Population Ecology-Contd

LECTURE-5

Key Terms

- **Population dynamics**: Variation among populations due to birth and death rates, by immigration and emigration, and concerning topics such as aging populations or population decline.
- **Youth bulge**: Age structure typical of fast-growing populations in which a majority of the population are relatively young.
- **Age structure**: The composition of a population in terms of the proportions of individuals of different ages; represented as a bar graph with younger ages at the bottom and males and females on either side.

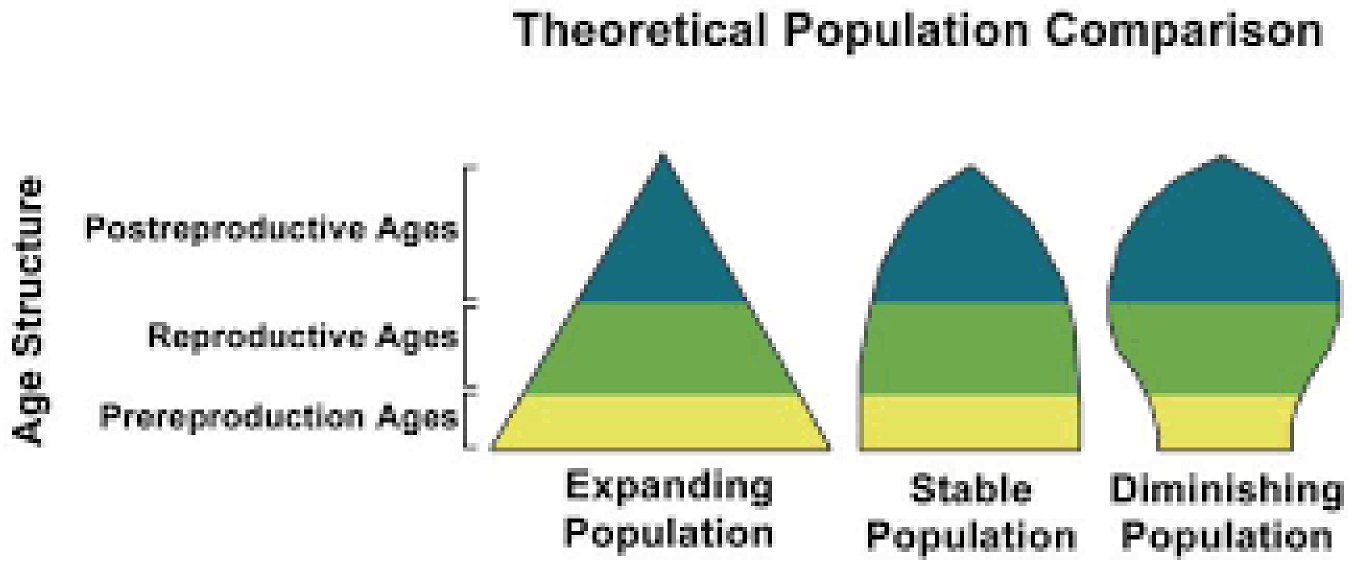
- Population dynamics are influenced by age structure, which is characteristic for populations growing at different rates.
- **Age structure** varies according to the age distribution of individuals within a population.
- Fast-growing populations with a high proportion of young people have a triangle-shaped age structure, representing younger ages at the bottom and older ages at the top.
- Slow-growing populations with a smaller proportion of young people have a column-shaped age structure, representing a relatively even distribution of ages.

AGE STRUCTURE

The age structure of a population can be helpful in determining the future growth rate of a population. Individuals can be categorized into three groups – **pre-reproductive, reproductive and post-reproductive.**

Populations with large pre-reproductive and reproductive groups are likely to experience growth in the near future.

If large proportions of populations are post-reproductive it means recruitment of new individuals is proportionally low for the population. This is likely to lead to either zero growth or a decrease in the population's size.

