# Teórica 9:
# Estructura comunitaria en el espacio: biodiversidad

# Teórica 9: Esquema conceptual

- Definición de comunidad
- Medición de la biodiversidad
- Gradientes geográficos en la diversidad
- Cambio comunitario: Sucesión

# Niveles de organización biológica

Paisajes*

Ecosistemas*

Comunidades*

Especies*

Poblaciones*

Organismos individuales(*)

Sistemas de órganos

Órganos

Tejidos

Células

Organelas

Complejidad creciente

Conocimiento científico decreciente

# La comunidad es...

- El conjunto de especies que viven en un lugar determinado (Krebs 2009).
- Un ensamble de plantas, animales, bacterias y hongos que viven un ambiente e interactúan entre sí, formando un sistema vivo distintivo con composición, estructura, relaciones ambientales, desarrollo y funciones propios (Whittaker 1975).

# Preguntas básicas de la ecología de comunidades

- ¿Por qué algunas especies son comunes y otras raras?
- ¿Por qué algunos sitios tienen muchas especies y otros pocas?
- ¿Funcionan de manera diferente las comunidades con muchas y con pocas especies?
- ¿Qué determina la coexistencia de las especies en las comunidades?

# Atributos comunitarios

- Riqueza: el número de especies en la comunidad
- Abundancia relativa
- Composición: la identidad de las especies
- Estructura trófica (o, en general, estructura de la “red” de interacciones)
- Arquitectura y formas de crecimiento

# Riqueza

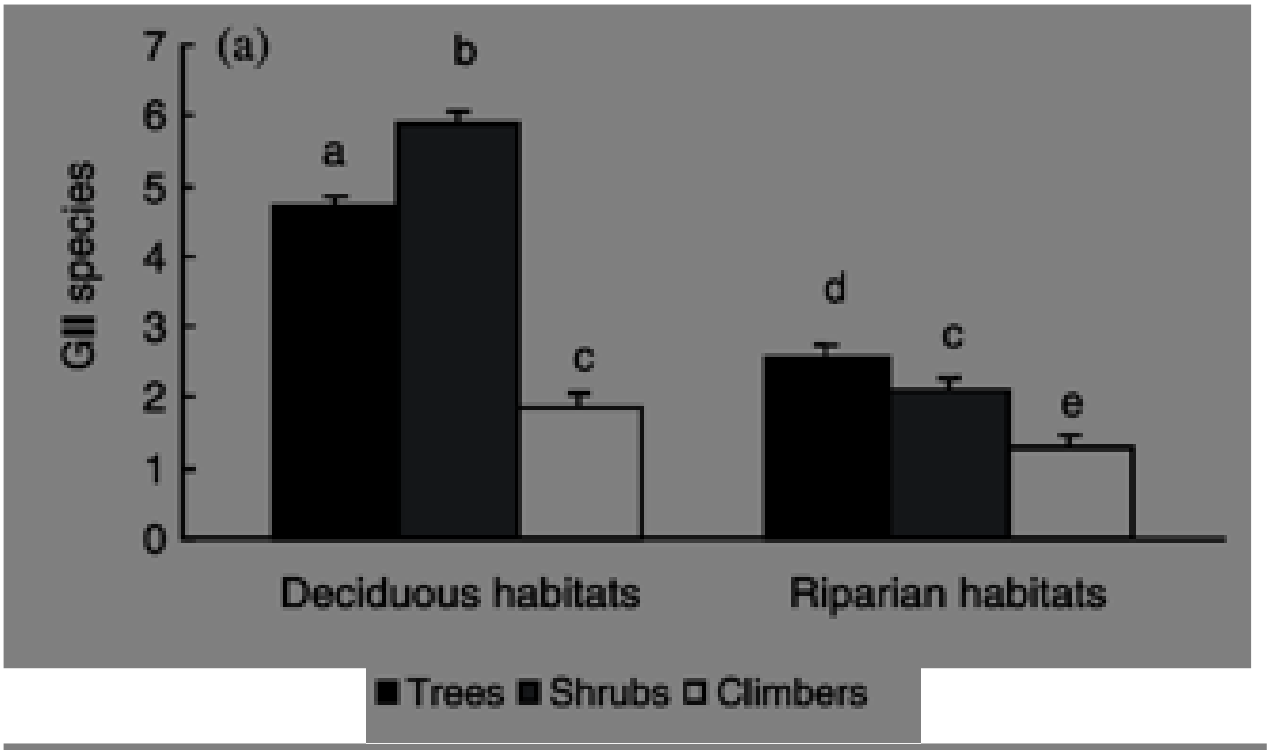
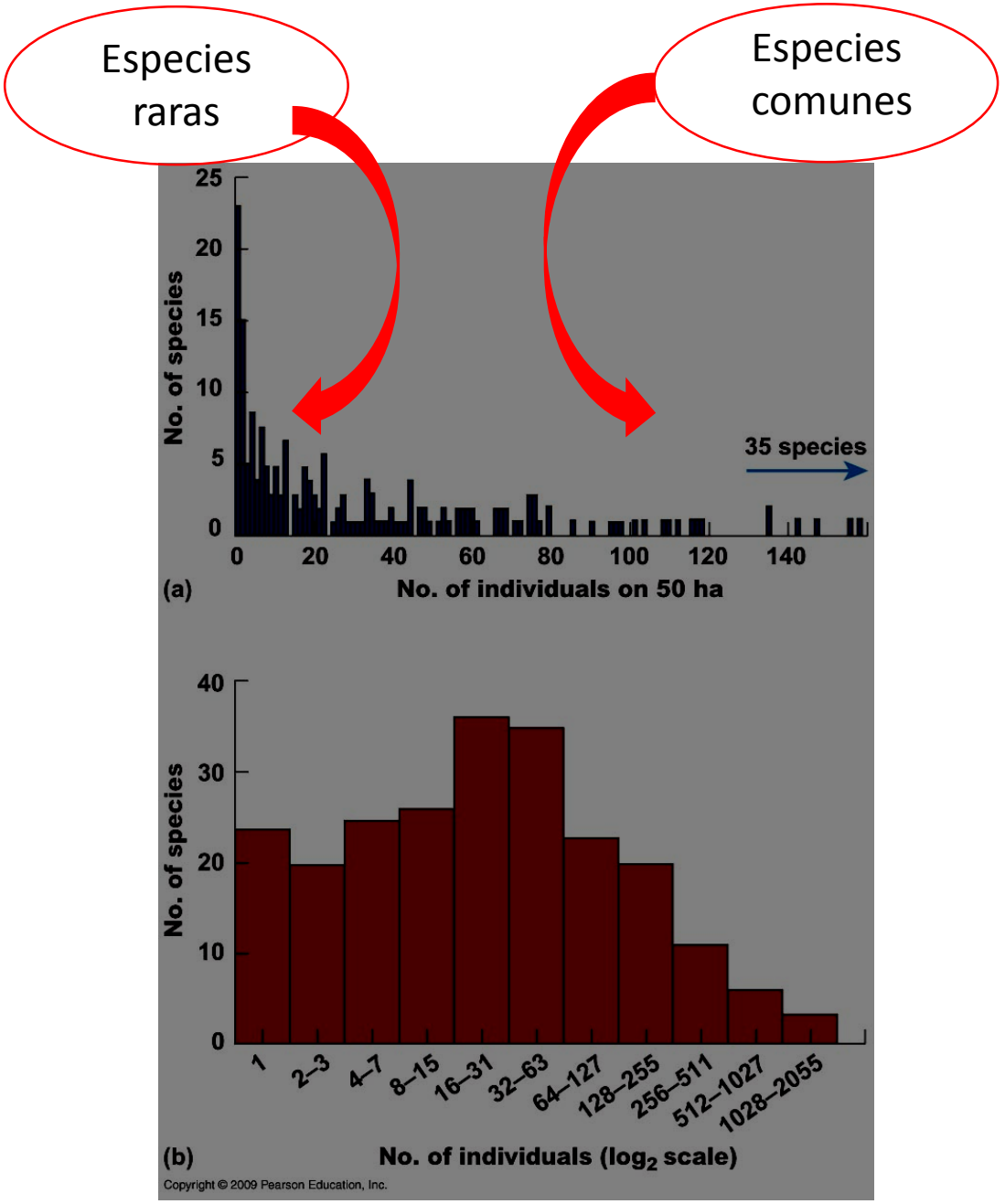



**Fig. 2** (a) Effect on GII of different life-forms in deciduous and riparian habitats species richness. Non-transformed data are shown. Values with the same letter did not differ significantly after an LSMeans multiple comparison test ($P > 0.001$).

Fuente: Cuevas-Reyes et al. (2004) Journal of Ecology 92: 707-716

# Abundancia relativa / Equidad



# Composición

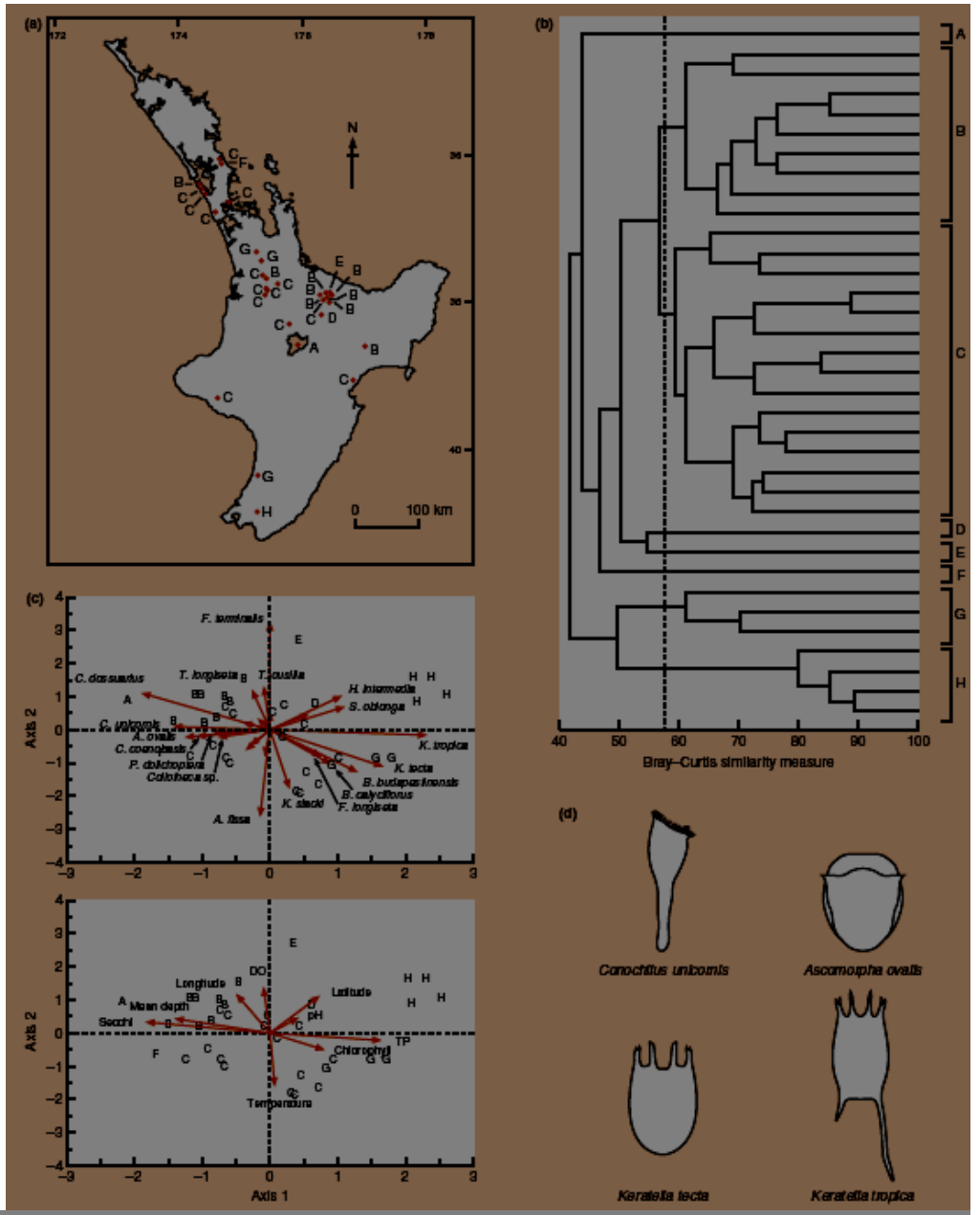



Figure 16.7 (*opposite*) (a) Thirty-one lakes in the North Island of New Zealand where rotifer communities (78 species in total) were sampled and described. (b) Results of cluster analysis (classification) on species composition data from the 31 lakes (based on the Bray–Curtis similarity measure); lake communities that are most similar cluster together and eight clusters are identified (A–H). (c) Results of canonical correspondence analysis (ordination). The positions in ordination space are shown for lake sites (shown as letters A–H corresponding to their classification), individual rotifer species (orange arrows in top panel) and environmental factors (orange arrows in lower panel). (d) Silhouettes of four of the rotifer species. (After Duggan *et al.*, 2002.)

# Estructura de las interacciones

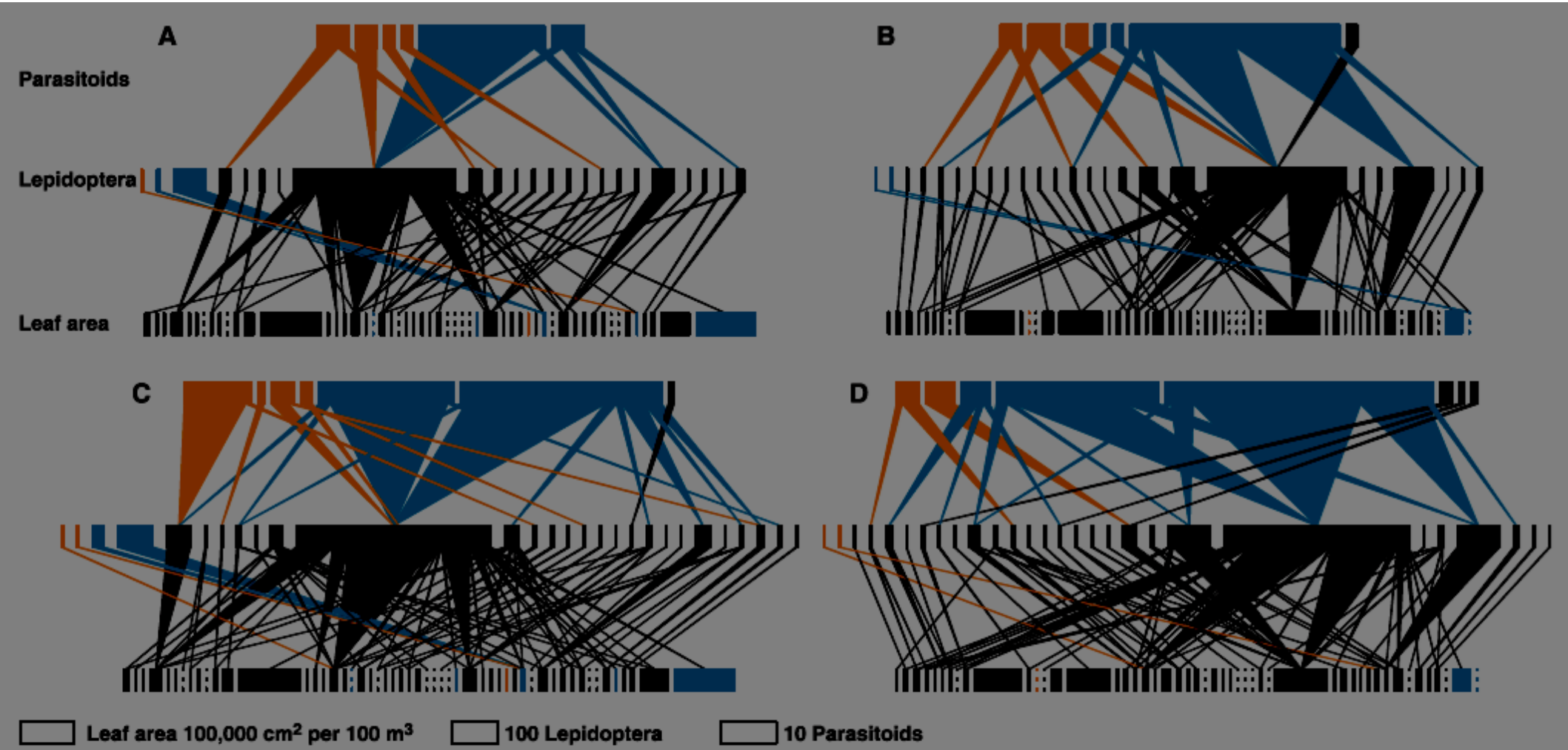



Fig. 1. Quantitative food webs for two plots over 2 years in the Alakai Swamp. Plant species are on the bottom, moths in the middle, and parasitoids on top. Each bar represents a species, and its width represents its relative abundance among all individuals collected. Relative plant abundance was measured using leaf area per 100 $m^3$ and was assessed by counting leaves of all plant species along four arbitrary transects in each plot and by measuring average leaf area for all species. The scale bar for leaf area represents 100,000 $cm^2$ per 100 $m^3$ of forest; the bar for Lepidoptera represents 100 individuals; and the bar for parasitoids represents 10 individuals. The width of the lines connecting trophic levels represents the relative numbers of the upper species attacking the lower species. Plants represented by dotted lines were in the plots but did not occur on these transects. Native species are black, accidental immigrants are yellow, and intentionally introduced species are blue. In the case of insects, intentionally introduced species are biological control agents; in the case of plants, intentionally introduced species are ornamentals and trees that were originally planted for erosion control. (A) Plot 1, 1999. (B) Plot 2, 1999. (C) Plot 1, 2000. (D) Plot 2, 2000. All webs are drawn at the same scale. See supplemental material (*20*) for figure detail and species names.

