

Chapter 05

A Study in Biodiversity: Rain Forest Tree Species Richness



PLATE 5-1
PASOH FOREST,
MALAYSIA



PLATE 5-2

The extreme high species richness of trees in many tropical forests such as this one in Ecuador is difficult to explain, hence the *paradox of the trees*.



PLATE 5-3

Part of a tree? Hummingbirds of the Neotropics, such as this white-necked Jacobin (*Florisuga mellivora*), are important cross-pollinators of many tree and other plant species.

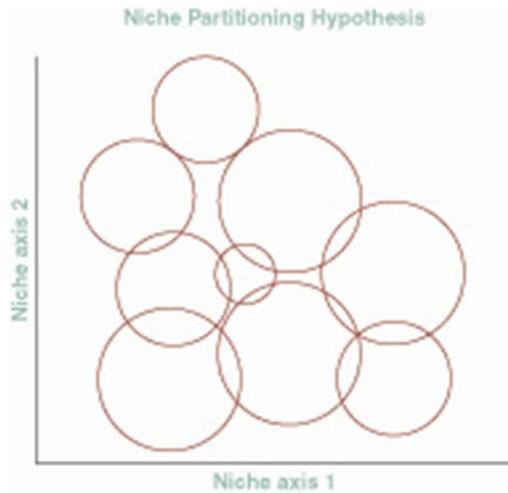


FIGURE 5-1
This diagram demonstrates how species' niches (shown in various-sized circles) attain minimal overlap when graphed against two hypothetical niche axes. This is the prediction of the niche-partitioning hypothesis.

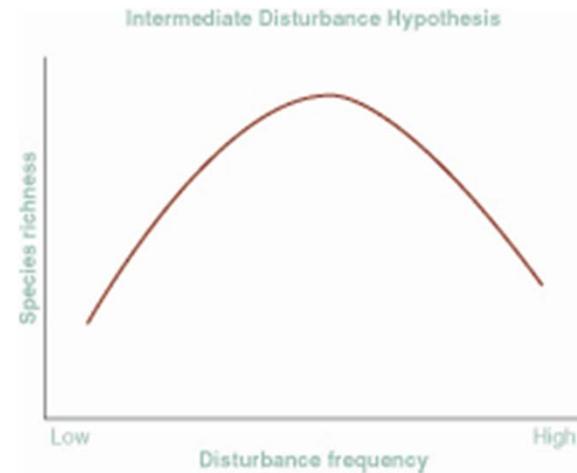


FIGURE 5-3
Species richness is maximal when disturbance frequency is intermediate. Too much disturbance reduces diversity because few species are adaptable to high disturbance. Too little disturbance results in lowering diversity due to competitive exclusion.

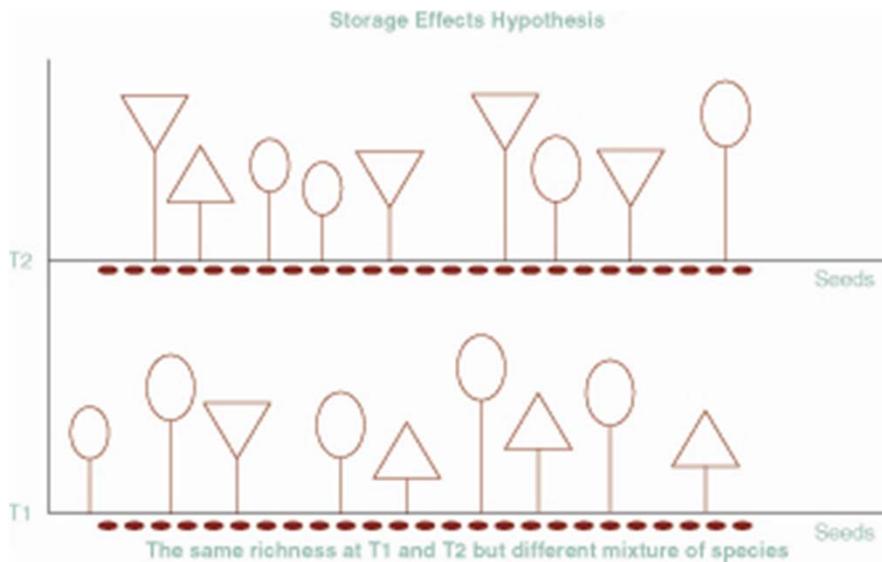
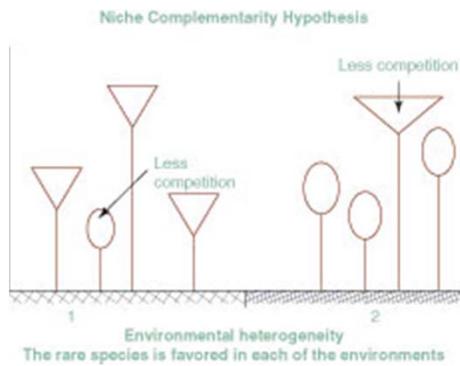
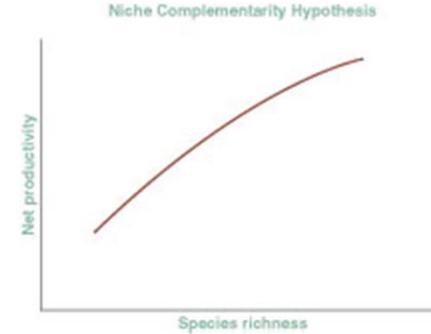


