GEOGRAPHY AND THE ENVIRONMENT

THE AMERICAN CHESTNUT FOUNDATION®

TACF Chestnut Chat:

Habitat Modeling for American Chestnut

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Chestnut: an ecologic, economic, & cultural asset

- Reliable mast
  - Wildlife
  - Livestock
- Fantastic lumber
- Fast growth
- Rot-resistant
- Grows on poorer sites
- Species diversity

acf.org

Washington Post

Appalachian Regional Reforestation Initiative

Restoring a Species

"There's nothing more important and visionary than planting a tree so that our grandchildren can enjoy its fruit."

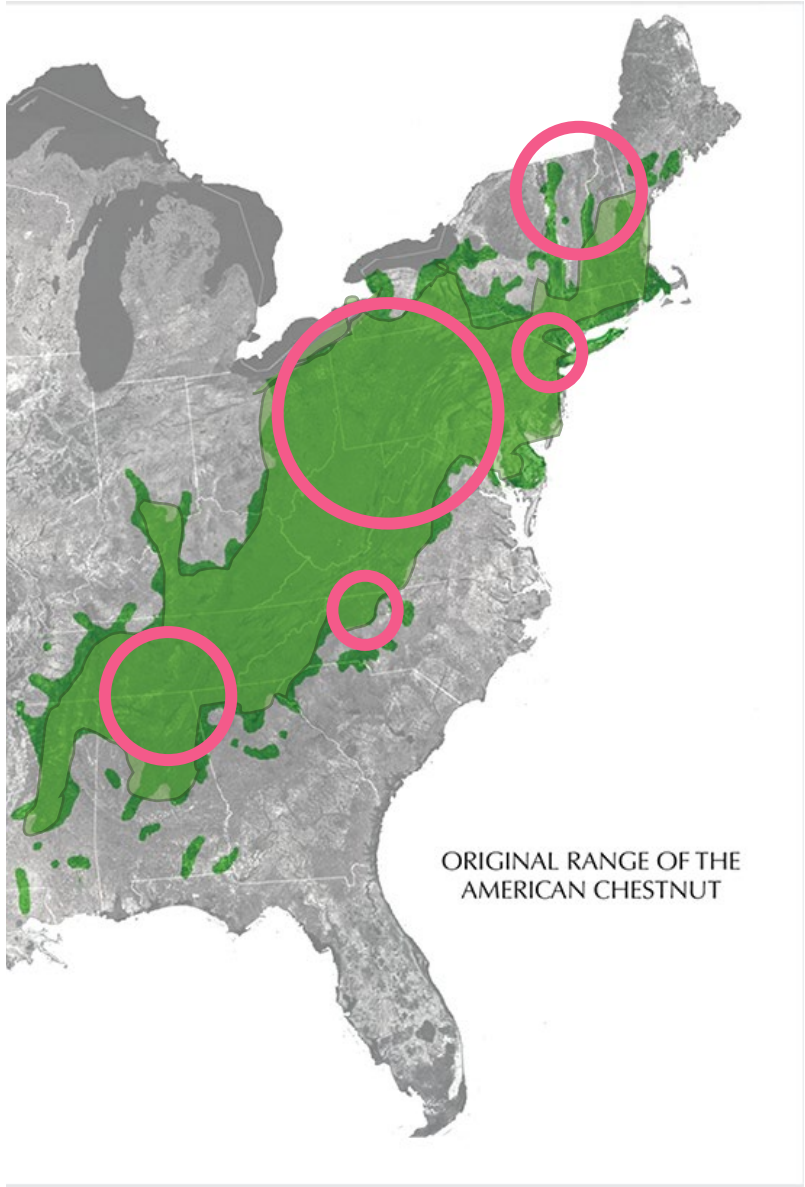
-Michael Doochin, Immediate Past Chair, Board of Directors

The American Chestnut Foundation (TACF) is committed to restoring the American chestnut tree to our eastern woodlands to benefit our environment, our wildlife, and our society. Unlike other environmental organizations, TACF's mission is not about preventing environmental loss or preserving what we already have. The concept of our mission is much bolder and more powerful. It's about restoration of an entire ecosystem and making our world a much better place than we found it.

Forest restoration is a specialized form of reforestation, but it differs from conventional tree plantations in that its primary goals are biodiversity recovery and environmental protection. This makes restoration of the American chestnut a long-term commitment. It is, quite simply, an investment in the future. The specialized work we do also provides opportunities to assist with other endangered species. Our ultimate goal is to create a template for the restoration of other tree and plant species throughout the world.

Chestnut Restoration

- Restoration does not end with a blight-resistant tree!
- Figuring out how and where to plant trees is necessary for reintroduction
- Give chestnuts the best shot at success



Chestnut Restoration

- Species-specific focus with ecosystem-level benefits
- Small-scale experiments to study planting stock type, density, timing, and species mixture compatibility
- How can we efficiently select the best sites / habitats for future plantings and reintroduction?

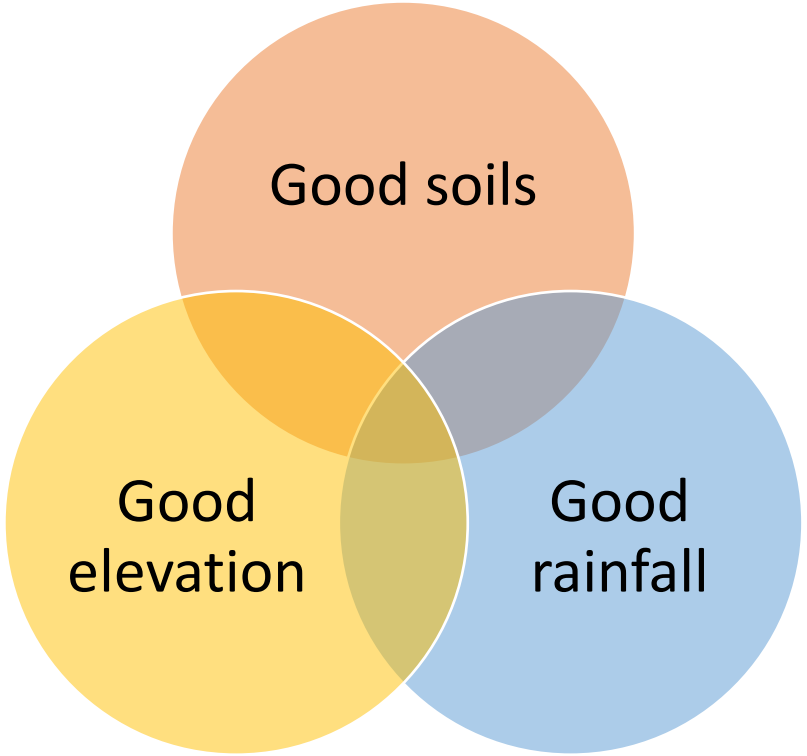
Planting in Northern Indiana. Photo from acf.org

Modeling Suitable Habitat

- Know something about the environment

- Using statistics and spatial analysis to predict the suitability of a location for a species based on its observed relationship with underlying environmental conditions

- Useful for analysis over large areas



Modeling Suitable Habitat… an example

Suitable Jen Habitat:

- Good winter skiing
- Close to lake or ocean
- Mountains nearby
- Not in a large city

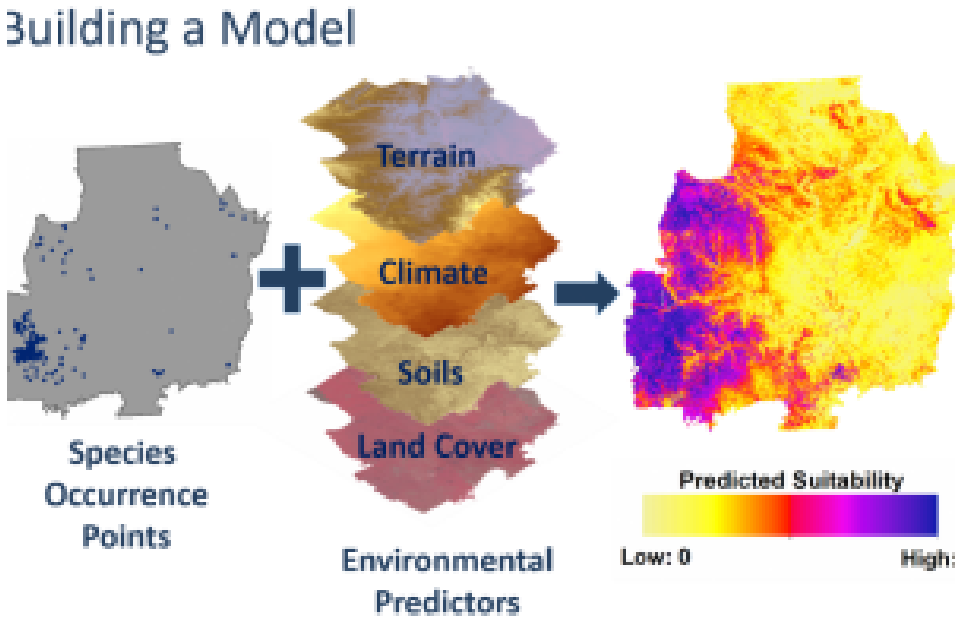
https://www.mountainzone.com/

What are the models?

