Theory of Island Biogeography

THEORY OF ISLAND BIOGEOGRAPHY

MacArthur and Wilson built a comprehensive model to explain the process of succession on newly formed Islands, where a gradual build-up of species proceeds from a sterile beginning. Their ideas have been termed the theory of island biogeography. This theory suggests that species recurrently enter an island and either flourish or become extinct. The number of species tends to attain an equilibrium number that reflects a balance between the rate of Immigration and the rate of extinction (*Figure 1*).

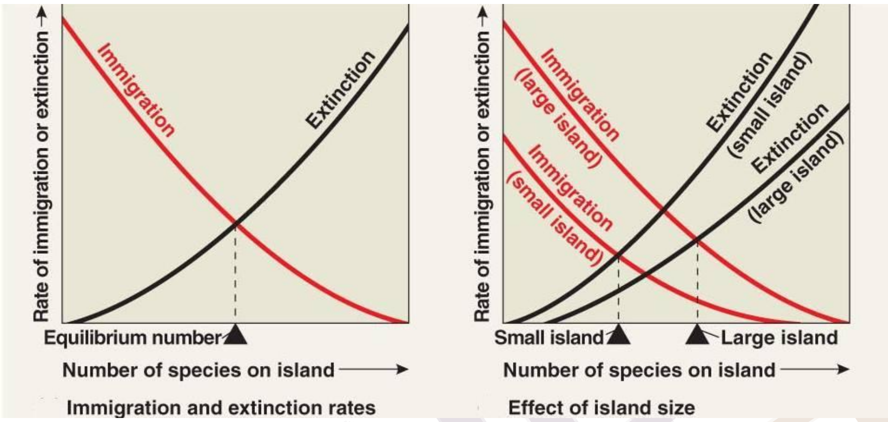

Figure 1. The theory of island biogeography. (a) The interaction of immigration rate and extinction rate produces an equilibrium number of species on an island. (b) In practice, the rate curves bend because some species immigrate more readily than others and because some species are better competitors than others.

The rate of immigration of new species is highest when there are no species present on the island, each invaded species is a new species. As the species start accumulating subsequent immigrants no longer represent new species. The rate of extinction is low at the initial colonization because few species are present and most have large population sizes. With the addition of new species, the population sizes of some species may happen to be smaller, 50 the probability of extinction of these species by probability increases. Species may continue to arrive and go extinct; however, the total number of species on the island remains the same. MacArthur and Wilson deduced that when plotted graphically, both the immigration and extinction lines would be curved for several reasons (*Figure 1*).

First, since the species arrive on islands at different rates. Some organisms, including plants with seed-dispersal mechanisms and winged animals, have higher dispersal abilities and will arrive quickly, while other organisms will arrive more slowly. This pattern causes the Immigration curve to start off steep but get progressively shallower. Conversely, extinctions start off slowly and rise at accelerating rates, because as later species arrive, competition increases, and more species are likely to go extinct. Earlier reaching species tend to be selected species, which are better dispersers, whereas species that arrive later are generally K-selected species, which are better competitors. Later arriving species usually outcompete earlier arriving ones, causing an increase in extinctions. Since, MacArthur and Wilson's effort, their concept of island biogeography has been applied to mainland areas, where patches of particular habitat can be viewed as "Islands". Dan Janzen extended this theory by putting forth the habitats-as-islands concept in which he proposed that individual host-plant species could be islands to their associated herbivore fauna, which was adapted only to feed on that particular type of vegetation. For example, many insects have complex biochemical machinery that allows them to detoxify certain plant tissues. However, the machinery is so specific that it works for only one or two species of the host plant. All other plants are essentially inedible to the insect. An example is the monarch butterfly caterpillar, which can feed only on milkweed plants. For the monarchs, milkweed patches are effectively islands surrounded by other vegetation that might as well be an open ocean.

The strength of the island biogeography model was that it generated several falsifiable predictions:

1. The number of species should increase with increasing island size. This is also known as the species-area hypothesis.
2. Extinction rates would be reduced on larger Islands since the population sizes would be larger and less susceptible to extinction (*Figure 2*).
3. The number of species decreases as the distance of the island from the mainland, or the source pool, increases.
4. Immigration rates would be greater on Islands near the source pool because species do not have as far to travel (Figure Below). This is also known as the **species distance hypothesis**.

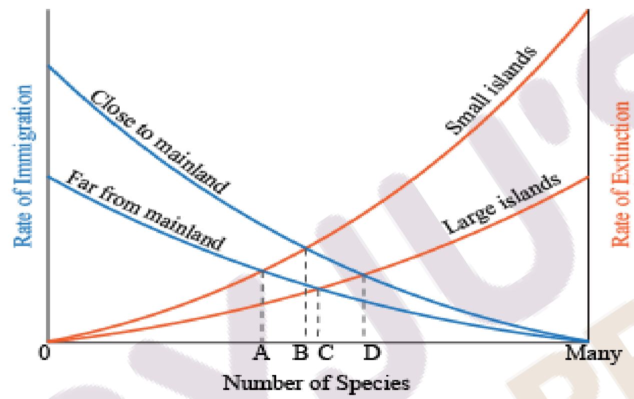

Figure 2. Island biota size varies with distance from the source pool and Island size. An increase in distance, from near far, lowers the immigration rate; an increase in Island areas, from small to large, lowers the extinction rate. The intersection of the immigration and extinction curves yields the equilibrium number of species.

5. The number of species on an island might remain the same, but the composition of the species would change continuously since new species would always colonize the Island and others would become extinct. The turnover of species should therefore be significant.
6. Recent studies have also shown low rates of species turnover when extinctions and immigrations tended to match each other, but again the majority of turnover was low, with most islands showing turnover rates of between zero and two species per census (or <0.1 species per year).