Habitat Fragmentation and Edge Effects

Topics:

- **Definition**
- **Root in Island Biogeography**
- **Ecological Consequences**
  - **Case studies:**
    - **East African Forest Fragments**
    - **EDF Birds**

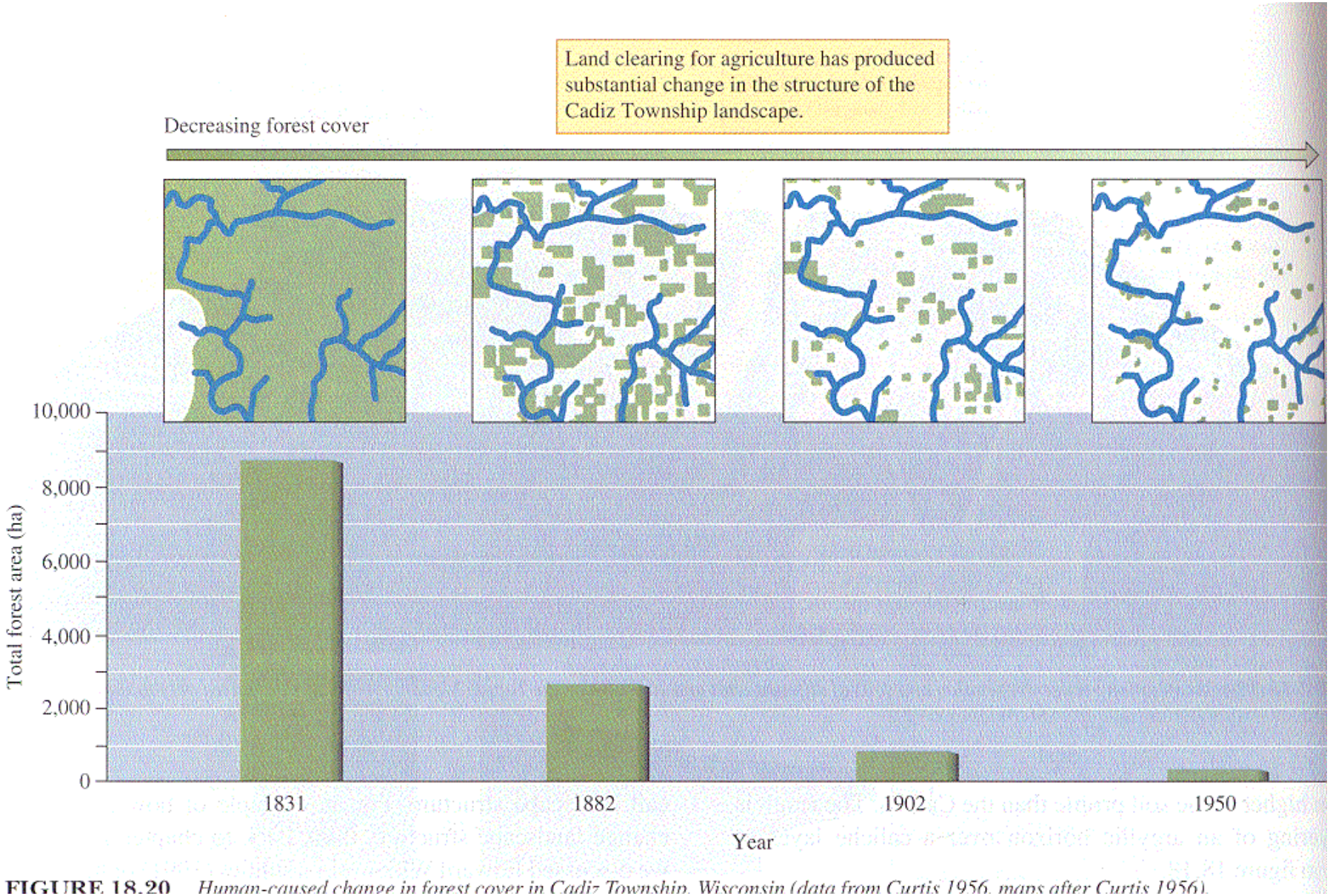
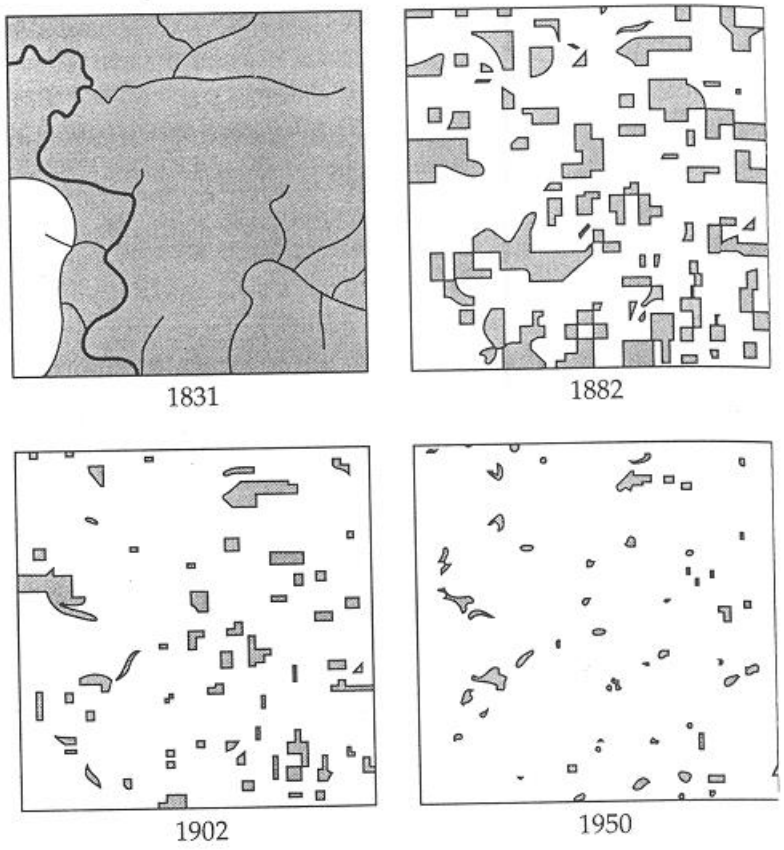


FIGURE 18.20 *Human-caused change in forest cover in Cadiz Township, Wisconsin (data from Curtis 1956, maps after Curtis 1956).*



Cadiz township, WI

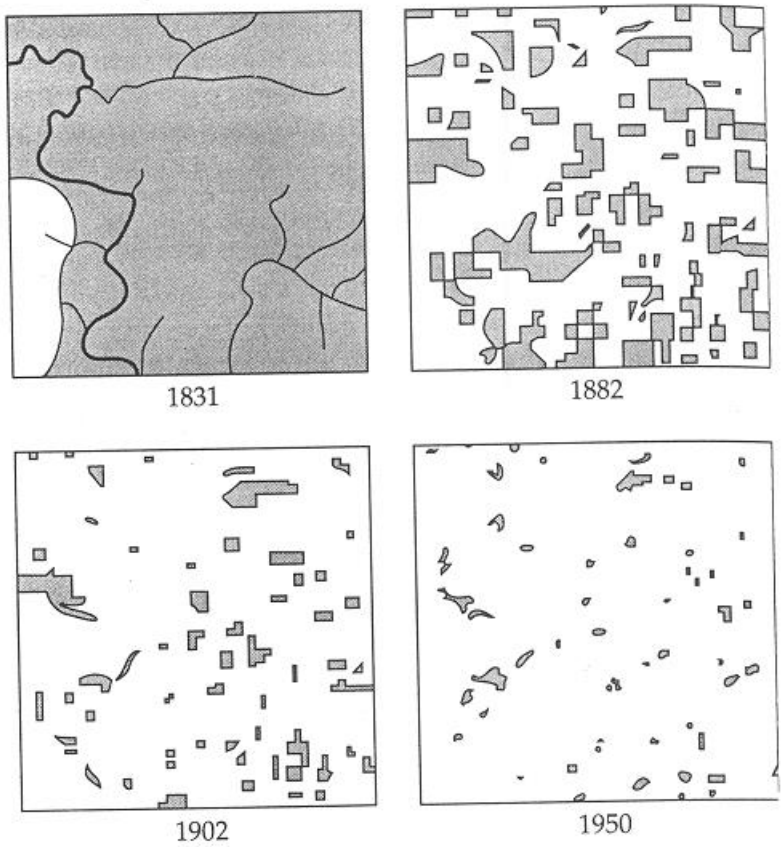
Curtis 1956

Habitat Fragmentation:

Breaking up of habitat into smaller pieces

More Specifically:

- **Reduction in habitat area**
- **Decrease in patch size (increase in edge effects)**
- **Increase in distance among patches (increase in isolation)**



Cadiz township, WI

Curtis 1956

Habitat Fragmentation:

Variations in base model:

- **Rate of recovery of disturbance patches;**
- **Disturbance history/natural vegetation dynamic;**
- **Type of matrix**

MacArthur and Wilson. 1967. A theory of island biogeography. Princeton Press.

Species Area Relationship

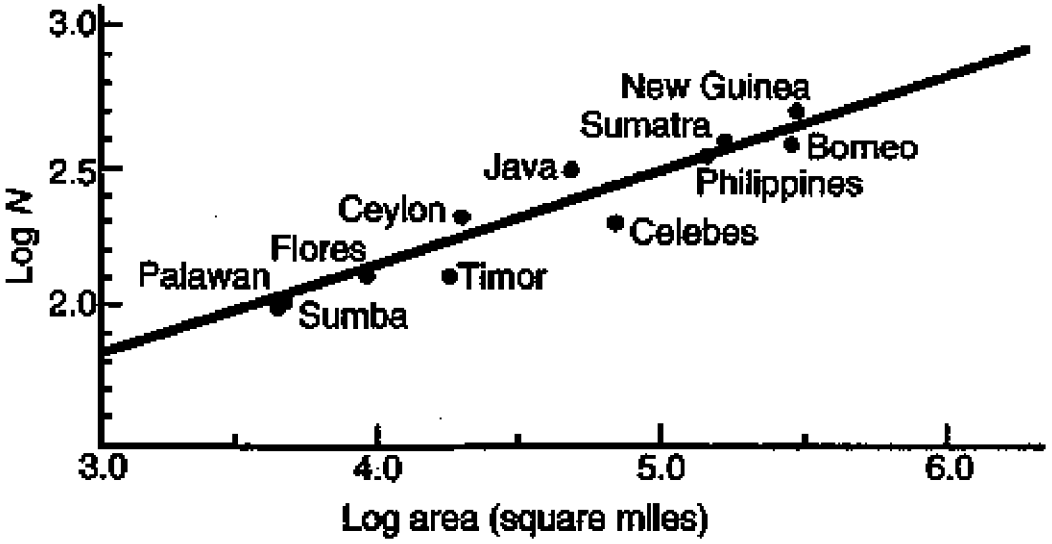
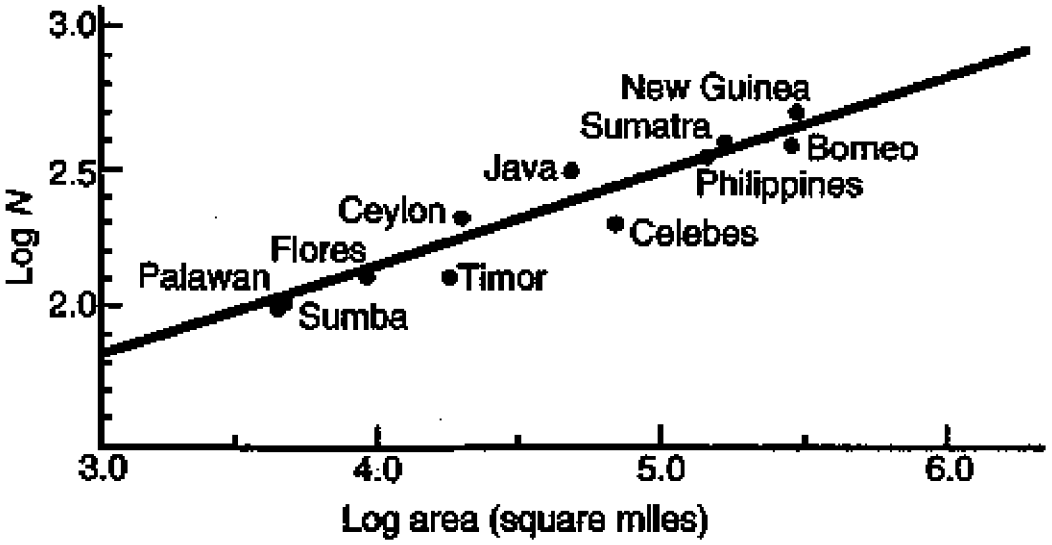


