Measurement of Biodiversity

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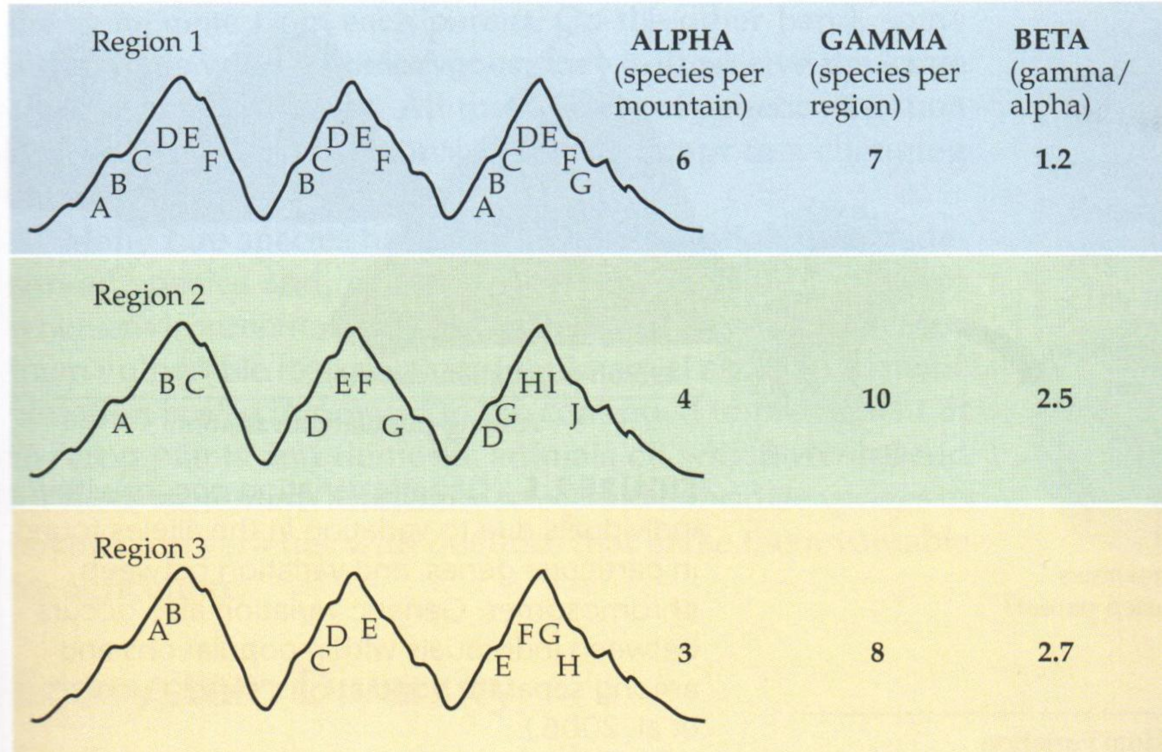


FIGURE 2.4 Biodiversity indexes for three regions, each consisting of three separate mountains. Each letter represents a population of a species; some species are found on only one mountain, while other species are found on two or three mountains. Alpha, gamma, and beta diversity values are shown for each region. If funds were available to protect only one *mountain range*, Region 2 should be selected because it has the greatest gamma (total) diversity. However, if only one *mountain* could be protected, a mountain in Region 1 should be selected because these mountains have the highest alpha (local) diversity, that is, the greatest average number of species per mountain. Each mountain in Region 3 has a more distinct assemblage of species than the mountains in the other two regions, as shown by the higher beta diversity. If Region 3 were selected for protection, the relative priority of the individual mountains should then be judged based on how many unique species are found on each mountain.

