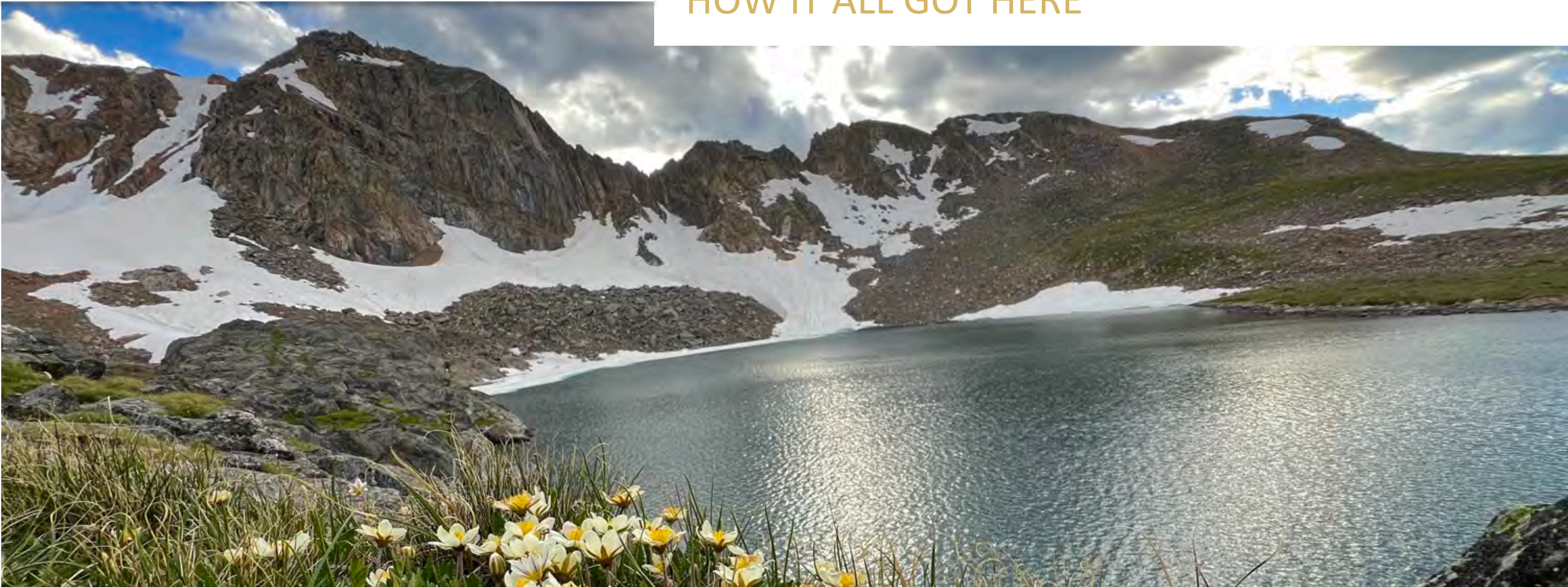
HOW IT ALL GOT HERE



Background

WHAT	TAXONOMY & SYSTEMATICS
WHERE	SPATIAL DATA
WHEN (and what)	GENETICS
WHY	ENVIRONMENT

Baby Bort

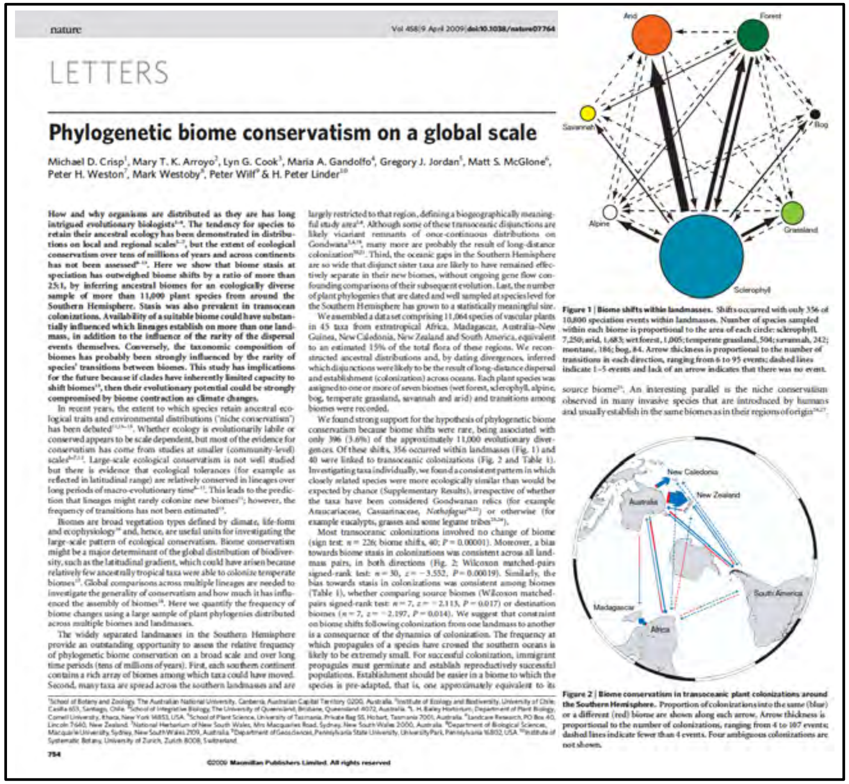
Crisp Lab

THE AUSTRALIAN NATIONAL UNIVERSITY

Cook Lab

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

"Using phylogenies to test hypotheses about date, rate and mode of diversification and evolution of Australian plants and animals"

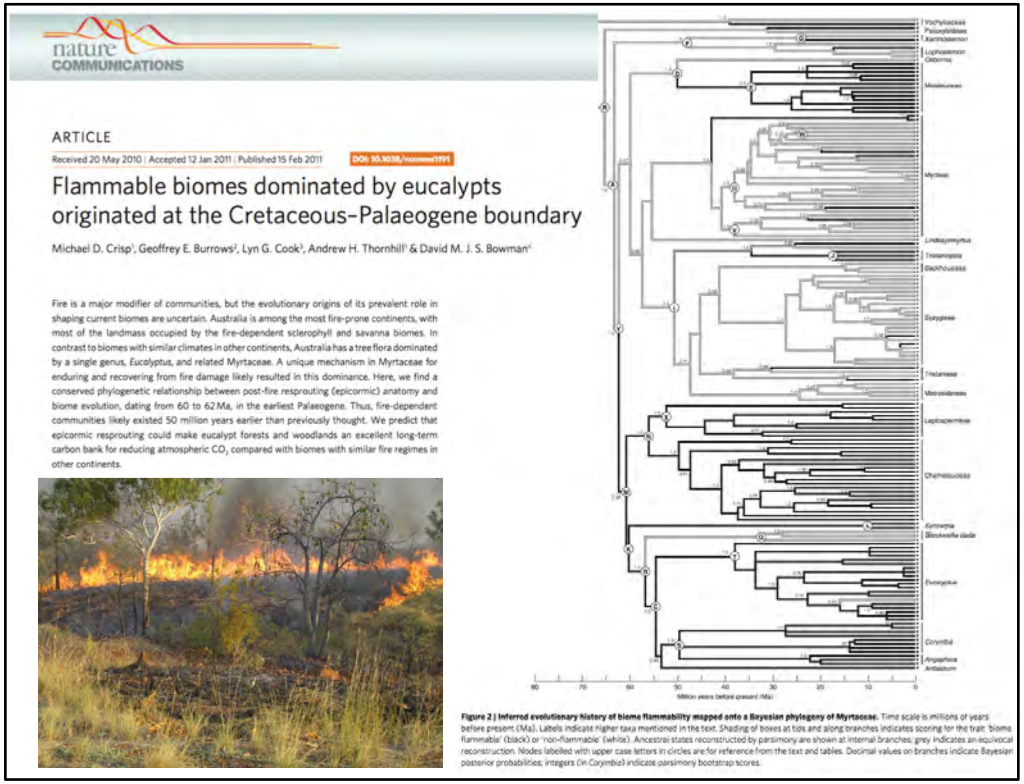


nature Vol 458|9 April 2009|doi:10.1038/nature07764

LETTERS

Phylogenetic biome conservatism on a global scale

Michael D. Crisp[1], Mary T. K. Arroyo[2], Lyn G. Cook[3], Maria A. Gandolfo[4], Gregory J. Jordan[5], Matt S. McGlone[6], Peter H. Weston[7], Mark Westoby[8], Peter Wilf[9] & H. Peter Linder[10]



nature COMMUNICATIONS

ARTICLE

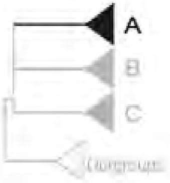
Received 20 May 2010 | Accepted 12 Jan 2011 | Published 15 Feb 2011

Flammable biomes dominated by eucalypts originated at the Cretaceous–Palaeogene boundary

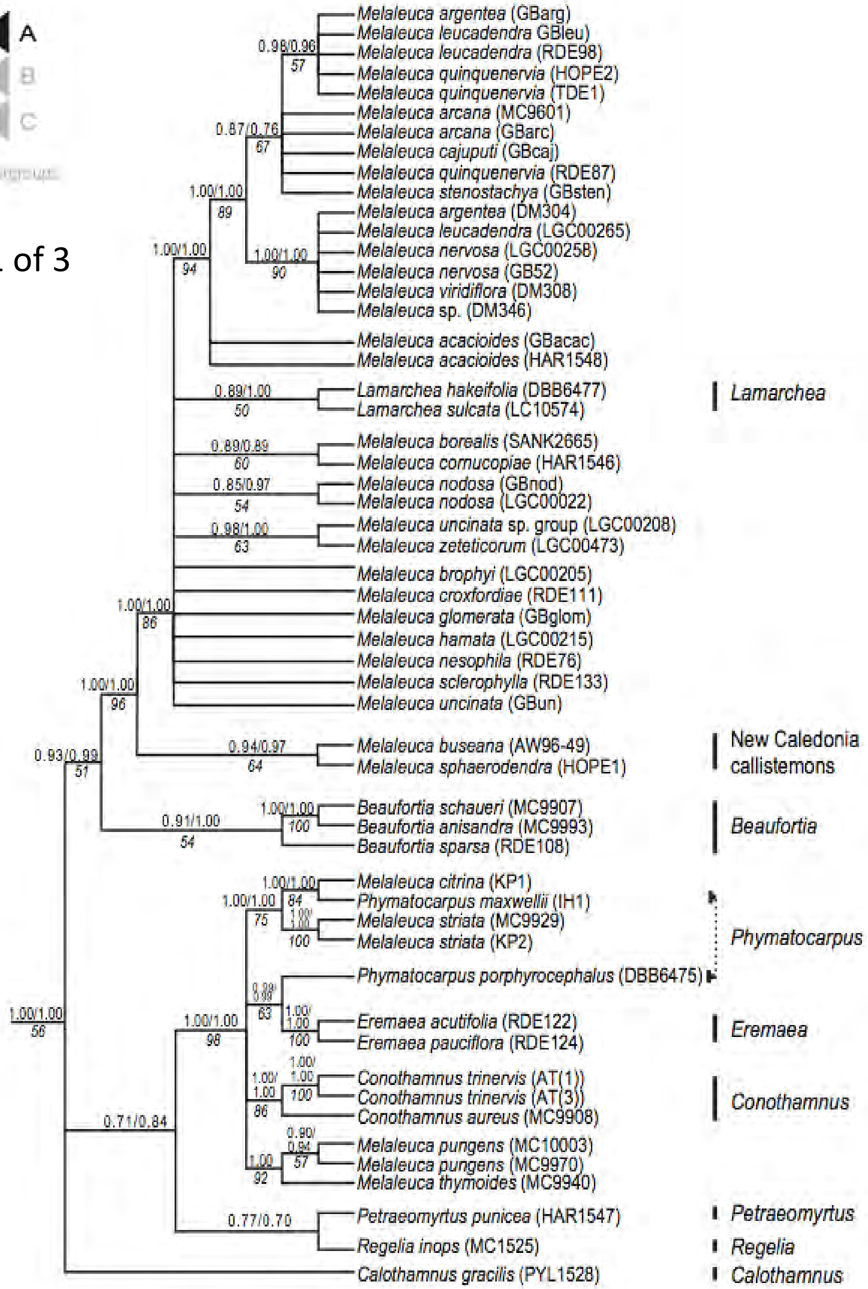
Michael D. Crisp[1], Geoffrey E. Burrows[2], Lyn G. Cook[3], Andrew H. Thornhill[1] & David M. J. S. Bowman[4]

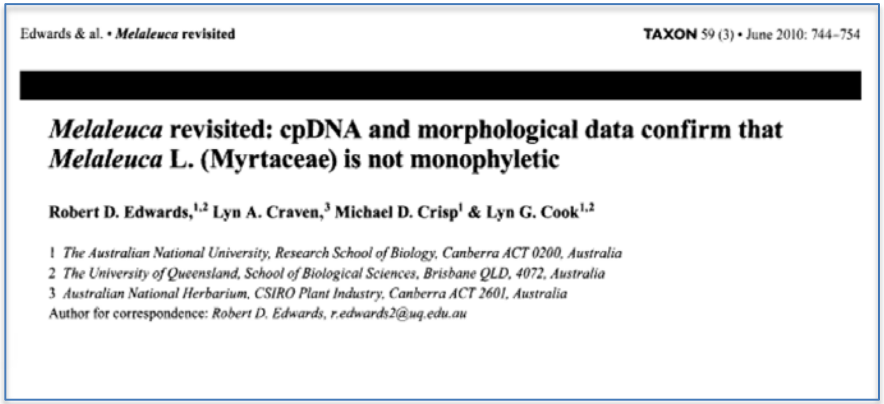
Fire is a major modifier of communities, but the evolutionary origins of its prevalent role in shaping current biomes are uncertain. Australia is among the most fire-prone continents, with most of the landmass occupied by the fire-dependent sclerophyll and savanna biomes. In contrast to biomes with similar climates in other continents, Australia has a tree flora dominated by a single genus, *Eucalyptus*, and related Myrtaceae. A unique mechanism in Myrtaceae for enduring and recovering from fire damage likely resulted in this dominance. Here, we find a conserved phylogenetic relationship between post-fire resprouting (epicormic) anatomy and biome evolution, dating from 60 to 62 Ma, in the earliest Palaeogene. Thus, fire-dependent communities likely existed 50 million years earlier than previously thought. We predict that epicormic resprouting could make eucalypt forests and woodlands an excellent long-term carbon bank for reducing atmospheric CO_2 compared with biomes with similar fire regimes in other continents.

Systematics of Melaleuca



Clade 1 of 3



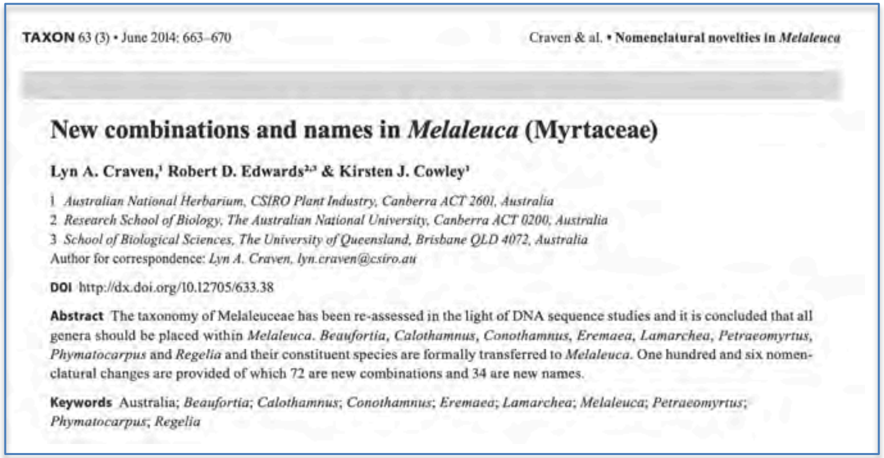


Edwards & al. • ***Melaleuca* revisited** | **TAXON** 59 (3) • June 2010: 744–754

Melaleuca revisited: cpDNA and morphological data confirm that *Melaleuca* L. (Myrtaceae) is not monophyletic

Robert D. Edwards,[1,2] Lyn A. Craven,[3] Michael D. Crisp[1] & Lyn G. Cook[1,2]

1 *The Australian National University, Research School of Biology, Canberra ACT 0200, Australia*
2 *The University of Queensland, School of Biological Sciences, Brisbane QLD, 4072, Australia*
3 *Australian National Herbarium, CSIRO Plant Industry, Canberra ACT 2601, Australia*
Author for correspondence: *Robert D. Edwards, r.edwards2@uq.edu.au*



TAXON 63 (3) • June 2014: 663–670 | Craven & al. • **Nomenclatural novelties in *Melaleuca***

New combinations and names in *Melaleuca* (Myrtaceae)

Lyn A. Craven,[1] Robert D. Edwards[2,3] & Kirsten J. Cowley[1]

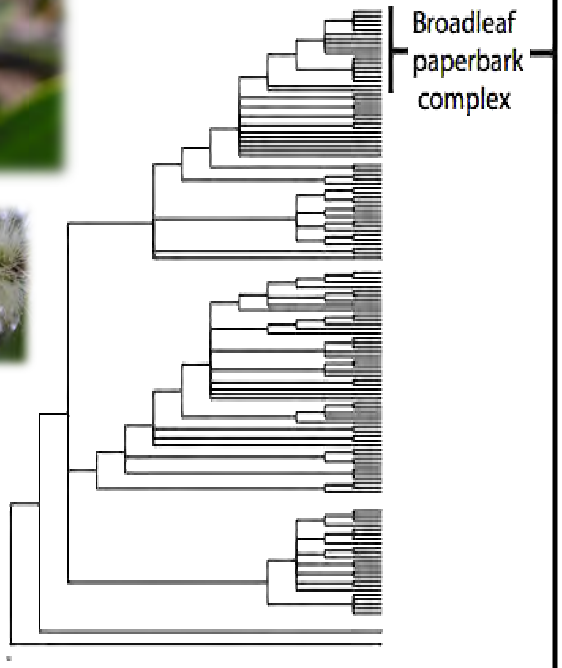
1 *Australian National Herbarium, CSIRO Plant Industry, Canberra ACT 2601, Australia*
2 *Research School of Biology, The Australian National University, Canberra ACT 0200, Australia*
3 *School of Biological Sciences, The University of Queensland, Brisbane QLD 4072, Australia*
Author for correspondence: *Lyn A. Craven, lyn.craven@csiro.au*

DOI http://dx.doi.org/10.12705/633.38

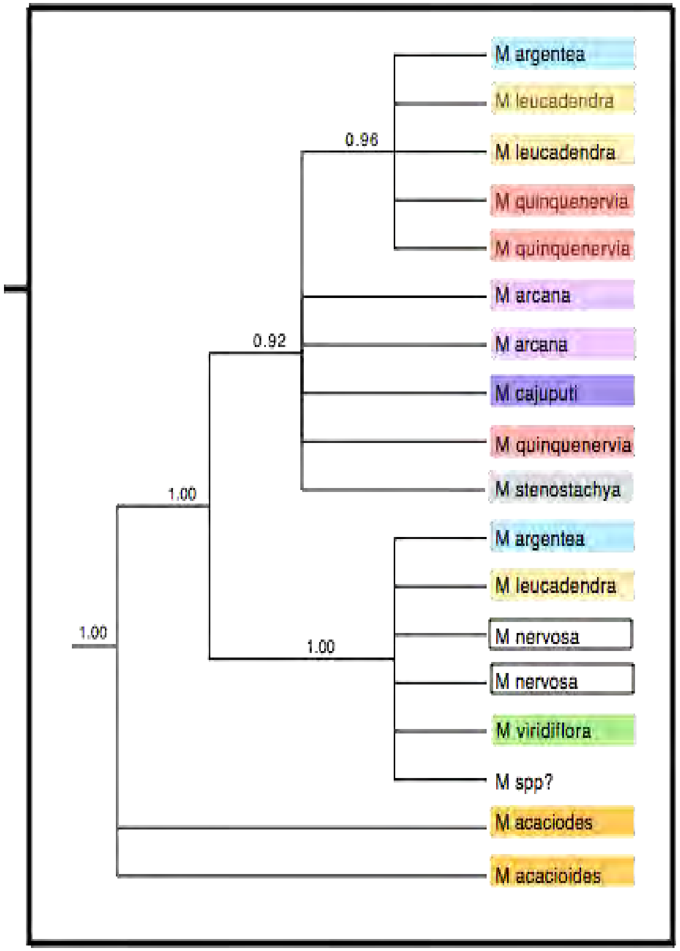
Abstract The taxonomy of Melaleuceae has been re-assessed in the light of DNA sequence studies and it is concluded that all genera should be placed within *Melaleuca*. *Beaufortia*, *Calothamnus*, *Conothamnus*, *Eremaea*, *Lamarchea*, *Petraeomyrtus*, *Phymatocarpus* and *Regelia* and their constituent species are formally transferred to *Melaleuca*. One hundred and six nomenclatural changes are provided of which 72 are new combinations and 34 are new names.

Keywords Australia; *Beaufortia*; *Calothamnus*; *Conothamnus*; *Eremaea*; *Lamarchea*; *Melaleuca*; *Petraeomyrtus*; *Phymatocarpus*; *Regelia*

Systematics of Melaleuca - Broadleaved Paperbarks

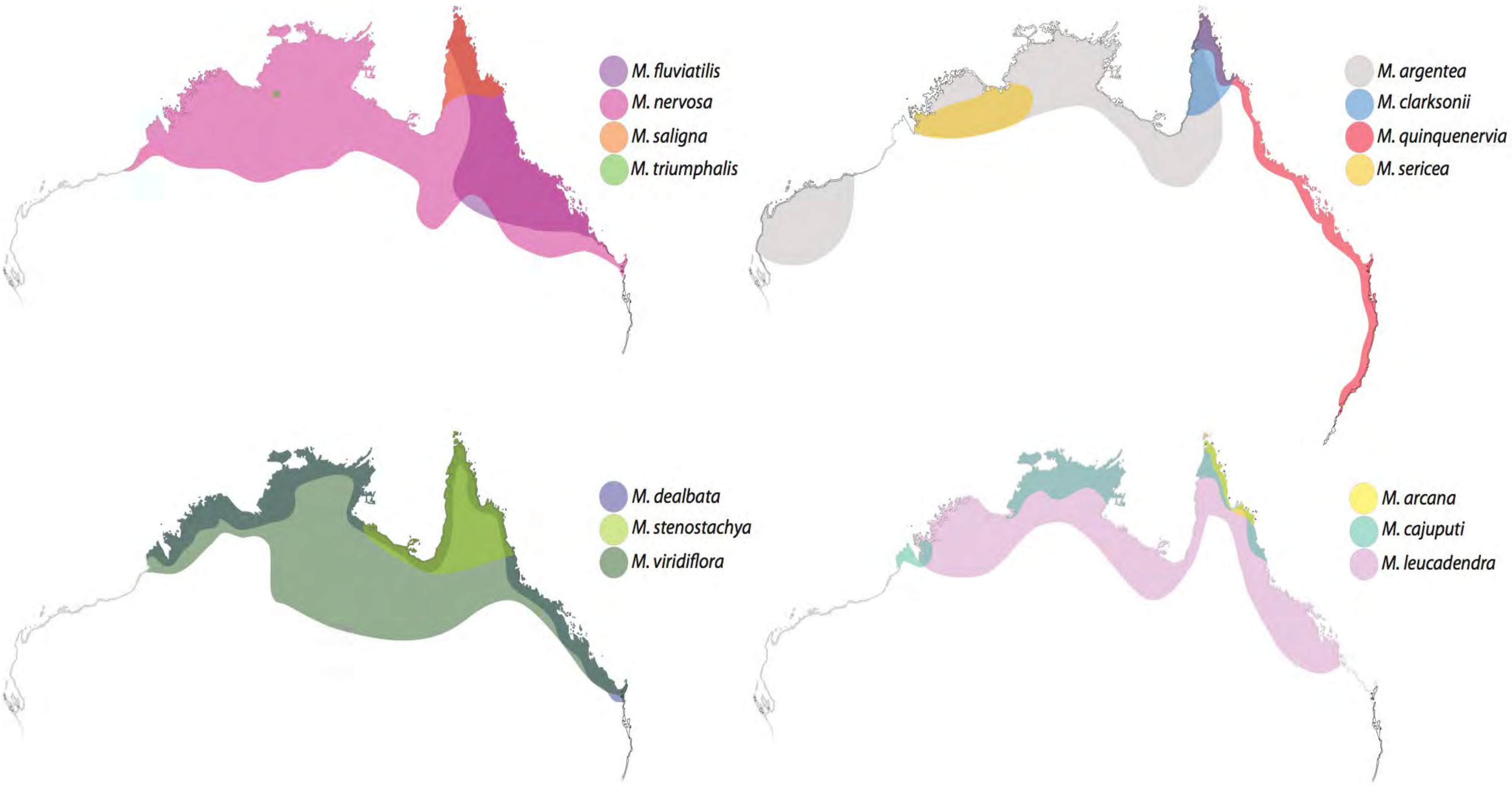


(Edwards et al., 2010)

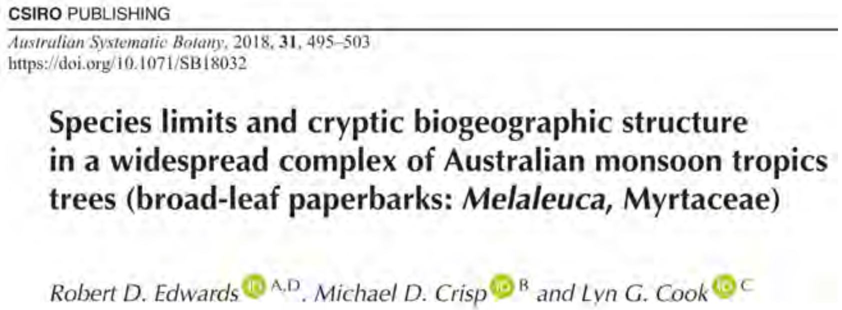


(Cook et al., 2008)

