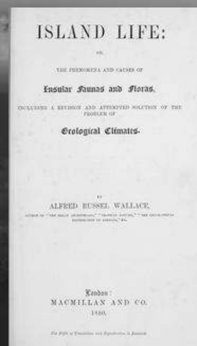
Biogeography of Islands

Special things go on in islands

- "island life" or "insular biology"



ISLAND LIFE:

OR,

THE PHENOMENA AND CAUSES OF

Insular Faunas and Floras,

INCLUDING A REVISION AND ATTEMPTED SOLUTION OF THE PROBLEM OF

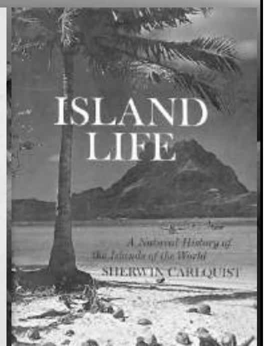
Geological Climates.

ALFRED RUSSEL WALLACE,

London:

MACMILLAN AND CO.

1880.



Biogeography of Islands

Special things go on in islands

- "island life" or "insular biology"
- replicate experiments

Dwarfism: dwarf elephants on Channel Islands

Biogeography of Islands

Special things go on in islands

- "island life" or "insular biology"
- replicate experiments

Gigantism: lizards and tortoises on Galapagos Islands

Biogeography of Islands

Special things go on in islands

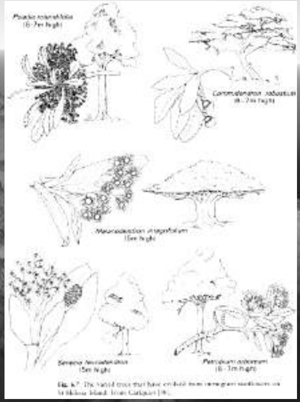
- "island life" or "insular biology"
- replicate experiments

Gigantism: "lily' trees on Canary Islands

Biogeography of Islands

Special things go on in islands

- "island life" or "insular biology"
- replicate experiments



Gigantism: convergent "sunflower" trees - St. Helena

Biogeography of Islands

Special things go on in islands

- "island life" or "insular biology"
- replicate experiments

Flightlessness: emu on Australia

Biogeography of Islands

Special things go on in islands

- "island life" or "insular biology"
- replicate experiments

Flightlessness: extinct moas on New Zealand

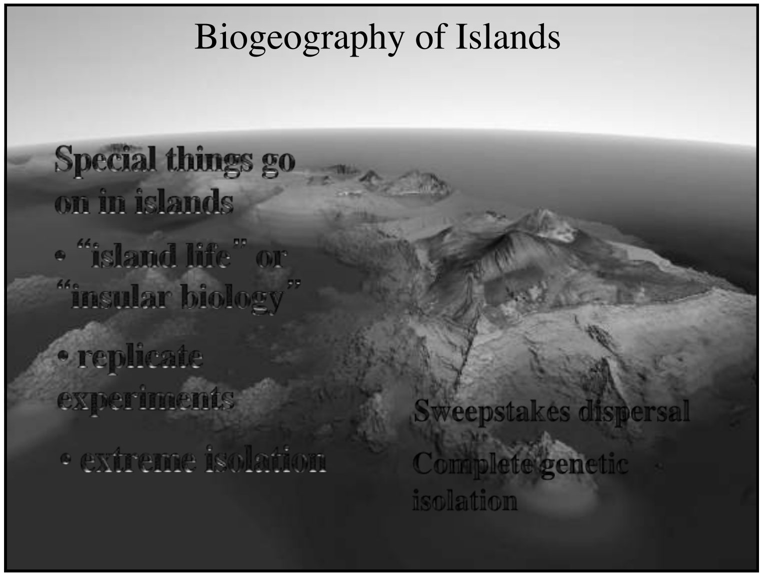
Biogeography of Islands

Special things go on in islands

- "island life" or "insular biology"
- replicate experiments

Niche shifts: NZ giant wetas (Orthoptera) as small mammals

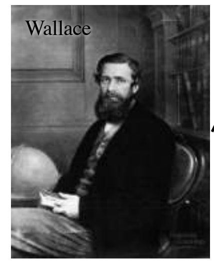
Biogeography of Islands



Biogeography of Islands

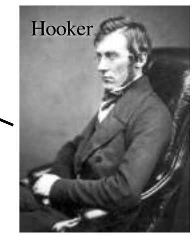
Islands historically important in biogeography

