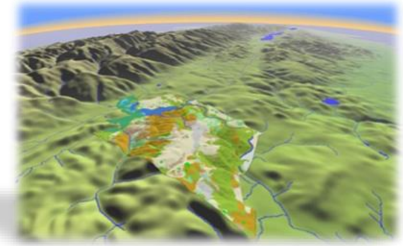
NICHOLAS SCHOOL OF THE
ENVIRONMENT AND EARTH SCIENCES
DUKE UNIVERSITY



ENVIRON 761: Conservation Planning & Biodiversity Support Potential

Instructor: John Fay

I. Conservation Planning

Conservation Planning

Systematic conservation planning

C. R. Margules* & R. L. Pressey†

**CSIRO Wildlife and Ecology, Tropical Forest Research Centre, and the Rainforest Cooperative Research Centre, PO Box 780, Atherton, Queensland 4883, Australia*

†NSW National Parks and Wildlife Service, PO Box 402, Armidale, New South Wales 2350, Australia

The realization of conservation goals requires strategies for managing whole landscapes including areas allocated to both production and protection. Reserves alone are not adequate for nature conservation but they are the cornerstone on which regional strategies are built. Reserves have two main roles. They should sample or represent the biodiversity of each region and they should separate this biodiversity from processes that threaten its persistence. Existing reserve systems throughout the world contain a biased sample of biodiversity, usually that of remote places and other areas that are unsuitable for commercial activities. A more systematic approach to locating and designing reserves has been evolving and this approach will need to be implemented if a large proportion of today's biodiversity is to exist in a future of increasing numbers of people and their demands on natural resources.

Nature 405, 243-253 (11 May 2000))

Systematic Conservation Planning

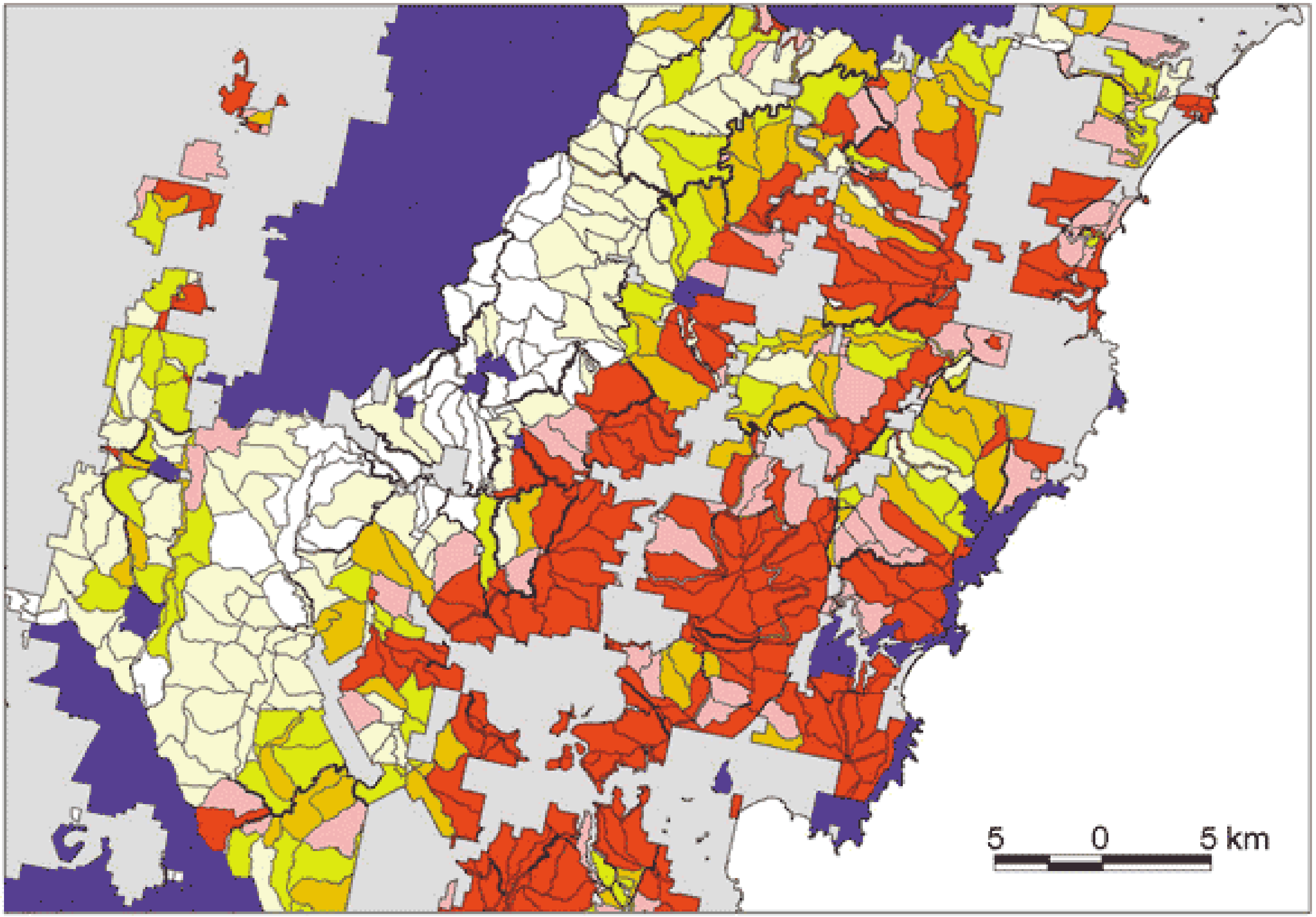
1. Measure and map biodiversity *Today*
2. Identify conservation goals for the planning region
3. Review existing reserves
4. Select additional reserves

4/3 & 4/8 — *Optimization*, *Prioritization*

5. Implement conservation actions on the ground
6. Manage and monitor reserves *Change detection*

Nature 405, 243-253 (11 May 2000))

Conservation Planning Units

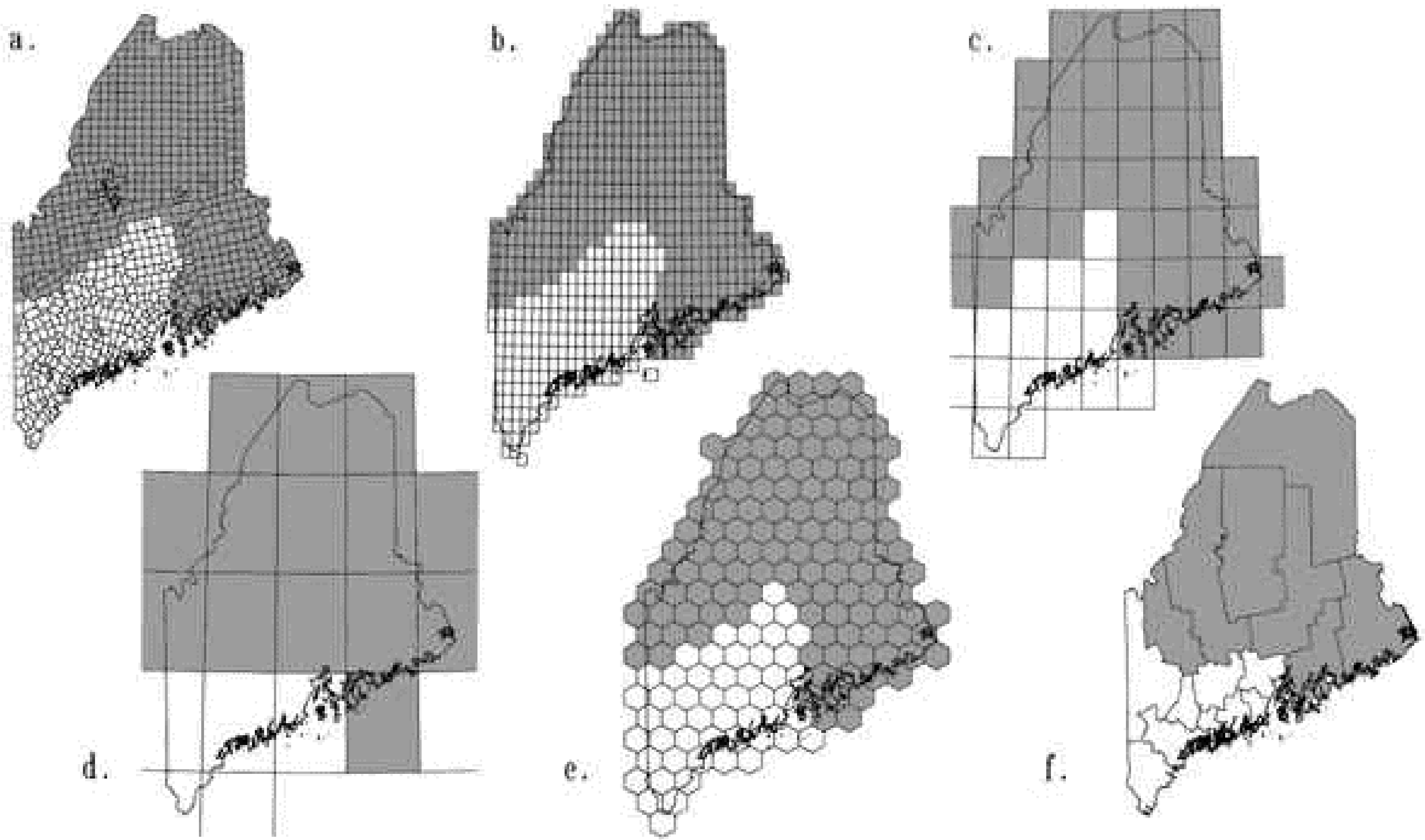


Land tenure areas in Papua New Guinea ranked by conservation potential

Nature 405, 243-253 (11 May 2000))

Conservation Planning Units

How do we parse a landscape into planning units?

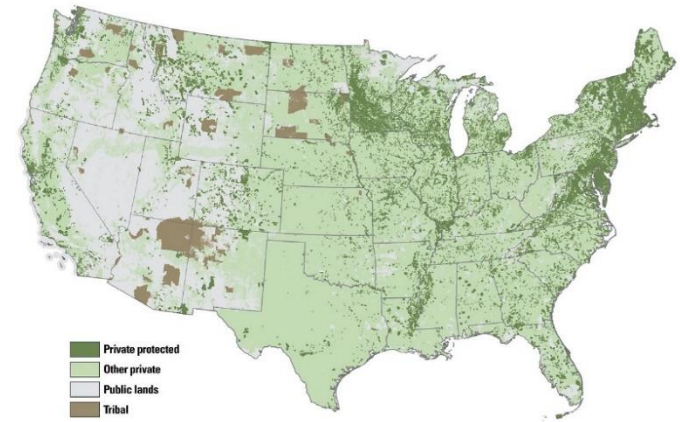


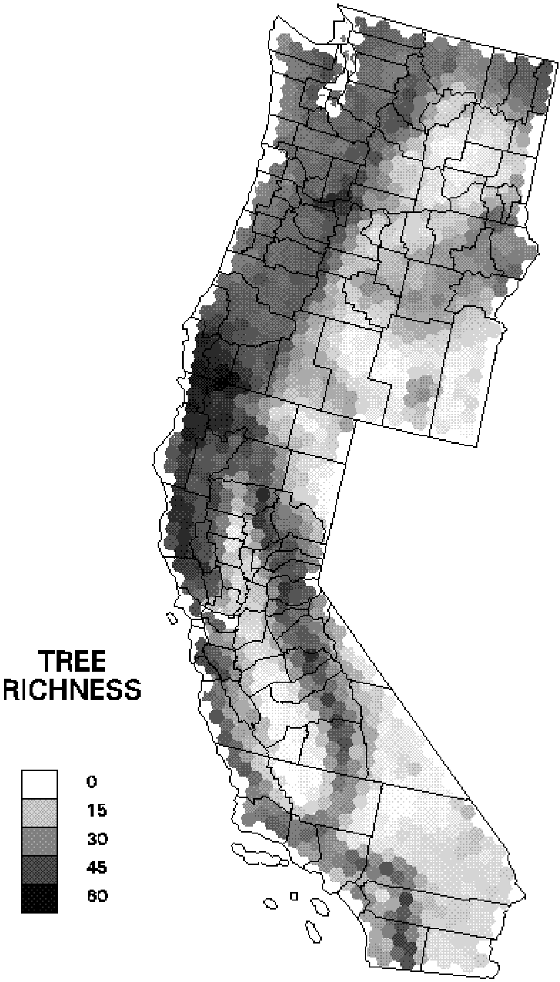
Boone & Krohn (1999) http://www.gap.uidaho.edu/bulletins/6/SO.htm

Conservation Planning Units

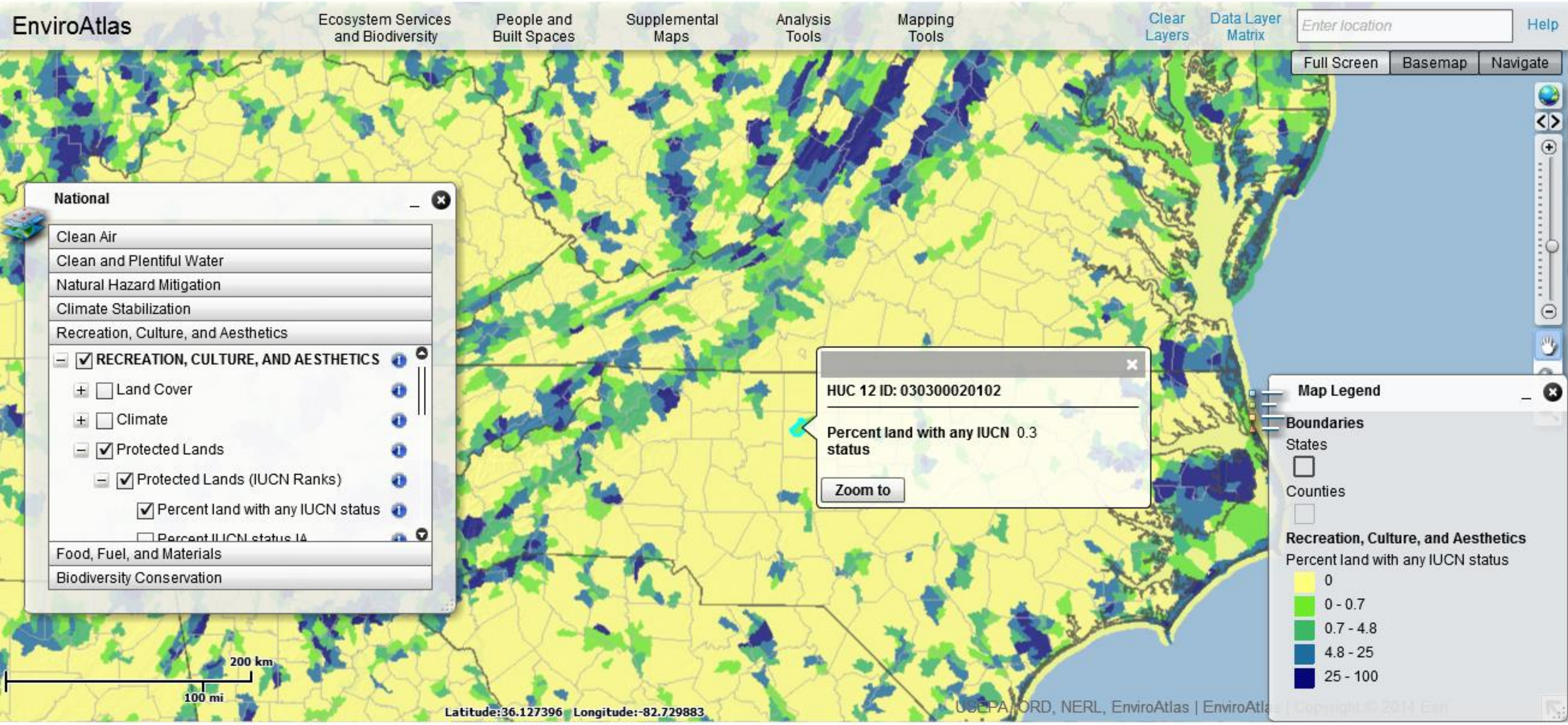
How do we parse a landscape into planning units?

- Political (counties, townships, etc.)
- Land tenure (timber blocks, parcels)
- Tessellated shapes (blocks/hexagons)
- Natural features (HUCs, roadless areas)
- Arbitrary (protected areas)





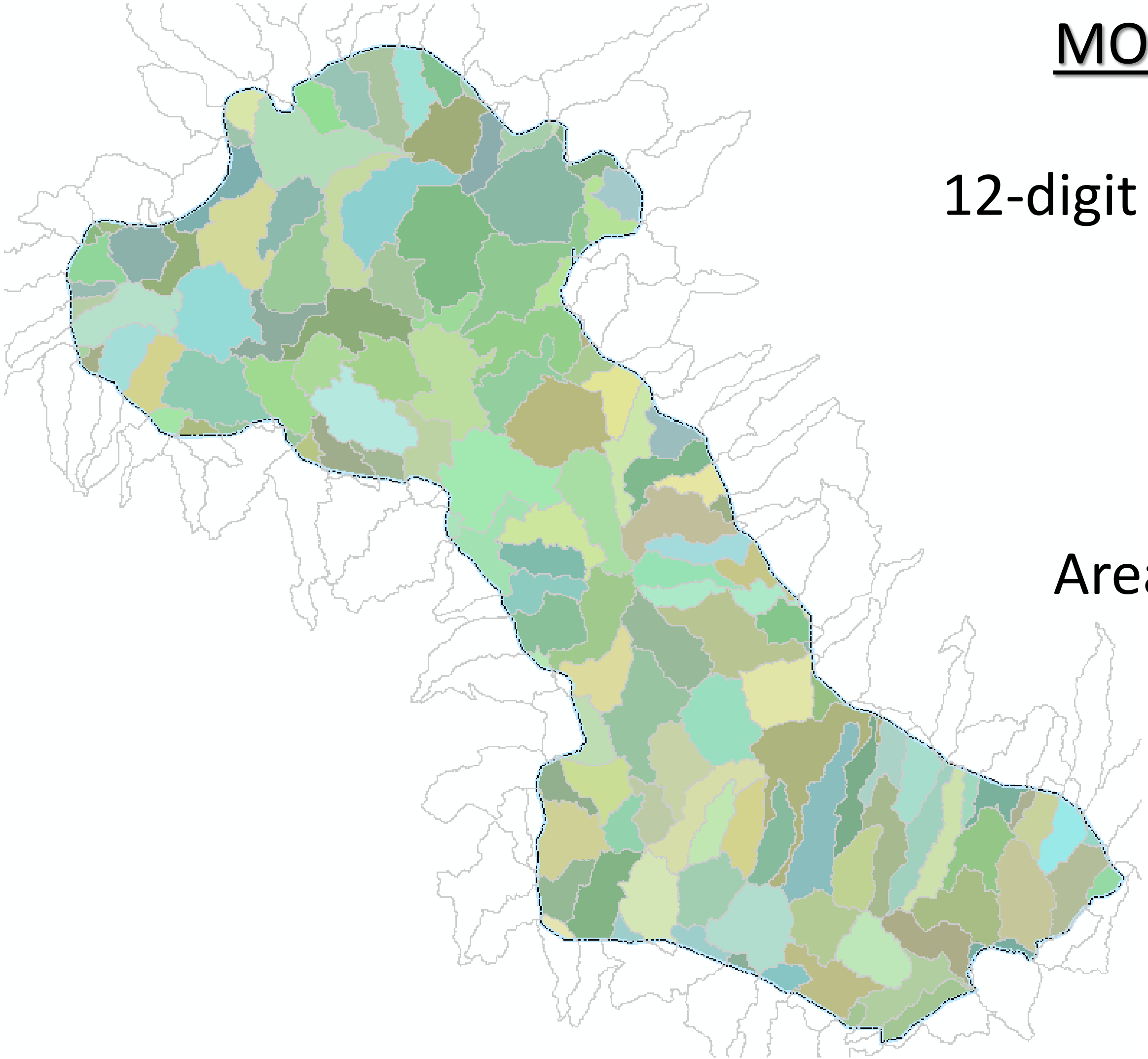
EPA's EnviroAtlas



http://enviroatlas.epa.gov/enviroatlas/InteractiveMapEntrance/InteractiveMap/index.html