Systematics of Melaleuca - Broadleaved Paperbarks



Systematics of Melaleuca - Broadleaved Paperbarks

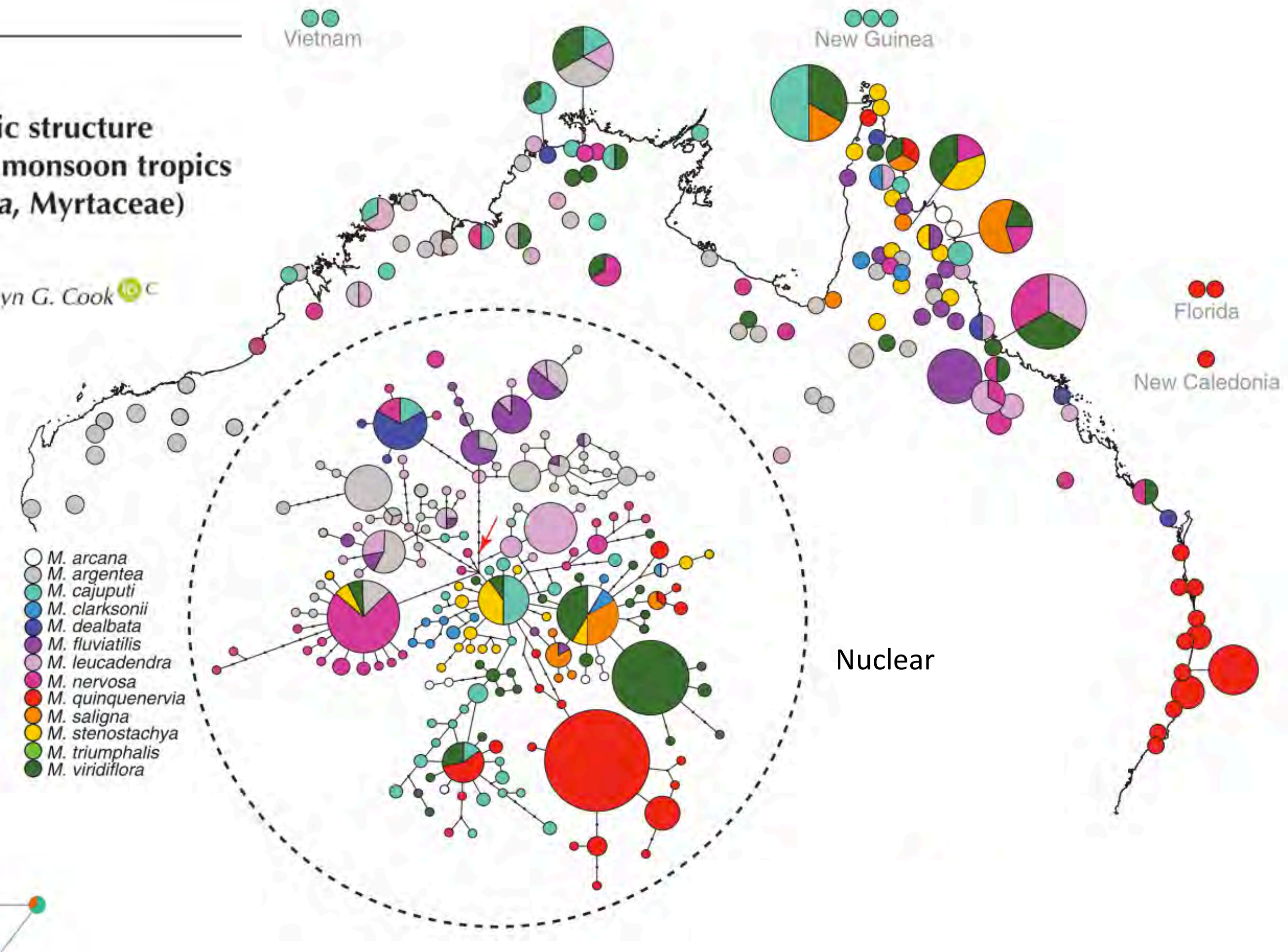


CSIRO PUBLISHING

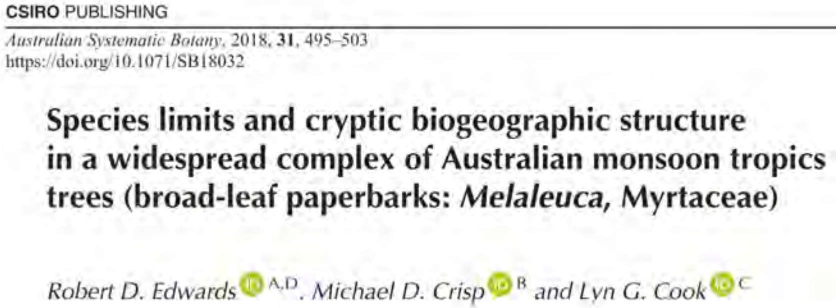
Australian Systematic Botany, 2018, **31**, 495–503
https://doi.org/10.1071/SB18032

Species limits and cryptic biogeographic structure in a widespread complex of Australian monsoon tropics trees (broad-leaf paperbarks: *Melaleuca*, Myrtaceae)

Robert D. Edwards [A,D], *Michael D. Crisp* [B] *and Lyn G. Cook* [C]



Systematics of Melaleuca - Broadleaved Paperbarks

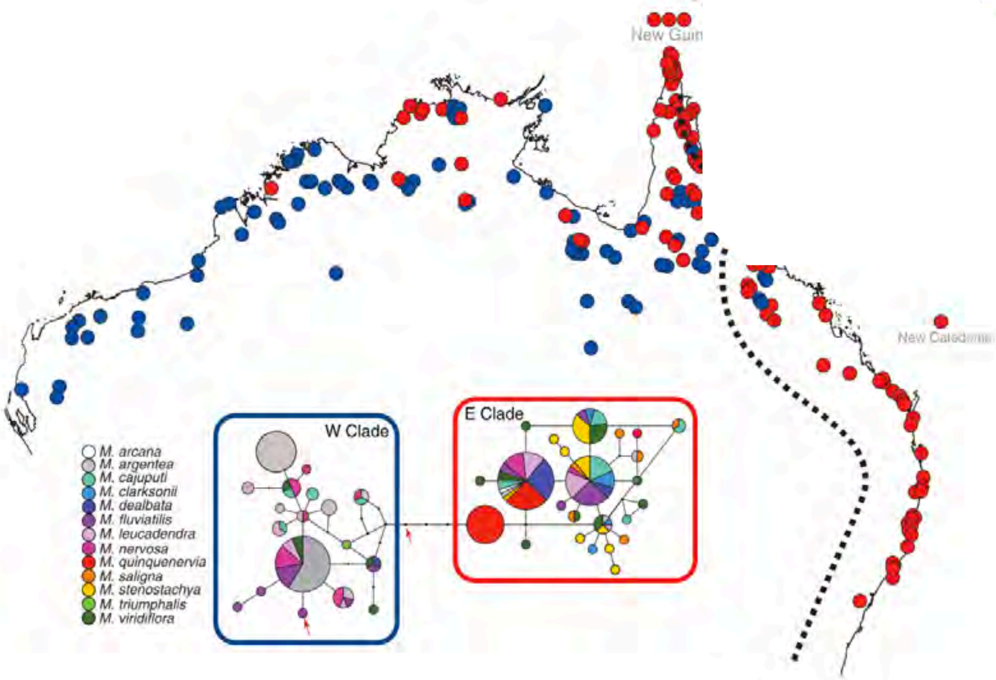


CSIRO PUBLISHING

Australian Systematic Botany, 2018, **31**, 495–503
https://doi.org/10.1071/SB18032

Species limits and cryptic biogeographic structure in a widespread complex of Australian monsoon tropics trees (broad-leaf paperbarks: *Melaleuca*, Myrtaceae)

Robert D. Edwards[A,D], *Michael D. Crisp*[B] *and Lyn G. Cook*[C]

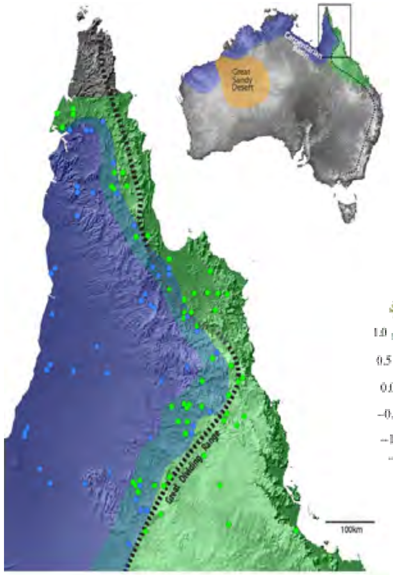


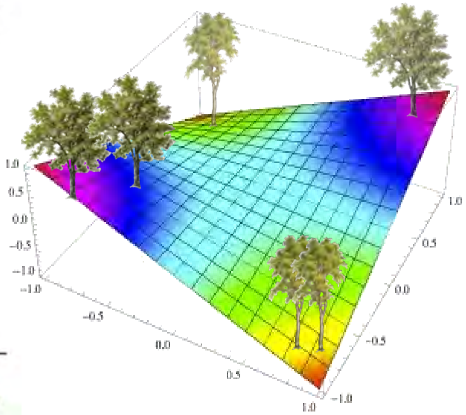
Journal of Biogeography (*J. Biogeogr.*) (2013) **40**, 559–569

ORIGINAL ARTICLE

Niche differentiation and spatial partitioning in the evolution of two Australian monsoon tropical tree species

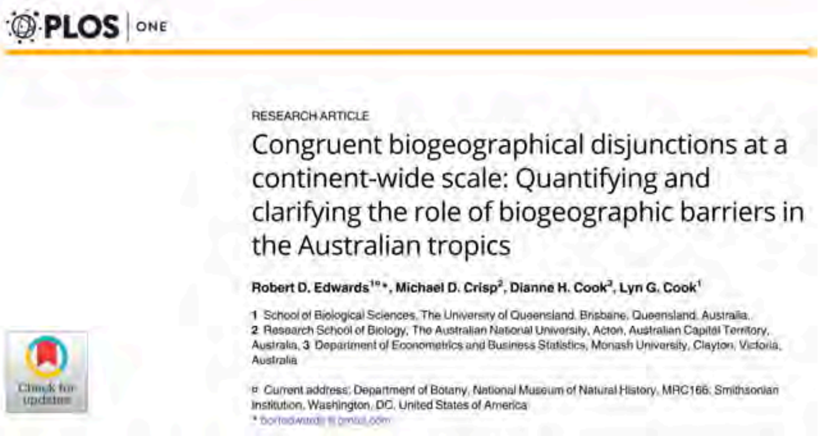
Robert D. Edwards[1]*, Michael D. Crisp[2] and Lyn G. Cook[1]





- Niche values estimated via MaxEnt (Phillips *et al*, 2006)
- Values within and between species ranges are compared against randomized distributions (ENMtools (Glor & Warren, 2010)

Biogeography of the Australian Monsoon Flora



PLOS | ONE

RESEARCH ARTICLE

Congruent biogeographical disjunctions at a continent-wide scale: Quantifying and clarifying the role of biogeographic barriers in the Australian tropics

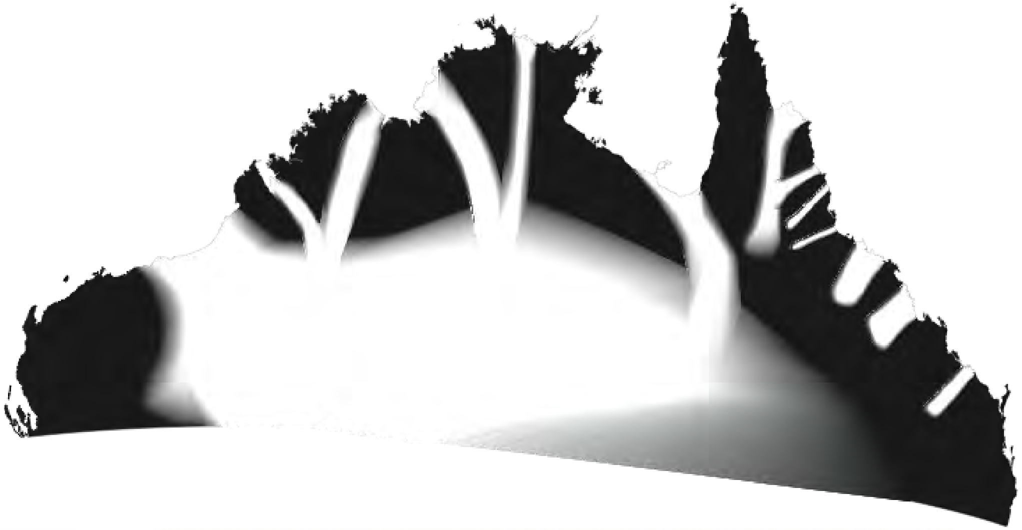
Robert D. Edwards[1¤*], **Michael D. Crisp**[2], **Dianne H. Cook**[3], **Lyn G. Cook**[1]

1 School of Biological Sciences, The University of Queensland, Brisbane, Queensland, Australia, 2 Research School of Biology, The Australian National University, Acton, Australian Capital Territory, Australia, 3 Department of Econometrics and Business Statistics, Monash University, Clayton, Victoria, Australia

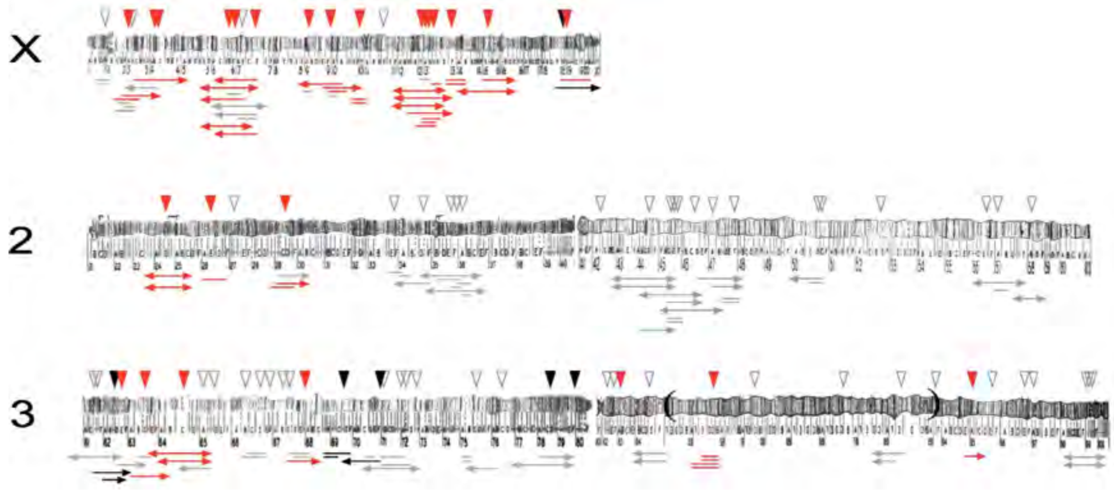
¤ Current address: Department of Botany, National Museum of Natural History, MRC166, Smithsonian Institution, Washington, DC, United States of America

* [illegible]

Check for updates



Species-isolation genes in Drosophila



Smithsonian Institution

Environmental Drivers of Species Diversity

Smithsonian Institution
Vicki Funk

CSIRO
Elisabeth Bui

UCF
Chase Mason

USGS
Marty Goldhaber

USGS
Ian Pearse

USGS
Travis Nauman

USGS
Jen Cartwright

UF UNIVERSITY of FLORIDA
Pamela Soltis

Boulder Parks & Recreation
Brian Anacker

GBIF Global Biodiversity Information Facility
Joe Miller

USDA
Jim Thompson

Powell Center

Smithsonian Institution

iDigBio Integrated Digitized Biocollections

Defining and Delimiting Extremes

Extreme environment: *a habitat where conditions are outside the optimal range for organisms to survive*

Defining and Delimiting Extremes

Extreme environment: *a habitat where conditions are outside the optimal range for organisms to survive*

- Extreme habitats are often identified by a lack of organisms or lack of diversity of organisms
- What for one organism is considered intolerable may not be so for another
- Multiple factors may be “extreme” and contribute to the inhospitableness of an environment
- As a result the threshold(s) for “extreme” are often idiosyncratic and determined on a by-species and/or by variable basis

Defining and Delimiting Extremes

Challenge:

Define extreme environments objectively

Test hypotheses on the response of biotic processes non-circularly and across many species

- – eg. trait presence, body size, species diversity

Defining and Delimiting Extremes

Challenge:

Define extreme environments objectively

Test hypotheses on the response of biotic processes non-circularly and across many species

- – eg. trait presence, body size, species diversity

For terrestrial organisms the comfortable envelope for survival typically exists towards the middle of the range of environmental variables

ie. (by definition) the upper and/or lower tail of values for a variable are the extremes

Defining and Delimiting Extremes

Climate

Worldclim2 – 19 variables

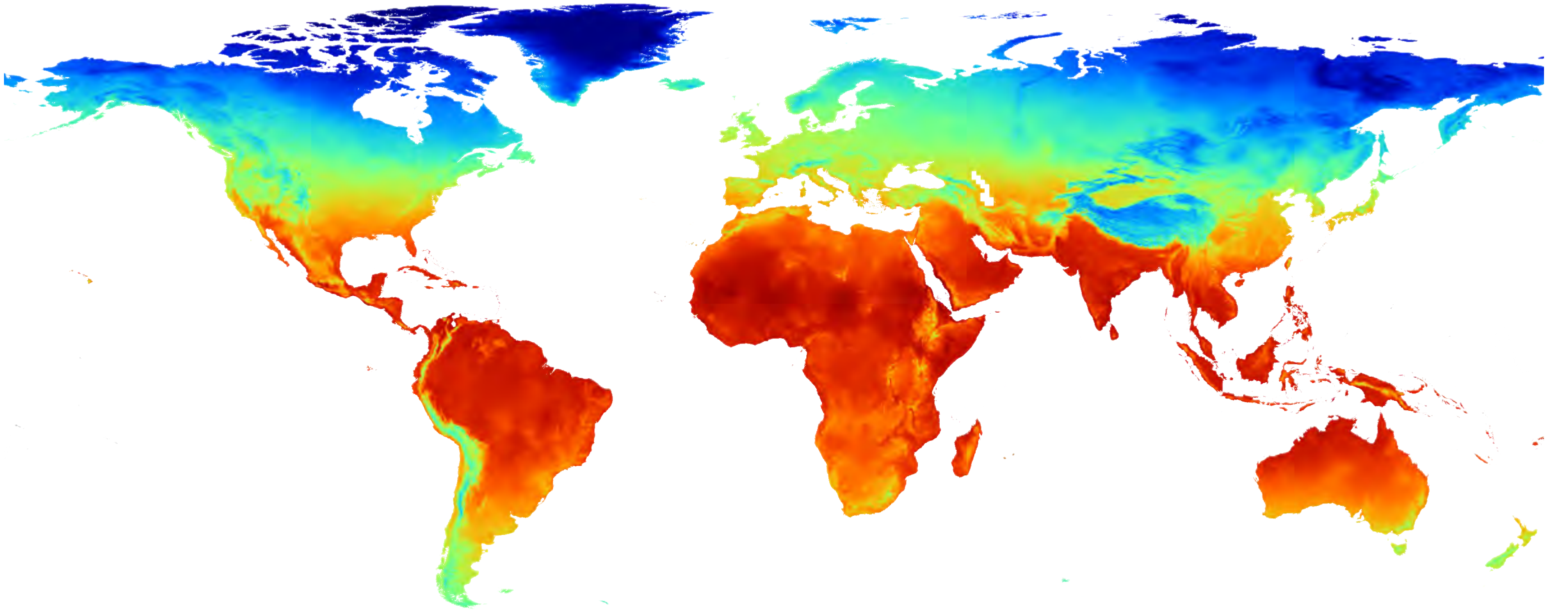
(Fick et al., 2017)

Soil and Elevation

SoilGrids 1km – 21 variables

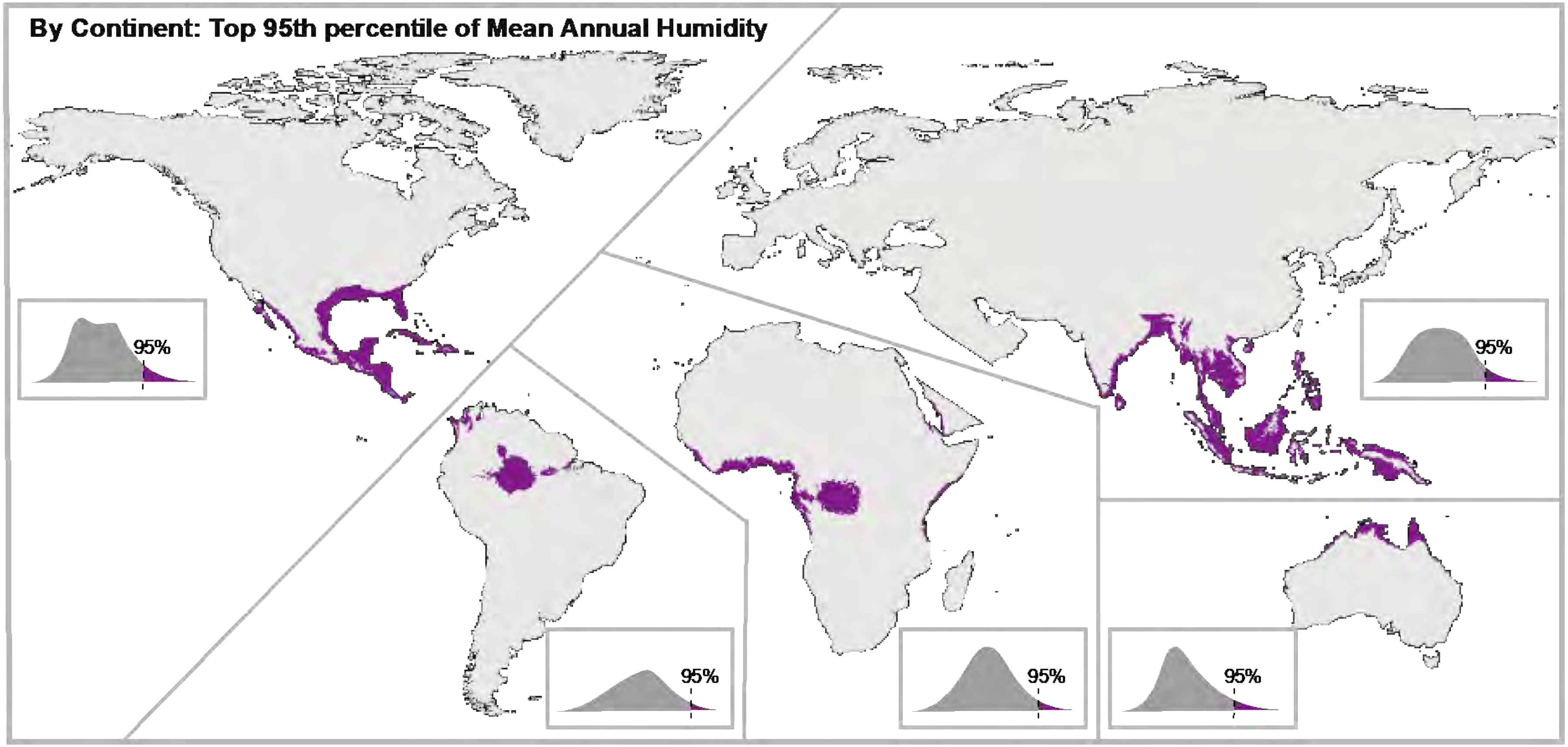
(Hengl et al., 2017)

