TOPIC 2.3
ISLAND BIOGEOGRAPHY

Enduring Understanding: Ecosystems have structure and diversity that change over time.

Learning Objective: Describe Island Biogeography and it's role in evolution and the diversity of life.

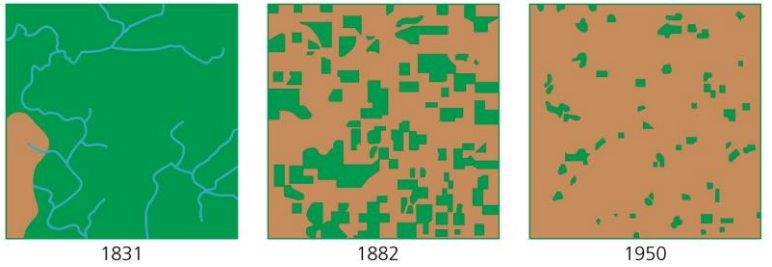
Related Readings: pg 327 – 332, "Environment; The Science Behind the Stories" 5th edition, Withgott, Jay and Laposata, Matthew.

Habitat "Islands" and Biodiversity

- Island ecosystems
  - Are small, and therefore vulnerable to disturbance and species loss.
  - Island ecosystems are often hotspots of biodiversity and have large numbers of ***endemic species*** (species found nowhere else) that are often ***specialists***.
- ***Habitat loss*** and ***habitat fragmentation*** are the primary causes of biodiversity loss.
  - Habitat fragmentation creates "islands" of habitat, isolating species on patches of suitable habitat, surrounded by a "sea" of unsuitable habitat.
  - Understanding the biodiversity of actual Islands provides insight on how biodiversity will be effected in these islands of remaining habitat.

Oceanic island surrounded by water

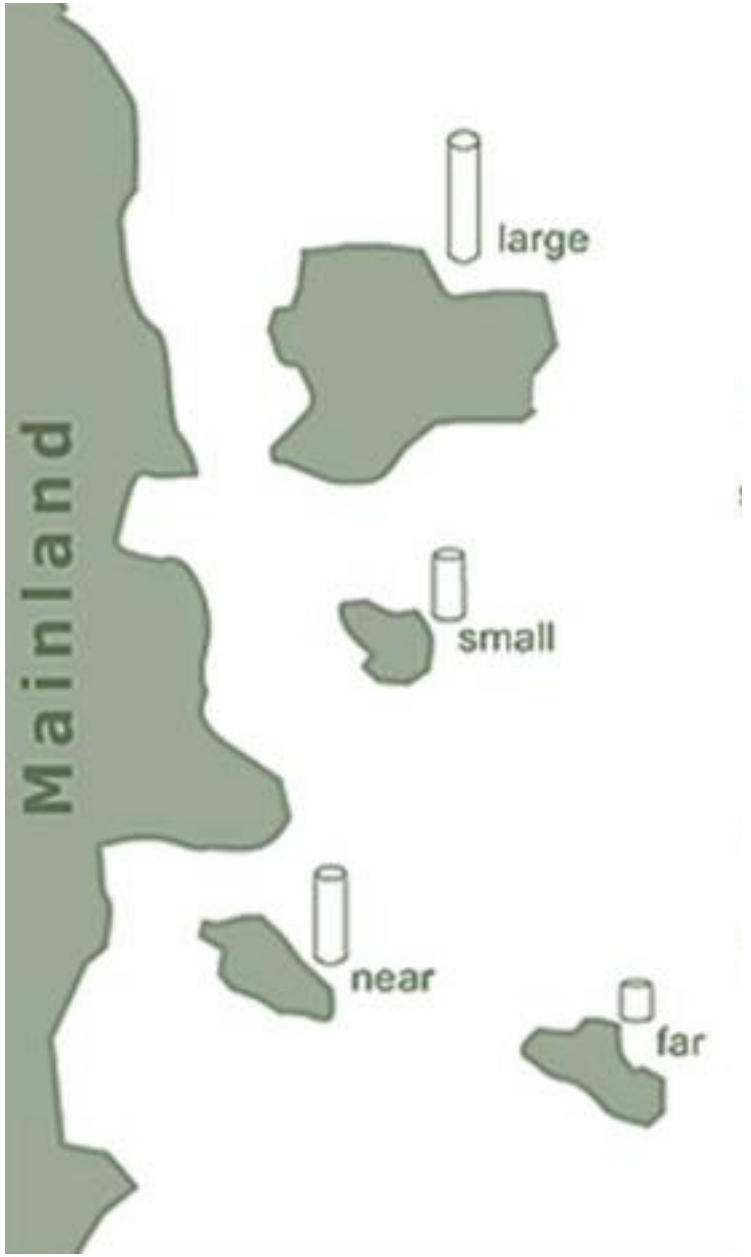
"Islands" of forest surrounded by urban and suburban development



