Mar 19 Vegetation Structure: Controls, Patterns, Consequences

Landscape Patterns

Human Land Use Effects

Topics

Stand Level

- **Description of vegetation structure**
- **Drivers**
- **Consequences**

Landscape Level

- **Habitat fragmentation defined**
- **Basis in island biogeography**
- **Ecological consequences**

Next Week: Variation among biomes

- **Stand level forest structure and consequences for biodiversity**
- **Forest fragmentation effects**

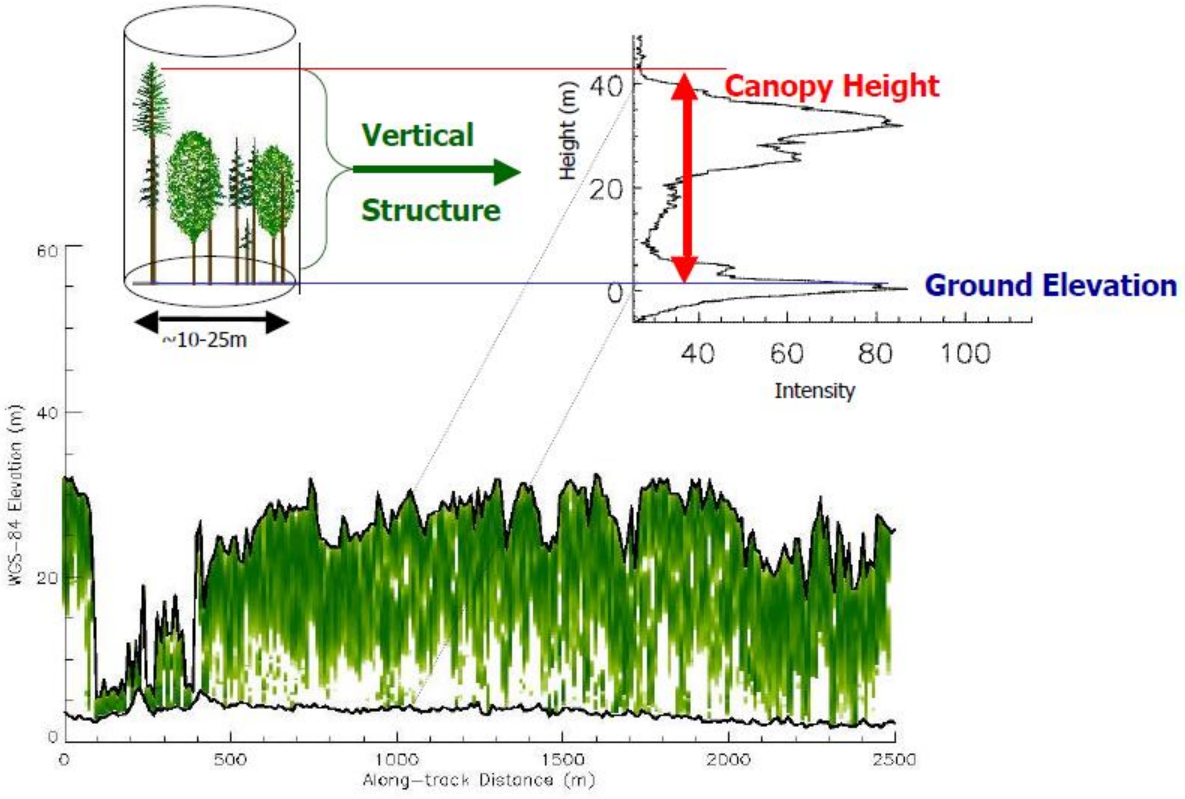
Stand-Level Vegetation Structure

Vegetation Structure – Distribution of vegetation biomass horizontally and vertically.

Stand-Level Vegetation Structure

Vegetation Structure – Distribution of vegetation biomass horizontally and vertically.

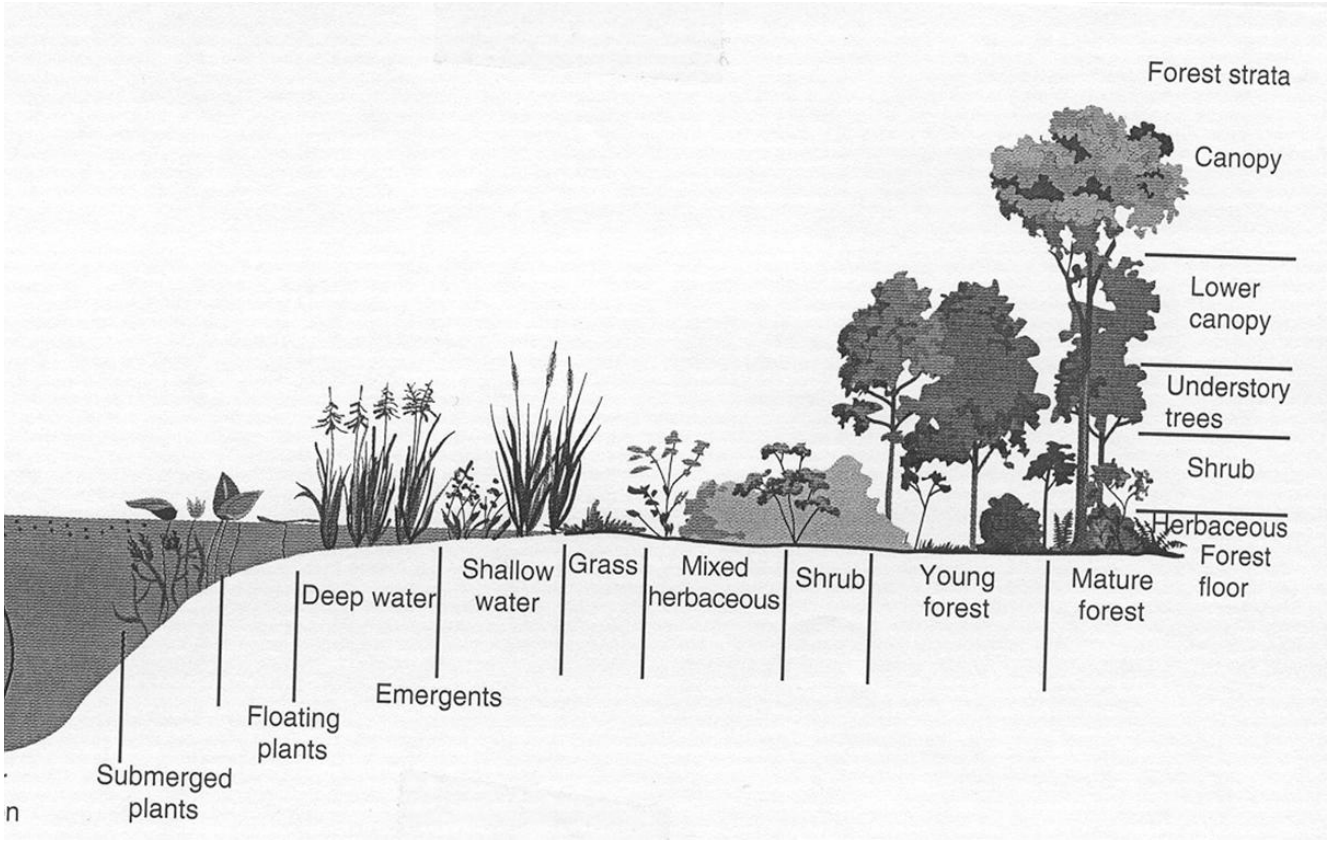
Canopy Cover – Percent cover of by height class or vegetation strata (canopy, subcanopy, shrub layer, understory)



Stand-Level Vegetation Structure

Vegetation Structure – Distribution of vegetation biomass horizontally and vertically.

Canopy Cover – Percent cover of by height class or vegetation strata (canopy, subcanopy, shrub layer, understory)



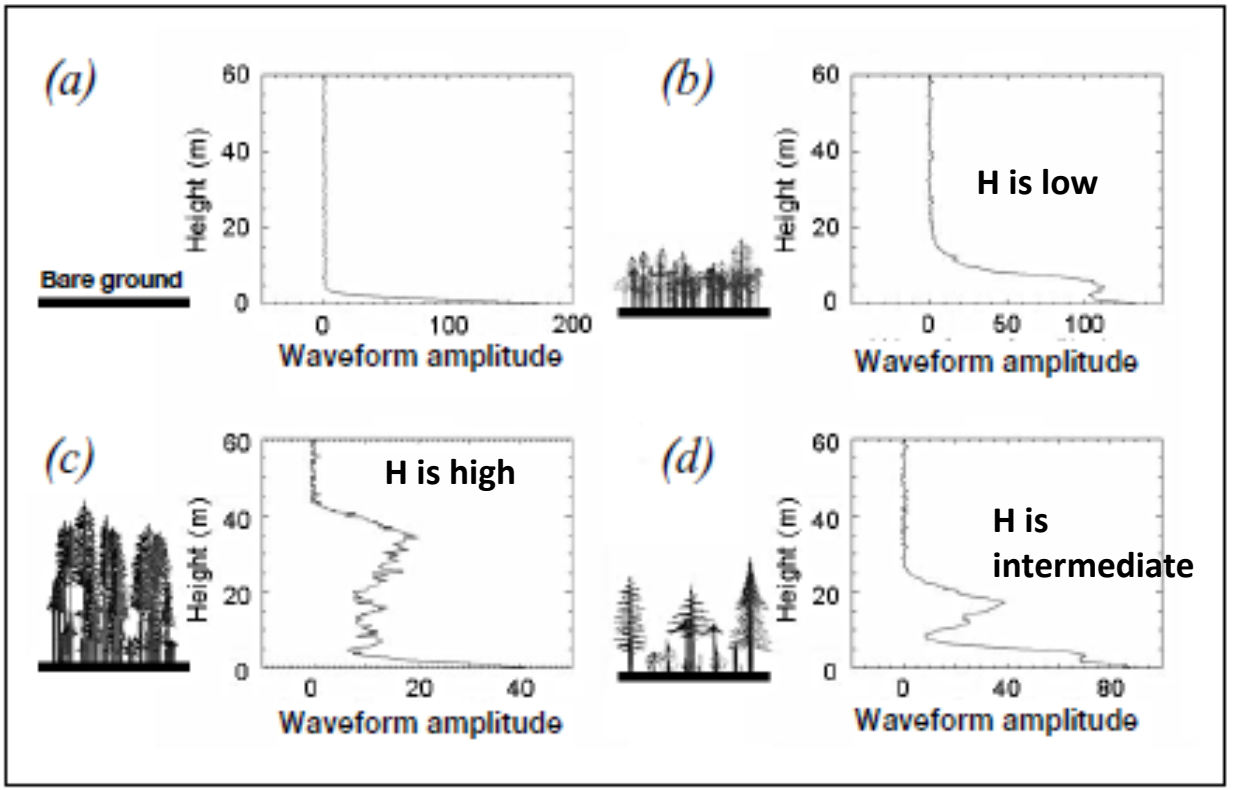
Stand-Level Vegetation Structure

Vegetation Structure – Distribution of vegetation biomass horizontally and vertically.

