Important Word Roots

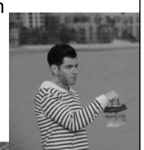
Eco	Ology	Population	Exponential
• Oikos = House	• The Study Of	• Populus = People	• exponere 'put out'

Intra	Inter
• Within	• Between/ Among

Population
• A Population consists of members of a species living in the same place at the same time.

Biology and Society: Invasion of the Lionfish

– Lionfish are favorites of saltwater aquarium enthusiasts. But lionfish
  - have venomous spines,
  - are merciless predators, and
  - grow quickly from 2 to 18 inches.



Biology and Society: Invasion of the Lionfish

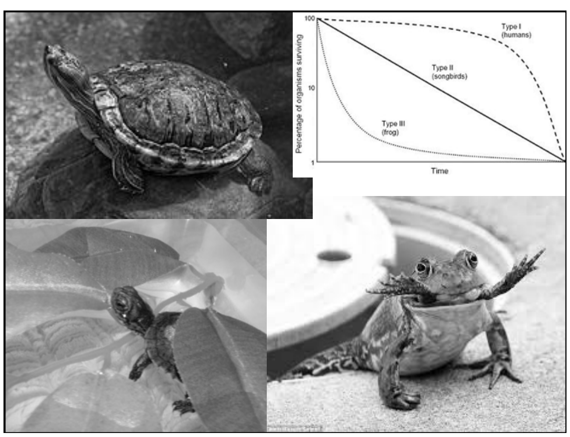
– Apparently some lionfish owners released their lionfish into the waters along the southeastern coast of Florida. Now lionfish populations have spread
  - up the East Coast of the United States,
  - throughout the Atlantic and Gulf of Mexico, and
  - into the Caribbean region.

Biology and Society:
Invasion of the Lionfish

– To slow the lionfish invasion, the National Oceanic and Atmospheric Administration (NOAA) has launched an "Eat Lionfish" campaign to encourage human predation on the tasty fish.

Biology and Society:
Invasion of the Lionfish

- Lionfish are just one example of many non-native species
  - spread intentionally or accidentally by humans and
    - leaving environmental havoc and radically changed environments in their wake.
      Why:
      1. No Natural Predators
      2. Often evolved with competition and those



AN OVERVIEW OF POPULATION ECOLOGY

– A **population** is a group of individuals of a single species that occupy the same general area.

AN OVERVIEW OF POPULATION ECOLOGY

– **Population ecology** focuses on the factors that influence a population's

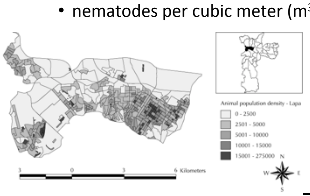
1. density,
2. structure,
3. size, and
4. growth rate.

Figure 19.1

Population Density

– **Population density** is the number of individuals of a species per unit of area or volume. Examples include the number of

- largemouth bass per cubic kilometer (km^3) of a lake,
- oak trees per square kilometer (km^2) in a forest, and
- nematodes per cubic meter (m^3) in a forest's soil.



Population Density

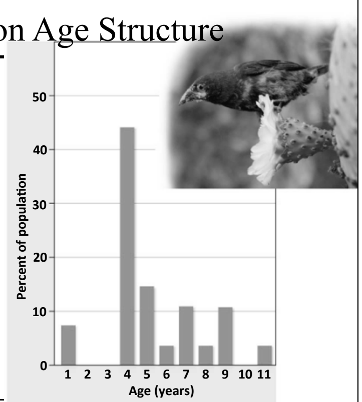
- How do we measure population density?
  - In most cases, it is impractical or impossible to count all individuals in a population.
  - In some cases, population densities are estimated by indirect indicators, such as
    - number of bird nests or
    - rodent burrows.

Figure 19.2

Figure 19.3

Population Age Structure

- The **age structure** of a population is the distribution of individuals in different age-groups.
- The age structure of a population provides insight into
  - the history of a population's survival,
  - reproductive success, and/or
  - how the population relates to environmental factors.



Life Tables and Survivorship Curves

- **Life tables**
  - track survivorship (the chance of an individual in a given population surviving to various ages) and
  - help to determine the most vulnerable stages of the life cycle.