Initial 40 variables reduced to 24 relevant non-colinear set



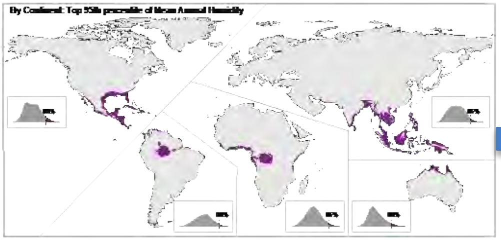
Defining and Delimiting Extremes

Individual variable

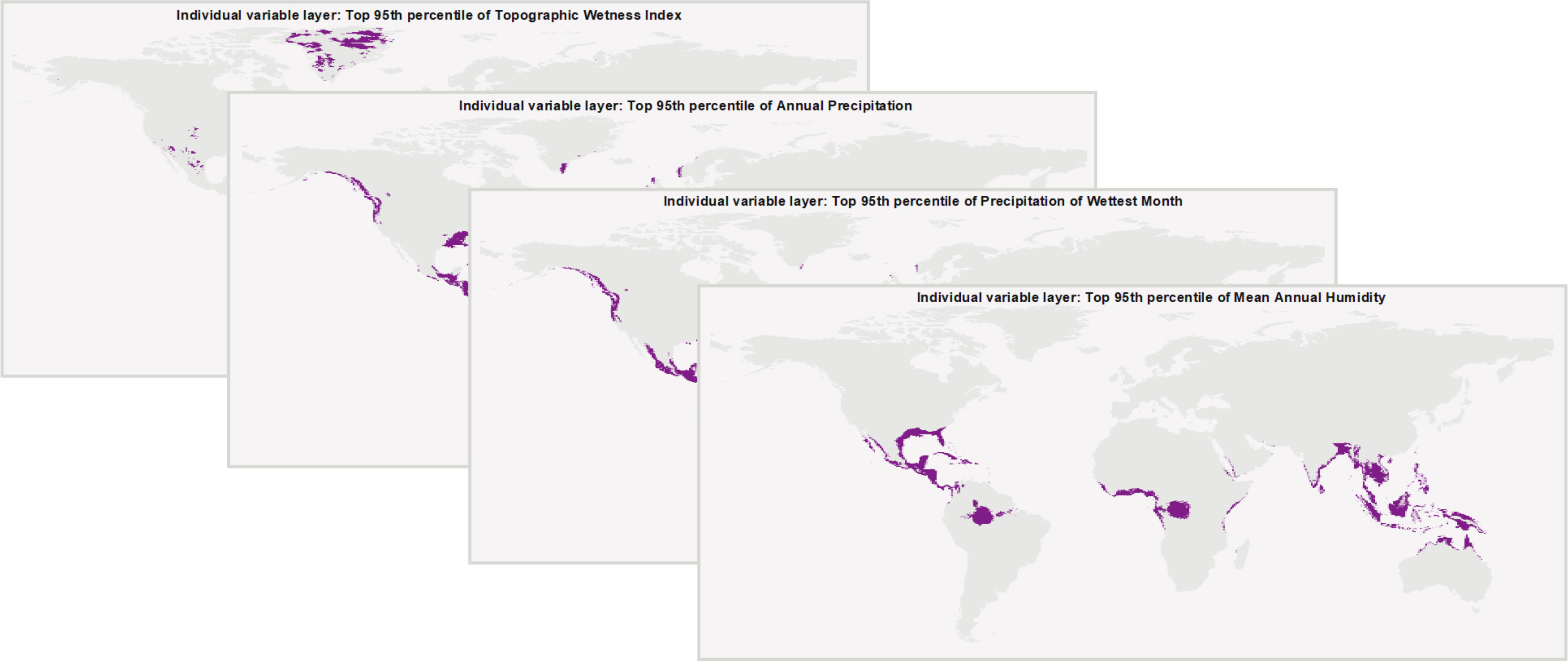


1km^2 pixel resolution

Defining and Delimiting Extremes

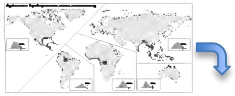


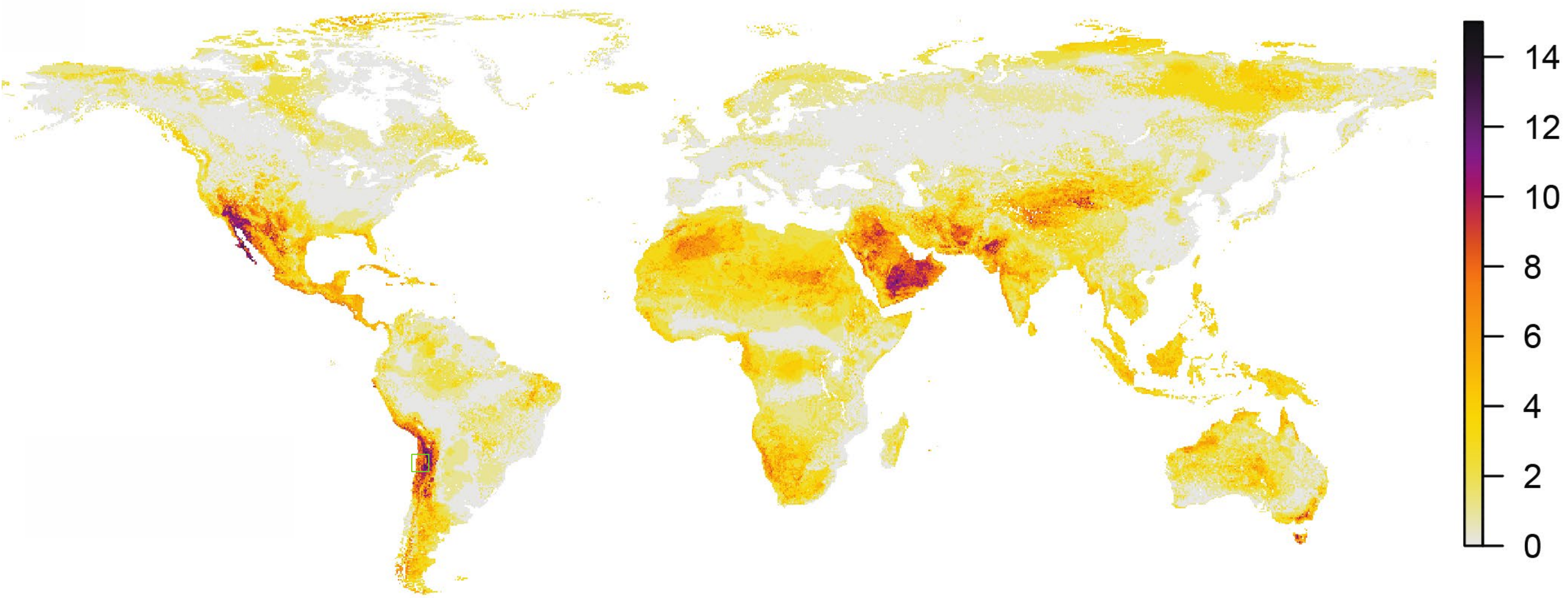
Stack of variables



Daisy Diversity Response to Extremes

- Defining and Delimiting Extremes

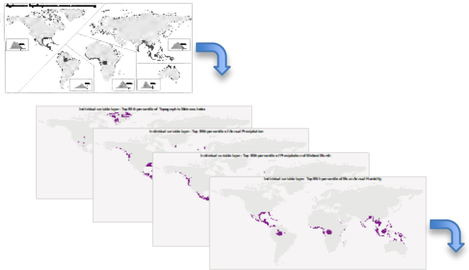




Number of Overlapping Extremes

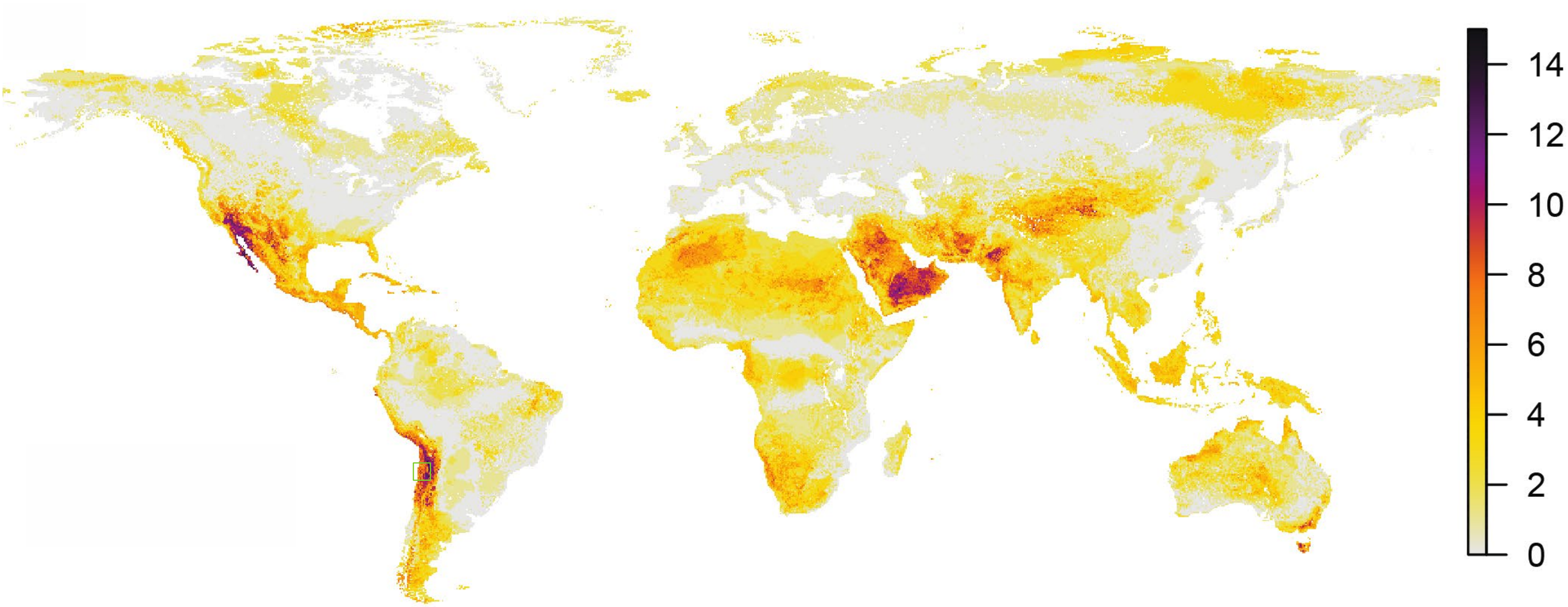
Daisy Diversity Response to Extremes

- Defining and Delimiting Extremes



Hypothesis:

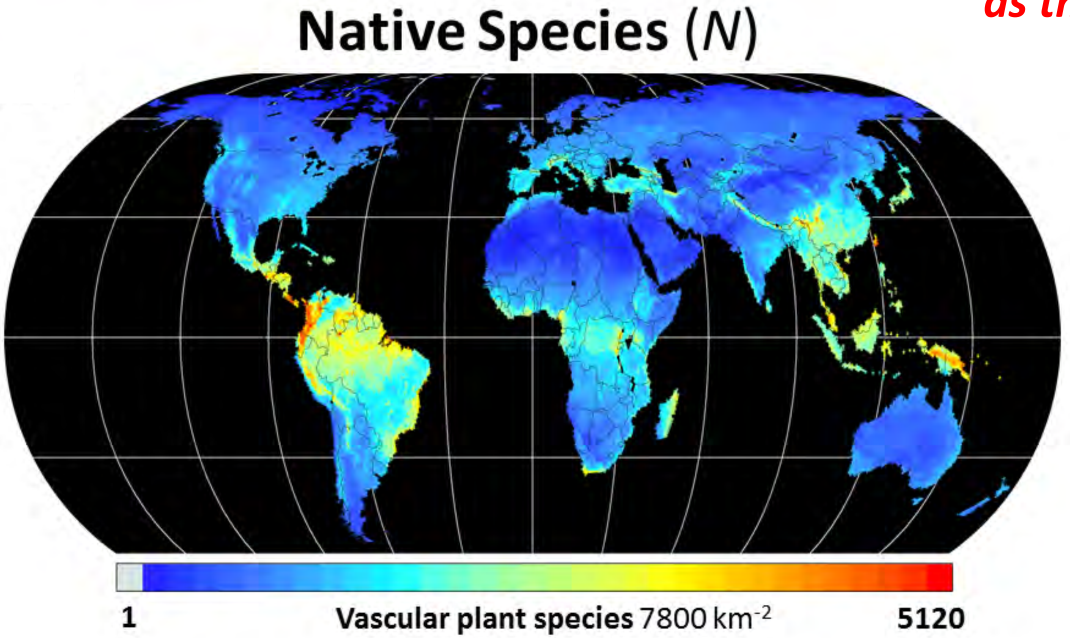
Species diversity will decrease as the number of overlapping extremes increases



Number of Overlapping Extremes

Flowering Plant Diversity Response to Extremes - Global

Hypothesis:
Species diversity will decrease as the number of overlapping extremes increases

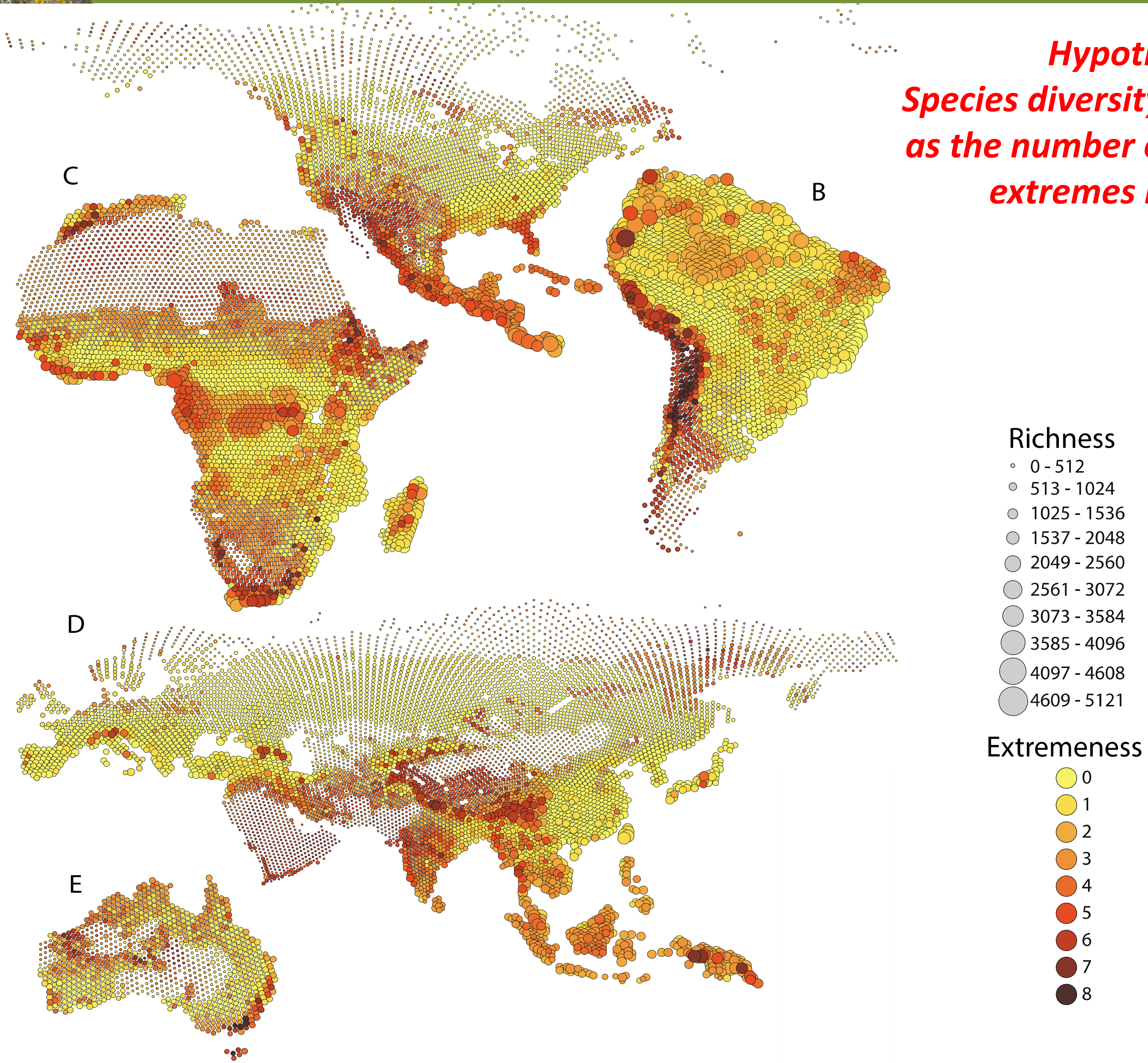


Ellis et al., 2012; after Kreft and Jetz, 2007.

- 16,461 equal area polygons each with a value for flowering plant richness

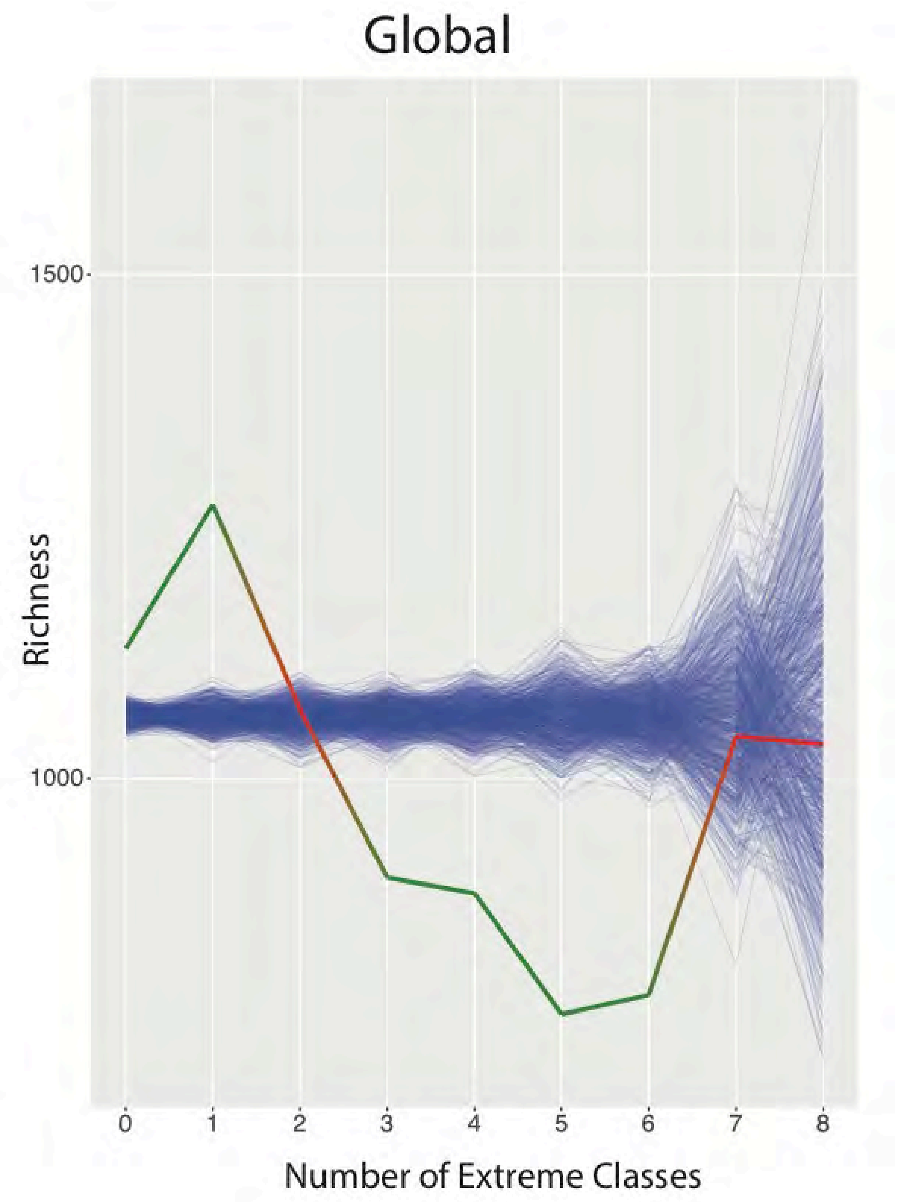
- Value for the number of extremes also recorded for the centroid of each polygon

Flowering Plant Diversity Response to Extremes - Global



Hypothesis:
Species diversity will decrease as the number of overlapping extremes increases

Flowering Plant Diversity Response to Extremes - Global



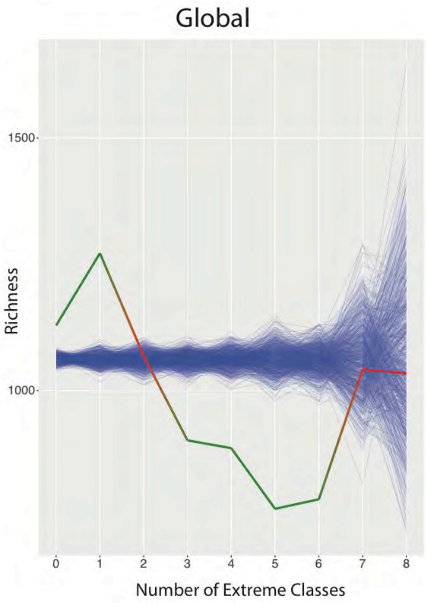
Hypothesis:
Species diversity will decrease as the number of overlapping extremes increases

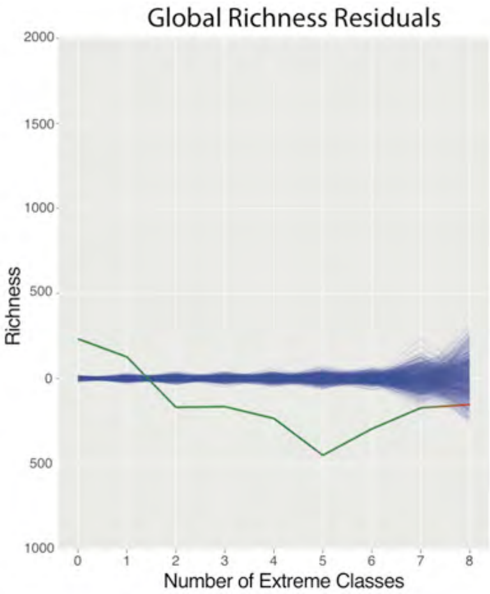
Calculate the average species richness for each number of overlapping classes

Null distribution generated from 999 Randomizations of richness values
for each grid cell while holding number of overlapping classes constant

Global Flowering Plant Diversity Response to Extremes

Latitudinal Species Gradient?

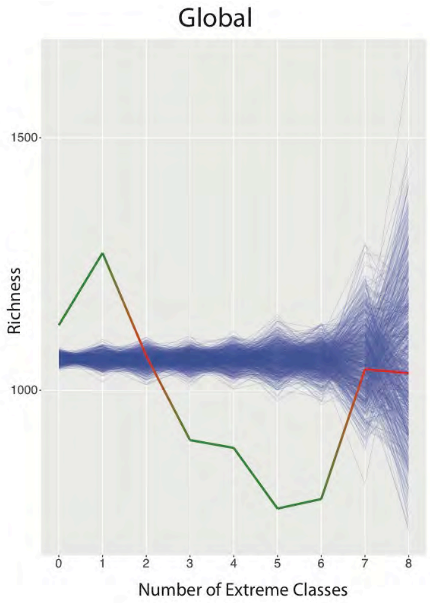


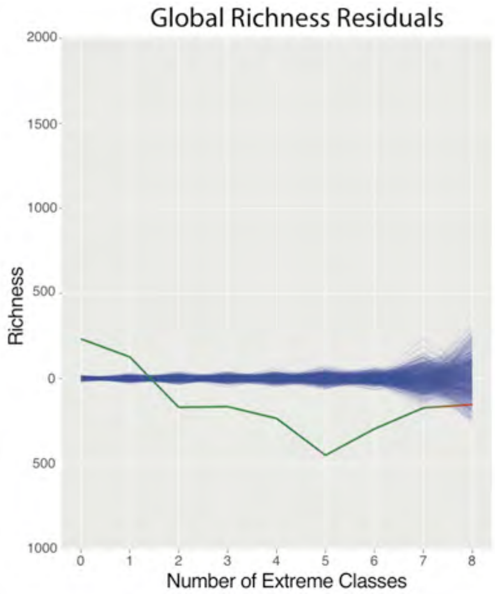


Regression of number
of extreme classes
against latitude:
$R^2 < 0.145$

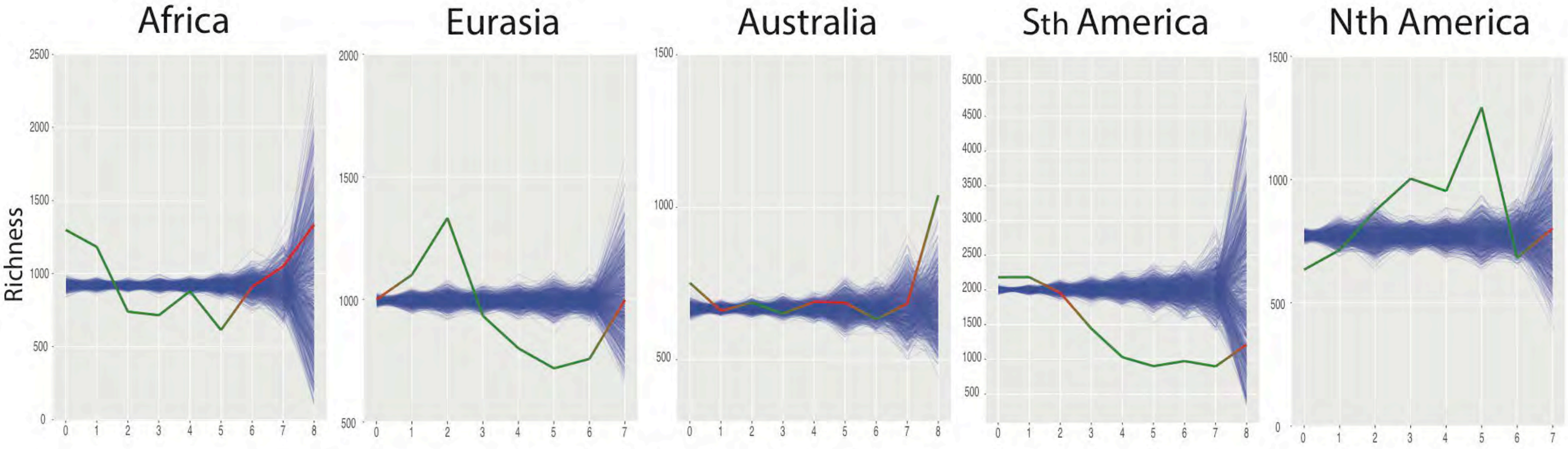
Global Flowering Plant Diversity Response to Extremes

Latitudinal Species Gradient?



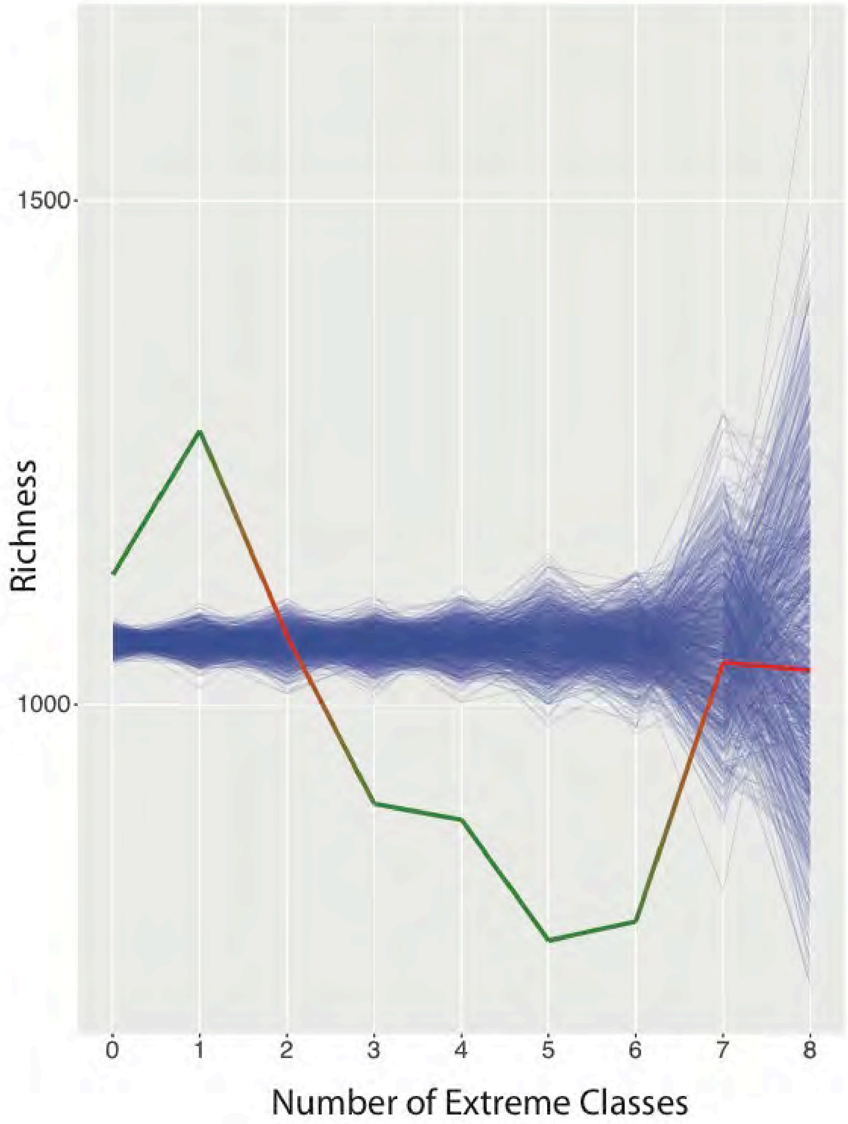


Regression of number
of extreme classes
against latitude:
$R^2 < 0.145$

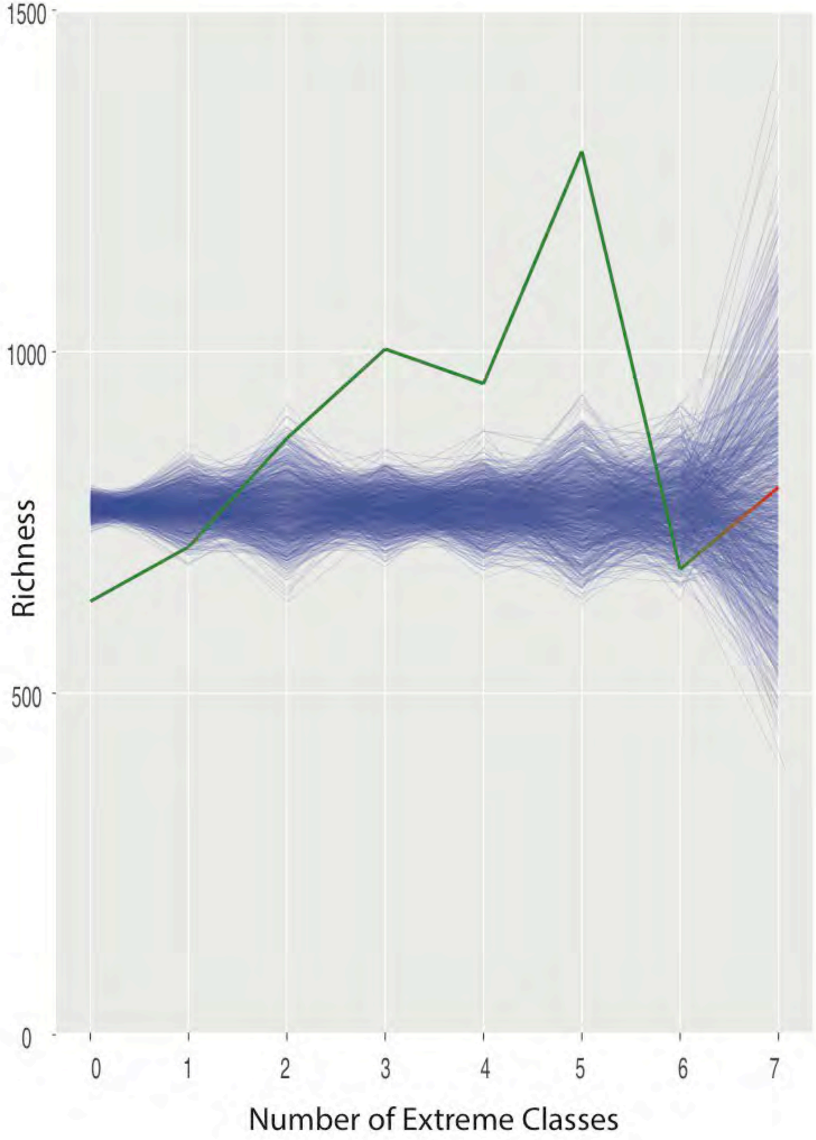


Number of extremes

Flowering Plant Diversity Response to Extremes



Global



Nth America
All Flowering Plants

North American Compositae (Asteraceae)

Daisies, sunflowers, thistles, tarweeds etc

Massively diverse (~1 in 10 flowering plants)

