Concepts of Island Biogeography

One of the most important foundations of conservation biology is nearly 4 decades old: Island Biogeography – authored by Robert MacArthur and E.O. Wilson in 1967. "The central observation that this model was built to explain is the **species-area relationship**: islands with large areas have more species than islands with smaller areas. This rule makes intuitive sense because large islands will tend to have a greater variety of local environments and community types than small islands. Also, large islands allow greater geographic isolation and a larger number of populations per species, increasing the likelihood of speciation and decreasing the probability of local extinction of newly evolved as well as recently arrived species" (Primack 1998:165-166).

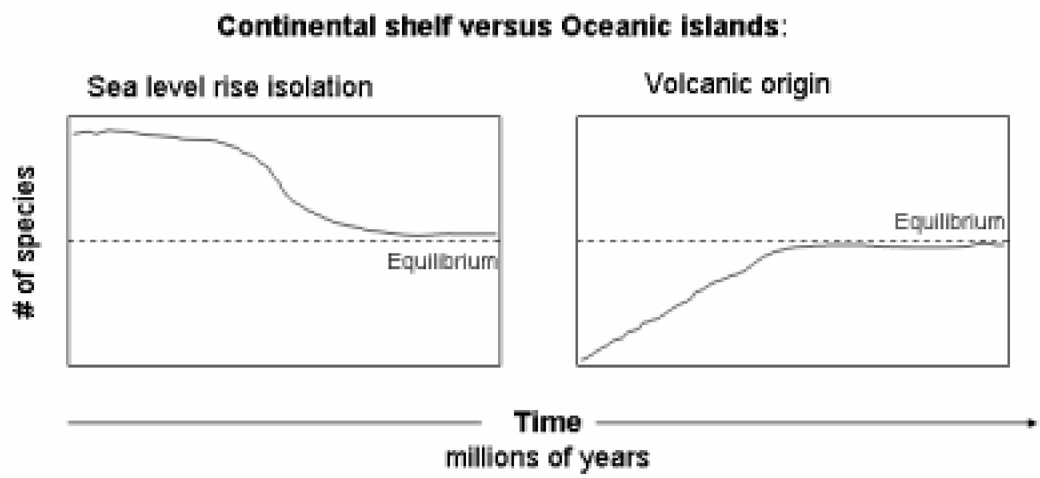
This is it: $S = CA^z$

where S is the number of species on an island, A is the area of the island, and C and z are constants – these depend on characteristics of the island such as climate, species involved, etc. The slope of the curve is determined by z.

Both Wallace & Darwin differentiated **continental shelf** islands (isolated by recent sea level rise) from true **oceanic** islands – islands created independently from continental processes (primarily volcanic).

As such, oceanic islands begin as barren lava-scapes. We know, however, that they are capable of developing into some of the most biotically diverse & unique places on earth – especially if they are in the tropics (Hawaii, for example). The process of biotic enrichment begins with initial, simple colonizers (algae, simple plants with wind- and water-borne seeds, wind- and water-borne animals…) and gradually develops complexity supported (or limited) by landscape, biological, and climatic factors (hence the equation's constants). **Immigration** and **colonization** rates, along with the factors that control these rates, drive the characteristics of the biota of such islands – at least initially.

In contrast are continental shelf islands (i.e., the Florida Keys, Aleutians) which exhibit reduced species diversity apparently as the result of their isolation – they were once a part of a mainland (North America) and contained the full complement of species expected for that region:



Dictionary **definitions** of “island” (from Webster’s)

1. a tract of land completely surrounded by water, and not large enough to be called a continent
2. a clump of woodland in a prairie
3. an isolated hill
4. something resembling an island, esp. in being isolated or having little or no direct communication with others (what is the definition of a peninsula?)(what is the definition of insular?)
5. a platform in the middle of a street

True Islands on the mainland:
A study of 42 volcanic cones (e.g. Mt. St. Helen’s) in the Oregon Cascades found that recent cones had an average of 45 plant species, whereas older cones with better developed soils had an average of 130 plant species. In this example, **time** seemed to be the most important factor in the development of the flora.

Compelling evidence suggests that the same **relaxation** that has occurred on continental islands has also occurred on mainland islands:

Mount Rainier National Park mammals declined from 50 in 1920 to 37 in 1976 (despite the colonization by 2 species – porcupine & striped skunk) – what can we say about the characteristics of these “colonizers”? early successional species, common…

Many conservation biologists are concerned with “**old growth**” forest. Following the continental shelf analogy: a true old-growth patch (a remnant) would be expected to maintain more species than an isolated replacement stand (i.e. one that is recreated from an early successional stand in isolation from true old-growth).

- How might this affect management decisions?
- What does this say about the potential to restore habitat?
- Are there values associated with understanding such concepts?