II. Upscaling Habitat Metrics to the Planning Unit

Conservation Planning Units



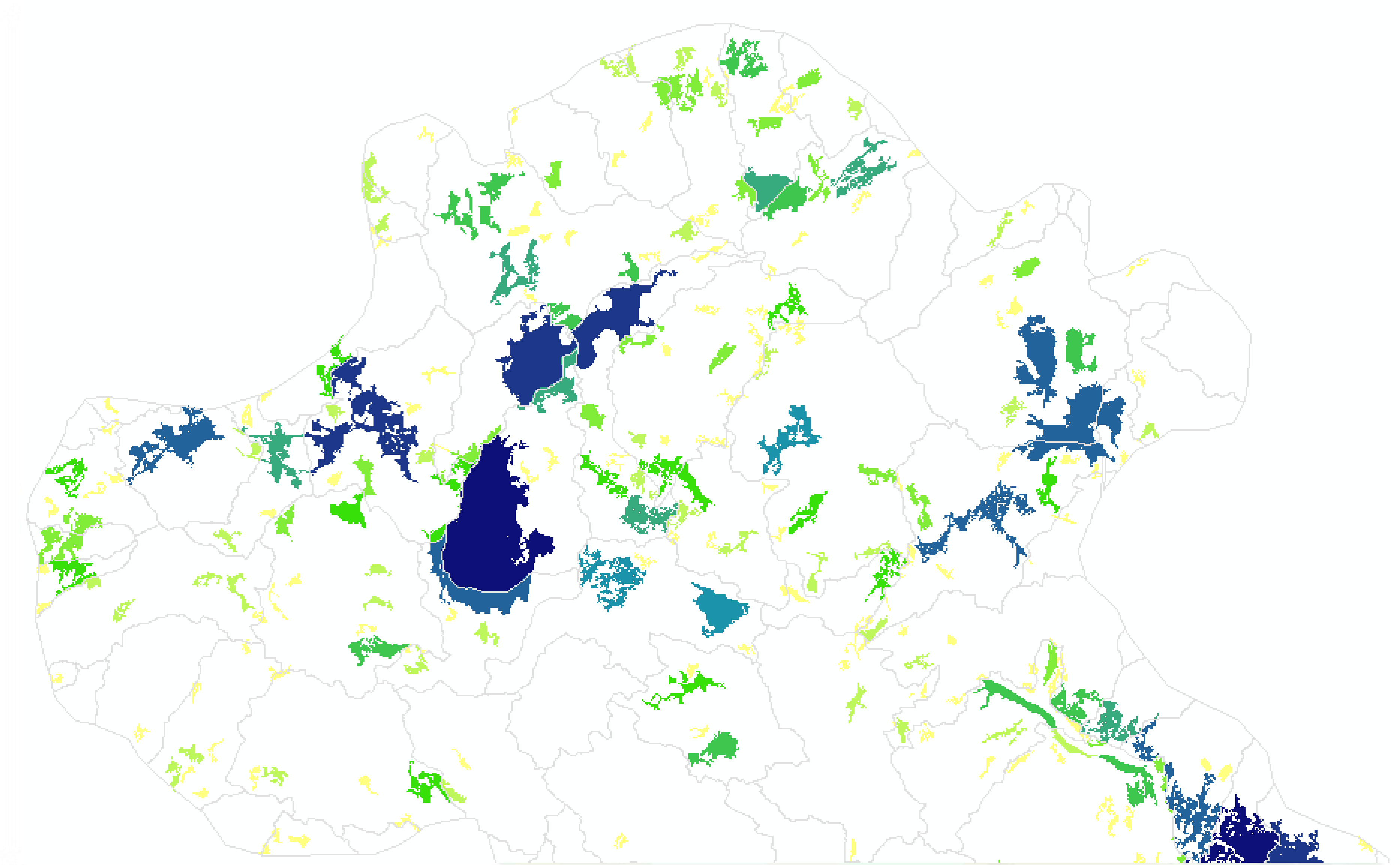
MOGOLLON PLATEAU

12-digit Hydrologic Unit Codes
"HUC12s"

N = 142

Area: 27.4 to 180 km^2

Patch metrics → P.U. metrics



Patch metrics → P.U. metrics

Table

HUCPatches

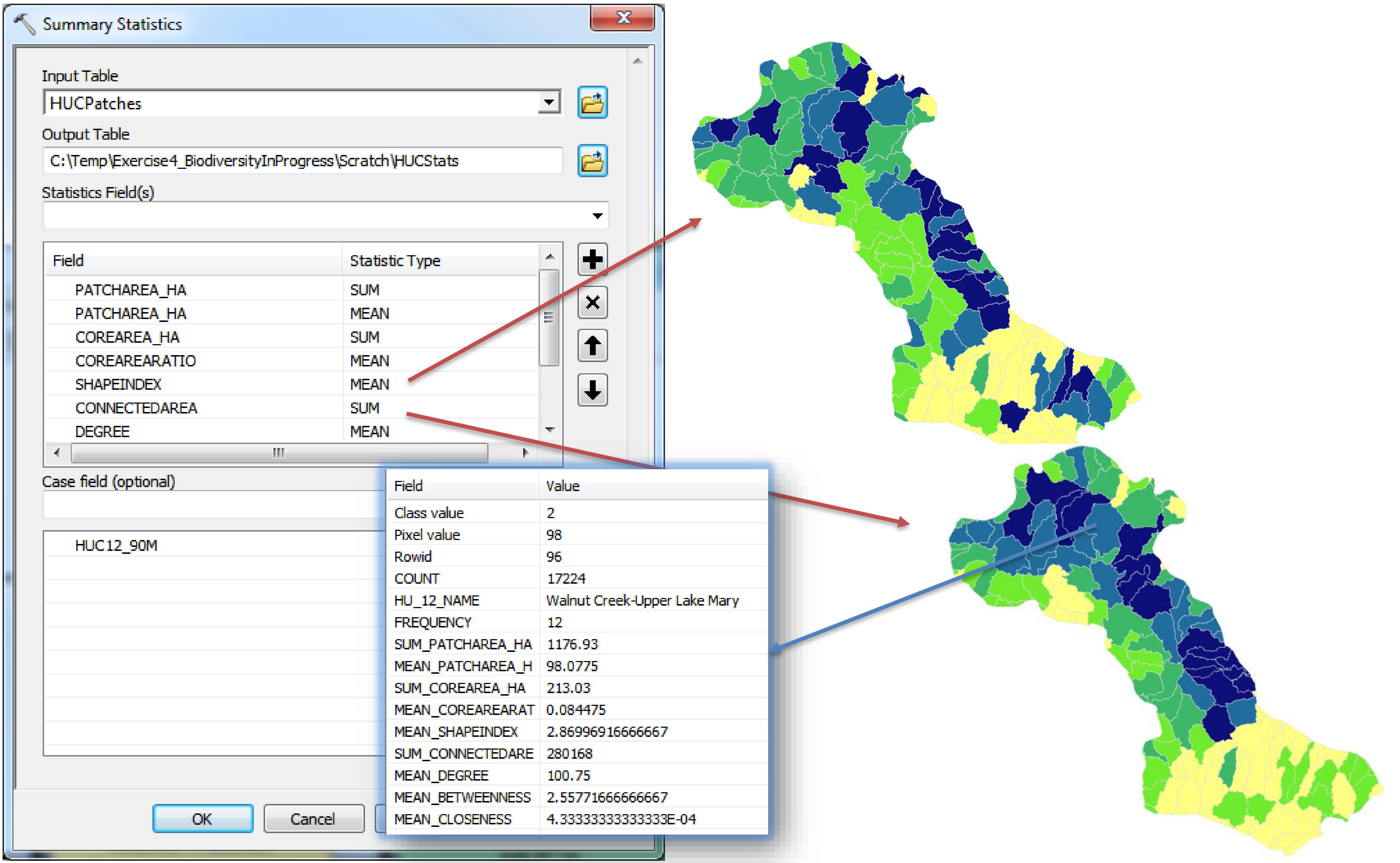
Rowid	VALUE	COUNT	HUC12_90M	HABPATCH	PATCHAREA_HA	COREAREA_HA	AVGDISTTOEDGE	COREAREARATIO	SHAPEINDEX	CONNECTEDAREA	IDWAREA	DEGREE	BETWEENNESS	CLOSENESS
0	1	471	136	1	381.51	59.94	130.3	0.1571	4.83814	1448	593	19	8.9947	0.0003
1	2	99	131	2	80.19	19.44	148	0.2424	2.21108	1317	416	13	0.4728	0.0002
2	3	8	137	2	6.48	0	94.7	0	1.94454	1391	481	13	0.4728	0.0002
3	4	143	131	3	115.83	10.53	121.7	0.0909	2.88504	1435	823	14	8.9947	0.0003
4	5	5	131	1	4.05	0	90	0	2.01246	1826	971	19	8.9947	0.0003
5	6	128	134	2	103.68	2.43	104.2	0.0234	4.28683	1293	383	13	0.4728	0.0002
6	7	42	131	4	34.02	0	98.4	0	2.3917	1796	1016	19	8.9947	0.0003
7	8	236	131	5	191.16	29.97	132.6	0.1568	3.48255	1639	874	19	8.9947	0.0003
8	9	172	135	6	139.32	56.7	182	0.407	1.82998	2770	524	18	2.4907	0.0004
9	10	26	136	7	21.06	0	105.5	0	2.25534	1809	967	19	8.9947	0.0003
10	11	200	131	8	162	68.85	203.1	0.425	2.43952	1577	889	19	0	0.0002
11	12	18	131	7	14.58	0	94.1	0	2.59272	1815	973	19	8.9947	0.0003
12	13	178	134	8	144.18	84.24	268.2	0.5843	2.02374	1455	862	15	0	0.0002
13	14	112	131	9	90.72	17.01	136.7	0.1875	2.50401	1739	904	19	8.9947	0.0003
14	15	26	135	10	21.06	0	102.7	0	1.66699	3050	699	19	2.4907	0.0004

HUC12 ID

Patch ID

Patch geometry and connectivity

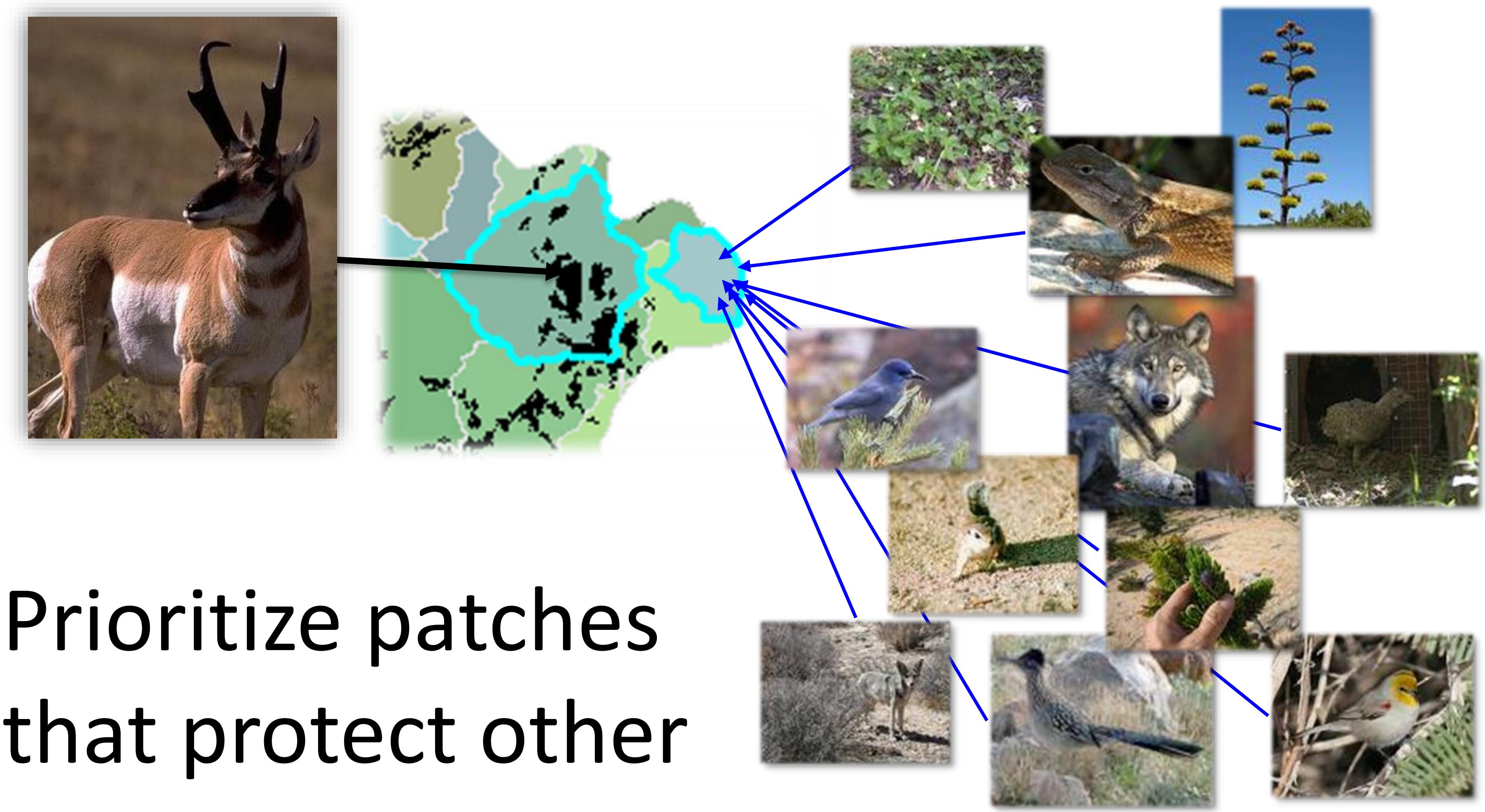
Patch metrics → P.U. metrics



Field	Value
Class value	2
Pixel value	98
Rowid	96
COUNT	17224
HU_12_NAME	Walnut Creek-Upper Lake Mary
FREQUENCY	12
SUM_PATCHAREA_HA	1176.93
MEAN_PATCHAREA_H	98.0775
SUM_COREAREA_HA	213.03
MEAN_COREAREARAT	0.084475
MEAN_SHAPEINDEX	2.86996916666667
SUM_CONNECTEDARE	280168
MEAN_DEGREE	100.75
MEAN_BETWEENNESS	2.55771666666667
MEAN_CLOSENESS	4.33333333333333E-04

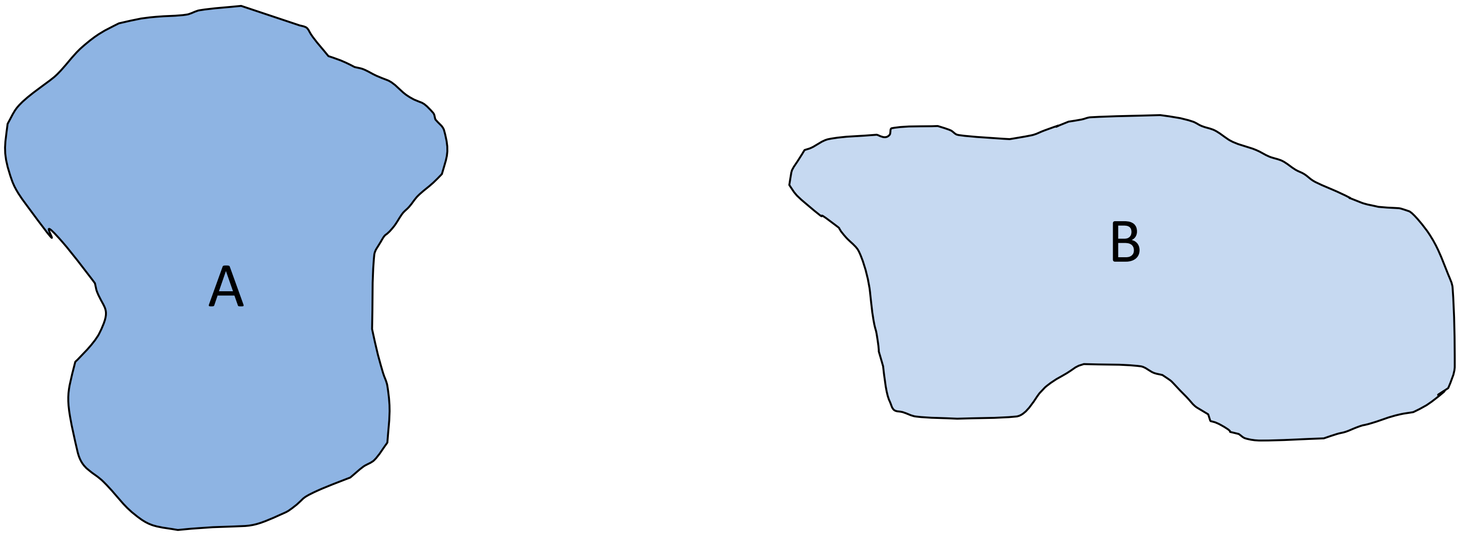
III. Biodiversity Calculations

Landscape Prioritization: Biodiversity



Prioritize patches that protect other species too…

Measuring Biodiversity



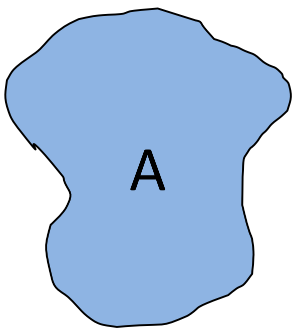
*What does it mean if **A** "has more biodiversity" than **B?***

Measuring Biodiversity

- Richness
  - *Abundance*
- Evenness
  - *Shannon's diversity index*
  - *Simpson's diversity index*
- Endemism & Rare species

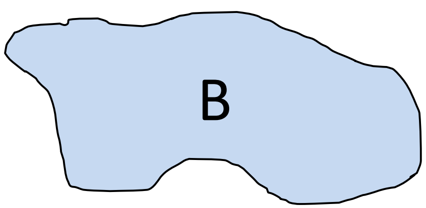
Measuring Biodiversity: <u>Abundance</u>

The number of individuals of a
species present within an ecosystem…



XXXXX XXXXX XXXXX
XXXXX XXXXX XXXXX
XXXXX XXXXX XXXXX
XXXXX XXXXX XXX

58

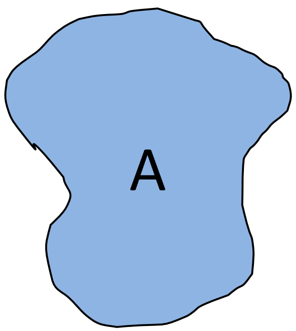


XXXXX XXXXX XXXXX
XXXXX XXXXX XXXXX
XXXXX XXXXX XXXXX X

46

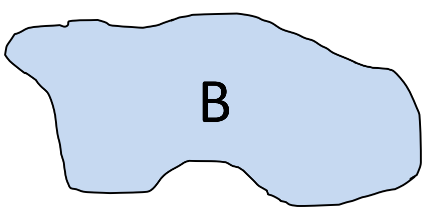
Measuring Biodiversity: Richness

The number of different species found within an ecosystem…



XXXXX XXXXX XXXXX XXXXX XXXXX
XXXXX XXXXX XXXXX XXXXX
XXXXX XXXXX XXX
n = 58

3 species

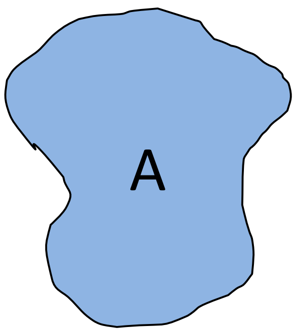


XXXXX XXXXX XXXXX XXXXX
XXXXX XXXXX XXXXX
XXXXX X
XXXXX
XX
XX
n = 46

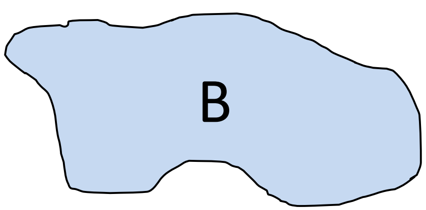
6 species

Measuring Biodiversity: <u>Evenness</u>

The *relative abundance*/proportion of individuals of a given species…



	p
XXXXX XXXXX XXXXX XXXXX XXXXX	*43.1%*
XXXXX XXXXX XXXXX XXXXX	*34.5%*
XXXXX XXXXX XXX	*22.4%*
-	*0%*
- (n = 58)	*0%*



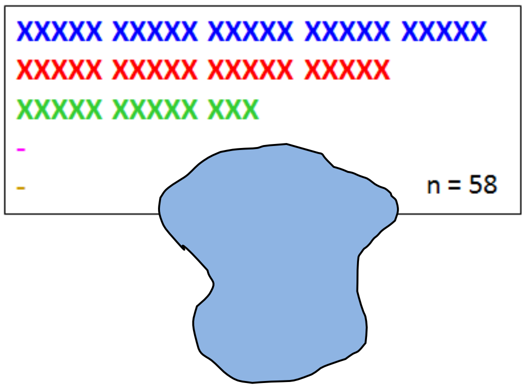
	p
XXXXX XXXXX XXXXX XXXXX	*43.5%*
XXXXX XXXXX XXXXX	*32.6%*
XXXX	*8.7%*
XXX	*4.3%*
XX	*4.3%*
XX (n = 46)	*4.3%*

Measuring Biodiversity: Evenness

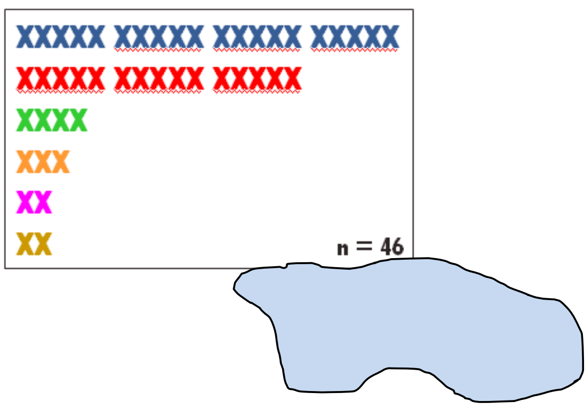
Shannon's Index (H)

$$H = -\sum_{i=1}^{S} p_i \ln p_i$$

p_i = proportion



Spp	Count	p	-p*ln(p)
n1	25	0.431	0.363
n2	20	0.345	0.367
n3	13	0.224	0.335
N	*58*		**1.065**



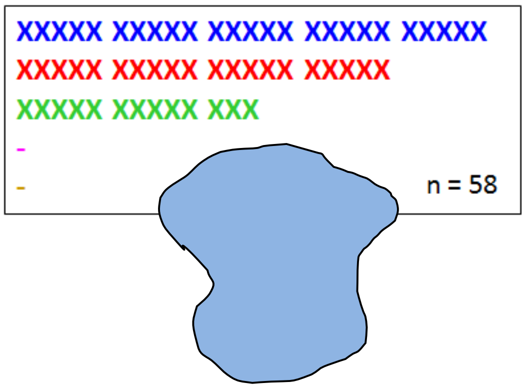
Spp ID	Count	p	-p*ln(p)
n1	20	0.345	0.367
n2	15	0.259	0.350
n3	4	0.069	0.184
n4	3	0.052	0.153
n5	2	0.034	0.116
n6	2	0.034	0.116
N	*46*		**1.287**

