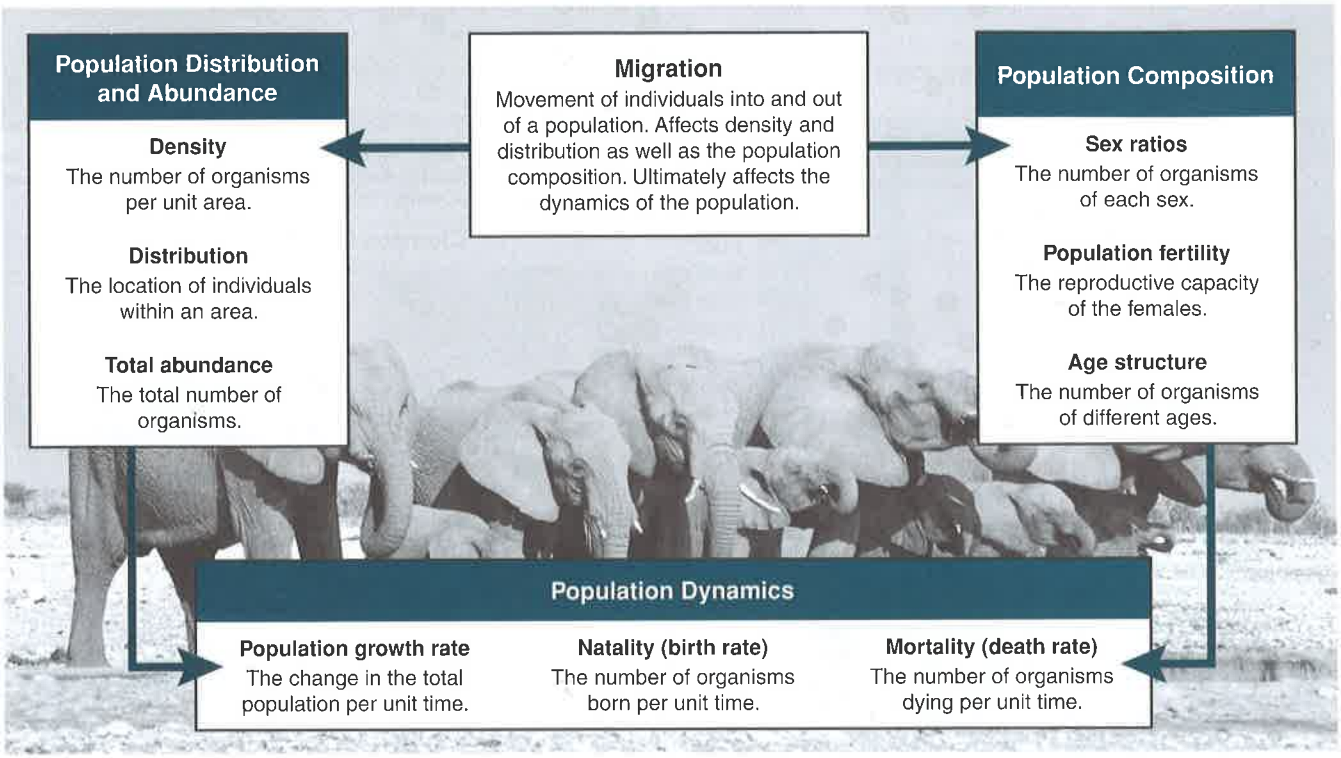
# Features of Populations

Populations have a number of attributes that may be of interest. Usually, biologists wish to determine **population size** (the total number of organisms in the population). It is also useful to know the **population density** (the number of organisms per unit area). The density of a population is often a reflection of the **carrying capacity** of the environment, i.e. how many organisms a particular environment can support. Populations also have structure; particular ratios of different ages and sexes. These data enable us to determine whether the population is declining or increasing in size. We can also look at the **distribution** of organisms within their environment and so determine what particular aspects of the habitat are favored over others. One way to retrieve information from populations is to **sample** them. Sampling involves collecting data about features of the population from samples of that population (since populations are usually too large to examine in total). Sampling can be done directly through a number of sampling methods or indirectly (e.g. monitoring calls, looking for droppings or other signs). Some of the population attributes that we can measure or calculate are illustrated on the diagram below.