Figure 28.12 Number of bird species on various islands of the East Indies in relation to area. The abscissa gives areas of the islands. The ordinate is the number of bird species breeding on each island. (From Preston 1962:185.)

Species Area Relationship



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$$S=cA^{z}$$

number of species=intercept*area ^{slope}

Smaller islands have fewer species than large islands.

Why?

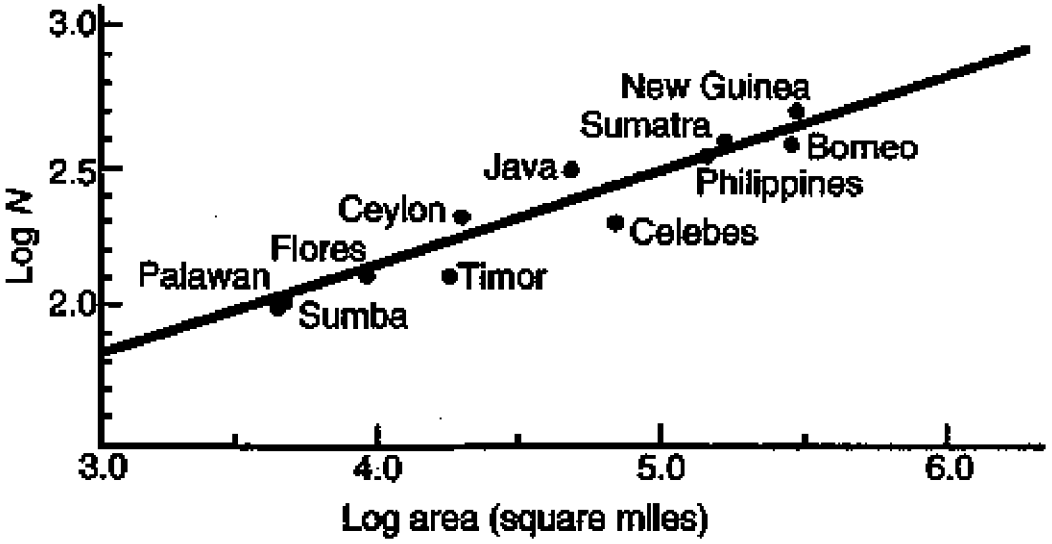

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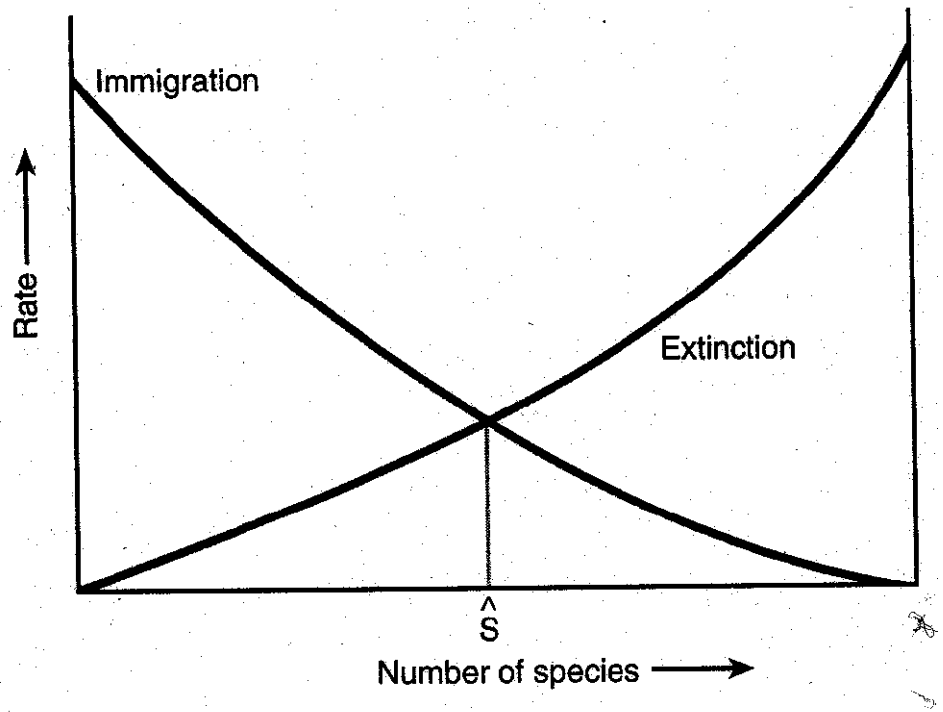
Figure 28.13 Equilibrium model of species on a single island. The point at which the curve for rate of immigration intersects the curve for rate of extinction determines the equilibrium number of species in a given taxon on the island. *S* represents the equilibrium number of species.



MacArthur and Wilson. 1967. Theory of Island Biogeography

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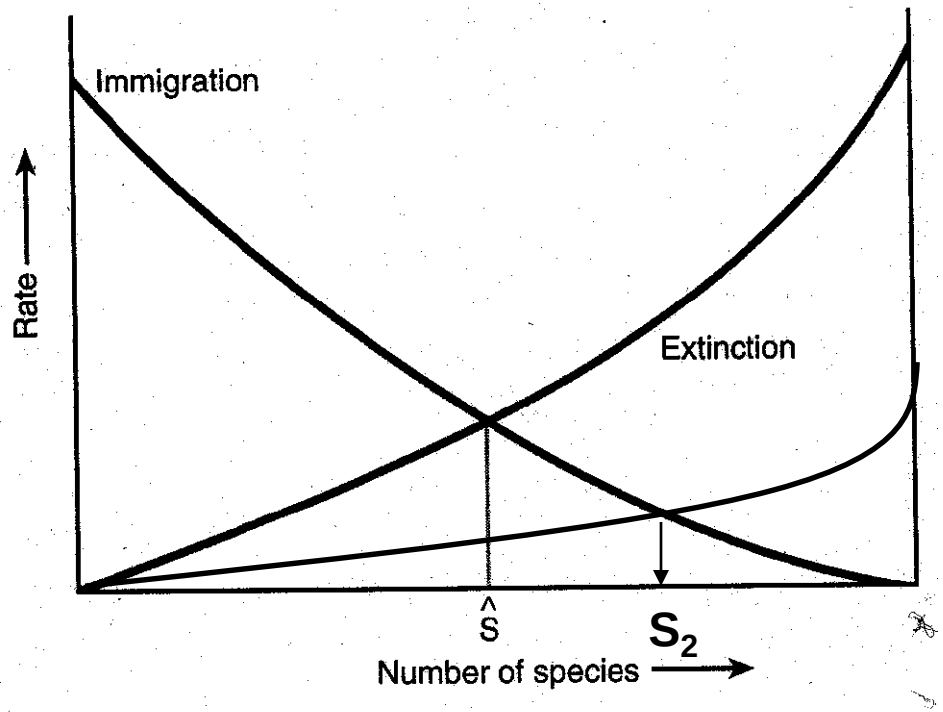


Small island

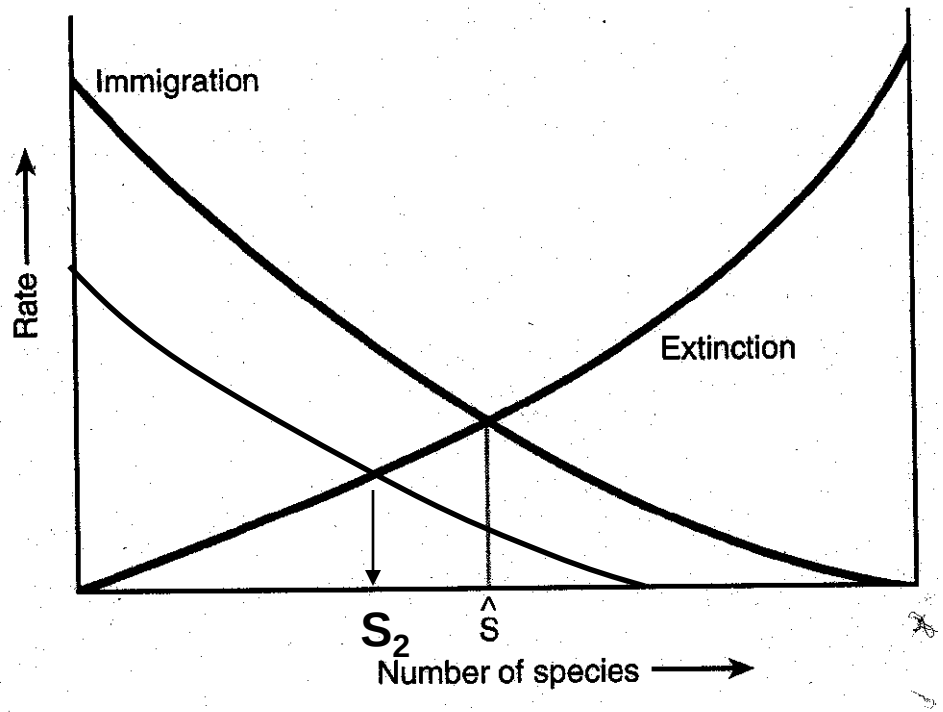
Large island

MacArthur and Wilson. 1967. Theory of Island Biogeography

Figure 28.13 Equilibrium model of species on a single island. The point at which the curve for rate of immigration intersects the curve for rate of extinction determines the equilibrium number of species in a given taxon on the island. *S* represents the equilibrium number of species.