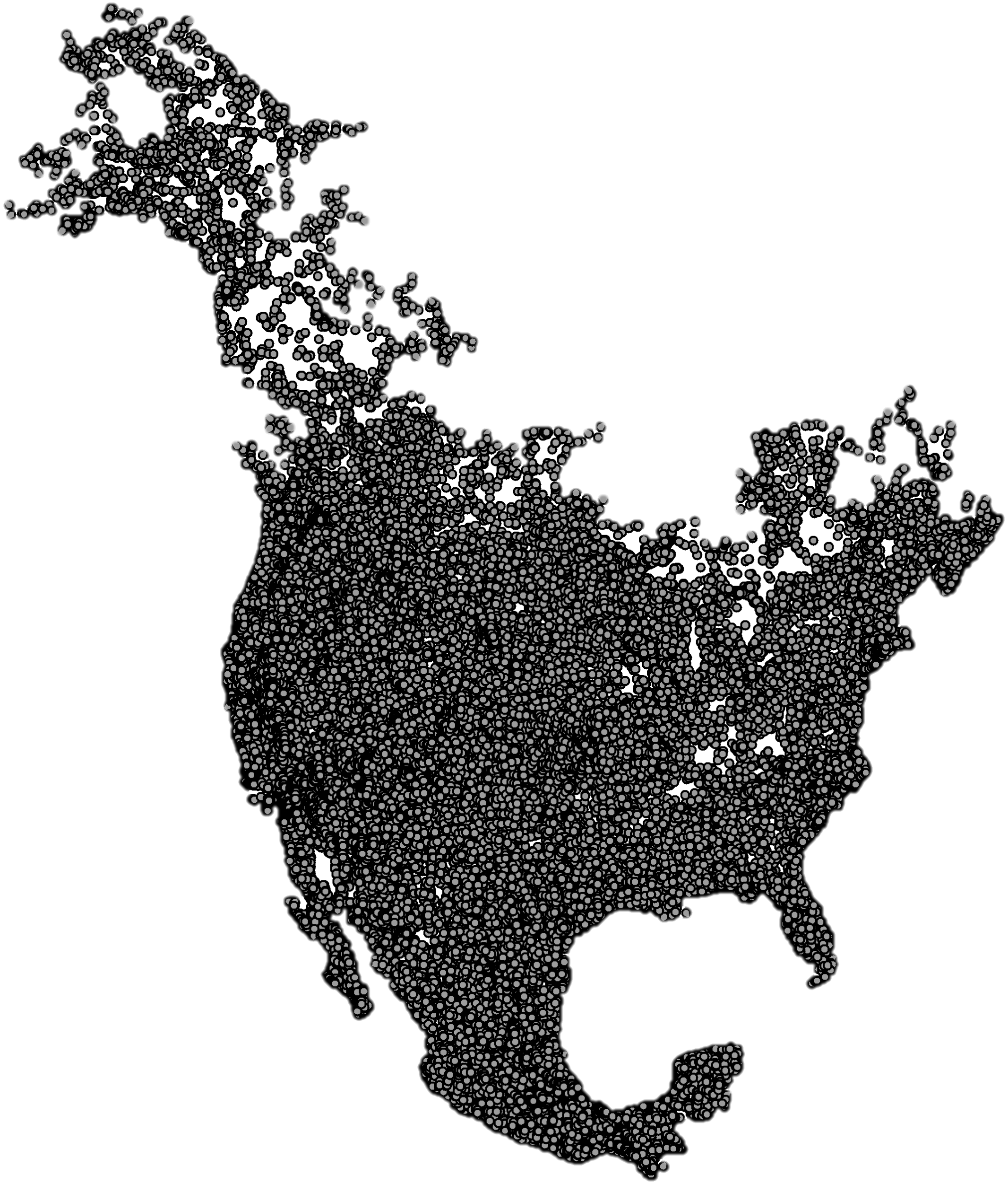
Known for occupying a wide range of challenging environments

Daisy Diversity Response to Extremes

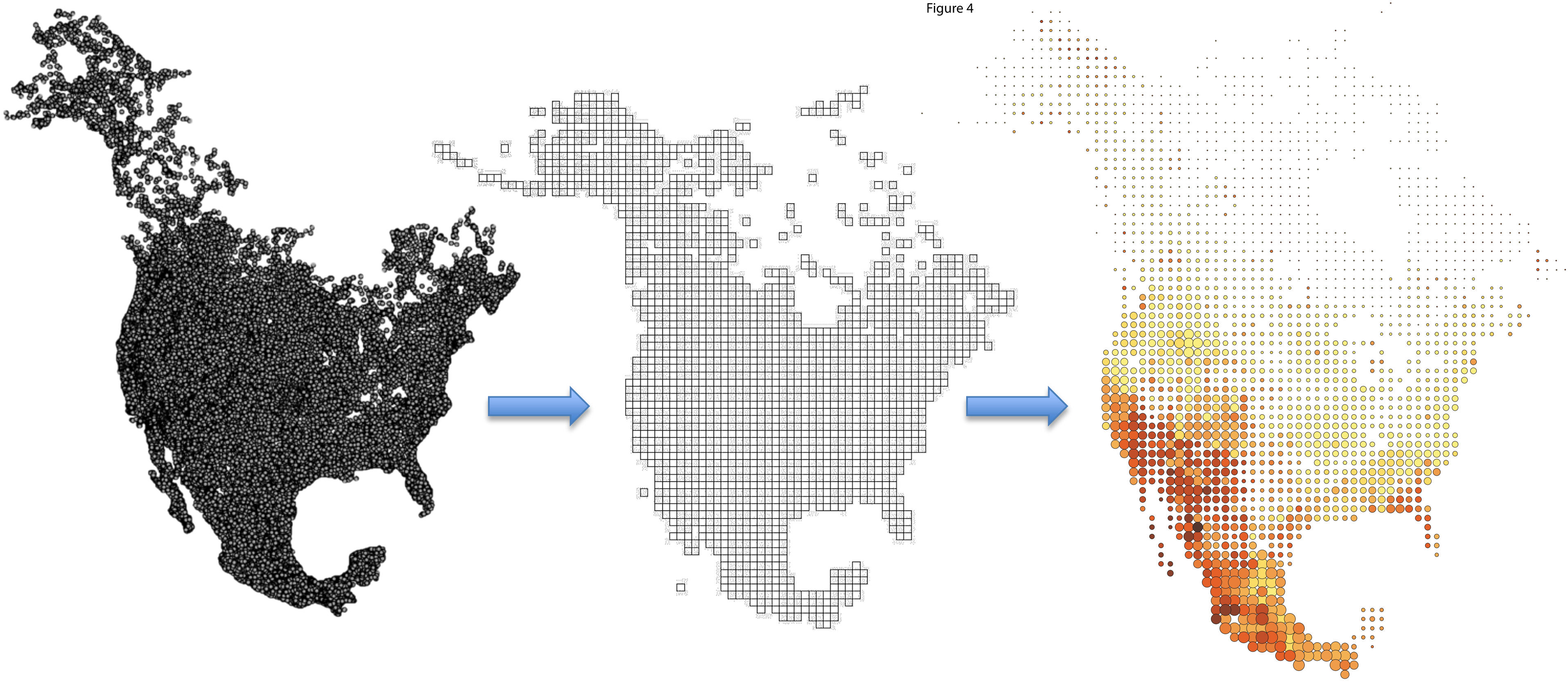
GBIF
Global Biodiversity
Information Facility

iDigBio
Integrated Digitized Biocollections

USGS
science for a changing world
Bison



Daisy Diversity Response to Extremes



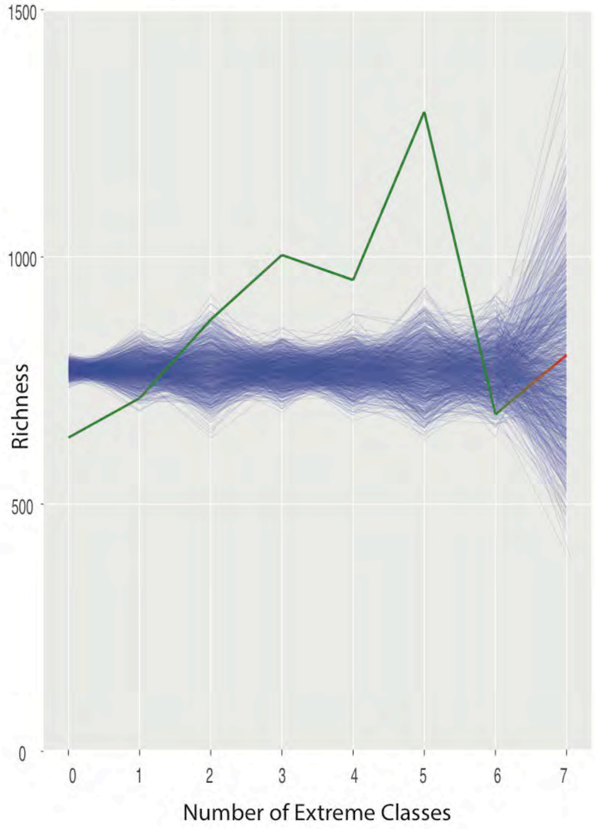
3,116 species
~500,000 collection records
(after cleaning)

Aggregated to 100km grid cells

Richness calculated

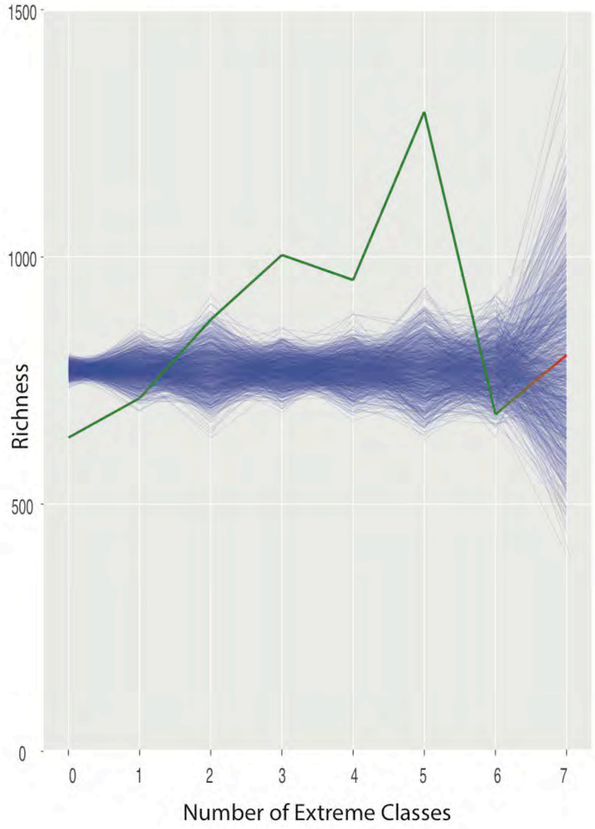
Daisy Diversity Response to Extremes

Nth America
All Flowering Plants

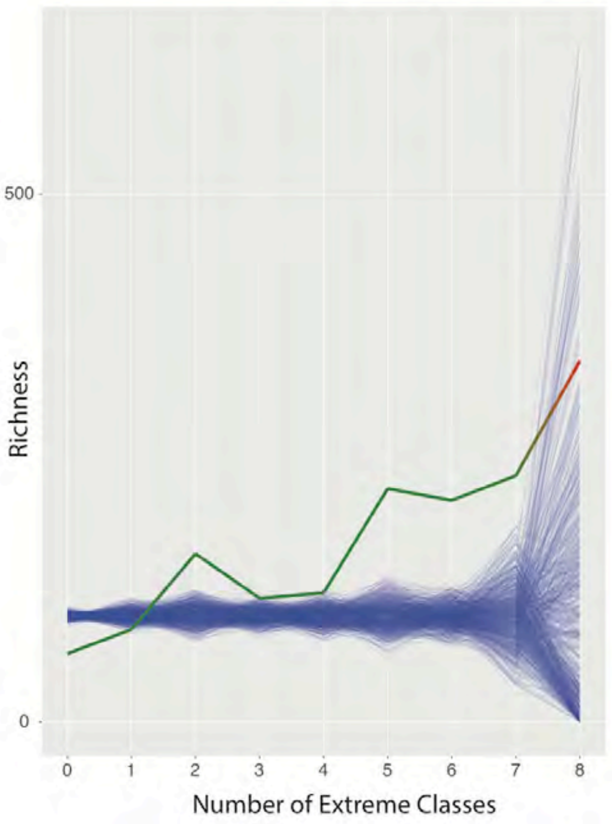


In Nth America species richness increases with extremeness…

Daisy Diversity Response to Extremes



Nth America
All Flowering Plants

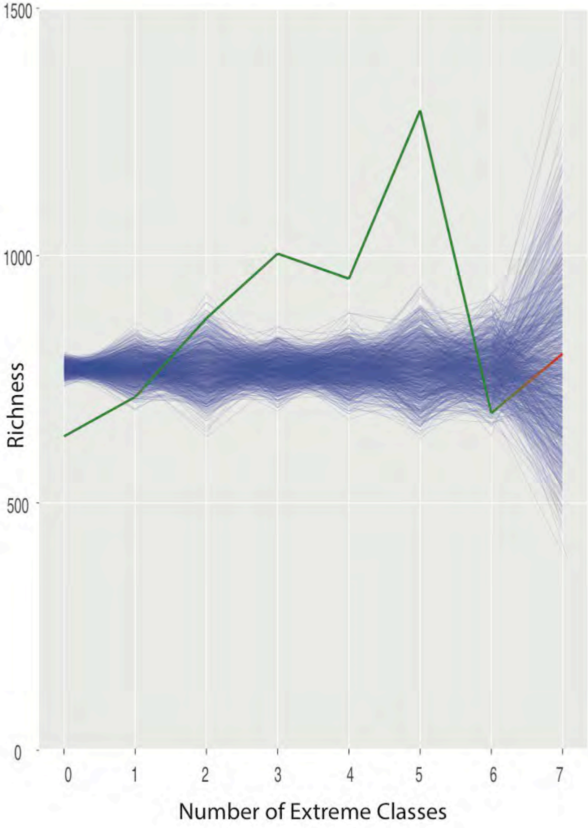


Nth American Compositae

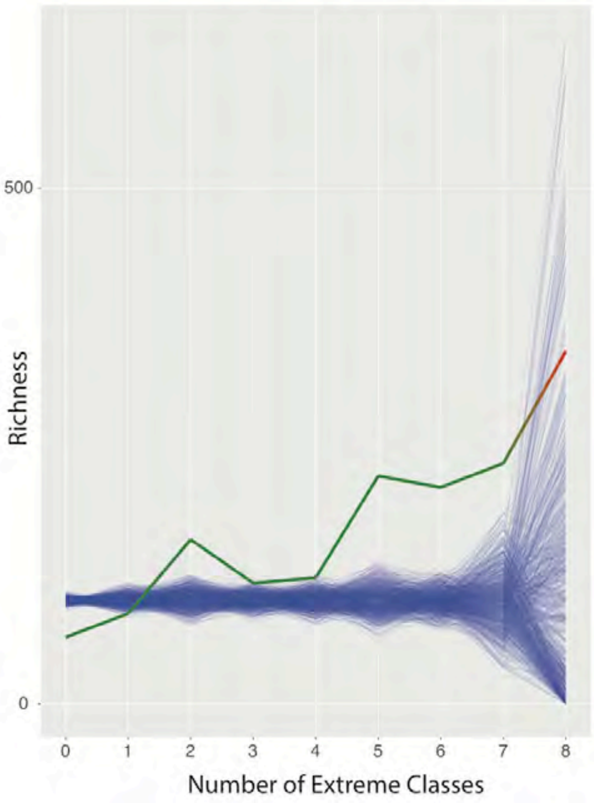
In Nth America species richness increases with extremeness…

…this trend is especially prominent in the daisy family…

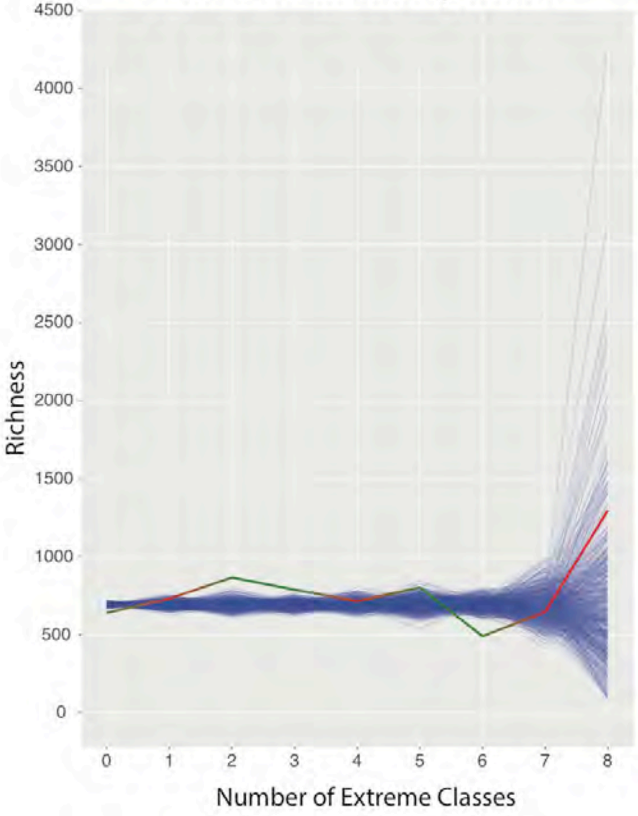
Daisy Diversity Response to Extremes



Nth America
All Flowering Plants



Nth American Compositae



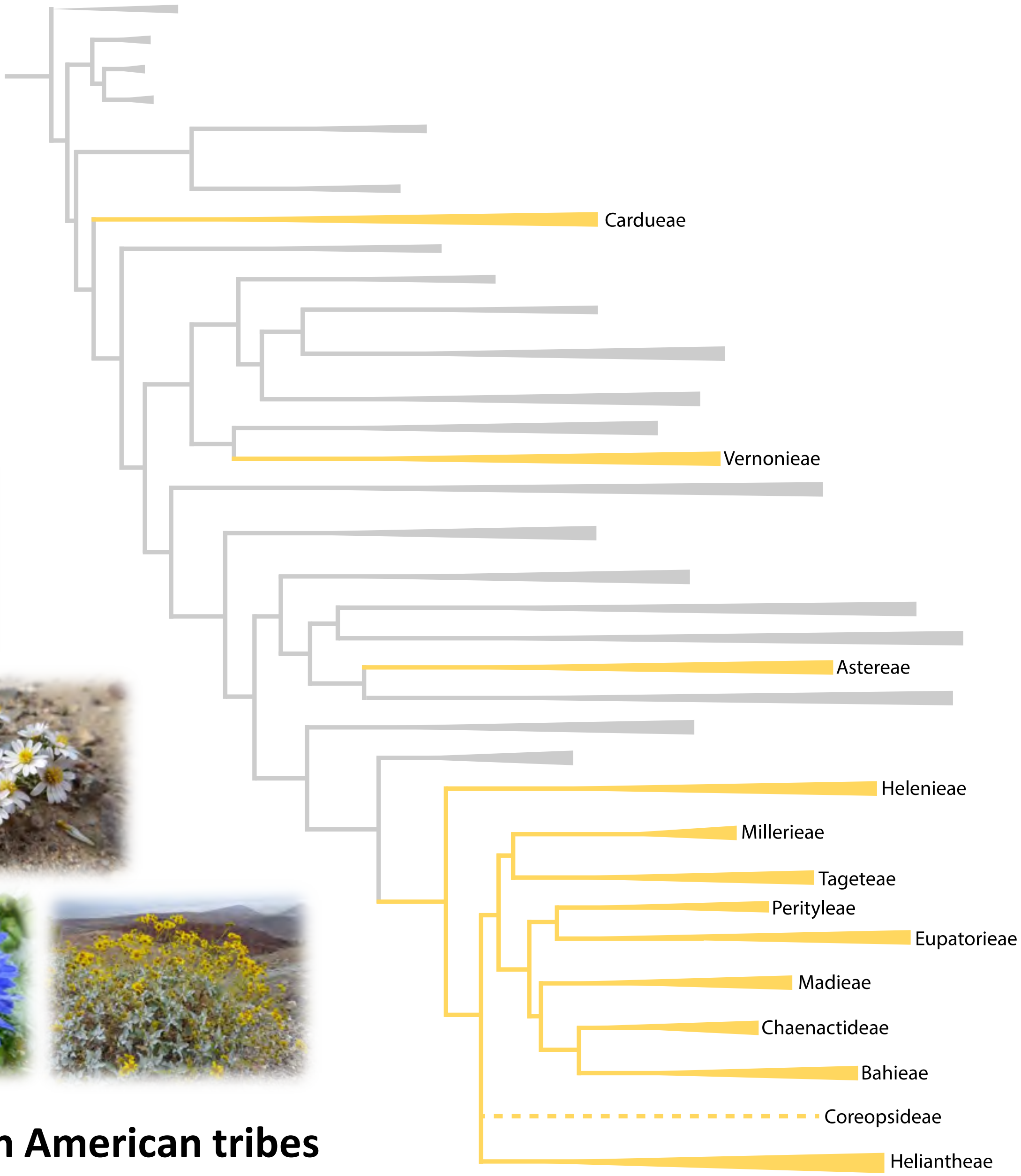
Nth American Flowering Plants Minus Compositae

In Nth America species richness increases with extremeness…

…this trend is especially prominent in the daisy family…

…to the point that they account for almost all of it!