Species Distribution Modeling (SDM): models the relationship between the known locations of a species and the environmental characteristics at those locations to predict a broader extent of suitable habitat

Need to know:

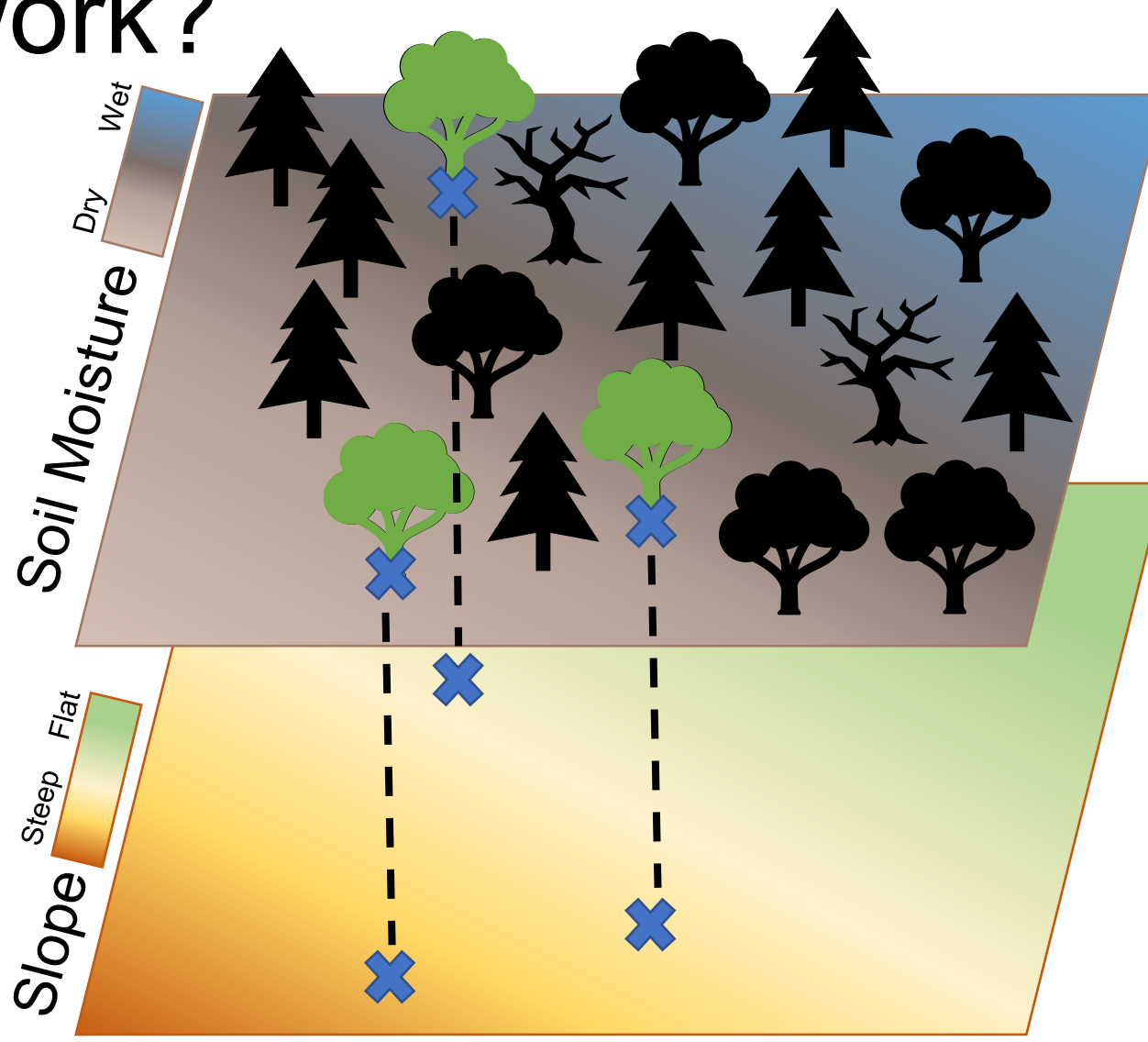
- Chestnut tree locations (coordinates)
- Environmental traits (moisture, temperature, soils…) that may help predict patterns of distribution



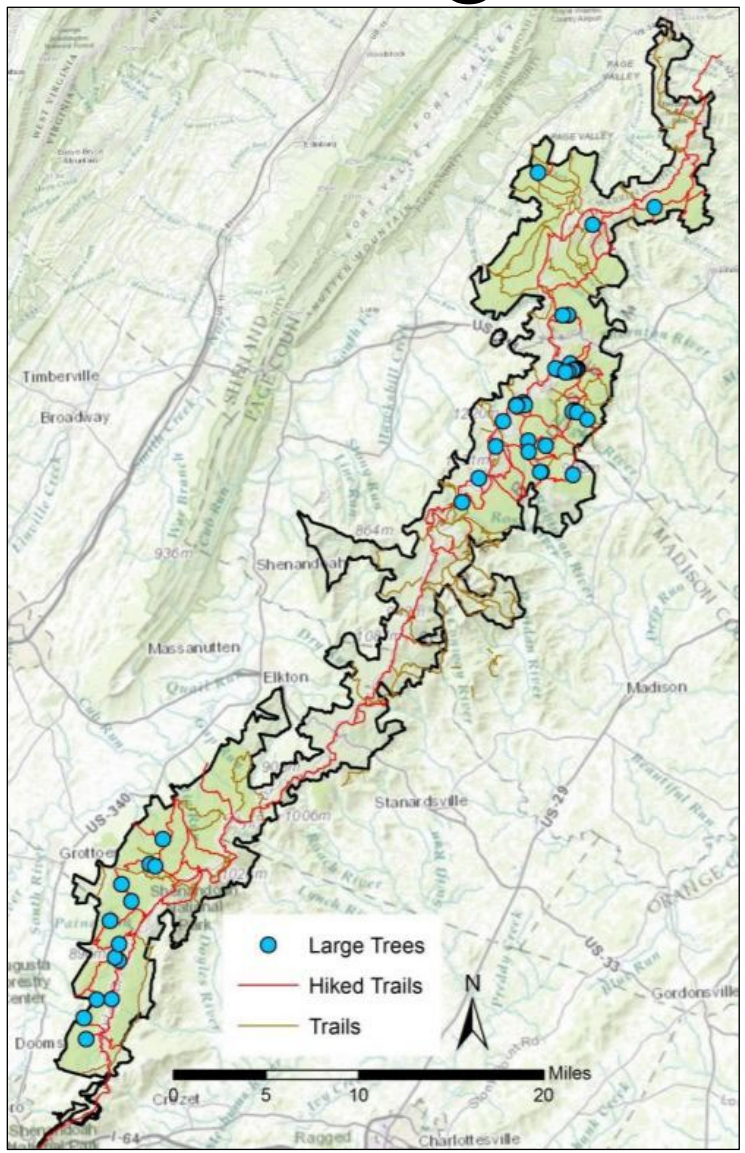
https://www.natureserve.org/

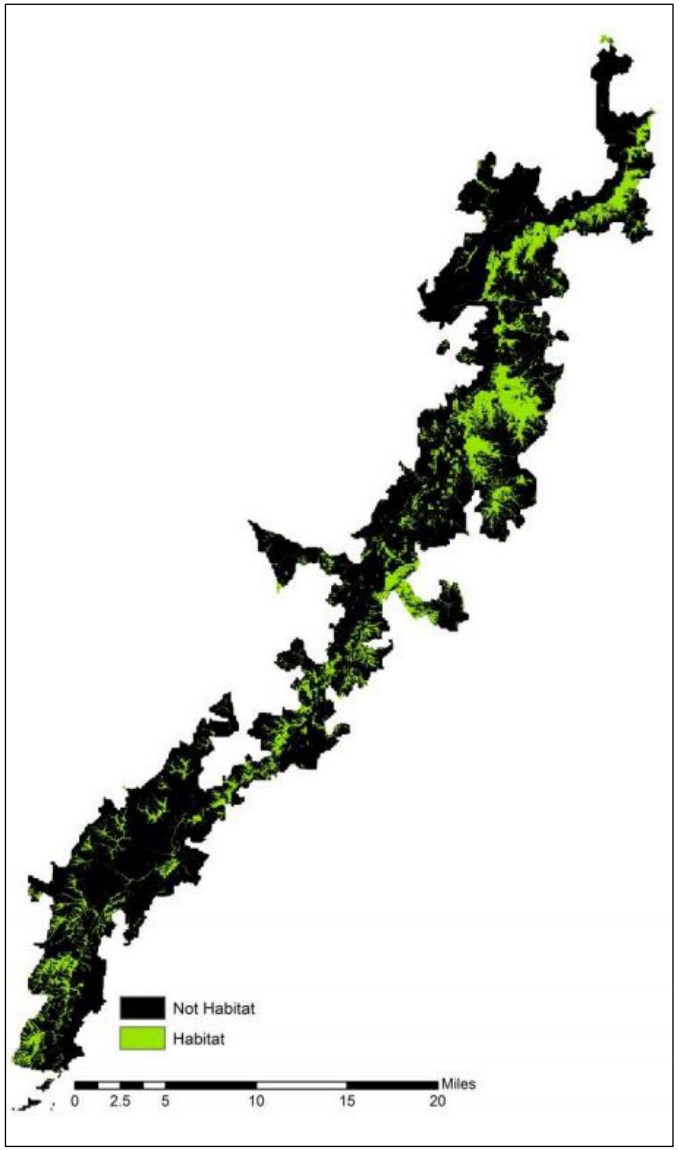
How do the models work?