Source: Conservation biology, R. B. Primack

Measures of species richness

1. Species Richness Indices

a. Margalef's diversity index

$$D_{Mg} = \frac{(S-1)}{\ln N}$$

b. Menhinick' index

$$D_{Mn} = \frac{S}{\sqrt{N}}$$

2. Species accumulation curves or Species area curves

Species Accumulation Curve

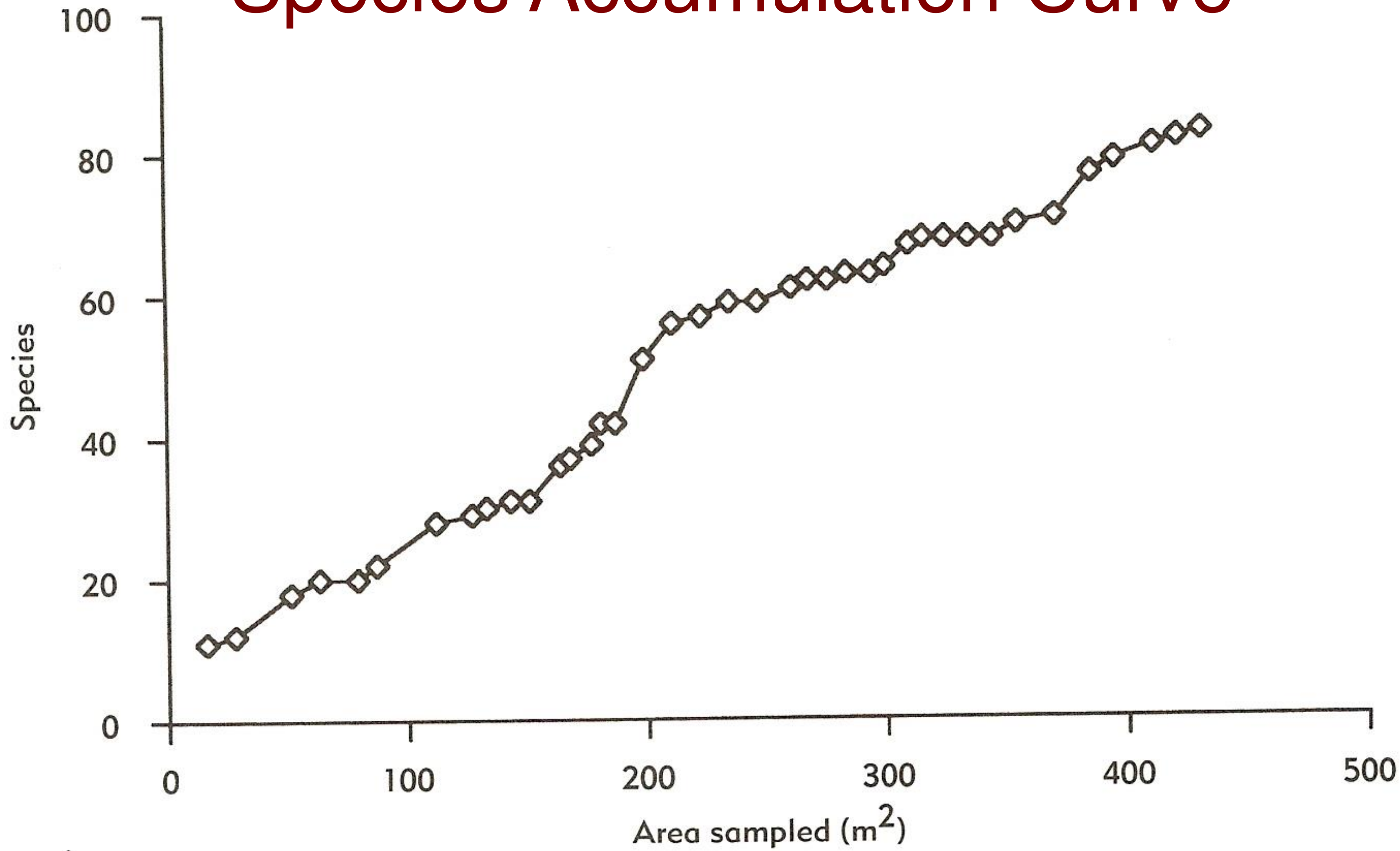


Figure 1.1 A species accumulation curve for fish found in the floating meadow habitat at the Mamirauá Sustainable Development Reserve in the Brazilian Amazon. The number of species encountered is plotted against the area sampled. Data points reflect the order in which samples were taken. These data were kindly supplied by P. A. Henderson and the sampling methodologies are described in Henderson and Hamilton (1995) and Henderson and Crampton (1997).