Values reflect both richness <u>and</u> evenness

Measuring Biodiversity: Evenness

Shannon's *Equitability* Index (E)

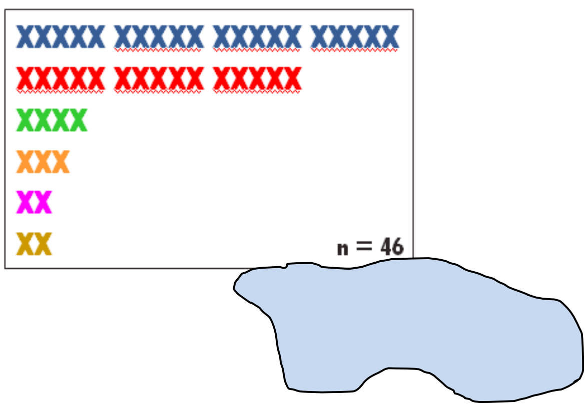
$$E = H' / Hmax$$



$$H_{max} = ln(richness)$$

Spp	Count	p	-p*ln(p)	Hmax	H/Hmax
n1	25	0.431	0.363		
n2	20	0.345	0.367		
n3	13	0.224	0.335		
N	*58*		1.065	1.099	0.969
				1.792	0.594

ln(3)



Spp ID	Count	p	-p*ln(p)	Hmax	H/Hmax
n1	20	0.345	0.367		
n2	15	0.259	0.350		
n3	4	0.069	0.184		
n4	3	0.052	0.153		
n5	2	0.034	0.116		
n6	2	0.034	0.116		
N	*46*		1.287	1.792	0.718

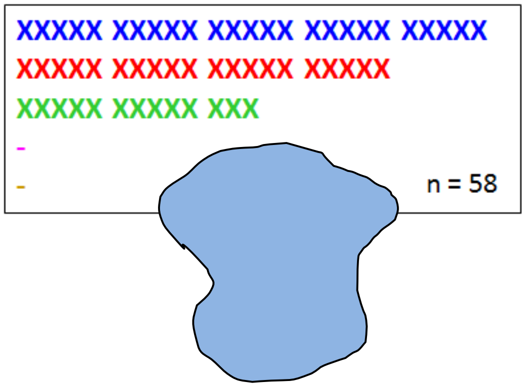
ln(6)

Measuring Biodiversity: Evenness

Simpson's Index (D)

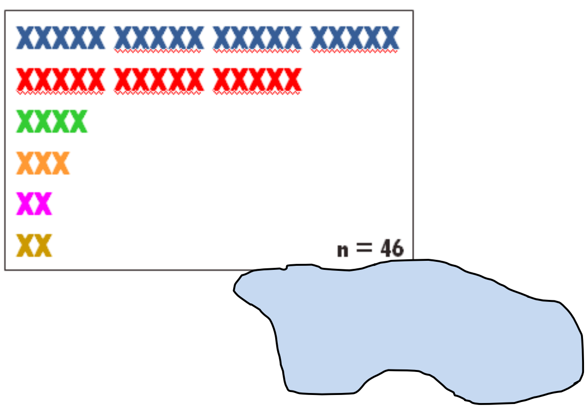
$$\frac{\sum_{i=1}^{S} n_i(n_i - 1)}{N(N-1)}$$

n_i = # indiv. of a species
N = total # individuals



Spp ID	Count	n(n-1)
n1	25	600
n2	20	380
n3	13	156
N	*58*	3306

$\Sigma\left(\frac{n*(n-1)}{N*(N-1)}\right)$ = **0.344**

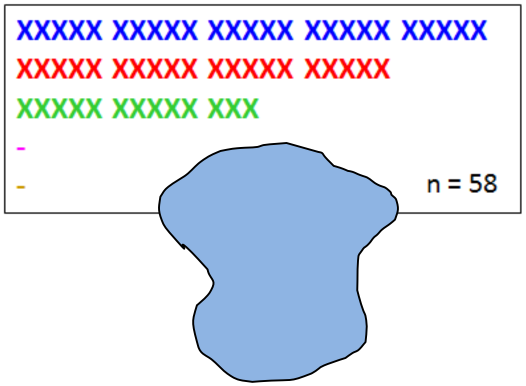


Spp ID	Count	n(n-1)
n1	20	380
n2	15	210
n3	4	12
n4	3	6
n5	2	2
n6	2	2
N	*46*	2070

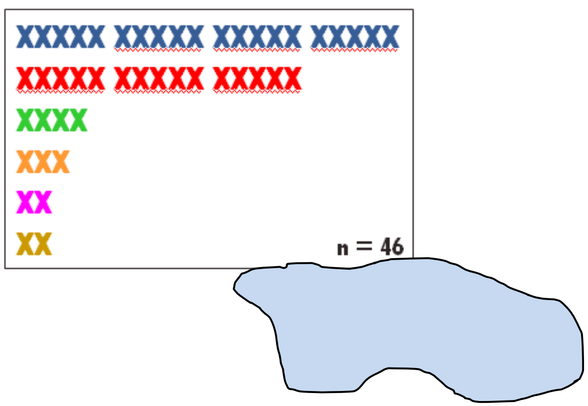
$\Sigma\left(\frac{n*(n-1)}{N*(N-1)}\right)$ = **0.296**

Measuring Biodiversity: Evenness

Simpson's Index of *diversity* (1/D)



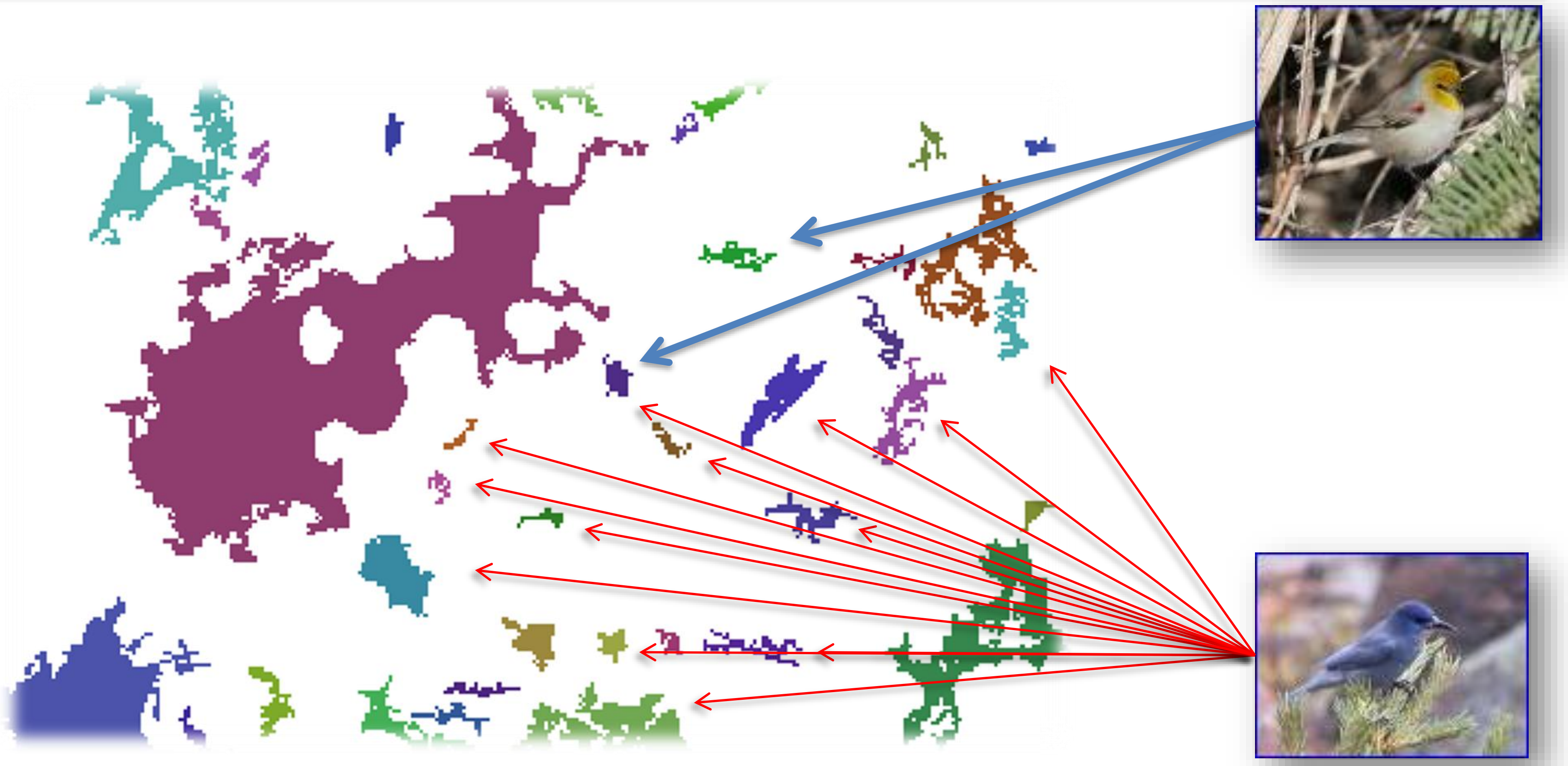
Spp ID	Count	n(n-1)	Σ(n*(n-1)) / N*(N-1)	1/D
n1	25	600		
n2	20	380		
n3	13	156		
N	*58*	3306	0.344	2.91



Spp ID	Count	n(n-1)	Σ(n*(n-1)) / N*(N-1)	1/D
n1	20	380		
n2	15	210		
n3	4	12		
n4	3	6		
n5	2	2		
n6	2	2		
N	*46*	2070	0.296	3.38

Measuring Biodiversity: <u>Endemism</u>

Are there patches that contain species found nowhere else?



In how many patches does a species exist?

Measuring Biodiversity: Analysis

- Analysis begins with a list of the species occurring within each planning unit

Attributes of Occurrences

P.U.	Species Code	# occurrences
1	34	1
1	36	10
1	67	13
2	36	78
2	67	137
2	76	31
2	34	147
2	71	2
2	51	79
2	64	1
3	67	121
3	36	89

PU #2 has an abundance of **137** individuals of Spp. #67

Measuring Biodiversity: Analysis

- **Richness** = # rows for each planning unit

Attributes of Occurrences

P.U.	Species Code	# occurrences
1	34	1
1	36	10
1	67	13
2	36	78
2	67	137
2	76	31
2	34	147
2	71	2
2	51	79
2	64	1
3	67	121
3	36	89

7 different species are observed within PU #2

Measuring Biodiversity: Analysis

- **Shannon Index =** $-\sum [p_i * \mathit{ln}(p_i)]$

Attributes of Occurrences

P.U.	Species Code	# occurrences
1	34	1
1	36	10
1	67	13
2	36	78
2	67	137
2	76	31
2	34	147
2	71	2
2	51	79
2	64	1
3	67	121
3	36	89

N	P	p * ln(P)
78	16.4%	-0.297
137	28.8%	-0.359
31	6.5%	-0.178
147	30.9%	-0.363
2	0.4%	-0.023
79	16.6%	-0.298
1	0.2%	-0.013
475		-1.531

PU #2 has a Shannon Index of <u>1.531</u>

Measuring Biodiversity: Analysis

So how do we get this table??

Attributes of Occurrences

P.U.	Species Code	# occurrences
1	34	1
1	36	10
1	67	13
2	36	78
2	67	137
2	76	31
2	34	147
2	71	2
2	51	79
2	64	1
3	67	121
3	36	89

Spatially combine species occurrence data with our HUC 12 planning units…

IV. Finding Data to Estimate Biodiversity

Species Occurrence Data – A Challenge

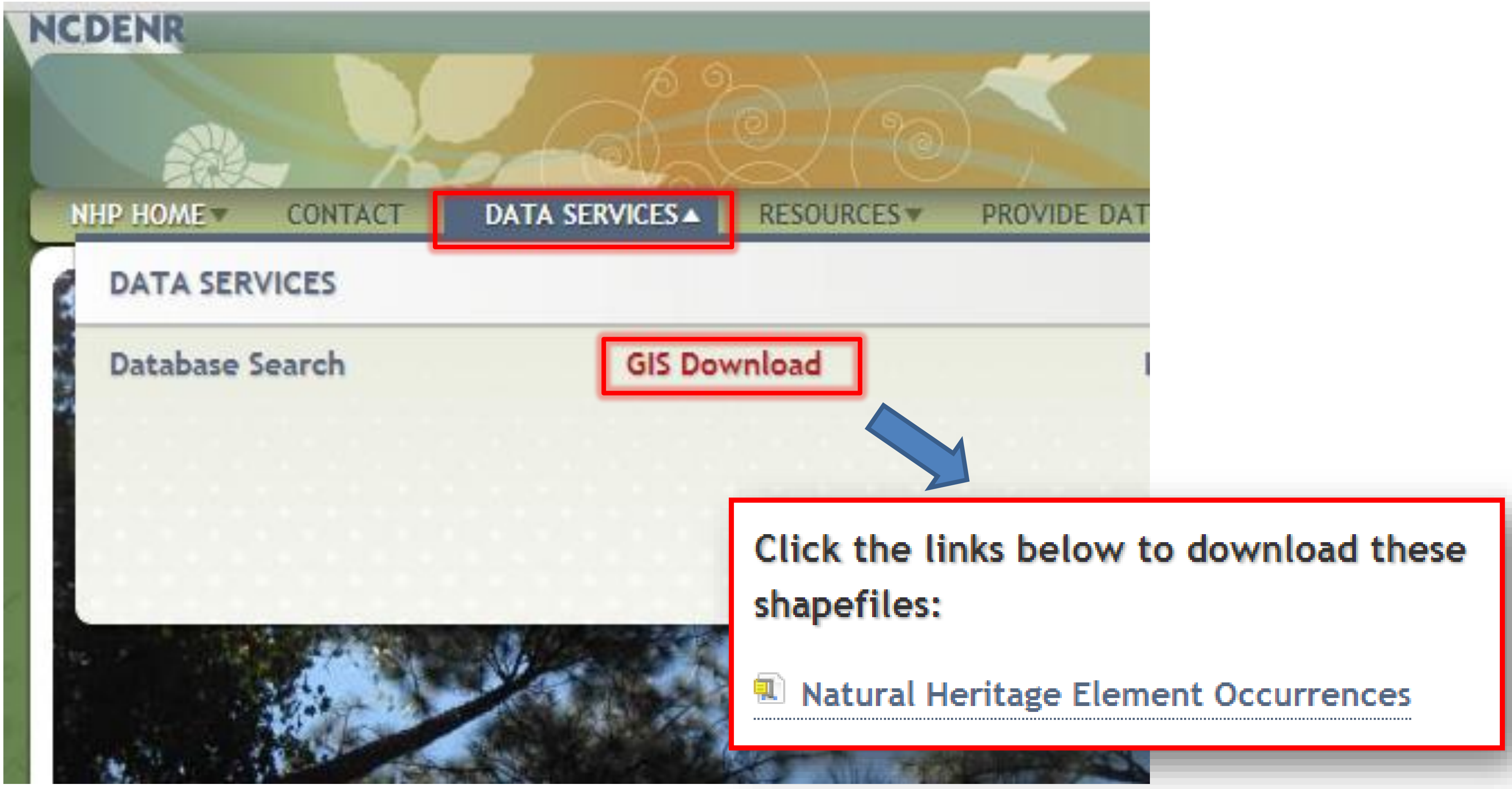
- Natural Heritage Element Occurrences (NHEO) data
- Biodiversity Information Serving Our Nation (BISON)
- Global Biodiversity Information Facility (GBIF) records
- GAP Species Distribution Models
- *Other sources? iNaturalist?*

Natural Heritage Element Occurrences

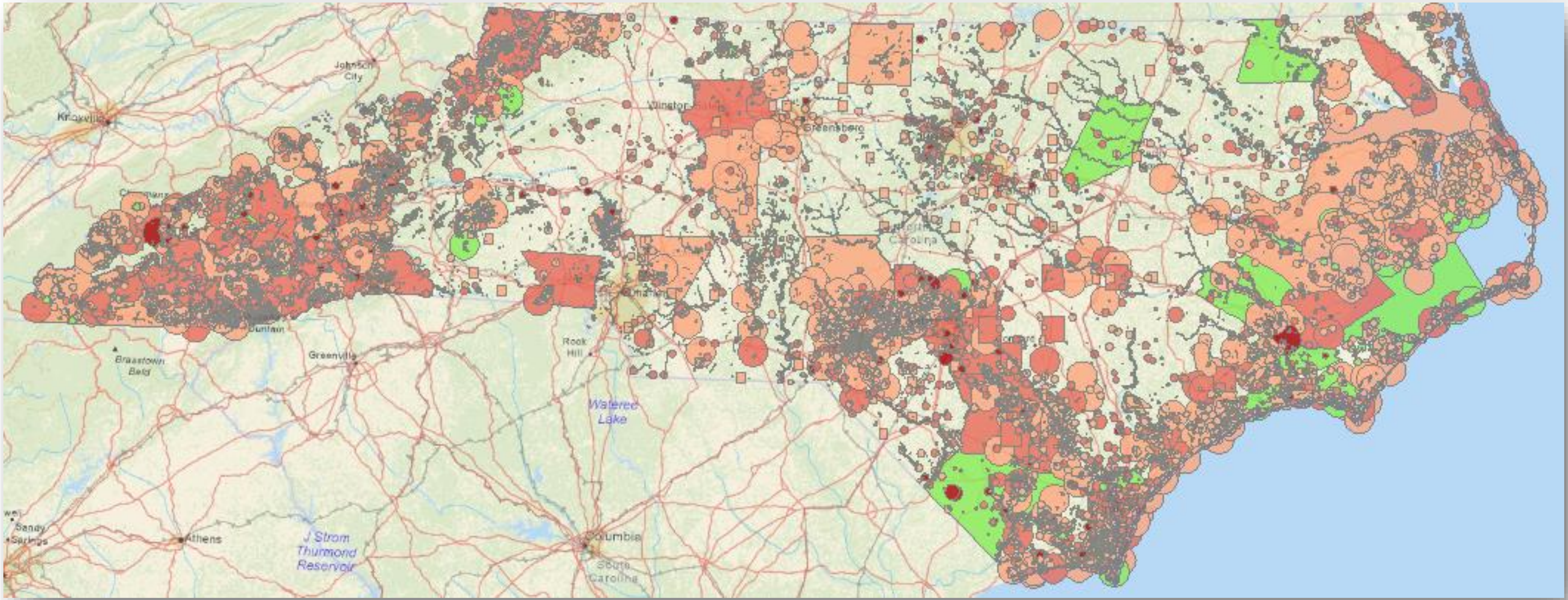
http://explorer.natureserve.org/

NC Natural Heritage Portal

http://www.ncnhp.org/



NC NHEO data



~~http://www.nconemap.net/Default.aspx?tabid=286~~

http://lmgtfy.com/?q=nc+nheo+download

http://www.ncnhp.org/web/nhp/element-occurrences

Arizona Natural Heritage Portal

ARIZONA GAME AND FISH DEPARTMENT

MANAGING TODAY FOR WILDLIFE TOMORROW

www.azgfd.gov

AZ.GOV Arizona's Official Web Site

BUY LICENSES | BIG GAME DRAW | eNEWS | CALENDAR | VIDEO | HUNTING | FISHING | WILDLIFE VIEWING | CONSERVATION | EDUCATION | BOATING |

Arizona's Natural Heritage Program: Heritage Data Management System (HDMS)

The HDMS is part of a global network of more than 80 Natural Heritage Programs and Conservation Data Centres. HDMS information is available so Arizonans can make prudent decisions weighing future development, economic growth, and environmental integrity.

It identifies elements of concern in Arizona and consolidates information about their status and distribution throughout the state.

- On-line Environmental Review Tool
- Arizona's Natural Heritage
- What is the Arizona HDMS?
- Products and Services the HDMS offers
- View Species data lists and status and ranking definitions.
- View Plant and Animal Abstracts, Distribution Maps & Illustrations, sorted by Taxon below:

Amphibians	Invertebrates	Plants
Birds	Mammals	Reptiles
Fish		

Looking for more information?
Our resources page links to external clubs, associations, government and other Web sites to help you find additional information.

Data Requests

Contact Us

NHEO data

- Estimated Representational Accuracy

Value	Definition
Very High (>95%)	Greater than 95% of the polygon is occupied by the element.
High (80%-95%)	Between 80% and 95% of the polygon is occupied by the element.
Medium (20%-80%)	Between 20% and 80% of the polygon is occupied by the element.
Low (5%-20%)	Between 5% and 20% of the polygon is occupied by the element.
Very Low (<5%)	Less than 5% of the polygon is occupied by the element.
Unknown	Percentage of the polygon occupied by the element is unknown.
(Blank)	An estimated representational accuracy has not been assigned.

NHEO data

- EO Status

Value	Definition
Extant	The occurrence is known to still exist.
Historic	The occurrence is old or recent surveys failed to found it, but there is no evidence it is destroyed.
Destroyed	The occurrence is known to be destroyed.
Unranked	The rank of the occurrence has not been assigned.