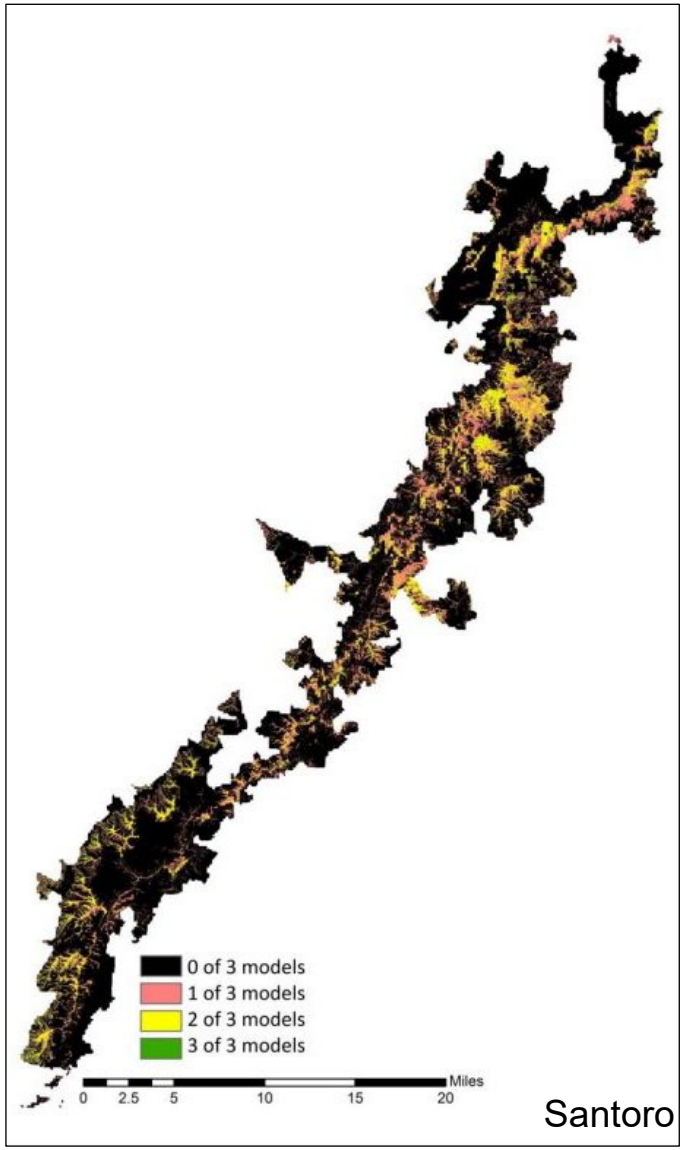
- Find chestnut trees (coordinates)
- Measure environmental traits at those locations (GIS)
- Build model
  - Which environmental traits have high predictive power?
  - Which have low predictive power?
- Use model results to predict suitable habitat elsewhere