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# Medición de la biodiversidad

| Especie | Comunidad 1 | Comunidad 2 |
|---|---|---|
| A | 99 | 50 |
| B | 1 | 50 |

**Atributos a tener en cuenta:**

- Riqueza
- Abundancia relativa/Equidad
- Composición

# Estimación de la riqueza

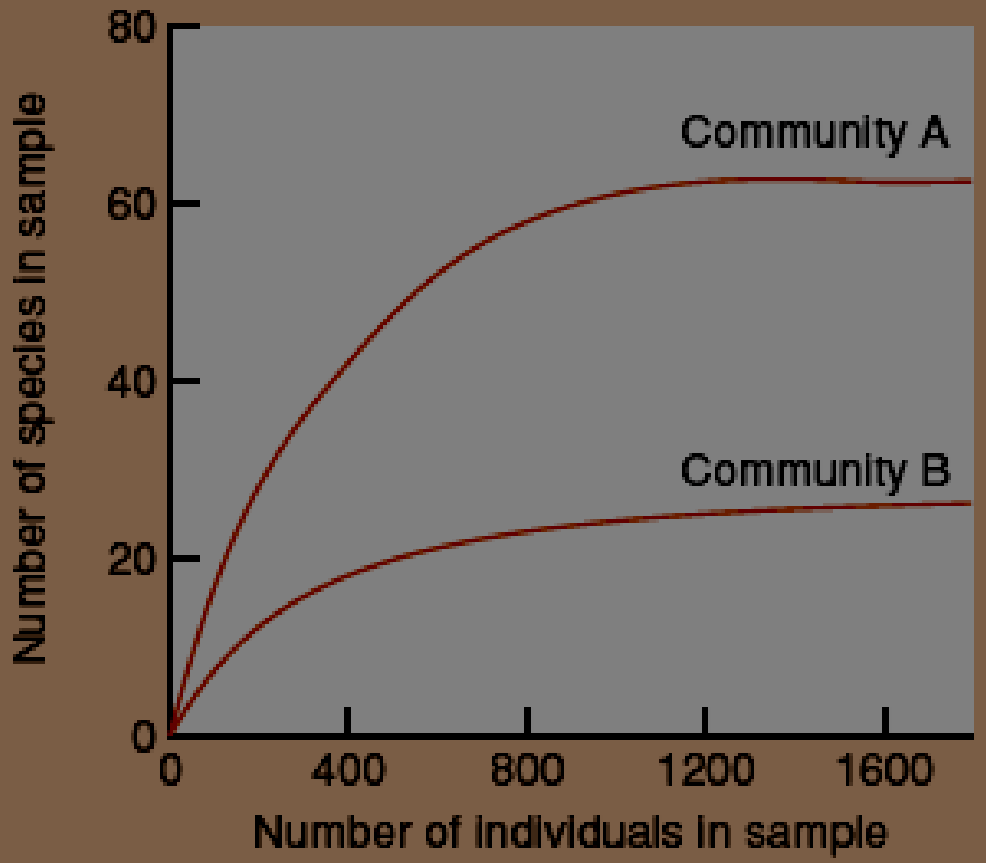



**Figure 16.3** The relationship between species richness and the number of individual organisms from two contrasting hypothetical communities. Community A has a total species richness considerably in excess of community B.

# Estimación de la riqueza

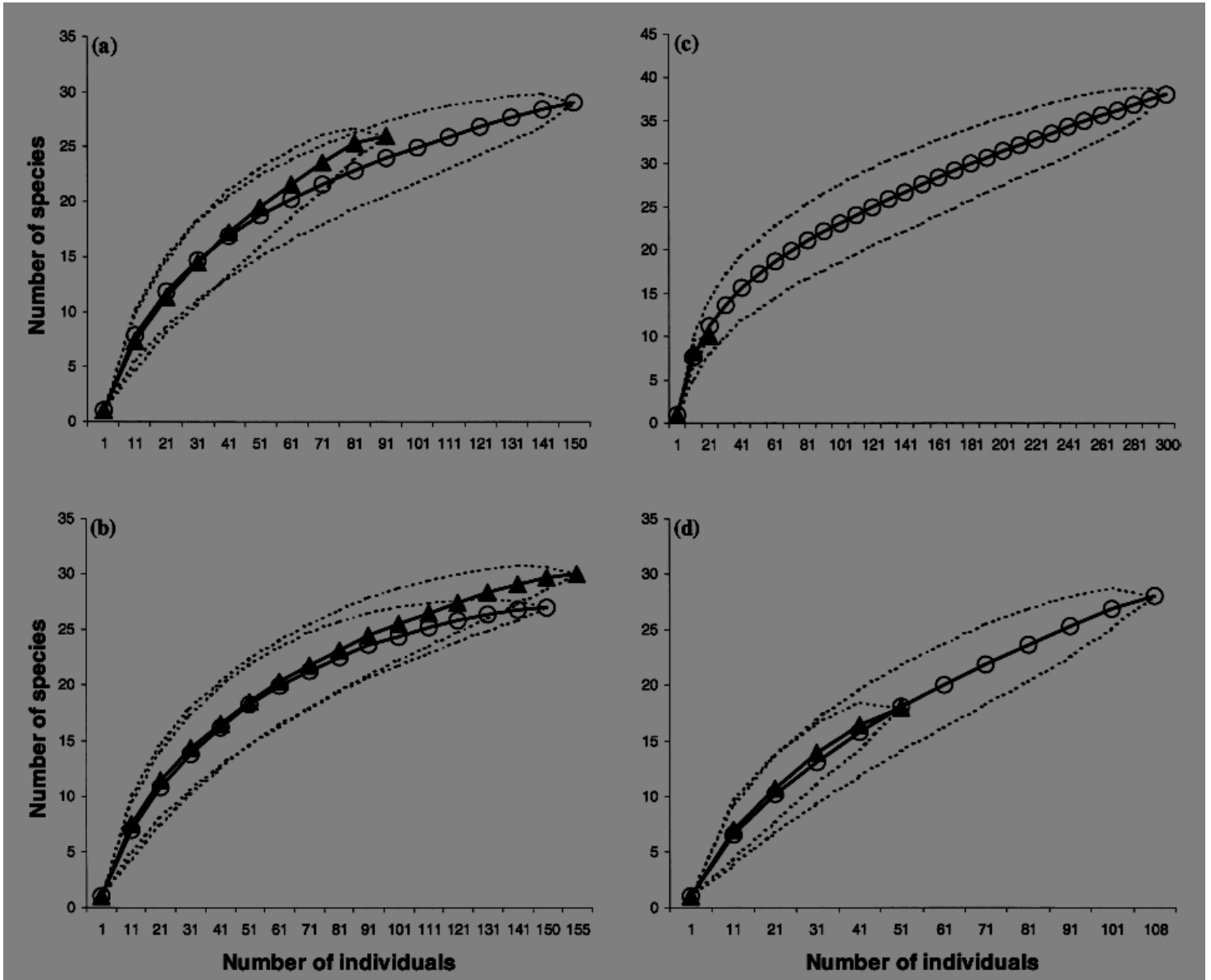
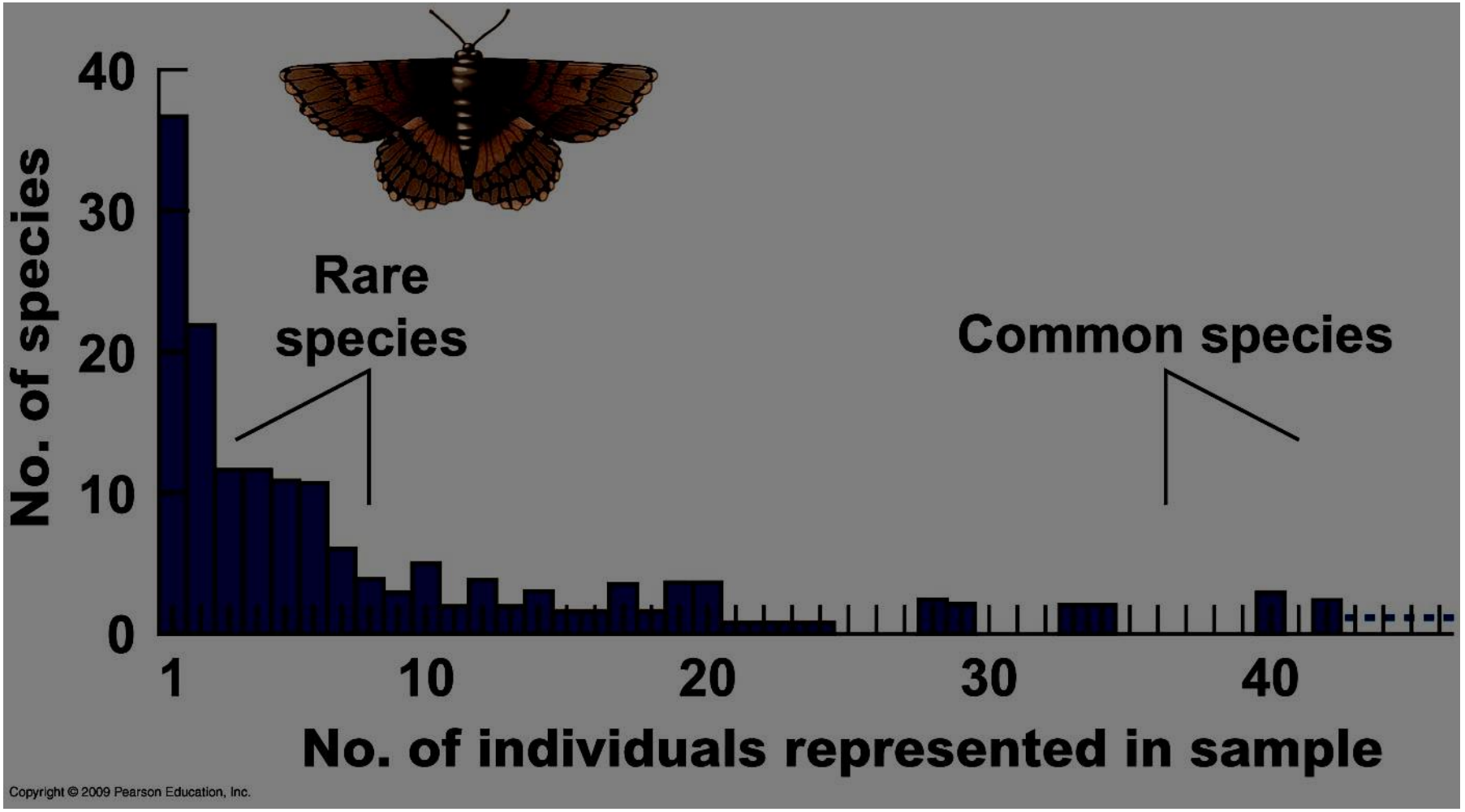


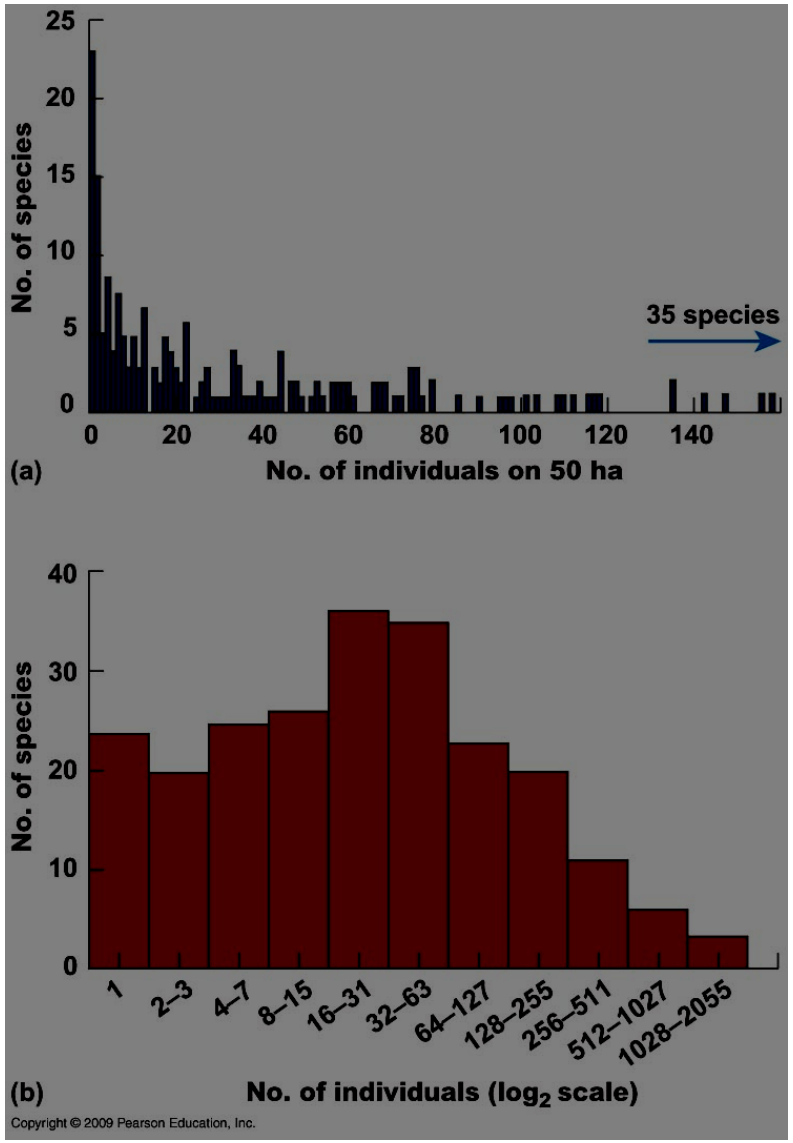

*Figure 1.* Rarefaction curves for the species richness of insects recorded visiting flowers of *Alstroemeria aurea* by Vázquez and Simberloff (2002). The rarefaction calculations were performed using EcoSim software (Gotelli and Entsminger 2000). The continuous lines indicate expected values of rarefaction curves; dashed lines above and below the expected values are 95% confidence limits calculated over 1000 iterations of the simulation. ▲: grazed sites; ○: ungrazed sites. Actual species richness corresponds to the upper-right end of the lines. Rarefaction curves given separately for each of four pairs of sites. Paired sites are: (a) Llao Llao (UG), Cerro López (G); (b) Safariland (UG), Arroyo Goye (G); (c) Mascardi (UG and G); (d) Quetrihué (UG and G) (UG, ungrazed site; G, grazed site).

