BIOL 3340 Ecology Study Guide for Exam 2: Lecture 14: Species Diversity

Source: the lecture slides (text, figures and slide notes). No textbook.

Each heading is one Study Lab objective. [L13 s08] = Lecture 13, slide 8.

(teal italics) = plain meaning of the word before it. ⚠ **Do not mix up = a look-alike pair to keep apart.** **Amber dotted words** = names printed on the figure beside them.

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Click a line to jump to it. The PDF side panel (bookmarks) has the same parts.

L14.1 Defining communities: organismic vs individualistic models

⚠ **Do not mix up: Individualistic is NOT sharp boundaries: species co-occur only because they share physiological needs.** [L14 s08, L14 s09]

Defining a community: walk up or down a mountain and the environment and communities change. [L14 s06]

Question: environment or competition, which matters more for predicting shifts in species composition? [L14 s06]

Organismic model: a community is equivalent to a **superorganism** *(one big living unit)*. [L14 s07]

Like an animal body, it is more than just a collection of organs. [L14 s07]

Organismic model (Clements): a community was predictable, with distinct associations of species. [L14 s08]

Organismic model: separate communities were separated by **sharp boundaries**. [L14 s08]

Individualistic model: species occur together because of similar physiological *(body function)* requirements and tolerances. [L14 s09]

Hypothesis **1** is the organismic model; hypothesis **4** is the individualistic model. [L14 s07, L14 s09]

Organismic vs individualistic model

Idea	Organismic model	Individualistic model
Community is	A superorganism	Species with similar physiological requirements and tolerances
Boundaries	Sharp boundaries between communities	No sharp boundaries
Species groups	Distinct, predictable associations	Species do not group together
Matches hypothesis	Hypothesis **1**	Hypothesis **4**
Whittaker's mountain results	Not supported	Supported

Table source: [L14 s07, L14 s08, L14 s09, L14 s11, L14 s12]

L14.2 Whittaker gradient test: what sets species composition

⚠ Do not mix up: Whittaker supported hypothesis 4, NOT the organismic model: no sharp boundaries, no defined groups. [L14 s12]

Environmental gradient *(steady change in conditions across space)*: such as moisture on an uninterrupted mountain slope. [L14 s10]

Whittaker proposed four hypotheses to explain plant distribution patterns on the gradient. [L14 s10]

In the four hypotheses, each curve is one species. [L14 s11]

Each curve shows that species population size along the environmental gradient. [L14 s11]

Whittaker tested the four hypotheses on vegetation of mountain ranges in the western U.S. [L14 s12]

Result: **competition** does not produce **sharp boundaries** between species. [L14 s12]

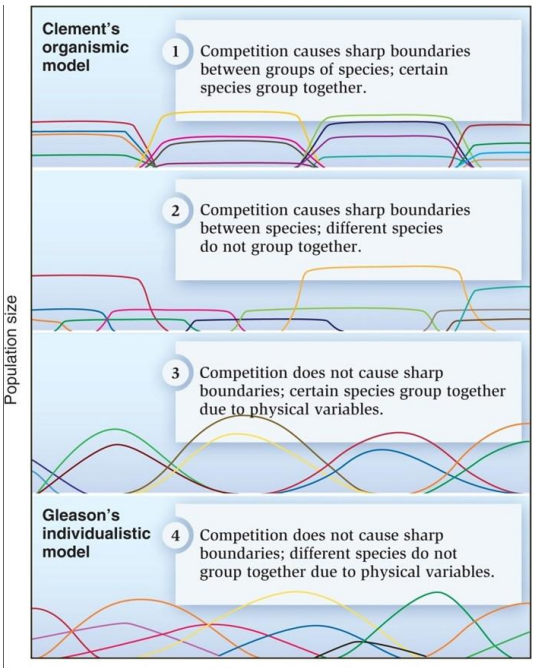
Adaptation to physical variables does not result in defined groups of species. [L14 s12]

Species interactions strongly affect where some species are able to exist. [L14 s12]

But adaptations of individual species to the environment matter more for most species' distributions. [L14 s12]