1. Describe one example of a population attribute that would be a good indicator of each of the following:

   (a) Whether the population is increasing or decreasing: ______________________

   (b) The ability of the environment to support the population: ______________________

2. (a) Identify the population attributes that can be measured directly from the population: ______________________

   (b) Identify the population attributes that must be calculated from the data collected: ______________________

3. Describe the value of population sampling for each of the following situations:

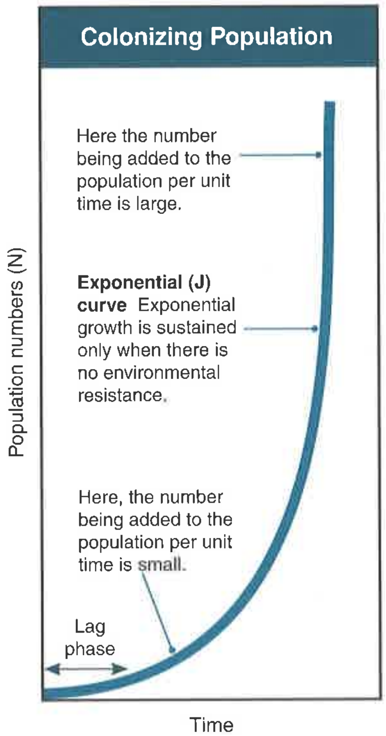
   (a) Conservation of a population of an endangered species: ______________________

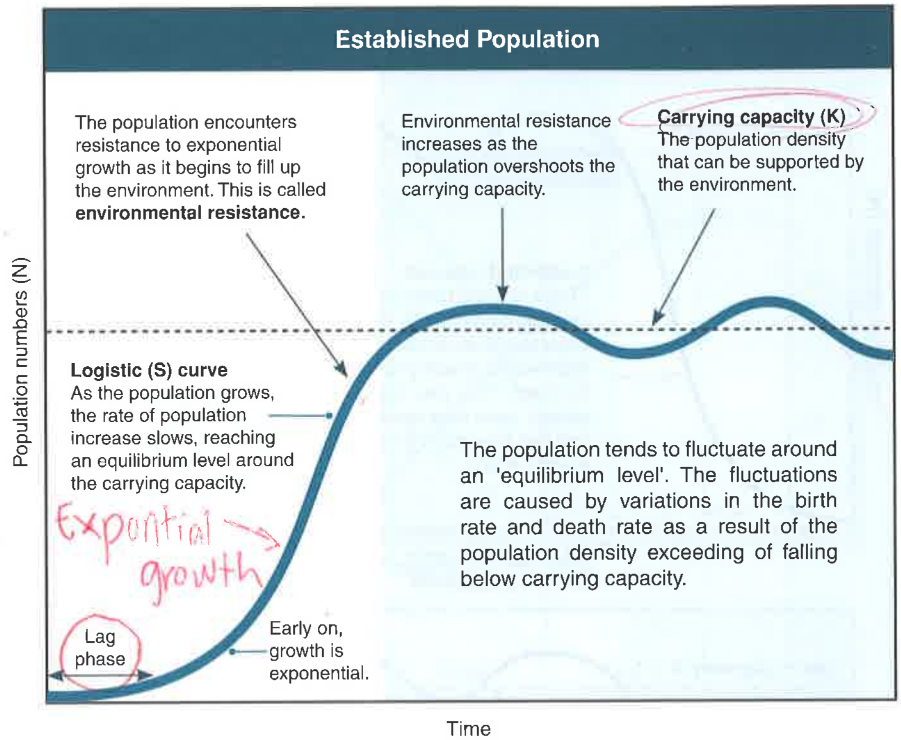
   (b) Management of a fisheries resource: ______________________

# Patterns of Population Growth

Populations becoming established in a new area for the first time are often termed **colonizing populations** (below, left). They may undergo a rapid **exponential** (logarithmic) increase in numbers as there are plenty of resources to allow a high birth rate, while the death rate is often low. Exponential growth produces a J-shaped growth curve that rises steeply as more and more individuals contribute to the population increase. If the resources of the new habitat were endless (inexhaustible) then the population would continue to increase at an **exponential** rate.

However, this rarely happens in natural populations. Initially, growth may be exponential (or nearly so), but as the population grows, its increase will slow and it will stabilize at a level that can be supported by the environment (called the carrying capacity or K). This type of growth is called sigmoidal and produces the **logistic growth curve** (below, right). **Established populations** will fluctuate about K, often in a regular way (blue area on the graph below, right). Some species will have populations that vary little from this stable condition, while others may oscillate wildly.