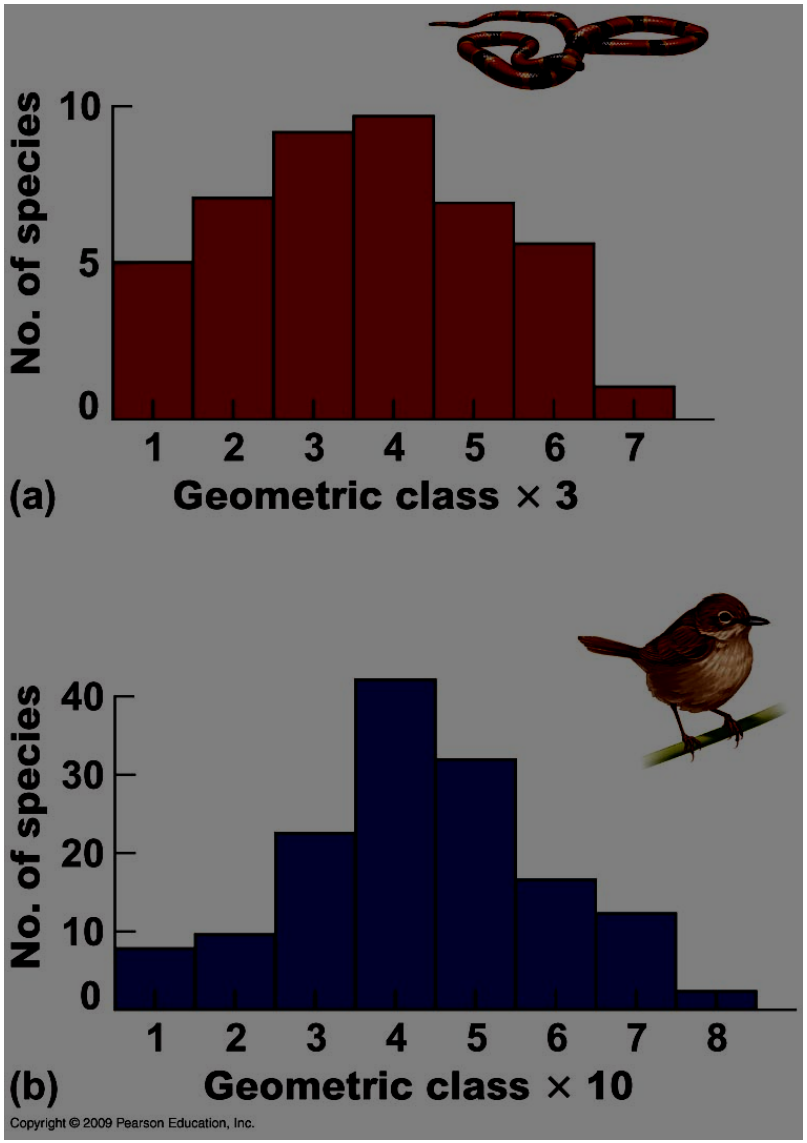
Fuente: Vázquez DP (2002) Biological Invasions 4: 175-191

# Diversidad:
# riqueza y abundancia relativa



# Diversidad:
# riqueza y abundancia relativa






Fuente: Sugihara (1980) American Naturalist 116: 770-787

# Indices de diversidad

| | Indice de Simpson | Indice de Shannon |
|---|---|---|
| Diversidad | $D = \frac{1}{\sum_{i=1}^{S} P_i^2}$ | $H = -\sum_{i=1}^{S} P_i \ln P_i$ |
| Equitatividad | $E = \frac{D}{D_{max}} = \frac{1}{\sum_{i=1}^{S} P_i^2} \times \frac{1}{S}$ | $J = \frac{H}{H_{max}} = \frac{-\sum_{i=1}^{S} P_i \ln P_i}{\ln S}$ |

¡Cuidado! Así como la riqueza, los índices son muy sensibles al esfuerzo de muestreo.

# Indices de diversidad

| Especie | Comunidad 1 | Comunidad 2 |
|---|---|---|
| A | 99 | 50 |
| B | 1 | 50 |

$$D = \frac{1}{\sum_{i=1}^{S} P_i^2}$$

$1/(0.99^2 + 0.01^2) = 1{,}02$

$1/(0.5^2 + 0.5^2) = 2$

$$E = \frac{D}{D_{\max}} = \frac{1}{\sum_{i=1}^{S} P_i^2} \times \frac{1}{S}$$

$1{,}02/2 = 0{,}51$

$2/2 = 1$

# Indices de diversidad

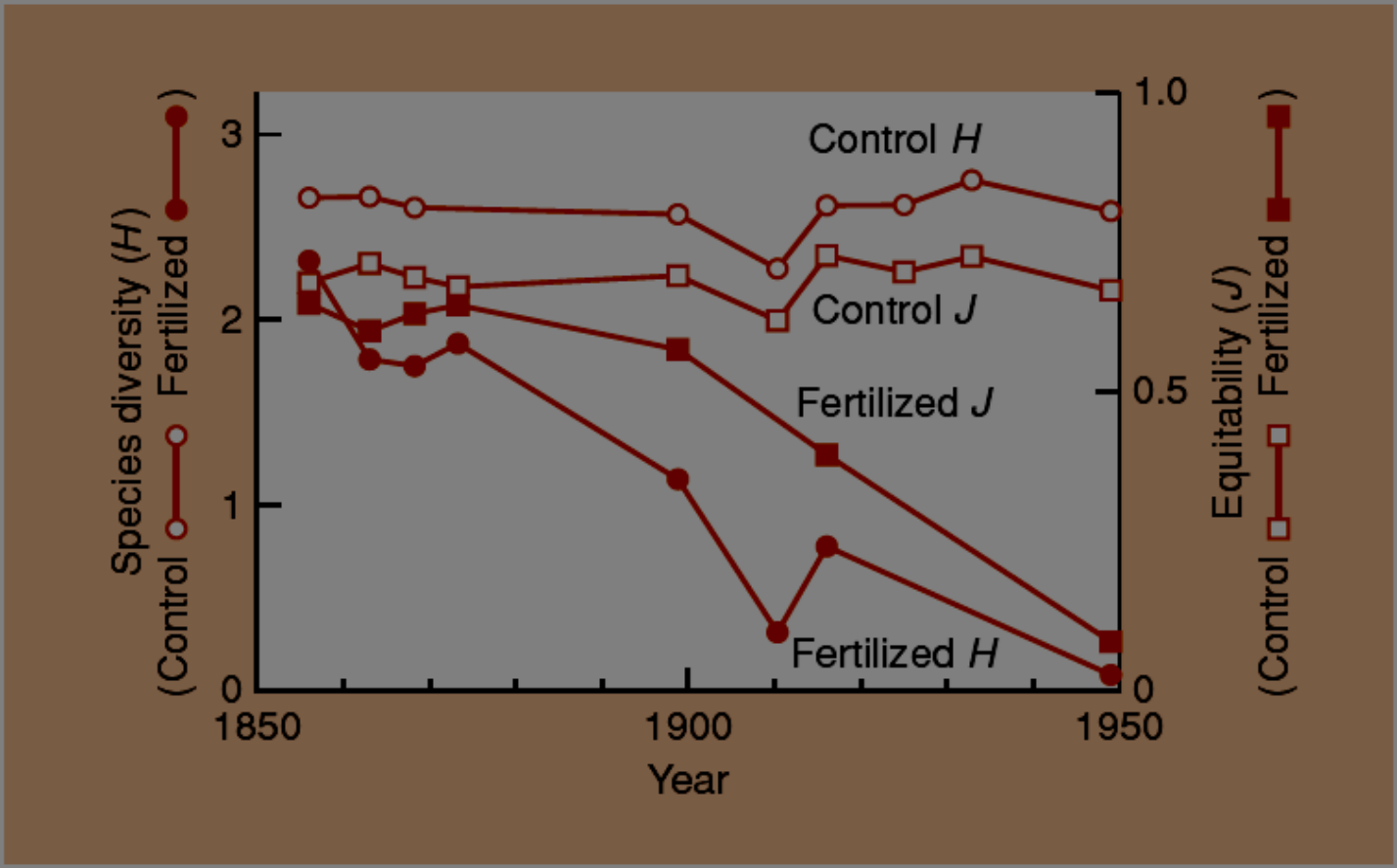



**Figure 16.4** Species diversity ($H$) and equitability ($J$) of a control plot and a fertilized plot in the Rothamsteard 'Parkgrass' experiment. (After Tilman, 1982.)

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# Gradientes geográficos de diversidad

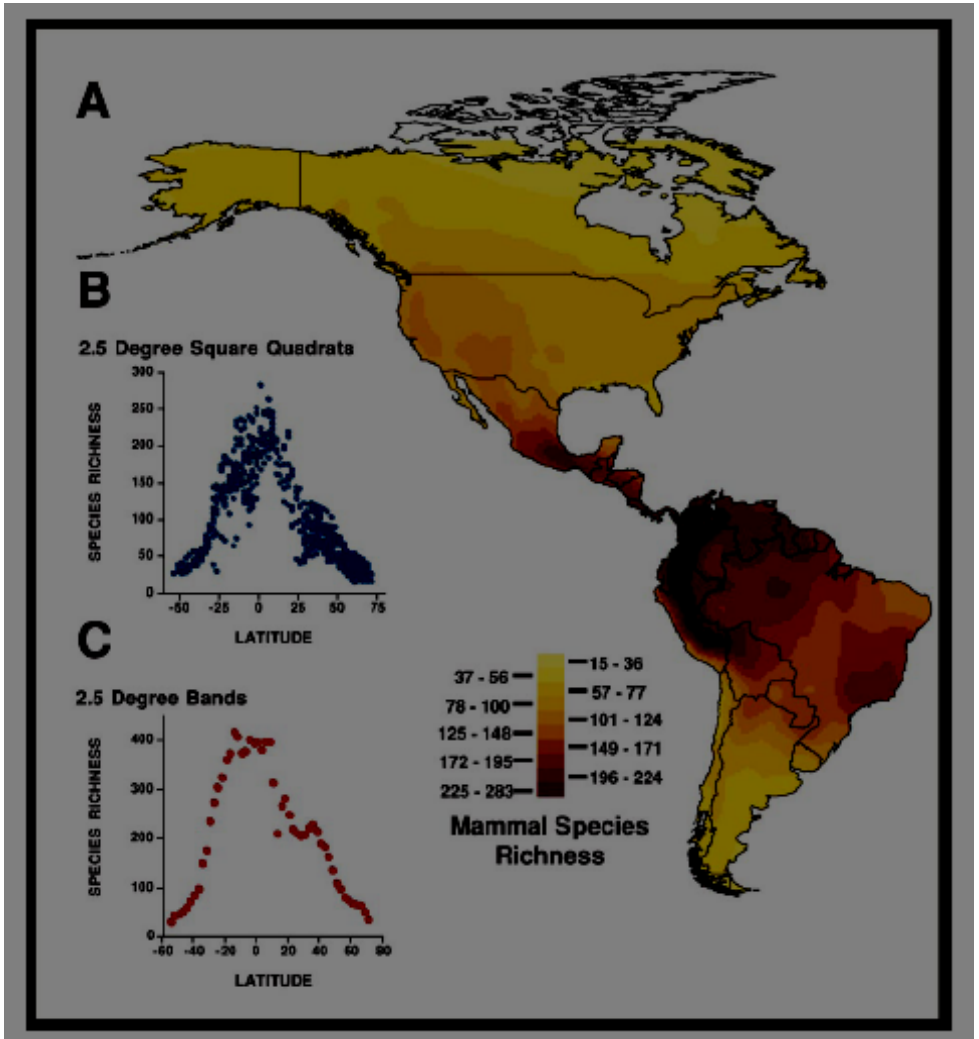



**Figure 4** Spatial gradient of mammalian species richness in the continental New World for cells defined by 2.5° parallels and meridians. (*A*). Interpolated richness values in the map were created using the tension spline function in the Spatial Analyst extension to ArcGIS 8.2. Graphic representation of the latitudinal gradient in species richness for those same data (negative values for latitude indicate southern parallels), based on 2.5° cells (*B*) and 2.5° latitudinal bands (*C*). Data from Kaufman & Willig (1998).

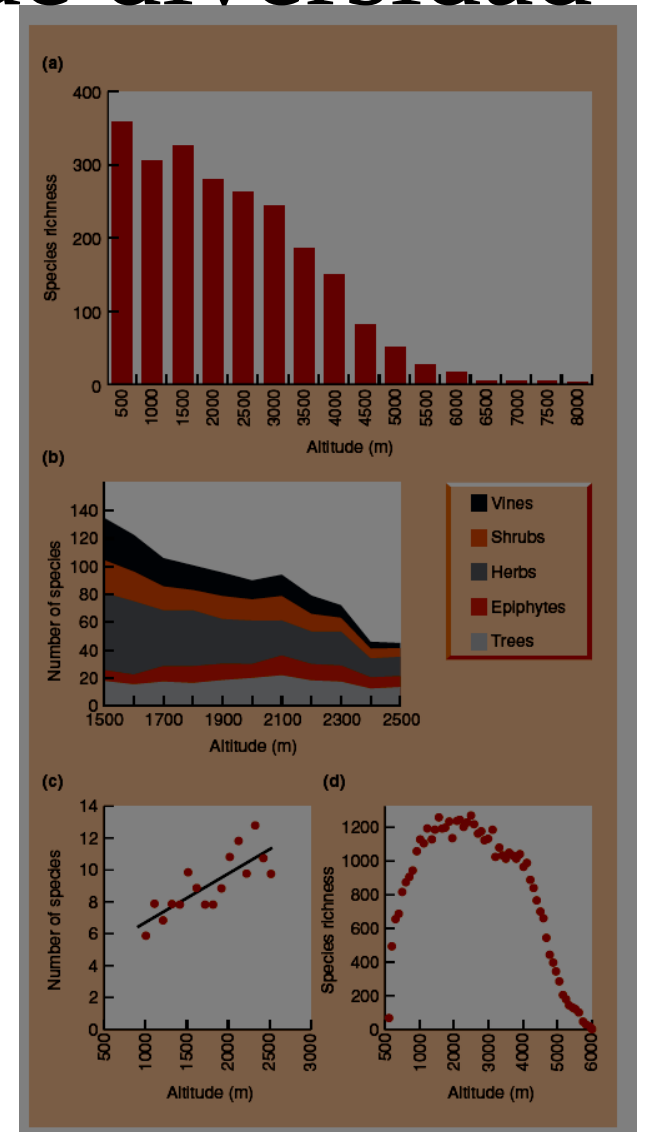



**Figure 21.22** Relationships between species richness and altitude for: (a) breeding birds in the Nepalese Himalayas (after Hunter & Yonzon, 1992); (b) plants in the Sierra Manantlán, Mexico (after Vázquez & Givnish, 1998); (c) ants in Lee Canyon in the Spring Mountains of Nevada, USA (after Sanders *et al.*, 2003); and (d) flowering plants in the Nepalese Himalayas (after Grytnes & Vetaas, 2002).