Modeling Suitable Habitat: Past Work

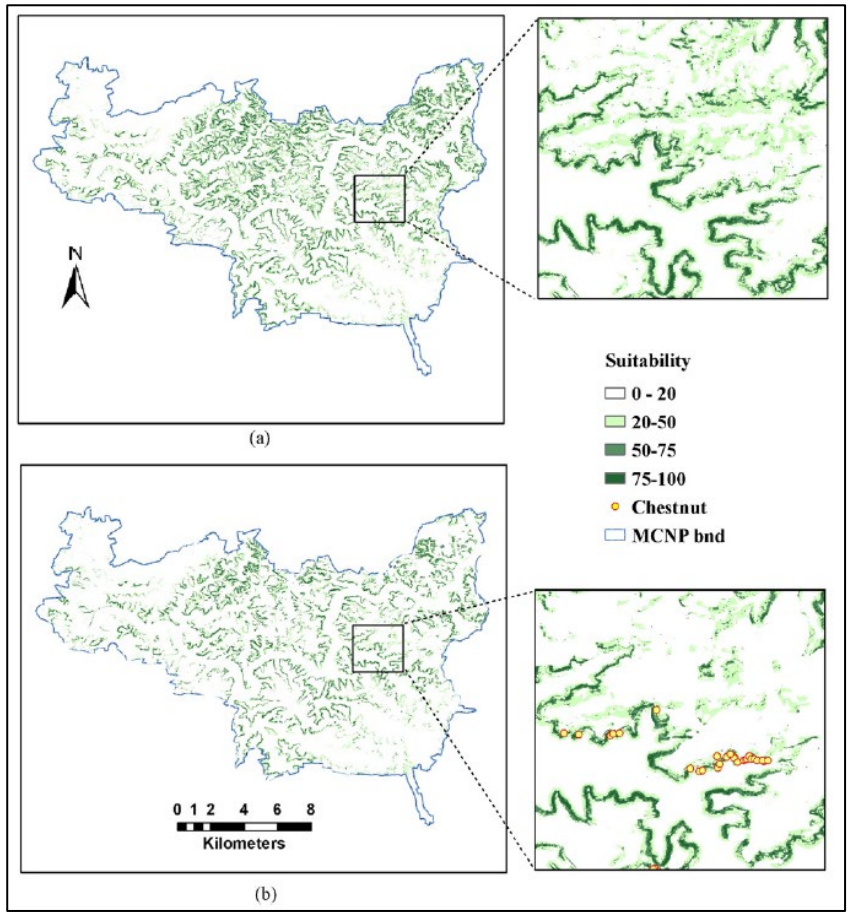




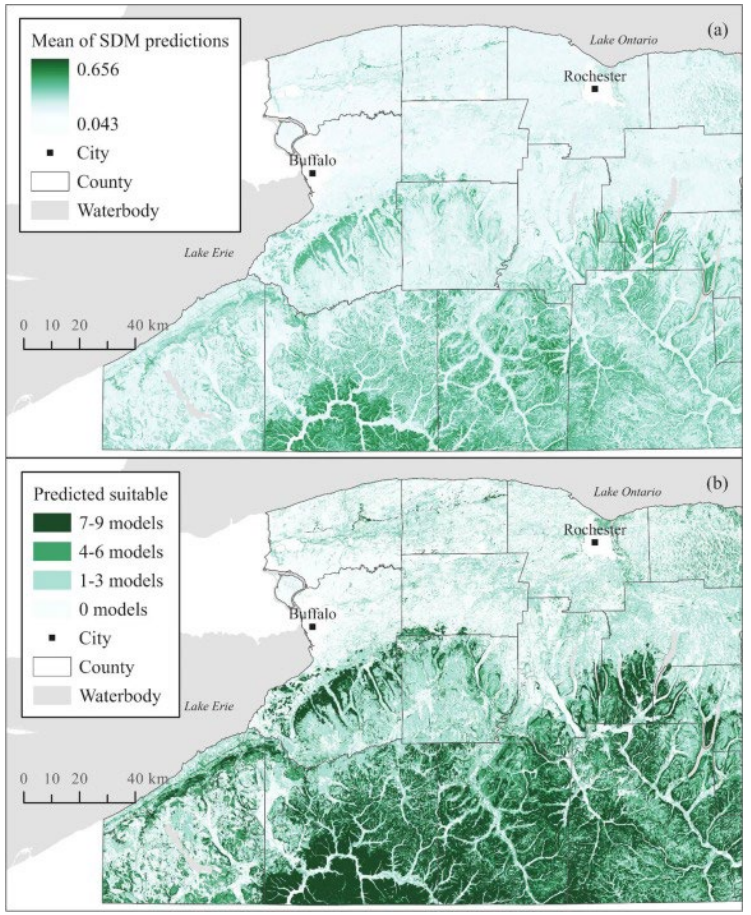


Santoro 2013

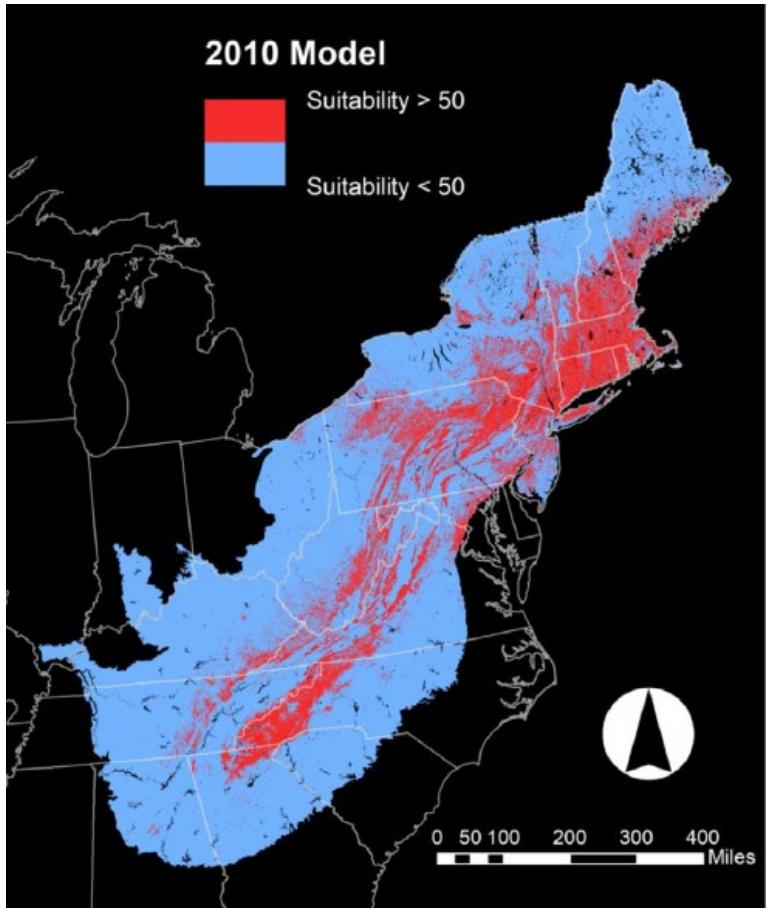
Modeling Suitable Habitat: Past Work



Fei et al. 2007



Tulowiecki 2020



Noah et al. 2021

Our Study: Habitat Modeling for Chestnut Restoration

Goal: locate the best American Chestnut habitat in Pennsylvania

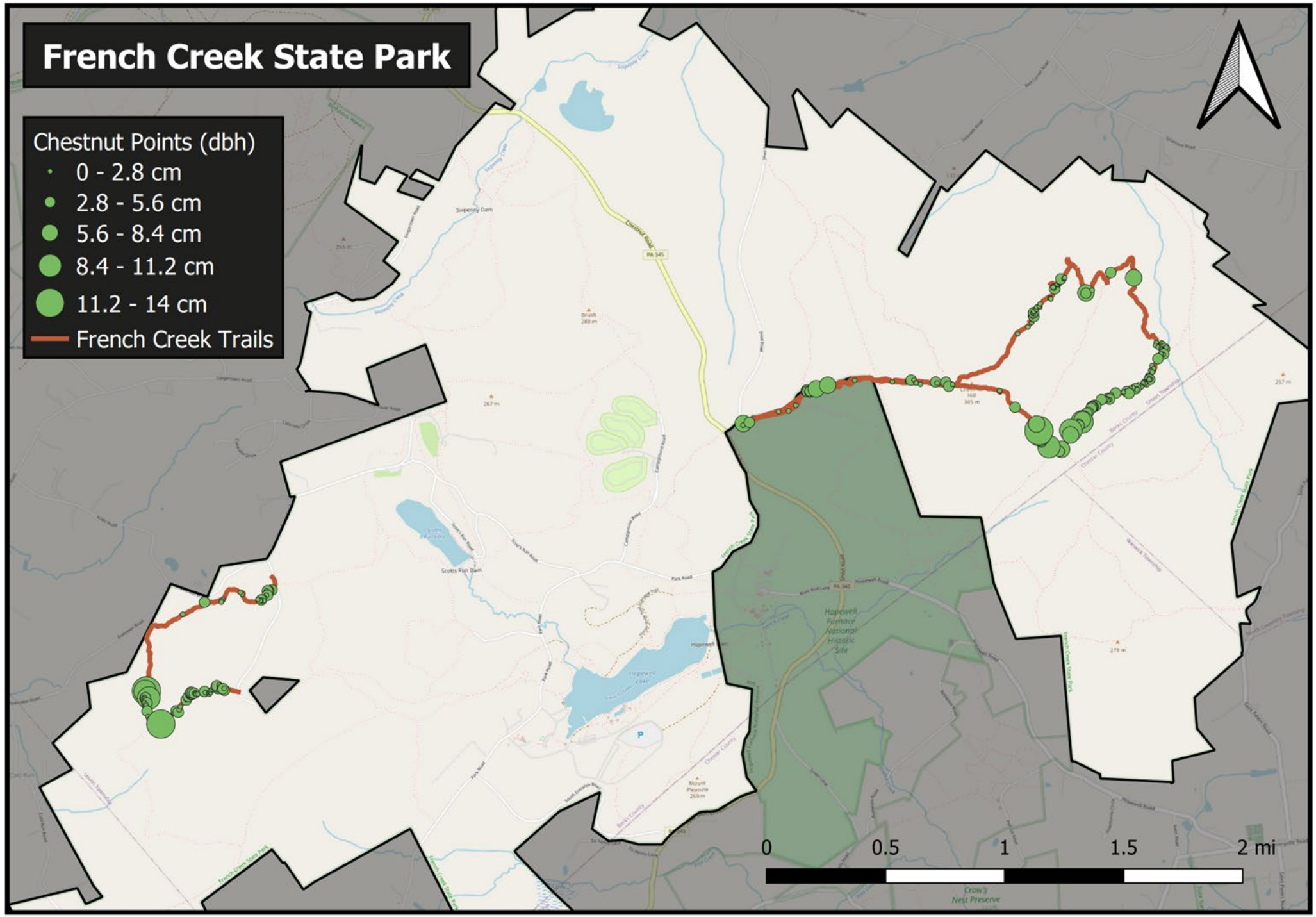
- Spatial-statistical models: Species Distribution Modeling (SDM)

Research Questions:

- What environmental characteristics predict the best chestnut habitat? (based on existing chestnut trees)
- How does spatial scale and model extent influence these results?

Chestnut Locations

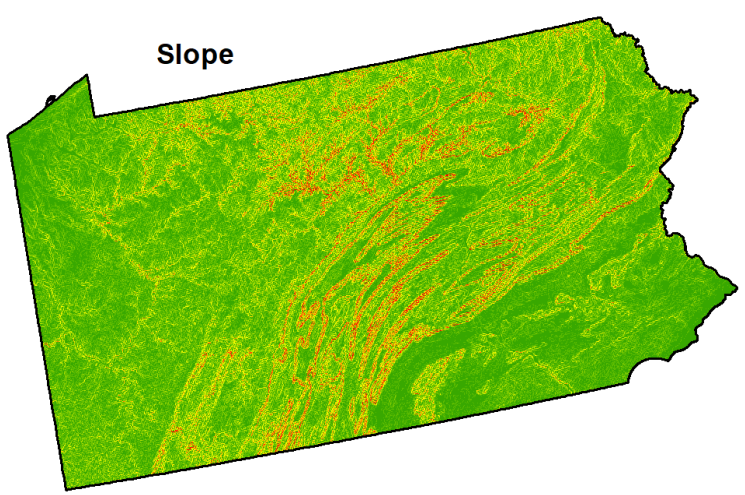
- Goal – Use SDMs to determine suitable chestnut habitat in PA
  - Explore how changing model parameters changes results
- Pennsylvania American chestnut locations from Sara Fitzsimmons
  - DentataBase! Citizen Science!
- Field data collection at French Creek State Park

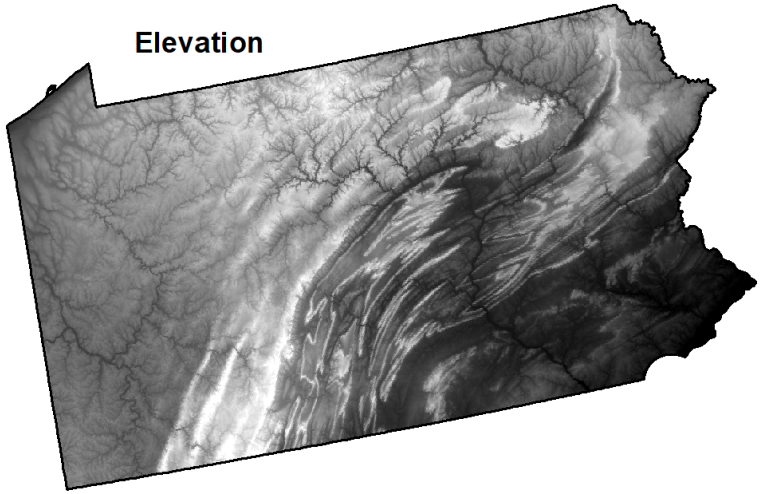

French Creek State Park
Chestnut Points (dbh)
0 - 2.8 cm
2.8 - 5.6 cm
5.6 - 8.4 cm
8.4 - 11.2 cm
11.2 - 14 cm
French Creek Trails
0
0.5
1
1.5
2 mi