Galapagos



East Indies

South Pacific



Biogeography of Islands

Islands historically important in biogeography

Galapagos

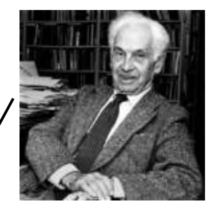
East Indies

South Pacific

Rosemary & Peter Grant: specialists on Darwin's finches

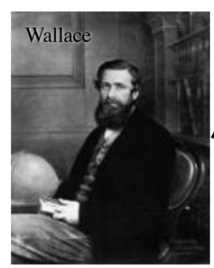
Biogeography of Islands

Islands historically important in biogeography



Ernst Mayr: specialist on Australasian birds

Galapagos



East Indies

South Pacific

Biogeography of Islands

Islands historically important in biogeography

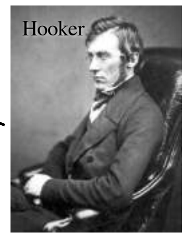
Rosemary Gillepsie: animal specialist on Pacific islands

Sherwin Carlquist: plant specialist on Pacific islands

Galapagos

East Indies

South Pacific



Biogeography of Islands

Islands biologically important in biogeography

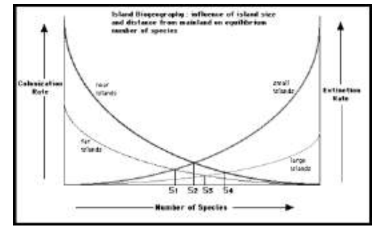
1. Island Biogeography

Identifying and quantifying the factors that control 3 phenonmena:

rate of island immigration

rate of island extinction

number of species per island



Biogeography of Islands

Islands biologically important in biogeography

2. Dispersal biology

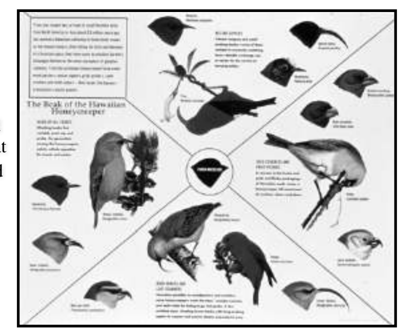
Nature of island biota: how it differs from that of the source-area, and the nature of adaptations of the successful immigrants that permitted them to reach and colonize the island

Biogeography of Islands

Islands biologically important in biogeography

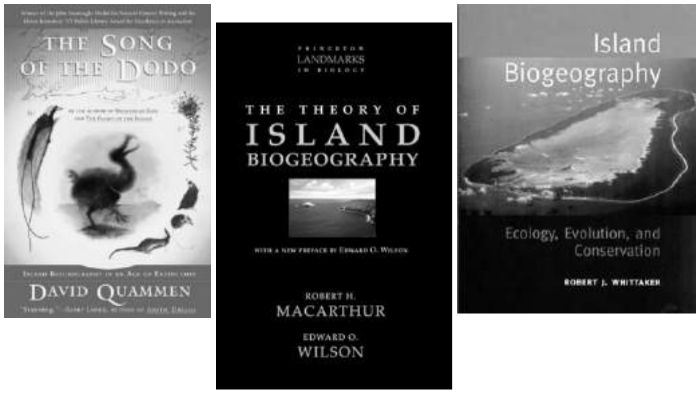
3. Adaptive radiations

Processes of evolutionary change by which immigrant species diversify and radiate to occupy ecological niches that on the mainland are normally occupied by other groups



