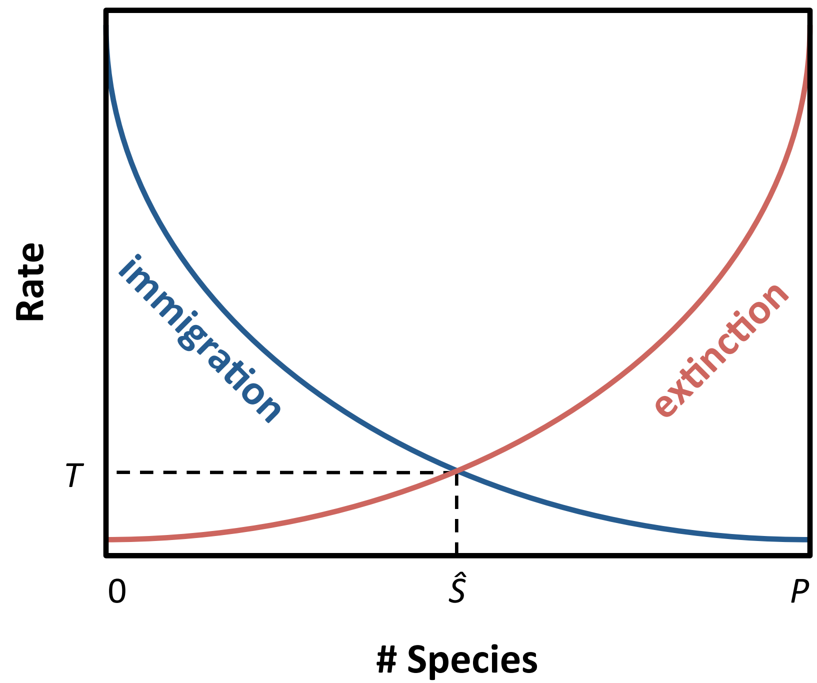
Island Biogeography II

Tests of the ETIB

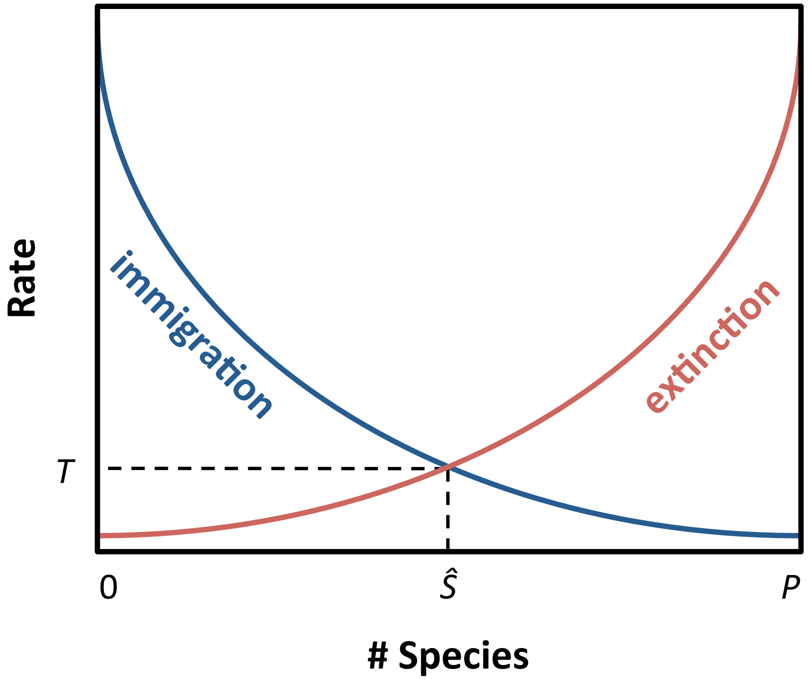
We have reviewed various expectations for the theory of island biogeography…

How does it hold up to tests with empirical data?



Tests of the ETIB

Where the immigration and extinction curves cross, the rates are exactly equal, resulting in an equilibrium number of species (S)
The equilibrium should be stable, because any temporary shift in S (decrease due to natural disaster, or increase due to an abundance of resources) should eventually return to S with normal conditions



Tests of the ETIB

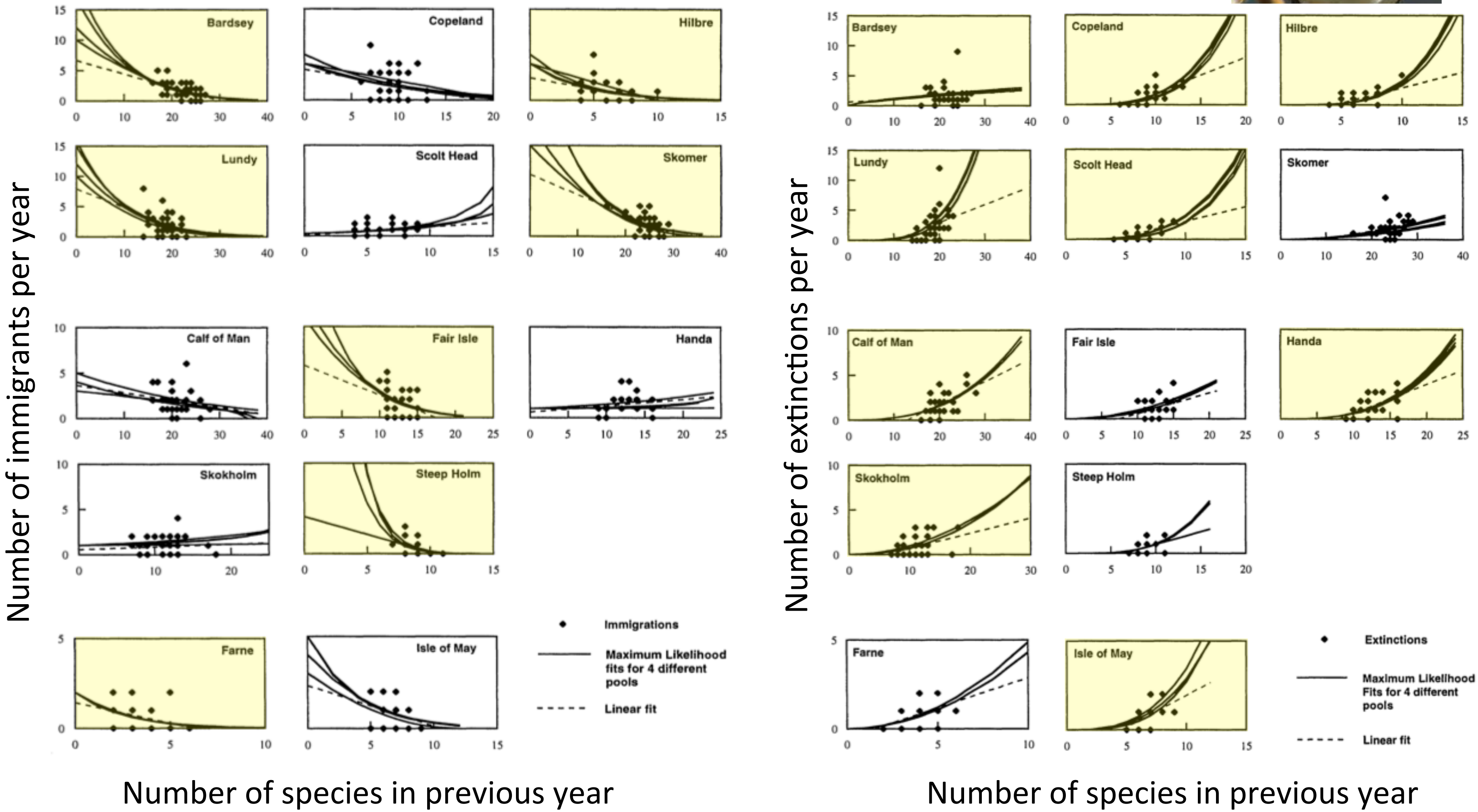
Test of the shapes of the immigration and extinction curves:

Islands surveyed in long-term study of breeding birds across the British Isles

(Manne *et al.* 1998)

Tests of the ETIB

Test of the shapes of the immigration (left) and extinction (right) curves:



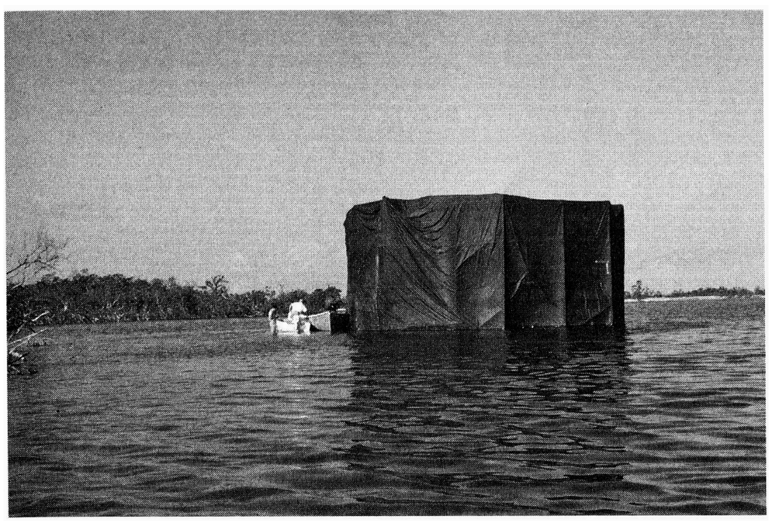
Bird species immigration and extinction curves for British Isles observed since the early 1900's. Cases where a non-linear relationship was the best fit are highlighted (Manne *et al.* 1998).

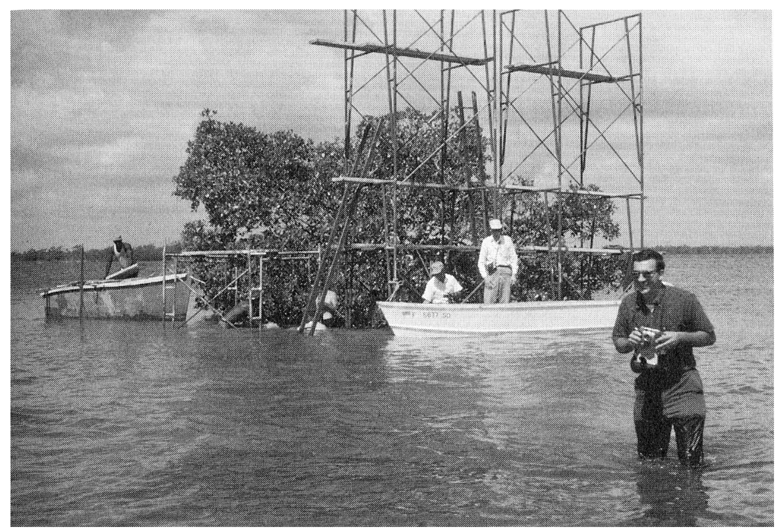
Tests of the ETIB

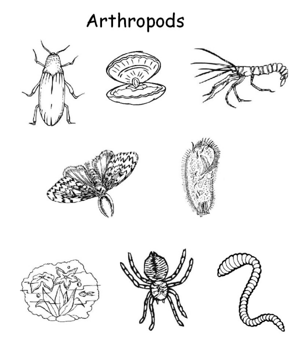
Tests of the equilibrium in species richness:

Defaunation experiment by Dan Simberloff and E.O. Wilson (1970)

Studied small islands of red mangrove in the Florida Keys. Islands (75-250 m^2) were surveyed for terrestrial arthropods, covered in plastic tents and fumigated with methyl bromide to remove all arthropods. Islands varied in distance from the mainland source fauna (300 species) from 20 – 1200 m.

