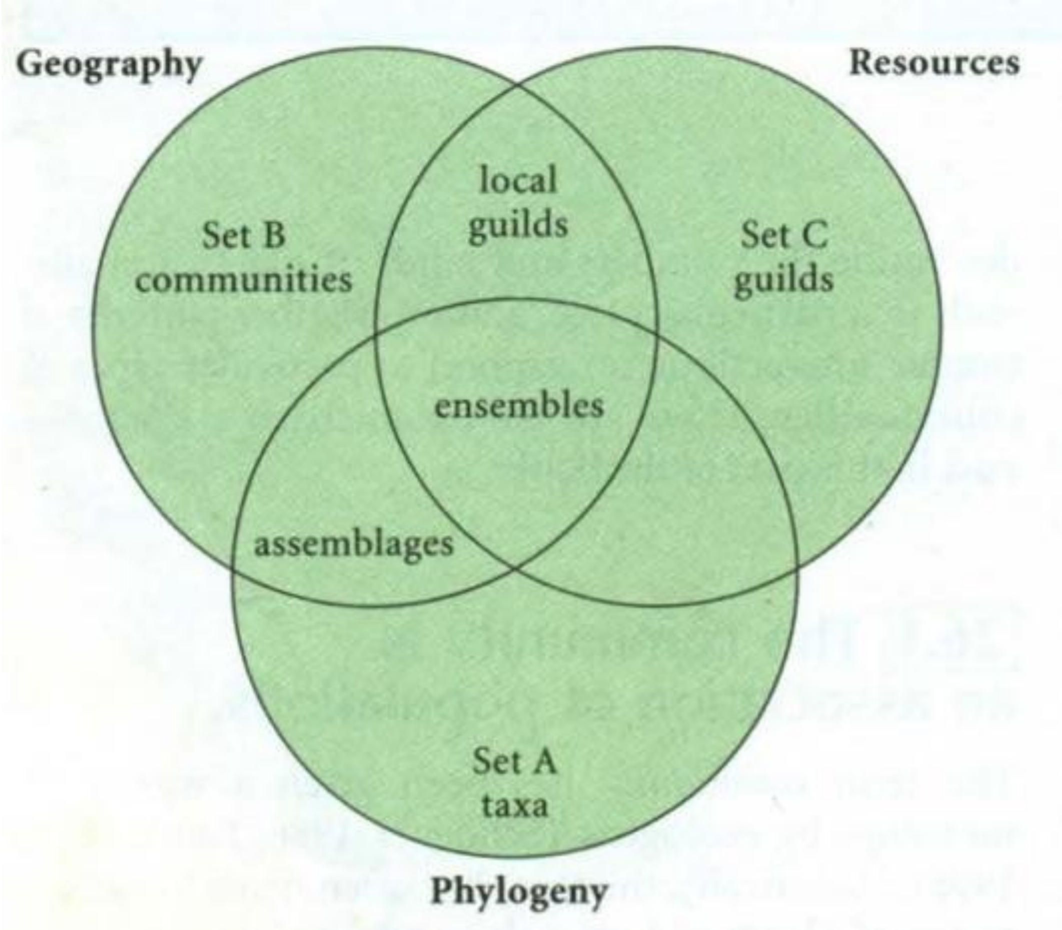
COMMUNITY ECOLOGY

Community

- Community is an assemblage of species populations that occur together in the same place at the same time.
- Community is the biological part of the ecosystem
- Communities are made up of organisms with interlocking food chain and one species dependent on many other species which are taxonomically unrelated.
- A community may be of any size.
- Communities are of 2 types:
    - *Major communities* are those that along with their habitats forms near complete or self-sustaining unit of ecosystems.
    - *Minor communities* are secondary congregates within the major communities and not completely independent unit as far as circulation of energy is concerned.

Community

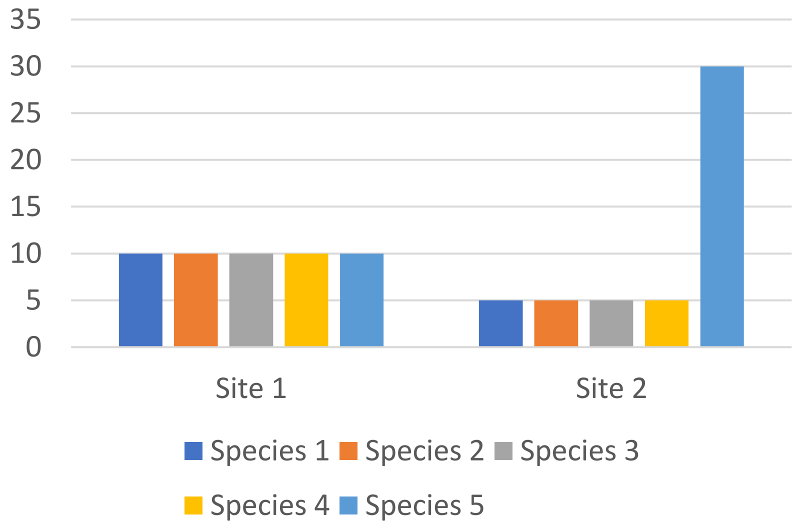
- Community has two major properties:
  - *Community structure:* It mainly determined by number of species, their relative abundance and their interactions.
  - *Community function:* It comprises of rates of energy flow, community resilience, resistance and productivity.



Diversity

- A community can be characterized by its diversity which is a function of number of species present (richness) and their abundance (evenness & dominance).
- Diversity indices are useful to measure diversity.
- **Richness (S):** Number of species.
- **Individual (N):** Number of individuals.
- **Dominance:**
  - *Berger-Perker index (d)=* $\frac{N_{max}}{N}$

  Where, N_{max} is the number of individual of the most dominant species and N is the total number of individuals of all species.



Diversity

- Shannon's diversity index (H) = -$\sum_1^S p_i ln p_i$

Where, $p_i = n_i/N$

Here, n_i=number of individuals of a particular species, N is total number of individuals of all species.

Maximum value for H is $\ln S$.

- Simpson's diversity index:
  - For finite population (closed system): $1 - \sum_1^S \frac{n_i(n_i-1)}{N(N-1)}$
  - Values of this Simpson's index formula ranges between 0 and 1.

  For infinite population (open system): $\frac{1}{\sum_1^S \left(\frac{n_i}{N}\right)^2}$. It does not have any bound.