Canopy Cover – Percent cover of vegetation strata (canopy, subcanopy, shrub layer, understory, or by height class

Foliage height diversity – Distribution of canopy cover among forest strata expressed as a diversity index.

$$H = -\sum_{i=1}^{S} p_i \ln p_i$$



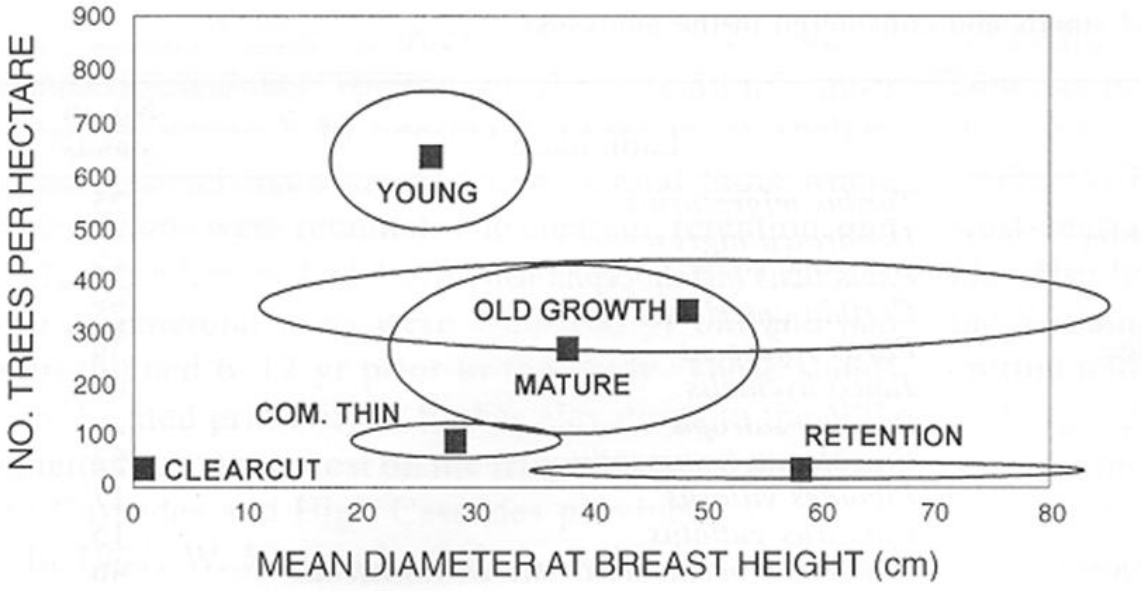
Stand-Level Vegetation Structure

Vegetation Structure – Distribution of vegetation biomass horizontally and vertically.

Canopy Cover – Percent cover of vegetation strata (canopy, subcanopy, shrub layer, understory, or by height class

Foliage height diversity – Distribution of canopy cover among forest strata.

Stem density by size class



Stand-Level Vegetation Structure

Vegetation Structure – Distribution of vegetation biomass horizontally and vertically.

Canopy Cover – Percent cover of vegetation strata (canopy, subcanopy, shrub layer, understory, or by height class

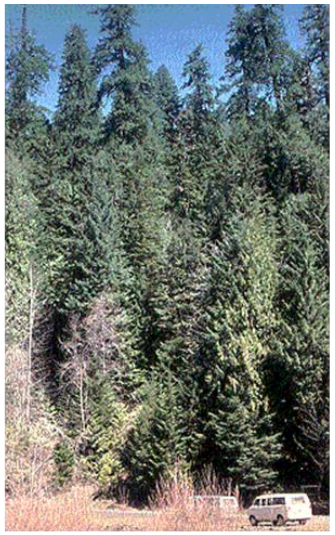
Foliage height diversity – Distribution of canopy cover among forest strata.

Stem density by size class

Snag and coarse woody debris density by size class and decomposition class.

Stand-Level Vegetation Structure - Drivers

Seral Stage



Old growth

Mature

Young

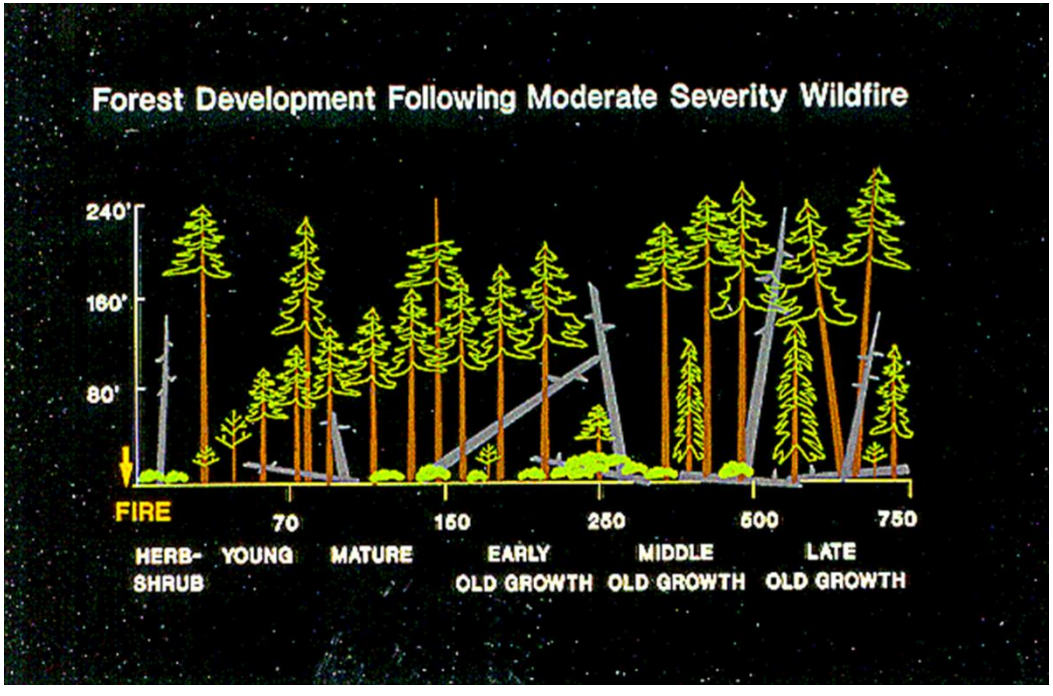
Seedling/sapling

Forest Seral Stages

Seedling/sapling

Stand-Level Vegetation Structure - Drivers

Natural Disturbance



Stand-Level Vegetation Structure - Drivers

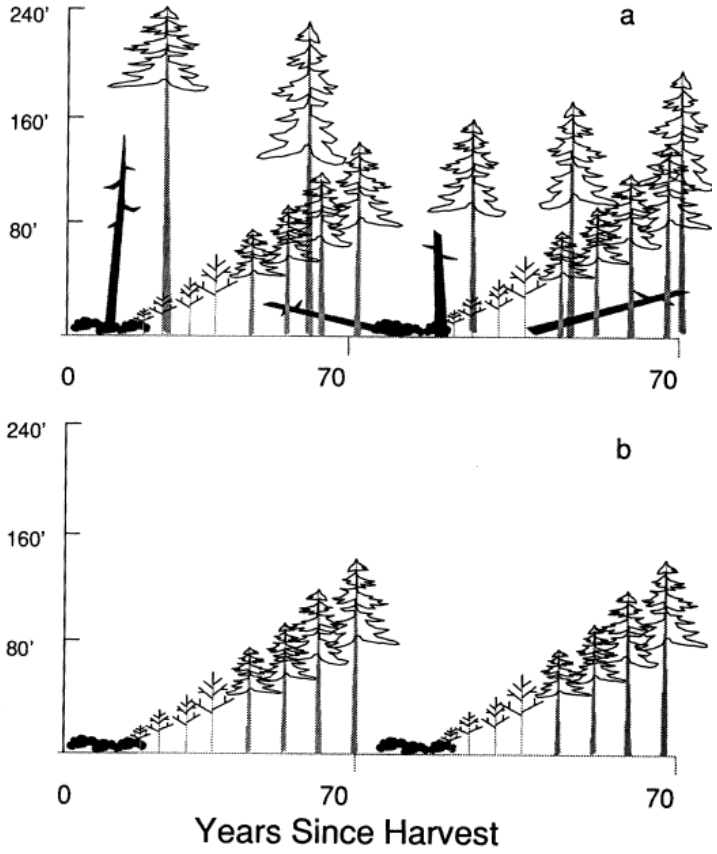
Growth Rates

Boreal forest

Coastal Redwood forest

Stand-Level Vegetation Structure - Drivers

Land Management



Ecological forestry

Ecological forestry uses silviculture to mimic natural disturbance and maintain within-stand and landscape structure.

