

Intensive Programme “Forests and storms: what forestry policy could be implemented after a major climatic event?”

Impact of climate change on the forests, the agroforestry systems and the wildlife
- The importance of landscape structure -

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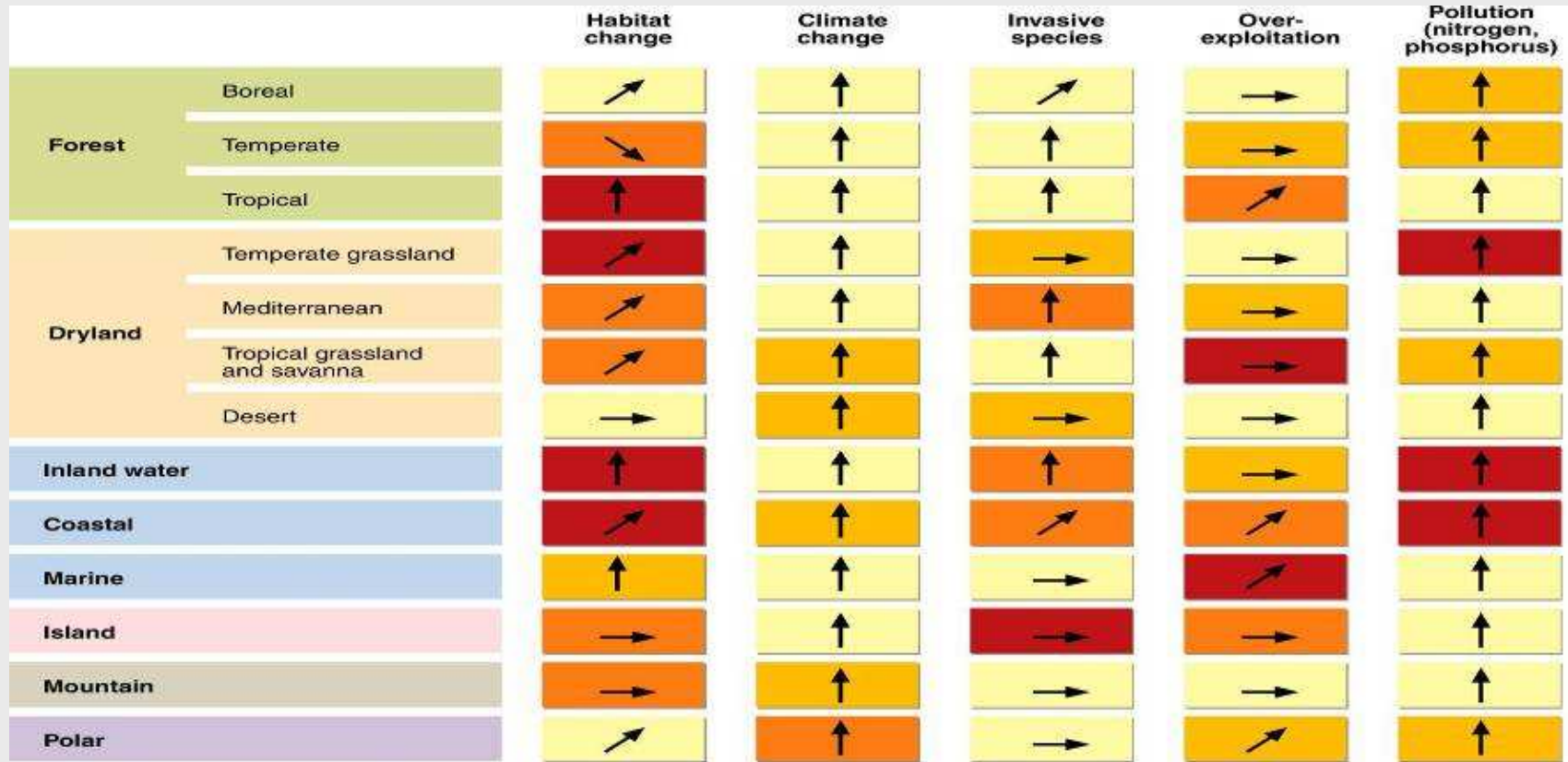
Trends in climate

- Long-term changes in climate (variations in temperature, rainfall and seasonality);
- Increased variability with more extreme weather events (e.g., drought duration and frequency, flooding);
- Shifting seasonal water availability;
- Abiotic disturbances (changes in fire occurrence, changes in wind storm frequency and intensity);
- Biotic disturbances (frequency and consequences of pest and disease outbreaks).

Expected effects on ecosystems and species

- Shifts and fluctuations of habitats and habitat conditions: shifts in the distributions of various species towards the poles and to higher altitudes.
- Synergetic effects between climate change and habitat fragmentation: fragmentation might increase species' vulnerability to climate change.
- Increase number of species threatened with extinction.
- Changes in the distribution of most types of vegetation.