Habitat Fragmentation of habitat over time

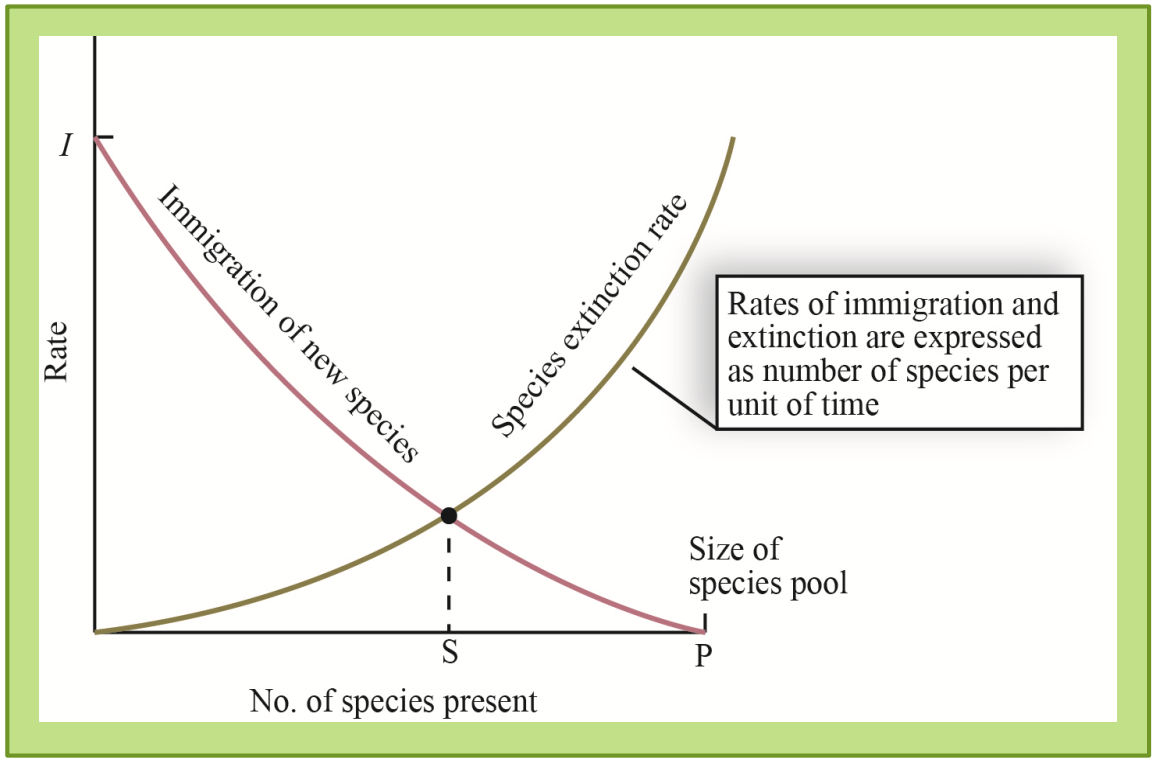
Island Biogeography Theory

- ***Island Biogeography Theory***, can predict biodiversity of island ecosystems and isolated habitats.
  - Assumes species disperse from source populations to "islands" of varying sizes and distances from the source population
  - The size of the island and its distance from the source population allow for predictions about the biodiversity of the island due to random dispersal.
- The number of island species results from a balance between:
  - species added through ***immigration***
  - and species lost through ***extirpation (local extinction)***