Fuente: Willig et al. (2003) AREES 34: 273-309

# Gradiente altitudinal de diversidad

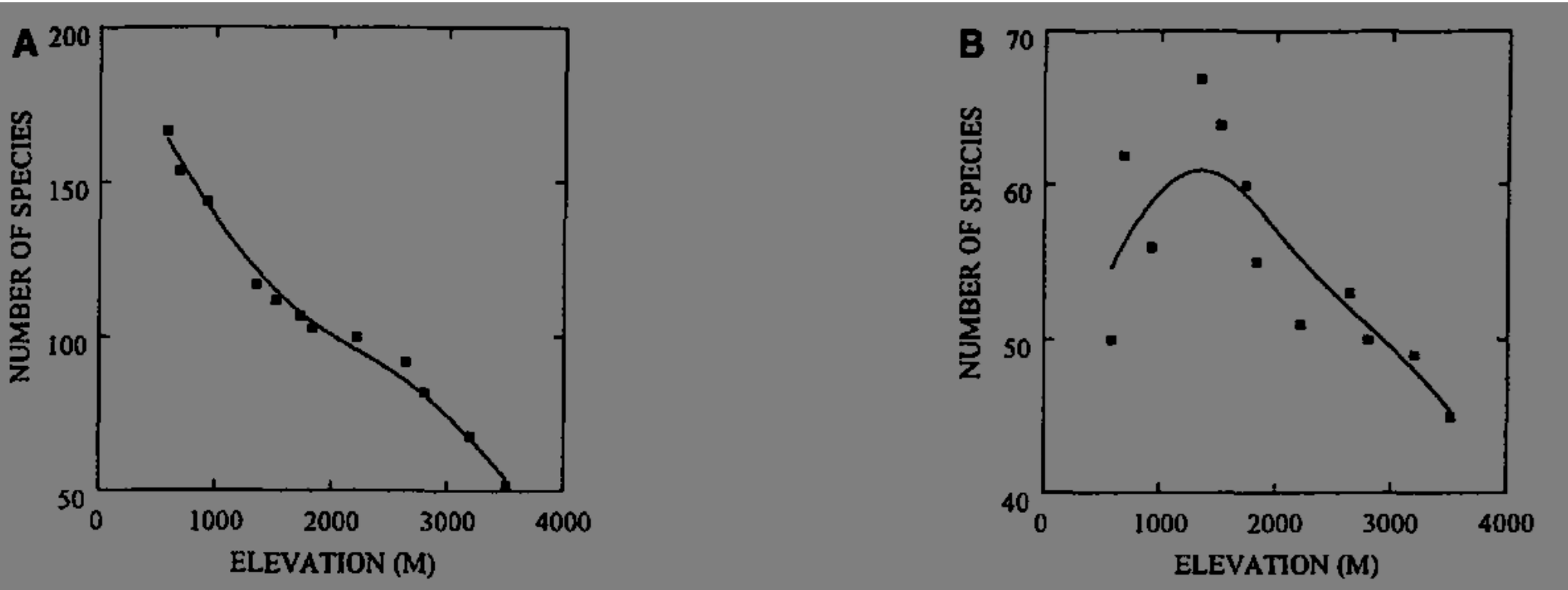
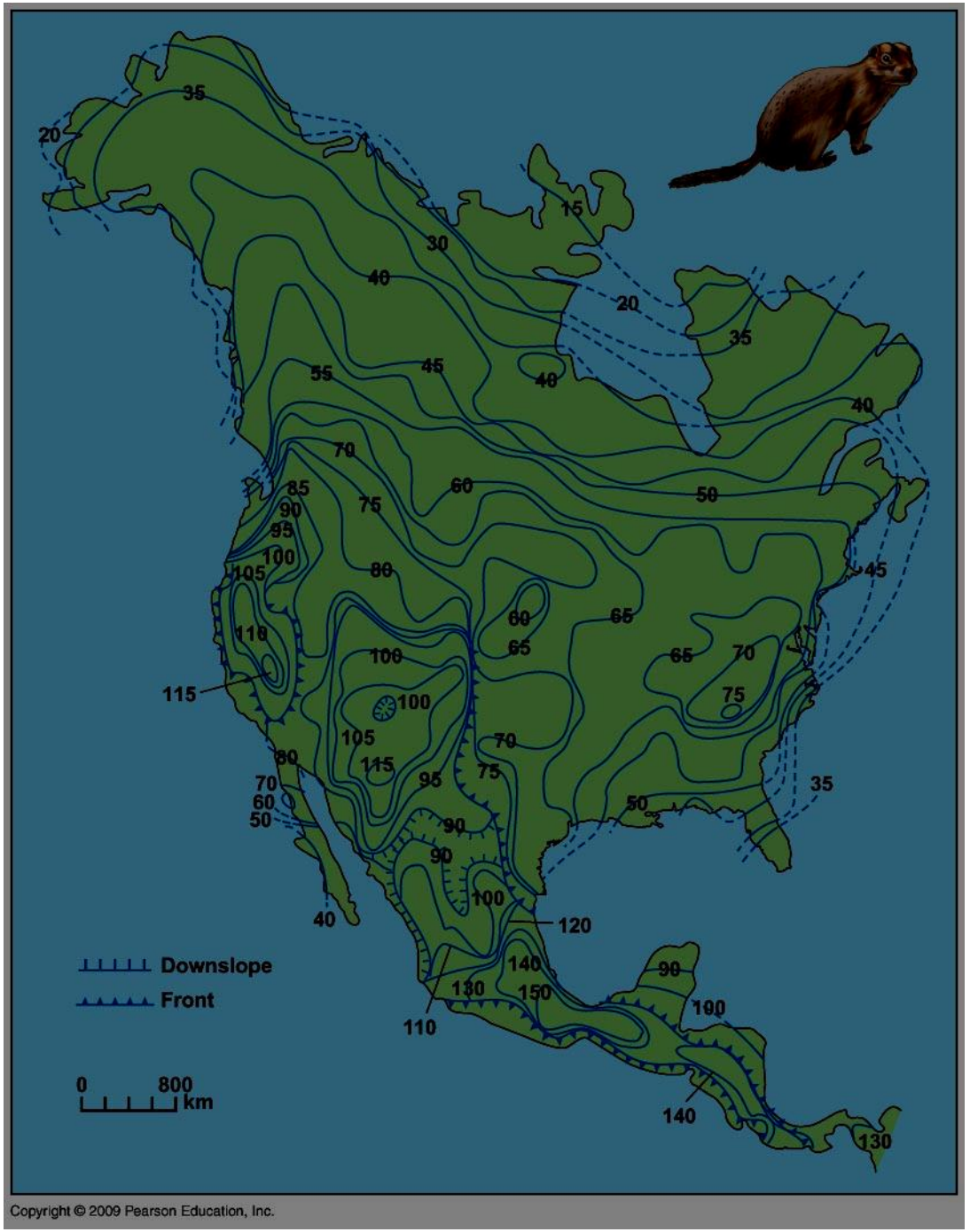



Fig 1 Species richness of syntopic birds versus elevation on an Amazonian slope of the Andes in Peru Figure 1A is based on data not standardized for area and sampling effort, whereas Fig 1B is based on standardized samples of 300 mist-netted birds (data from Terborgh 1977) I have fitted the lines by distance-weighted least-squares smoothing

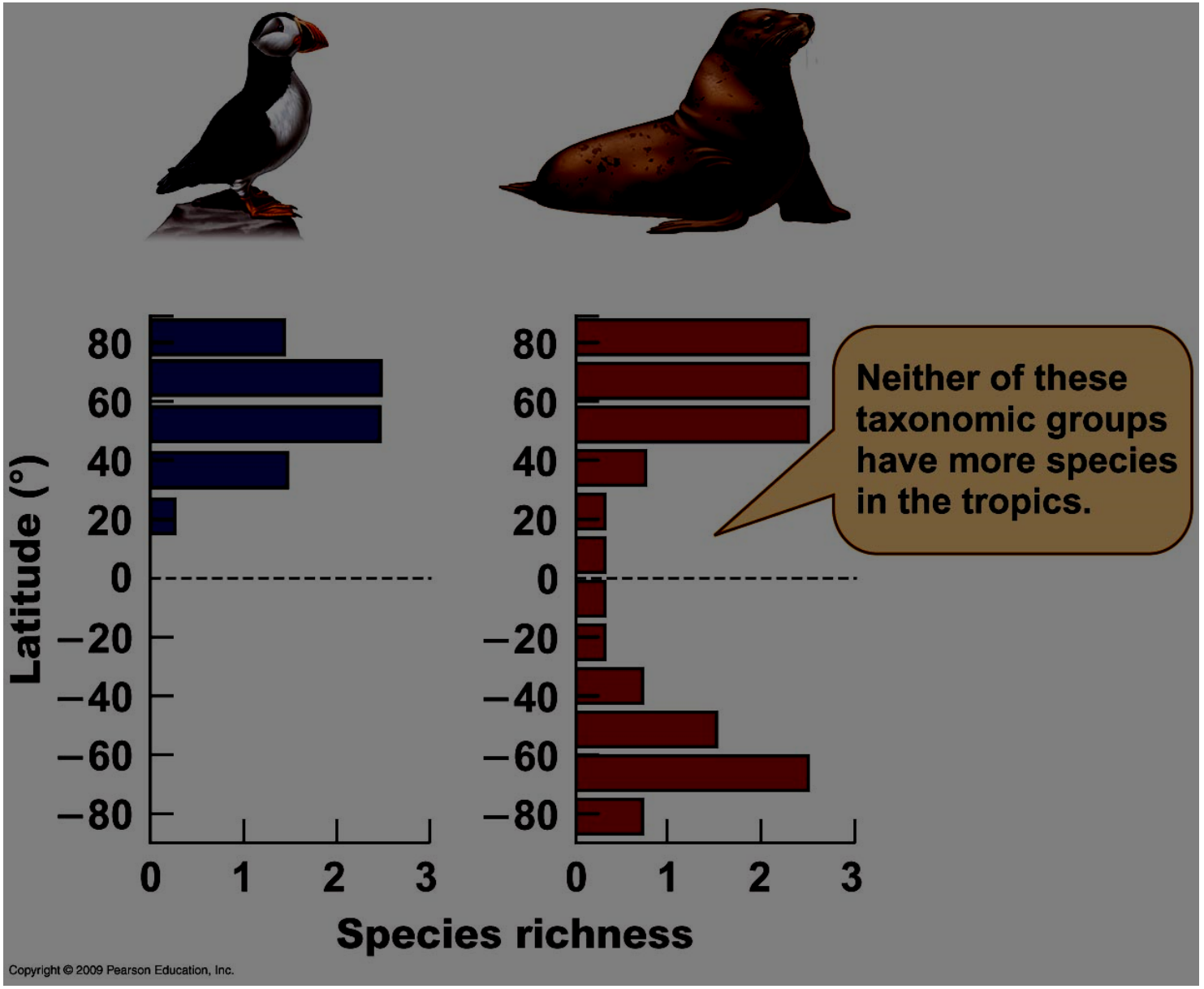
Leer artículo de Rahbek (1995) antes de salida de campo a Vallecitos.
Discusión: viernes 26/5

Fuente: Rahbek (1995) Ecography 18: 200-205

# Gradiente latitudinal de diversidad



# Gradiente latitudinal de diversidad



# Explicaciones del gradiente latitudinal de diversidad

**TABLE 1** Hypotheses proposed to account for the latitudinal gradient of diversity*

| | | |
|---|---|---|
| †**Abiotic-biotic**[1] | §**Geographic area**[RI] | §**Rapoport rescue**[4] |
| §**Ambient energy**[R] | §**Geometric constraints**[3] | Rapoport's rule[RI] |
| Environmental predictability[RI] | Interspecific interactions[B] | †**Scale hierarchy**[5] |
| Environmental stability[P, RI] | Competition[P, RC] | **Spatial heterogeneity**[P, B] |
| Harshness[B, RC] | ‡Host diversity[RC] | Biotic spatial heterogeneity[RC] |
| Seasonality[RI] | Mutualism[RC] | Epiphyte load[RC] |
| †**Energetic-equivalents**[2] | Niche width[B, RC] | Number of habitats[RI] |
| **Evolutionary rates** | Predation[P, RC] | Patchiness[RC] |
| Extinction rate[B] | **Population dynamics** | Physical heterogeneity[RI] |
| Origination rate[B] | Epidemics[RC] | ‡Solar angle[RI] |
| §**Evolutionary speed**[R] | Population growth rate[RC] | **Time**[P, B] |
| Temperature-dependent chemical reactions[R] | Population size[RC] | Abiotic rarefaction[RI] |
| | §**Productivity**[P, B, RI] | Ecological time[R] |
| | ‡Aridity[RI] | Evolutionary time[R] |

*Augmented from Rohde (1992) and modified from D.M. Kaufman & J.H. Brown (in review). Originating authors follow for those hypotheses not included in Rohde; for others, see Rohde (1992).

†Recent hypotheses not yet evaluated thoroughly in the literature; published sources are indicated by numeric superscript: ([1]Kaufman 1995, 1998; [2]Allen et al. 2002; [3]Colwell & Hurtt 1994, Lyons & Willig 1997; and [5]Whittaker et al. 2001).

§Hypotheses discussed in detail in text ([4]Taylor & Gaines 1999).

‡Hypotheses too specific to provide a general mechanism.

[P]Hypotheses included by Pianka (1966).

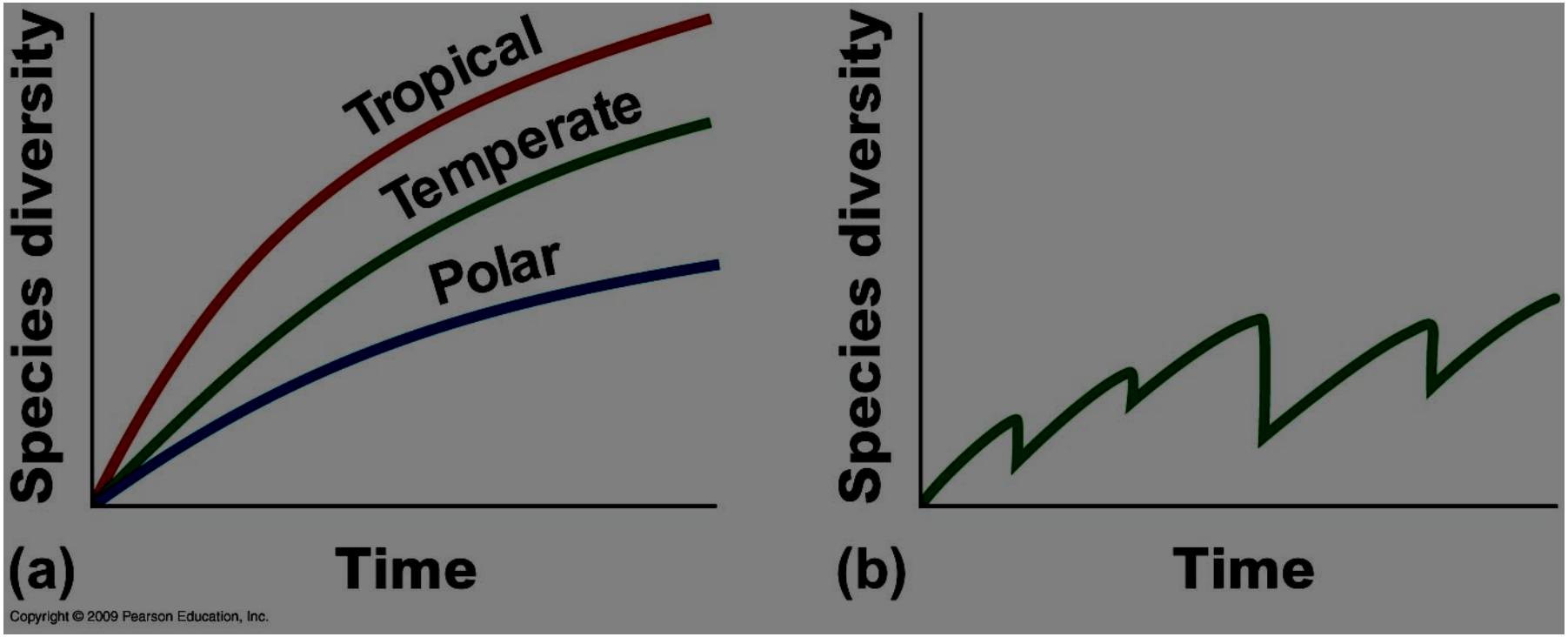
[B]Hypotheses included by Brown (1988, Brown & Gibson 1983).

[R]Hypotheses included by Rohde (1992; with [C] denoting "circular" hypotheses and [I] for "insufficiently supported" hypotheses).