1. Explain why populations tend not to continue to increase exponentially in an environment: ______

2. Explain what is meant by environmental resistance: ______

3. (a) Explain what is meant by carrying capacity: ______

   (b) Explain the importance of **carrying capacity** to the growth and maintenance of population numbers: ______

4. Species that expand into a new area, such as rabbits did in areas of Australia, typically show a period of rapid population growth followed by a slowing of population growth as density dependent factors become more important and the population settles around a level that can be supported by the carrying capacity of the environment.

   (a) Explain why a newly introduced consumer (e.g. rabbit) would initially exhibit a period of exponential population growth: ______

   (b) Describe a likely outcome for a rabbit population after the initial rapid increase had slowed: ______

5. Describe the effect that introduced grazing species might have on the carrying capacity of the environment: ______

# Population Growth

Organisms do not generally live alone. A **population** is a group of organisms of the same species living together in one geographical area. This area may be difficult to define as populations may comprise widely dispersed individuals that come together only infrequently (e.g. for mating). The number of individuals comprising a population may also fluctuate considerably over time. These changes make populations dynamic: populations gain individuals through births or immigration, and lose individuals through deaths and emigration. For a population in **equilibrium**, these factors balance out and there is no net change in the population abundance. When losses exceed gains, the population declines.

Births, deaths, immigrations (movements into the population) and emigrations (movements out of the population) are events that determine the numbers of individuals in a population. Population growth depends on the number of individuals added to the population from births and immigration, minus the number lost through deaths and emigration. This is expressed as:

**Population growth =**

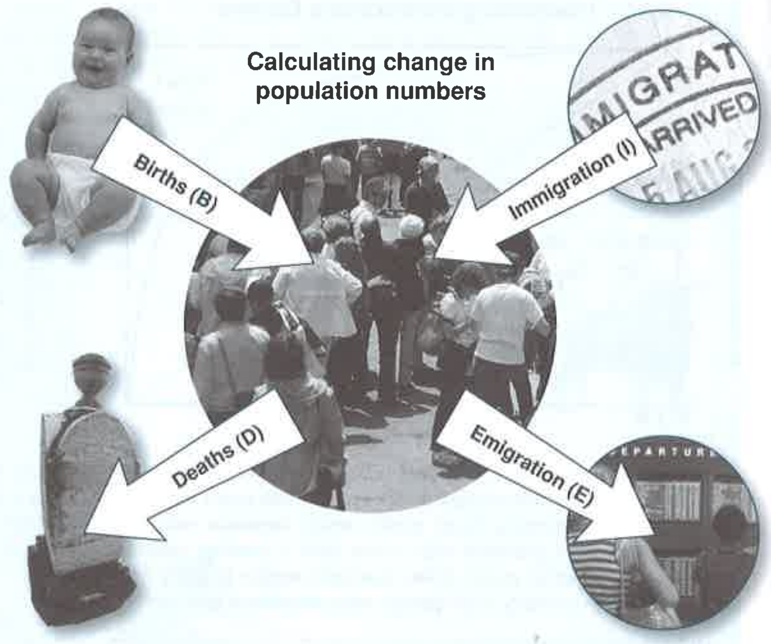
**Births – Deaths + Immigration – Emigration**
**(B) (D) (I) (E)**

The difference between immigration and emigration gives net migration. Ecologists usually measure the **rate** of these events. These rates are influenced by environmental factors (see below) and by the characteristics of the organisms themselves. Rates in population studies are commonly expressed in one of two ways:

- Numbers per unit time, e.g. 20,150 live births per year.
- Per capita rate (number per head of population), e.g. 122 live births per 1000 individuals per year (12.2%).

### Limiting Factors

Population size is also affected by limiting factors; factors or resources that control a process such as organism growth, or population growth or distribution. Examples include availability of food, predation pressure, or available habitat.




Human populations often appear exempt from limiting factors as technology and efficiency solve many food and shelter problems. However, as the last arable land is used and agriculture reaches its limits of efficiency, it is estimated that the human population may peak at around 10 billion by 2050.