Answer to the mountain question: environment matters more than competition for most species. [L14 s06, L14 s12]

Composition at any gradient point is largely set by temperature, water availability, light, pH. [L14 s13]



Four hypotheses: one curve per species along an environmental gradient [L14 s11]

On the figure: environmental gradient · competition · sharp boundaries

Four hypotheses along a gradient

Hypothesis	Competition causes sharp boundaries?	Species group together?	Model
1	Yes, between groups of species	Yes, certain species group together	Organismic model
2	Yes, between species	No, different species do not group	Not named
3	No	Yes, certain species group, due to physical variables	Not named
4	No	No, different species do not group, due to physical variables	Individualistic model (supported)

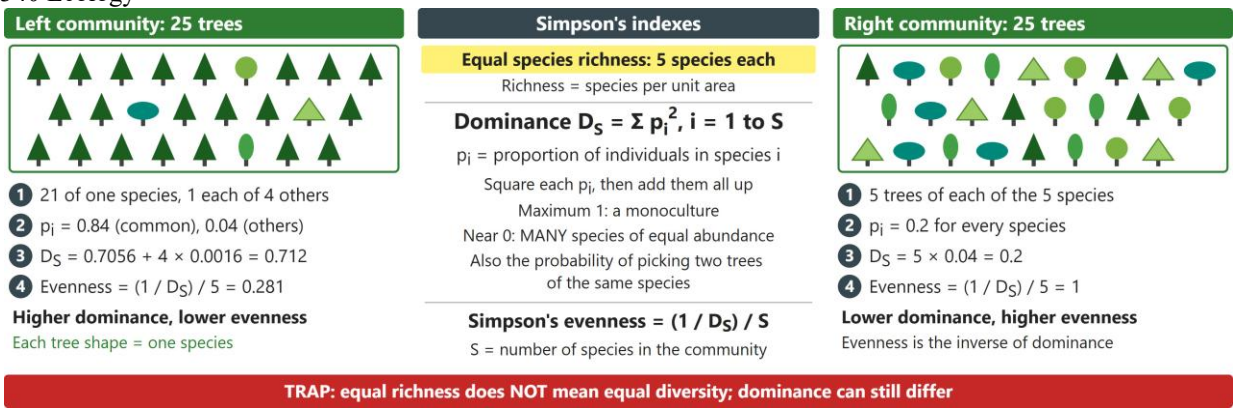
Table source: [L14 s11, L14 s12]

L14.3 Species richness and Simpson dominance

⚠ Do not mix up: Equal richness does NOT mean equal diversity: both have 5 species but dominance differs. [L14 s17, L14 s18]

Question: which of two tree communities contains greater species diversity? [L14 s15]

Two ways to measure one location: **1**) species richness; **2**) species dominance (or evenness). [L14 s16]



Two 25 tree communities with equal richness but different dominance and evenness [L14 s20]

On the figure: left community · species richness · dominance · monoculture · evenness

Species richness: the number of species per unit area (such as species per hectare). [L14 s17]

Both tree communities contain five species, so they are equal in species richness. [L14 s17]

Species dominance: higher when one species is present in greater proportion than others. [L14 s18]

Evenness is the inverse of dominance. [L14 s18]

The **left community** has higher species dominance than the right. [L14 s18]

Simpson's dominance is one of the most common of many dominance methods. [L14 s18]

Simpson's dominance index: Ds = sum of pi squared, from species **1** through species S. [L14 s19]

pi *(share of all individuals)*: the proportion of individuals in the ith species. [L14 s19]

Square each species' proportion, then sum the values for all species. [L14 s19]

Range: maximum **1** in a **monoculture** *(only one species)*; minimum near **0,** MANY species of equal abundance. [L14 s19]

Probability meaning: the chance of picking two trees of the same species. [L14 s21]

Community **1**: p(species **1** AND species **1**) = **0.84** x **0.84** = **0.7056.** [L14 s21]

Community **2**: p(species **1** AND species **1**) = **0.2** x **0.2** = **0.04.** [L14 s21]