FIGURE 5-2
The storage effects hypothesis predicts that seeds are maintained in soil for long periods. Adult trees live to have many opportunities to reproduce, but a comparison of time T1 with time T2 shows that the species richness gradually changes with time.



(a)



(b)

FIGURE 5-4

The niche complementarity hypothesis predicts that as species pack into a habitat that has some heterogeneity, rare species are under less competitive pressure and so enjoy an advantage and persist, adding to the species richness of the site.

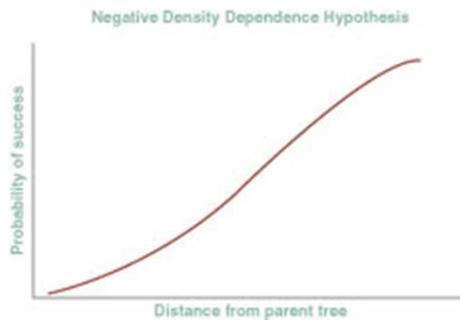


FIGURE 5-5

The negative density dependence model predicts that the probability of a seed sprouting and eventually becoming a mature reproducing tree is a function of how distant the seed is from its parent tree. Being close to the parent tree creates a *seed shadow* that reduces the chances of success due to competition with the parent tree.

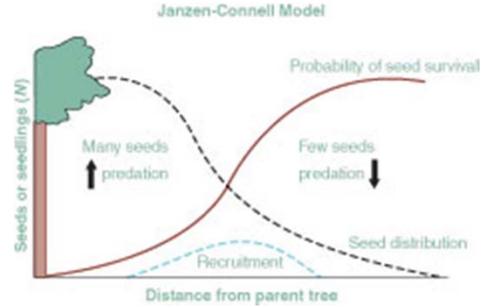


FIGURE 5-6
 Predation pressure from pathogens and herbivores is most intense near mature trees, and thus seeds that are moderately distant from the tree survive best. Compare this model with the previous model. Both are similar.

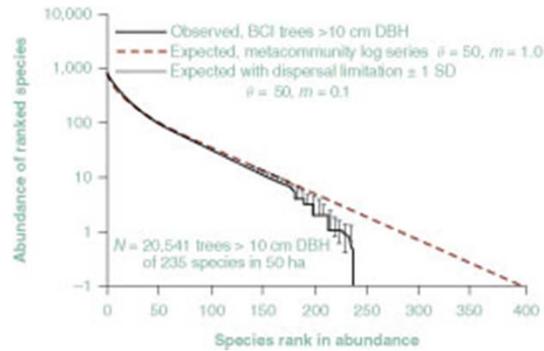


FIGURE 5-7
 The neutral theory applied to known tree species abundances on BCI shows a very close fit even though the model makes none of the assumptions contained in the preceding models.