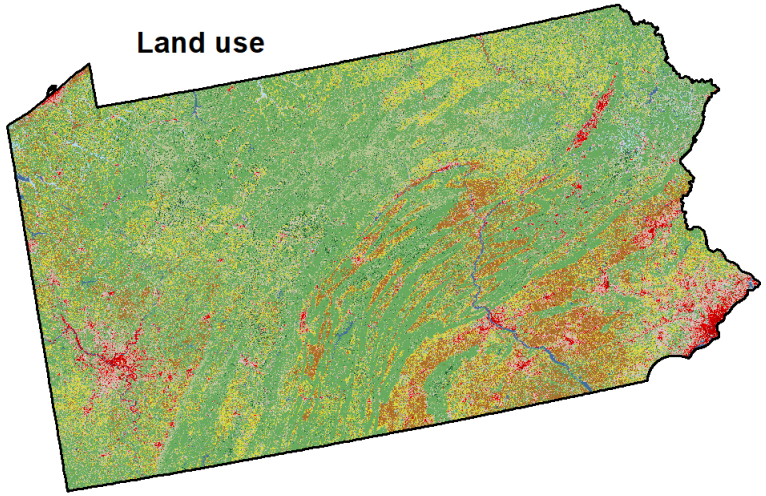
GIS Data Collection

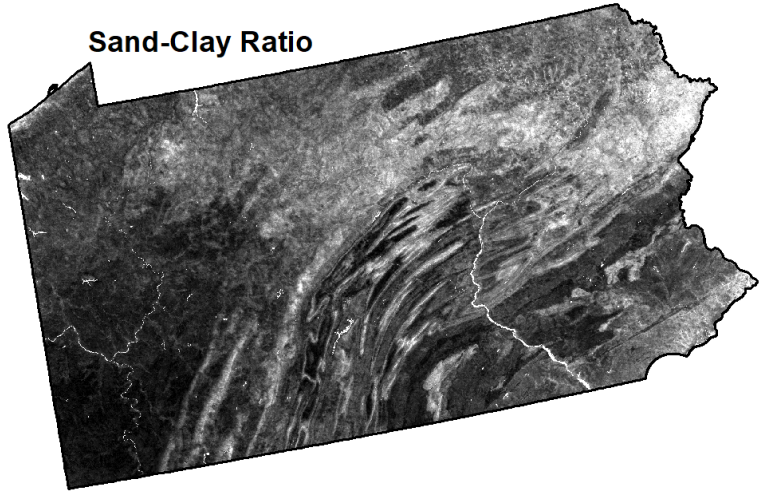
	Environmental variable	Variable range within study area	Variable code	Initial resolution (m)	Source
		Full State Model			
Land cover	Land use type	Discrete variable with 15 different land use types	palanduse2016	30m	NLCD
	Canopy cover	0-99%	pacanopy	30m	NLCD
	Distance to streams	0-3431.82 m	padts	238m	PASDA
Topography	Elevation	1-890 m	padem	30m	PASDA
	Slope	0-31.27 °	paslope	238m	PASDA
	Aspect	0-2 (Beers transformation of 360°)	paaspect	238m	PASDA
	Curvature	-0.51(upwardly convex) - 0.53(upwardly concave)	pacurvature	238m	PASDA
	Topographic convergence index	2.69(low water accumulation) - 24.97(high water accumulation)	patci	238m	PASDA
	Topographic position index	-129(valleys) - 149(peaks)	patpi	238m	PASDA
	Topographic relative moisture index	14(lower soil moisture - 59(higher soil moisture)	patrmi	238m	PASDA
Soil	Sand to clay ratio	0.64-6.11	pasandclayratio	238m	ISRIC
		French Creek Model			
Land cover	Canopy cover	0-99%	canopy	30m	NLCD
	Distance to streams	0-1216.17 m	dts	3m	PASDA
Topography	Elevation	38.58 - 303.69 m	fcdem	3m	PASDA
	Slope	0-80.99°	slope	3m	PASDA
	Aspect	0-2 (Beers transformation of 360°)	aspect	3m	PASDA
	Curvature	-349.95(upwardly convex) - 132.32(upwardly concave)	curvature	3m	PASDA
	Topographic convergence index	0.892(low water accumulation) - 28.75(high water accumulation)	tci	3m	PASDA
	Topographic position index	-32.16(valleys) - 54.58(peaks)	tpicoarse	3m	PASDA
	Topographic relative moisture index	10(lower soil moisture) - 58(higher soil moisture)	trmi	3m	PASDA
Soil	Soil description	Discrete variable with 17 different soil types	soildesc	3m	SSURGO
	Soil field capacity	0-28.373%	soilfieldcap	3m	SSURGO
	Soil sand content	0-67.67%	soilsand	3m	SSURGO

