Measurement of Biodiversity (MoB): methodological details

Measurement of Biodiversity (MoB) Team

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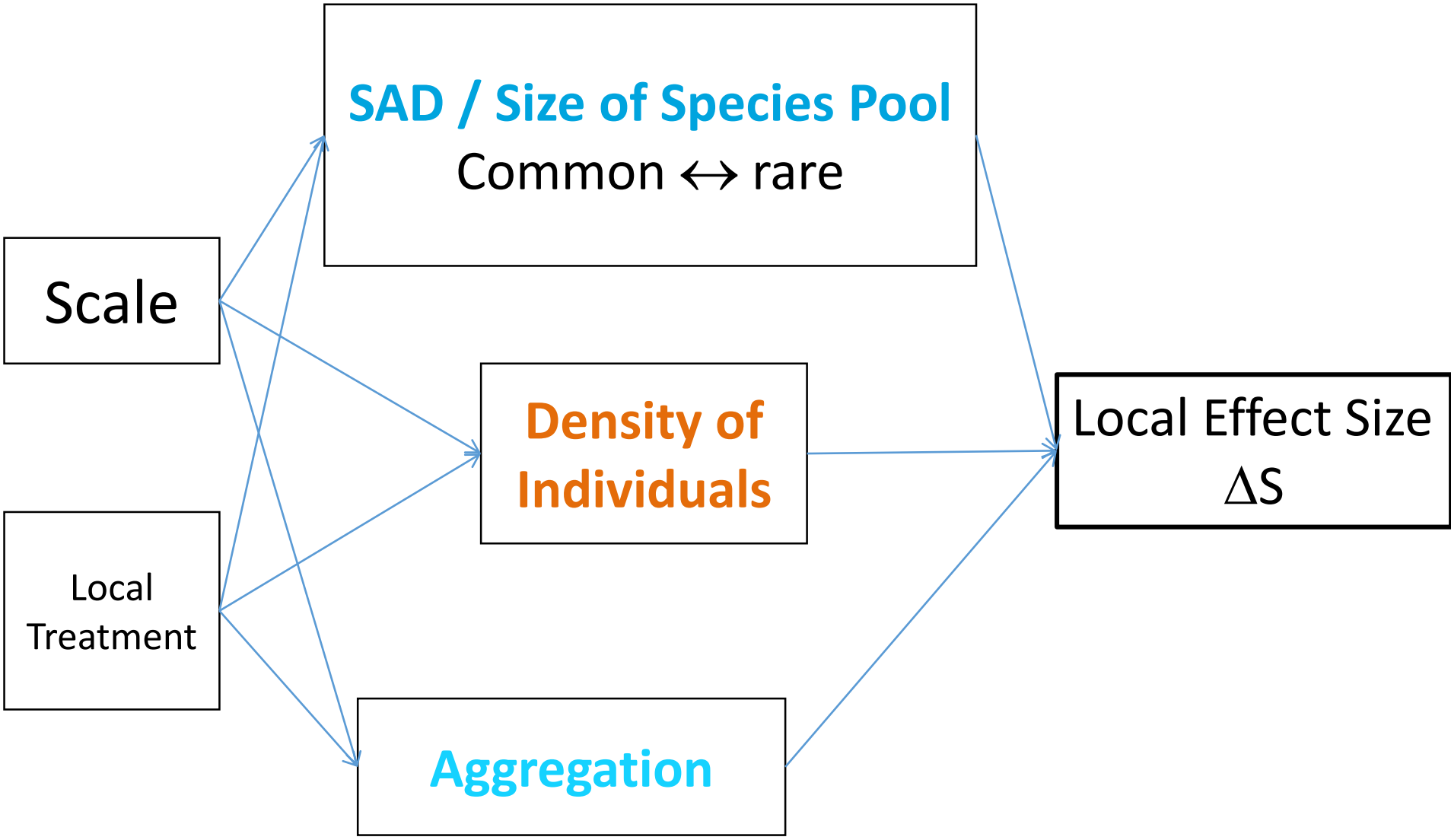
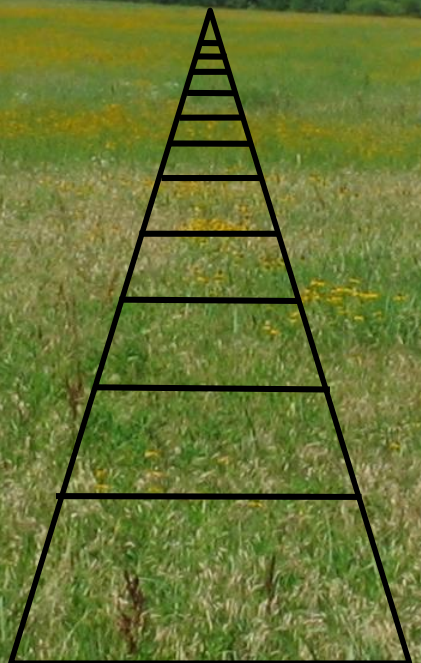
MoB Framework



Different ways to collect species

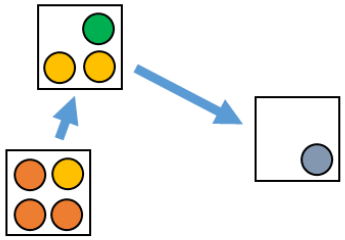
- Spatial sample-based rarefaction
- Non-spatial sample-based rarefaction
- Individual-based rarefaction

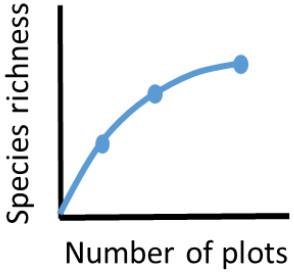
Provide unique information on community structure



Spatial, plot-based accumulation

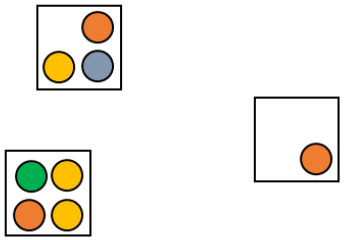
Sample nearest neighbors

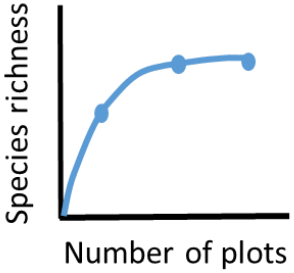




Non-spatial, plot-based rarefaction

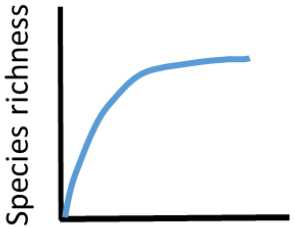
Shuffle individuals maintain density



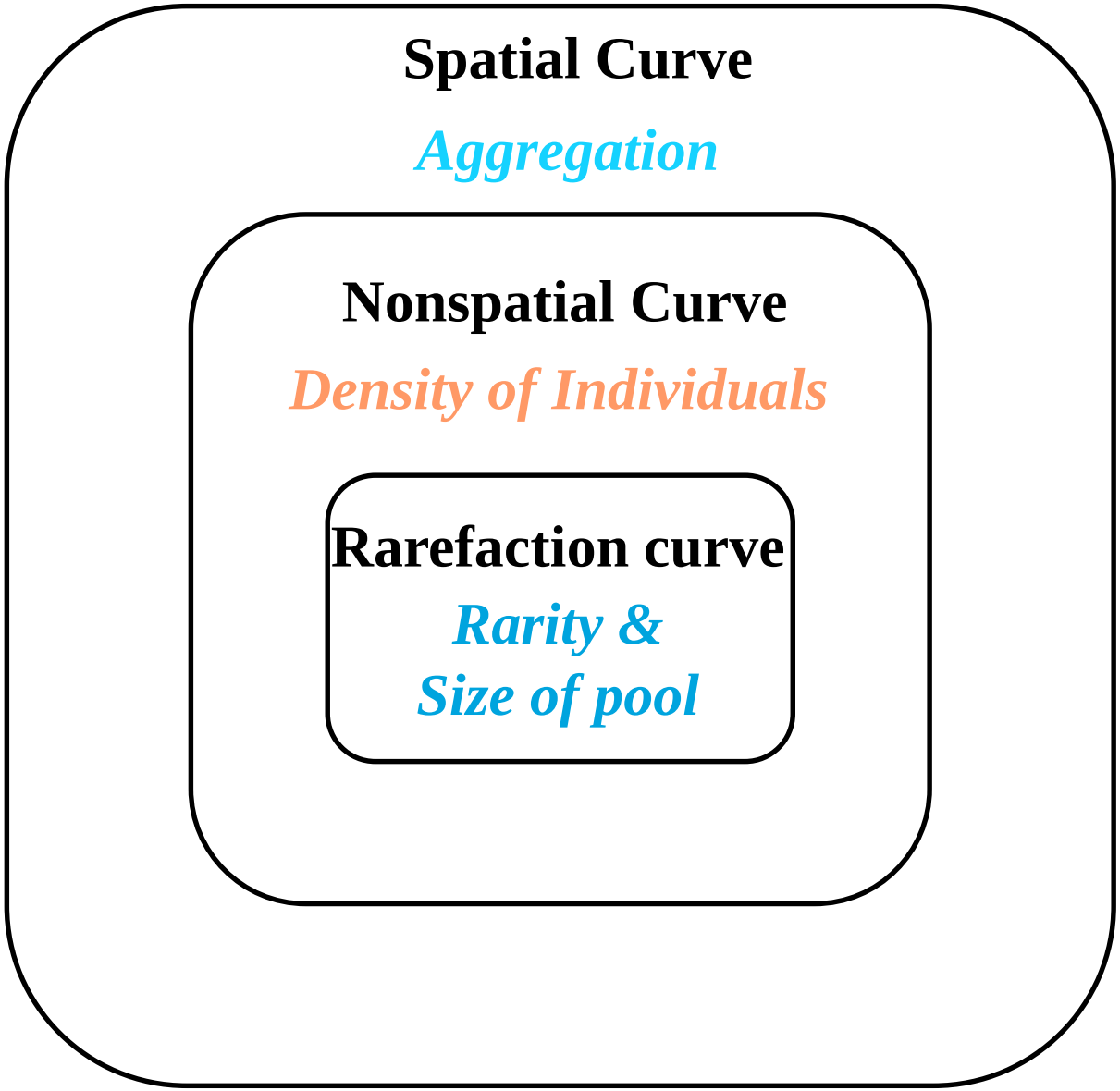


Individual-based rarefaction

Randomly sample individuals



Nested Information

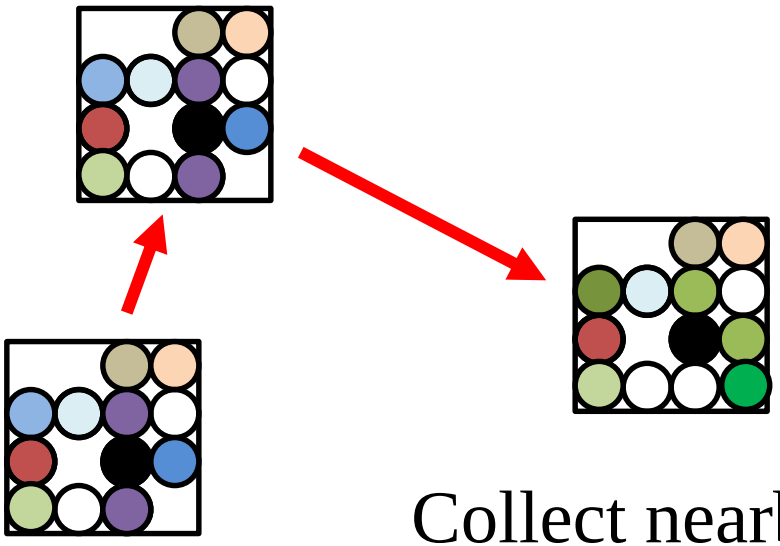


Three types of Collector Curves

Spatial sample-based

Depends on

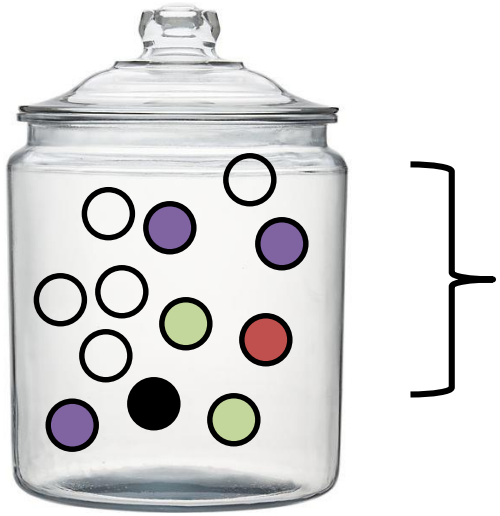
- SAD
- Density of Individuals (N)
- Intraspecific spatial aggregation (Agg.)



Collect nearby samples first,
do not shuffle individuals.

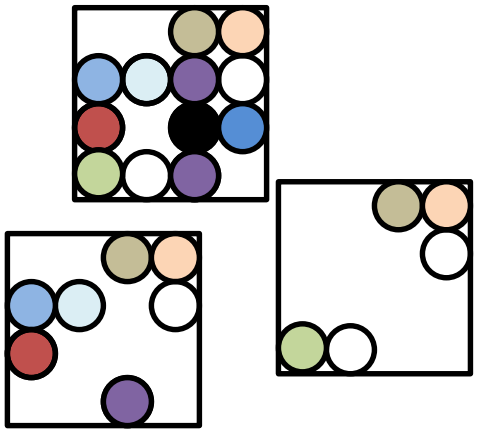
Three types of Collector Curves

Non-spatial, sample-based



Depends on

- SAD
- Density of Individuals (N)