PLATE 5-4

This is one of 19,400 legume species (Fabaceae), making legumes the third largest plant family in the world. Legumes abound in the tropics, but many species range well into higher latitudes. Many legume species have feathery compound leaves, and all produce seeds in pods.

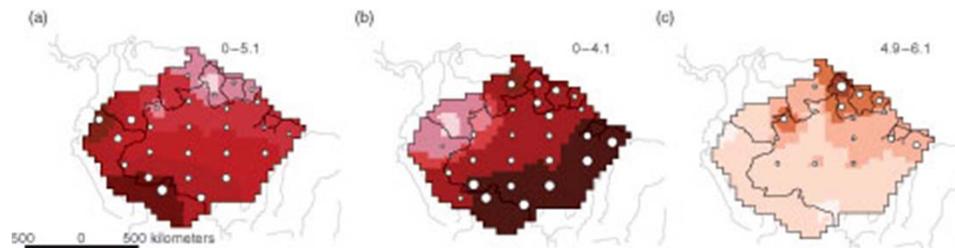


FIGURE 5-8

These maps illustrate geographic variation in community characteristics of South American tree communities. Maps (a) soil fertility gradient and (b) dry season gradient illustrate scores on two gradient axes, and (c) shows community-weighted seed mass.

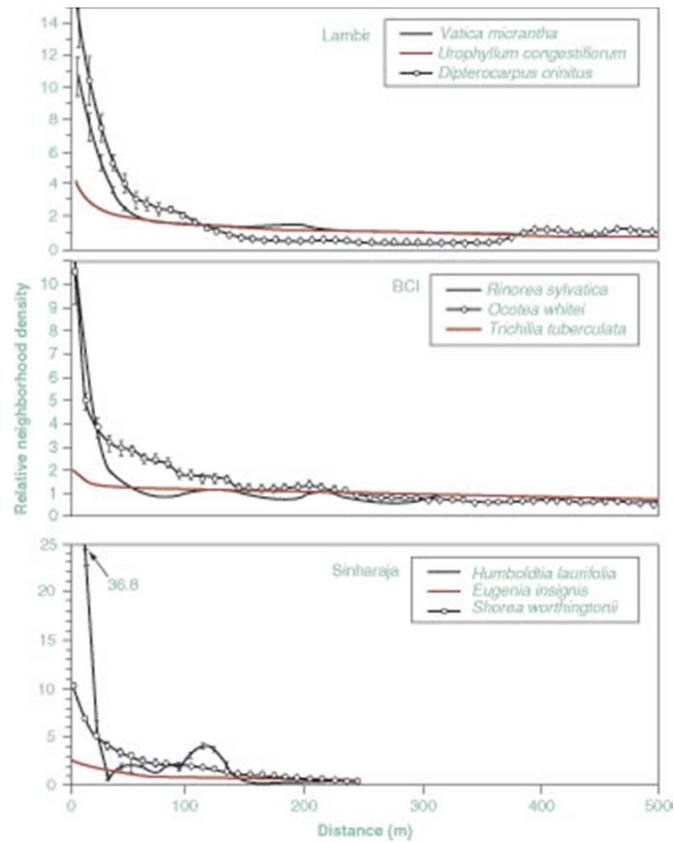


FIGURE 5-9

This figure plots relative neighborhood density against distance in meters for species in three different forest plots. Note the similarity of patterns in the three forests, each showing aggregation.

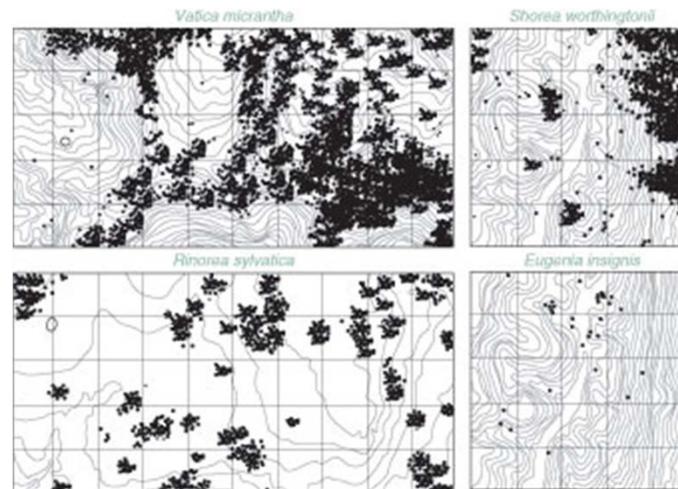
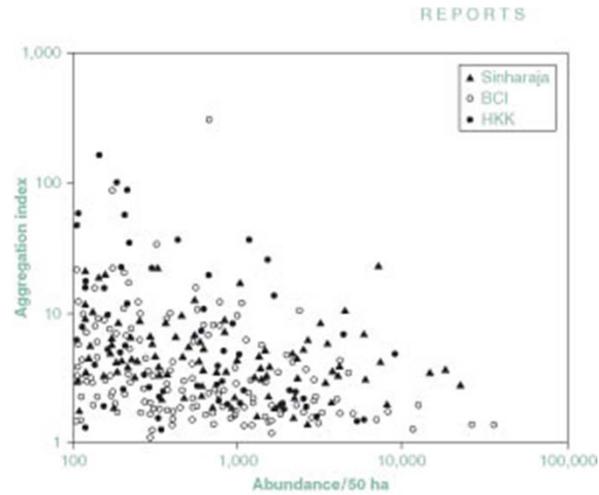


FIGURE 5-10

Graph shows the relationship between aggregation of conspecific trees and abundance. Rarer species showed more aggregation. The bottom maps illustrate four examples of species distributions. *Vatica* clumps follow ridges in Lambir. *Rinorea* clumps on BCI do not correlate with any known canopy, topographic, or soil feature and may be due to limited seed dispersal. *Shorea* follows ridge tops in Sinharaja, and *Eugenia* is a rare species in Sinharaja, with most individuals near their conspecifics.

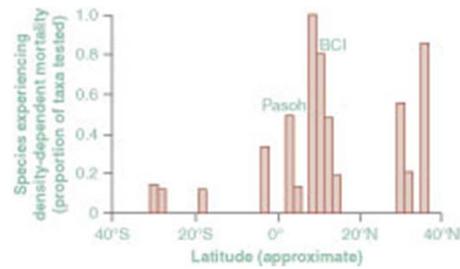


FIGURE 5-12

The proportion of tree taxa experiencing density-dependent mortality at different latitudes. Each bar represents a community of forest trees tested for density-dependent mortality. The proportion of the forest community experiencing density-dependent mortality does not increase at tropical latitudes.

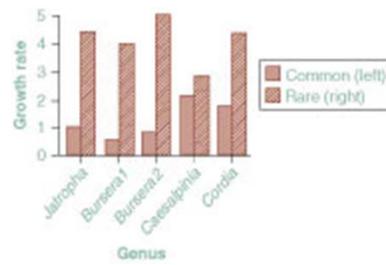


FIGURE 5-13

For five tree genera tested with the Kelly and Bowler model, growth rate was highest when the genus was rare.



PLATE 5-6

A severe hurricane cleared much of this mangrove forest on an offshore cay in Belize. The cay hosts a colony of magnificent frigatebirds (*Fregata magnificens*) that persist in attempting to nest.

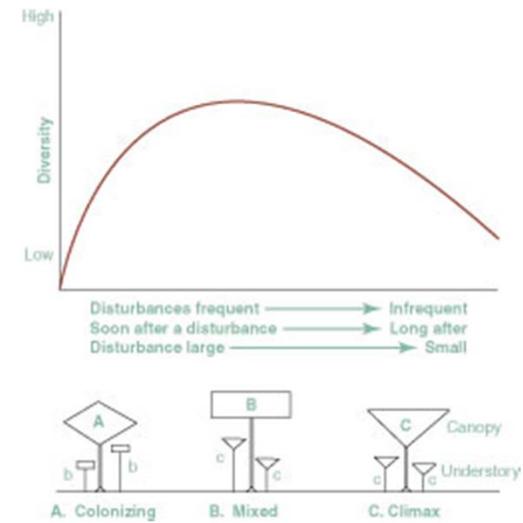


FIGURE 5-14

The Connell and Slatyer model predicts a peak in diversity at intermediate disturbance frequencies.

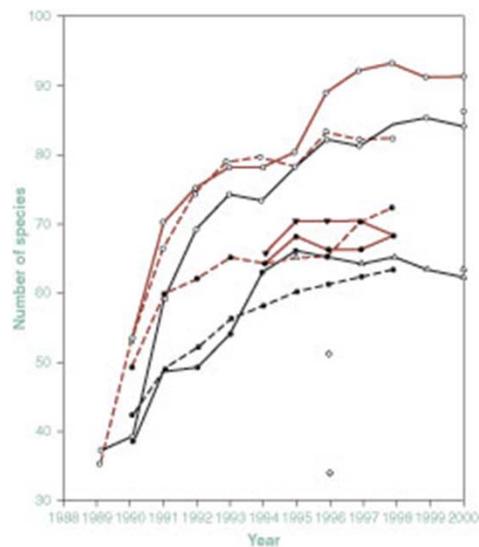


FIGURE 5-15

The eight plots in the Vandermeer et al. (2000) study each showed strong increases in species richness following the hurricane. Open circles are Bodega (three plots), solid circles are Fonseca (three plots), open triangles are La Unión (one plot), solid triangles are Loma de Mico (one plot), and open diamonds are Kurinwas (which was sampled only once).

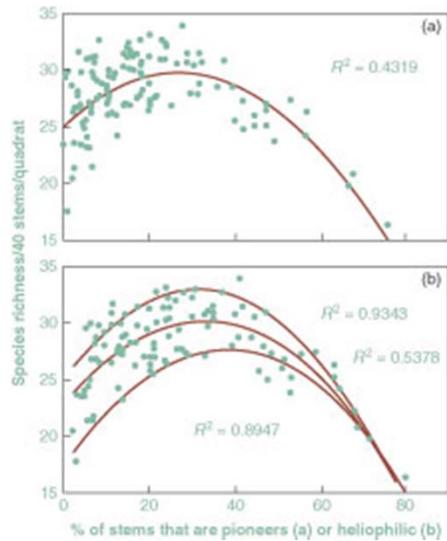


FIGURE 5-16

These graphs illustrate data obtained by Molino and Sabatier. (a) shows pioneer species, and (b) shows heliophilic species. The species richness peaks with a moderate abundance of both pioneer and heliophilic species.

PLATE 5-7

The Galápagos Islands, about 1,000 kilometers (600 miles) west of Ecuador in the Pacific Ocean, provide a good example of island biogeography.





PLATE 5-8

The large ground finch (*Geospiza magnirostris*) is one of 13 species of Darwin's finches found on the Galápagos Islands.

PLATE 5-9

This plate shows a cluster of leaves from Galápagos *Miconia* (*Miconia robinsoniana*), endemic to the Galápagos Islands and common at certain elevations on various islands. *Miconia* is a widespread genus with many species in the Neotropics, and thus *Miconia* colonized from either Central or South America. Also notice bracken fern (*Pteridium aquilinum*). Bracken fern colonizes widely, and many species are found in many regions throughout the world.



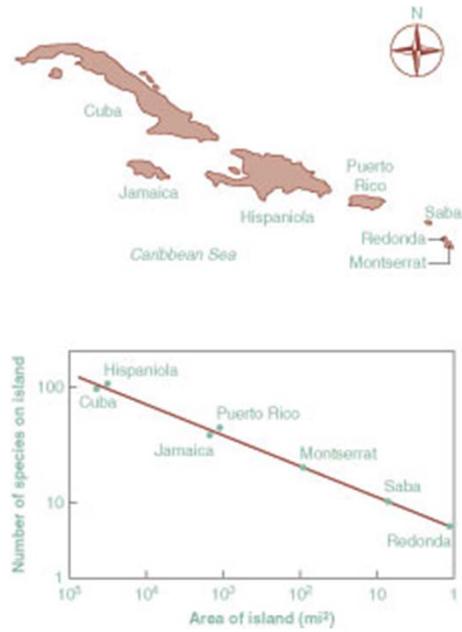


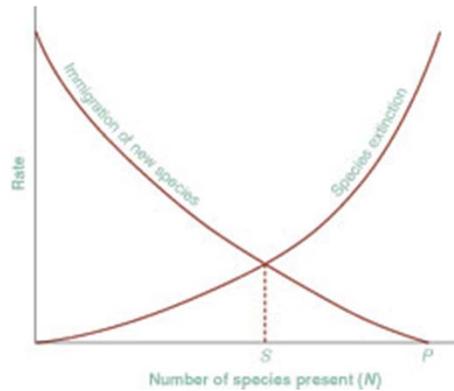
FIGURE 5-17

The relationship between number of species (in this case, of reptiles and amphibians) per island and island area.

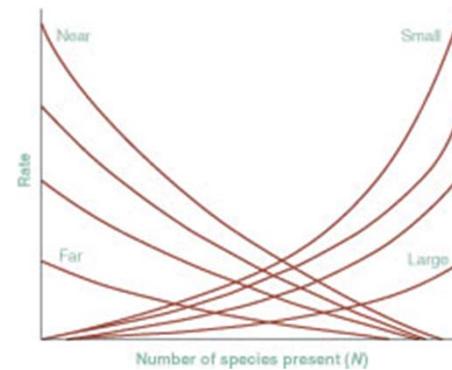


PLATE 5-10

Green iguana, a widespread species throughout the Neotropics that has colonized the Caribbean island of Anguilla.



(a)



(b)

FIGURE 5-18

(a) The basic relationship between immigration rate and extinction rate on an island. The point where the curves cross is the equilibrium point for the island. (b) This graph shows how distance from colonization source and island size each affect the eventual equilibrium point. Small, distant islands have much lower equilibrium points than large islands close to the mainland.

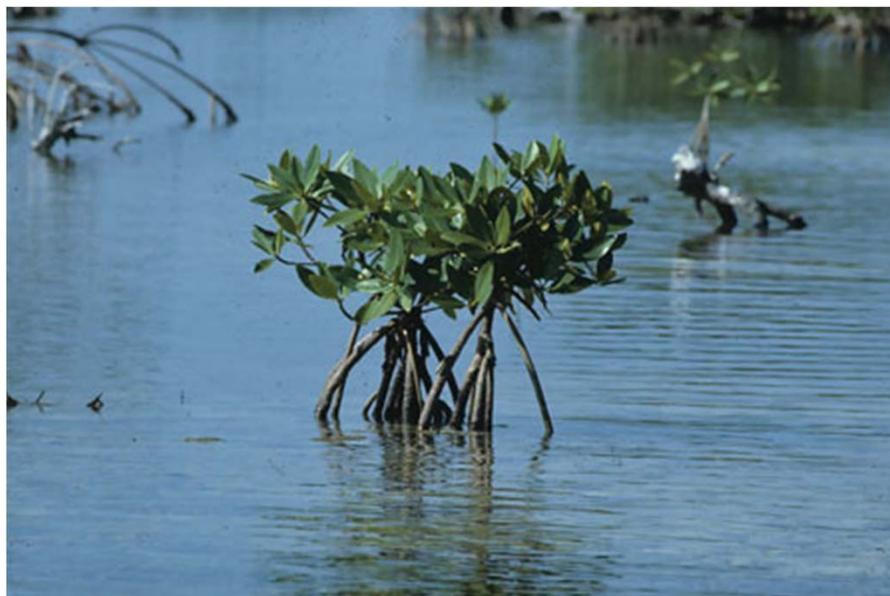


PLATE 5-11

This is a small mangrove "island" (of *Rhizophora*) similar to the kinds used in the study by Simberloff and Wilson discussed earlier.



PLATE 5-12

Great curassow (*Crax rubra*), now extinct from BCI.



PLATE 5-13

Black-faced antthrush (*Formicarius analis*), now extinct from BCI.



FIGURE 5-19

The possible evolutionary trade-off between colonization (dispersal) ability and ability to compete indefinitely once established. Good competitors are poor colonizers.

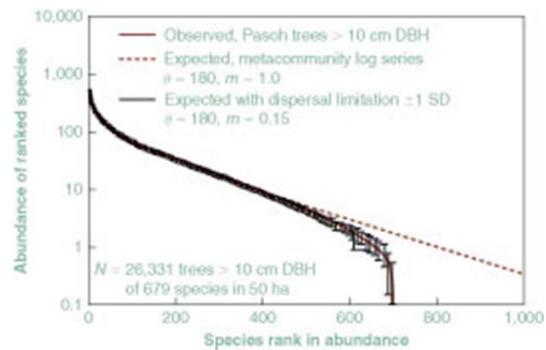


FIGURE 5-20

Fitted and observed dominance–diversity distributions for trees . 10 centimeters in diameter in a 50-hectare plot in Pasoh Forest Reserve, Malaysia. The u value was 180. Note that very rare species do not fit the curve well, but all others do.

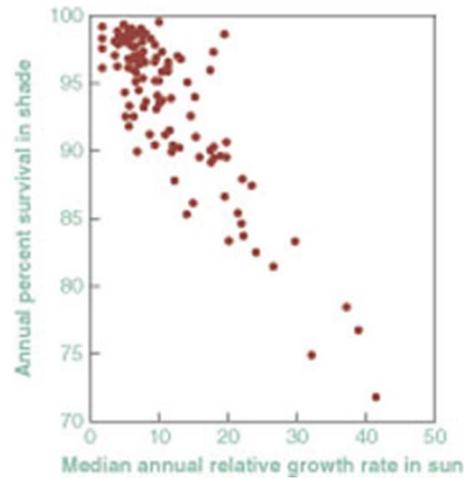


FIGURE 5-21

This graph shows niche differentiation along the shade tolerance–shade intolerance life history characteristics for BCI tree species. Dots represent species means for stems 1 to 4 centimeters in diameter at breast height. The graph shows that most species of trees on BCI are shade-adapted.

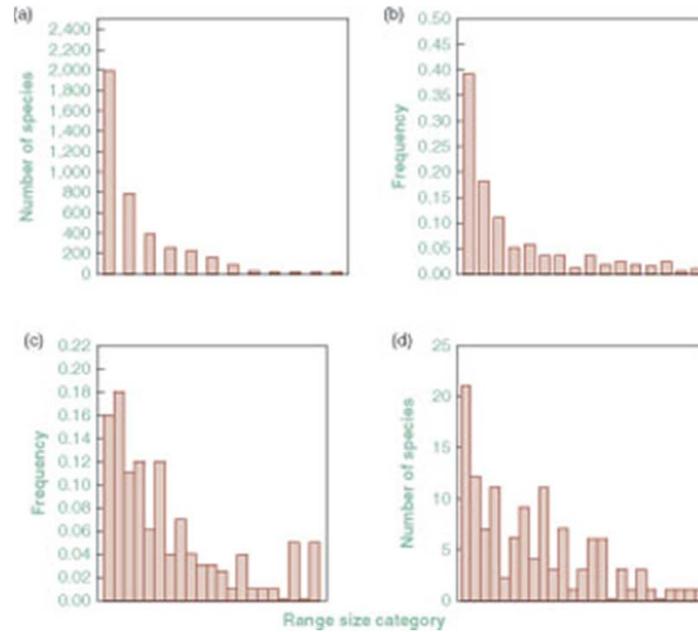


FIGURE 5-22

The actual distribution of bird species and range size for (a) New World birds, (b) passerine birds in Australia, and (c) North American birds compared with the distribution in range in (d) a neutral community. The neutral community comprised 125 species. Note that the neutral model based on local dispersal among species predicts a very similar distribution to the other data sets.

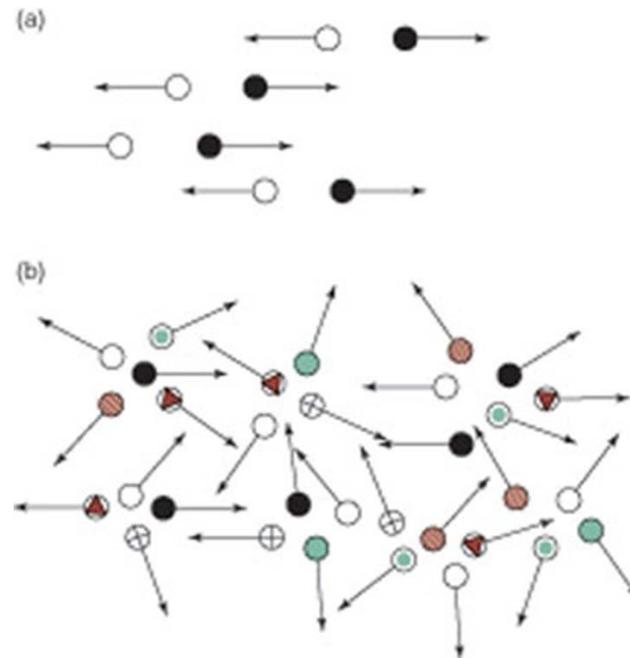


FIGURE 5-23

Hubbell's "cartoon" to illustrate diffuse coevolution in (a) a species-poor community compared with (b) a species-rich community. Each symbol represents an individual, and different symbols represent different species. Character displacement (niche separation) evolves in simple communities because pairwise species encounters are chronic and predictable. In the complex community, such encounters are much less frequent between any two species, so character displacement evolves very slowly, if at all.

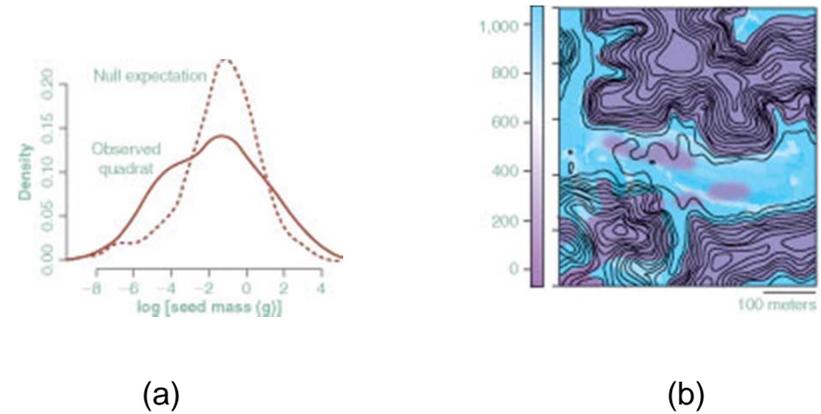


FIGURE 5-24

(a) This map of Yasuni shows contours indicating topography. The color densities indicate variation in SLA. The map shows a pattern illustrating that ridgetops have lower than expected SLAs (based on a null model) and valleys have a higher than expected SLA. (b) The graph shows the difference between the predicted distribution of seed mass in relation to density between the null expectation and the actual observed distribution.

PLATE 5-14

Tropical moist forest tree species richness: deterministic or neutral?



PLATE 5-15

The widely distributed great antshrike (*Taraba major*) is one of hundreds of species of suboscine birds found in the Neotropics.

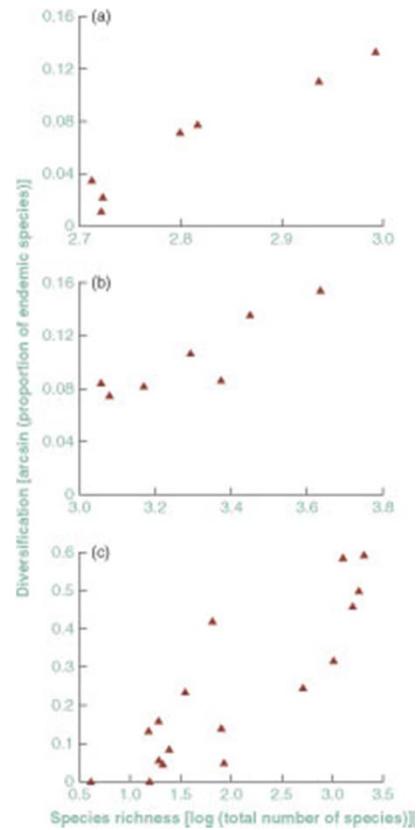


FIGURE 5-25

These three plots show the relationship between species richness and diversification (based on proportion of endemic species). (a) is plants in the Canary Islands, (b) is arthropods in the Canary Islands, and (c) is arthropods in the Hawaiian Islands.