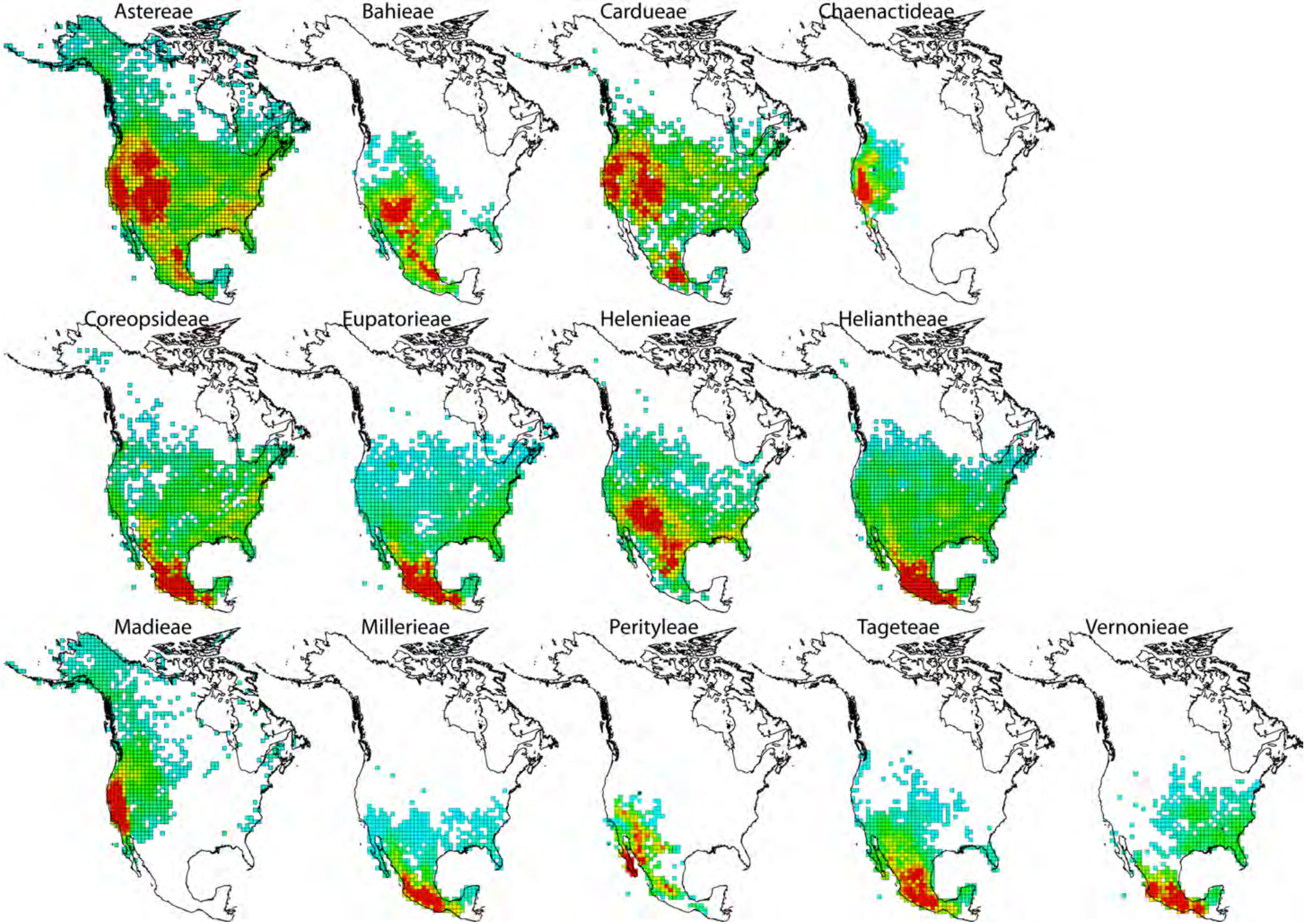
Drivers of Diversification



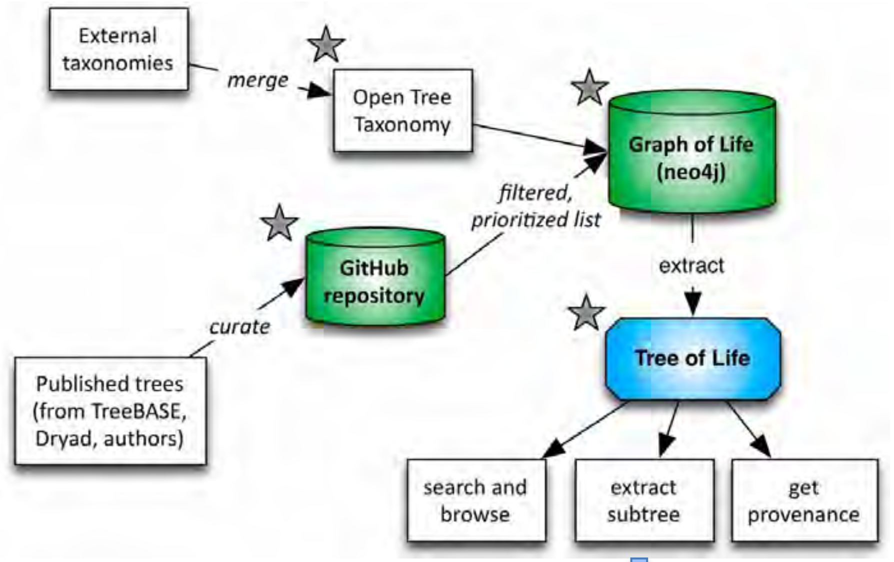
Modified from Mandel et al., 2019

13 majority endemic Nth American tribes
4 ~independent radiations

Daisy Diversity Response to Extremes



Generating a species-level meta-phylogeny



Open Tree of Life
+
GenBank
+
Expert assessment and regrafting

Provisional subtree

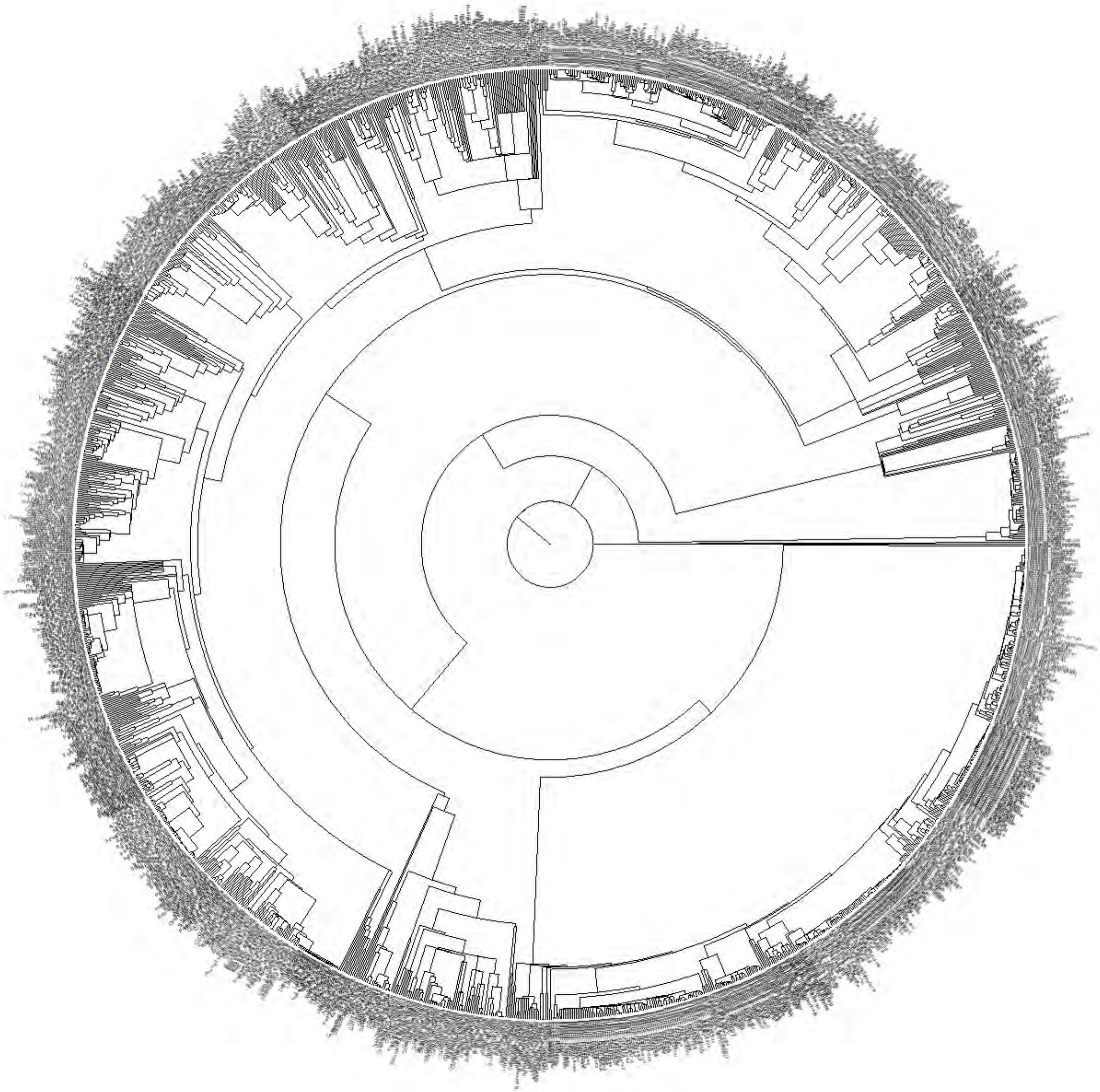
Review and regrafting

Final phylogeny

- Polytomies
- Misclassifications
- Missing taxa

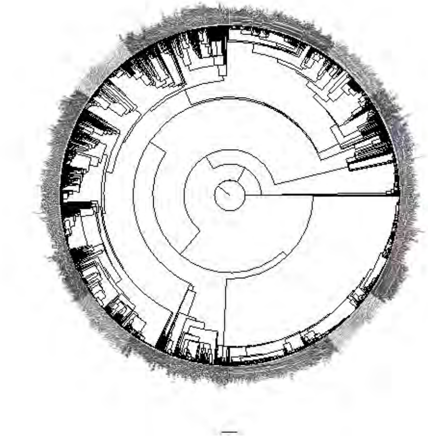
Stephen Smith

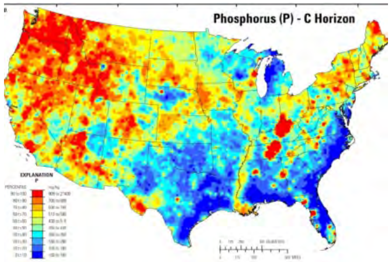
Drivers of Diversification

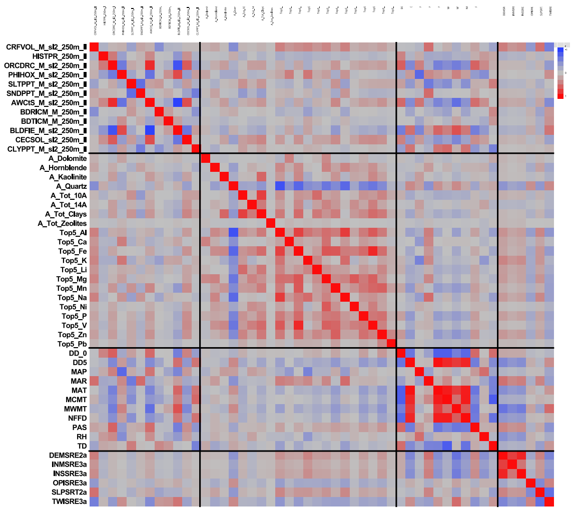


1642 taxa

Drivers of Diversification







Which environmental variables are associated with increased/decreased diversification?

Climate – AdaptWest 1km (ClimateNA v5.10)[1]

Soil Profile/Texture – SoilGrids 250m v0.5[2]

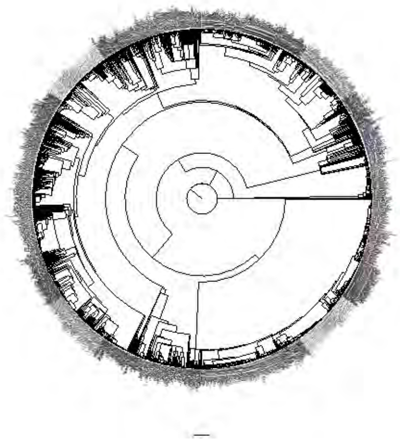
Topography – DEM-derived, via SoilGrids[2]

Soil Geochemical/Mineralogical Data
– USGS (OFR 2014-1082)[3] [interpolated from 4800 sites]

- 182 variables reduced to 50 non-colinear

"Variable reduction is a truly dark art" – Voldemort (probably)

Drivers of Diversification

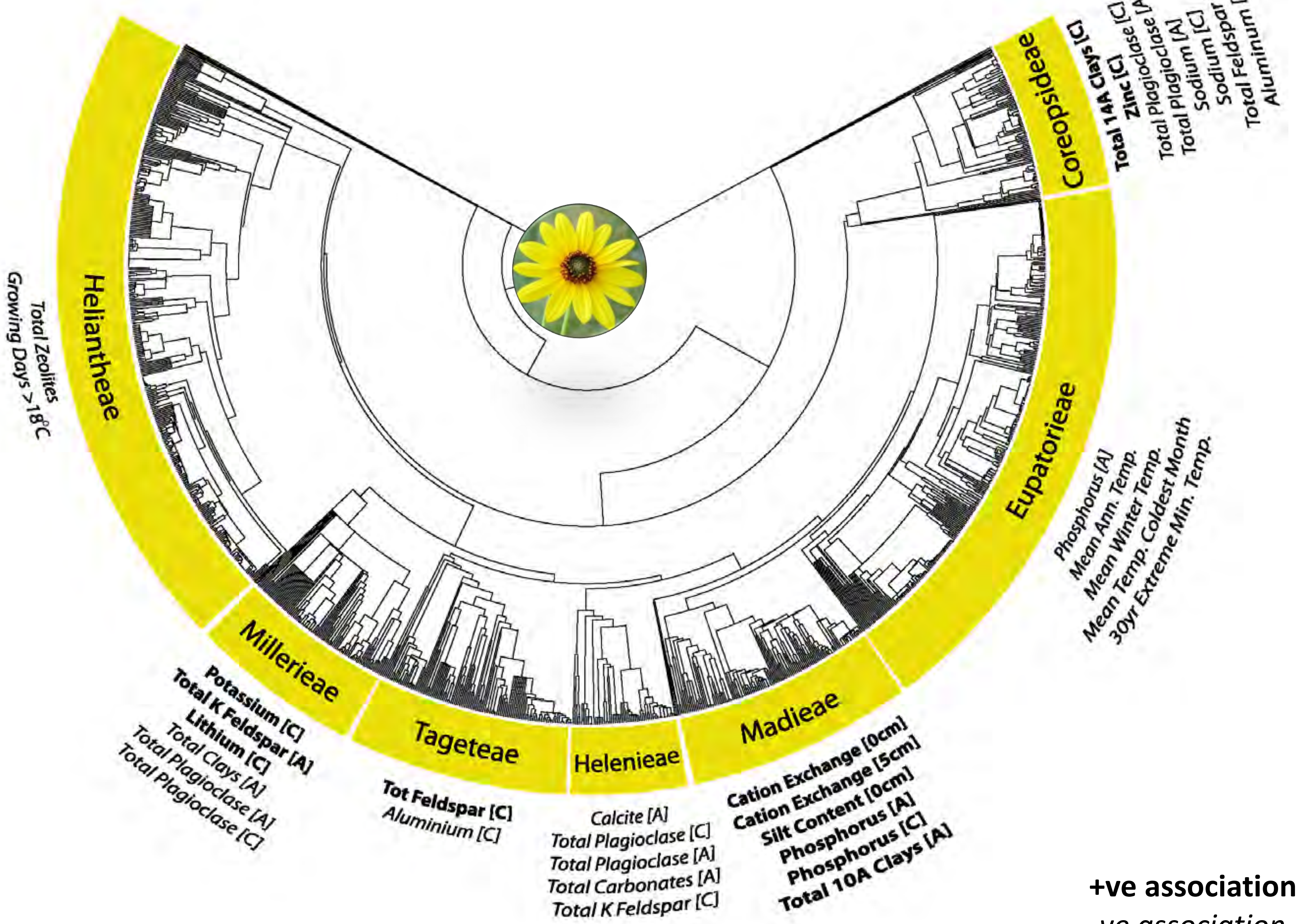


- Tip-rate correlation tests using the Diversification Rate metric (Jetz et al., 2012)
- Ordinary Least Squares regression (to meet assumptions and proven better performance over PGLS - Revell, 2010)
- First regressed diversification rate against single environmental variables

- Then multiple regression with all pairwise combinations of environmental variables that were not autocorrelated ($r > 0.75$), including additive (A + B) and multiplicative (A*B).
- To control for false positives, we replaced our environmental data with randomly generated data (x1000) and repeated the analysis process for each simulated dataset.
- R^2 values were pooled across runs, and the 95th percentile was used as a cutoff value for interpreting the reliability of results with real data.

Chase Mason & Eric Goolsby

Drivers of Diversification



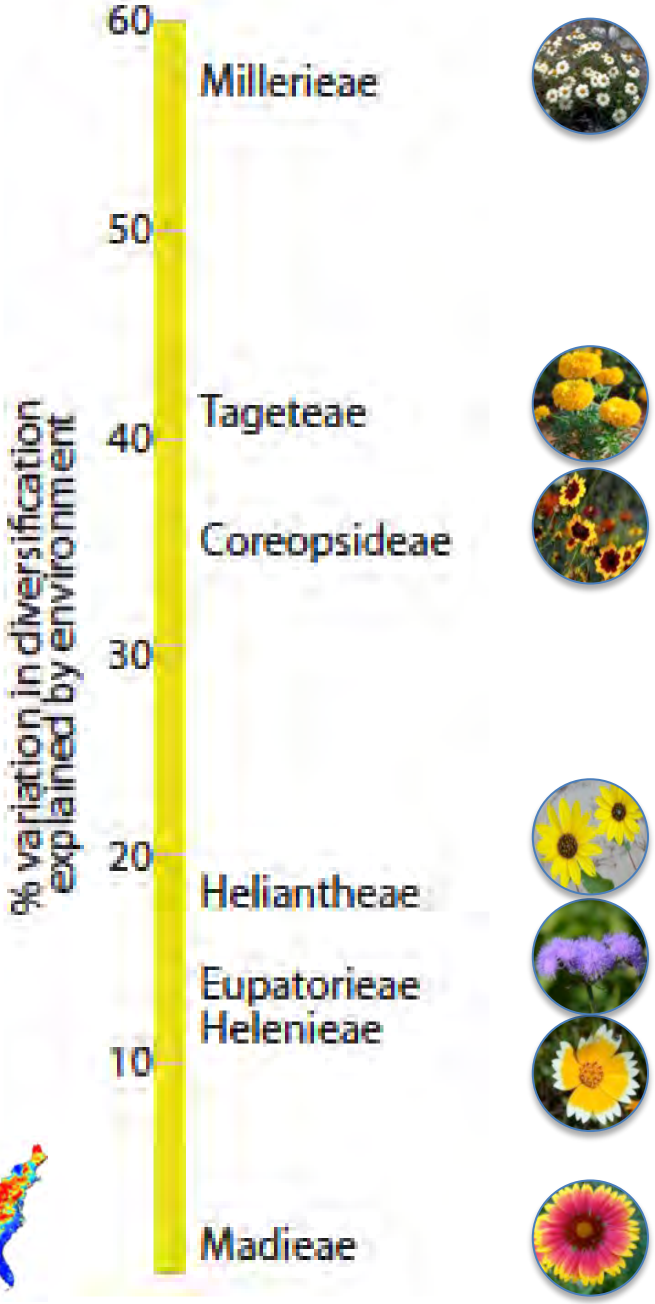
+ve association

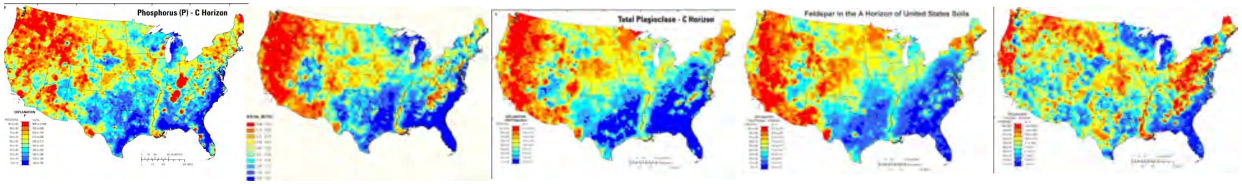
-ve association

What factors drive diversification across North American Asteraceae?

- Abiotic environmental factors can explain >50% of variation in diversification rate, and up to 30% above randomly simulated data.
- This varies substantially among tribes.
- As a variable class, geochemical and mineralogical factors are consistently more correlated with diversification rate than climate, topography, or soil profile/texture:

Phosphorus, Potassium, Aluminum
Plagioclases, Feldspars, Clays





Map Of Life

Global **Va**scular **P**lant **Ma**ster **T**axonomy

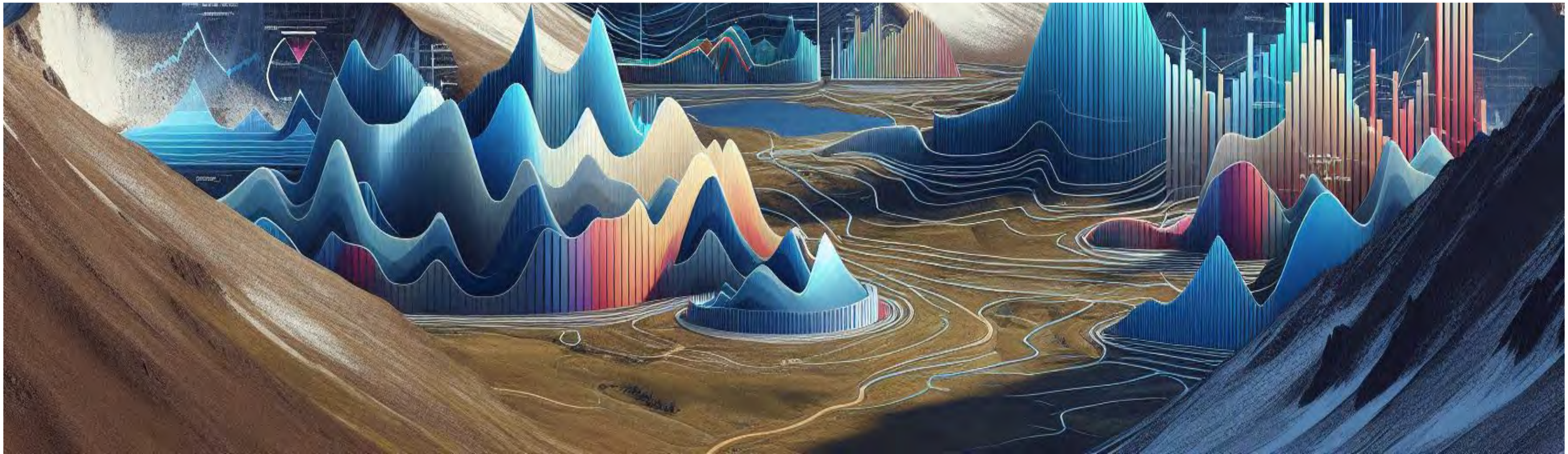
```
Enkleia paniculata Hallier f.|Enkleia|paniculata||NA|NA|TRUE|Hallier f.|Enkleia paniculata|NA|synonym|Enkleia paniculata (Merr.) Hallier.f.|species|GBIF|Author Variant|Enkleia par
Enkleia riouwensis Hallier.f.|Enkleia|riouwensis||NA|NA|TRUE|Hallier.f.|Enkleia riouwensis|NA|synonym|Enkleia malaccensis Griff.|species|LCVP||Enkleia malaccensis|Enkleia|malaccen
Enkleia siamensis (Kurz) Nevling|Enkleia|siamensis||NA|NA|TRUE|(Kurz) Nevling|Enkleia siamensis|1961|synonym|Enkleia malaccensis Griff.|species|LCVP||Enkleia malaccensis|Enkleia|m
Enkleia siamensis subsp. andamanica (Hutch. ex C. E. Parkinson) Nevling|Enkleia|siamensis||subsp.|andamanica|TRUE|(Hutch. ex C.E.Parkinson) Nevling|Enkleia siamensis subsp. andama
Enkleia siamensis subsp. andamanica (Hutch. ex C.E.Parkinson) Nevling|Enkleia|siamensis||subsp.|andamanica|TRUE|(Hutch. ex C.E.Parkinson) Nevling|Enkleia siamensis subsp. andamani
Enkleia thorelii (Lecomte) Nevling|Enkleia|thorelii||NA|NA|TRUE|(Lecomte) Nevling|Enkleia thorelii|1961|accepted|Enkleia thorelii (Lecomte) Nevling|species|LCVP|NA|Enkleia thoreli
Enkleia zippeliana Hallier.f.|Enkleia|zippeliana||NA|NA|TRUE|Hallier.f.|Enkleia zippeliana|NA|synonym|Enkleia paniculata (Merr.) Hallier.f.|species|LCVP||Enkleia paniculata|Enklei
Enkylia digyna Griff.|Enkylia|digyna||NA|NA|TRUE|Griff.|Enkylia digyna|1845|synonym|Gynostemma pentaphyllum (Thunb.) Makino|species|LCVP||Gynostemma pentaphyllum|Gynostemma|pentap
Enkylia trigyna Griff.|Enkylia|trigyna||NA|NA|TRUE|Griff.|Enkylia trigyna|1845|synonym|Gynostemma pentaphyllum (Thunb.) Makino|species|LCVP||Gynostemma pentaphyllum|Gynostemma|pen
Enlychnia floresii F.Ritter & Y.Itô|Enlychnia|floresii||NA|NA|TRUE|F.Ritter & Y.Itô|Enlychnia floresii|1981|unresolved|unresolved|unresolved|LCVP|NA|NA|NA|NA|NA|NA|NA
Enlychnia longispina F.Ritter & Y.Itô|Enlychnia|longispina||NA|NA|TRUE|F.Ritter & Y.Itô|Enlychnia longispina|1981|unresolved|unresolved|unresolved|LCVP|NA|NA|NA|NA|NA|NA|NA
Enneadynamis polonorum Bubani|Enneadynamis|polonorum||NA|NA|TRUE|Bubani|Enneadynamis polonorum|1901|synonym|Parnassia palustris L.|species|LCVP||Parnassia palustris|Parnassia|palu
Ennealophus amazonicus N.E.Br.|Ennealophus|amazonicus||NA|NA|TRUE|N.E.Br.|Ennealophus amazonicus|1909|synonym|Ennealophus foliosus (Kunth) Ravenna|species|LCVP||Ennealophus folios
Ennealophus boliviensis (Baker) Ravenna|Ennealophus|boliviensis||NA|NA|TRUE|(Baker) Ravenna|Ennealophus boliviensis|1977|accepted|Ennealophus boliviensis (Baker) Ravenna|species|
Ennealophus euryandrus (Gris.) Ravenna|Ennealophus|euryandrus||NA|NA|TRUE|(Gris.) Ravenna|Ennealophus euryandrus|NA|synonym|Ennealophus euryandrus (Griseb.) Ravenna|species|GBIF|A
Ennealophus euryandrus (Griseb.) Ravenna|Ennealophus|euryandrus||NA|NA|TRUE|(Griseb.) Ravenna|Ennealophus euryandrus|1973|accepted|Ennealophus euryandrus (Griseb.) Ravenna|species
Ennealophus euryandrus subsp. euryandrus|Ennealophus|euryandrus||subsp.|euryandrus|NA|NA|Ennealophus euryandrus subsp. euryandrus|NA|autonym|Ennealophus euryandrus subsp. euryandr
Ennealophus euryandrus subsp. oxydandrus Ravenna|Ennealophus|euryandrus||subsp.|oxydandrus|TRUE|Ravenna|Ennealophus euryandrus subsp. oxydandrus|2005|accepted|Ennealophus euryandr
Ennealophus fimbriatus Ravenna|Ennealophus|fimbriatus||NA|NA|TRUE|Ravenna|Ennealophus fimbriatus|1983|accepted|Ennealophus fimbriatus Ravenna|species|LCVP|NA|Ennealophus fimbriatu
Ennealophus foliosus (Kunth) Ravenna|Ennealophus|foliosus||NA|NA|TRUE|(Kunth) Ravenna|Ennealophus foliosus|1977|accepted|Ennealophus foliosus (Kunth) Ravenna|species|LCVP|NA|Ennea
Ennealophus foliosus subsp. amazonicus (N.E. Br.) Ravenna|Ennealophus|foliosus||subsp.|amazonicus|TRUE|(N.E.Br.) Ravenna|Ennealophus foliosus subsp. amazonicus|NA|synonym|Ennealop
Ennealophus foliosus subsp. amazonicus (N.E.Br.) Ravenna|Ennealophus|foliosus||subsp.|amazonicus|TRUE|(N.E.Br.) Ravenna|Ennealophus foliosus subsp. amazonicus|1977|accepted|Enneal
Ennealophus foliosus subsp. foliosus|Ennealophus|foliosus||subsp.|foliosus|NA|NA|Ennealophus foliosus subsp. foliosus|NA|autonym|Ennealophus foliosus subsp. foliosus|subspecies|GB
Ennealophus foliosus subsp. spruceanus (Baker) Ravenna|Ennealophus|foliosus||subsp.|spruceanus|TRUE|(Baker) Ravenna|Ennealophus foliosus subsp. spruceanus|1977|synonym|Ennealophus
Ennealophus simplex (Ravenna) Roitman & J.A.Castillo|Ennealophus|simplex||NA|NA|TRUE|(Ravenna) Roitman & J.A.Castillo|Ennealophus simplex|2007|accepted|Ennealophus simplex (Raven
Ennealophus tucumanensis Huaylla|Ennealophus|tucumanensis||NA|NA|TRUE|Huaylla|Ennealophus tucumanensis|2015|accepted|Ennealophus tucumanensis Huaylla|species|LCVP|NA|Ennealophus t
Enneapogon abyssinicus (Hochst.) Rendle|Enneapogon|abyssinicus||NA|NA|TRUE|(Hochst.) Rendle|Enneapogon abyssinicus|1899|synonym|Enneapogon cenchroides (Licht. ex Schult.) C.E.Hubb
Enneapogon arenicola (Domin) N.T.Burb.|Enneapogon|arenicola||NA|NA|TRUE|(Domin) N.T.Burb.|Enneapogon arenicola|1941|synonym|Enneapogon nigricans (R.Br.) P.Beauv.|species|LCVP||Enn
Enneapogon asperatus C.E.Hubb.|Enneapogon|asperatus||NA|NA|TRUE|C.E.Hubb.|Enneapogon asperatus|1937|accepted|Enneapogon asperatus C.E.Hubb.|species|LCVP|NA|Enneapogon asperatus|En
Enneapogon avenaceus (Lindl.) C.E.Hubb.|Enneapogon|avenaceus||NA|NA|TRUE|(Lindl.) C.E.Hubb.|Enneapogon avenaceus|1934|accepted|Enneapogon avenaceus (Lindl.) C.E.Hubb.|species|LCVP
Enneapogon benguellensis Rendle|Enneapogon|benguellensis||NA|NA|TRUE|Rendle|Enneapogon benguellensis|1899|synonym|Enneapogon scaber Lehm.|species|LCVP||Enneapogon scaber|Enneapog
Enneapogon borealis (Griseb.) Honda|Enneapogon|borealis||NA|NA|TRUE|(Griseb.) Honda|Enneapogon borealis|1936|synonym|Enneapogon desvauxii P.Beauv.|species|LCVP||Enneapogon desvaux
Enneapogon brachystachyus (Jaub. & Spach) Stapf|Enneapogon|brachystachyus||NA|NA|TRUE|(Jaub. & Spach) Stapf|Enneapogon brachystachyus|1900|synonym|Enneapogon desvauxii P.Beauv.|sp
Enneapogon brachystachyus var. macrantherus Stapf|Enneapogon|brachystachyus||var.|macrantherus|TRUE|Stapf|Enneapogon brachystachyus var. macrantherus|1900|synonym|Enneapogon desva
Enneapogon caerulescens (Gaudich.) N.T.Burb.|Enneapogon|caerulescens||NA|NA|TRUE|(Gaudich.) N.T.Burb.|Enneapogon caerulescens|1941|accepted|Enneapogon caerulescens (Gaudich.) N.T.
Enneapogon caerulescens var. caerulescens|Enneapogon|caerulescens||var.|caerulescens|NA|NA|Enneapogon caerulescens var. caerulescens|NA|autonym|Enneapogon caerulescens var. caerul
Enneapogon caerulescens var. occidentalis Kakudidi|Enneapogon|caerulescens||var.|occidentalis|TRUE|Kakudidi|Enneapogon caerulescens var. occidentalis|1989|synonym|Enneapogon caeru
Enneapogon cenchroides (Licht. ex Schult.) C.E.Hubb.|Enneapogon|cenchroides||NA|NA|TRUE|(Licht. ex Schult.) C.E.Hubb.|Enneapogon cenchroides|NA|accepted|Enneapogon cenchroides (Li
Enneapogon cenchroides (Licht.) C.E.Hubb.|Enneapogon|cenchroides||NA|NA|TRUE|(Licht.) C.E.Hubb.|Enneapogon cenchroides|1934|synonym|Enneapogon cenchroides (Licht. ex Schult.) C.E.
```

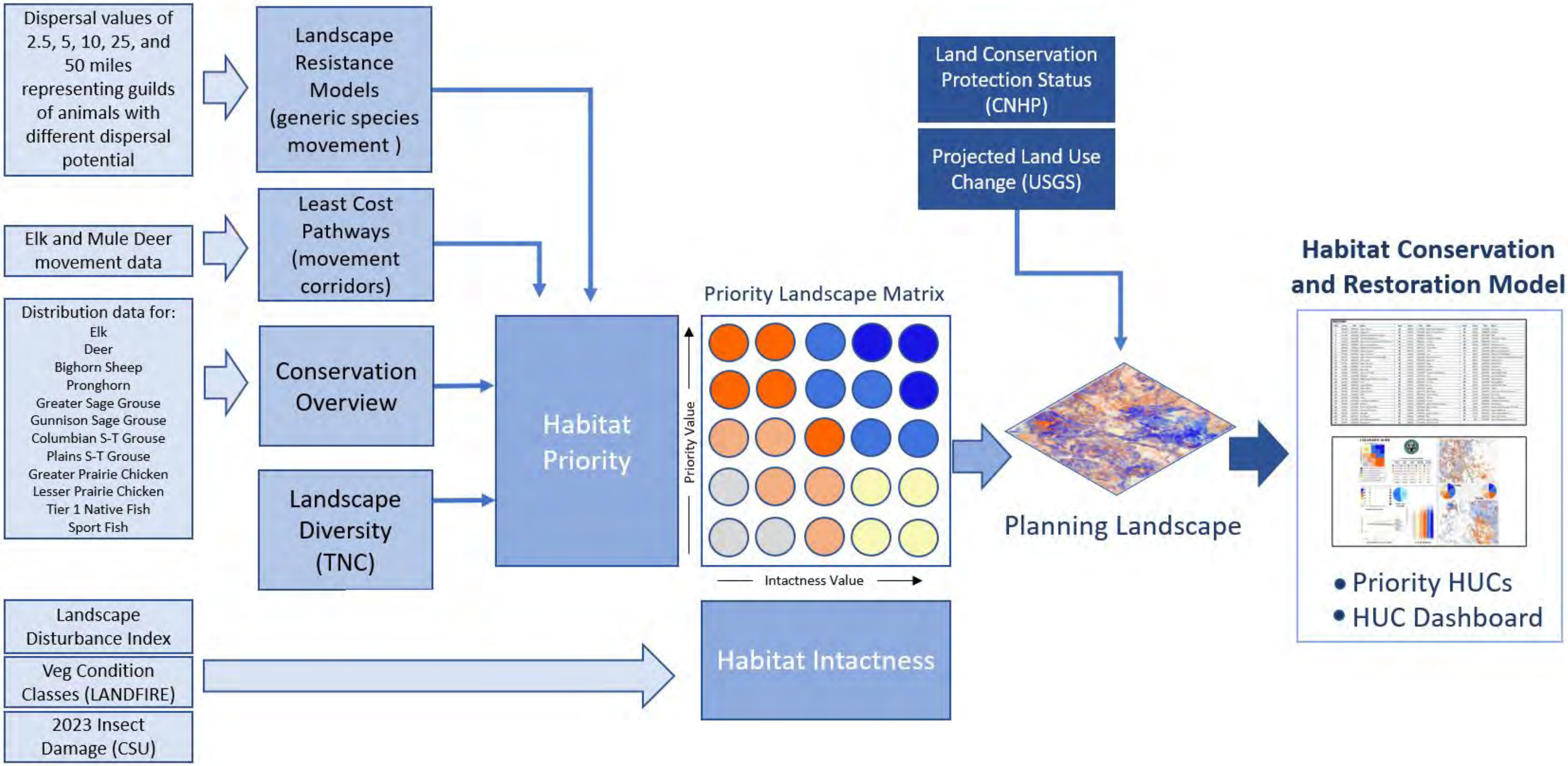
1,831,687 vascular plant names and name variants

CNHP- VaPMaT Taxonomy Resolution Tool

Input Name	VaPMaT	GBIF	Flora of Colorado	SEINet	Flora Wyoming	Betty Ford
Alnus incana (L.) Moench	Alnus incana (L.) Moench	Alnus incana (L.) Moench	Alnus incana (L.) Moench	Alnus incana (L.) Moench	Alnus incana (L.) Moench	
Alnus incana (L.) Moench var. occidentalis (Dipp	Alnus incana subsp. tenuifolia (Nutt.) Breit	Alnus incana subsp. tenuifolia (Nutt.	Alnus incana (L.) Moench ssp. tenui	Alnus incana subsp. tenuifoli	Alnus incana (L.) Moench var. occidentalis (Dippel)	
Alnus incana var. occidentalis (Dippel) C.L. Hitch	Alnus incana subsp. tenuifolia (Nutt.) Breit	Alnus incana subsp. tenuifolia (Nutt.	Alnus incana (L.) Moench ssp. tenui	Alnus incana var. occidentali	Alnus incana var. occidentalis (Dippel) C.L. Hitchc.	
Alnus viridis (Chaix) DC.	Alnus alnobetula (Ehrh.) K.Koch	Alnus alnobetula subsp. alnobetula		Alnus viridis (Chaix) DC.	Alnus viridis (Chaix) DC.	
Alopecurus aequalis var. aequalis	Alopecurus aequalis Sobol.	Alopecurus aequalis Sobol.	Alopecurus aequalis Sobol.	Alopecurus aequalis Sobol.	Alopecurus aequalis Sobol.	
Alopecurus aequalis Sobol.	Alopecurus aequalis Sobol.	Alopecurus aequalis Sobol.	Alopecurus aequalis Sobol.	Alopecurus aequalis Sobol.	Alopecurus aequalis Sobol.	
Alopecurus aequalis Sobol. var. aequalis	Alopecurus aequalis Sobol.	Alopecurus aequalis Sobol.	Alopecurus aequalis Sobol.	Alopecurus aequalis Sobol.	Alopecurus aequalis Sobol.	
Alopecurus arundinaceus Poir.	Alopecurus arundinaceus Poir.	Alopecurus arundinaceus Poir.	Alopecurus arundinaceus Poir.	Alopecurus arundinaceus Po	Alopecurus arundinaceus Poir.	
Alopecurus carolinianus Walter	Alopecurus carolinianus Walter	Alopecurus carolinianus Walter	Alopecurus carolinianus Walt.	Alopecurus carolinianus Wal	Alopecurus carolinianus Walter	
Alopecurus geniculatus L.	Alopecurus geniculatus L.	Alopecurus geniculatus L.	Alopecurus geniculatus L.	Alopecurus geniculatus L.	Alopecurus geniculatus L.	
Alopecurus magellanicus Lam.	Alopecurus magellanicus Lam.	Alopecurus magellanicus Lam.	Alopecurus magellenicus Lam.	Alopecurus magellanicus Lar	Alopecurus magellanicu	Alopecurus magellanicus L
Alopecurus pratensis L.	Alopecurus pratensis L.	Alopecurus pratensis L.	Alopecurus pratensis L.	Alopecurus pratensis L.	Alopecurus pratensis L.	
Alyssum alyssoides (L.) L.	Alyssum alyssoides (L.) L.	Alyssum alyssoides (L.) L.	Alyssum alyssoides (L.) L.	Alyssum alyssoides (L.) L.	Alyssum alyssoides (L.) L.	
Alyssum desertorum Stapf	Alyssum desertorum Stapf	Alyssum turkestanicum Regel & Schr	Alyssum desertorum Stapf	Alyssum desertorum Stapf	Alyssum desertorum Stapf	
Alyssum simplex Rudolphi	Alyssum simplex Rudolphi	Alyssum simplex Rudolphi	Alyssum simplex Rudolphi	Alyssum simplex Rudolphi	Alyssum simplex Rudolphi	
Amaranthus albus L.	Amaranthus albus L.	Amaranthus albus L.	Amaranthus albus L.	Amaranthus albus L.	Amaranthus albus L.	
Amaranthus arenicola I.M. Johnst.	Amaranthus arenicola I.M.Johnst.	Amaranthus arenicola I.M.Johnst.	Amaranthus arenicola I.M. Johnsto	Amaranthus arenicola I. M. J	Amaranthus arenicola I.M. Johnst.	
Amaranthus blitoides S. Watson	Amaranthus blitoides S.Watson	Amaranthus blitoides S.Watson	Amaranthus blitoides S. Watson	Amaranthus blitoides S. Wat	Amaranthus blitoides S. Watson	
Amaranthus californicus (Moq.) S. Watson	Amaranthus californicus (Moq.) S.Watson	Amaranthus californicus (Moq.) S.W	Amaranthus californicus (Moq.) S.	Amaranthus californicus (M	Amaranthus californicus (Moq.) S. Watson	
Amaranthus palmeri S. Watson	Amaranthus palmeri S.Watson	Amaranthus palmeri S.Watson	Amaranthus palmeri S. Watson	Amaranthus palmeri S. Wats	Amaranthus palmeri S. Watson	
Amaranthus powellii S. Watson	Amaranthus powellii S.Watson	Amaranthus powellii S.Watson	Amaranthus powellii S. Watson	Amaranthus powellii S. Wats	Amaranthus powellii S. Watson	
Amaranthus retroflexus L.	Amaranthus retroflexus L.	Amaranthus retroflexus L.	Amaranthus retroflexus L.	Amaranthus retroflexus L.	Amaranthus retroflexus L.	

COLORADO HABITAT CONSERVATION AND CONNECTIVITY PLAN DASHBOARD





Dispersal values of 2.5, 5, 10, 25, and 50 miles representing guilds of animals with different dispersal potential

Landscape Resistance Models (generic species movement)

Elk and Mule Deer movement data

Least Cost Pathways (movement corridors)

Distribution data for:
Elk
Deer
Bighorn Sheep
Pronghorn
Greater Sage Grouse
Gunnison Sage Grouse
Columbian S-T Grouse
Plains S-T Grouse
Greater Prairie Chicken
Lesser Prairie Chicken
Tier 1 Native Fish
Sport Fish

Conservation Overview

Landscape Diversity (TNC)

Habitat Priority

Landscape Disturbance Index

Veg Condition Classes (LANDFIRE)

2023 Insect Damage (CSU)

Habitat Intactness

Priority Landscape Matrix

Land Conservation Protection Status (CNHP)

Projected Land Use Change (USGS)

Planning Landscape

Habitat Conservation and Restoration Model

- Priority HUCs
- HUC Dashboard

1

species & spatial data selection

2

modeling & analysis

3

aggregation of data

4

matrix construction

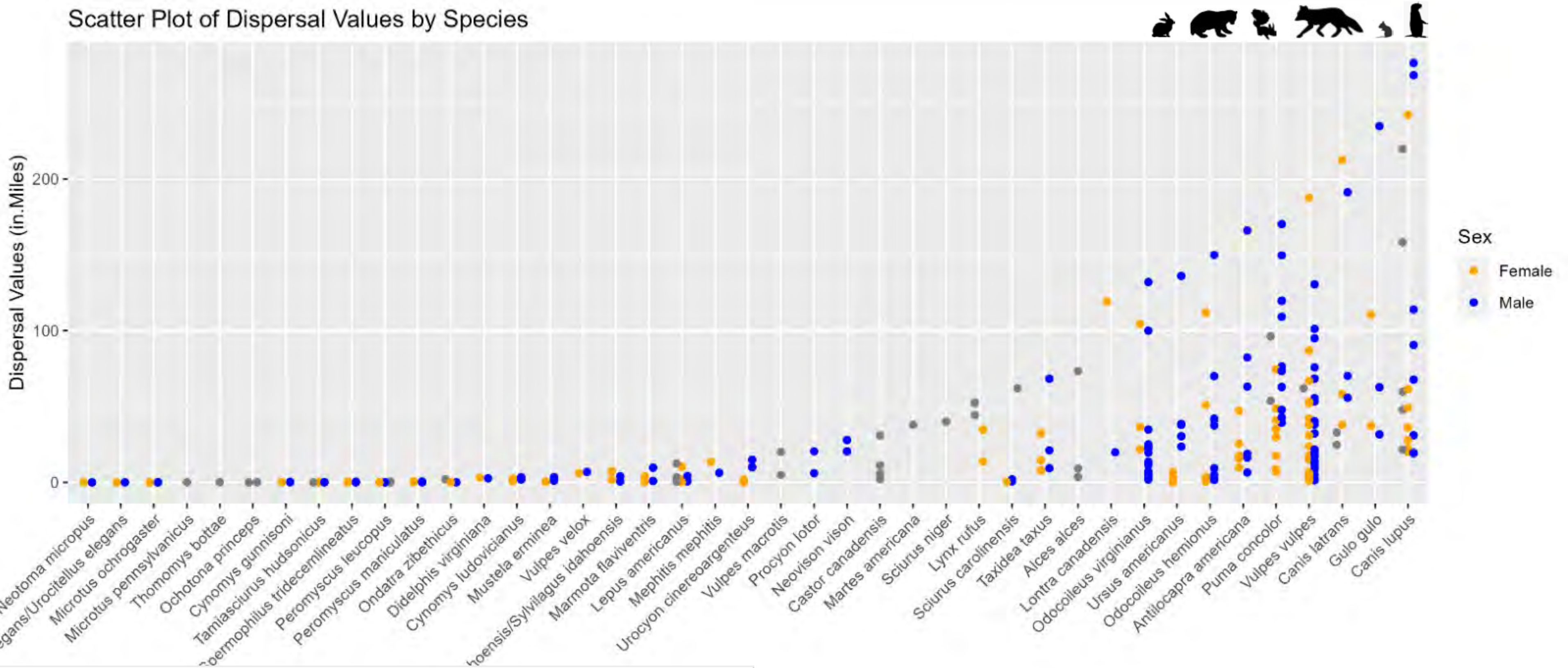
5

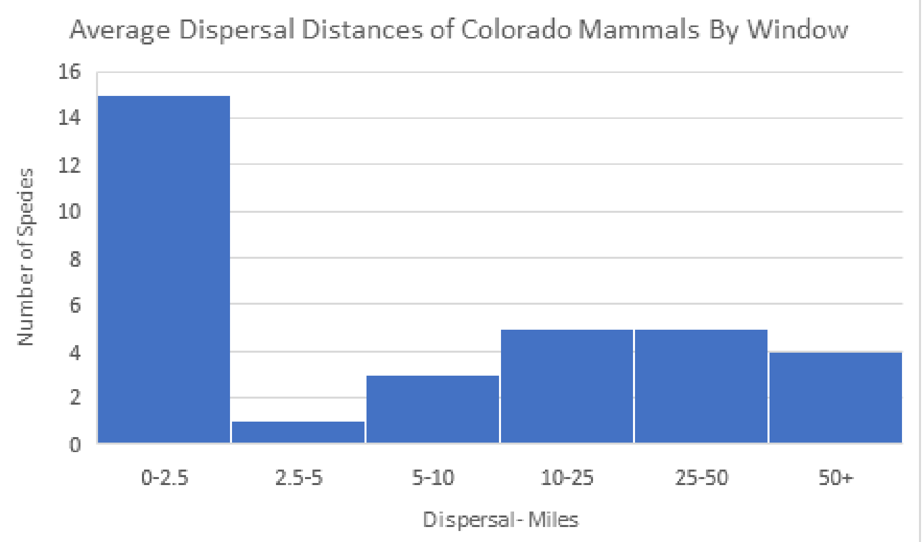
projection of matrix back to landscape

6

summary of data & data-interactions by spatial units

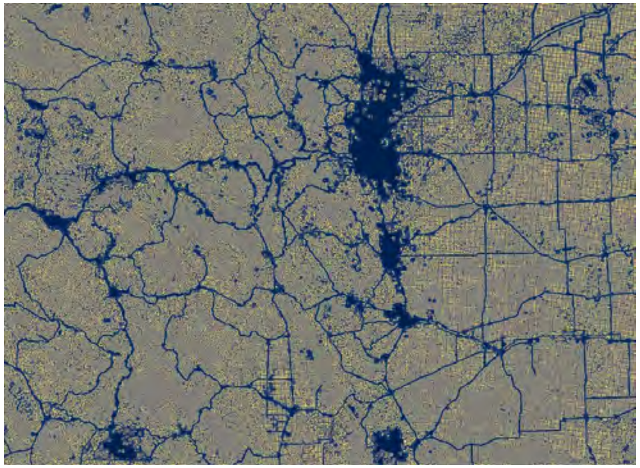
Ominscape is agnostic of individual species traits and represents generalized movement potential



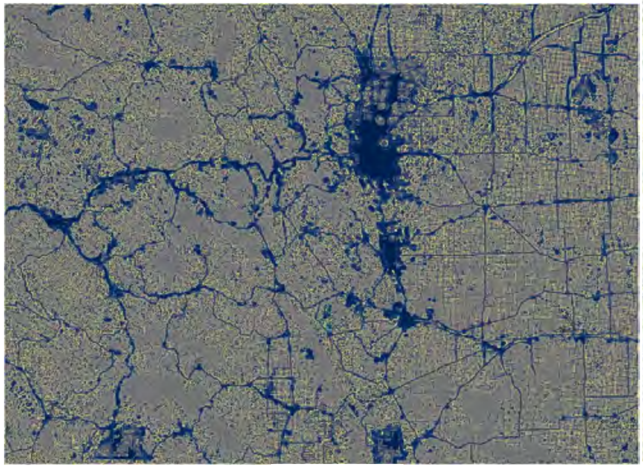


Movement for Colorado mammals skews local

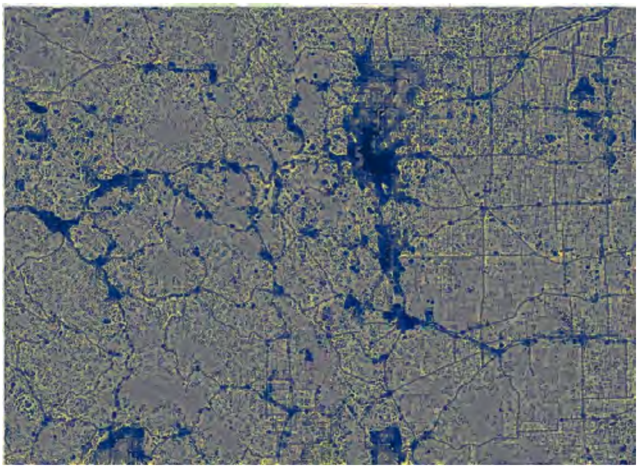
0.25, 5, 10, 25, and 50 mile radii were used in this study



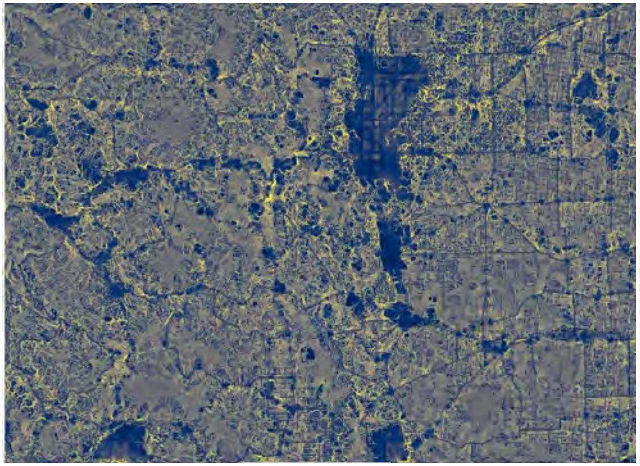
2.5 miles



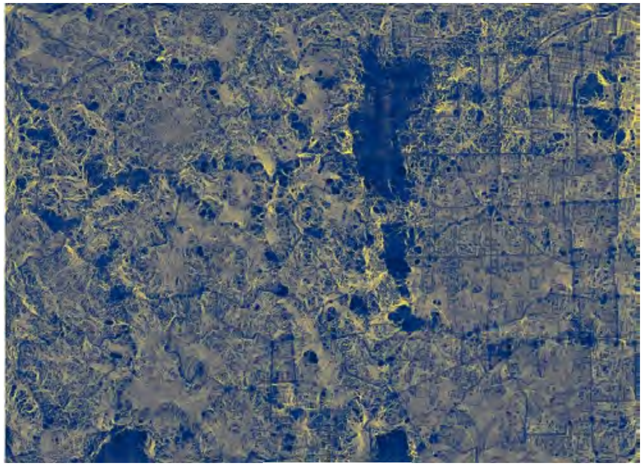
5 miles



10 miles

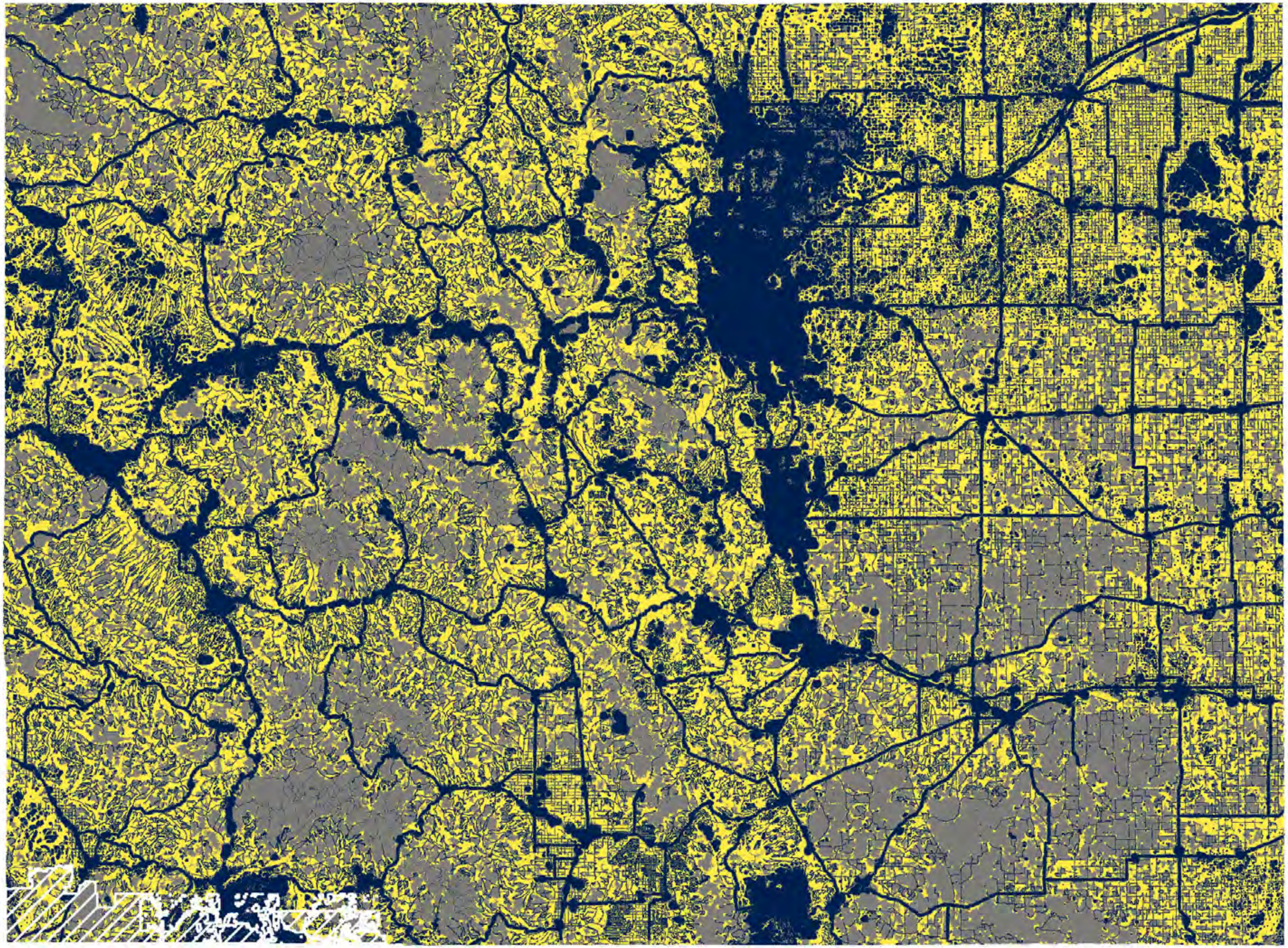


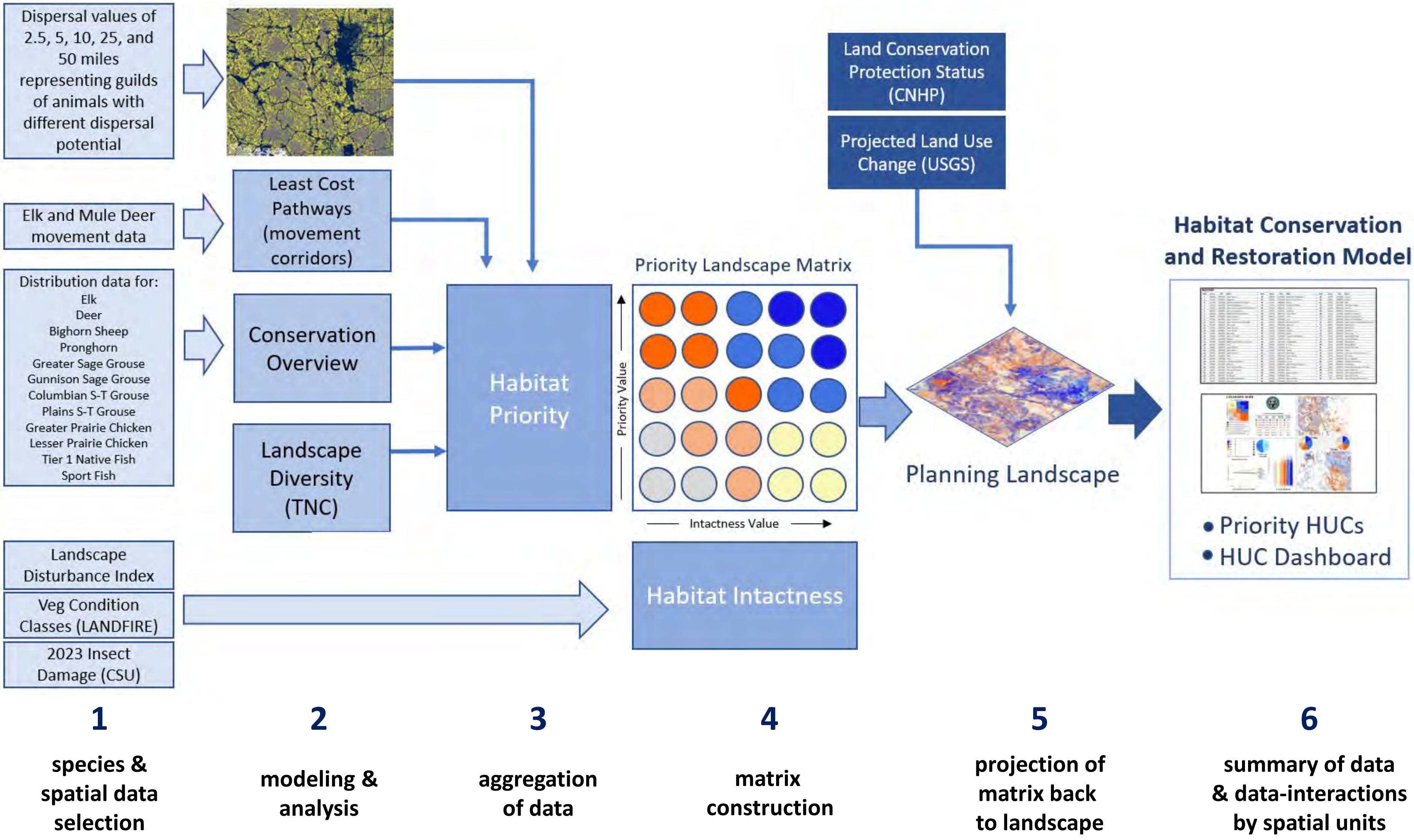
25 miles



50 miles

Concentrated Permeability
Free Permeability
Low Permeability





Dispersal values of 2.5, 5, 10, 25, and 50 miles representing guilds of animals with different dispersal potential

Elk and Mule Deer movement data

Distribution data for:
Elk
Deer
Bighorn Sheep
Pronghorn
Greater Sage Grouse
Gunnison Sage Grouse
Columbian S-T Grouse
Plains S-T Grouse
Greater Prairie Chicken
Lesser Prairie Chicken
Tier 1 Native Fish
Sport Fish

Landscape Disturbance Index

Veg Condition Classes (LANDFIRE)

2023 Insect Damage (CSU)

Least Cost Pathways (movement corridors)

Conservation Overview

Landscape Diversity (TNC)

Habitat Priority

Priority Landscape Matrix

Habitat Intactness

Land Conservation Protection Status (CNHP)

Projected Land Use Change (USGS)