Island Biogeography

Three interrelated ecological and biogeographical patterns seen on islands



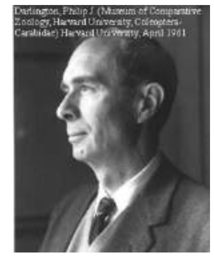
Island Biogeography

1. Species-area relationships - relationship within archipelagos between the sizes of individual islands and the number of species that comprise their biota

- de Candolle recognized that larger islands contain more species than small islands
- Philip Darlington in 1938 quantified this relationship with the herp-fauna of the West Indies

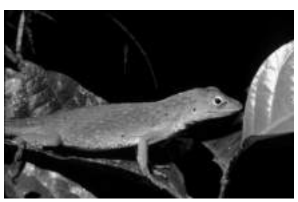
Darlingtonia
Haitian ground snake

Darlingtonia
Cobra lily

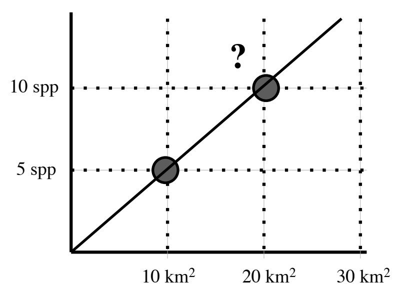


Island Biogeography

- Darlington's species area relationship – is it arithmetic, e.g. simply double island size to get double species number?



Anolis

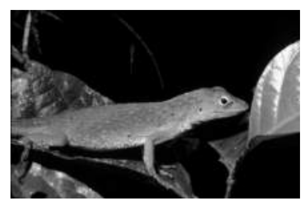


Island Biogeography

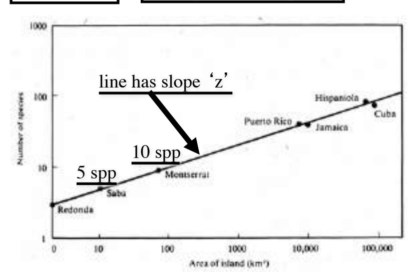
- Darlington's species area relationship – NO, increase island size ~10X to get 2X number of species

$S = CA^z$

$\log S = C + z\log A$



Anolis



Relationship between number of species (S) and island area (A) for reptiles and amphibians of the West Indies (Darlington 1957)

Island Biogeography

• Similar patterns are seen in Pacific islands for angiosperm and bird genera

. . . but with exceptions

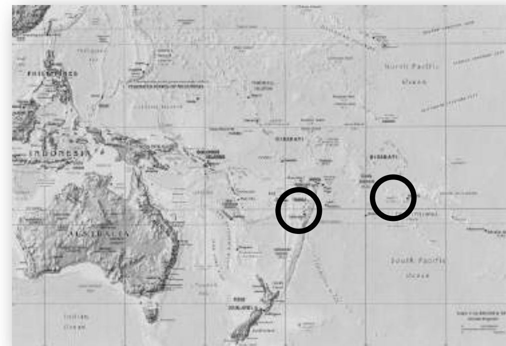
Table 6.1 The relationships between island area and the diversity of bird genera and non-endemic flowering plant genera in some Pacific islands. Data from Van Balgooy [5]; Mayr, [6]; MacArthur & Wilson [7]

	Area (km^2)	Angiosperm genera	Bird genera
Solomon Islands	40 000	654	126
New Caledonia	22 000	655	64
Fiji Islands	18 500	476	54
New Hebrides	15 000	396	59
Samoa group	3100	302	33
Society Islands	1700	201	17
Tonga group	1000	263	18
Cook Islands	250	126	10