Species-area Relations
Given any homogeneous biotic community, the average number of species per quadrat sample will increase with quadrat size. Plotted on arithmetic paper, the relationship looks like this:

A Biogeographic Axiom

"An island of 10 times greater size is required to support a fauna of 2 times as many species"
conversely:
"An area reduction of 90% will
obtain a reduction in faunal **species richness** of 50%"

What else besides area appears to be important in determining the number of species in an area?
Many have claimed that habitat **heterogeneity** is very important if not of over-riding importance. For example in old-growth forests –

- Ecosystem diversity
- Temperature
- Light
- Moisture
- Aspect
- Soil
- Parent materials
- Presence of dead & dying trees
- Fallen logs
- Broken-topped trees
- Cavities

How might modern forestry practices affect some of the variables above?

How does island (patch) size affect community organization?
Insectivores & carnivores have proportionally larger home ranges than herbivores of similar size. Thus, they are inherently rare because they require larger areas – reductions in habitat area often eliminate these species first.

A western example:

Species	Home range size (ha)
Deer mouse	0.06
Townsend vole	0.18
Wandering shrew	0.28
Woodrat	0.48
Gray squirrel	1.76
Brush rabbit	1.76
Long-tailed weasel	30.70
Porcupine	34.90
Coyote	453.00
Mule deer	420.00
Elk	943.00
Black bear	1,760.00
Lynx	5,710.00
Cougar	49,700.00
Gray wolf	153,000.00
Grizzly bear	377,000.00

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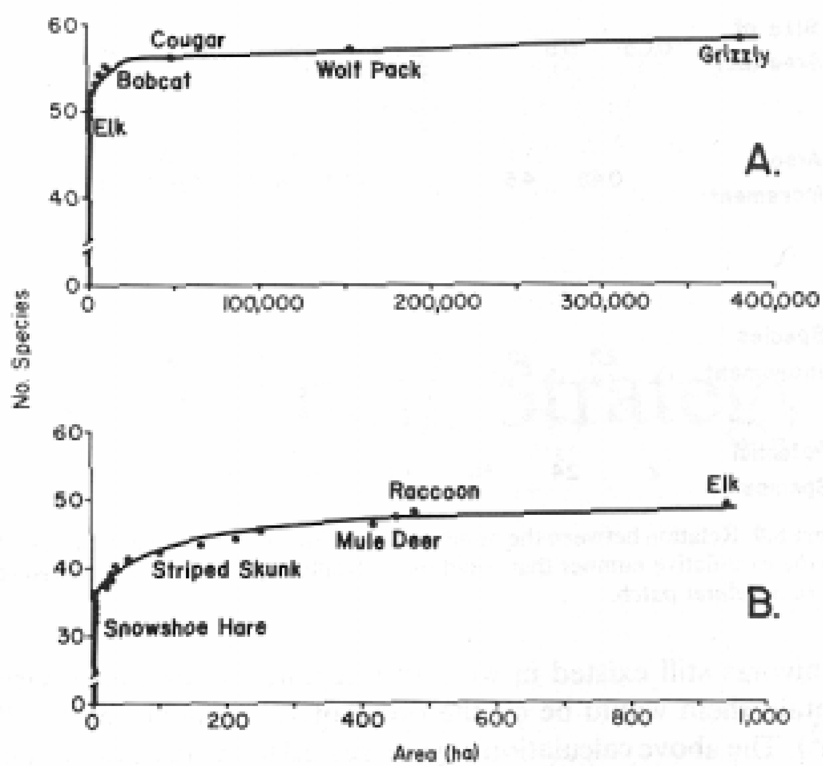