The community with **21** trees of one species has lower species evenness. [L14 s21]

The community with **5** trees of each species has higher evenness. [L14 s21]

Simpson's dominance worked example

Step	Left community	Right community
1. Count trees	**21** trees of the most common species, **1** tree each of **4** others (25 trees)	**5** of each of the **5 species** (25 trees)
2. Proportion pi	**0.84** (most common), **0.04** (each other)	**0.2** for each species
3. Square each pi	**0.84** x **0.84** = **0.7056**; **0.04** x **0.04** = **0.0016**	**0.2** x **0.2** = **0.04**
4. Sum = Ds	**0.7056** + **0.0016** + **0.0016** + **0.0016** + **0.0016** = **0.712**	**0.04** + **0.04** + **0.04** + **0.04** + **0.04** = **0.2**

Table source: [L14 s20]

L14.4 Simpson evenness and rank abundance diagrams

⚠ **Do not mix up: Evenness is NOT Ds/S but (1/Ds)/S; higher dominance means LOWER evenness.** [L14 s22]

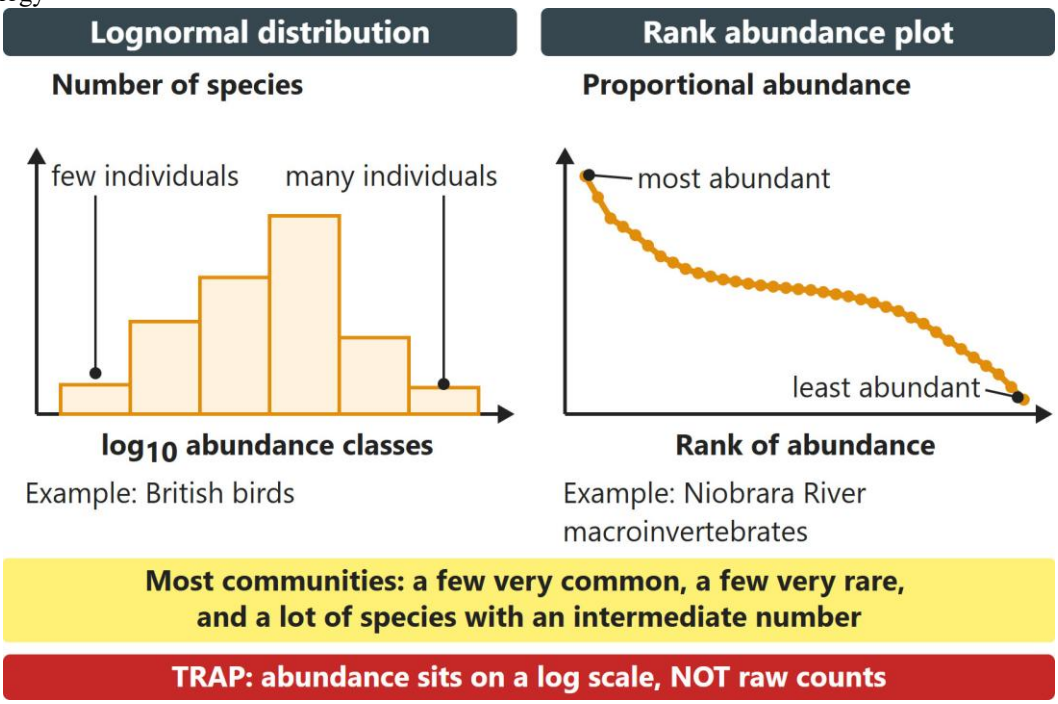
Simpson's evenness = (1 / Ds) / S. [L14 s22]

S: the number of species in the community. [L14 s22]

Evenness measures give a higher value when species are present at more equal proportions. [L14 s22]

Simpson's evenness is the best measure to use when examining evenness. [L14 s22]

1. Find Ds. **2.** Divide **1** by Ds. **3.** Divide that by S. [L14 s22]



Lognormal bell of abundance classes beside the rank abundance curve [L14 s25]