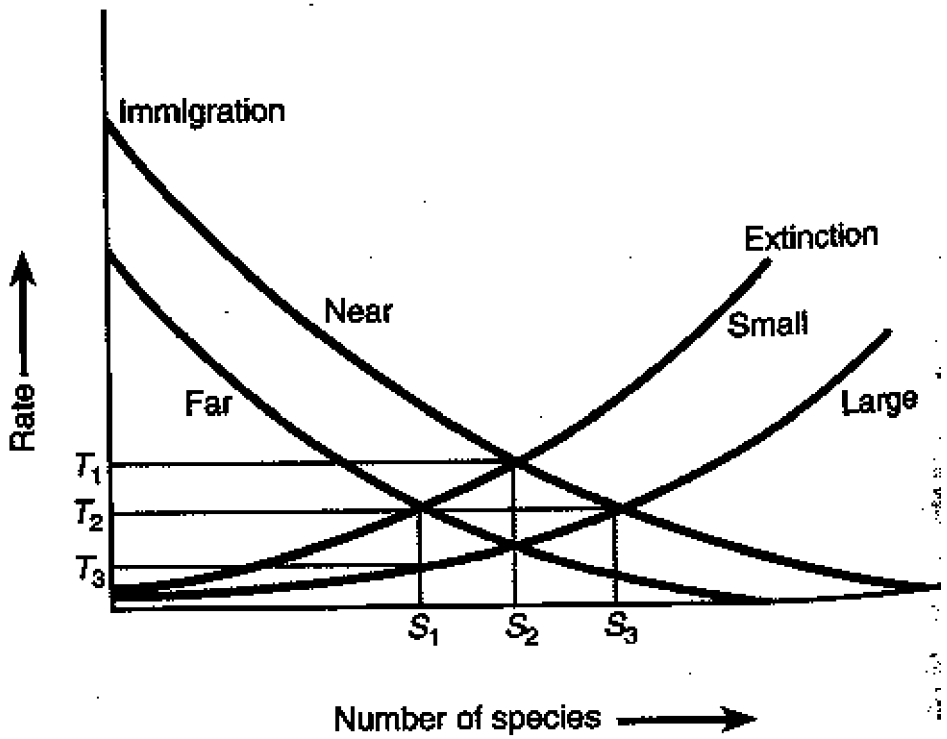
Near island

Far island



MacArthur and Wilson. 1967. Theory of Island Biogeography

Figure 28.14 Graphical representation of the island biogeography theory, involving both distance and area. Immigration rates decrease with increasing distance from a source area. Thus distant islands attain species equilibrium with fewer species than near islands, all else being equal ($S_3 > S_2$ for large islands; $S_2 > S_1$ for small islands). Extinction rates increase as the size of the island becomes smaller.



MacArthur and Wilson. 1967. Theory of Island Biogeography

Implications for Habitat Islands?

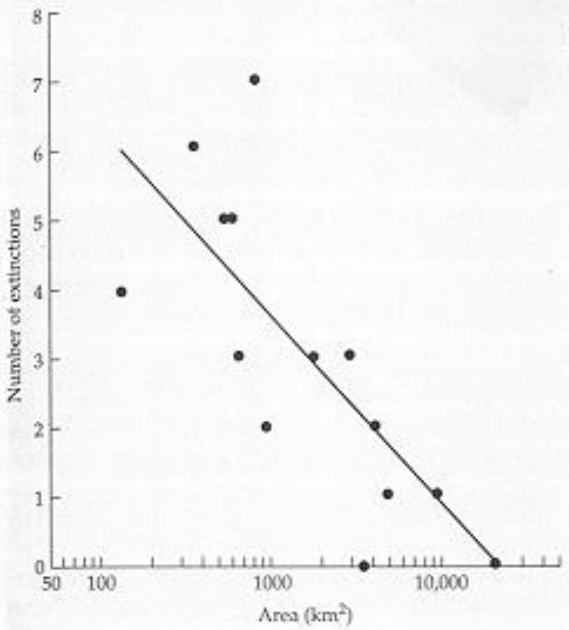


Figure 10.8 Naturally caused extinctions that occurred after reserve establishment as a function of park area in 14 western North American national parks. (From Newmark 1987.)

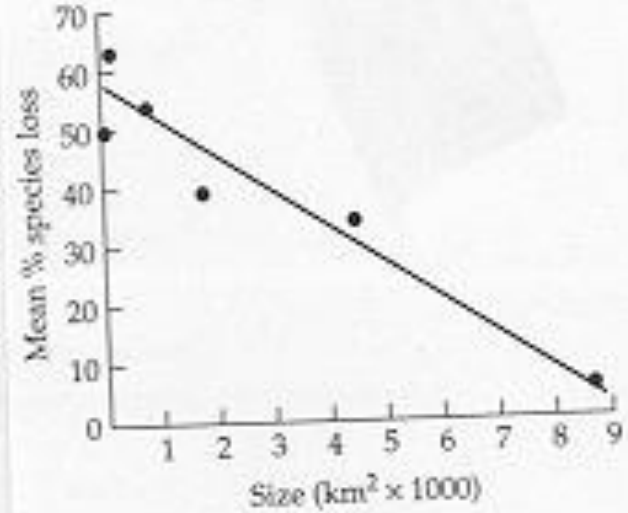


Figure 10.9 Percentage loss of large mammal species since European settlement as a function of area of isolated ranges in the northern Rocky Mountains. (From Harris 1984; data from Picton 1979.)

Habitat as islands?

If habitats in an inhospitible matrix act as islands, then we expect smaller, more isolated habitat patches hold fewer species.

Ecological Consequences of Fragmentation

- Reduction in habitat area
  - reduction in population sizes;
  - decreased habitat heterogeneity.

Ecological Consequences of Fragmentation

•Reduction in habitat area

- reduction in population sizes;

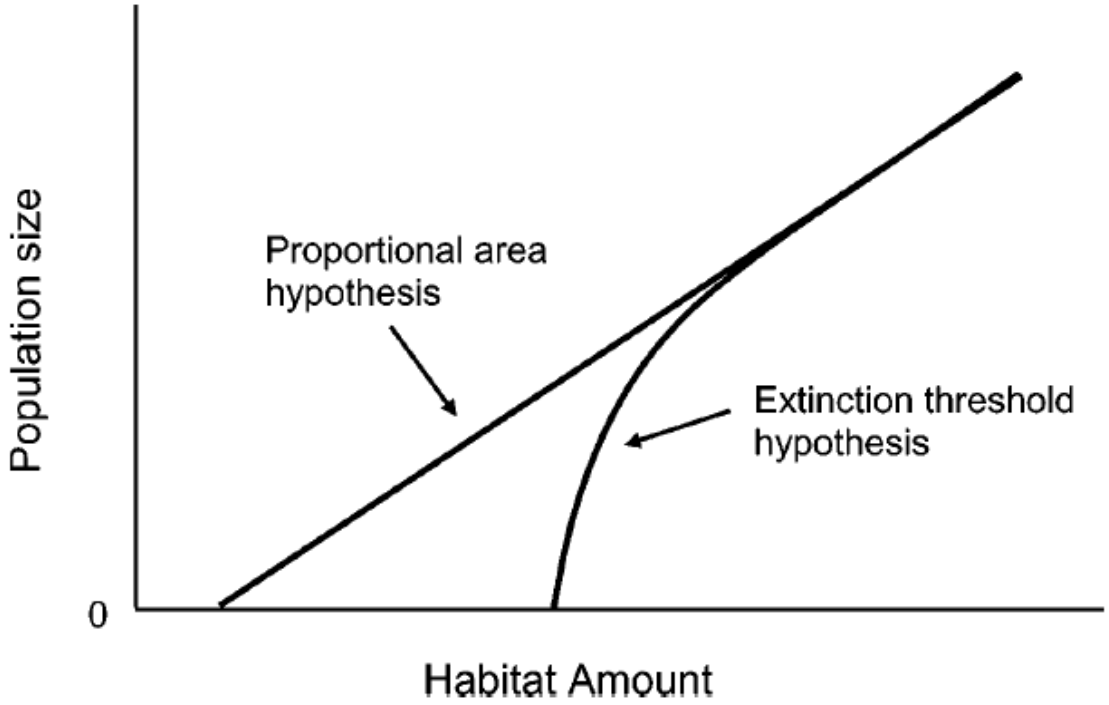


Figure 8 Illustration of the extinction threshold hypothesis in comparison to the proportional area hypothesis.

- **Total resource availability decreases with area of habitat.**
- **Population size is proportional to resource availability.**
- **Small populations are more prone to extinction due to demographic, genetic, and environmental variability.**

Fahrig 2003

Ecological Consequences of Fragmentation

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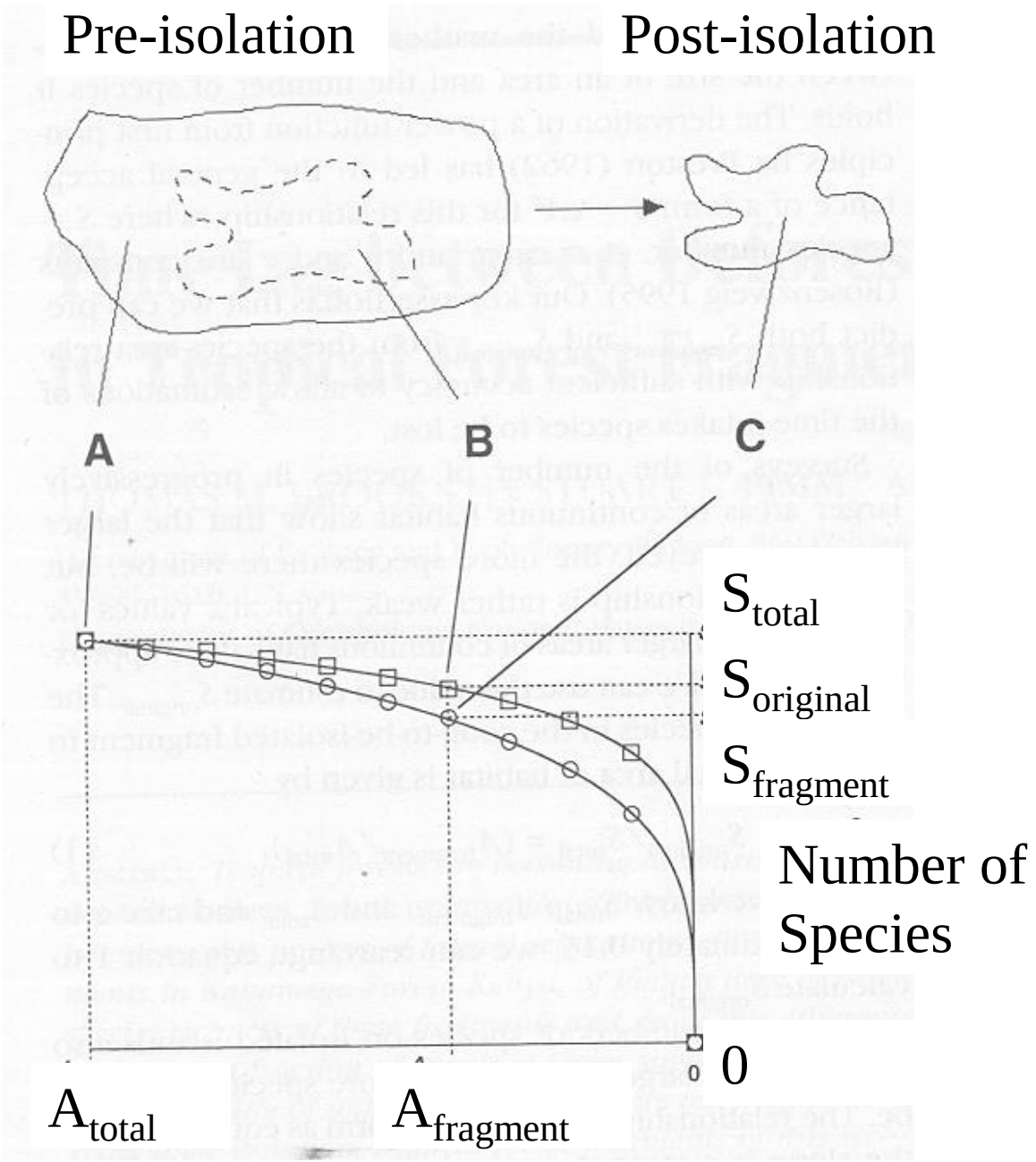


Brooks et al. 1999

Bird Extinctions in Forest Fragments: Kenya (Brooks et al. 1999)

Fragment	$A_{fragment}$	$S_{original}$	S_{now}	$S_{fragment}$	Half-life
Malava	100	32	19	18	23
Kisere	400	39	32	26	55
Ikuywa	1450	48	44	36	38
Yala	1500	48	44	36	42
Kakamega	8600	62	59	56	80

Ecological Consequences of Fragmentation

- Reduction in habitat area - reduction in population sizes; decreased habitat heterogeneity.
- Reduction in Patch Size - Increasing edge effects

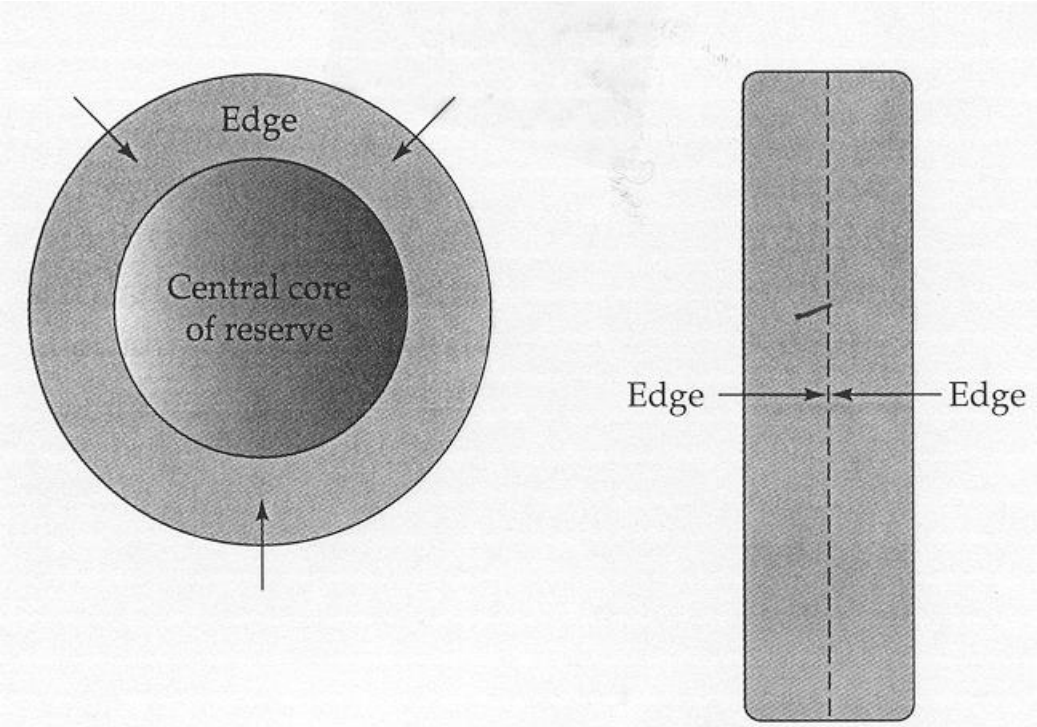
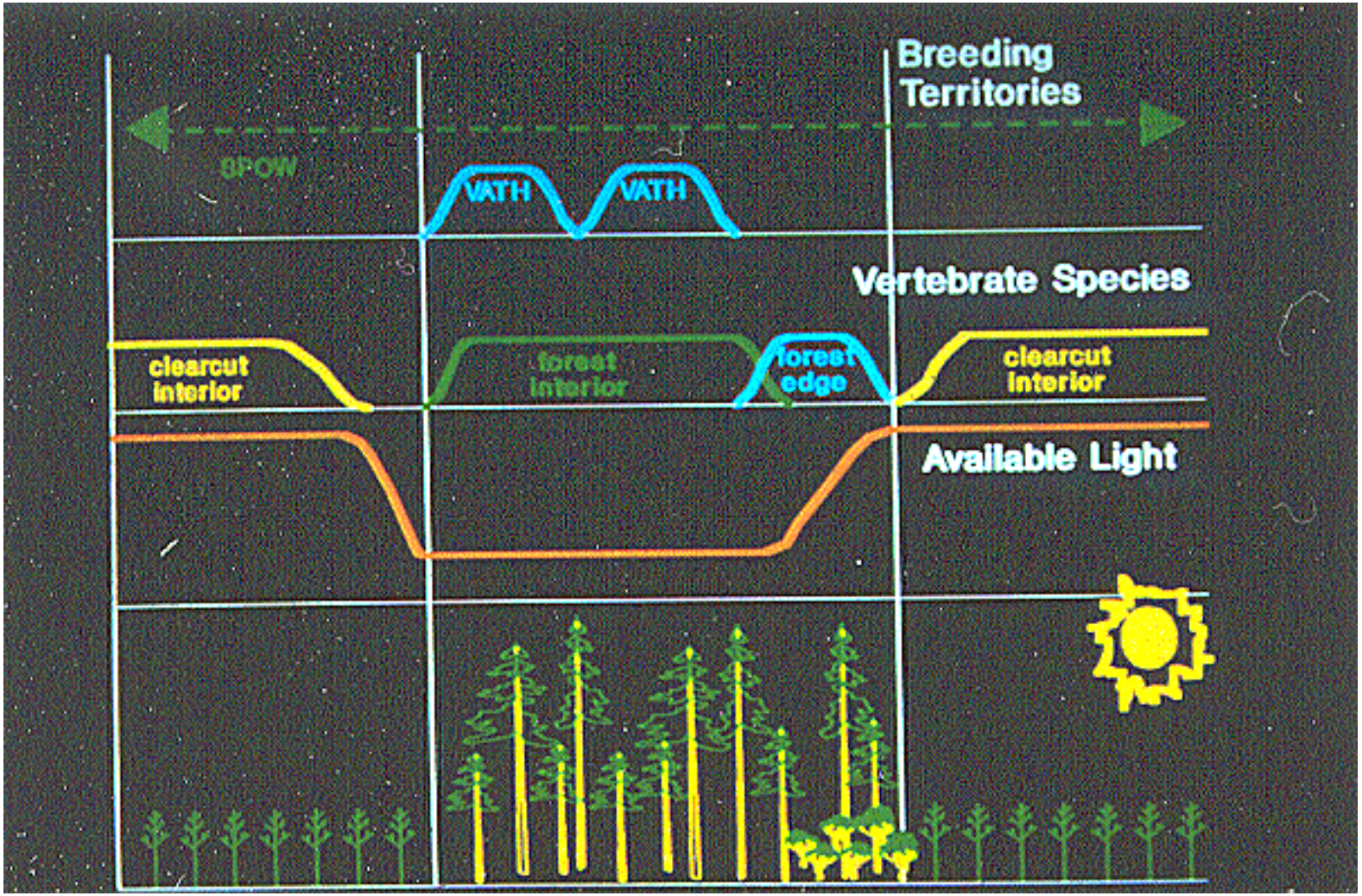
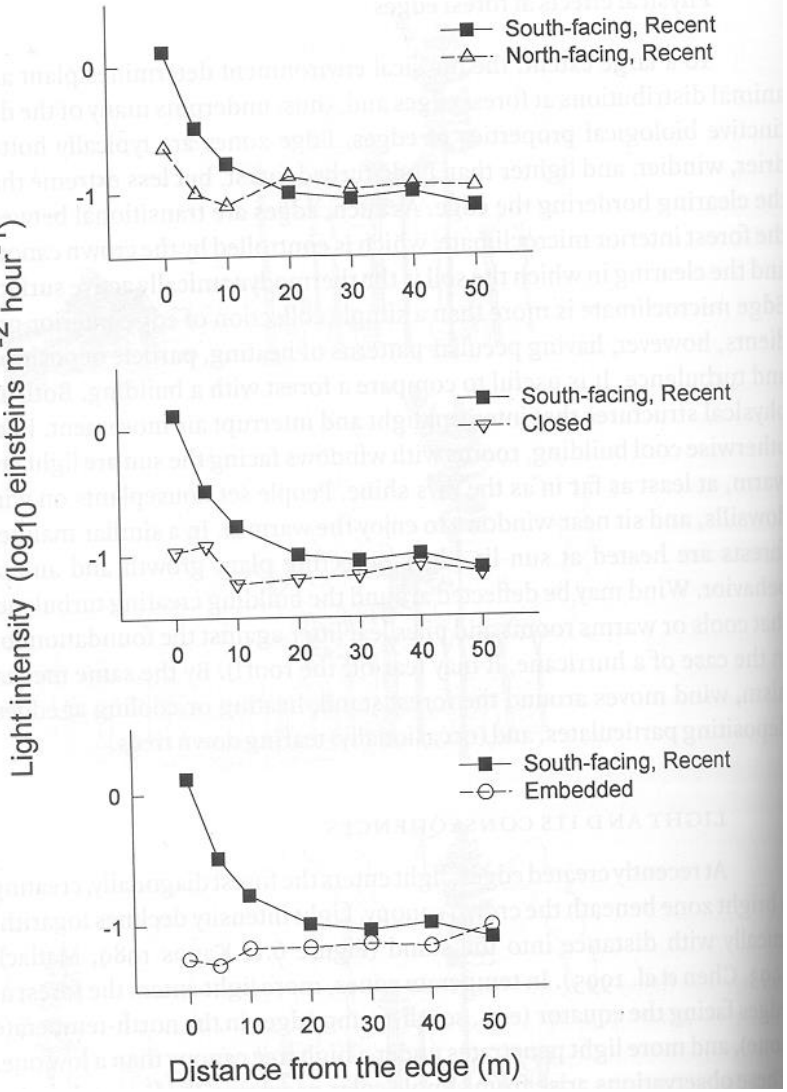
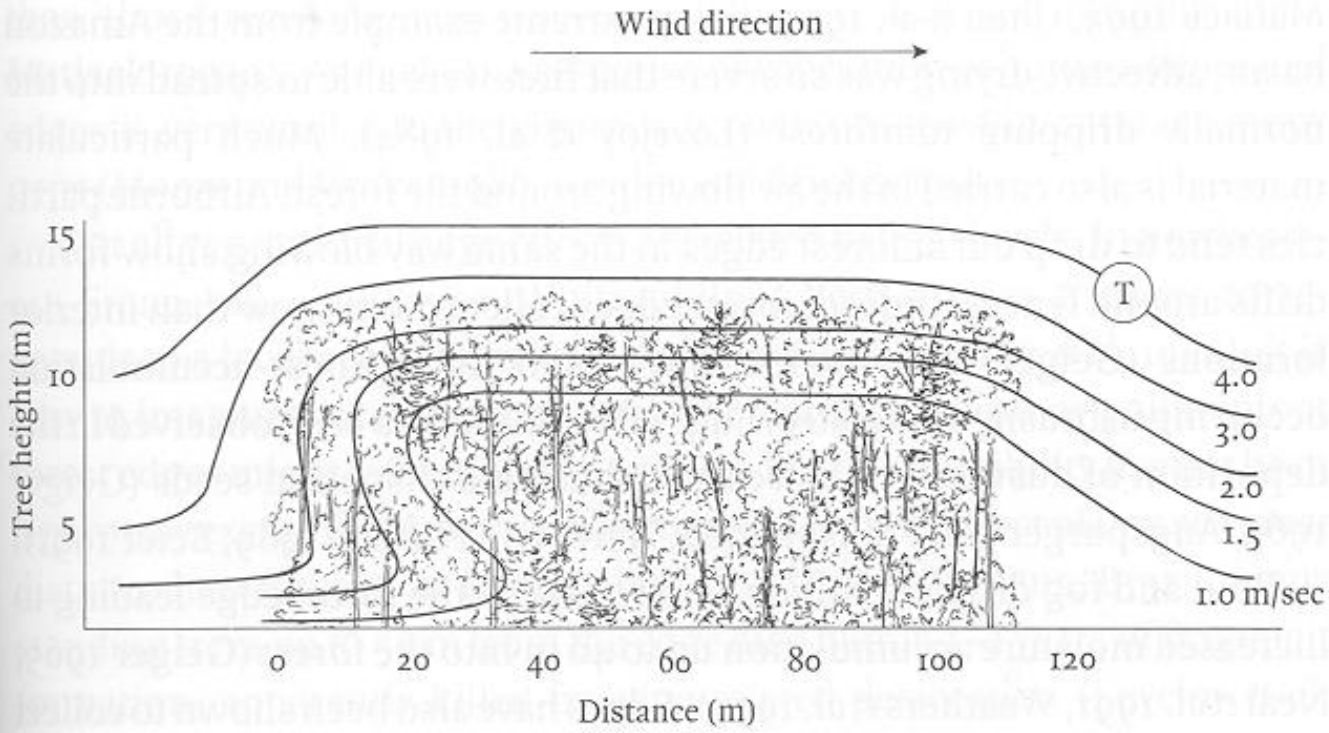


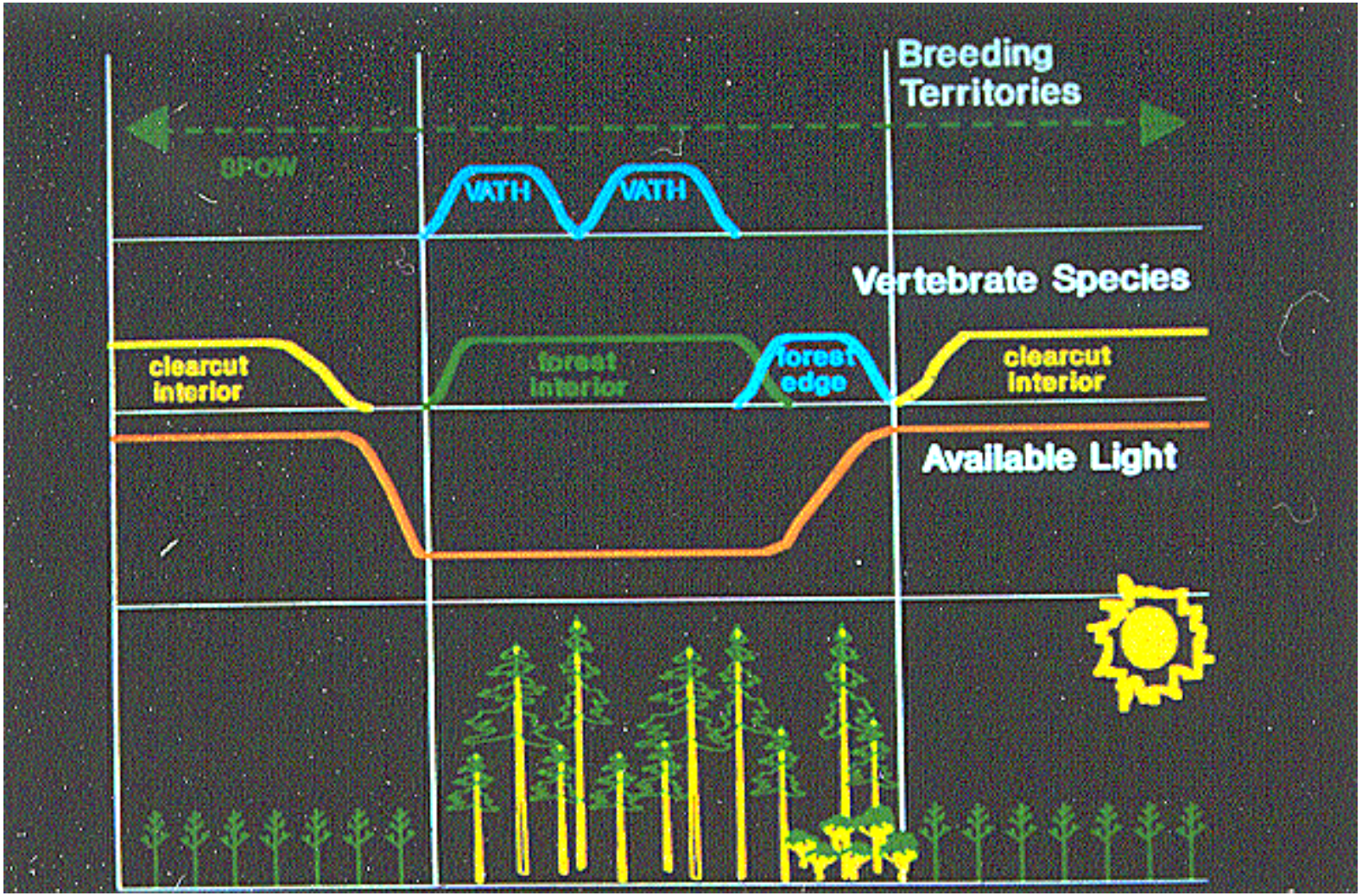
Figure 18.11 The effects of edges on small nature reserves of equal area but different shape. Note that long, thin reserves have a greater proportion of their area as an edge and that circular reserves will have more interior habitat.



Hypotheses about edge effects


South-facing, Recent
North-facing, Recent
South-facing, Recent
Closed
South-facing, Recent
Embedded
Light intensity (log10 einsteins m-2 hour-1)
0
-1
0 10 20 30 40 50
Distance from the edge (m)


Wind direction
15
10
5
Tree height (m)
T
4.0
3.0
2.0
1.5
1.0 m/sec
0
20
40
60
80
100
120
Distance (m)



Hypotheses about edge effects

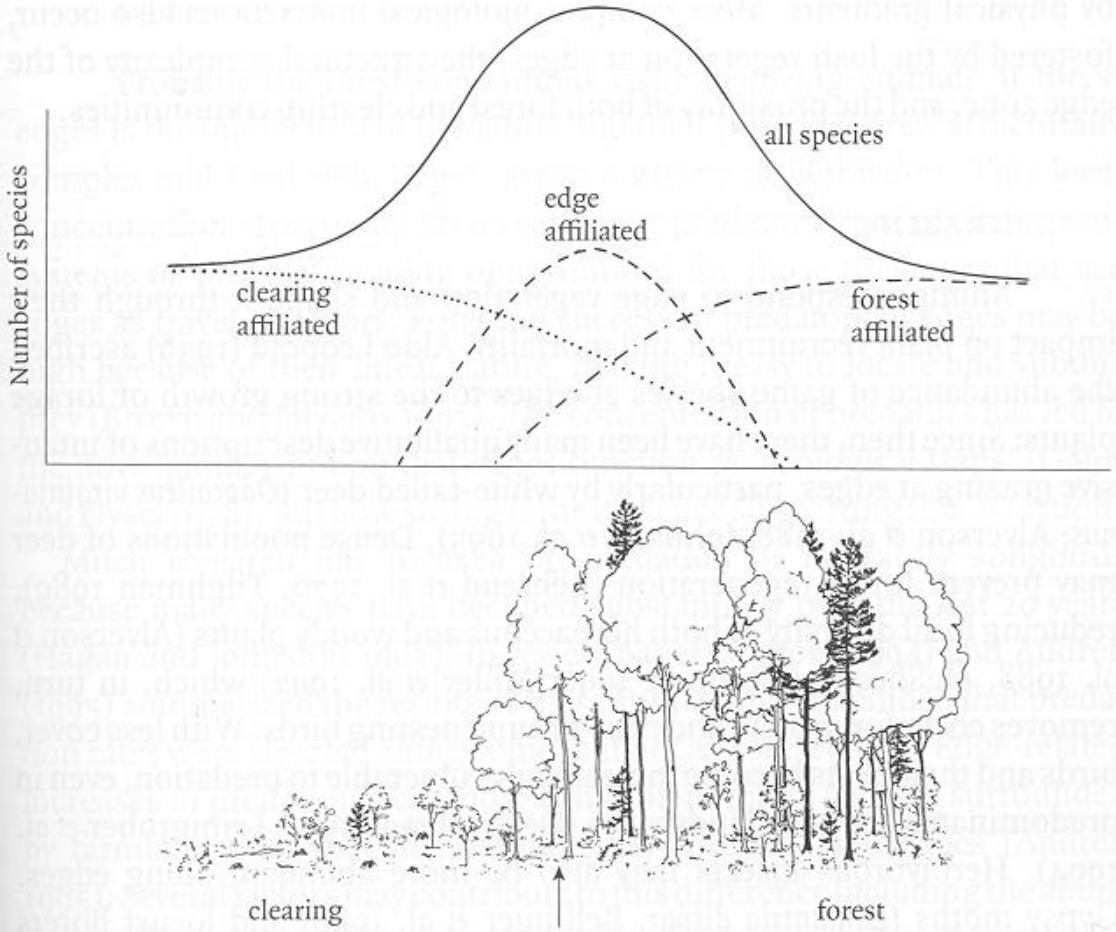
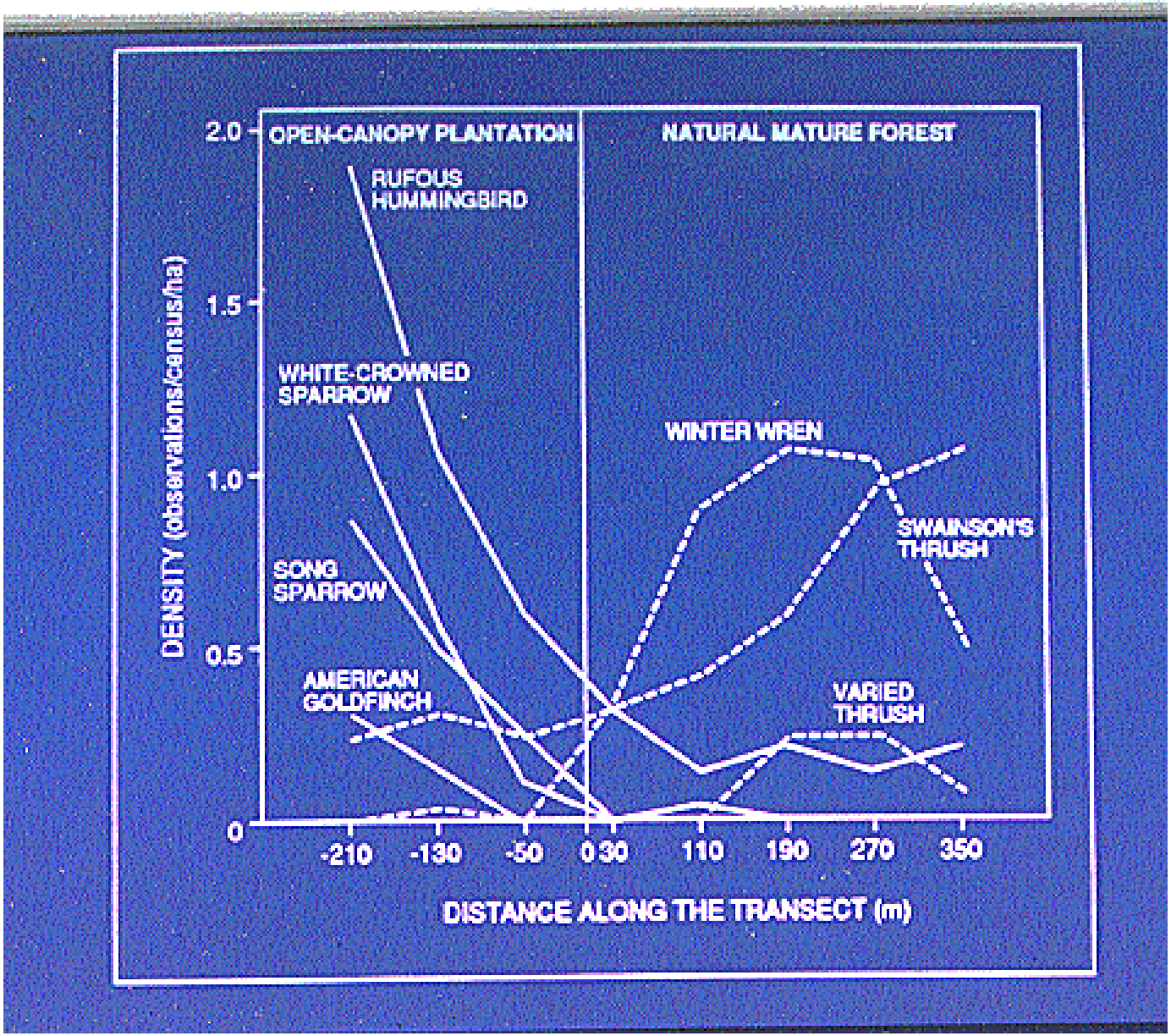


Fig. 6.4. A typical distribution of animal species at a closed forest edge. The arrow indicates the boundary of the gap-forming disturbance.



Bird distributions across clearcut/forest edges

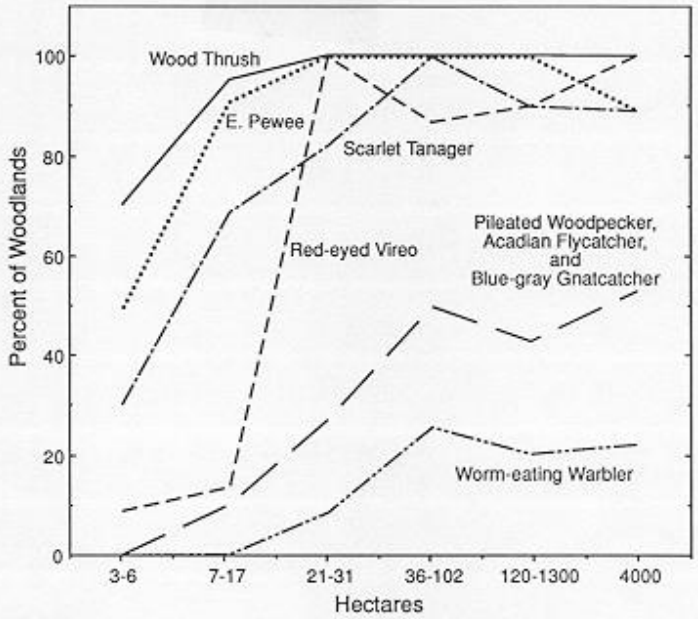


FIG. 5.1 Proportion of woodlots of each size class in which the species indicated were found (Robbins 1980).

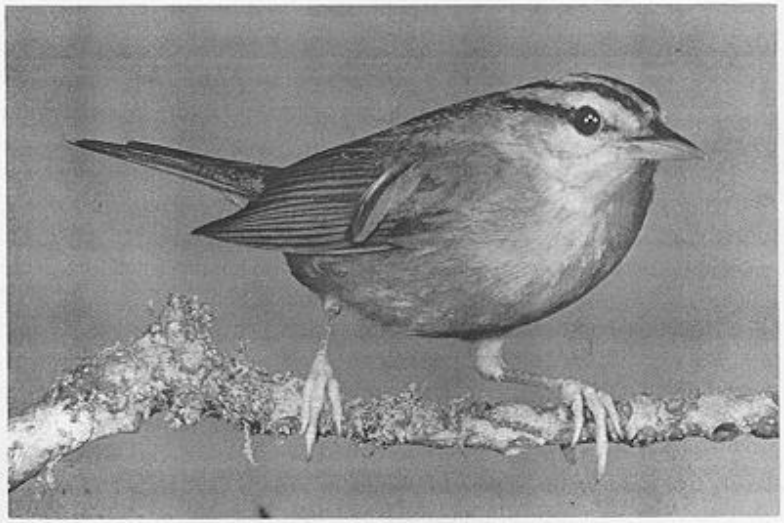


FIG. 5.2 Worm-eating warbler.

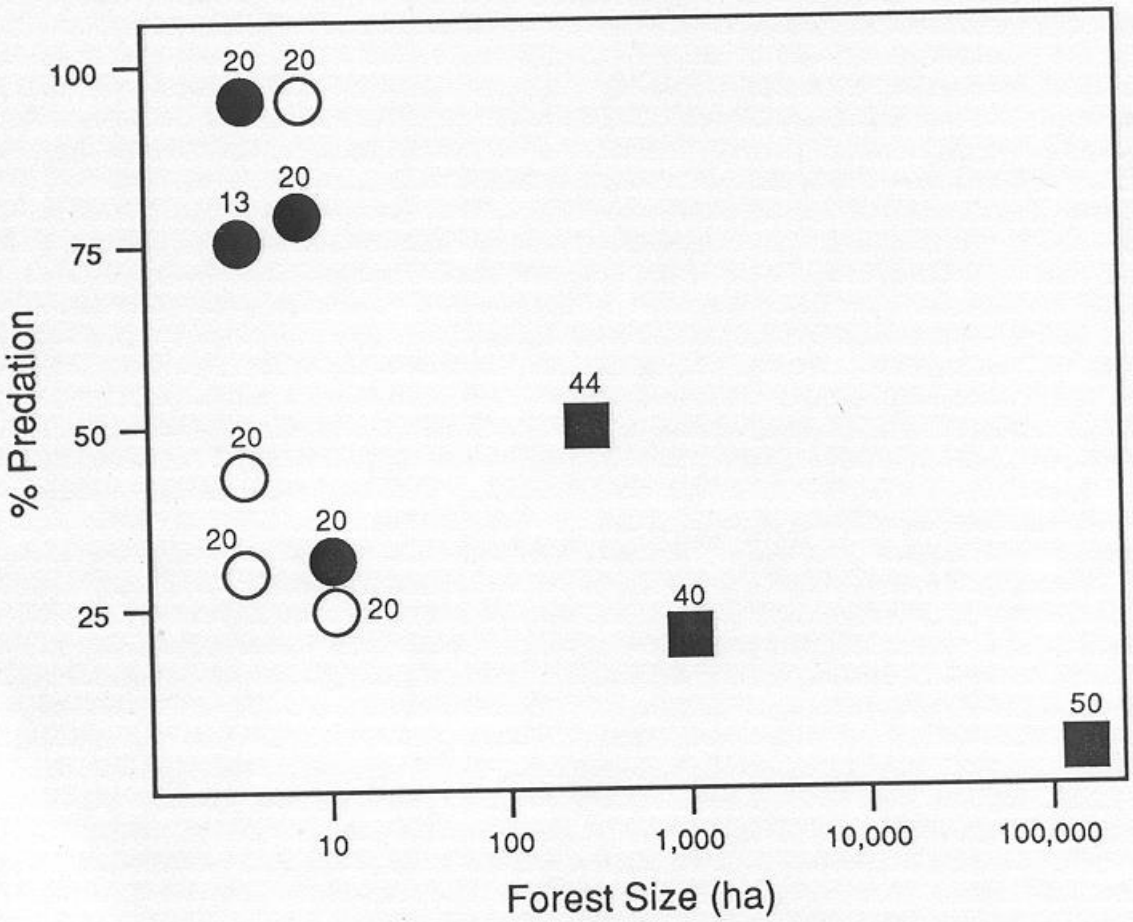


FIG. 5.3 Percentage of nests preyed upon as a function of forest size. Closed squares are large forest tracts, open circles are rural fragments, and closed circles are suburban fragments. The number above each point is the number of artificial nests placed in that forest (Wilcove 1985b).