Island Biogeography

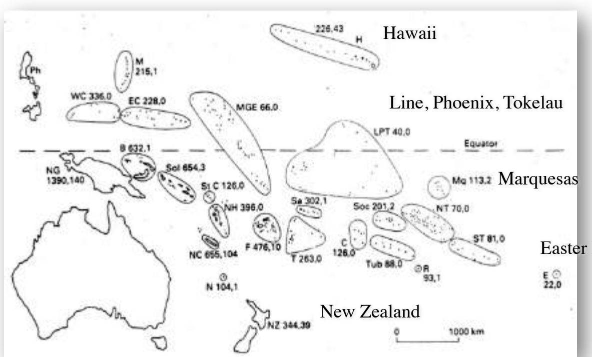
2. Effect of isolation - isolated islands have fewer species than expected

• Pacific islands show this dramatically



Island Biogeography

• Distribution of seed plant genera in Pacific islands (#genera / #endemic)



Island Biogeography

• Species area relationship has high correlation coefficient (0.94)

but isolated islands too low

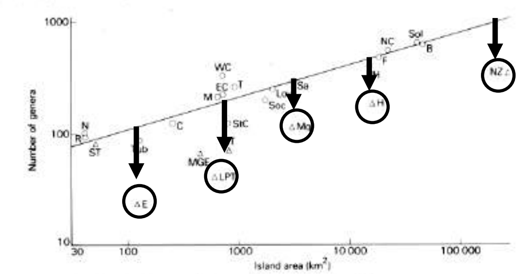
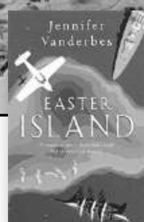


Fig. 6.2 The relationship between island area and diversity of conifer and flowering plant genera in the Pacific Islands. The more isolated islands are indicated by triangles. The data from the other islands lie very close to a straight line (the regression coefficient), suggesting that generic diversity in these islands is almost wholly controlled by island area – the correlation coefficient is 0·94, indicating a very high degree of correlation. For abbreviations, see legend of Fig. 6.1, plus Loy, Loyalty Islands. Data from Van Balgooy [5].

Island Biogeography

• Easter Island (Rapa Nui) is one of the most isolated - 22 seed plant genera

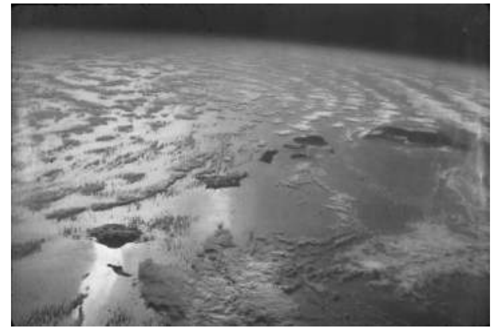


Dr. Greer Farraday, an American botanist, travels to Easter Island to research the island's ancient pollen, but more important, to put back the pieces of her life after the death of her husband.

Island Biogeography

• Extreme impoverishment of isolated islands indicates distance limits successful colonization

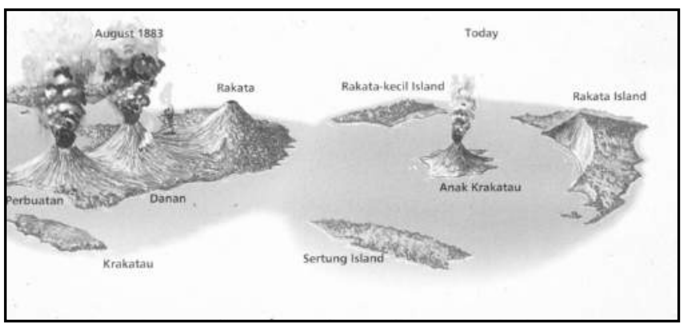
• Supported by observation that successful colonists have special features allowing for long distance dispersal



Island Biogeography

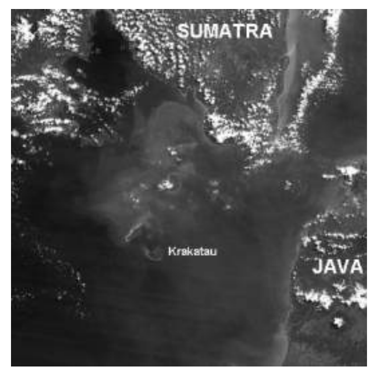
3. Species turnover - islands have higher species turnover than continental mainlands