Table 19.1 Life Table for the U.S. Population in 200

Age Interval	Number Living at Start of Age Interval (N)	Number Dying During Interval (D)	Chance of Surviving Interval 1–(D/N)
0–10	100,000	853	0.991
10–20	99,147	400	0.996
20–30	98,747	988	0.990
30–40	97,759	1,264	0.987
40–50	96,495	2,745	0.972
50–60	93,750	5,693	0.939
60–70	88,057	11,396	0.871
70–80	76,661	22,460	0.707
80–90	54,201	33,303	0.386
90+	20,898	20,898	0.000

Life Tables and Survivorship Curves

- **Survivorship curves**
  - plot the number of individuals still alive at each age in the maximum life span and
  - are classified based upon the rate of mortality over the life span of an organism.

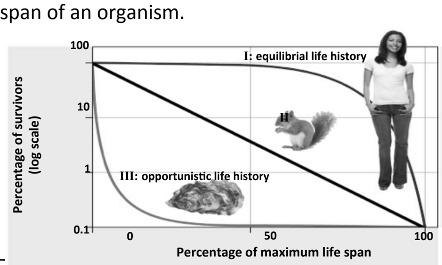
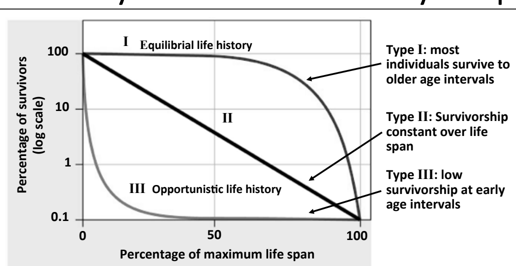


Figure 19.4

Figure 19.UN03

Summary Slide of Life History Graphs



Life History Traits as Evolutionary Adaptations

– An organism's **life history** is the set of traits that affect the organism's schedule of
  - reproduction and
  - survival.

– Key life history traits include the
  - age at first reproduction,
  - frequency of reproduction,
  - number of offspring, and
  - amount of parental care given.

– Life history traits
  - evolve and
  - represent a compromise of the competing needs for
    - time,
    - energy, and
    - nutrients.

Life History Traits as Evolutionary Adaptations

– Organisms with an **opportunistic life history**
  - take immediate advantage of favorable conditions and
  - typically exhibit a type III survivorship curve.

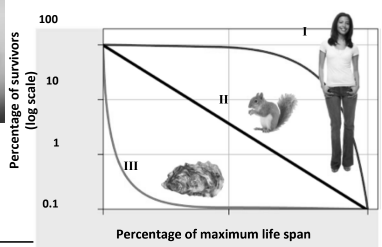


Figure 19.UN01

Dandelions have an opportunistic life history.

Life History Traits as Evolutionary Adaptations

- Organisms with an **equilibrial life history**
  - develop and reach sexual maturity slowly,
  - produce few, well-cared-for offspring,
  - are typically larger-bodied and longer-lived, and
  - typically exhibit a type I survivorship curve.

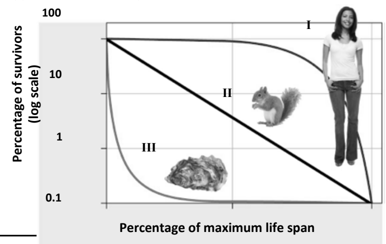


Figure 19.UN02

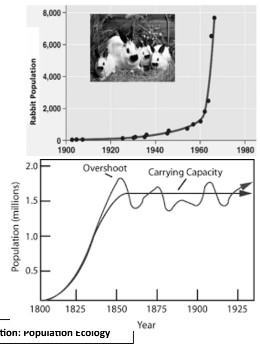
Elephants have an equilibrial life history.

POPULATION GROWTH MODELS

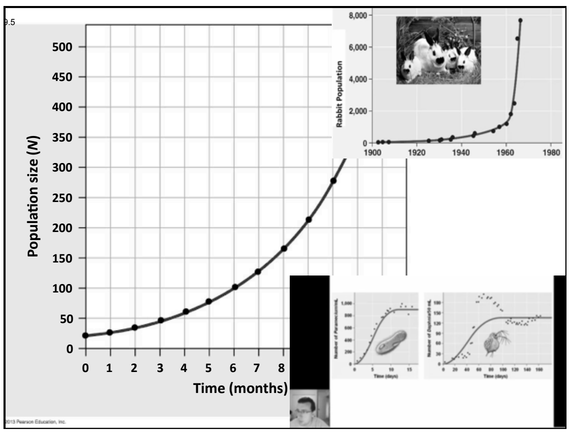
- Population size fluctuates as new individuals
  - are born,
  - immigrate into an area,
  - emigrate away, and
  - die.