Environmental Variables

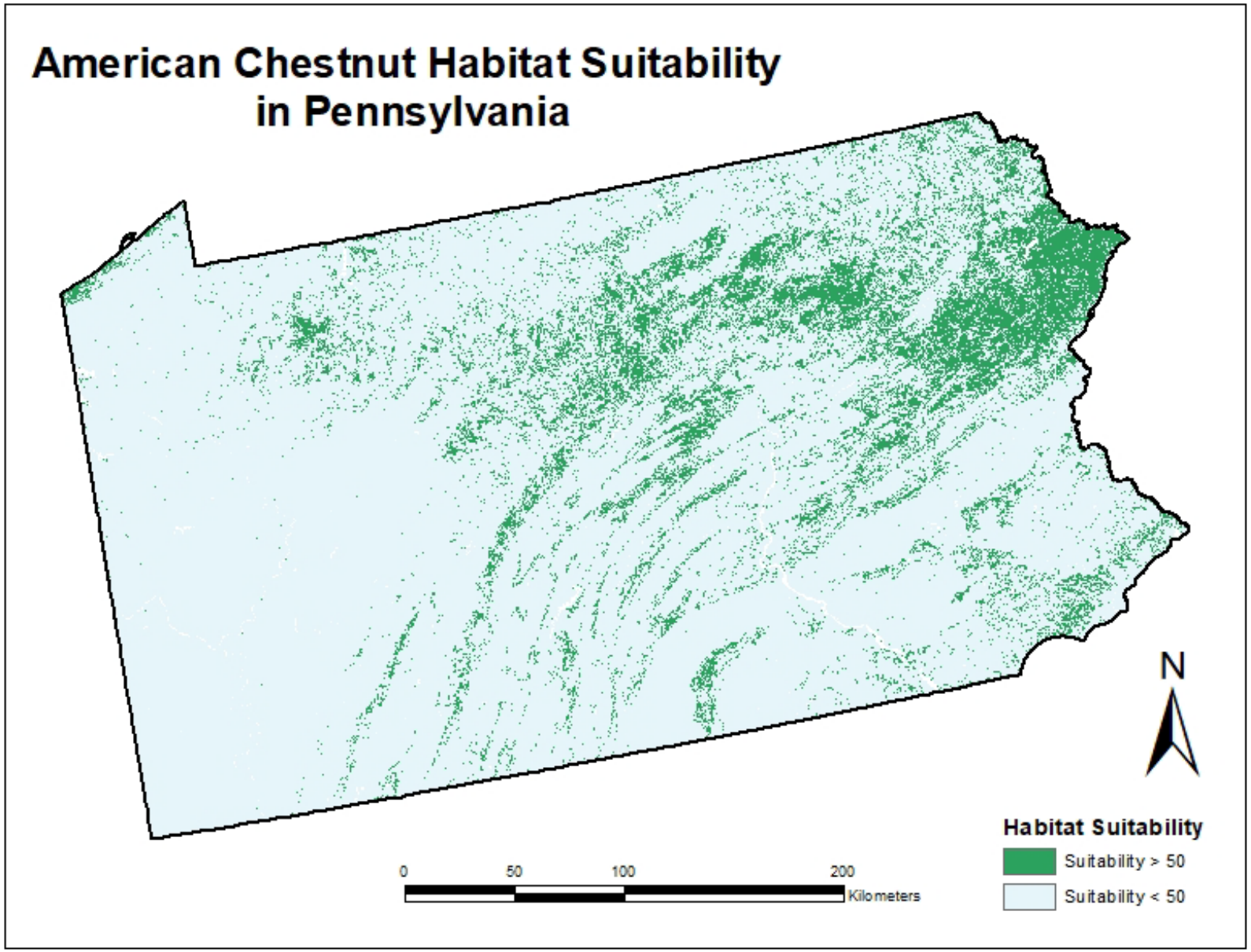




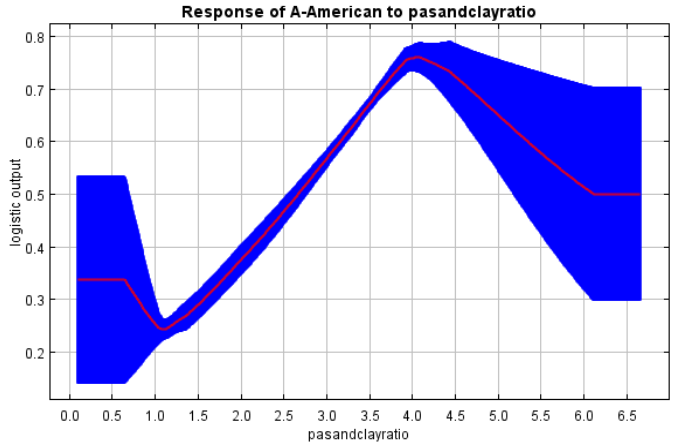


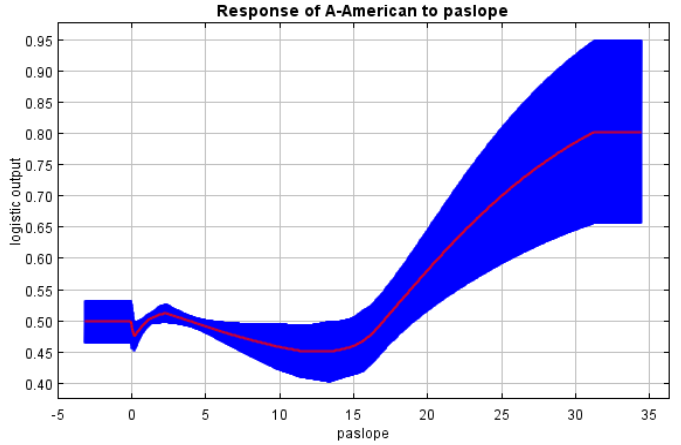


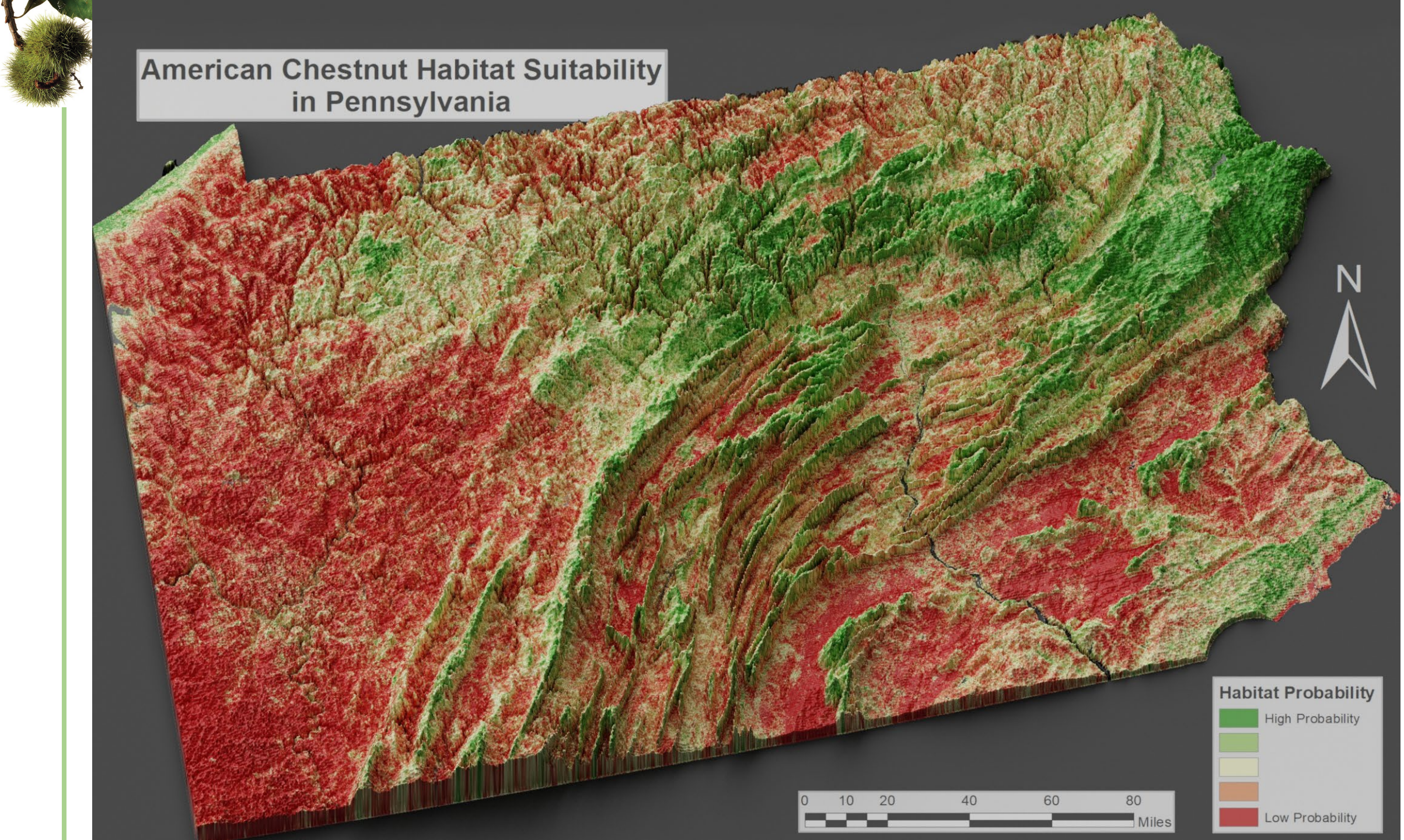
Full State SDM



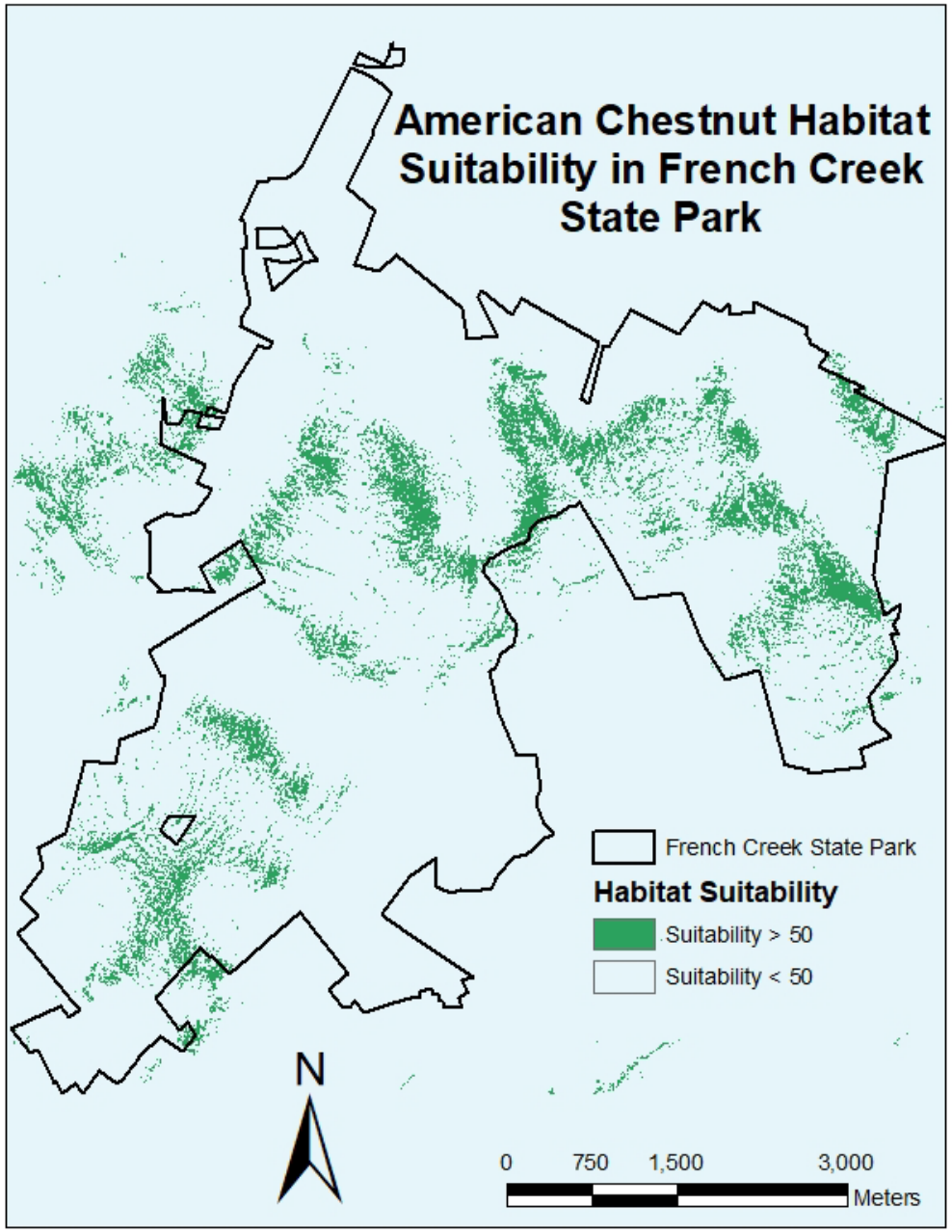
	Full State Model	
	Predictor	Permutation Importance
Land cover	Land use type	6.1
	Canopy cover	8.0
	Distance to streams	3.5
Topography	Elevation	6.2
	Slope	10.6
	Aspect	6.3
	Curvature	4.8
	Topographic convergence index	5.6
	Topographic position index	6.1
	Topographic relative moisture index	10.8
Soil	Sand to clay ratio	32.1
		AUC = 0.764