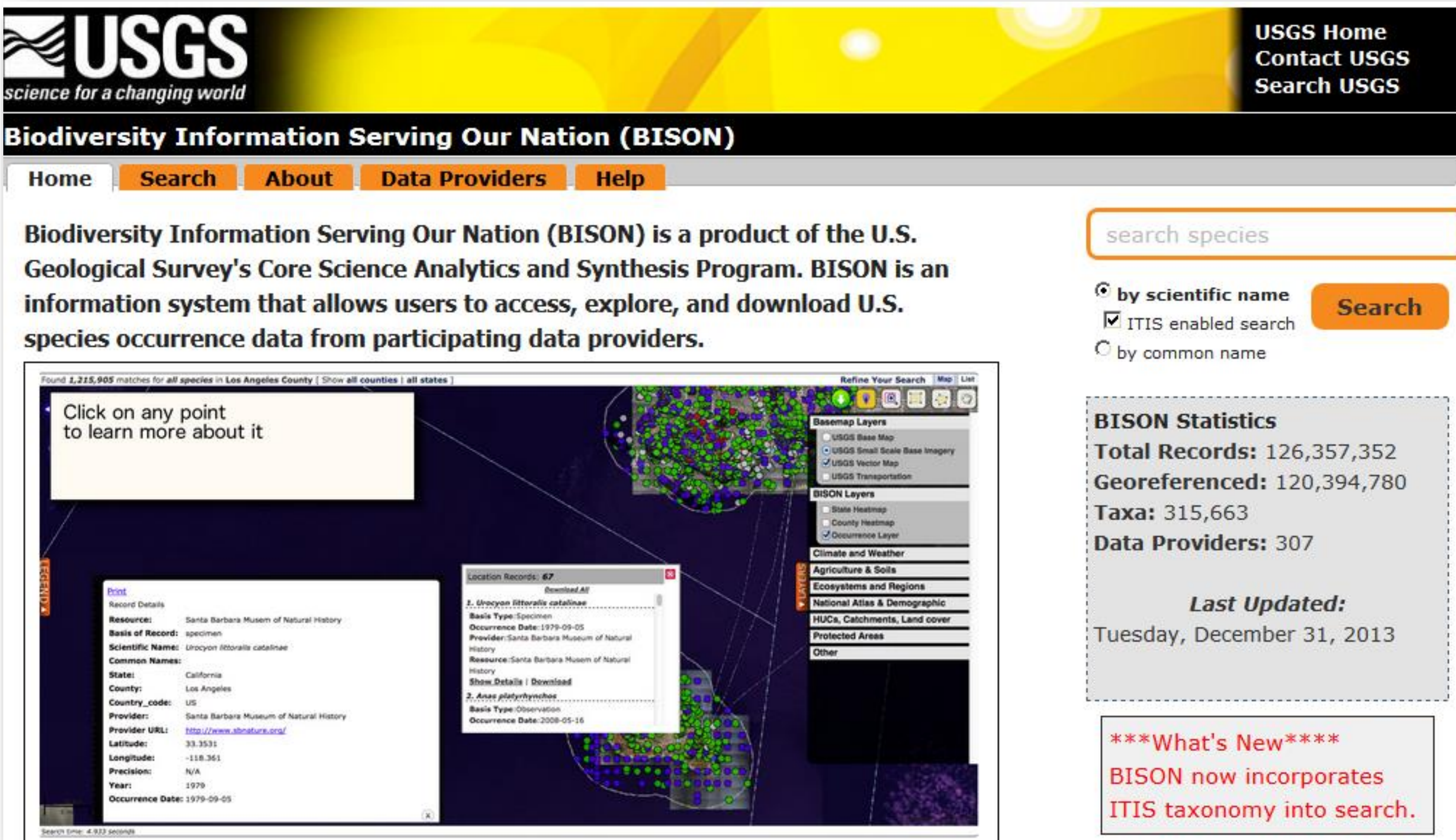
NHEO data

- Category

Value	Definition
Vertebrate Animal	Includes mammals, birds, reptiles, amphibians, and fishes.
Invertebrate Animal	Includes mollusks,arachnids, crustaceans, and insects.
Vascular Plant	Includes dicots, monocots, gymnosperms, ferns, and fern allies.
Nonvascular Plant	Includes mosses, liverworts, hornworts, and lichens.
Natural Community	A distinct and reoccurring assemblage of populations of plants, animals, bacteria, and fungi naturally associated with each other and their physical environment.
Animal Assemblage	A concentration of animal species using the same site for a phase of their life cycle (feeding, reproduction, migration, hibernating, etc) e.g. bird colonies, bat or reptile lubernacula, concentrations of migrating shorebirds, multispecific spawning grounds, or multispecific mussel habitats.

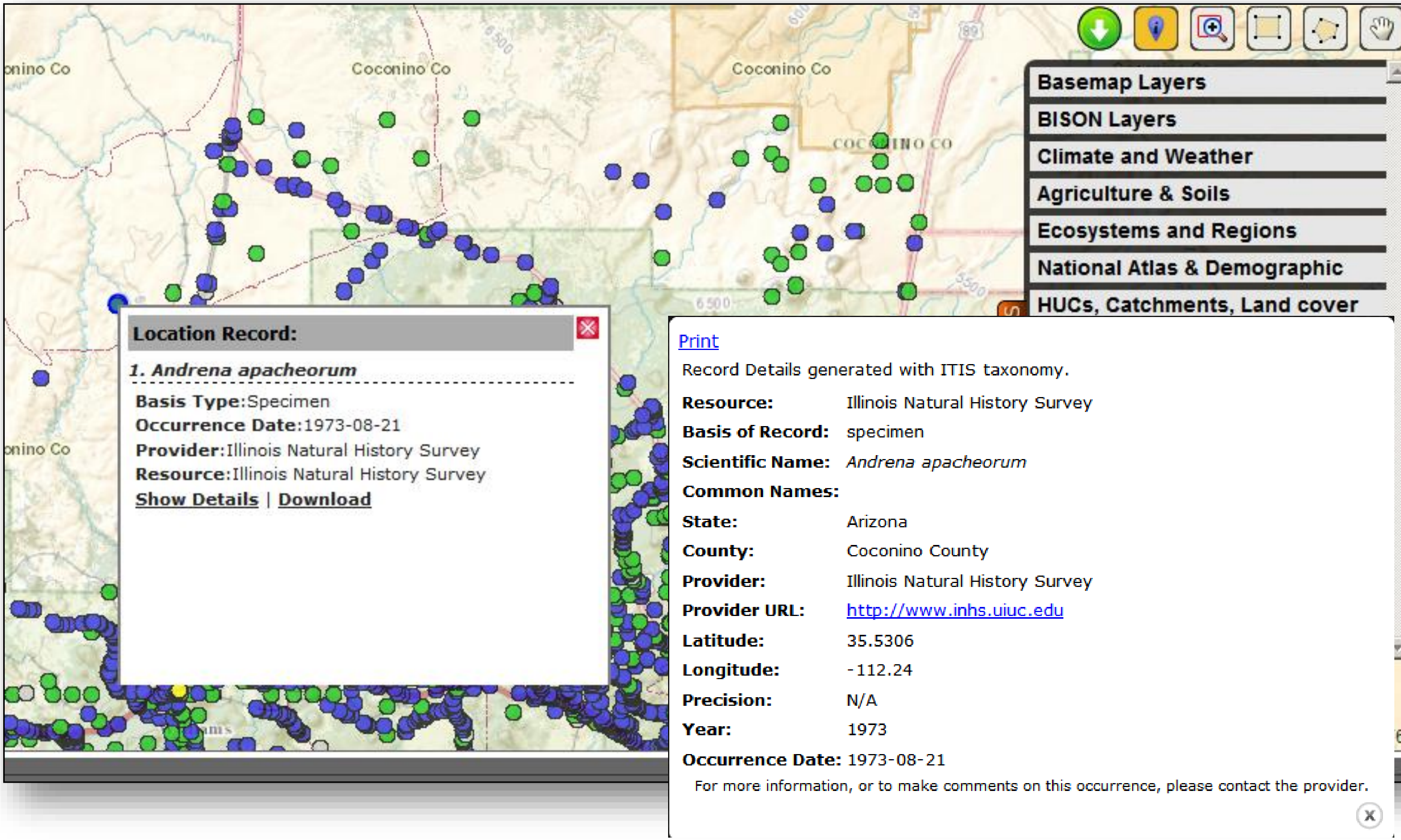
BISON

https://bison.usgs.gov



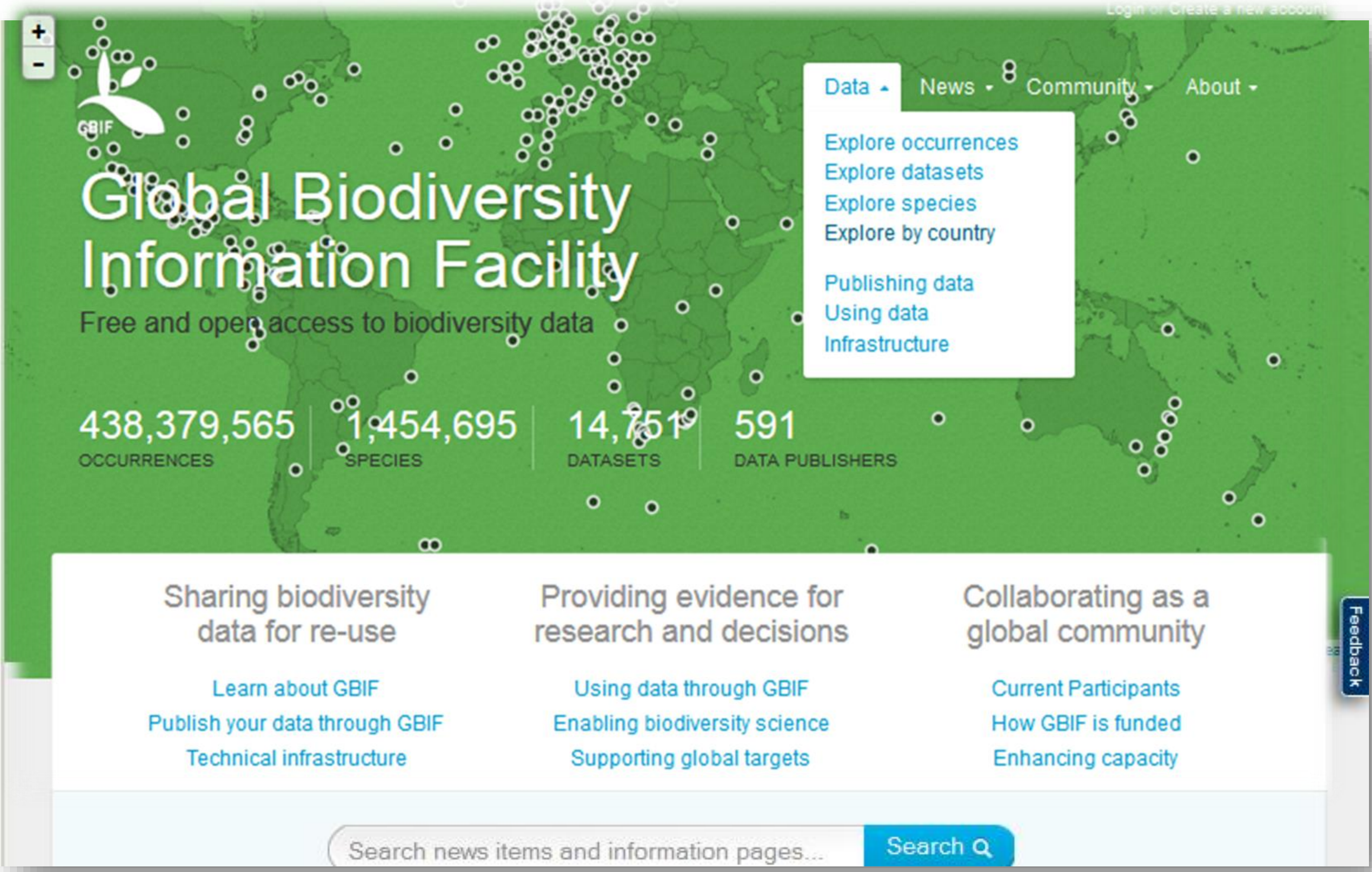
BISON

http://bison.usgs.ornl.gov/



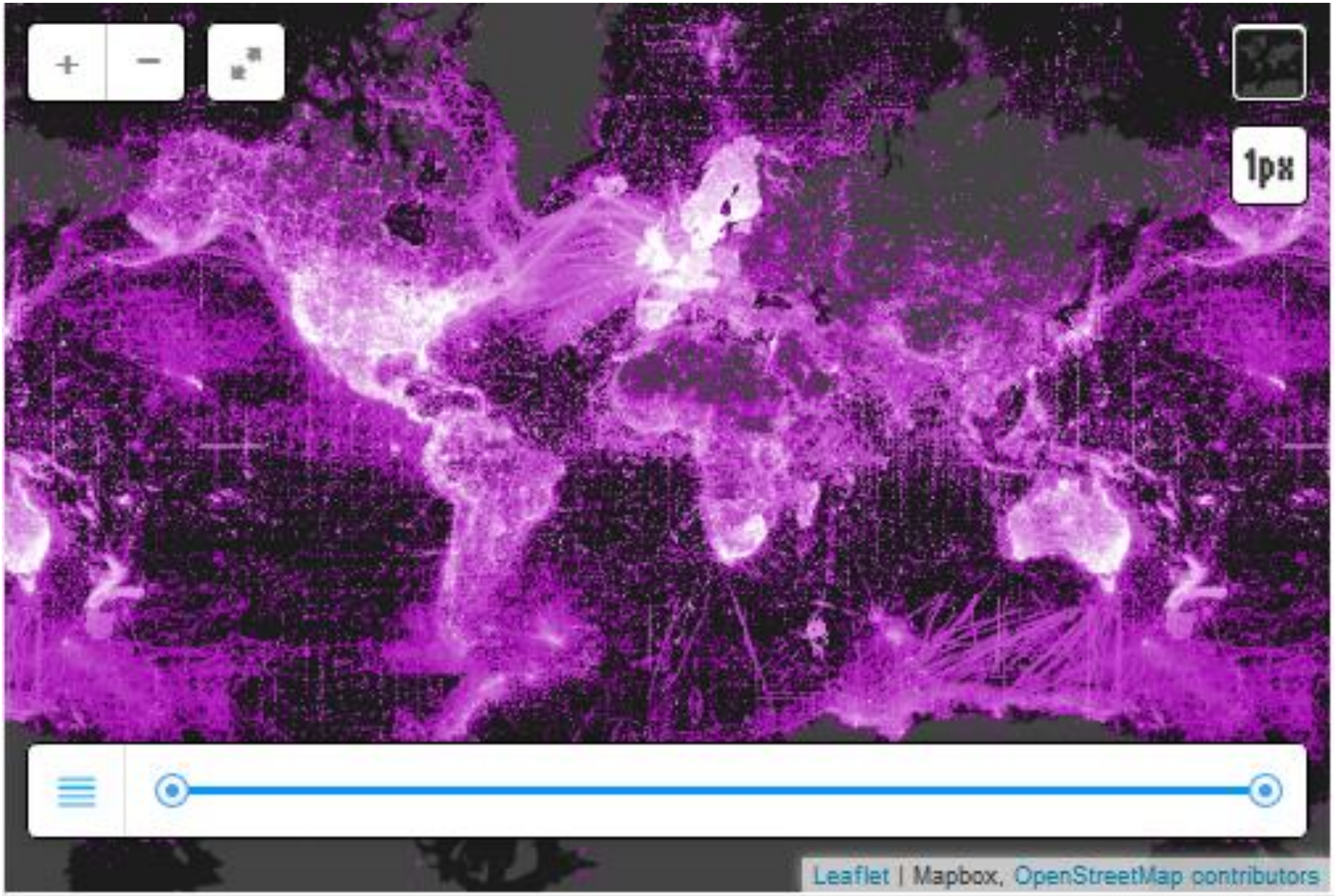
Global Biodiversity Information Facility

http://www.gbif.org/



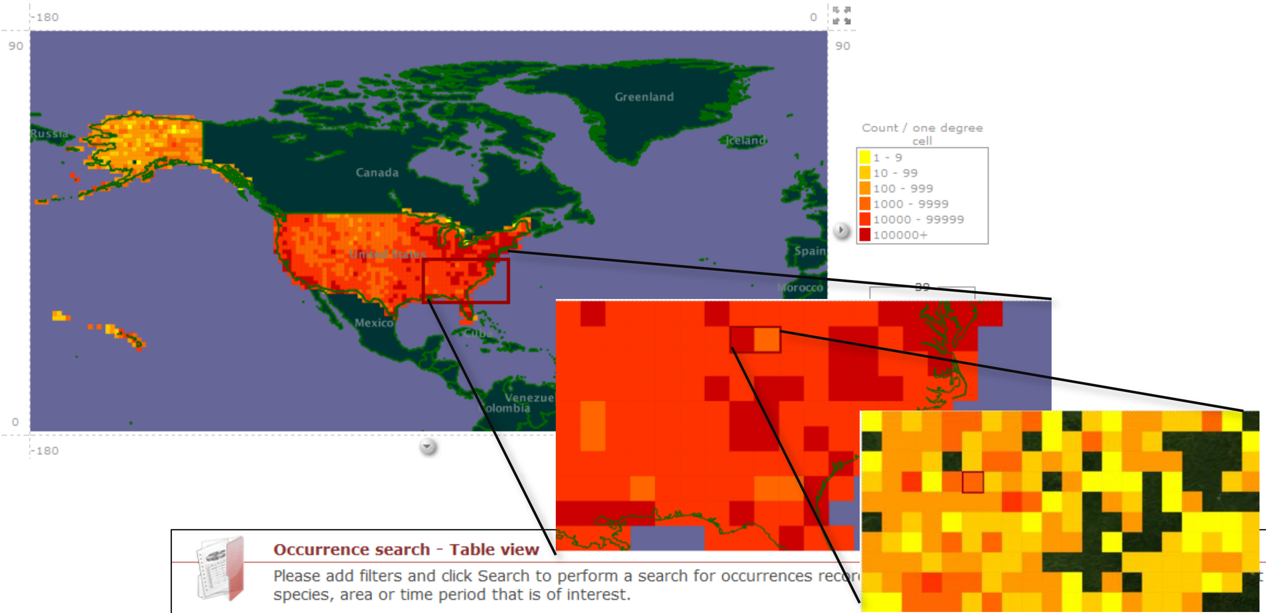
Global Biodiversity Information Facility

http://www.gbif.org/occurrence



GBIF Data Portal

Occurrence overview



Occurrence search - Table view

Please add filters and click Search to perform a search for occurrences reco... more accurate results for the species, area or time period that is of interest.