On the figure: Lognormal distribution · log10 abundance classes · number of species · rank of abundance · proportional abundance · British birds · Niobrara River macroinvertebrates

Rank abundance diagram: **proportional abundance** of species, on a log scale, against **rank of abundance**. [L14 s23]
It gives a more complete picture of a community, another way to describe richness and evenness. [L14 s23]
It visually describes the distribution of individuals among species in communities. [L14 s23]
Species are ranked in order from the most abundant to the least abundant. [L14 s25]
Lognormal distribution *(bell shape on a log scale)*: species grouped into **log10 abundance classes** form a normal distribution. [L14 s24, L14 s25]
British birds example: **number of species** plotted against log10 abundance classes. [L14 s24]
Niobrara River macroinvertebrates *(small animals without backbones)*: an example of a rank abundance plot. [L14 s26]
It shows a few very common species, a few very rare, many intermediate. [L14 s24, L14 s26, L14 s27]

Simpson's evenness worked example

Community	Ds	S	Evenness = (1 / Ds) / S
Left (21 + 1 + 1 + 1 + 1)	**0.712**	**5**	(1 / **0.712**) / **5** = **0.281**
Right (5 of each)	**0.2**	**5**	(1 / **0.2**) / **5** = **1**

Table source: [L14 s20, L14 s22]

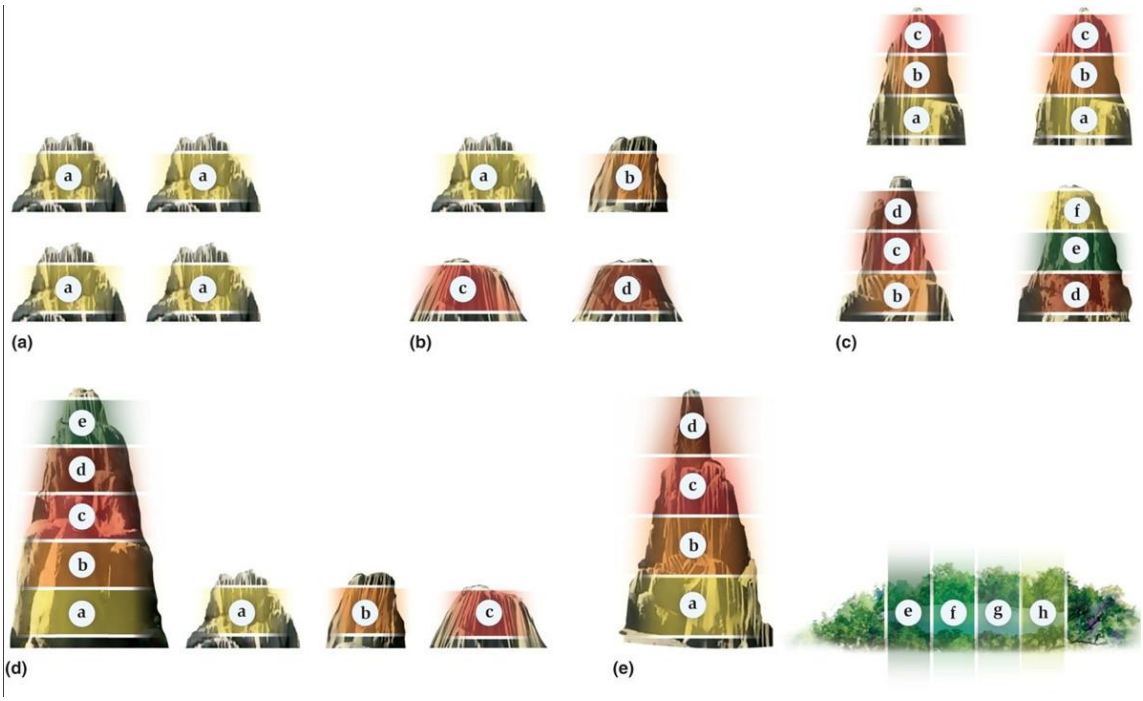
Rank abundance: main conclusion

Main conclusion
Most communities have a few species that are very common, a few species that are very rare, and a lot of species that have an intermediate number of individuals.