Planning Landscape

Habitat Conservation and Restoration Model

- Priority HUCs
- HUC Dashboard

1

species & spatial data selection

2

modeling & analysis

3

aggregation of data

4

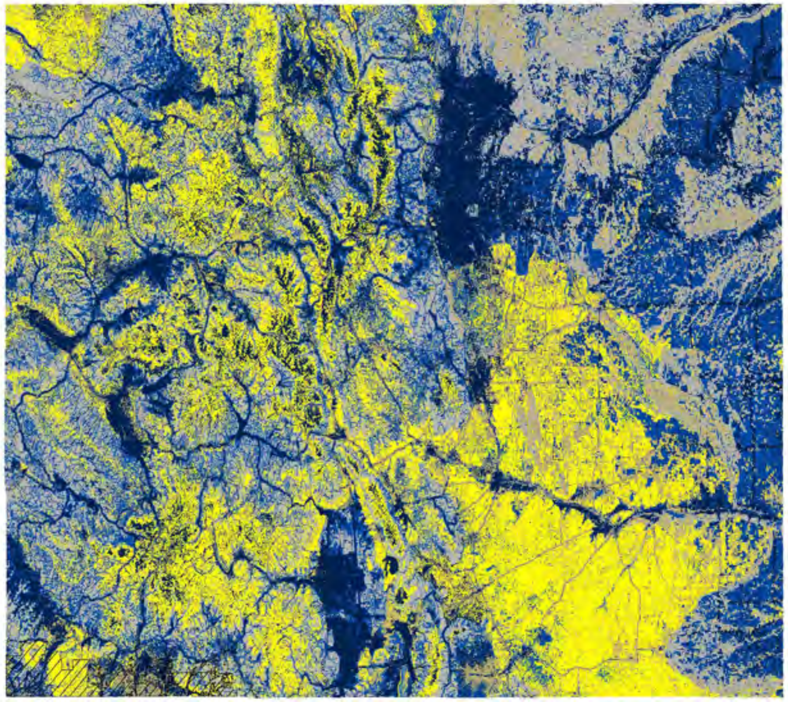
matrix construction

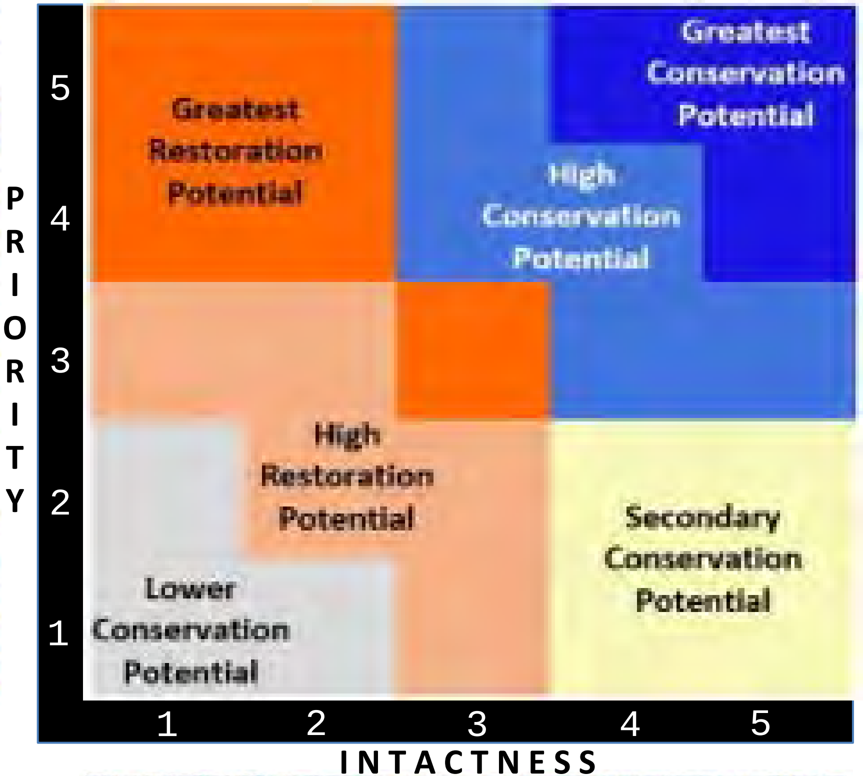
5

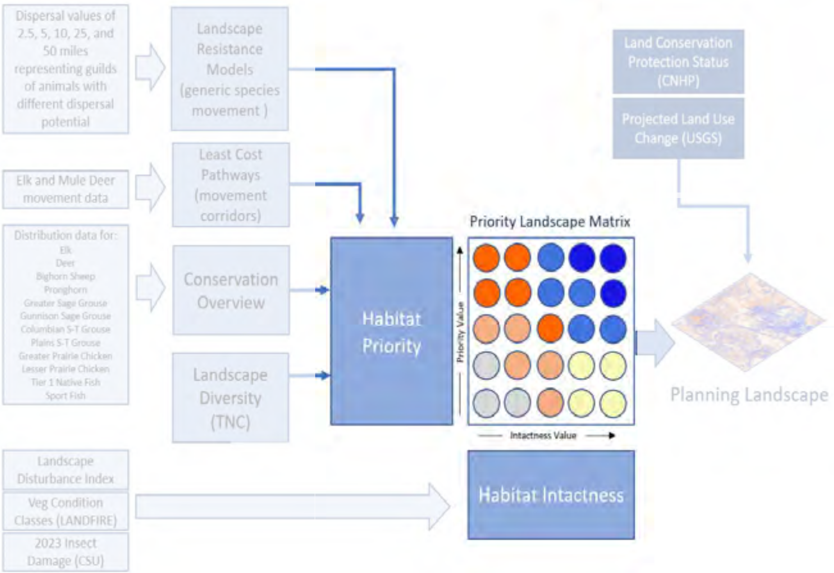
projection of matrix back to landscape

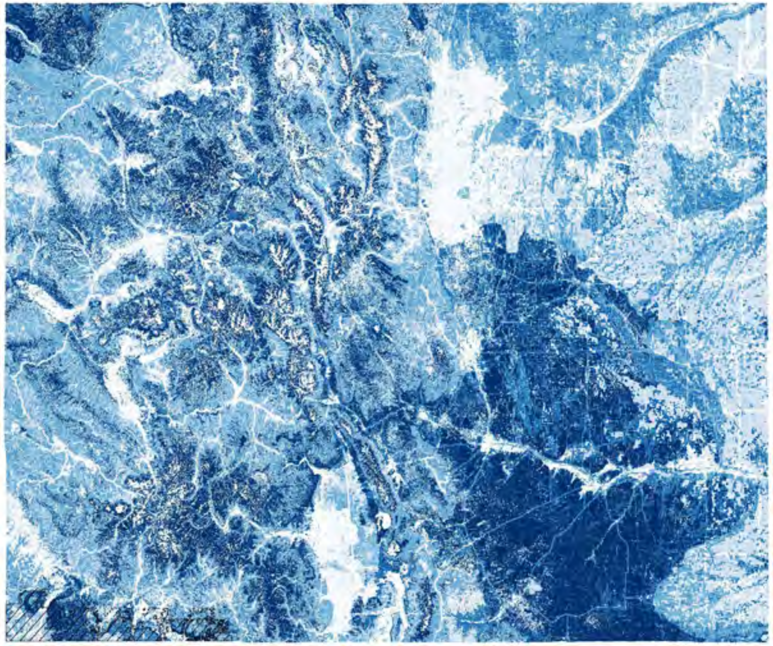
6

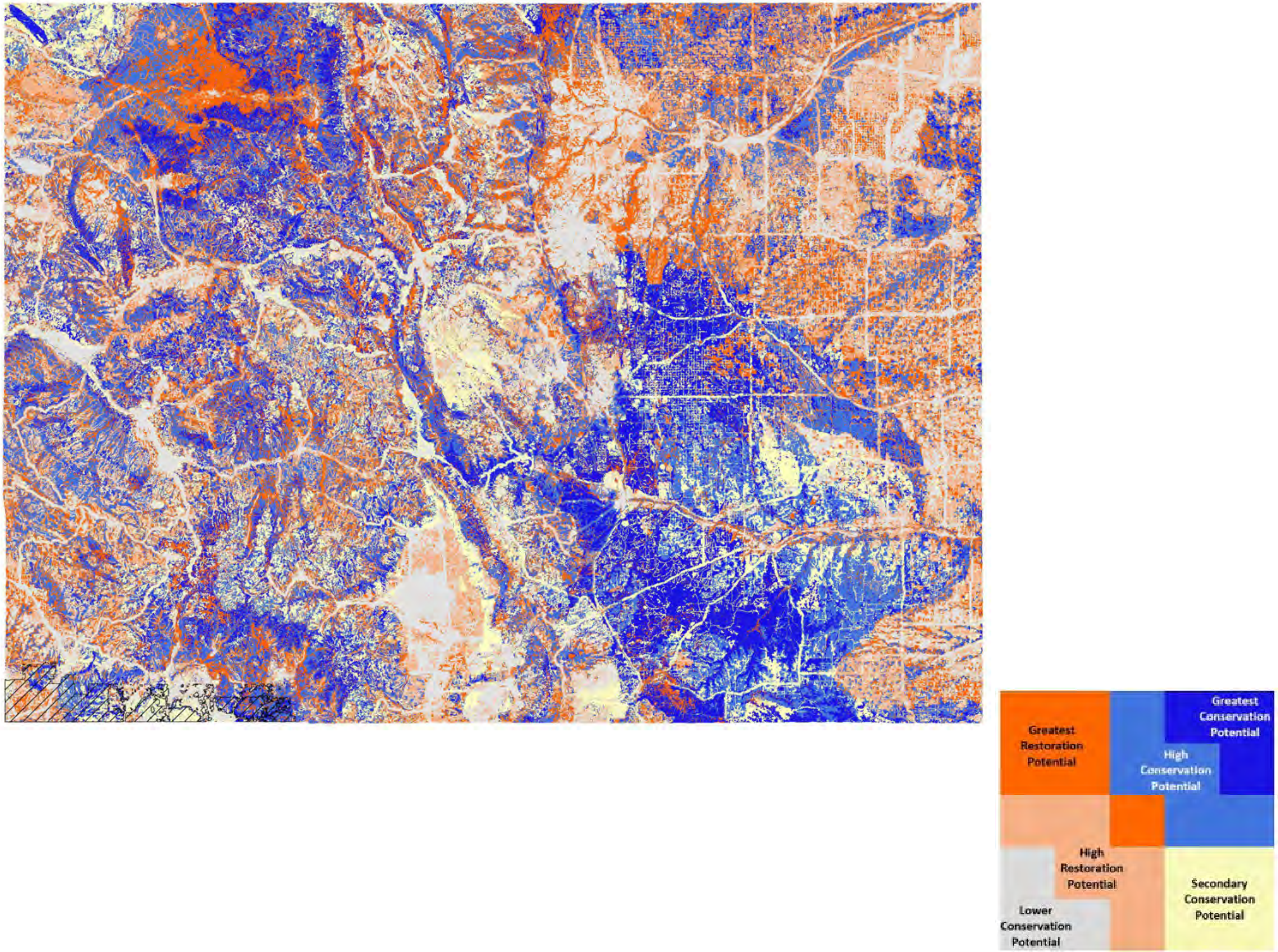
summary of data & data-interactions by spatial units



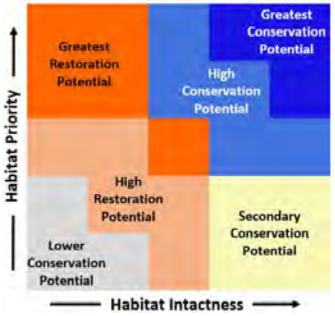

PRIORITY
5
4
3
2
1
Greatest Restoration Potential
Greatest Conservation Potential
High Conservation Potential
High Restoration Potential
Secondary Conservation Potential
Lower Conservation Potential
1
2
3
4
5
INTACTNESS


Dispersal values of 2.5, 5, 10, 25, and 50 miles representing guilds of animals with different dispersal potential
Landscape Resistance Models (generic species movement)
Elk and Mule Deer movement data
Least Cost Pathways (movement corridors)
Distribution data for:
Elk
Deer
Bighorn Sheep
Pronghorn
Greater Sage Grouse
Gunnison Sage Grouse
Columbian S-T Grouse
Plains S-T Grouse
Greater Prairie Chicken
Lesser Prairie Chicken
Tier 1 Native Fish
Sport Fish
Conservation Overview
Landscape Diversity (TNC)
Habitat Priority
Priority Landscape Matrix
Priority Value
Intactness Value
Land Conservation Protection Status (CNHP)
Projected Land Use Change (USGS)
Planning Landscape
Landscape Disturbance Index
Veg Condition Classes (LANDFIRE)
2023 Insect Damage (CSU)
Habitat Intactness




Greatest Restoration Potential
Greatest Conservation Potential
High Conservation Potential
High Restoration Potential
Lower Conservation Potential
Secondary Conservation Potential

COLORADO



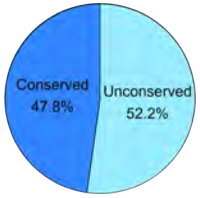
- 🟦 Greatest Conservation Potential
- 🟦 High Conservation Potential
- 🟧 Greatest Restoration Potential
- 🟧 High Restoration Potential
- 🟨 Secondary Conservation Potential
- ⬜ Lower Conservation Potential

Landscape Summary Statistics

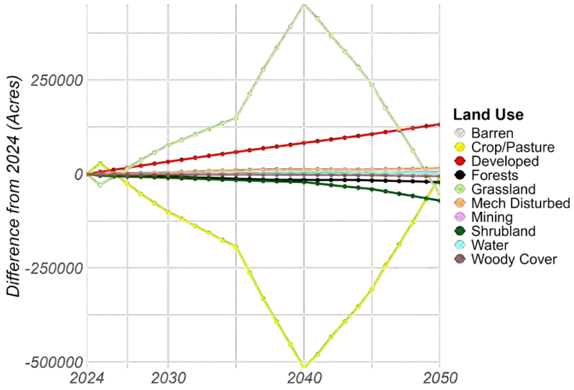
	Total Area (acres)	Conserved (acres)	Unconserved (acres)	Aggregation (out of 100)	Cohesion (out of 100)
🟦	8,898,313	4,766,693	4,021,916	84.56	98.70
🟦	15,827,261	8,933,664	6,696,712	84.45	98.65
🟧	11,081,396	5,189,446	5,717,744	82.21	99.05
🟧	11,592,918	5,044,816	6,393,939	83.42	98.33
🟨	7,467,712	3,960,664	3,407,847	82.65	98.80
⬜	11,751,269	3,408,508	8,138,105	89.41	99.91
	66,618,872	**31,303,794**	**34,376,266**	**84.45**	**98.91**

Bubble size proportional to land area for each category

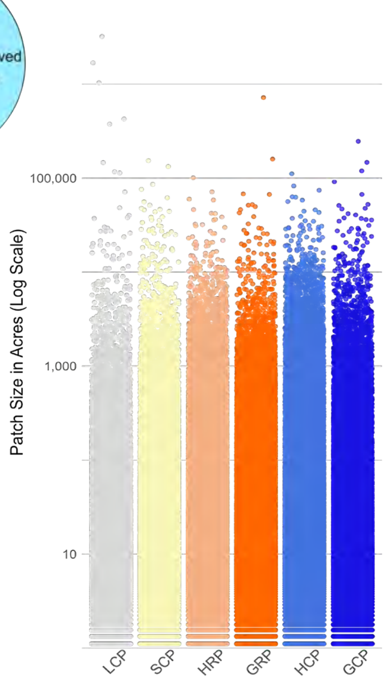
Current Land Protection



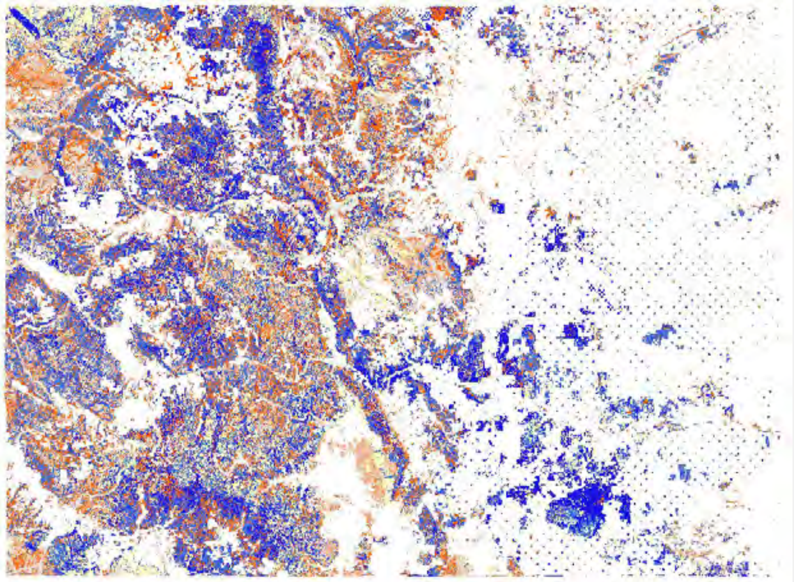
Current Land Ownership

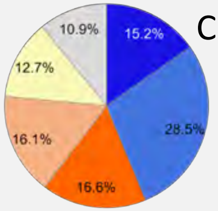


Future Predicted Land Use Change

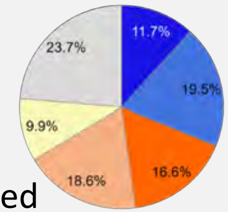


Patch Size Distribution

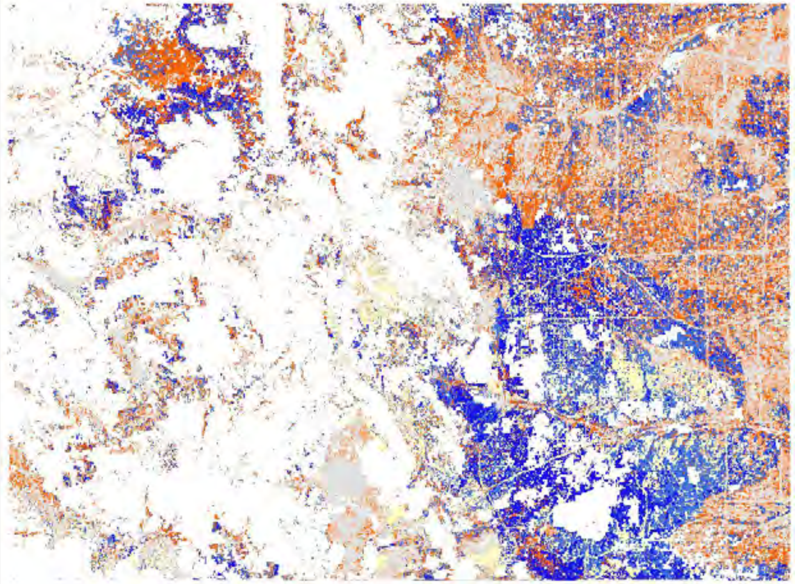




Conserved



Unconserved



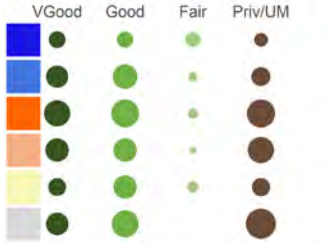
NORTH PLATTE HEADWATERS 10180001

Protect (Potential Land Conservation) rank:	43/92
Defend (Maintain Land Conservation) rank:	28/92
Restore (Habitat Restoration) rank:	32/92
Combined Rank:	**30/92** (tied)

- 🟦 Greatest Conservation Potential
- 🟦 High Conservation Potential
- 🟧 Greatest Restoration Potential
- 🟧 High Restoration Potential
- 🟨 Secondary Conservation Potential
- ⬜ Lower Conservation Potential

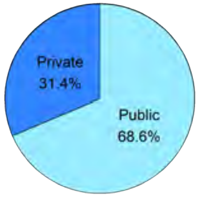
Landscape Summary Statistics

Total Area (acres)	Conserved (acres)	Unconserved (acres)	Aggregation (out of 100)	Cohesion (out of 100)
🟦 88,117	🟦 70,189	🟦 16,317	🟦 75.58	🟦 96.84
🟦 139,820	🟦 105,314	🟦 32,076	🟦 74.12	🟦 95.71
🟧 209,852	🟧 137,993	🟧 67,396	🟧 81.70	🟧 98.96
🟧 163,930	🟧 102,233	🟧 59,048	🟧 78.29	🟧 97.82
🟨 119,921	🟨 89,073	🟨 28,627	🟨 76.54	🟨 97.15
⬜ 191,075	⬜ 111,282	⬜ 75,832	⬜ 85.07	⬜ 99.26
912,718	616,086	279,298	78.55	97.62

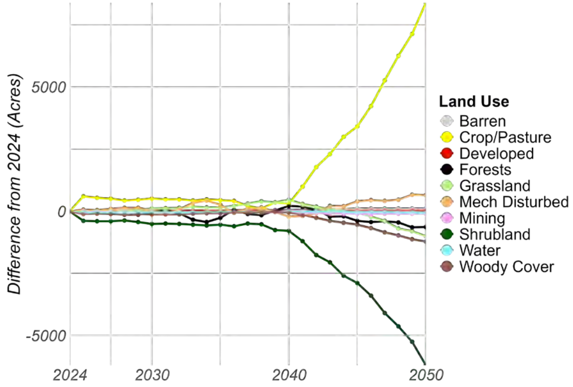


Bubble size proportional to land area for each category

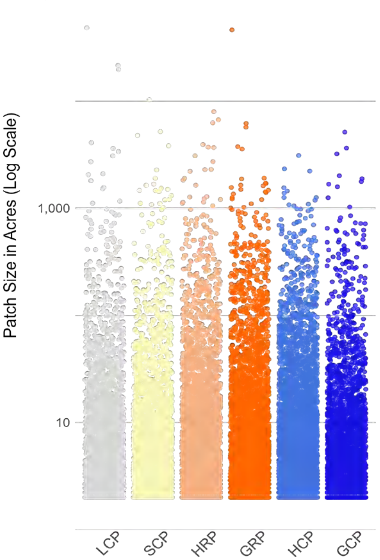
Current Land Protection



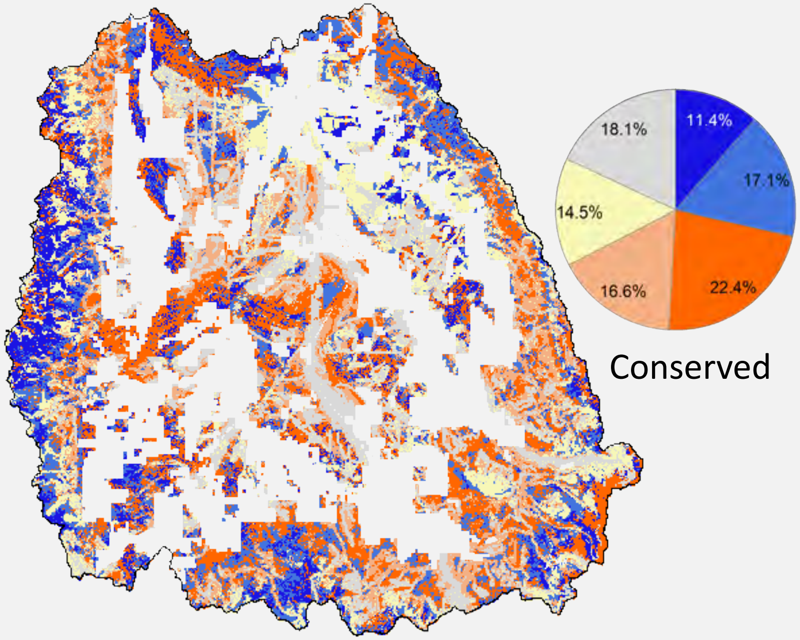
Current Land Ownership

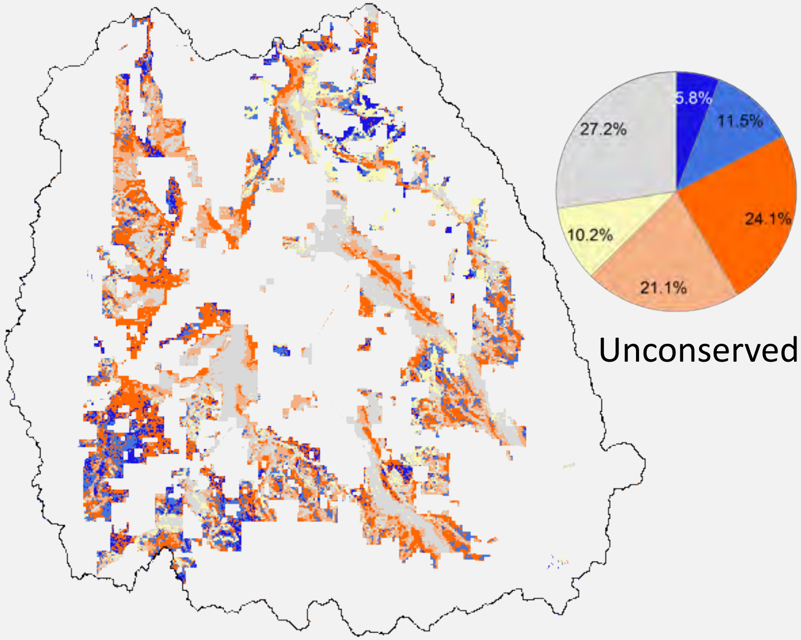


Future Predicted Land Use Change



Patch Size Distribution





RIO GRANDE HEADWATERS 13010001

Protect (Potential Land Conservation) rank:	72/92
Defend (Maintain Land Conservation) rank:	13/92
Restore (Habitat Restoration) rank:	30/92
Combined Rank:	**40/92**

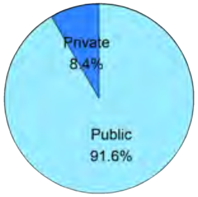
- 🟦 Greatest Conservation Potential
- 🟦 High Conservation Potential
- 🟧 Greatest Restoration Potential
- 🟧 High Restoration Potential
- 🟨 Secondary Conservation Potential
- ⬜ Lower Conservation Potential

Landscape Summary Statistics

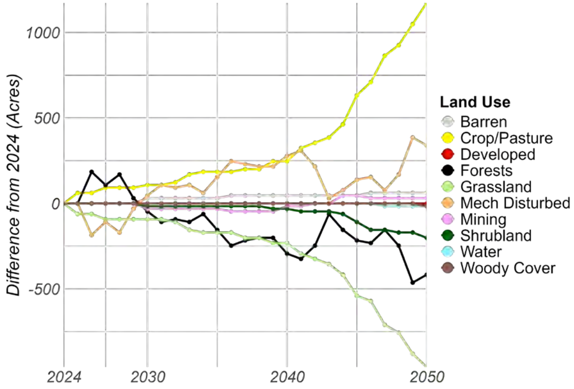
	Total Area (acres)	Conserved (acres)	Unconserved (acres)	Aggregation (out of 100)	Cohesion (out of 100)
🟦	89,520	85,630	3,000	79.03	96.78
🟦	255,789	246,599	7,431	80.15	98.10
🟧	110,610	98,494	10,591	73.21	95.94
🟧	107,535	94,490	11,495	71.45	94.59
🟨	217,402	210,041	5,822	84.94	98.54
⬜	104,411	69,465	32,186	81.18	99.01
	885,269	**804,722**	**70,528**	**78.33**	**97.16**