Randomly draw individuals
into samples
based on observed density

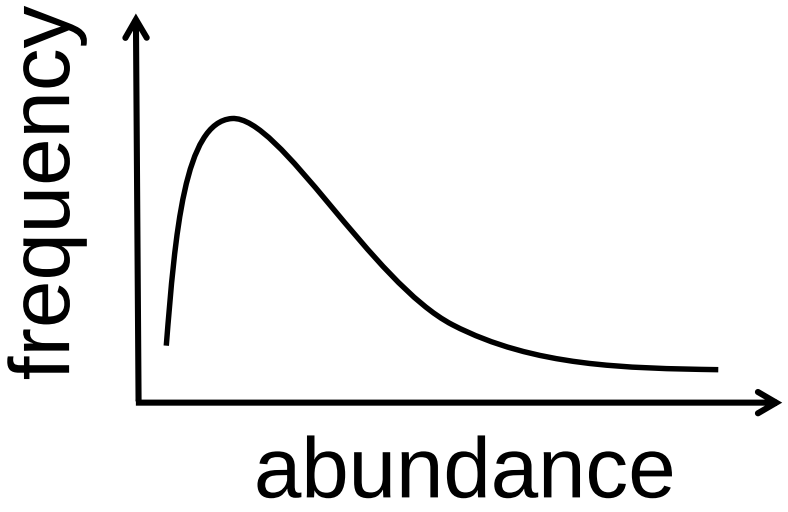
Three types of Collector Curves

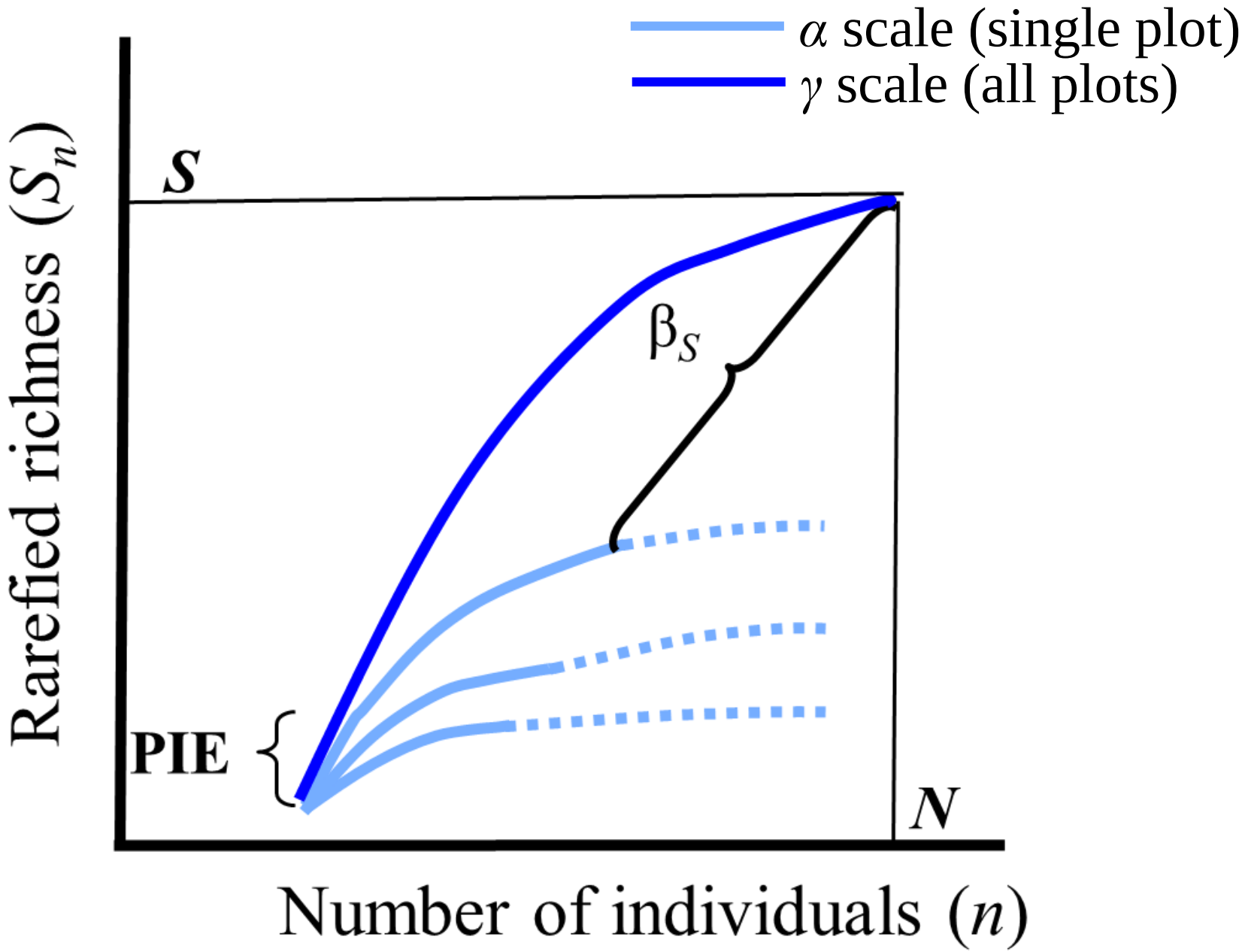
Individual-based, spatially random

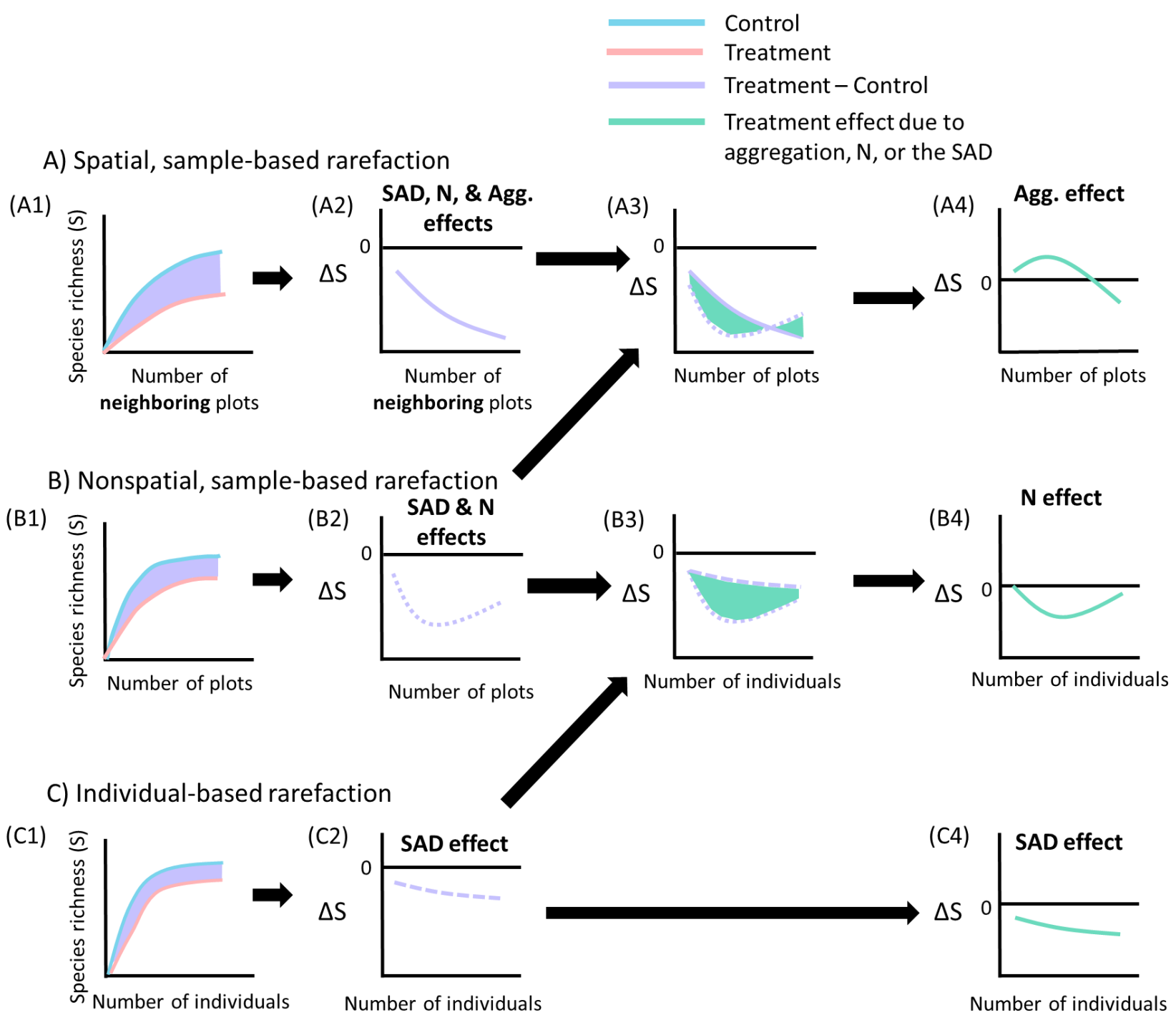
Randomly draw individuals

Depends on

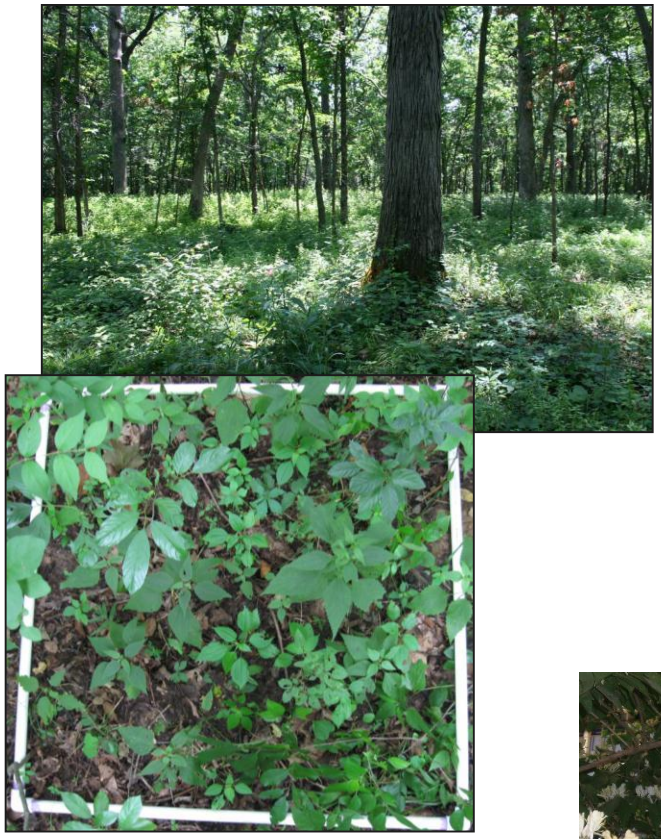
- Species Abundance Distribution (SAD)
  - commonness & rarity, size of species pool




α scale (single plot)
γ scale (all plots)
Rarefied richness (S_n)
S
β_S
PIE
N
Number of individuals (n)

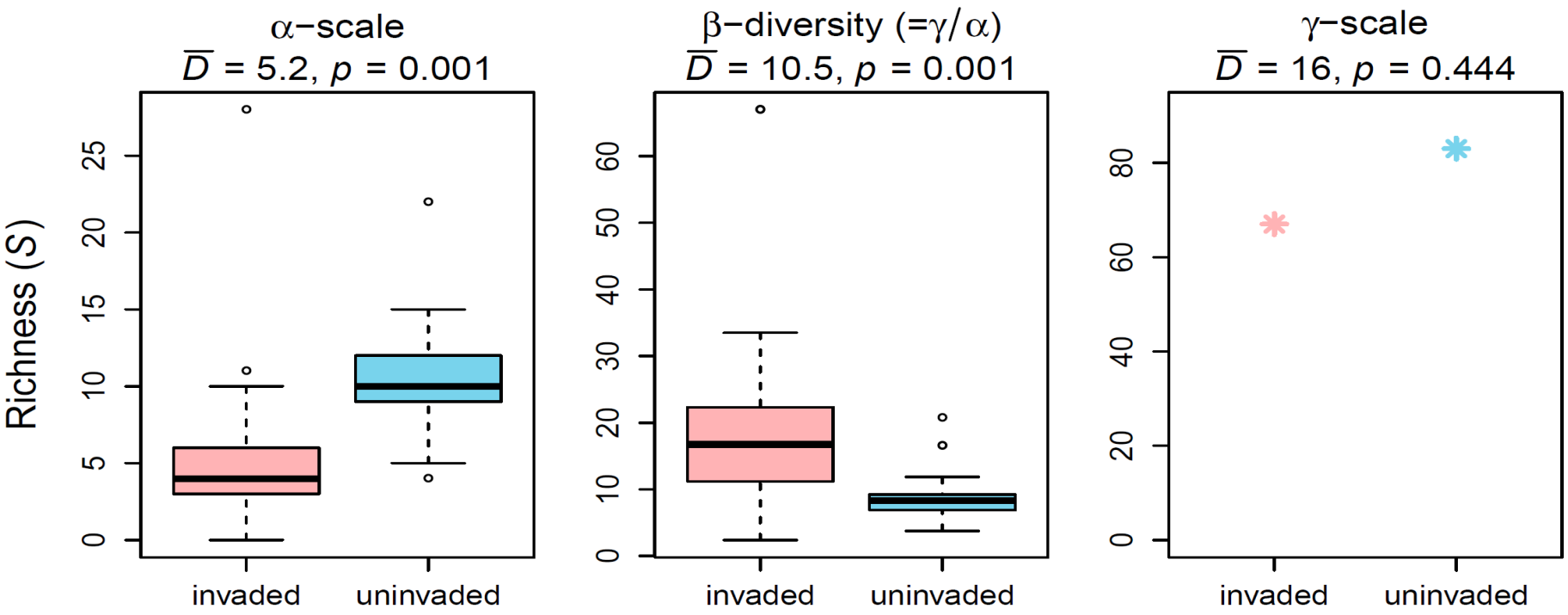

Control
Treatment
Treatment – Control
Treatment effect due to aggregation, N, or the SAD
A) Spatial, sample-based rarefaction
(A1)
Species richness (S)
Number of neighboring plots
(A2)
SAD, N, & Agg. effects
0
ΔS
Number of neighboring plots
(A3)
0
ΔS
Number of plots
(A4)
Agg. effect
ΔS
0
Number of plots
B) Nonspatial, sample-based rarefaction
(B1)
Species richness (S)
Number of plots
(B2)
SAD & N effects
0
ΔS
Number of plots
(B3)
0
ΔS
Number of individuals
(B4)
N effect
ΔS
0
Number of individuals
C) Individual-based rarefaction
(C1)
Species richness (S)
Number of individuals
(C2)
SAD effect
0
ΔS
Number of individuals
(C4)
SAD effect
ΔS
0
Number of individuals

Case Study:
How does invasion effect diversity?