Table source: [L14 s27]

L14.5 Alpha, beta and gamma diversity

⚠ **Do not mix up: Alpha is NOT the regional total: alpha is local site richness, gamma is the overall area.** [L14 s30]



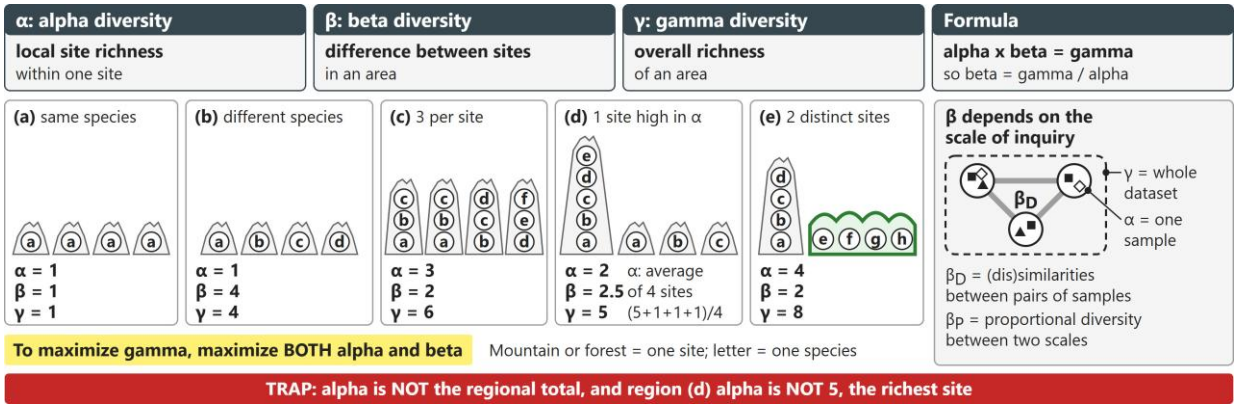
Five regions of mountains and a forest, each letter a different species [L14 s29]

On the figure: (a) · (b) · (c) · (d) · (e)

Question: which region, (a) to (e), contains a greater number of species? [L14 s29]

Letters are different species (a to h); each mountain or forest is a different location. [L14 s29]

Species diversity is lowest in region (a), highest in (e), intermediate in (b), (c), (d). [L14 s29]



Alpha, beta and gamma counted for each region, with the scale idea [L14 s29]

On the figure: Alpha · Beta · Gamma · local site richness · overall richness · difference between sites · scale of inquiry

Alpha (α) diversity: **local site richness**. [L14 s30]

Gamma (γ) diversity: the **overall richness** of an area. [L14 s30]

Beta (β) diversity: the **difference between sites** in an area. [L14 s30]

Formula: alpha x beta = gamma, therefore beta = gamma / alpha. [L14 s30]

Beta for regions (a), (b), (d) and (e) is found as gamma / alpha. [L14 s30, L14 s31, L14 s32, L14 s34, L14 s36]

Main point: to maximize gamma diversity, maximize **BOTH** alpha and beta diversity. [L14 s30]

Gamma diversity can therefore **increase** due to **increases** in alpha or beta diversity. [L14 s36]

Beta diversity can depend on the **scale of inquiry** *(size of the area studied)*. [L14 s35]

βD: (dis)similarities between pairs of samples. [L14 s35]

βP: proportional diversity, the relationship between two scales of investigation. [L14 s35]

βP = gamma / mean alpha *(average local richness)*. [L14 s35]

In the scale diagram, gamma is the whole dataset and alpha is each sample. [L14 s35]

Alpha, beta, gamma in regions (a) to (e)