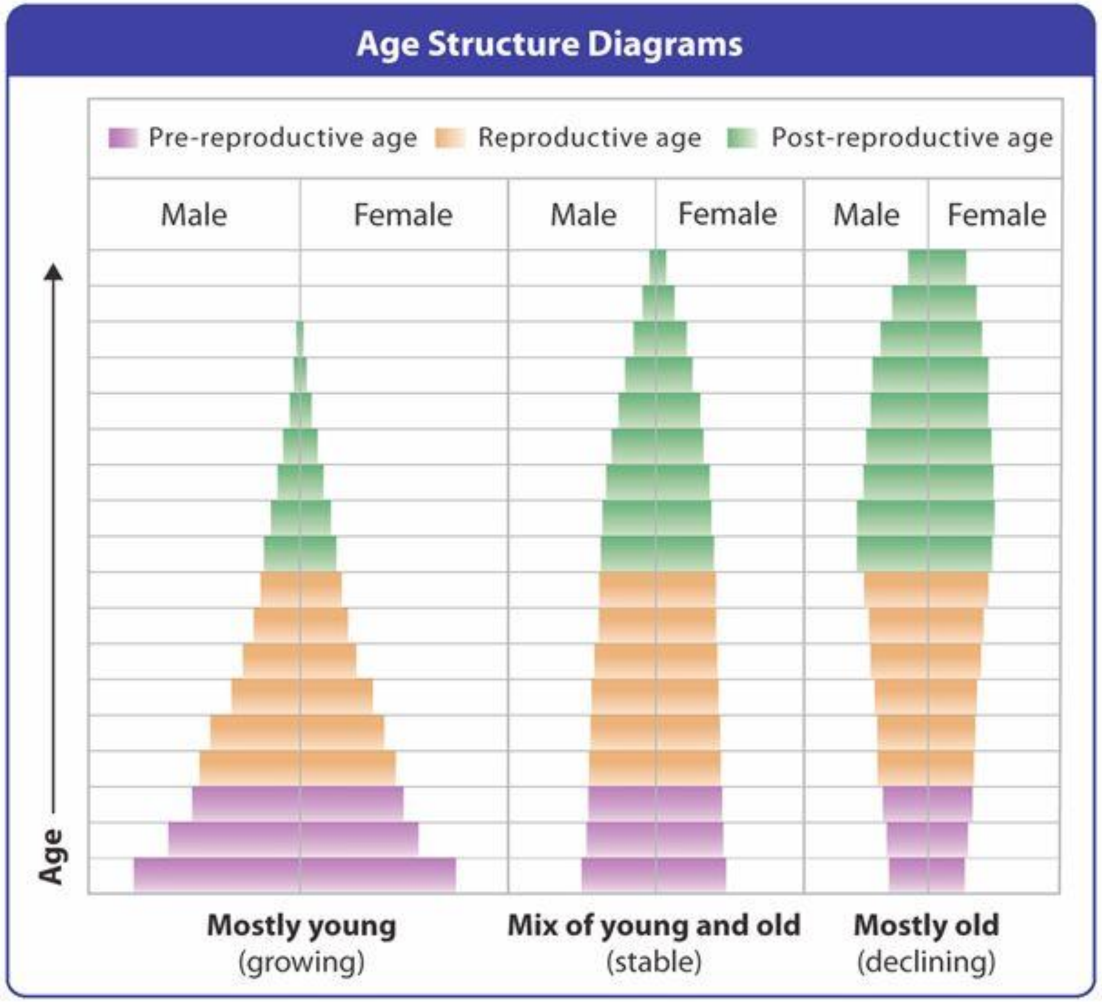

Theoretical Population Comparison
Age Structure
Postreproductive Ages
Reproductive Ages
Prereproduction Ages
Expanding Population
Stable Population
Diminishing Population

Age Structure

- Age Structure:

  Relative number of organisms of each age group within population

- Can be used to predict future population growth of a population



Age structure is very important in the management of fisheries and wild populations.

In management schemes it is important to maintain significant levels of reproductive individuals and in harvested stocks knowledge of the populations age structure can be used to influence which individuals are important to keep in the population.

Contrary to a common belief, the principal factor tending to change the age distribution of a population—and, hence, the general shape of the corresponding pyramid—is not the death or mortality rates, but rather the rate of fertility.

A rise or decline in mortality generally affects all age groups in some measure, and hence has only limited effects on the proportion in each age group. A change in fertility, however, affects the number of people in only a single age group—the group of age zero, the newly born.

Hence a decline or increase in fertility has a highly concentrated effect at one end of the age distribution and thereby can have a major influence on the overall age structure.

SEX RATIO

The sex ratio of a population is simply the number of males relative to females.

Sex ratio is often influenced with time and the life stage of individuals.

The sex ratio at fertilization is usually around 1:1 but this has often changed by the time individuals reach a sexually active age, where females regularly have an increased abundance.

At the post-reproductive stage, female abundance is also often higher than that of their male counter-parts. These are, however, only trends and differ from species to species.

Sex ratio can have important effects on population dynamics.

We will consider some of the forces that act to change sex ratios as well as broad patterns of sex ratio variation n the animal kingdom.

Sex ratio is the proportion of males relative to the proportion of females.

Ernst Mayr classified sex ratios according to the stage in the life cycle:
Primary sex ratio: sex ratio at conception (the point at which the sperm fertilize the eggs). This is usually near 50:50 in natural populations, though a few cases exist where parasites can change the primary sex ratio by for example, having lethal effects on sperm.
Secondary sex ratio: sex ratio at time of hatch or birth. Often nearly 50:50 but more examples exist of skewed secondary sex ratios than of skewed primary sex ratios.
Tertiary sex ratio: sex ratio at some later stage of life such as at age of first reproduction or "adult" stage. Skewed sex ratios are most often observed at this stage.

Classification (after Ernst Mayr)

- **Primary sex ratio:** sex ratio at conception.
  - This is usually near 50:50 in natural populations.
- **Secondary sex ratio:** sex ratio at time of hatch or birth.
  - Often nearly 50:50 but more examples exist of skewed secondary sex ratios.
- **Tertiary sex ratio:** sex ratio at some later stage of life such as "adult" stage.
  - Skewed sex ratios are most often observed at this stage.

Two generalities emerge from the broad patterns we have considered above:

1) Sex ratio skew tends to become **more pronounced at later stages**. For example, primary sex ratios seem rarely to differ much from 50:50, secondary sex ratios can vary slightly more and we most often find skew in tertiary sex ratios.

2) **Bird pattern differs from mammal pattern.** Avian tertiary sex ratios seem generally to be skewed towards males, tertiary ratios of mammals tend to be biased towards females. Let's look at some data:

The following table shows both a change in sex ratio (away from 50:50) with age, and a difference between birds and mammals in the direction of the bias. The three mammals at the end of the table all show a bias towards females. The birds show the reverse.

Species	Juvenile sex ratio (% males)	Adult sex ratio (% males)
Hungarian partridge	50	56
Bobwhite quail	51	62
California quail	50	58
Ruffed grouse	50	54
Willow ptarmigan	54	60
Sharp-tailed grouse	49	55
Mallard	51.2	63.8
Black duck	48.6	61.3
Pintail	51.6	54.9
Canvasback	44.0	56.8
Scaup	49.7	61.4
Starling	52	66
Brown rat	51	41
Muskrat	57	50
Cottontail rabbit	50	46

Fish are strongly influenced by climate variability with regards to reproduction, productivity, food availability, and recruitment. Global temperatures are on the rise and sea surface temperatures have been increasing at an average rate of 0.18 °C per decade, with coastal waters having a greater rate of increase than open oceans[2].

When factors in the environment including temperature affect an organism's sex, it is termed environmental sex determination (ESD).

Teleost fishes display a great deal of sexual plasticity and a wide range of sex determination patterns including those in which sex is determined by cues from the physical and social environments[1]

Warm temperatures have been strongly correlated to masculinized sex ratios in southern flounder in fish reared in tanks (constant temperatures, fluctuating temperatures; current study) and now in natural populations. Exposure to temperature fluctuations has been shown to impact sex ratios in fish and turtles that exhibit TSD/ESD (*M. menidia*; *Carassius auratus*; *Pimephales promelas*; *Trachemys scripta*).

In the case of sea turtles, cool temperatures tend to produce males and warm temperatures produce more females, so global warming could feminize sea turtle populations. A recent study on sex ratios of sea turtles near the Great Barrier Reef showed variation in sex ratios across regions, with mildly female-biased ratios in cooler, southern beaches and extreme female-biased sex ratios in warmer more northern nesting sites.

This latitudinal variation in sex ratios of natural turtle populations shows a response due to TSD in a warming environment similar to what we observed across a temperature cline in southern flounder. This phenomenon may not be limited to turtles and southern flounder and should be investigated for other species that exhibit TSD.

The variation of populations over time, also known as population dynamics, depends on biological and environmental processes that determine population changes. A population’s growth rate is strongly influenced by the proportions of individuals of particular ages. With knowledge of this age structure, population growth can be more accurately predicted.

A.Pollutants also contribute to environmental stress, limiting the growth rates of populations. Although each species has specific tolerances for environmental toxins, amphibians in general are particularly susceptible to pollutants in the environment. For example, pesticides and other endocrine disrupting toxins can strongly control the growth of amphibians. These chemicals are used to control agricultural pests but also run into freshwater streams and ponds where amphibians live and breed.

They affect the amphibians both with direct increases in mortality and indirect limitation in growth, development, and reduction in fecundity. Rohr *et al*. (2003) found, among many other examples, that these compounds affect salamander embryo survival in affected ponds, increased deformities, and delayed development and growth, lengthening their vulnerability to predators by remaining small sized for longer periods. These effects limit population growth irrespective of the size of the amphibian population and are not limited to pesticides but also include pH and thermal pollution, herbicides, fungicides, heavy metal contaminations, etc.

B.Environmental catastrophes such as fires, earthquakes, volcanoes and floods can strongly affect population growth rates via direct mortality and habitat destruction. A large-scale natural catastrophe occurred in 2005 when hurricane Katrina impacted the coastal regions of the Gulf of Mexico in the southern United States. Katrina altered habitat for coastal vegetation by depositing more than 5 cm of sediment over the entire coastal wetland zone. In these areas, substantial improvement in the quality of wetlands for plant growth occurred after many years of wetland loss due to control of the Mississippi River flow (Turner *et al*. 2006). At the same time, however, almost 100 km^2 of wetland was destroyed and converted to open sea, completely eliminating wetland vegetation (Day *et al*. 2007). More recently the Gulf oil spill in 2010 has again impacted the coastal wetland vegetation. Though human derived, this large-scale environmental disaster will have long-term impacts on the population growth of not only vegetation but all organisms in the wetlands and nearshore regions of the Gulf of Mexico.

Population Cycles

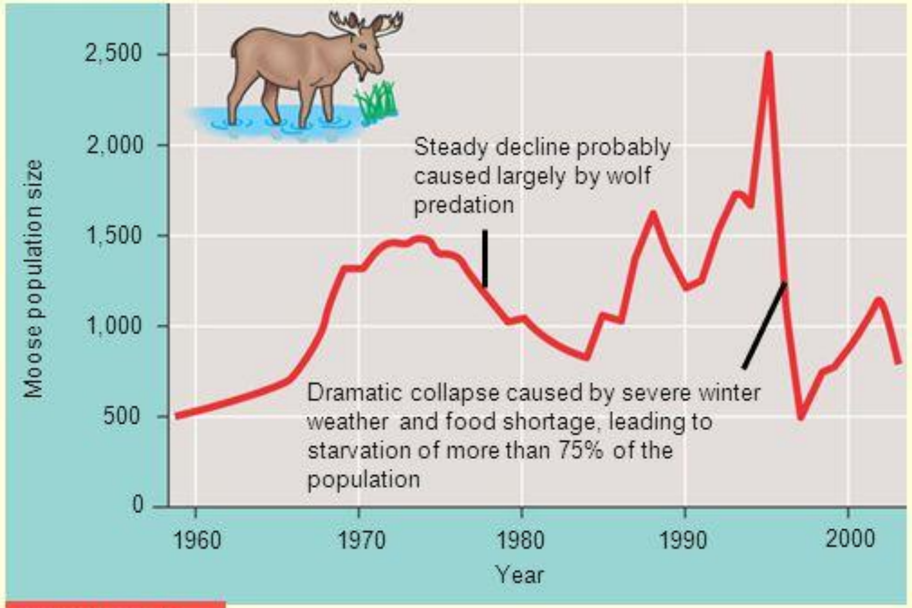
A population cycle in zoology is a phenomenon where populations rise and fall over a predictable period of time.

Stability and Fluctuation

- Long-term population studies
  - Have challenged the hypothesis that populations of large mammals are relatively stable over time

FIELD STUDY Researchers regularly surveyed the population of moose on Isle Royale, Michigan, from 1960 to 2003. During that time, the lake never froze over, and so the moose population was isolated from the effects of immigration and emigration.

RESULTS Over 43 years, this population experienced two significant increases and collapses, as well as several less severe fluctuations in size.



CONCLUSION The pattern of population dynamics observed in this isolated population indicates that various biotic and abiotic factors can result in dramatic fluctuations over time in a moose population.

Figure 52.18

Natural Population Curves

Population sizes may stay about the same, suddenly increase and then decrease, vary in regular cycles, or change erratically.

Four general types of population fluctuations in nature are (1) stable, (2) irruptive, (3) cyclic, and (4) irregular.

A stable population fluctuates slightly above and below carrying capacity and is characteristic of many species Living under fairly constant environmental conditions.

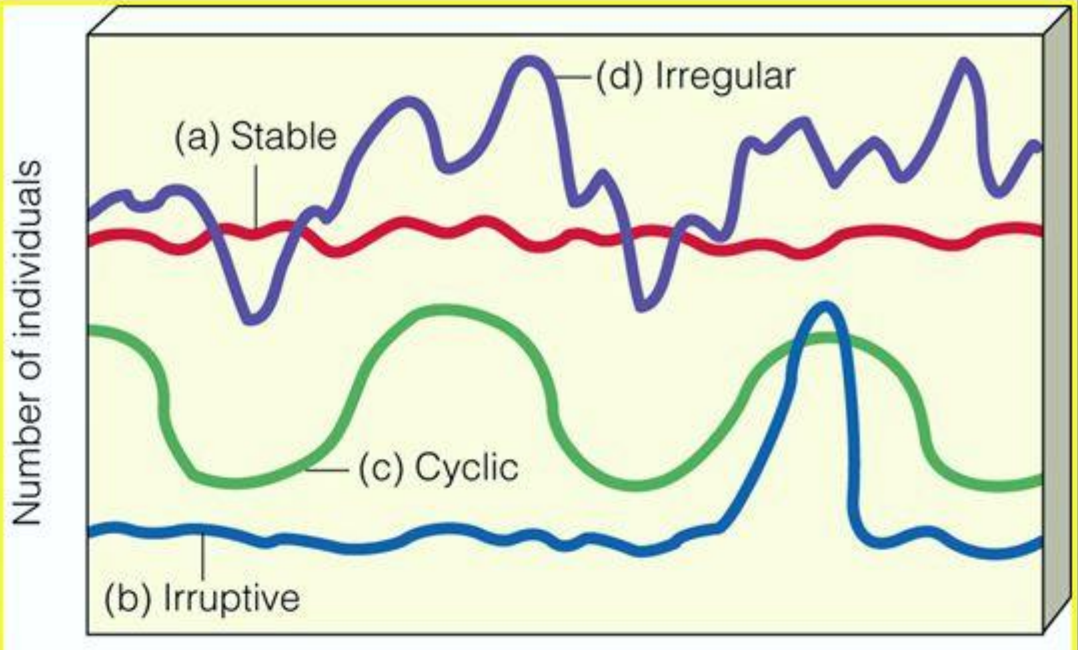
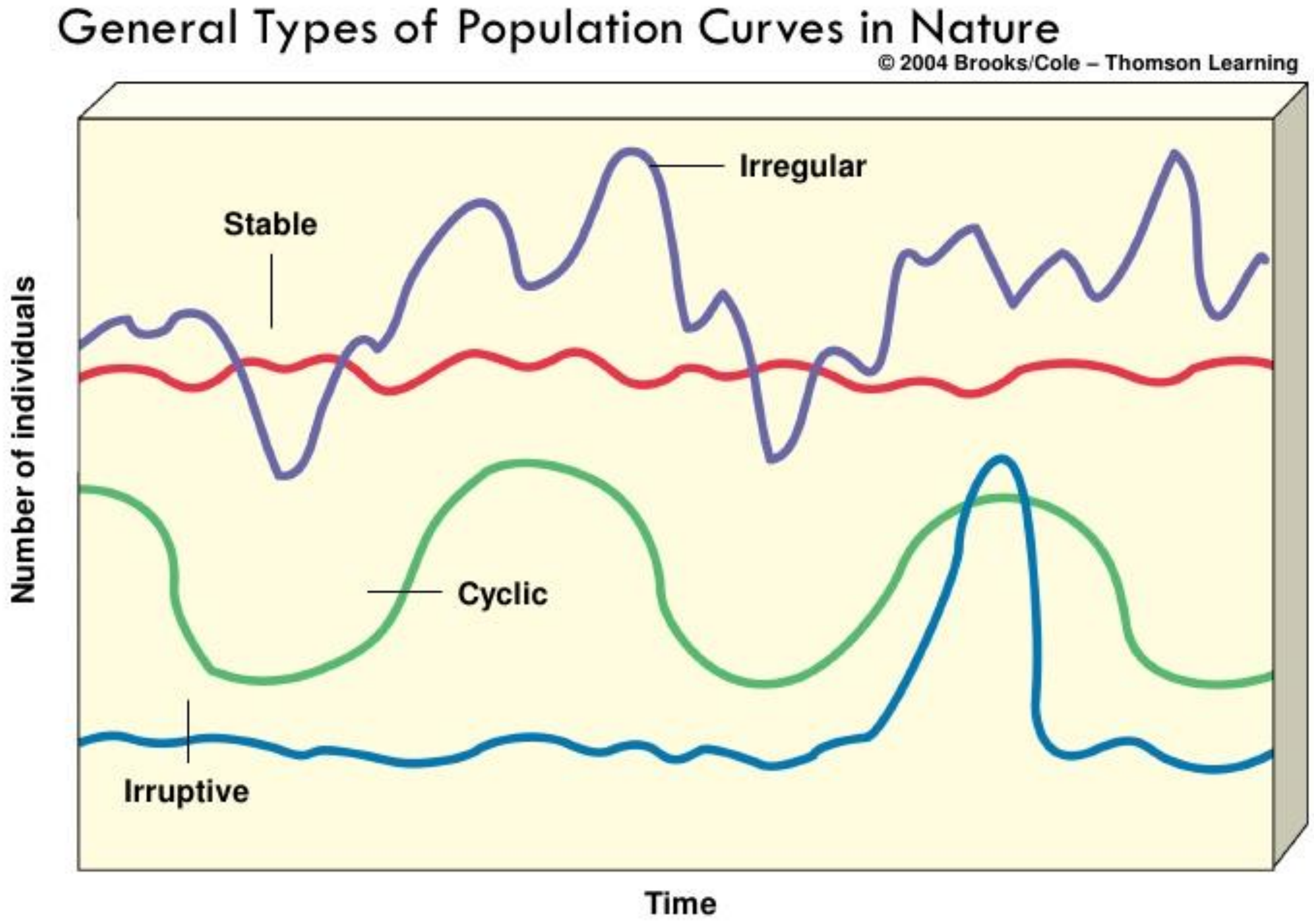


Fig. 9-7 p. 168

Some species have a fairly stable population size That may occasionally irrupt to a high peak and then crash to below carrying capacity. This is characteristic of short-lived, rapidly reproducing species.

Cyclic fluctuations occur over a regular time period, generally a multiple year cycle.

Irregular behavior is poorly understood. Some scientists attribute irregular behavior to chaos in the system; others disagree.


General Types of Population Curves in Nature
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Irregular
Stable
Cyclic
Irruptive
Number of individuals
Time

Population Change Curves in Nature 4 general types of population fluctuations:

1. **Stable –** population size fluctuates slightly above and below carrying capacity .Usually found in undisturbed areas or where there is little change in climate

2. **Irruptive –** fairly stable populations that have a population explosion but then return to a lower size rather quickly Impacted by favorable weather, increase in food supply, decrease in predator

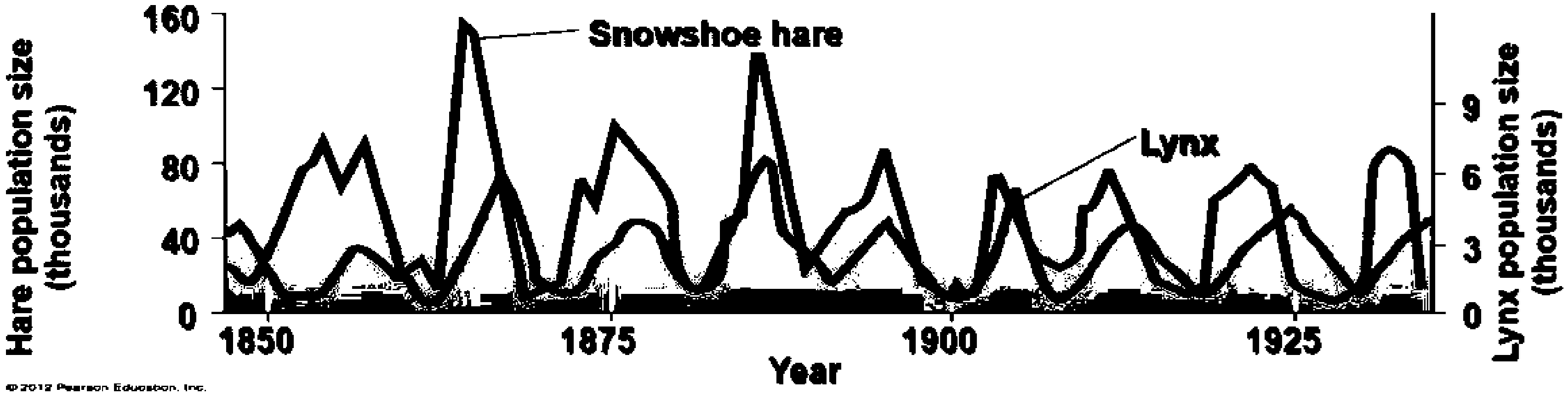
3. **Chaotic Behavior** – irregular changes in size with no real pattern seen

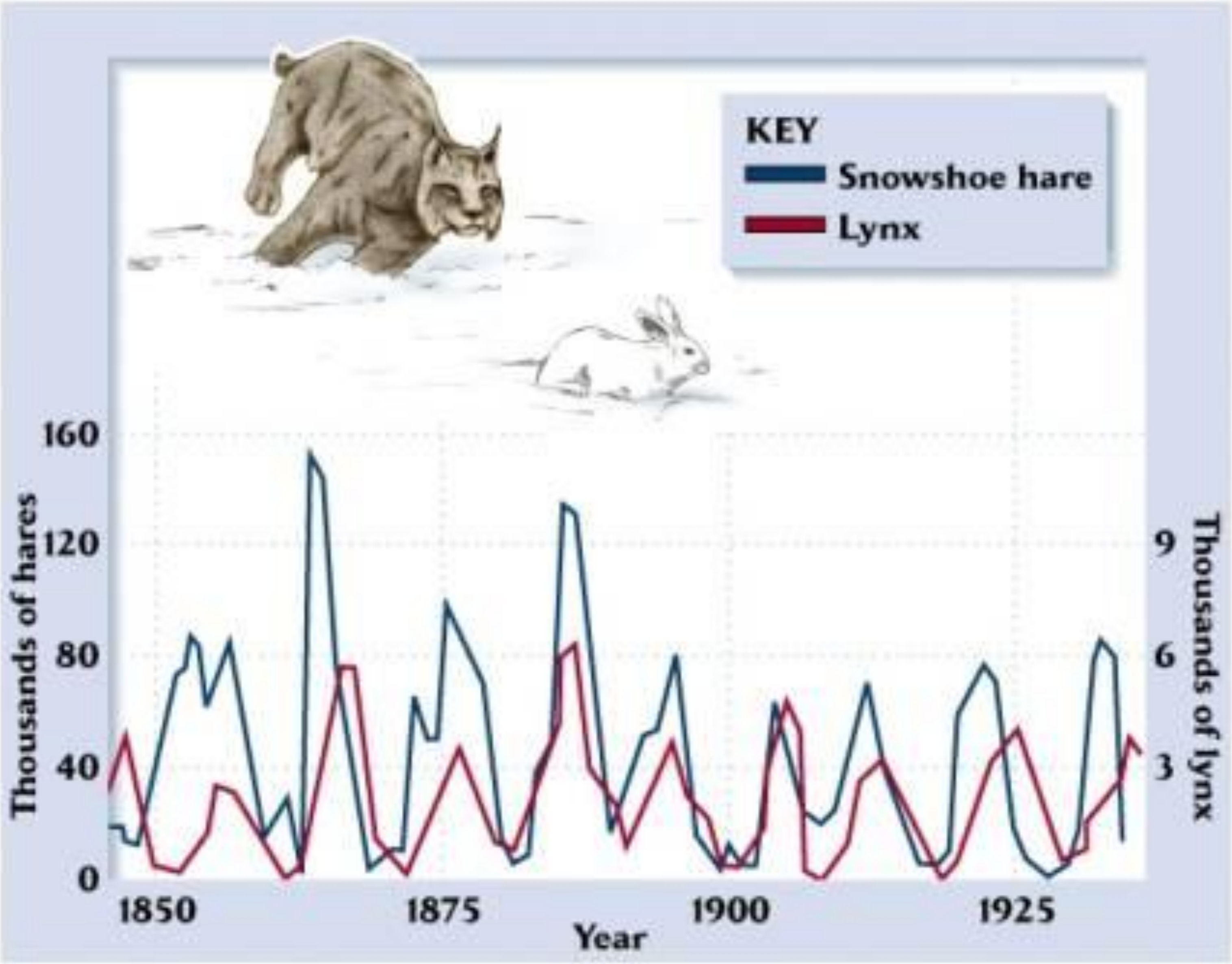
4. **Cyclic –** changes occur in a pattern over a regular period of time Lynx and hare (10-year cycle)

Population Cycles

- Some populations fluctuate in density with regularity
- Boom-and-bust cycles may be due to
  - food shortages or
  - predator-prey interactions.

Hare & Lynx populations




KEY
Snowshoe hare
Lynx
160
120
80
40
0
Thousands of hares
9
6
3
Thousands of lynx
1850
1875
1900
1925
Year