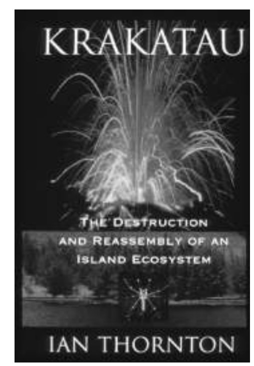
• 136 years of Krakatau recolonization



Island Biogeography

• recolonization from Sumatra and Java; extensive data collected on species composition ever since



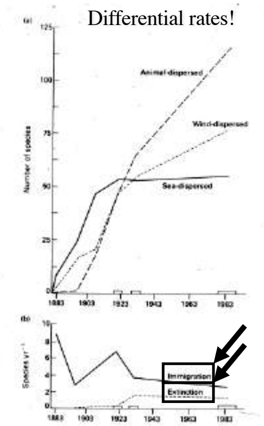


Island Biogeography

- by the 1930s a tropical forest had developed
- number of bird species increased until 1920, then has remained fairly constant despite changes in avifauna
- some later colonists were successful, replacing about same number of bird species that went "extinct"

Island Biogeography

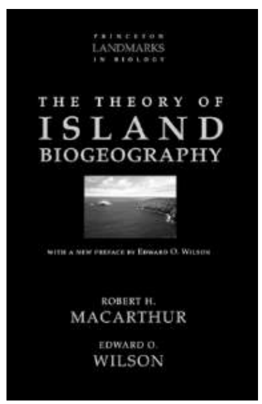
- water dispersed plants arrived quickly and have maintained at about 50 species
- wind and then animal dispersed species arrived later
- immigration rates slowing down, extinction rates increasing



Island Biogeography

Theory of Island Biogeography - unifying theory to explain these three basic characteristics of insular biotas (1963 article, 1967 book)

1. Species-area relationships
2. Effect of isolation
3. Species turnover, but numbers same



Robert MacArthur - ecologist, competition

E. O. Wilson - ant taxonomist, biogeographer

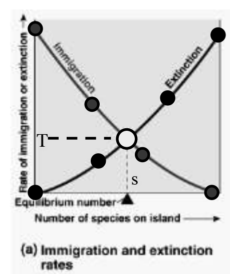
Island Biogeography

Equilibrium Theory of Island Biogeography

immigration rate - starts high, then saturates

extinction rate - starts low, then rises

equilibrium species (s) number - where two rates (T) intersect



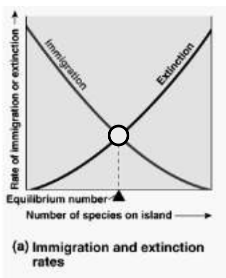
- Species turn over through time, but same number (s) of species
- Island size?
- Island distance?

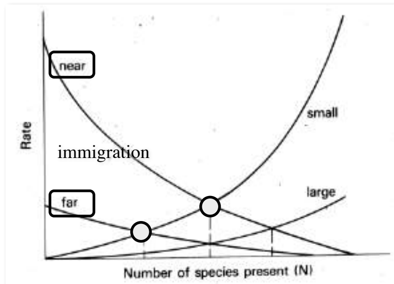
Island Biogeography

Equilibrium Theory of Island Biogeography

distance effect - near vs. far island will have different colonizations

equilibrium species (s) number varies!





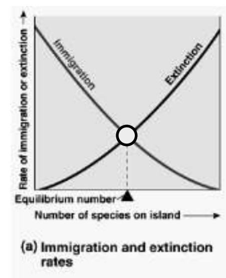
Island Biogeography

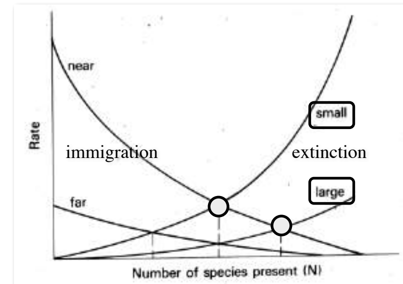
Equilibrium Theory of Island Biogeography

distance effect - near vs. far island will have different colonizations

size effect - large vs. small island will have different extinction rates

equilibrium species (s) number varies!