Island Biogeography Theory

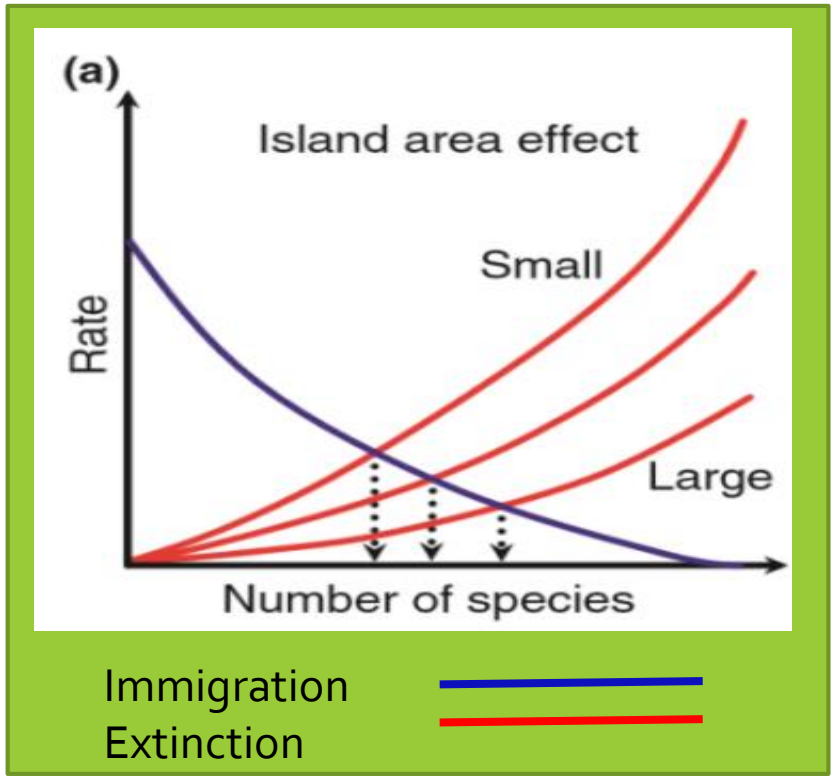
- As the number of species present increases, the rate of colonization by new species decreases
  - When more species are present, it is less likely that a NEW species will arrive from the source population.



- As the number of species present on the island increases, the rate of extirpation increases.
  - When the number of species present is low, it is less likely that niches will overlap and competition for resources will be low.
  - As the number of species increases, the chance of any two species having overly similar niches increases, resulting in interspecific competition the will lead one species to competitively exclude the other.
- At some point the rate of immigration and the rate of extinction (extirpation) will be equal and the total number of species on the island will be relatively constant.

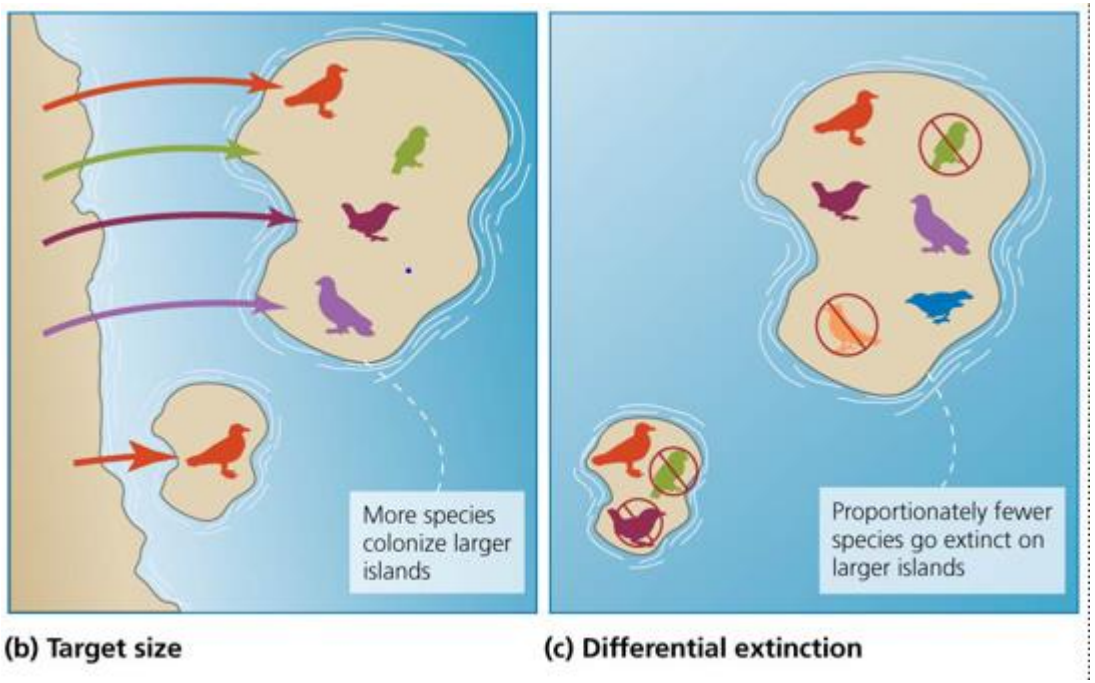
Island Biogeography Theory – Area Effect

