Answers to Exercise 9

Island Biogeography

1. Note in Figure 2 that as species richness increases, immigration rate decreases, and extinction rate increases. At some value of species richness, the two lines cross, indicating that immigration and extinction rates are equal. At that point, species richness is at equilibrium. In this figure, equilibrium species richness is a little less than 400 species.

2. It is stable, as you can see from examination of Figure 2. When species richness is less than the equilibrium value, the immigration rate is higher than the extinction rate, and so species richness will increase. If species richness exceeds the equilibrium value, the extinction rate is greater than the immigration rate, and species richness will decrease. Thus, even if species richness deviates from the equilibrium value, it tends to return to it.

3. It is a dynamic equilibrium. Figure 2 shows that when species richness is at equilibrium, immigration and extinction are both still greater than zero: thus even though overall species richness has reached equilibrium, individual species are still going extinct and new species are still arriving. In this example, the rates of immigration and extinction are equal at about 20 (e.g., in units of species per year). This is the turnover rate.

4. Examine Figure 4, the graph of immigration rates for islands at three distances from the mainland.

   You should see that the immigration line for the near island is the steepest and the line for the far island is the shallowest. Consequently, the immigration line for the near island crosses the extinction line farthest to the right, and that for the far island, farthest to the left.

   If you drop a vertical line from each of the three crossing points to the horizontal axis, you will see that the near island has the highest equilibrium species richness (about 550), and the far island has the lowest (about 225).

5. Again examine Figure 4. This time, draw a horizontal line from each crossing point to the vertical axis. You should see that the near island also has the highest turnover rate (about 30 species per time unit), and the far island has the lowest (about 12 species per time unit).

6. Examine Figure 5, the graph of extinction rates for islands of three different areas.

   You should see that the extinction line for the small island is the steepest and the line for the large island is the shallowest. Consequently, the extinction line for the small island crosses the immigration line farthest to the left, and that for the large island, farthest to the right.

   If you drop a vertical line from each of the three crossing points to the horizontal axis, you will see that the large island has the highest equilibrium species richness (about 525), and the small island has the lowest (about 250).

7. Again examine Figure 5. This time, draw a horizontal line from each crossing point to the vertical axis. You should see that the large island has the lowest turnover rate (about 15 species per time unit), and the small island has the highest (about 25 species per time unit).

8. OPTIONAL: If you made the optional graph described in Step 12 on p. 132, draw vertical and horizontal lines from the nine crossing points to the axes.

   You should see that the highest species richness occurs on a large island near the mainland: the lowest on a small island far from the mainland.

   The highest turnover rate occurs on small island near the mainland: the lowest on a large island far from the mainland.

9. As you can see from Figure 7, species accumulate at a decreasing rate, eventually stabilizing at an equilibrium value of species richness.

10. You should also see from Figure 7 that the immigration rate declines with time and increasing species richness, but does not reach zero. Likewise, the extinction rate increases with time and increasing species richness, but levels off. At some value of species richness, immigration and extinction rates become equal, and species richness stabilizes at its maximum value. You can think of this as roughly analogous to changing per capita birth and death rates and stabilizing population size in the logistic population model.

    Note again that species continue to turn over after equilibrium species richness has been reached. From Figure 7, you should be able to see that the turnover rate in this example is about 20 species per time unit.

11. The fact that the species-area curves are nearly straight on a log-log plot indicates a power relationship. This is also shown in the equation of equilibrium species richness, in which area is raised to a power.

12. The species-area curve for near islands has the shallowest slope; the curve for far islands has the steepest. Islands near the mainland are well stocked with species regardless of area because immigration is relatively easy, and so even small islands have high species richness. Because no island can have more species than the mainland pool, there is little room for increasing species richness with increasing area—hence the shallow species-area curve. Islands far from the mainland are species-poor regardless of area because immigration is so difficult. However, as island area increases, the extinction rate decreases, so species richness increases rapidly in comparison to near islands.

    Species-area curves are used to estimate the rate of species loss as habitats become increasingly fragmented, effectively producing smaller islands of suitable habitat for endangered species. These curves predict that as habitats islands become smaller, species will be lost at an increasing rate (see Figure 10).