Mapping Unprotected Evolutionary Distinctiveness of Bryophytes

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How to maximize use of resources?
How to address poorly understood species?
How to minimize extinction effects?

Where in the USA are the collections of the most evolutionarily distinct unprotected species of bryophytes?

1) Maxent Modeling

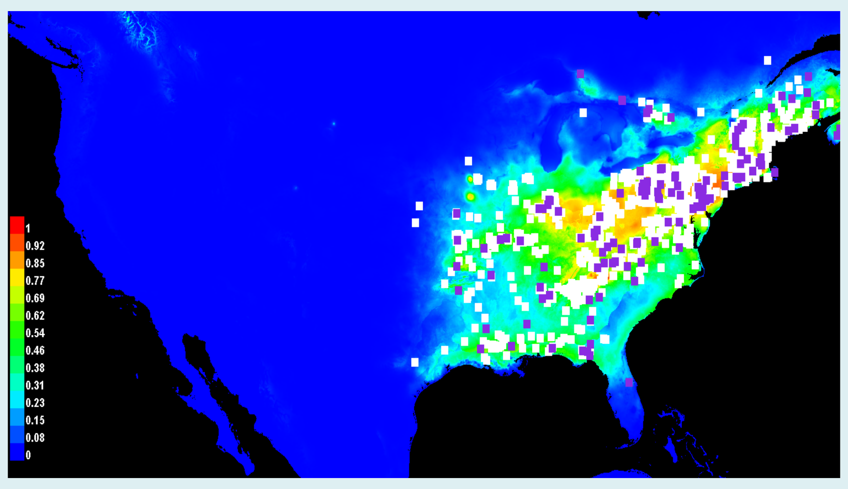
Using observation records from the Consortium of North American Bryophyte Herbaria, WorldClim, and Maxent modeling I produced Species Distribution Models for 835 species. To avoid the information-degrading effect of thresholds,[1,3] I carry prob-abilistic range models all the way through my calculations.

Models are a valuable tool for when we have limited information on abundance, threatened status, nor complete range maps. Biodiversity modeling allows the focusing of resources on efficiently protecting as many as possible.

Working with bryophyte models is advantageous because they are efficient dispersers[8] and are more determined by abiotic factors than most species.

Consortium of North American Bryophyte Herbaria
- building a Global Consortium of Bryophytes and Lichens as keystones of cryptobiotic communities -

WorldClim



Maxent

EDGE or "Evolutionarily Distinct, Globally Endangered" is a valuable metric with calculations for mammals, birds, gymnosperms, and amphibians.[2] Threatened status is not available for bryophytes nor are comprehensive abundance estimates so I restricted myself to ED only.

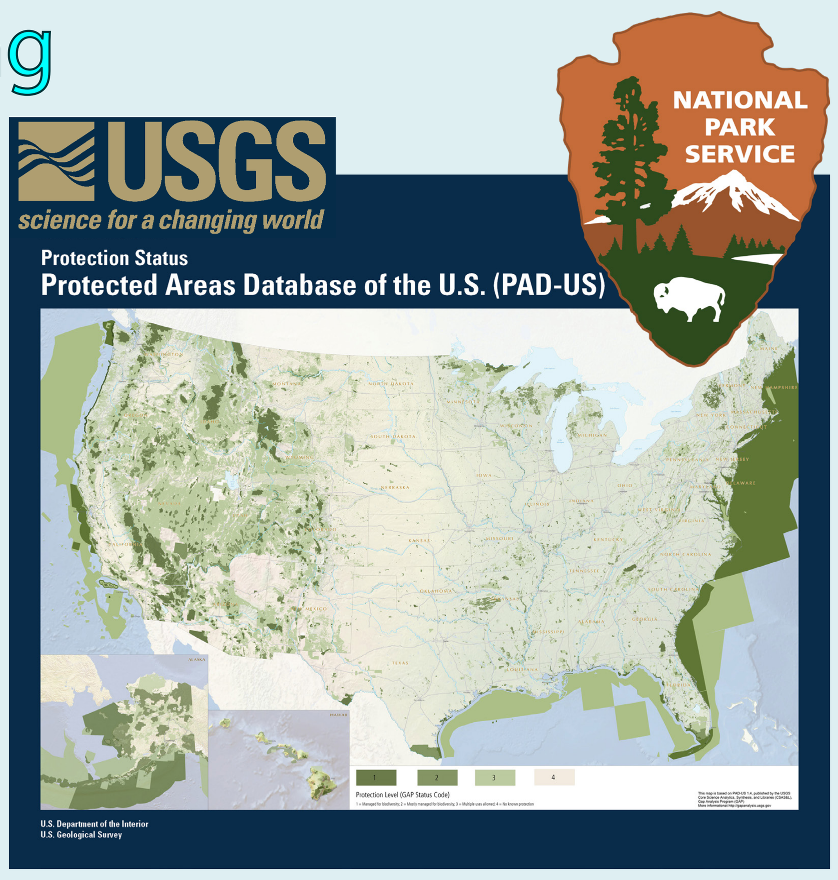
NatureServe also is taking a similar approach with their Map of Biodiveristy Importance project.[5]

In ED, designating a separate species "divides" the branch so it is evenly shared between the two populations, rather than doubling the value of the species.