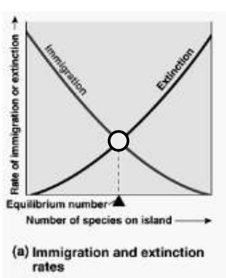
Island Biogeography

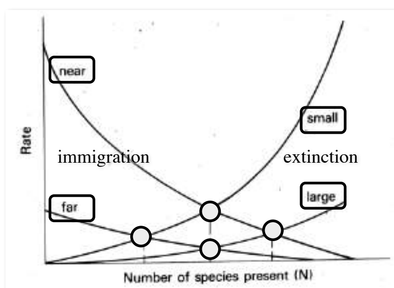
Equilibrium Theory of Island Biogeography

distance effect - near vs. far island will have different colonizations

size effect - large vs. small island will have different extinction rates

equilibrium species (s) number varies!



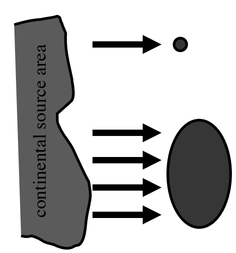


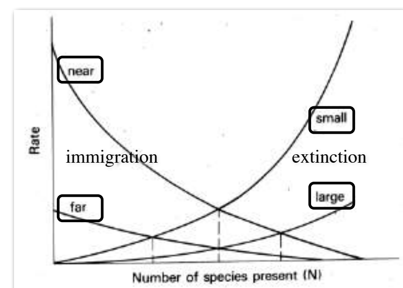
Island Biogeography

Equilibrium Theory of Island Biogeography - short comings!

1. immigration - not just affected by distance, but also island size

'target' effect



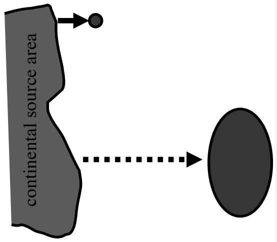


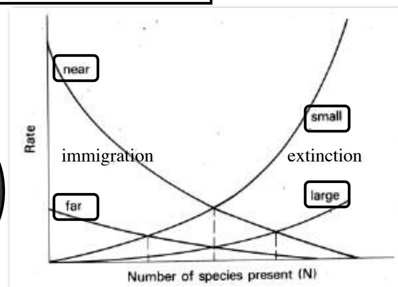
Island Biogeography

Equilibrium Theory of Island Biogeography - short comings!

2. extinction - not just affected by size, but also distance

‘rescue’ effect - extinction bailed out by recolonization





Island Biogeography

Equilibrium Theory of Island Biogeography - short comings!

3. Diversity of habitats increases with island size

- keystone species change carrying capacity
- permits *in-island* speciation (~300 introductions ➔ 3000 species in Hawaii)

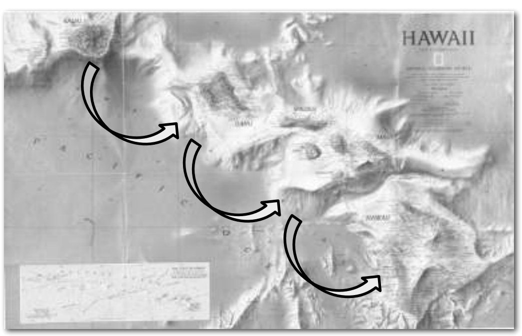
Metrosideros - ohia

Hawaiian bird diversity increases

Island Biogeography

Equilibrium Theory of Island Biogeography - short comings!

4. Archipelago effect - islands influence each other

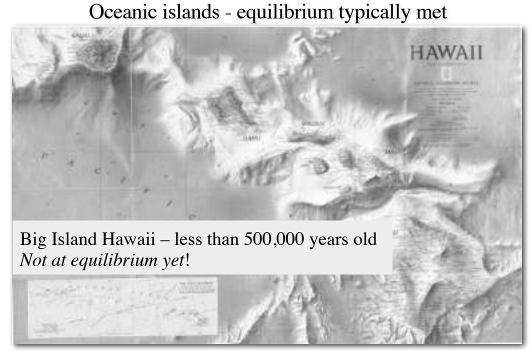


Island Biogeography

Equilibrium Theory of Island Biogeography - short comings!

5. “Equilibrium” not yet reached in some cases

Oceanic islands - equilibrium typically met

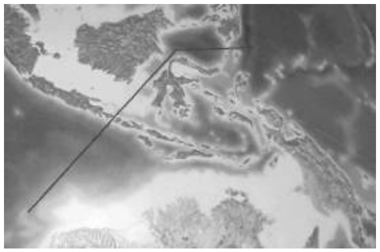


Island Biogeography

Equilibrium Theory of Island Biogeography - short comings!

5. "Equilibrium" not yet reached in some cases

Continental islands - equilibrium typically not met

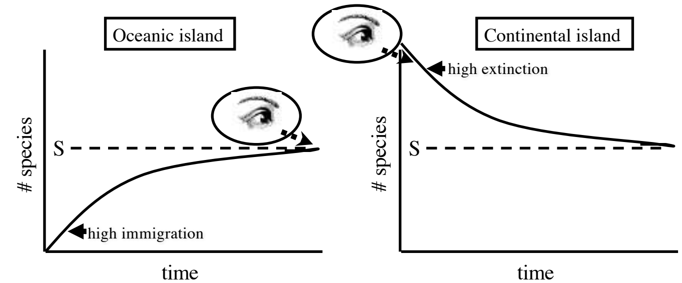


Malay Archipelago "islands" were recently continental during Pleistocene!

Island Biogeography

Equilibrium Theory of Island Biogeography - short comings!

5. "Equilibrium" not yet reached in some cases



• we view oceanic islands late when at equilibrium

• we view continental islands early (faunal/flora collapse, relaxation)

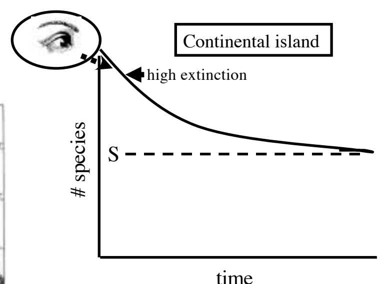
Island Biogeography

Equilibrium Theory of Island Biogeography - short comings!

5. "Equilibrium" not yet reached in some cases

• Faunal collapse in Sunda Shelf 0.5% decline/generation

• Time to equilibrium very slow



• we view continental islands early (faunal/flora collapse, relaxation)

Island Biogeography

Equilibrium Theory of Island Biogeography - short comings!

5. "Equilibrium" not yet reached in some cases

• Great Britain - continental island - shares many orchid and bee pollinators with Europe, including bee mimic orchids and their pollinators

• 120 native bee species, but declining

• *Ophrys apifera* apparently has lost its specific bee pollinator and is now entirely selfing

Island Biogeography

Equilibrium Theory of Island Biogeography - short comings!

6. Not predicted outcomes (or real life is more complex!)

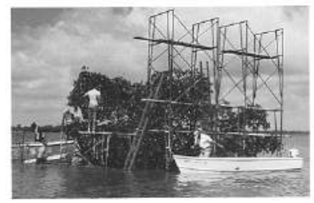
- Barro Colorado Island - continental island (formed with Panama Canal)
- Carnivores went "extinct" almost immediately
  - Seed eating herbivores increased tremendously
    - Rapid changes in plants not predicted by EToIB

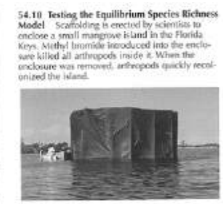
Island Biogeography

Equilibrium Theory of Island Biogeography - short comings!