Impact on biodiversity



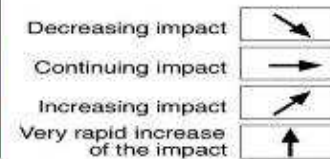
RESULT OF PAST EVOLUTION

Driver's impact on biodiversity over the last century



WHAT HAPPENS TODAY

Driver's actual trends



Source: Millennium Ecosystem Assessment

Conversion of original biomes

- **Habitat transformation**

Further 10–20% of grassland and forestland is projected to be converted by 2050

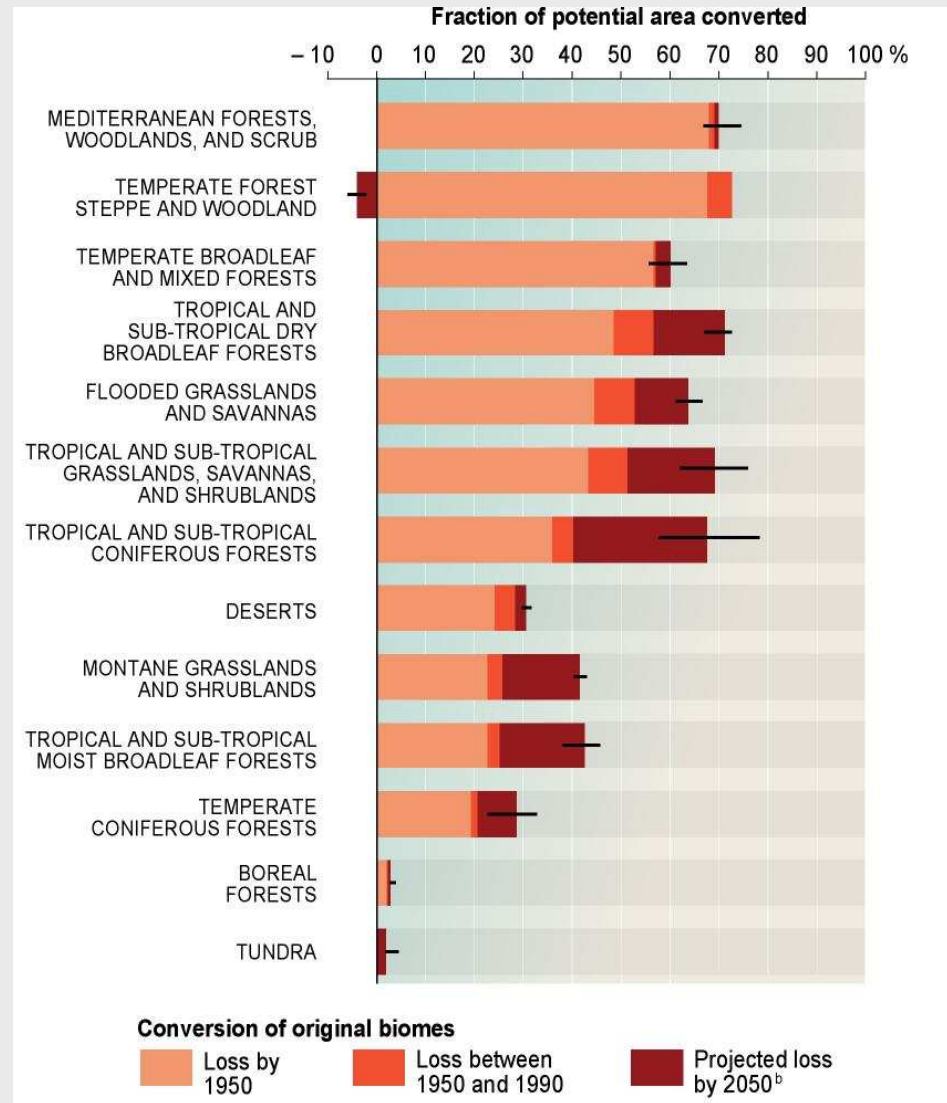
- **Overexploitation**

Pressures continue to grow in all scenarios

- **Invasive alien species**

Spread continues to increase

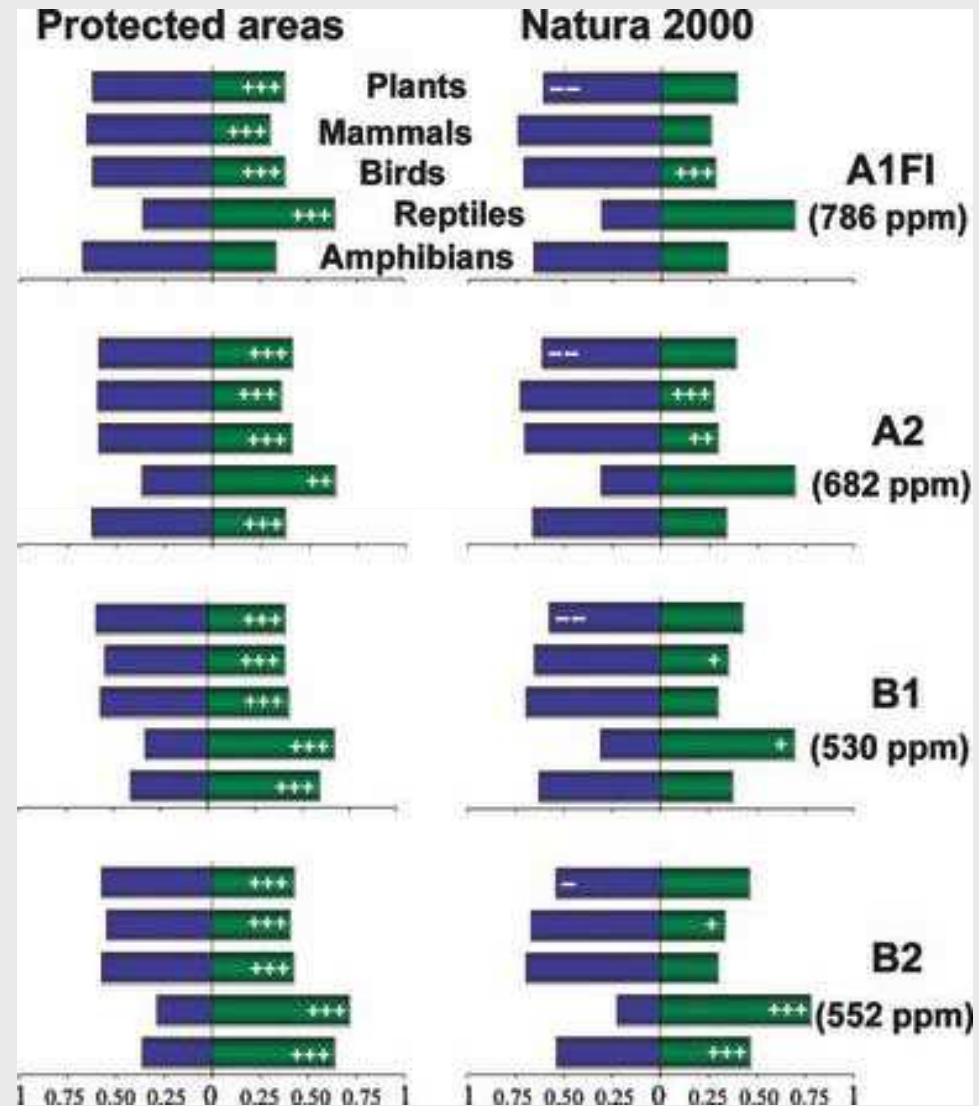
Source: Millennium Ecosystem Assessment, 2005



Climate change and species in European conservation areas

Proportion of species projected to gain climatic suitability in European conservation areas under four emission scenarios by 2080 (**winners; green**) or lose (**losers; blue**)

Source: Araújo et al., 2011



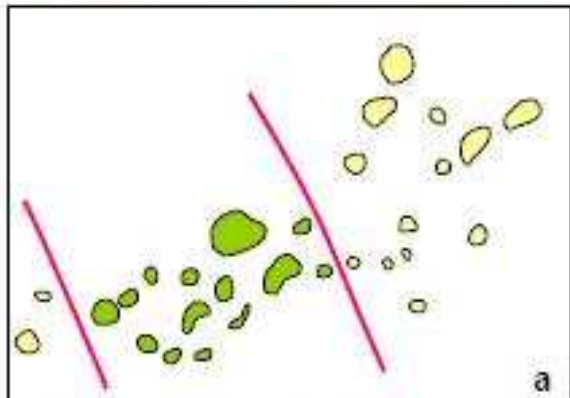
Synergetic effects between climate change and habitat fragmentation

The persistence of a particular species lies in its ability to adapt to the new ecological regime. The easiest way for a species to adapt is to shift its geographic range to a new area that has the appropriate climate.

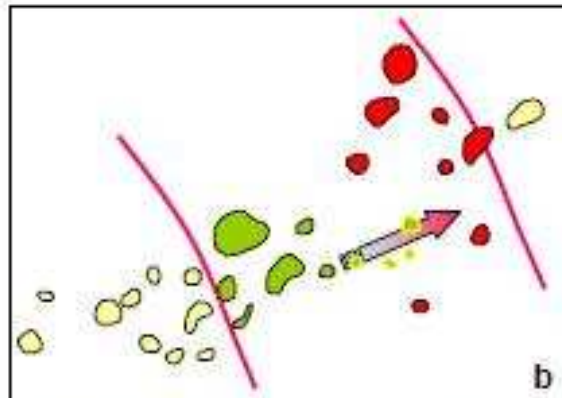
However, this may not be as easy as in the geologic past for two reasons:

- (1) current populations of native species are already stressed by competition with exotic species, mortality from pesticides and pollution, and the effects of overexploitation - because stressed populations tend to be small and produce few offspring, they have a reduced ability of dispersal into a new habitat.
- (2) human alteration of landscapes has reduced the total amount of suitable habitat for many species and fragmented these landscapes with roads, dams, croplands, and urban areas.

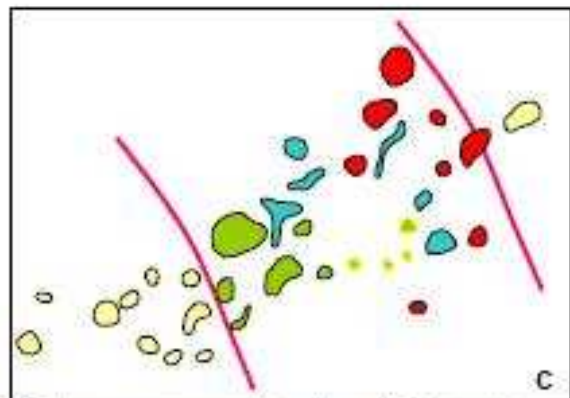
Example of synergetic effects of temperature rise and habitat fragmentation on species range



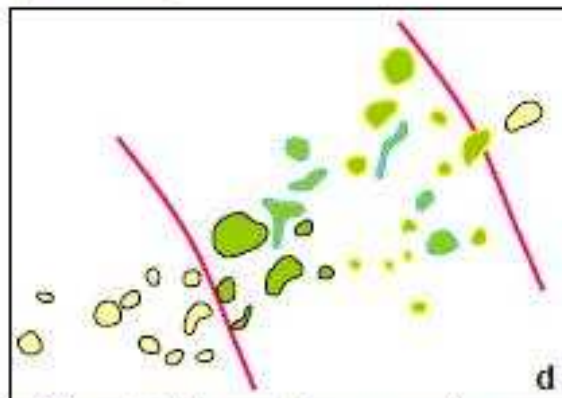
Species range between minimum and maximum temperatures



After mean temperature rise some patches become unsuitable, while others become suitable. However, some are too isolated (red patches)



Distances need to be bridged, e.g. by creating the blue patches

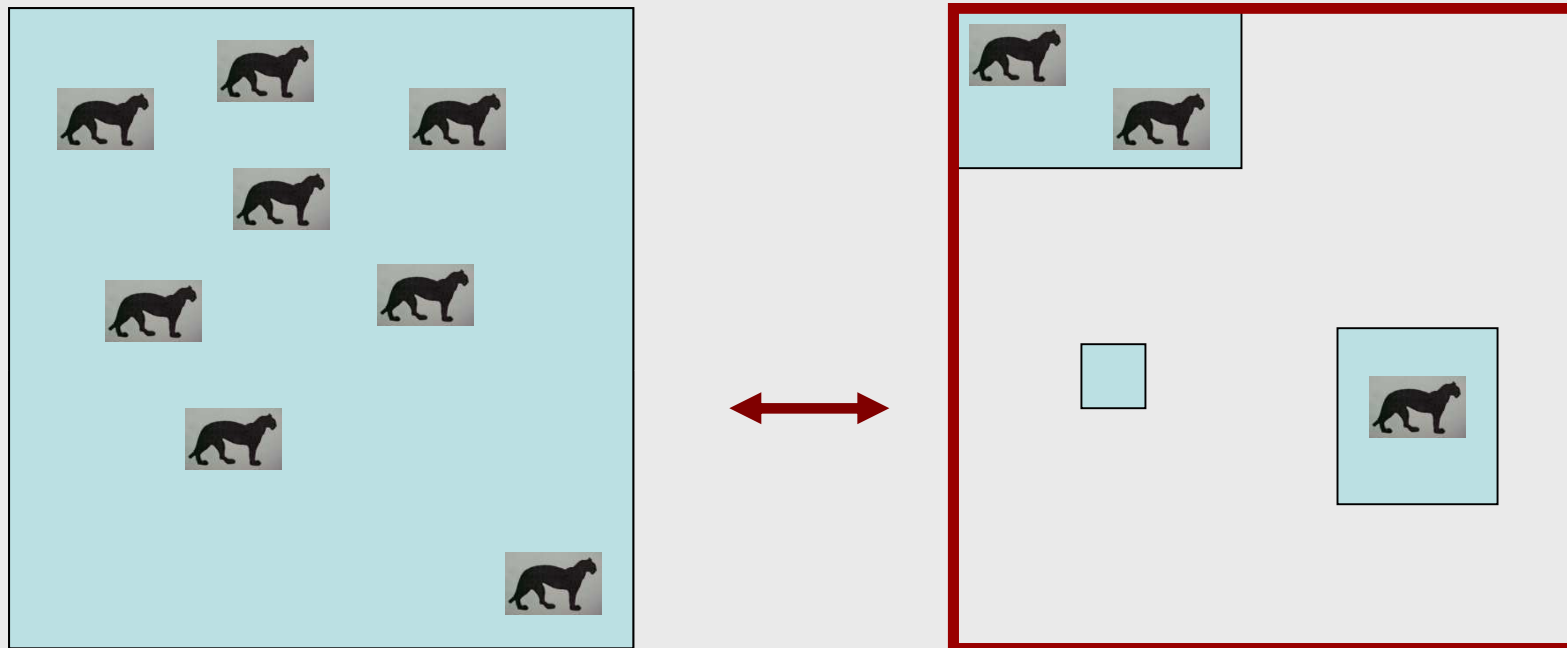


All suitable patches can be reached

Combined effect of temperature rise and habitat fragmentation on the shifting butterfly species ranges.

Source: Cormont, 2007

Habitat fragmentation

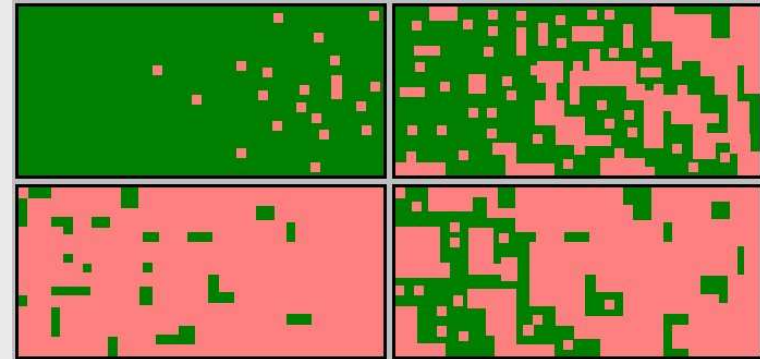


Fragmentation leads to change in a species' abundance and/or distribution via altered species interactions.

Fragmentation

Impacts on habitats:

- Area reduction
- Isolation of parts
- Changes in heterogeneity
- Structural impoverishment
- High edge effect (contrast)



Impacts on species:

- Isolation
- Changes in abundance, richness and composition
- Genetic impoverishment
- Favors invasions by exotics
- Extinctions

Main factors that affects biodiversity in fragmented forests

- **Area reduction:** changes in species abundance, richness and composition (island effect).
- **Degree of isolation:** distance between fragments and matrix type could be a barrier that prevents the individual spreading.
- **Degree of structural connectivity.**
- **Vegetation structural diversity and heterogeneity:** Often the resources used by a species are not evenly distributed in a forest and fragmentation can cause the loss of resources.

Island effect

Isolation of forest fragments - Islands Biogeographical Theory (MacArthur & Wilson 1963).

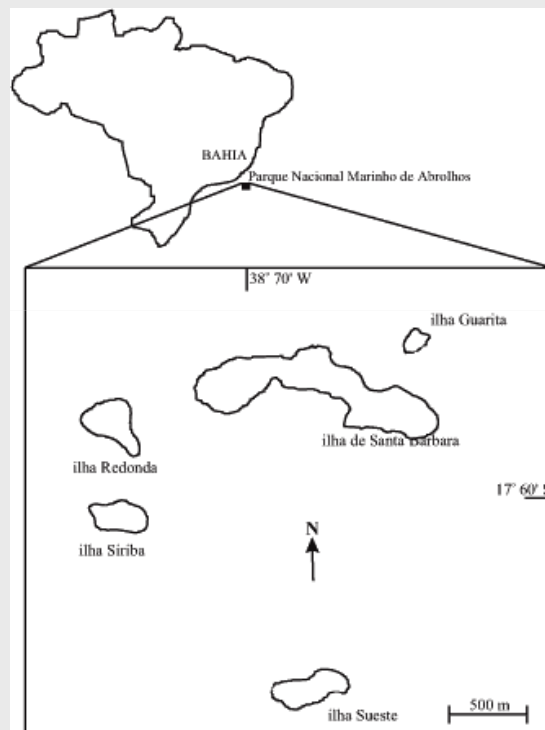


Figura 1. Localização do Parque Nacional Marinho de Abrolhos e disposição das ilhas no arquipélago.

Figure 1. Location of the Abrolhos National Marine Park showing the distribution of islands in the archipelago.

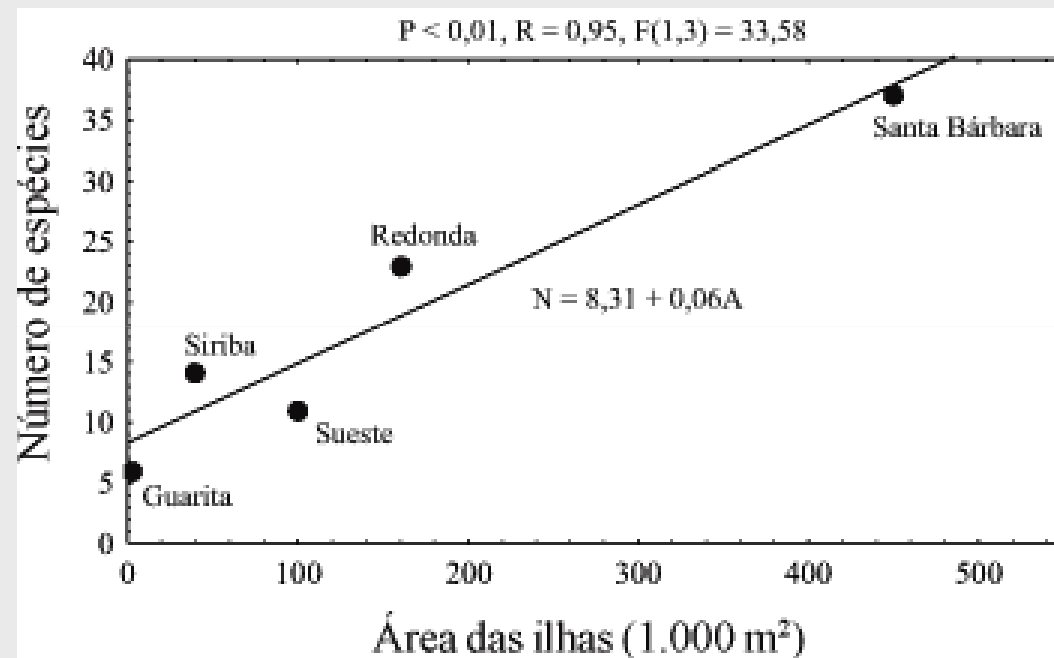
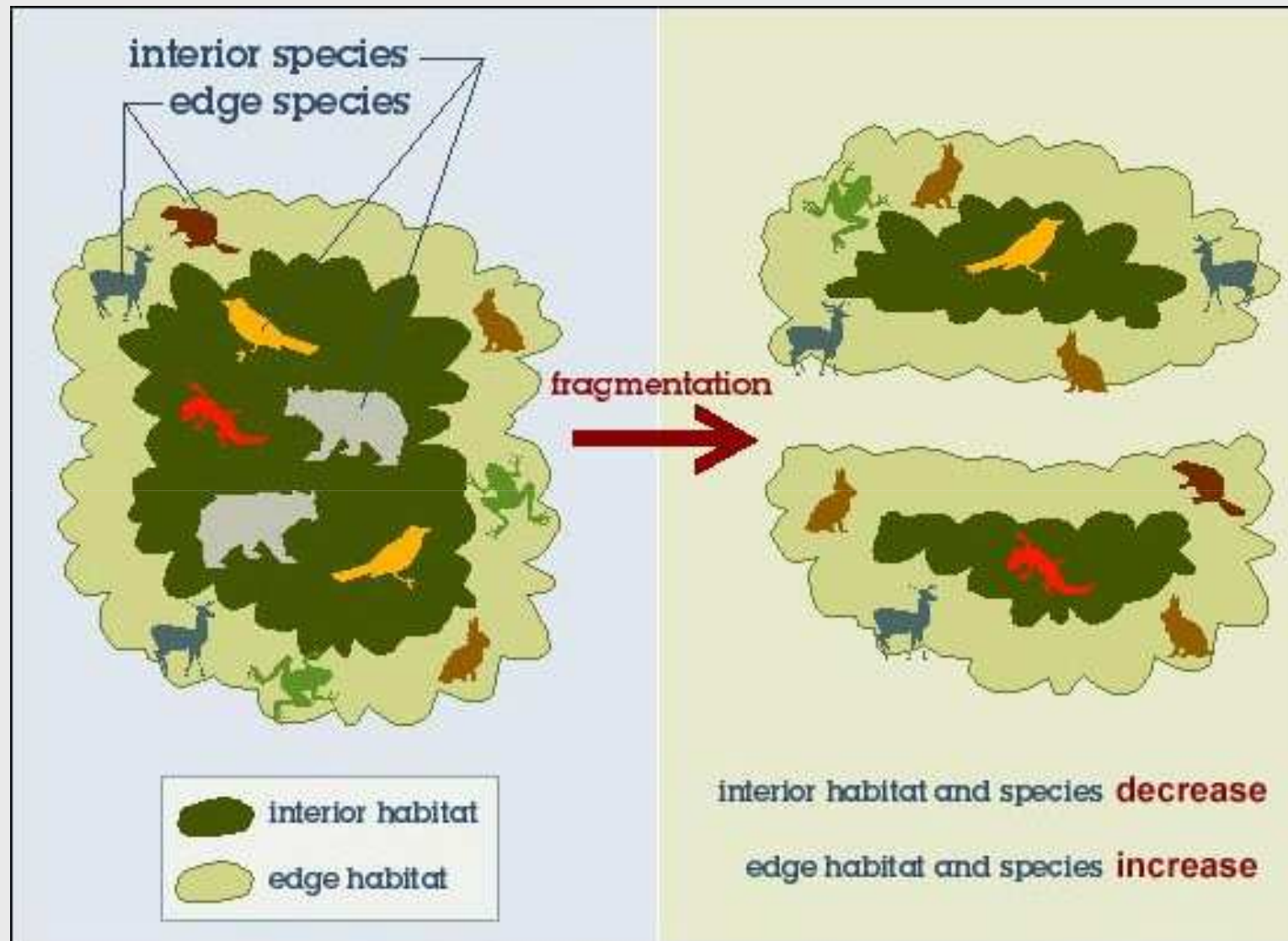


Figura 4. Relação entre o número de espécies e o tamanho das ilhas no arquipélago de Abrolhos.

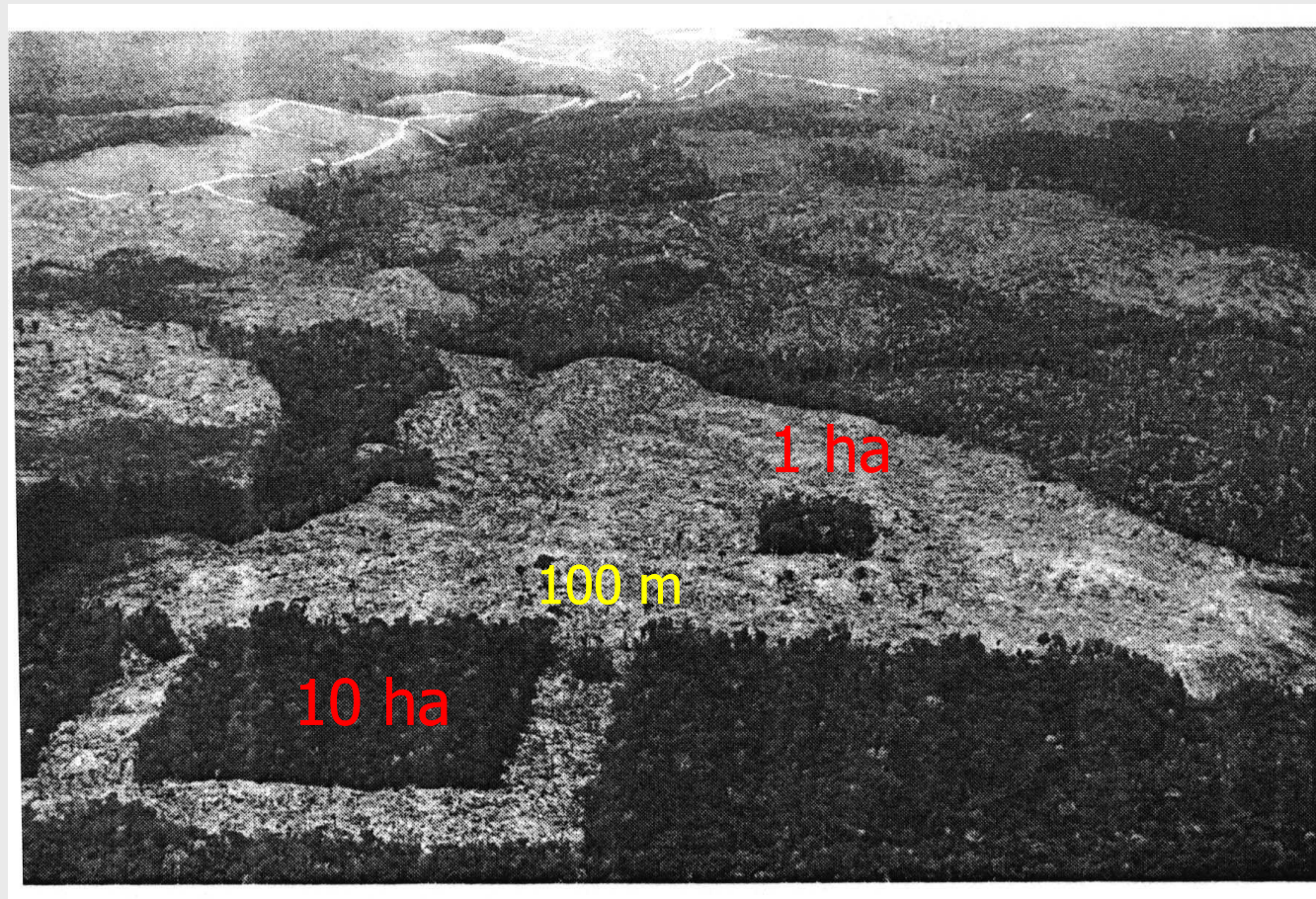
Figure 4. Relationship between the number of species and the size of the islands in the Abrolhos archipelago.

Source: Kemenes, 2003



Source: Defenders of Wildlife, 2011

Experimental fragments - Brazil Project: Minimum Critical Size Ecosystem Project

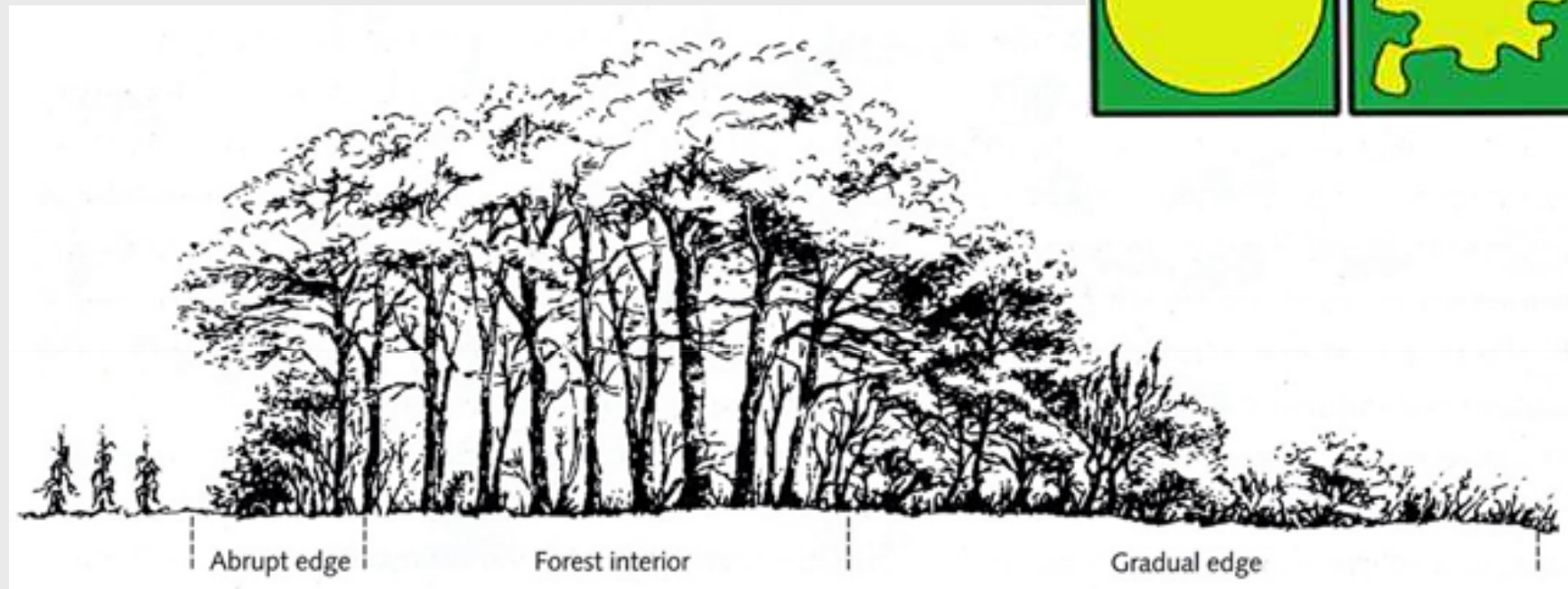


Source: INPA & Smithsonian Institution

Fragmentation - More sensitive species

- Rares (specialized/ limited distribution)
- That need large areas (e.g., large mammals)
- That requires core areas
- That requires several habitats
- With low mobility (e.g., non-flyer insects)
- With short live cycles
- Vulnerable to human activities or exploitation

Edge effect



Results from the juxtaposition or placing side by side of contrasting environments on an ecosystem. Creates mixed communities, containing elements of both systems in contact.

Fragmentation – Edge effect

- Losses in Core area
- Ecological trap (vulnerability to predation)
- Invasion by exotics
- Microclimate changes
- Edge contrast (measure of fragmentation)

Edge = selective filter

Fragmentation - Edge effect

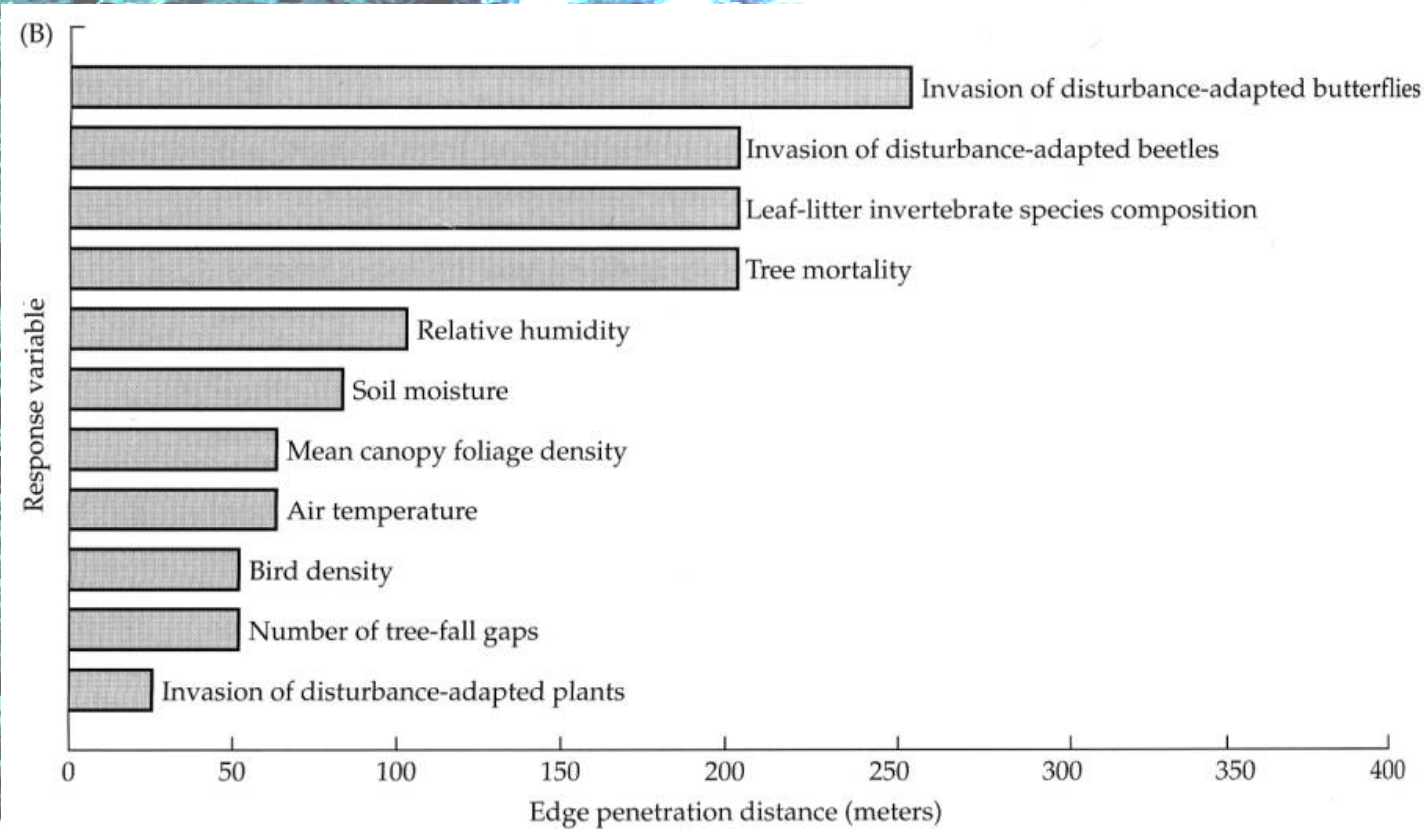
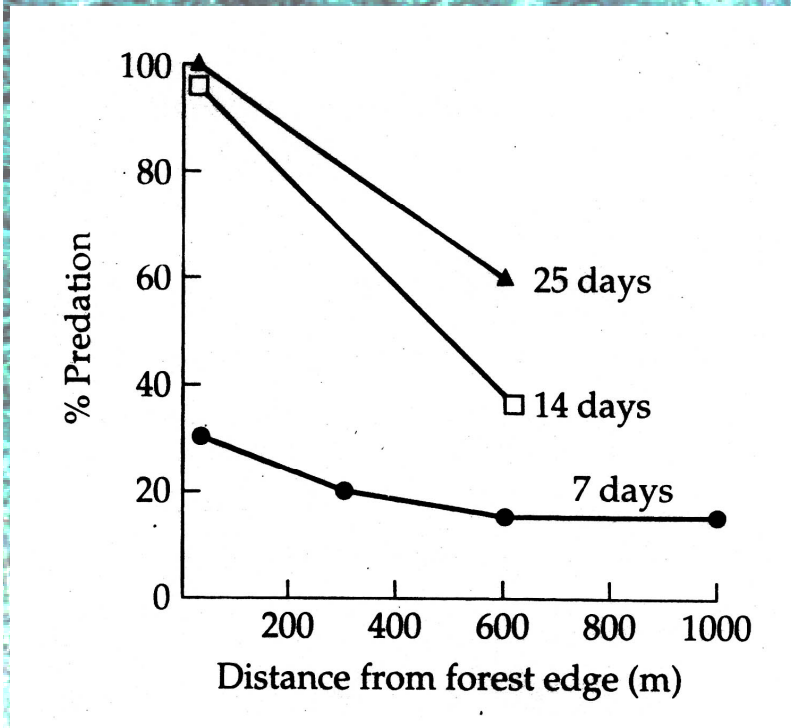


FIGURE 9.16 (B) Various effects of habitat fragmentation, as measured from the edge into the interior of an Amazon rain forest fragment. For example, disturbance-adapted butterflies migrate 250 m into the forest from an edge, and the relative humidity of the air is lowered within 100 m of the forest edge. (A, photograph by R. Bierregaard; B, after Laurance and Bierregaard 1997.)

Fragmentation - Edge effect

Nests predation



Source: Wilcove et al. (1986)

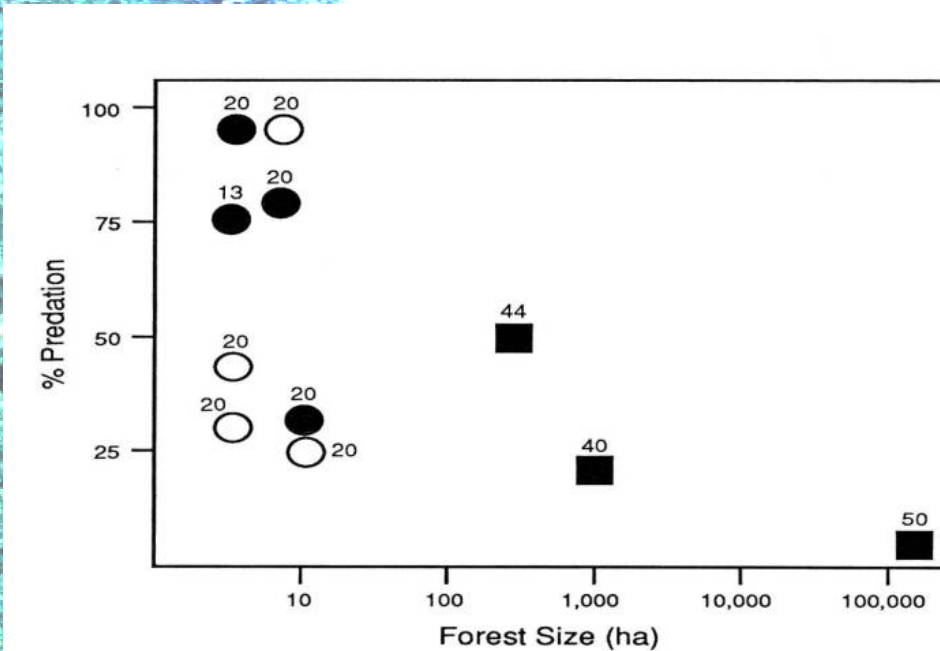
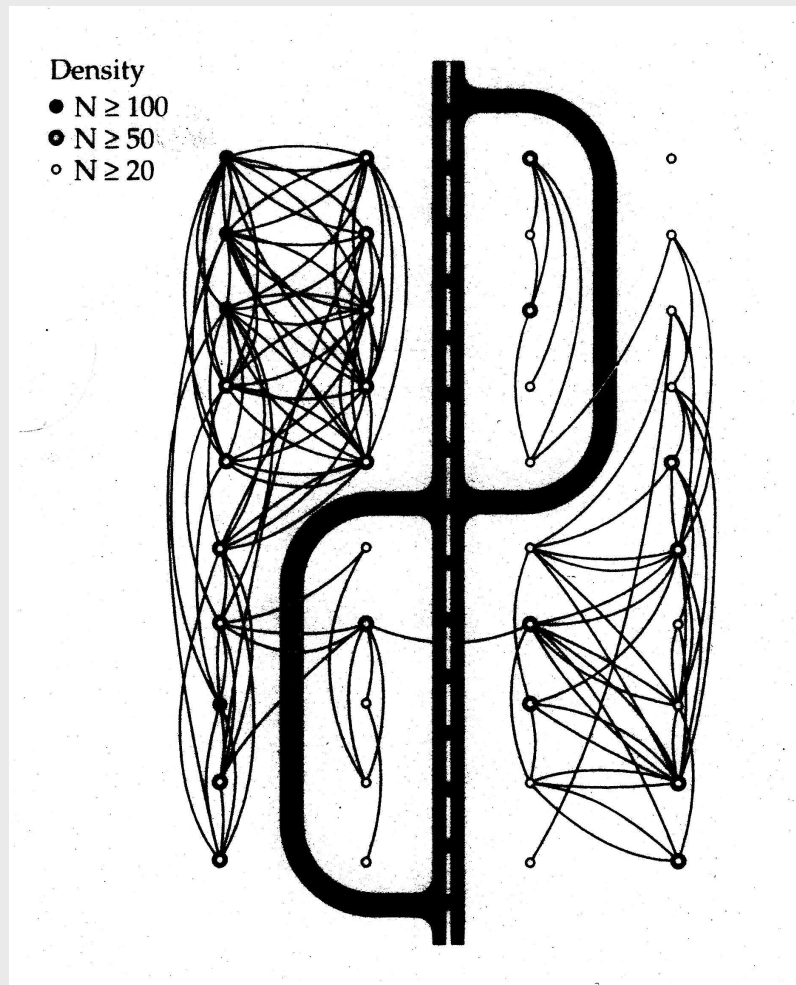


FIG. 5.3 Percentage of nests preyed upon as a function of forest size. Closed squares are large forest tracts, open circles are rural fragments, and closed circles are suburban fragments. The number above each point is the number of artificial nests placed in that forest (Wilcove 1985b).

Fragmentation - Barriers

Carabids



Populations of the forest-dwelling carabid beetle were almost completely divided by a road and parking loops (unpaved).

Source: Mader, 1984

Conserving biodiversity

- Genetic level: seed, egg, sperm banks
- Population and species level:
 - *Ex-situ* breeding (ex: zoological and botanical gardens)
 - Population management:
 - Protection (hunting, disease, habitat)
 - Genetic management (reintroductions)
 - Habitat restoration
- Ecosystem, habitat and species level:
 - Protected areas
 - Management plans

Climate change and conservation policies

What should be the focus of biodiversity conservation under climate change?

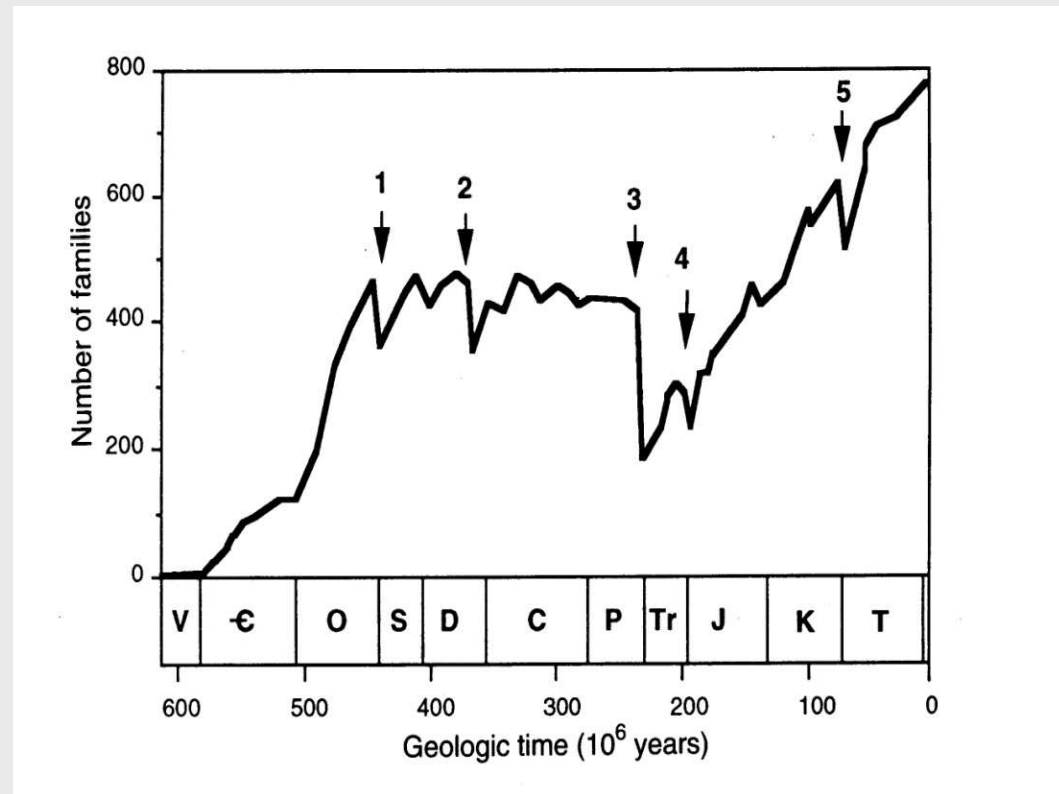
- Currently present rare species?
- Immigrating rare species that loose their current habitats?
- Currently common species, that might become threatened in the future?

Areas for biodiversity conservation

Select the areas that represent and maintain biodiversity over time...
(Margules e Pressey, 2000)

- Biodiversity is not static but constantly changing.
- 99% of the species that ever lived have gone extinct.

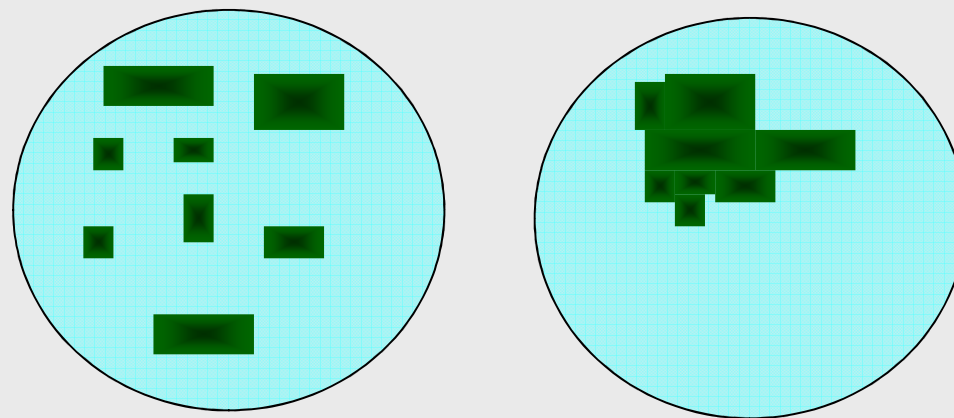
- 1 - Ordovician/Silurian
- 2 - Devonian
- 3 - Permian/Triassic
- 4 - Triassic/Jurassic
- 5 - Cretaceous/Tertiary



Design of protected areas

- Key questions for reserve design:
 - What is better for biota: single large or several small?
 - How important are corridors for wildlife to travel from one reserve to another?

Several small islands lose species faster than one single island of equivalent size (Burkey 1995).



Design of protected areas – Landscape Ecology

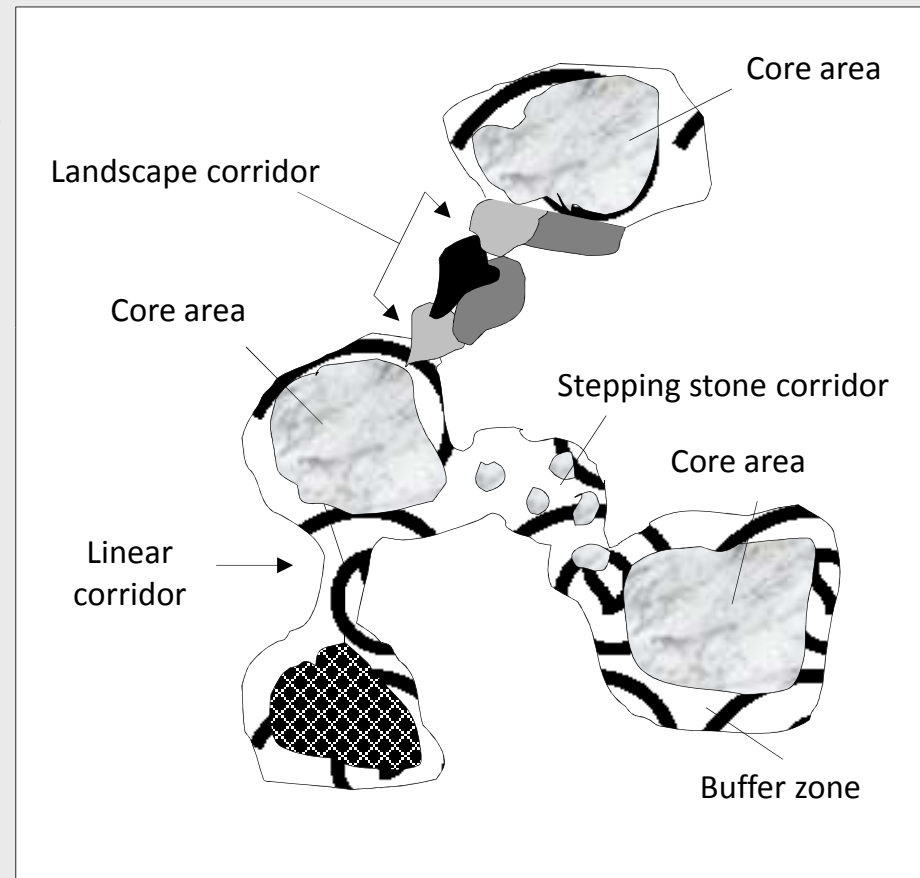
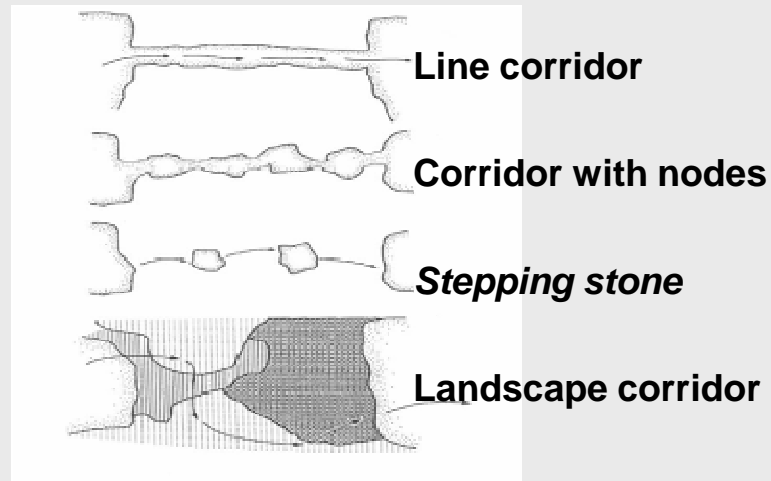
- Before: each area was considered separately.
- Now: Landscape as a set of areas - Landscape Ecology.
- Focus on Habitat Fragmentation: effects of area, edges and degree of isolation on Biodiversity.

Landscape elements:

- Patches
 - size, number, shape
- Edges
 - structure, shape
- Connectivity
 - Corridors, barriers
- Matrix
 - Network, fragmentation, pattern, scale



Design of protected areas



Source: Bennett, 2004

Natura 2000 Network

