# Chapter 6
# Population and Community Ecology

# Nature exists at several levels of complexity

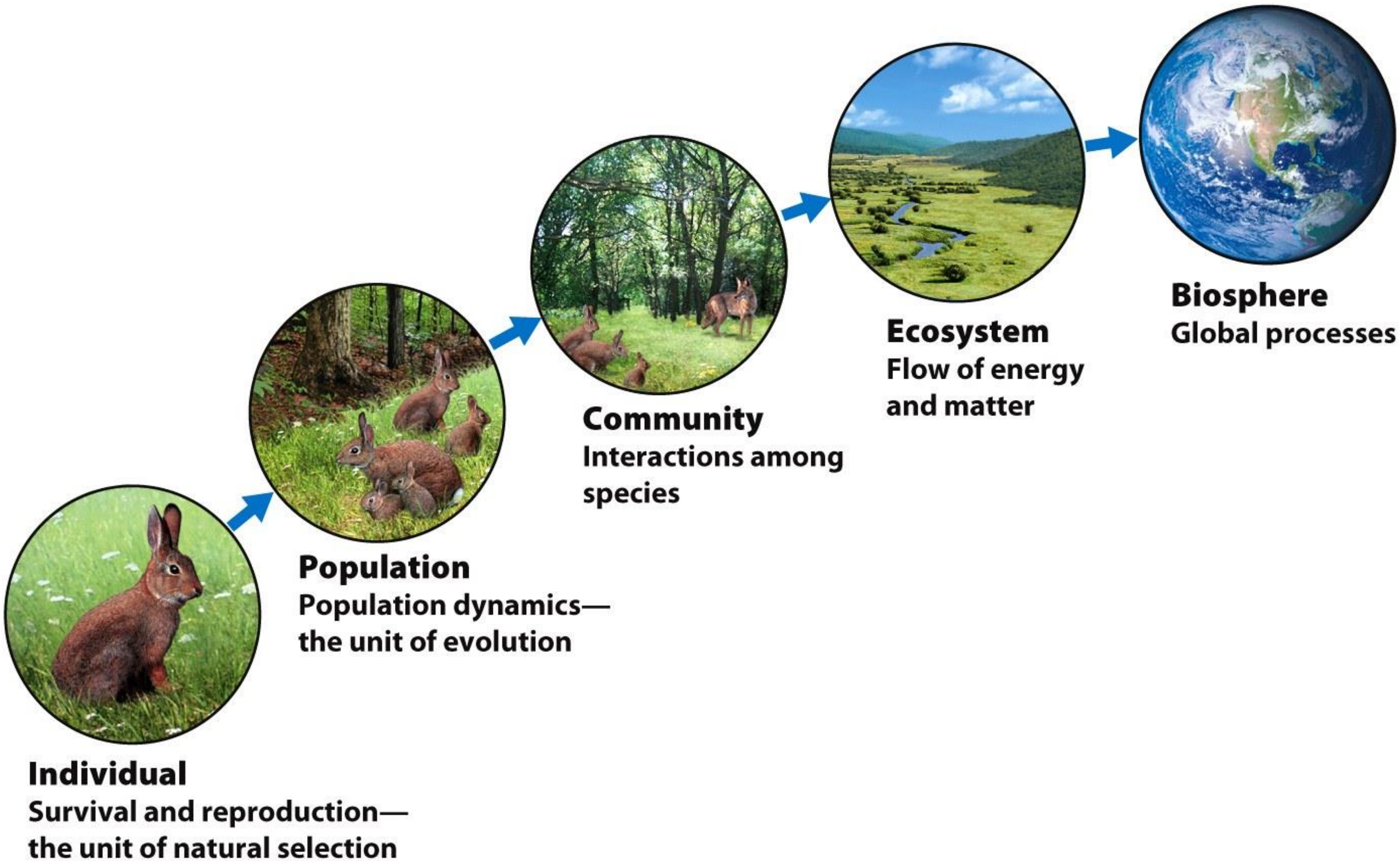



**Figure 6.1**
*Environmental Science*

# Population ecology:
# Population ecologists study the factors that regulate population abundance and distribution.

# Factors that Regulate Population Abundance and Distribution

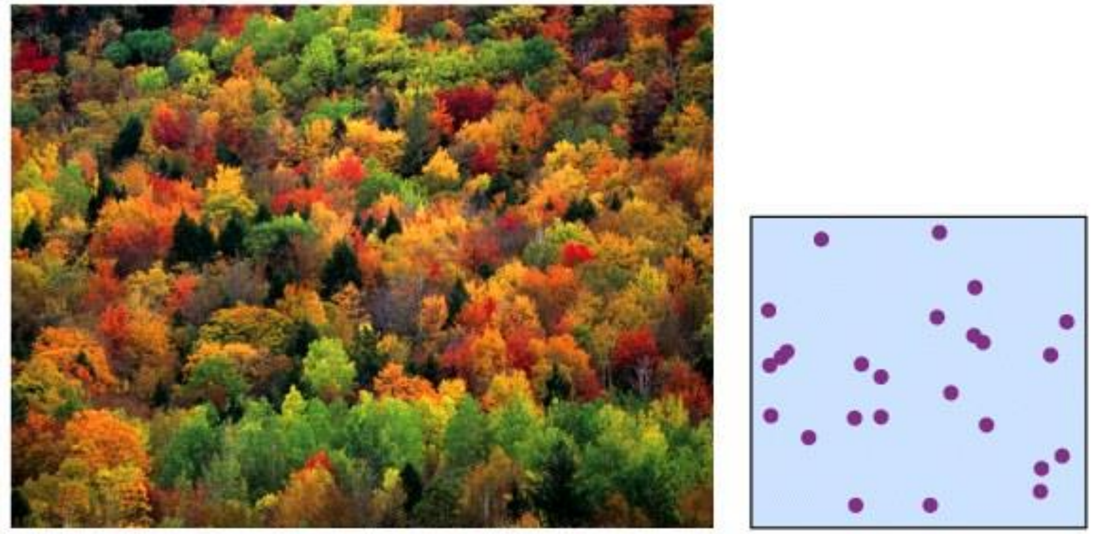
- ***Population size:*** the *total number* of individuals within a *defined area* at a given time.
- ***Population density:*** the number of individuals per unit area at a given time.

# Factors that Regulate Population Abundance and Distribution

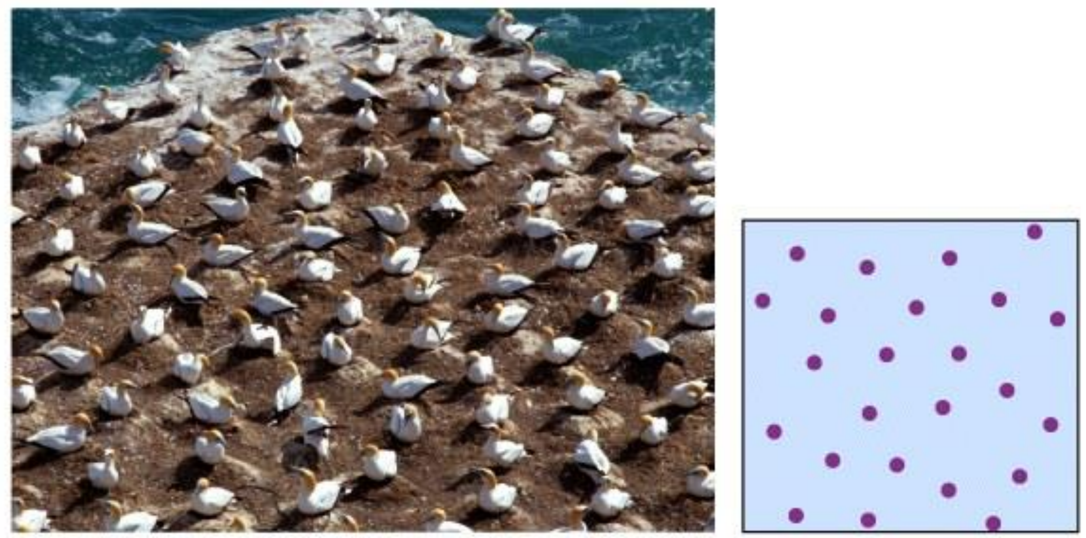
- ***Population distribution:*** how individuals are distributed with respect to one another.
- ***Population sex ratio:*** the ratio of males to females.
- ***Population age structure:*** how many individuals fit into particular age categories.

# Population Distribution

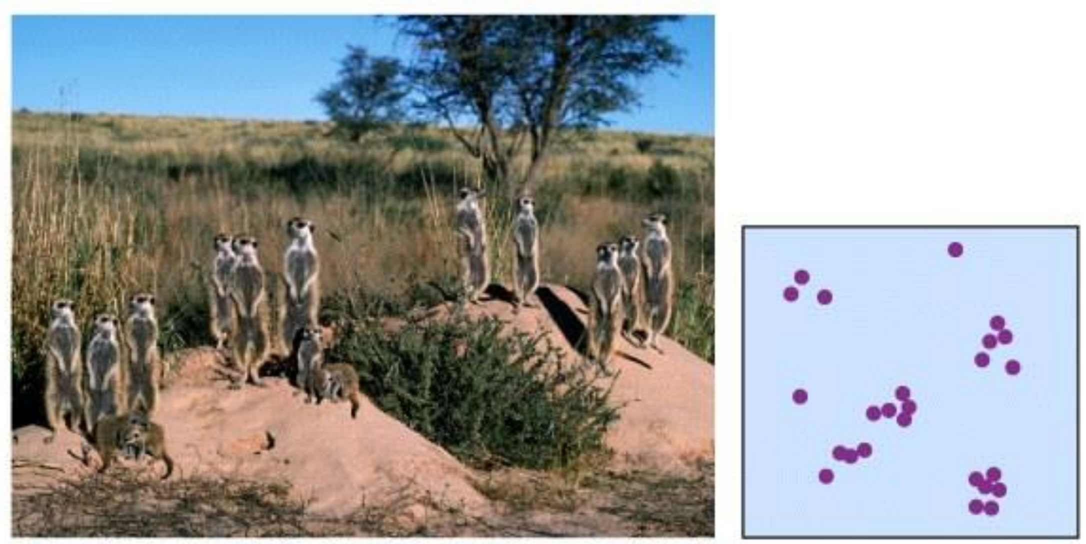
- ***Population distribution:*** how individuals are distributed with respect to one another. There are three types:
  1. Random
  2. Uniform
  3. Clumped



**(a) Random distribution**



**(b) Uniform distribution**



**(c) Clumped distribution**

**Figure 6.3**
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# Factors that Influence Population Size

- ***Density-dependent factors:*** the size of the population will influence an individual's probability of survival.
- ***Density-independent factors:*** the size of the population has no effect on the individual's probability of survival.

# Factors that Influence Population Size

- ***Density-dependent factors:*** these are ***limiting resources*** and influence an individual’s probability of survival and reproduction in a way that depends on the size of the population.

# Factors that Influence Population Size

- *Density-dependent factors include:*
  - For terrestrial plants: water and soil nutrients.
  - For animals: food, water, and nesting sites.

# Factors that Influence Population Size

- ***Density-independent factors*** have the same effect on an individual's likelihood of survival and amount of reproduction, at any population size.

# Factors that Influence Population Size

- *Density-independent factors* include:

  Hurricanes, tornados, floods, fires, volcanic eruptions, environmental temperatures, etc.

**Growth models help ecologists understand population changes.**

# Growth Models

***Population growth models*** are mathematical equations used to predict population size at any moment in time.

# Growth Models

***Growth rate:*** the number of offspring an individual can produce in a given time period, minus the deaths of the individual or offspring during the same period.

# Growth Models

***Intrinsic growth rate:*** under ideal conditions, with unlimited resources, the maximum potential for growth (denoted as ***r***) for a population.

# Exponential Growth Model

If we know:

- the *intrinsic growth rate* for a population ($r$), and
- *current number* of reproducing individuals ($N_0$),

we can estimate the population's *future size* ($N_t$) after a period of *time* ($t$) has passed.

# Exponential Growth Model

- That is, we can use the *exponential growth model* to estimate future population size:

$$N_t = N_0 e^{rt}$$

where ***e*** is the base (2.72) of the natural logarithms.

# Exponential Growth Model

If a population *is not limited by resources*, growth can be very rapid due to many births, forming a *J-shaped curve* when population size is graphed against time.

# Exponential Growth Model

***J-shaped curve:*** when graphed, the *exponential growth model* looks like this:

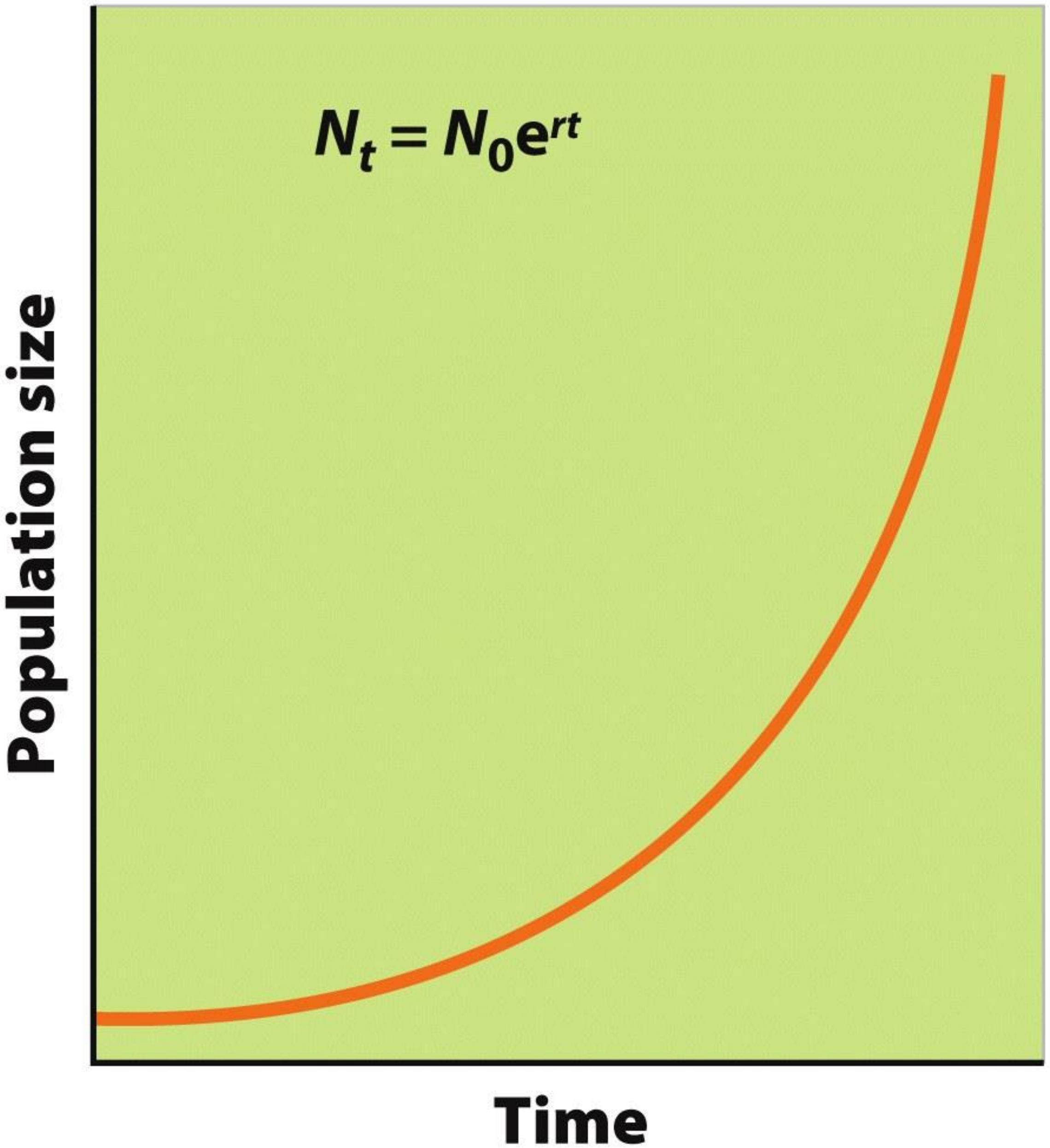


**Figure 6.5**
***Environmental Science***

# Exponential Growth Model

The *exponential growth model* describes a population that grows continuously and at a fixed rate.

# Logistic Growth Model

- ***Logistic growth:*** when a population whose growth is initially exponential, but slows as the population approaches the *carrying capacity*.
- ***S-shaped curve:*** when graphed, the logistic growth model looks like an “S”.

# Logistic Growth Model

***Carrying capacity*** (*K*) is the limit of how large a population can be sustained by the *limiting resources*, especially food.

# Logistic Growth Model

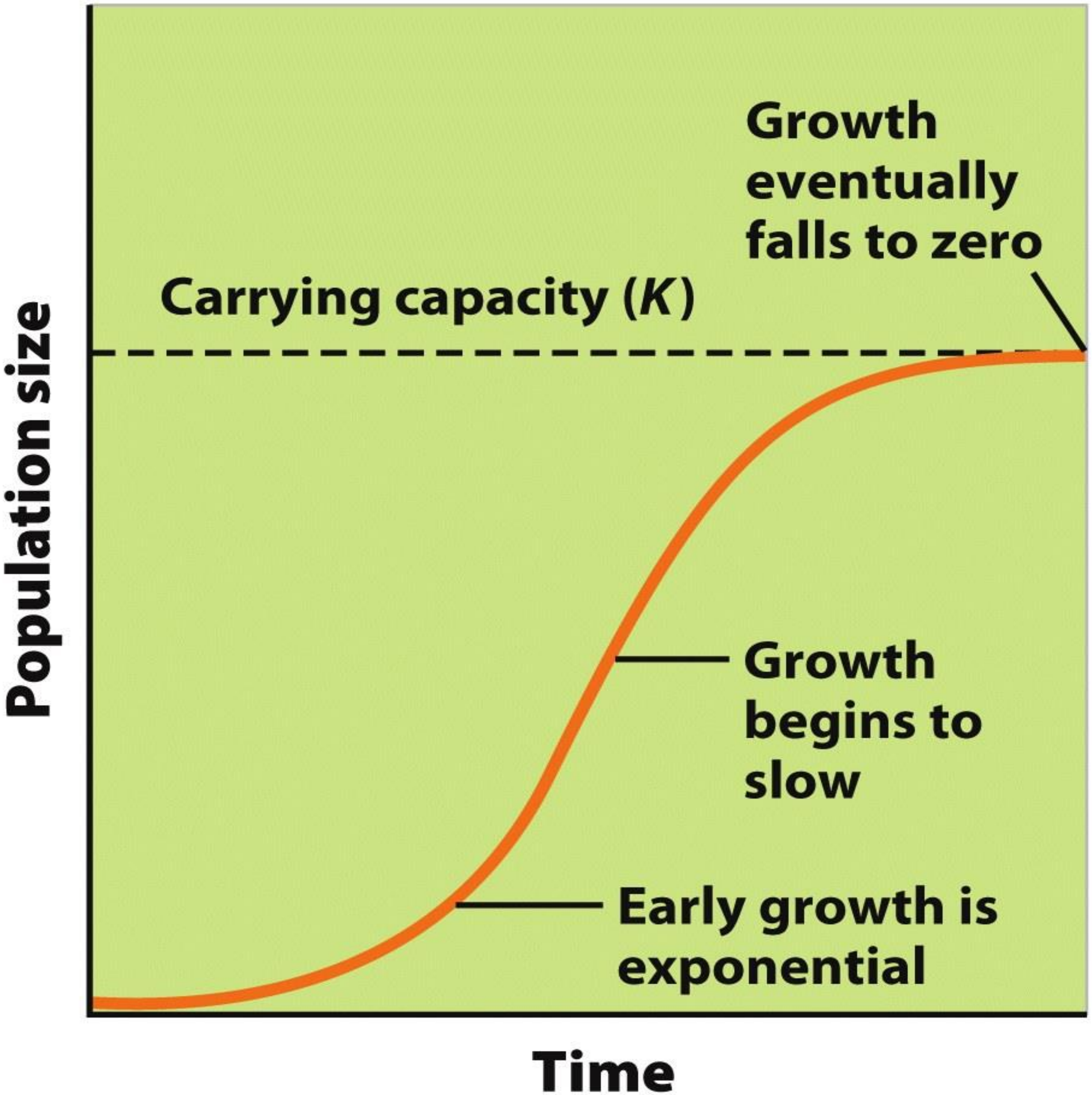


Figure 6.7
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# Logistic Growth Model

At *carrying capacity*, growth ceases as the number of births equals the number of deaths.

# Variations on the Logistic Model

- If food or other limiting resources become scarce, the population will experience an ***overshoot*** by becoming larger than the carrying capacity.
- This will result in a ***die-off***, or population crash.

# Variations of the Logistic Model

*Overshoot* and *die-off*.

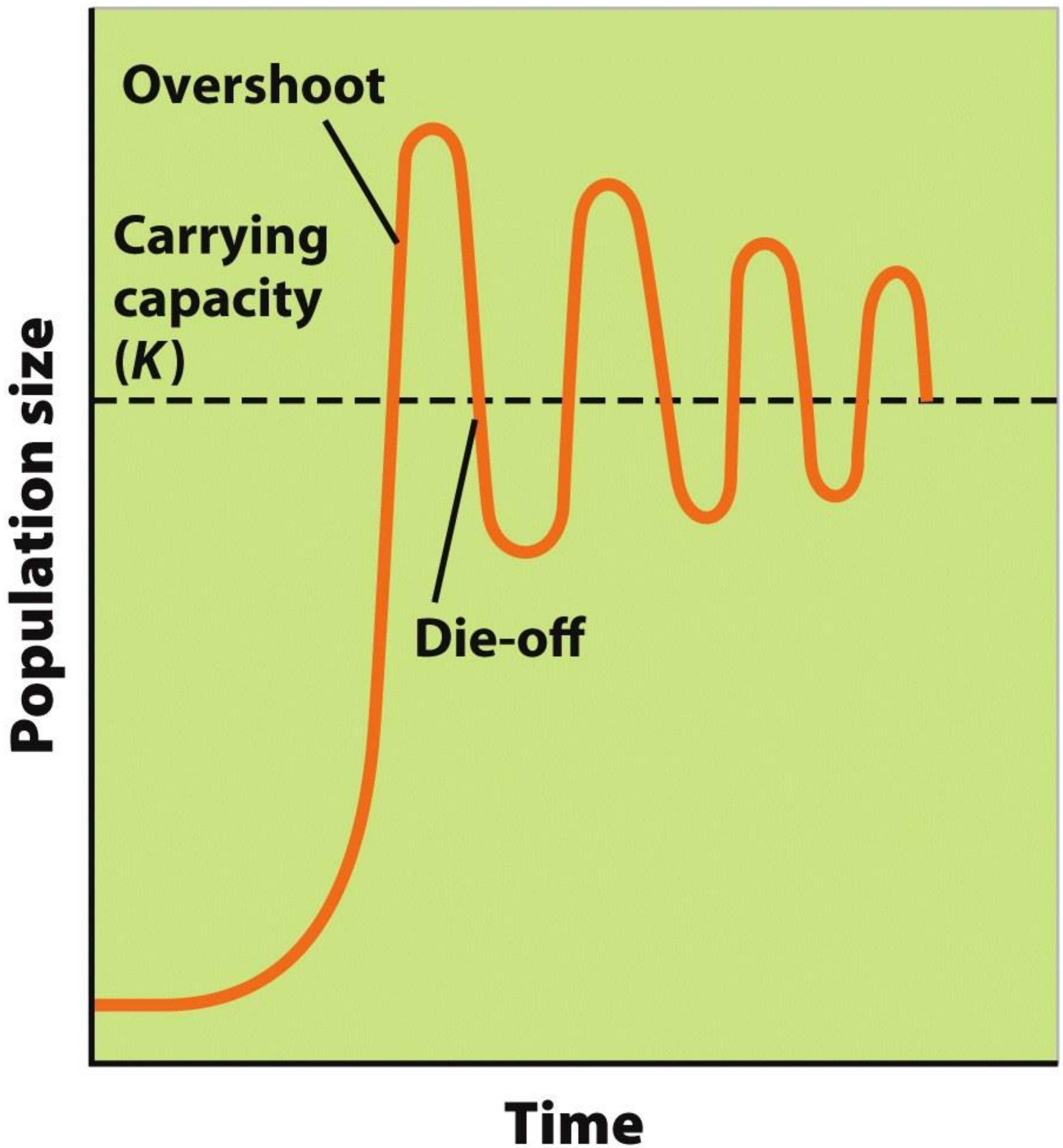


**Figure 6.9**
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# Reproductive Strategies

- ***K-selected species:*** the population of a species that grows slowly until it reaches the carrying capacity.
- Abundance is determined by carrying capacity, hence the use of "*K*".
- Examples include elephants, whales, and humans.

# Reproductive Strategies

- ***R-selected species:*** the population of a species that grows quickly, and is often followed by overshoots and die-offs.
- So-called because "*r*" denotes the intrinsic growth rate.
- Examples include mosquitoes and dandelions.

## TABLE 6.1 Traits of *K*-selected and *r*-selected species

| Trait | *K*-selected species | *r*-selected species |
|---|---|---|
| Life span | Long | Short |
| Time to reproductive maturity | Long | Short |
| Number of reproductive events | Few | Many |
| Number of offspring | Few | Many |
| Size of offspring | Large | Small |
| Parental care | Present | Absent |
| Population growth rate | Slow | Fast |
| Population regulation independent | Density dependent | Density |
| Population dynamics | Stable, near carrying capacity | Highly variable |

**Table 6.1**
***Environmental Science***

# Survivorship Curves

- Different species have distinct *survivorship patterns* of the life span:
  - ***Type I curve:*** excellent survivorship over life span.
  - ***Type II curve:*** relative constant decline.
  - ***Type III curve:*** low rates of early survivorship.

# Survivorship Curves

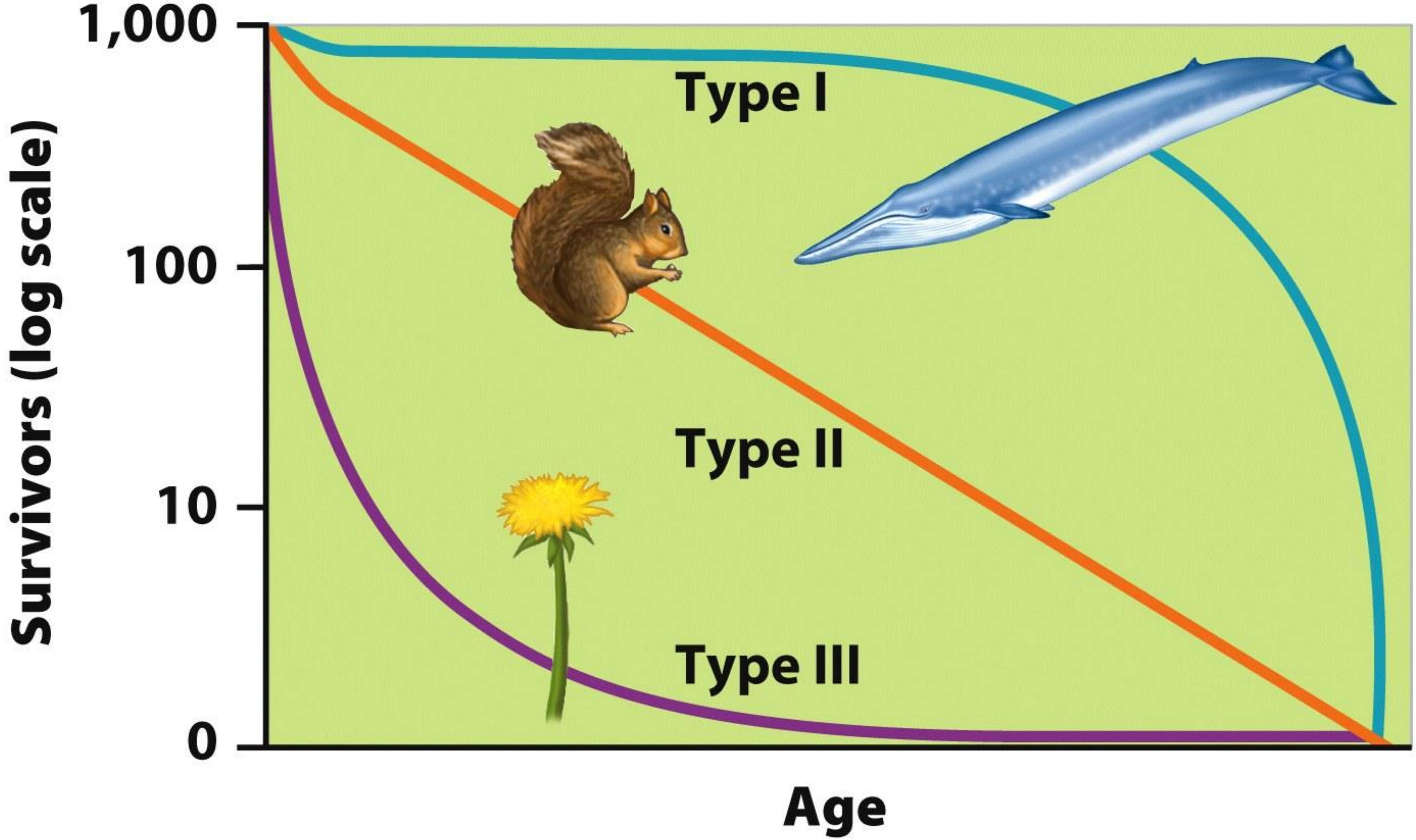



Figure 6.12
*Environmental Science*

# Metapopulations

- ***Metapopulations:*** a group of spatially distinct populations that are connected by occasional movements of individuals between them.
- This connectedness is important for each population's survival.
- Small, isolated populations are more likely to go extinct.

# Metapopulations

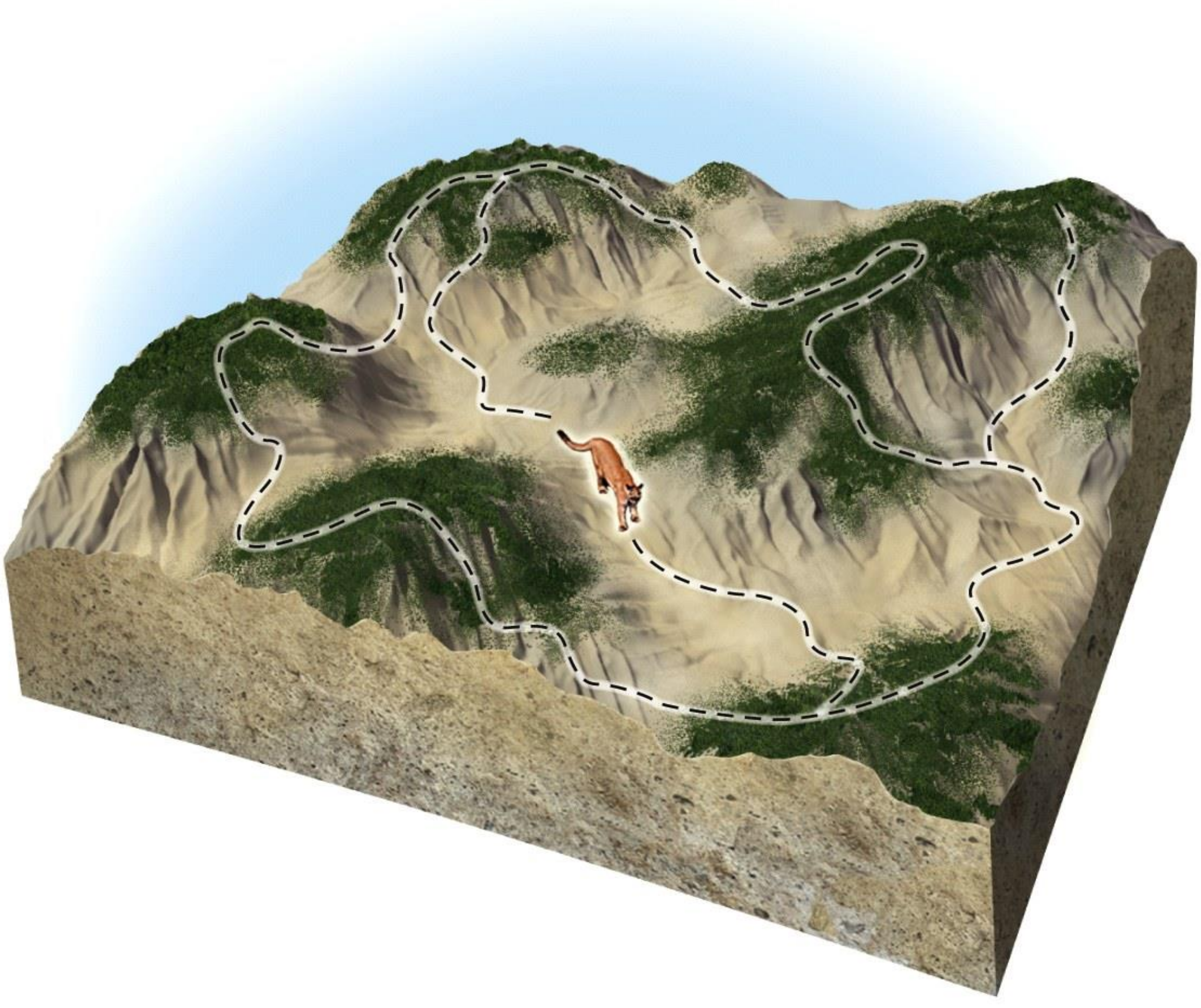


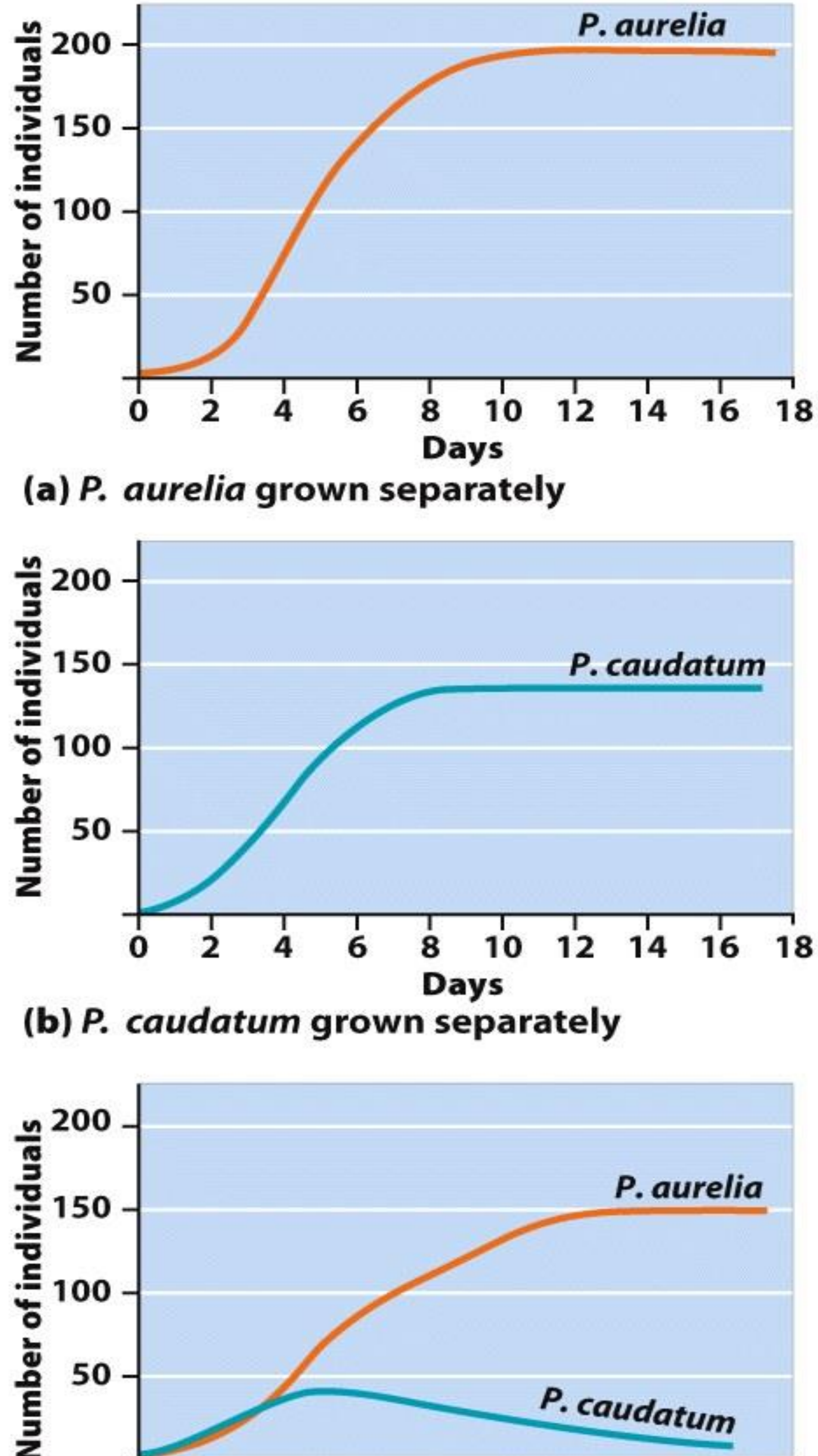
Figure 6.13
*Environmental Science*

# Community ecologists study species interactions.

# Competition

- ***Competition:*** individuals struggling to obtain a limiting resource.

# Competition




(a) *P. aurelia* grown separately

(b) *P. caudatum* grown separately

(c) *P. aurelia* and *P. caudatum* grown together

**Figure 6.14**
***Environmental Science***

# Competition

- ***Competitive exclusion principle:*** two species competing for the same limiting resources cannot coexist. This can lead to *resource partitioning*.
- ***Resource partitioning:*** two species co-evolve to divide a limiting resource, through differences in species behavior or form.

# Resource Partitioning

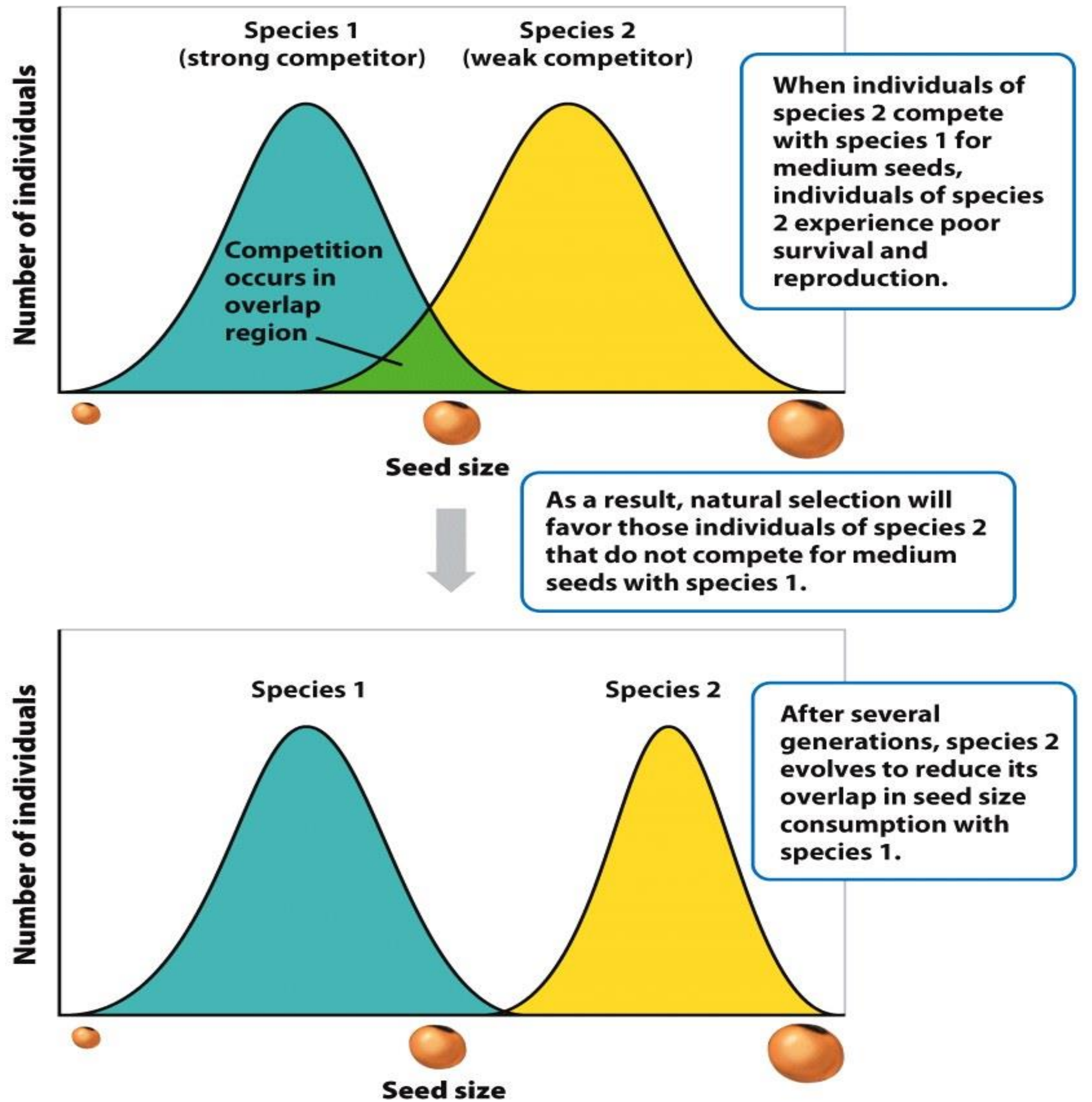



**Figure 6.15**
***Environmental Science***

# Predation

- ***Predation:*** the use of one species as a resource by another species.
- Predators are found in four forms: *true predators, herbivores, parasites*, and *parasitoids*.

# Predation

- ***True predators:*** kill their prey.
- ***Herbivores:*** consume plants as prey.
- ***Parasites:*** live on or in the organism they consume. If they cause disease, they are *pathogens*.
- ***Parasitoids:*** lay eggs inside other organisms.

# Mutualism

- ***Mutualism:*** A type of *interspecific interaction* where both species benefit.

Figure 6.18
*Environmental Science*


Figure 6.18 (inset)
*Environmental Science*

# Commensalism

- ***Commensalism:*** a type of relationship in which one species benefits but the other is neither harmed nor helped.

# Symbiosis

- ***Symbiotic relationships:*** two species live in close association.
- *Commensalism*, *mutualism*, and *parasitism* are all examples of symbiotic relationships.

# Summary of Species Interactions

**+ is a positive effect, – negative, and 0 is neutral.**

**TABLE 6.2 Interactions between species and their effects**

| Type of interaction | Species 1 | Species 2 |
|---|---|---|
| Competition | – | – |
| Predation | + | – |
| Mutualism | + | + |
| Commensalism | + | 0 |

Table 6.2
*Environmental Science*

# Keystone Species

- ***Keystone species:*** a species that plays a role in its community that is far more important than its relative abundance might suggest.

**Figure 6.22 (inset)**
***Environmental Science***


**Figure 6.22**
***Environmental Science***

# Keystone Species

- ***Keystone species*** typically exist in low numbers.
- They may be predators, sources of food, mutualistic species, or providers of other *ecological services*.
- For instance, North American beavers can act as ***ecological engineers,*** modifying their environment in ways that create and maintain their habitat.

# The composition of a community changes over time.

# Ecological Succession

- ***Ecological succession*** occurs as:
  - *Primary succession*
  - *Secondary succession*
  - *Aquatic succession*

# Primary Succession

- ***Primary succession:*** occurs on surfaces that are initially devoid of soil.

# Primary Succession

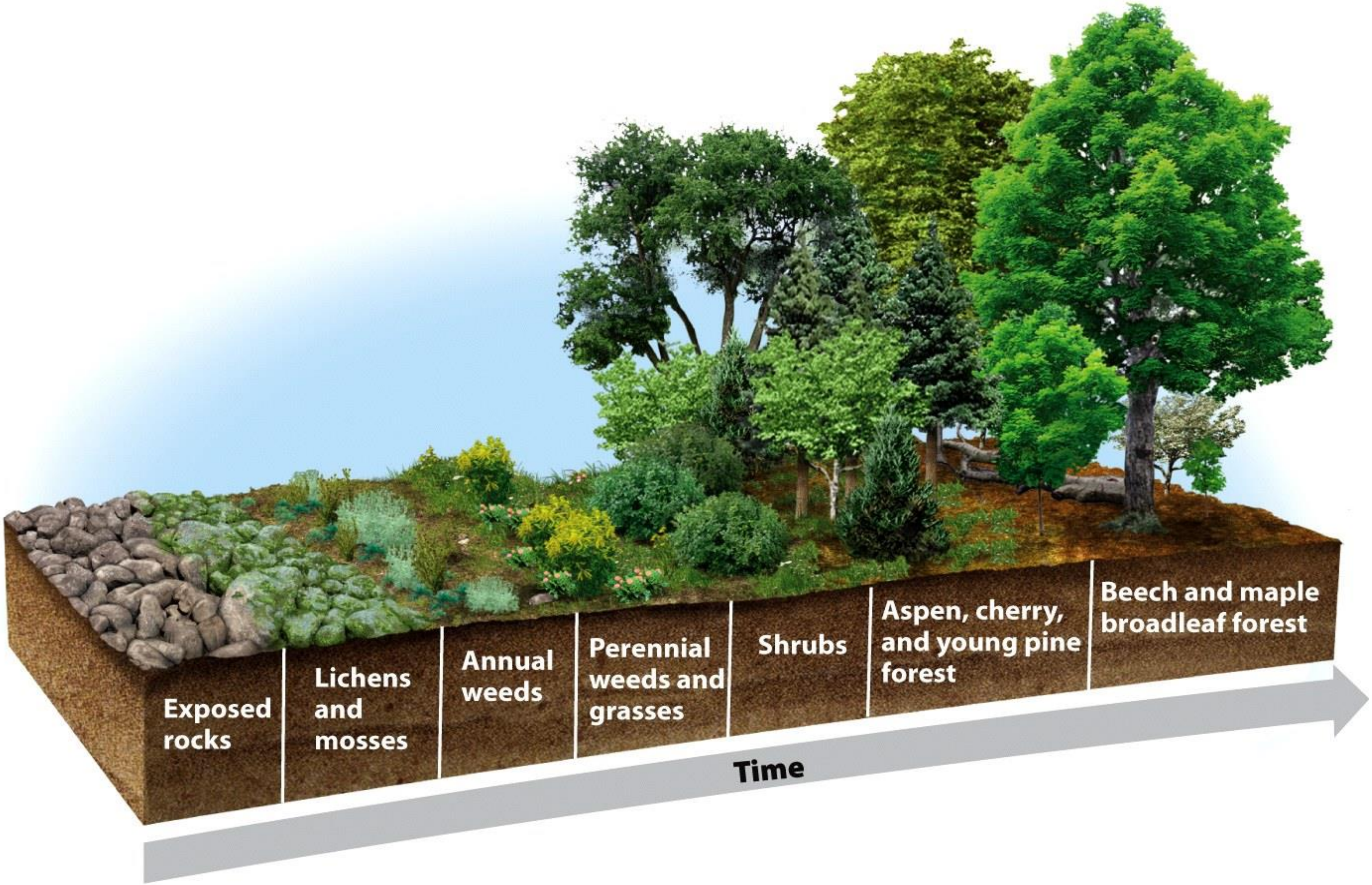



**Figure 6.23**
***Environmental Science***

# Secondary Succession

- ***Secondary succession:*** occurs in areas that have been disturbed but have not lost their soil.

# Secondary Succession

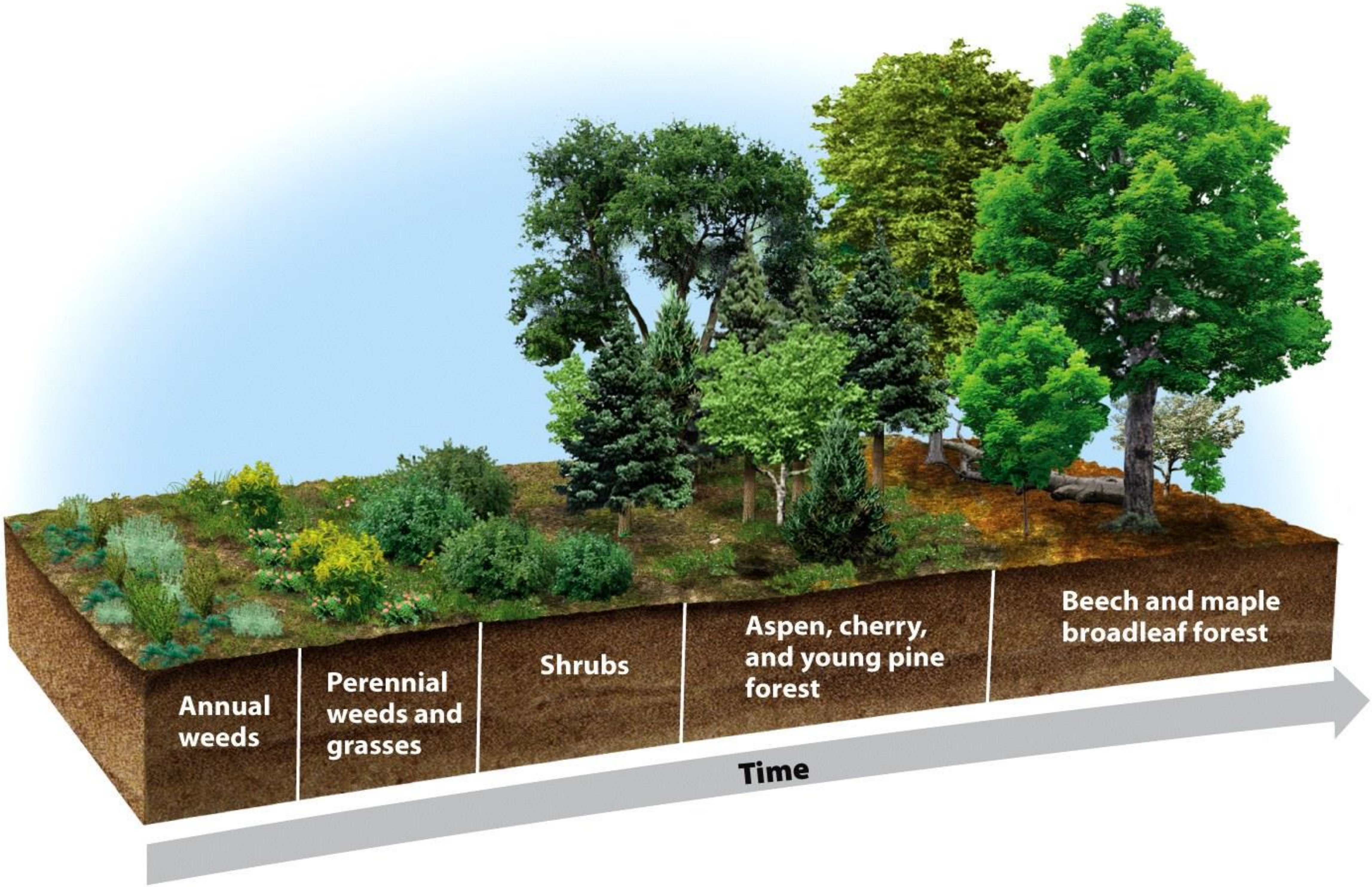



Figure 6.24
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# Aquatic Succession

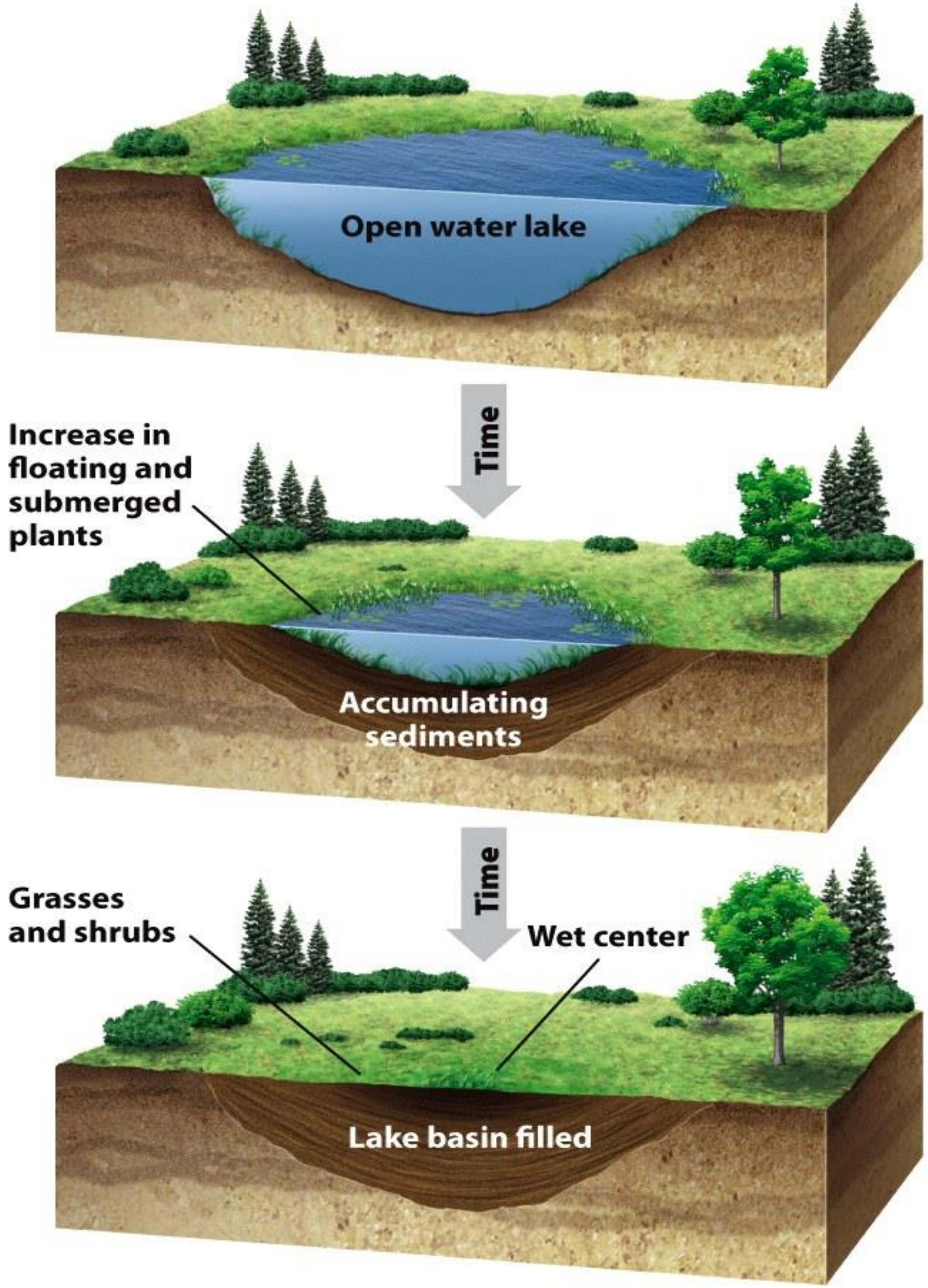


**Figure 6.25**
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**The species richness of a community is influenced by many factors.**

# Factors that determine species richness

- ***Latitude:*** moving north or south away form the equator, species richness declines.
- ***Time:*** older habitats show more variety of species.

# Factors that determine species richness

- ***Habitat size and distance:*** *size of the habitat* and *distance from the colonizing species* affects the number and types of species. This is the basis for *the theory of island biogeography*.

# Theory of Island Biogeography

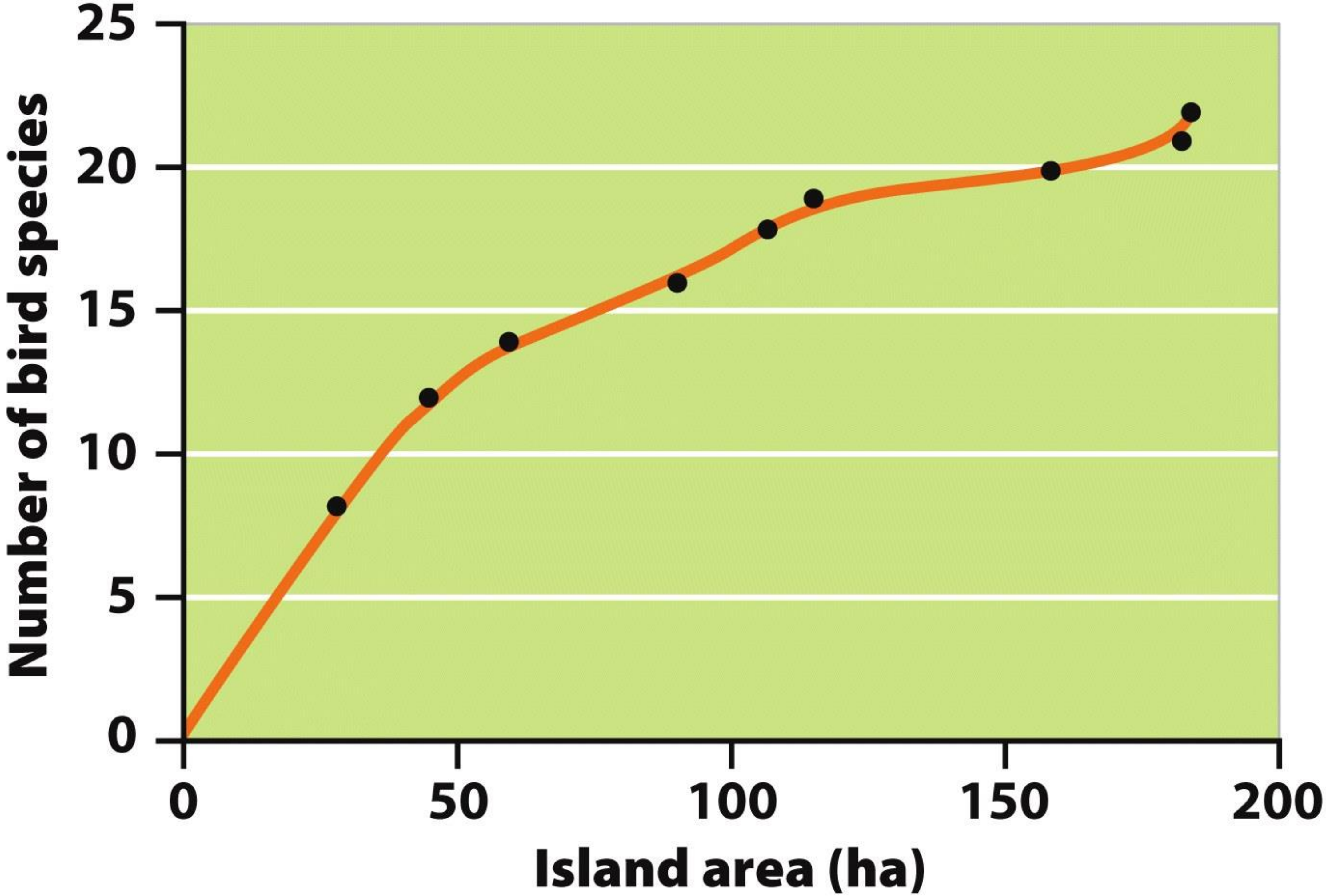


Figure 6.26
*Environmental Science*

# Review Questions

1. List the levels of complexity that make up the biosphere.
2. Distinguish a *population* from a *community*.
3. What is the difference between immigration and emigration?
4. What are the three ways in which a population can be distributed?

# Review Questions

5. What is the difference between a *density-dependent* and a *density-independent* factor?
6. Give an example of each type of factor.
7. The *J-shaped curve* is associated with what model?
8. The *S-shaped curve* is associated with what model?

# Review Questions

9. How is a die-off associated with carrying capacity?
10. Give some characteristics of a *K*-selected species? Give an example.
11. What are some characteristics of an *r*-selected species? Give an example.
12. What are the three types of survivorship curves, and how do they differ form one another?

# Review Questions

13. Name and describe the four forms of *predation*.
14. What is a pathogen?
15. Distinguish mutualism from commensalism.
16. What is a keystone species? Why are they important in ecosystems?

# Review Questions

17. What is primary succession?
18. What is secondary succession?
19. Which type of succession would occur on an abandoned parking lot?
20. What are the two factors underlying the *theory of island biogeography*?