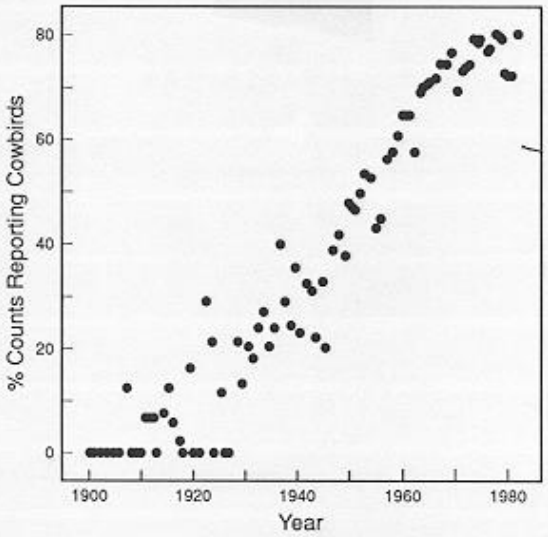
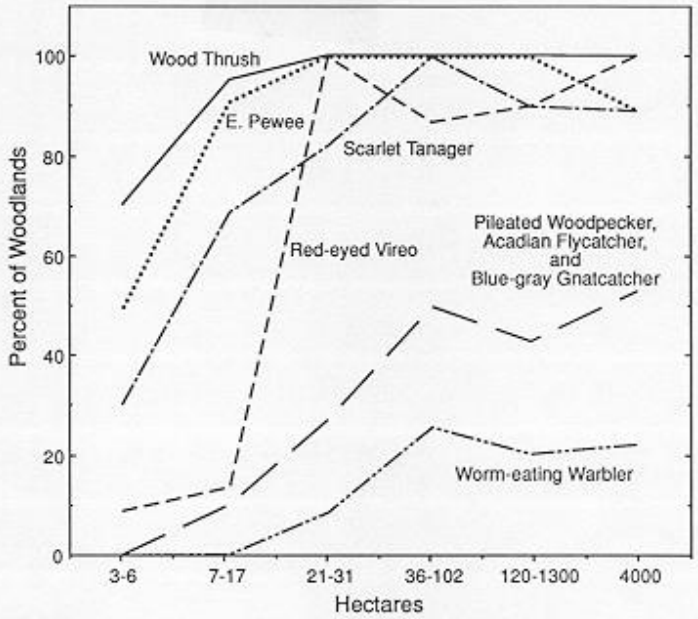


FIG. 5.5 An index to cowbird abundance from 1900 to 1980 taken from Audubon Christmas bird count records (Brittingham and Temple 1983).

FIG. 5.6 Brown-headed cowbird



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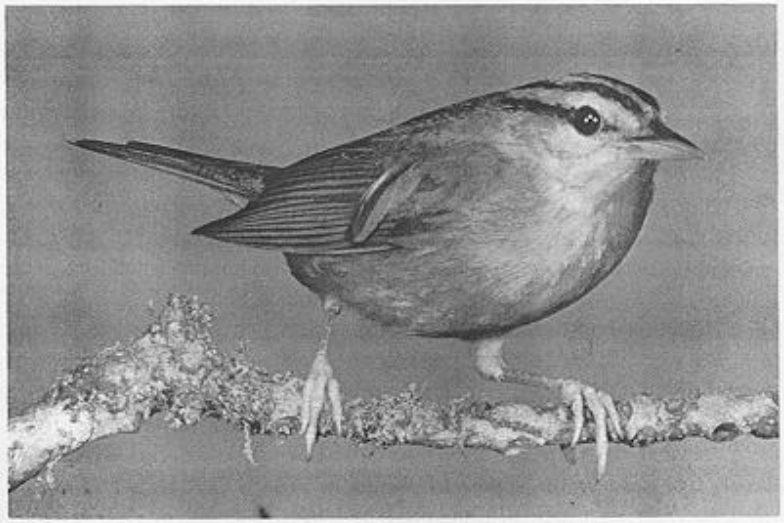


FIG. 5.2 Worm-eating warbler.

Ecological Consequences of Fragmentation

- Reduction in habitat area - reduction in population sizes; decreased habitat heterogeneity.
- Reduction in Patch Size - Increasing edge effects
- Patch Isolation - Less exchange of organisms

Discussion

Based on Farhig 2003:

To what extent do we expect correlations between measures of landscape composition, patch size, patch isolation?

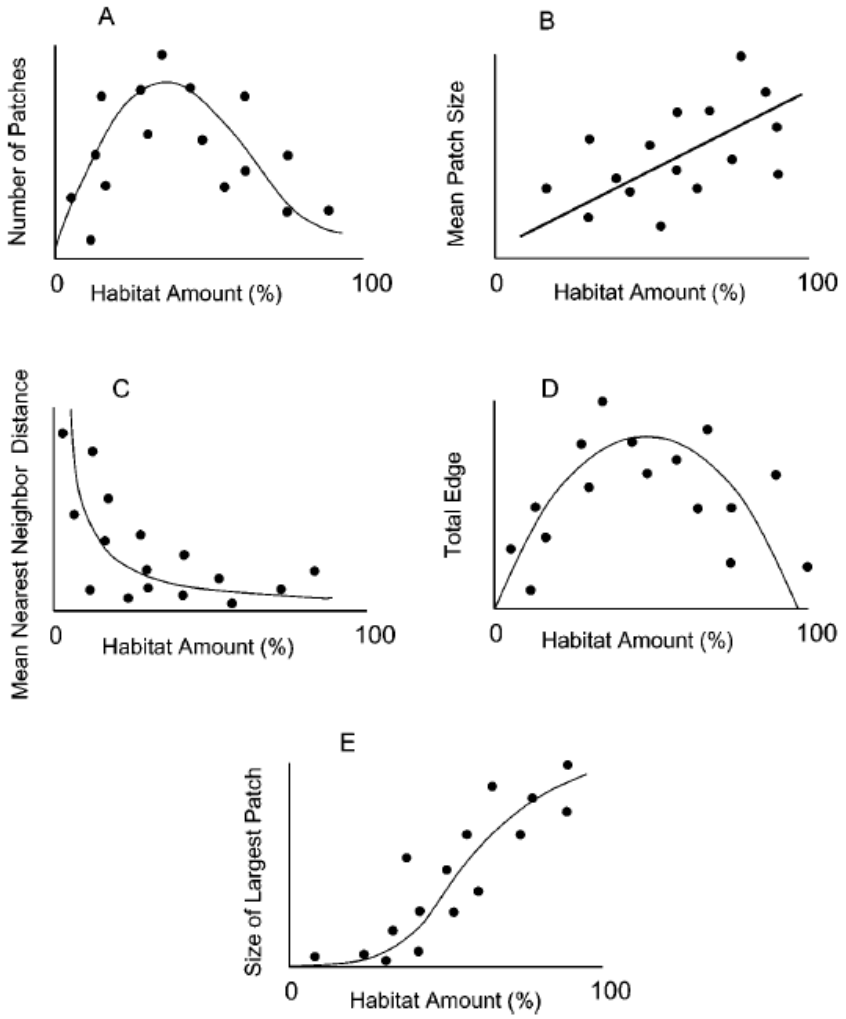


Figure 3 Illustration of the typical relationships between habitat amount and various measures of fragmentation. Individual data points correspond to individual landscapes. Based on relationships in Bélisle et al. (2001), Boulinier et al. (2001), Drolet et al. (1999), Gustafson (1998), Haines-Young & Chopping (1996), Hargis et al. (1998), Robinson et al. (1995), Schumaker (1996), Trzcinski et al. (1999), and Wickham et al. (1999).

Discussion

Based on Farhig 2003:

What are the relative roles of change in landscape composition and landscape spatial configuration in determining the effects of fragmentation?

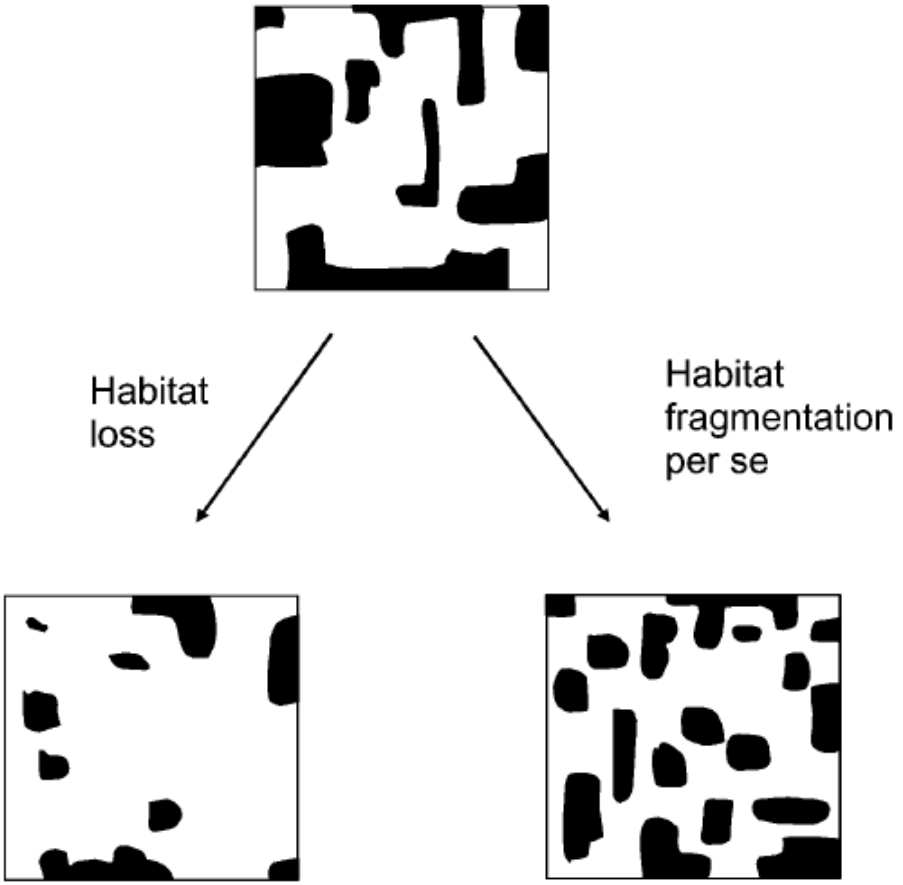
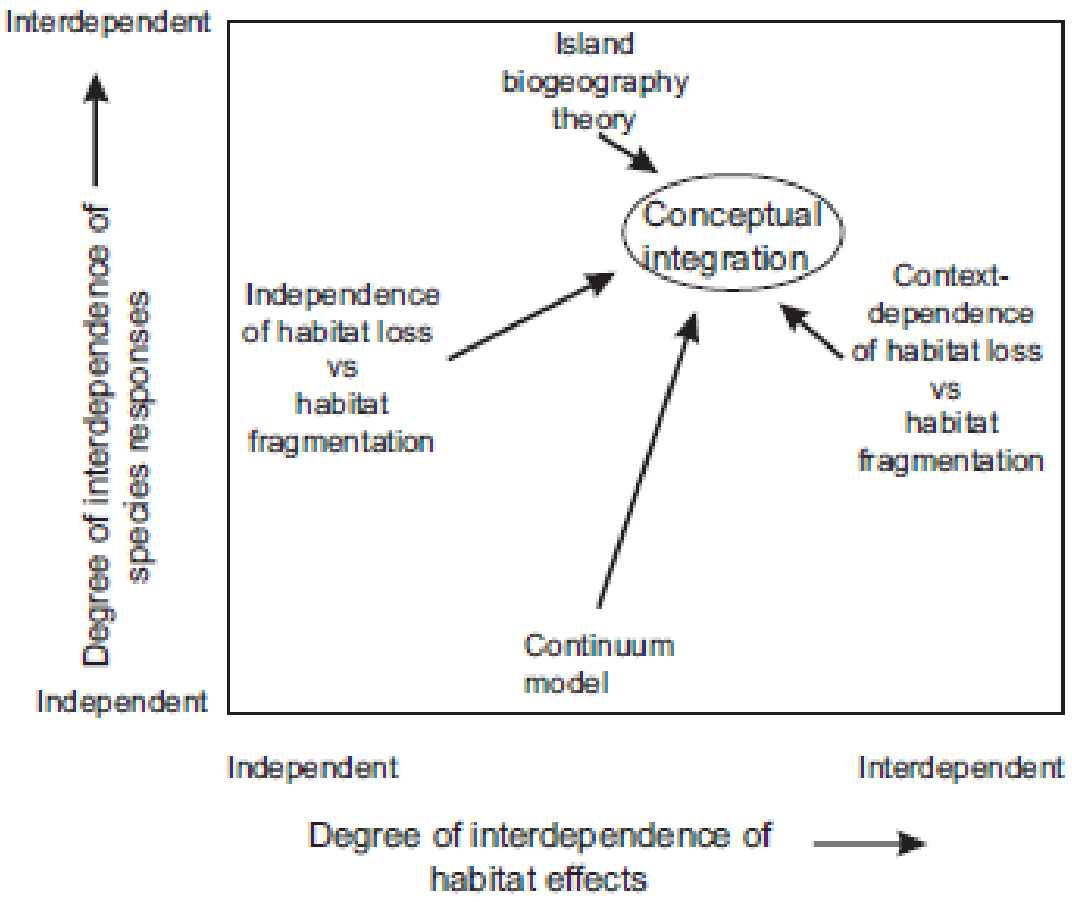


Figure 5 Both habitat loss and habitat fragmentation per se (independent of habitat loss) result in smaller patches. Therefore, patch size itself is ambiguous as a measure of either habitat amount or habitat fragmentation per se. Note also that habitat fragmentation per se leads to reduced patch isolation.

Discussion

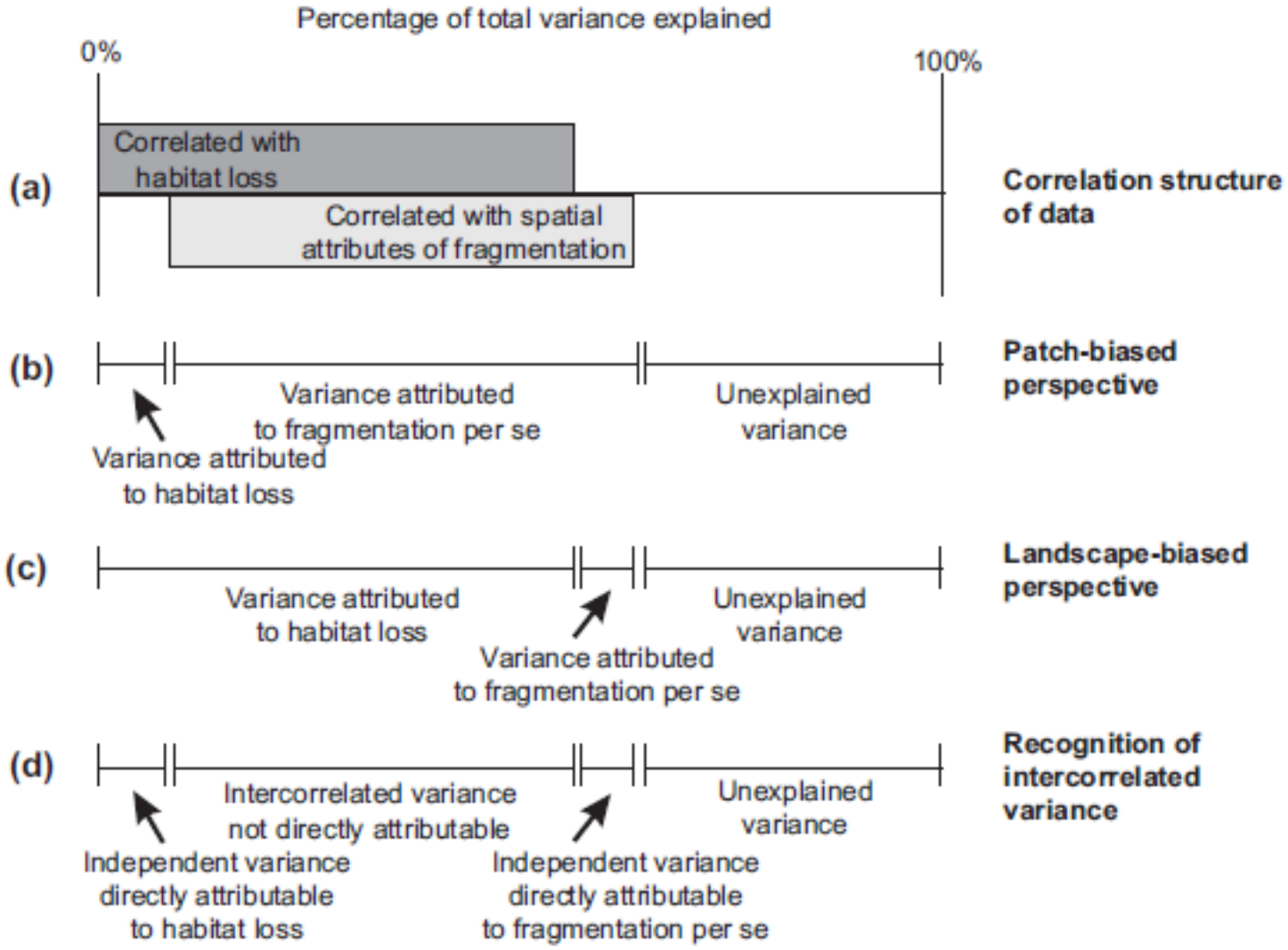
Based on Didham et al. 2012:

What is the range of current thought about the independence of elements of landscape fragmentation and of species responses in the concept of habitat fragmentation?



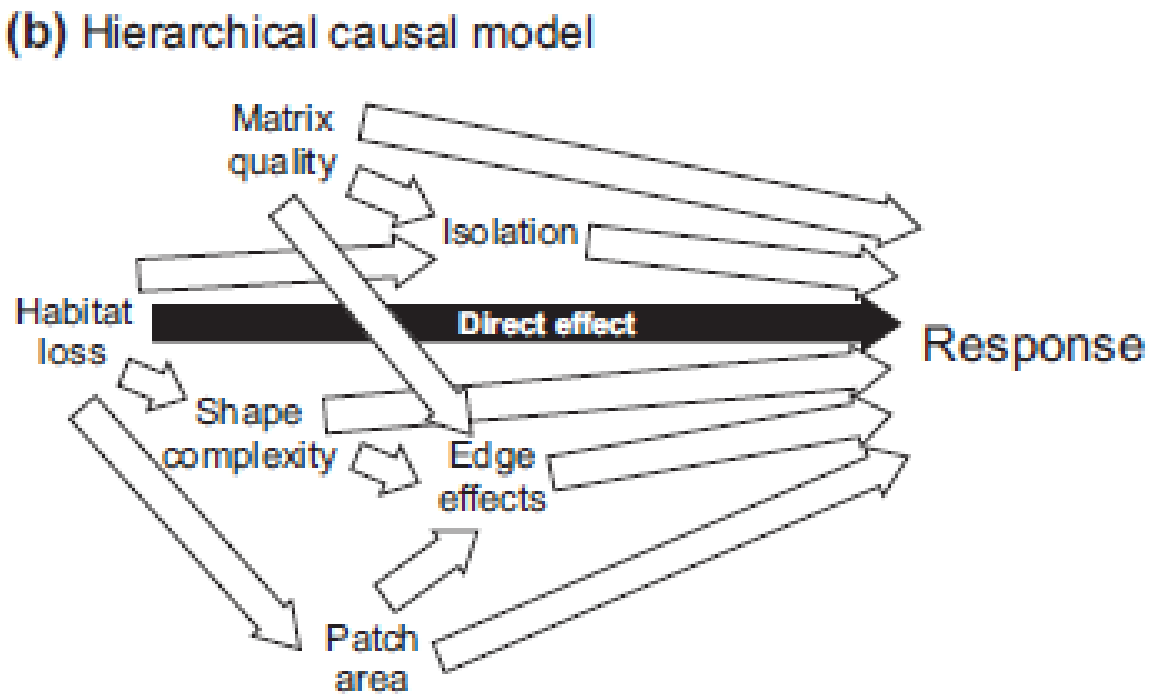
Discussion

Based on Didham et al. 2012:
They assume the effects of habitat area and habitat configuration on biodiversity are correlated. What are the implications for interpreting the results of past studies?



Discussion

Based on Didham et al. 2012:
“habitat loss acts via the change in habitat arrangement, not independently of it.”
Defend or refute.



Discussion

Based on Gibson et al. 2013:

Does habitat loss or spatial configuration drive the results of this study?

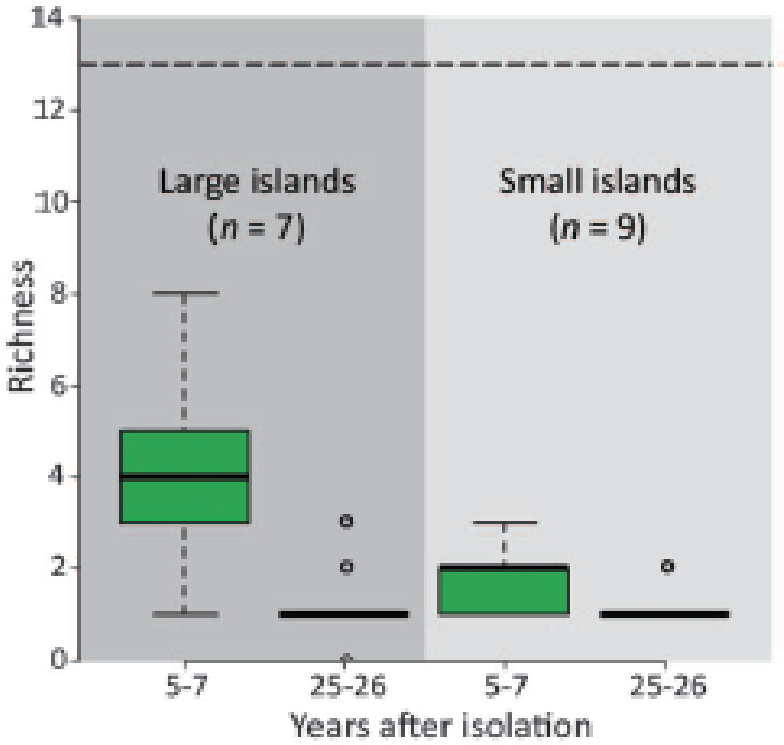


Fig. 2. Small mammal species richness per transect in large (10.1 to 56.3 ha, *n* = 7) and small (0.3 to 4.7 ha, *n* = 9) islands 5 to 7 years and 25 to 26 years after isolation. Plotted are median values, interquartile ranges, and full ranges (outliers are plotted as open circles). The upper dashed line represents the number of small mammal species found in surrounding mainland forest (table S3).

Discussion

Based on Gibson et al. 2013:

What are possible mechanisms for loss of mammal species in fragmented habitats?