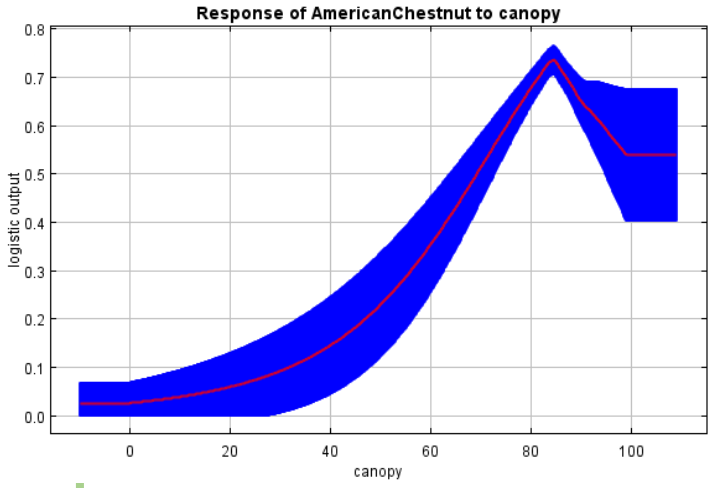


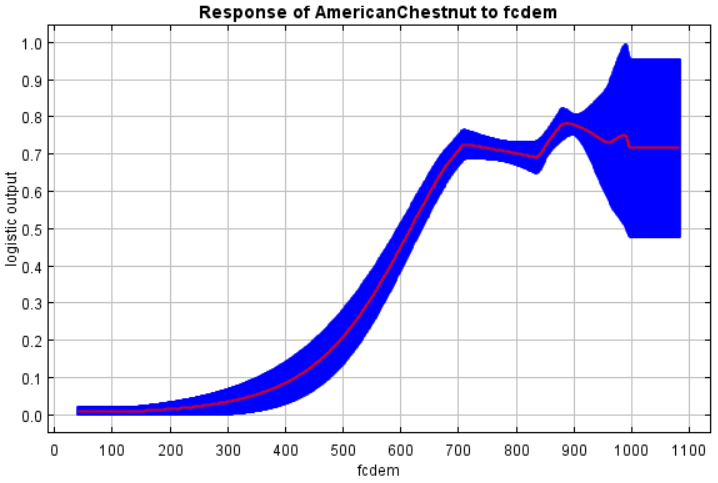

American Chestnut Habitat Suitability
in Pennsylvania
N
0 10 20 40 60 80
Miles
Habitat Probability
High Probability
Low Probability

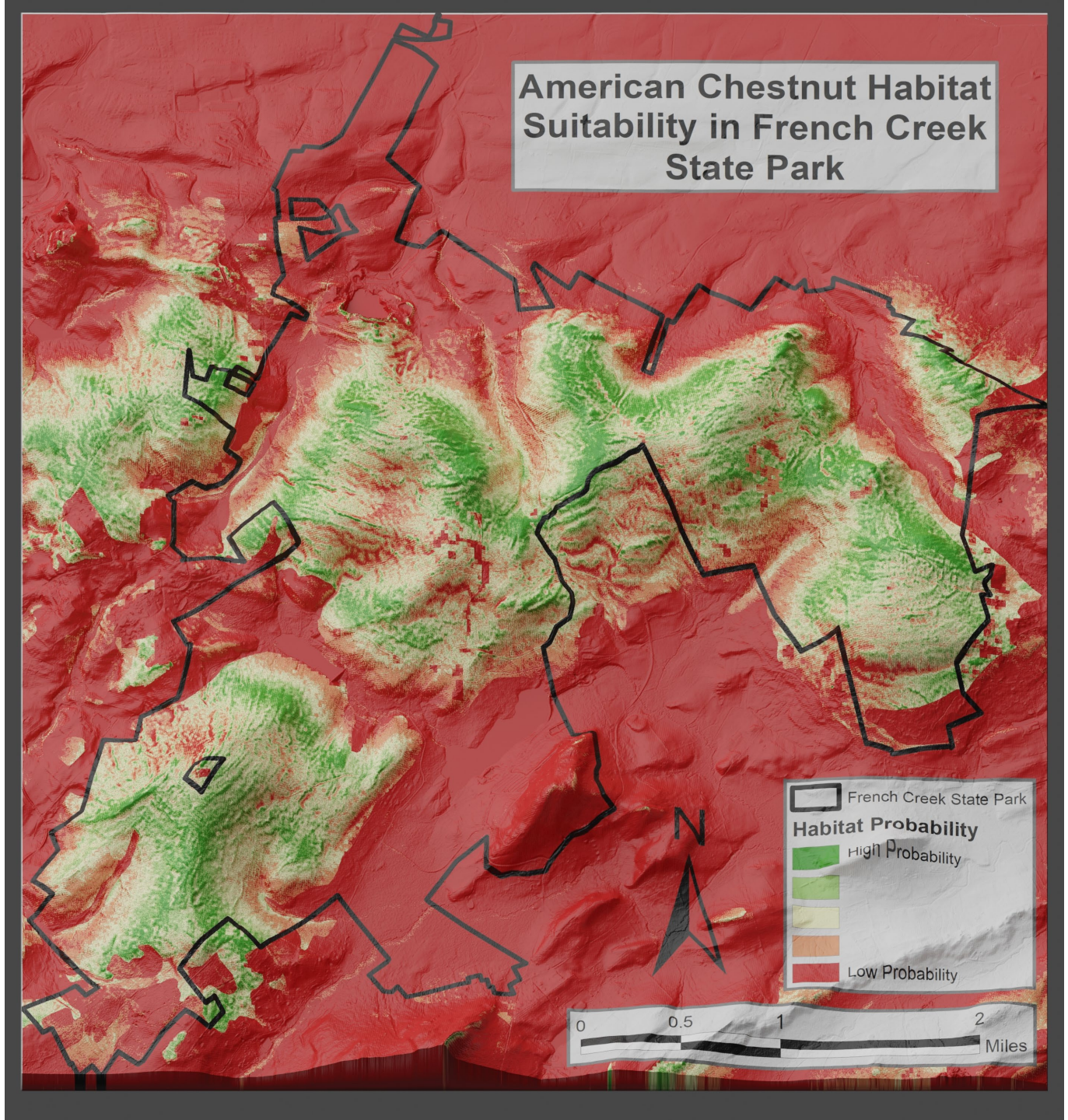
French Creek State Park SDM



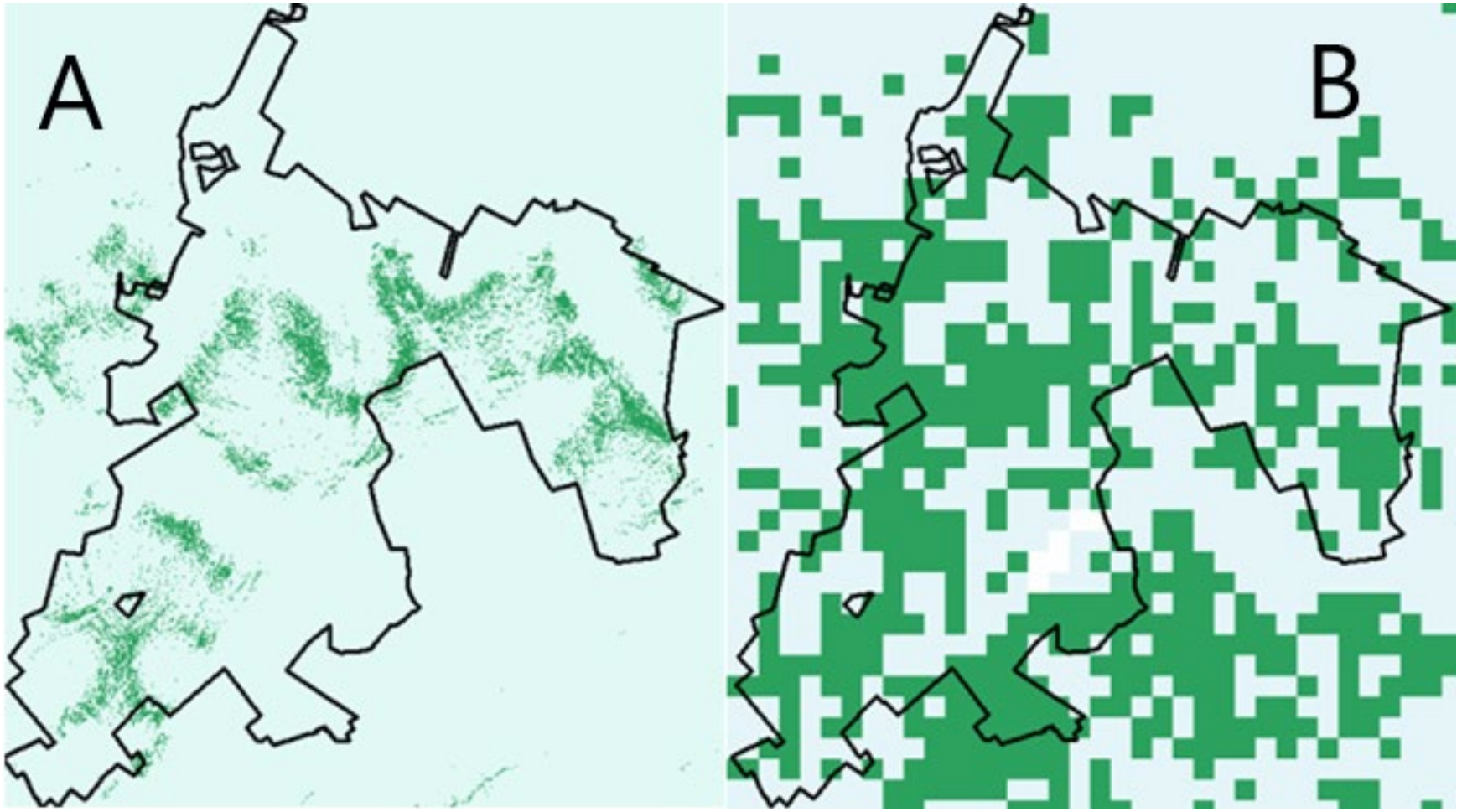
	French Creek Model	
	Predictor	Permutation Importance
Land cover	Canopy cover	17.1
	Distance to streams	9.5
Topography	Elevation	31.6
	Slope	1.8
	Aspect	4.0
	Curvature	0.3
	Topographic convergence index	0.9
	Topographic position index	6.9
	Topographic relative moisture index	5.4
Soil	Soil description	10.0
	Soil field capacity	12.3
	Soil sand content	0.3
		AUC = 0.941






American Chestnut Habitat Suitability in French Creek State Park
French Creek State Park
Habitat Probability
High Probability
Low Probability
N
0
0.5
1
2
Miles

FCSP/Full State Model Comparisons



American chestnut habitat suitability in French Creek State Park by the French Creek State Park model (A) and full state model (B)

Large Extent Coarse Resolution	Local Extent Fine Resolution
•Covers much more area	•Covers significantly less area
•Considers wider range of environmental variables	•Considers narrower range of environmental variables
•Computationally faster	•Computationally intensive
•Less accurate	•More accurate
•Large patch suitability	•Site-specific habitat suitability

Different SDM Techniques

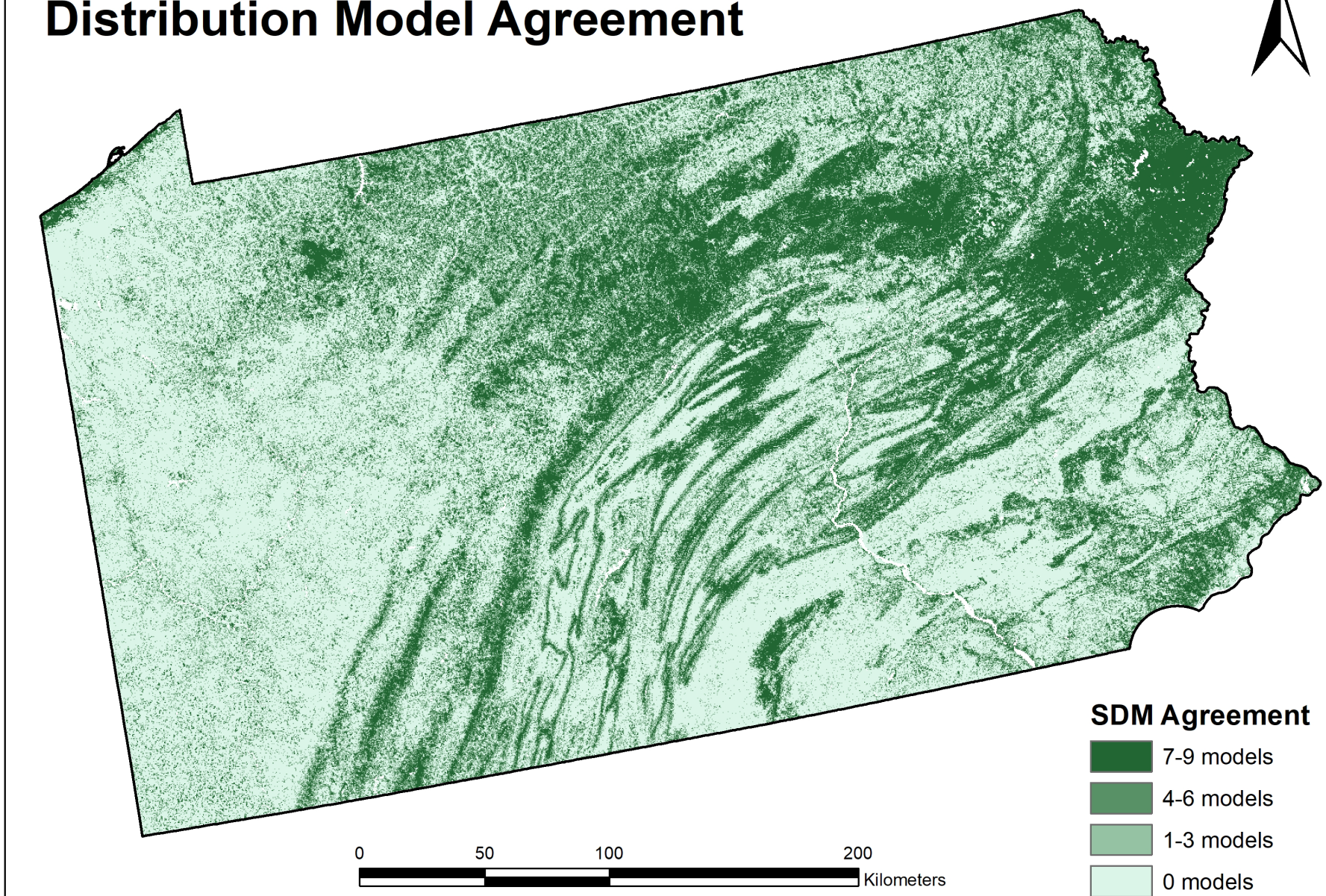
- Statistical or machine learning?
- Linear or non-linear relationships?
- Model interactions between variables?

	AUC	TSS
Technique		
ANN	0.711	0.311
CTA	0.646	0.292
FDA	0.730	0.365
GAM	0.737	0.359
GBM	0.864	0.583
GLM	0.727	0.350
MARS	0.738	0.376
MaxEnt	0.772	0.413
RF	1.000	1.000

Variable Importance Scores

	Modeling technique								
Predictor	ANN	CTA	FDA	GAM	GBM	GLM	MARS	MaxEnt	RF
Land use type	0.209	0.000	0.000	0.038	0.019	0.040	0.000	0.073	0.028
Canopy cover	0.403	0.000	0.000	0.016	0.012	0.000	0.000	0.107	0.054
Distance to streams	0.404	0.000	0.000	0.005	0.004	0.000	0.000	0.026	0.016
Elevation	0.395	0.000	0.000	0.003	0.024	0.000	0.000	0.014	0.046
Slope	0.036	0.000	0.029	0.022	0.024	0.000	0.051	0.022	0.036
Aspect	0.002	0.000	0.000	0.005	0.007	0.000	0.000	0.021	0.021
Curvature	0.000	0.000	0.096	0.122	0.015	0.019	0.109	0.078	0.028
Topographic convergence index	0.063	0.000	0.000	0.173	0.029	0.099	0.038	0.122	0.038
Topographic position index	0.207	0.000	0.107	0.151	0.029	0.096	0.036	0.124	0.032
Topographic relative moisture index	0.090	0.000	0.000	0.098	0.005	0.028	0.000	0.056	0.017
Sand to clay ratio	0.030	0.813	0.739	0.561	0.714	0.691	0.651	0.431	0.328

American Chestnut Species Distribution Model Agreement



Implications

- Large extent, coarse model still produced "good" results
  - Fine scale model performed exceptionally well
- Suggested restoration methodology
  - Extensive, coarse model to identify habitat patches

    -> Local fine scale modeling of patches

    -> Fieldwork to ground truth models

Concluding Thoughts

Translating models to boots-on-the ground: use results to locate planting/experiment sites

Can we trust the models?

- SDM is a *prediction*
- Models are only as good as the data that go into them
- A mix of field studies, models of different types and scales, and experiments is needed to prepare for reintroduction

https://acf.org/

Thank you!

Questions?

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