2) Protection Weighting

The goal is to identify biodiverse areas for conservation that would preserve the most vulnerable species. Species which have no habitat in federally protected lands managed for biodiversity are emphasized.

Protected areas are from PAD-US by the USGS GAP Analysis Project.[7]

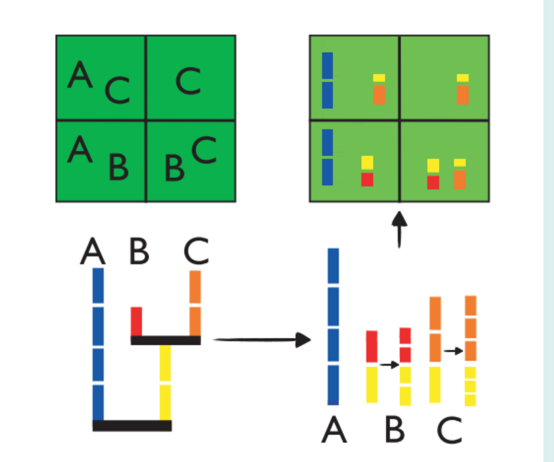


Species maps which are less certain to be accurate representations are penalized. Model accuracy was checked by a 20% Jackknife and AUC and MAE.[4] A low-confidence species map has less influence on the final map.

Thus, to improve the power of the final map,[6] I include all maps but weight each range map by an uncertainty factor related to that map's quality.

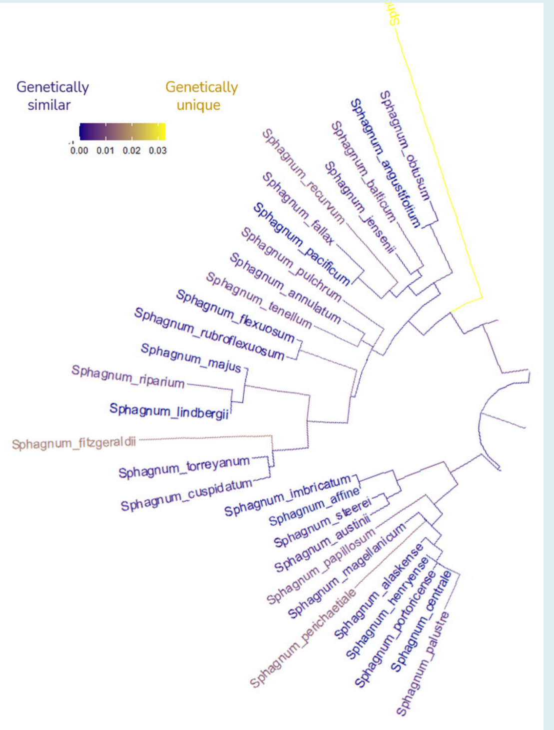
3) Evolutionary Distinctiveness Weighting

Evolutionary Distinctiveness is an indicator of unique traits.



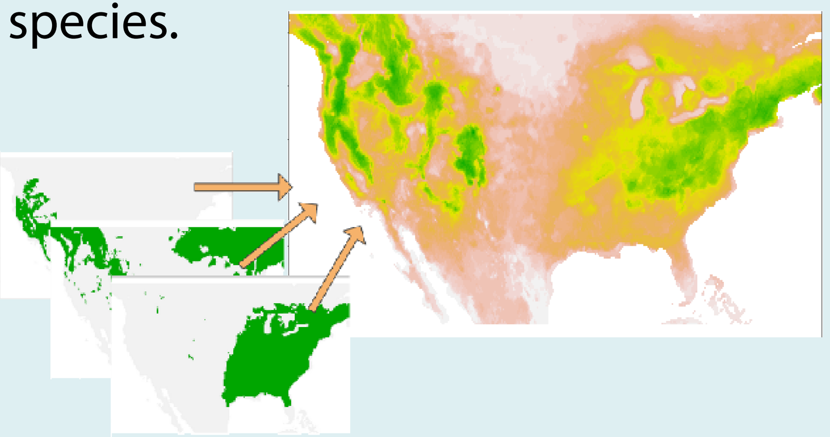
The effect of this is:
Species which have diverged significantly from their relatives score higher
Species with few remaining relatives score higher

Evolutionary Distinctiveness is a measure of the branch lengths from tip to root for all species. Shared branch lengths are equally divided by the species which share them.[2]