Region	Alpha	Gamma	Beta = gamma / alpha	Why
(a)	**1**	**1**	**1** / **1** = **1**	**4** sites, each with the same single species a
(b)	**1**	**4**	**4** / **1** = **4**	**4** sites, each with a different species (a, b, c, d)
(c)	**3**	**6**	**6** / **3** = **2**	**3 species** per site; **6 species** (a to f) in the region
(d)	**2** (average of the **4** sites: (5 + **1** + **1** + **1**) / **4**)	**5**	**5** / **2** = **2.5**	**1** site has species a to e; the other **3** sites have one species each (a, b, c)
(e)	**4**	**8**	**8** / **4** = **2**	**2** distinct sites (mountain a to d, forest e to h), each with **4** unique species

Table source: [L14 s29, L14 s31, L14 s32, L14 s33, L14 s34, L14 s36]

L14.6 Habitat differences and protecting gamma diversity

⚠ **Do not mix up: TNC does NOT maximize alpha alone: it maximizes both alpha and beta to maximize gamma.** [L14 s38]

Question: yellow and blue circles cover equal land; which would contain more species, and why? [L14 s37]

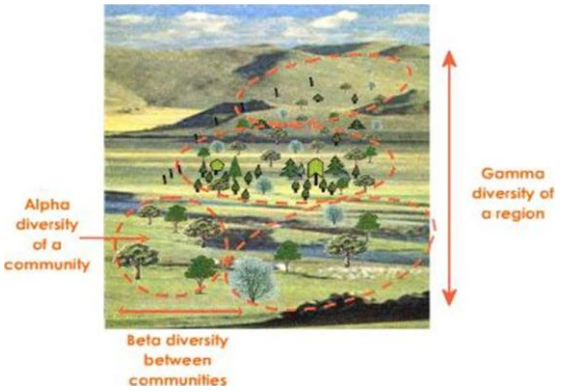
Principle: greater difference between habitats across the landscape should **increase** **beta** and **gamma** diversity. [L14 s38]

So the circles that cross more different habitats should contain more species. [L14 s37, L14 s38]

Across a landscape: **alpha** is one community, beta is **between communities**, gamma is the whole region. [L14 s38]

The Nature Conservancy (TNC): buys land to protect as many species as possible. [L14 s38]

TNC maximizes both alpha and beta diversity in land purchases, thereby maximizing gamma. [L14 s38]



Alpha is one community, beta is between communities, gamma is the whole region [L14 s38]

On the figure: alpha · beta · gamma · between communities

TNC California preserves are spread across many habitats. [L14 s38]

Restructuring predator communities may change human Lyme disease risk. [L14 s39, L13 s31]

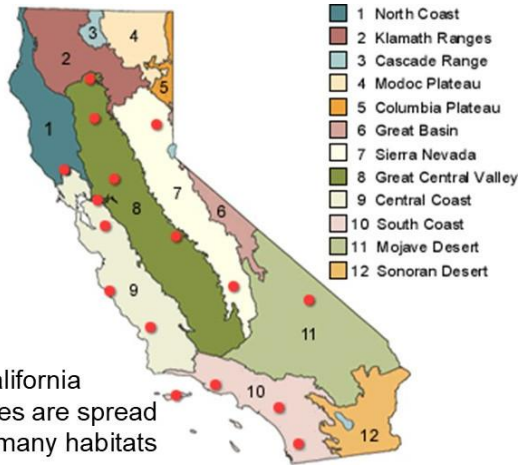
More coyotes per fox, more Lyme; more foxes, less Lyme. [L14 s39, L13 s32]

Lyme diagram chain: coyotes reduce foxes, and foxes reduce small mammal hosts. [L14 s39, L13 s31]

Trophic dead end = predation resistant taxa within a trophic level that higher levels cannot use. [L14 s39, L13 s19]

Trophic dead end example: nutrients added to a headwater stream raised primary consumers but not predators. [L14 s39, L13 s19]

Pycnopsyche *(case-building caddisfly)* is the example taxon of a trophic dead end. [L14 s39, L13 s19, L13 s18]



Nature Conservancy preserves in California are spread across many habitats [L14 s38]

On the figure: TNC · California

It is a detritivore *(dead matter eater)* that **increased** dramatically with nutrient addition. [L14 s39, L13 s18]