Source: Measuring biological diversity, Magurran

Species Accumulation Curve

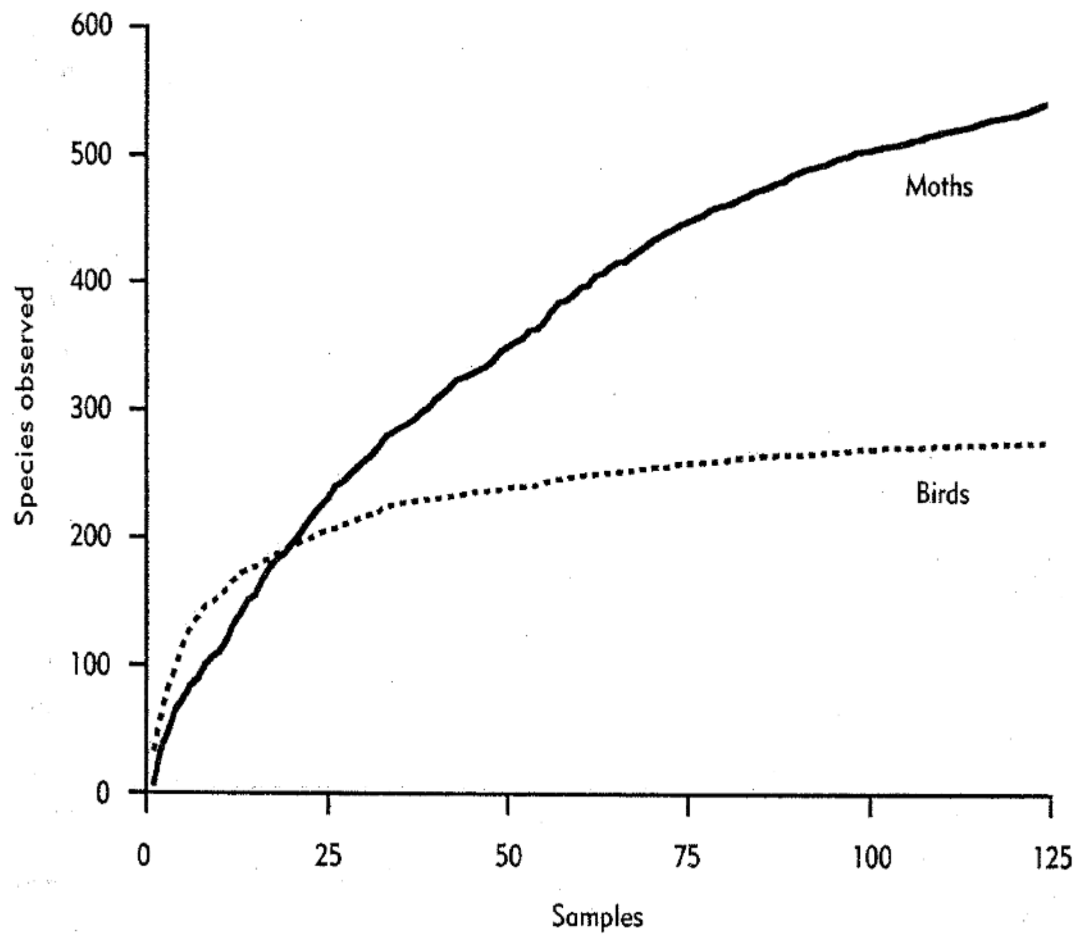


Figure 3.4 Species accumulation curves of moths and birds in Fife, Scotland. Graphs are based on species occurrence in 125, 5×5 km grid squares. Average species richness (based on 50 randomizations; see Colwell (2000)) is shown. The accumulation curve for birds—an extremely well-recorded group—is beginning to reach an asymptote. In contrast, the curve for moths, a much less intensively sampled taxon, shows no signs of leveling off. (Data courtesy of Fife Nature.)

Source: Measuring biological diversity, Magurran

Measures of species richness

3. Non-parametric Estimators:

Chao1 (abundance data)

$$S_{\text{Chao 1}} = S_{\text{obs}} + \frac{F_1^2}{2F_2}$$

Chao2 (presence-absence data)

$$S_{\text{Chao 2}} = S_{\text{obs}} + \frac{Q_1^2}{2Q_2}$$

Jackknife and Bootstrap methods

Where S_{obsv} = No. of species in sample; F1 = No. of singletons; F2 = At least two individuals

Q1= No. of species that occur in one sample only (unique); Q2 = Np. Pf species that occur in more than 1

Which index is better? Which one to use?

- Homogeneity vs Heterogeneity of sample
- Turnover between sites
- Comparative studies to check reliability of estimates

Species-Abundance data

1. Rank/abundance plots or
   Dominance/diversity plots

2. Fischer Plots

3. Preston Plots

Rank Abundance Plot

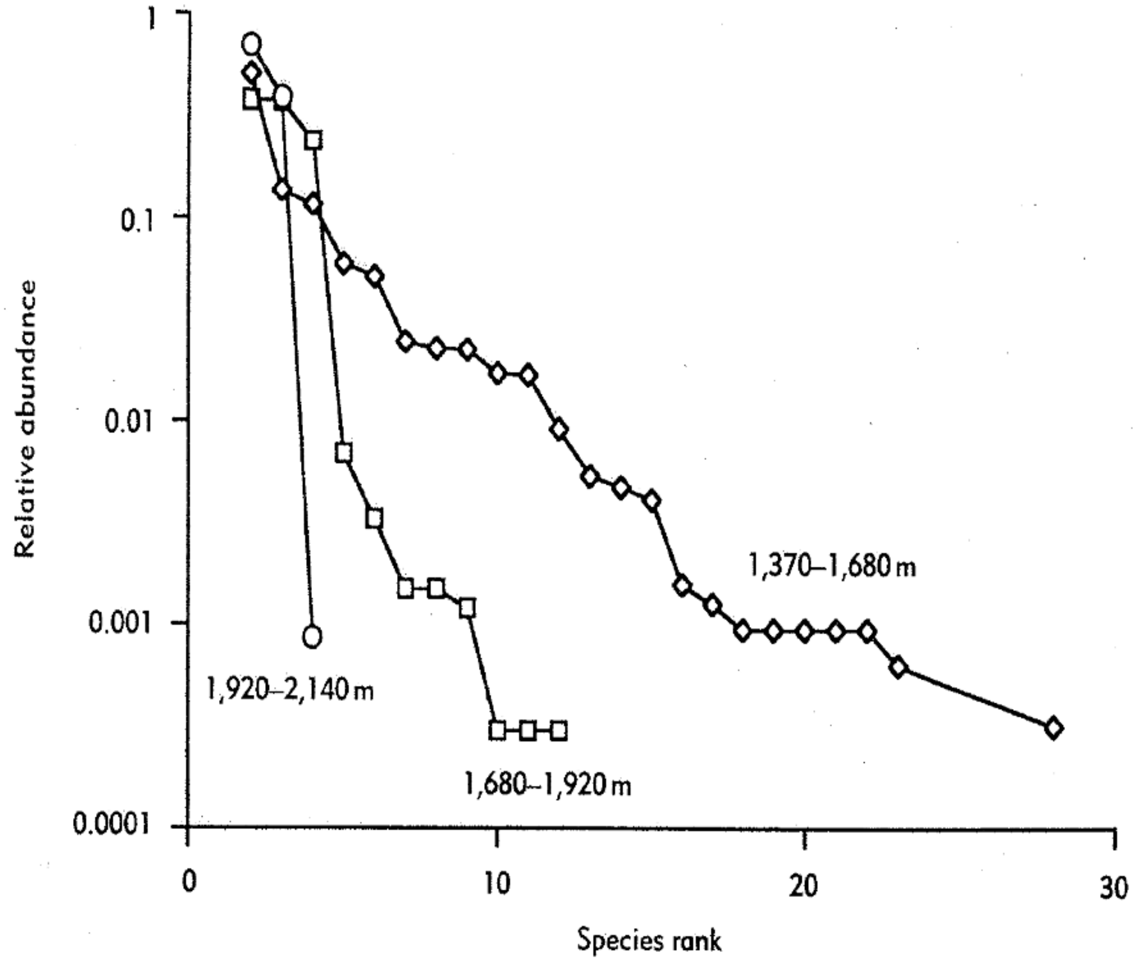
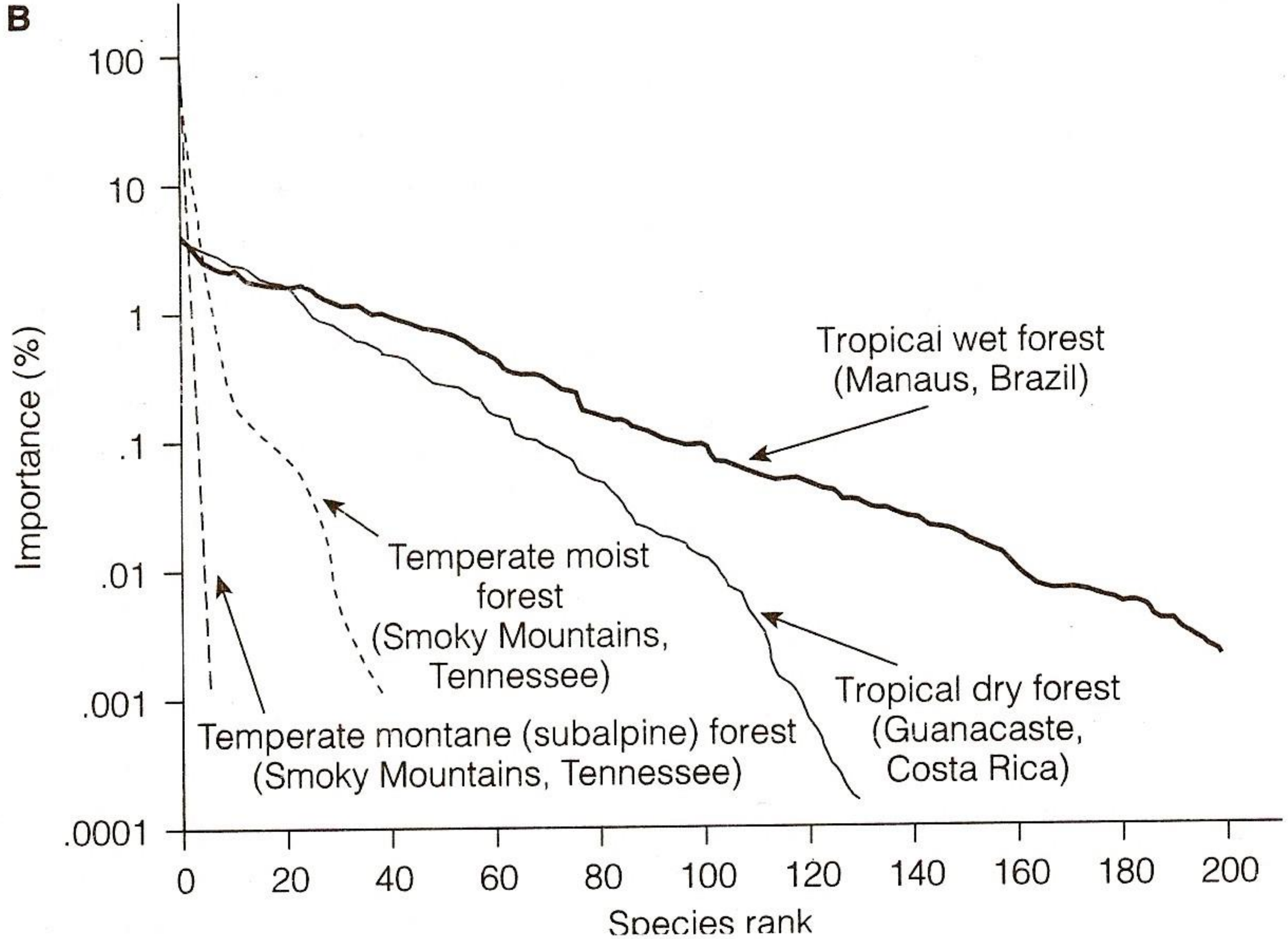