Actions

View: Matching records as table | Matching records on map

Specify: Data publishers to be included in search | Datasets to be included in search | Countries to be included in search

Download: Spreadsheet of results | Darwin core (maximum 100,000) | Google Earth (maximum 50,000) | Species in results

Create: Niche Model

Your current search

Bounding box is 84.5°W, 37.6°N, 84.4°W, 37.7°N

Country is United States

Change your current search

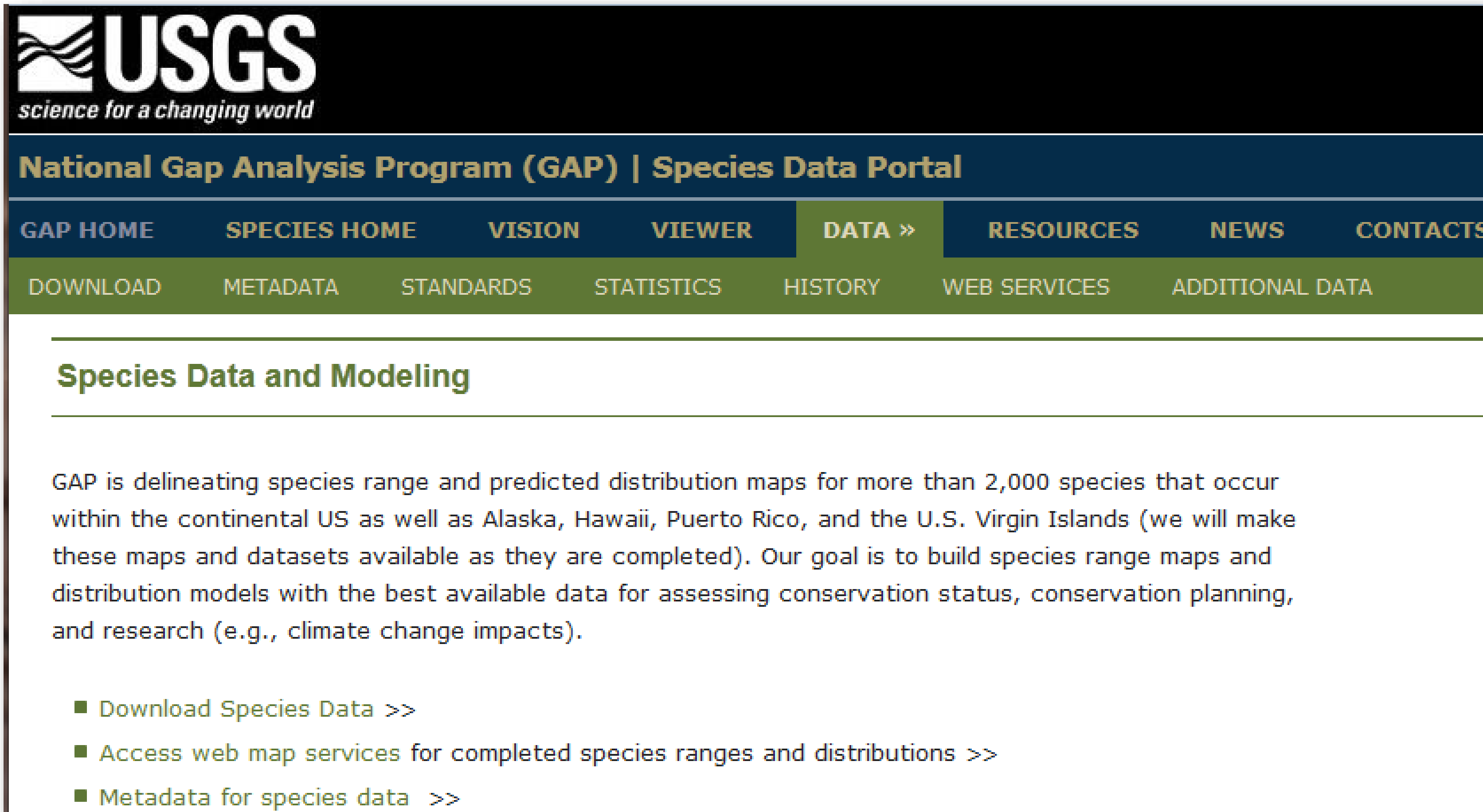
Table of results

Displaying 1 to 20. [First / Prev] 1, 2, 3, 4, 5, 6 [Next]

Scientific Name	Dataset	Institution Code	Collection Code	Catalogue Number	Basis of Record	Date	Coordinates	Country	
Aves	Project FeederWatch	CLO	PFW	OBS25659803	Observation	08/04/2005	37.608°N, 84.434°W	United States	View
Poecile	Project FeederWatch	CLO	PFW	OBS12839709	Observation	22/11/2001	37.608°N, 84.434°W	United States	View
Poecile	Project FeederWatch	CLO	PFW	OBS12839722	Observation	30/11/2001	37.608°N, 84.434°W	United States	View
Poecile	Project FeederWatch	CLO	PFW	OBS12839746	Observation	23/12/2001	37.608°N, 84.434°W	United States	View
Poecile	Project FeederWatch	CLO	PFW	OBS12839790	Observation	01/01/2002	37.608°N, 84.434°W	United States	View
Poecile	Project FeederWatch	CLO	PFW	OBS12839803	Observation	19/01/2002	37.608°N, 84.434°W	United States	View
Poecile	Project FeederWatch	CLO	PFW	OBS12839843	Observation	16/02/2002	37.608°N, 84.434°W	United States	View
Poecile	Project FeederWatch	CLO	PFW	OBS12839880	Observation	01/03/2002	37.608°N, 84.434°W	United States	View
Poecile	Project FeederWatch	CLO	PFW	OBS12839917	Observation	16/03/2002	37.608°N, 84.434°W	United States	View
Poecile	Project FeederWatch	CLO	PFW	OBS12839929	Observation	30/03/2002	37.608°N, 84.434°W	United States	View

GAP Species Distribution Models

http://gapanalysis.usgs.gov/species/data/


USGS
science for a changing world

National Gap Analysis Program (GAP) | Species Data Portal

GAP HOME | SPECIES HOME | VISION | VIEWER | DATA » | RESOURCES | NEWS | CONTACTS

DOWNLOAD | METADATA | STANDARDS | STATISTICS | HISTORY | WEB SERVICES | ADDITIONAL DATA

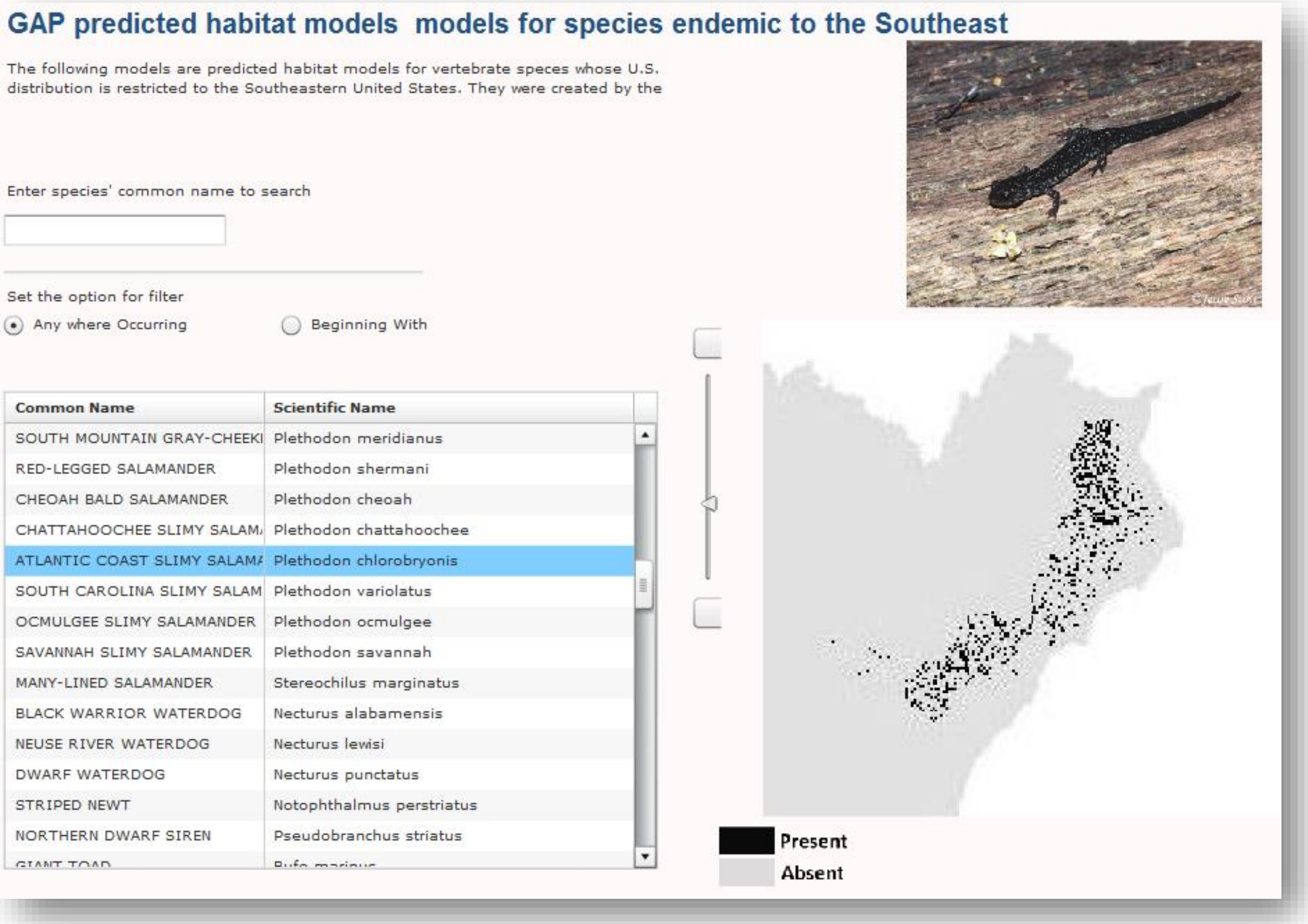
Species Data and Modeling

GAP is delineating species range and predicted distribution maps for more than 2,000 species that occur within the continental US as well as Alaska, Hawaii, Puerto Rico, and the U.S. Virgin Islands (we will make these maps and datasets available as they are completed). Our goal is to build species range maps and distribution models with the best available data for assessing conservation status, conservation planning, and research (e.g., climate change impacts).

- Download Species Data >>
- Access web map services for completed species ranges and distributions >>
- Metadata for species data >>

GAP Species Distribution Models

http://www.gap.uidaho.edu/portal/Species%20modeling/EndemicSpecies.html#app=8367&de93-selectedIndex=3



Species Occurrence Data – A Challenge

Natural Heritage Element Occurrences (NHEO) data /

Biodiversity Information Serving Our Nation (BISON)

Best bet, but…

- Limited access
- Spatially/temporally biased & incomplete

Global Biodiversity Information Facility (GBIF) records

More accessible than NHEO data, but…

- Spatially/temporally biased & incomplete
- Limited precision

GAP Species Distribution Models

- Cumbersome
- Imperfect/incomplete

V. *Creating* Data to Estimate Biodiversity

Species Occurrence Data – Surrogates

GAP Land Cover Maps

- Combine spectral reflectance (land cover) & land form (terrain) to obtain classes that reflect different habitat types

If the diversity of habitats is a reasonable surrogate for species diversity…

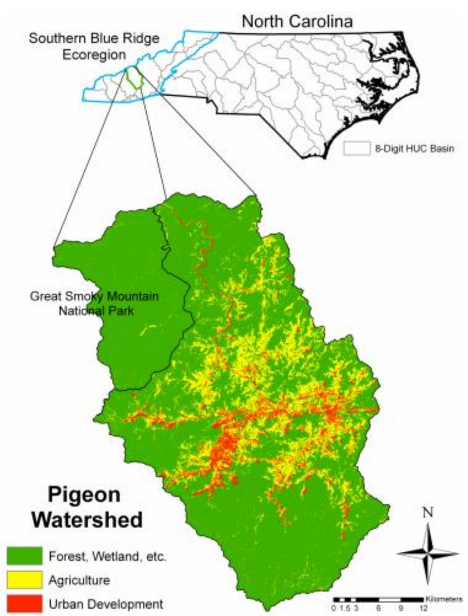
Then, we can aim for patches with high GAP cover richness and evenness…

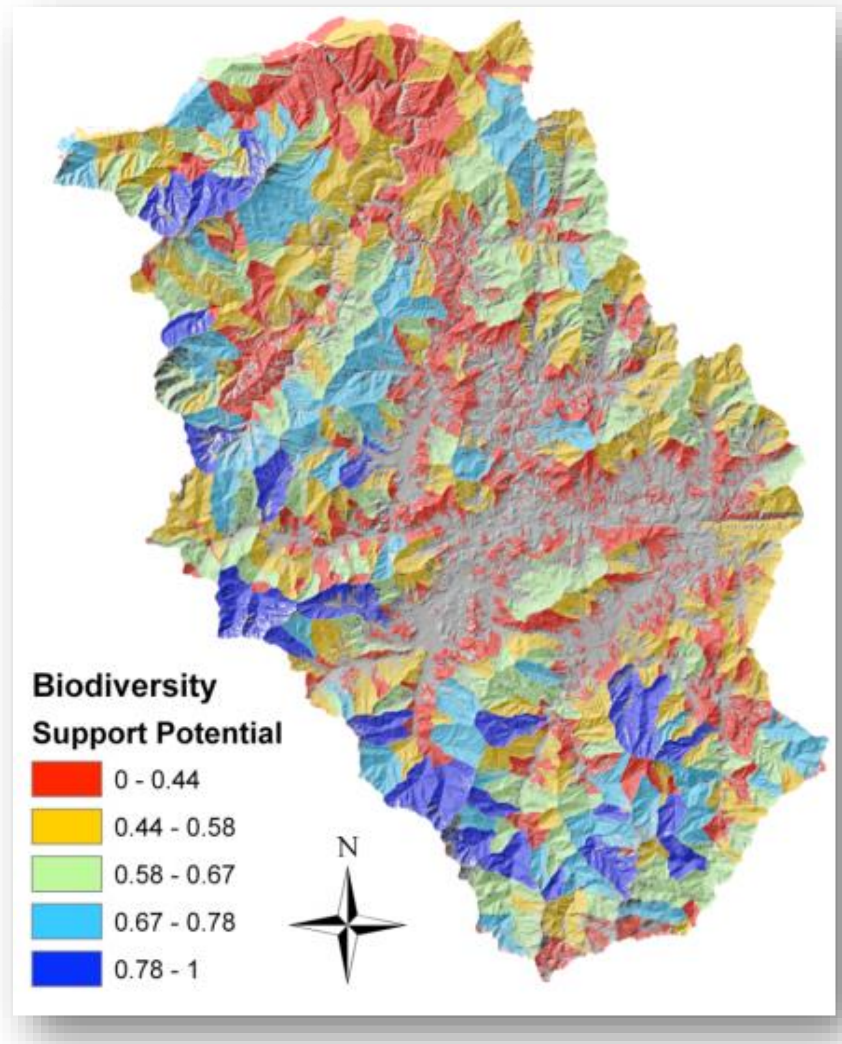
Surrogate Data: "Zip Codes"

ASSESSING THE BIODIVERSITY SUPPORT POTENTIAL OF FOREST PATCHES FOR CONSERVATION PLANNING

by

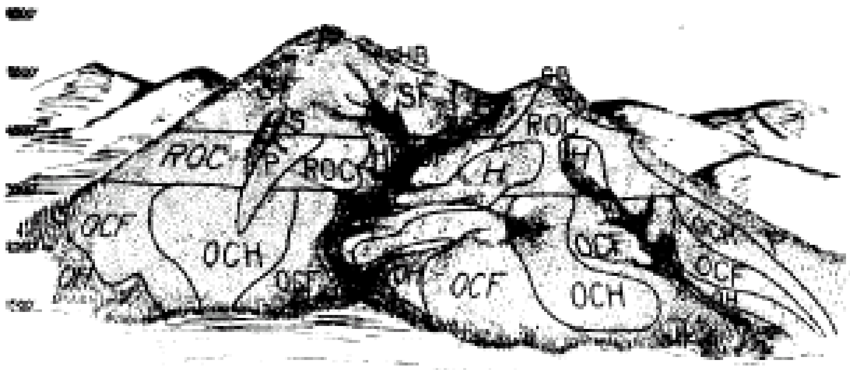
Jesse Emerson Leddick
Dr. Dean Urban, Advisor
December 2008





http://dukespace.lib.duke.edu/dspace/bitstream/handle/10161/844/MP_pyt56_a_200812.pdf

Biodiversity Surrogates or Proxies



Logic:
Use biophysical variables known or suspected to correlate with biodiversity

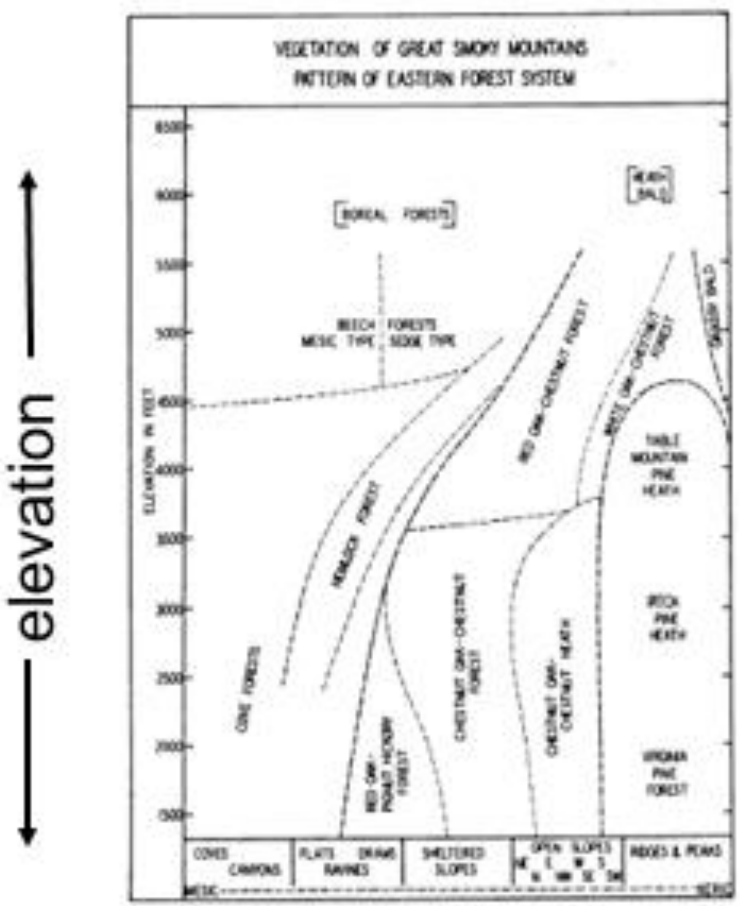


FIG. 19. (Vegetation of Great Smoky Mountains, pattern of Eastern Forest System.)

cove ⟷ ridge

Biodiversity Surrogates or Proxies

For plants:

- temperature
- soil moisture
- soil fertility (chemistry)

For animals:

- habitat or land cover types
- temperature and moisture (via vegetation)

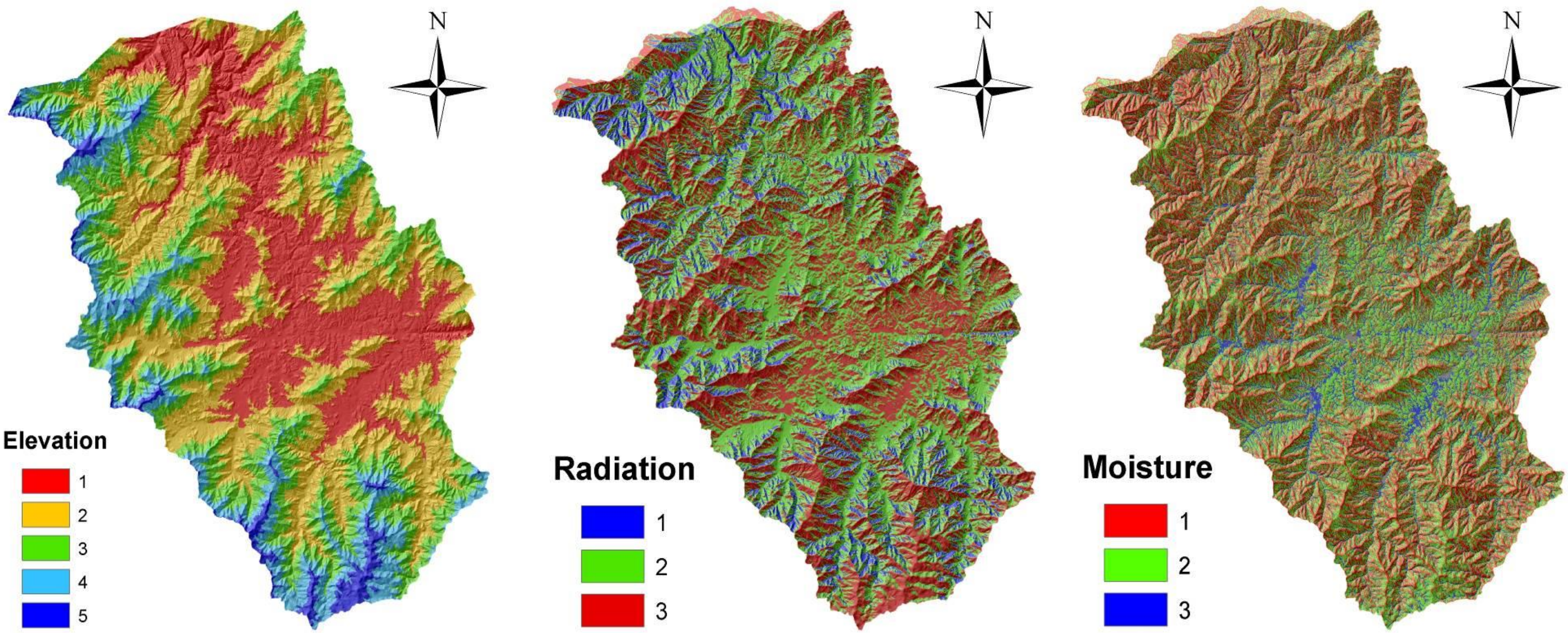
Biodiversity Surrogates or Proxies

Constructing surrogates as biophysical settings:

- Partition proxies into a few relevant levels
  - Elevation zones to reflect **temperature**
  - High (bright)/medium/low (dark) **radiation load**
  - High (wet)/medium/low (dry) **convergence**
- Calibration to actual field data would be nice…
  - Elevation zones to capture known vegetation ecotones, …