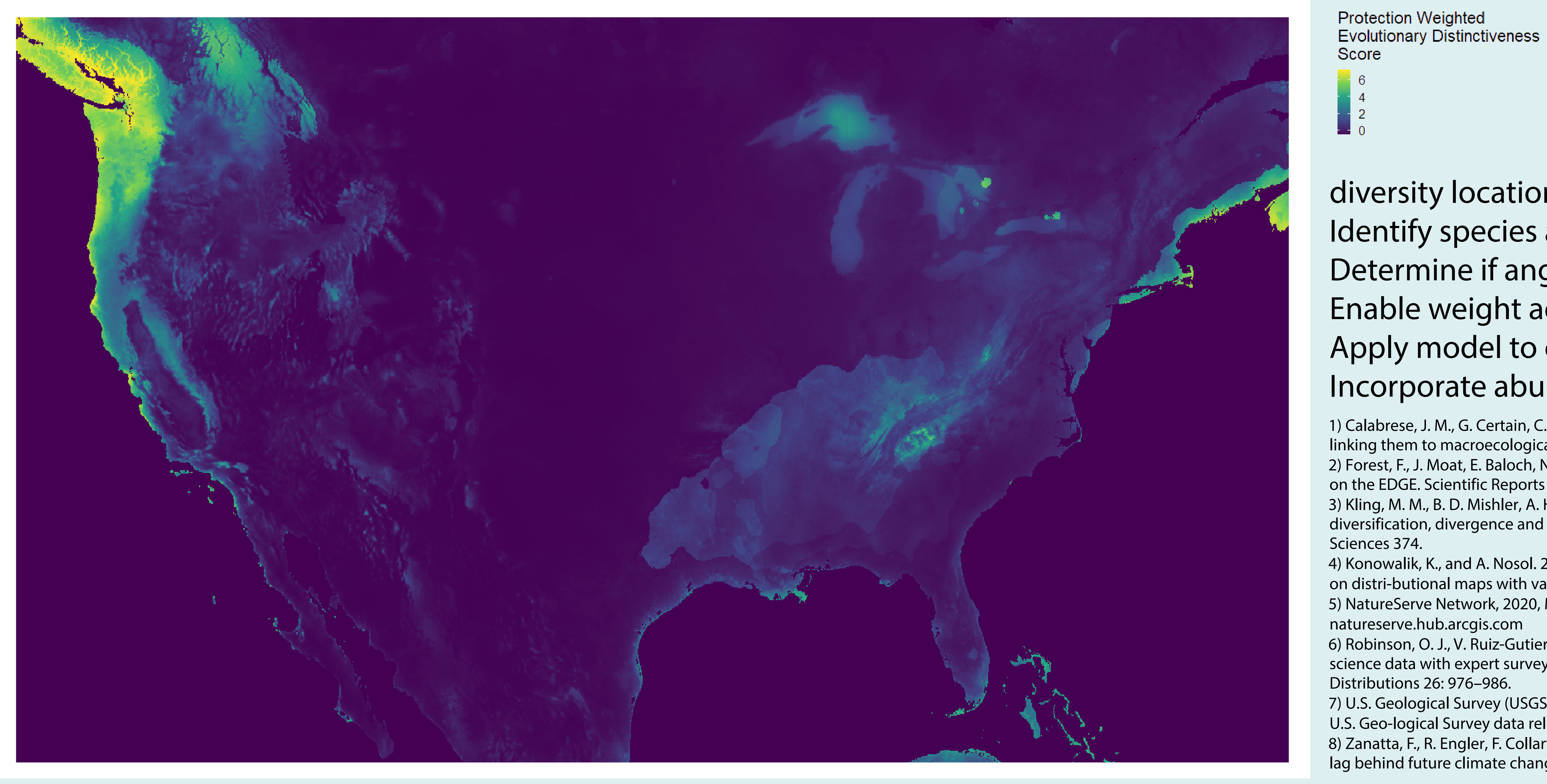


By measuring genetic divergence rather than species, ED is linked more directly to trait variety, evolutionary history, and many other goals in conservation.
Evolutionary Distinctiveness is a measure of total unique genetic mutations and proportion of the phylogenetic tree represented by that species.

In the final stage, species range maps are weighted and combined to generate a final map highlighting regions with high unprotected evolutionary distinctiveness.



This map of the least protected, most evolutionarily distinct bryophyte species can add to conservation understanding of the best hotspots of biodiveristy to protect. Despite limited information, actions can be taken to prioritize the species most in need of attention.



Ongoing Work:

Improve modeling results and scaling.
Estimate ED for an additional 1200 species.
Compare collection intensities with predicted diversity locations.
Identify species and species traits which modeled poorly.
Determine if angiosperms display similar patterns of ED.
Enable weight adjustment according to management goals.
Apply model to other Orders.
Incorporate abundance & extinction risk.

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3) Kling, M. M., B. D. Mishler, A. H. Thornhill, B. G. Baldwin, and D. D. Ackerly. 2019. Facets of phylodiversity: Evolutionary diversification, divergence and survival as conservation targets. Philosophical Transactions of the Royal Society B: Biological Sciences 374.
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6) Robinson, O. J., V. Ruiz-Gutierrez, M. D. Reynolds, G. H. Golet, M. Strimas-Mackey, and D. Fink. 2020. Integrating citizen science data with expert surveys increases accuracy and spatial extent of species distribution models. Diversity and Distributions 26: 976–986.
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