The Exponential Population Growth Model: The Ideal of an Unlimited Environment

- **Exponential population growth** describes the expansion of a population in an ideal and unlimited environment.
- Exponential growth explains how
  - a few dozen rabbits can multiple into millions and
  - in certain circumstances following disasters, organisms that have opportunistic life history patterns can rapidly recolonize a habitat.



PLAY Bioflix Animation: Population Ecology



The Logistic Population Growth Model: The Reality of a Limited Environment

- **Limiting factors**
  - are environmental factors that hold population growth in check and
  - restrict the number of individuals that can occupy a habitat.

The Logistic Population Growth Model: The Reality of a Limited Environment

- The **carrying capacity** is the maximum population size that a particular environment can sustain.
- **Logistic population growth** occurs when the growth rate decreases as the population size approaches carrying capacity.

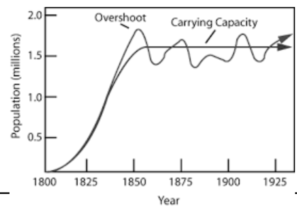
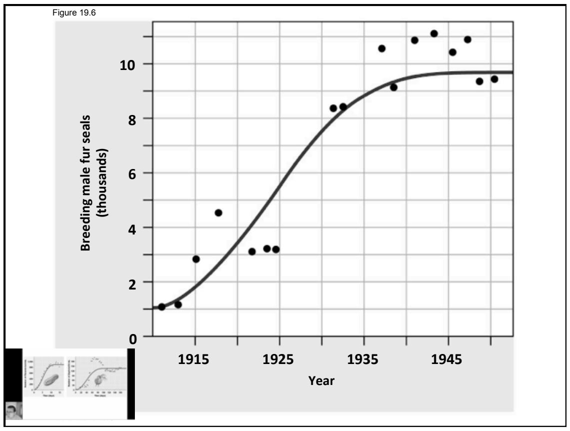


Figure 19.6



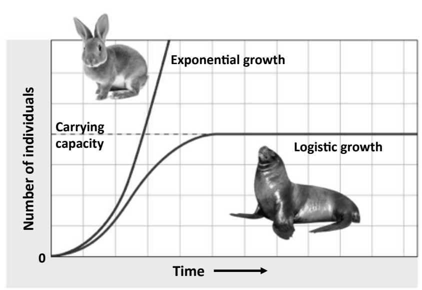
The Logistic Population Growth Model: The Reality of a Limited Environment

- The carrying capacity for a population varies, depending on the
  - species and
  - resources available in the habitat.
- Organisms exhibiting equilibrial life history patterns occur in environments where the population size is at or near carrying capacity.

**The Logistic Population Growth Model:
The Reality of a Limited Environment**

- The logistic model and the exponential model are theoretical ideals of population growth.
- No natural population fits either one perfectly.

Figure 19.7



Regulation of Population Growth
Density-Dependent Factors

- The logistic model is a description of **intraspecific competition**, competition between individuals of the same species for the same limited resources.
- A **density-dependent factor** is a population-limiting factor whose effects intensify as the population increases in density.
- **Intraspecific competition** is competition between individuals of the same species for the same limited resources.

Density-Dependent Factors

- As population size increases,
  - competition becomes more intense and
  - birth rates decline.

Density-Dependent Factors

- Density-dependent factors may include
  - accumulation of toxic wastes,
  - Disease
  - limited food supply, and
  - limited territory.

Density-Independent Factors

- **Density-independent factors**
  - are population-limiting factors whose intensity is unrelated to population density and
  - include abiotic factors such as
    - fires,
    - floods, and
    - storms.

Density-Independent Factors

– In many natural populations, abiotic factors may limit or reduce population size before other limiting factors become important.
– Over the long term, most populations are probably regulated by a mixture of
  - density-independent factors and
  - density-dependent factors.

Population Cycles

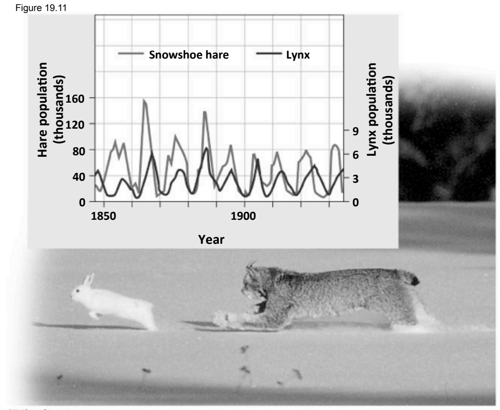
– Some populations have regular boom-and-bust cycles characterized by
  - periods of rapid, exponential growth followed by
  - steep population declines.