Figure 2.4 An example of a rank/abundance or Whittaker plot. The *y* axis shows the relative abundance of species (plotted using a $\log_{10}$ scale) while the *x* axis ranks each species in order from most to least abundant. The three lines show the densities of trees, in relation to elevation, on quartz diorite in the central Siskiyou Mountains in California and Oregon. Species richness decreases, and assemblages become less even (as indicated by increasingly steeper slopes) at higher altitudes. (Data from table 12, Whittaker 1960.)

Source: Measuring biological diversity, Magurran

Rank Abundance Plot



Source: Ecology, Odum

Fischer Plot

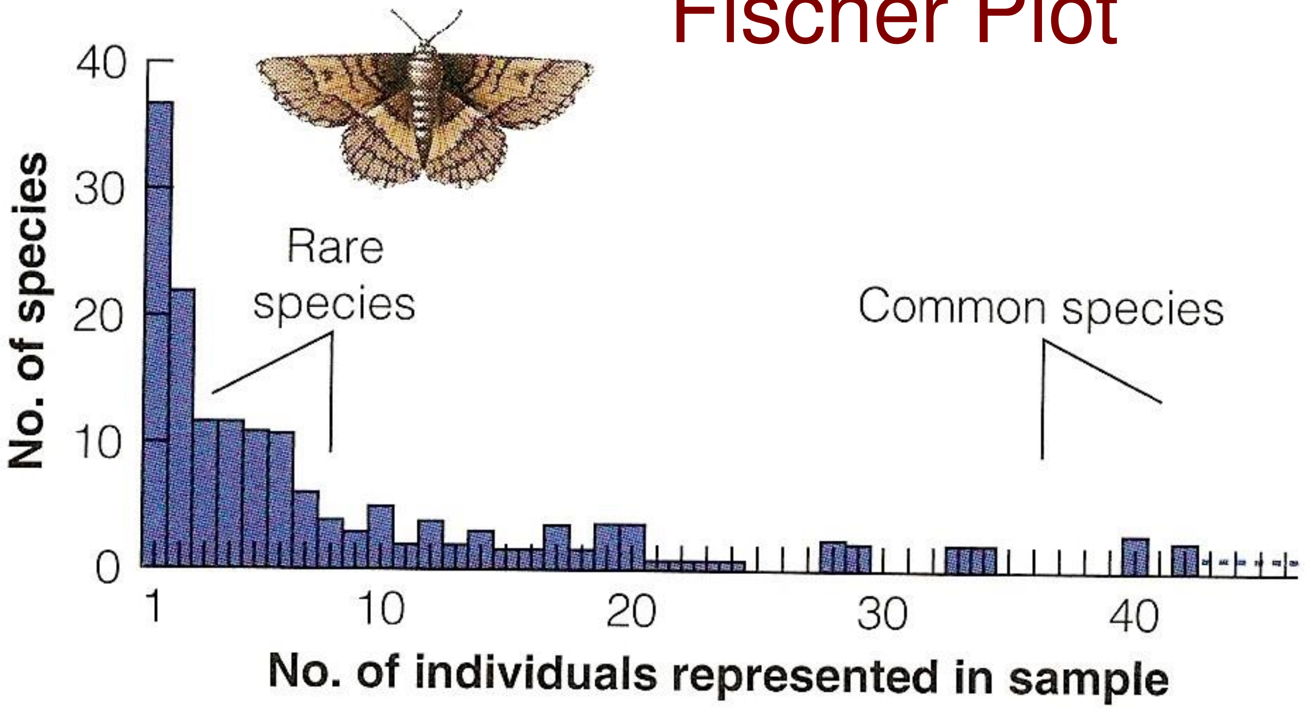
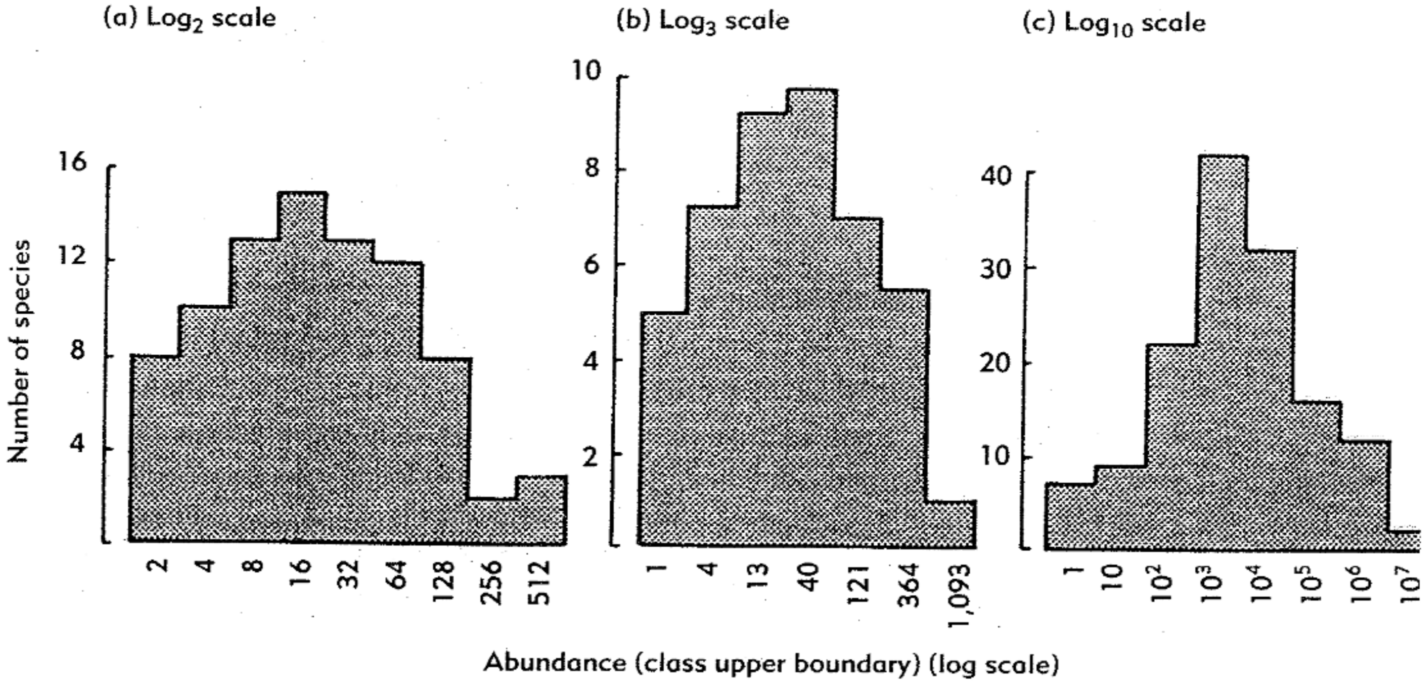