Diversity

Species	Site 1	Site 2
A	10	30
B	10	5
C	10	5
D	10	5
E	10	5
Total	50	50

CALCULATE ALL INDEX

- S: Richness is 5 in both site.
- H
  - Site 1: $-\left(\frac{10}{50}\ln\frac{10}{50}\right) * 5 = -(0.2ln0.2) * 5 = -(-0.32 * 5) = 1.6$
  - Site 2: $-\left(\frac{30}{50}\ln\frac{30}{50} + \left(\frac{5}{50}\ \ln\frac{5}{50}\right) * 4\right) = -\left(-0.31 + (-0.23 * 4)\right) = (0.31 + 0.92) = 1.23$

Rank abundance

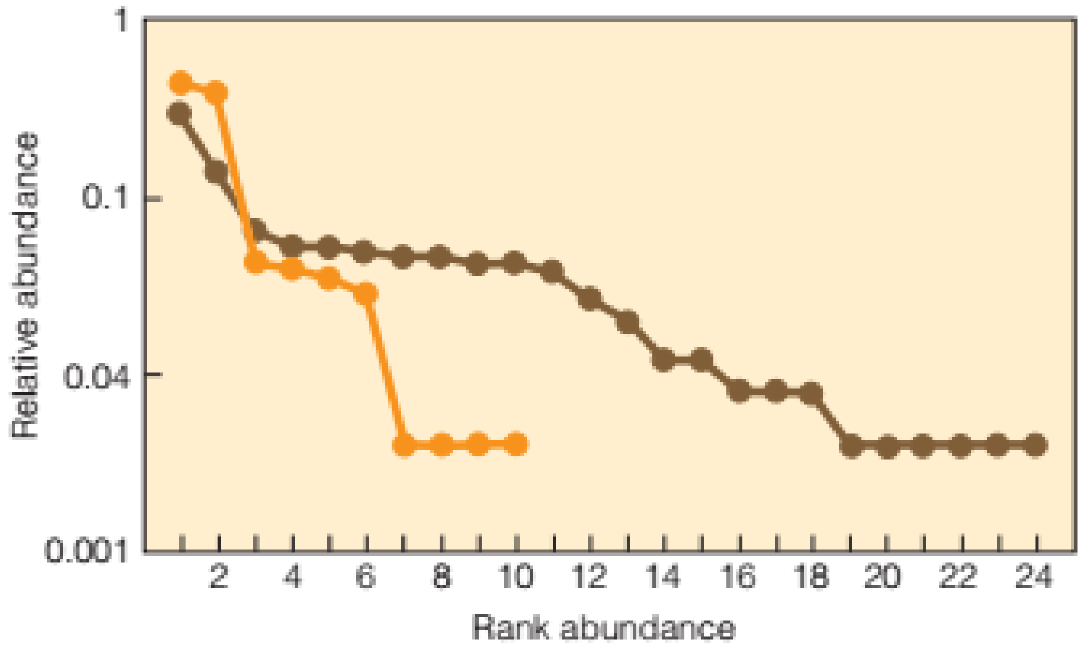


Figure 17.1 Rank-abundance curves for the two forest communities described in Tables 17.1 and 17.2. Rank abundance is the species ranking based on relative abundance, ranked from the most to least abundant (*x*-axis). Relative abundance (*y*-axis) is expressed on a $\log_{10}$ axis. The forest community in Table 17.1 (brown line) has a higher species richness (length of curve) and evenness (slope of curve) than the forest community in Table 17.2 (orange line).

Table 17.2 Structure of a Second Deciduous Forest Stand in Northern West

Species	Number of Individuals	Relative Abundance (Percentage of Total Individuals)
Yellow poplar (*Liriodendron tulipifera*)	122	44.5
Sassafras (*Sassafras albidum*)	107	39.0
Black cherry (*Prunus serotina*)	12	4.4
Cucumber magnolia (*Magnolia acuminata*)	11	4.0
Red maple (*Acer rubrum*)	10	3.6
Red oak (*Quercus rubra*)	8	2.9
Butternut (*Juglans cinerea*)	1	0.4
Shagbark hickory (*Carya ovata*)	1	0.4
American beech (*Fagus grandifolia*)	1	0.4
Sugar maple (*Acer saccharum*)	1	0.4
	274	**100.0**

Species-Area relationship

- More species are used to found in large areas than small areas.
- The concept of species-area relationship was put forwarded by botanist Olaf Arrhenius (1921).

$$S = cA^z$$

Where, S is species richness and A is area. c & z are constant fitted to the data.

After log transformation this relationship becomes:

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

This is a equation for straight line with the slope z.

Species-Area relationship

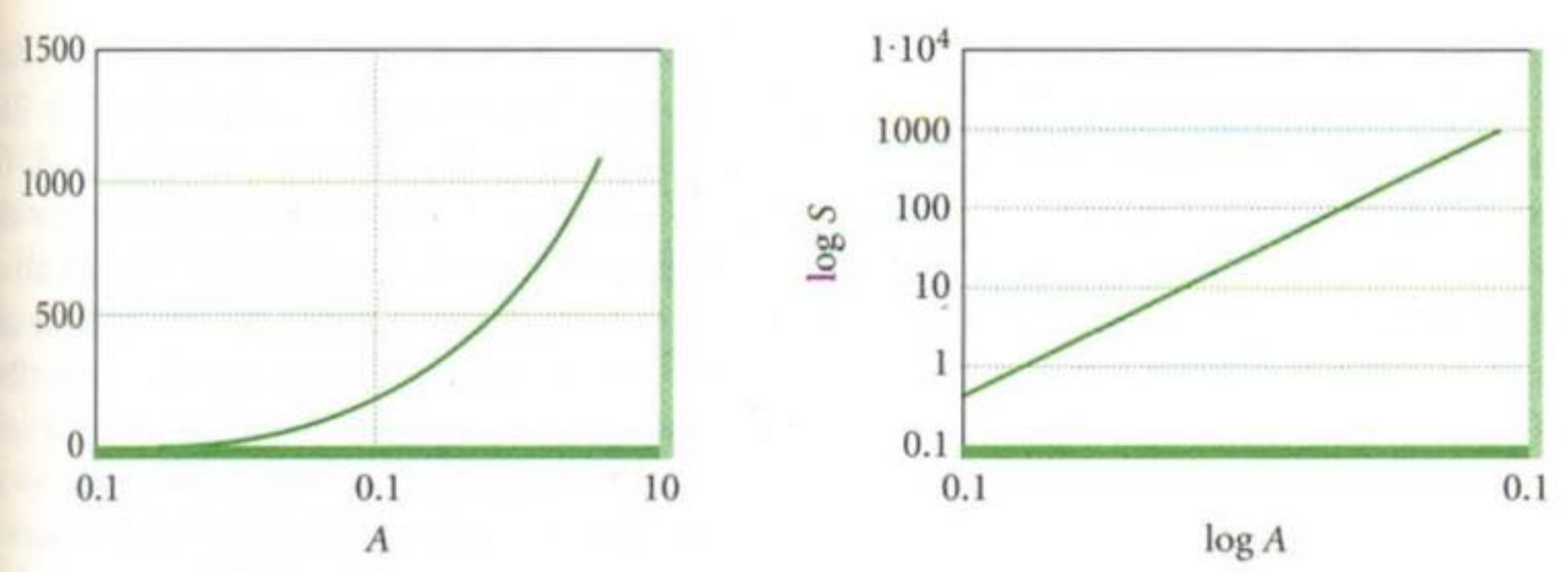
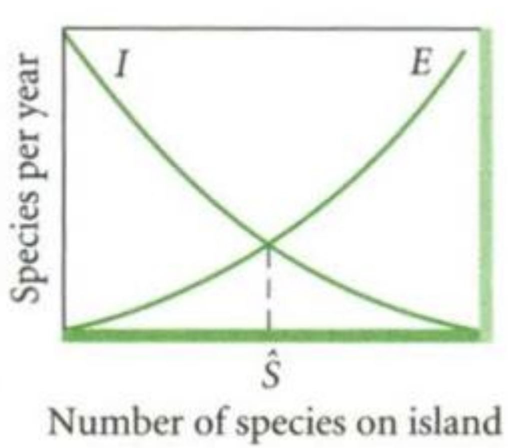
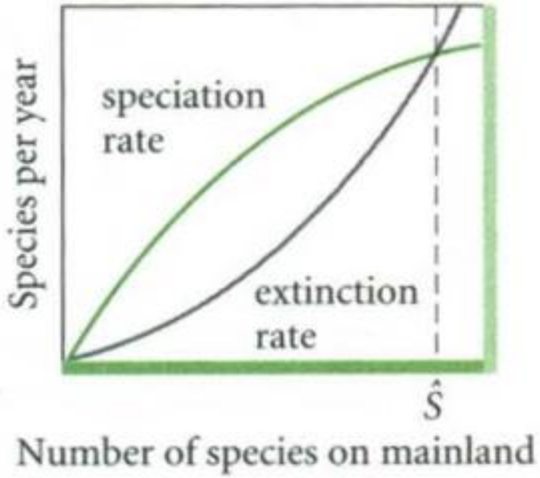


