A data-intensive assessment of the species-abundance distribution.

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A data-intensive assessment of the species-abundance distribution.

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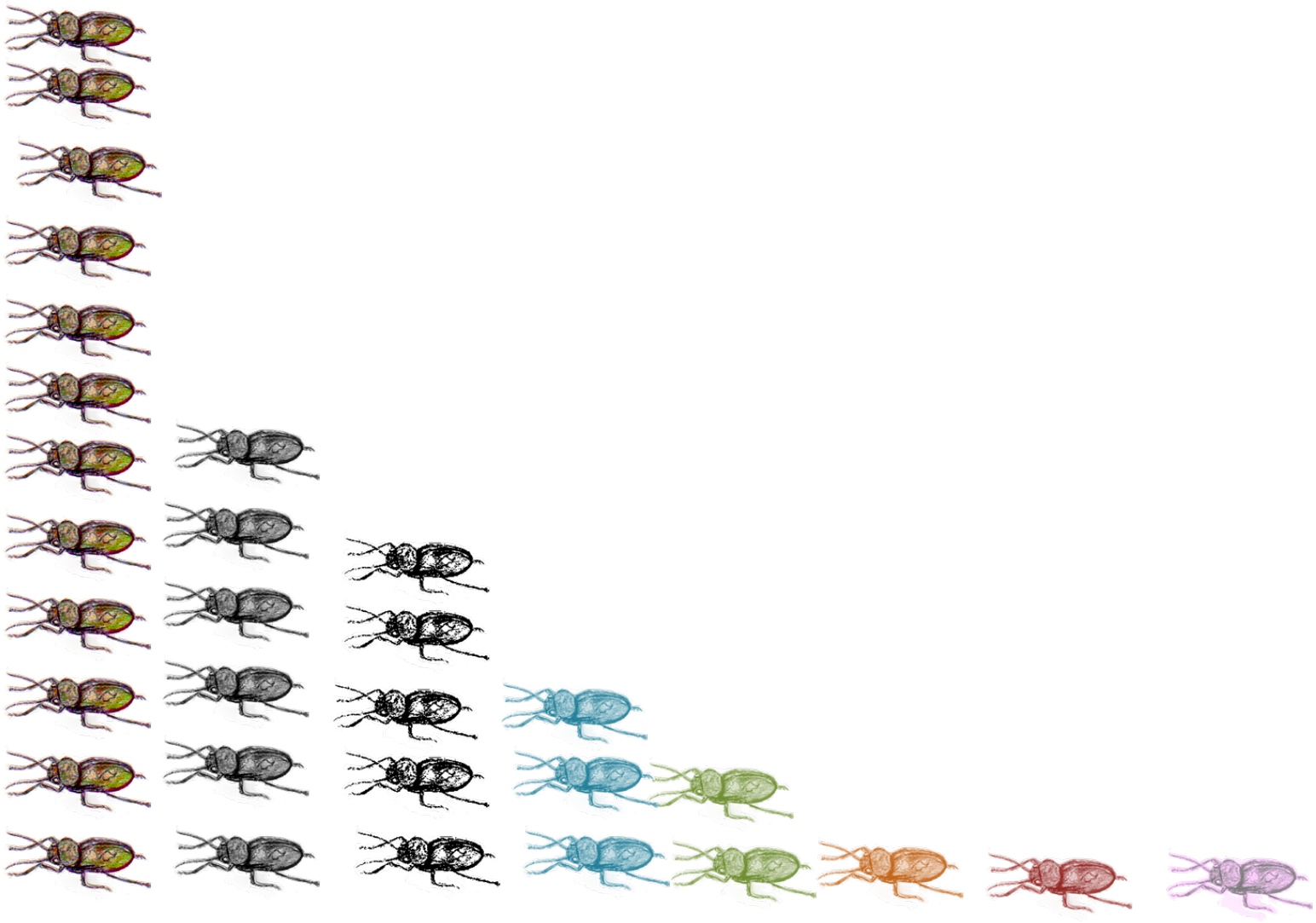
ECOLOGY CENTER

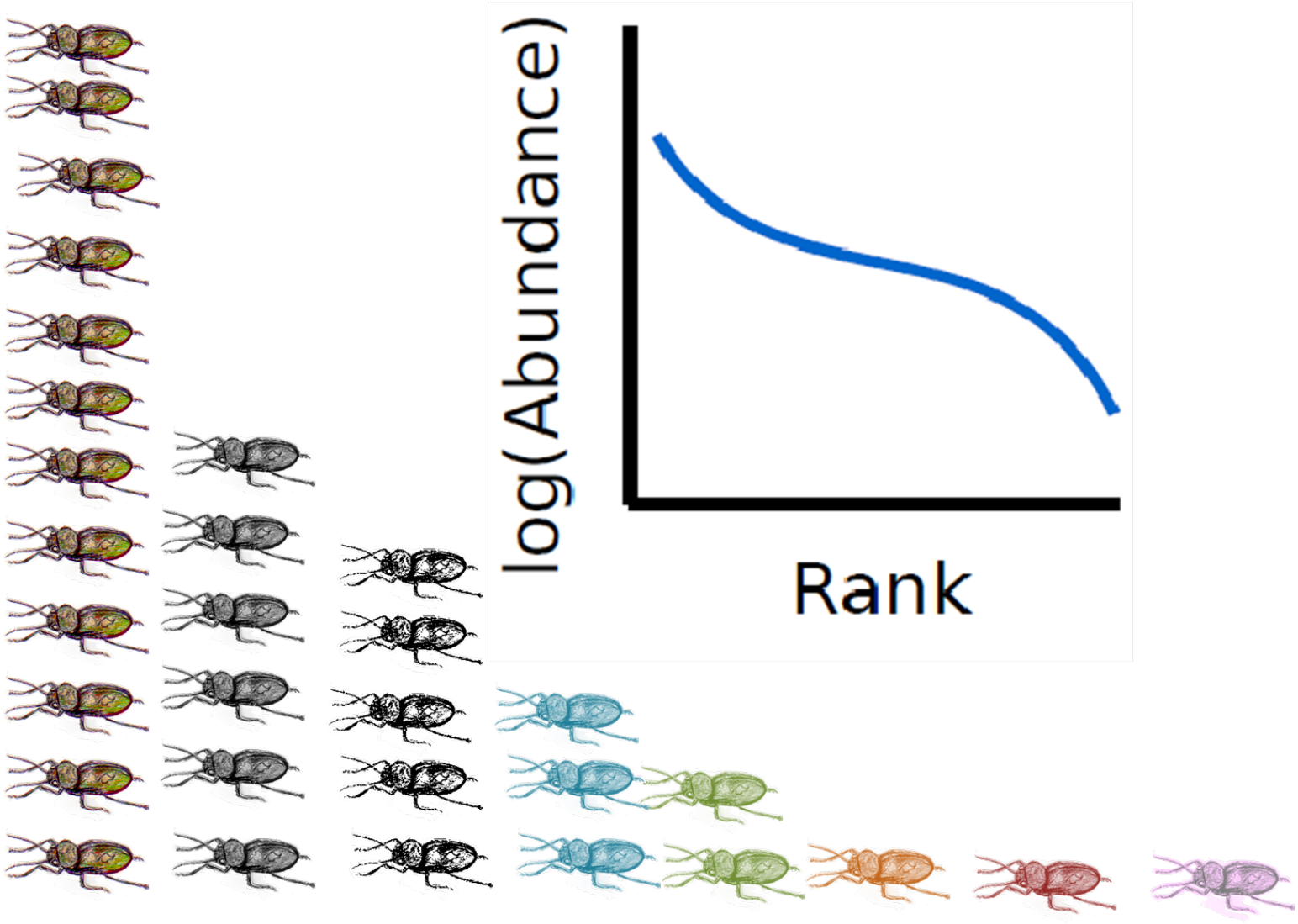
Open science

- Code:
  - github.com/embaldridge
  - github.com/weecology
- Data: figshare.com

Let's begin with an example...



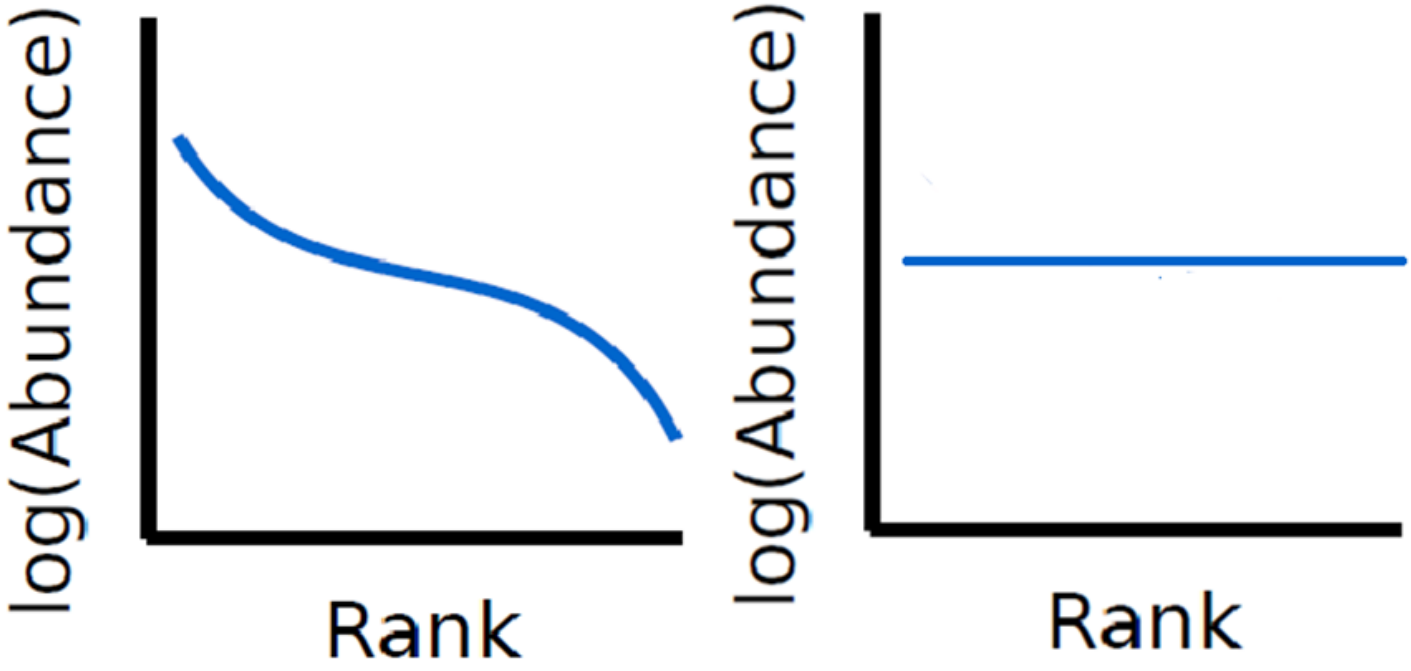
Let's begin with an example...



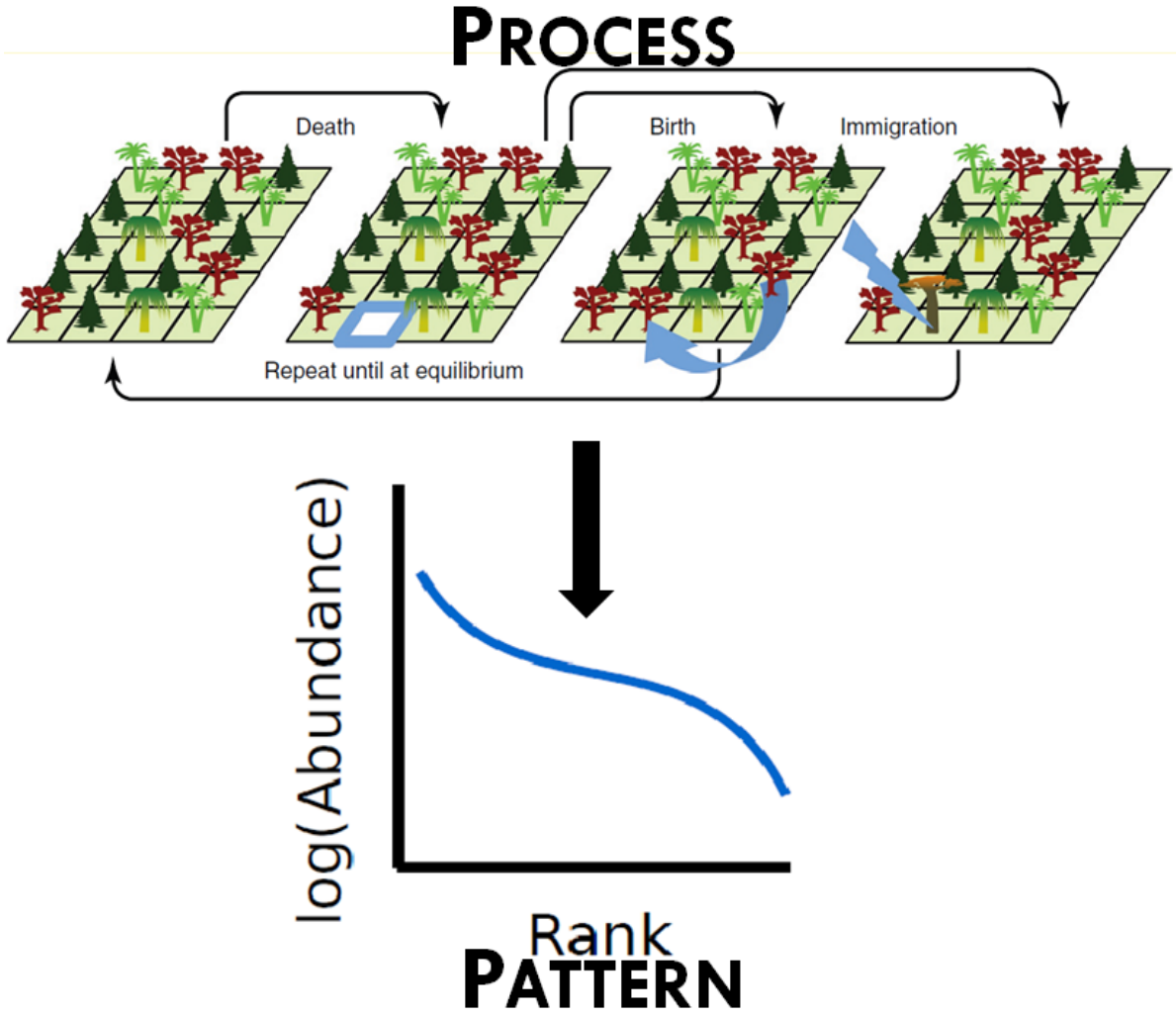
Pattern & process.

Species abundance distribution (SAD)

- Reveals pattern-generating mechanisms of community structure.



Pattern & process.

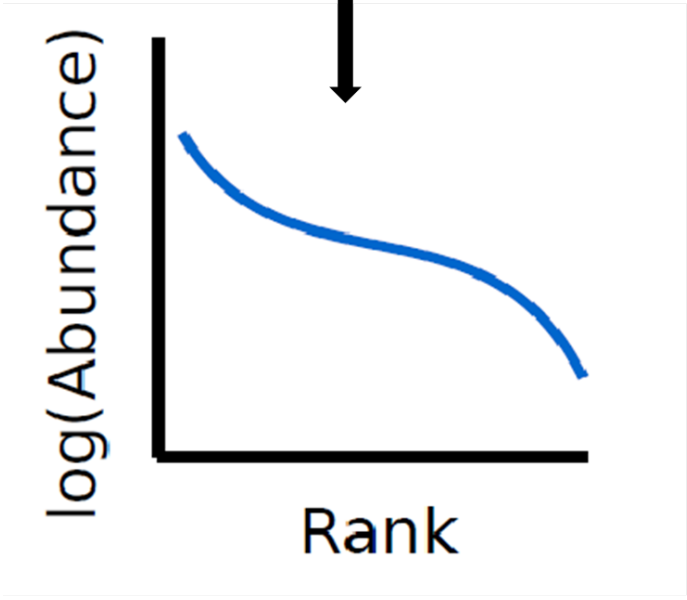


Patterns & process.

Process

Competition Niches Dispersal

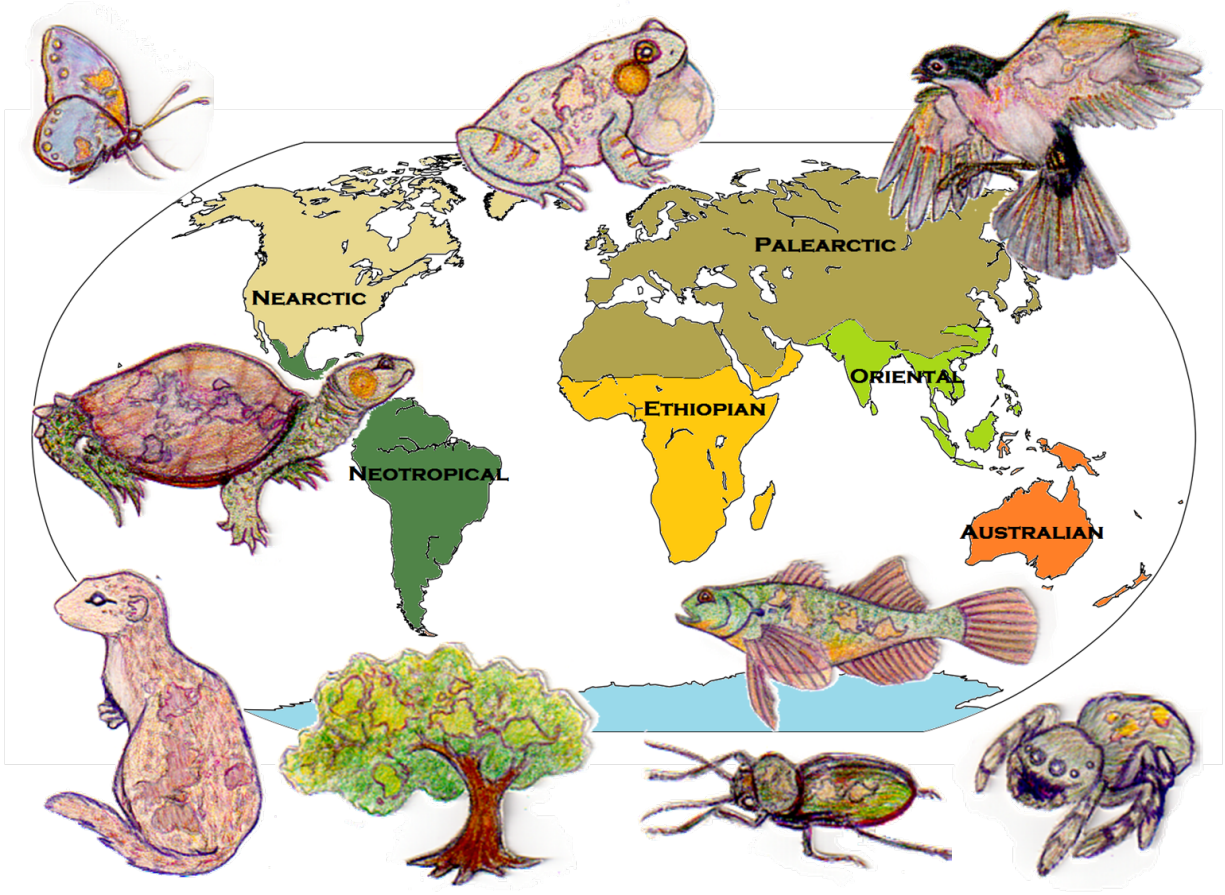
Nutrients Neutrality Etc.



Pattern

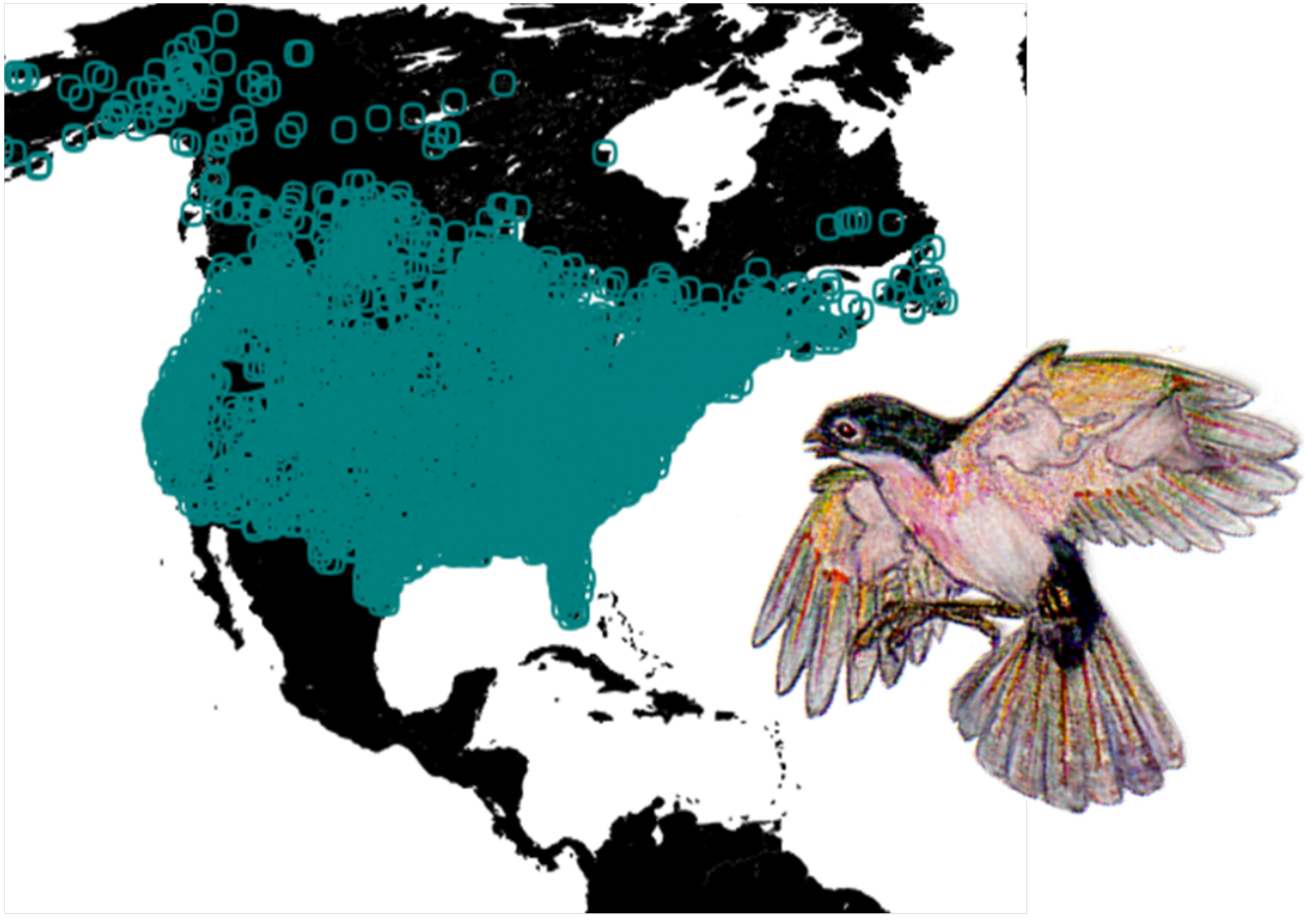
Macroecology

One approach for identifying general ecological patterns & processes.



Traditional approach

Broader approach

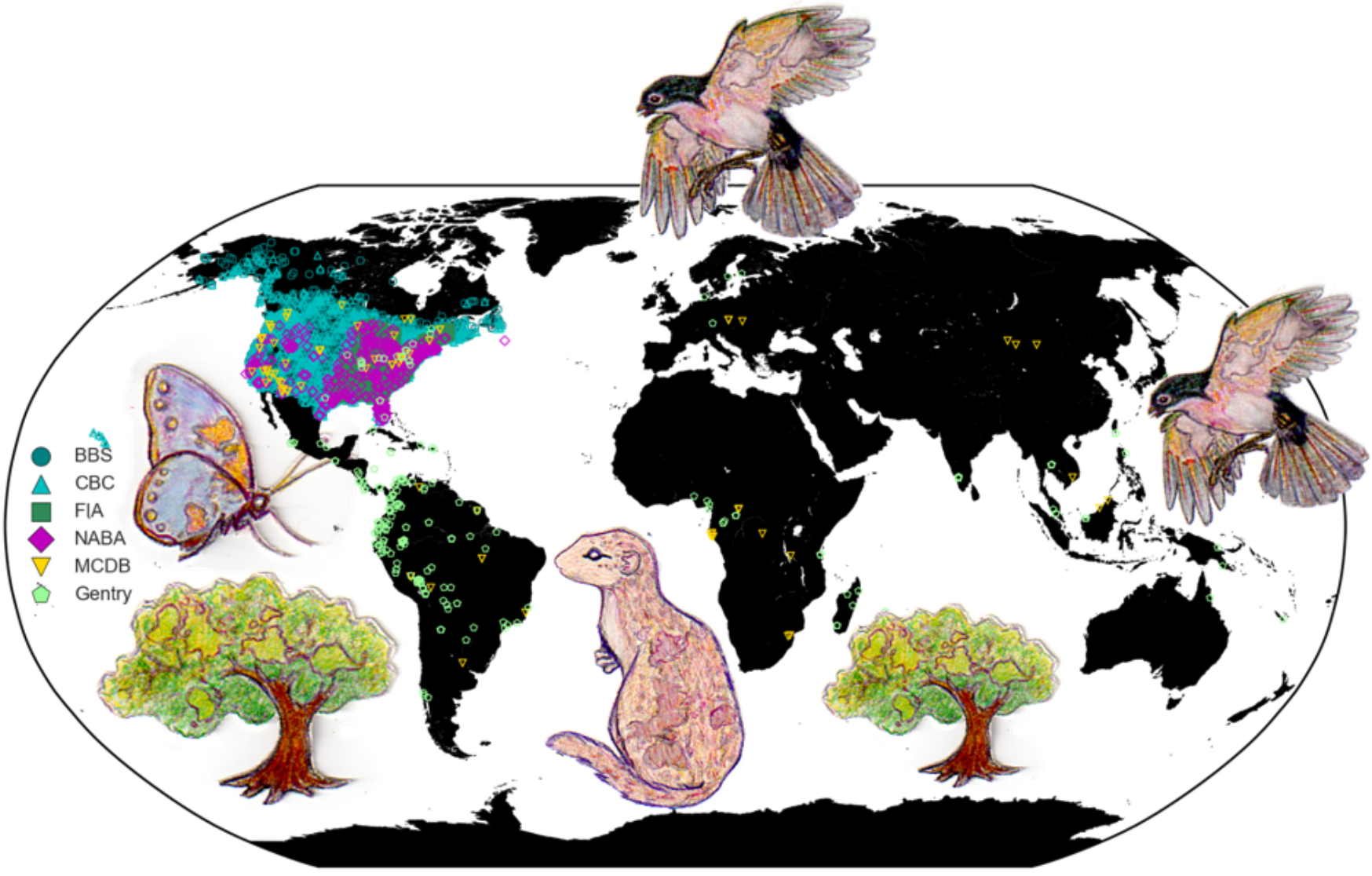


Pattern & Process; Signal & Noise

Data-intensive ecology

- Leveraging existing ecological data.
- The species abundance distribution.
- The statistical approach.
- The mechanistic approach.

Current Data



Macroecological data

Challenges of macroecology

- Lack of identification of process.

Best practice recommendations

- Test with multiple taxonomic groups/ecosystems.

Plenty of data in the literature.

The Rules of Ecoinformatics

Garbage in, garbage out.

- All data are good, not all data are appropriate.
- Fit the data to the question.

Building a database

Record decisions at all steps:

Metadata are important.

Abundance database

Inclusion criteria:

- Quantitative abundances (counts).
- Complete sampling.
- Raw data (not heavily processed).
- Observational.

Abundance database

Variables collected
Class
Family
Genus
Species (Specific epithet)
Abundance
Collection Year, starting
Collection Year, ending
Site Name
Biogeographic region
Site notes
Citation

Table : List of variables collected.

Data wrangling

– Fire and a Tallgrass Prairie Reptile Community: Effects on Relative Abundance and Seasonal Activity

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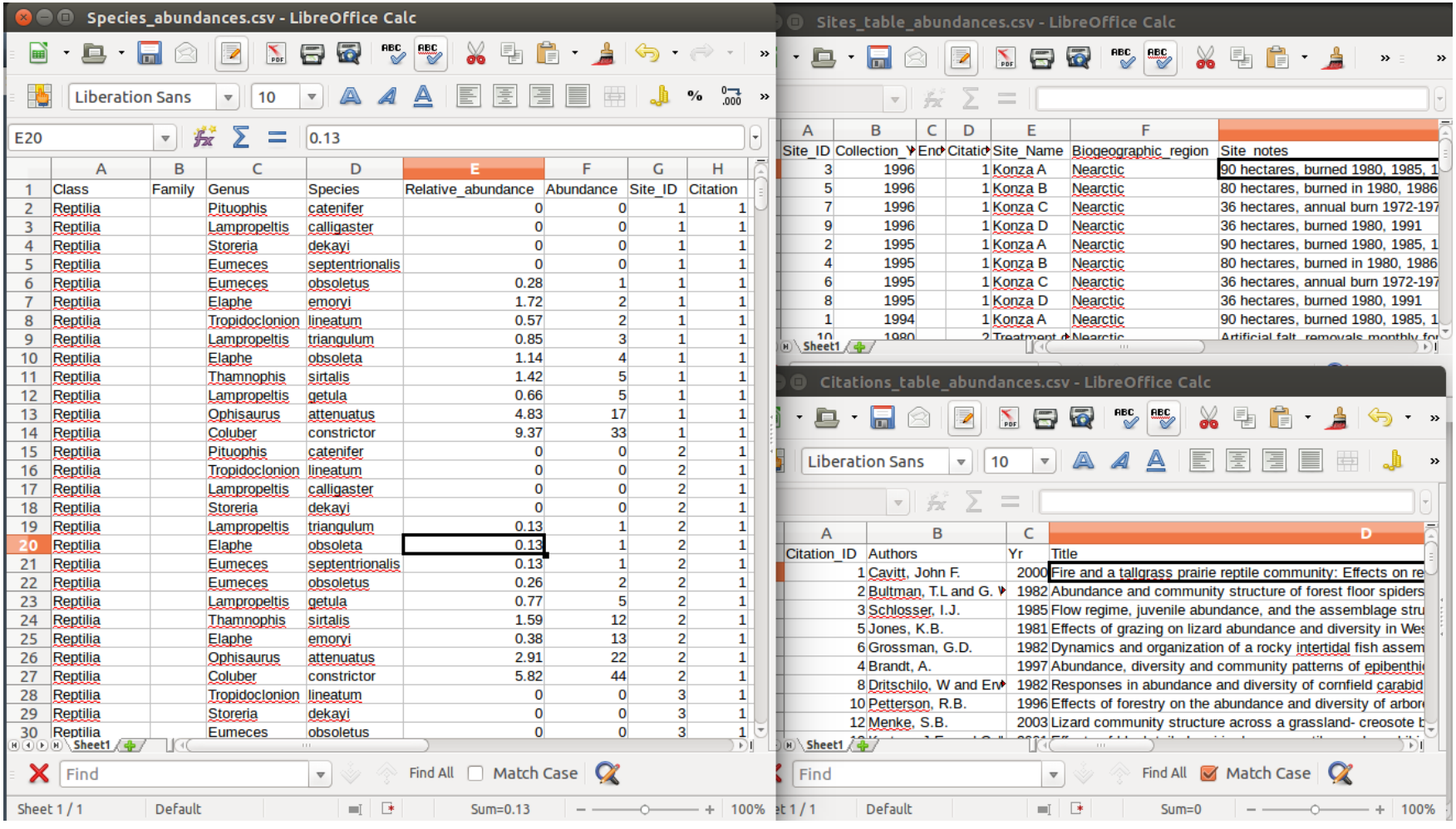
TABLE 1. Number of individuals and relative abundance (#/100 Trap array days) by year and site for the 10 species of snakes and three species of lizards captured (* indicates focal species).

Site	A			B		C		D		
	1994	1995	1996	1995	1996	1995	1996	1995	1996	
Number of Trap arrays	4	9	9	9	9	4	4	4	4	Total
Snakes										
**Coluber constrictor*	33	44	52	58	20	4	31	15	28	285
	9.37	5.82	6.64	7.67	2.55	1.82	7.75	7.81	7.00	
**Thamnophis sirtalis*	5	12	9	15	10	21	10	26	7	115
	1.42	1.59	1.15	1.98	1.28	9.55	2.50	13.54	1.75	
Elaphe emoryi	2	13	3	3	7	5	3	8	4	48
	0.57	1.72	0.38	0.40	0.89	2.27	0.75	4.17	1.0	
Lampropeltis getula	5	5	6	7	7	1	1	1	5	38
	1.42	0.66	0.77	0.93	0.89	0.45	0.25	0.52	1.25	
Lampropeltis triangulum	3	1	3	7	4	—	1	3	4	26
	0.85	0.13	0.38	0.93	0.51	—	0.25	1.56	1.0	
Pituophis catenifer	—	—	2	3	—	2	2	5	12	26
	—	—	0.26	0.40	—	0.91	0.5	2.60	3.0	
Elaphe obsoleta	4	1	1	—	2	—	—	—	—	8
	1.14	0.13	0.13	—	0.26	—	—	—	—	
Tropidoclonion lineatum	2	—	—	—	—	—	—	—	—	2
	0.57	—	—	—	—	—	—	—	—	
Lampropeltis calligaster	—	—	1	—	—	—	—	—	—	1
	—	—	0.13	—	—	—	—	—	—	
Storeria dekayi	—	—	—	—	—	—	—	1	—	1
								0.52		
Lizards										
**Ophisaurus attenuatus*	17	22	10	30	10	2	—	—	—	91
	4.83	2.91	1.28	3.97	1.28	0.91	—	—	—	
Eumeces obsoletus	1	2	—	6	1	—	1	—	—	11
	0.28	0.26	—	0.79	0.13	—	0.25	—	—	
Eumeces septentrionalis	—	1	—	5	—	—	—	—	—	6
	—	0.13	—	0.66	—	—	—	—	—	

Data wrangling

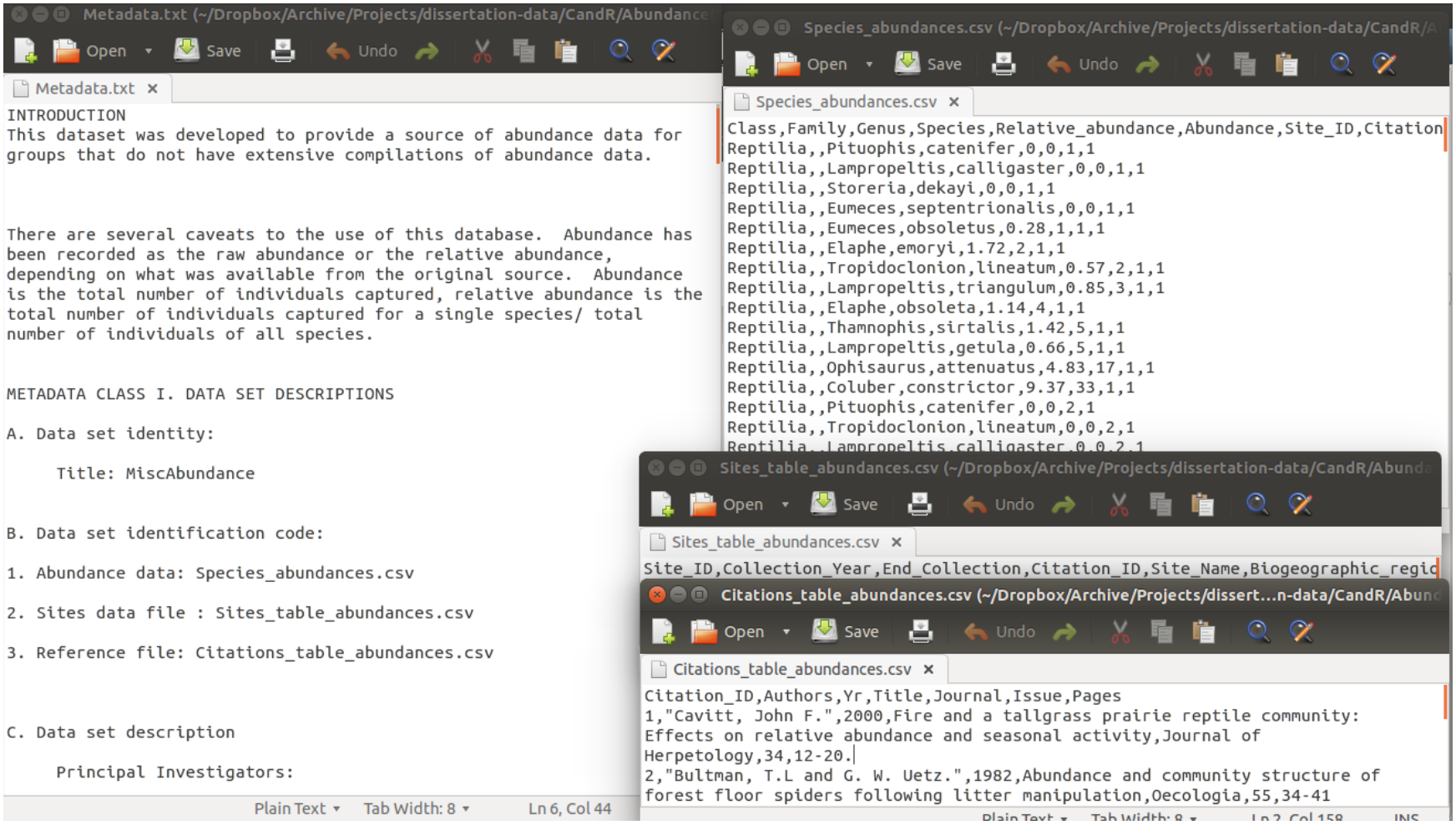


	A	B	C	D	E	F	G	H
1	Class	Family	Genus	Species	Relative_abundance	Abundance	Site_ID	Citation
2	Reptilia		Pituophis	catenifer	0	0	1	1
3	Reptilia		Lampropeltis	calligaster	0	0	1	1
4	Reptilia		Storeria	dekayi	0	0	1	1
5	Reptilia		Eumeces	septentrionalis	0	0	1	1
6	Reptilia		Eumeces	obsoletus	0.28	1	1	1
7	Reptilia		Elaphe	emoryi	1.72	2	1	1
8	Reptilia		Tropidoclonion	lineatum	0.57	2	1	1
9	Reptilia		Lampropeltis	triangulum	0.85	3	1	1
10	Reptilia		Elaphe	obsoleta	1.14	4	1	1
11	Reptilia		Thamnophis	sirtalis	1.42	5	1	1
12	Reptilia		Lampropeltis	getula	0.66	5	1	1
13	Reptilia		Ophisaurus	attenuatus	4.83	17	1	1
14	Reptilia		Coluber	constrictor	9.37	33	1	1
15	Reptilia		Pituophis	catenifer	0	0	2	1
16	Reptilia		Tropidoclonion	lineatum	0	0	2	1
17	Reptilia		Lampropeltis	calligaster	0	0	2	1
18	Reptilia		Storeria	dekayi	0	0	2	1
19	Reptilia		Lampropeltis	triangulum	0.13	1	2	1
20	Reptilia		Elaphe	obsoleta	0.13	1	2	1
21	Reptilia		Eumeces	septentrionalis	0.13	1	2	1
22	Reptilia		Eumeces	obsoletus	0.26	2	2	1
23	Reptilia		Lampropeltis	getula	0.77	5	2	1
24	Reptilia		Thamnophis	sirtalis	1.59	12	2	1
25	Reptilia		Elaphe	emoryi	0.38	13	2	1
26	Reptilia		Ophisaurus	attenuatus	2.91	22	2	1
27	Reptilia		Coluber	constrictor	5.82	44	2	1
28	Reptilia		Tropidoclonion	lineatum	0	0	3	1
29	Reptilia		Storeria	dekayi	0	0	3	1
30	Reptilia		Eumeces	obsoletus	0	0	3	1

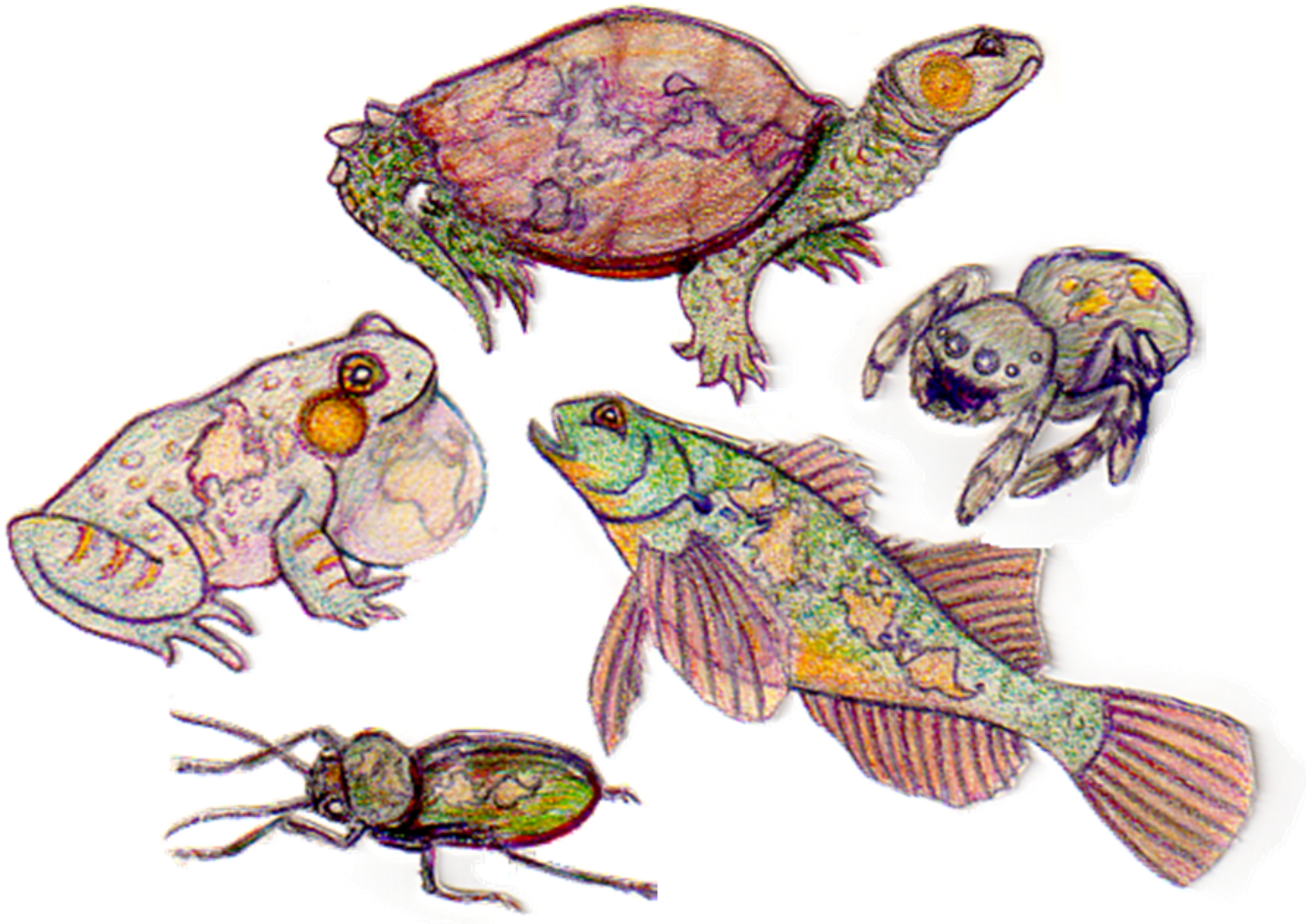
	A	B	C	D	E	F
1	Site_ID	Collection_Y	End	Citatio	Site_Name	Biogeographic_region	Site_notes
2	3	1996		1	Konza A	Nearctic	90 hectares, burned 1980, 1985, 1
3	5	1996		1	Konza B	Nearctic	80 hectares, burned in 1980, 1986
4	7	1996		1	Konza C	Nearctic	36 hectares, annual burn 1972-197
5	9	1996		1	Konza D	Nearctic	36 hectares, burned 1980, 1991
6	2	1995		1	Konza A	Nearctic	90 hectares, burned 1980, 1985, 1
7	4	1995		1	Konza B	Nearctic	80 hectares, burned in 1980, 1986
8	6	1995		1	Konza C	Nearctic	36 hectares, annual burn 1972-197
9	8	1995		1	Konza D	Nearctic	36 hectares, burned 1980, 1991
10	1	1994		1	Konza A	Nearctic	90 hectares, burned 1980, 1985, 1
11	10	1980		2	Treatment A	Nearctic	Artificial fall removals monthly for

	A	B	C	D
1	Citation_ID	Authors	Yr	Title
2	1	Cavitt, John F.	2000	Fire and a tallgrass prairie reptile community: Effects on re
3	2	Bultman, T.L and G. W	1982	Abundance and community structure of forest floor spiders
4	3	Schlosser, I.J.	1985	Flow regime, juvenile abundance, and the assemblage stru
5	5	Jones, K.B.	1981	Effects of grazing on lizard abundance and diversity in Wes
6	6	Grossman, G.D.	1982	Dynamics and organization of a rocky intertidal fish assem
7	4	Brandt, A.	1997	Abundance, diversity and community patterns of epibenthic
8	8	Dritschilo, W and En	1982	Responses in abundance and diversity of cornfield carabid
9	10	Petterson, R.B.	1996	Effects of forestry on the abundance and diversity of arbor
10	12	Menke, S.B.	2003	Lizard community structure across a grassland- creosote b

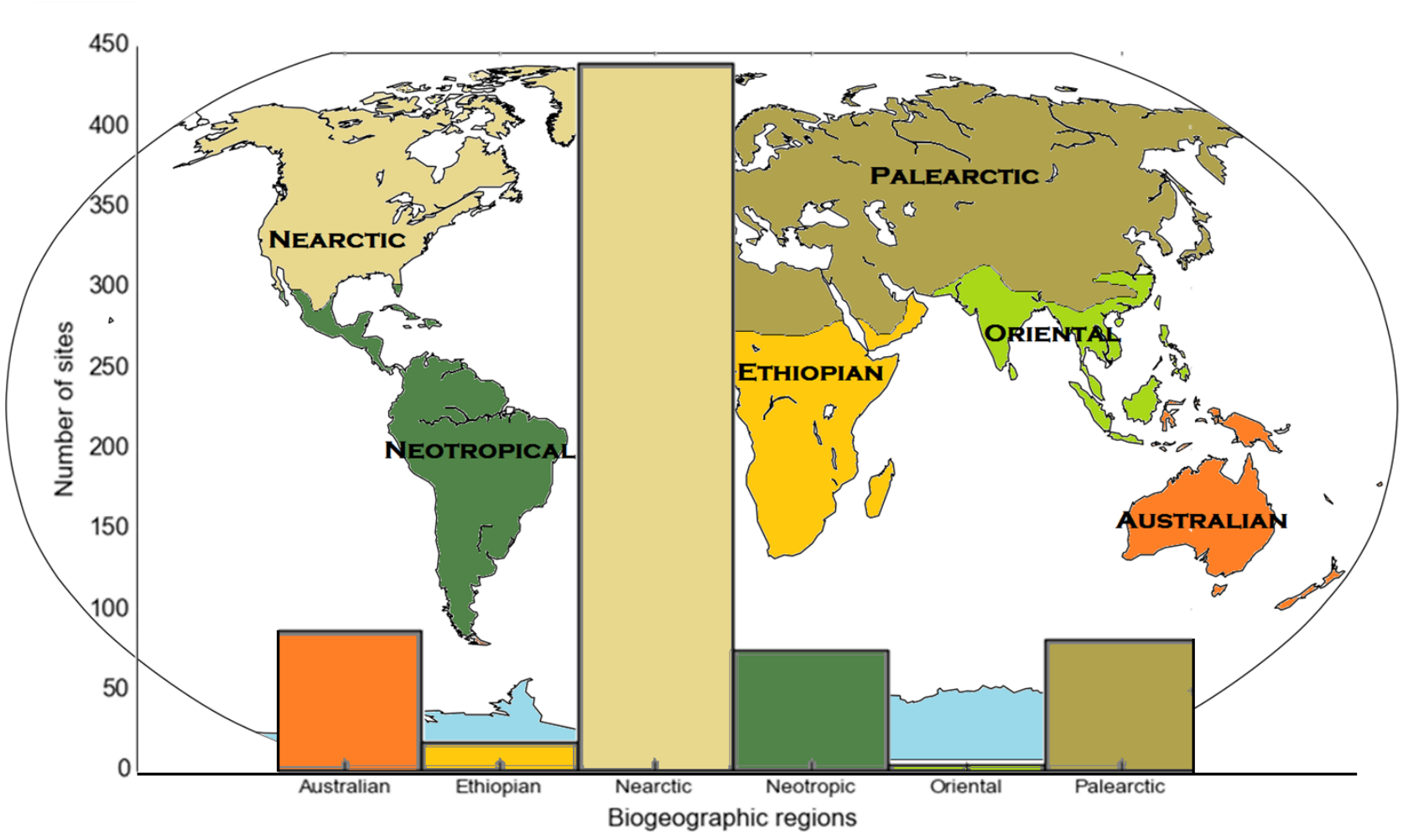
Data wrangling



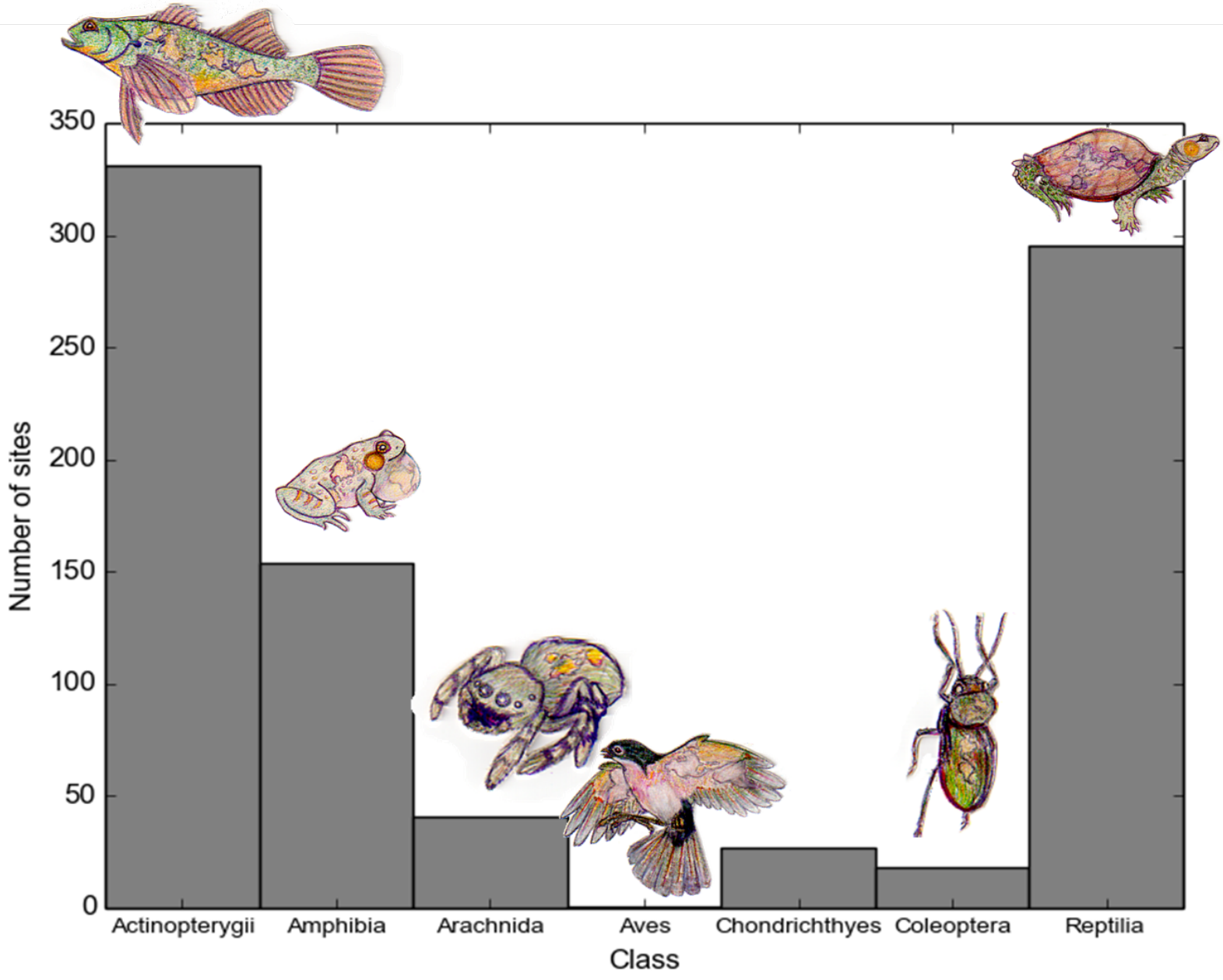
Abundance database



Abundance database



Abundance database



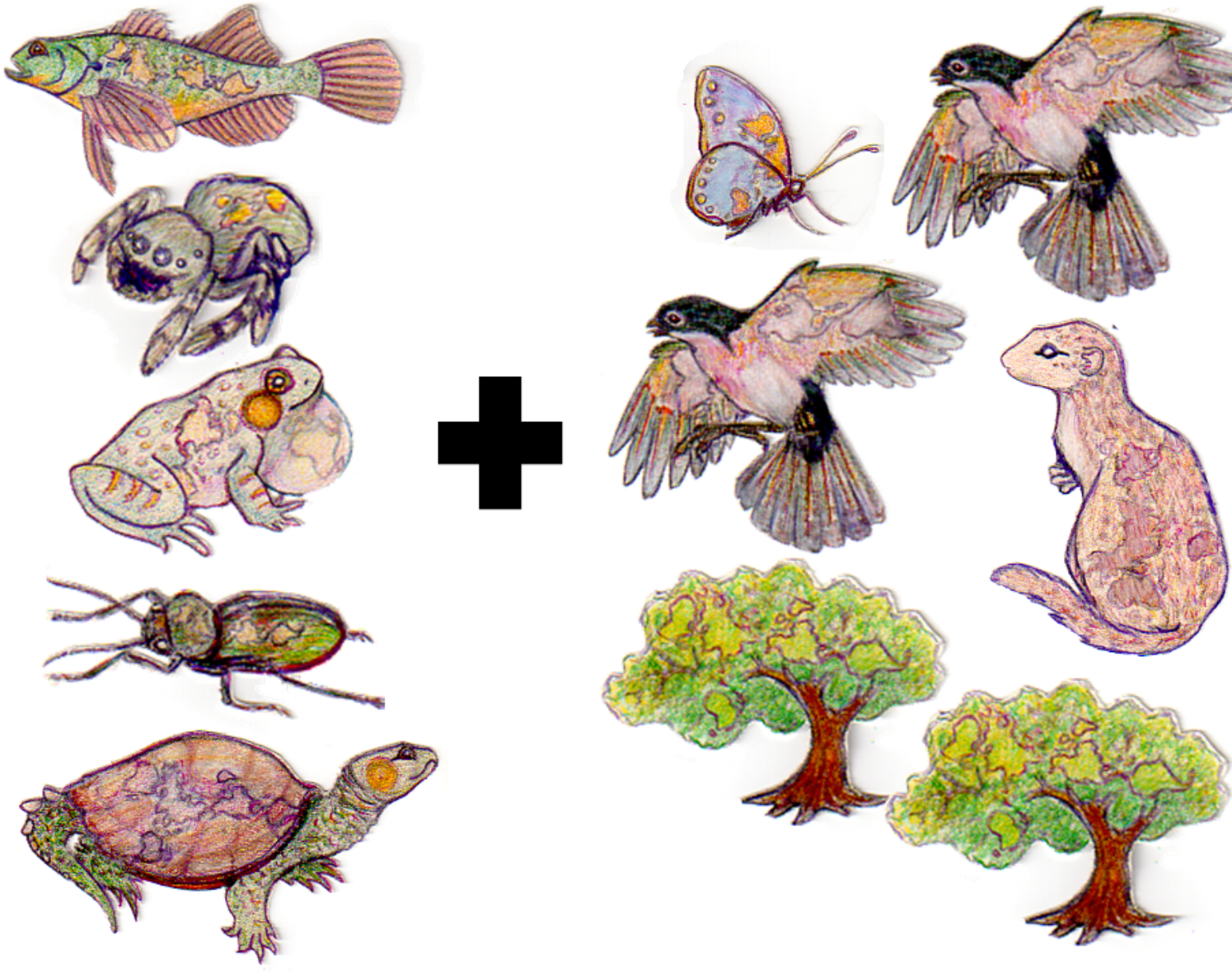
Data Availability

Public & open access through figshare.
EcoData Retriever importable.

```
(http://figshare.com)
(http://www.ecodataretriever.org)
sad_data =
ecoretriever::fetch('MiscAbundanceDB')
```

Data

Data



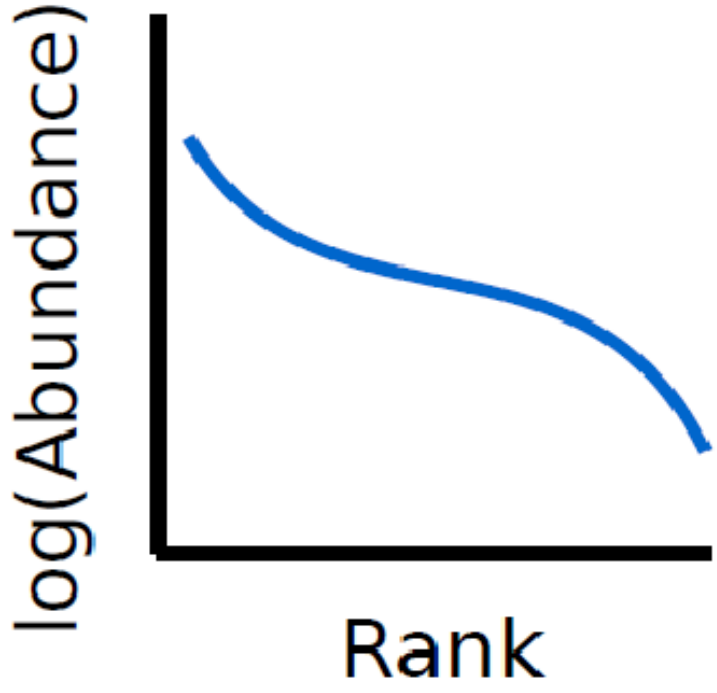
SAD Comparisons

Dataset	Dataset code	Availability	Sites
Gentry's Forest Transects	Gentry	Public	10355
Breeding Bird Survey	BBS	Public	2769
Christmas Bird Count	CBC	Private	1999
Forest Inventory Analysis	FIA	Public	220
N. American Butterfly Count	NABA	Private	400
Actinopterygii, compiled	Actinopterygii	Public	161
Reptilia, compiled	Reptilia	Public	138
Mammal Community Database	MCDB	Public	103
Amphibia, compiled	Amphibia	Public	43
Arachnida, compiled	Arachnida	Public	25
Coleoptera, compiled	Coleoptera	Public	5

Table : Datasets used for species-abundance distribution comparisons. Datasets marked as Private obtained through data requests to the providers with Memorandums of Understanding.

Commonness & rarity

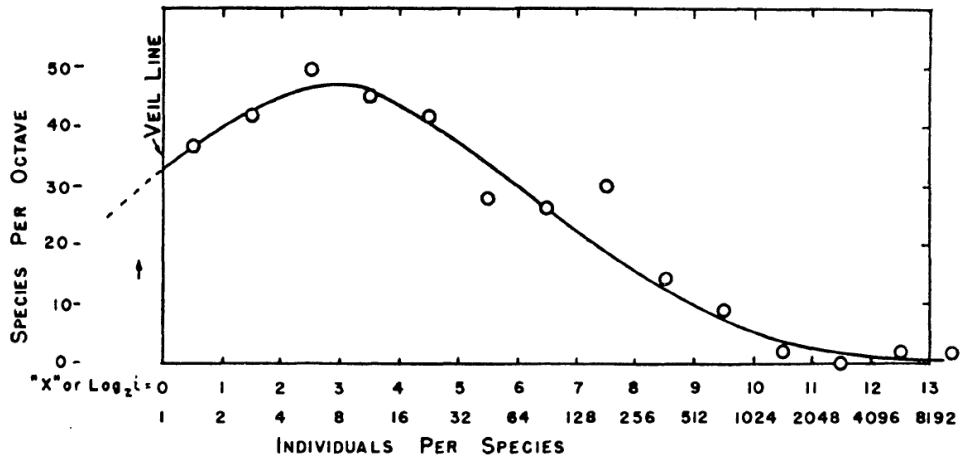
The species abundance distribution:



Many models of the species abundance distribution (SAD).

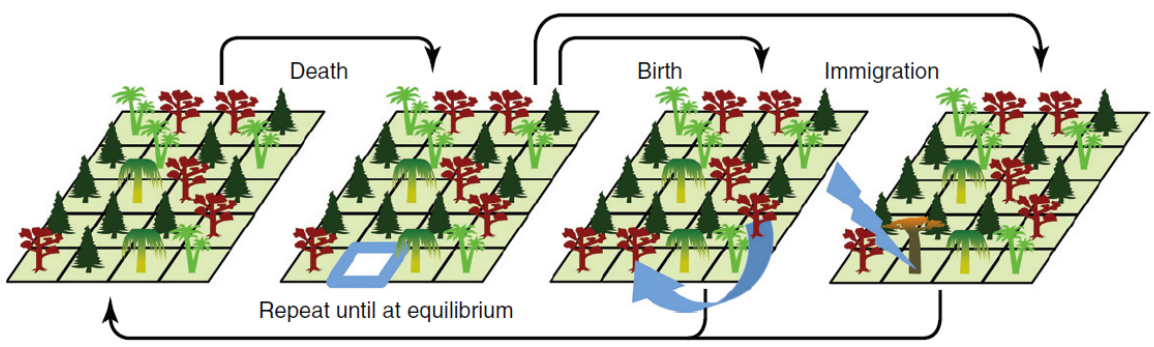
SAD models

Statistical description



Preston 1962a.

Process-based



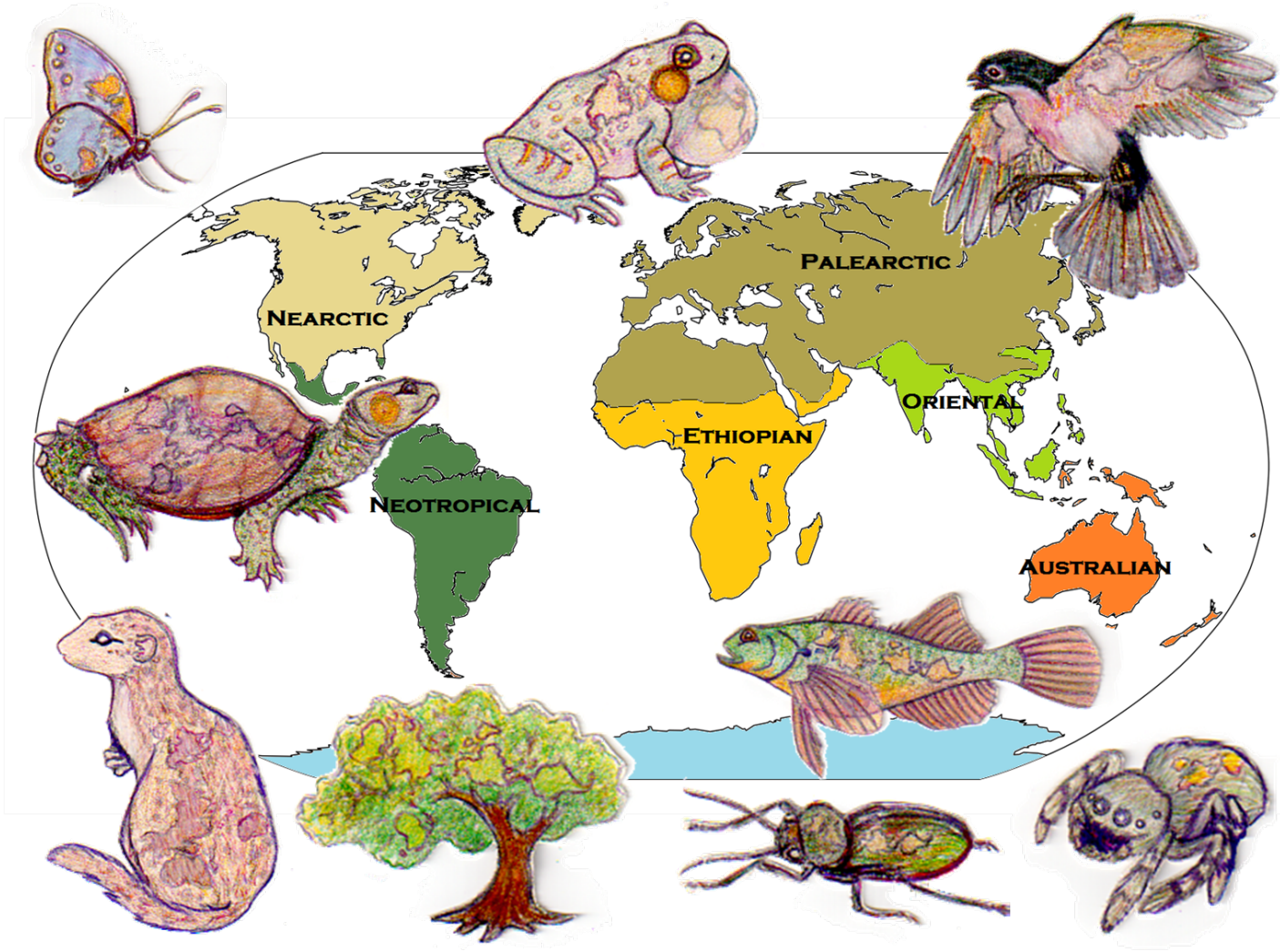
Rosindell et al. 2011.

SAD comparisons: The statistical approach.

Most comparisons of the different models:

- Use a small subset of available models (typically two).
- Focus on a single ecosystem or taxonomic group
- Fail to use most appropriate statistical methods.

SAD Comparisons



SAD Comparisons

Selected five models from four classes for comparison.

Model class	Form of the distribution
Purely statistical	Logseries, Poisson lognormal
Branching process	Zipf
Population dynamics	Negative binomial
Niche partitioning	Geometric

Table : After B.J. McGill et al. 2007.

SAD Comparisons

Analysis:

- Model fitting with maximum likelihood estimation.
    - For a given model, estimates model parameters that provide the most likely characterization of the data.
    - Best practice for fitting species abundance distributions. Matthews & Whittaker 2014.

SAD Comparisons

Analysis:

- Likelihood based model selection to compare the fits of the different models.
    - How well does the model describe the data?

SAD Comparisons

Analysis:

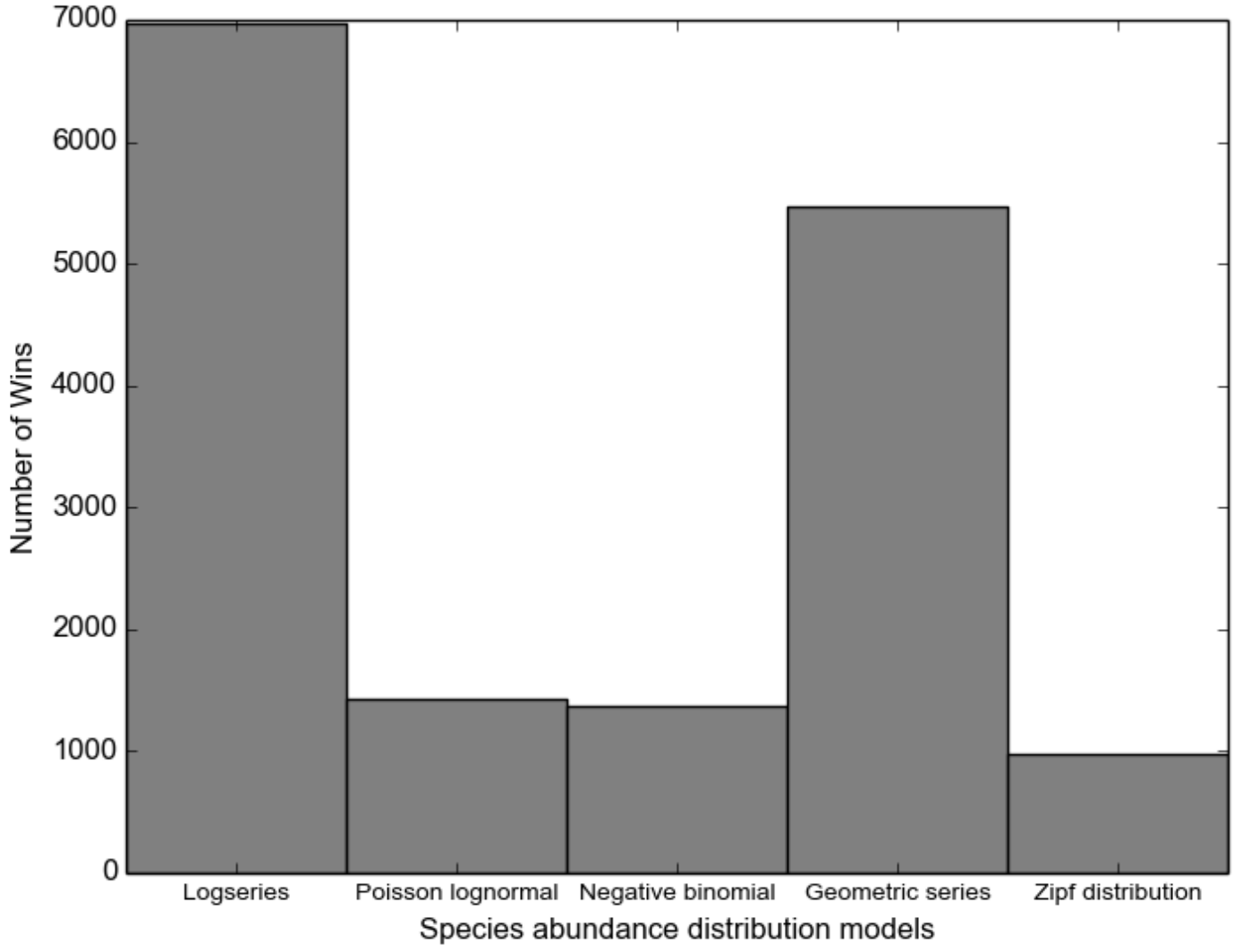
- Model comparison with corrected Aikaike Information Criterion (AICc) weights.
  - How well does the model describe the data relative to the number of parameters?
- The best fitting model had the greatest AICc weight.

SAD Comparisons

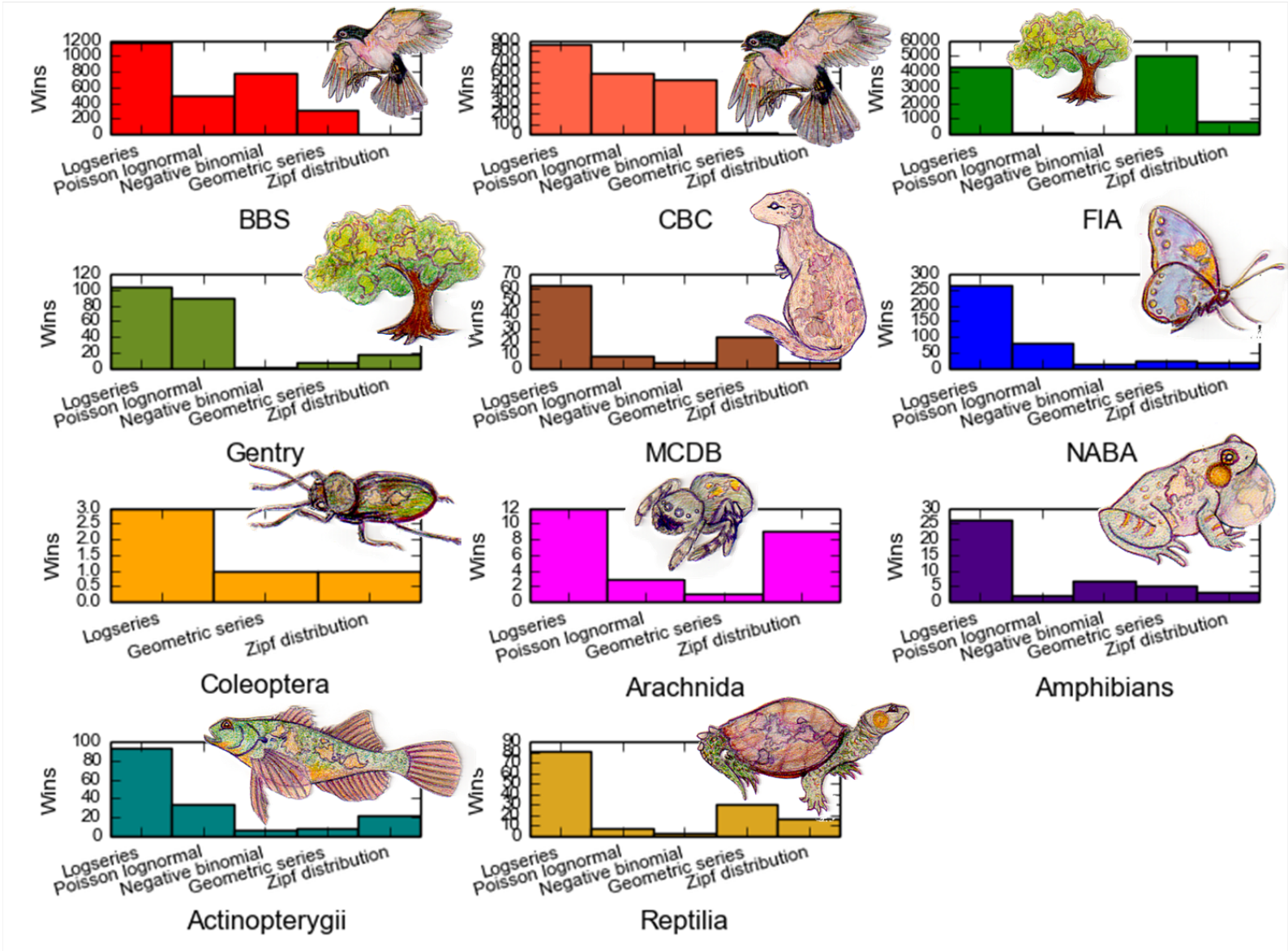
Computational tools:

- Model fitting, log-likelihood, & AICc: macroecotools Python package.
  (https://github.com/weecology/macroecotools)
- All code & majority of data are publicly available.
  (https://github.com/weecology/sad-comparison)

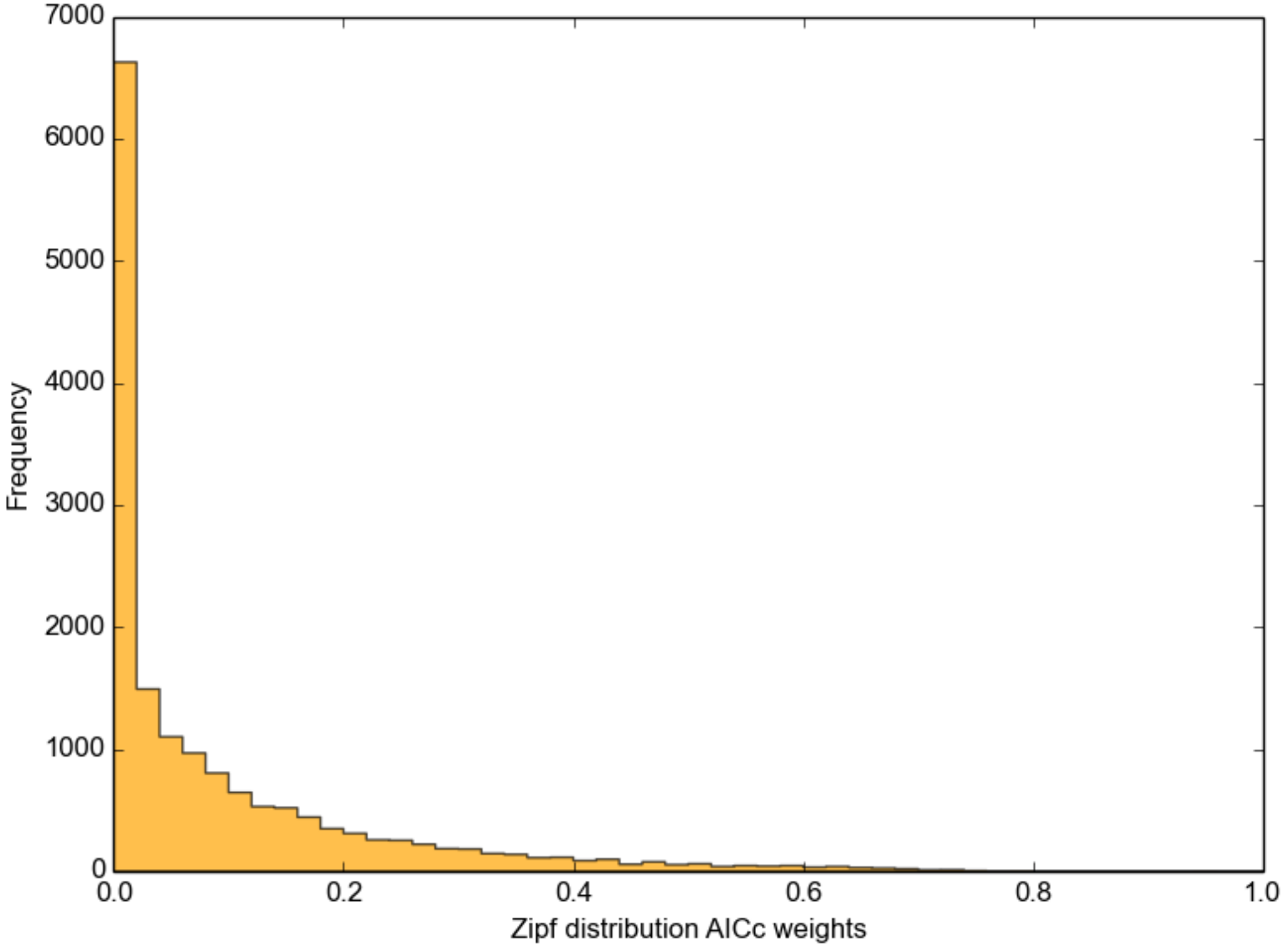
SAD Comparisons



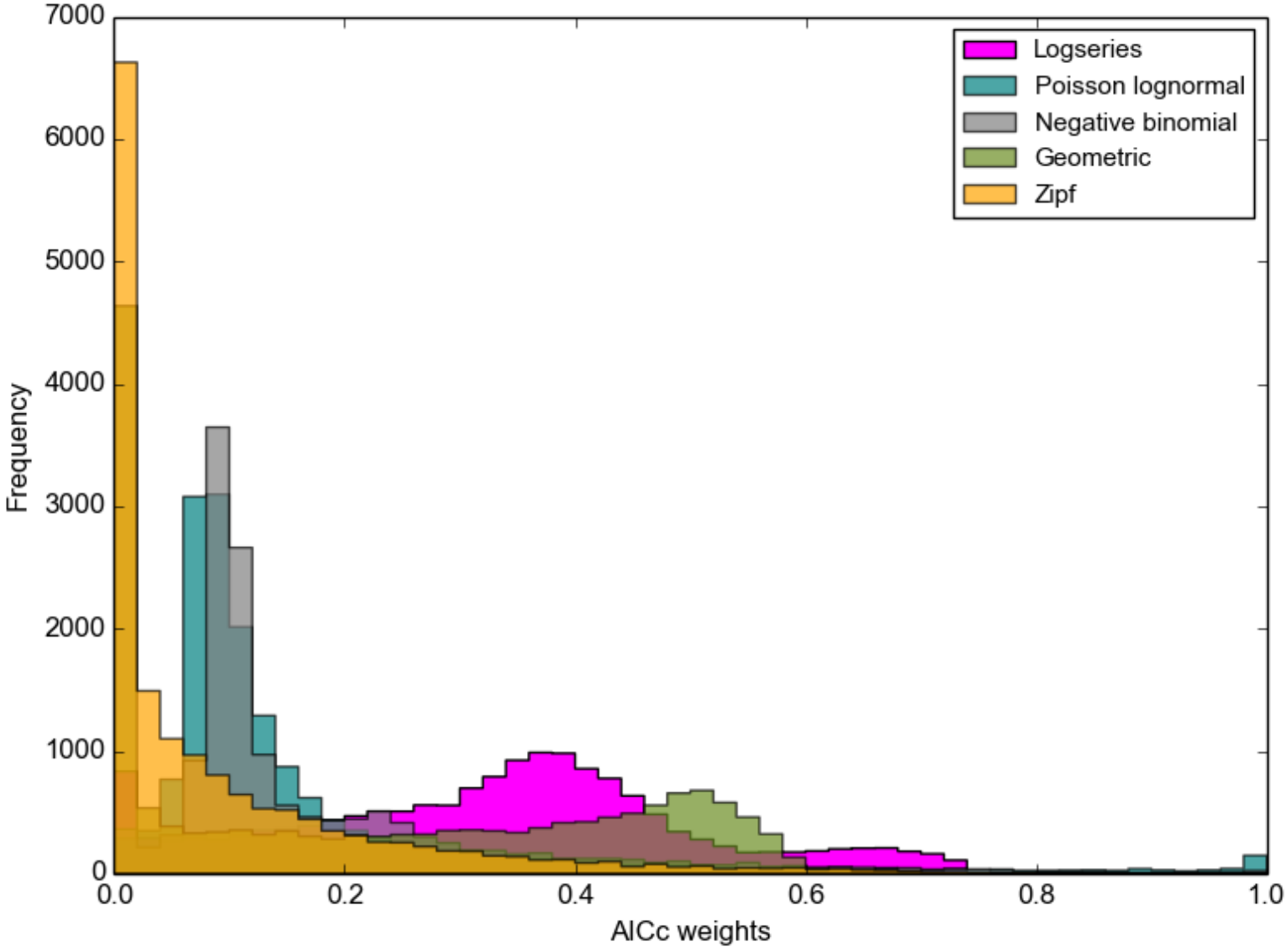
SAD Comparisons



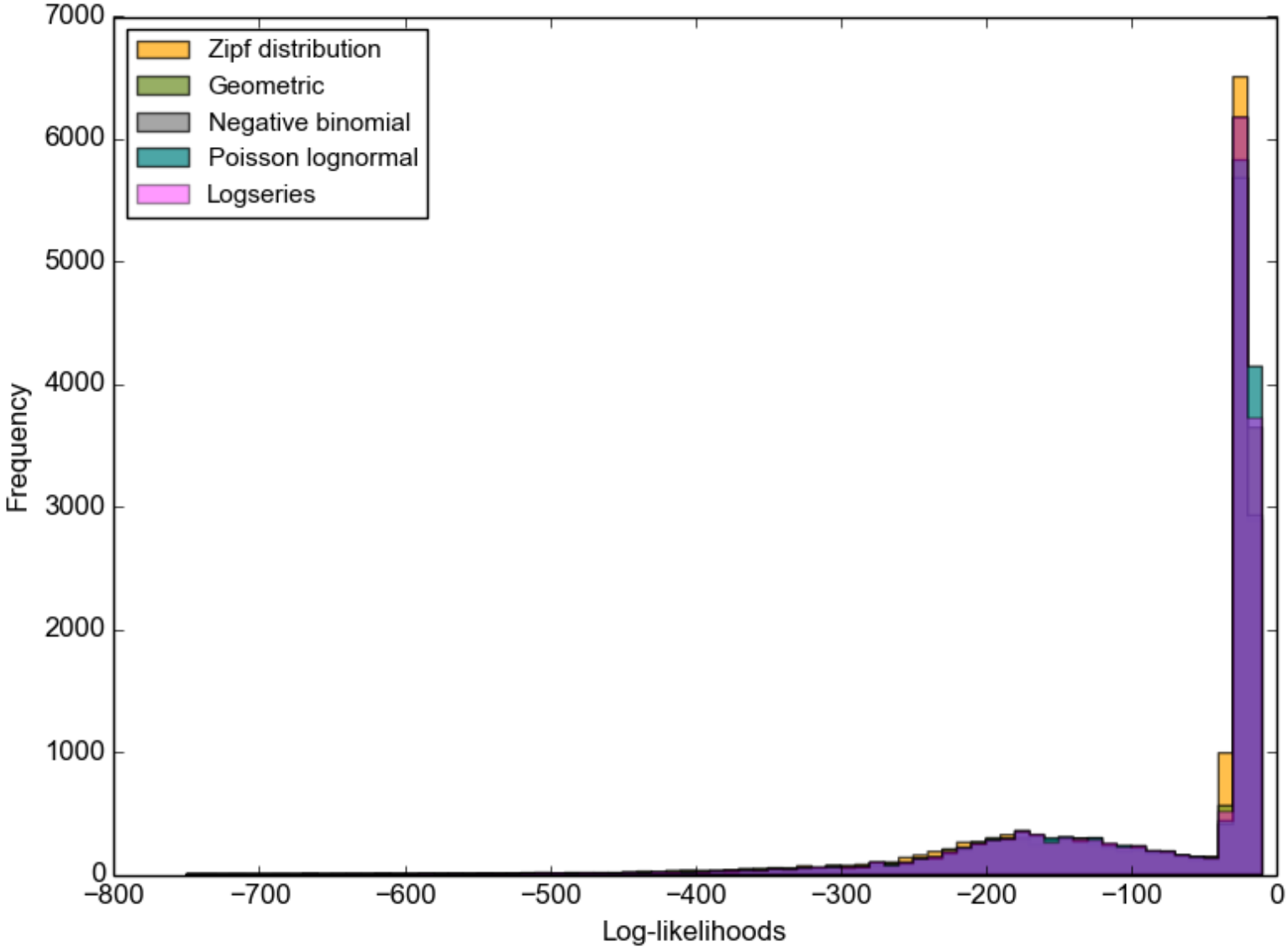
SAD Comparisons



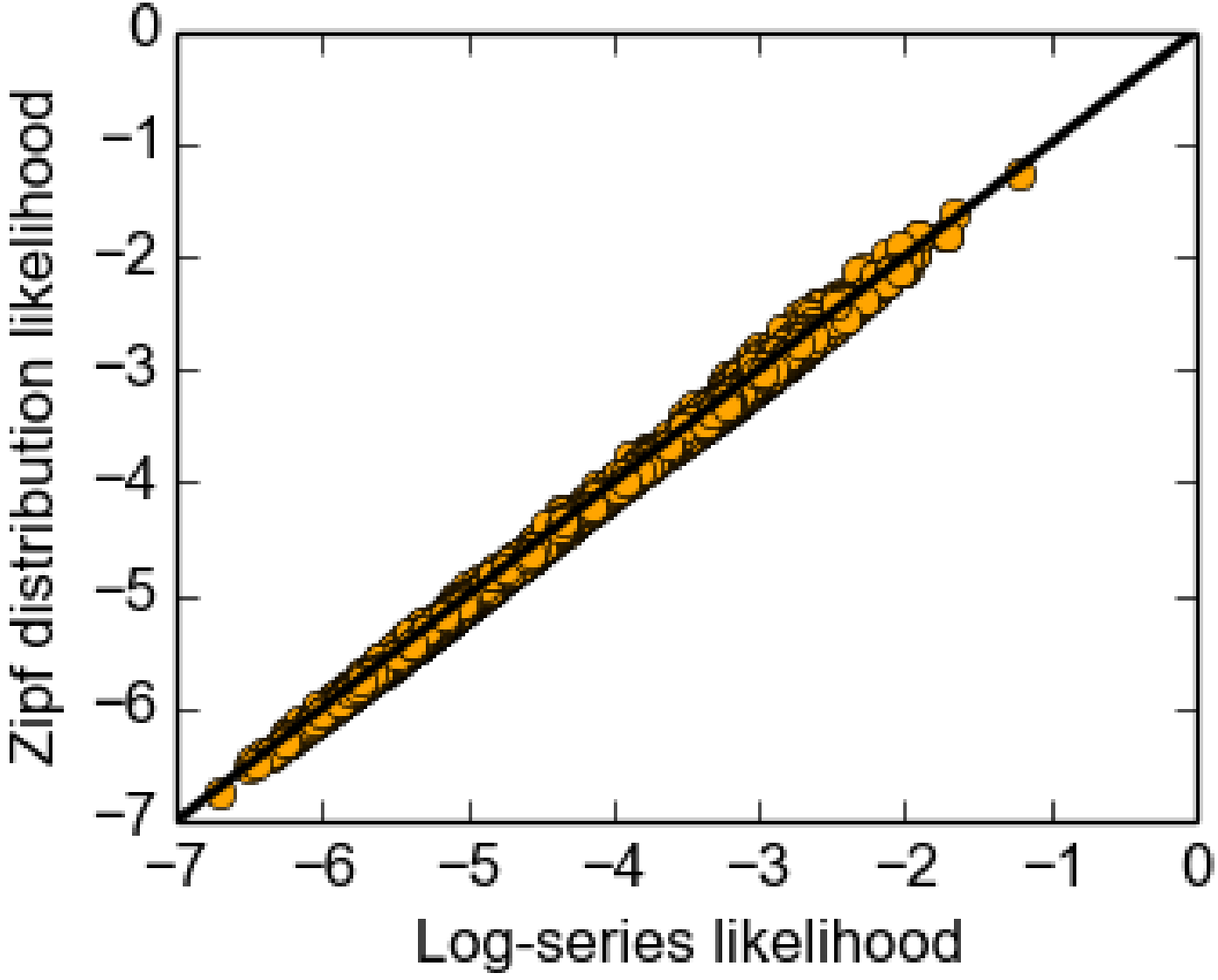
SAD Comparisons



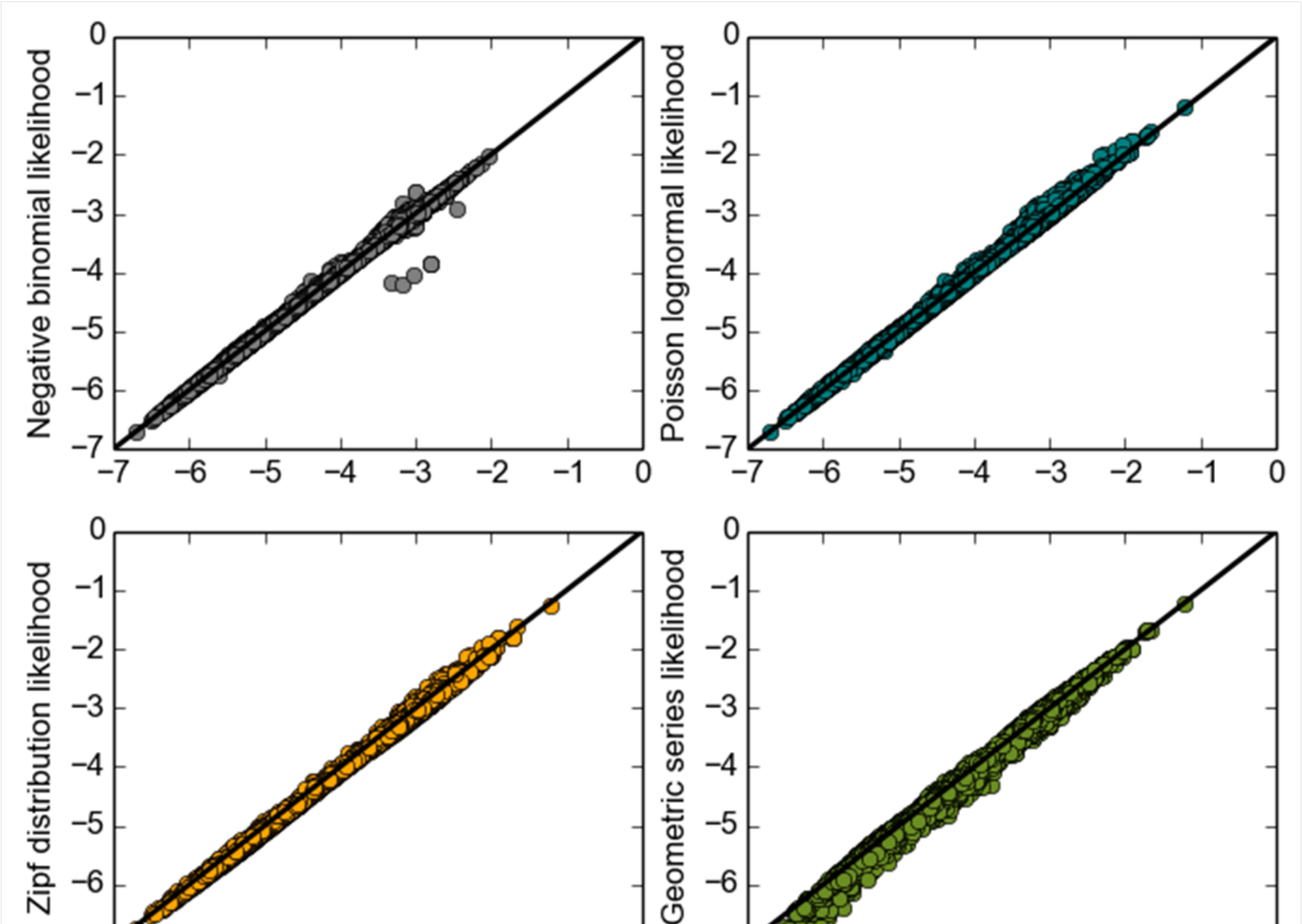
SAD Comparisons



SAD Comparisons



SAD Comparisons

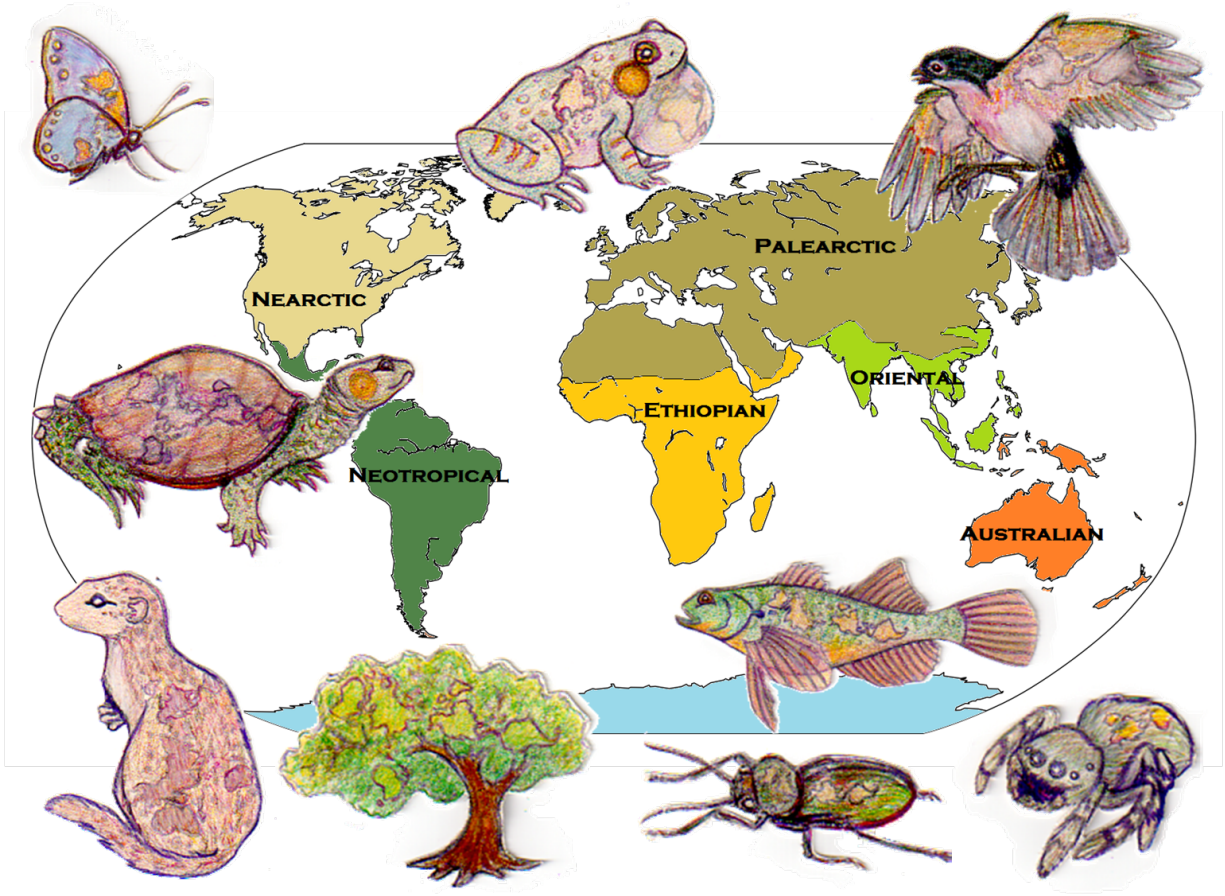


SAD Comparisons

Existing models provide equivalently good absolute fits to empirical data.

- Models with fewer parameters perform better in AIC-based model selection.
- Logseries provides a good naive model for fitting SADs.

Identifying process:

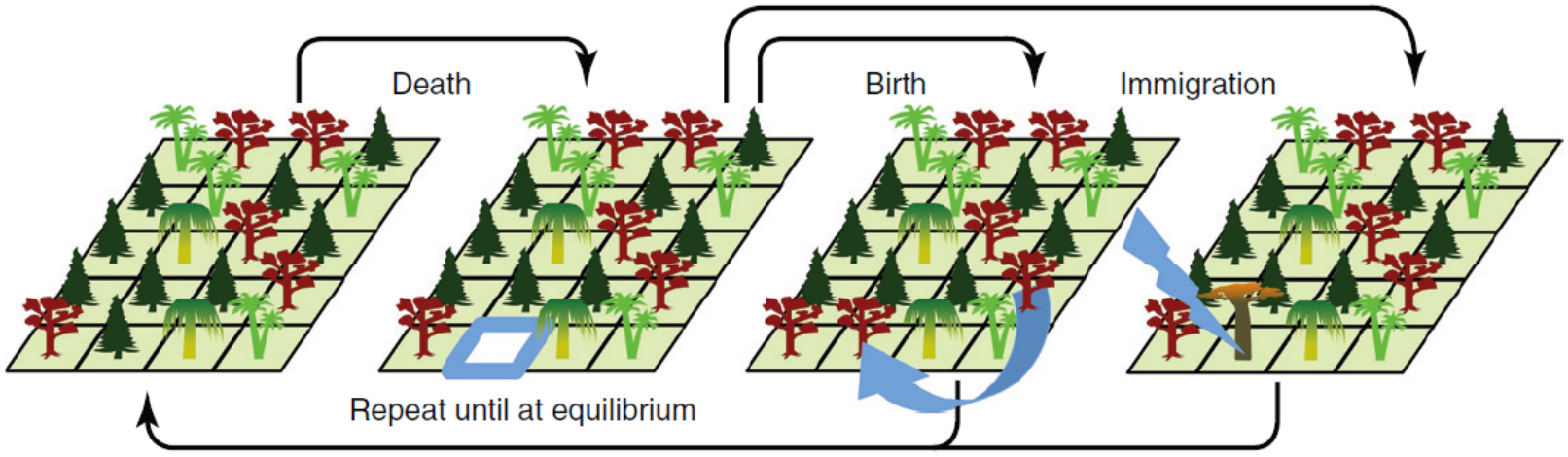


- Examine scale dependence of pattern.
- More general approach to process?

Neutral processes

Many formulations of neutral theory, but:

- Species & individuals ecologically & demographically equivalent.



Rosindell et al. 2011.

Non-neutral processes

Competition Niches Dispersal

Nutrients Etc.

Many specific mechanisms, but:

- Shape of the abundance distribution due to differences among species.

The mechanistic approach: Neutral analysis.

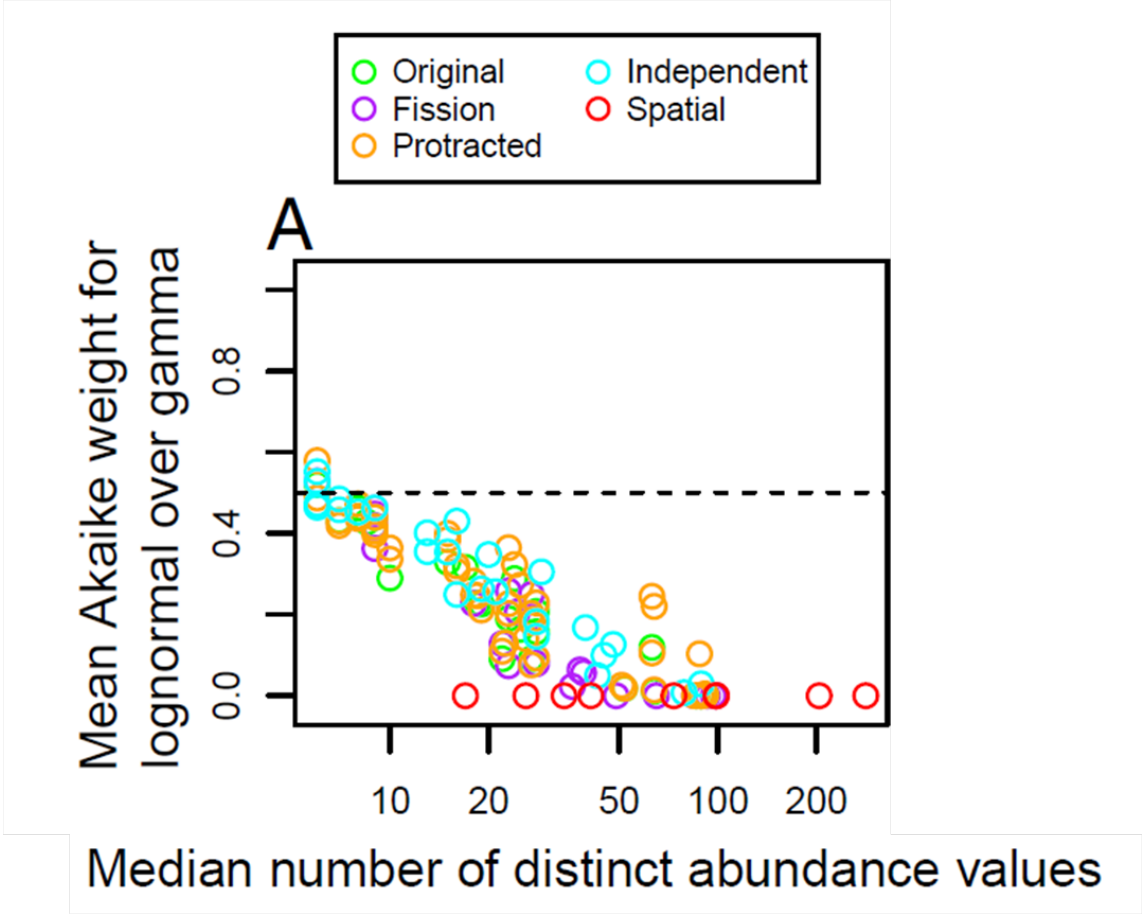
Early tests of neutral theory compared the fit of empirical species abundance distributions to the neutral prediction.

Later tests suggested species abundance comparisons were insufficient for a rigorous test of neutrality.

However...

Neutral Analysis

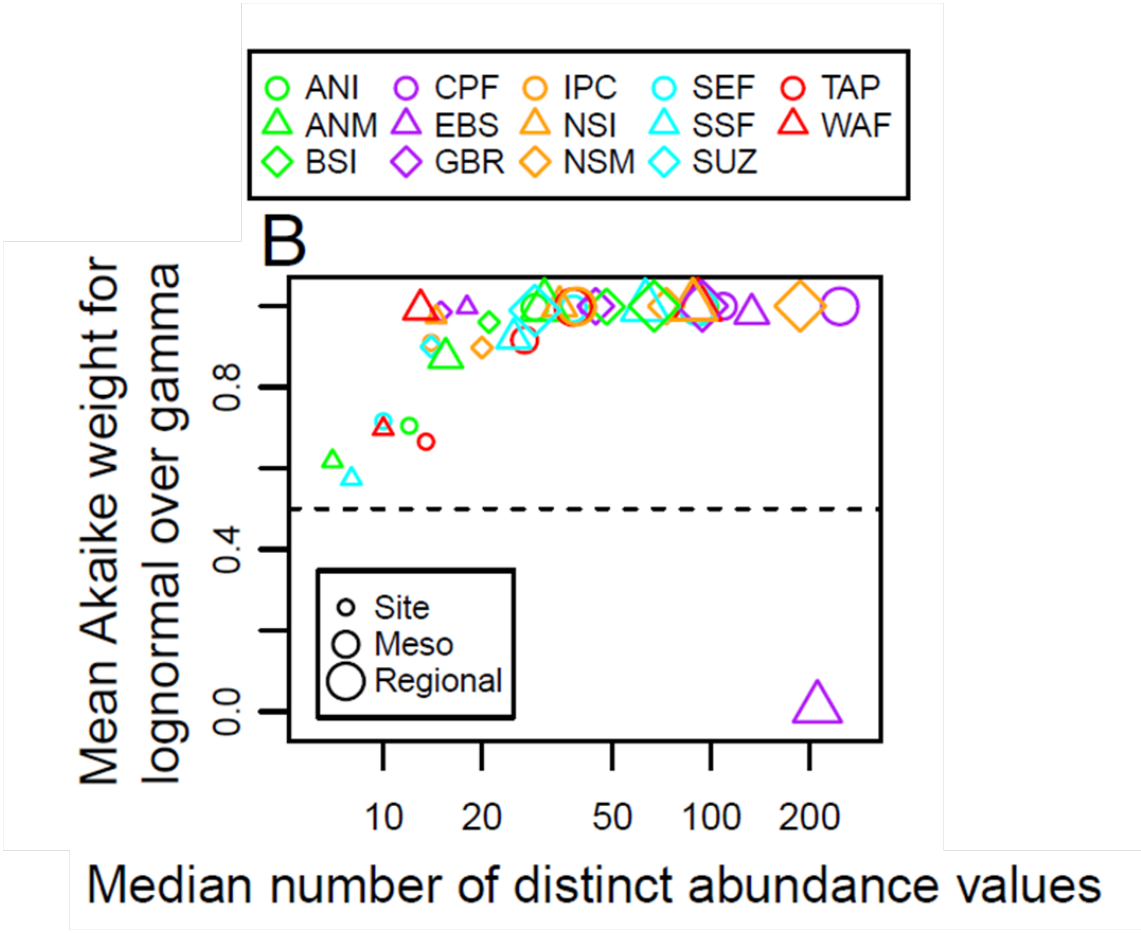
Connolly et al. 2014 simulated neutral communities.



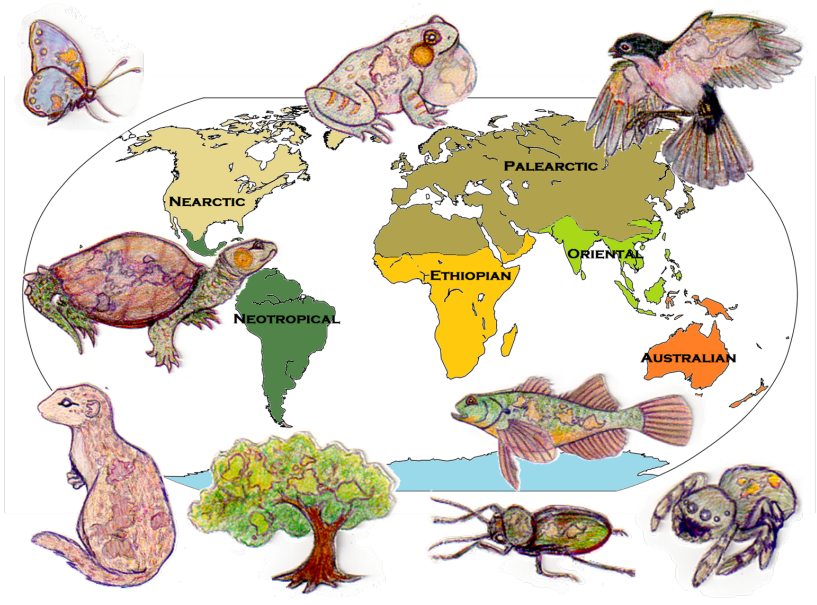
Identified a signal of neutrality.

Neutral Analysis

Connolly et al. 2014 identified non-neutral species abundance distributions in marine communities.



SAD Comparisons



Used the same data and model fitting approach.

Neutral Analysis

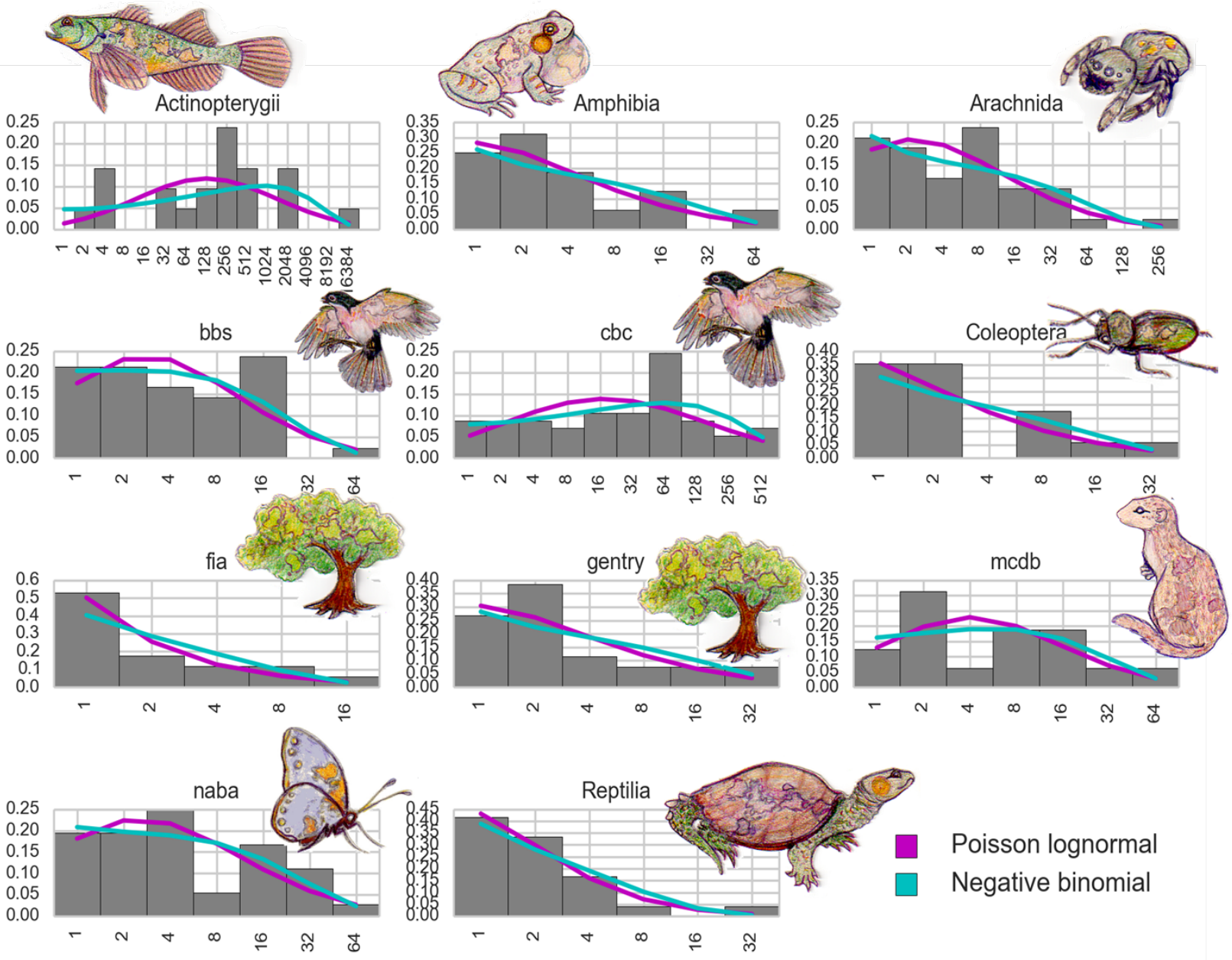
Non-neutral model (Poisson lognormal)

- Describes communities generated by non-neutral processes.

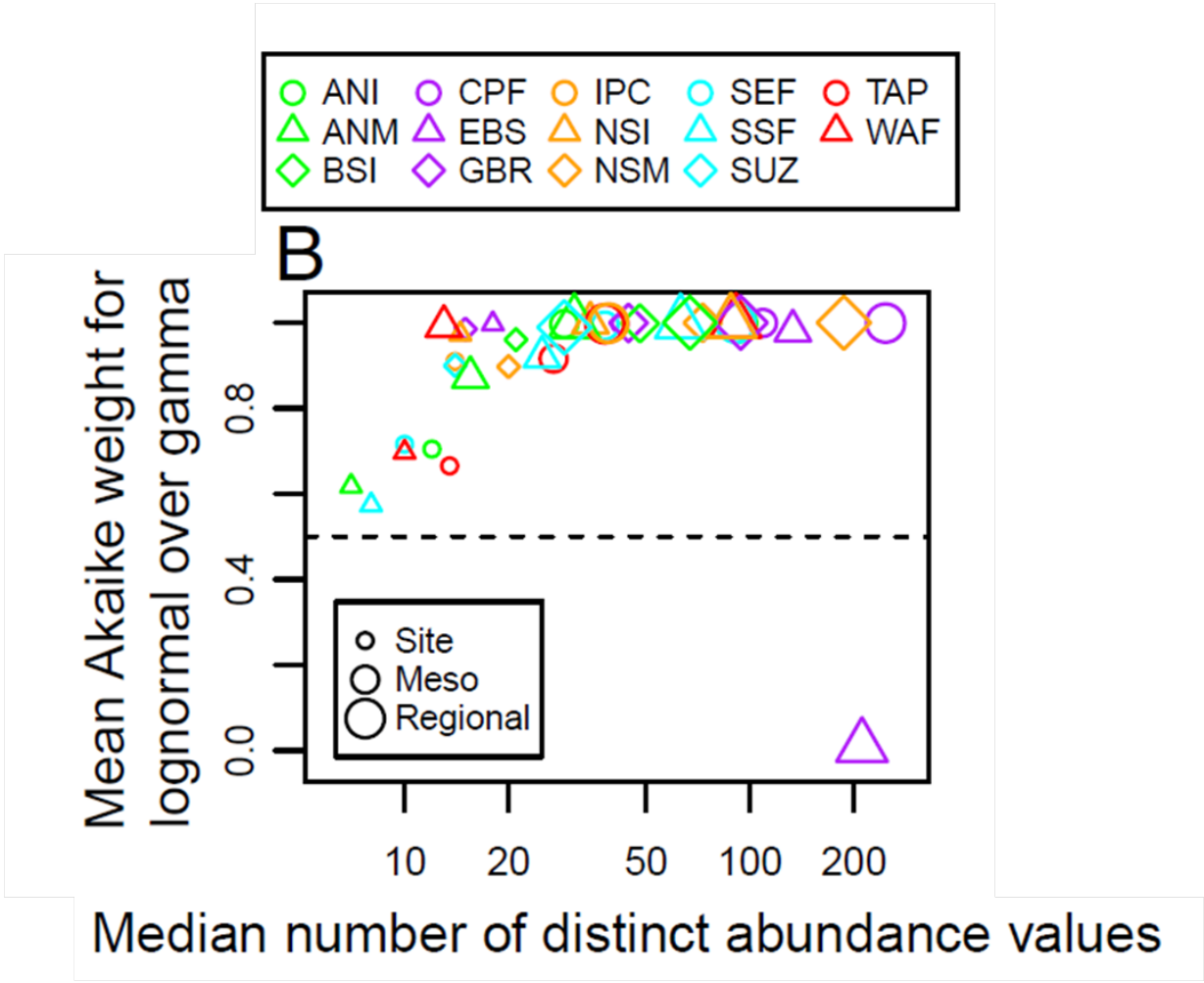
Neutral model (negative binomial).

- Describes communities generated by neutral processes.

Neutral Analysis

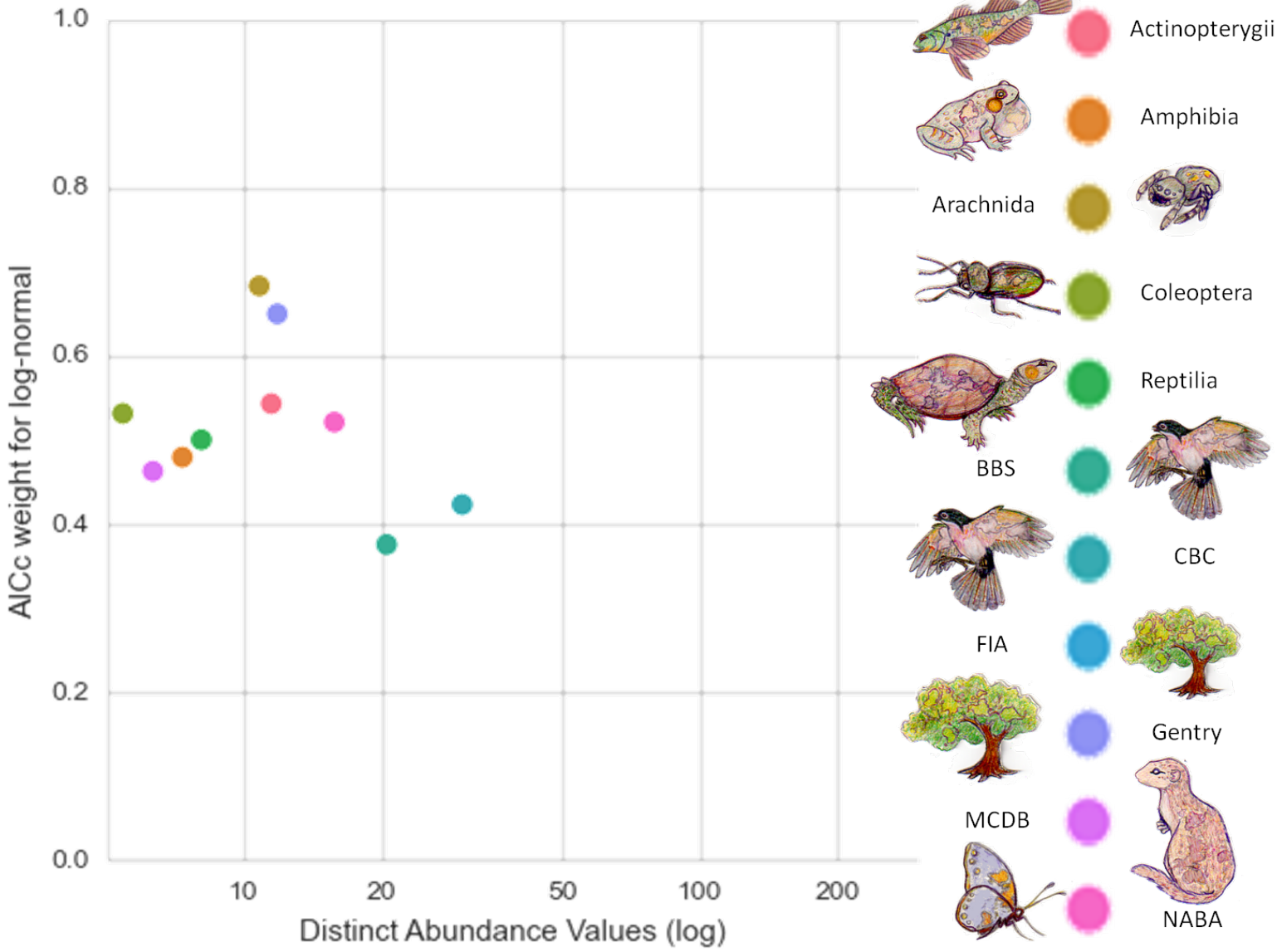


Neutral Analysis

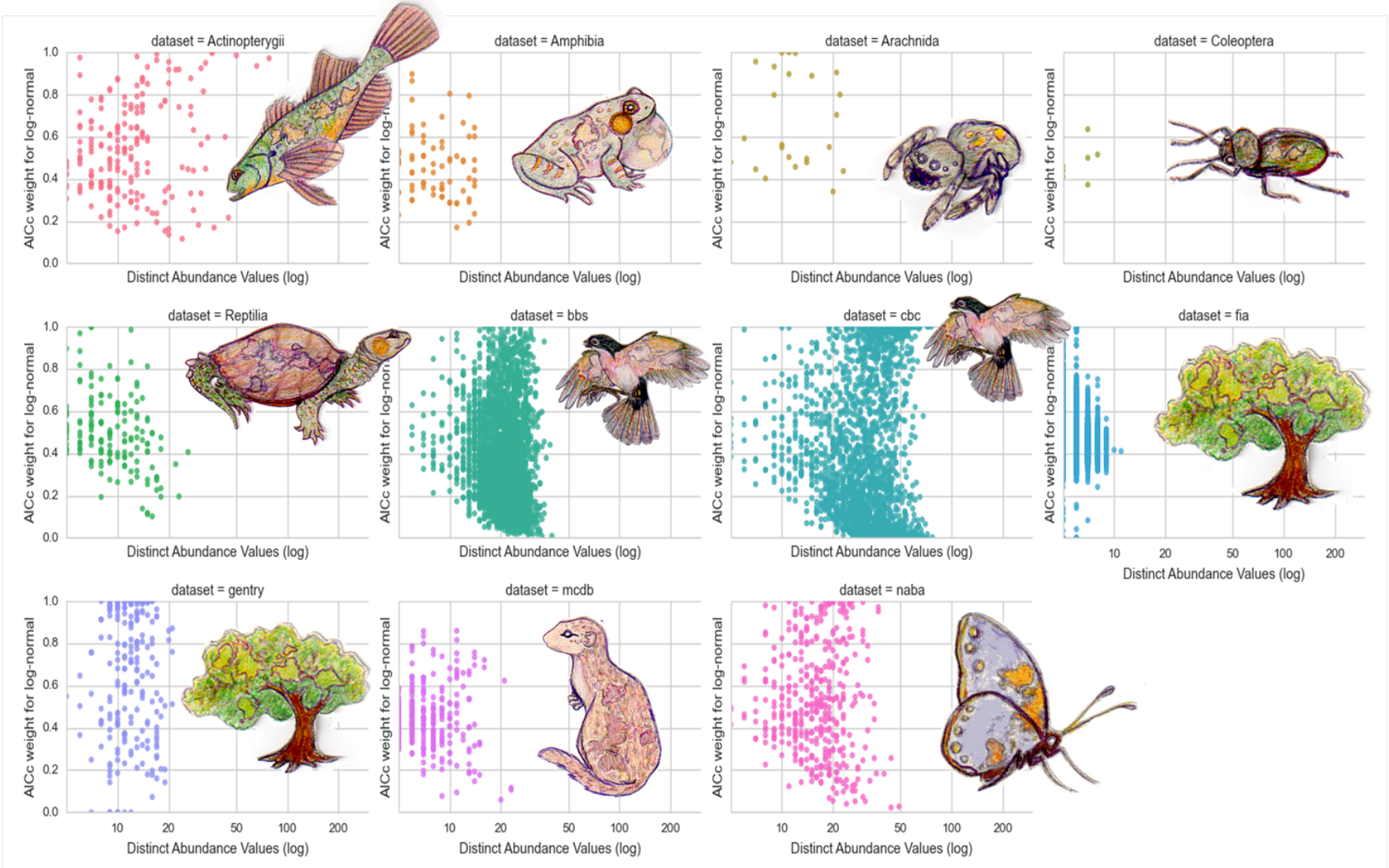


Connolly et al. 2014.

Neutral Analysis



Neutral Analysis



Neutral analysis

Difficult to identify a clear winning model.

- Demonstrates the importance of testing with multiple ecosystems.

A data-intensive approach

Challenging to infer process from species abundance distributions alone.

- Broad model categorization (i.e. neutral or non-neutral) may be more productive.
- May not be one single suite of processes that dominates.

A data-intensive approach

Challenges in identifying mechanism among datasets.

- Biological vs. non-biological differences (spatial structuring, sampling intensity).
- Diverse data removes uncertainty about non-biological pattern generating mechanisms.
- Even with a great deal of data, identifying mechanism is still challenging.

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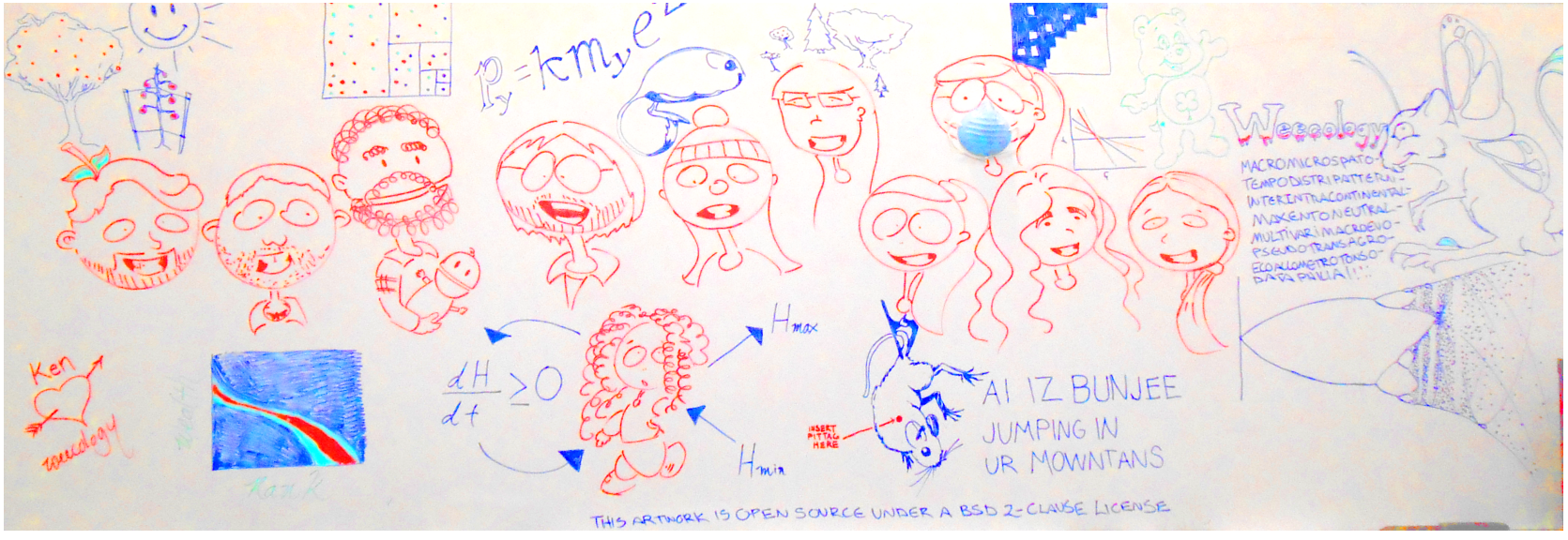
Weecologists past, present, & future



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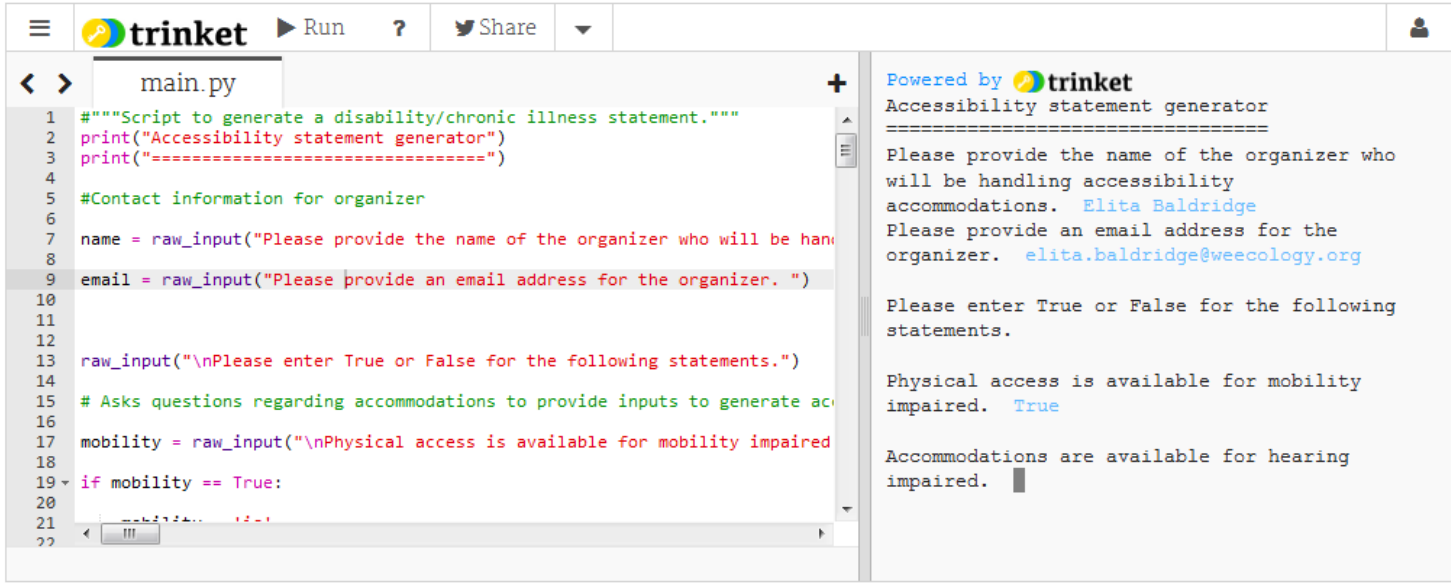
Disability accommodations

Tea, heating pads, & the Flint Hills of Kansas.

Accessibility statement generator



https://trinket.io/python/2df3ea45cf

Questions?

Abundance database