Figure 19.1 Relative abundance of Lepidoptera (butterflies and moths) captured in a light trap in Rothamsted, England, in 1935. A total of 6814 individuals of 197 species were caught (some of the abundant species are not shown). Thirty-seven species were represented in the catch by only a single specimen, and six common species constituted 50% of the catch. One very common species was represented by 1799 individuals in the catch. (Modified from Williams 1964.)

Source: Ecology, Krebs



Preston Plot

Figure 2.9 Frequency of species in relation to abundance. A "normal" bell-shaped curve of species frequencies may be achieved by logging species abundances. Three log bases (2, 3, and 10) have been used for this purpose. The choice of base is largely a matter of scale – it is clearly inappropriate to use $\log_{10}$ if the abundance of the most abundant species is $<10^2$ or to adopt $\log_2$ if it is $>10^6$. Less obviously, the selection of one base in preference to another can determine whether a mode is present. This is a crucial consideration since the presence of a mode is often used to infer "log normality" in a distribution. (The position of the class boundaries can also affect the likelihood of detecting a mode, see text for further details.) The figure illustrates three assemblages, each plotted using a different log base. (a) Log_2: diversity of ground vegetation in a deciduous woodland at Banagher, Northern Ireland. This usage follows Preston (1948). Species abundances are expressed in terms of doublings of the number of individuals. For example, successive classes could be ≤ 2 individuals, 3–4 individuals, 5–8 individuals, 9–16 individuals, and so on. It is conventional to refer to these classes as octaves. (b) Log_3: snakes in Panama. In this example the upper bounds of the classes are 1, 4, 13, 40, 121, 364, and 1,093 individuals. (c) Log_{10}: British birds. Classes in $\log_{10}$ represent increases in order of magnitude: 1, 10, 100, 1,000, and so on. In all cases the *y* axis shows the number of species per class. These graphs may be referred to as "Preston" plots. (Data in (b) and (c) from Williams 1964; redrawn with kind permission of Kluwer Academic Publishers from fig. 2.7, Magurran 1988.)

Source: Measuring biological diversity, Magurran

Fischer & Preston Plots

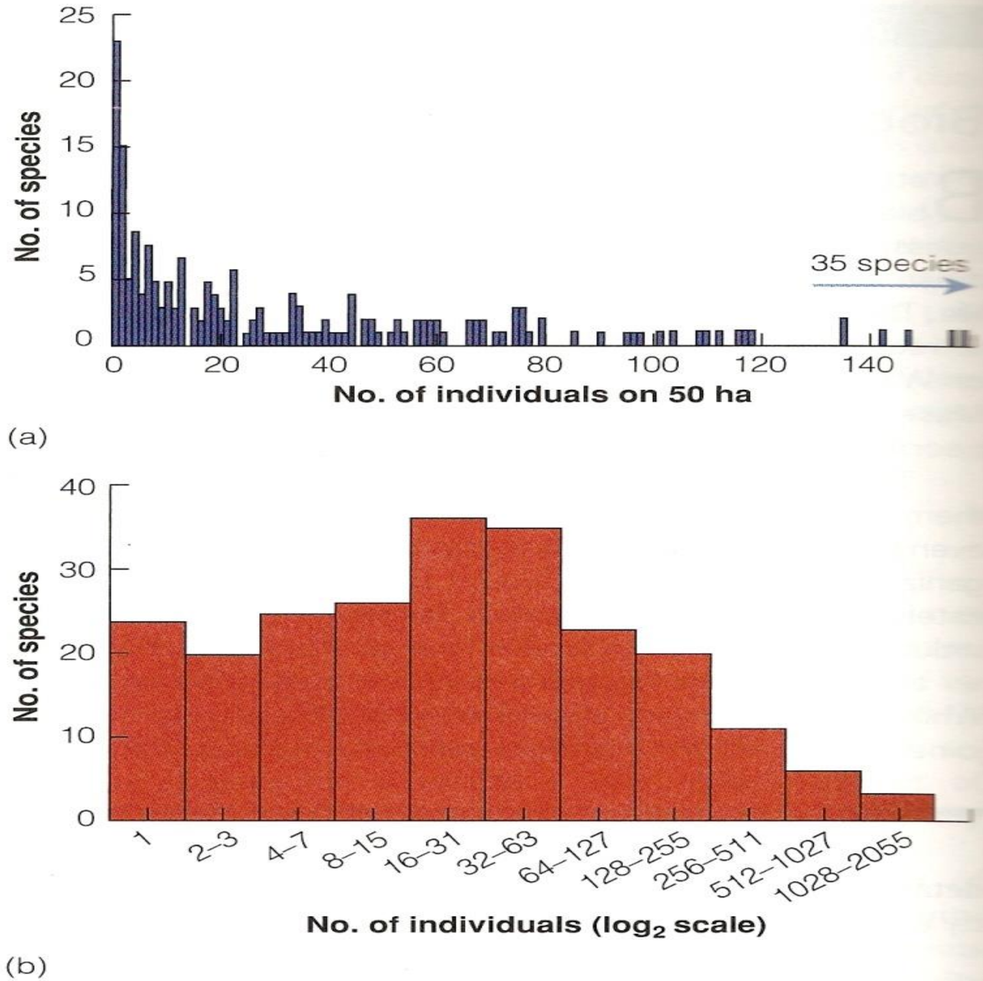


Figure 19.2 Relative abundance of tropical rainforest trees >10 cm diameter on a 50-ha plot on Barro Colorado Island, Panama, in 2005. A total of 229 tree species were present on this plot. Twenty-four species were represented in the census by only a single tree, and nine common species constituted 40% of the total tree count of 21,456 trees. One very common species was represented by 1909 individuals. (a) Presents the data on a linear scale, while (b) uses a logarithmic scale for the *x*-axis. (Data from Barro Colorado Island Web site http://ctfs.si.edu/datasets/bci, courtesy of Hubbell et al. 2005.)

Source: Ecology, Krebs

Species diversity measures

- Simpson’s diversity index
- Shannon Wiener index

Measuring Beta diversity

Beta diversity (or turnover) is a measure of the extent to which the diversity of two or more spatial units differ in terms of their species composition

1. Indices of Beta diversity

Whittaker's measure

Measuring beta-diversity

2. Measure of complementarity:

Jacard similarity index

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

Sorensen Index

$$C_S = \frac{2a}{2a+b+c}$$

Where
a= number of species common between site 1 and site 2
b= number of species in site 1
c= number of species in site 2

Biodiversity Measurements at different levels

Table 26.10. Levels of inventory, and examples of techniques and information provided (see Singh 2002, Singh and Khurana, 2002).

Level	Techniques	Examples of information provided
Genetic	Molecular techniques, e.g. allozyme electrophoresis, RFLP (restriction fragment length polymorphism), DNA fingerprinting, PCR (polymerase chain reaction), etc.	Genetic variability among individuals within a population, subdivisions of populations, genetic differentiation among species, inbreeding and out breeding depression, morphologically cryptic species
Population	Point and Distance sampling, Population viability analyses	Rarity and threat status, sustainable harvest/ yield, population size, minimum viable population
Species	Natural history collections, Taxonomic studies, Geographic information system, Point and Broad scale sampling, Indices for alpha, beta and gamma diversities	Identity and geographic distribution, new taxa, areas of endemism, phylogenetic relationships, possible uses, organisation of individuals in community, species turnover
Ecosystems and landscape	Broad scale sampling, Remote sensing, Forest inventories, Pattern diversity	Ecosystem inventories, fragmentation, habitat destruction, threatened ecosystems, ecosystem processes, earth cover and land use, compositional diversity

Biodiversity Measurements

Table 26.13. Important multispecies inventory approaches (compiled from various sources, see Singh and Khurana, 2002).

Inventory type	Proposed monitoring
All taxa biodiversity inventory (ATBI)	Presence, occupancy and natural history of all the species inhabiting a site
Rapid biodiversity assessment (RBA)	Selected focal taxa to measure biological richness and uniqueness of a site
Visual encounter surveys (VES)	Used for RBAs
All biota taxonomic inventory (ABTI)	Focus on specific taxa and inventory of all species in those groups on a global basis

References

- Magurran, A.E., 2013. *Measuring biological diversity*. John Wiley & Sons.

- Krebs, C.J., 2009. Ecology the Experimental Analysis of Distribution. *San Francisco, London*, p.416. (Pearson sixth edition

- Primack, R.B., 2012. *A primer of conservation biology* (Sinauer Associates, 5th edition).