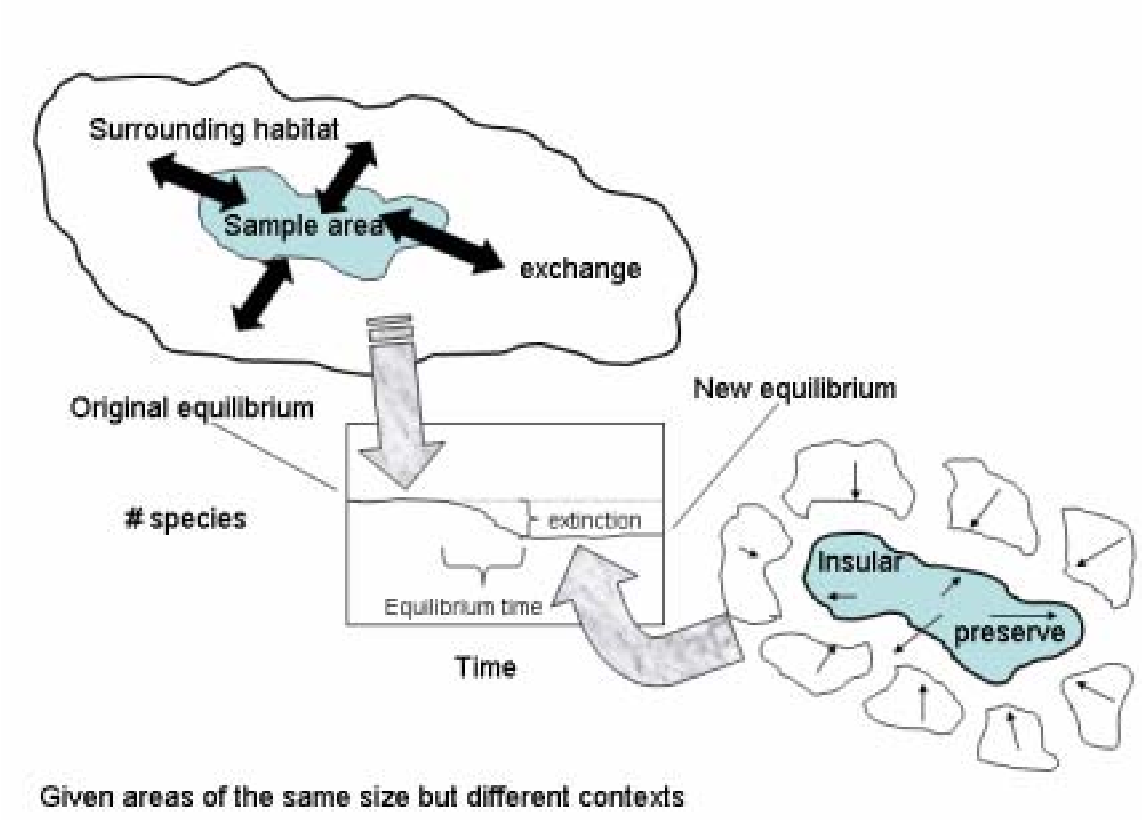
Figure 8.8 Theoretical maximum species-area curve for western Oregon mammals based on the cumulative number of species whose home-range size is encompassed by any given area. B is simply a higher resolution extension of A. The area below the curve represents the feasible domain for empirical species-area curves.

From Harris 1984

Some other generalizations about this relation:

Habitat specificity of animals tends to be inversely related to area requirements. Thus, large, wide-ranging species such as cougar tend not to have specific habitat (nor often food) requirements.

As a forest fragment becomes more isolated and different from the surrounding landscape, the rarer species will be lost. Here is the idea:



Thus, many parks and preserves have lost rare or other distinctive species – they are exhibiting the **species-area relation** and dynamic equilibrium defined by **Island Biogeographic Theory**

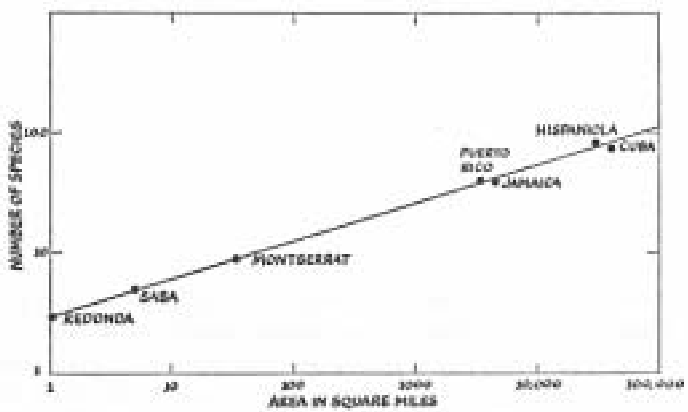


FIGURE 2. The area-species curve of the West Indian herpetofauna (amphibians plus reptiles).

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Figure 7 shows the basic idea of the equilibrium condition.

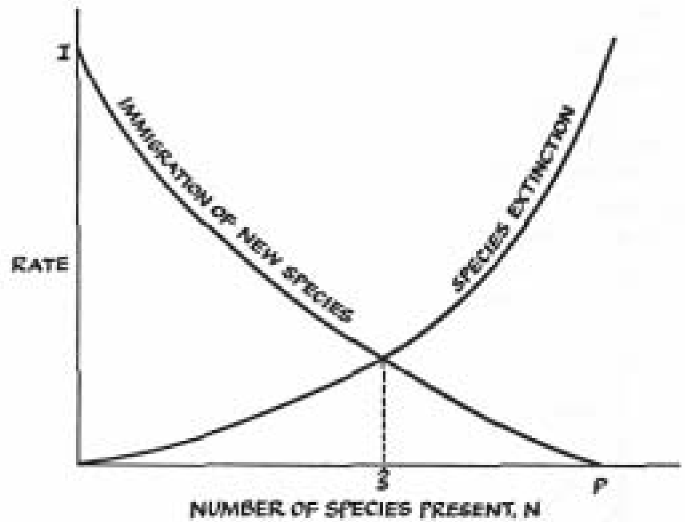

FIGURE 7. Equilibrium model of a biota of a single island. The equilibrial species number is reached at the intersection point between the curve of rate of immigration of new species, not already on the island, and the curve of extinction of species from the island. (After MacArthur and Wilson, 1963.)

Both from MacArthur and Wilson 1967