

TOPIC 2

THREE MEASURES OF BIODIVERSITY



In this section...

What is biodiversity?

Where does it come from?

How did it become structured in the way we observe today?



Some more important reading...

Ordination Methods for Ecologists

<http://ordination.okstate.edu>

Guide to Statistical Analysis in Microbial Ecology (GUSTA ME)

<https://sites.google.com/site/mb3gustame/>

Multivariate Analysis of Ecological Data

<https://www.fbbva.es/microsite/multivariate-statistics/publications.html>

Three measures of diversity

- Coined by Whittaker (1972).
- Represents the measurement of biodiversity across different spatial scales.
- α -, β -, and γ -diversity.

Diversity can consider either,

- whether species are present or absent; this kind of data is called **presence-absence** data
 - this kind of data is binary (i.e. a species is there, or it is not there), or
- it can include aspects of how much (biomass, abundance, % cover) of each of the species that is present
 - we will call this kind of data **abundance** data.

{vegan}

decostand(x, method = "pa", ...)

site	sp_A	sp_B	sp_C	sp_D	sp_E	sp_F
site_A	1	1	1	2	1	10
site_B	1	2	1	1	2	1
site_C	4	4	5	4	5	4
site_D	10	11	10	10	10	11
site_E	0	0	0	0	1	1
site_F	0	0	0	0	1	10
site_G	1	1	1	1	1	1
site_H	10	10	10	10	10	10

site	sp_A	sp_B	sp_C	sp_D	sp_E	sp_F
site_A	1	1	1	1	1	1
site_B	1	1	1	1	1	1
site_C	1	1	1	1	1	1
site_D	1	1	1	1	1	1
site_E	0	0	0	0	1	1
site_F	0	0	0	0	1	1
site_G	1	1	1	1	1	1
site_H	1	1	1	1	1	1

- *Alpha (α) diversity* is the diversity of a community at the **local scale**, i.e. within a site, plot, transect, or quadrat.
- Represents the diversity of the smallest sampling unit (or, preferably, the mean number of species across these small subunits that comprise the sample of an ecosystem).
- Usually represented as
 1. **species richness**, which simply is the number of species,
 2. a **univariate diversity index**, e.g. Shannon or Simpson's index, or
 3. a **dissimilarity index**, e.g. Bray-Curtis, Sørensen, Jaccard, etc.

A C
B D E

A G
F D E

A C
F I D E

G C
B D E

A C
E D

A B
H

1. Species richness

- simply the number of species (S)
- as mean of all subunits, or quadrats as in this example
- $(5 + 5 + 6 + 5 + 4 + 3) / 6 = 4.667$
- can be calculated from presence-absence or abundance data (but in the case of the latter, this info is not used)

2. Univariate diversity indices

- in addition to accounting for if the species are there or not, also accounts for some measure of the relative amounts of each species, i.e. abundance data needed
- Shannon-Weaver and Simpson diversity

A C
B D E

A G
F D E

A C
F I D E

G C
B D E

A C
E D

A B
H

	Site	A	B	C	D	E	F
1	low_light	0.75	0.62	0.24	0.33	0.21	0.14
2	mid_light	0.38	0.15	0.52	0.57	0.28	0.29
3	high_light	0.08	0.15	0.18	0.52	0.54	0.56

Species A and B are dominant in low light
Species E and F are dominant in high light

site	richness	shannon	simpson
low_light	5	1.49	0.75
mid_light	5	1.52	0.77
high_light	5	1.38	0.71

Shannon index (H')

- accounts for richness as well as the relative abundances into a single metric.

Simpsons index (λ)

- emphasises evenness.

One loses all information about the individual species responses in these univariate measures of biodiversity.

Use the **vegan** R package, and the `specnumber()` and `diversity()` functions.

See the 'The Seaweeds in Two Oceans Data' PDF supplement for examples. The data are available for you to use.

3. Dissimilarity indices

- We will return to this in Topic 5.

A C
B D E

A G
F D E

A C
F I D E

G C
B D E

A C
E D

A B
H

- *Gamma (γ) diversity* is the **total diversity** of species in a region or landscape.
- Represents the species richness of all samples combined, i.e. the regional scale.
- Same metric as α -diversity (i.e. simply the number of species, or one of the univariate diversity indices).



γ -diversity

> these species are present in the ecosystem:

> A, B, C, D, E, F, G, H, I

> i.e. 9

A C
B D E

A G
F D E

A C
F I D E

G C
B D E

A C
E D

A B
H



- *Beta (β) diversity* represents the 'rate of change' in species composition of a community (or ecosystem or habitat) from place to place – with rate I mean how many species are lost or gained with distance across a landscape.
- It can be seen as a measure of heterogeneity.
- Usually applied along **gradients**.
- β -diversity can be measured in several ways...

1. True β -diversity

$$\beta = \gamma/\alpha$$

Using the previously calculated values, this would be
 $9/4.667 = 1.928$

Above, γ -diversity is the total species diversity of the ecosystem, and α -diversity is its mean species richness calculated from the sampling units (e.g. quadrats).

A C
B D E

A G
F D E

A C
F I D E

G C
B D E

A C
E D

A B
H

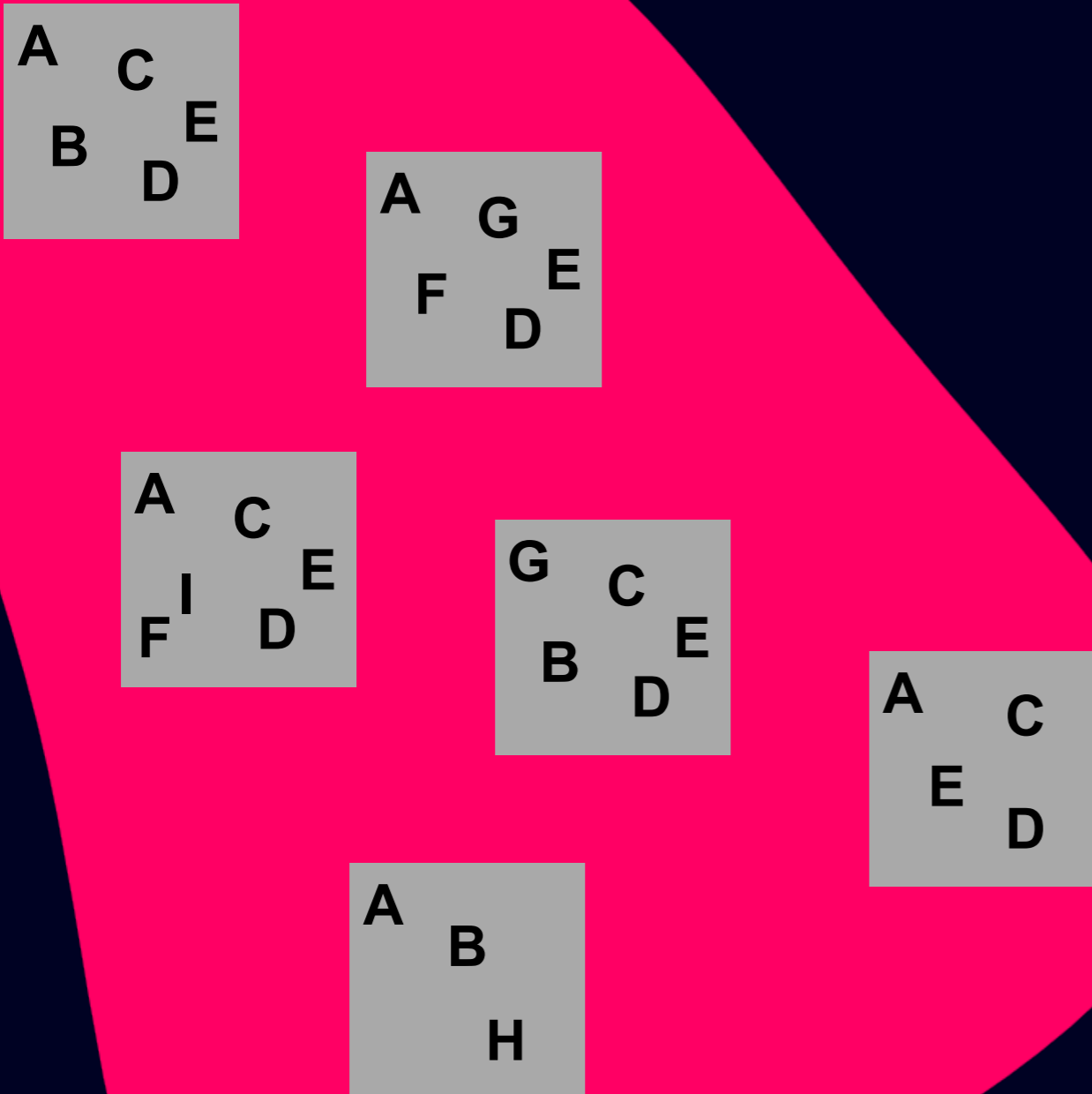
2. Absolute species turnover

$$\beta_A = \gamma - \alpha$$

Using the previously calculated values, this would be $9 - 4.667 = 4.333$

The meanings of α and γ are as before.

This quantifies how much more species diversity the entire dataset contains than an average subunit within the dataset.



3. β -diversity based on pairwise comparisons

- These are also dissimilarity indices, so we will return to this in Topic 6.