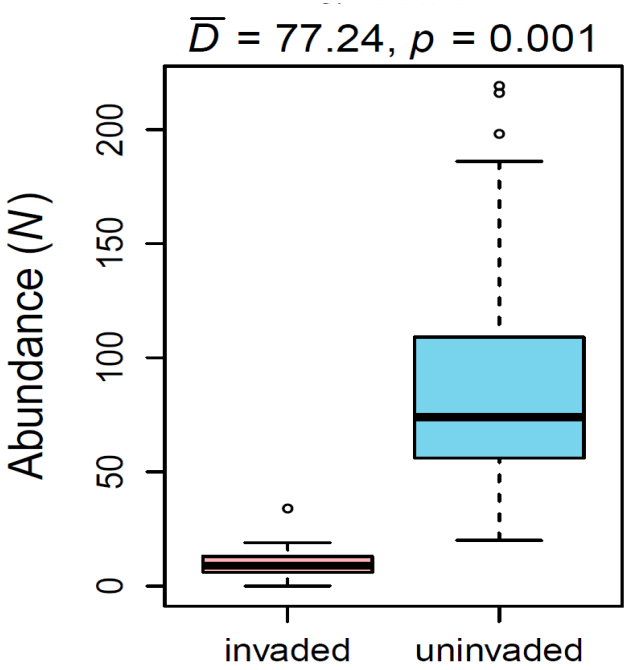


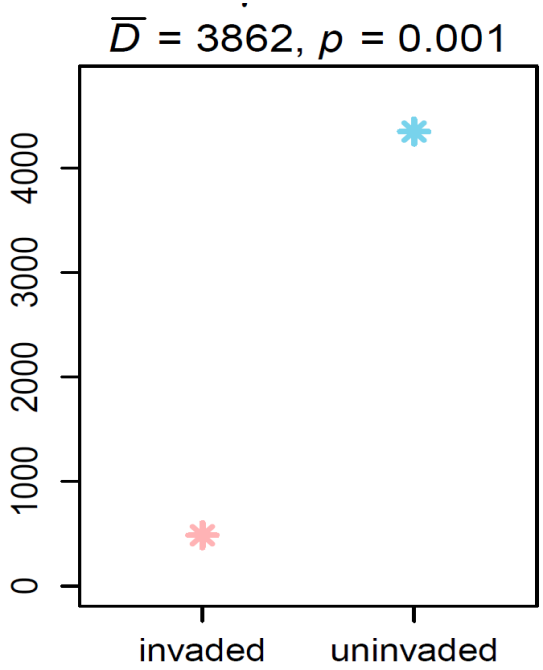
Powell et al. 2013

Traditional Analysis

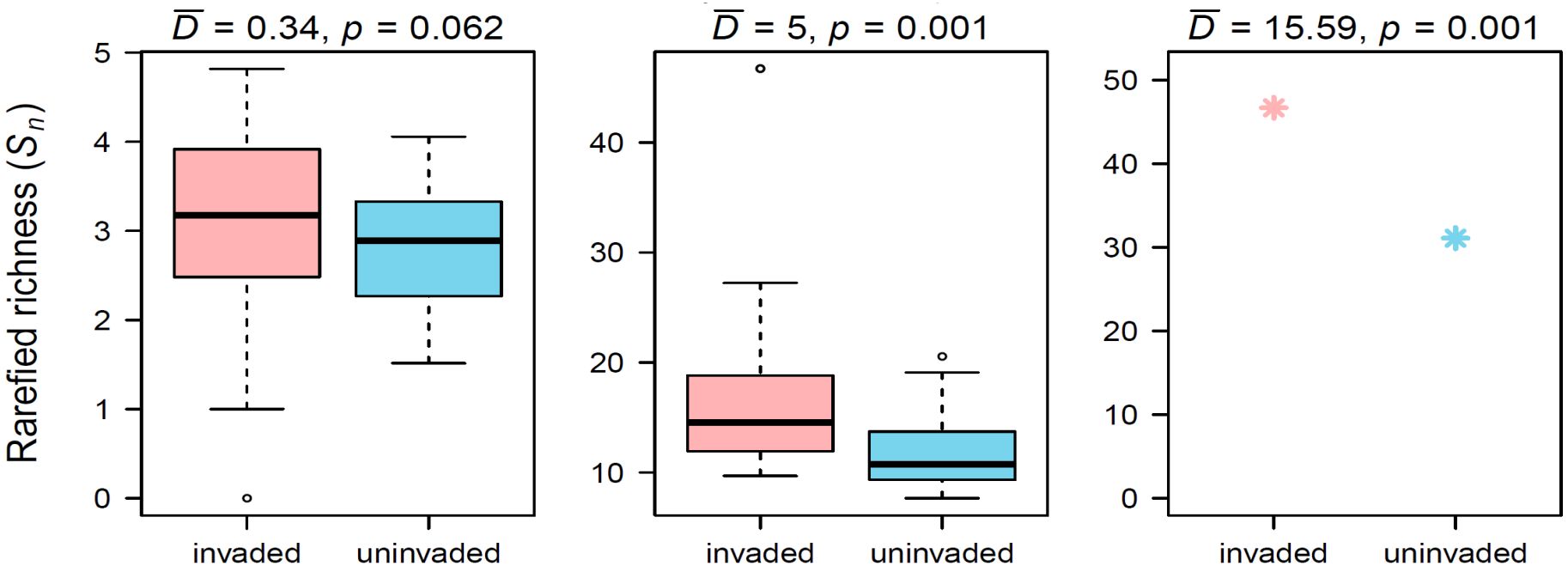


Invasion decreased density

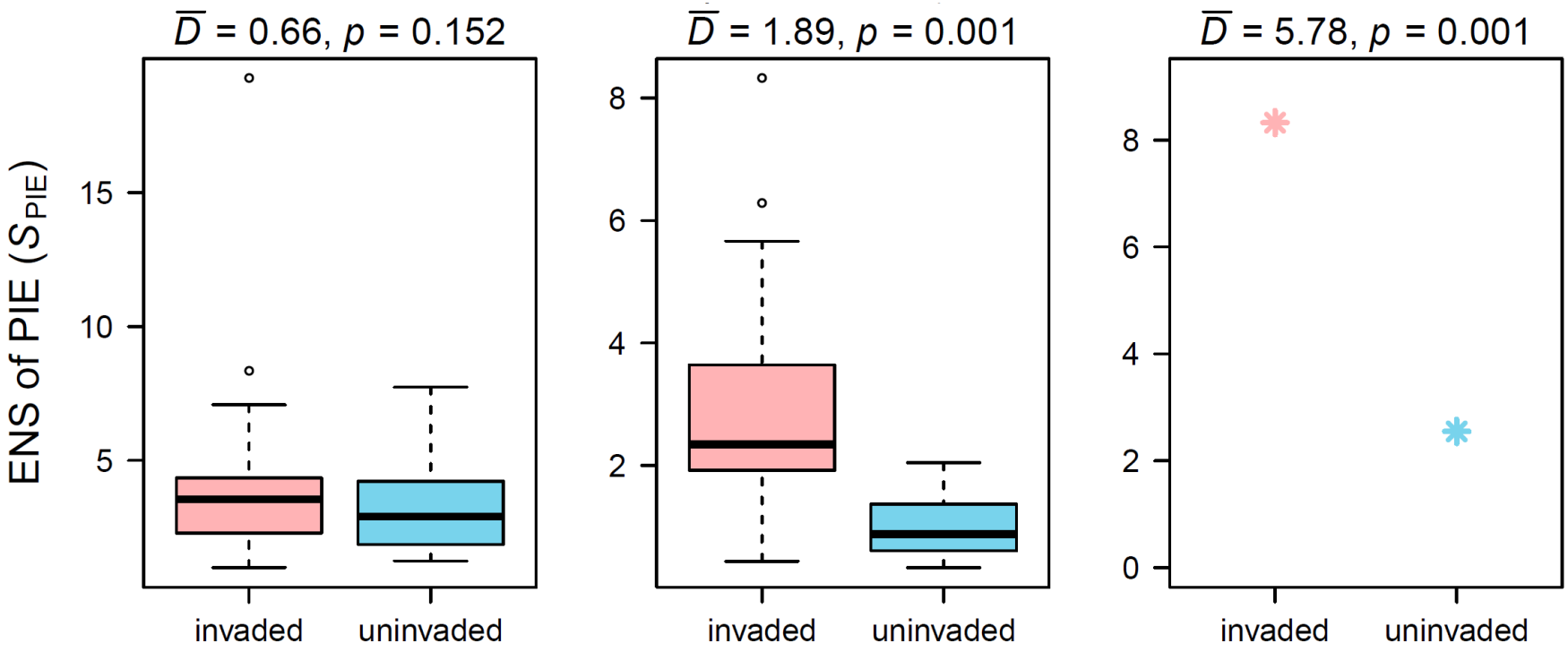




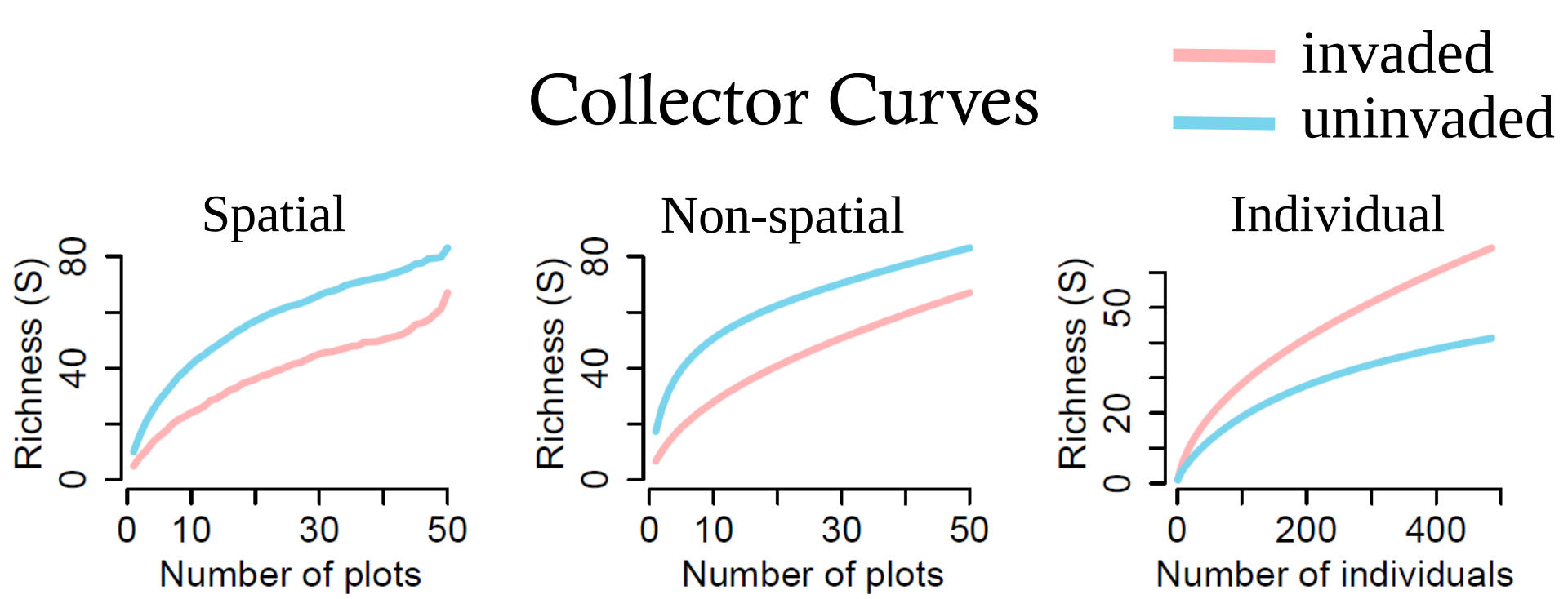
Change in density influences S

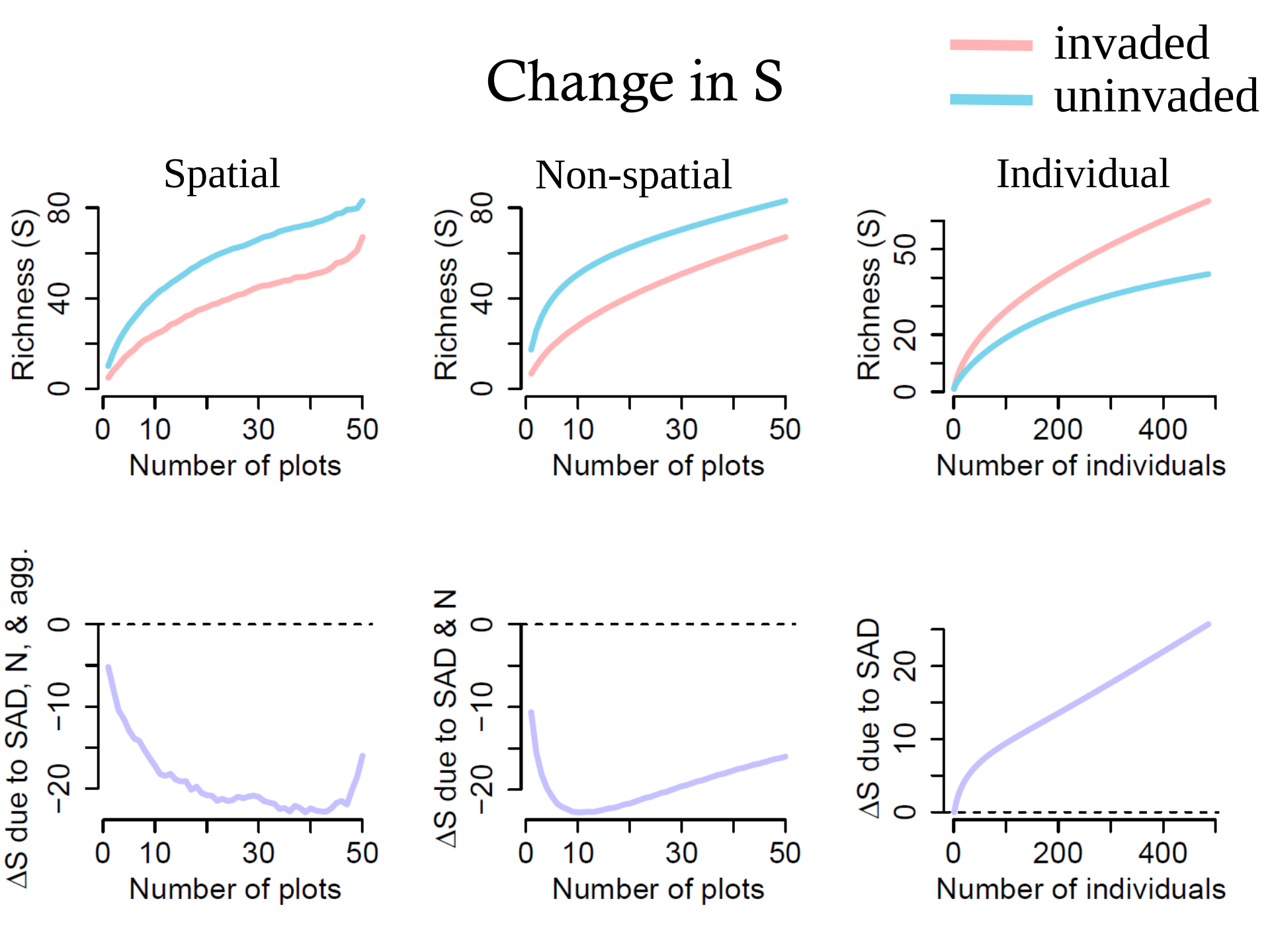


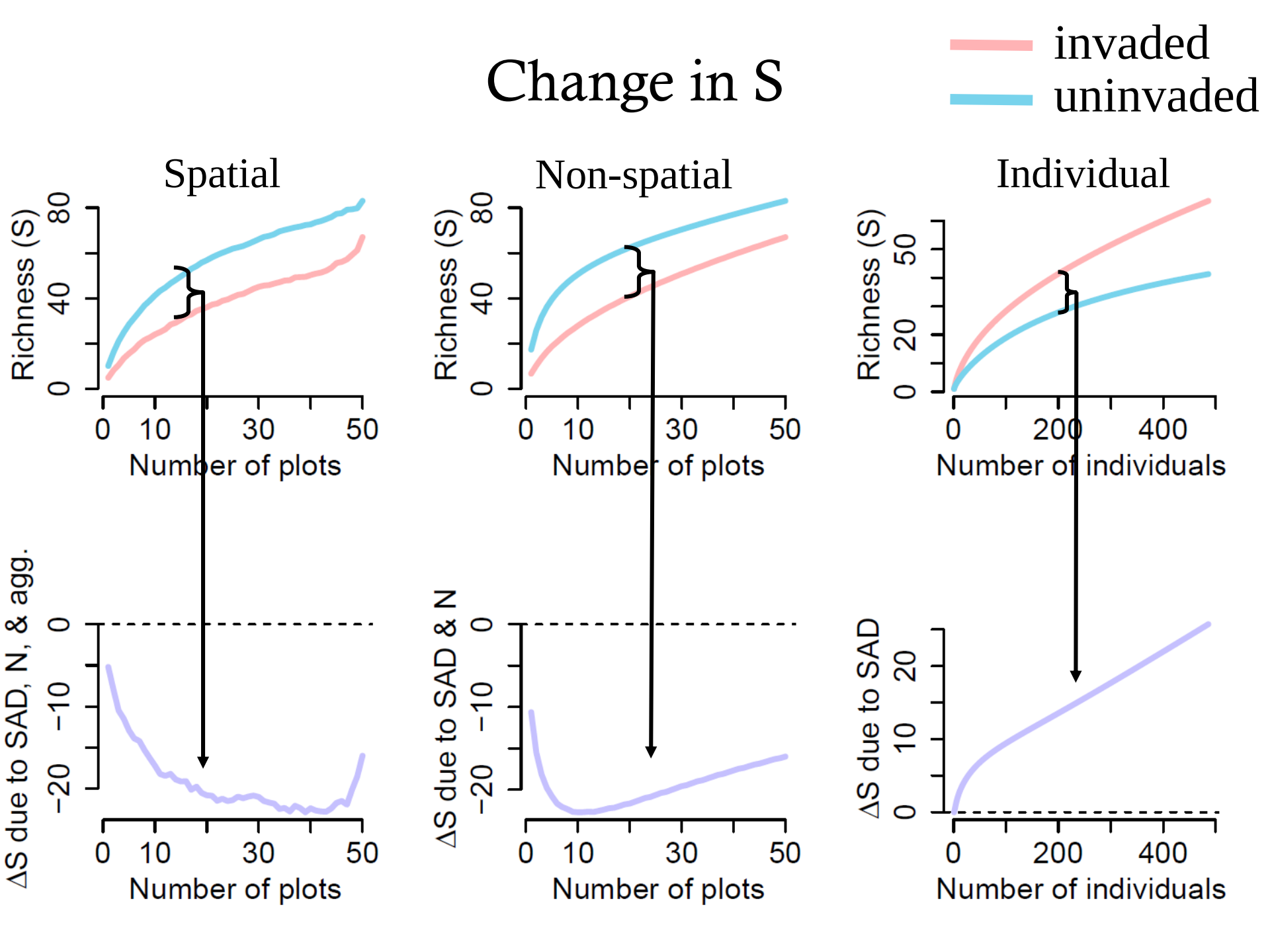
Evenness scale dependent



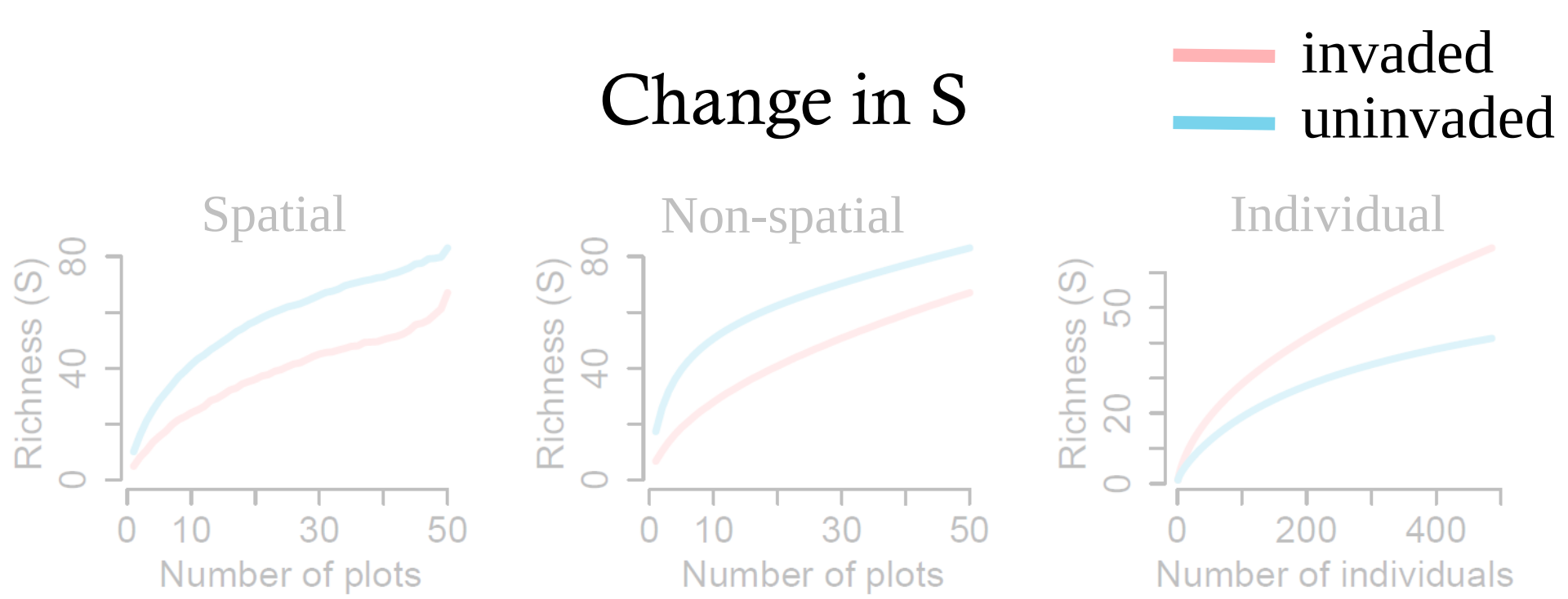
Collector Curves



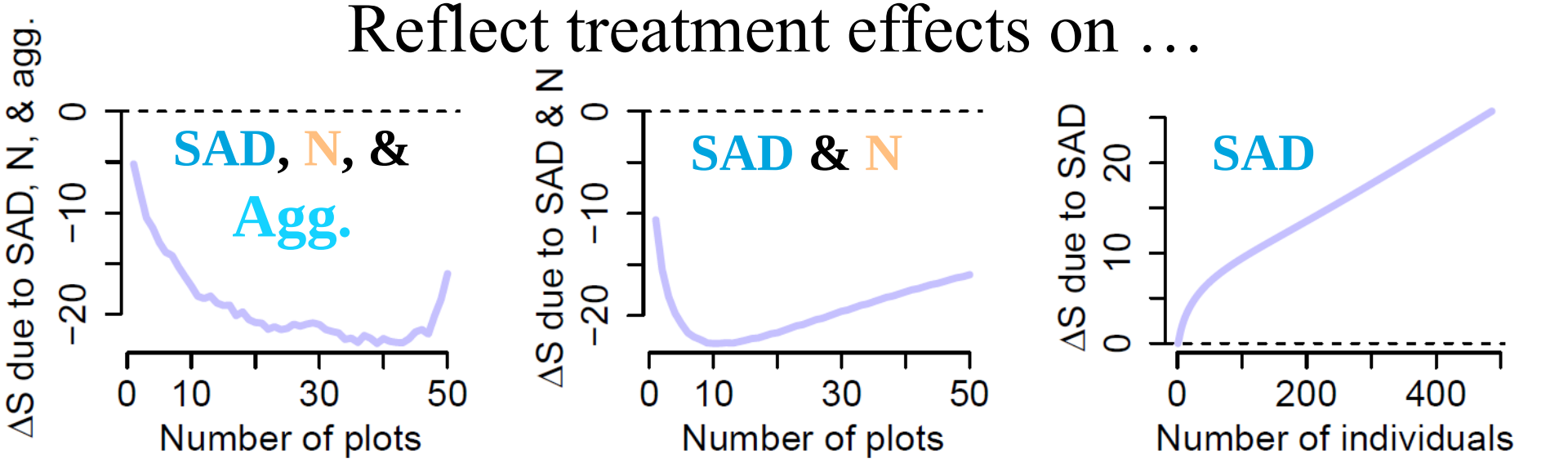

Change in S
invaded
uninvaded
Spatial
Non-spatial
Individual
Richness (S)
0
40
80
0
10
30
50
Number of plots
Richness (S)
0
40
80
0
10
30
50
Number of plots
Richness (S)
0
20
50
0
200
400
Number of individuals
ΔS due to SAD, N, & agg.
0
−10
−20
0
10
30
50
Number of plots
ΔS due to SAD & N
0
−10
−20
0
10
30
50
Number of plots
ΔS due to SAD
0
10
20
0
200
400
Number of individuals