Fuente: Willig et al. (2003) Ann. Rev. Ecol., Evol. & Syst. 34: 273-309

# Explicaciones de los gradientes: Factores históricos, Velocidad Evolutiva



# Explicaciones de los gradientes: Velocidad evolutiva

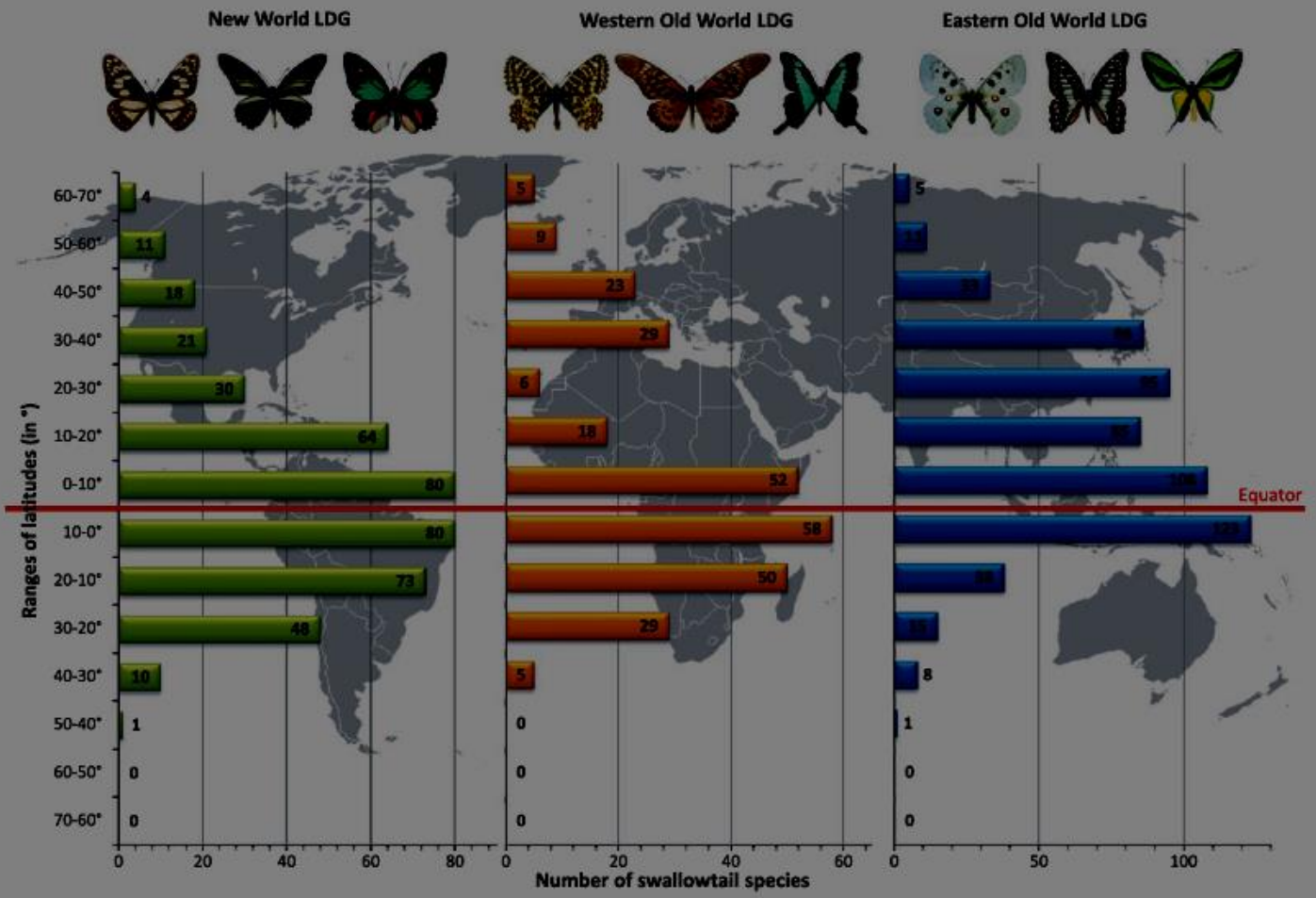
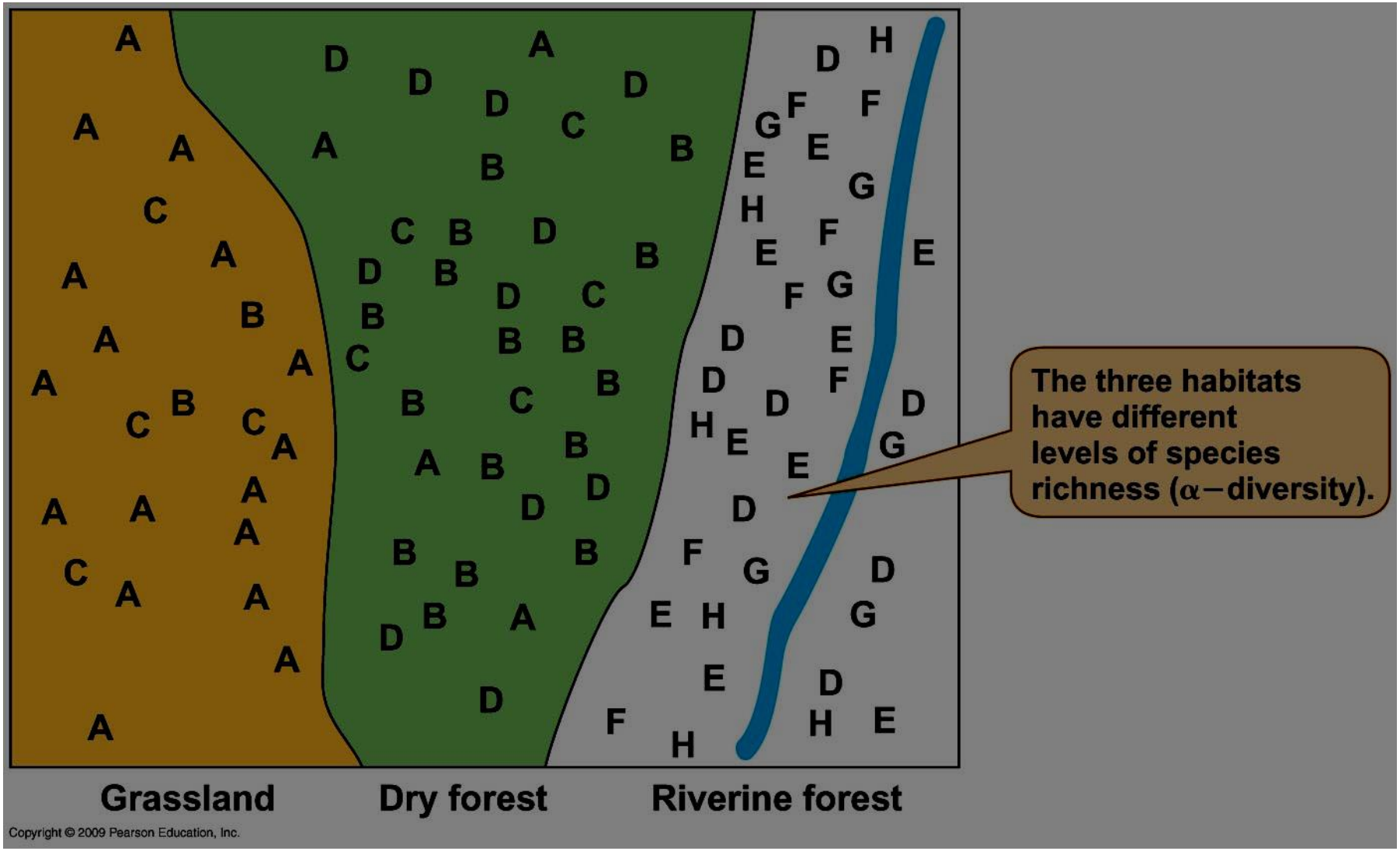
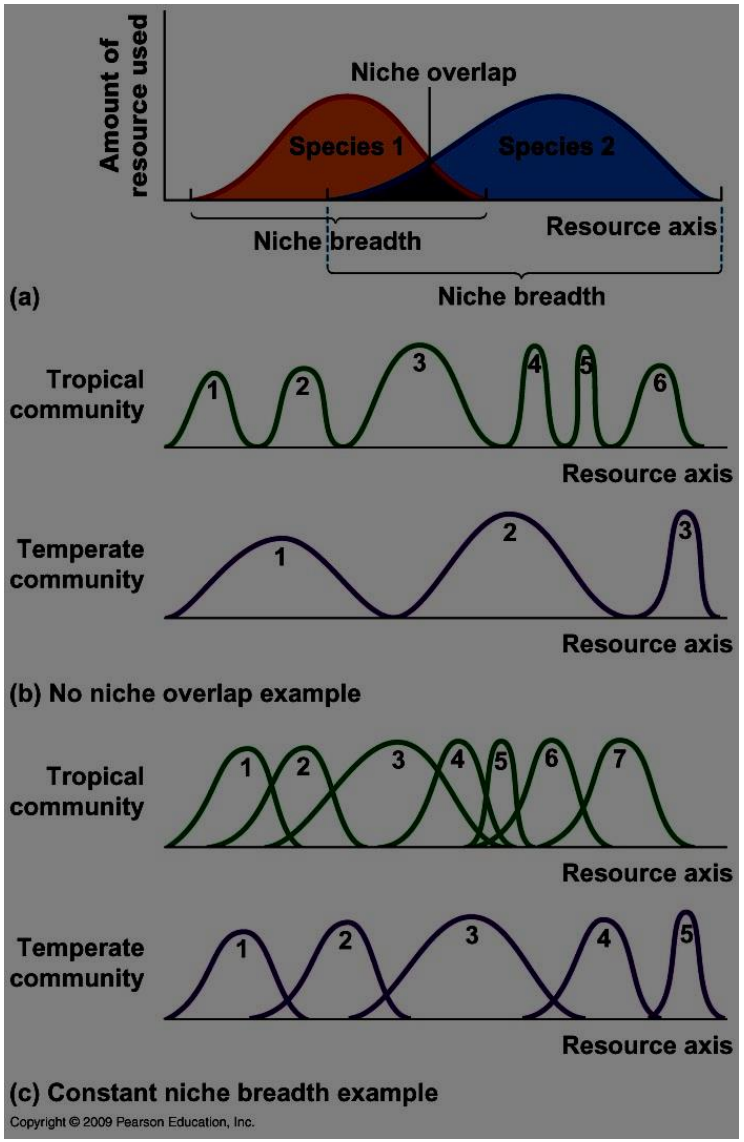


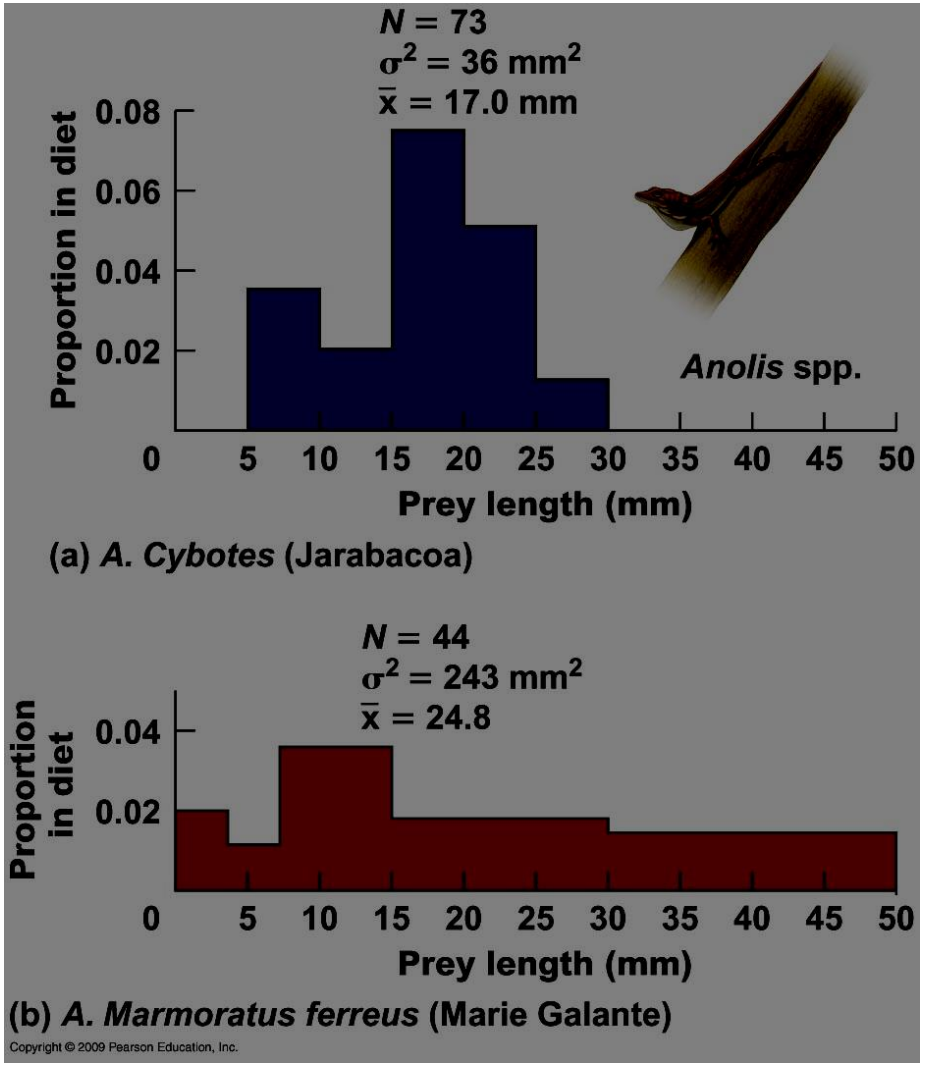

**Figure 1** Latitudinal diversity gradients for swallowtail butterflies in three different parts of the world. Species richness increases from the poles toward the equator (red line) and applies to all tropical regions. One easily explained exception occurs in the western Old World, where a dip in species richness coincides with North African desert. Well-known species from each region are figured above. Data are compiled from various sources (e.g. Collins & Morris 1985).