- Large islands have more species than small islands. There are multiple reasons:
  - They have more habitats, environments, and variety
    - Greater habitat/ecosystem diversity increases species diversity by increasing the number of available niches.
  - Larger islands have lower extinction rates
    - more space allows for larger populations
    - Larger populations generally have greater genetic diversity and are more likely to be able to adapt
    - Larger populations are less likely to go extinct due to chance events.
  - Larger islands have higher immigration rates.
    - Larger islands present larger targets for organisms randomly dispersing from source populations

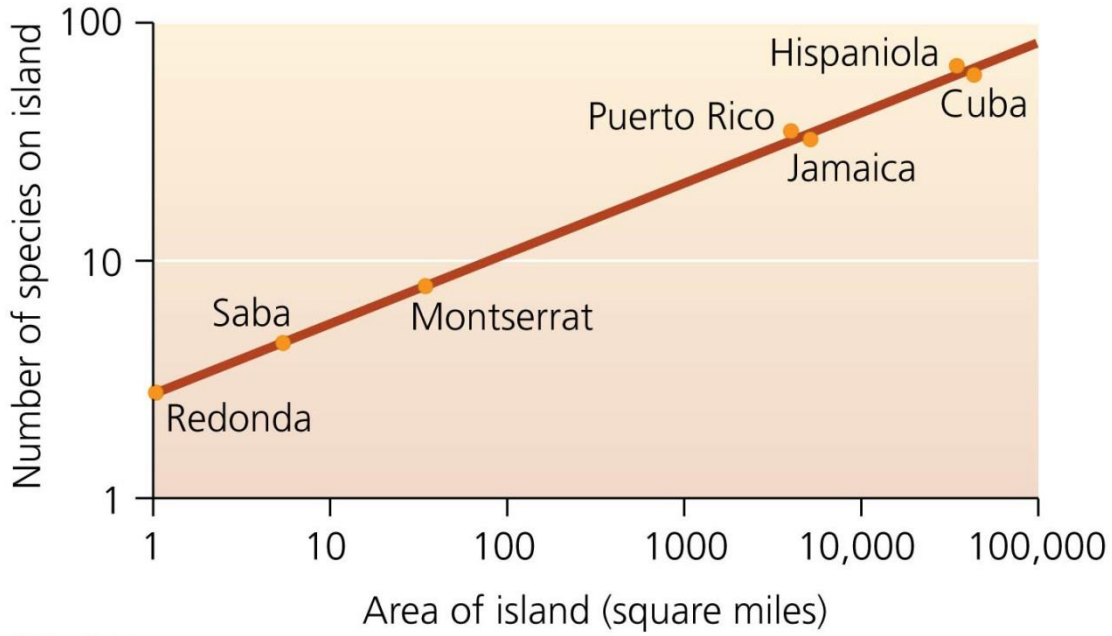


If immigration rates remain constant, and extinction rates decrease as islands increase in area, than the number of species present at equilibrium will increase.

Island Biogeography Theory – Area Effect



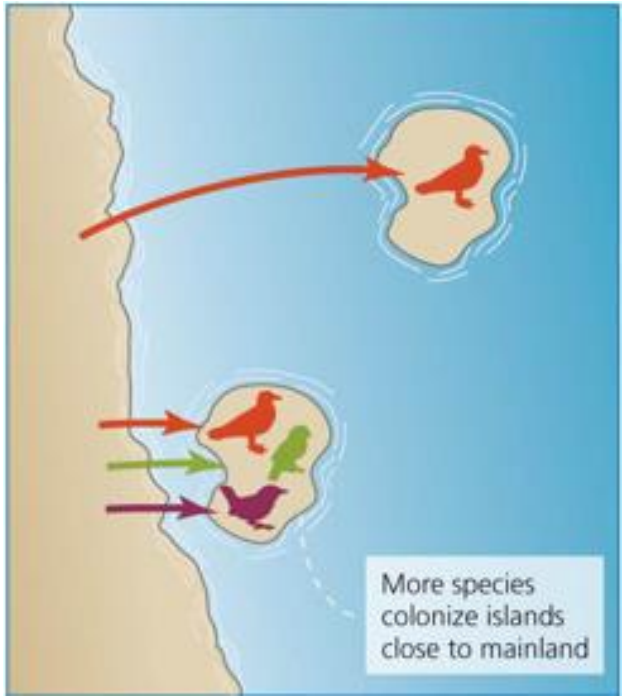
Target size and differential extinction explain why the area effect occurs.



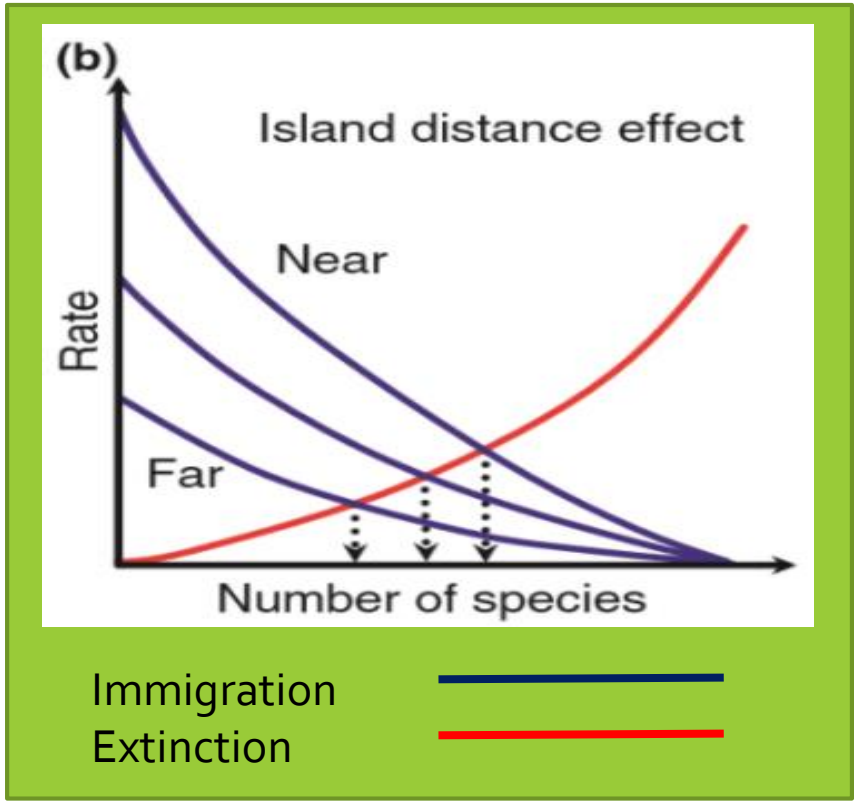
Observational studies of Caribbean Islands show the area effect. Notice that it is not linear.

Island Biogeography Theory – Distance Effect

- Less distant islands have more species than more distant islands due to higher immigration rates.
  - Islands closer to source populations are easier to reach for migrating species.
  - Not all species have the dispersal mechanisms to reach distant islands or patches of suitable habitats
  - Plant and bird species are disproportionately common on islands because they have the dispersal mechanisms to travel long distances over the water to colonize the island.



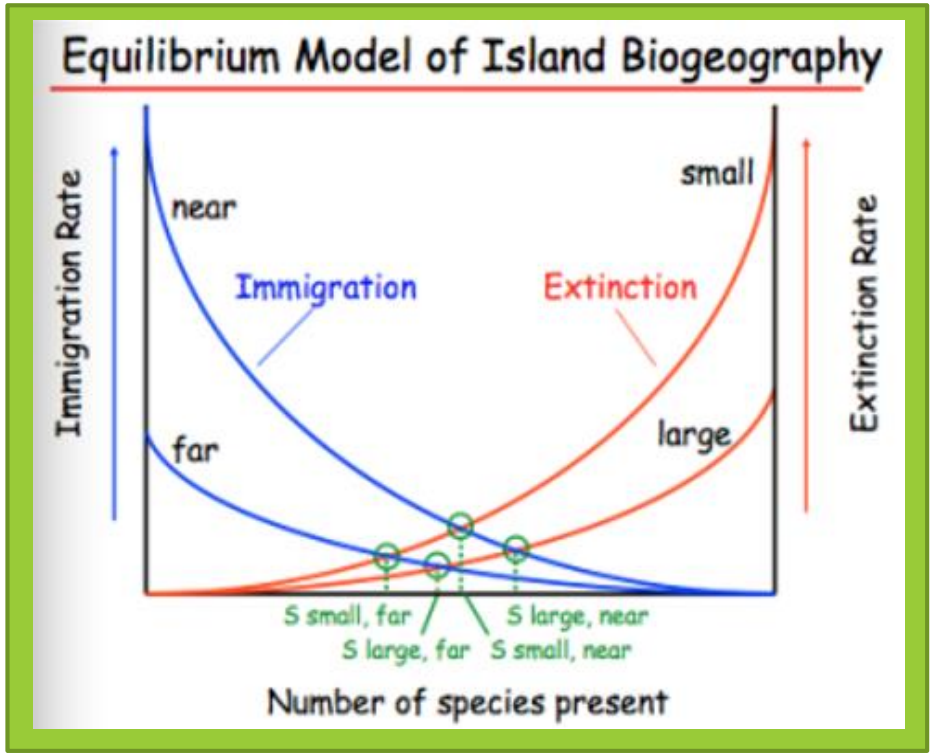
In this example islands are the same size, but the island closer to the mainland has more species because it is easier to reach from the source populations



If extinction rates remain constant and immigration decrease as islands get farther away, than the number of species present at equilibrium will decrease

Island Biogeography Theory - Summary

- The combination of island area and distance from source populations is predictive of the number of species present.
  - Island area primarily affects the rate of extirpation / extinction
  - Island distance primarily affects the rate of immigration
  - In general, large islands near source populations will hold more species the small islands which are far from source populations.
- Additional variables will also affect biodiversity when comparing islands from different regions or at different points in time
  - Climate (remember the latitude gradient of biodiversity)
  - Length of time in isolation (effects speciation on the island)
  - Location relative to ocean currents (affects immigration)



S = species number at equilibrium for islands of various sizes and distance from source populations

Island Species Are Often Unique

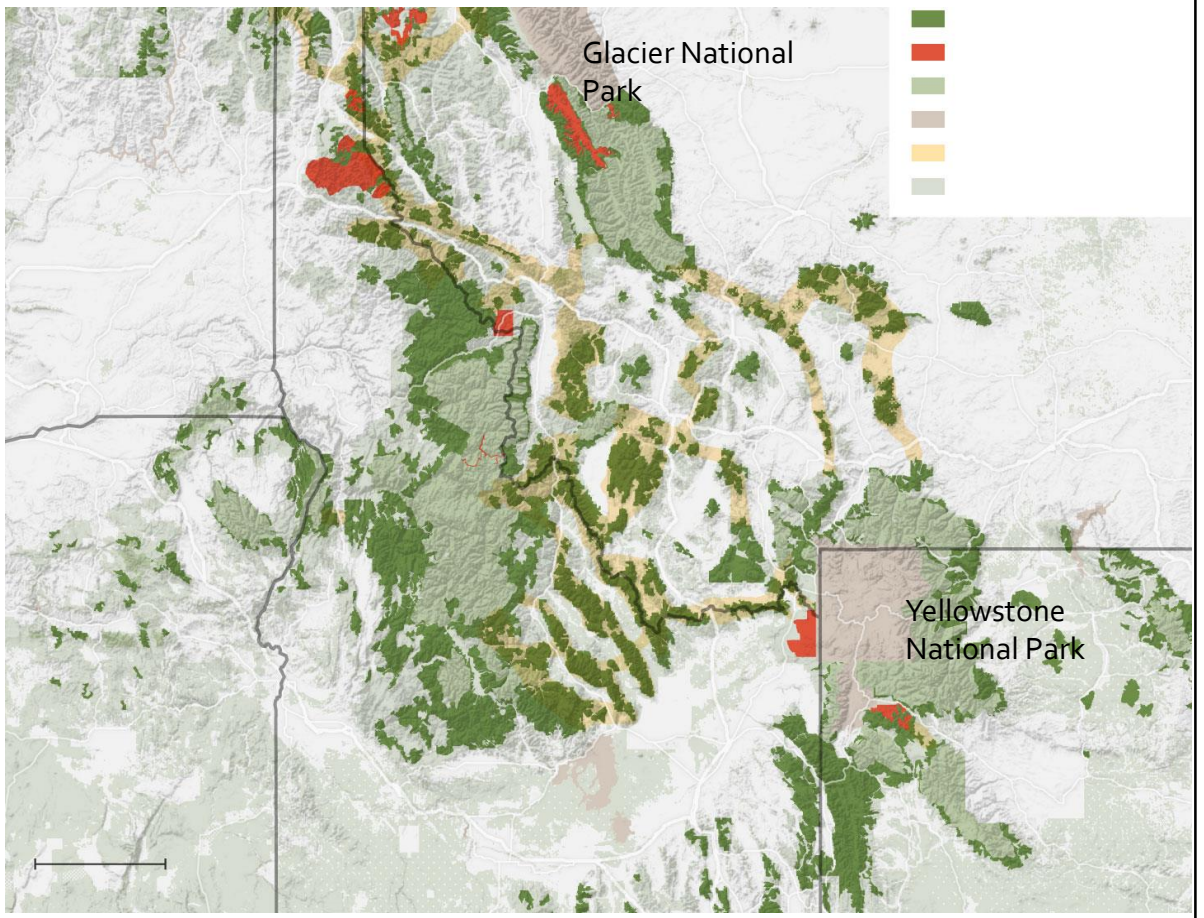
- Globally, islands have a high number of endemic species who are specialists
- Specialization results from the limited range of resources available on islands.
  - Colonizing species become increasing well adapted to acquiring a narrower range of specific resources that are available
  - Due to limited amounts of resources, colonizing species must partition existing resources to minimize competition with one another.
  - Intraspecific competition may lead some genetic variants within a population to specialize in different ways than other member of its species
- The high rates of endemism on islands results from the pressures to specialize.
  - Increasing specialization leads to adaptive radiations on islands

Specialization among island colonists lead to speciation in the Galapagos Islands

Adaptive radiation of Honey creepers in the Hawaiian Archipelago

Reserve design has consequences for biodiversity

- Island Biogeography Theory can inform land managers about reserve design and locations
  - With habitat fragmentation, the size and placement of protected areas are key to protecting biodiversity
- The ***SLOSS dilemma***
  - Limited amount of land can be set aside
  - "single large or several small" Which is better for a preserve?
  - Depends on the species (grizzly bears vs. insects) and management goals
- ***Corridors***
  - Relatively narrow strips of protected land that allows animals to travel between islands of suitable habitat
  - Animals get more habitat diversity
  - Enables gene flow between populations which maintains genetic diversity



Yellow corridors connect "islands" of wilderness between Yellowstone and Glacier National Parks. Such corridors help protect the biodiversity of both parks. Without them these islands become smaller and more isolated.