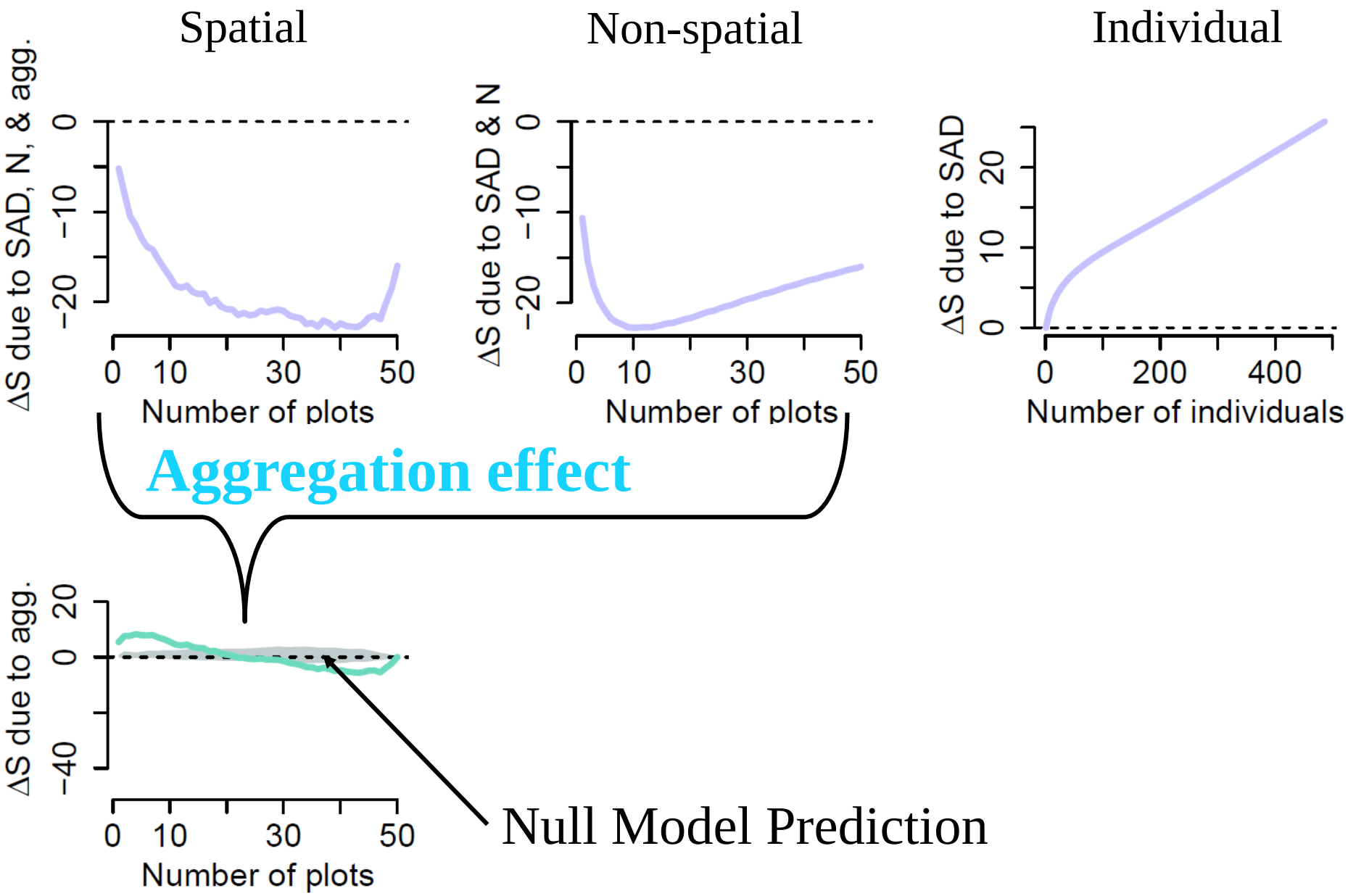

Change in S
invaded
uninvaded
Spatial
Non-spatial
Individual
Richness (S)
Number of plots
Number of individuals
ΔS due to SAD, N, & agg.
ΔS due to SAD & N
ΔS due to SAD