Traditional clearcut forestry

Stand-Level Vegetation Structure - Consequences

Microclimate

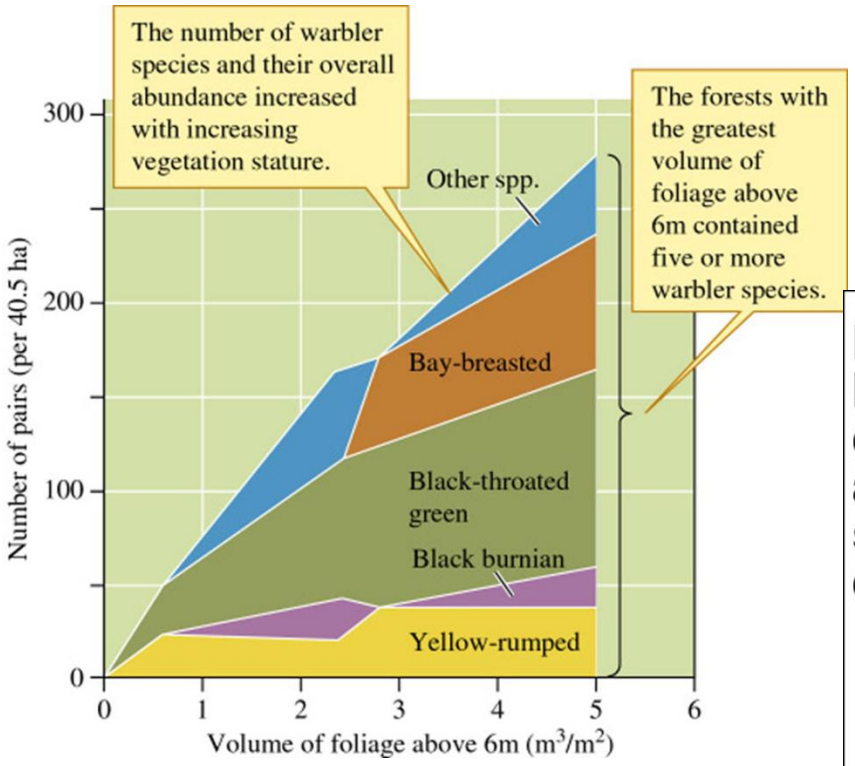
Decomposition and nutrient cycling

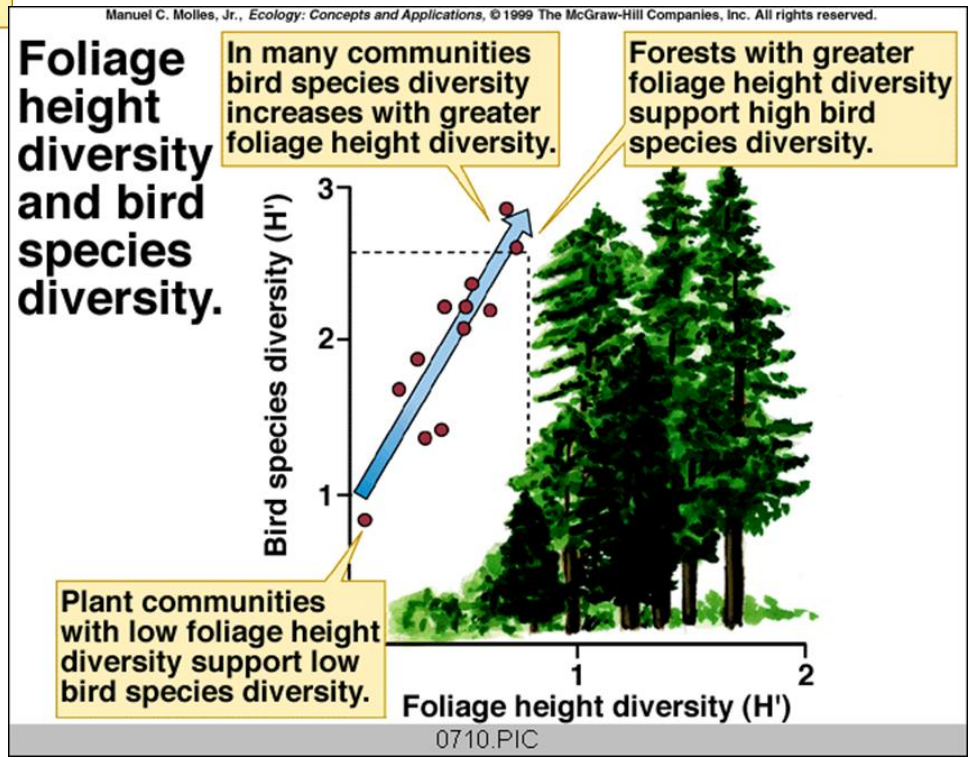
Forest Productivity

Fuel Loads and fire behavior

Stand-Level Vegetation Structure - Consequences

Biodiversity





Habitat Fragmentation and Edge Effects

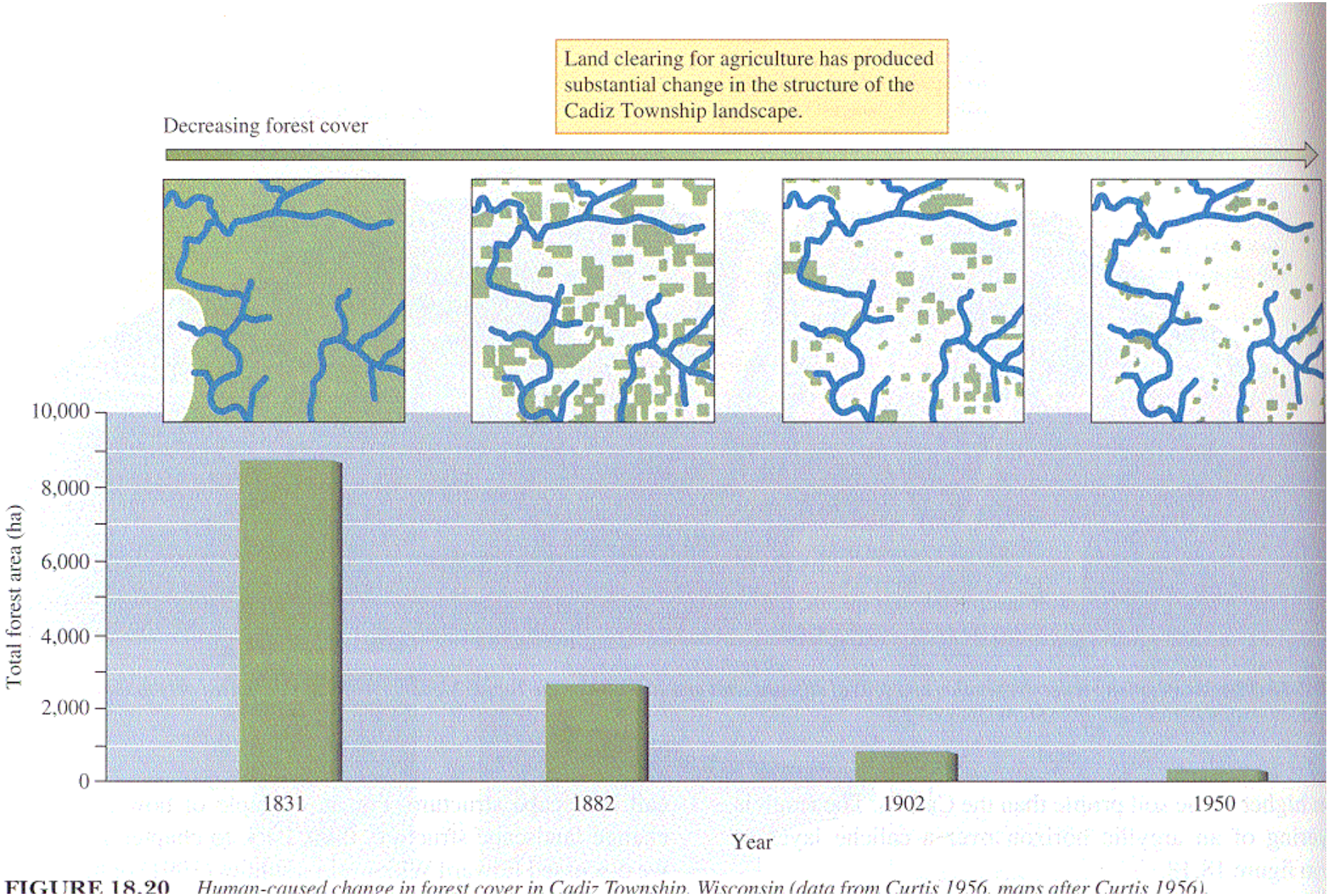
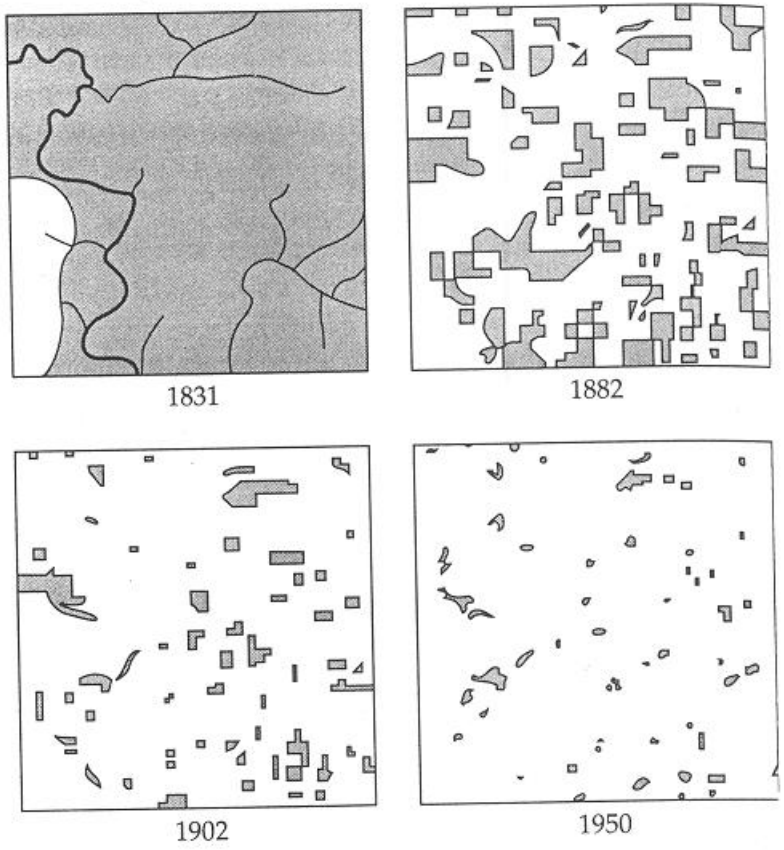


FIGURE 18.20 *Human-caused change in forest cover in Cadiz Township, Wisconsin (data from Curtis 1956, maps after Curtis 1956).*



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 (change in connectivity)**

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

Species Area Relationship

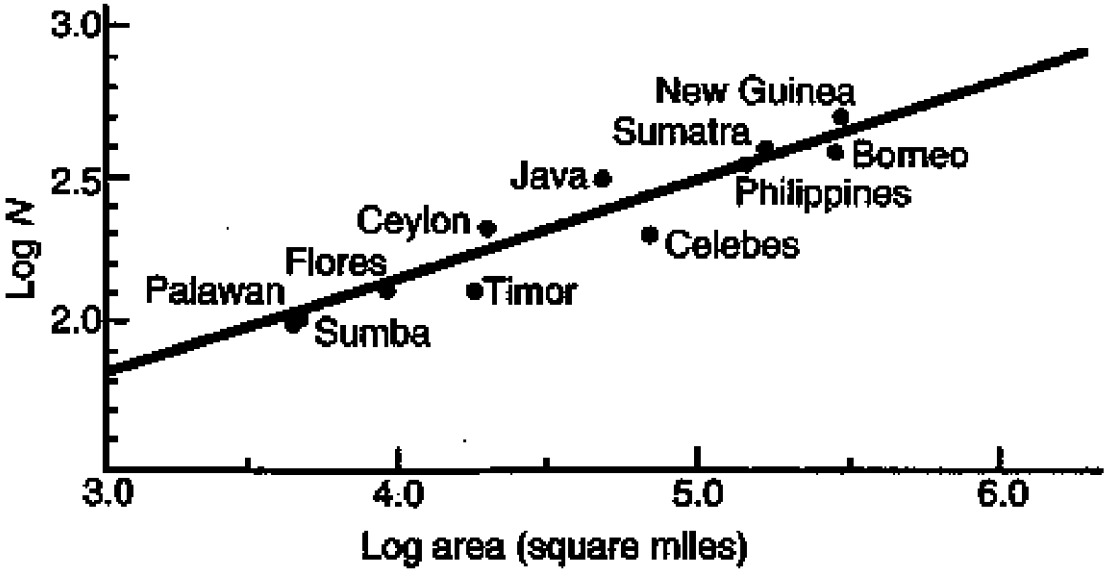


Figure 28.12 Number of bird species on various islands of the East Indies in relation to area. The abscissa gives areas of the islands. The ordinate is the number of bird species breeding on each island. (From Preston 1962:185.)

Species Area Relationship

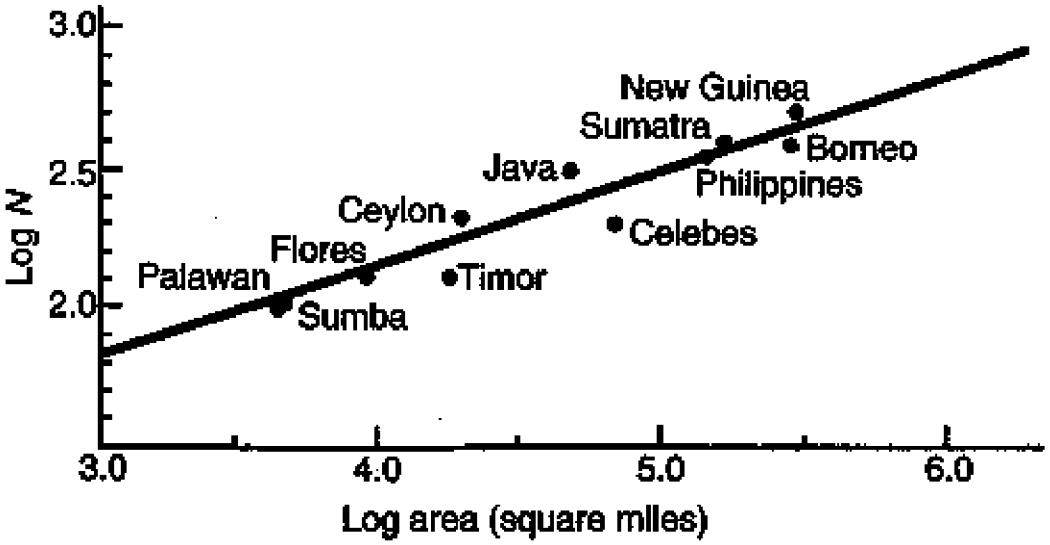


Figure 28.12 Number of bird species on various islands of the East Indies in relation to area. The abscissa gives areas of the islands. The ordinate is the number of bird species breeding on each island. (From Preston 1962:185.)

$$S=cA^{z}$$

number of species=intercept*area ^{slope}

Smaller islands have fewer species than large islands.

Why?

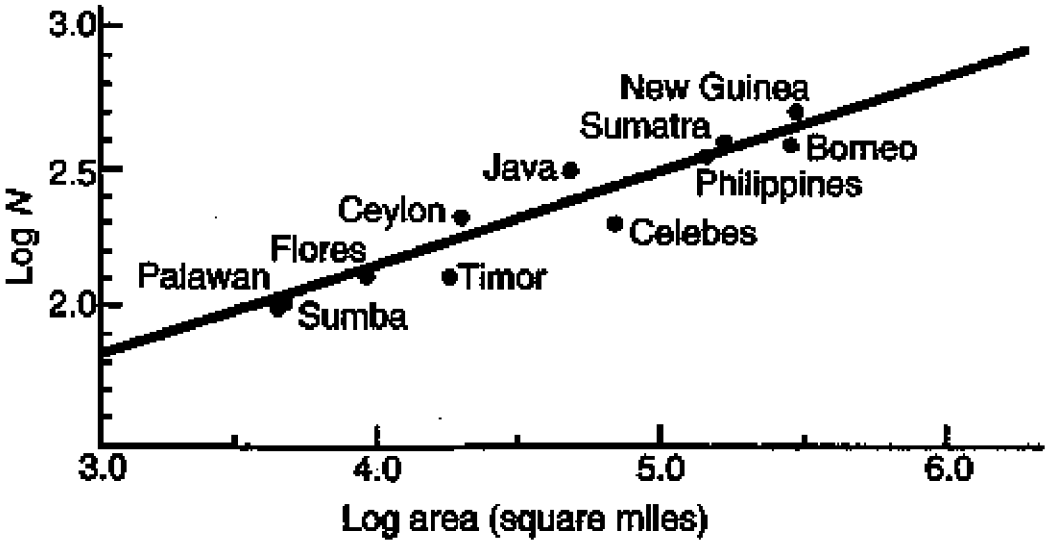
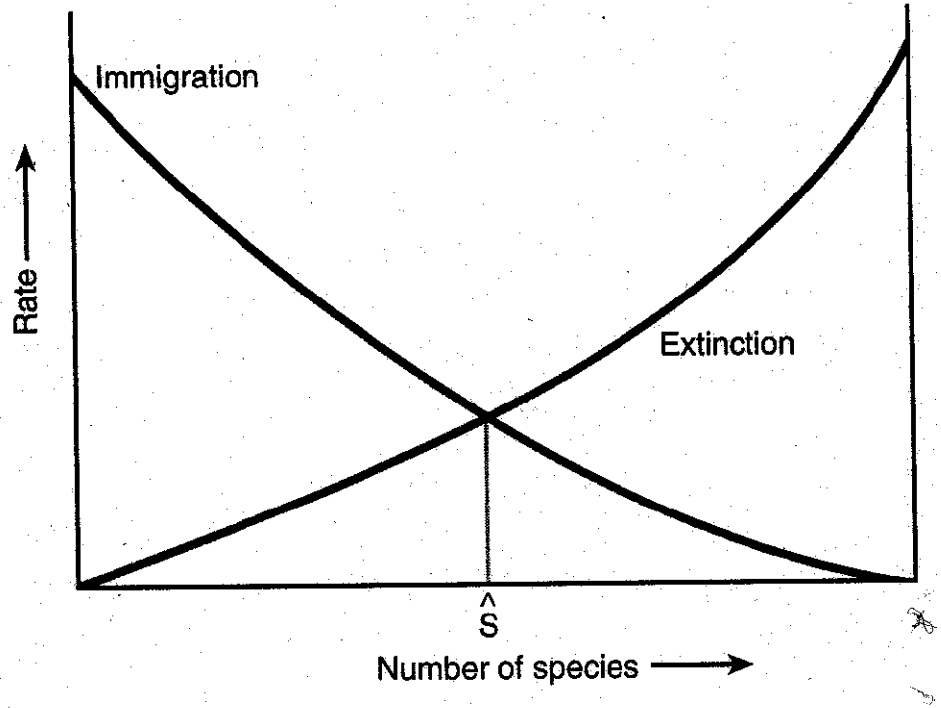


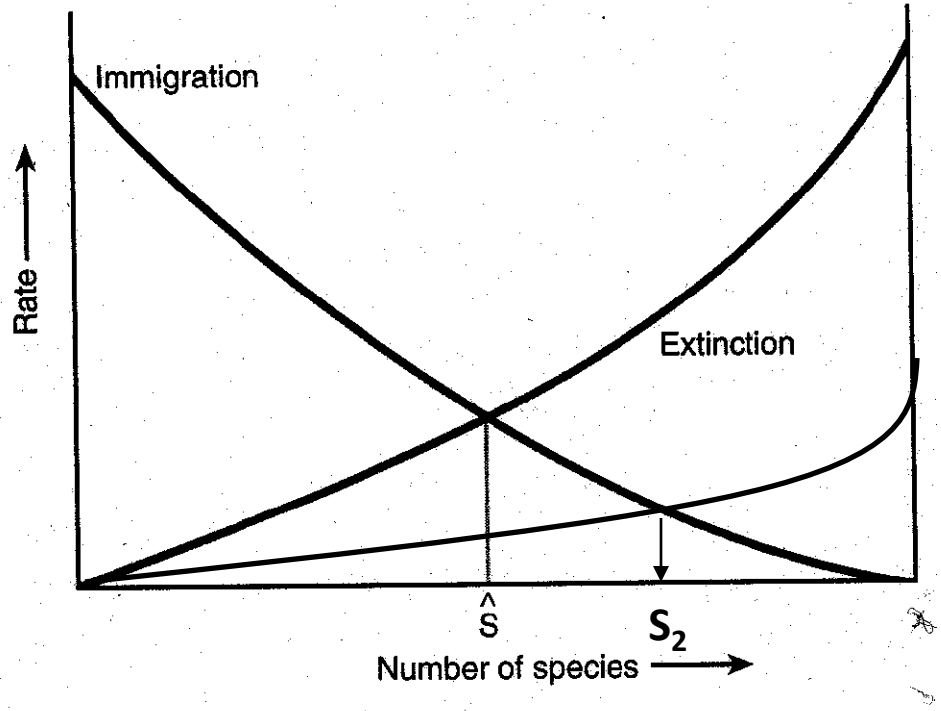
Figure 28.12 Number of bird species on various islands of the East Indies in relation to area. The abscissa gives areas of the islands. The ordinate is the number of bird species breeding on each island. (From Preston 1962:185.)

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

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.



Small island

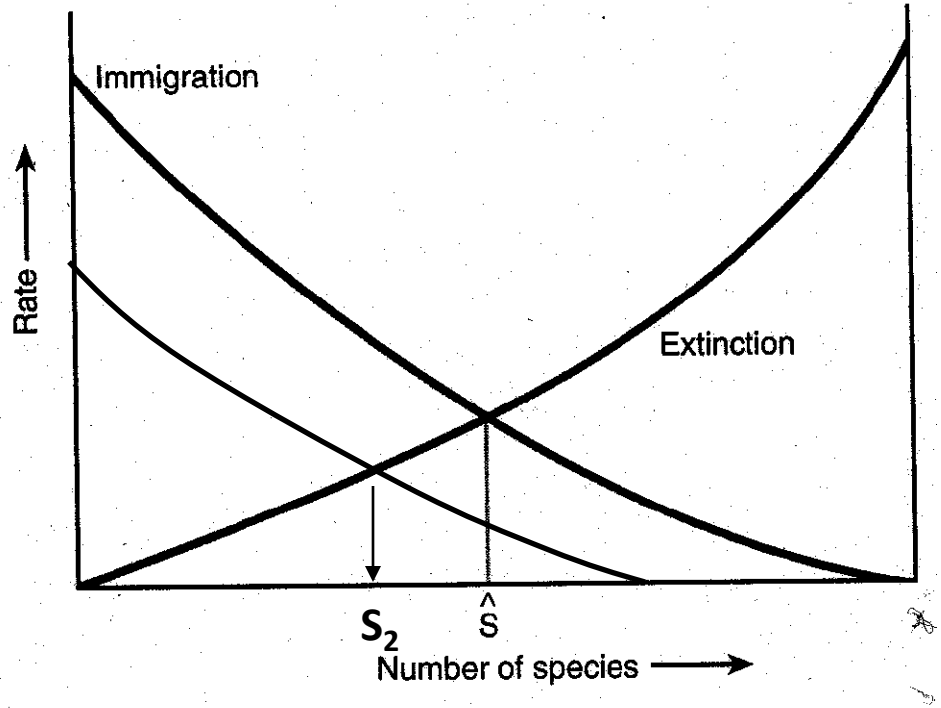
Large island

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.

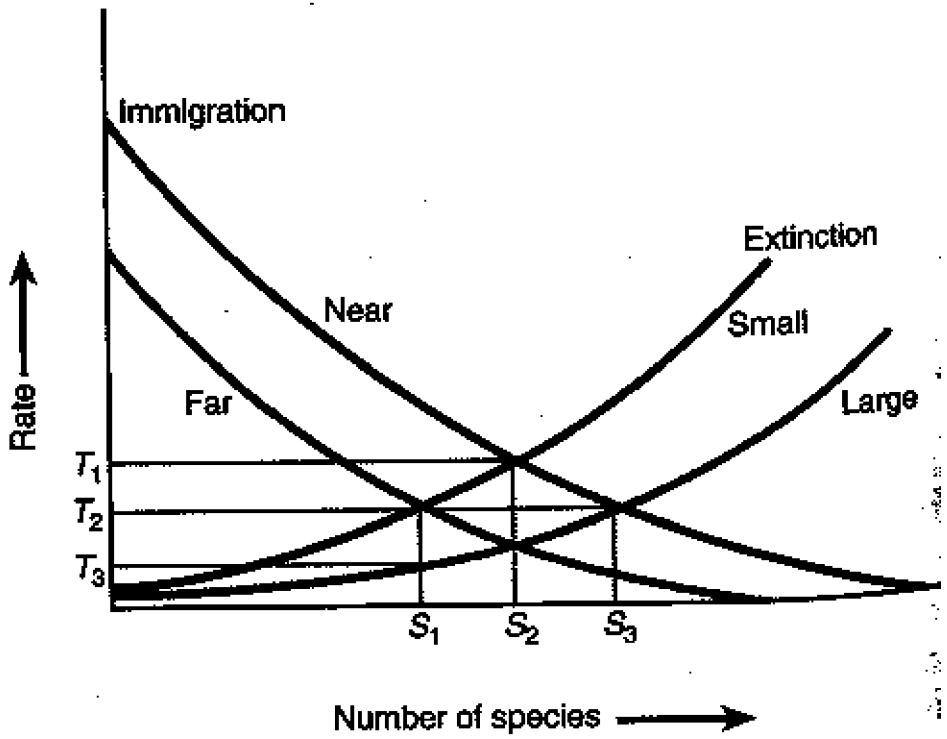
Near island

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?

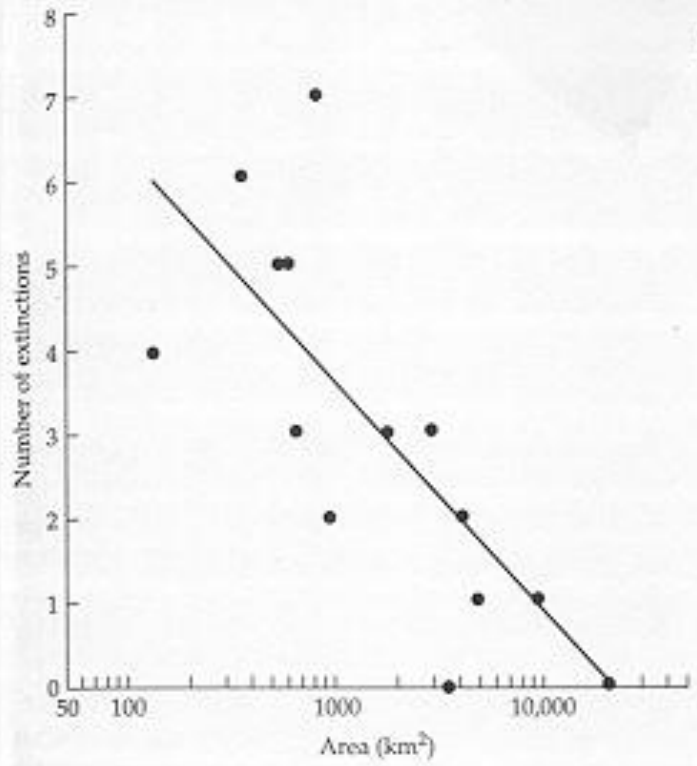


Figure 10.8 Naturally caused extinctions that occurred after reserve establishment as a function of park area in 14 western North American national parks. (From Newmark 1987.)

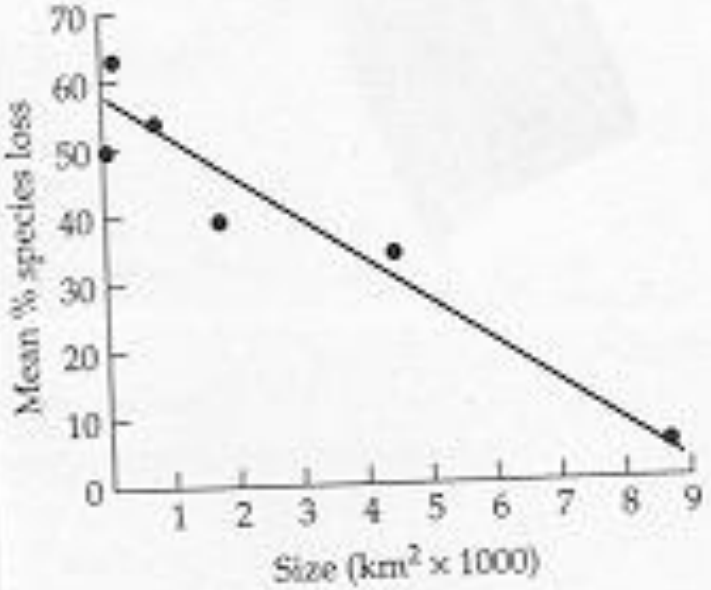


Figure 10.9 Percentage loss of large mammal species since European settlement as a function of area of isolated ranges in the northern Rocky Mountains. (From Harris 1984; data from Picton 1979.)

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;

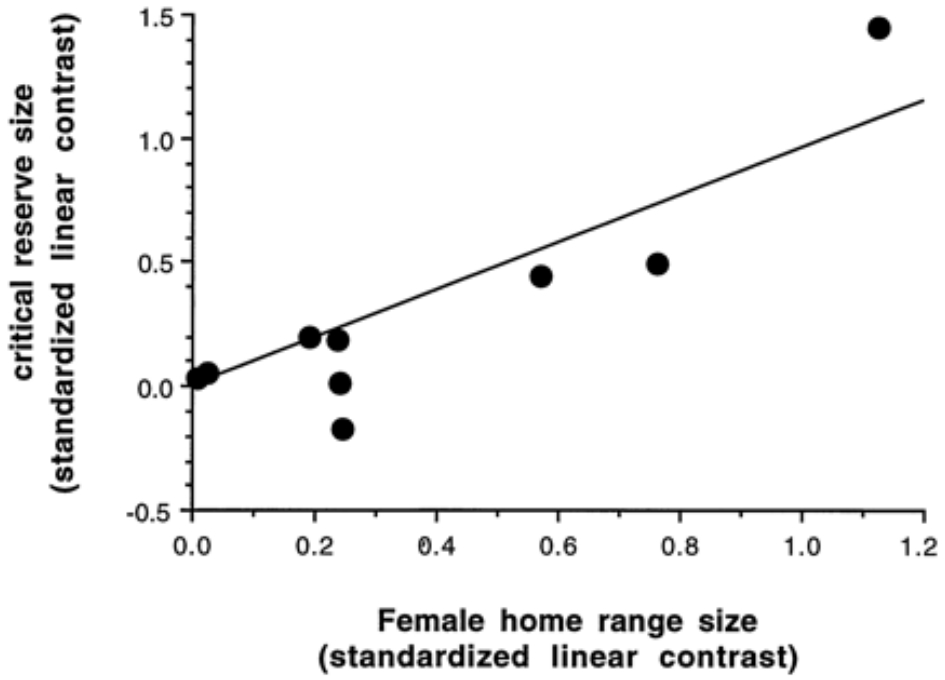


Figure 2. Relation critical reserve size and female home range size calculated for 10 species of large carnivore. $r^2 = 0.84$, $F_{1,8} = 42.1$, $P < 0.005$.) Critical reserve size estimated by using the logistic regression models to predict the area at which populations persisted with a probability of 50%. (Woodroffe and Ginsberg 1998)

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; decreased habitat heterogeneity.**
- **Reduction in Patch Size - Increasing edge effects**

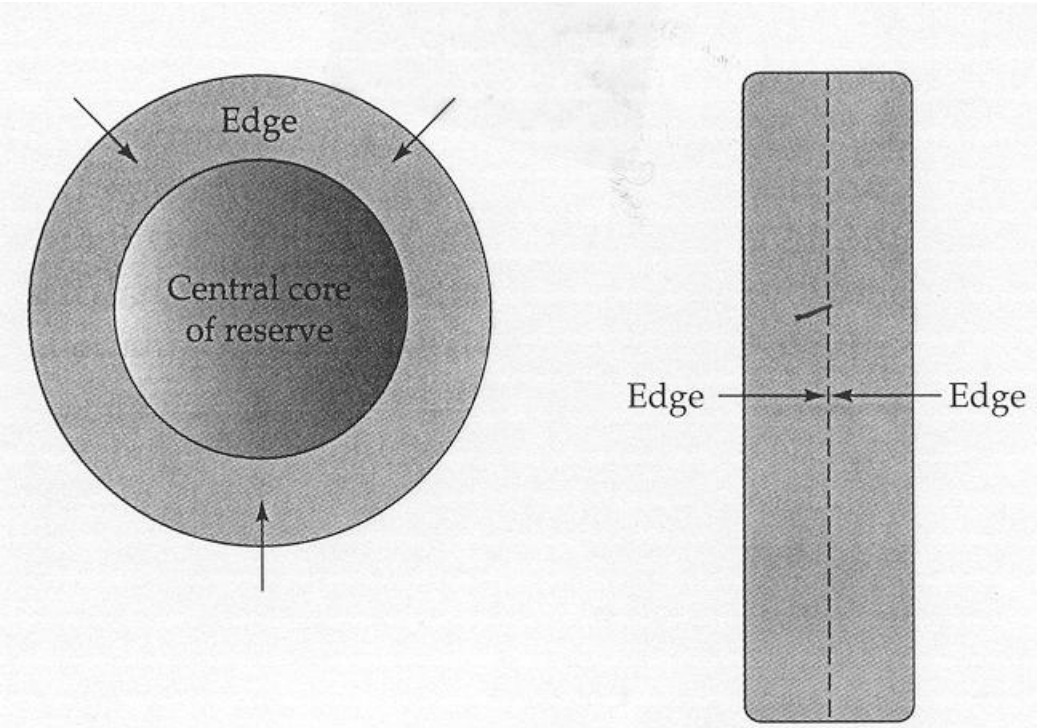
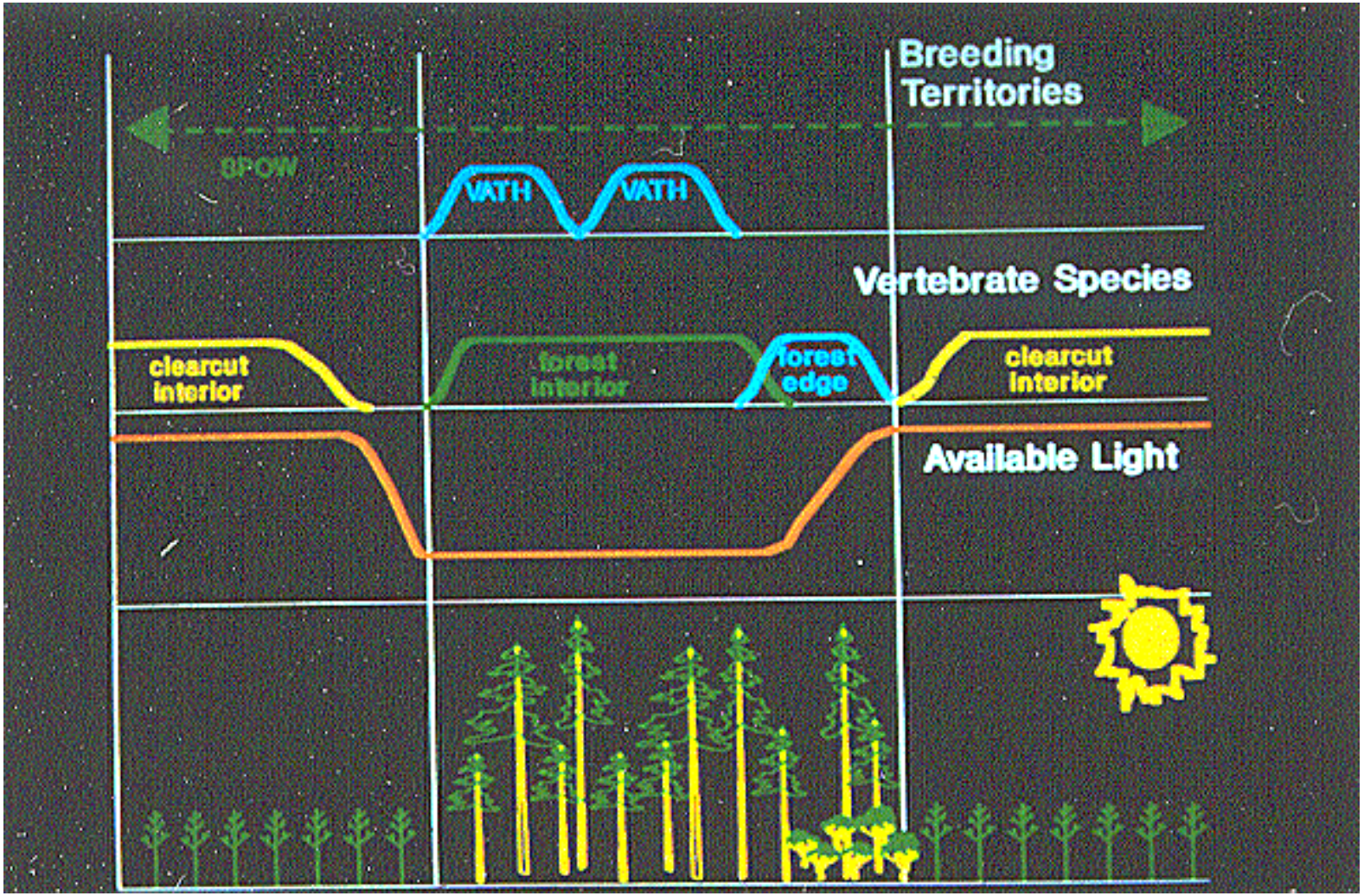
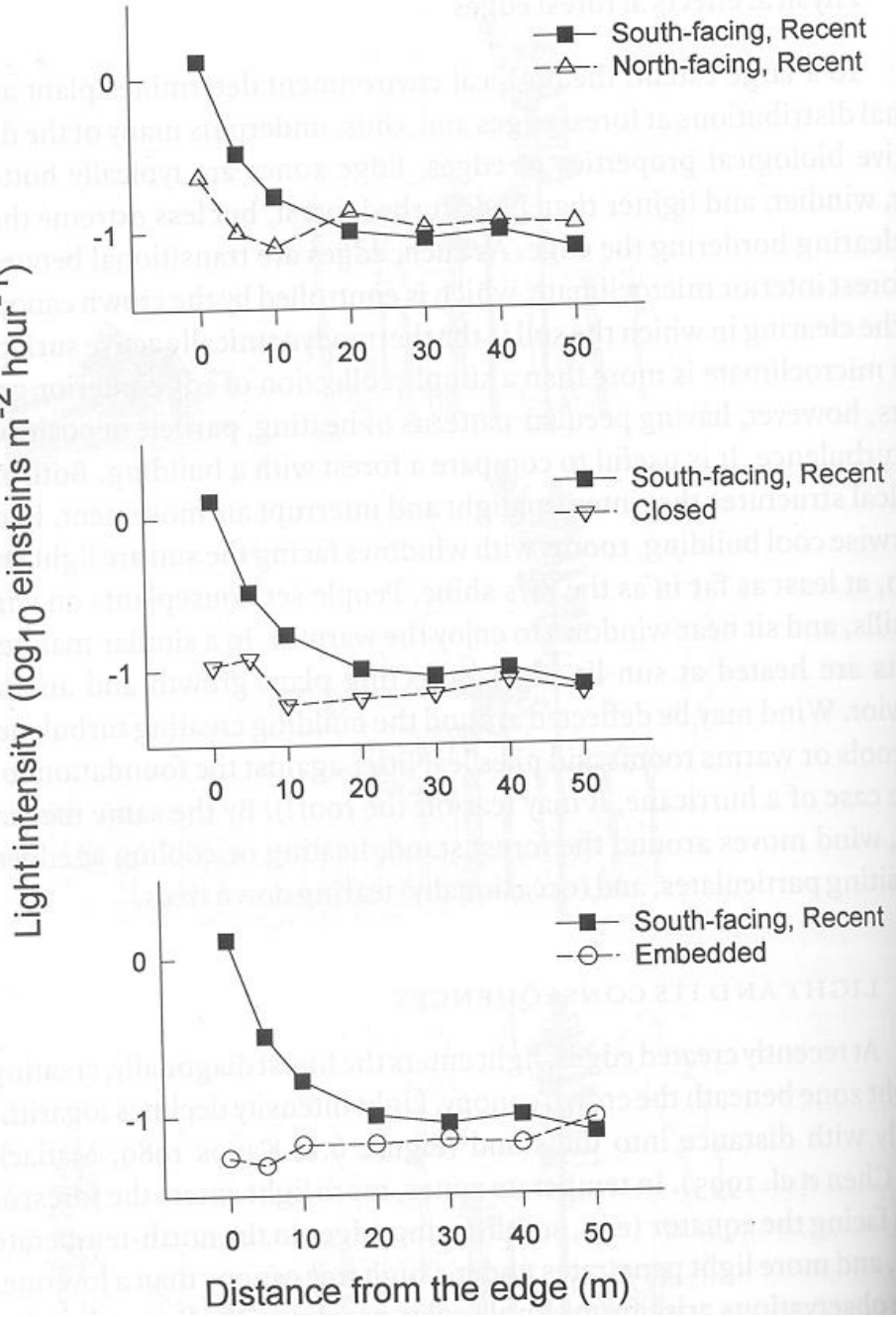
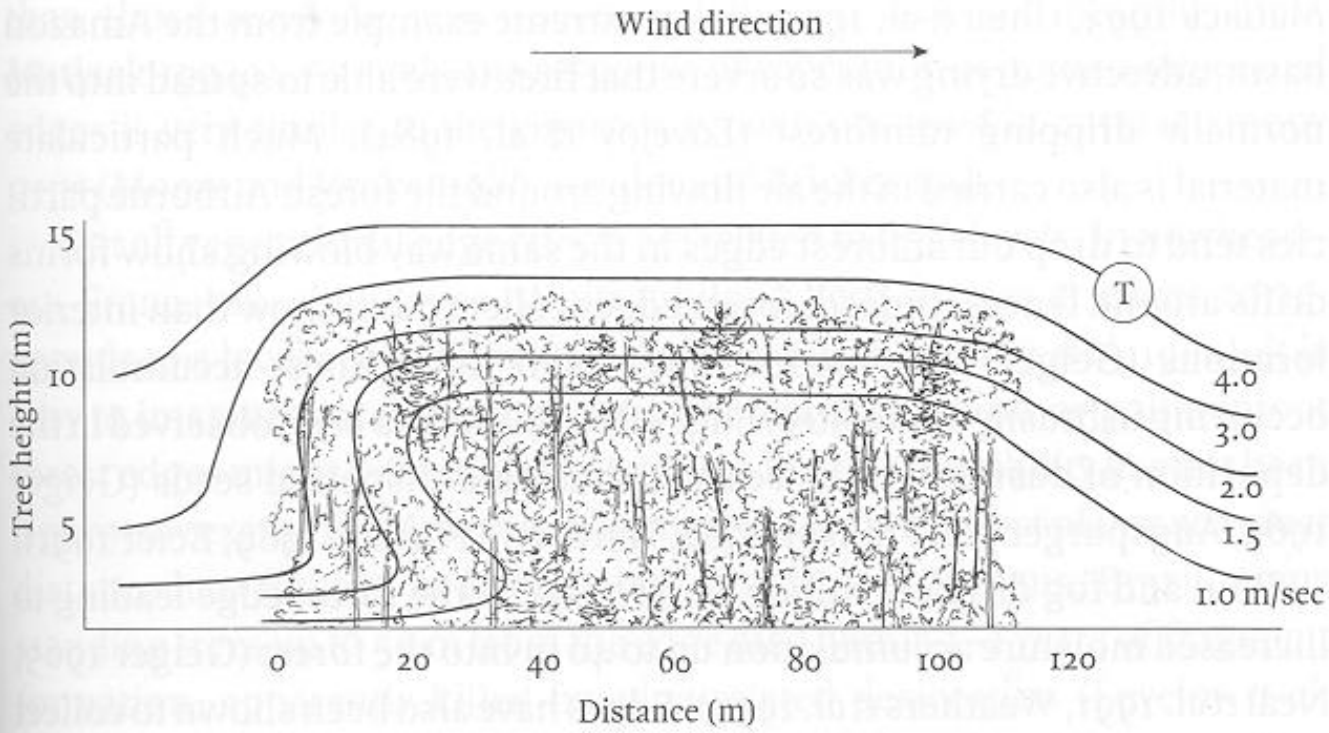


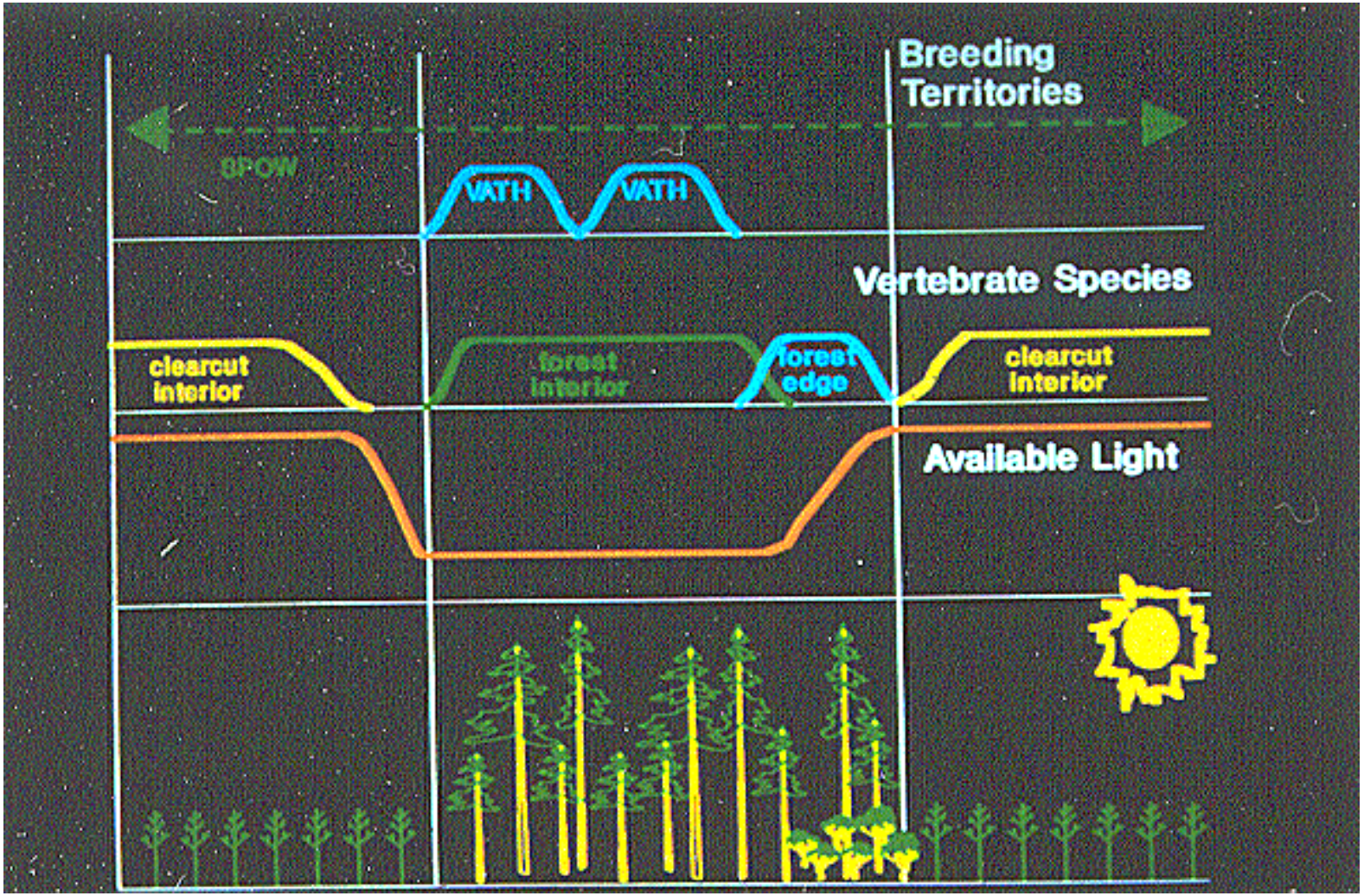
Figure 18.11 The effects of edges on small nature reserves of equal area but different shape. Note that long, thin reserves have a greater proportion of their area as an edge and that circular reserves will have more interior habitat.



Hypotheses about edge effects


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

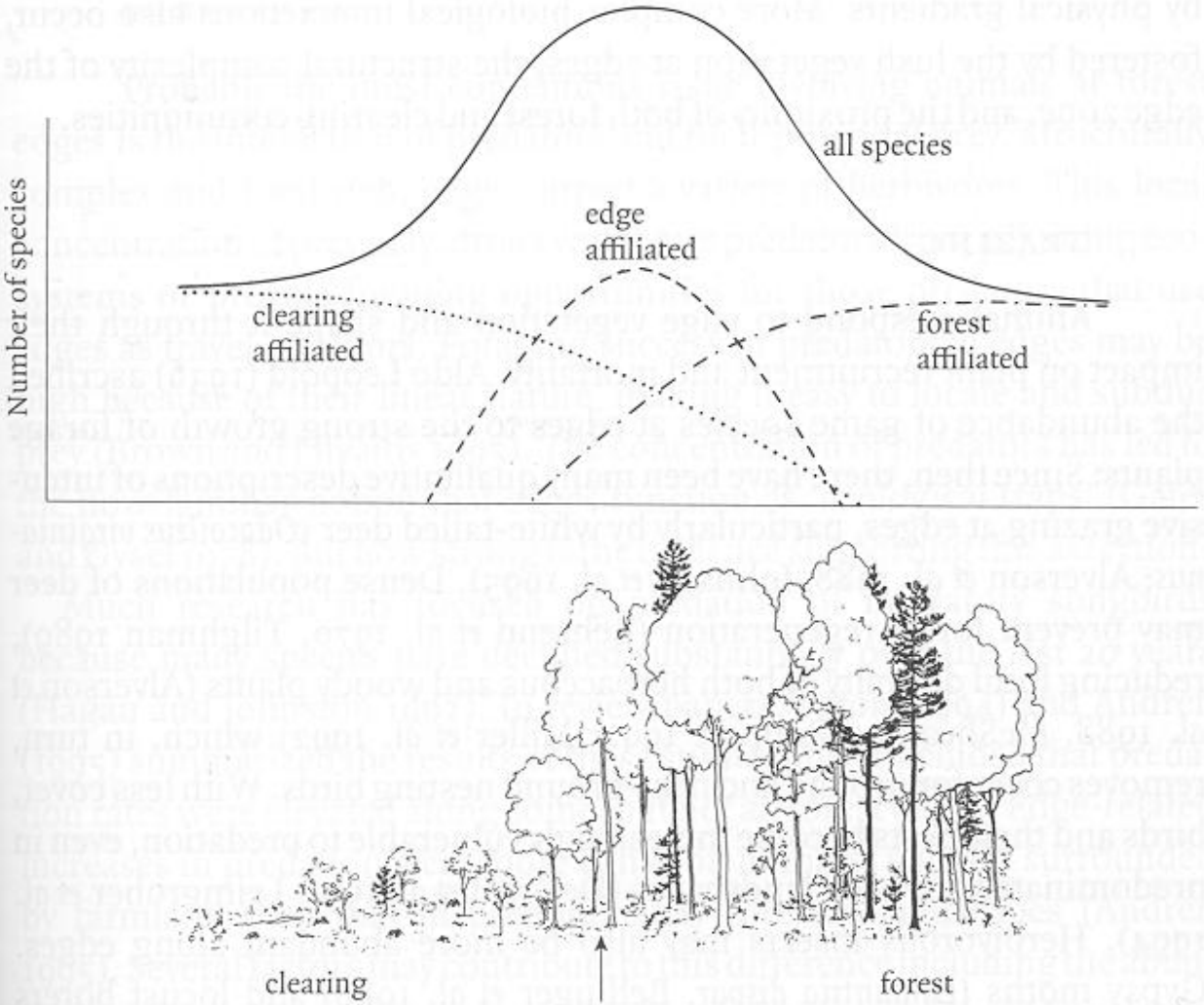
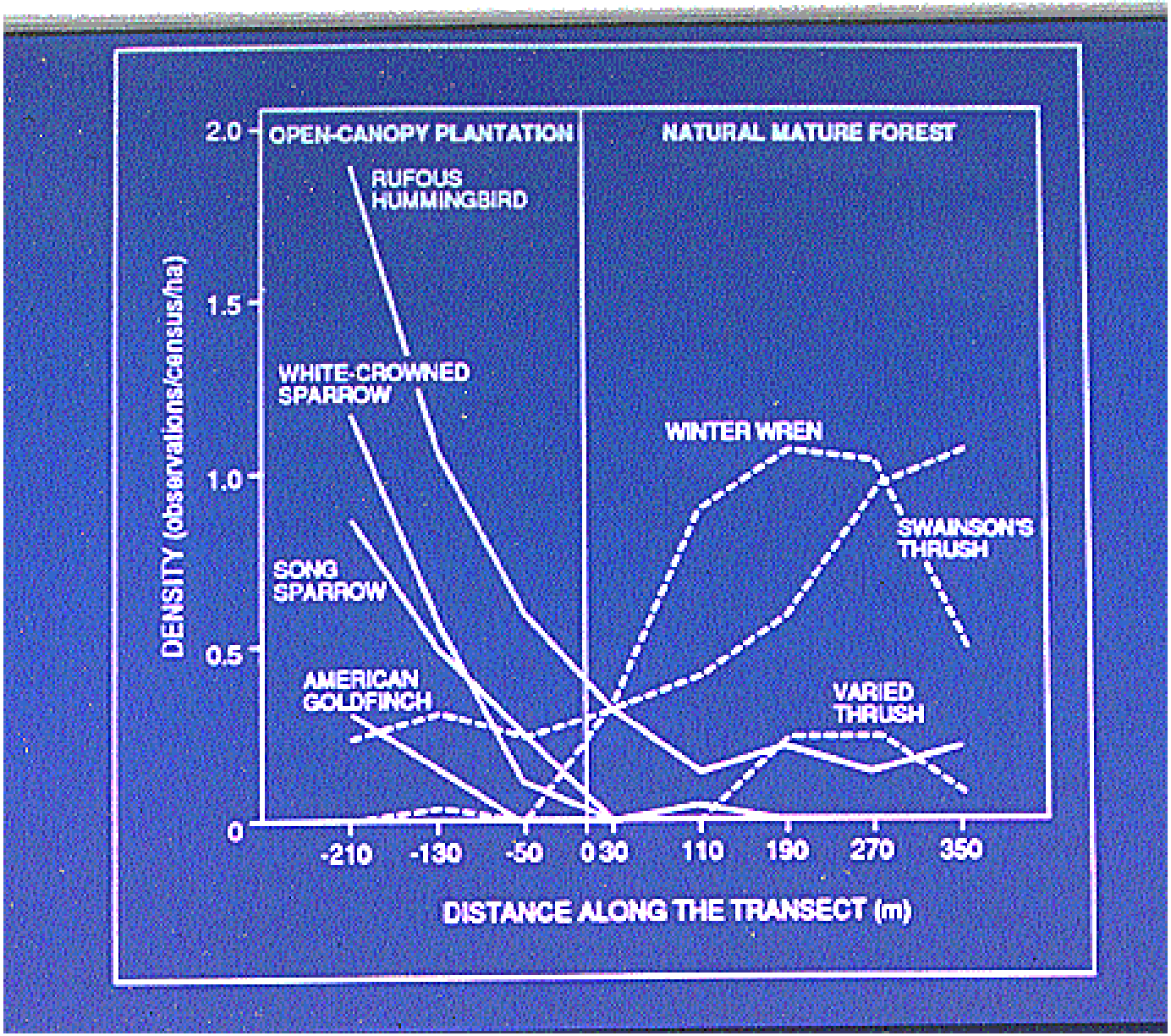
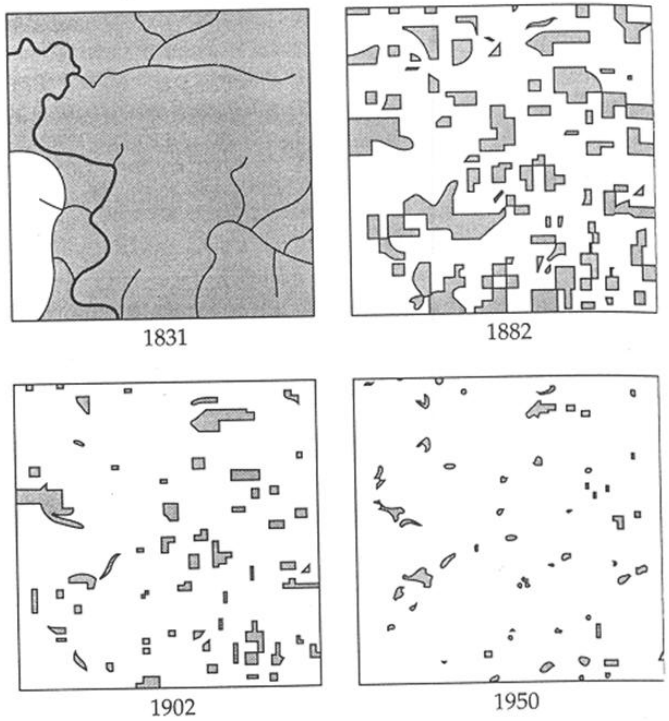


Fig. 6.4. A typical distribution of animal species at a closed forest edge. The arrow indicates the boundary of the gap-forming disturbance.



Bird distributions across clearcut/forest edges

Case Study Eastern Deciduous Forest: Where have the Birds Gone?



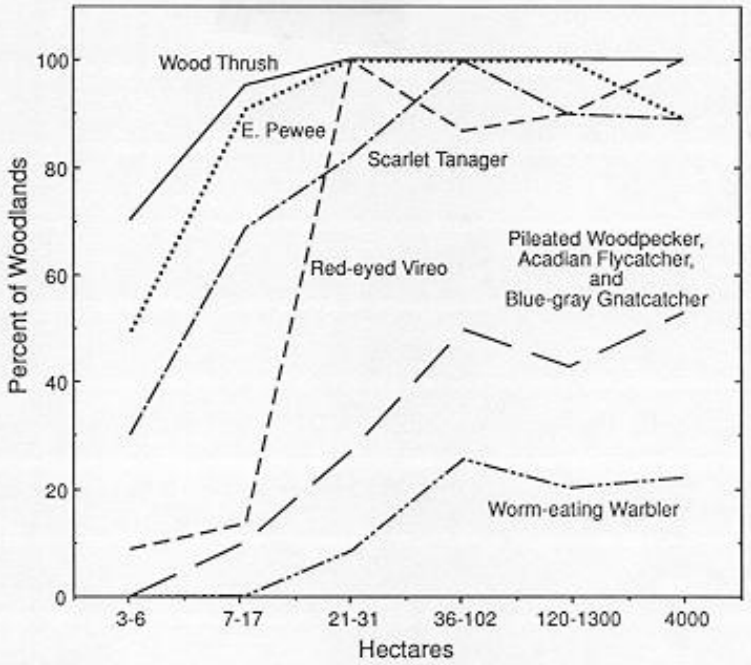


FIG. 5.1 Proportion of woodlots of each size class in which the species indicated were found (Robbins 1980).