1. Define the following terms used to describe changes in population numbers:

(a) Death rate (mortality): ______

(b) Birth rate (natality): ______

(c) Net migration rate: ______

2. Explain how the concept of limiting factors applies to population biology: ______

3. Using the terms, B, D, I, and E (above), construct equations to express the following (the first is completed for you):

(a) A population in equilibrium: B + I = D + E

(b) A declining population: ______

(c) An increasing population: ______

4. A population started with a total number of 100 individuals. Over the following year, population data were collected. Calculate birth rates, death rates, net migration rate, and rate of population change for the data below (as percentages):

(a) Births = 14: Birth rate = ______ (b) Net migration = +2: Net migration rate = ______

(c) Deaths = 20: Death rate = ______ (d) Rate of population change = ______

(e) State whether the population is increasing or declining: ______

5. The human population is around 6.7 billion. Describe and explain two limiting factors for population growth in humans:

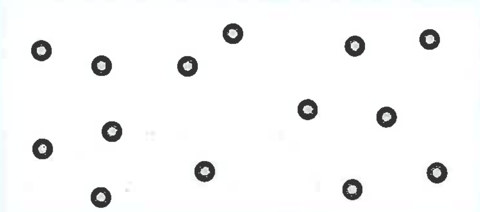
______

______

# Density and Distribution

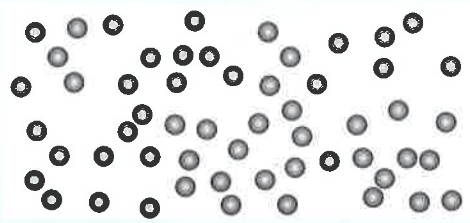
Distribution and density are two interrelated properties of populations. Population density is the number of individuals per unit area (for land organisms) or volume (for aquatic organisms). Careful observation and precise mapping can determine the distribution patterns for a species. The three basic distribution patterns are: random, clumped and uniform. In the diagram below, the circles represent individuals of the same species. It can also represent populations of different species.

### Low Density



In low density populations, individuals are spaced well apart. There are only a few individuals per unit area or volume (e.g. highly territorial, solitary mammal species).

### High Density

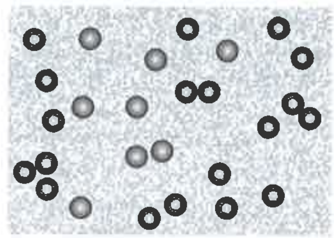


In high density populations, individuals are crowded together. There are many individuals per unit area or volume (e.g. colonial organisms, such as many corals).

Tigers are solitary animals, found at low densities.

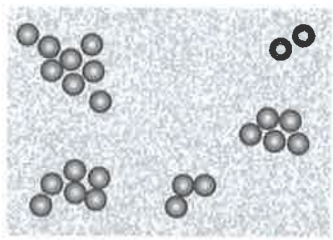
Termites form well organized, high density colonies.

### Random Distribution



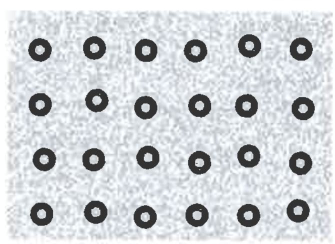
Random distributions occur when the spacing between individuals is irregular. The presence of one individual does not directly affect the location of any other individual. Random distributions are uncommon in animals but are often seen in plants.

### Clumped Distribution



Clumped distributions occur when individuals are grouped in patches (sometimes around a resource). The presence of one individual increases the probability of finding another close by. Such distributions occur in herding and highly social species.

### Uniform Distribution



Regular distribution patterns occur when individuals are evenly spaced within the area. The presence of one individual decreases the probability of finding another individual very close by. The penguins illustrated above are also at a high density.