# Explicaciones de los gradientes: Heterogeneidad espacial

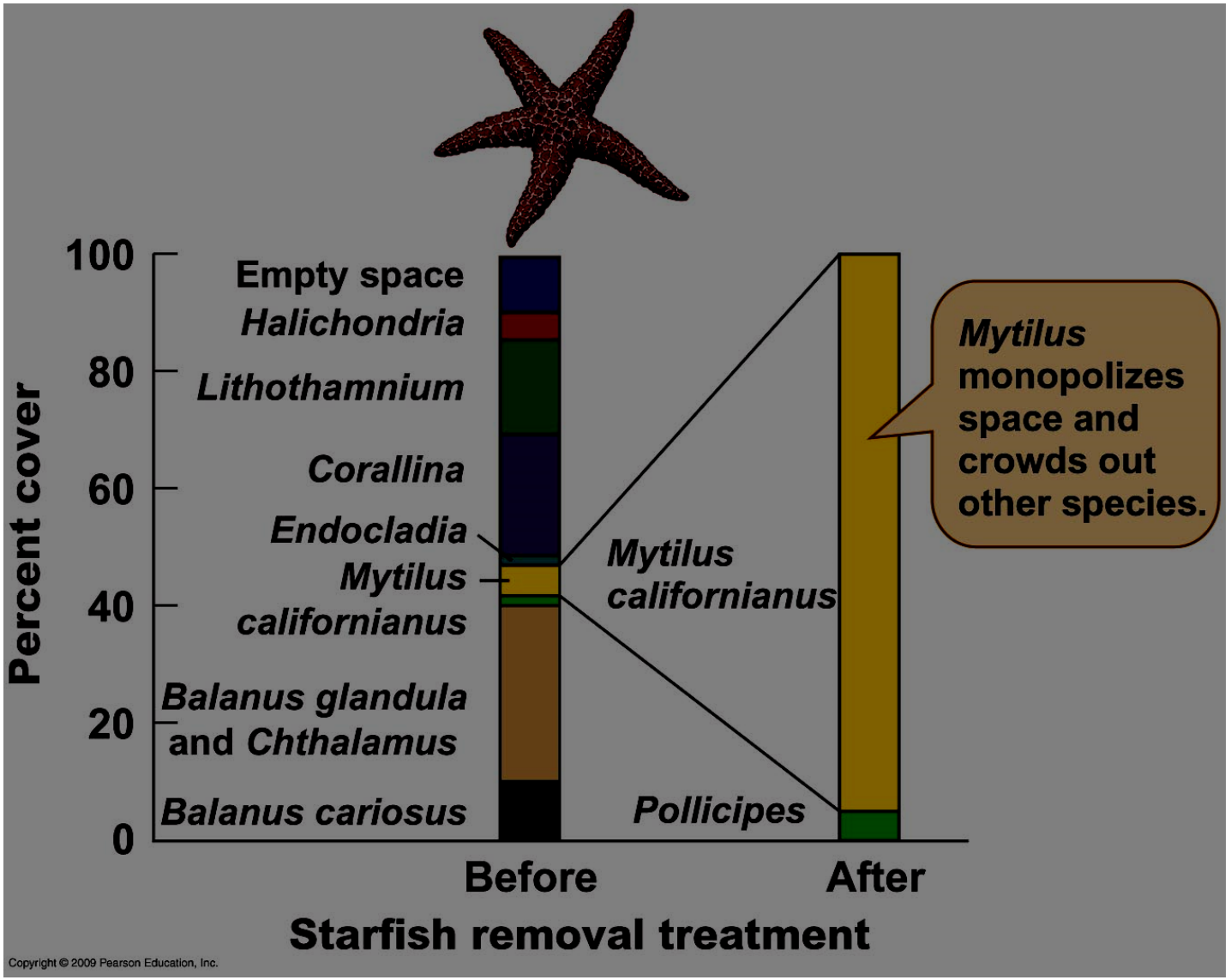


# Explicaciones de los gradientes: Interacciones interespecíficas: competencia

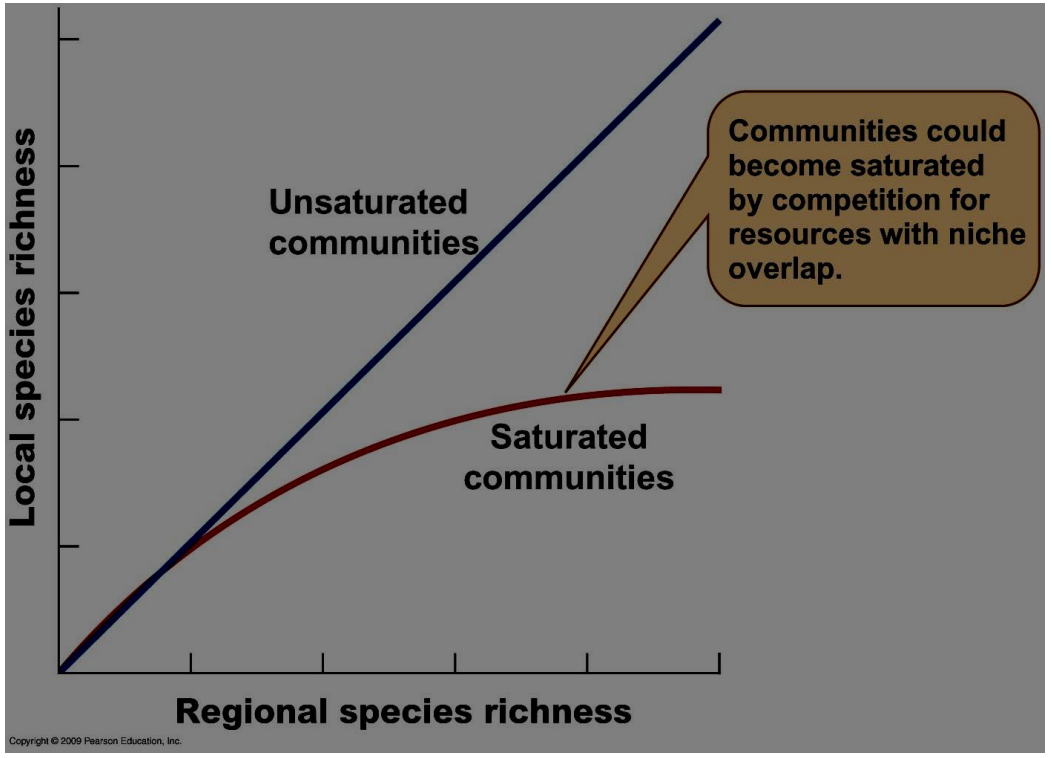


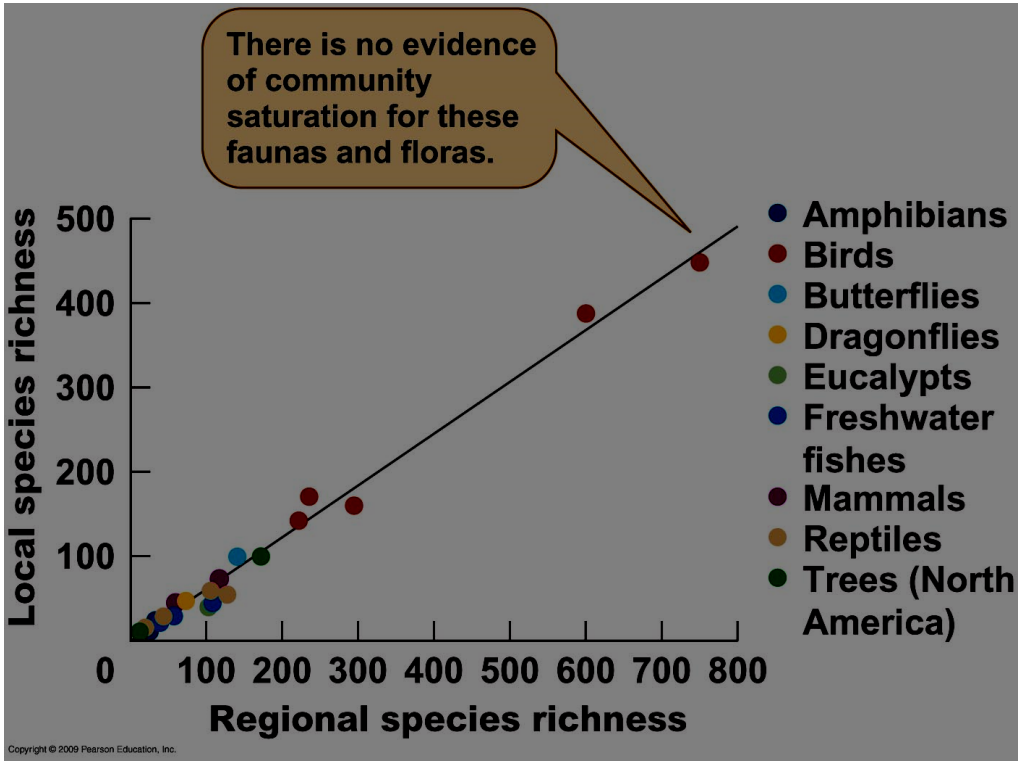



# Explicaciones de los gradientes: Interacciones interespecíficas



# Explicaciones de los gradientes: Interacciones interespecíficas Diversidad local vs. regional



# Explicaciones de los gradientes: Interacciones interespecíficas Diversidad local vs. regional

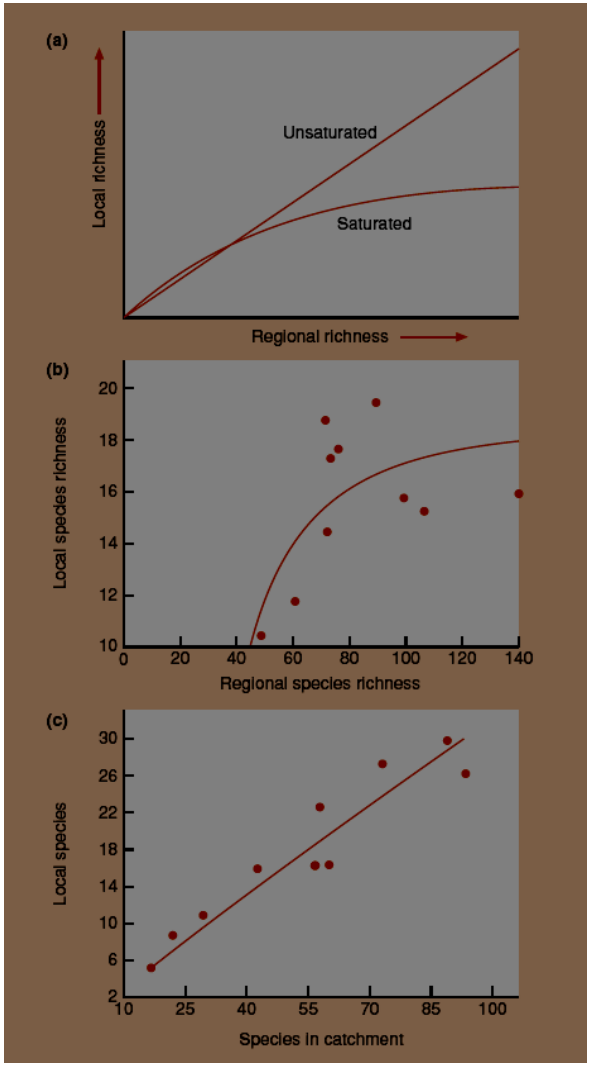
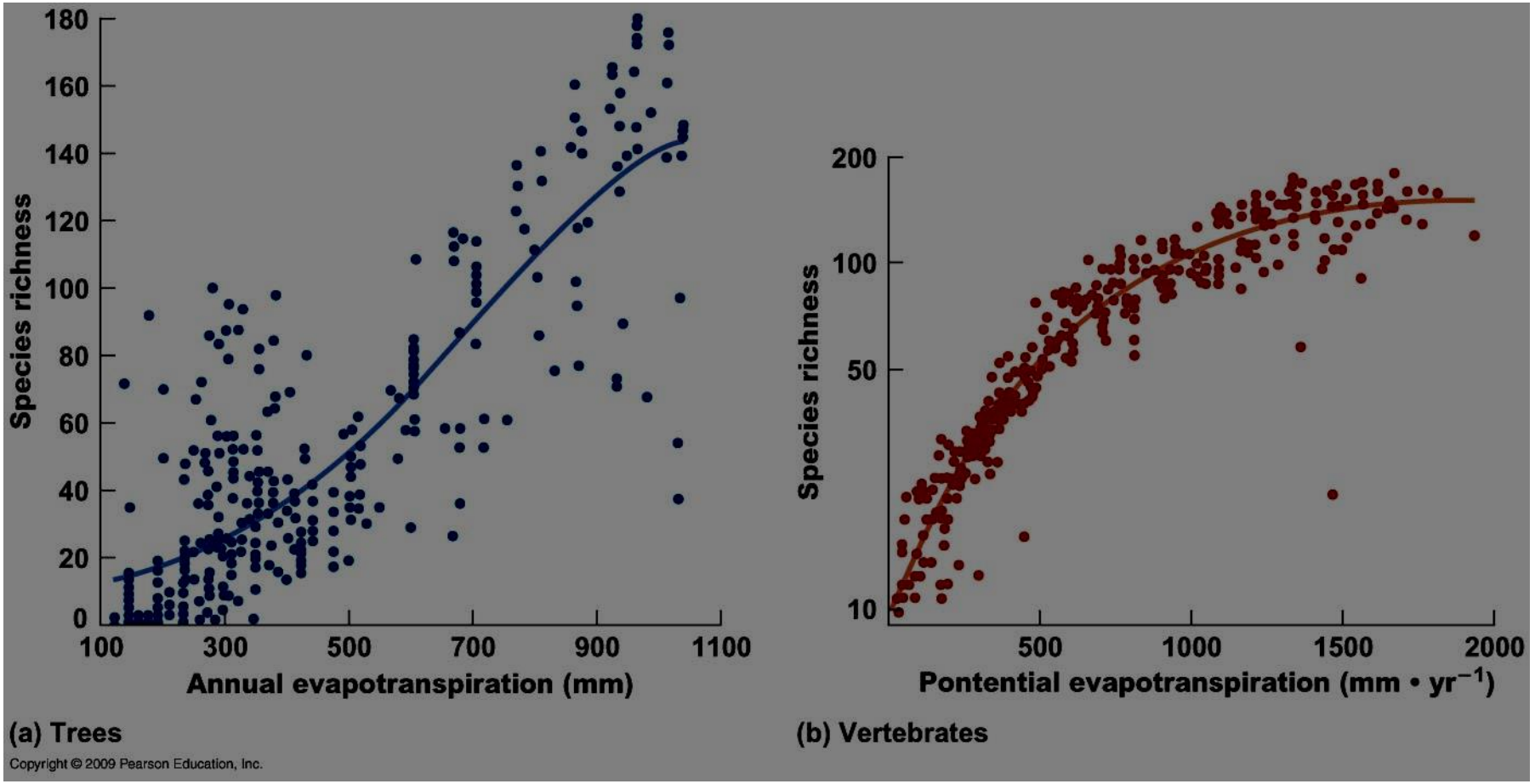
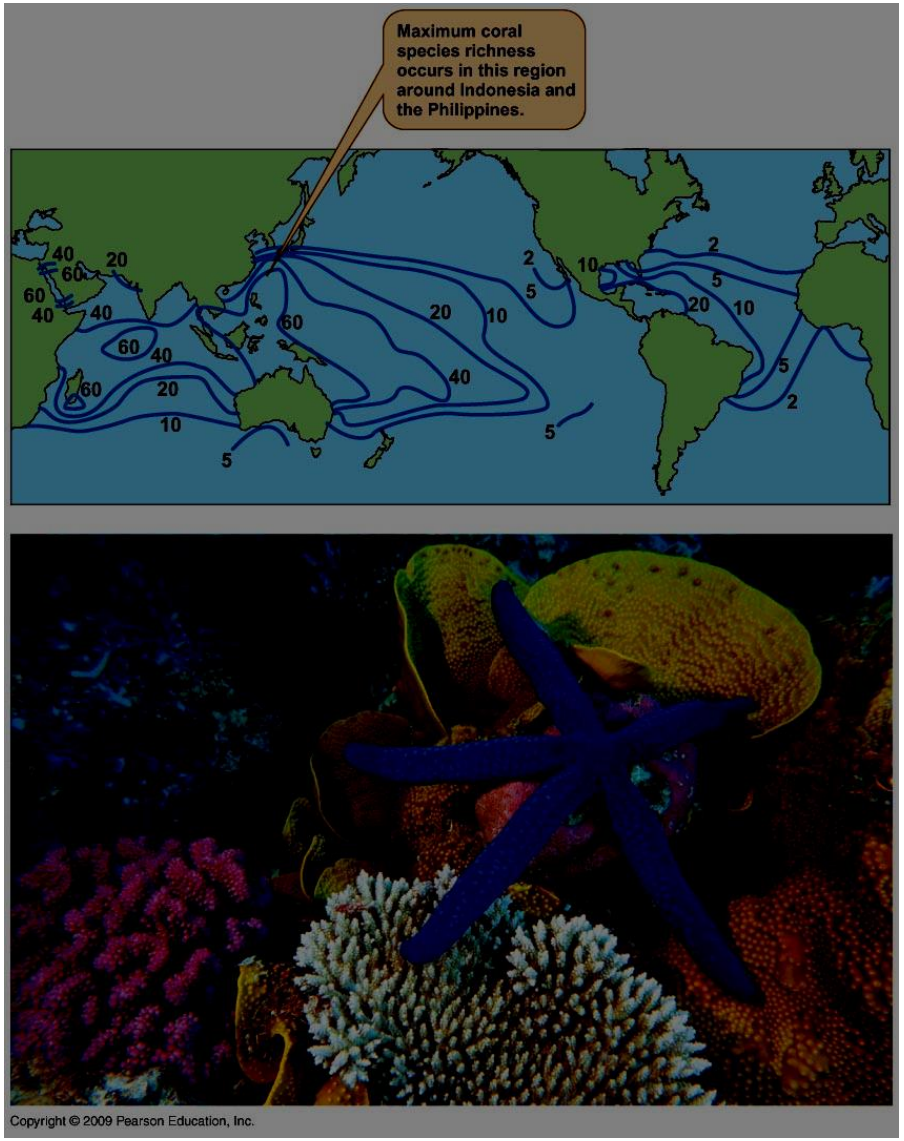



**Figure 21.2** (a) In a saturated community, local richness is expected to increase with regional richness at very low levels of regional richness, but to quickly reach an upper limit. In an unsaturated community, on the other hand, local richness is expected to be a constant proportion of regional richness. (After Srivastava, 1999.) (b) Asymptotic relationship between local richness of litter-dwelling ant communities in 1 $m^2$ quadrats in 10 forest remnants in Brazil in relation to the size of the regional species pool (assumed to be the total number of species in the forest remnant concerned). (After Soares *et al.*, 2001.) (c) Nonasymptotic relationship between local species richness (number recorded over equal-sized areas of a river bed) and regional species pools (the number of species present in the entire drainage basin from which the local sample was drawn). (After Rosenzweig & Ziv, 1999.)

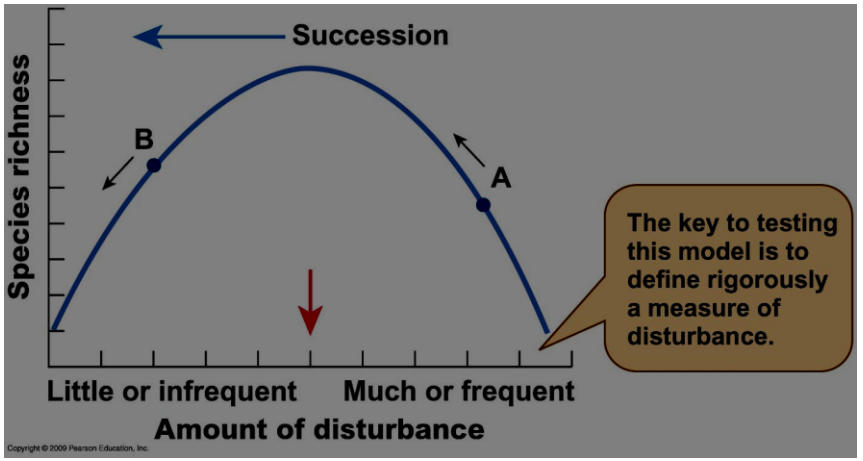
# Explicaciones de los gradientes: Energía disponible

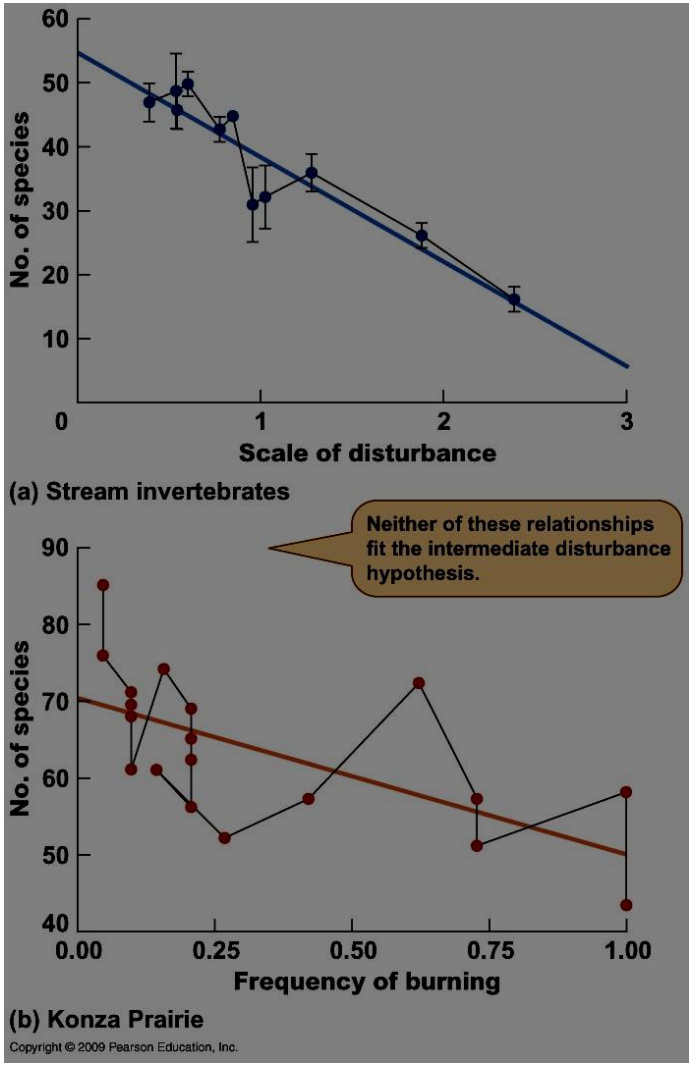


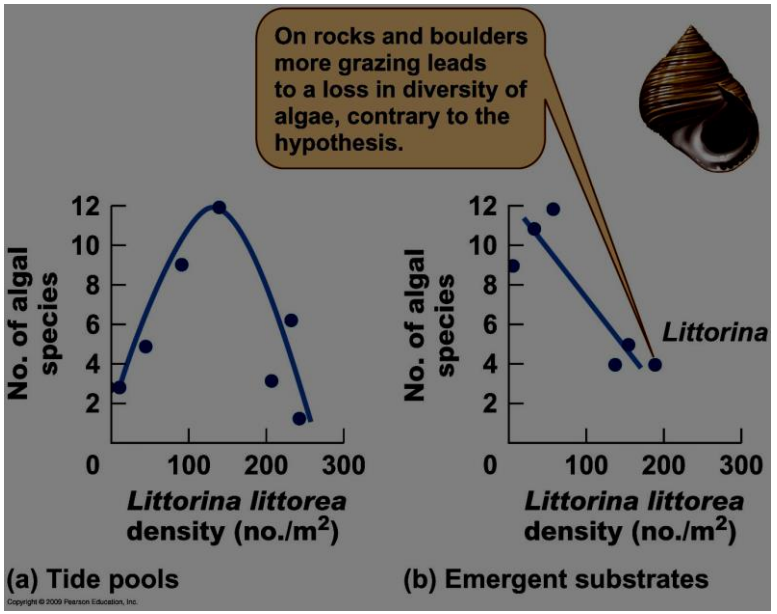
# Explicaciones de los gradientes: Energía disponible



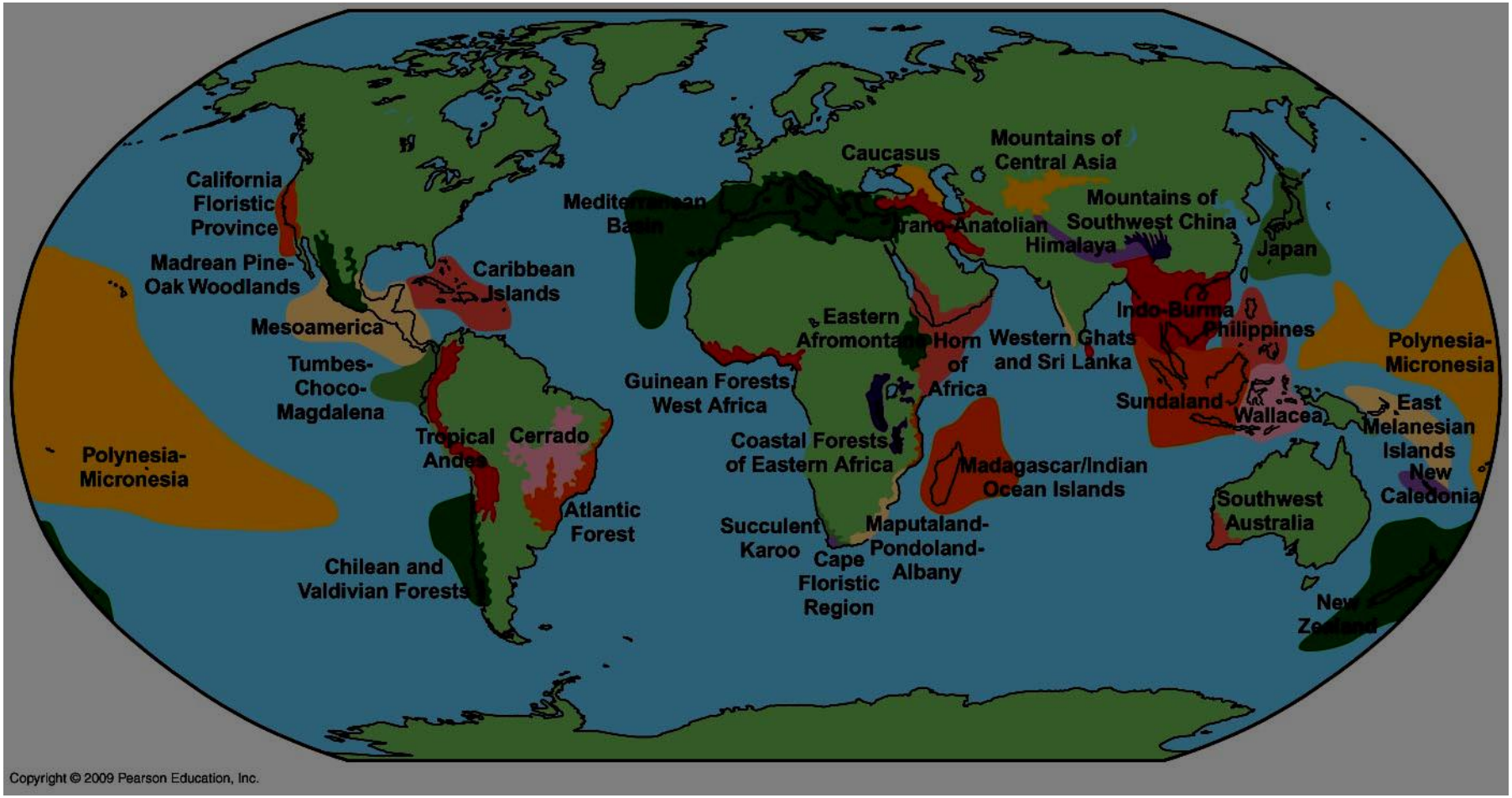
# Gradientes a escala local y perturbaciones



# Centros de biodiversidad (“hotspots”)



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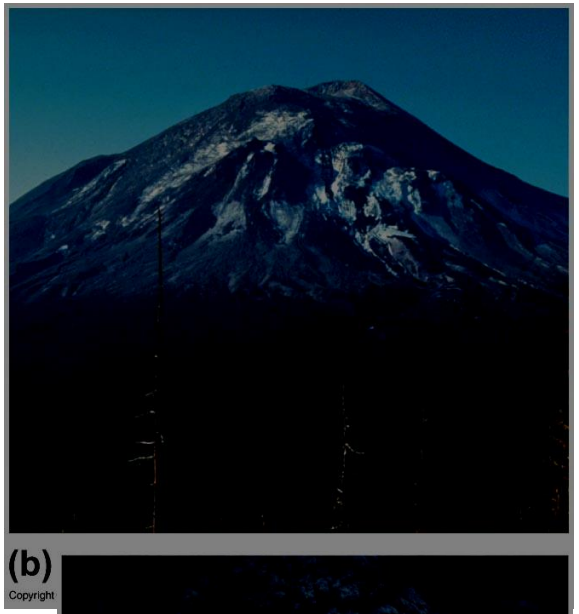
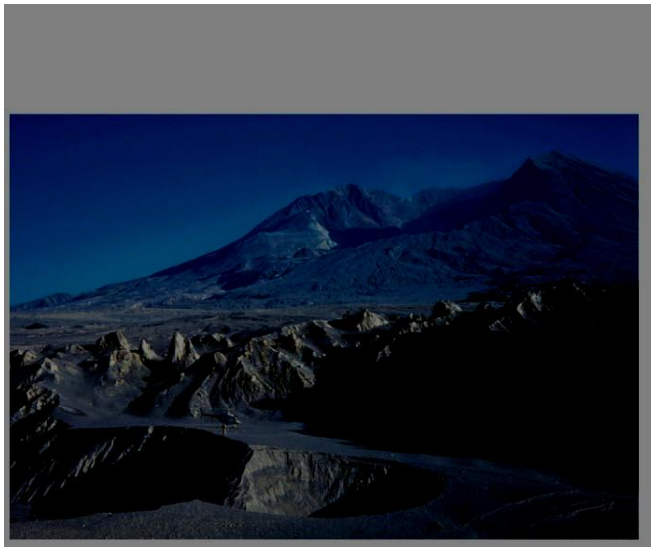
# Sucesión: cambio en la composición comunitaria

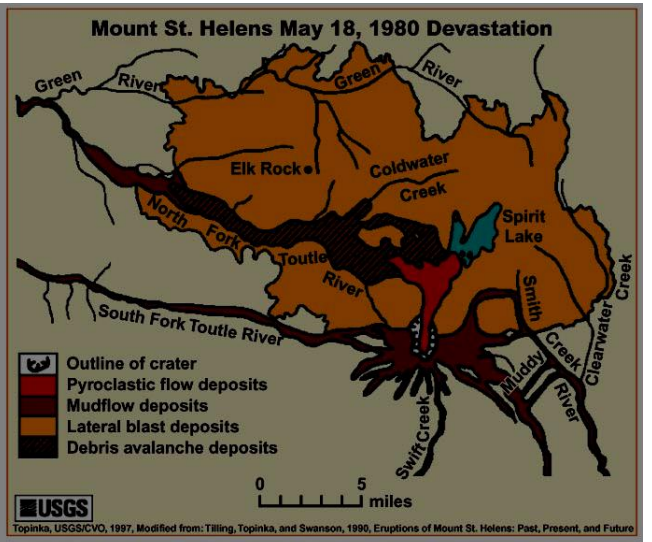
- Sucesión primaria: colonización de sitios nuevos, estériles hasta el momento
- Sucesión secundaria: cambios que suceden a las perturbaciones en sitios ya colonizados

# Sucesión primaria en el Monte Saint Helens

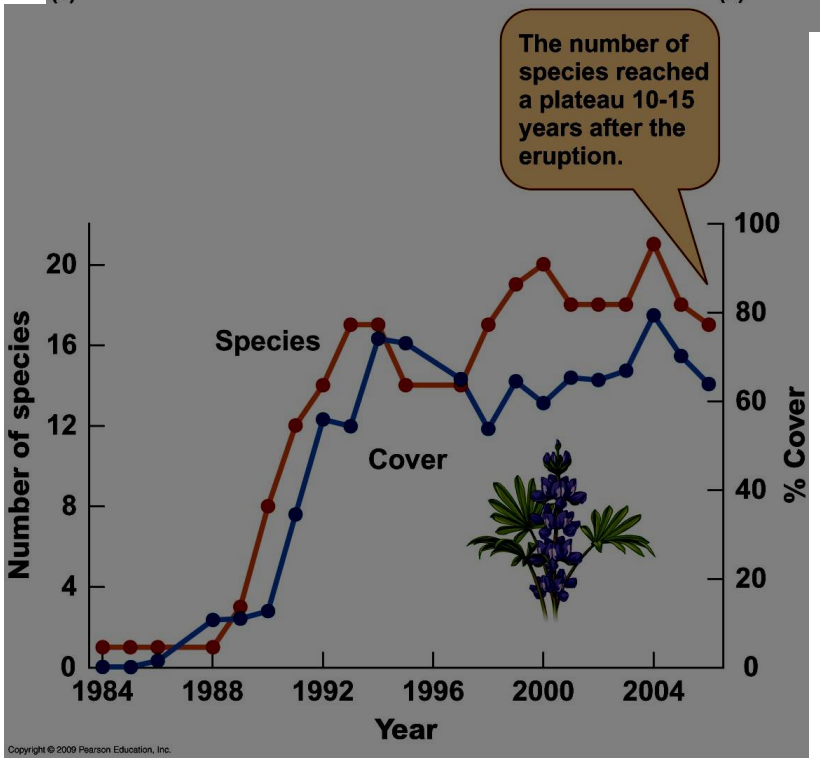






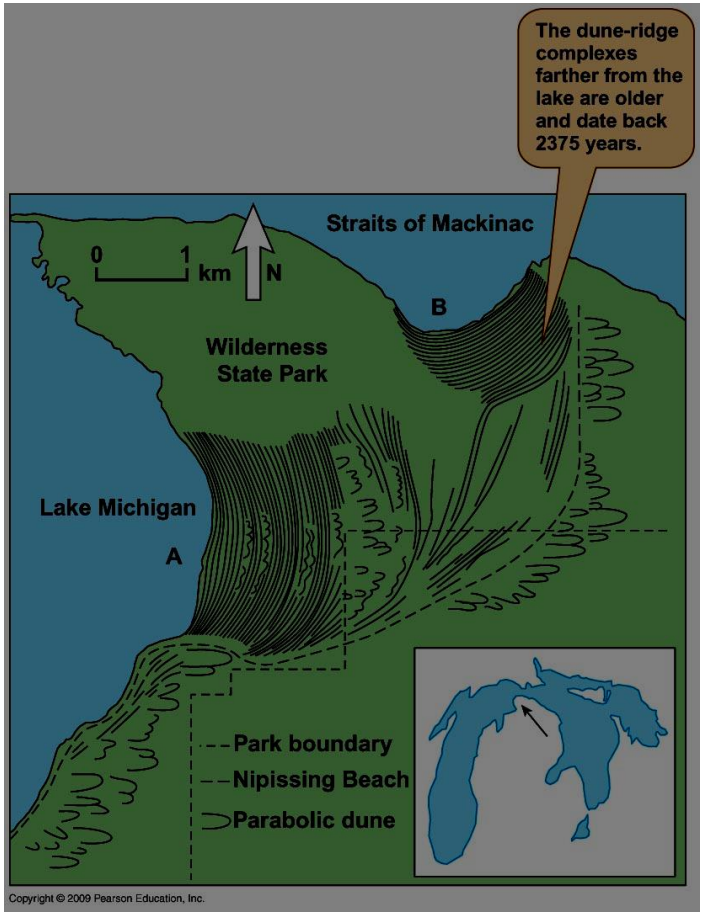



(a) (b)

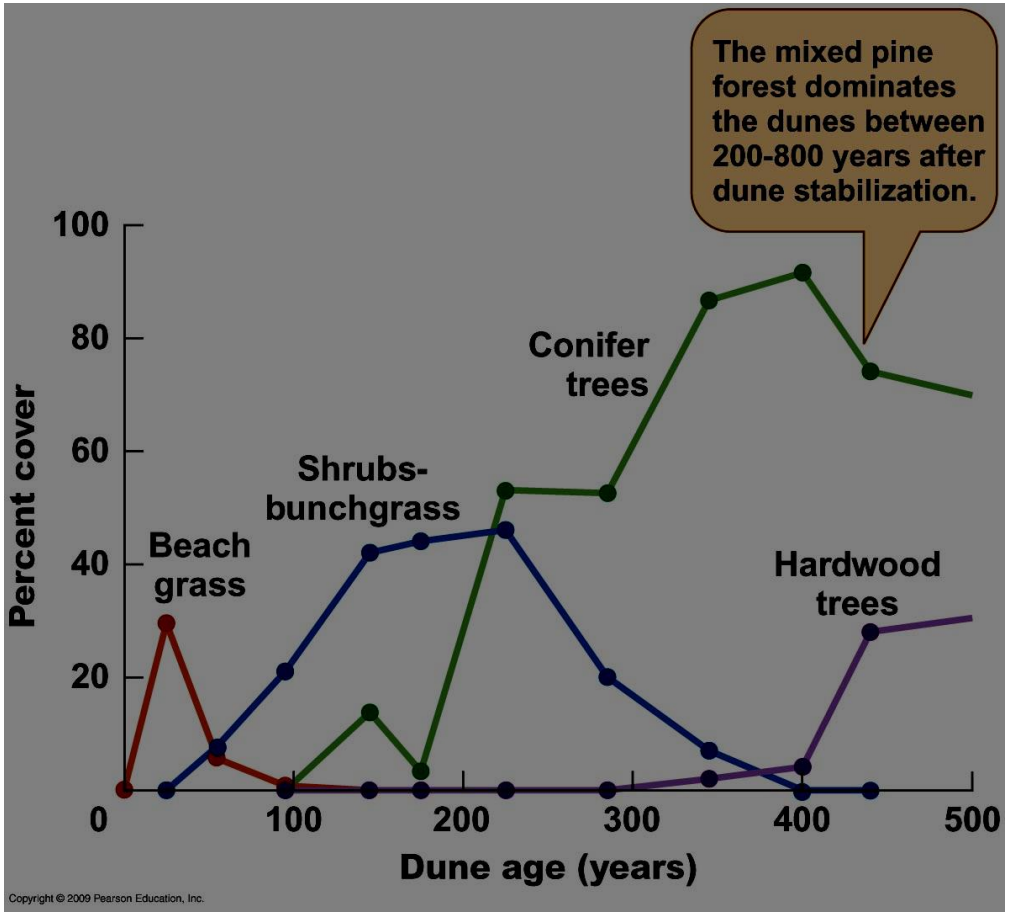



*Lupinus lepidus*

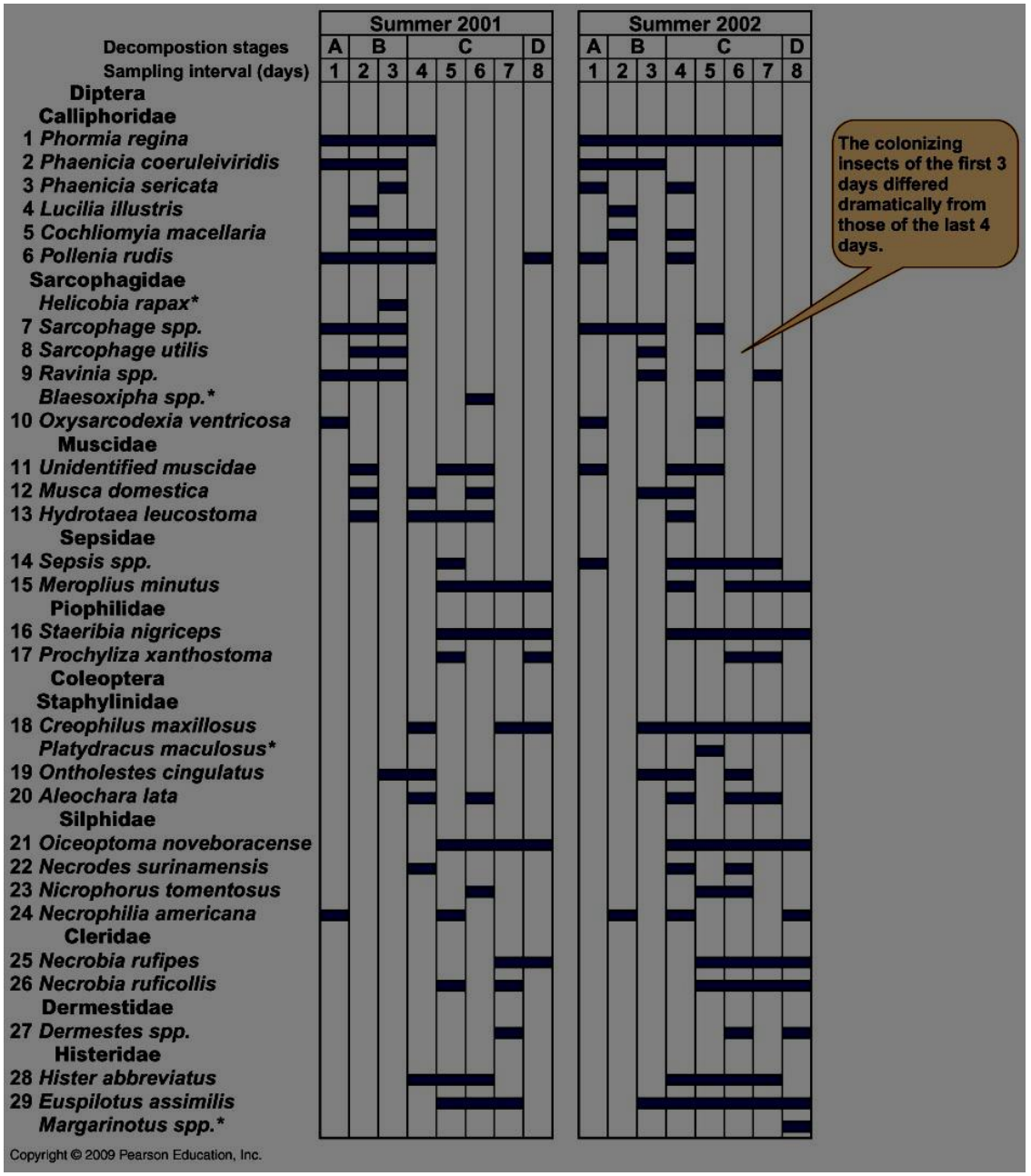
# Dunas del lago Michigan, EE.UU.



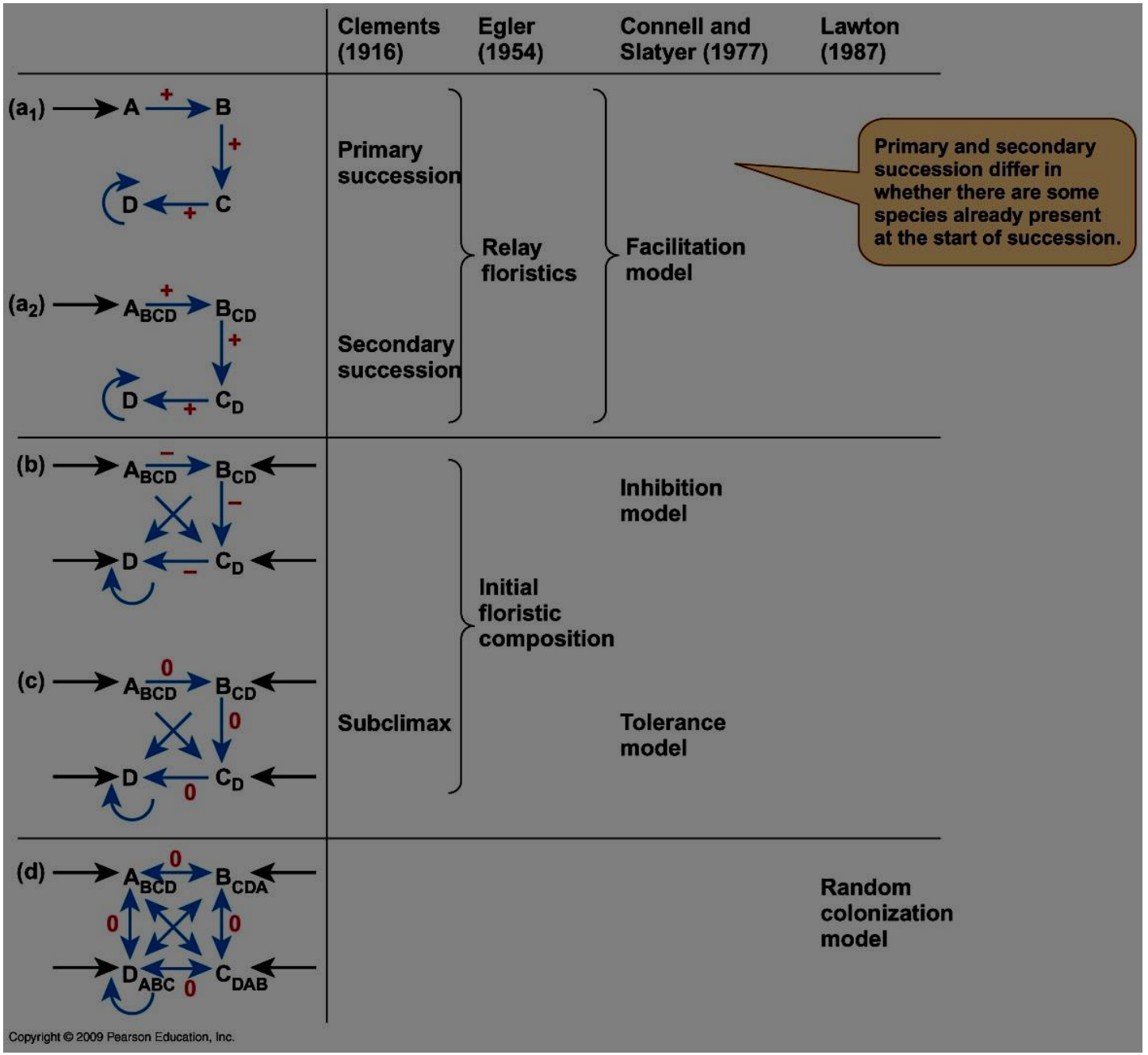
# Dunas del lago Michigan, EE.UU.



# Sucesión de insectos en cadáveres



# Hipótesis sobre sucesión



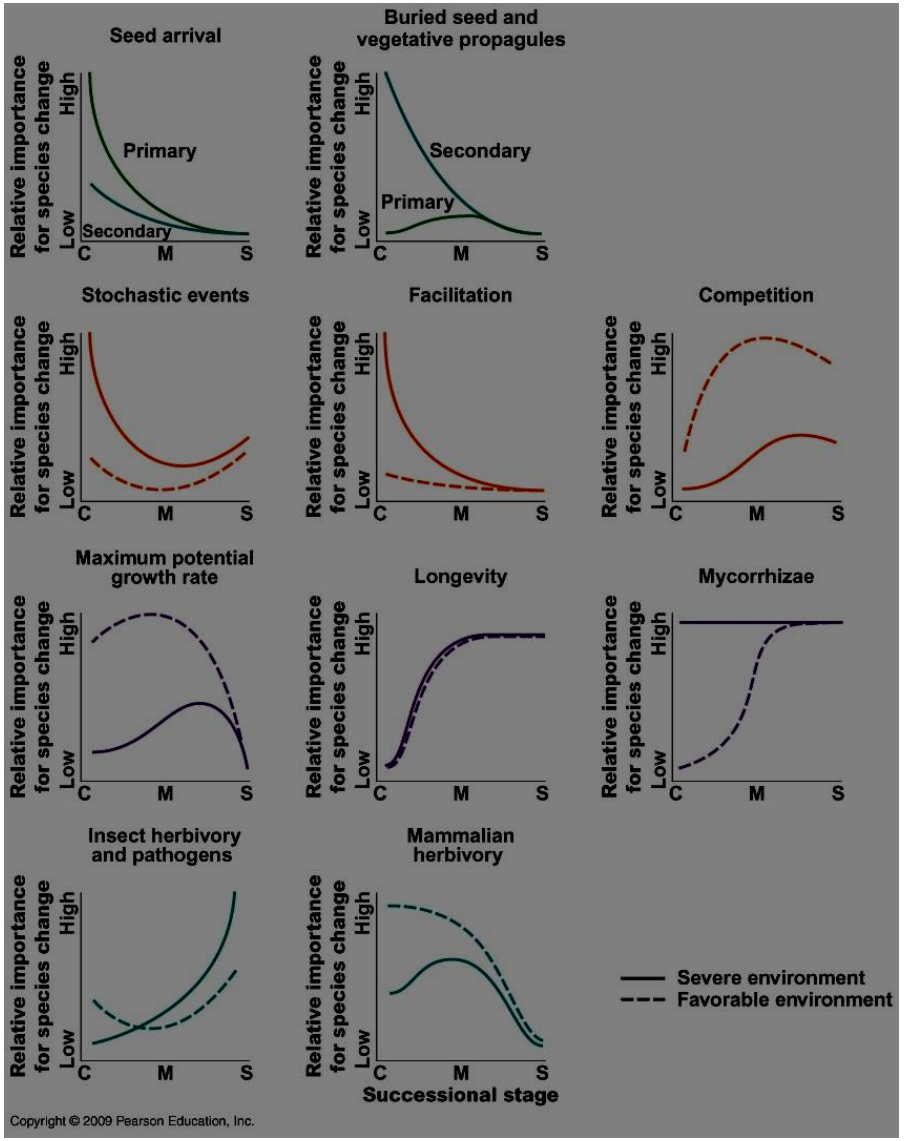
# Características de las especies en las etapas sucesionales

**Table 18.1** Physiological and life history characteristics of early- and late-successional plants.

| Characteristic | Early succession | Late succession |
|---|---|---|
| Photosynthesis | | |
| Light-saturation intensity | high | low |
| Light-compensation point | high | low |
| Efficiency at low light | low | high |
| Photosynthetic rate | high | low |
| Respiration rate | high | low |
| Water-use efficiency | | |
| Transpiration rate | high | low |
| Mesophyll resistance | low | high |
| Seeds | | |
| Number | many | few |
| Size | small | large |
| Dispersal distance | large | small |
| Dispersal mechanism | wind, birds, bats | gravity, mammals |
| Viability | long | short |
| Induced dormancy | common | uncommon? |
| Resource-acquisition rate | high | low? |
| Recovery from nutrient stress | fast | slow |
| Root-to-shoot ratio | low | high |
| Mature size | small | large |
| Structural strength | low | high |
| Growth rate | rapid | slow |
| Maximum life span | short | long |

SOURCE: From Huston and Smith (1987).

# Mecanismos sucesionales



- Explicaciones de la estructura de las comunidades

Vellend (2010) Quart. Rev. Biol. 85:183-206

# Teórica 9: Recapitulación

- Las comunidades pueden caracterizarse por su riqueza, abundancia relativa, composición y estructura de interacciones
- La diversidad de especies varía geográficamente, lo cual puede ser explicado por varios procesos alternativos no excluyentes
- Las comunidades cambian en el tiempo por procesos de sucesión primaria y secundaria