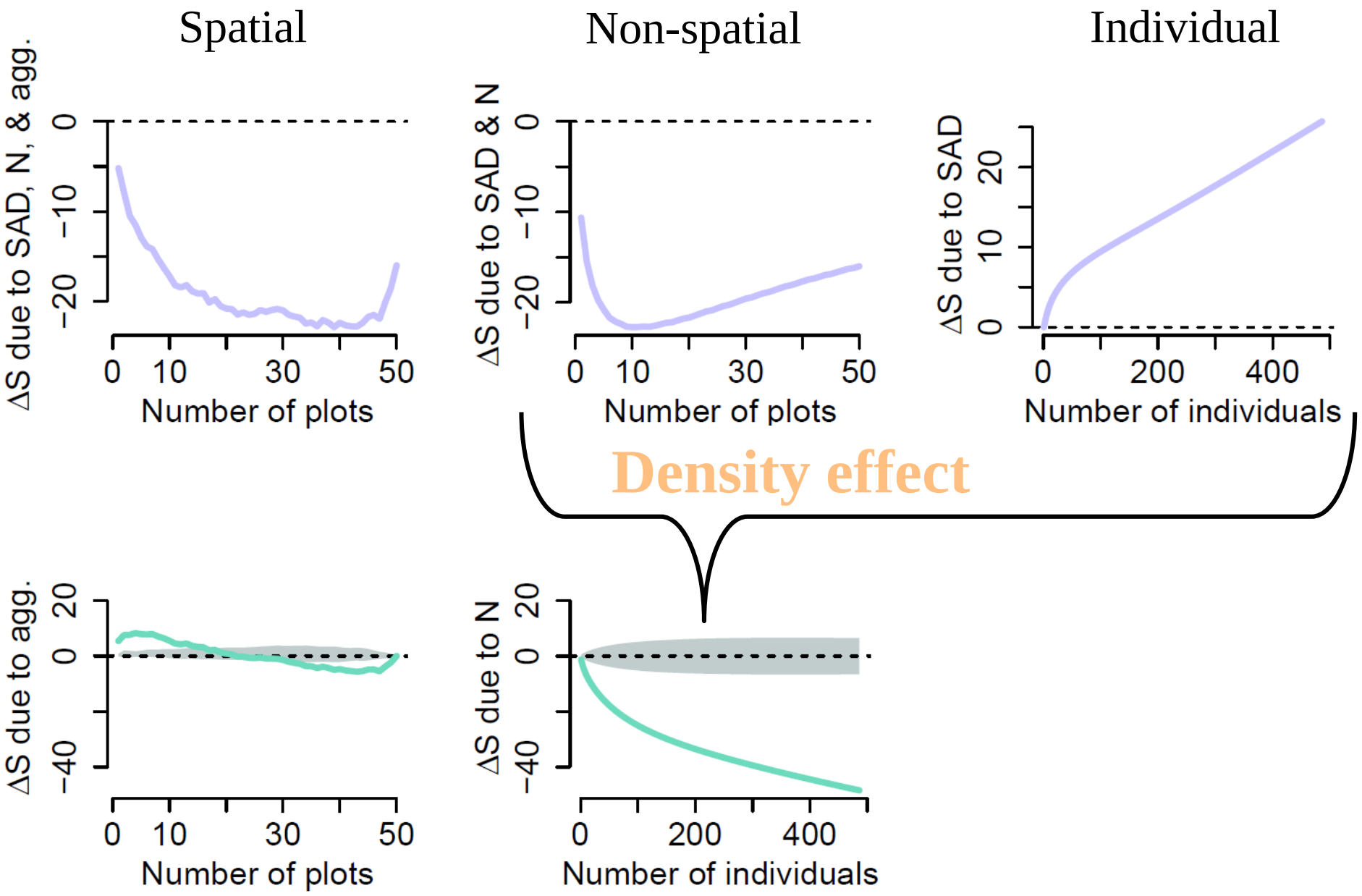
Change in S

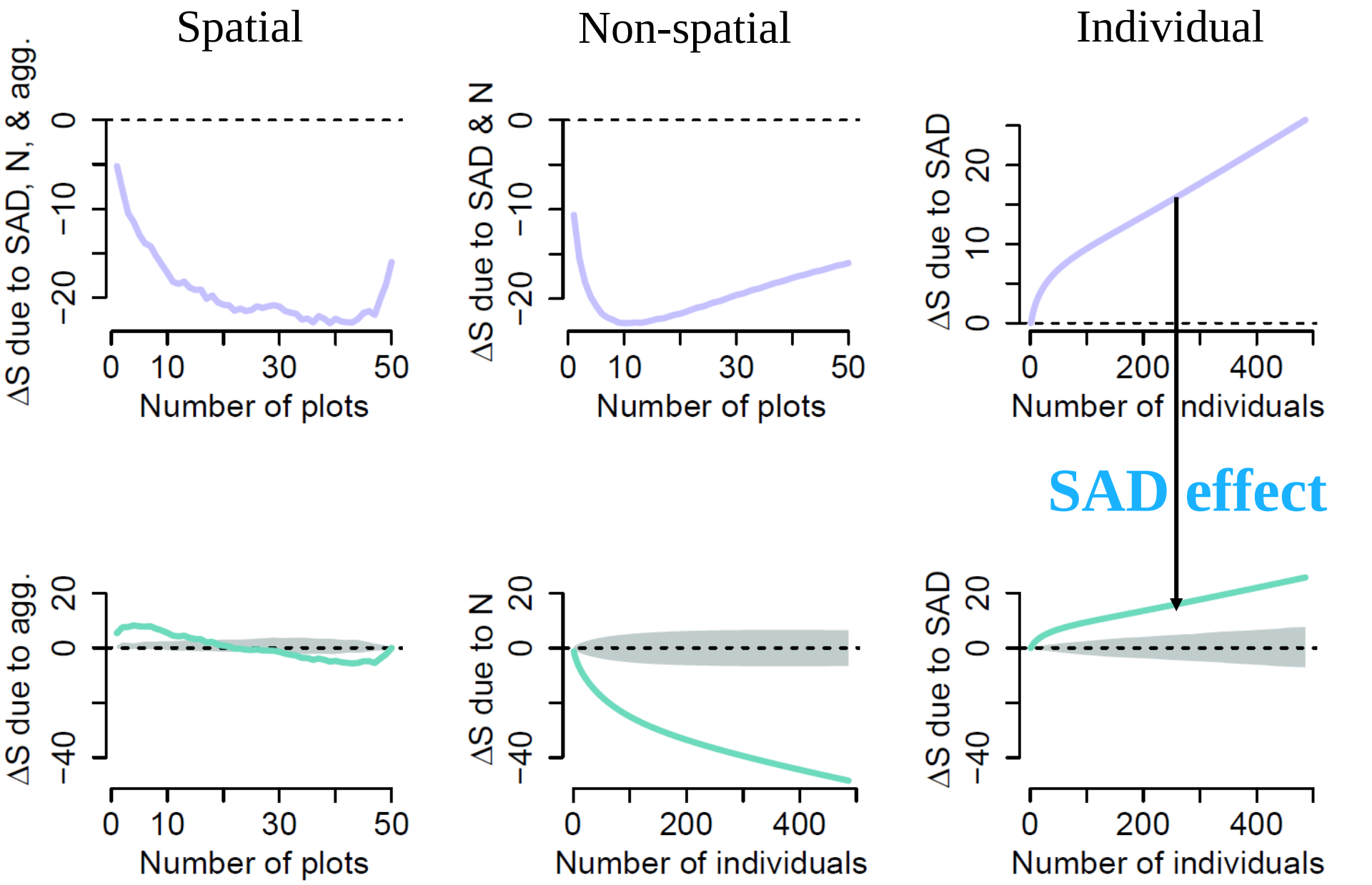


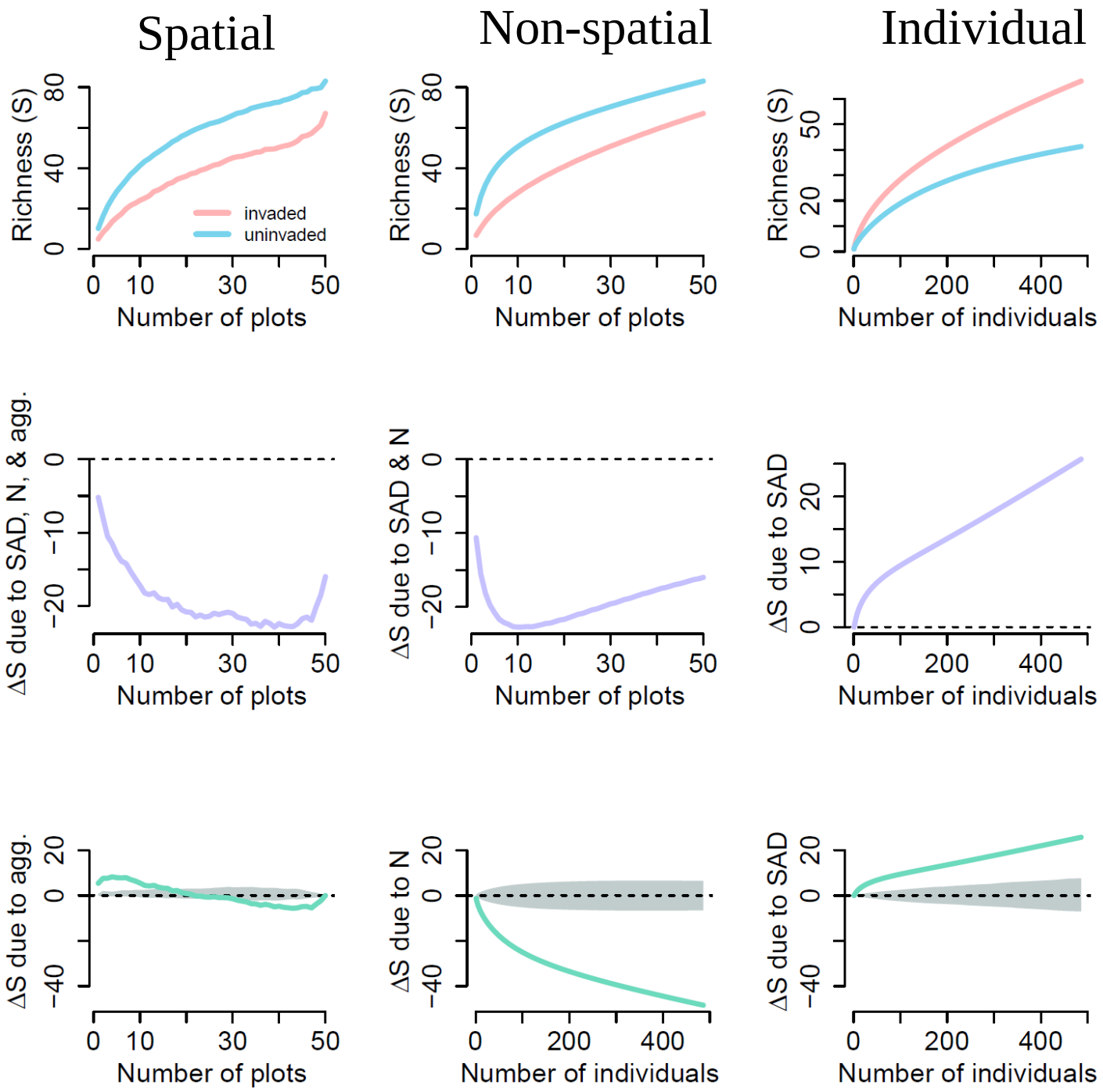
Reflect treatment effects on …

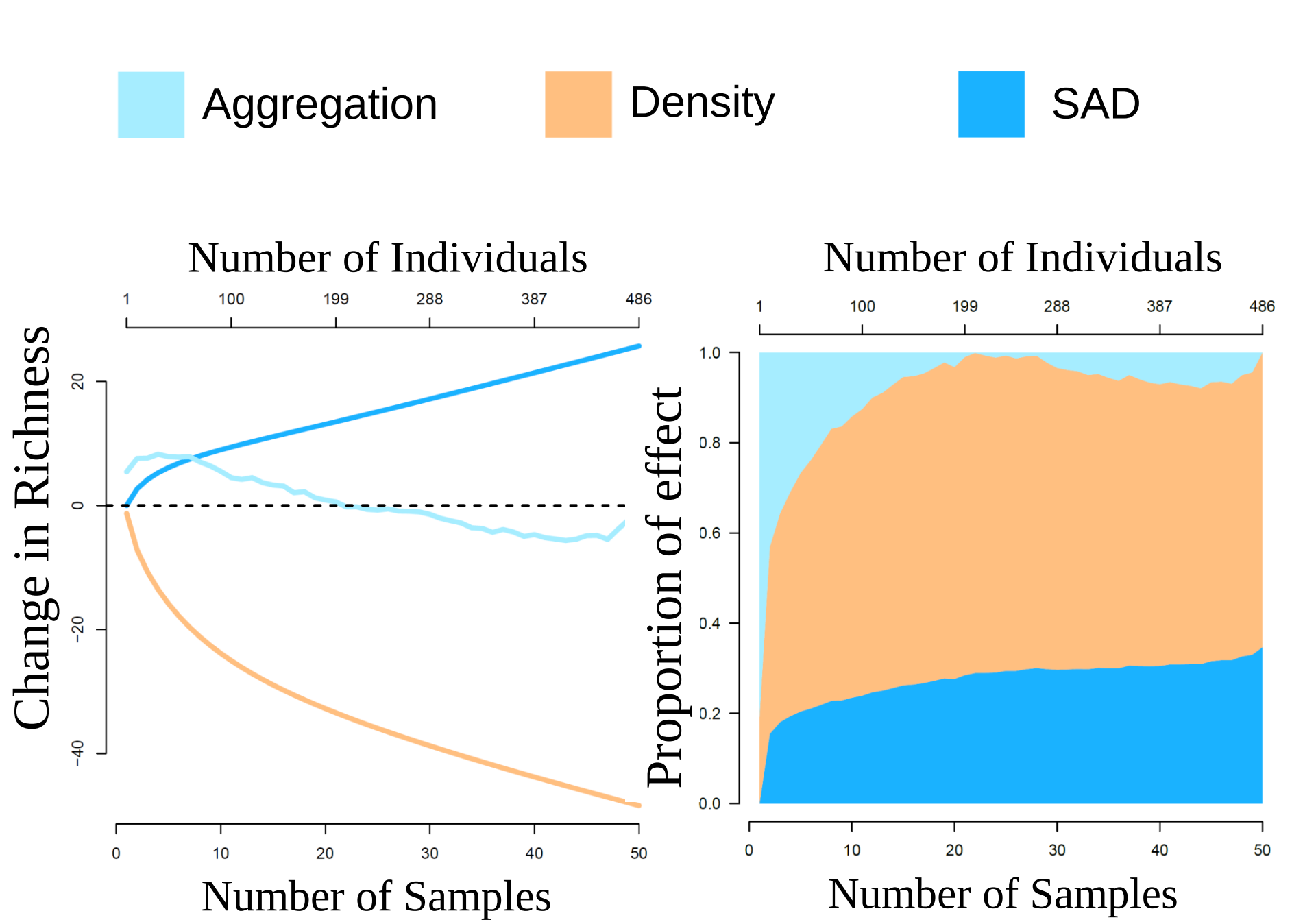


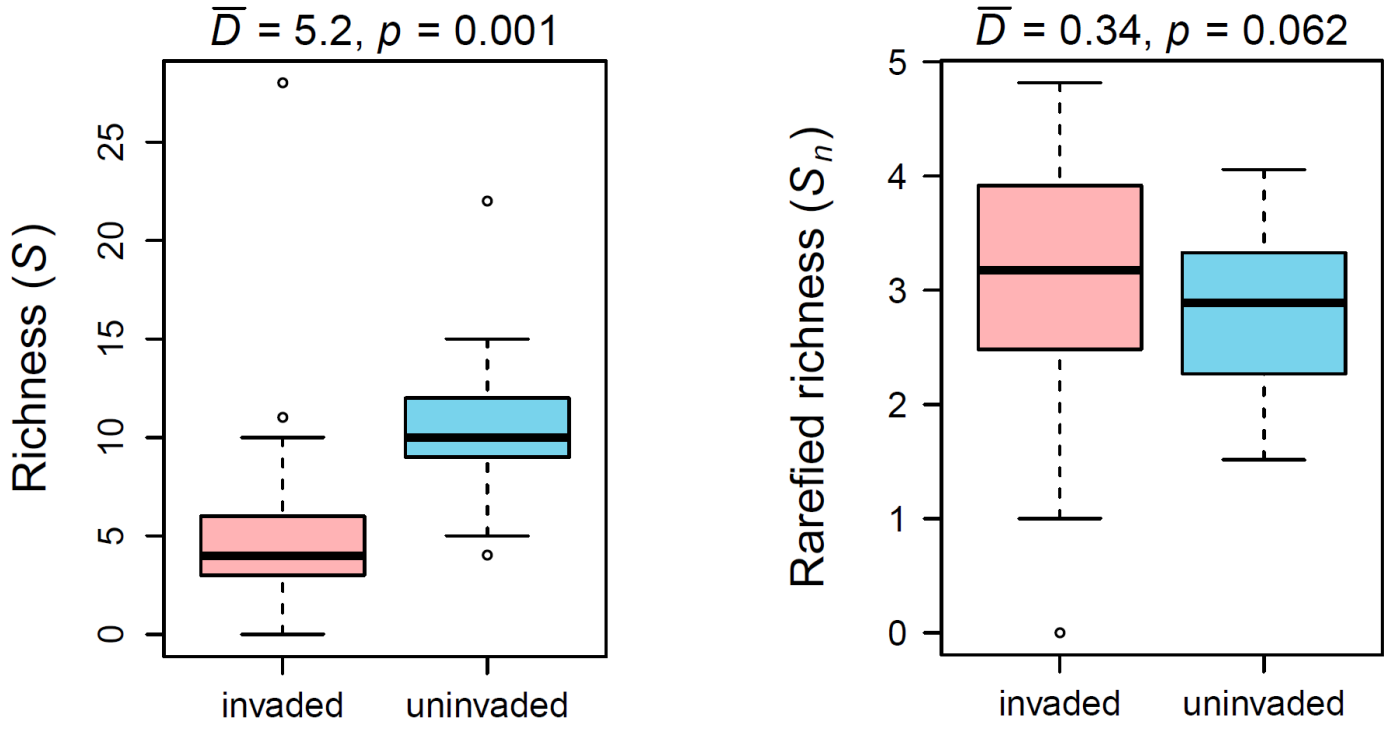

Spatial
Non-spatial
Individual
ΔS due to SAD, N, & agg.
ΔS due to SAD & N
ΔS due to SAD
0
−10
−20
0
10
20
0
10
30
50
0
200
400
Number of plots
Number of plots
Number of individuals
Aggregation effect
ΔS due to agg.
20
0
−40
0
10
30
50
Number of plots
Null Model Prediction


Spatial
Non-spatial
Individual
ΔS due to SAD, N, & agg.
ΔS due to SAD & N
ΔS due to SAD
0
−10
−20
0
10
30
50
Number of plots
0
200
400
Number of individuals
Density effect
ΔS due to agg.
ΔS due to N
20
0
−40


Spatial
Non-spatial
Individual
ΔS due to SAD, N, & agg.
ΔS due to SAD & N
ΔS due to SAD
ΔS due to agg.
ΔS due to N
0
−10
−20
10
30
50
200
400
Number of plots
Number of individuals
SAD effect
−40
20


Spatial
Non-spatial
Individual
Richness (S)
invaded
uninvaded
Number of plots
Number of individuals
ΔS due to SAD, N, & agg.
ΔS due to SAD & N
ΔS due to SAD
ΔS due to agg.
ΔS due to N


Aggregation
Density
SAD
Number of Individuals
1
100
199
288
387
486
Change in Richness
20
0
−20
−40
0
10
20
30
40
50
Number of Samples
Number of Individuals
1
100
199
288
387
486
Proportion of effect
1.0
0.8
0.6
0.4
0.2
0.0
0
10
20
30
40
50
Number of Samples

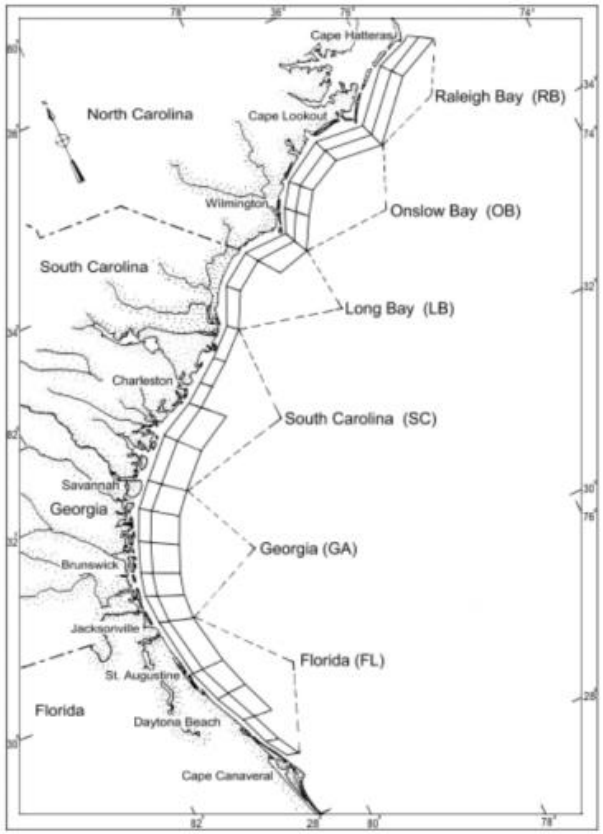


- Invasion increases evenness → gain of biodiversity
- Invasion decreases abundance → loss of biodiversity

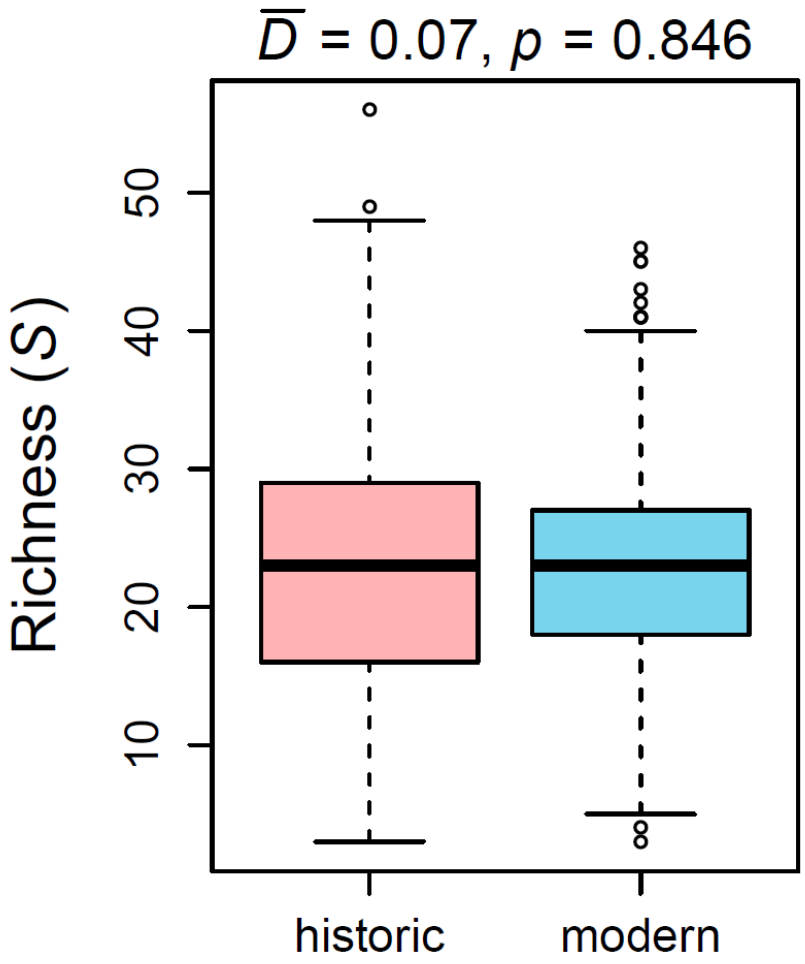
- The univariate analyses capture different aspects of these results and make sense in the context of the MoB analysis.

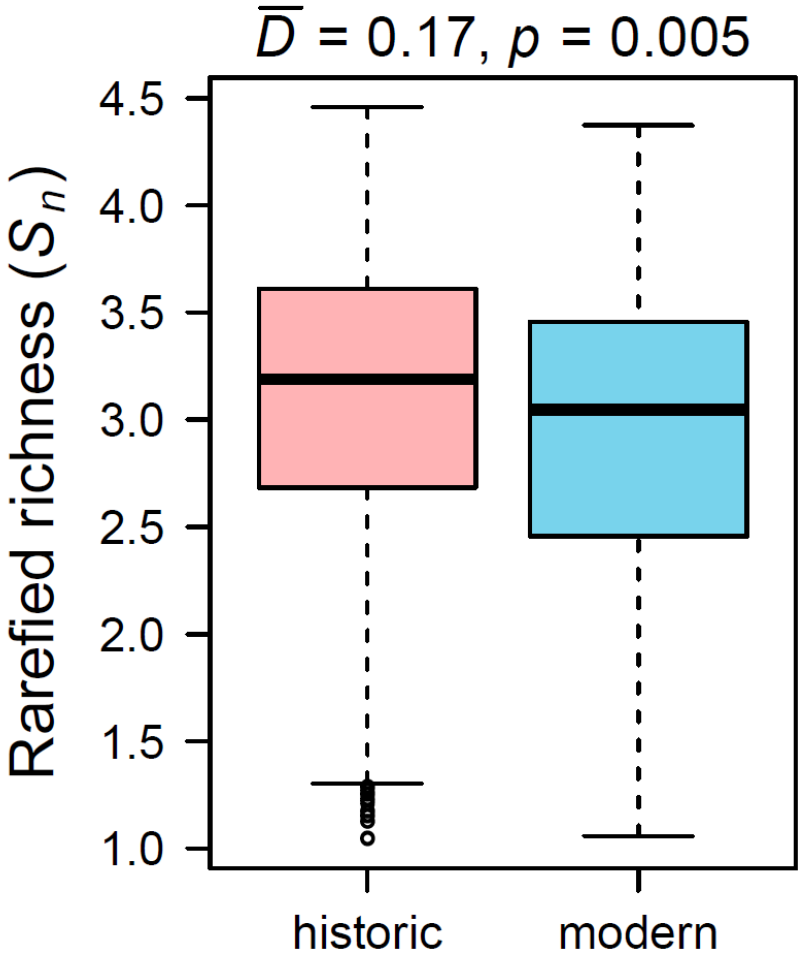
20 Years of Change in South Eastern Coastal Atlantic Fish