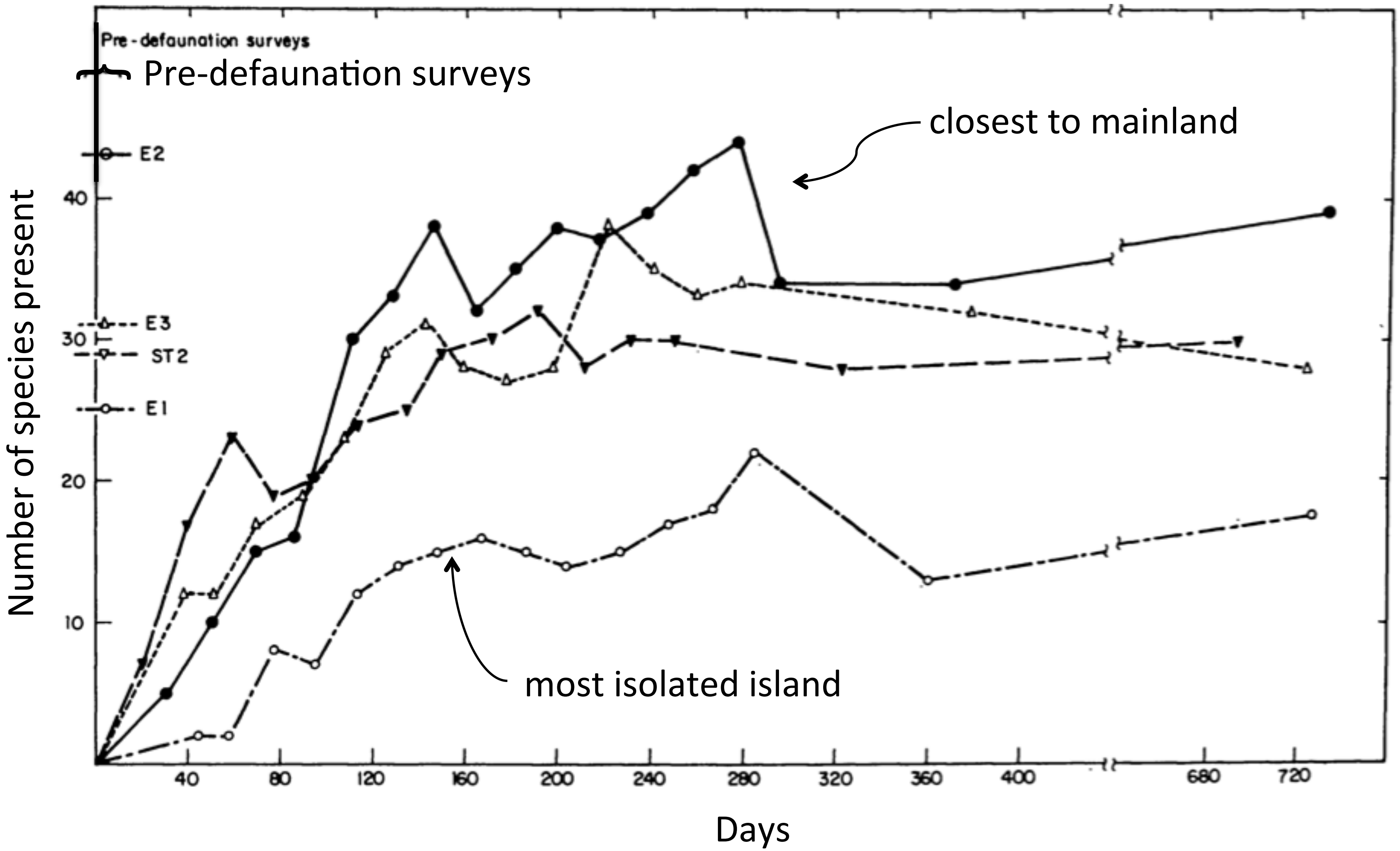






Tests of the ETIB

Tests of the equilibrium in species richness:



Colonization curves of four small mangrove islands (E1, E2, E3, ST2) in lower Florida Keys. Arthropod faunas of islands were exterminated by fumigation (Simberloff and Wilson 1970).

Tests of the ETIB

Tests for turnover in species composition:

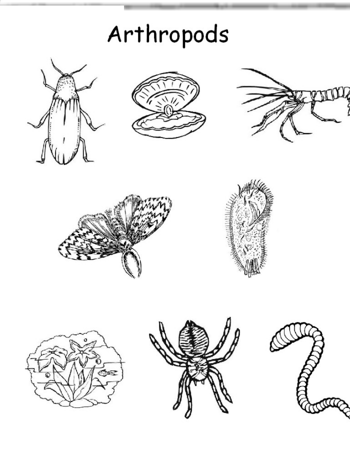
Turnover of arthropod species on experimentally-defaunated mangrove islands. Shows percentages of species present at both of two given census times.

Name of experimental island	A. Censuses: just before defaunation and one year later			B. Censuses: just before defaunation and two years later			C. Censuses: one and two years after defaunation		
	No. spp. in common	Total no. in both censuses	Per cent in common	No. spp. in common	Total no. in both censuses	Per cent in common	No. spp. in common	Total no. in both censuses	Per cent in common
E1	2	29	6.9%	5	26	19.2%	7	18	38.9%
E2	10	54	18.5%	13	51	25.5%	16	34	37.2%
E3	8	40	20.0%	7	35	20.0%	16	31	51.6%
ST2	11	37	29.7%	17	31	54.8%	12	34	35.3%

Faunas closer in composition to original pre-defaunation communities in second year than in first year (A vs B)

Still experiencing high turnover
(comparing first and second year in C)

(Simberloff and Wilson 1970)

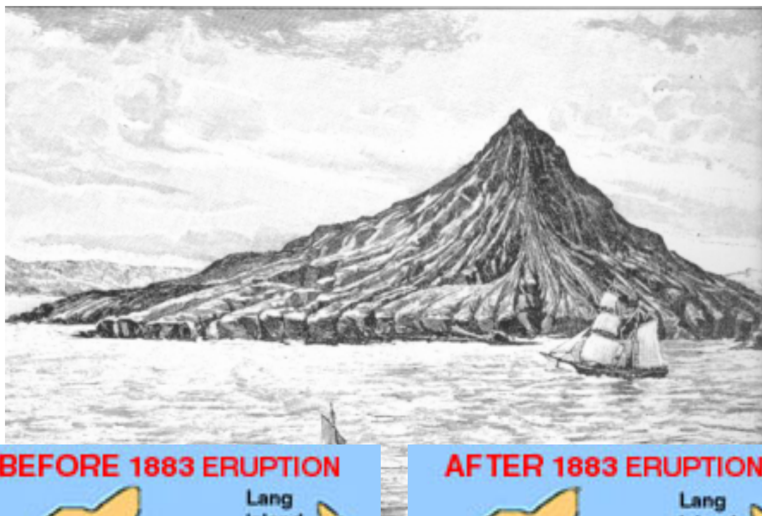


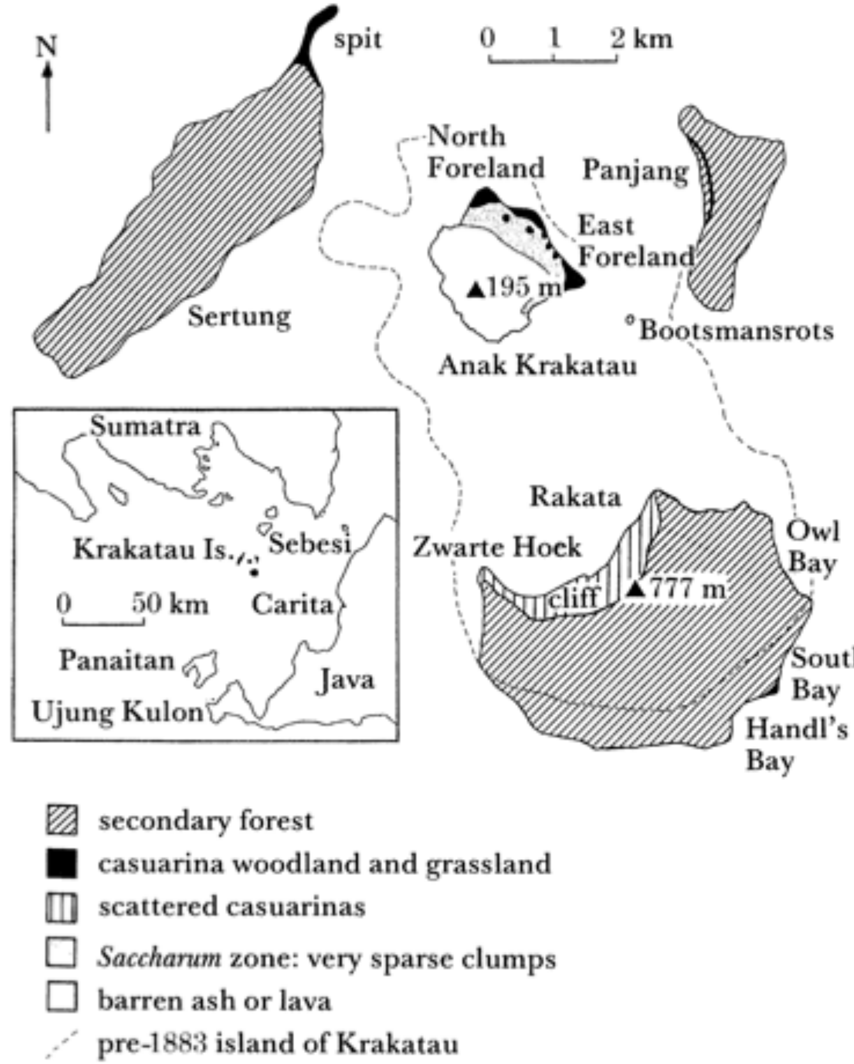
Tests of the ETIB

Tests for turnover in species composition:

Islands of Krakatau

Sterilized by an eruption in 1883



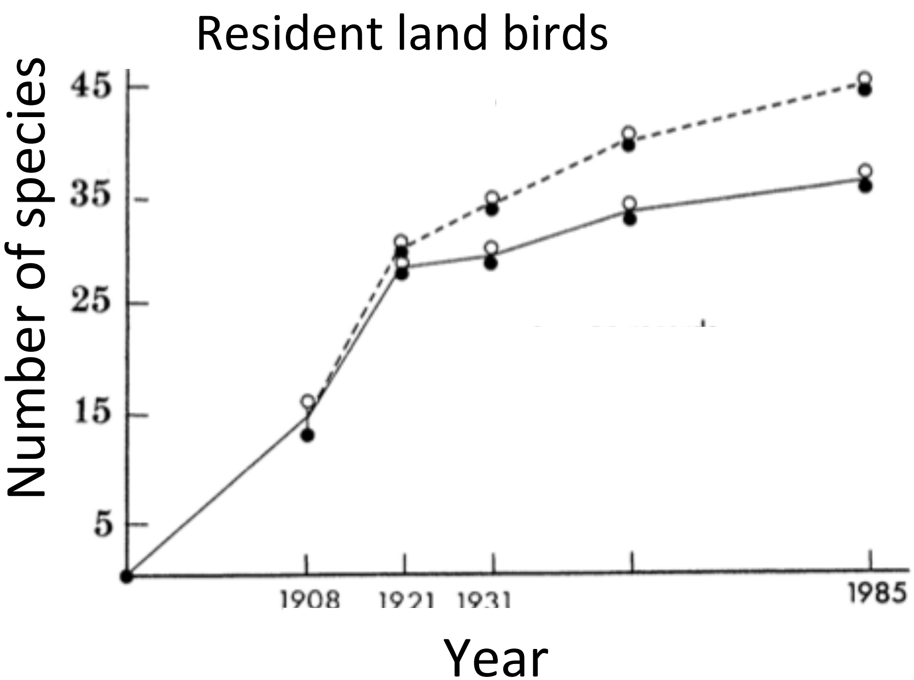


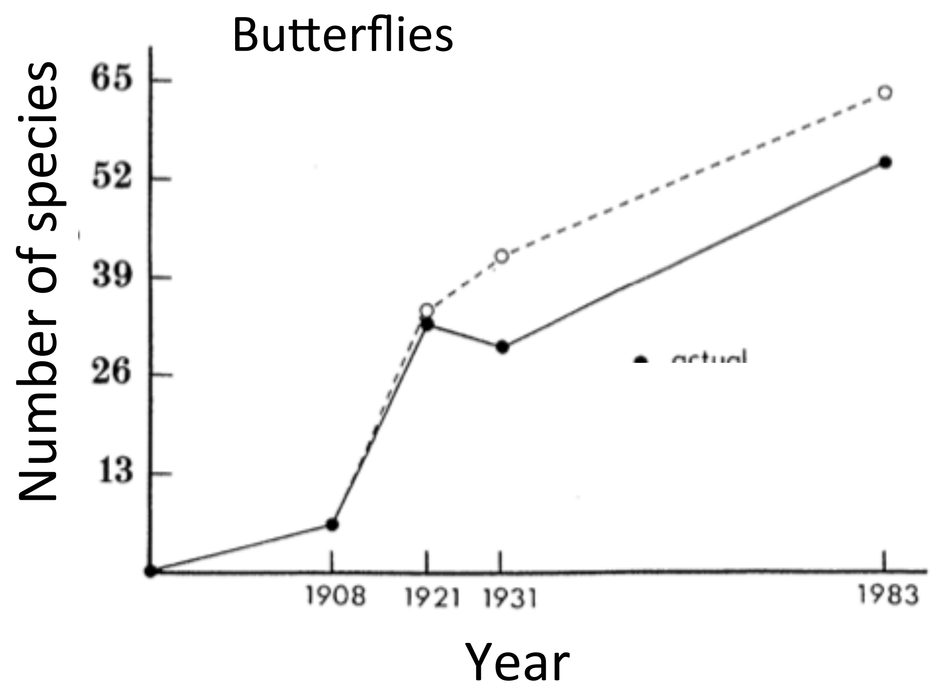
The Krakatau Islands, showing vegetation cover in 1983 (from Thornton *et al.* 1990).

Tests of the ETIB

Tests for turnover in species composition:

Islands of Krakatau - Sterilized by an eruption in 1883





Colonization curves of resident land birds and butterflies to Krakatau Islands. Solid lines show actual numbers at the time of survey, dashed lines are cumulative numbers (Thornton *et al.* 1990)

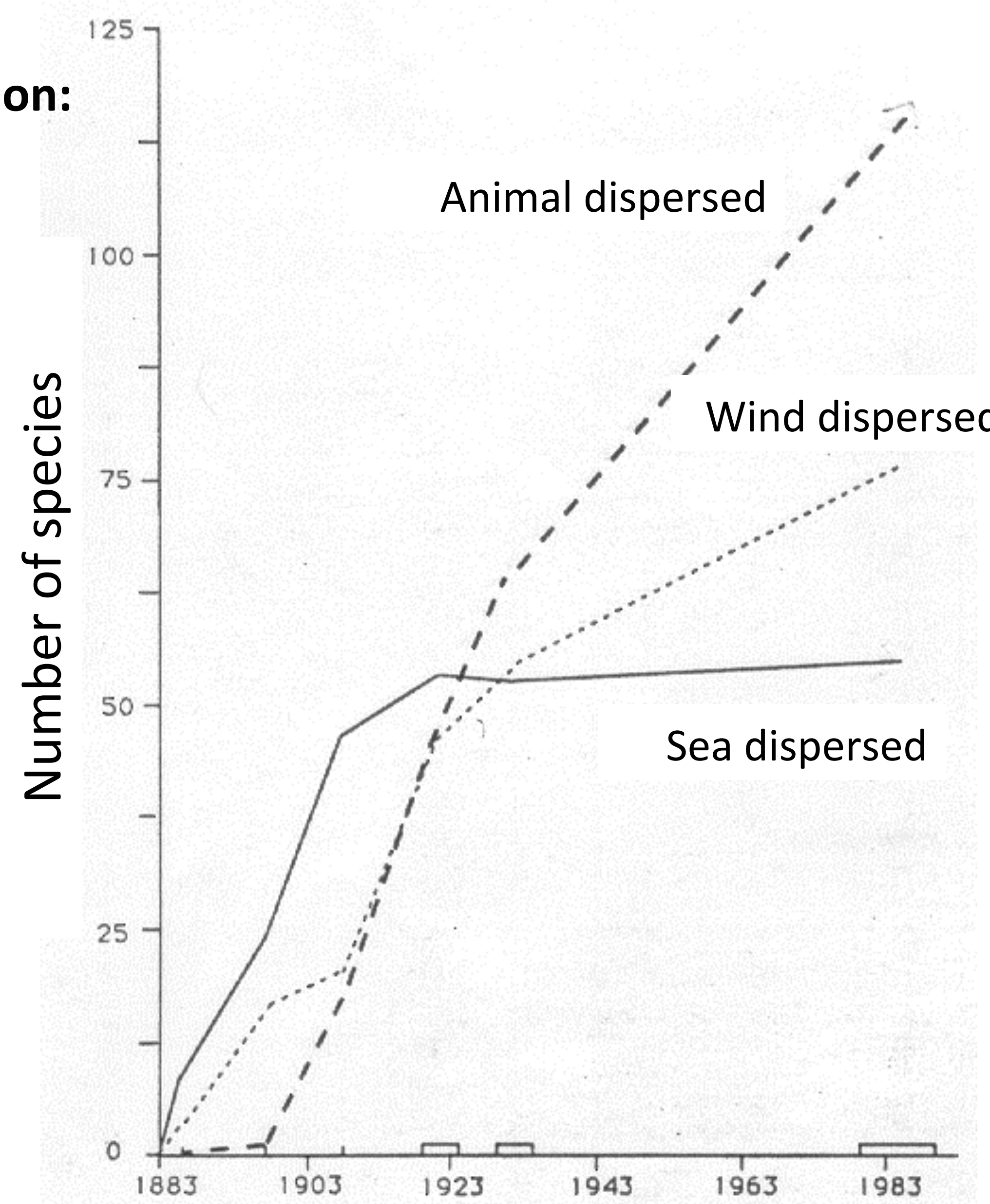
Tests of the ETIB

Tests for turnover in species composition:

Species colonization curves for sea-, wind-, and animal-dispersed plants on Rakata Island

Early colonizing species are biased towards water- and wind-dispersed species

Animal-dispersed species increase in representation from 1920 onwards

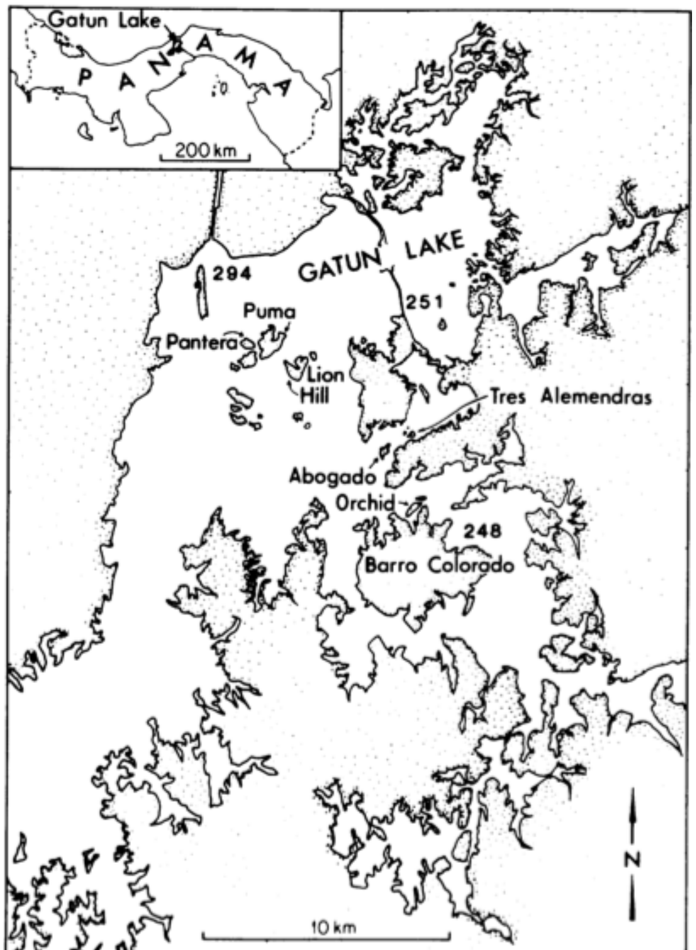


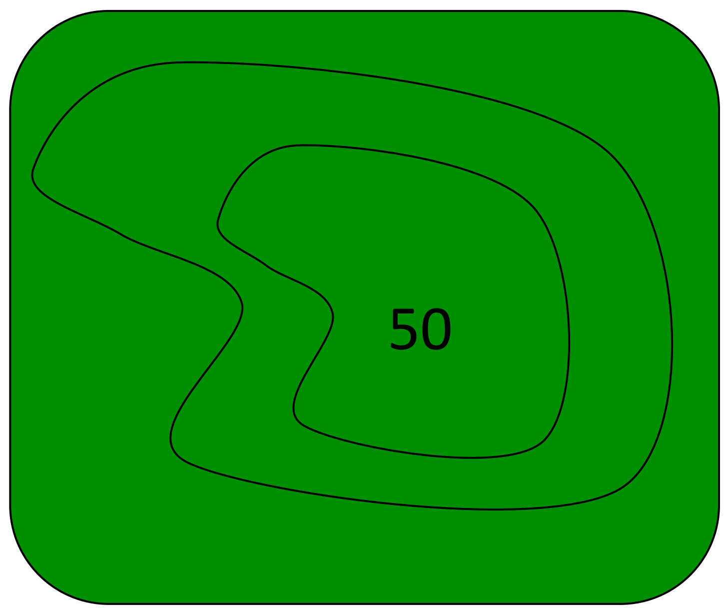
(Bush and Whittaker 1991)

Tests of the ETIB

Tests for turnover in species composition:

Gatun Lake formed by creation of the Panama Canal





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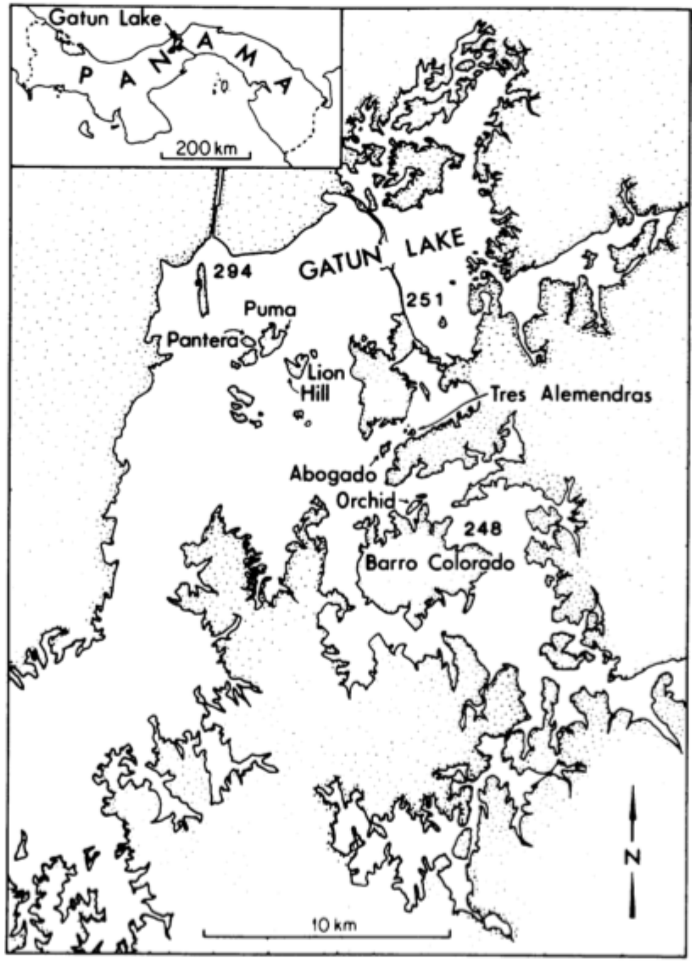
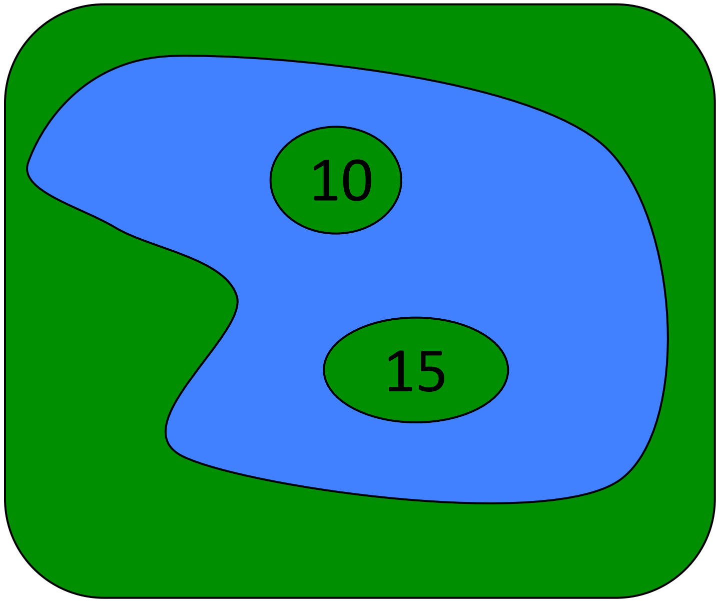


Flooding the lowland areas transformed hilltop forests into islands



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Tests for turnover in species composition:

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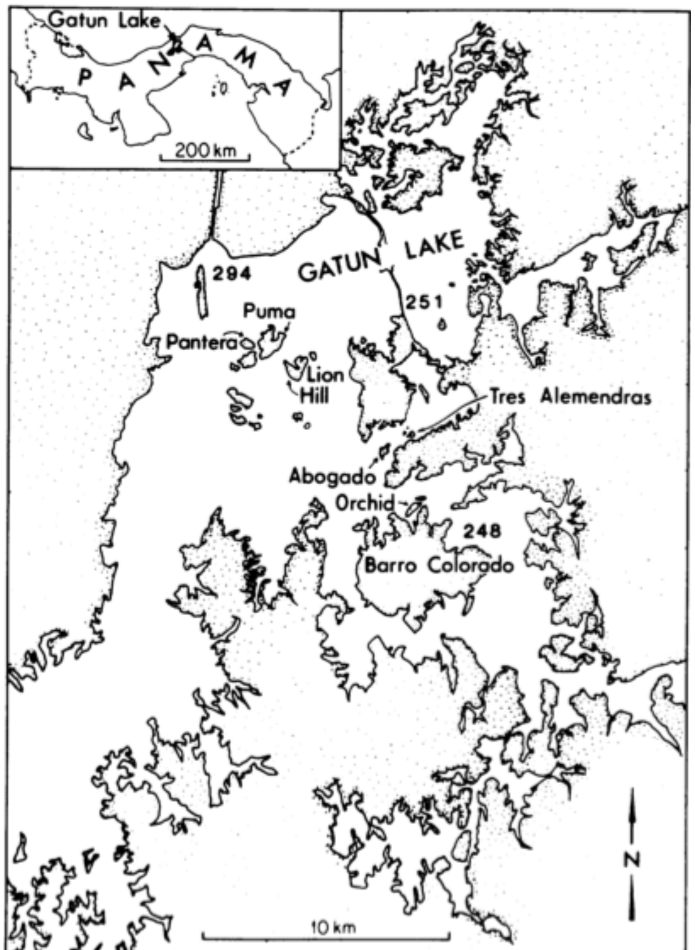
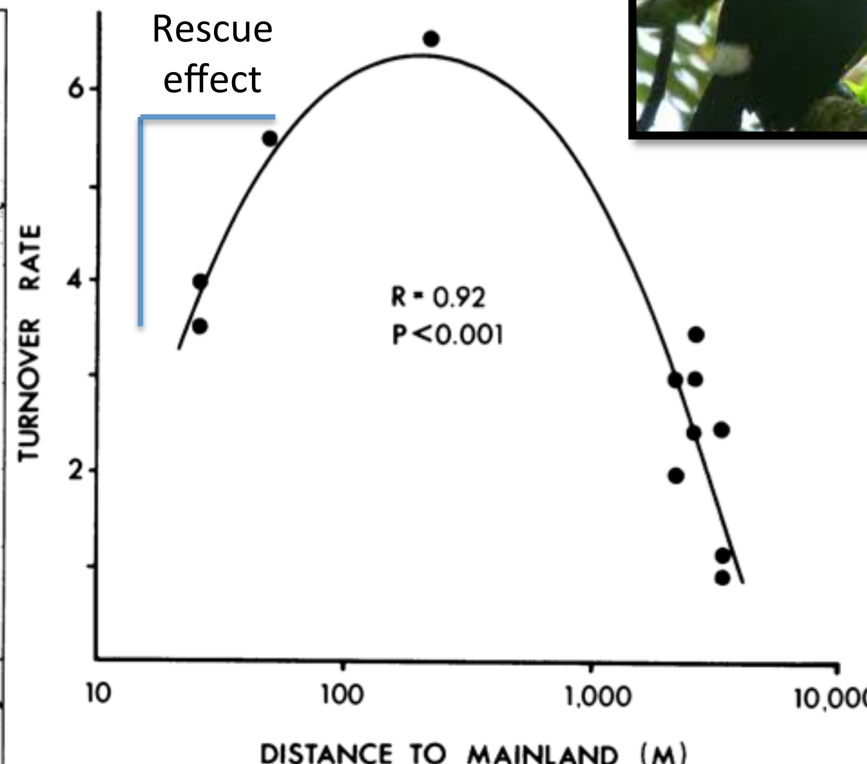




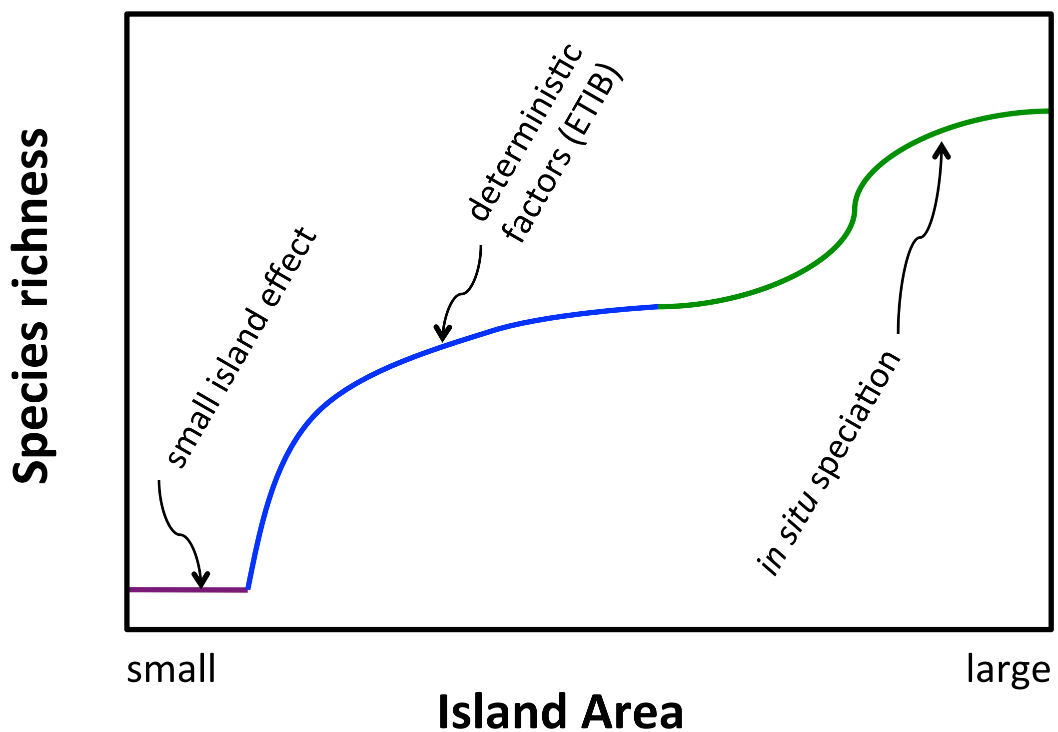
Areas closest to mainland have lower turnover – opposite to expectation. In this case, proximity to mainland prevented extinction – ***rescue effect*** (from Wright 1985).

Fate of the ETIB

Much of development has been driven by discovery of exceptions:

Small island effect and *in situ* speciation (island endemics).

Small Island Effect: the tendency for species richness to vary independently of island area or isolation on very small islands.

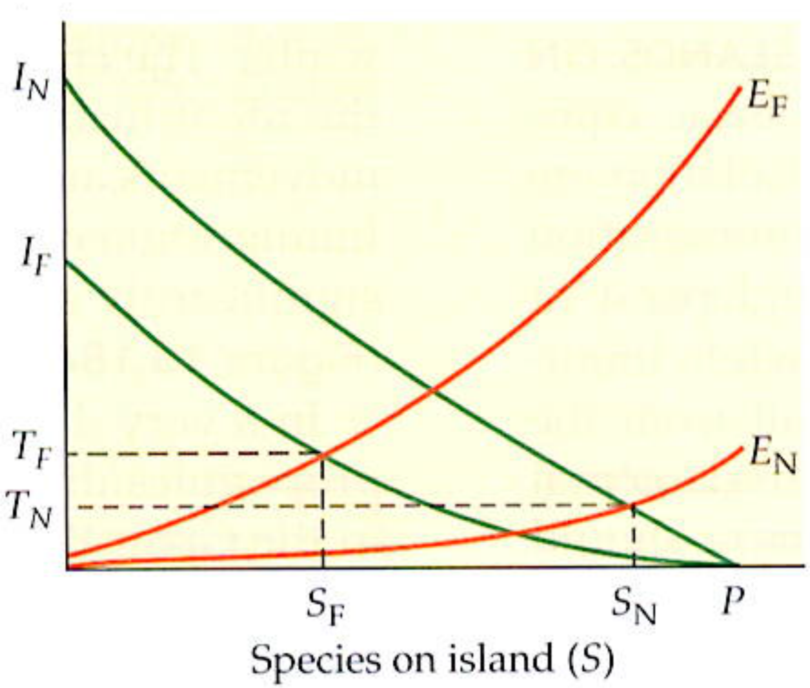


Fate of the ETIB

Much of development has been driven by discovery of exceptions:

Rescue effect and *target effect*.

Rescue Effect: the tendency for extinction rates to be relatively low when islands are very close to the mainland because island populations are augmented by immigration.