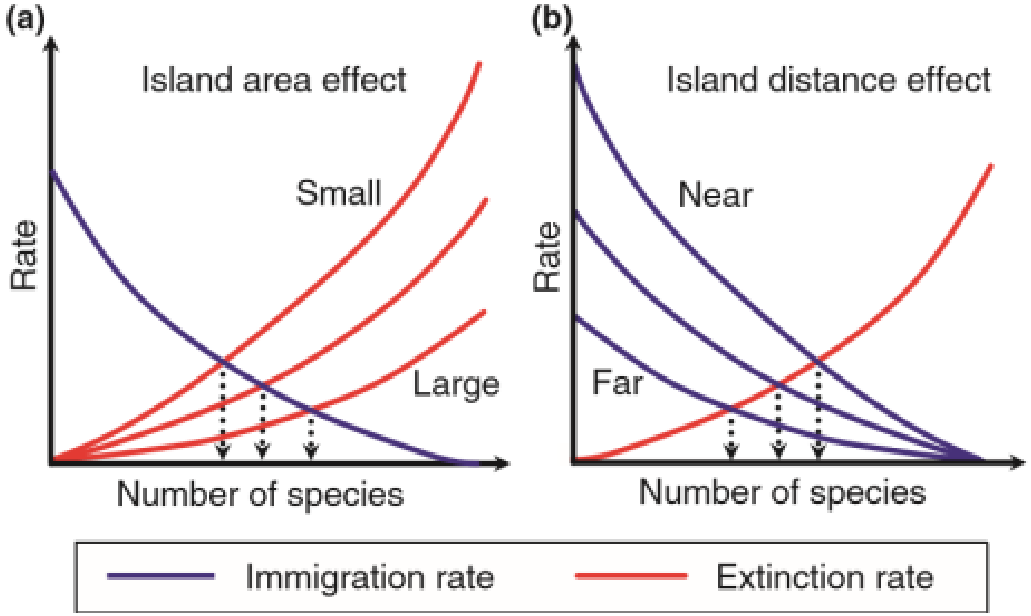
FIGURE 27-11 The power curve $S = cA^z$, where $c = 1$ and $z = 1.2$, and the linear transformation, $\log S = \log c + z \log A$.

Island Biogeography

- It was proposed by Robert MacArthur and EO Wilson (1963).
- ‘Island’ not only means the oceanic island but also habitat islands.
- The theory proposes that the number of species on any island reflects the balance between the rate at which new species colonizes it (immigration) and the rate at which population of established species become extinct.
- Large islands may ultimately have a larger equilibrium number of species than small islands because of chances of more habitat heterogeneity and more resource.
- Near islands tend to have larger equilibrium number of species due to higher immigration rate.
- Islands often attains a greater density than their mainland counterparts, called *density compensation.*
- Island species may explore other habitats than would normally be filled by the mainland habitats, called *habitat expansion.*
- Together density compensation and habitat expansion is called *ecological release*.