Bubble size proportional to land area for each category

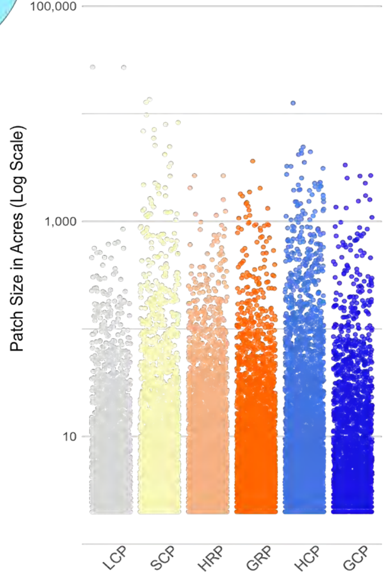
Current Land Protection



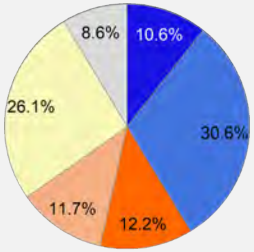
Current Land Ownership



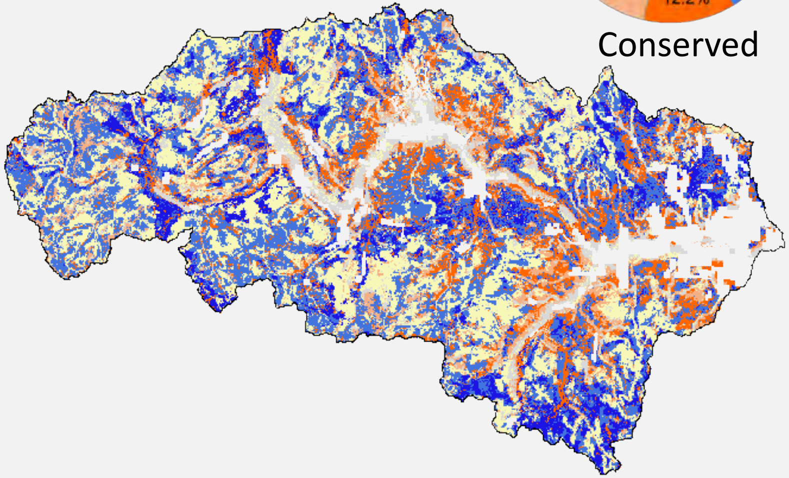
Future Predicted Land Use Change

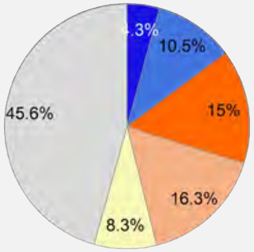


Patch Size Distribution

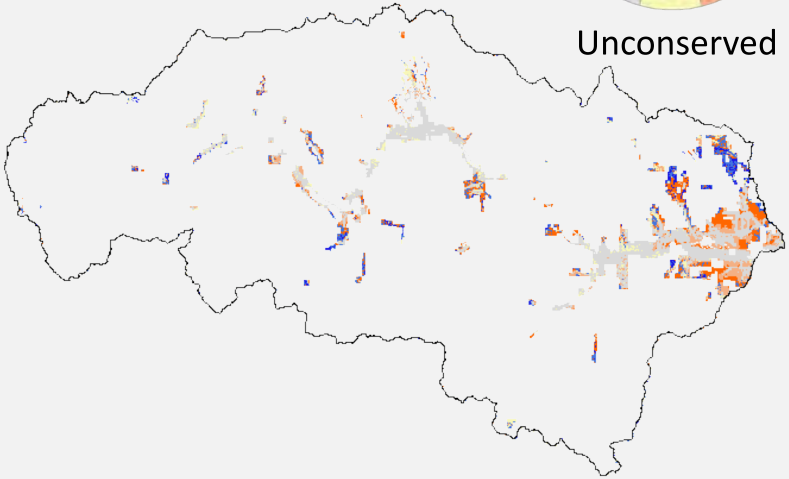


Conserved

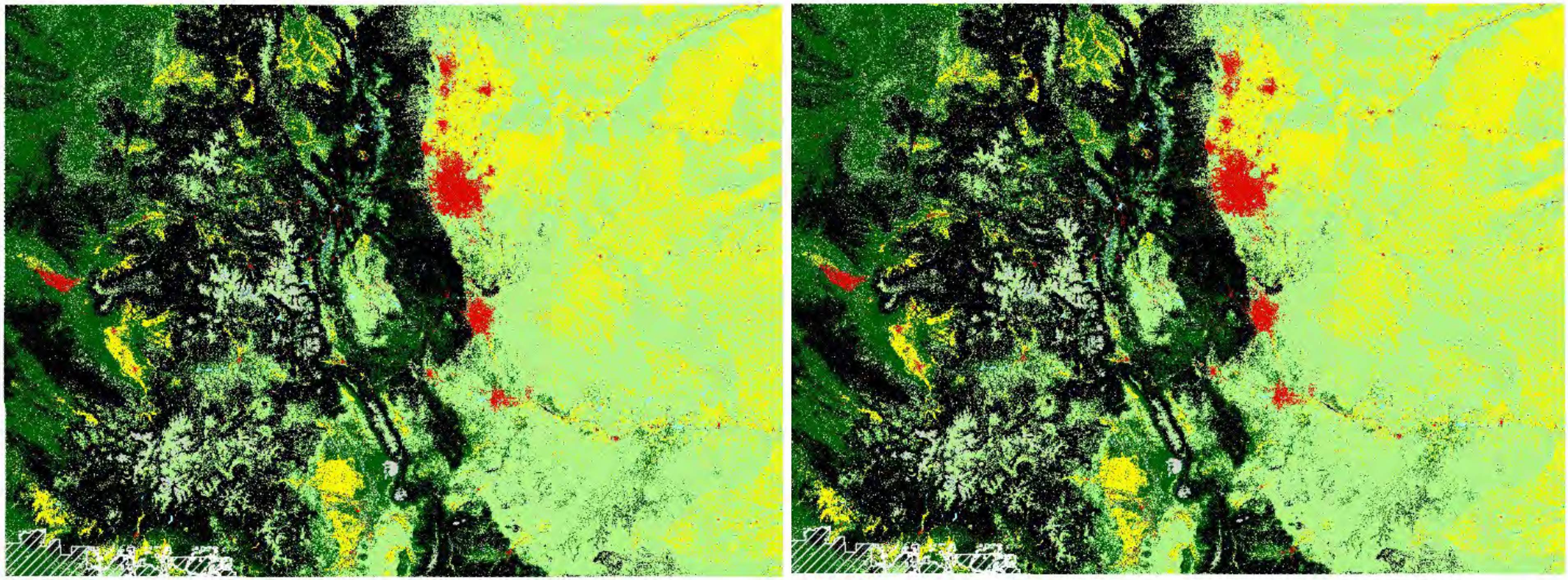




Unconserved



BASE DATA PROJECTED LANDUSE CHANGE



2024

2050

USGS FORE-SCE Model

- Uses the **IPCC SRES** “A2” scenario (socioeconomic impacts on anthropogenic land use incorporating demographics, energy use, agricultural economics, and other socioeconomic considerations).

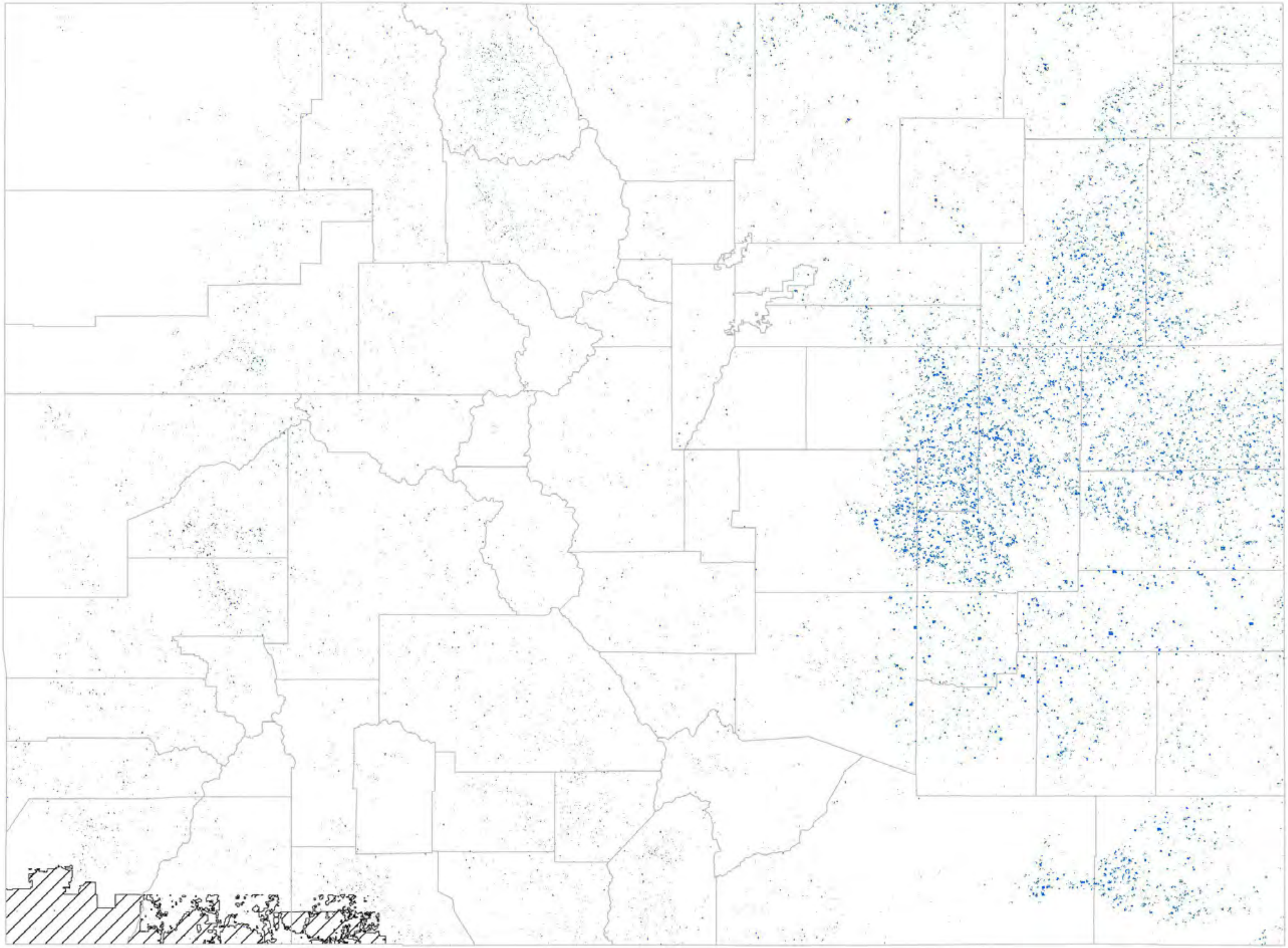
- A2 is the “worst case” scenario, with continued economic development and temperature increases 2.0-5.4 degrees C.

- The FORE-SCE model “known” landscape data from 1992-2005 using the A2 scenario, then projects 2006-2100.

- Predicts future land use and land cover.

🟦 Water
🟥 Developed
🟧 Mechanically Disturbed
🟪 Mining
⬜ Barren
⬛ Forest
🟩 Grassland
🟩 Shrubland
🟨 Crop/Pasture
🟫 Woody Cover
🟦 Perennial Ice/Snow

PROJECTED LAND USE CHANGE



Projected Land Use Change 2024 vs 2050 Under USGS A2 Model

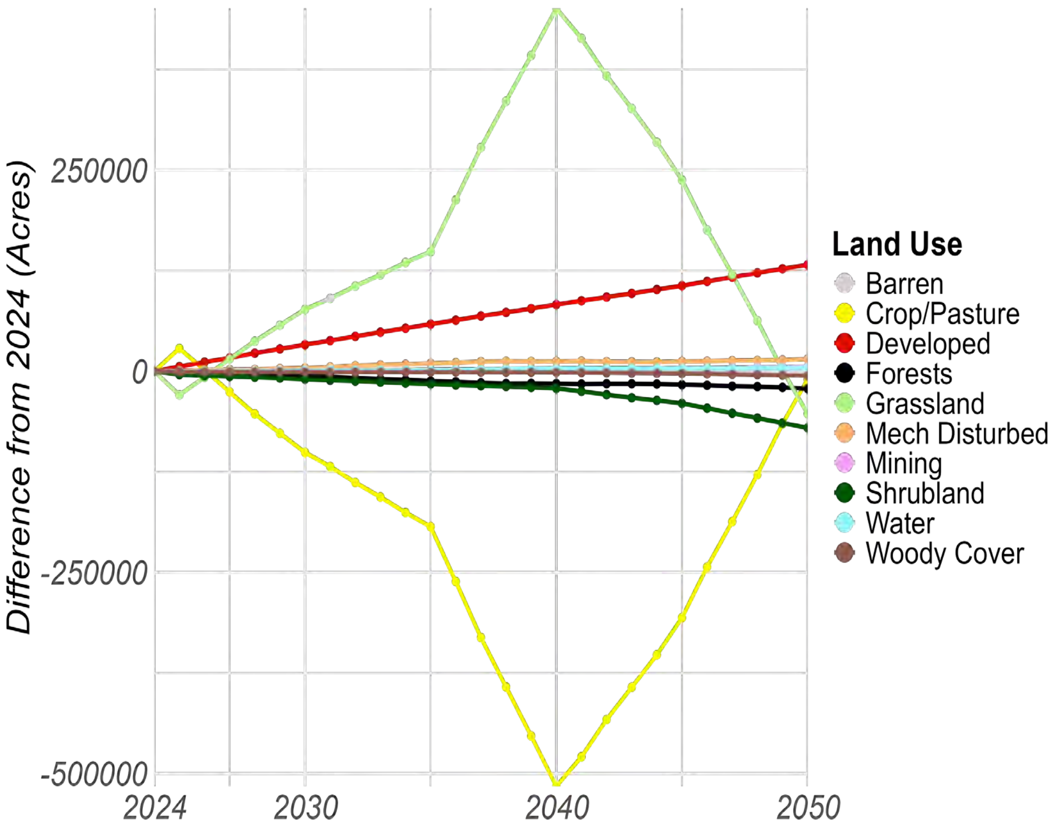
🟦 Land Use Change

▨ Tribal Land

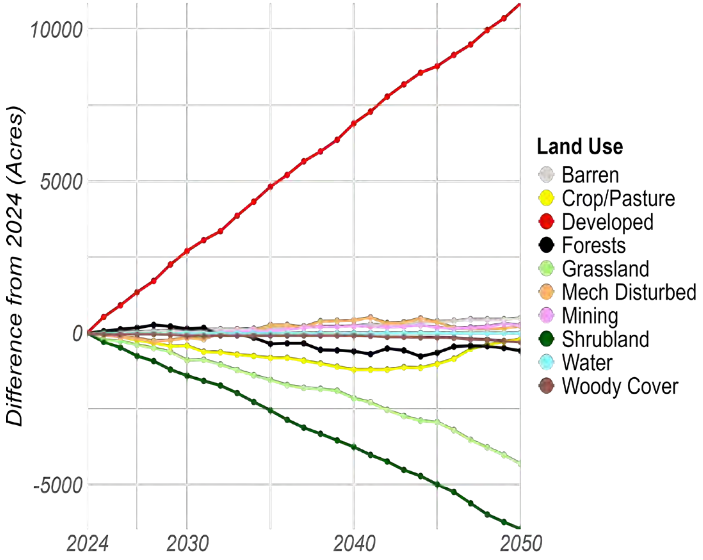
Colorado County Boundaries

PROJECTED LAND USE CHANGE

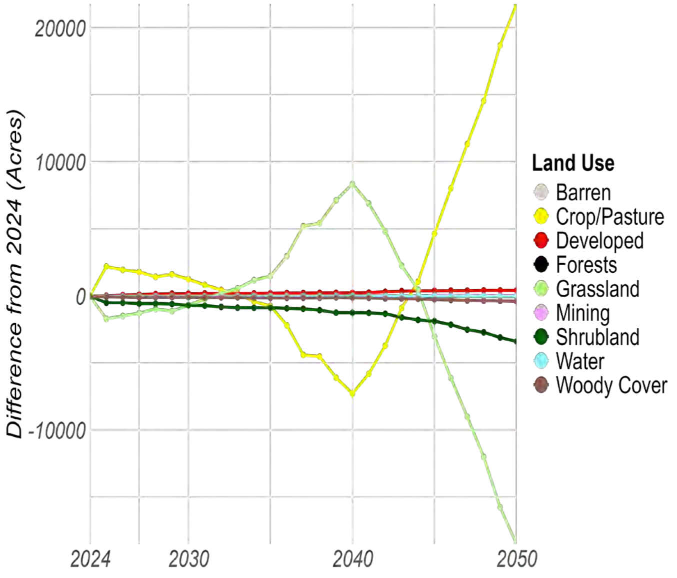
ALL COLORADO



UPPER ARKANSAS

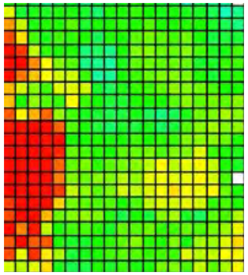


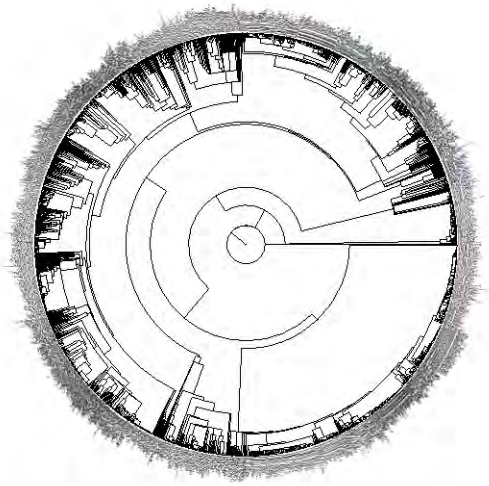
UPPER ARKANSAS-JOHN MARTIN RESERVOIR



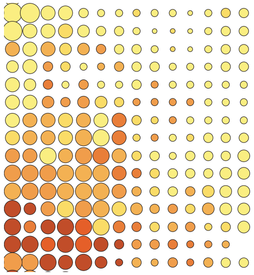
Future Hopes & Dreams

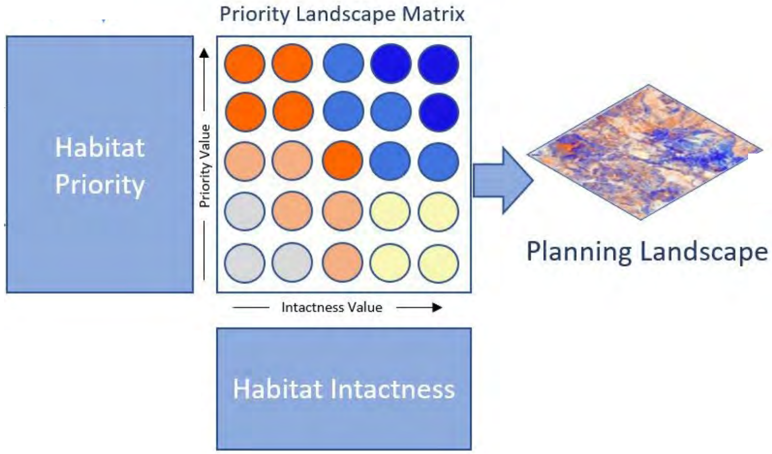
Colorado
Species
Diversity

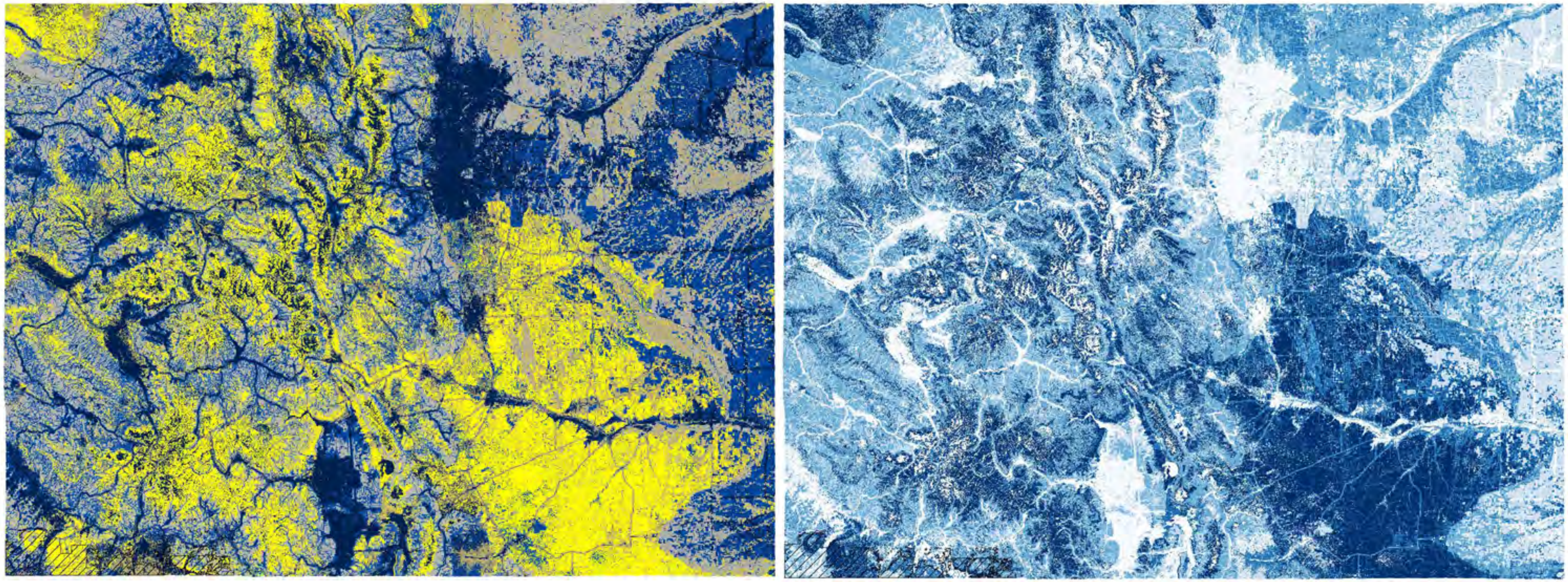




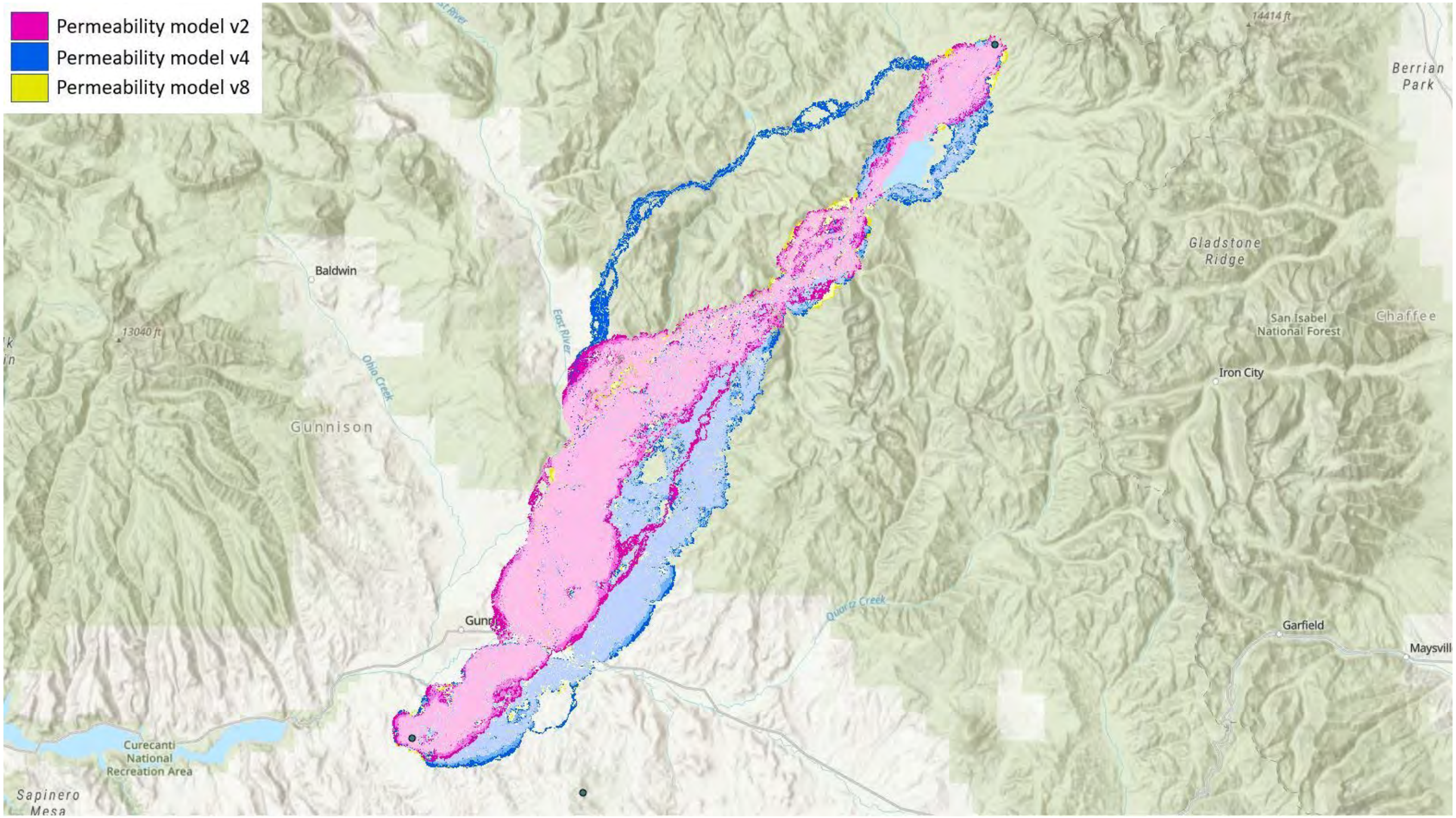
Colorado
Genetic
Diversity



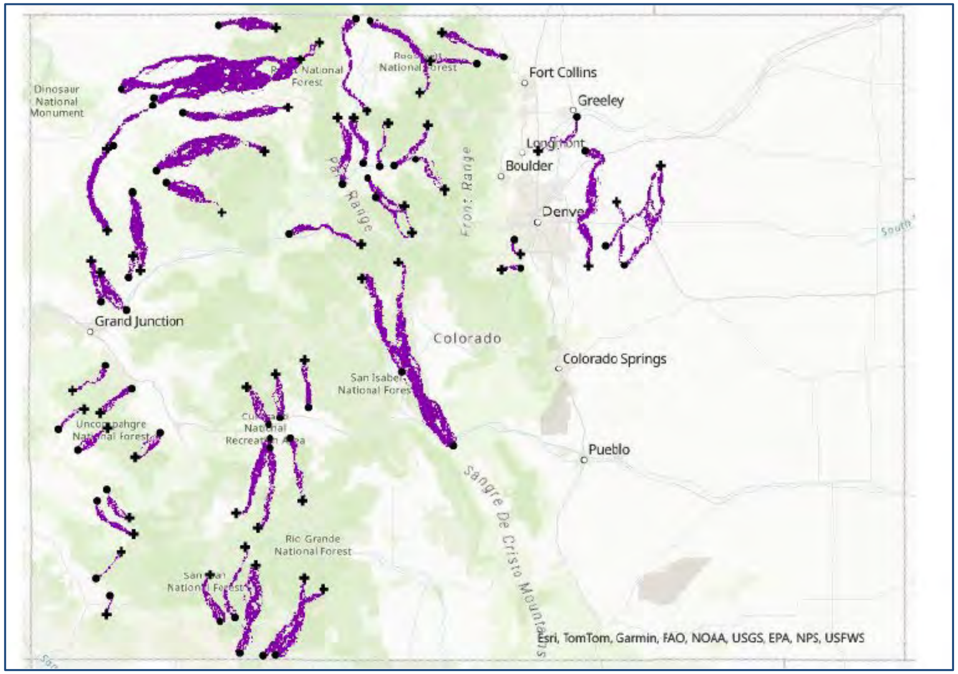




- Ran a set of “known” corridor paths using a subset of the candidate models
- Tested the overlap of those models with the know movement paths



The final model was then used to extrapolate between “unknown” start and end points



Esri, TomTom, Garmin, FAO, NOAA, USGS, EPA, NPS, USFWS

Mule Deer

Elk