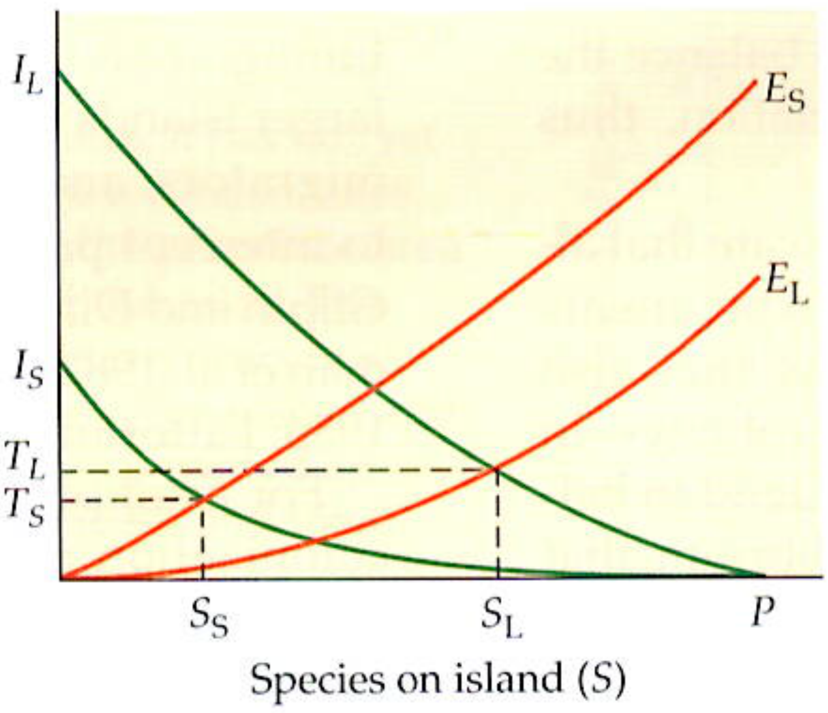


Fate of the ETIB

Much of development has been driven by discovery of exceptions:

Rescue effect and *target effect*.

Target Effect: the tendency for immigration rates to be higher on larger islands because larger islands have more shoreline, can be seen from farther away, etc.

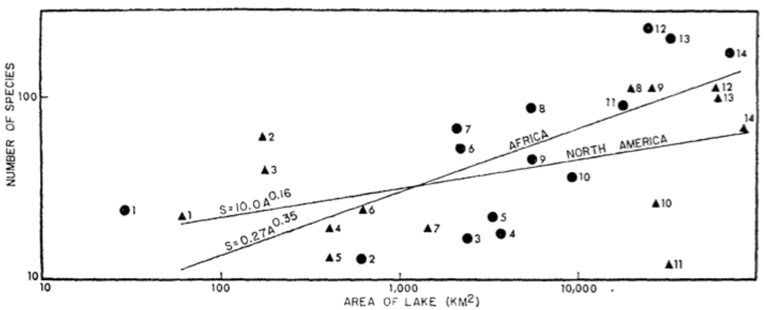


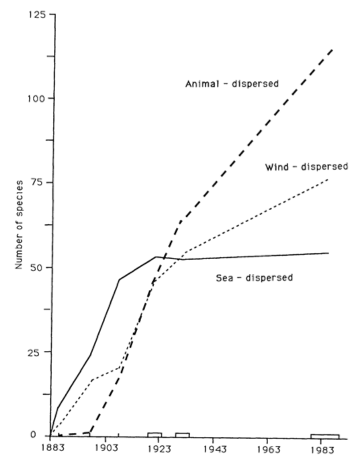
Fate of the ETIB

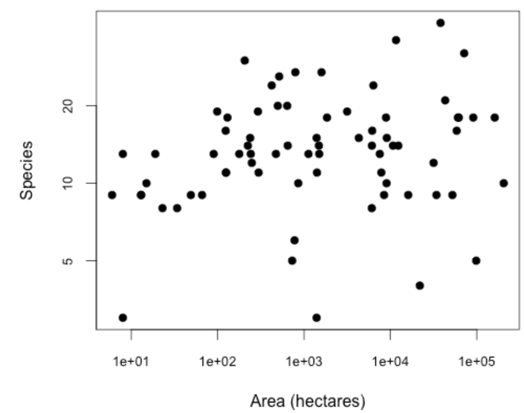
Much of development has been driven by discovery of exceptions:

Non-equilibrium cases

- age (time for colonization) might influence diversity
    - e.g., fish species in African and North American lakes
    - e.g., different modes of dispersal to the islands of Krakatau





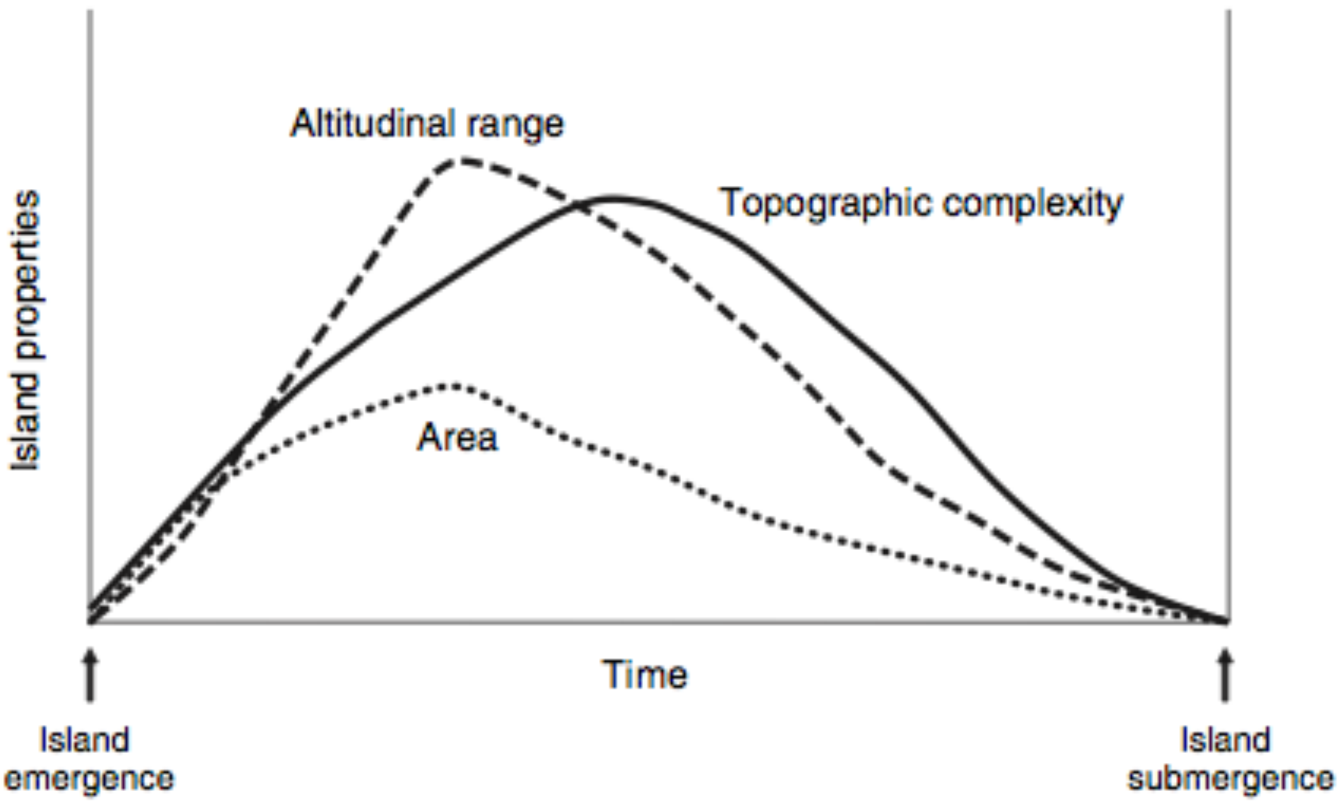


Differences between species, interactions among species.

- ecological interactions may be more important than ETIB processes
    - e.g., much residual variation in butterfly diversity on British islets (explained by ecological factors?)

Fate of the ETIB

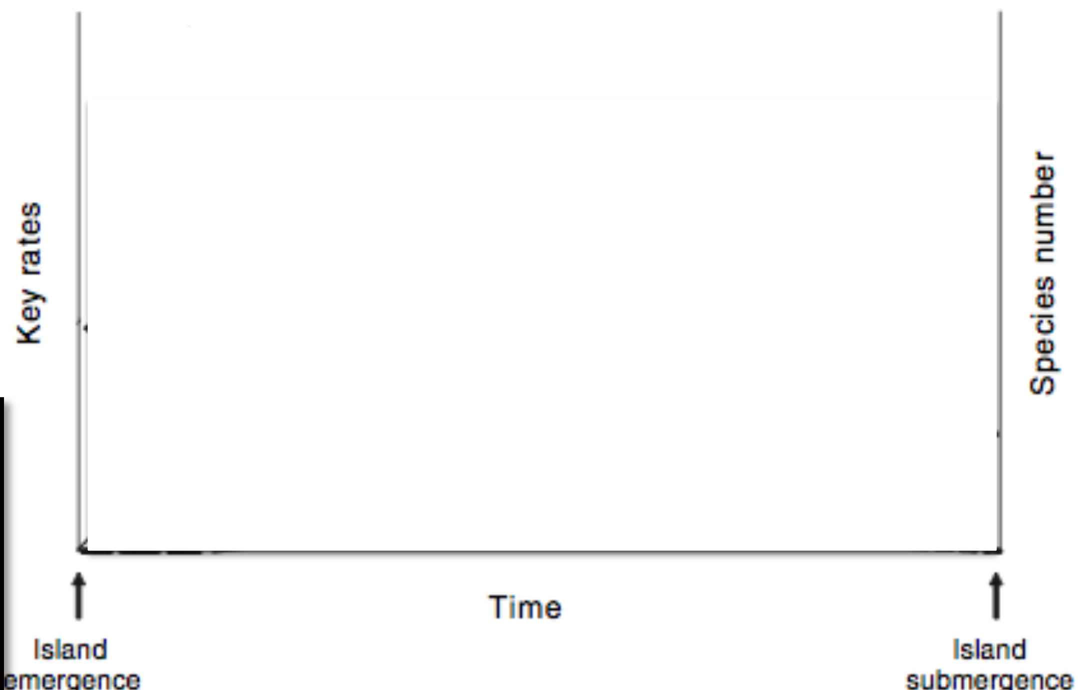
A General Theory of Volcanic Island Biogeography



A scenario most applicable to islands with simple ontogenies, such as those found within hotspot archipelagos (from Whittaker *et al.* 2008).

Fate of the ETIB

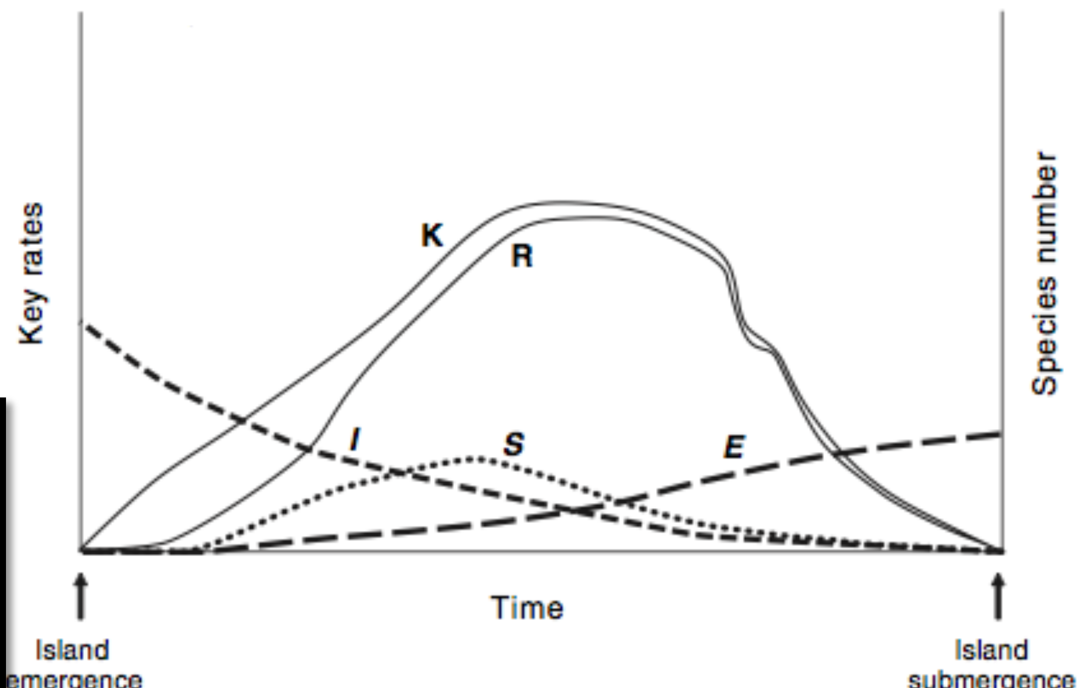
A General Theory of Volcanic Island Biogeography