1. Describe why some organisms may exhibit a clumped distribution pattern because of:

   (a) Resources in the environment: ______________________________

   ______________________________

   (b) A group social behavior: ______________________________

   ______________________________

2. Describe a social behavior found in some animals that may encourage a uniform distribution: ______________________________

   ______________________________

3. Describe the type of environment that would encourage uniform distribution: ______________________________

   ______________________________

4. Describe an example of each of the following types of distribution pattern:

   (a) Clumped: ______________________________

   (b) Random (more or less): ______________________________

   (c) Uniform (more or less): ______________________________

# Survivorship Curves

The survivorship curve depicts age-specific mortality. It is obtained by plotting the number of individuals of a particular cohort against time. Survivorship curves are standardized to start at 1000 and, as the population ages, the number of survivors progressively declines. The shape of a survivorship curve thus shows graphically at which life stages the highest mortality occurs. Survivorship curves in many populations fall into one of three hypothetical patterns (below). Wherever the curve becomes steep, there is an increase in mortality. The convex Type I curve is typical of populations whose individuals tend to live out their physiological life span. Such populations usually produce fewer young and show some degree of parental care. Organisms that suffer high losses of the early life stages (a Type III curve) compensate by producing vast numbers of offspring. These curves are conceptual models only, against which real life curves can be compared. Many species exhibit a mix of two of the three basic types. Some birds have a high chick mortality (Type III) but adult mortality is fairly constant (Type II). Some invertebrates (e.g. crabs) have high mortality only when molting and show a stepped curve.

## Hypothetical Survivorship Curves

### Type I

**Late loss survivorship curve**

Mortality (death rate) is very low in the infant and juvenile years, and throughout most of adult life. Mortality increases rapidly in old age. **Examples**: Humans (in developed countries) and many other large mammals (e.g. big cats, elephants).

### Type II

**Constant loss survivorship curve**

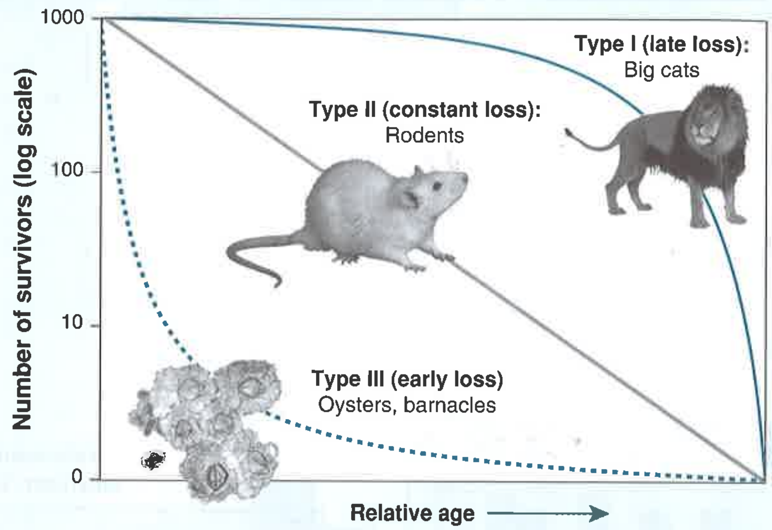
Mortality is relatively constant through all life stages (no one age is more susceptible than another). **Examples**: Some invertebrates such as *Hydra*, some birds, some annual plants, some lizards, and many rodents.

### Type III

**Early loss survivorship curve**

Mortality is very high during early life stages, followed by a very low death rate for the few individuals reaching adulthood. **Examples**: Many fish (not mouth brooders) and most marine invertebrates (e.g. oysters, barnacles).

**Graph of Age Specific Survival**




Three basic types of survivorship curves and representative organisms for each type. The vertical axis may be scaled arithmetically or logarithmically.

Elephants have a close matriarchal society and a long period of parental care. Elephants are long-lived and females usually produce just one calf.

Rodents are well known for their large litters and prolific breeding capacity. Individuals are lost from the population at a more or less constant rate.

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Despite vigilant parental care, many birds suffer high juvenile losses (Type III). For those surviving to adulthood, deaths occur at a constant rate.

