Ecological Niche Modeling: Introduction

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Why is a species where it is ?

Why is a species where it is ?

- Mutation
- Dispersion
- Selection
  - Competition
  - Human activity
- Chance
- Time

- GEOLOGY
- GEOGRAPHY
- CLIMATE

What is a niche ???

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- Grinellian niche: habitat requirements that allow a species to persist and reproduce
- Eltonian niche: role that a species plays in a community, rather than habitat
- Hutchinsonian niche:
  - Fundamental niche: area with optimal biotic and abiotic conditions, but **free of interference** from other species
  - Realized niche: subset of the fundamental niche actually occupied by the species, due to pressures from other species.

What is a niche ???

- **Optimum environment for growth, reproduction, and survival of a species**

- **Defined by:**
  - **Substrate**
  - **Microclimate**
  - **Competition**

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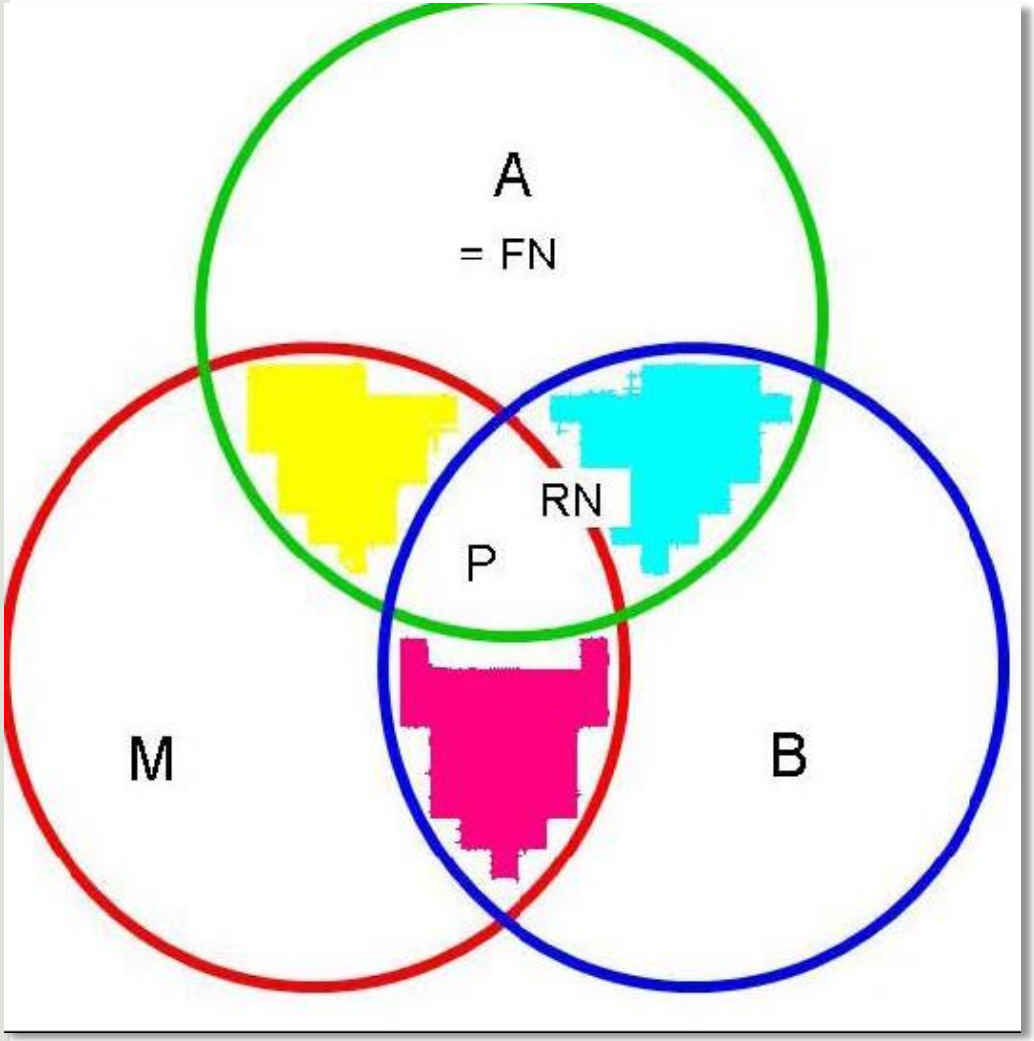
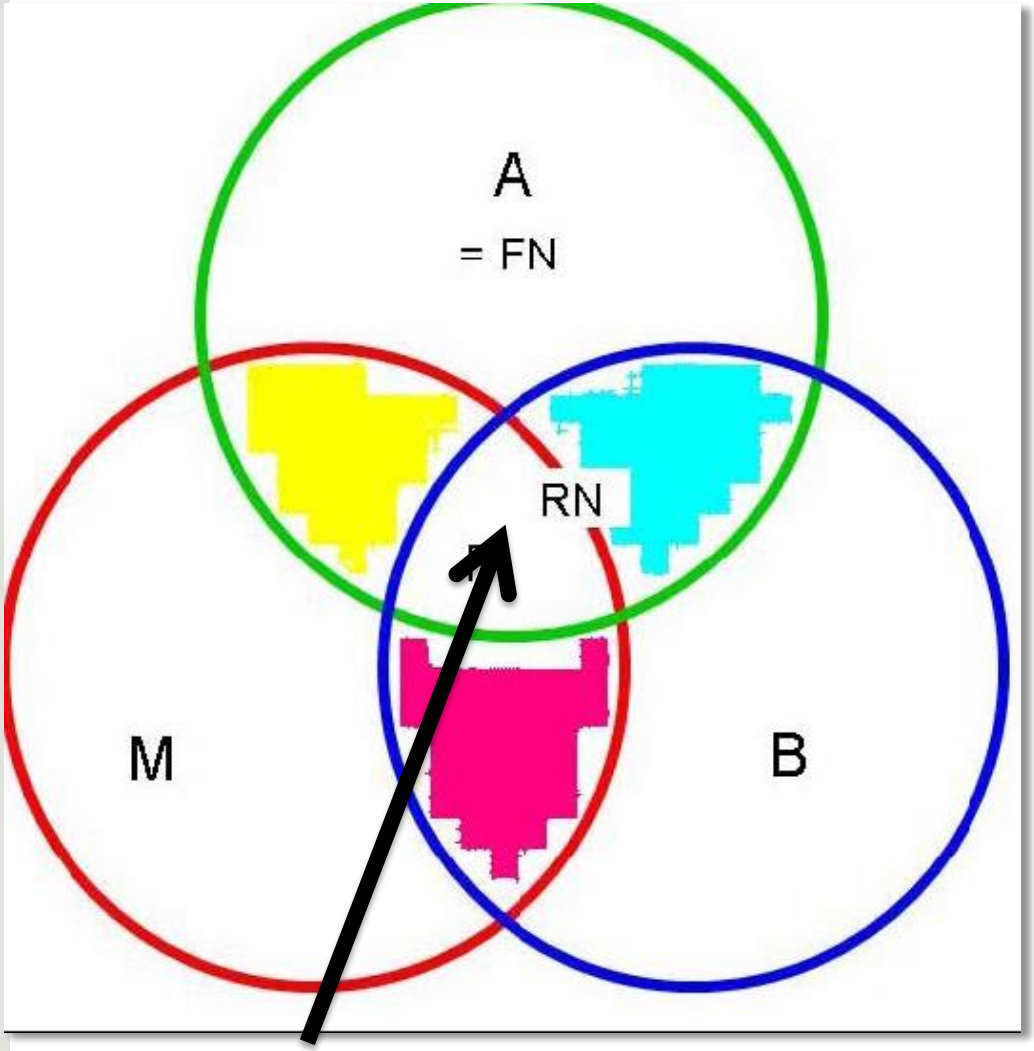


Appropriate set of abiotic factors – fundamental niche

Right combination of species interactions – realized niche

Regions accessible ecologically

Soberon and Peterson (2005) Biodiversity Informatics 2:1-10



Occupied niche

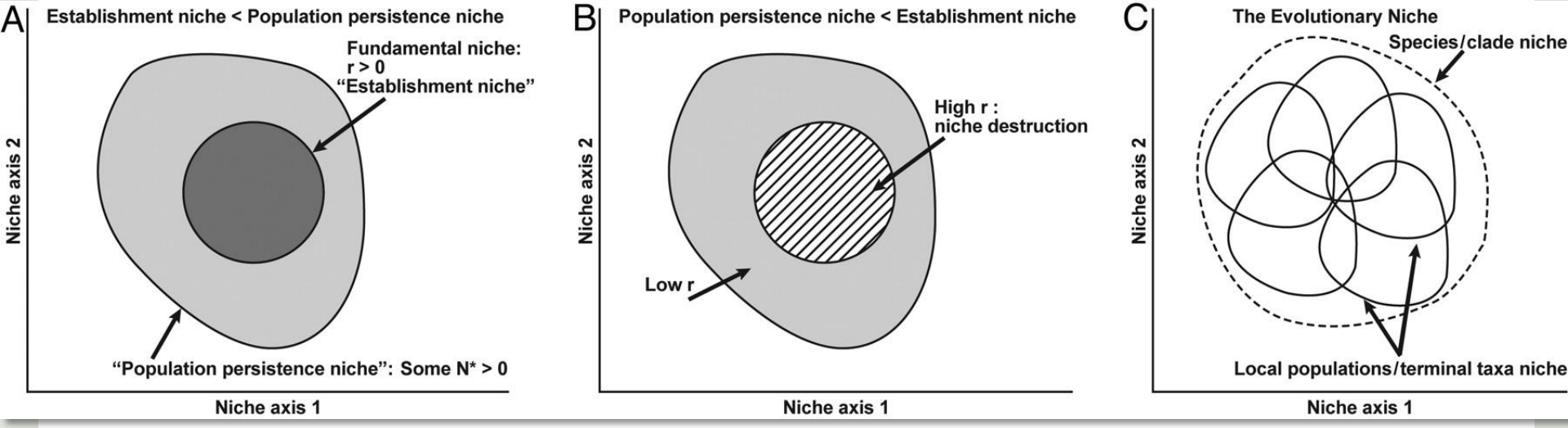
Appropriate set of abiotic factors – fundamental niche

Right combination of species interactions – realized niche

Regions accessible ecologically

Soberon and Peterson (2005) Biodiversity Informatics 2:1-10

The occupied niche can change and shift over time, within the realized niche.

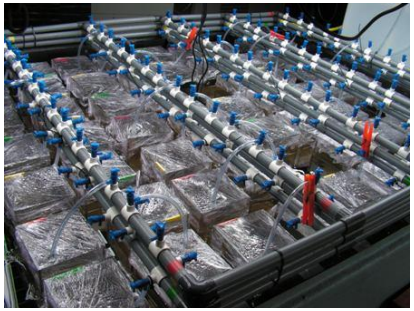


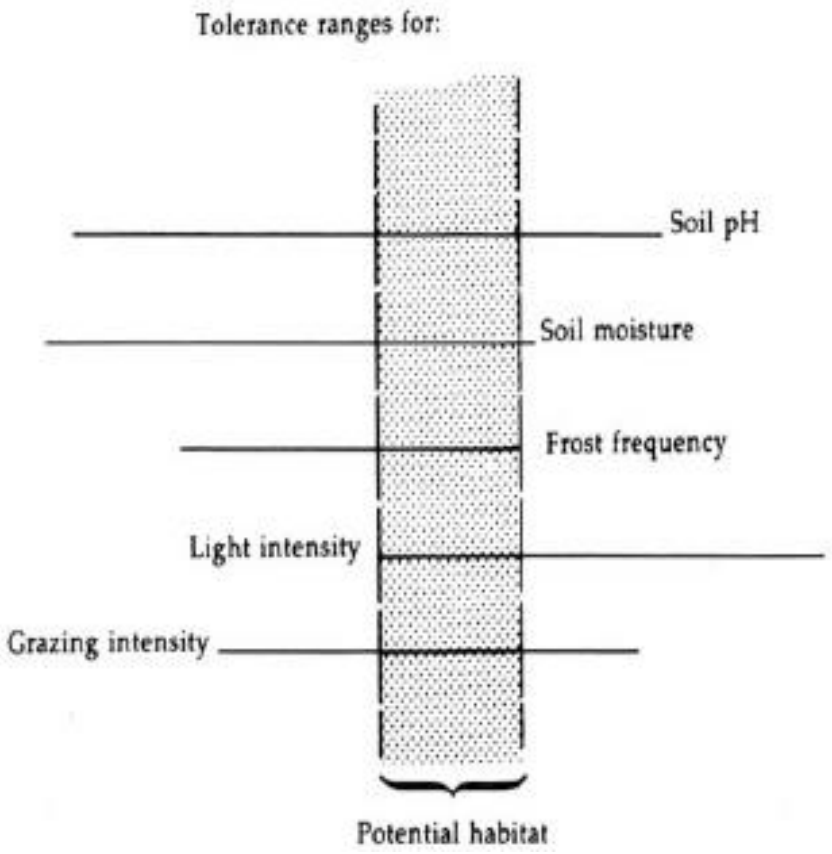
Fundamental niche is still worth estimating, even if it is not a perfect representation of a species distribution at a precise point in time.

Holt, R. D. (2009) PNAS 106 : 19659-19665

Establishing a species' environmental tolerance

- Ex situ: Common garden experiment on site (controlled field conditions)
- Common garden experiment in situ (where the tested climate occurs)
- Thorough field surveys over time (usually leads to distribution map = absence map)





- VERY DIFFICULT !!!

Ecological niche models

Look at a set of conditions under which a species occurs naturally (presence data)
When possible, also look at conditions under which the species does NOT occur (absence data)

- BUILD THE MODEL

Apply the model in space (around where it occurs naturally, or in another area), or in time (where did it use to occur, or where will it occur in the future)

- PROJECT THE MODEL

Ecological niche models

<u>Occurrence data:</u>
where the species is present, but not where it is absent

<u>Distribution map:</u>
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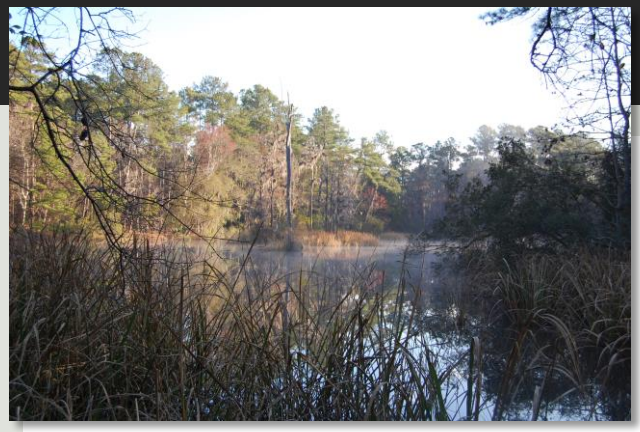
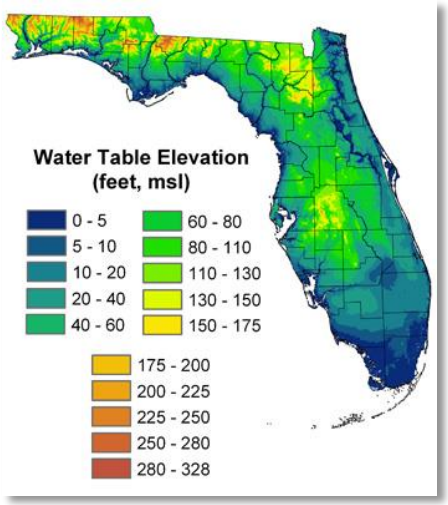
Niche Model applications |

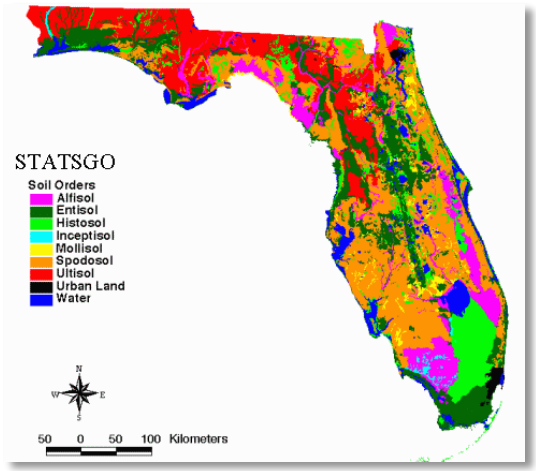
- PRACTICAL
  - Invasive species
  - Disease
  - Data deficient species
  - Conservation/Land Management

- THEORETICAL
  - Diversity through time
  - Evolutionary patterns

Florida Plant Diversity





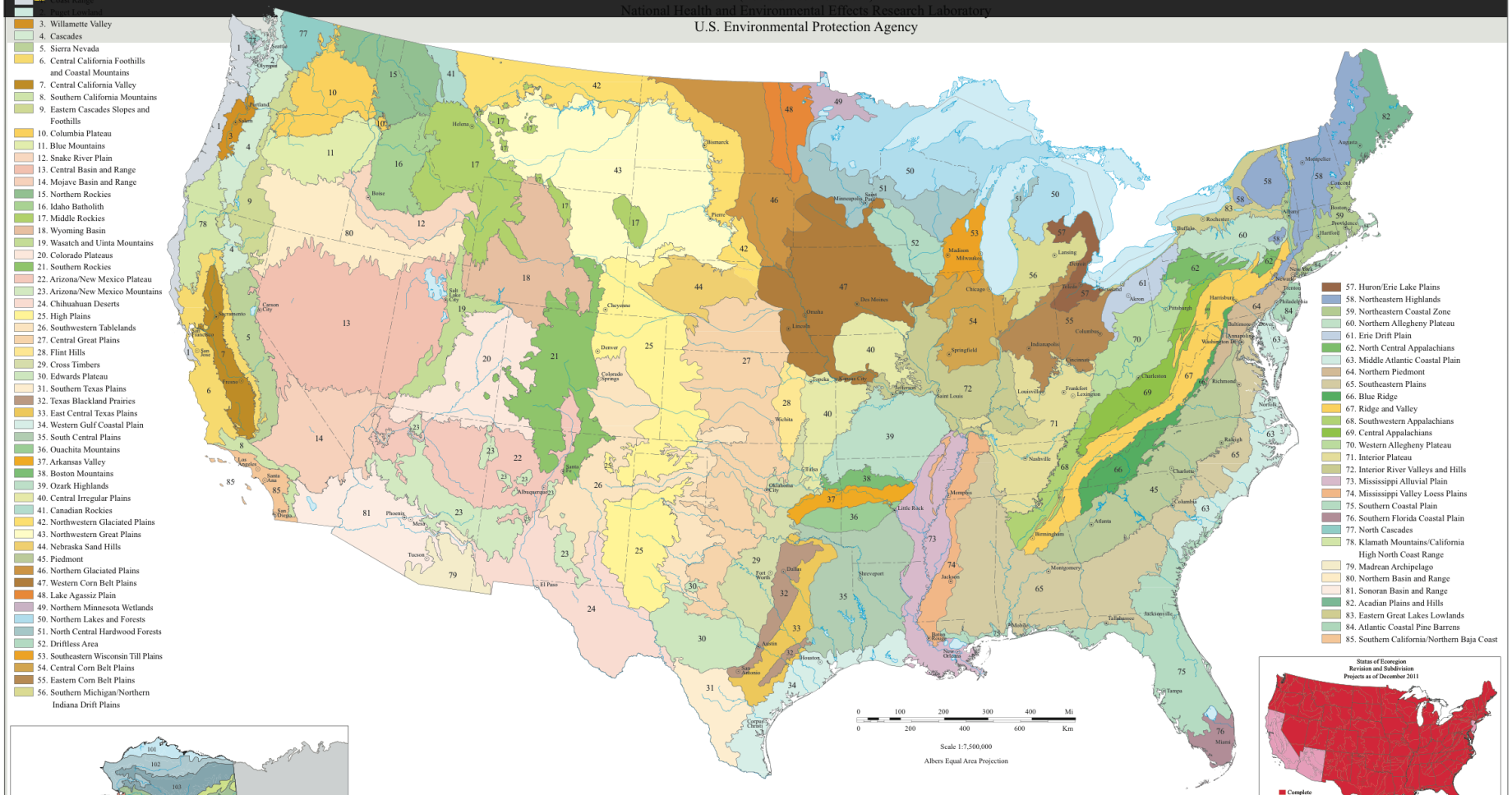


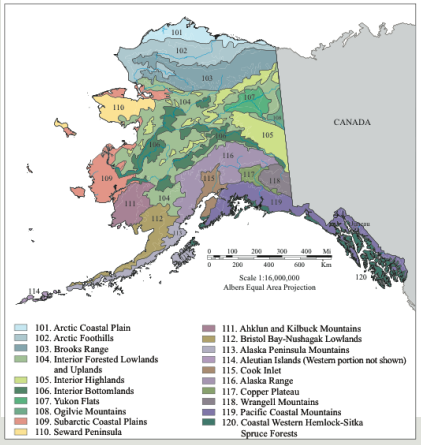
Level III Ecoregions of the Continental United States

(Revised December 2011)

National Health and Environmental Effects Research Laboratory

U.S. Environmental Protection Agency





The ecoregions shown here have been derived from Omernik (1987) and from refinements of Omernik's framework that have been made for other projects. These ongoing or recently completed projects, conducted in collaboration with the U.S. EPA regional offices, state resource management agencies, and with other federal agencies, involve refining ecoregions, defining subregions, and locating sets of reference sites. Designed to serve as a spatial framework for environmental resource management, ecoregions denote areas within which ecosystems (and the type, quality, and quantity of environmental resources) are generally similar. The most immediate needs are to develop regional biological criteria and water quality standards and to set management goals for nonpoint source pollution.

The approach used to compile this map is based on the premise that ecological regions can be identified through the analysis of the patterns and the composition of biotic and abiotic phenomena that affect or reflect differences in ecosystem quality and integrity (Wiken 1986; Omernik 1987, 1995). These phenomena include geology, physiography, vegetation, climate, soils, land use, wildlife, and hydrology. The relative importance of each characteristic varies from one ecological region to another regardless of the hierarchical level. Because of possible confusion with other meanings of terms for different levels of ecological regions, a Roman numeral classification scheme has been adopted for this effort. Level I is the coarsest level, dividing North America into 15 ecological regions, whereas at Level II the continent is subdivided into 50 classes (CEC 1997). Level III is the hierarchical level shown on this map. For portions of the United States (see map inset) the ecoregions have been further subdivided to Level IV. The applications of the ecoregions are explained in reports and publications from the state and regional projects (e.g., Bryce et al., 1998, 2003; Chapman et al., 2001, 2006; Daigle et al., 2006; Gallant et al., 1989, 1995; Griffith et al., 1998, 2002, 2004; McGrath et al., 2002; Omernik et al., 2000, 2004; Thorson et al., 2003; and Woods et al., 1996, 2002, 2004). For additional information, contact James M. Omernik, U.S. EPA National Health and Environmental Effects Laboratory (NHEERL), 200 SW 35th Street, Corvallis, OR 97333; phone: (541) 754-4458, email: omernik.james@epa.gov.

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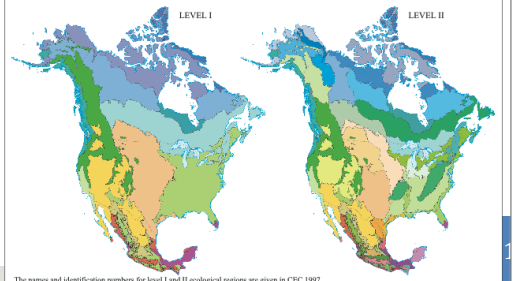
ECOLOGICAL REGIONS OF NORTH AMERICA



The names and identification numbers for level I and II ecological regions are given in CEC 1997.

Ecoregion maps, publications, GIS files, and contact information are available at www.epa.gov/wed/pages/ecoregions.htm

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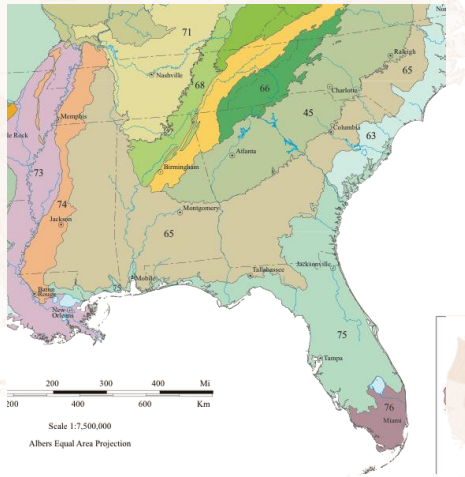


1. Coast Range
2. Puget Lowland
3. Willamette Valley
4. Cascades
5. Sierra Nevada
6. Central California Foothills and Coastal Mountains
7. Central California Valley
8. Southern California Mountains
9. Eastern Cascades Slopes and Foothills
10. Columbia Plateau
11. Blue Mountains
12. Snake River Plain
13. Central Basin and Range
14. Mojave Basin and Range
15. Northern Rockies
16. Idaho Batholith
17. Middle Rockies
18. Wyoming Basin
19. Wasatch and Uinta Mountains
20. Colorado Plateaus
21. Southern Rockies
22. Arizona/New Mexico Plateau
23. Arizona/New Mexico Mountains
24. Chihuahuan Deserts
25. High Plains
26. Southwestern Tablelands
27. Central Great Plains
28. Flint Hills
29. Cross Timbers
30. Edwards Plateau
31. Southern Texas Plains
32. Texas Blackland Prairies
33. East Central Texas Plains
34. Western Gulf Coastal Plain
35. South Central Plains
36. Ouachita Mountains
37. Arkansas Valley
38. Boston Mountains
39. Ozark Highlands
40. Central Irregular Plains
41. Canadian Rockies
42. Northwestern Glaciated Plains
43. Northwestern Great Plains
44. Nebraska Sand Hills
45. Piedmont
46. Northern Glaciated Plains
47. Western Corn Belt Plains
48. Lake Agassiz Plain
49. Northern Minnesota Wetlands
50. Northern Lakes and Forests
51. North Central Hardwood Forests
52. Driftless Area
53. Southeastern Wisconsin Till Plains
54. Central Corn Belt Plains
55. Eastern Corn Belt Plains
56. Southern Michigan/Northern Indiana Drift Plains
57. Huron/Erie Lake Plains
58. Northeastern Highlands
59. Northeastern Coastal Zone
60. Northern Allegheny Plateau
61. Erie Drift Plain
62. North Central Appalachians
63. Middle Atlantic Coastal Plain
64. Northern Piedmont
65. Southeastern Plains
66. Blue Ridge
67. Ridge and Valley
68. Southwestern Appalachians
69. Central Appalachians
70. Western Allegheny Plateau
71. Interior Plateau
72. Interior River Valleys and Hills
73. Mississippi Alluvial Plain
74. Mississippi Valley Loess Plains
75. Southern Coastal Plain
76. Southern Florida Coastal Plain
77. North Cascades
78. Klamath Mountains/California High North Coast Range
79. Madrean Archipelago
80. Northern Basin and Range
81. Sonoran Basin and Range
82. Acadian Plains and Hills
83. Eastern Great Lakes Lowlands
84. Atlantic Coastal Pine Barrens
85. Southern California/Northern Baja Coast

101. Arctic Coastal Plain
102. Arctic Foothills
103. Brooks Range
104. Interior Forested Lowlands and Uplands
105. Interior Highlands
106. Interior Bottomlands
107. Yukon Flats
108. Ogilvie Mountains
109. Subarctic Coastal Plains
110. Seward Peninsula
111. Ahklun and Kilbuck Mountains
112. Bristol Bay-Nushagak Lowlands
113. Alaska Peninsula Mountains
114. Aleutian Islands (Western portion not shown)
115. Cook Inlet
116. Alaska Range
117. Copper Plateau
118. Wrangell Mountains
119. Pacific Coastal Mountains
120. Coastal Western Hemlock-Sitka Spruce Forests

BIG DATA !!!

- Florida Plant Atlas
- Florida Native Area Inventory
- Global Information Facility
- Florida State University Herbarium
- Louisana State University Herbarium
- University of North Carolina Herbarium
- Alabama Plant Atlas
- Mississippi State University Herbarium
- Florida Museum of Natural History Herbarium
    - >500,000 georeferenced points

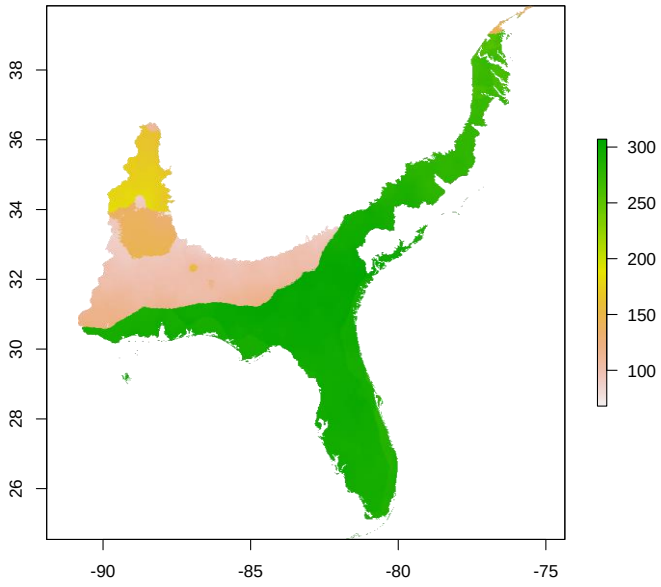
Data cleaning

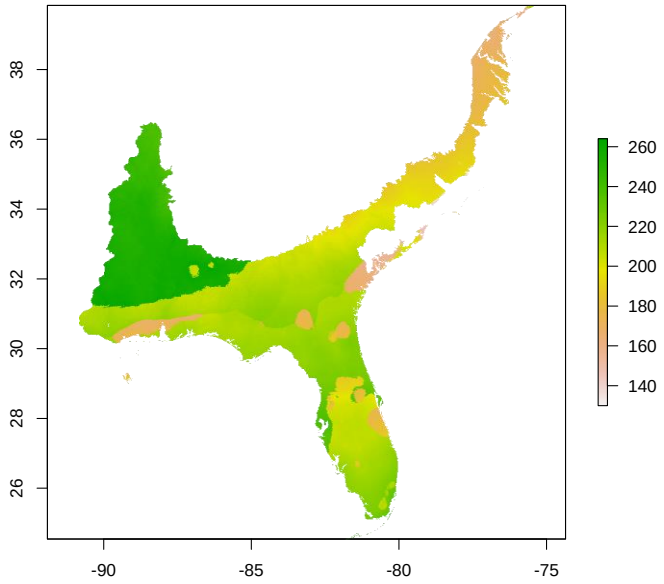
- Wunderlin list of 4,094 species of Florida plants
- Check list against Tropicos accepted names
- Same batch resolution for all datasets

- All non-Florida species removed
- Duplicates removed
- 3 EPA ecoregions
    - 391,937 343,266 dated
- 30+ points per species
    - 372,241 pts for 1,738 species

Climate layers processing

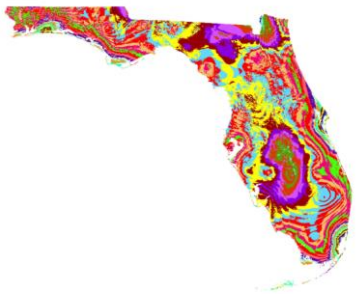
- Bioclim correlation 8 layers < 0.85
- Altitude
- Geology

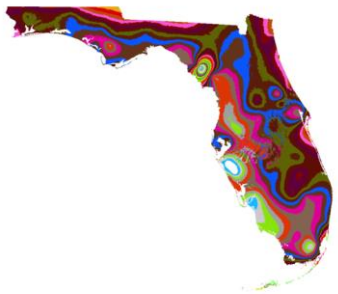


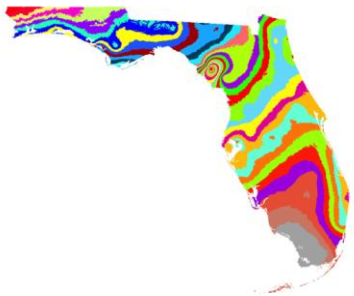


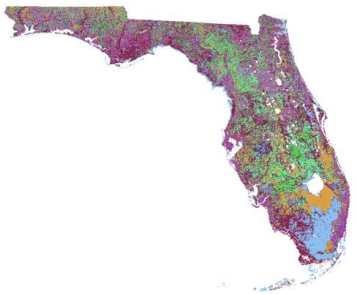
Ecological Niche Modeling

Flatspike Sedge



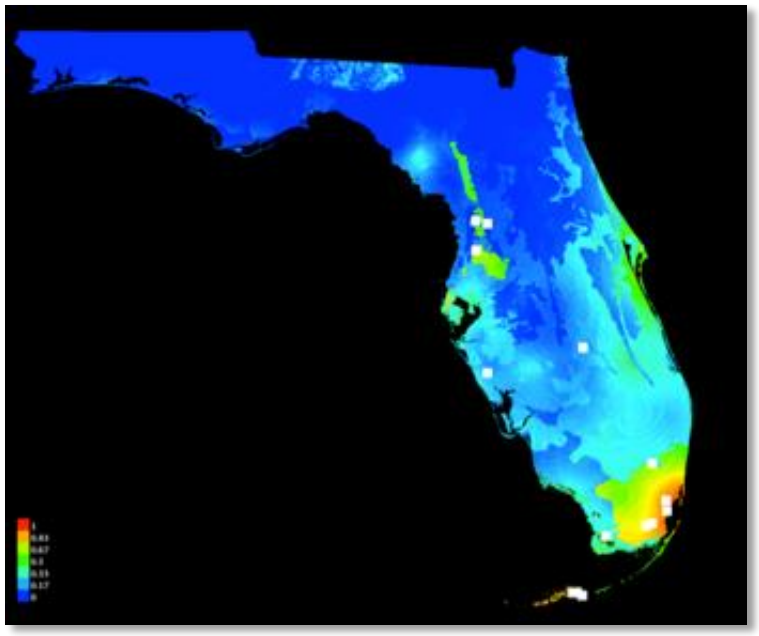




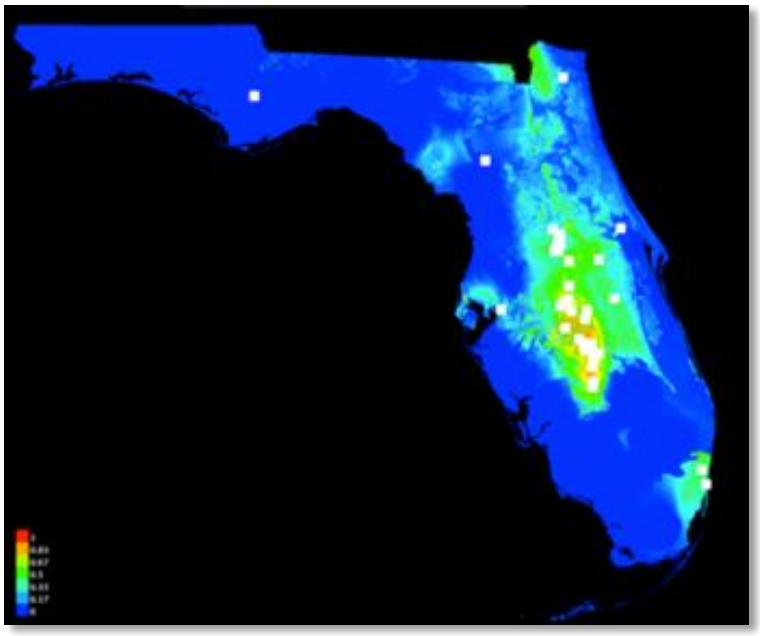


Single species

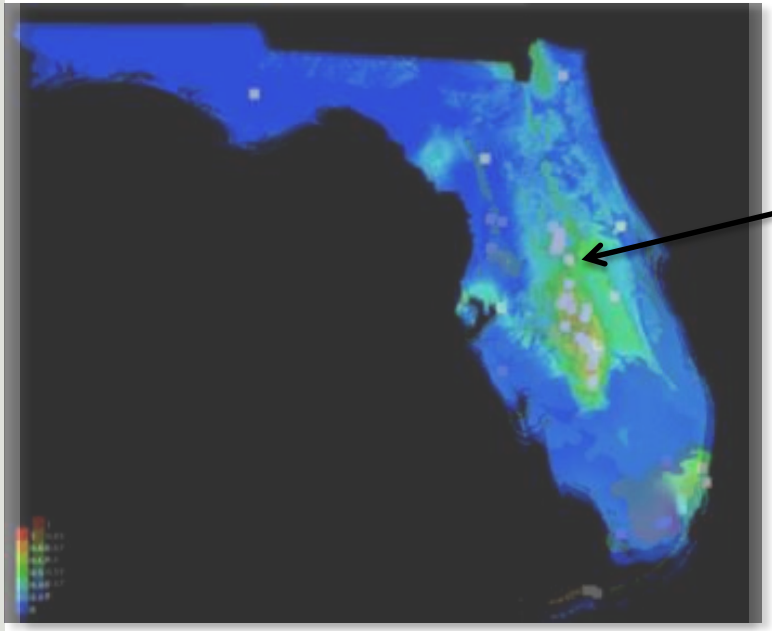
Flatspike Sedge



Scrub Palm

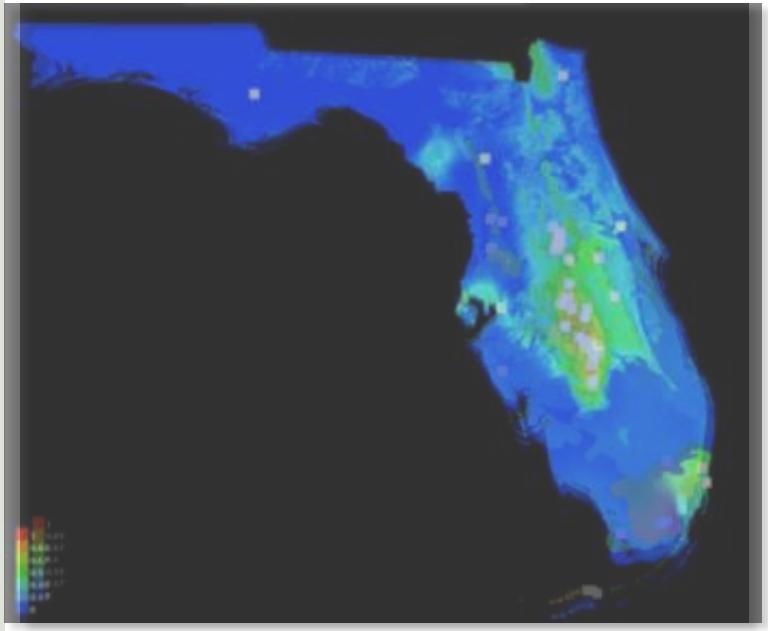


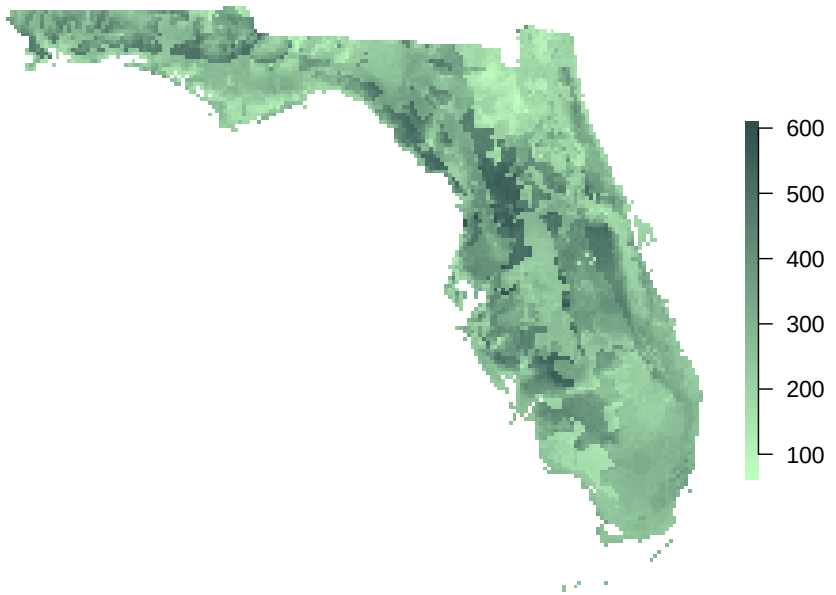
Species diversity



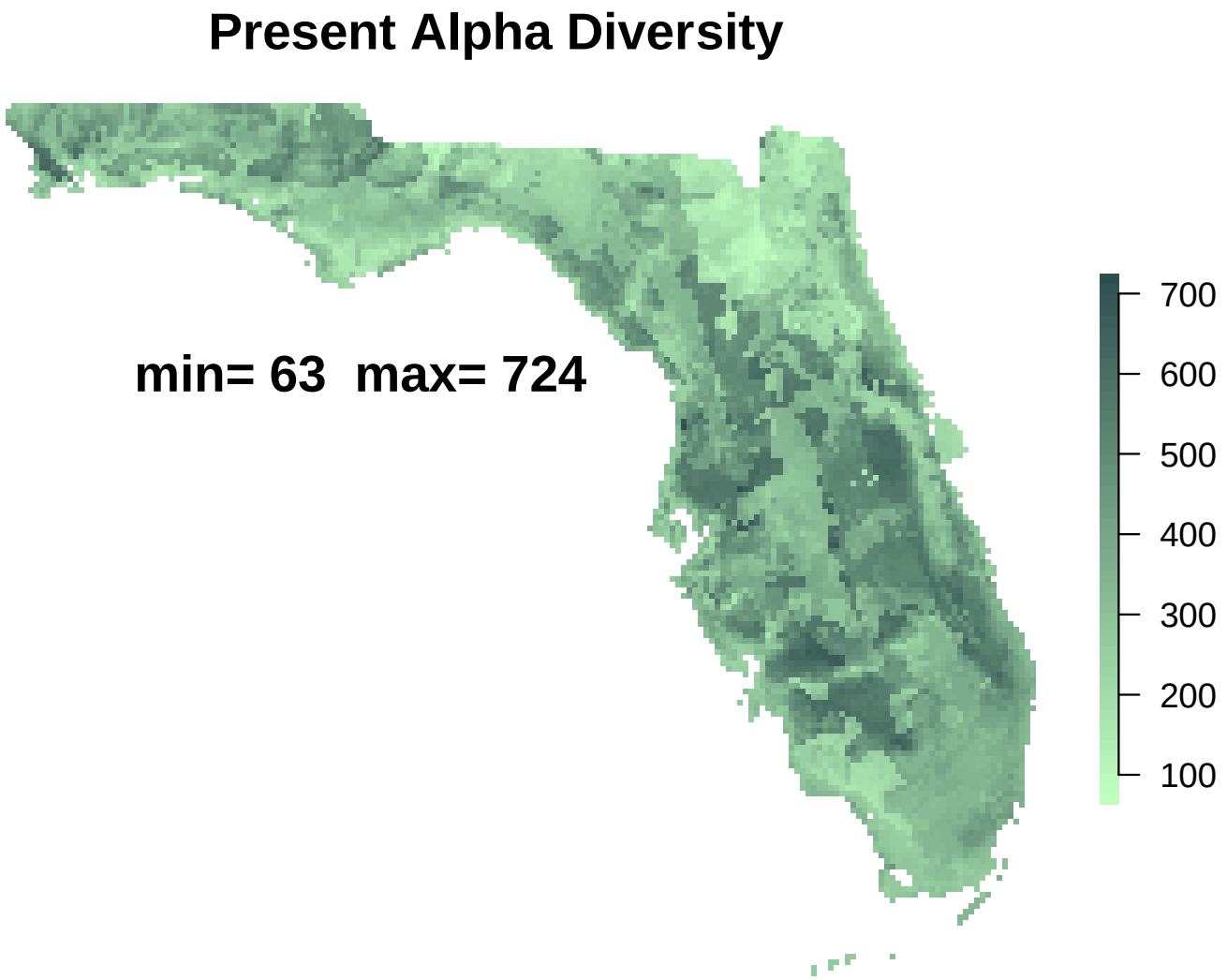
How many species are predicted to reside in this point?

All Plant Diversity



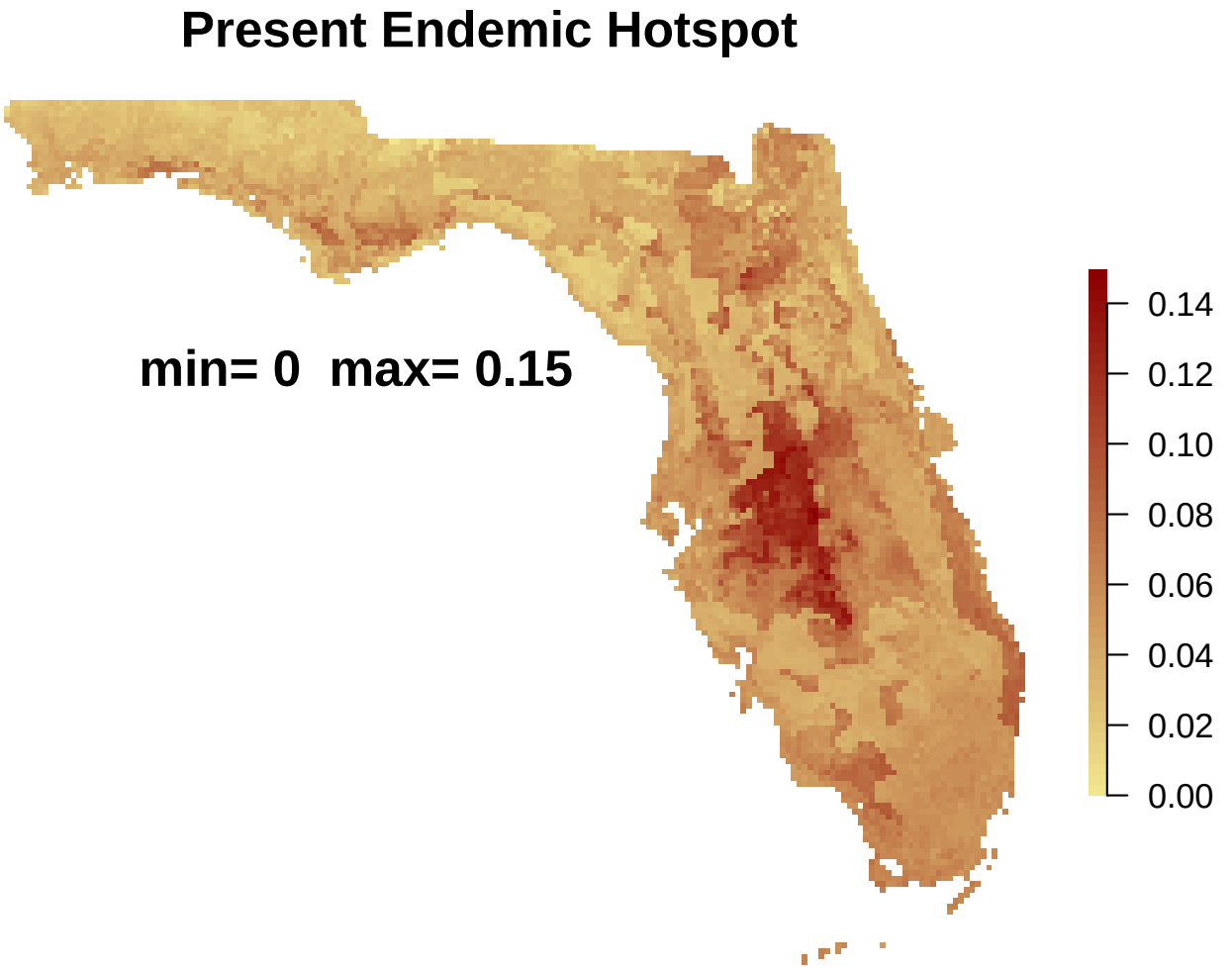


Alpha diversity



2002 - 2012

Endemism hotspots



2002 - 2012

Endemic diversity / Total diversity