I is the immigration rate, *S* is the speciation rate, and *E* is the extinction rate. For species number, *K* is the potential carrying capacity, and *R* is the realized species richness (from Whittaker *et al.* 2008)

Fate of the ETIB

A General Theory of Volcanic Island Biogeography



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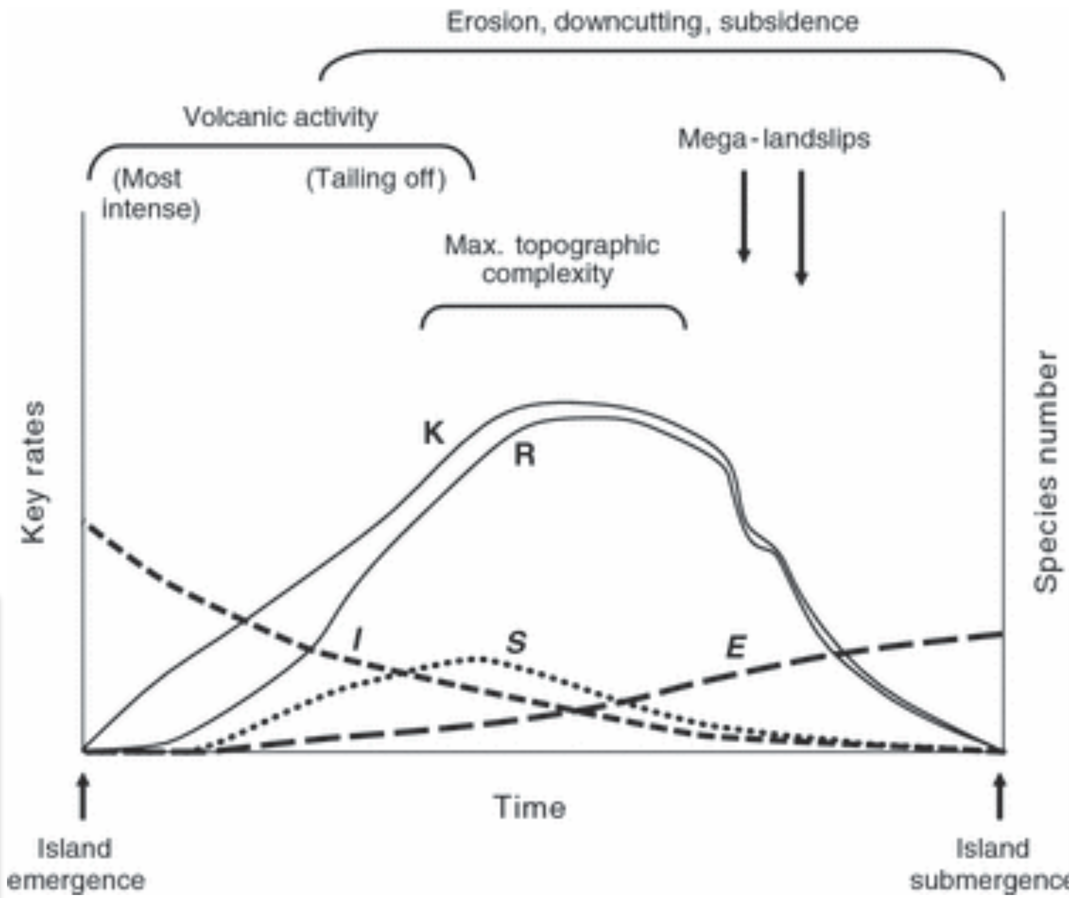

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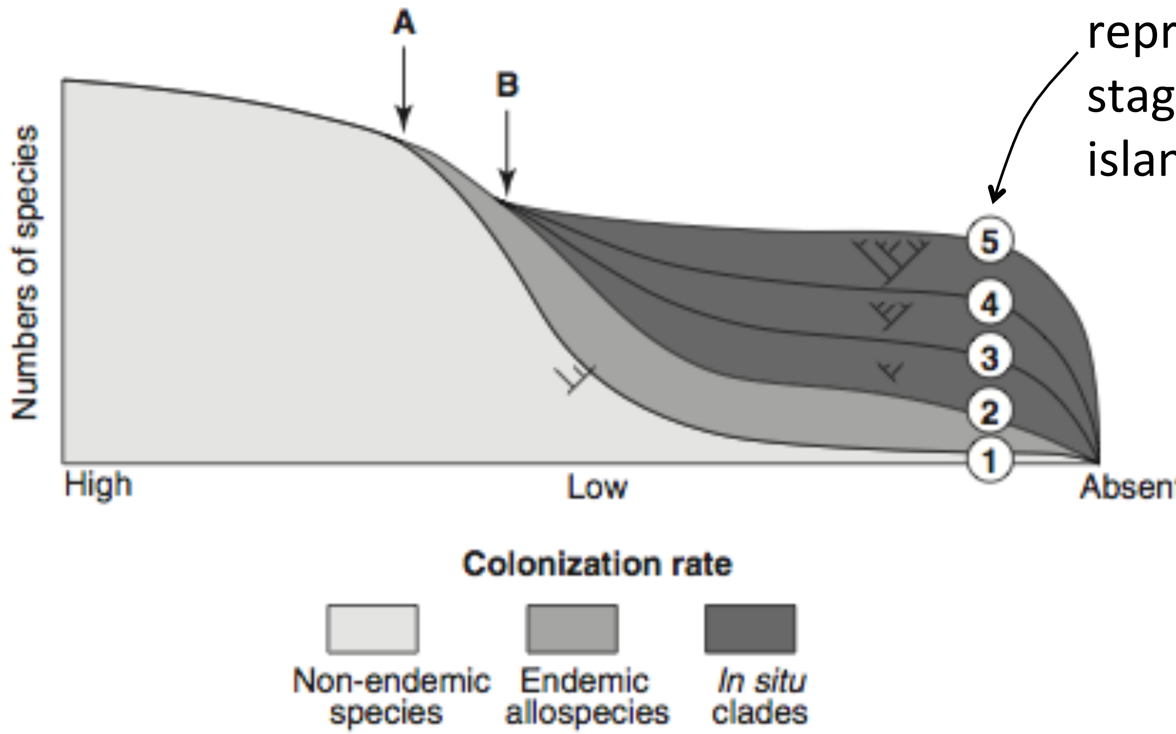
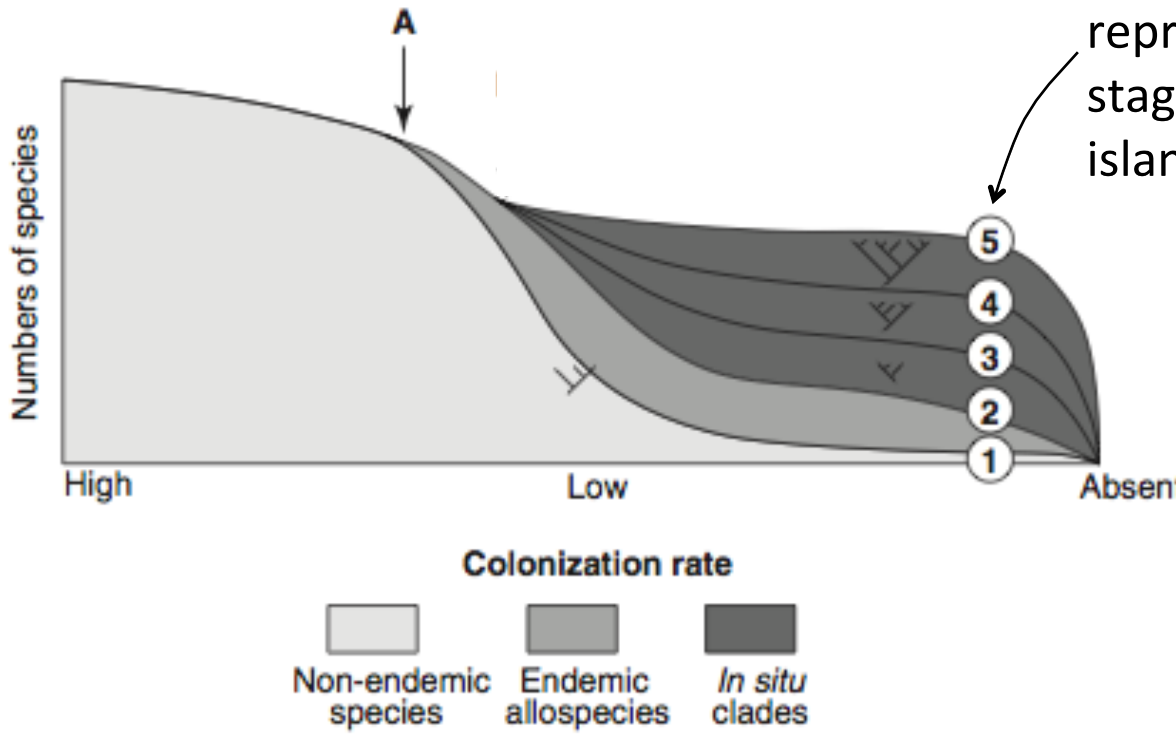


numbered lines represent time stages since island formation

Heaney's (2000) model of the development of species richness on large islands or archipelagos that experience varying rates of colonization as a result of varying degrees of isolation.

Fate of the ETIB

A General Theory of Volcanic Island Biogeography



numbered lines represent time stages since island formation

As average rate of gene flow drops below approx. one individual per generation (point A), speciation will begin to take place, and endemic species will develop. Endemic species will have sister taxon in the source area, not on the island/archipelago.

As colonization becomes less frequent, endemic clades will be produced in which endemic taxa have sister taxon on the island or archipelago, not in the source area (Whittaker *et al.* 2008).

Fate of the ETIB

The Insular Distribution Function

The presence of particular species on an island will depend largely on:

- The traits of the island (e.g., area, isolation, environment, age)
- The traits of the species (e.g., dispersal ability, colonization ability, competitive ability, population density, trophic level)

Insular Distribution Function: a line describing the constraint on the presence of a focal species on islands in an archipelago. The slope and intercept of the line vary in a predictable manner with characteristics of the islands and of the focal species.