1. Explain why human populations might not necessarily show a Type I curve: ______________________

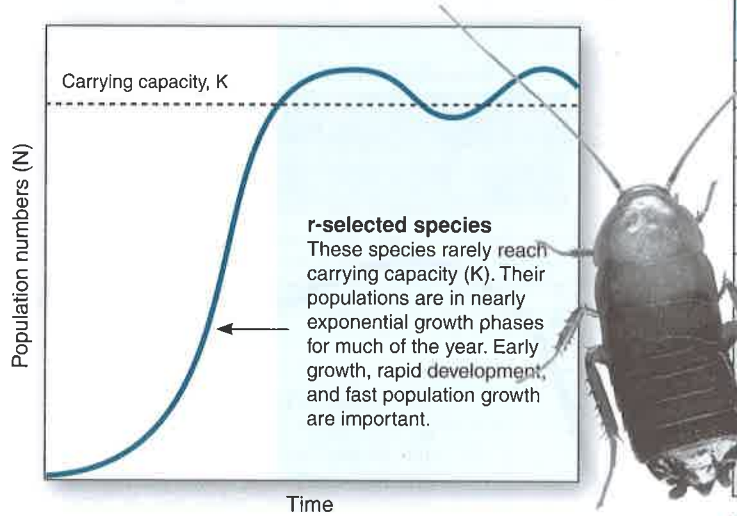
2. Explain how organisms with a Type III survivorship compensate for the high mortality during early life stages:

3. Describe the features of a species with a Type I survivorship that aid in high juvenile survival: ______________________

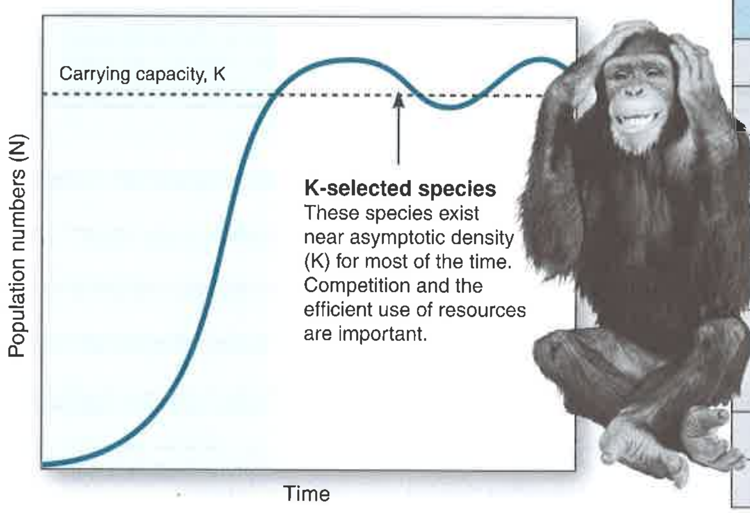
4. Discuss the following statement: "There is no standard survivorship curve for a given species; the curve depicts the nature of a population at a particular time and place and under certain environmental conditions.":

# *r* and K Selection

The capacity of a species to increase in numbers is called its **biotic potential**. It is a measure of reproductive capacity and is assigned a set value (denoted by the letter ***r***) that is specific to the organism involved. Species with a high biotic potential are called ***r*-selected species**. They include algae, bacteria, rodents, many insects, and most annual plants. These species show life history features associated with rapid growth in disturbed environments. To survive, they must continually invade new areas to compensate for being replaced by more competitive species. The population growth of species with lower biotic potential tends to depend on the carrying capacity of the environment (**K**).These species, which include most large mammals, birds of prey, and large, long-lived plants, exist near the **carrying capacity** of their environments and are forced, through their interactions with other species, to use resources more efficiently. These species have fewer offspring and longer lives, and put their energy into nurturing their young to reproductive age. Most organisms have reproductive patterns between these two extremes.




| Correlates of *r*-Selected Species | |
|---|---|
| Climate | Variable and/or unpredictable |
| Mortality | Density independent |
| Survivorship | Often Type III (early loss) |
| Population size | Fluctuates wildly. Often below K |
| Competition | Variable, often lax. Generalist niche. |
| Selection favours | Rapid development, high biotic potential, early reproduction, small body size, single reproduction (annual). |
| Length of life | Short (usually less than one year) |
| Leads to: | Productivity |




| Correlates of K-Selected Species | |
|---|---|
| Climate | Fairly constant and/or predictable |
| Mortality | Density dependent |
| Survivorship | Types I or II (late or constant loss) |
| Population size | Fairly constant in time. Near equilibrium with the environment. |
| Competition | Usually keen. Specialist niche. |
| Selection favours | Slower development, larger body size, greater competitive ability, delayed reproduction, repeated reproduction. |
| Length of life | Longer (greater than one year) |
| Leads to: | Efficiency |

1. Explain why *r*-selected species tend to predominate in unstable, disturbed, or early successional communities:

2. Explain why many K-selected species tend to predominate in stable, climax communities:

3. Describe factors that might cause a change in the predominance of K-selected species in a climax community: