How do we describe a community?

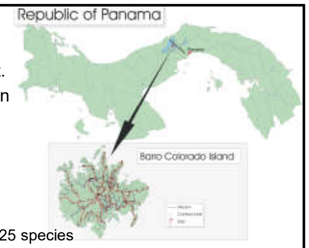
- **Community** - assemblage of spatially delimited species

Aerial view of Barro Colorado Island

- A community dataset has multiple layers
  - Overall abundance or biomass
  - Number of “species”
  - Abundance of individual species
  - Demographic or age structure of each species
  - Spatial and temporal structure of all of the above

Community Ecology Data

- Smithsonian Research Institute, very complete, publically available dataset.
- Tree counts from 50, 1 hectare plots in a regular grid covering the whole island
- Abundance of 225 species across 50 plots
- Spatial and temporal components

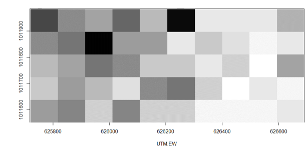


Plot	Acalypha.macrosta	Adelia.triloba	Aegiphila.paname	Alchornea.costaric	Alchornea.latifolia
1	0	0	0	2	0
2	0	0	0	1	0
3	0	0	0	2	0
4	0	3	0	18	0
5	0	1	1	3	0
6	0	0	0	2	1
7	0	0	1	0	0
8	0	0	0	2	0
9	0	5	0	2	0
10	0	0	1	2	0
11	0	0	0	10	0
12	0	1	1	3	0
13	0	1	1	1	0
14	0	0	0	4	0
15	0	2	0	2	0
16	0	2	0	2	0
17	0	0	1	2	0
18	0	1	1	0	0
19	0	0	1	1	0

→ 225 species

↓ 50 plots

Tabernaemontana arborea



Biodiversity

- Simplest form - number of species
- 1st problem – what is a species?
  - 1.4 million described species
  - Estimated 11 million undescribed
- 2nd problem – researcher taxonomic bias
  - 8 million insects
  - 1 million fungi
  - 500,000 nematodes
  - 400,000 bacteria
  - 50,000 vertebrates (about 90% described)
- 3rd problem – artificial boundaries to communities

Biodiversity

- Number of species
- Genetic diversity
- Indices of diversity:
  - Species richness (S)
  - Shannon Index (H`)
  - Simspon’s Index (D)
    - Where n_i=individuals of species I
    - S = number of species
    - N = total number of individuals
    - P_i = relative abundance of each species

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

$$D = \frac{1}{\sum_{i=1}^{s} p_i^2}$$

Equitability

- Measure of the evenness of species abundances within the community.
- Maximum = D or H if all species abundances the same
- Equitability is a percentage of the max.

$$E = \frac{D}{D_{\max}} = \frac{1}{\sum_{i=1}^{s} p_i^2} * \frac{1}{s}$$

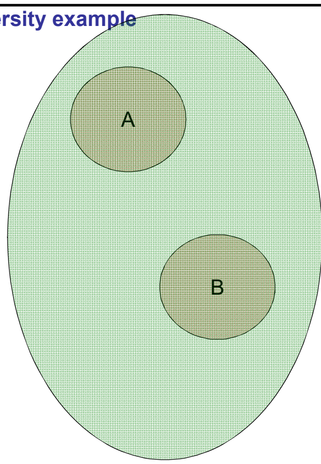
$$J = \frac{H`}{H`_{\max}} = \frac{-\sum_{i=1}^{S} p_i \ln p_i}{\ln S}$$

Spatial component of diversity

- Alpha diversity (α)
  - Number of species (S) within a given habitat
- Beta diversity (β)
  - Proportion of species in common among two areas
- Gamma diversity (γ)
  - Total biodiversity over a broad area (ecosystem level biodiversity)

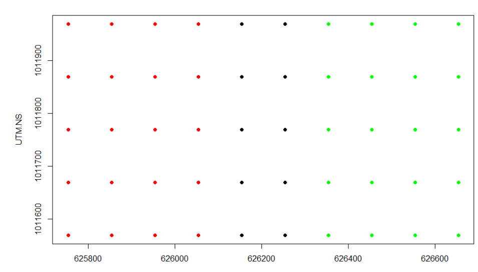
Spatial component of diversity example

- Alpha diversity (α)
  - 20 species in A
  - 15 species in B
- Beta diversity (β)
  - 8 species in both A and B
- Gamma diversity (γ)
  - 100 species in the region as a whole



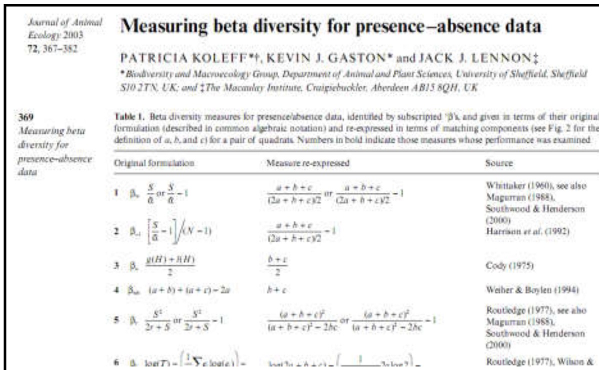
BCI Data

- Divide Island into East (green) and West (red) halves



BCI Data

- Alpha diversity (measured as mean across all 20 plots)
  - S
    - West – 92.0 (sd=6.6)
    - East – 87.6 (sd=6.6)
  - Shannon
    - West – 3.90 (sd=0.106)
    - East – 3.70 (sd=0.309)
  - Simpson
    - West – 0.966 (sd=0.006)
    - East – 0.949 (sd=0.038)
- Beta diversity (average pairwise similarity within area)
  - West – 0.401 (range 0.27 – 0.61)
  - East – 0.462 (range 0.26 – 0.76)
- Gamma diversity (total number of species in east+west)
  - 216 (why not 225?)



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Measuring beta diversity for presence–absence data

PATRICIA KOLEFF*†, KEVIN J. GASTON* and JACK J. LENNON‡

**Biodiversity and Macroecology Group, Department of Animal and Plant Sciences, University of Sheffield, Sheffield S10 2TN, UK; and ‡The Macaulay Institute, Craigiebuckler, Aberdeen AB15 8QH, UK*

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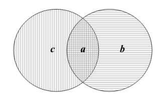
Measuring beta diversity for presence–absence data

Table 1. Beta diversity measures for presence/absence data, identified by subscripted 'β's and given in terms of their original formulation (described in common algebraic notation) and re-expressed in terms of matching components (see Fig. 2 for the definition of *a*, *b*, and *c*) for a pair of quadrats. Numbers in bold indicate those measures whose performance was examined

	Original formulation	Measure re-expressed	Source
1	$\beta_w \quad \frac{S}{\bar{\alpha}}$ or $\frac{S}{\bar{\alpha}} - 1$	$\frac{a+b+c}{(2a+b+c)/2}$ or $\frac{a+b+c}{(2a+b+c)/2} - 1$	Whittaker (1960), see also Magurran (1988), Southwood & Henderson (2000)
2	$\beta_{-1} \quad \left[\frac{S}{\bar{\alpha}} - 1\right] / (N-1)$	$\frac{a+b+c}{(2a+b+c)/2} - 1$	Harrison *et al.* (1992)
3	$\beta_c \quad \frac{g(H)+l(H)}{2}$	$\frac{b+c}{2}$	Cody (1975)
4	$\beta_{wb} \quad (a+b)+(a+c)-2a$	$b+c$	Weiher & Boylen (1994)
5	$\beta_r \quad \frac{S^2}{2r+S}$ or $\frac{S^2}{2r+S} - 1$	$\frac{(a+b+c)^2}{(a+b+c)^2-2bc}$ or $\frac{(a+b+c)^2}{(a+b+c)^2-2bc} - 1$	Routledge (1977), see also Magurran (1988), Southwood & Henderson (2000)
6	[illegible]	[illegible]	Routledge (1977), Wilson &

Etc… numerous measures.



Comparing communities

- Index of community similarity
- One qualitative (Jaccards Index), one quantitative (PSI)
- Percent Similarity Index (PSI)
  - Quantitative

$$PSI = \sum_{i=1}^{S} \min P_i$$

  - Where P_i = the proportion of the community composed of species i.
- 0.0 = species proportional abundances not similar among communities
- 1.0 = species proportional abundances identical

Jaccards Index (Qualitative)

- Species abundance ignored, only presence or absence of species used.

$$Jaccards = \frac{a}{a+b+c}$$

- Where
  - a = number of species in both communities
  - b= number of species unique to community 1
  - c = number of species unique to community 2

- 0 = no species in common
- 1.0 = all species in common

PSI Example

	Com. 1	Com 2	$p_{i\ sp.\ 1}$	$p_{i\ sp.\ 2}$	Min p_i
Species 1	**9**	**5**	0.183673	0.084746	0.084746
Species 2	**7**	**5**	0.142857	0.084746	0.084746
Species 3	**3**	**4**	0.061224	0.067797	0.061224
Species 4		**5**	0	0.084746	0
Species 5	**5**	**28**	0.102041	0.474576	0.102041
Species 6	**25**	**9**	0.510204	0.152542	0.152542
Species 7		**3**	0	0.050847	0
N	49	59		**PSI**	**0.485299**

Diversity Indices		
S	**5**	**7**
H'	**1.34**	**1.60**

Jaccards Index Example

	Com. 1	Com 2	Jaccards		
Species 1	**9**	**5**	a		
Species 2	**7**	**5**	a		
Species 3	**3**	**4**	a		
Species 4	**0**	**5**	c		
Species 5	**5**	**28**	a	**Total**	**7**
Species 6	**25**	**9**	a	**A**	**5**
Species 7	**0**	**3**	c	**B**	**0**
				C	**2**

$$Jaccards = \frac{a}{a+b+c}$$

Jaccards	**0.714286**

Spreadsheet

	Community 1	Community 2	Community 3	Community 4		P_i^2				
Species 1	60	20	45	50		0.054505	0.015625	0.101856	0.0625	
Species 2	24	25	25	25		0.008721	0.024414	0.031437	0.015625	
Species 3	1	0	0	0		1.51E-05	0	0	0	
Species 4	8	12	0	0		0.000969	0.005625	0	0	
Species 5	5	6	5	0		0.000379	0.001406	0.001257	0	
Species 6	6	7	23	0		0.000545	0.001914	0.026608	0	
Species 7	27	40	25	25		0.011037	0.0625	0.031437	0.015625	
Species 8	126	50	18	100		0.240367	0.097656	0.016297	0.25	
Species 9	0	0	0	0		0	0	0	0	
Species 10	0	0	0	0		0	0	0	0	
Species 11	0	0	0	0		0	0	0	0	
Species 12	0	0	0	0		0	0	0	0	
Species 13	0	0	0	0		0	0	0	0	
Species 14	0	0	0	0		0	0	0	0	
Species 15	0	0	0	0		0	0	0	0	
Total Abundance	**257**	**160**	**141**	**200**		0.316538	0.209141	0.208893	0.34375	
Within Site										
S	8	7	6	4						
Simpsons Index (D)	3.16	4.78	4.79	2.91						
Simp.Equitability (E)	0.39	0.68	0.80	0.73						
Shannon Diversity (H)	1.44	1.71	1.65	1.21						
Shan.Equitability (J)	0.69	0.88	0.92	0.88						
Among Sites										
γ diversity		8								
Comm. 1-2		**PSI**	0.710							
a	7	**Jaccards**	0.875							
b	0	**Bray Curtis**	0.671							
c	1									
β diversity	1.07									
Comm. 1-3		**PSI**	0.602							
a	6	**Jaccards**	0.750							
b	0	**Bray Curtis**	0.618							
c	2									
β diversity	1.14									
Comm. 1-4		**PSI**	0.922							
a	4	**Jaccards**	0.500							
b	0	**Bray Curtis**	0.871