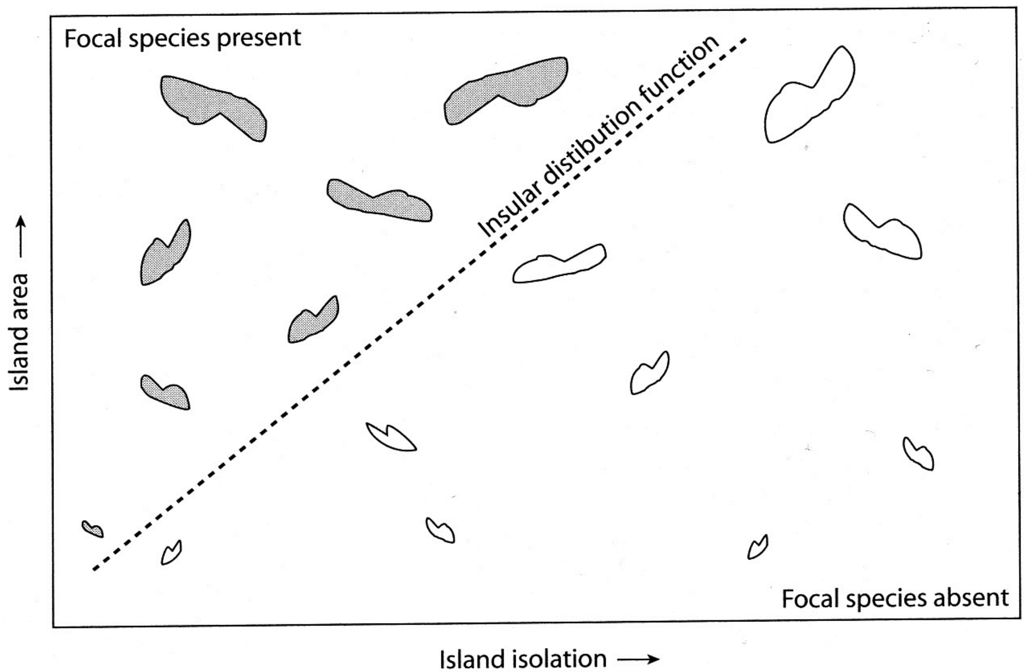
Fate of the ETIB

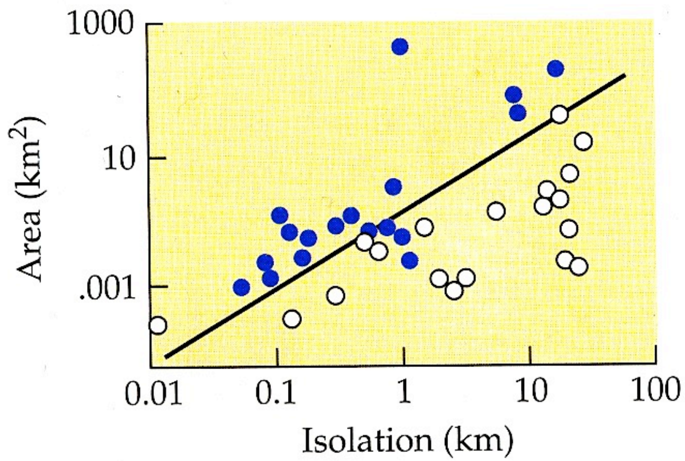
The Insular Distribution Function

Focal species occurs where immigration rate exceeds extinction rate

Can occur on isolated islands that are large enough that extinction rates are low enough to compensate for infrequent immigration

Can occur on small islands if they are close enough to the mainland that high immigration rates compensates for frequent extinctions





Minimal area required to maintain populations should increase as isolation increases

A hypothetical insular distribution function (from Lomolino *et al.* 2010a).

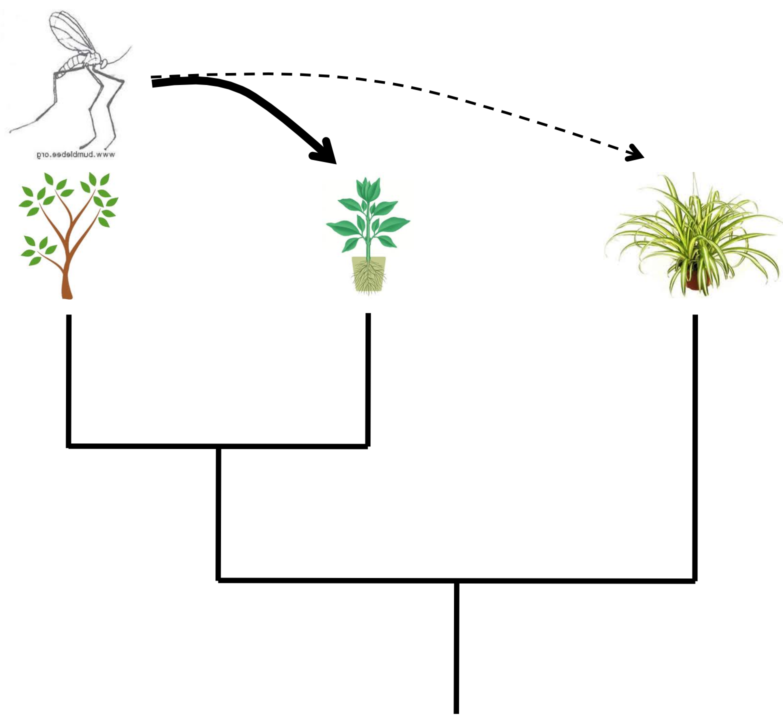
Fate of the ETIB

Host Plants as Analogs of Islands for Phytophagous Insects

There are many species of gall midge.

Most are specialists on particular host plant species, and a host plant can support multiple species of gall midge.

Can gall midges can more easily switch hosts (i.e., immigrate) if the new host is closely related to the previous host (i.e., low isolation)?



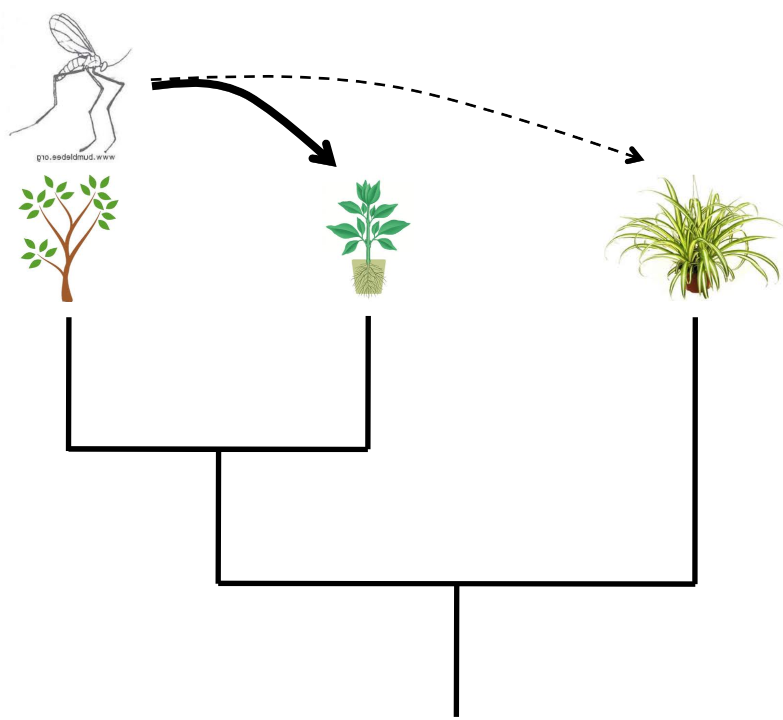
(Joy and Crespi 2012)

Fate of the ETIB

Host Plants as Analogs of Islands for Phytophagous Insects

Island area = host plant geographic range size

Island isolation = evolutionary distinctiveness of host plant



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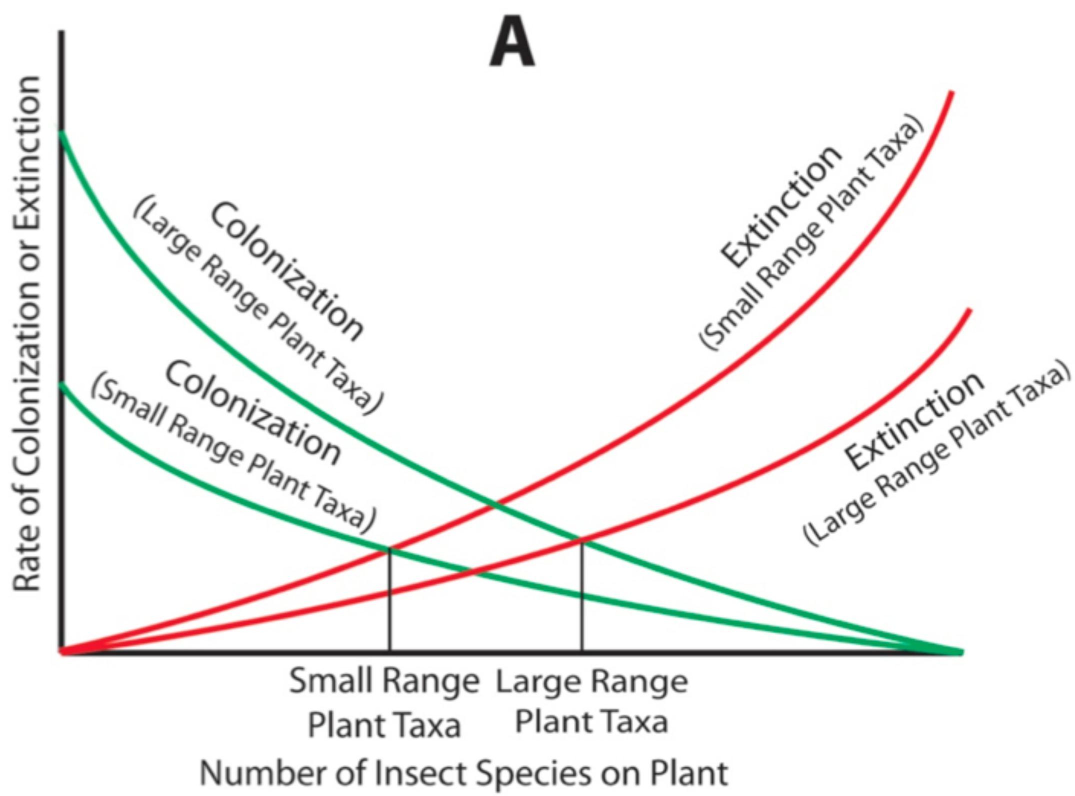

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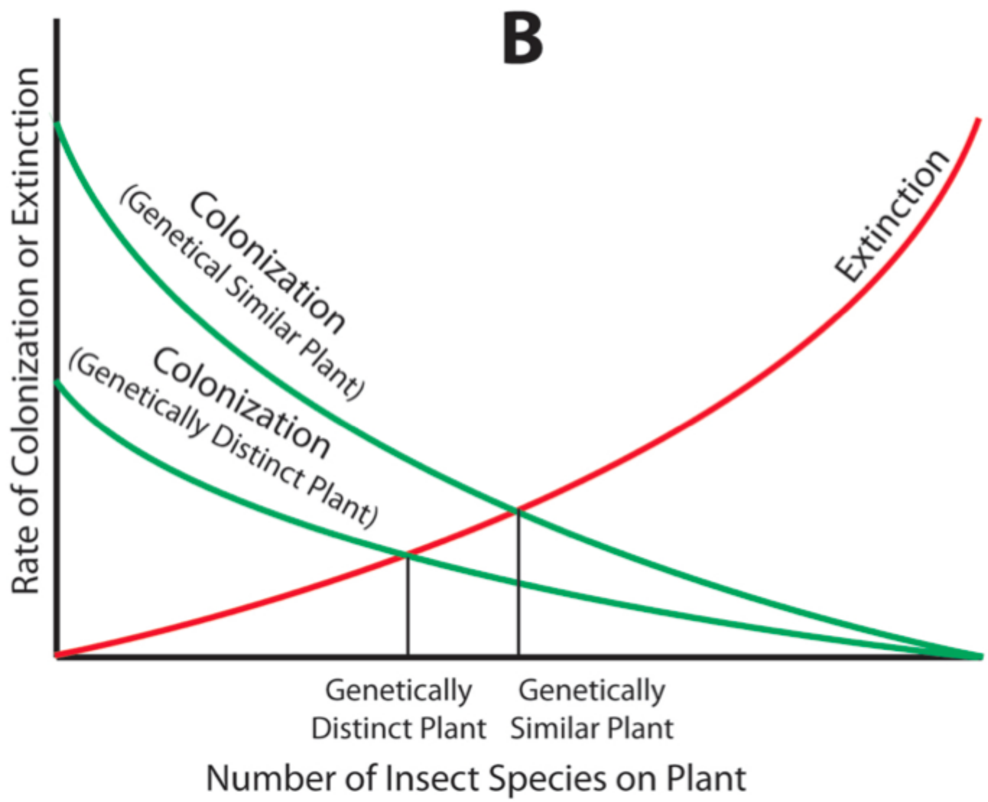
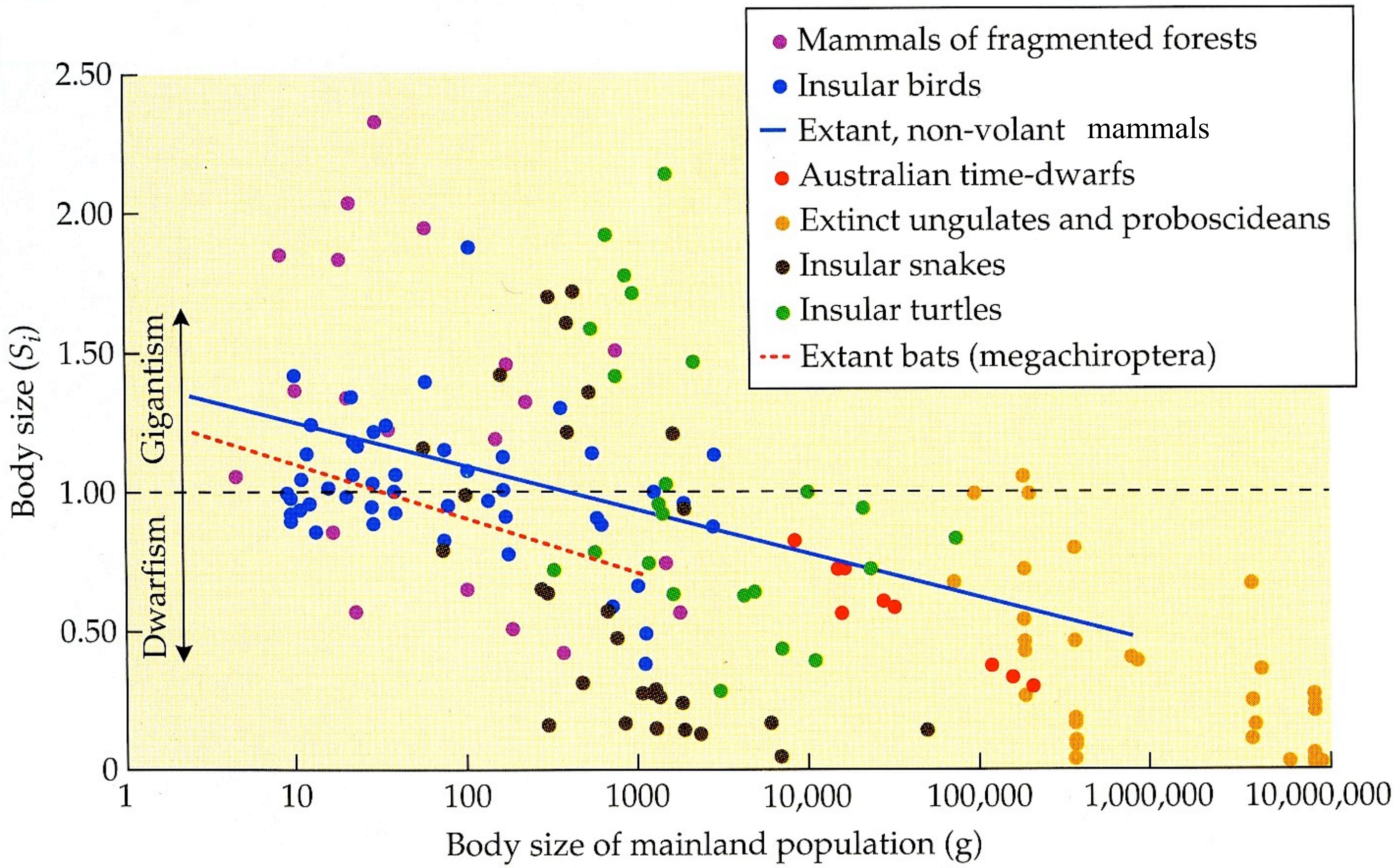


(Joy and Crespi 2012)

The Island Rule

Island Rule: The trend (in island-inhabiting vertebrates) from gigantism of species with small mainland ancestors (e.g., mice and voles) to dwarfism of species with large mainland ancestors (e.g., canids, ungulates, and elephants).



Body size trends for a variety of vertebrates (from Lomolino *et al.* 2010b)

The Island Rule

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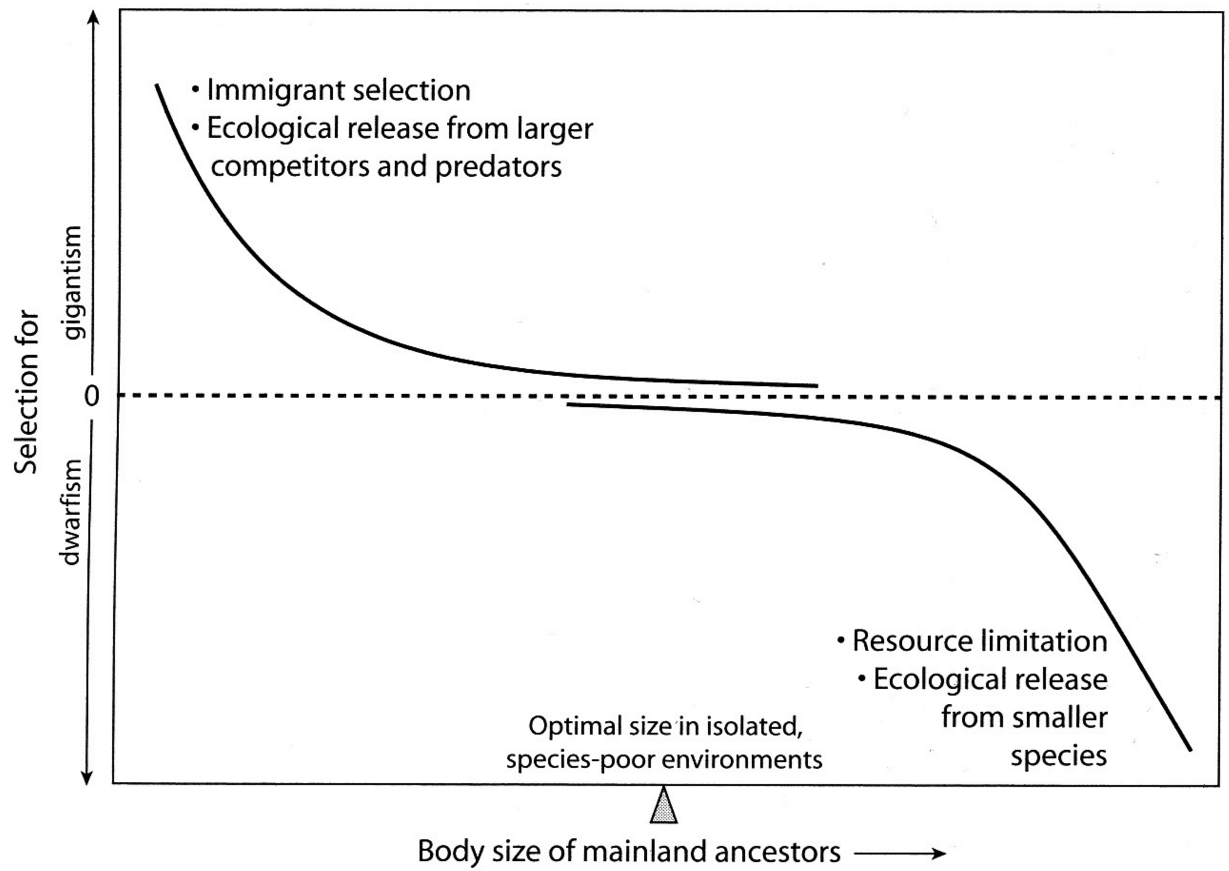
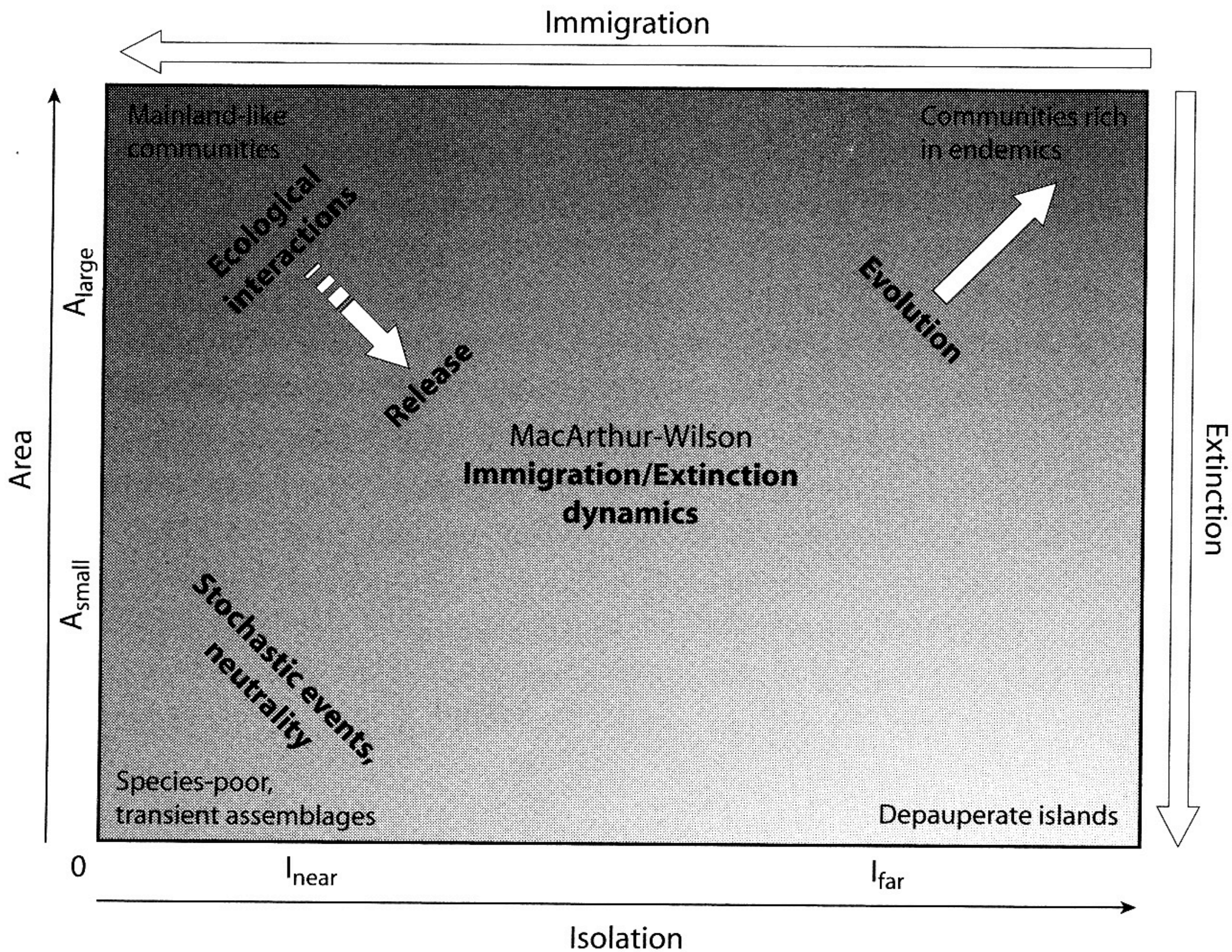


Explanations for the island rule (from Lomolino *et al.* 2010a)

Summary



Scale-dependence of ecological, evolutionary, and biogeographic processes for island biotas (from Lomolino *et al.* 2010a)

Island Biogeography

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