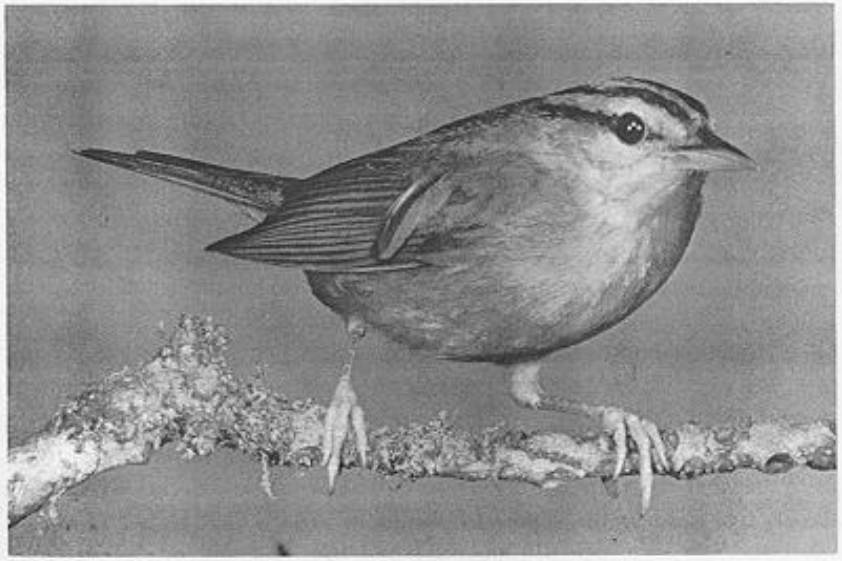


FIG. 5.2 Worm-eating warbler.

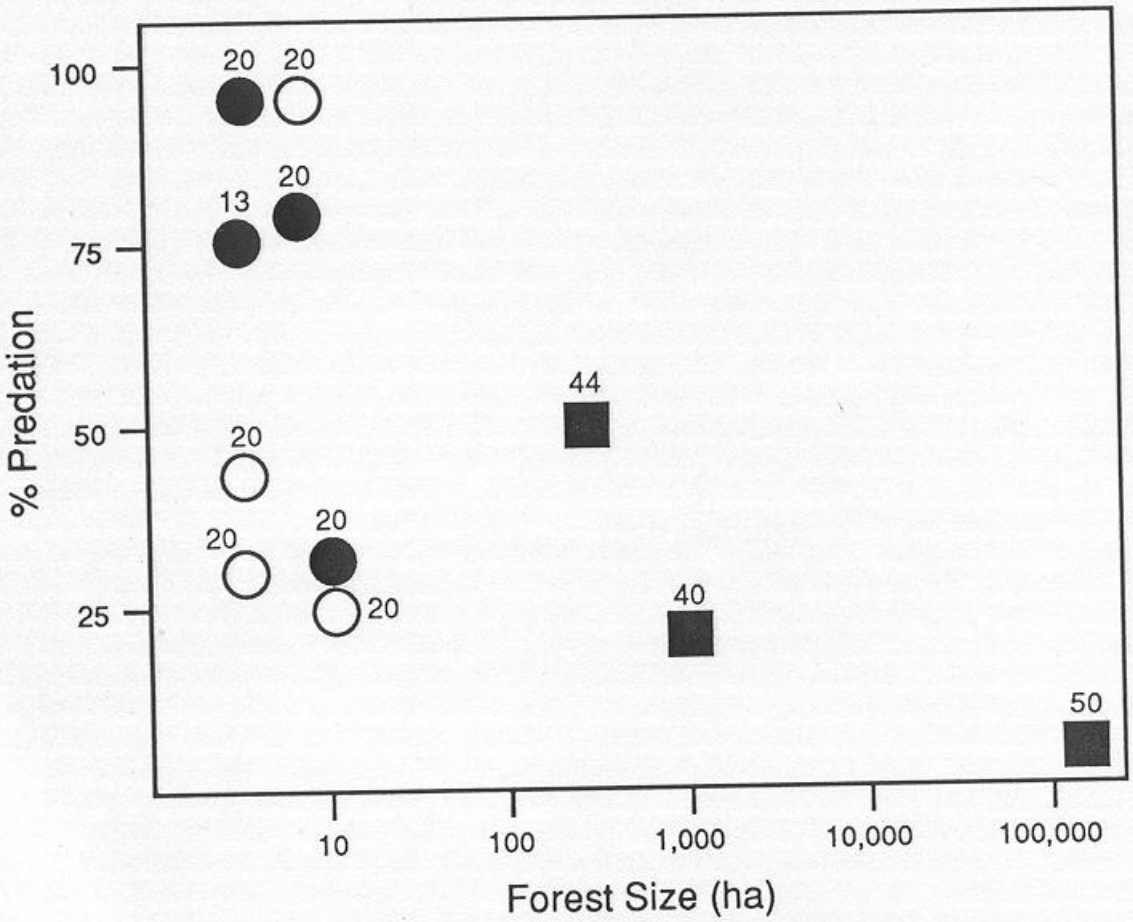


FIG. 5.3 Percentage of nests preyed upon as a function of forest size. Closed squares are large forest tracts, open circles are rural fragments, and closed circles are suburban fragments. The number above each point is the number of artificial nests placed in that forest (Wilcove 1985b).

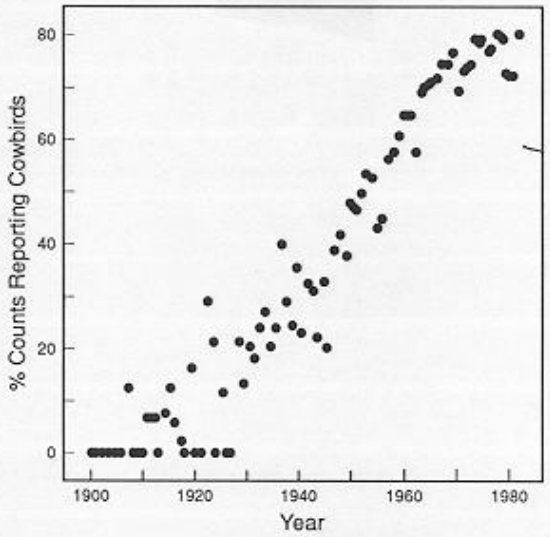


FIG. 5.5 An index to cowbird abundance from 1900 to 1980 taken from Audubon Christmas bird count records (Brittingham and Temple 1983).

FIG. 5.6 Brown-headed cowbird

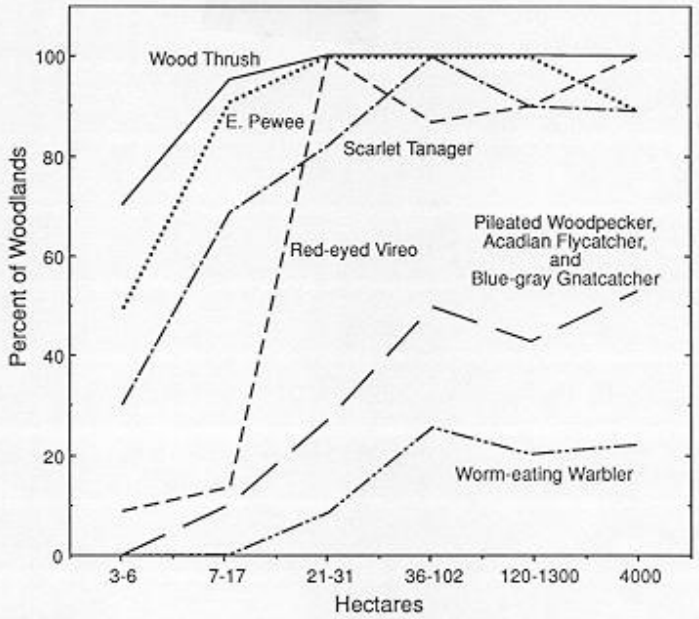


FIG. 5.1 Proportion of woodlots of each size class in which the species indicated were found (Robbins 1980).

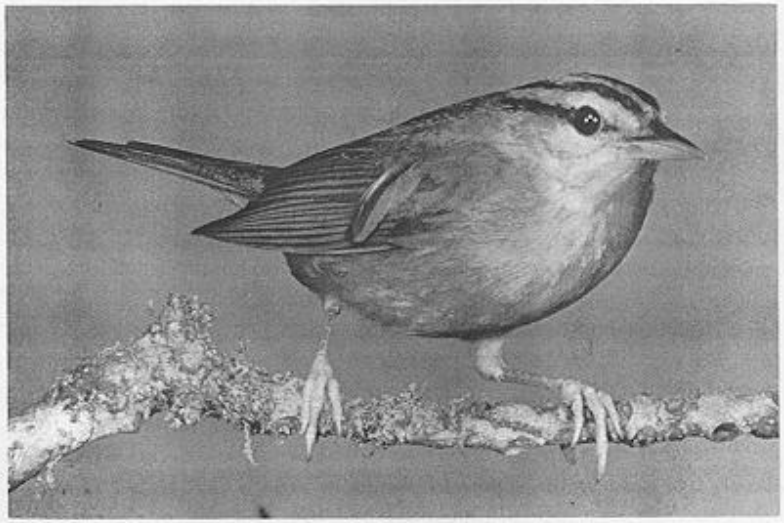


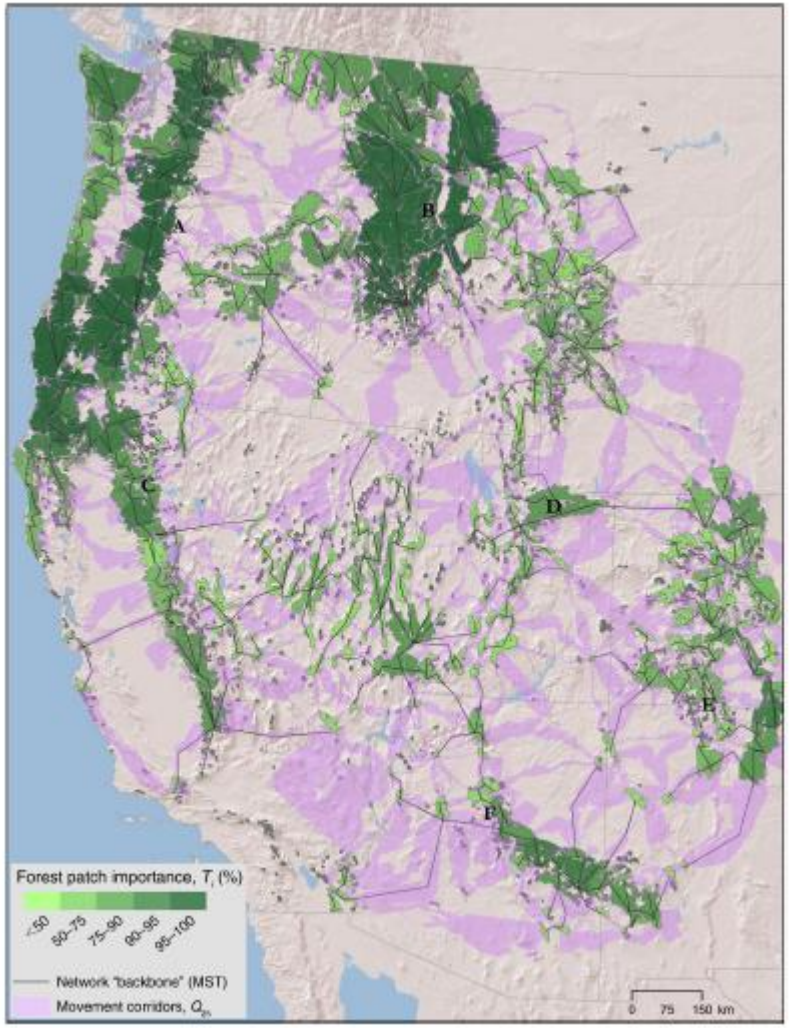
FIG. 5.2 Worm-eating warbler.

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**

Ecological Consequences of Fragmentation

- **Patch Isolation - Less exchange of organisms**



Theobald et al. 2011

Management of Landscape Pattern

Natural disturbance vs traditional forestry and ecological forestry