Nathan Baker

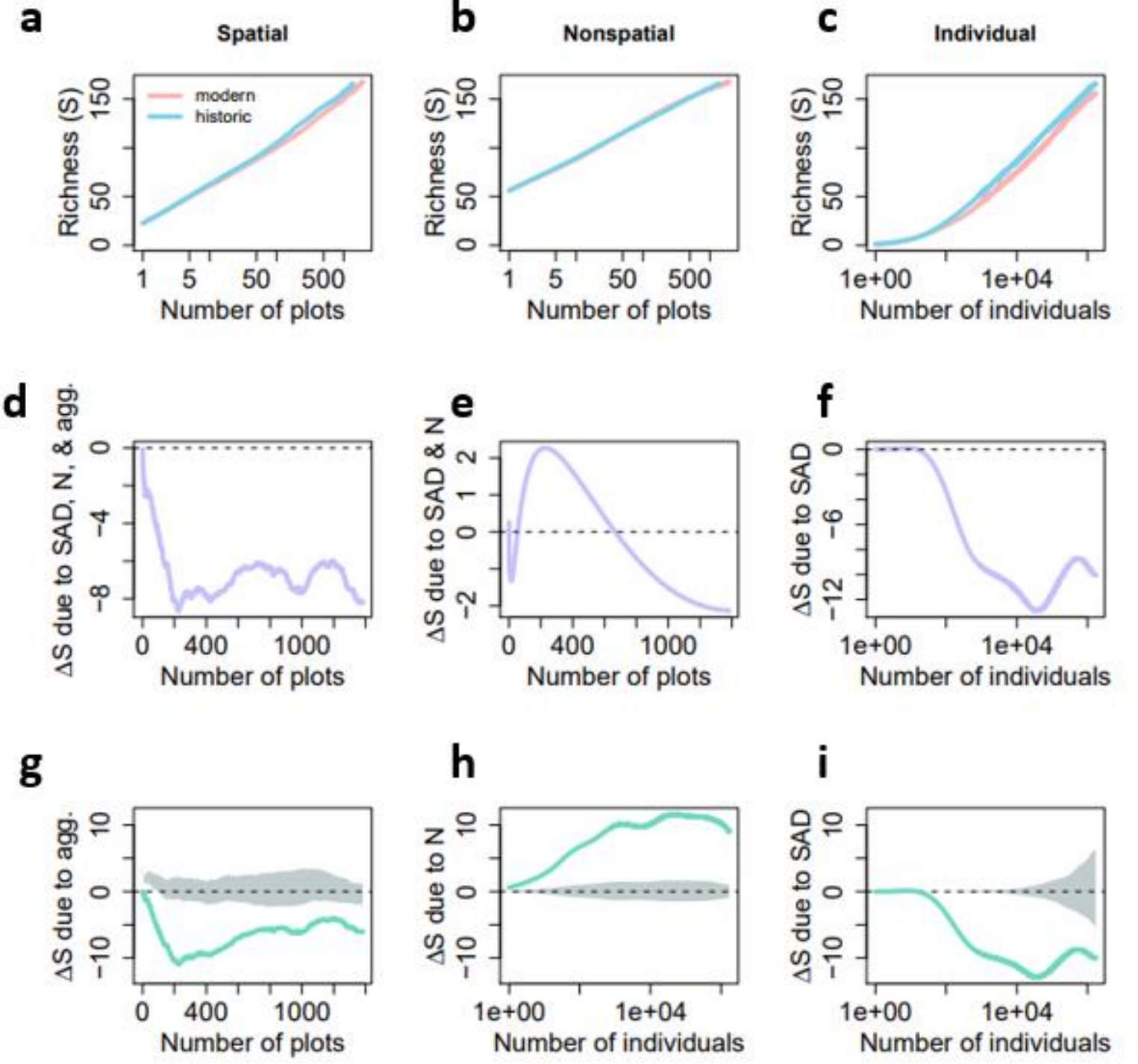


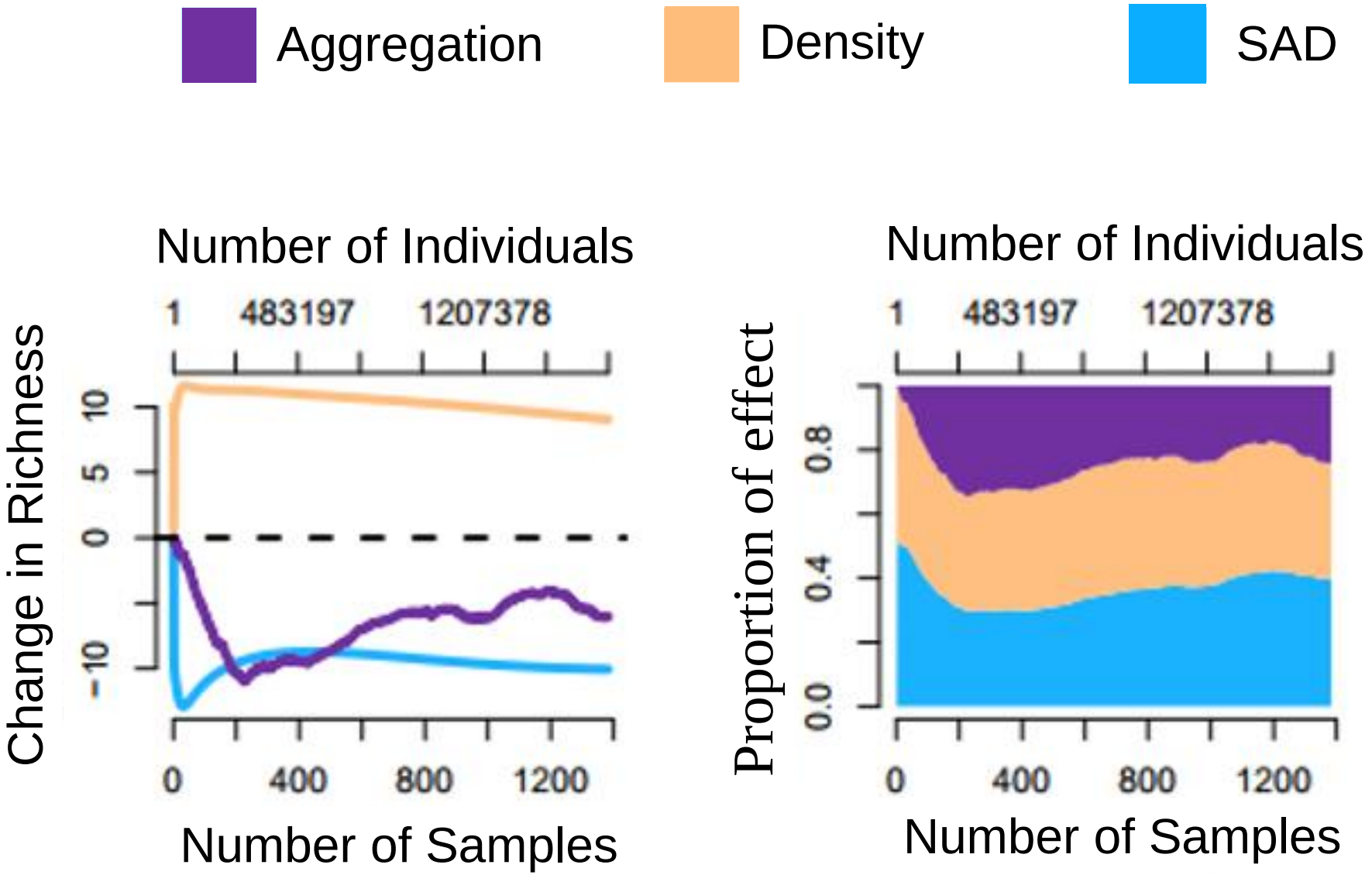
No Change in Richness






SPOTTAIL BASS
SPOTTED SEATROUT
FLOUNDER
BLACK SEA BASS
WHITING


a
Spatial
b
Nonspatial
c
Individual
modern
historic
Richness (S)
0
50
150
1
5
50
500
Number of plots
1e+00
1e+04
Number of individuals
d
e
f
ΔS due to SAD, N, & agg.
ΔS due to SAD & N
ΔS due to SAD
0
400
1000
g
h
i
ΔS due to agg.
ΔS due to N
−10
10

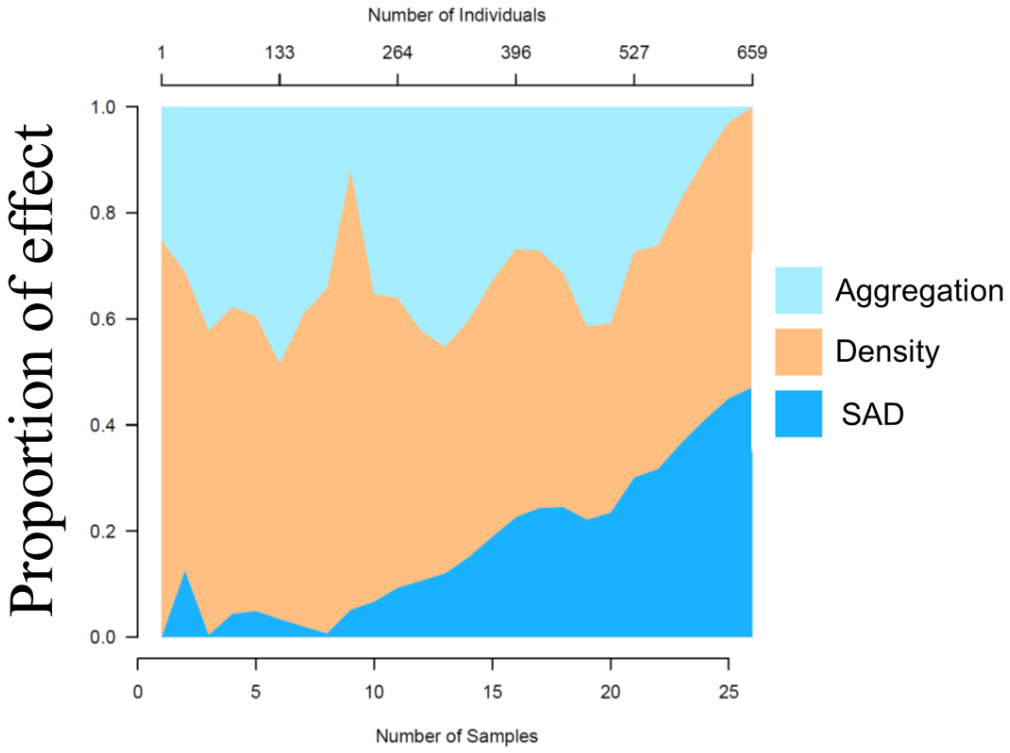

Aggregation
Density
SAD
Number of Individuals
1
483197
1207378
Change in Richness
10
5
0
−10
0
400
800
1200
Number of Samples
Number of Individuals
1
483197
1207378
Proportion of effect
0.8
0.4
0.0
0
400
800
1200
Number of Samples

Caveats and Future Directions

- Abundance data is not easy to collect
  - For perennial herbs this is very difficult
  - Other estimates of frequency (e.g., cover, biomass) may also provide insight
  - Presence-Absence data allow for spatial analysis
- Spatial sampling design will strongly influence results
  - Treatments need to have similar spatial sampling designs
- MoB approach can be extended to continuous explanatory variables and other metrics of biodiversity

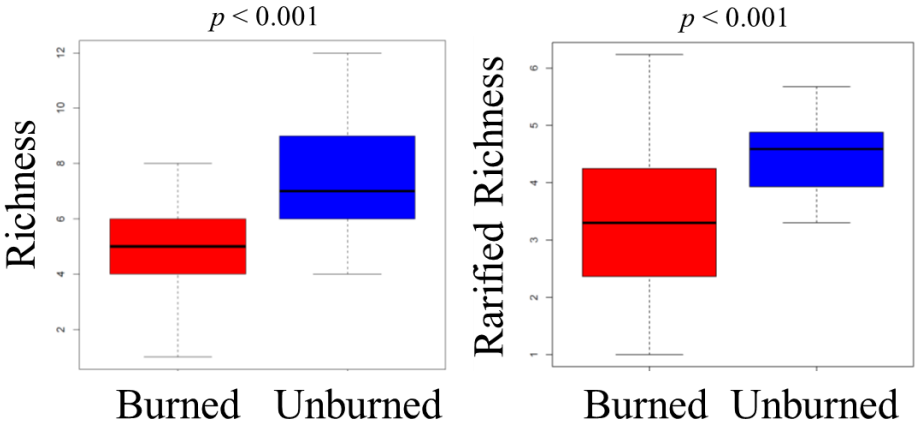
Take Home Messages

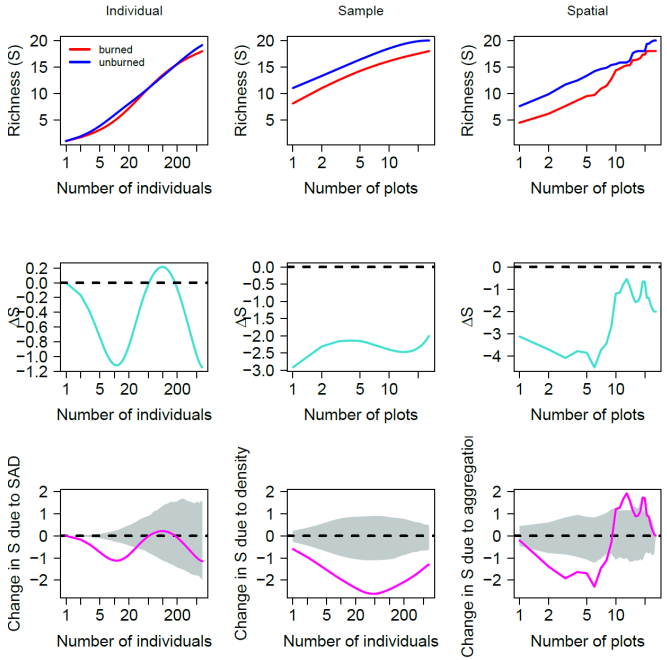
- MoB can decompose richness into its underlying components across scales



Take Home Messages

- Provides a great deal more insight than traditional analyses
- But it comes at a cost

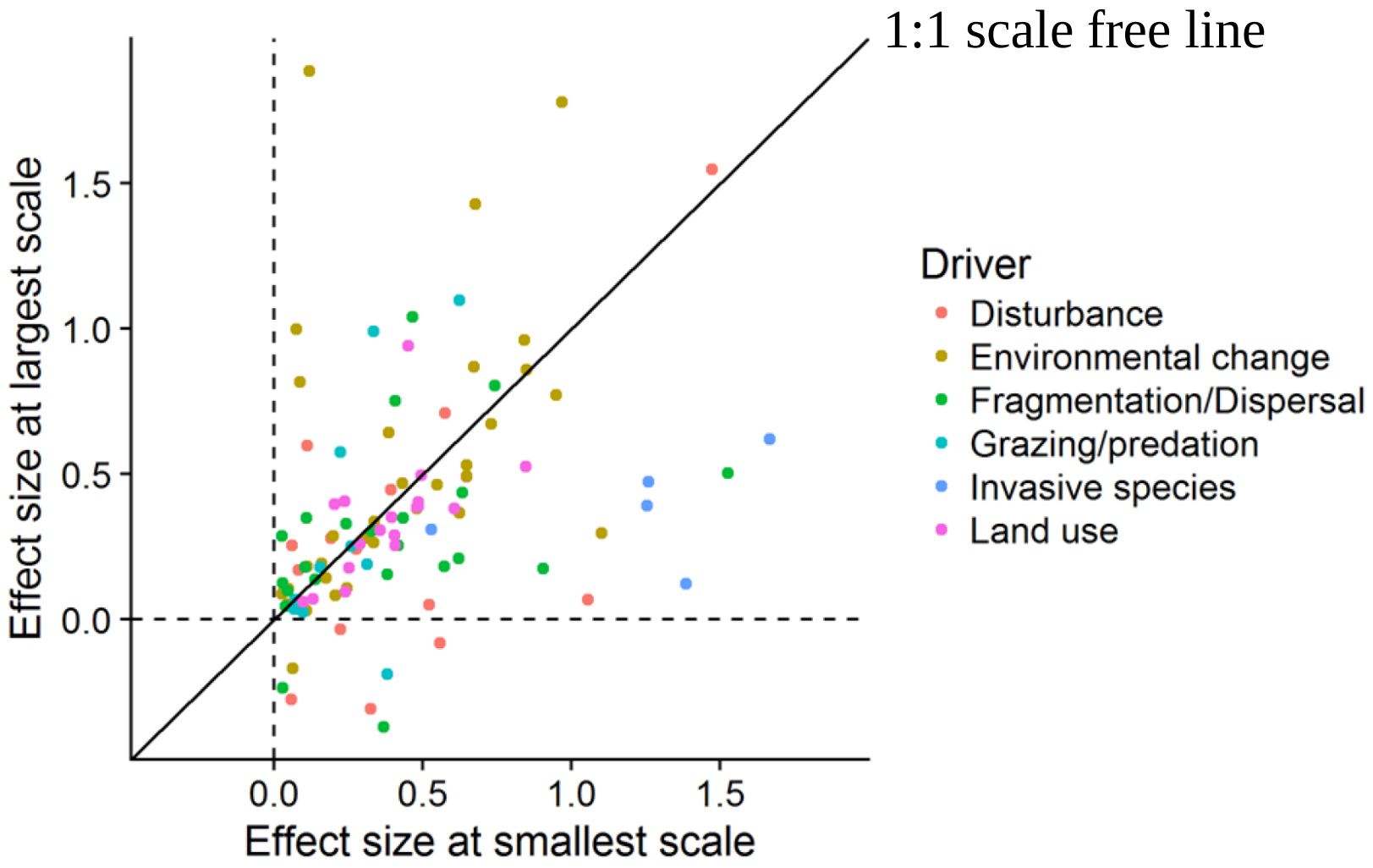




Questions!

Meta-analysis of Scale Depenedence

103 comparisons within 52 studies



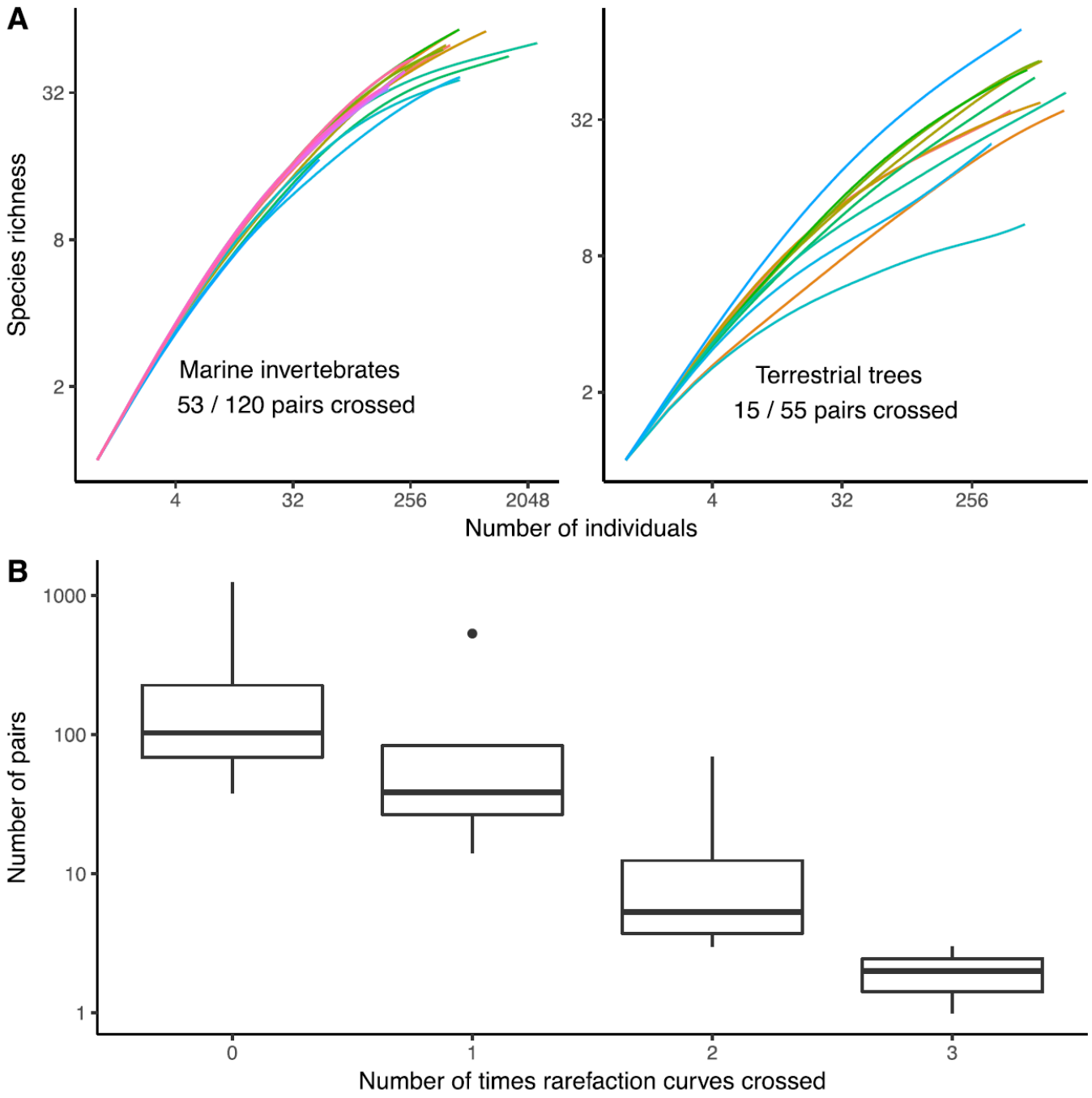

A
Species richness
32
8
2
Marine invertebrates
53 / 120 pairs crossed
Terrestrial trees
15 / 55 pairs crossed
4
32
256
2048
Number of individuals
B
Number of pairs
1000
100
10
1
0
1
2
3
Number of times rarefaction curves crossed

TABLE 1. Observed and null relationships between native and exotic species richness from a riparian plant community sampled at four spatial scales.

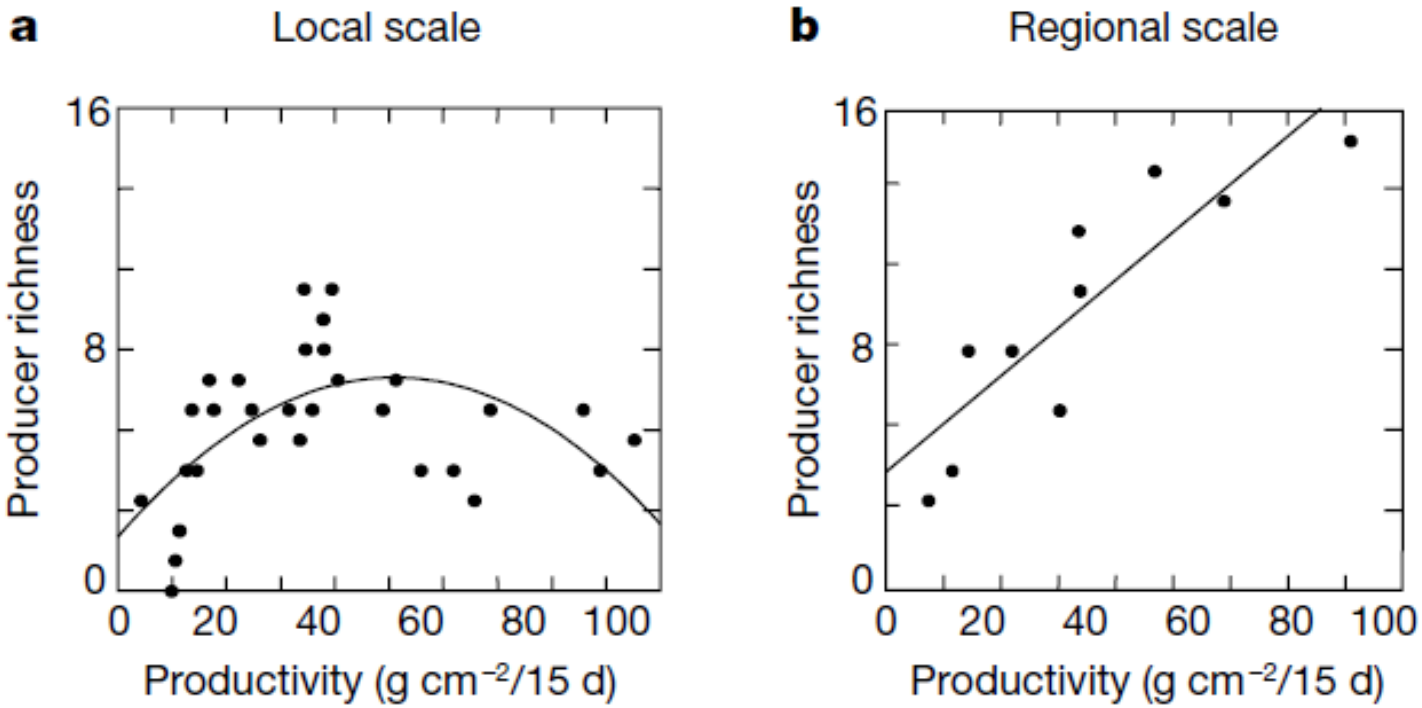
Scale (m^2)	N	Observed relationship		Null relationship		Observed vs. null	
		r	Slope	r	Slope	r	Slope
100	119	0.439***	0.170	0.765***	0.159	***	NS
1	119	0.223*	0.052	0.337***	0.075	NS	NS
0.1	113	0.029	0.012	0.142	0.053	NS	NS
0.01	106	−0.225*	−0.137	−0.125	−0.063	NS	*

Notes: Observed correlation coefficients and regression slopes of the native–exotic richness relationship at each scale are followed by those statistics determined under a null model, where correlation coefficients and slopes are calculated as means of those from 499 random permutations of native–exotic labels. The final two columns are one-tailed tests of whether observed correlation coefficients and slopes significantly differ from the null model, with P values determined by the proportion of permutation-derived values that are as extreme or more extreme than the observed statistic.

* $P < 0.05$; *** $P < 0.001$.

Fridley et al. 2004

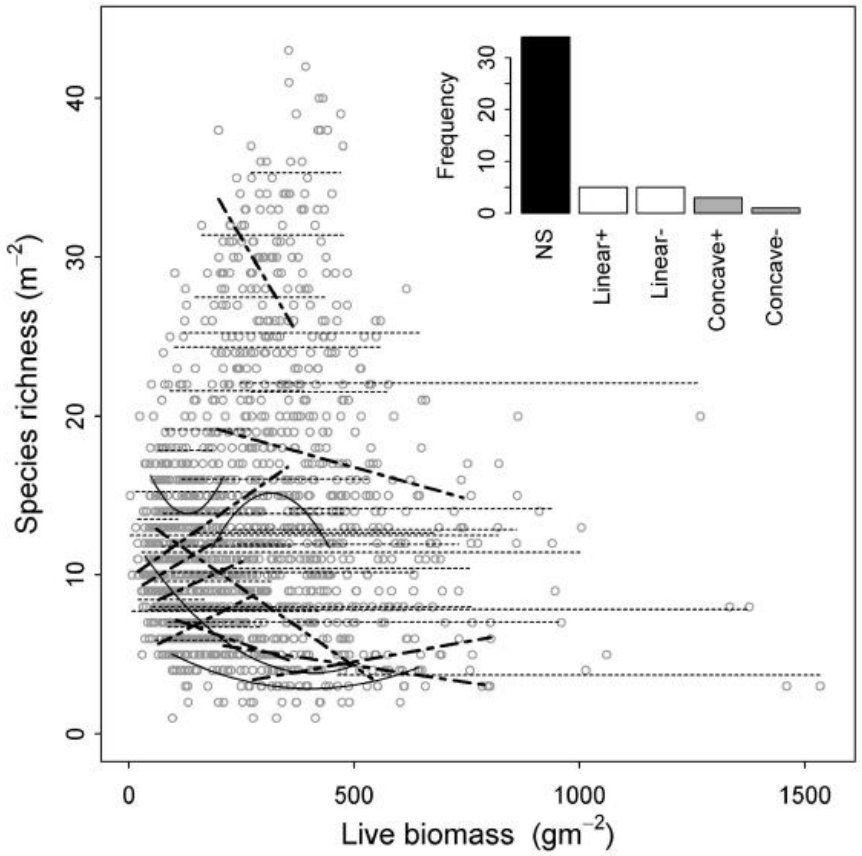
Productivity – Richness Controversy

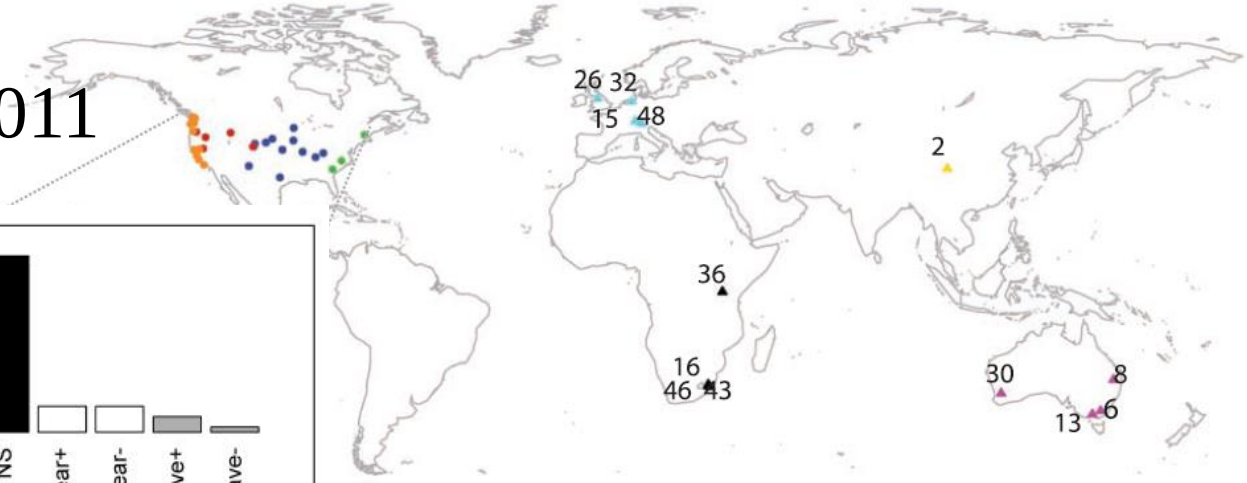


Chase and Leibold 2002

Productivity – Richness Controversy

Adler et al. 2011

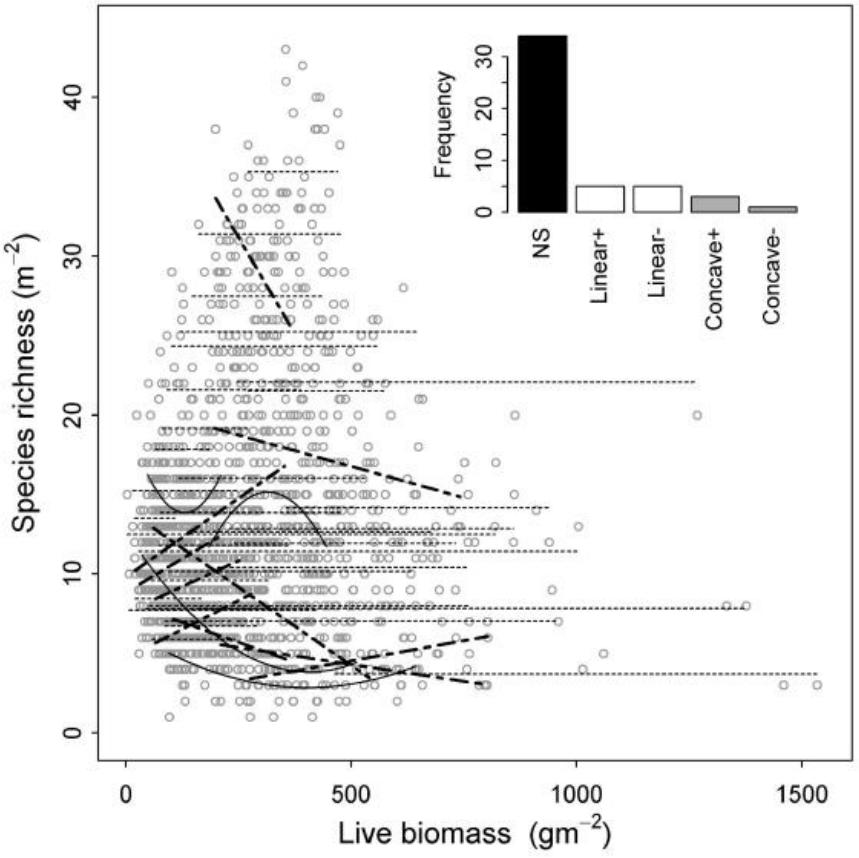




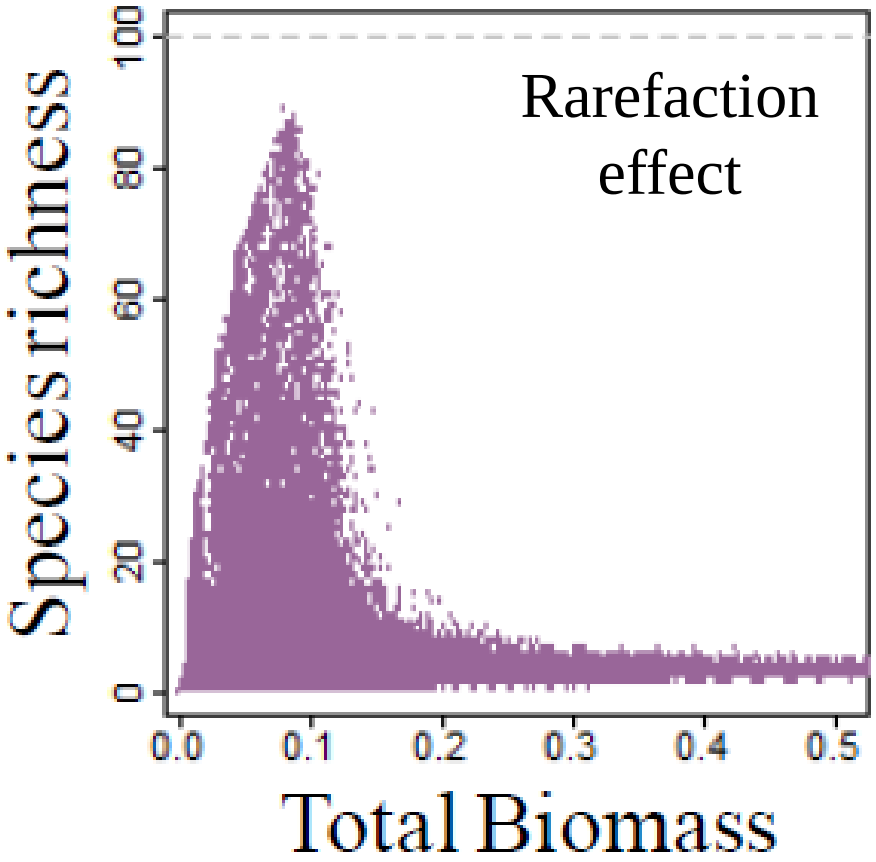
nutrient network

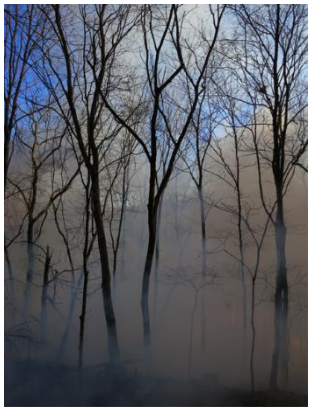
Productivity – Richness Controversy

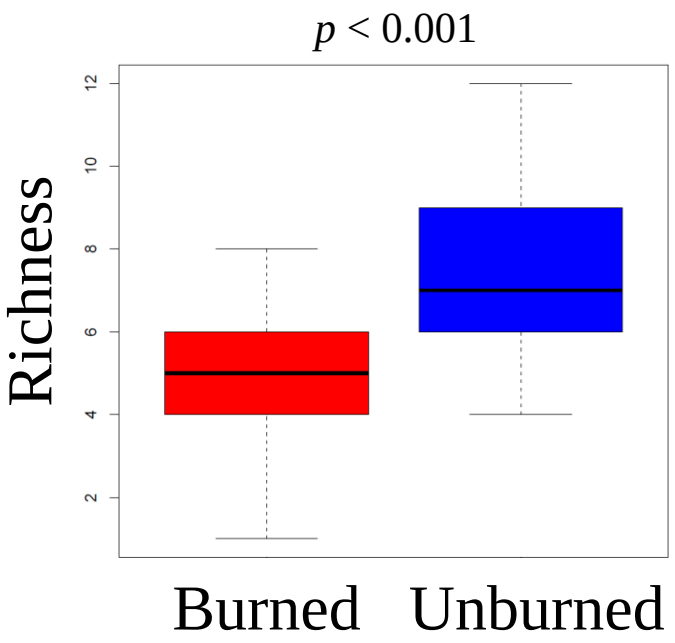
Adler et al. 2011

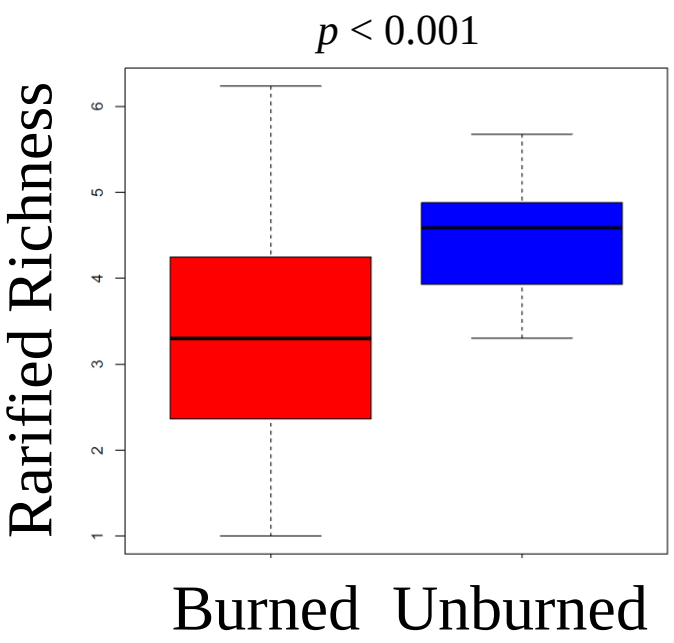


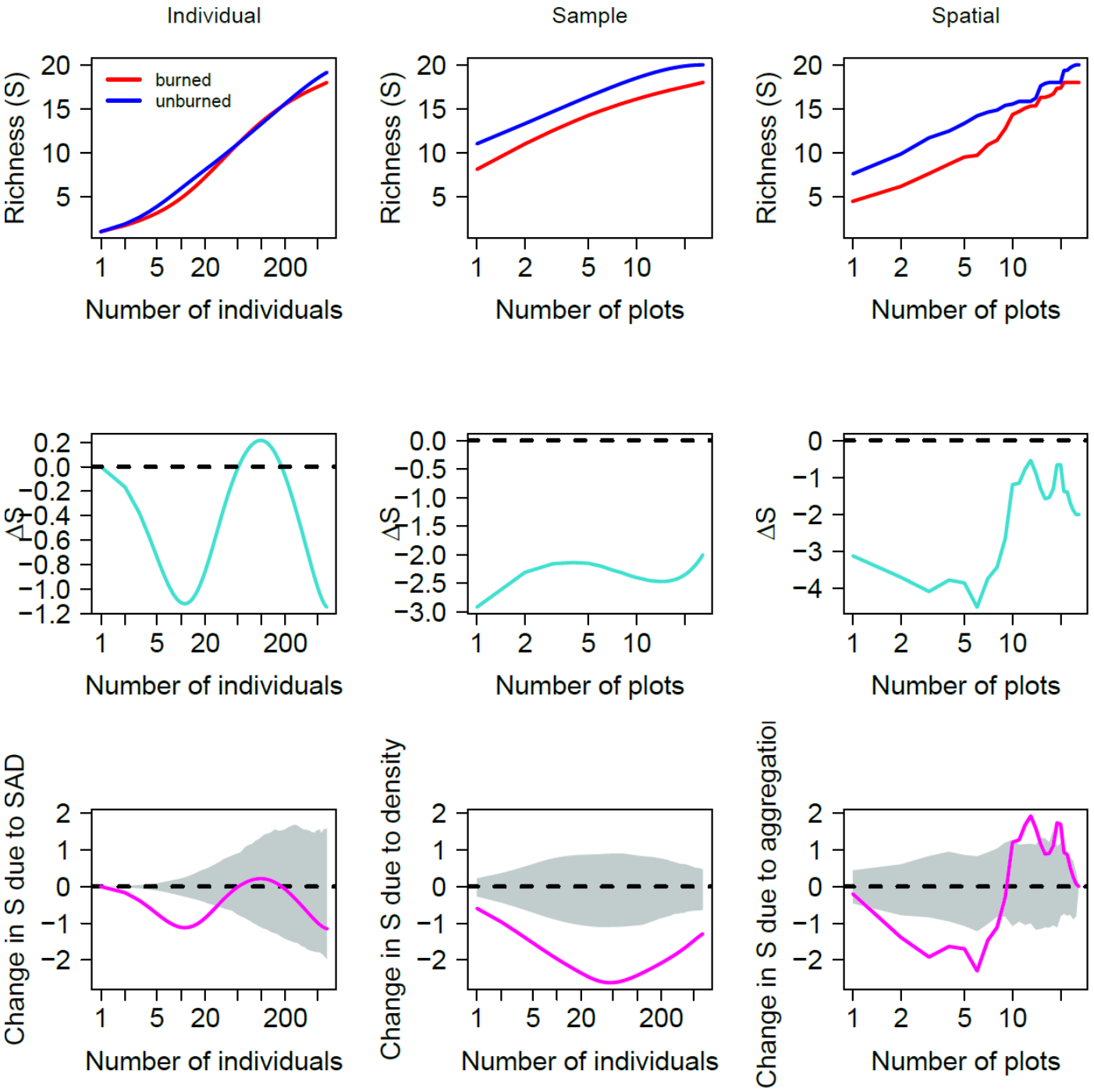
McGlinn and Palmer 2010

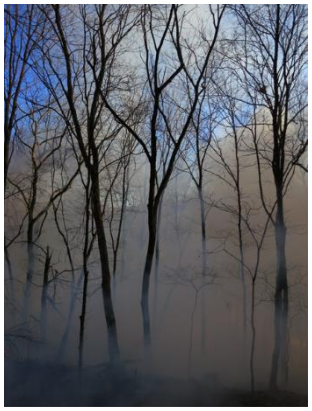


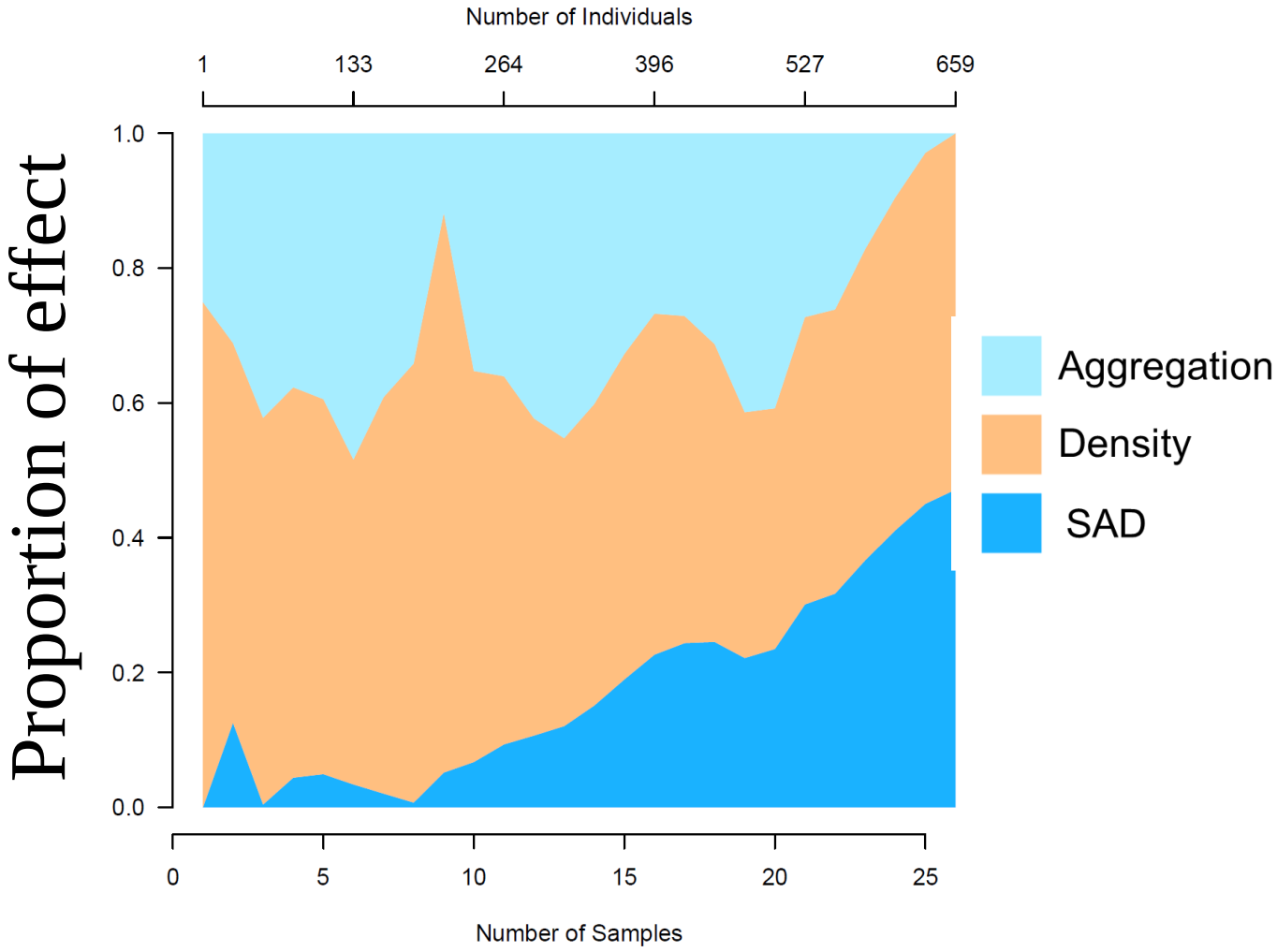


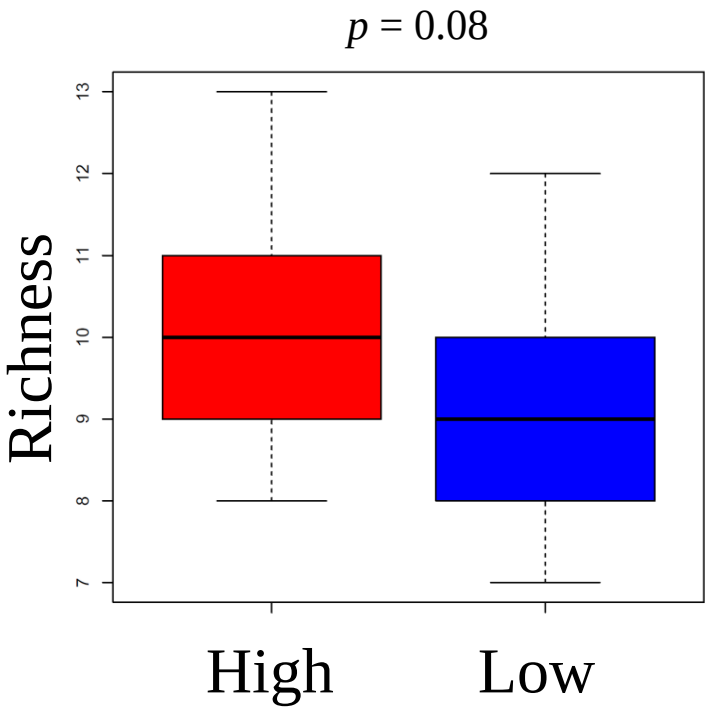

$p < 0.001$
Richness
2
4
6
8
10
12
Burned
Unburned

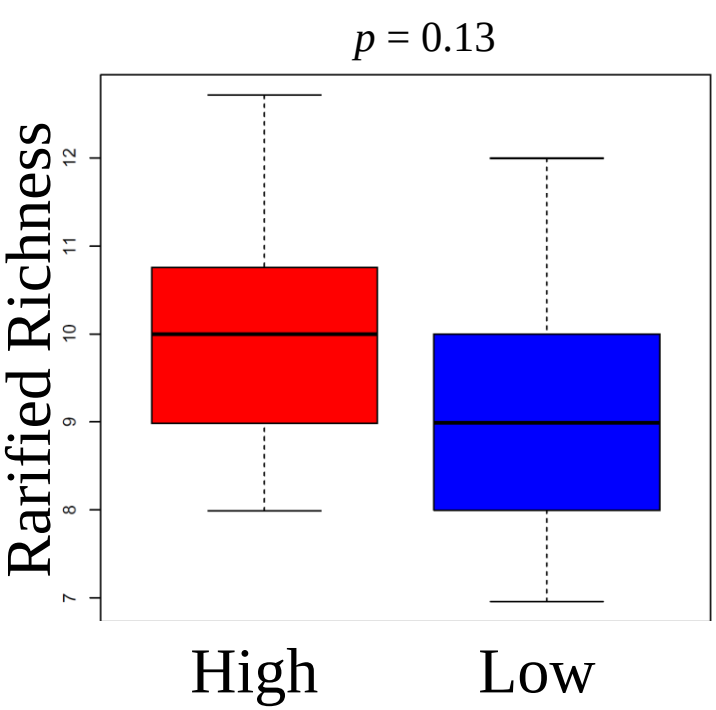

$p < 0.001$
Rarified Richness
1
2
3
4
5
6
Burned
Unburned

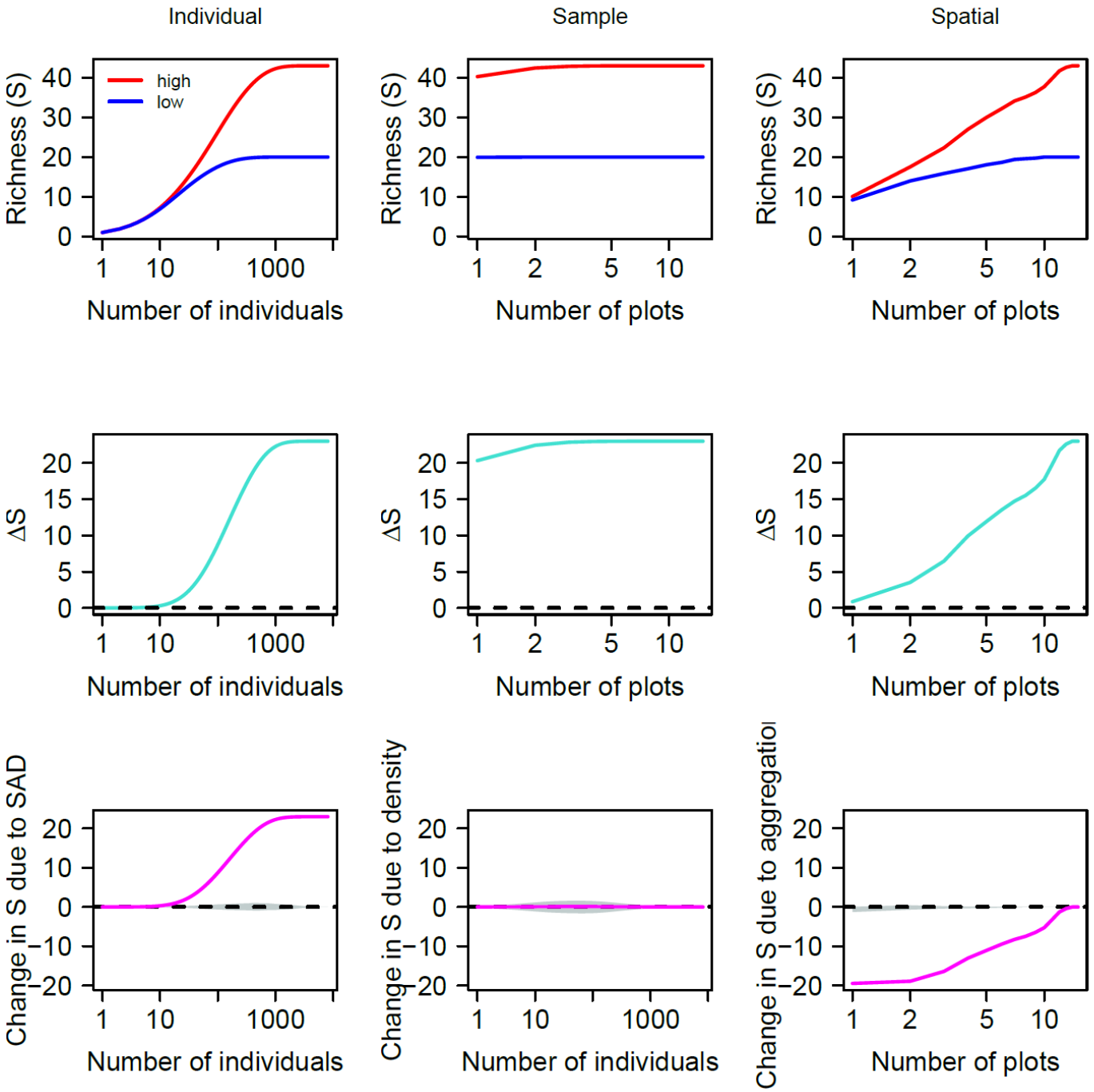

Individual
Sample
Spatial
Richness (S)
burned
unburned
Number of individuals
Number of plots
ΔS
Change in S due to SAD
Change in S due to density
Change in S due to aggregatio
1
2
5
10
20
200

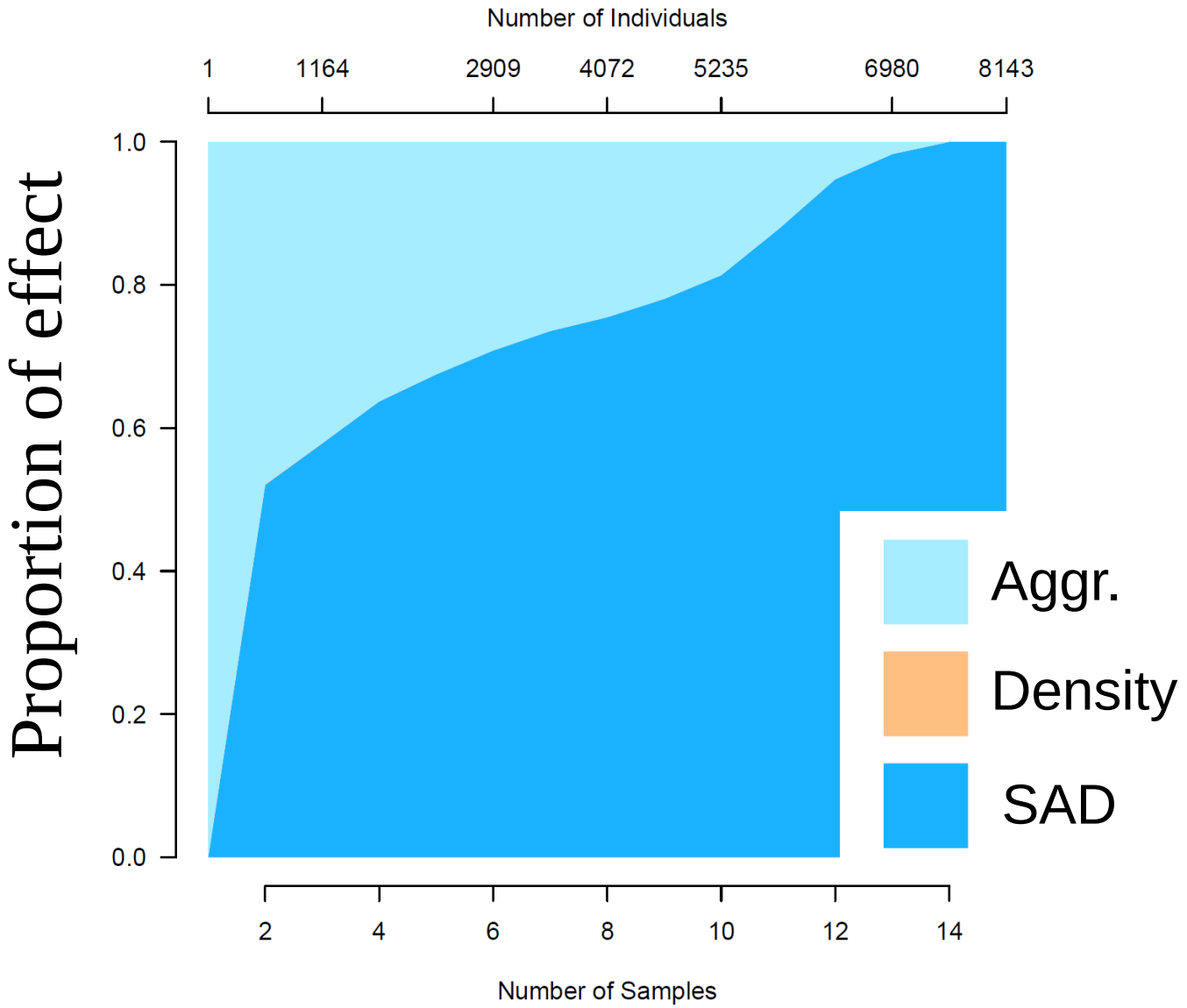



Number of Individuals
1
133
264
396
527
659
Proportion of effect
1.0
0.8
0.6
0.4
0.2
0.0
0
5
10
15
20
25
Number of Samples
Aggregation
Density
SAD


p = 0.08
Richness
13
12
11
10
9
8
7
High
Low


p = 0.13
Rarified Richness
12
11
10
9
8
7
High
Low


Individual
Sample
Spatial
Richness (S)
high
low
Number of individuals
Number of plots
ΔS
Change in S due to SAD
Change in S due to density
Change in S due to aggregatio


Number of Individuals
1
1164
2909
4072
5235
6980
8143
Proportion of effect
1.0
0.8
0.6
0.4
0.2
0.0
Aggr.
Density
SAD
2
4
6
8
10
12
14
Number of Samples

Take Home Messages

- Provides a great deal more insight than traditional analyses
- But it comes at a cost