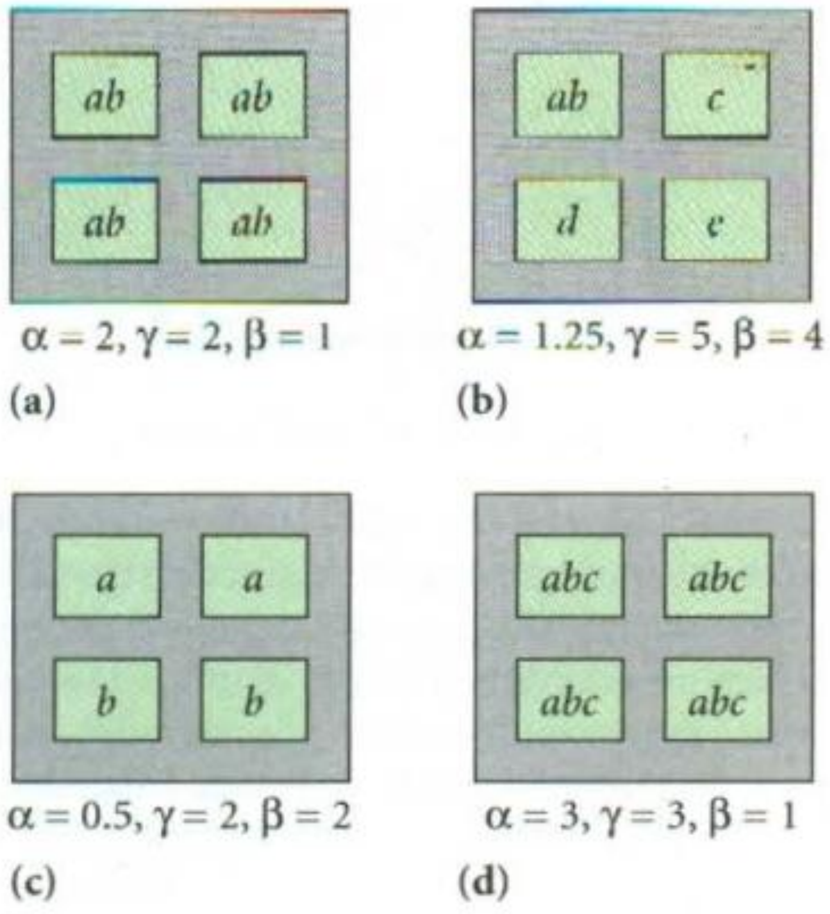






Local and regional components of biodiversity

- **α diversity:** Local diversity, i.e. species found with in a local patch.
- **β diversity:** Difference of diversity between two local patch. Greater the difference between two patch greater the β diversity.
- **γ diversity:** Regional diversity. It is total number of species observed in a region considering all patches.
- If all species occur in all patches in a region then α and γ diversities are same and β diversity will be 1.
- γ diversity = α diversity × β diversity, or β diversity = γ diversity/ α diversity
- Usually, the difference in diversity results from increase habitat heterogeneity, but in case of islands similar kinds of habitat may show different species composition.



Community boundaries

- Clement believed that species belonging to a community are closely associated with one another and that the ecological limits of distribution of each species coincides with distribution of the all species in a community as a whole. This kind of communities called *closed communities.*
- Gleason believed that each species was distributed independently of others that co-occurred with it in a particular association, a concept referred to as an *open community*.
- Open communities have no natural boundaries; therefore, their limits are arbitrary with respect to the geographic and ecological distributions of their component species, which may extend their ranges independently into other associations.
- The transitional zone between two communities is called *ecotone*. It is often characterised by specialized kind of vegetations.
- The ecotone may be narrow or wide.
- Ecotone usually have greater number and density of species than the neighbouring habitat. This effect is called *edge effect*.
- Species that uses edges for the survival or reproduction called *edge species.*

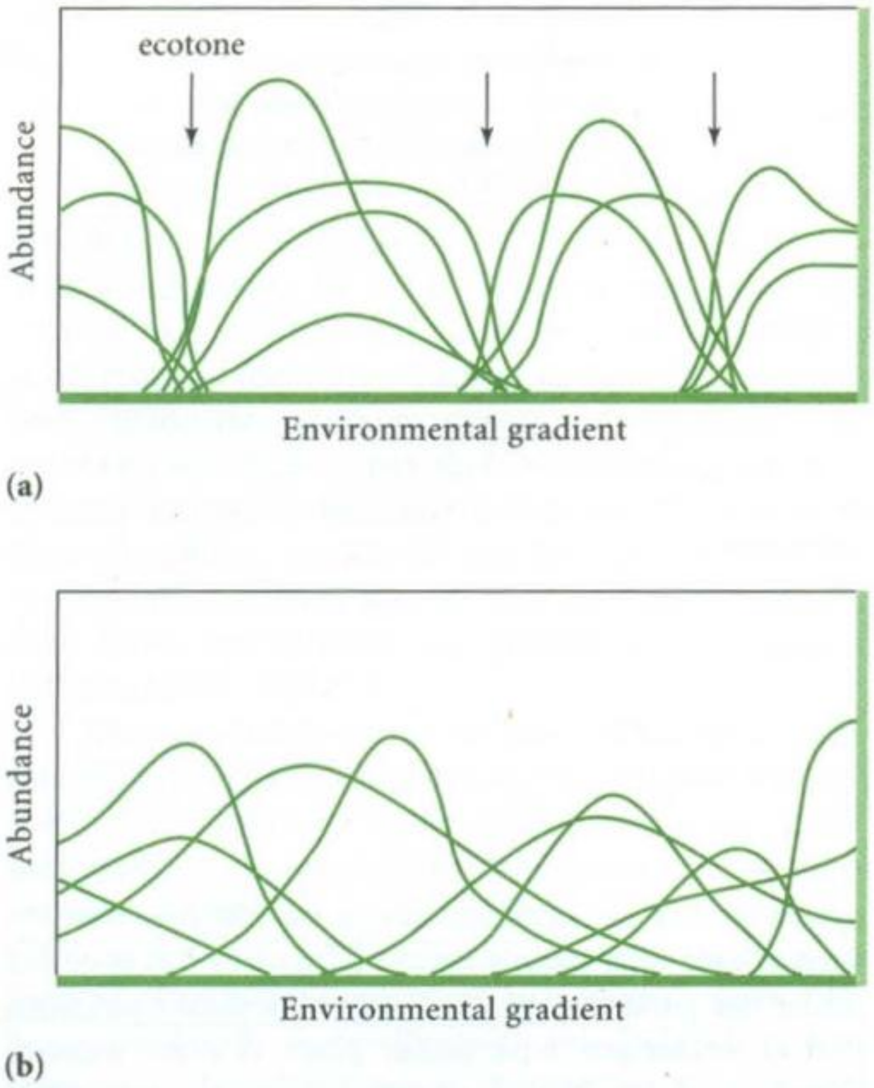
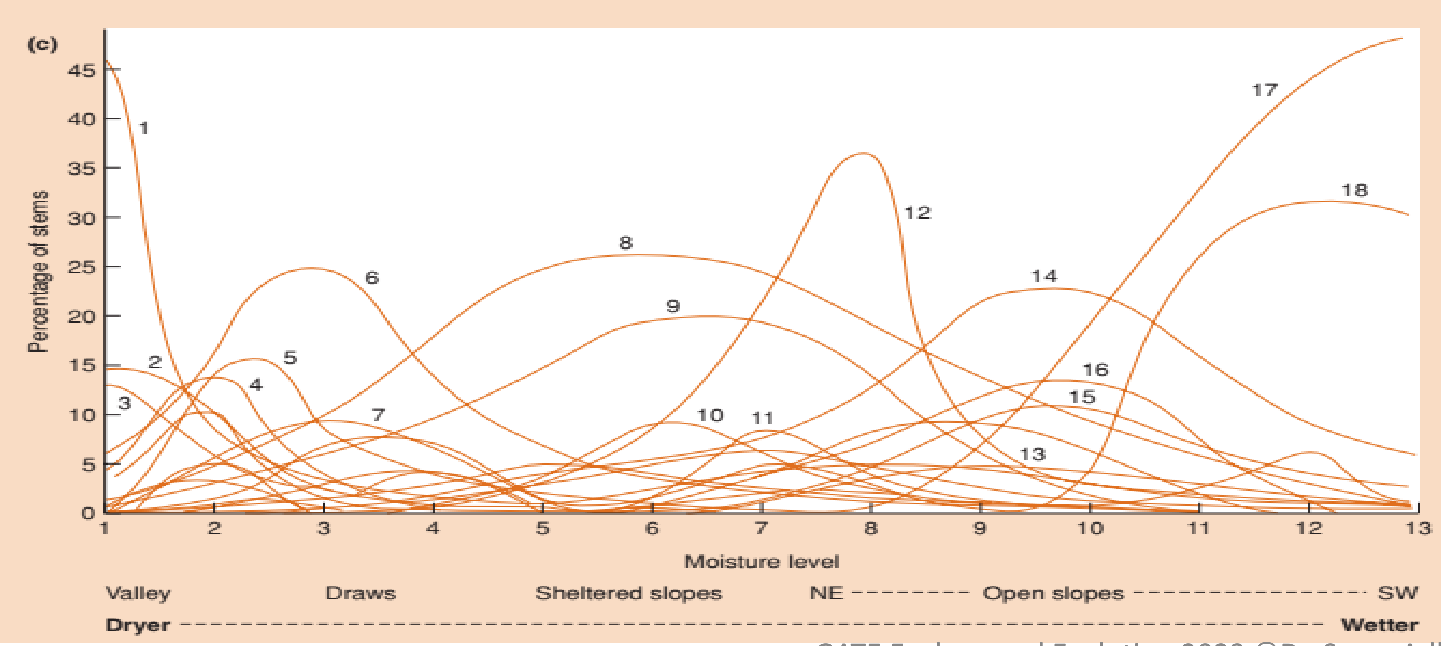
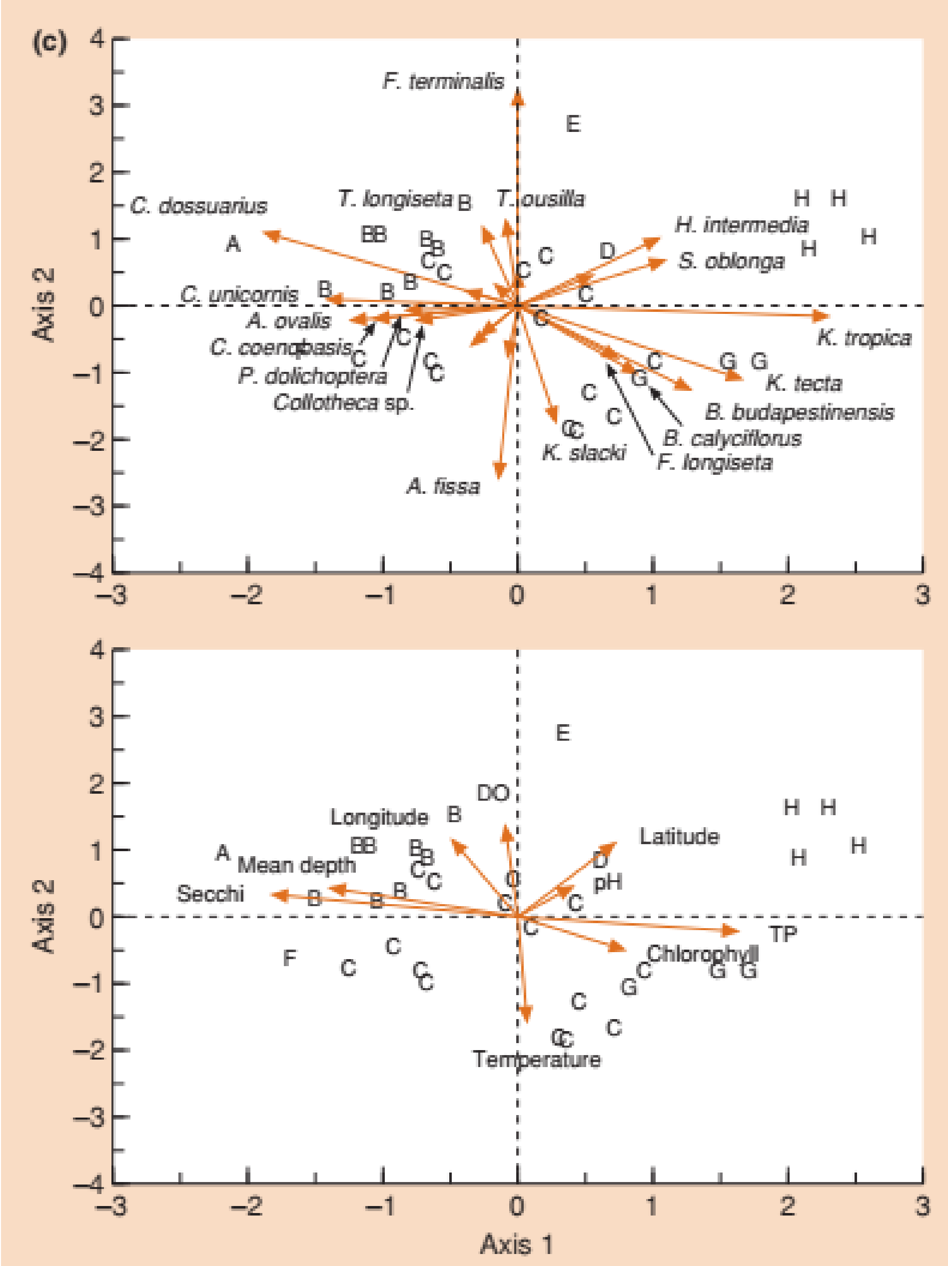


FIGURE 26-3 Hypothetical distributions of species according to two concepts of communities. (a) Species are organized into distinct assemblages, referred to as closed communities. The communities are separated by ecotones (indicated by arrows). (b) Species are distributed at random along a gradient of environmental conditions, indicating open communities.

Community boundaries

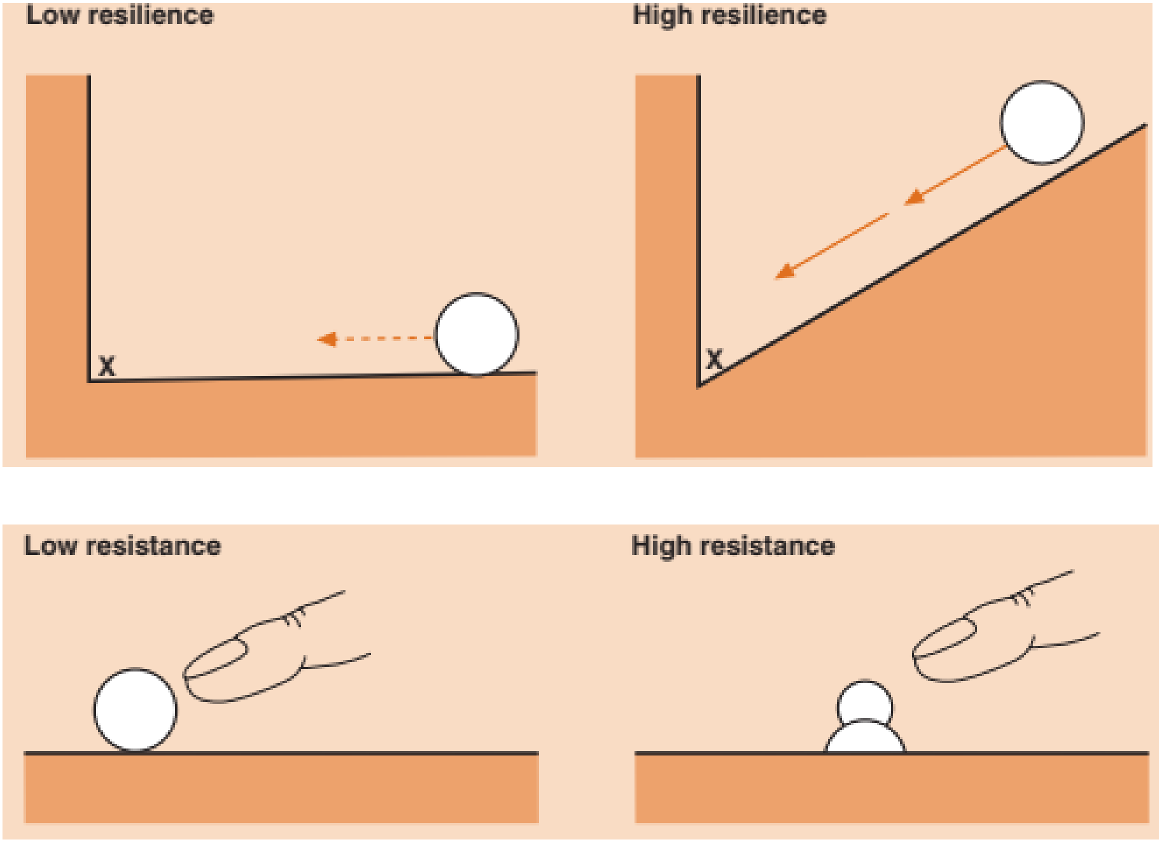
- One way to portray change in community structure is to plot the abundances of species along some continuous gradient of ecological conditions, a procedure referred to as *gradient analysis.*
- A second method of describing community structure within the continuum concept is to place communities along one or more artificial axes based on data obtained from the communities themselves. Such a procedure results in a graph in which each community is represented as a point, with similar communities occurring near one another on the graph. The statistical procedures used to accomplish this are together referred to as *ordination.*





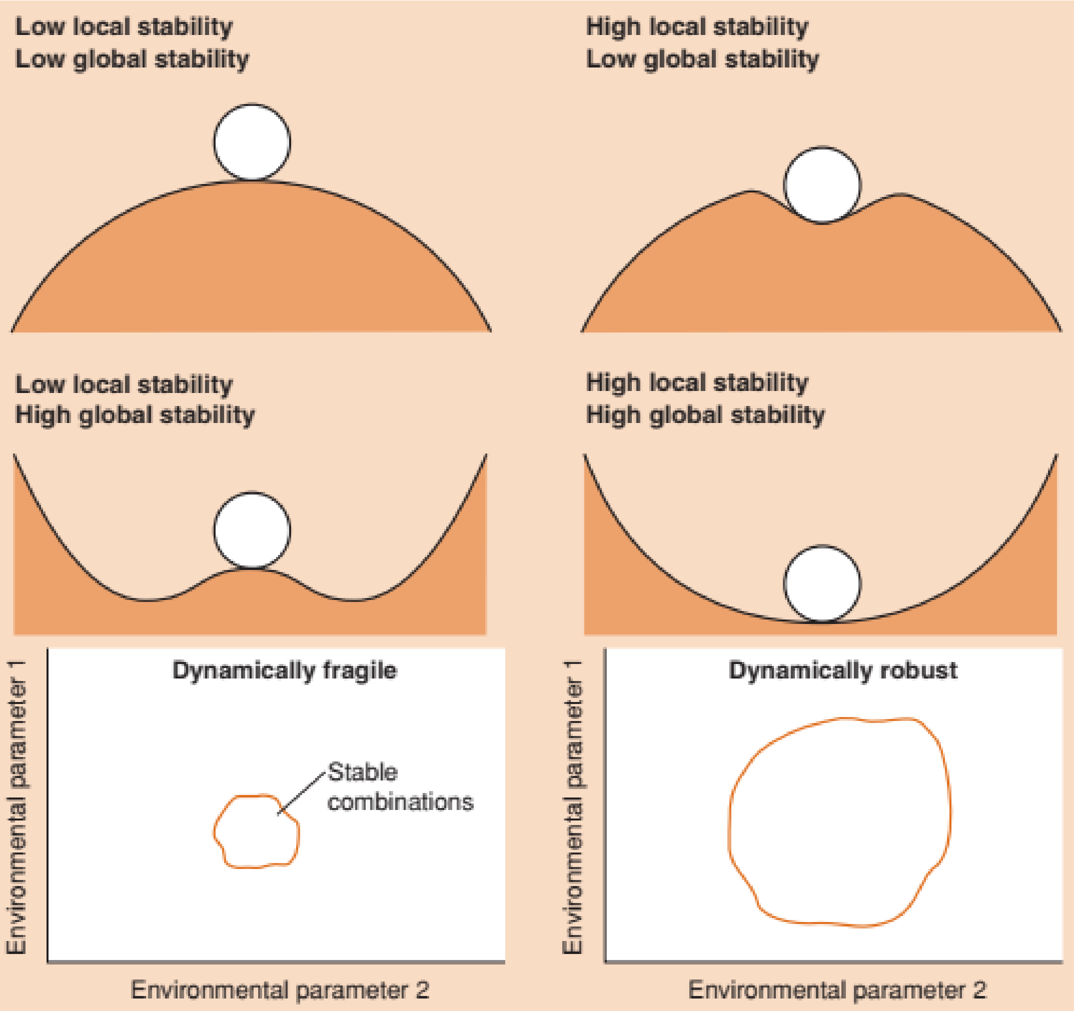
Community complexity and stability

- Community complexity is a function of number of interconnections between community element.
- Complexity increases as the number of the interacting species increases.
- The interaction can of 2 types:
  - *Horizontal:* Interactions between the species of same trophic level.
  - *Vertical:* Interactions between species of different trophic level.
- Stability involves 2 components:
  - *Resilience*: The ability of a community to return to its original state quickly following displacement. It is associated with the dominance of r-selected species.
  - *Resistance:* The ability to avoid displacement. It is associated with the dominance of K-selected species.



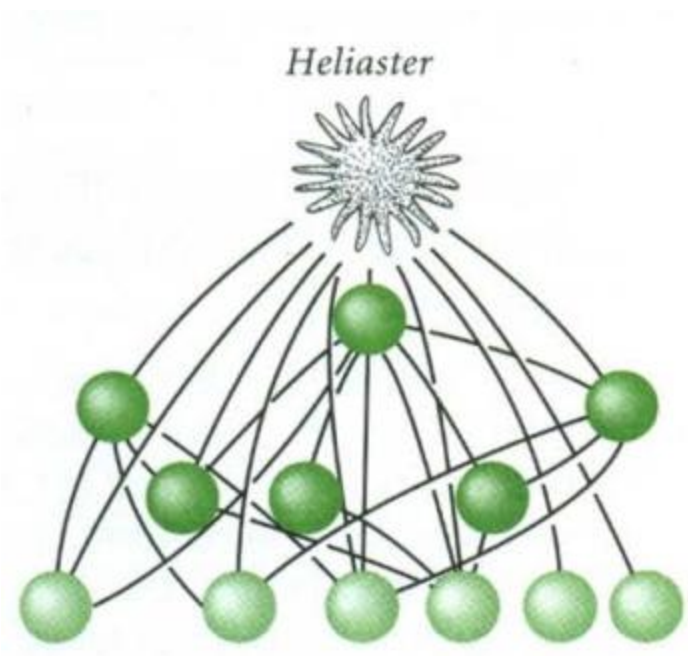
Community complexity and stability

- Stability is of 2 types:
  - *Local stability* describes the tendency of a community to return to its original state after small perturbations.
  - *Global stability* describes the same tendency when the community is subjected to a large perturbation.
- Community stability also depends on the environmental conditions and species characteristics:
  - A community that is stable only within a narrow range of environmental conditions, or for only a very limited range of species' characteristics, is said to be *dynamically fragile*.
  - Conversely, one that is stable within a wide range of conditions and characteristics is said to be *dynamically robust.*



Different kinds of species

- *Keystone species:* These are the species upon which several species depends irrespective their number and whose removal will result in collapse of the food web and ultimate disappearance of the other species. Concept was introduced by Robert T Paine (1969).
- *Endemic species:* Endemic species are those plants and animals that exist only in one geographical region.
- *Endangered/Threatened species:* The species that is very likely to become extinct in the near future, either worldwide or in a particular political jurisdiction. Endangered species may be at risk due to factors such as habitat loss, poaching and invasive species.



Different kinds of species

- *Umbrella species:* Conservation and protection of these species indirectly affects the conservation and protection of other species within their ecosystem. The protection extended to the other species by the presence of the umbrella species is known as the umbrella effect.
- *Flagship species:* It is a species chosen to raise support for biodiversity conservation in a given place or social context. Definitions have varied, but they have tended to focus on the strategic goals and the socio-economic nature of the concept, to support the marketing of a conservation effort. The species need to be popular, to work as symbols or icons, and to stimulate people to provide money or support.

Flagship vs Umbrella species

- Similarities between Flagship and Umbrella species?
  - Flagship and umbrella species make conservation decisions easier.
  - However, the use of both flagship and umbrella species has limitations.
  - Both types of species are relatively large animals.
  - Conservation of both flagship and umbrella species causes the conservation of many other species in ecosystems.
  - Both types of species emphasize and encourage people to conserve biodiversity.
  - Most flagship and umbrella species are endangered.

Flagship vs Umbrella species

	Flagship species	Umbrella species
Definition	This species acts as icon or symbol of a defined habitat.	Conservation of this species leads to conservation of many other species in the ecosystem.
Properties	This species draws the attention of people to conserve the biodiversity of an ecosystem	This species makes the conservation related decision easier.
Example	Bengal Tiger, Asiatic Elephant, Giant Panda	Butterfly, Grizzly Bear, Tiger, Great Indian Bustard

Diversity gradients and causes of variations

- *Latitudinal gradient:* Diversity increases from pole to tropics
- *Altitudinal gradient:* Diversity decreases from lower to higher altitudes.

Table 12.2 Ecological and evolutionary factors that can have an influence on biodiversity. More than one of these factors can operate in any particular ecological community or in any particular taxonomic group. Some factors operate at a local scale and others at regional scales.

Factor	Rationale
1. Evolutionary speed	More time and more rapid evolution permits the evolution of new species
2. Geographical area	Larger areas and physically or biologically complex habitats provide more niches
3. Interspecific interactions	Competition affects niche partitioning and predation retards competitive exclusion
4. Ambient energy	Fewer species can tolerate climatically unfavorable conditions
5. Productivity	Richness is limited by the partitioning of production or energy among species
6. Disturbance	Moderate disturbance retards competitive exclusion

(Modified after Currie 1991, and Willig *et al.* 2003).

In-situ and ex-situ conservations

- **In-situ conservation:** Conservation of habitats and ecosystem where organisms naturally occurs. Ex. Biosphere reserve, Wildlife Sanctuary, Sacred Groves.
- **Ex-situ conservation:** Conservations of elements of biodiversity out of the context of their natural habitat. Ex. Zoos, Botanical Gardens, Gene Bank.

Difference between NP/WLS/BR

	Wildlife Sanctuary	National Park	Biosphere Reserve
Protection type	Usually Species-oriented	Habitat-oriented	Ecosystem-oriented
Legislation	Wildlife (Protection) Act 1972	Wildlife (Protection) Act 1972	UNESCO's Man and Biosphere 1971, implemented in India in 1986
Restriction	Less restriction and open to visitation by general public with some legal limitations under section 27 to 33 of WLPA	Highly restricted, random access to general public is not allowed	Typically divided into following area: **Core:** No human activity is there **Buffer:** Limited human activity is permitted **Manipulation zone:** Several human activities can occur in this zone.
Tourism	Permissible	Encouraged	Only in the buffer zone
IUCN Status	Category IV	Category II	Roughly corresponds to Category V

Ecological Succession

- It is a universal process of directional sequential change in community composition on an ecological time scale.
- In succession the *pioneer* species first established in an area and with multiple unidirectional changes of species composition ultimately *climax community* established.
- Entire story of succession from bare land to a climax community called *successional series* or *sere*.
    - A sere beginning at the water called *hydrosere*.
    - Successional sequence beginning in a place with a deficiency of water such as bare rock, sand dune etc., is termed as *xerosere*.
    - Xerosere developing on rocks called *lithosere*.
- Each temporary stages during the succession process called *seral stages.*
- The concept of succession was proposed by F.E. Clements (1916).