Zipcodes: Illustration

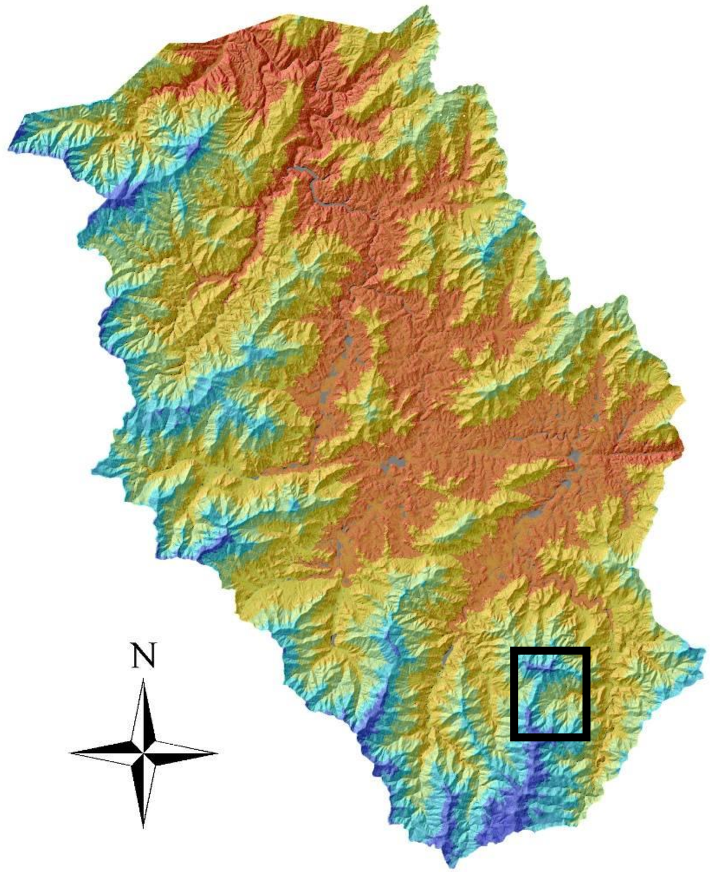
Environmental Proxies, Western NC



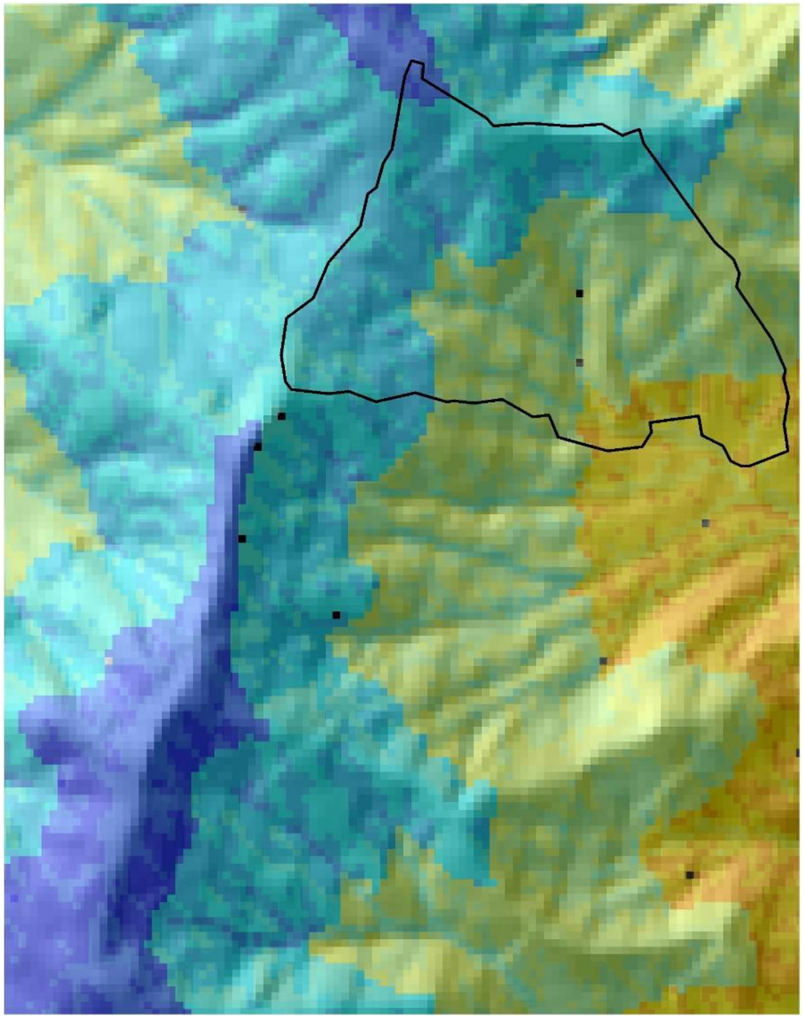
Pigeon Watershed – Jesse Leddick (MEM, 2008)

Zipcodes: Illustration

Zipcodes



Inset



Biodiversity Surrogates or Proxies

Biophysical settings:

- Combine levels of proxies …

  100 * Elevation band

  + 10 * Radiation load level

  + Topographic convergence level

  = a 3-digit "environmental zipcode"

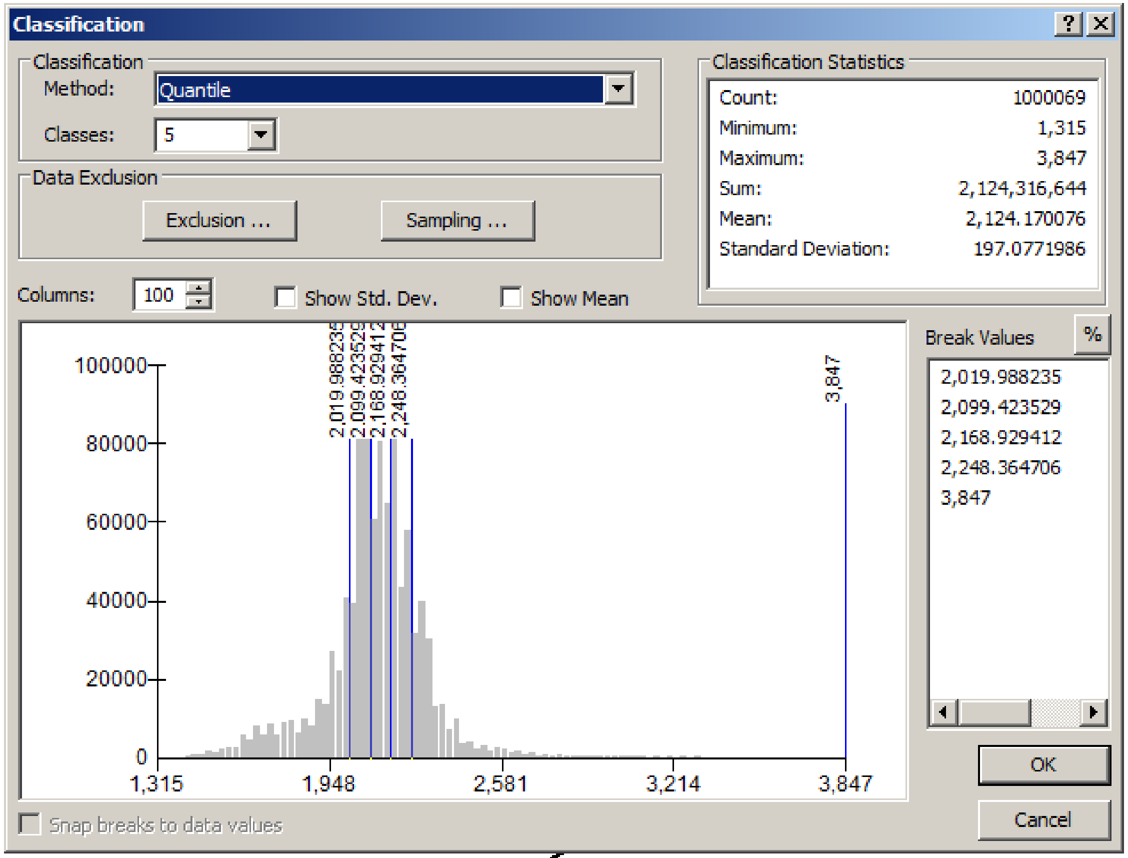
- E.g., 531 = high elevation, bright, dry

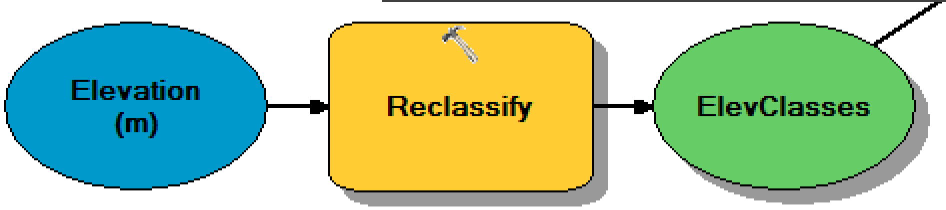
  213 = lower elevation, shaded, wet

Or... use the Combine tool

How to partition layers

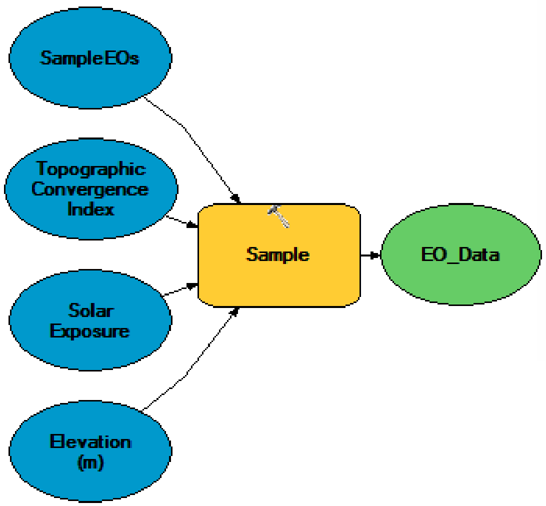
- Elevation → Elevation classes -- **Quantiles**

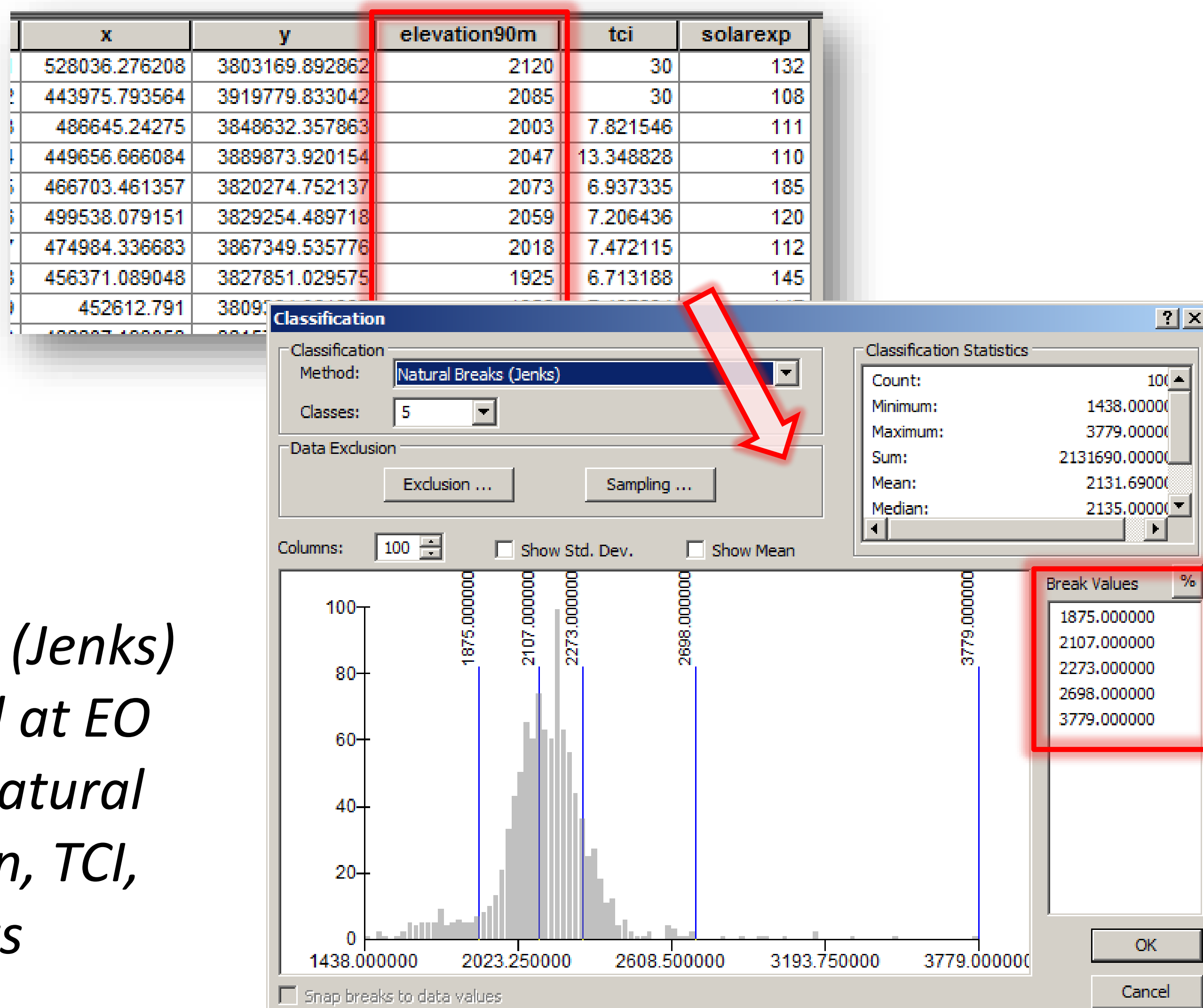




How to partition layers

- Elevation → Elevation classes: **Calibrated w/EOs**



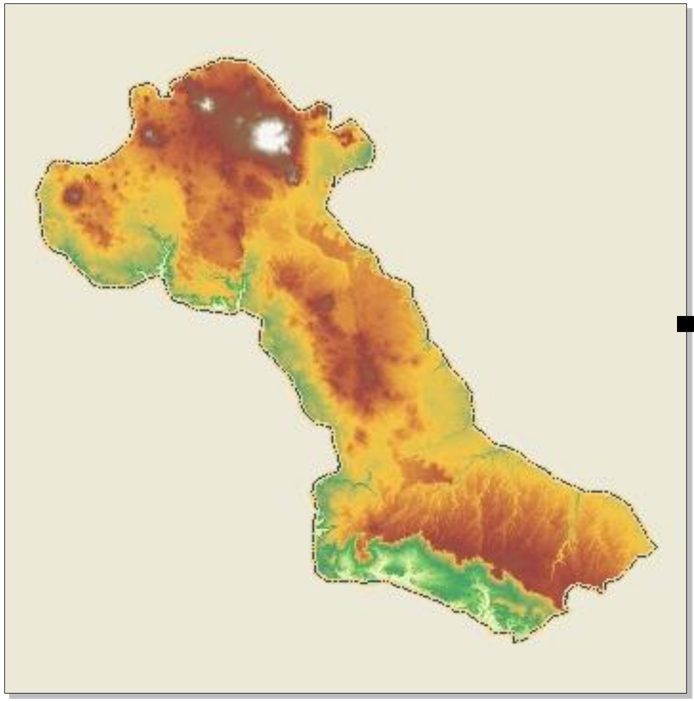


Use Natural Breaks (Jenks) on values sampled at EO locations to find natural breaks in elevation, TCI, solar datasets

Zip Codes: Temperature (Elevation)

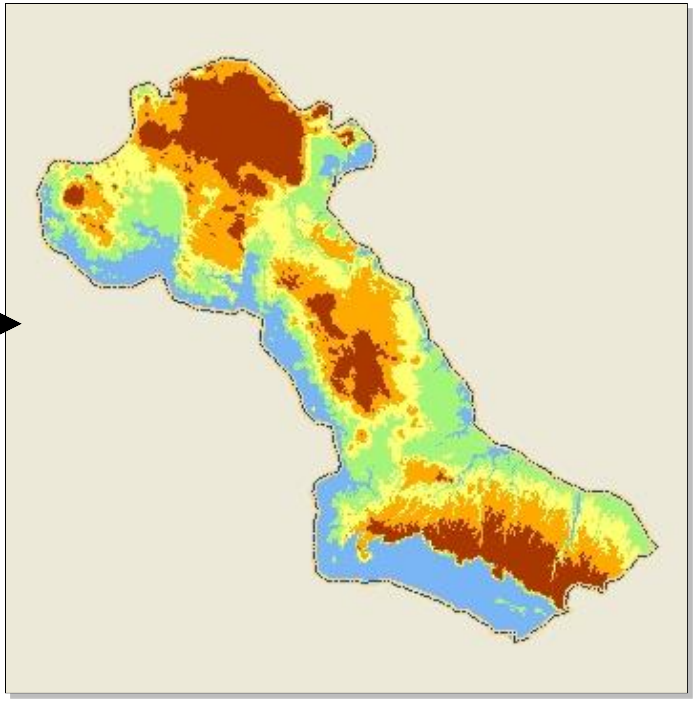
Adiabatic lapse rates correlates elevation with temperature…

Elevation



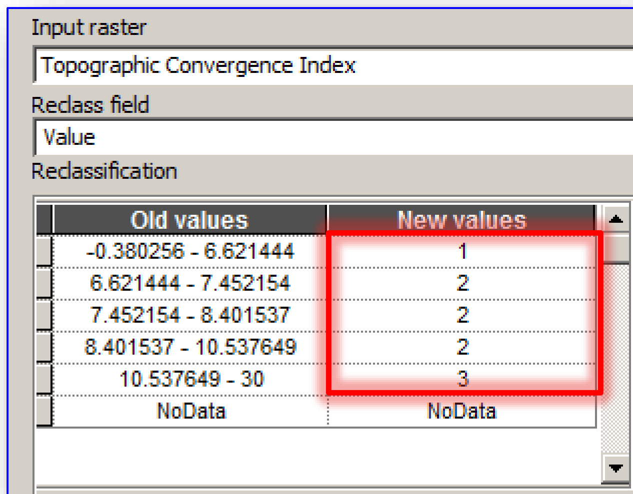
Break elevation range into quintiles

Temperature Classes (5)



How to partition layers: TCI & Solar Exp.

- Break into 5 quantiles
- Recode 2nd, 3rd, and 4th quantile to the same value

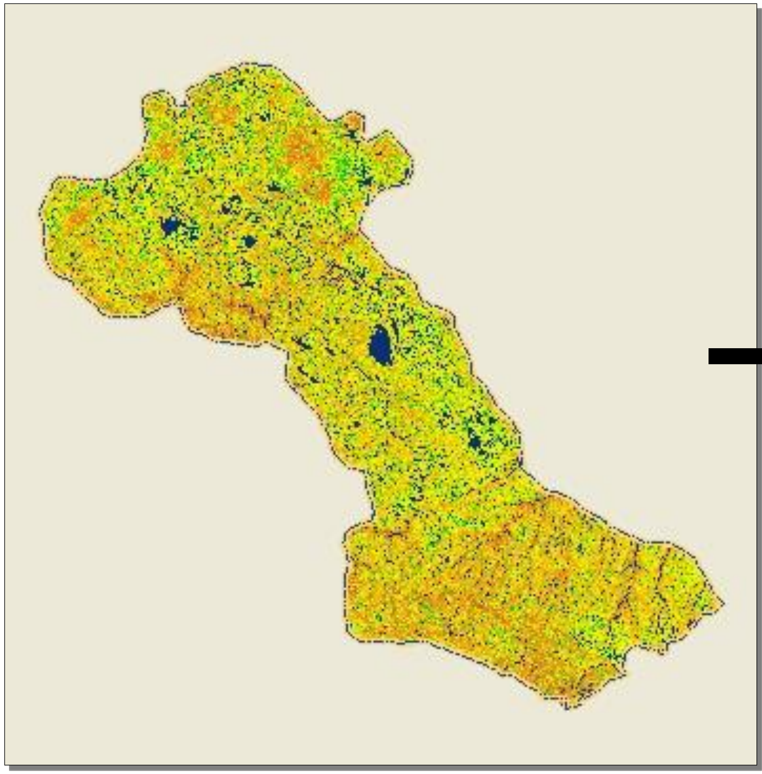


- Doing so focuses zip code breaks on extremes (lowest and highest 20% of range)

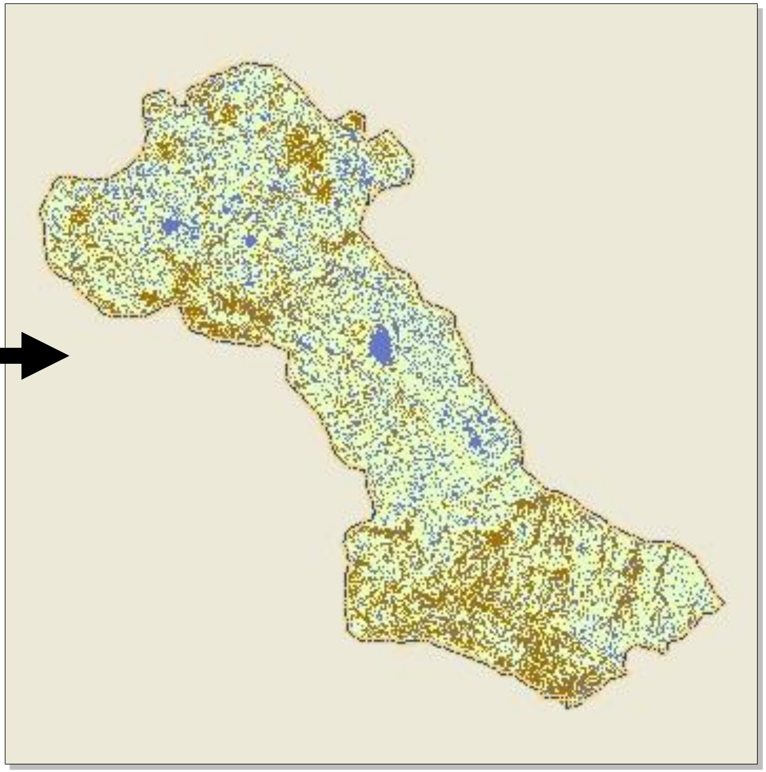
Zip Codes: Moisture (Soils or TCI)

In the absence of soil moisture data, TCI can be used.

- Lowest 20% of values → wet;
- Highest 20% → dry;
- Everything else → moderate.



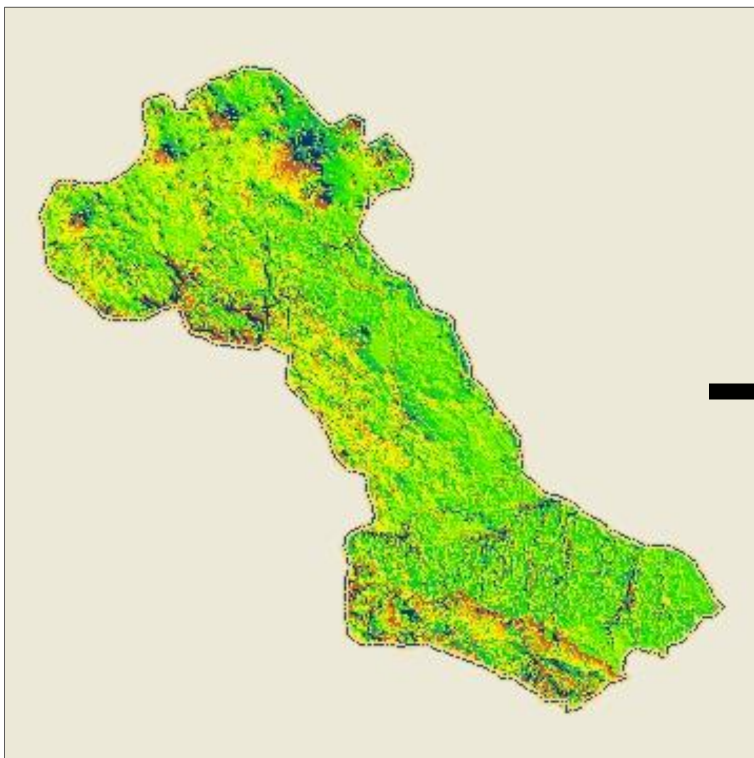
→ Break TCI range into quintiles
* * *
Clump the middle three as one class →



Zip Codes: Light (Solar Exposure)

Modified hillshade method is used to calculate exposure:

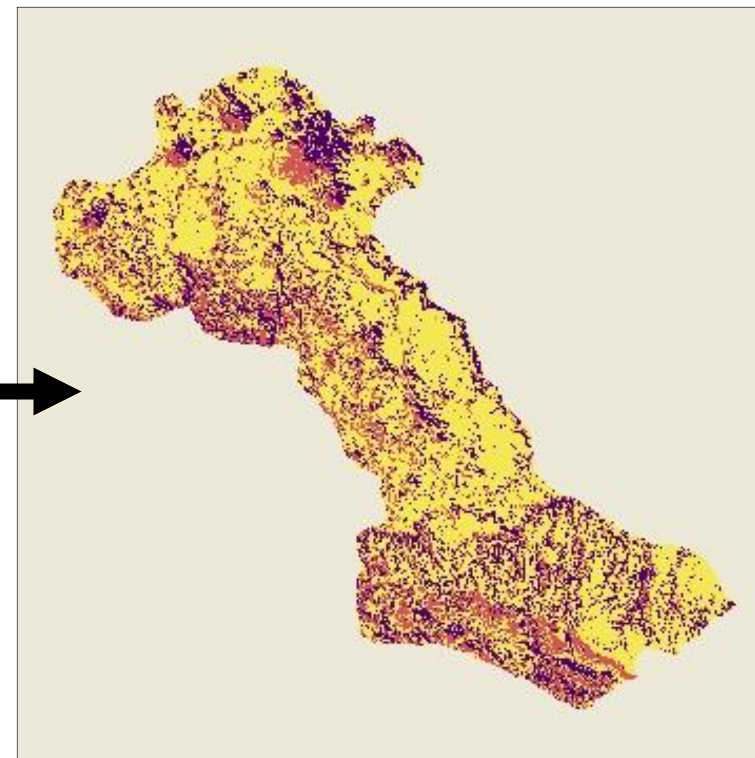
- **Lowest 20% of values → cool slopes;**
- **Highest 20% → hot slopes;**
- **Everything else → moderate.**



Break solar exposure range into quintiles

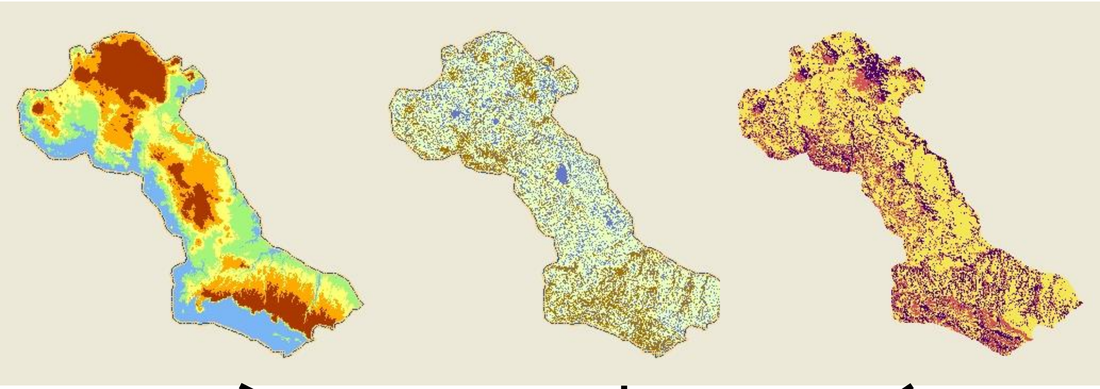
* * *

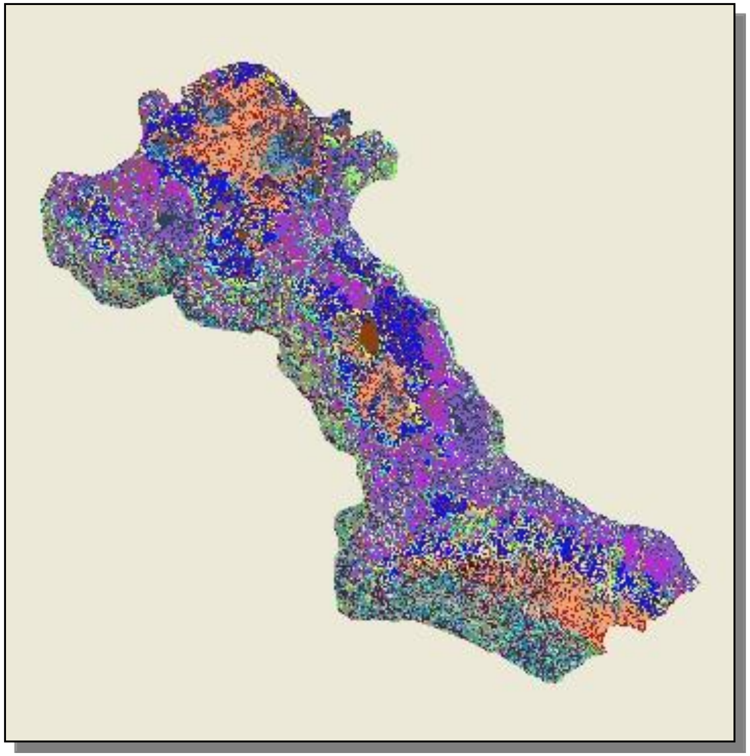
Clump the middle three as one class



Biophysical ZipCodes

The three classified maps are combined, producing a map containing classes for each unique combination of elevation class, TCI class, and solar exposure class.





Each zipcode represents a single habitat (e.g. like GAP cover classes…)

Biodiversity Surrogates or Proxies

Summary:

- Zipcodes represent ecologically relevant environmental settings (habitat types)

- The factors and levels can be …
  - calibrated to the study area (in AZ, by ecoregion, etc.)
  - expanded to include additional factors (soils, etc.)

Biodiversity Surrogates or Proxies

Applications:

- Biophysical settings ~ potential diversity
  - *Assumes that different species occur in different zipcodes*
- Biophysical diversity provides *buffering capacity* under environmental variability (allows for local movement to track climate)

Biodiversity Surrogates or Proxies

Applications:

- Zipcodes also can be calibrated to known biodiversity to yield a weighted index
  - Associate Element Occurrences with zipcode for that location
  - Compute EO density per zipcode
  - Use these densities as weights → effective "value" of each zipcode

V. Lab Exercise

Measuring Biodiversity: *Lab Exercise*

So how do we get this table??

Attributes of Occurrences

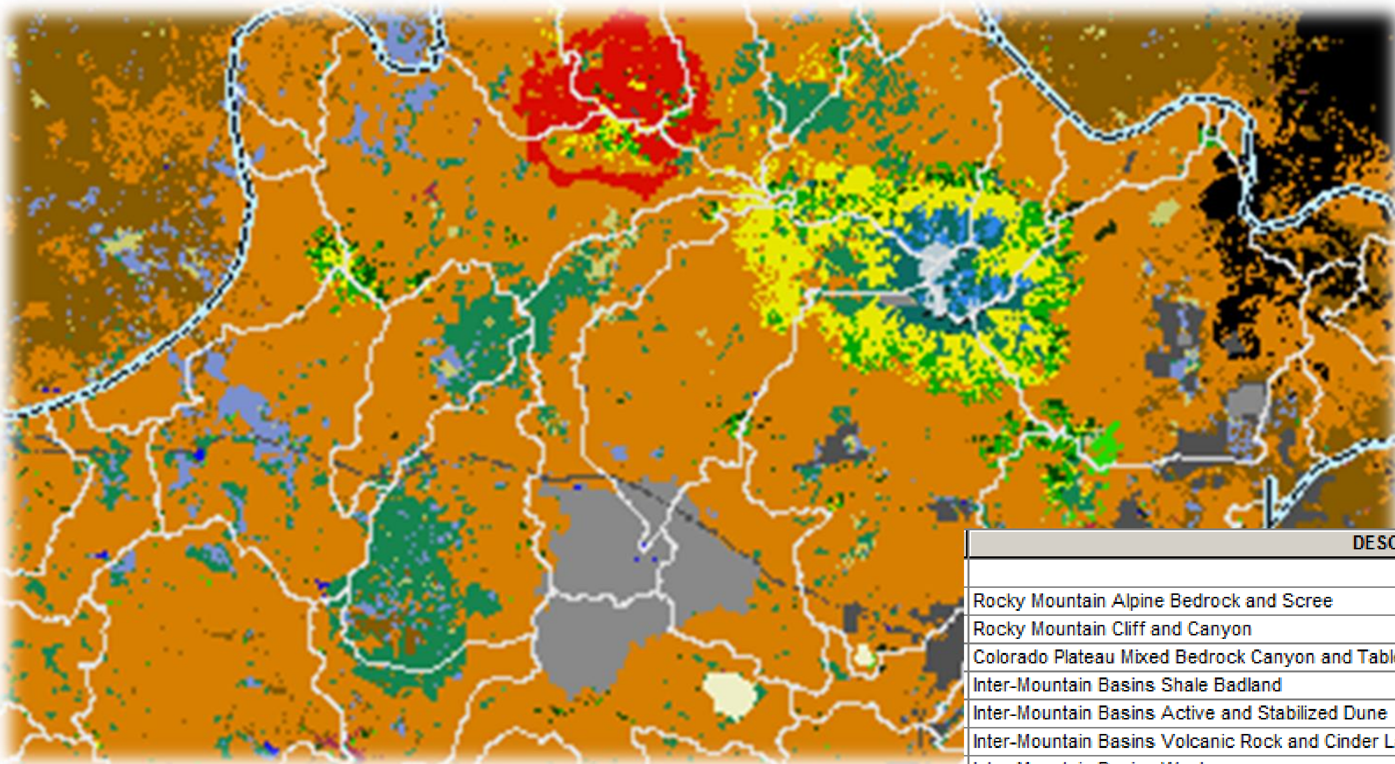
P.U.	Species Code	# occurrences
1	34	1
1	36	10
1	67	13
2	36	78
2	67	137
2	76	31
2	34	147
2	71	2
2	51	79
2	64	1
3	67	121
3	36	89

Spatially combine species occurrence data with our Mogollon Plateau planning units (HUC12s)…

Pronghorn Patch Biodiversity

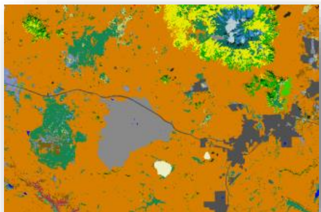
Task:

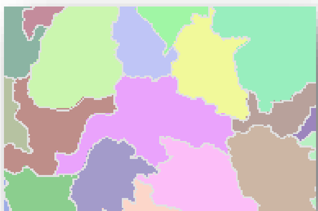
Calculate HUC12 diversity using SW Region GAP land cover

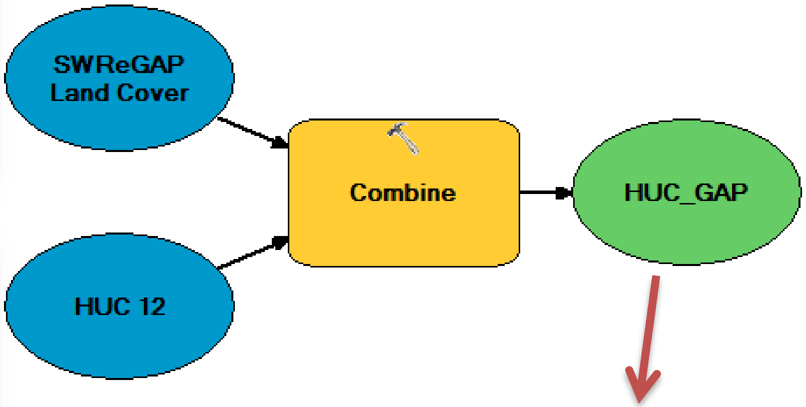


DESCRIPTION
Rocky Mountain Alpine Bedrock and Scree
Rocky Mountain Cliff and Canyon
Colorado Plateau Mixed Bedrock Canyon and Tableland
Inter-Mountain Basins Shale Badland
Inter-Mountain Basins Active and Stabilized Dune
Inter-Mountain Basins Volcanic Rock and Cinder Land
Inter-Mountain Basins Wash
Inter-Mountain Basins Playa
North American Warm Desert Bedrock Cliff and Outcrop
North American Warm Desert Badland
North American Warm Desert Active and Stabilized Dune
North American Warm Desert Volcanic Rockland

Calculating richness







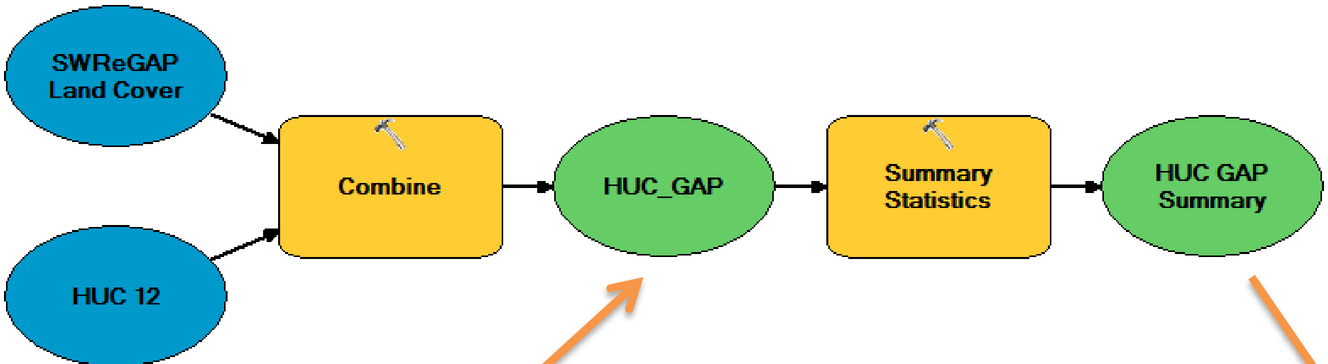
Table

huc_gap

Rowid	VALUE	COUNT	AZ_LANDCOVER	HUC12_90M
1339	1340	1519	34	1
1342	1343	61	112	1
1346	1347	2	36	1
1350	1351	5	71	1
1369	1370	1	110	1
902	903	7446	34	2
904	905	9	30	2
906	907	22	71	2
907	908	9	32	2

5 GAP types in HUC #1

Calculating richness



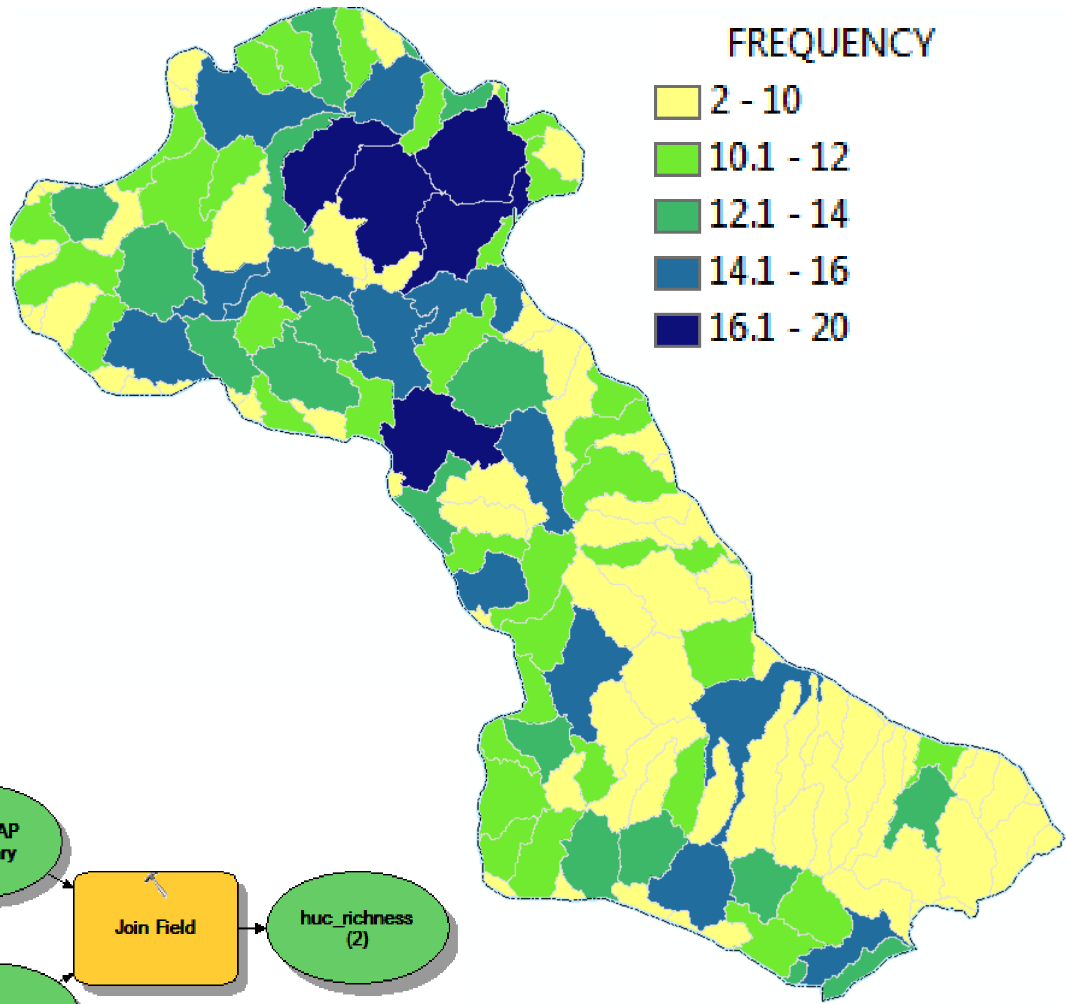
huc_gap

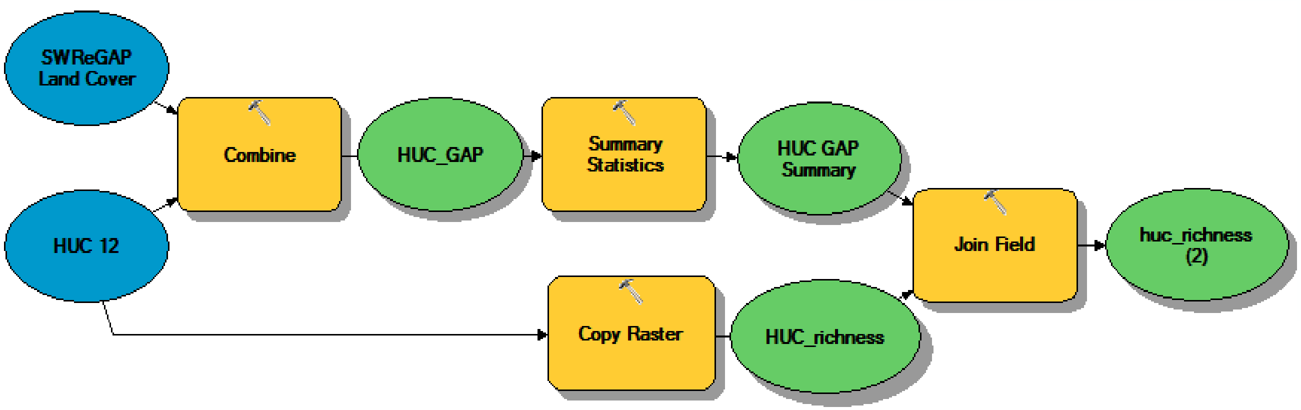
Rowid	VALUE	COUNT	AZ_LANDCOVER	HUC12_90M
1339	1340	1519	34	1
1342	1343	61	112	1
1346	1347	2	36	1
1350	1351	5	71	1
1369	1370	1	110	1
902	903	7446	34	2
904	905	9	30	2
906	907	22	71	2
907	908	9	32	2

HUC GAP Summary

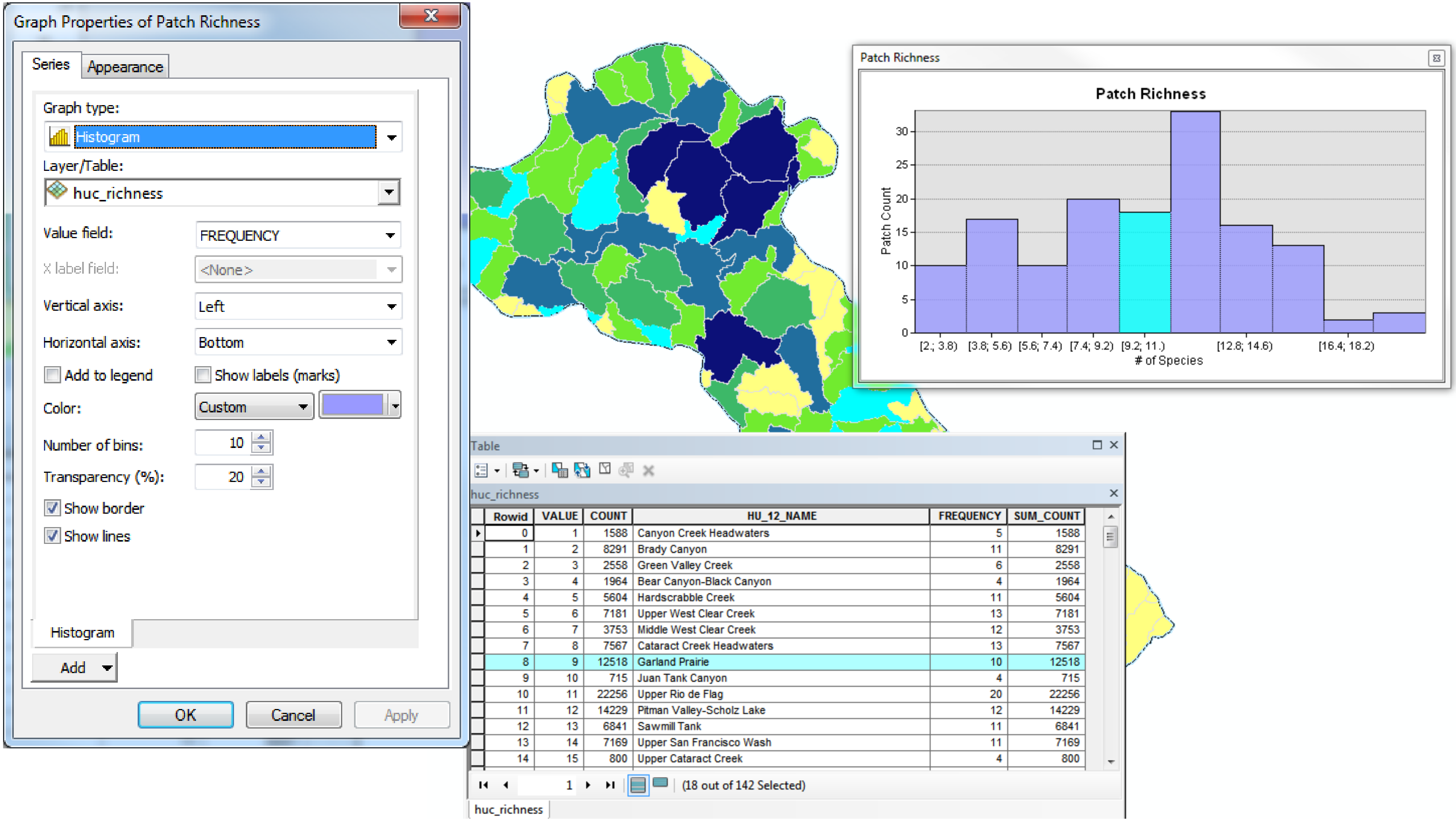
OID	HUC12_90M	FREQUENCY	SUM_COUNT
0	1	5	1588
1	2	11	8291
2	3	6	2558
3	4	4	1964
4	5	11	5604
5	6	13	7181
6	7	12	3753

Calculating Richness





Richness histogram



Rowid	VALUE	COUNT	HU_12_NAME	FREQUENCY	SUM_COUNT
0	1	1588	Canyon Creek Headwaters	5	1588
1	2	8291	Brady Canyon	11	8291
2	3	2558	Green Valley Creek	6	2558
3	4	1964	Bear Canyon-Black Canyon	4	1964
4	5	5604	Hardscrabble Creek	11	5604
5	6	7181	Upper West Clear Creek	13	7181
6	7	3753	Middle West Clear Creek	12	3753
7	8	7567	Cataract Creek Headwaters	13	7567
8	9	12518	Garland Prairie	10	12518
9	10	715	Juan Tank Canyon	4	715
10	11	22256	Upper Rio de Flag	20	22256
11	12	14229	Pitman Valley-Scholz Lake	12	14229
12	13	6841	Sawmill Tank	11	6841
13	14	7169	Upper San Francisco Wash	11	7169
14	15	800	Upper Cataract Creek	4	800

Calculating Shannon's index

“HUC_GAP” table

huc_gap

Rowid	VALUE	COUNT	AZ_LANDCOVER	HUC12_90M
1339	1340	1519	34	1
1342	1343	61	112	1
1346	1347	2	36	1
1350	1351	5	71	1
1369	1370	1	110	1
902	903	7446	34	2
904	905	9	30	2
906	907	22	71	2
907	908	9	32	2

Gap cover type

(34 = "Mogollon Chaparral")

Area

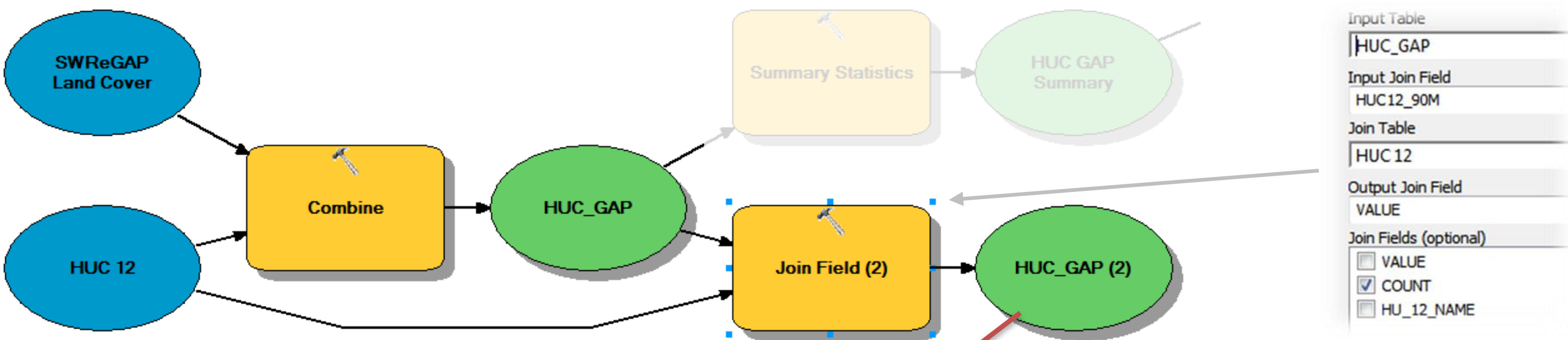
(proxy for species count)

Shannon Index: Patch #1

	Count	p	ln(p)	-p*ln(p)
n1	1519	0.9565	-0.0444	0.04249
n2	61	0.0384	-3.2594	0.1252
n3	2	0.0013	-6.6771	0.00841
n4	5	0.0031	-5.7608	0.01814
n5	1	0.0006	-7.3702	0.00464
N	*1588*			**0.19888**

Calculating Shannon's index

Join the Habitat Patches' COUNT field to the combined Patch-GAP table



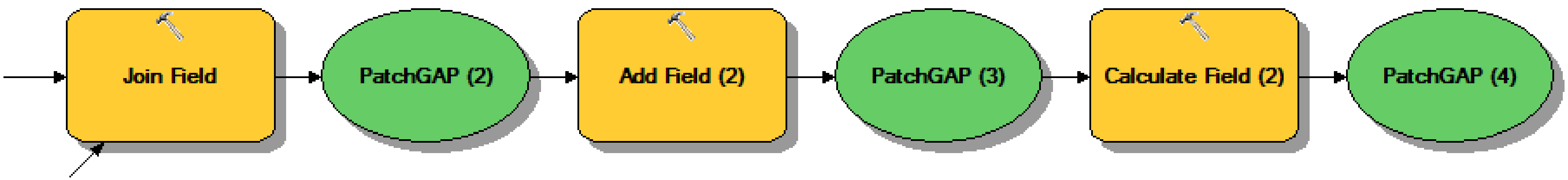
huc_gap

Rowid	VALUE	COUNT	HUC12_90M	AZ_LANDCOVER	COUNT_1
0	1	447	131	36	8432
1	2	5999	131	34	8432
2	3	443	131	67	8432
3	4	325	136	67	6029
4	5	4043	136	34	6029
5	6	437	136	36	6029
6	7	572	131	71	8432
7	8	859	136	71	6029
8	9	518	135	36	3623
9	10	2543	135	34	3623

Total # of cells in HUC

$$p = \frac{\text{“COUNT”}}{\text{“COUNT\_1”}}$$

Calculating Shannon's index

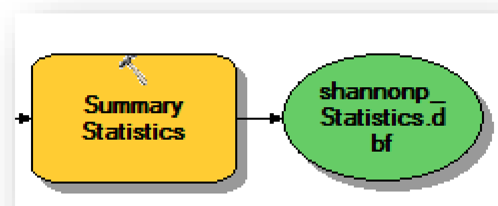


-1 * ([COUNT] / [COUNT_1]) * Log ([COUNT] / [COUNT_1])

huc_gap

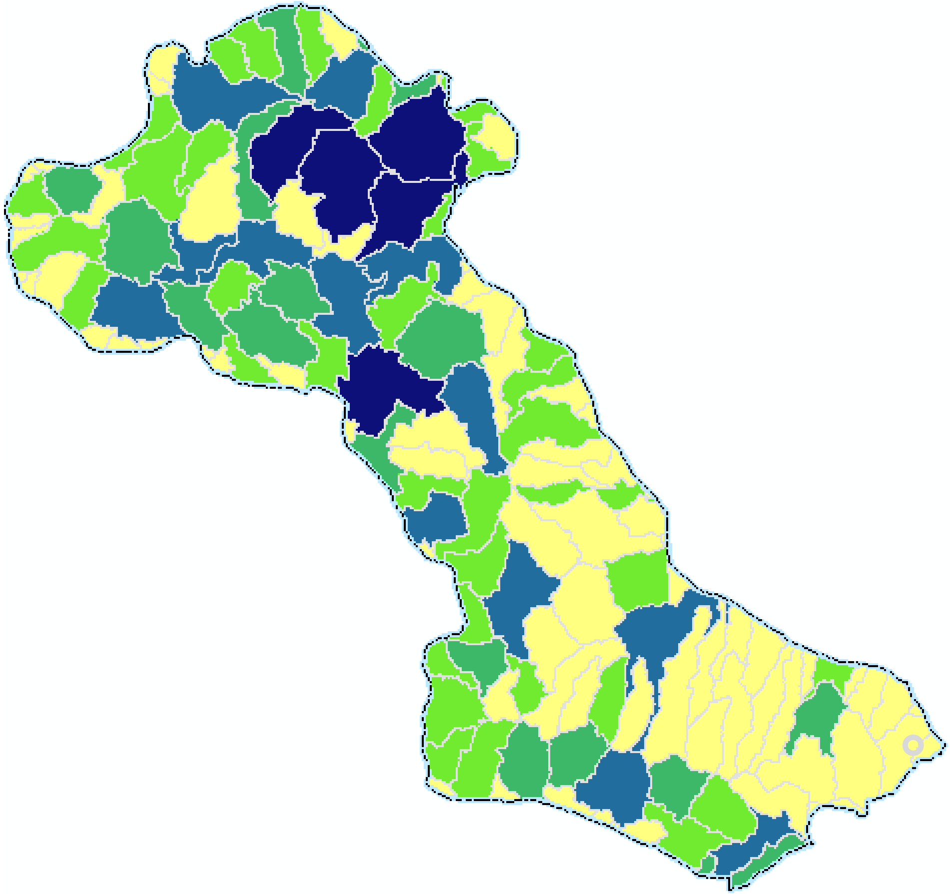
Rowid	VALUE	COUNT	AZ_LANDCOVER	HUC12_90M	COUNT_1	P_LNP
0	1	447	36	131	8432	0.155709
1	2	5999	34	131	8432	0.242209
2	3	443	67	131	8432	0.154788
3	4	325	67	136	6029	0.157433
4	5	4043	34	136	6029	0.267965
5	6	437	36	136	6029	0.190225
6	7	572	71	131	8432	0.182525
7	8	859	71	136	6029	0.277628

Σ *(P_LNP)* for each patch

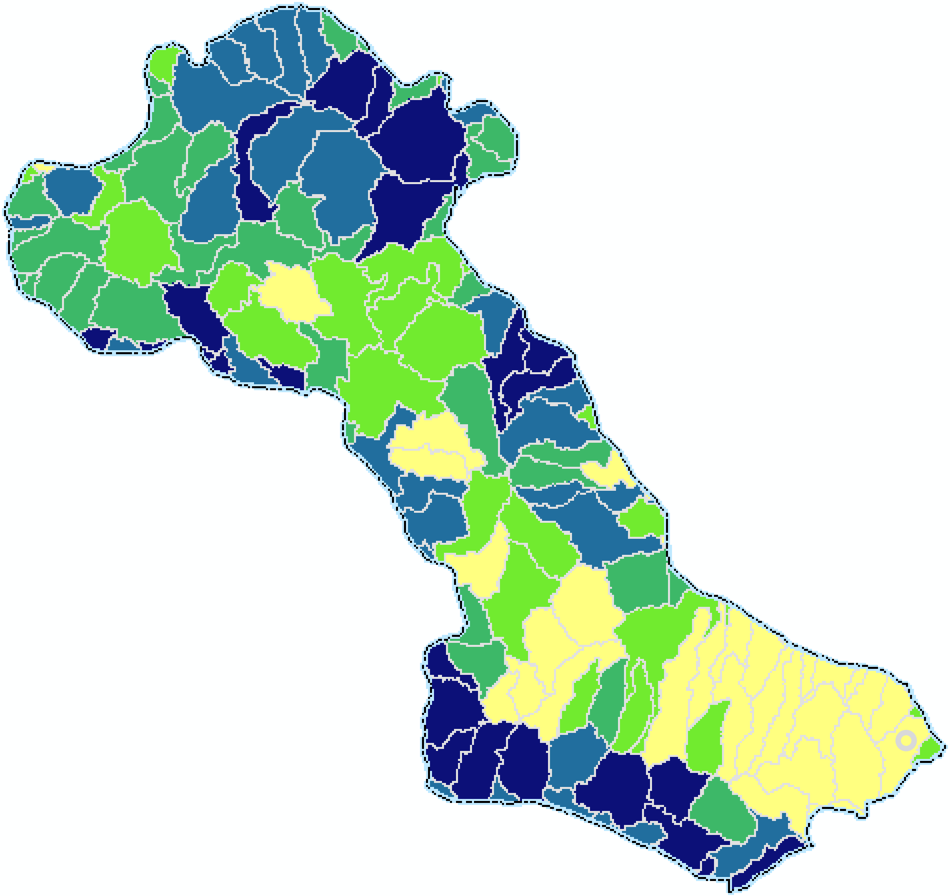


Richness & Evenness Maps

Richness

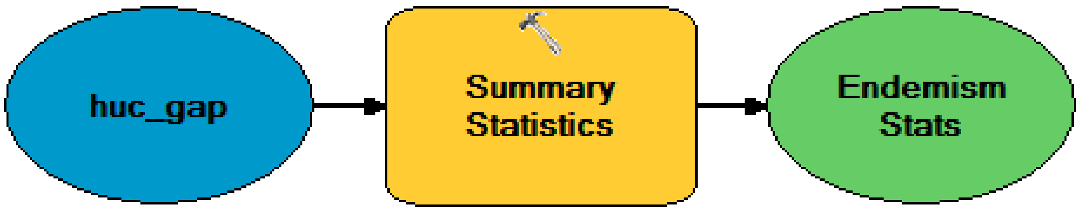


Evenness



Calculating Endemism

Calculate frequency of *az_landcover* values across *HUC_GAP values*



Endemism Stats

Rowid	AZ_LANDCOVER	FREQUENCY	SUM_COUNT
1	2	5	604
2	5	28	463
3	9	51	4567
4	11	1	6
5	12	7	3998
6	14	2	648
7	22	47	10641
8	24	4	191
9	26	16	2590
10	28	6	804
11	30	101	16394
[illegible]	[illegible]	[illegible]	[illegible]

Land cover #11 (*North American Warm Desert Active and Stabilized Dune*) is found in **only 1** HUC.

Land cover #30 (*Colorado Plateau Pinyon-Juniper Shrubland*) is found in 101 (of 142) different HUCs.

Calculating Endemism

Type = Long

Int(((345 - [FREQUENCY]) / 345) * 100)

Normalize the number of patches in which a species is observed by the total number of patches

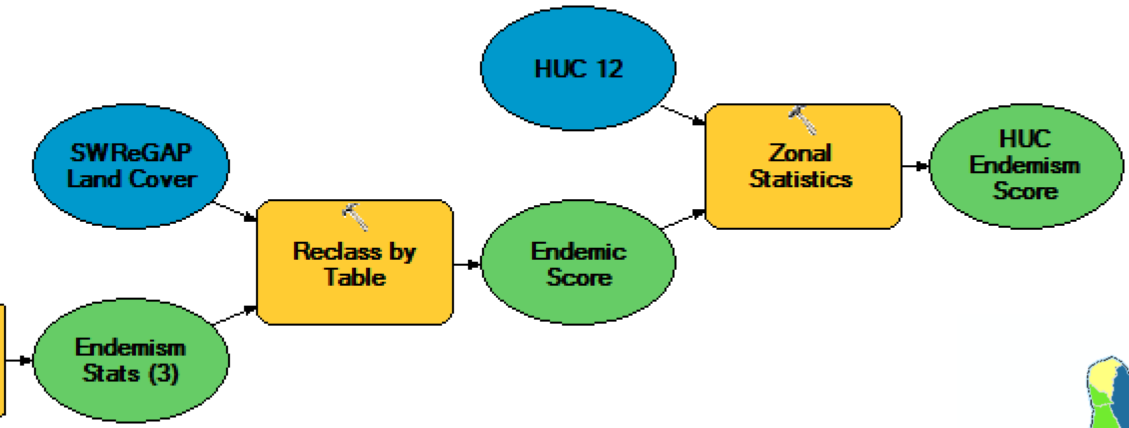
Endemism Stats (3)

Rowid	AZ_LANDCOVER	FREQUENCY	SUM_COUNT	Endemism
1	2	5	604	96
2	5	28	463	80
3	9	51	4567	64
4	11	1	6	99
5	12	7	3998	95
6	14	2	648	98
7	22	47	10641	66
8	24	4	191	97
9	26	16	2590	88
10	28	6	804	95
11	30	101	16394	28
12	32	98	6615	30
13	33	81	45737	42
14	34	142	696196	0
15	36	135	81682	4

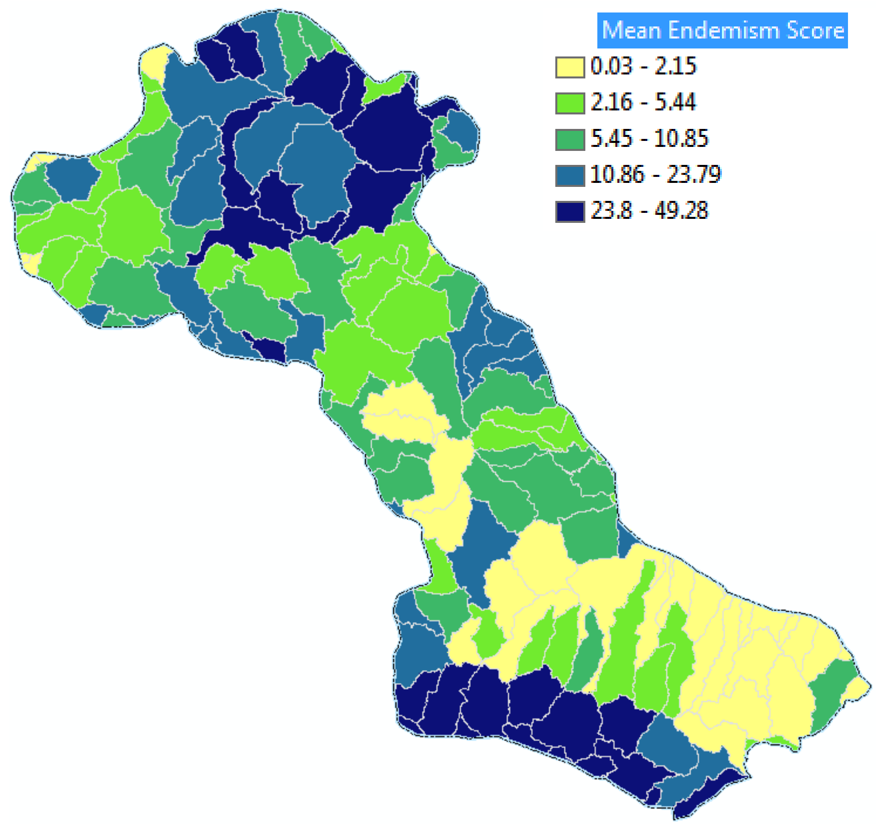
Land cover #2 = 96
→ Highly endemic!

Land cover #34 = 0
→ Ubiquitous

Calculating Endemism



Calculate mean endemic score for each habitat patch…



What are we neglecting in this approach?

How might we fix it?

Assignment

- Calculate HUC12 biodiversity metrics
  - Richness & Evenness of GAP cover types
- Create biophysical zip-codes for the Mogollon
  - Elevation/TCI/Solar exposure
- Calculate HUC12 biodiversity metrics again…
  - Richness & Evenness of zip-codes

See lab for deliverables…