6. Not predicted outcomes (or real life is more complex!)

- Florida Key mangrove arthropod communities - experimental test by Dan Simberloff
- Four islands, far and near, had arthropod community exterminated and then biodiversity assessed at regular intervals

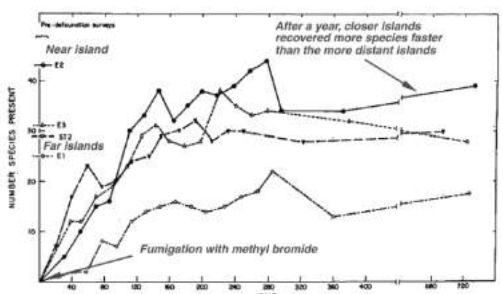




Island Biogeography

Equilibrium Theory of Island Biogeography - short comings!

- Equilibrium reached within a year, but 'overshooting' before stabilizing
- Species number fit distance of islands and pre-defaunation levels
- Actual species varied

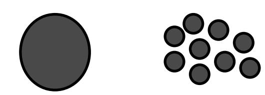


Simberloff & Wilson 1970. Experimental zoogeography of islands: a two-year record of colonization. Ecology 51: 934-937.

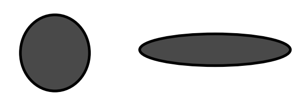
Island Biogeography

Applications of Equilibrium Theory of Island Biogeography

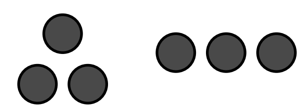
- design of nature preserves - the SLOSS debate (single large or several small): *sum of species in series of small areas does not sum to list of one large area!*



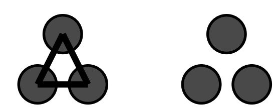
- circular vs. 'peninsular'



- clumped vs. spread out



- corridors vs. unconnected



Island Biogeography

Applications of Equilibrium Theory of Island Biogeography

- Oceanic islands
- Sky islands (mountain tops)
- Forest fragments
- Prairie potholes
- Prairie remnants

Ecological Determinants of Species Loss in Remnant Prairies

Mark K. Leach and Thomas J. Givnish

Recensuses of 54 Wisconsin prairie remnants showed that 8 to 60 percent of the original plant species were lost from individual remnants over a 32- to 52-year period. The pattern of species loss was consistent with the proposed effects of fire suppression caused by landscape fragmentation. Short, small-seeded, or nitrogen-fixing plants showed the heaviest losses, as did species growing in the wettest, most productive environments. The interruption of landscape-scale processes (such as wildfire) by fragmentation is an often overlooked mechanism that may be eroding biodiversity in many habitats around the world.

Science 1996

Island Biogeography

Applications of Equilibrium Theory of Island Biogeography

• 54 prairie patches undergoing ‘relaxation’ or species loss since mid-1800s
• resampled 50 years after the mid-1900’s

Ecological Determinants of Species Loss in Remnant Prairies

Mark K. Leach and Thomas J. Givnish

Recensuses of 54 Wisconsin prairie remnants showed that 8 to 60 percent of the original plant species were lost from individual remnants over a 32- to 52-year period. The pattern of species loss was consistent with the proposed effects of fire suppression caused by landscape fragmentation. Short, small-seeded, or nitrogen-fixing plants showed the heaviest losses, as did species growing in the wettest, most productive environments. The interruption of landscape-scale processes (such as wildfire) by fragmentation is an often overlooked mechanism that may be eroding biodiversity in many habitats around the world.

Science 1996

1. size of patch determined rate of species loss
2. number of species originally determined rate of species loss
3. correlated species features to species loss

Island Biogeography

Applications of Equilibrium Theory of Island Biogeography

Platanthera leucophaea - prairie finged orchid

• loss of herbs with small seeds, N_2 fixers, and sphingid moth-pollinated