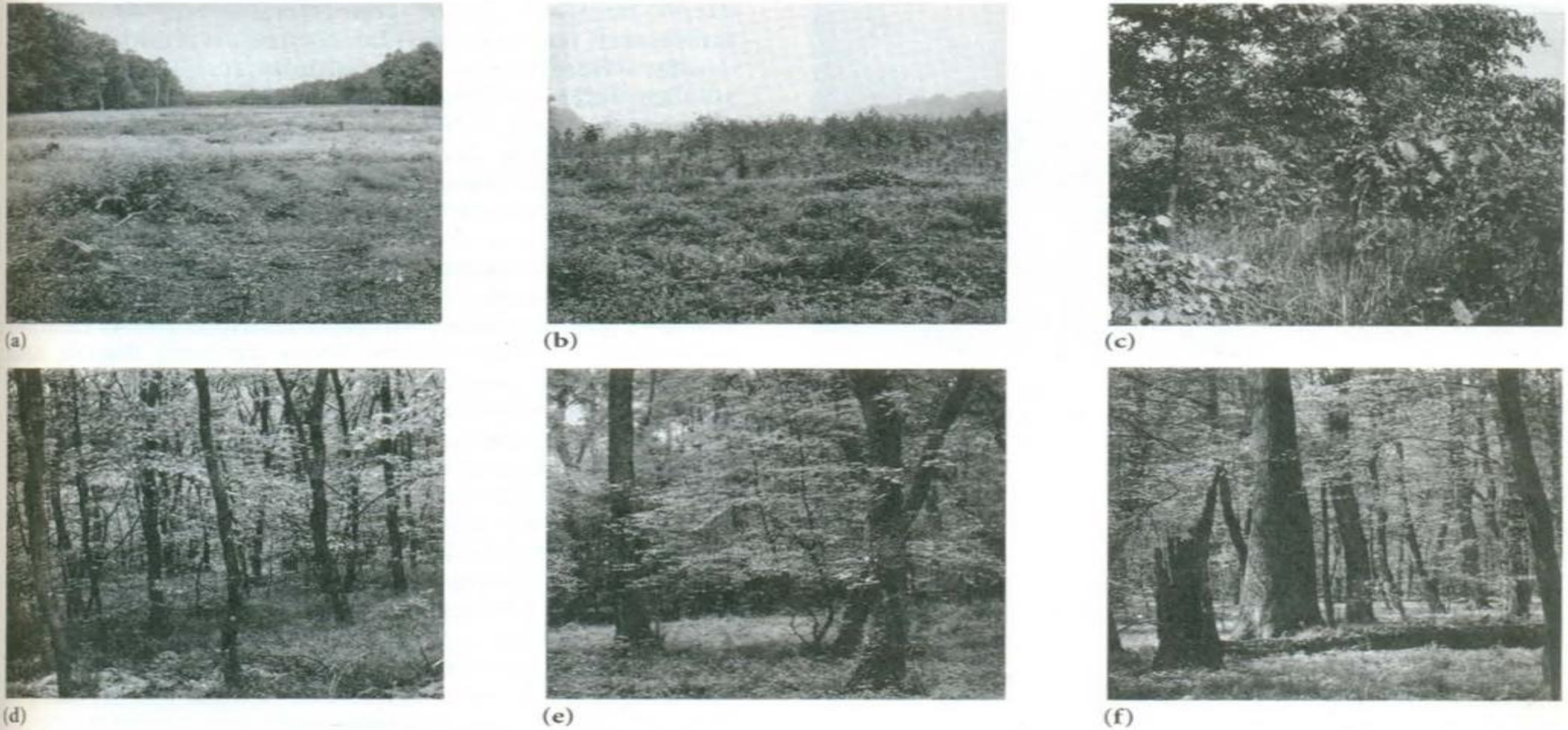


FIGURE 28-1 Stages of succession leading to an oak-hornbeam forest in southern Poland. From (a) to (f), the time since clear-cutting progresses from 0 to 7, 15, 30, 95, and 150 years. (*Photographs by Z. Glowacinski, courtesy of O. Jarvinen; from Glowacinski and Jarvinen 1975.*)

Ecological Succession

- Succession occurring on bare areas such as on a new volcanic island, where no community existed before, called *Primary succession* and the sere is called *prisere.*
- *Secondary succession* occurs at a site from where an already developed community has been destroyed by some natural disturbance or by human activity. The sere is called *subsere*.
- Rate of secondary succession is usually faster than the primary succession.
- *Autogenic succession* is self-driven, resulting from the interaction between organism and their environment. In this case successional changes are brought about by the organisms themselves. Example: changes of the agricultural field to mature forest.
- *Allogenic succession* occurs as a result of the changes brought about in the habitat by external agencies and not by the existing community itself. Example: Filling of a pond by sand.

Ecological Succession

- *Autotrophic succession:* The succession where autotrophs are much greater in quantity than the animals. This kinds of succession takes place in a medium rich in inorganic substances.
- *Heterotrophic succession*: The population of heterotrophic organisms like animals, fungi are present in greater quantities in the initial stages. It begins prominently in organic rich environment.
- *Progressive succession:* simple and few life forms to complex and more life forms. Example: Grassland to forest.
- *Retrogressive succession*: The community becomes simplistic and contains less biomass over time. Example: a forest changing into a grassland community.

Stages of succession

- Nudation: Development of bare area without any life form. The probable factor may be topographic (soil erosion), climatic (glaciation, long dry period, storm, fire), anthropogenic.
- Invasion or migration
- Ecesis: Process of successful establishment of species as a result of adjustment with the prevailing conditions. It is said to be complete if migrating species are able to reproduce there.
- Aggregation: Increase in number as a result of reproduction.
- Competition: Aggregation leads to intra- and interspecific competition.
- Reaction: The modification of the existing environment through the interactions of the living organisms of its own. The modification made gradually the environment unsuitable for the existing community and it is replaced by another community.
- Stabilisation

Theories Interpreting Climax

- *Monoclimax* theory proposed by Clements. As per this hypothesis, climax community is solely determined by the climate of the region.
- *Polyclimax* theory was proposed by Tansley. This theory recognized the validity of many different types of vegetation as climaxes, depending on local conditions.
- *Climax pattern theory* was proposed by RH Whittaker. This recognizes a regional pattern of open climax communities whose composition at any one locality depends on the particular environmental conditions at that point.

Model behind mechanism of succession

1. Facilitation model: Reaction of earlier species makes the environment more suitable for later species.
2. Tolerance model: Reactions of earlier species have little or no impact on the growth of the later species.
3. Inhibition model: Reaction of earlier species makes the environment less suitable for later species.