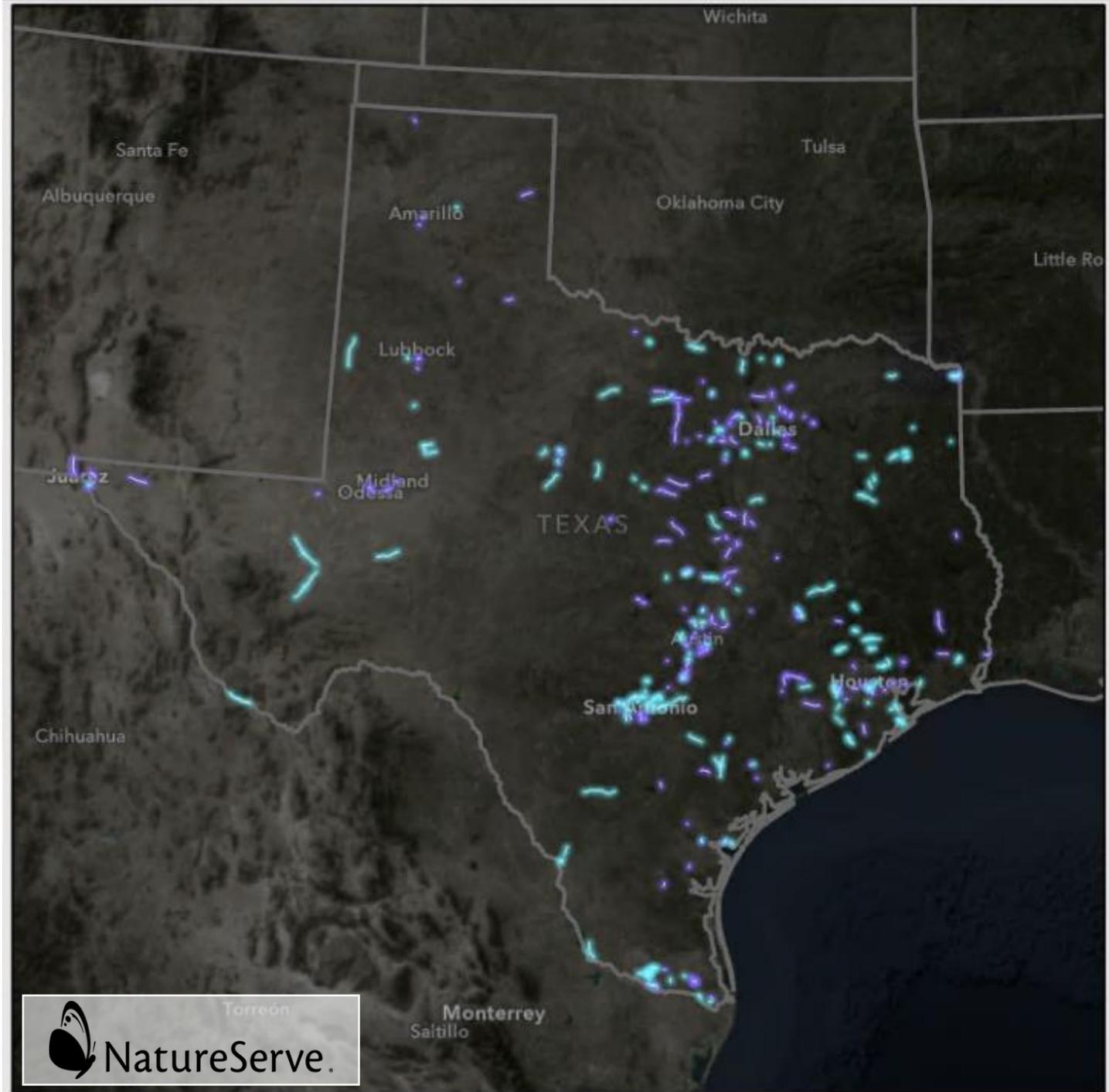


Construction Project



Widening Project

Source: TX DOT Open Data Portal



Texas DOT Projects

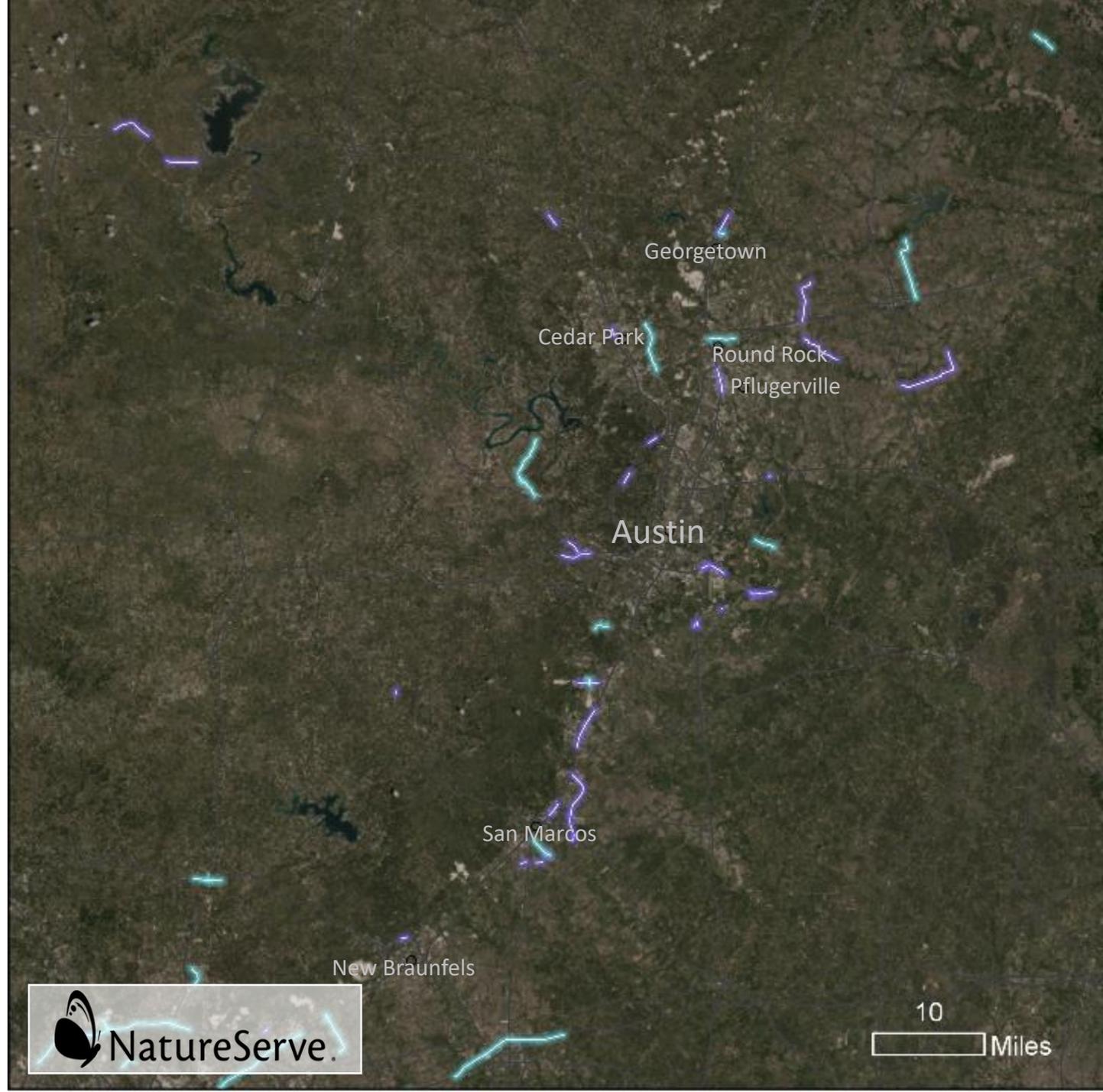
planned within the next 4 years



Construction Project



Widening Project



Source: TX DOT Open Data Portal

Jollyville Plateau Salamander

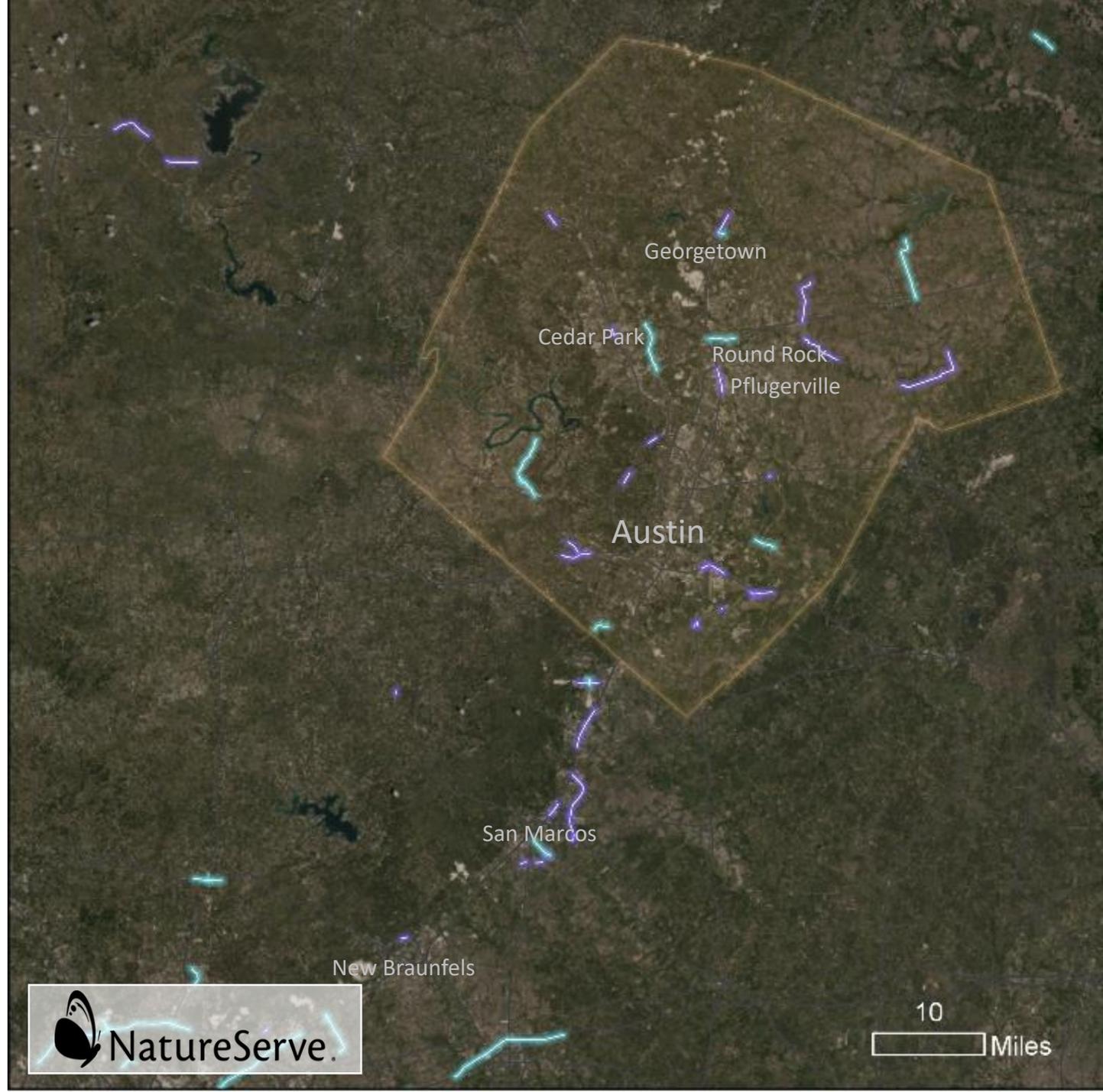
Eurycea tonkawae

G1-Critically Imperiled, Listed Threatened



 Construction Project
 Widening Project

 USFWS ECOS Range



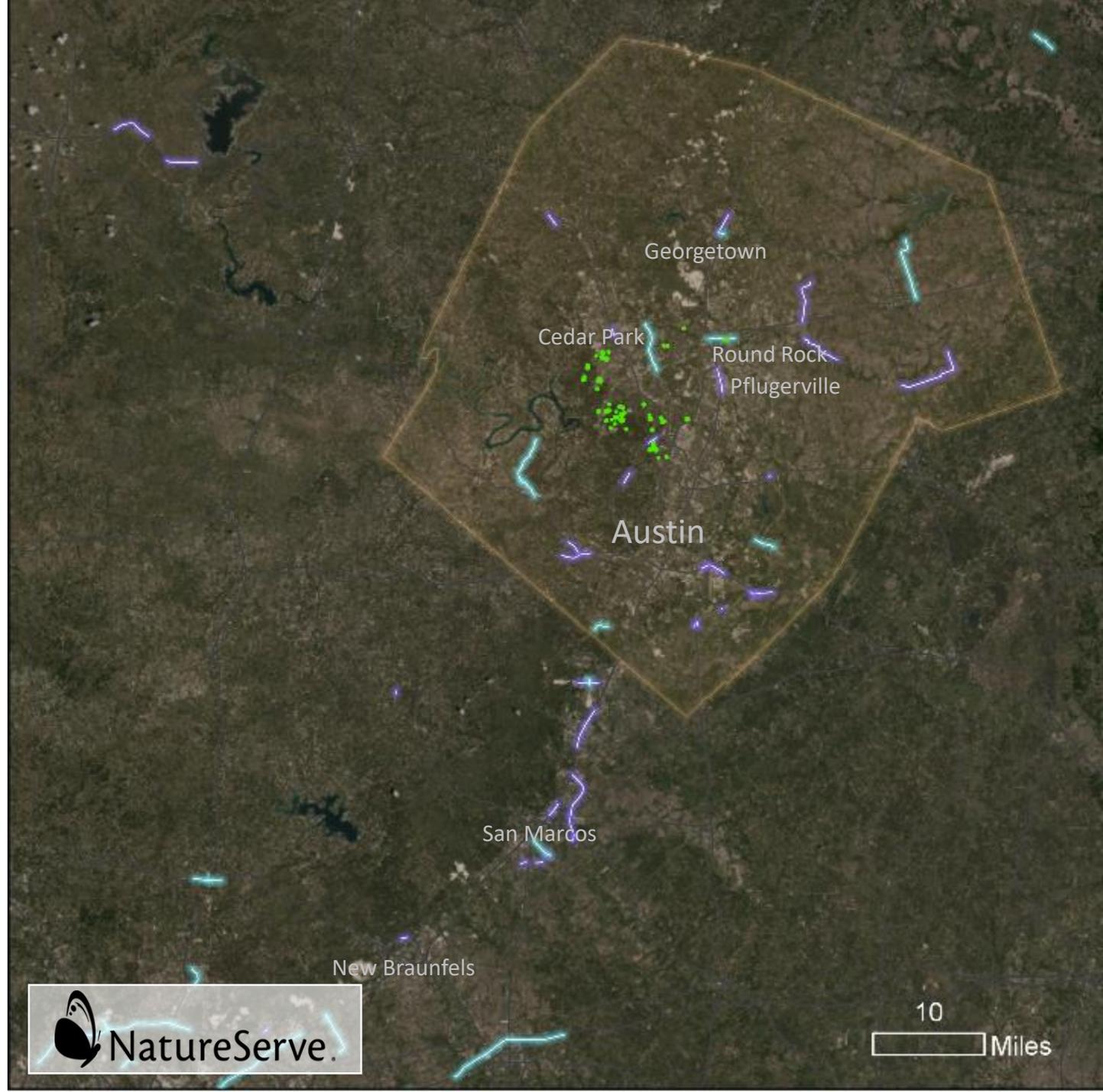
Jollyville Plateau Salamander

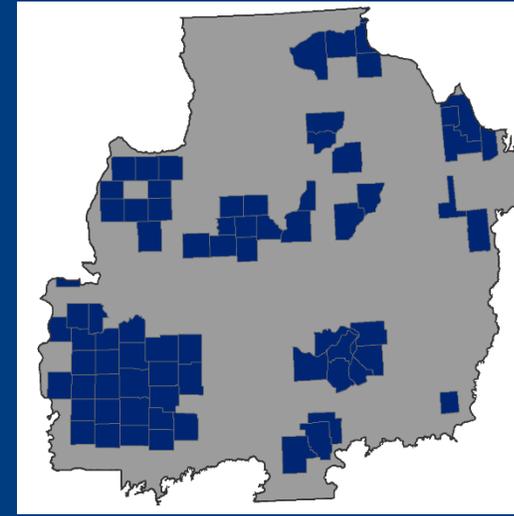
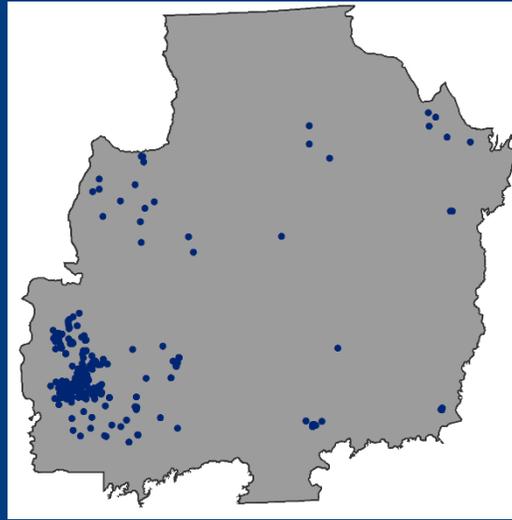
Eurycea tonkawae

G1-Critically Imperiled, Listed Threatened



-  Construction Project
-  Widening Project
-  Documented Occurrence
-  USFWS ECOS Range





**When observations are used
as a distribution map :**

- Under represents occupied area
- Over represents unoccupied area
- Accuracy depends on intensity & distribution of sampling effort
- Can be difficult to validate or test

**When a range map is used
as a distribution map :**

- Over represents occupied area
- Under represents unoccupied area
- Can be difficult to replicate; often subjective
- Can be difficult to validate or test

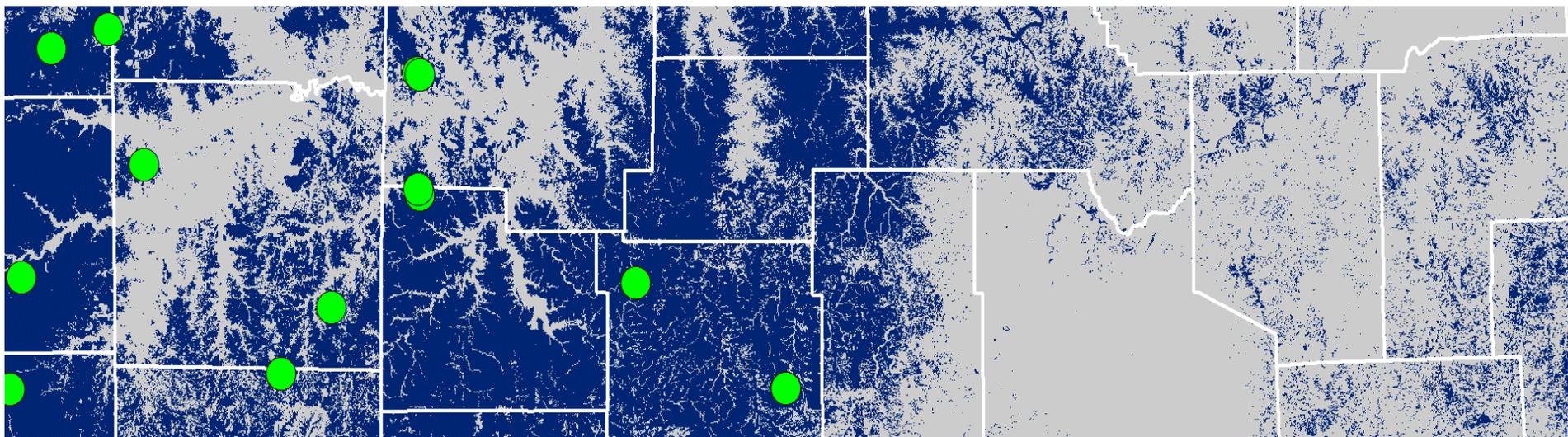
The species distribution modeling alternative:

Build a model of the environmental conditions at points of known occurrence...

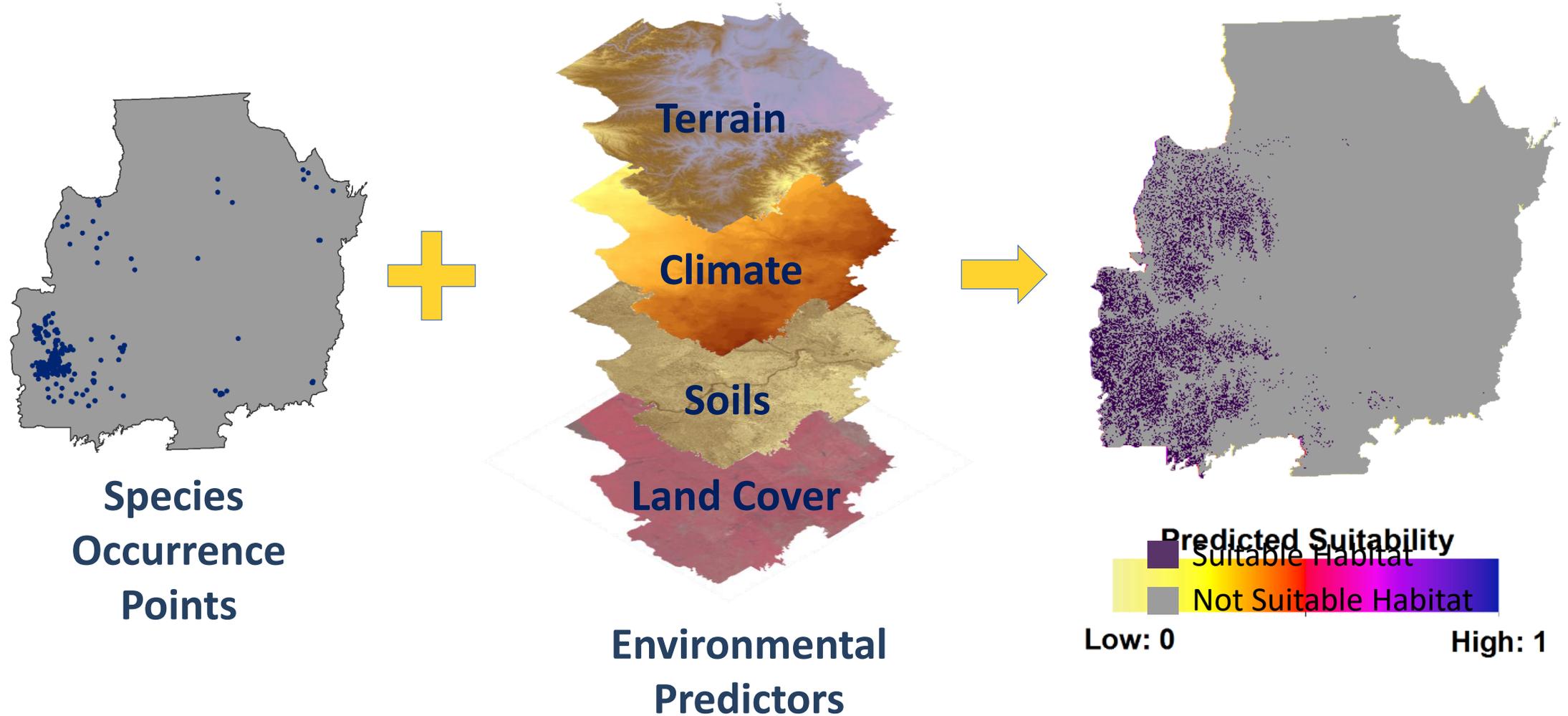
MODELING

... then identify and map all areas where those conditions occur

MAPPING



Building a Model



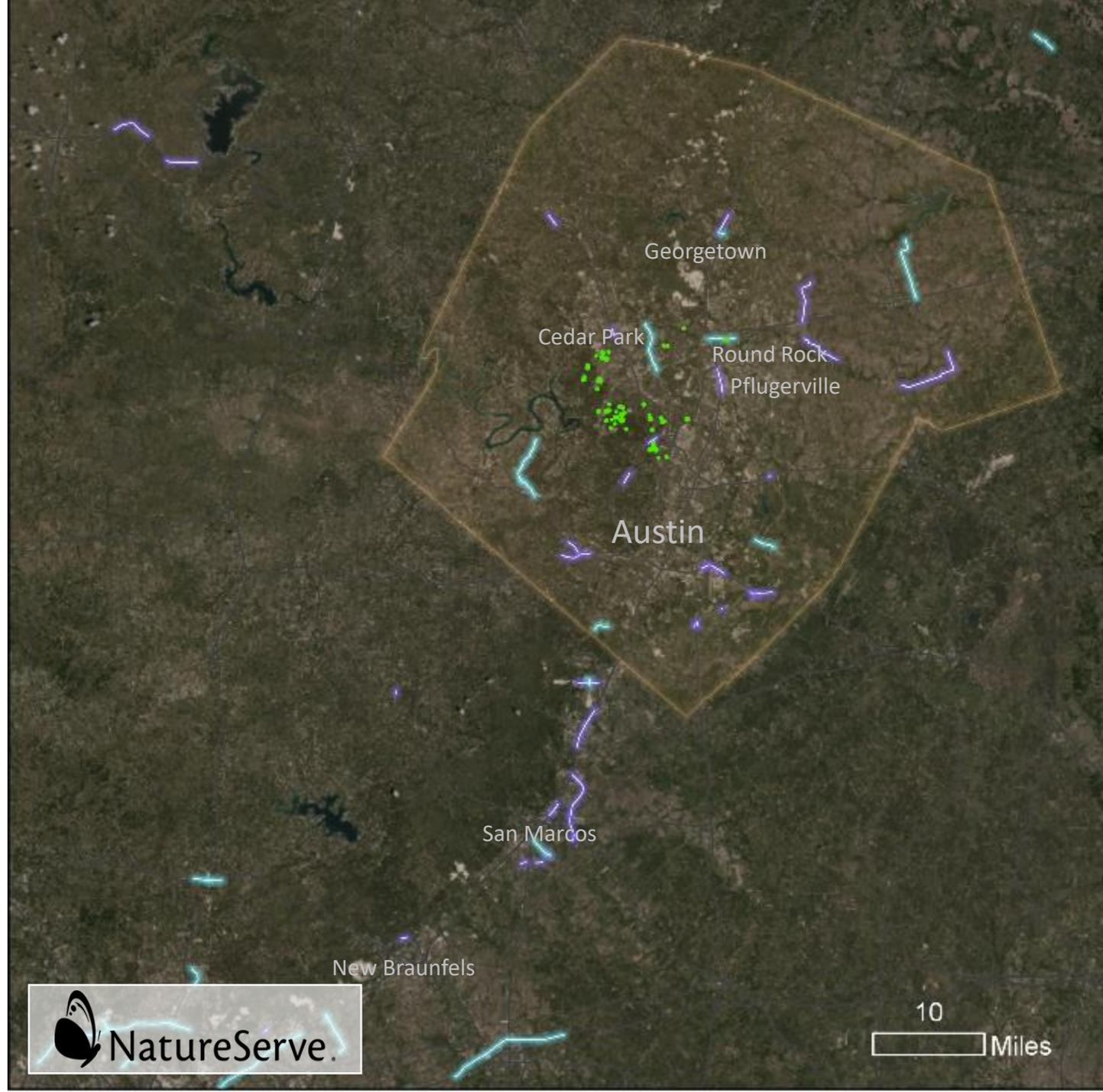
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Jollyville Plateau Salamander

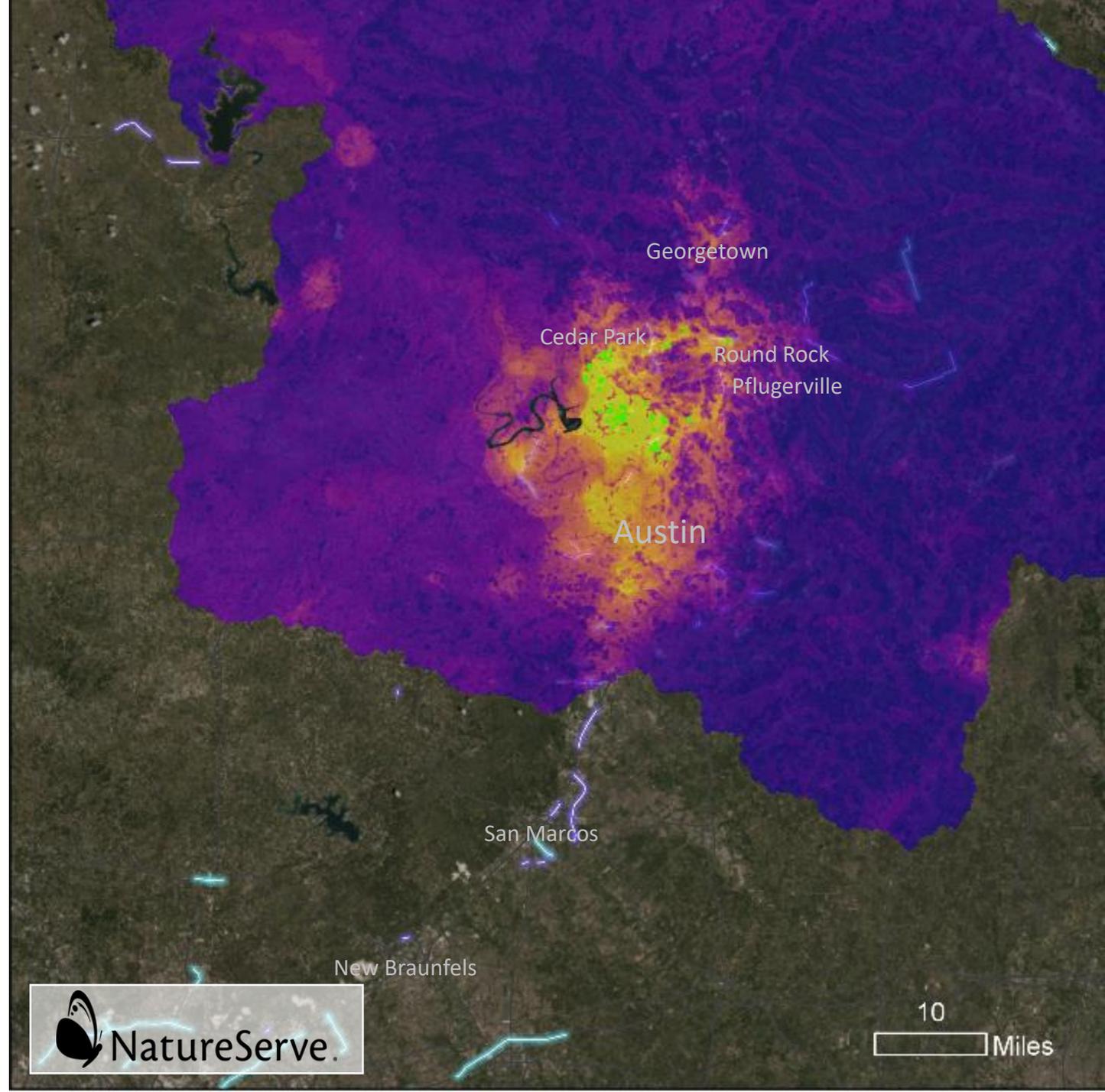
Eurycea tonkawae

G1-Critically Imperiled, Listed Threatened



-  Construction Project
-  Widening Project

Predicted Suitability



Jollyville Plateau Salamander

Eurycea tonkawae

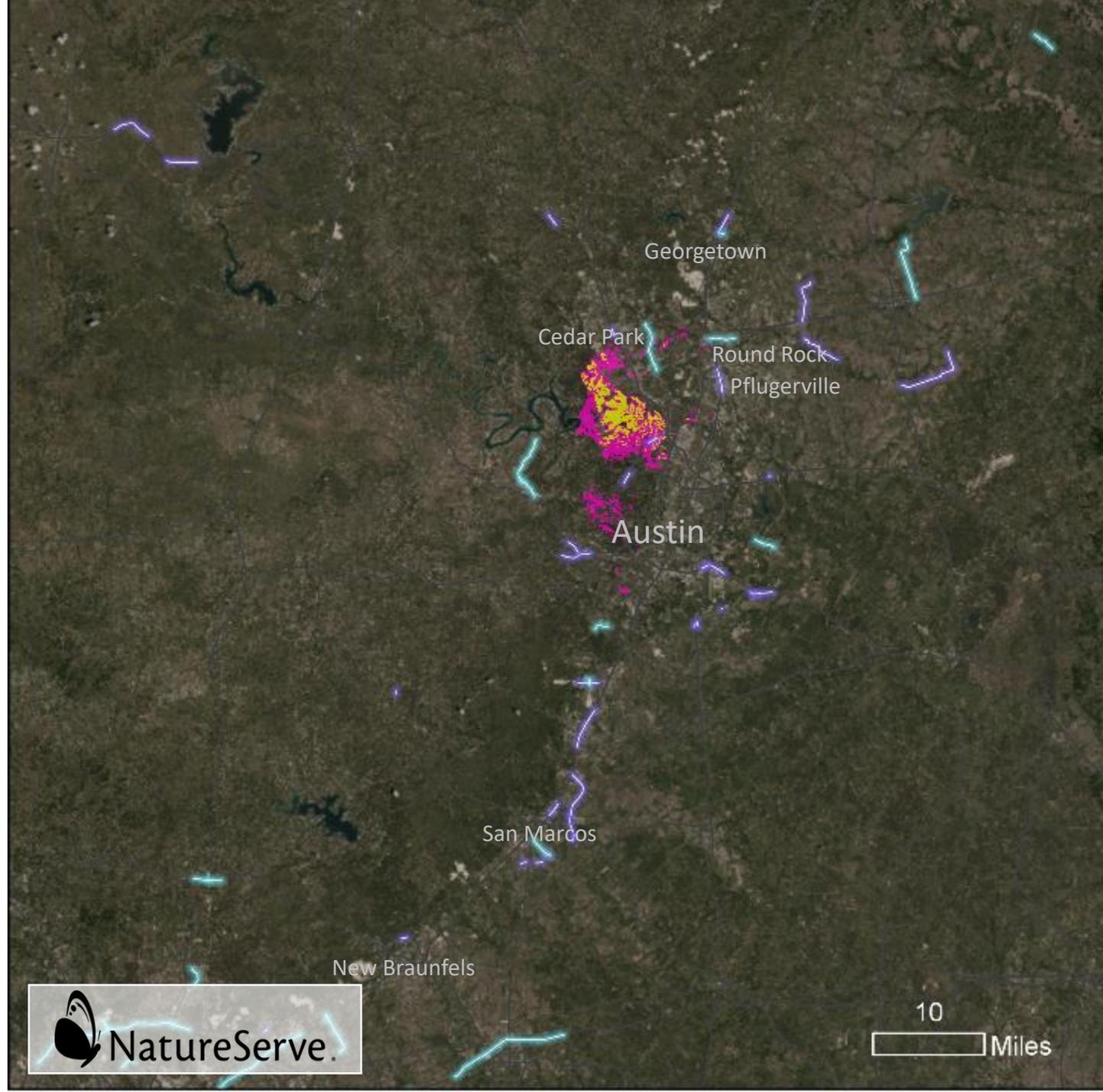
G1-Critically Imperiled, Listed Threatened



-  Construction Project
-  Widening Project

Predicted Habitat

-  High Suitability
-  Medium Suitability



Jollyville Plateau Salamander

Eurycea tonkawae

G1-Critically Imperiled, Listed Threatened



- Construction Project
- Widening Project

Predicted Habitat

- High Suitability
- Medium Suitability
- USFWS ECOS Range



Jollyville Plateau Salamander

Eurycea tonkawae

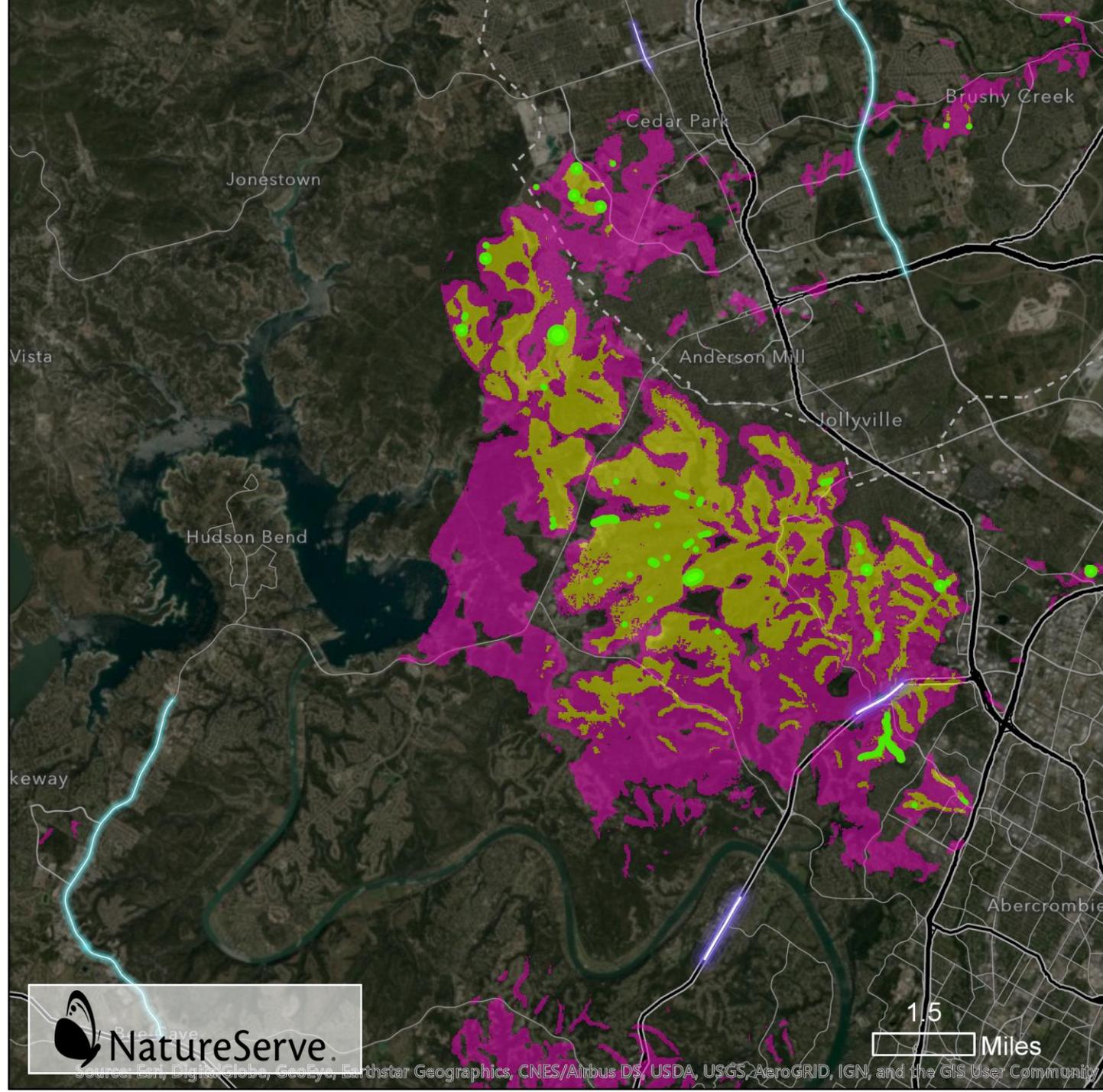
G1-Critically Imperiled, Listed Threatened



-  Construction Project
-  Widening Project

Predicted Habitat

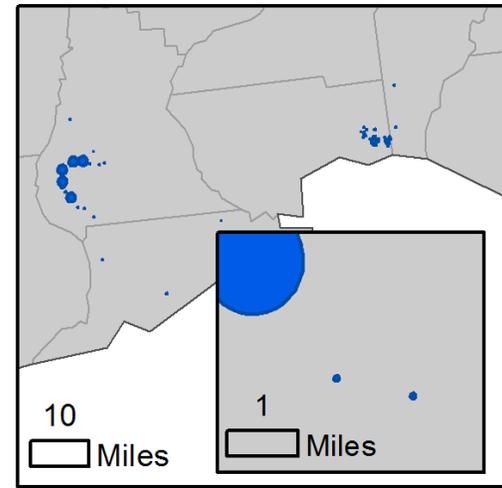
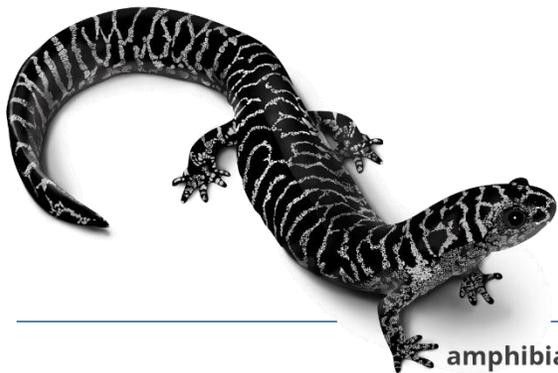
-  High Suitability
-  Medium Suitability
-  USFWS ECOS Range



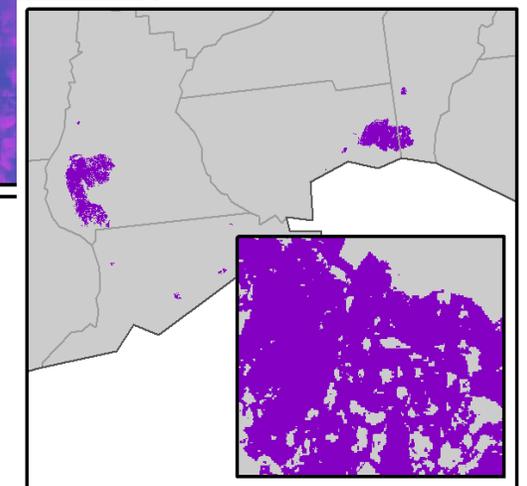
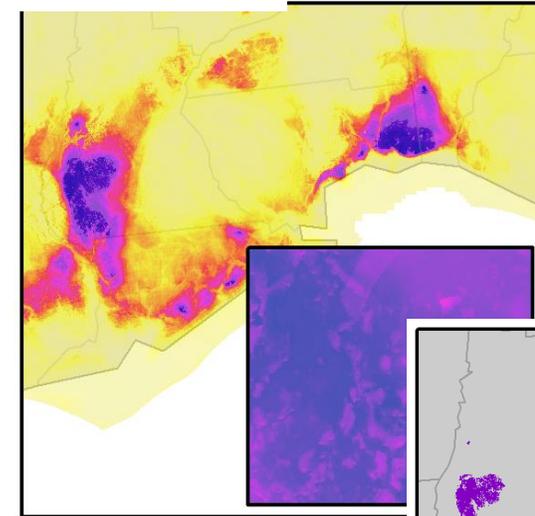
The NatureServe Network SDM Initiative:

The NatureServe Network is a leading source of information on where at-risk species have been observed *and* where they are likely to be found.

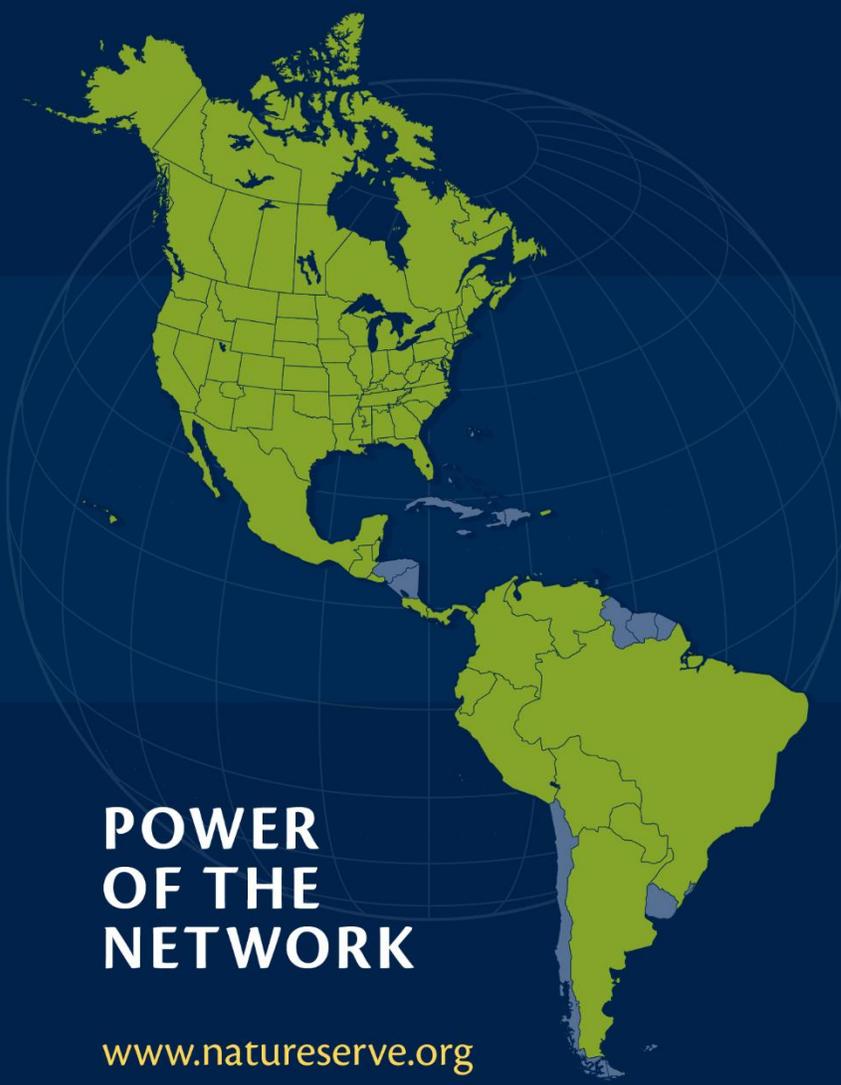
We advocate for the collaborative development of a **dynamic national library of decision-quality species distribution models**



Known Occurrence (EO)



Predicted Habitat



**POWER
OF THE
NETWORK**

www.natureserve.org

90+

NETWORK PROGRAMS
IN THE UNITED STATES,
CANADA, AND
LATIN AMERICA

OVER
1,000

CONSERVATION PROFESSIONALS

The network collects, analyzes, and distributes detailed scientific data about plants, animals, and ecosystems in their jurisdictions

90,000+

Species Assessed



7,000+

Ecosystem Types Classified



The NatureServe Network: Providing Key Information on Biodiversity



What Exists?



Where Are They Found?



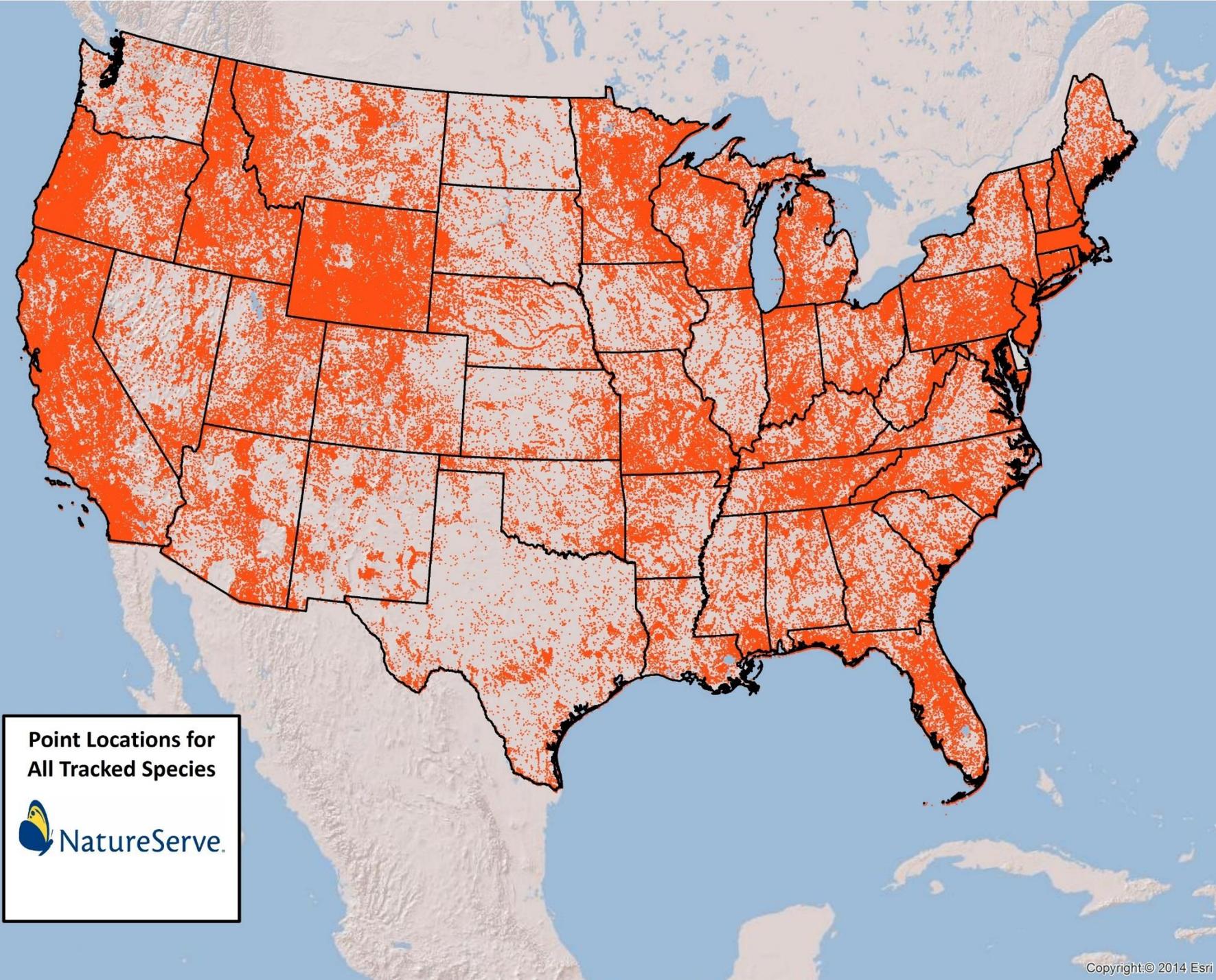
How Are They Doing?



What Actions Will Help?

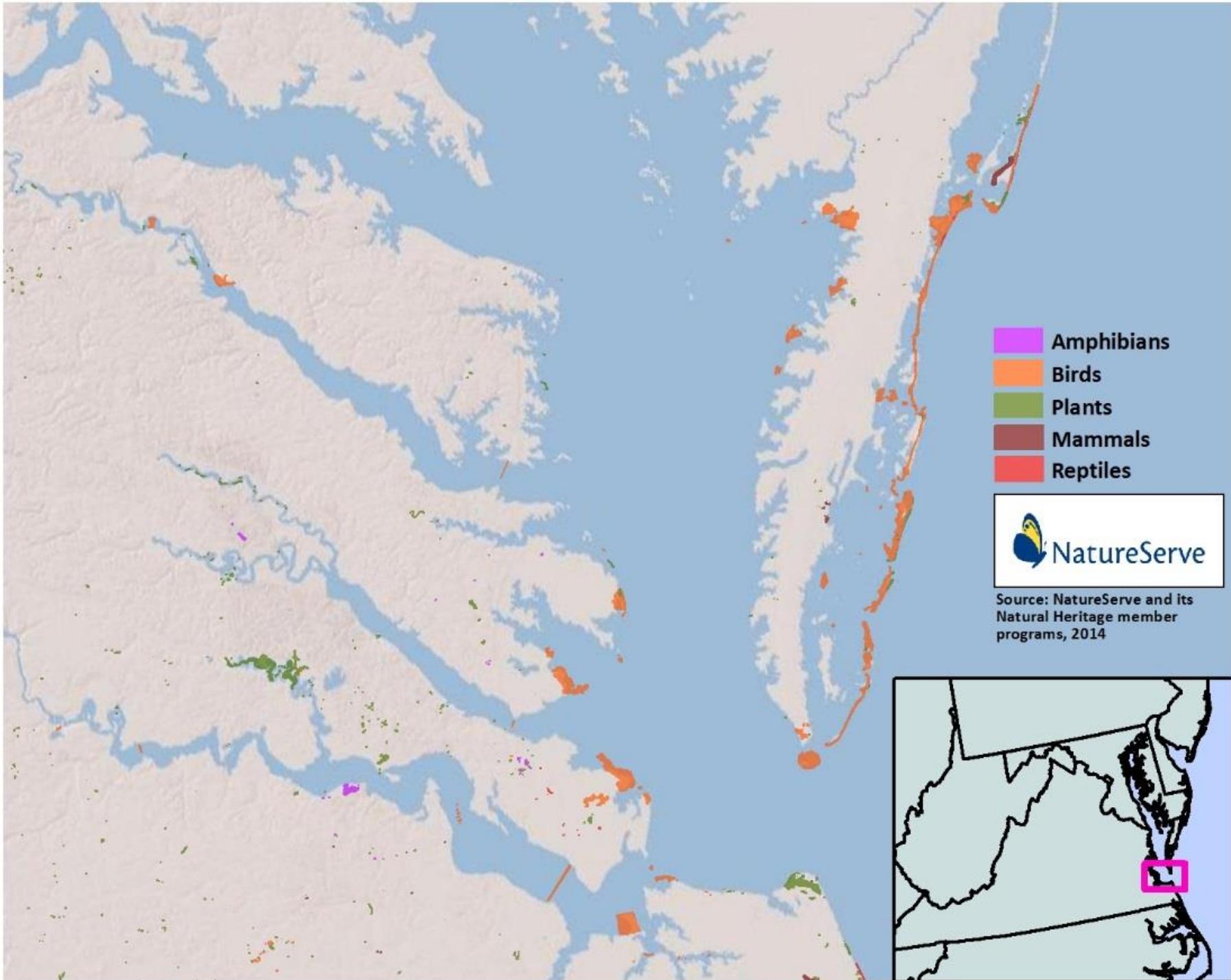


Are The Actions Working?



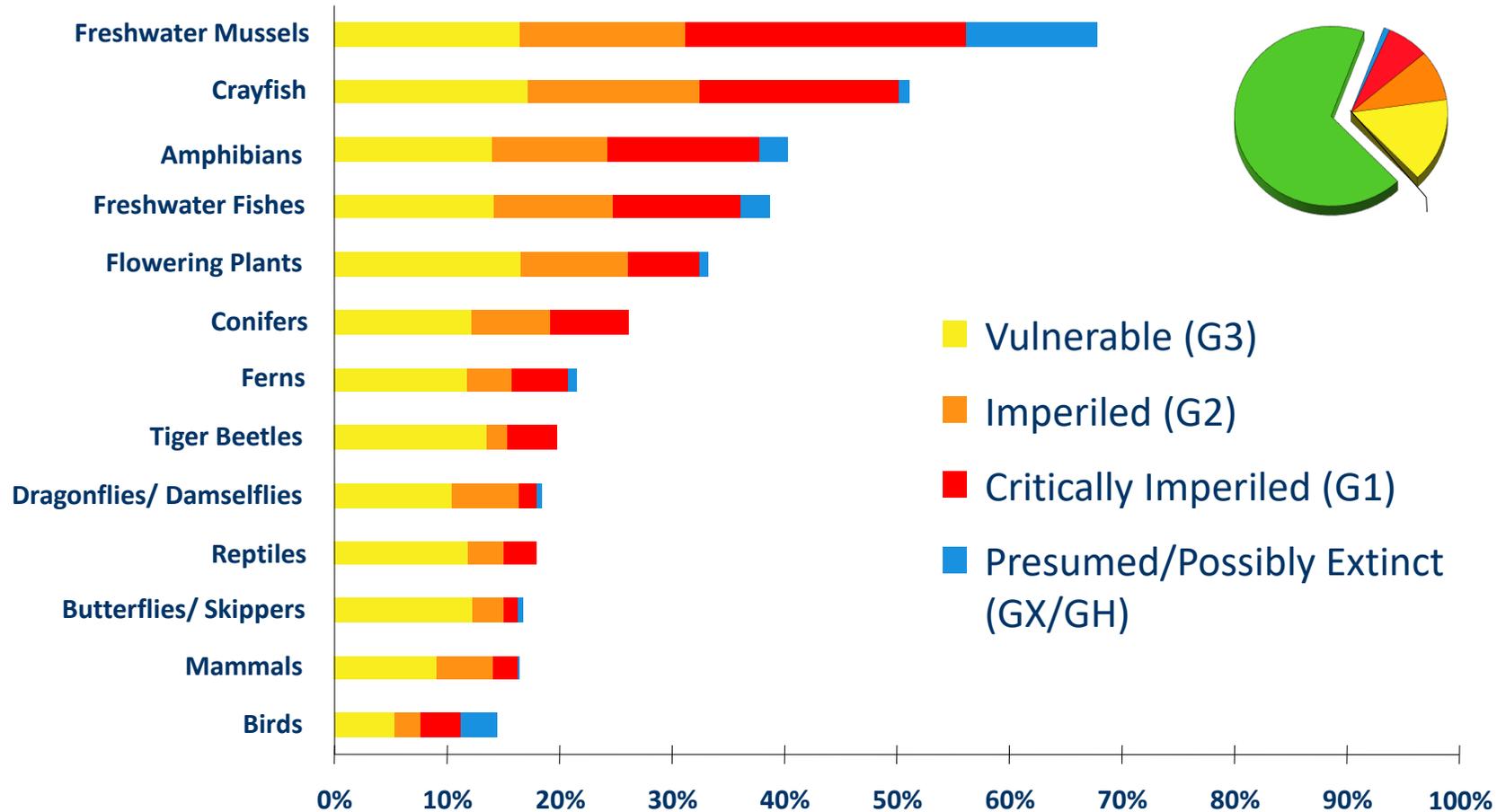
**Point Locations for
All Tracked Species**





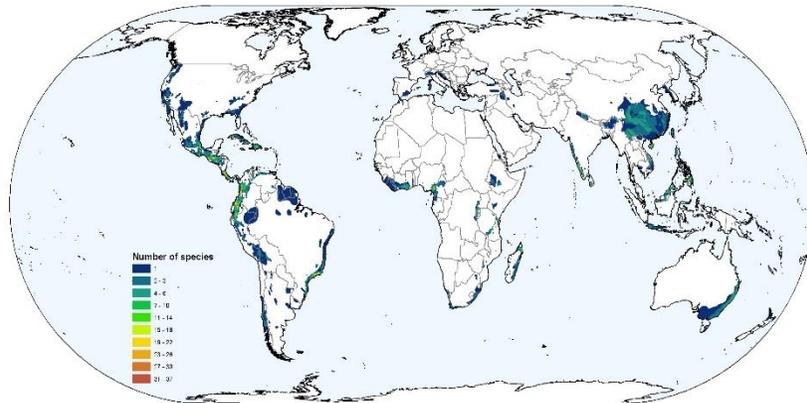
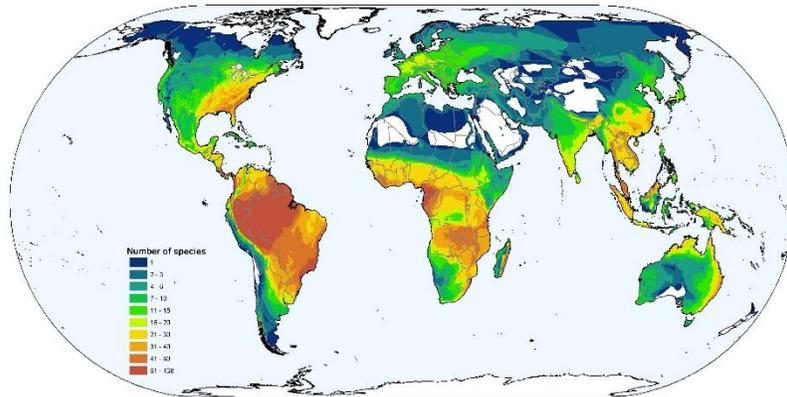
Assessing Conservation Status

Proportion of U.S. Species at Risk

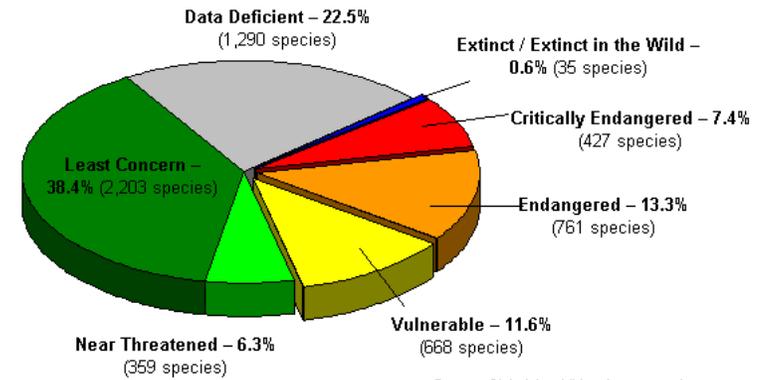


Partnering with IUCN to document global patterns

Global Amphibian Assessment



Summary of Red List Assessment for Amphibians

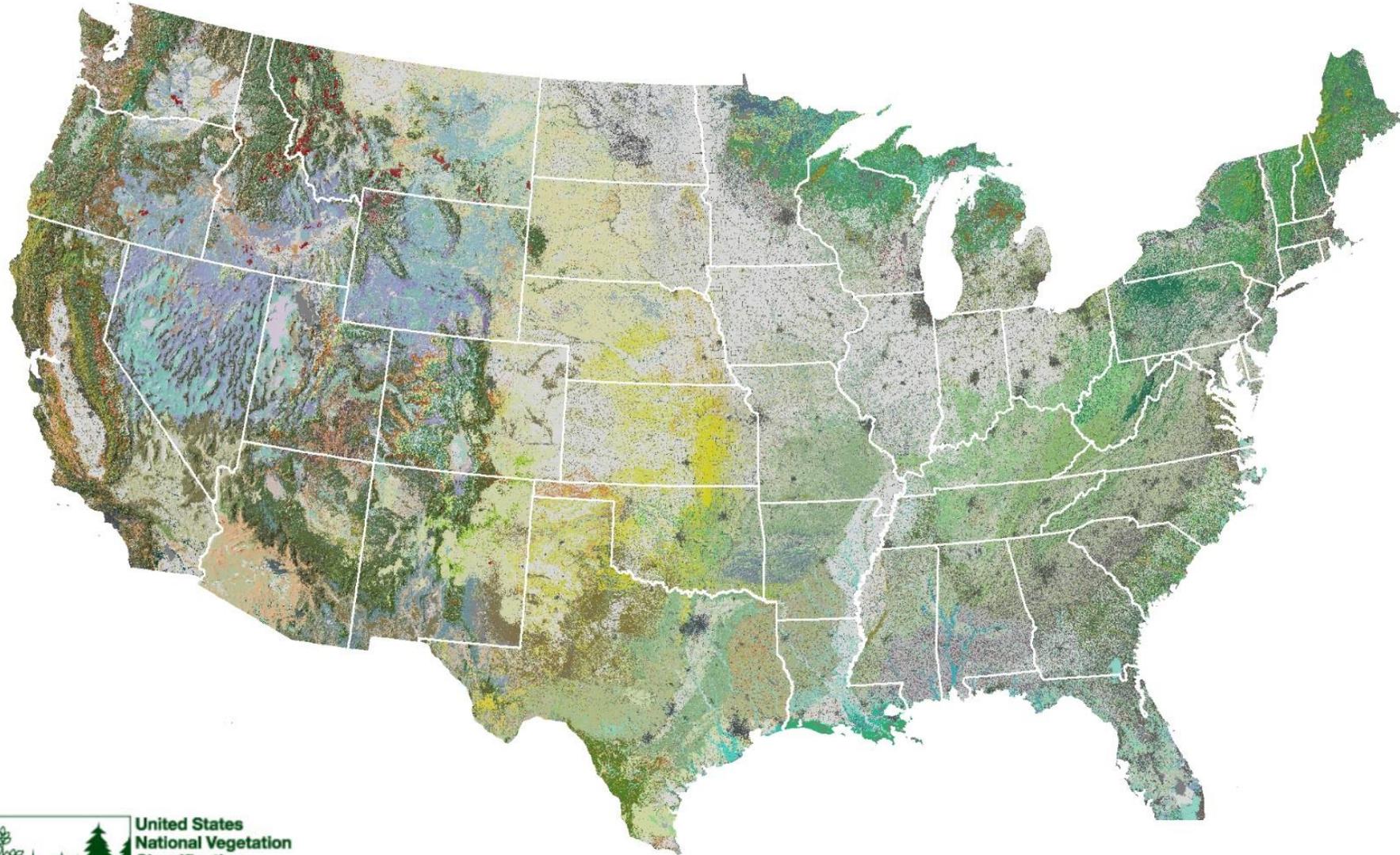


Source: Global Amphibian Assessment



Red-eyed leaf frog, Central America
Photo by Piotr Naskrecki

Terrestrial Ecosystem Types -- Current Extent and Land Use



500 Miles





Conservation and Management of NORTH AMERICAN MASON BEES



Bruce E. Young
Dale F. Schweitzer
Nicole A. Sears
Margaret F. Ormes

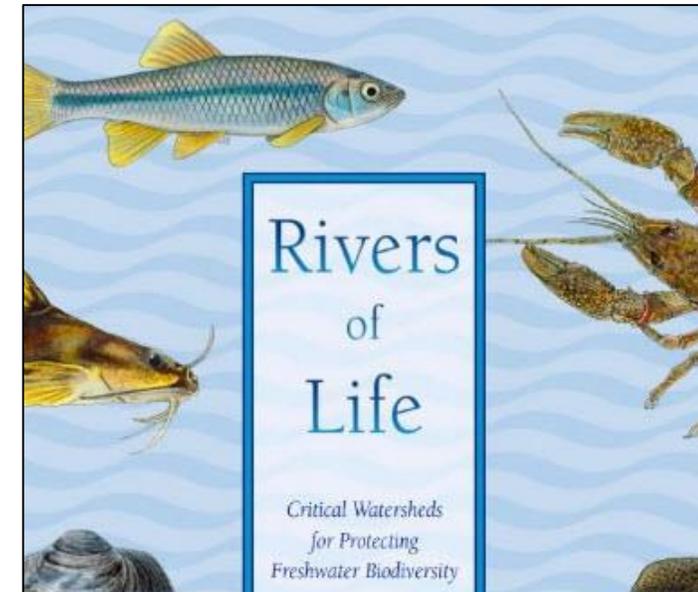
Hidden in Plain Sight

The Role of Plants in
State Wildlife Action Plans



Conservation Status and Ecology of the Monarch Butterfly in the United States

Sarina Jepsen, Dale F. Schweitzer, Bruce Young, Nicole Sears,
Margaret Ormes, and Scott Hoffman Black



Guidelines for Using the NatureServe Climate Change Vulnerability Index



Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind



Original articles

Modeling landscape condition for biodiversity assessment—Application in temperate North America

John C. Hak*, Patrick J. Comer

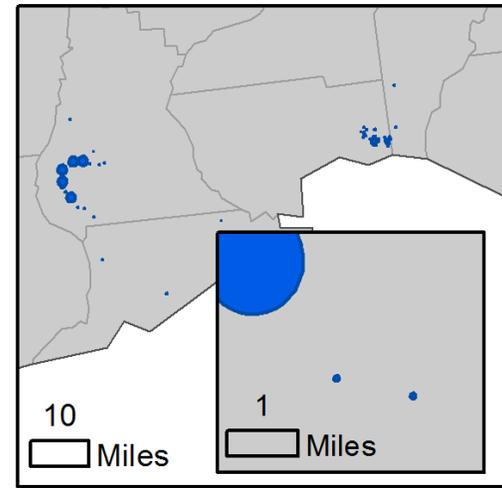
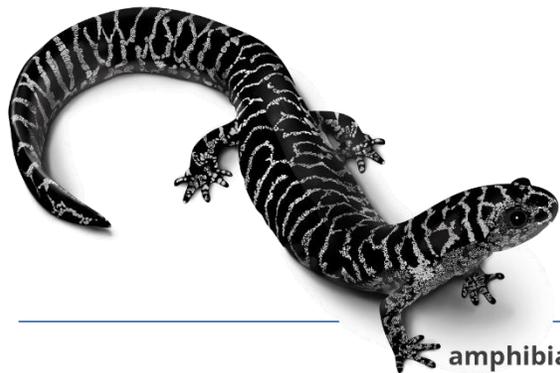
NatureServe, 2208 55th Street, Suite 220, Boulder, CO, USA



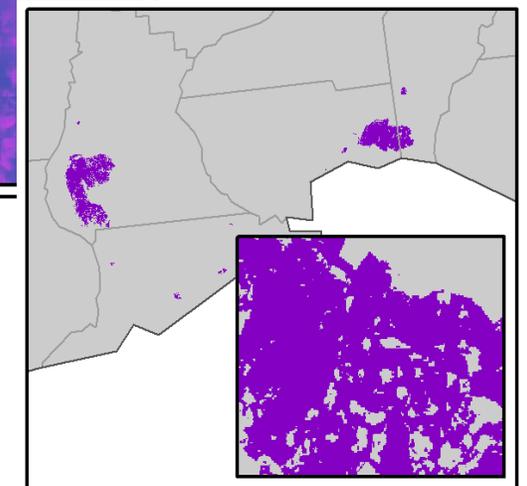
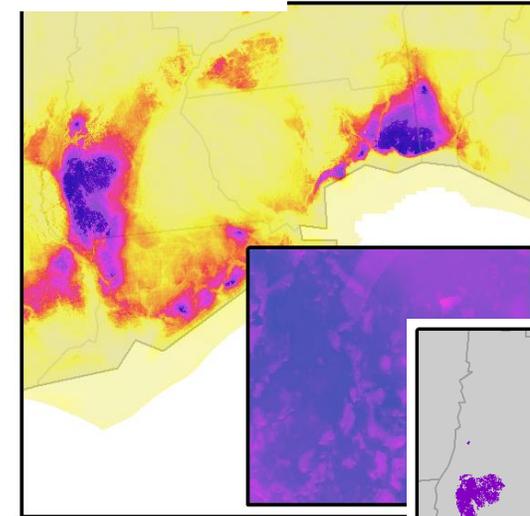
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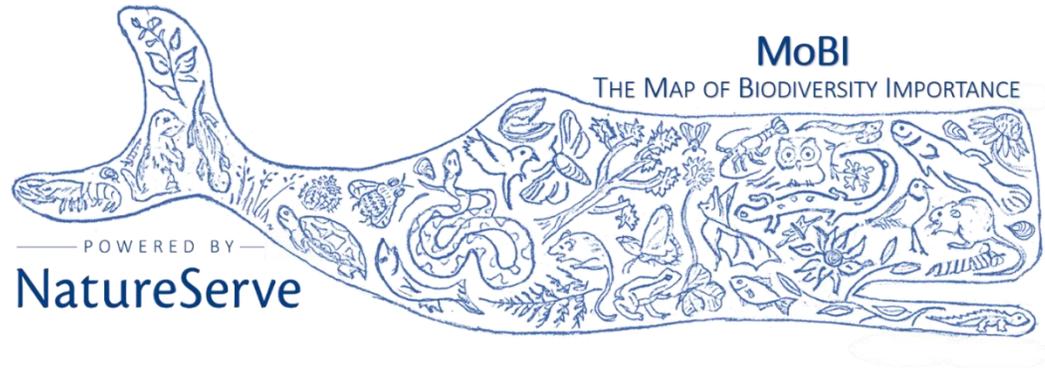


Known Occurrence (EO)



Predicted Habitat

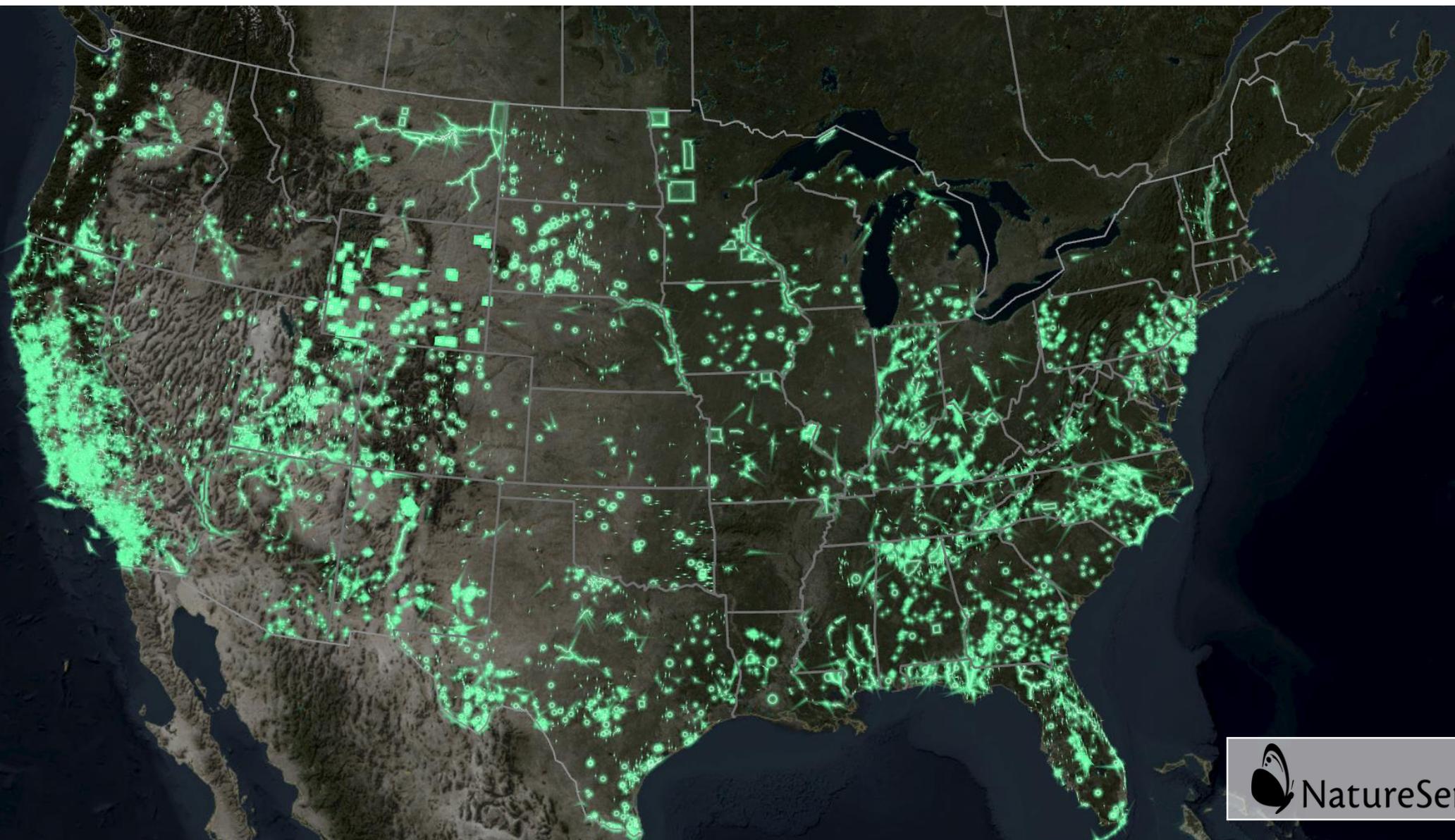
The Map of Biodiversity Importance



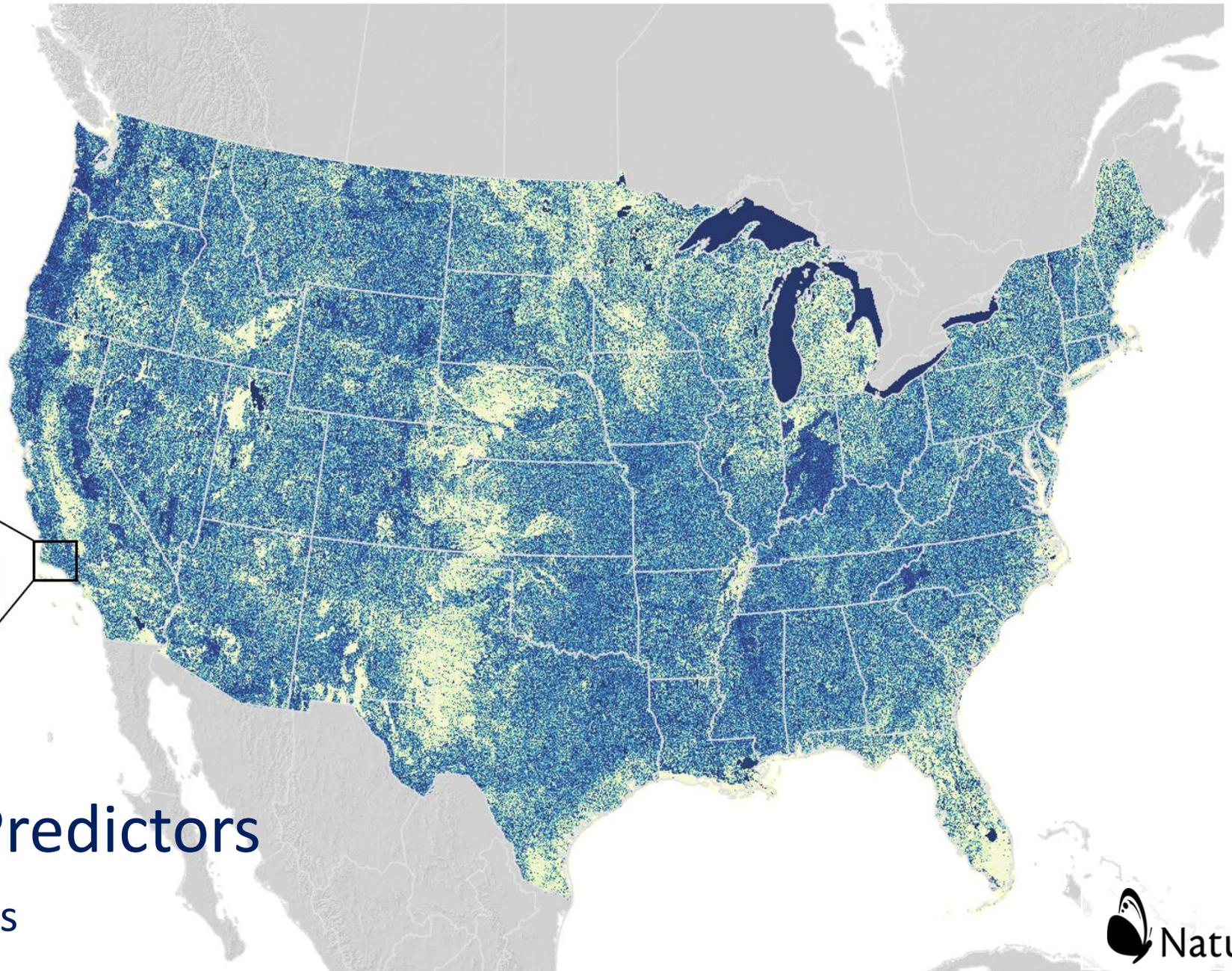
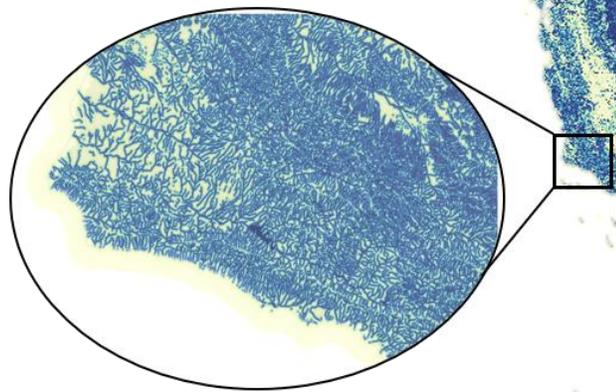
>2000 G1, G2, and ESA Listed Species

- 144 Tetrapods
- 168 Freshwater and Anadromous Fishes
- 43 Pollinating Insects
- 236 Aquatic Invertebrates
- 1654 Vascular Plants





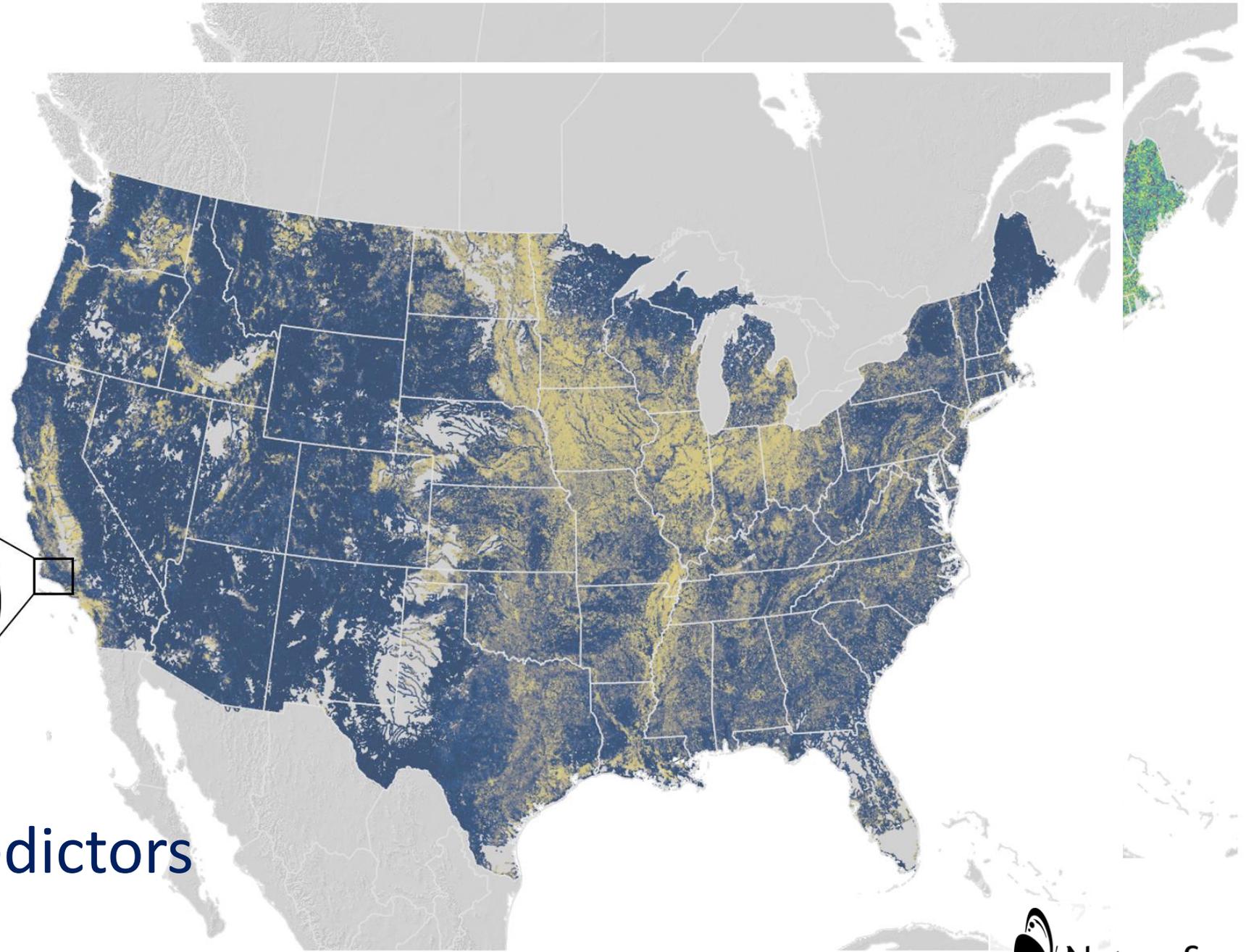
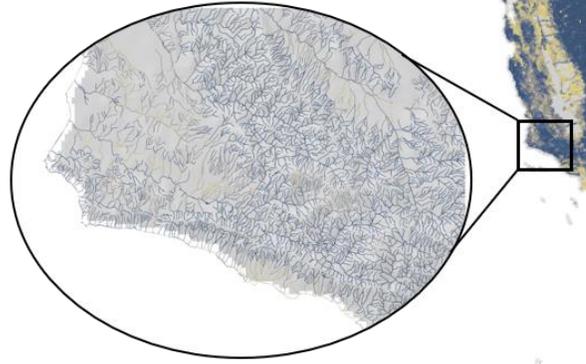
Species Training Data from State Heritage Programs



Environmental Predictors

100+ Terrestrial Variables

Hydrologic Connectivity
Low High



Environmental Predictors

170+ Aquatic Variables

Species Reviewer



Amphibians



Plethodon chattahoochee



Search/Add Data

- Predicted Habitat
- Modeling Extent
- Add to Modeling Extent
- Remove from Modeling Extent
- Comment on Predicted Habitat

Overall Feedback from all users

Mobi.Nathan.Shepard



This model seems mostly consistent with the known EO records in North Carolina. Inferences in states outside of North Carolina cannot be made by NC NHP. Some slight over predicting might occur with this model, especially in areas north of Murphy, North Carolina. This reviewer

Model Review

Standards for Species Distribution Modeling

ScienceAdvances

REVIEW | ECOLOGY

Standards for distribution models in biodiversity assessments

Miguel B. Araújo^{1,2,3,*}, Robert P. Anderson^{4,5,6}, A. Márcia Barbosa³, Colin M. Beale⁷, Carsten F. Dormann⁸, Regan Early⁹, Raquel A. Garcia^{2,3,10,11}, Antoine Guisan^{12,13}, Luigi Maiorano^{14,15}, Babak Naimi², Robert B. O'Hara^{16,17}, Niklaus E. Zimmermann^{18,19} and Carsten Rahbek^{2,20}

Forum

OXFORD
ACADEMIC

BioScience

Development and Delivery of Species Distribution Models to Inform Decision-Making

HELEN R. SOFAER¹, CATHERINE S. JARNEVICH, IAN S. PEARSE, REGAN L. SMYTH, STEPHANIE AUER, GERICKE L. COOK, THOMAS C. EDWARDS JR., GERALD F. GUALA, TIMOTHY G. HOWARD, JEFFREY T. MORISETTE, AND HEALY HAMILTON

Standards for Species Distribution Modeling

Table 1a. Effects of the quantity and quality of species data on model credibility.

	Interpret with caution	Acceptable	Ideal	References
Presence data	Poor or unassessed quality of data (precision, taxonomy).	Spatial error in coordinates < spatial grain of model. Correction of taxonomic inconsistencies.	Verified and spatially precise records or weighting of occurrences to place greater emphasis on locations with	Graham et al. 2008, Lozier et al. 2009

Table 1b. Attributes of environmental predictors affecting model credibility.

	Interpret with caution	Acceptable	Ideal	References
Absence/ background data				
Ecological and predictive relevance				

Table 1c. Attributes of the modeling process affecting model credibility.

	Interpret with caution	Acceptable	Ideal	References
Algorithm choice	Models prone to overfitting used for extrapolation, goals of prediction versus explanation confounded.	Selection of algorithm aligned with objectives, including need for actual versus potential distribution.	Selection of algorithm aligned with objectives, including need for actual versus potential distribution. Multiple evaluated.	Qiao et al. 2015
Sensitivity	Single algorithm without evaluation of settings. Ensemble of multiple algorithms based on default settings and without assessment of sensitivity.	Assessment of sensitivity to choice of algorithm(s) and selected settings and input data.	Multiple algorithms with evaluation of model settings and input data, model agreement and uncertainties evaluated via ensemble techniques.	Araújo and New 2007
Statistical rigor	Assumptions not recognized or evaluated.	Assumptions recognized and considered.	Assumptions formally evaluated.	Dormann 2007, Dormann et al. 2013
Performance	Based on single metric, and/or evaluation scores are below generally accepted levels.	Multiple metrics evaluated and evaluation scores are close to generally accepted levels, ecological plausibility evaluated.	Multiple metrics evaluated with scores at or above generally accepted levels, scores connected with implications for intended use considered, ecological plausibility is described	Jarnevich et al. 2015

Model Metadata

Plethodon asupak

Species Distribution Model (SDM) assessment metrics and metadata

Common name: [Scott Bar Salamander](#)

Grank: G1G2 - Critically Imperiled

Date: 12 Mar 2019

Code: pletasup (EGT_ID: 777949)



The following metadata describes the SDM for one species of 2,700 included in a Map of Biodiversity Irreplaceability (MoBI) in the continental U.S. developed by NatureServe and the Network of Natural Heritage Programs and funded by ESRI. This SDM incorporates the number of known and background locations indicated in Table 1, modeled with the random forests routine^{1,2} in the R statistical environment^{3,4}. We validated the model by jackknifing (also called leave-one-out^{5,6,7}) by spatial grouping for a total of 38 groups. The statistics in Table 2 report the mean and variance of validation statistics for these jackknifing runs.

Table 1. Input statistics. Presence points are points placed in polygon-based location information or point-based observations. Groups describe groupings of points based on polygon data or spatial grouping of observations. Background points are placed throughout model area excluding known species locations.

Name	Number
Presence points	4776
Groups	38
Background points	9938

Table 2. Validation statistics for jackknife trials. Overall Accuracy = Correct Classification Rate, TSS = True Skill Statistic, AUC = area under the ROC curve^{8,9,6}.

Name	Mean	SD	SEM
Overall Accuracy	0.92	0.10	0.02
Specificity	0.89	0.04	0.01
Sensitivity	0.95	0.21	0.03
TSS	0.84	0.21	0.03
Kappa	0.84	0.21	0.03
AUC	0.95	0.05	0.01

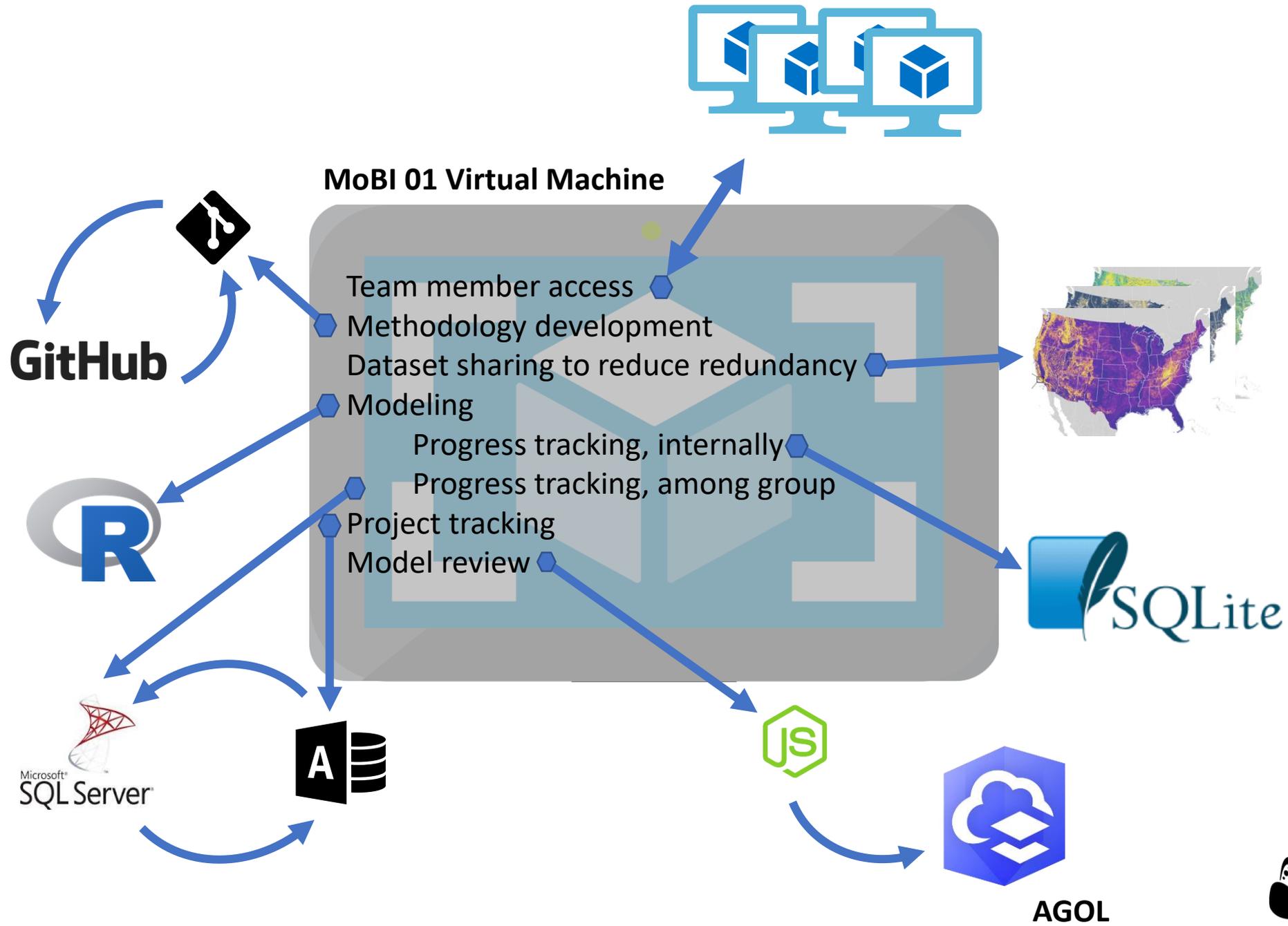
Validation runs used 51 environmental variables, the most important of 83 variables (top 75 percent). Each tree was built with 8 variables tried at each split (mtry) and 750 trees built. The final model was built using 2000 trees, all presence and background points, with an mtry of 8, and 51 environmental variables.

- Open cover 100-cell mean
- Dist to stream poly
- Deciduous forest cover 100-cell mean
- Dist to fresh marsh
- Coniferous forest cover 100-cell mean
- Canopy 100-cell mean
- Annual Precipitation
- Precipitation of Wettest Quarter
- Shrub cover 100-cell mean
- Precipitation of Driest Quarter
- Impervious surface 100-cell mean
- Mean Temperature of Warmest Quarter
- Dist to woody wetland
- Dist to lake or pond
- Roughness 100-cell circle
- Upper slope (flat) 10-cell mean
- Woody wetlands 100-cell mean
- Mean Temperature of Coldest Quarter
- Annual Mean Temperature
- Topographic position index 100-cell radius
- Impervious surface 10-cell mean
- Lower slope (cool) 10-cell mean
- Elevation
- Topographic position index 10-cell radius
- Upper slope (cool) 10-cell mean
- Water cover 100-cell mean
- Dist to fresh waters
- Peak/ridge (cool) 10-cell mean
- Lower slope (flat) 10-cell mean
- Lower slope 10-cell mean
- Upper slope 10-cell mean
- Beers aspect
- Dist to stream line
- Polaris soils percent clay
- Upper slope (flat) 1-cell mean
- Peak/ridge 10-cell mean
- Deciduous forest cover 1-cell mean
- Valley 10-cell mean
- Cliff 10-cell mean
- Coniferous forest cover 1-cell mean
- Mountain/divide 10-cell mean
- Upper slope (cool) 1-cell mean
- Lower slope (cool) 1-cell mean
- Peak/ridge (warm) 10-cell mean
- Valley (narrow) 10-cell mean
- Impervious surface 1-cell mean
- Lower slope (flat) 1-cell mean
- Peak/ridge (cool) 1-cell mean
- Topographic moisture
- Water cover 10-cell mean

Table 4. Model evaluation results based on Sofaer et al. 2019. Scores can be attributed as ideal, acceptable, or interpret with caution.

Category	Metric	Score	Notes
Species Data	Presence data quality	Ideal	Heritage Network data are vetted for accuracy and weighted for spatial representation.
	Absence/Background Data	Acceptable	Background points randomly placed throughout study area excluding species locations.
	Evaluation Data	Acceptable	Models are validated by jackknifing (i.e. leave-one-out).
Environmental Predictors	Ecological and predictive relevance	Acceptable	Selection of predictor variables were based on previous modeling experience by the Natural Heritage Network. Time constraints of this project prevented making species specific selections.
	Spatial and temporal alignment	Acceptable	Reasonable attempts to align predictor and presence data were made.
Modeling Process	Algorithm choice	Acceptable	Random Forest is highly rated classification model that is well documented as suitable for modeling rare species.
	Sensitivity	Acceptable	Settings for Random Forest were adjusted to best model the species; however, different models/parameters were not tested within one model run.
	Statistical rigor	Acceptable	Collinearity of predictors recognized and addressed; presence points grouped to minimize sample bias and minimize spatial autocorrelation boost during validation; other assumptions recognized and considered.
Performance	Performance	Acceptable	Model TSS ≥ 0.6 . Mapped model output is evaluated for ecological plausibility by expert review.
	Model review	Interpret with Caution	Model was not reviewed by regional, taxonomic experts.
Model Products	Mapped products	Acceptable	Single calculated threshold selected for all final models to be integrated into MoBI.
	Interpretation support products	Ideal	All standards met.
	Reproducibility	Ideal	All standards met.
	Iterative	Interpret with Caution	Model not revised.

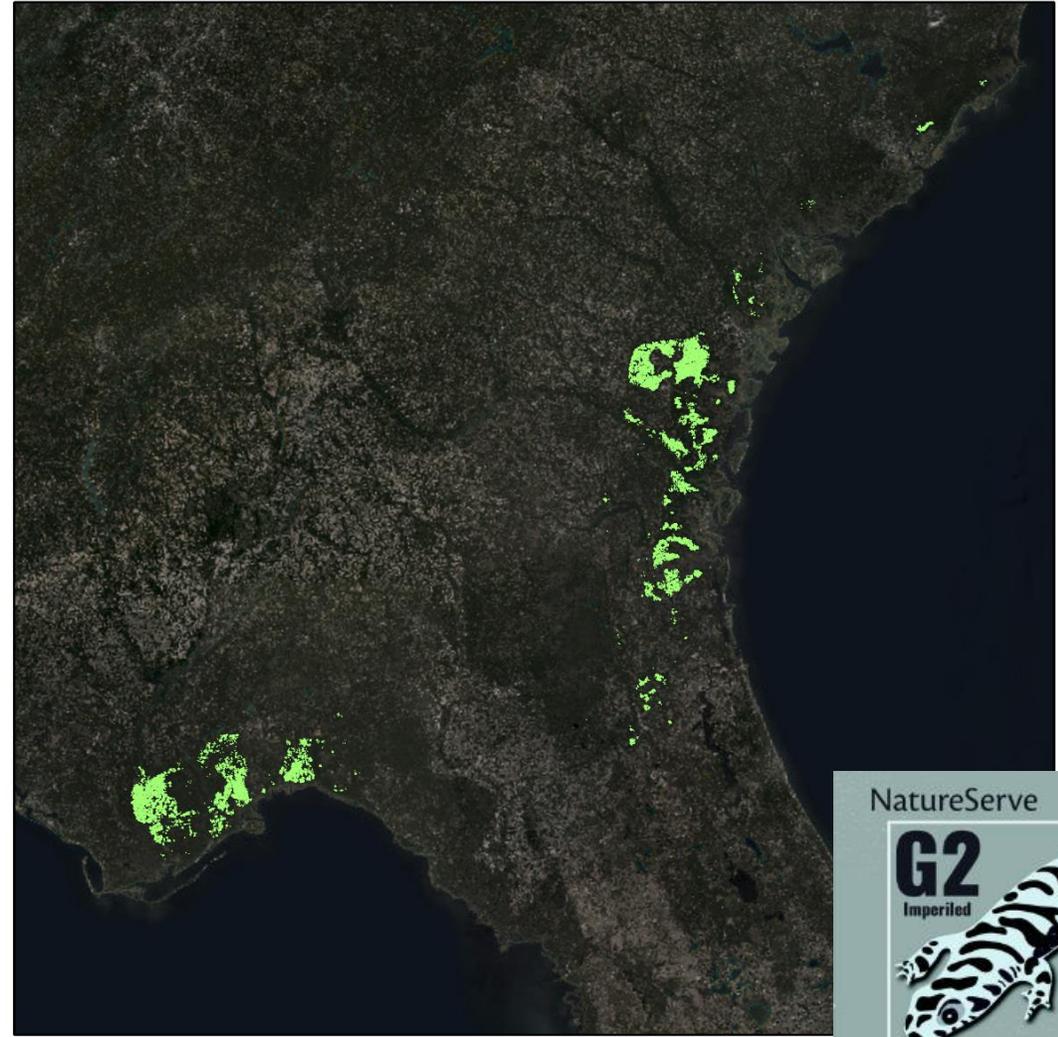
Model Comments



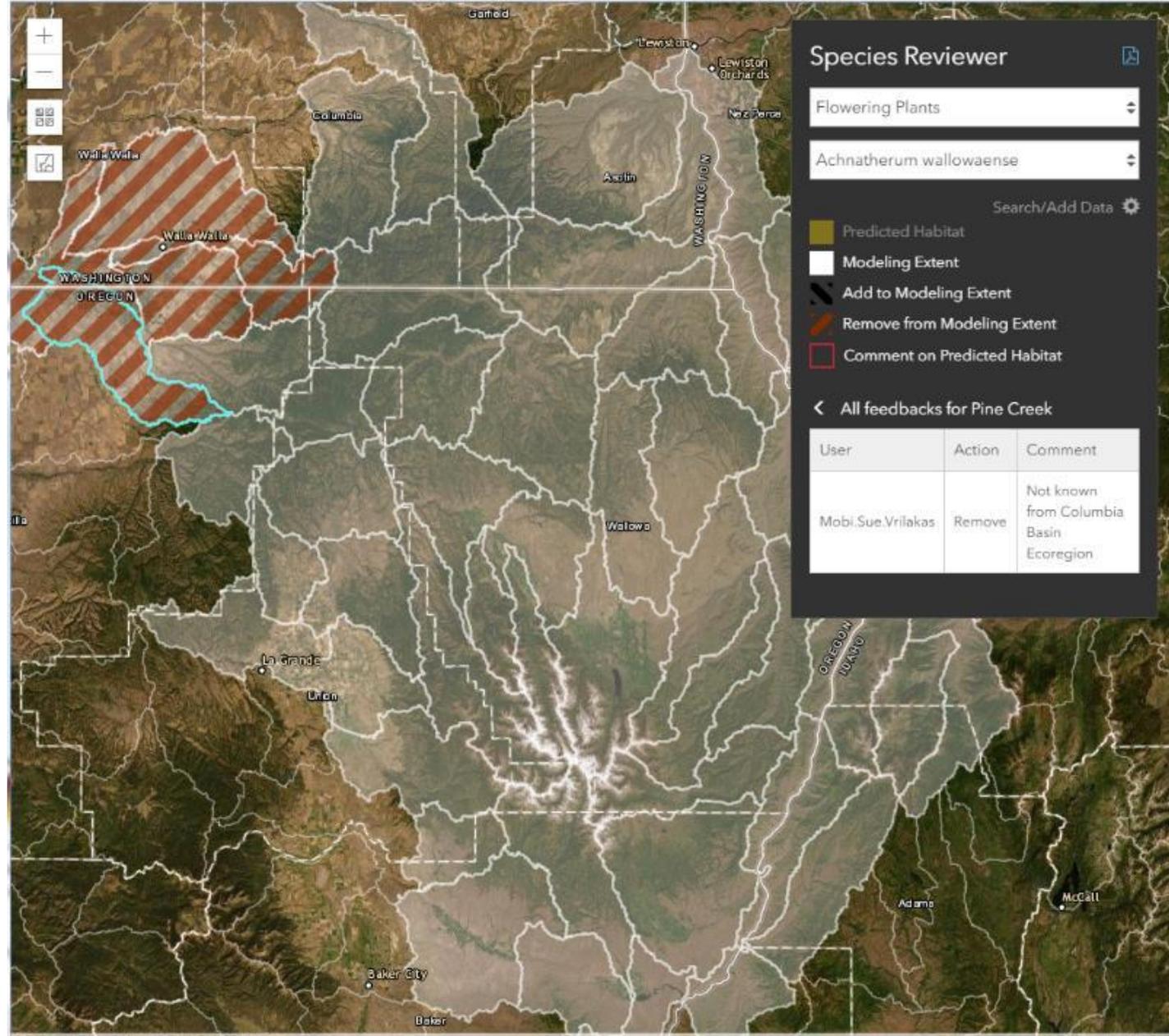
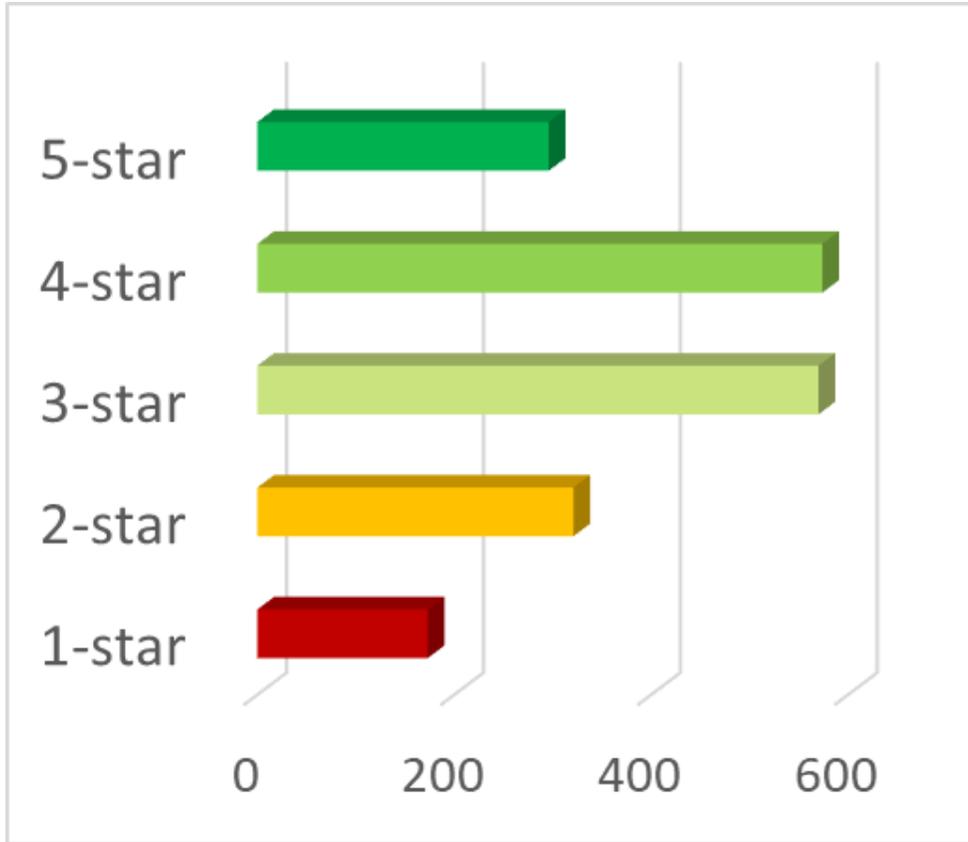
Previously Available Data



Newly Available Data



Model Performance



DRAFT

UNITED STATES

Richness of At-Risk Species Amphibians

Count of At-Risk Species



DRAFT

UNITED STATES

Richness of At-Risk Species Vascular Plants

Count of At-Risk Species



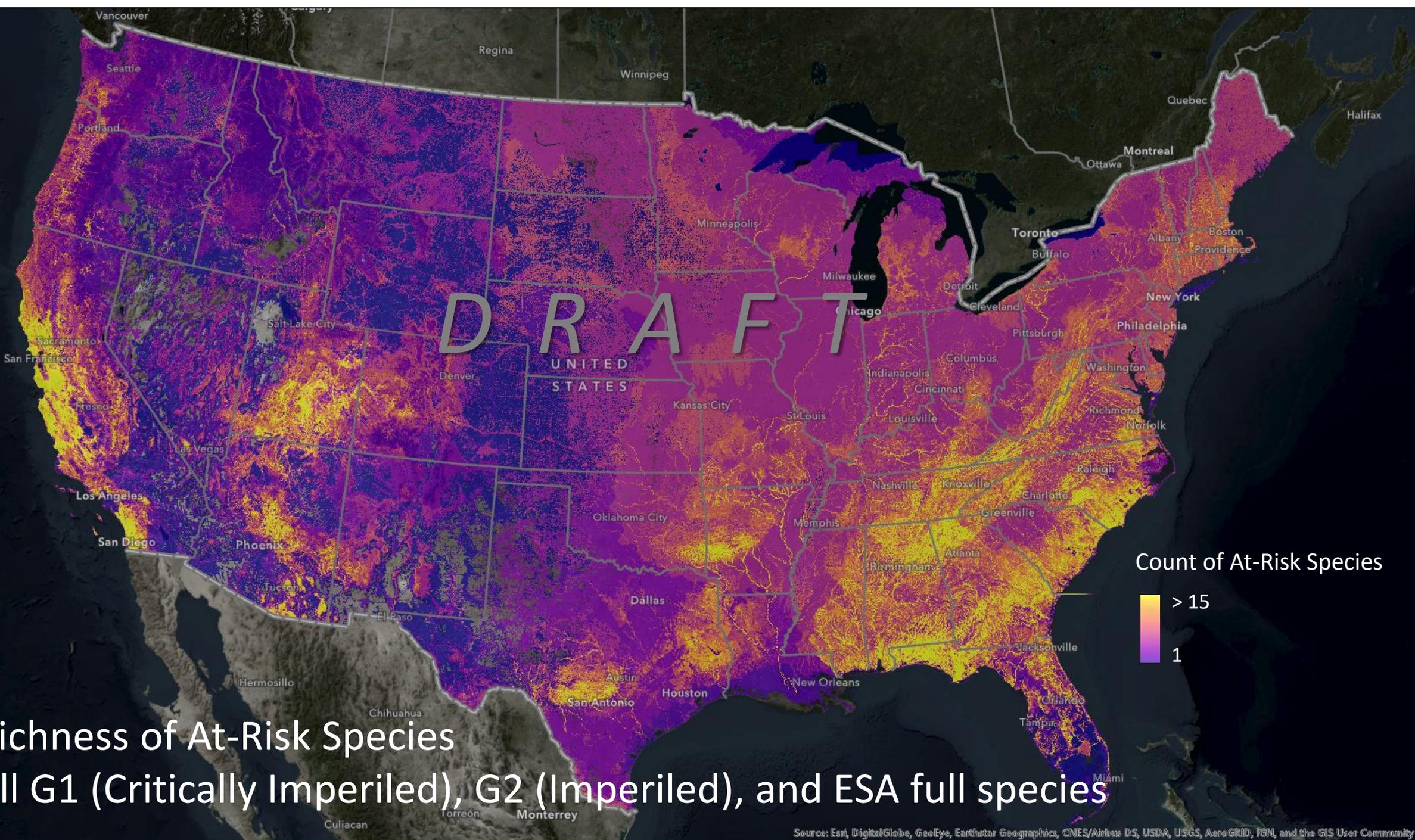
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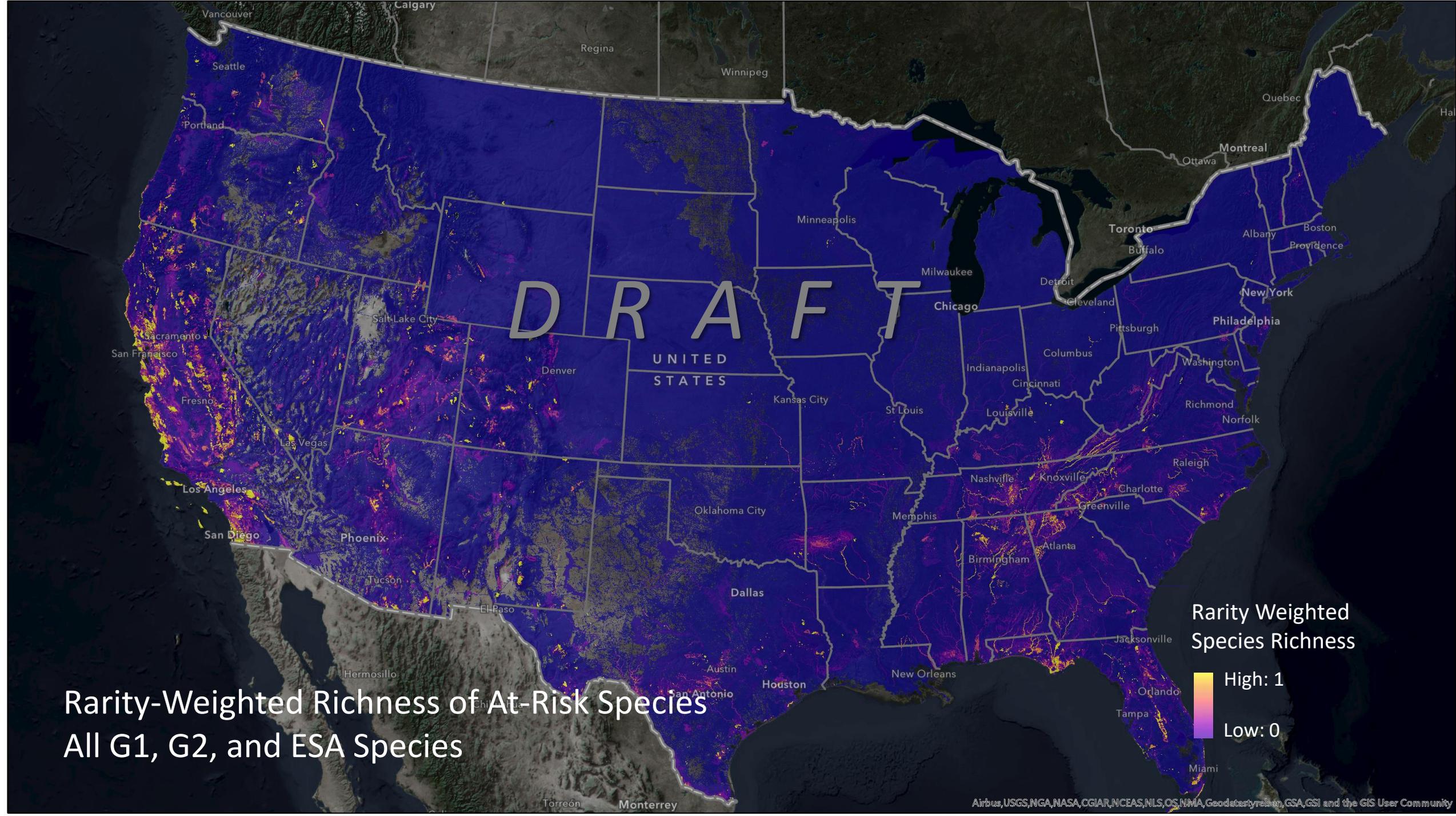
UNITED STATES

Richness of At-Risk Species Freshwater Species

Count of At-Risk Species







DRAFT

UNITED STATES

Rarity Weighted Species Richness



Rarity-Weighted Richness of At-Risk Species
All G1, G2, and ESA Species

DRAFT

UNITED STATES

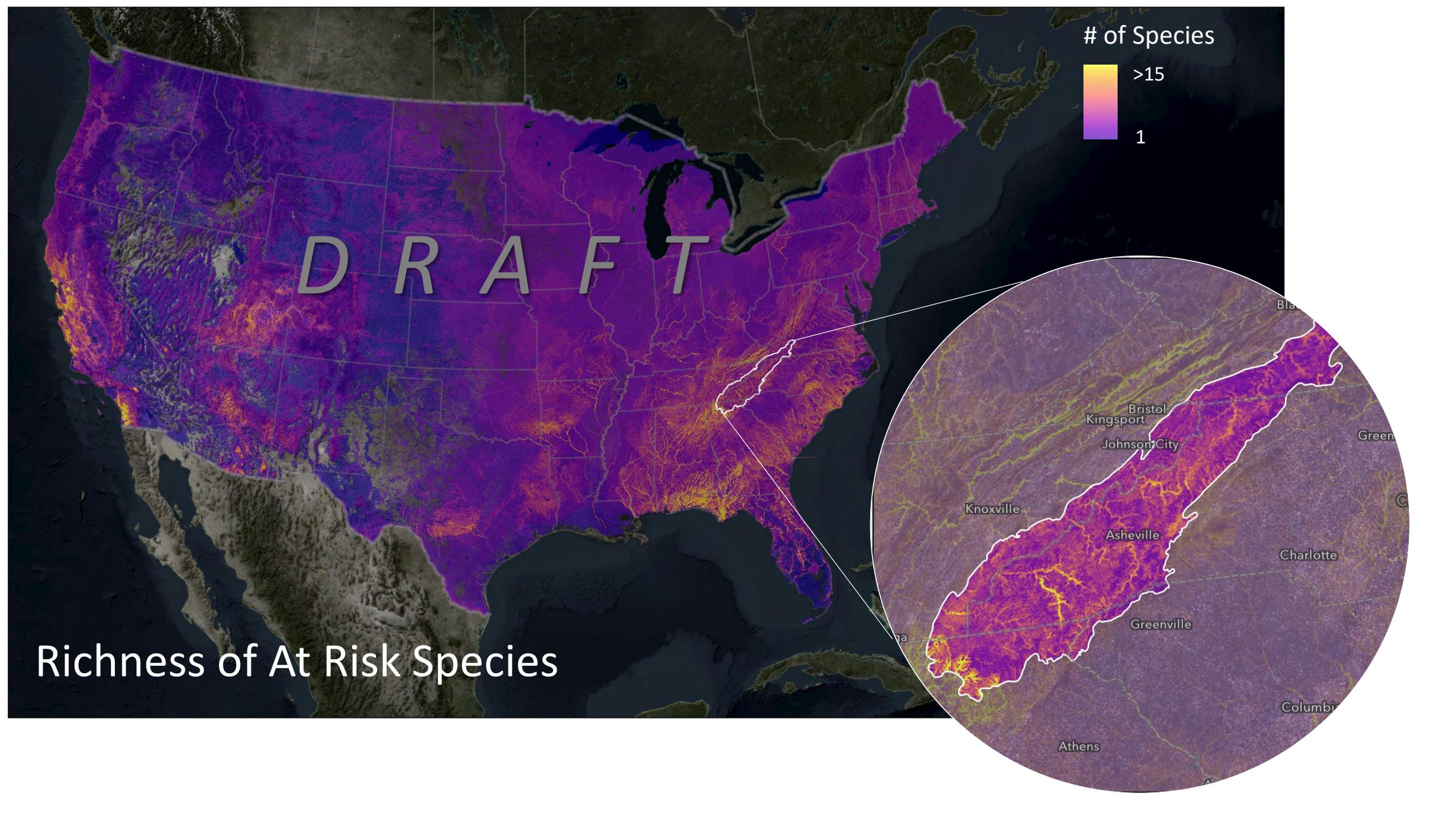
Biodiversity Importance Beyond Protected Areas



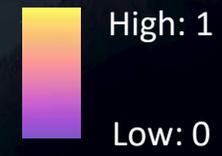
Biodiversity
at Risk



Protected Area



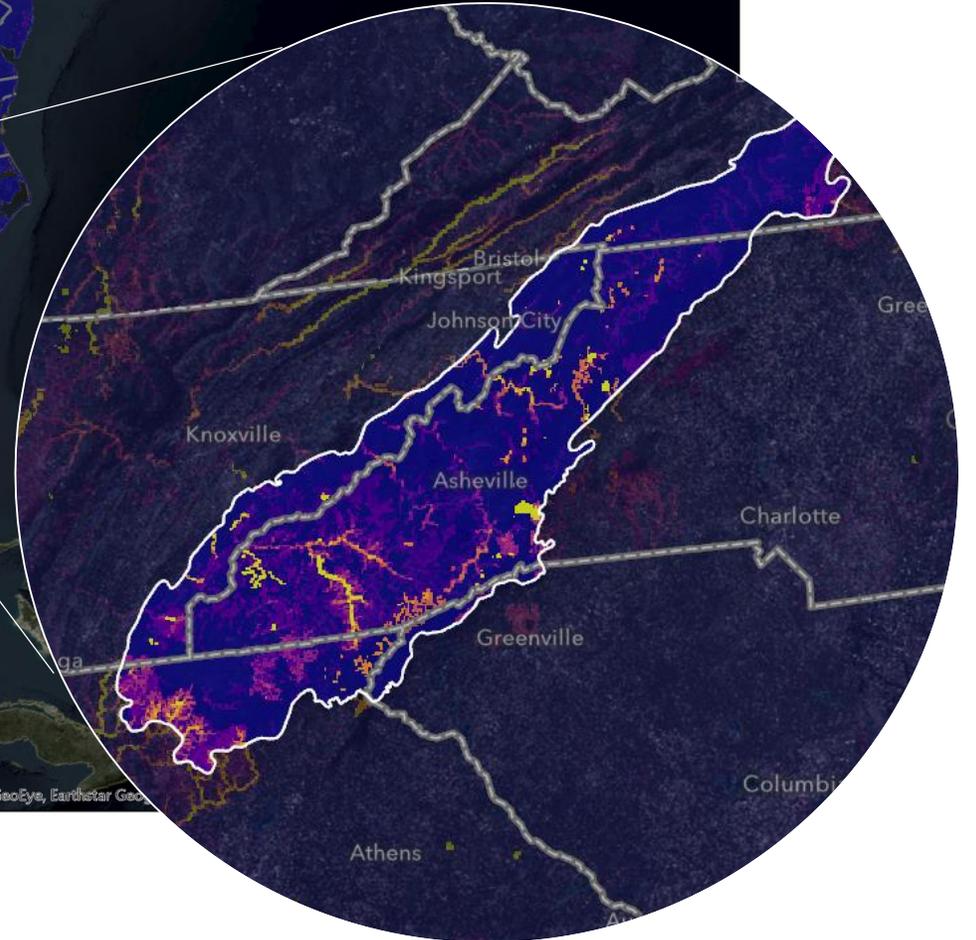
Rarity-weighted
Richness



DRAFT

Range Size Rarity Weighted Richness

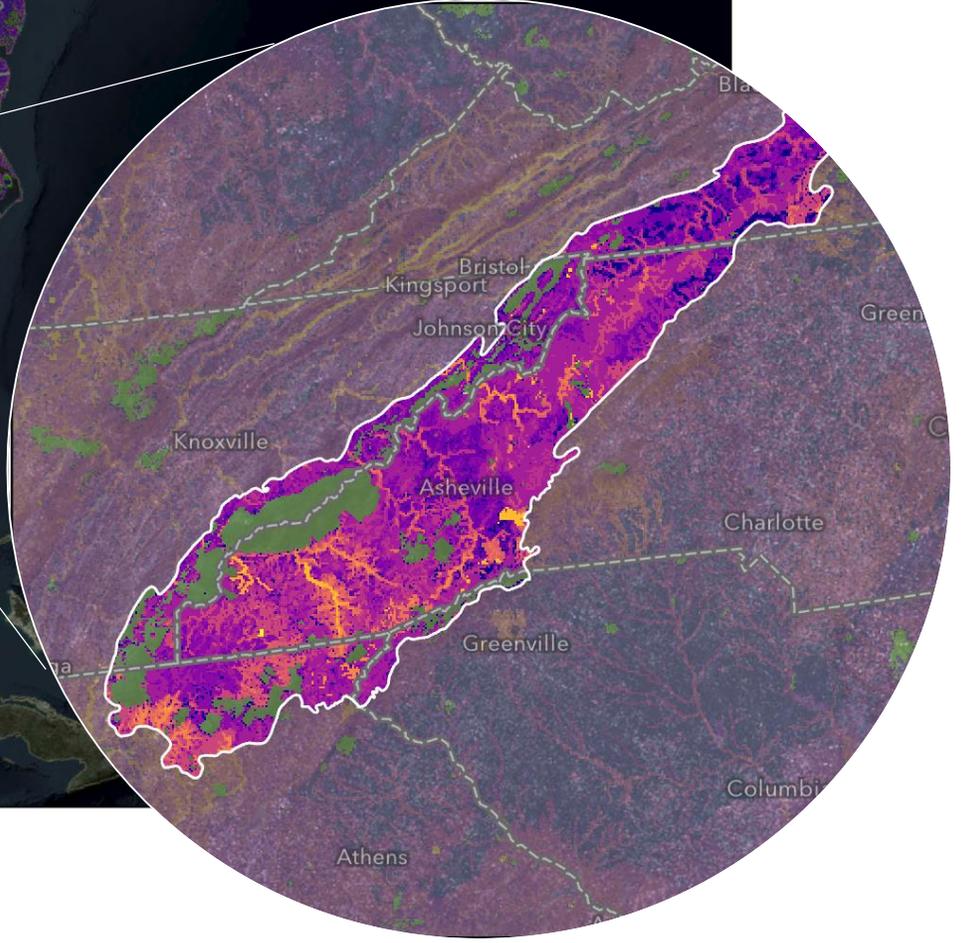
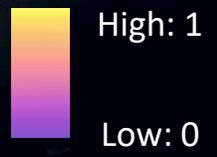
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geo



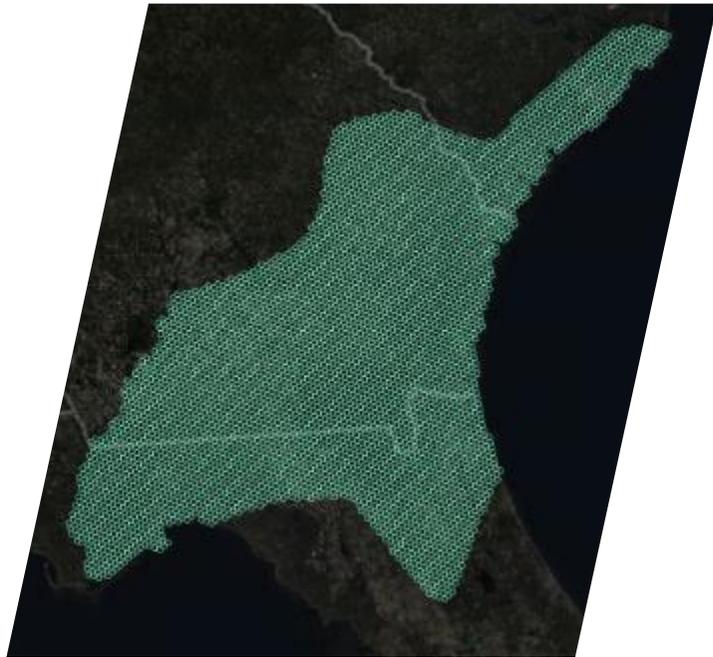
Biodiversity Importance Beyond Protected Areas

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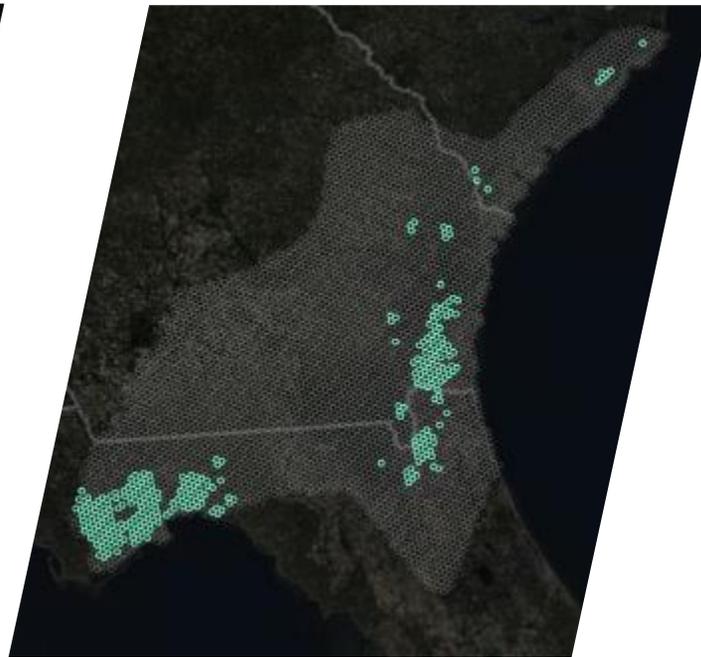
Protection &
Rarity-weighted
Richness



Full Spectrum of Biodiversity Location Data



Range



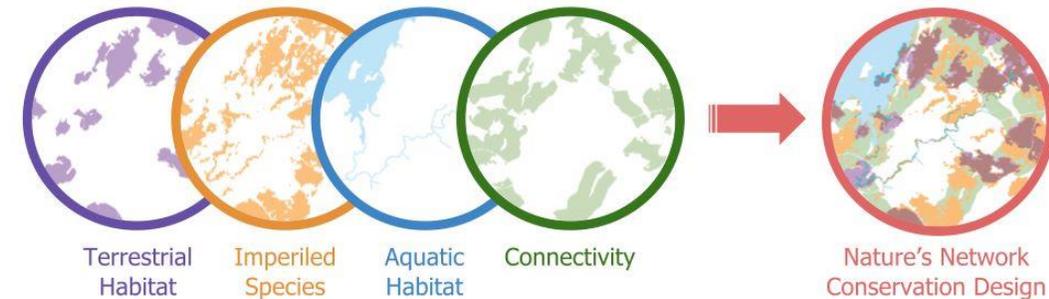
Predicted Habitat



Observations

NatureServe collaborative federal projects to refine at-risk species distributions

- US FWS, Southeast region, Science Applications
Develop a library of distribution models for SEAFWA/FWS regional priority species
Point of Contact: David Todd Jones-Farrand, Columbia MO
- US FWS, Northeast region, Science Applications
Incorporate MoBI models into Nature's Network 2.0 LCD
Point of Contact, B.J. Richardson
- BLM New Mexico
Develop and field validate decision quality SDMs for 7 listed rare plant species
Point of Contact: Zoe Davidson, BLM NM T&E species lead



To Learn More:

Email: healy_hamilton@natureserve.org

<https://www.natureserve.org/conservation-tools/projects/map-biodiversity-importance>

Watch NatureServe's 2019 Esri User Conference video on YouTube



MoBI layers available on Esri's Living Atlas January 2020