Where have we seen this trend before?

Population Cycles

– A well-studied example of boom-and-bust cycles is the cycles of
  - snowshoe hares and
  - one of the hares' predators, the lynx.

Figure 19.11



Population Cycles

- The cause of these hare and lynx cycles may be
  - winter food shortages for the hares,
  - overexploitation of hares by lynx and other predators, and
  - a combination of both of these mechanisms.

PLAY Blast Animation: Population Dynamics

APPLICATIONS OF POPULATION ECOLOGY

- Population ecology is used to
  - increase populations of organisms we wish to harvest,
  - decrease populations of pests, and
  - save populations of organisms threatened with extinction.

Conservation of Endangered Species

– The U.S. Endangered Species Act defines
  - an **endangered species** as one that is in danger of extinction throughout all or a significant portion of its range and
  - a **threatened species** as one that is likely to become endangered in the foreseeable future.

– A major factor in population decline is
  - habitat destruction or
  - habitat modification.

Conservation of Endangered Species

– The red-cockaded woodpecker
  - requires longleaf pine forests with clear flight paths between trees,
  - suffered from fire suppression, increasing the height of the vegetation on the forest floor, and
  - recovered from near-extinction to sustainable populations due to controlled burning and other management methods.

Figure 19.12

High, dense undergrowth impedes the woodpecker,

A red-cockaded woodpecker

Low undergrowth offers birds a clear flight path.

Sustainable Resource Management

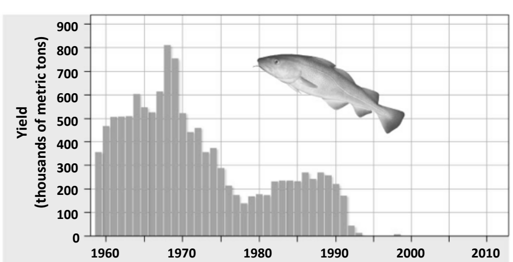
– According to the logistic growth model, the fastest growth rate occurs when a population size is at roughly half the carrying capacity.
– Theoretically, populations should be harvested down to this level, assuming that growth rate and carrying capacity are stable over time.

Sustainable Resource Management

– In the northern Atlantic cod fishery,
  - estimates of cod stocks were too high, and
  - the practice of discarding young cod (not of legal size) at sea caused a higher mortality rate than was predicted.

– The fishery collapsed in 1992 and has not recovered.

Figure 19.13



Invasive Species

- An **invasive species**
  - is a non-native species that has spread far beyond the original point of introduction and
  - causes environmental or economic damage by colonizing and dominating suitable habitats.
- In the United States, invasive species cost about $137 billion a year.
- Invasive species typically exhibit an opportunistic life history pattern.

Invasive Species

- Cheatgrass
  - is an invasive species in the western United States,
  - currently covers more than 60 million acres of rangeland formerly dominated by native grasses and sagebrush,
  - produces seeds earlier and in greater abundance than native species, and
  - forms highly flammable brush, creating fires that native plants cannot tolerate.

Invasive Species

- Burmese pythons
  - are another invasive species,
  - were set loose in South Florida, either deliberately or accidentally, and
  - are now abundant in South Florida, eating native species of
    - birds,
    - mammals,
    - reptiles, and
    - amphibians.

Biological Control of Pests

- Invasive species may benefit from the absence of
  - pathogens,
  - predators, or
  - herbivores.
- **Biological control** is
  - the intentional release of a natural enemy to attack a pest population and
  - used to manage an invasive species.

Biological Control of Pests

- Leaf beetles have been used to control St. John's wort, a perennial European weed that invaded the western United States in the 1930s.
- Mongooses
  - were introduced to the Hawaiian Islands to control rat populations, but
  - soon became an invasive species themselves as they ate native amphibians, reptiles, birds, and domestic poultry.

The Process of Science: Can Biological Control Defeat Kudzu?

- Kudzu
  - is an invasive Asian vine,
  - covers about 12,000 square miles of the southeastern United States, and
  - has a range limited by cold winters.

The Process of Science: Can Biological Control Defeat Kudzu?

- Many strategies to control kudzu have been considered with little success.
- A fungal pathogen called *Myrothecium verrucaria* appears to be a promising candidate for biological control.

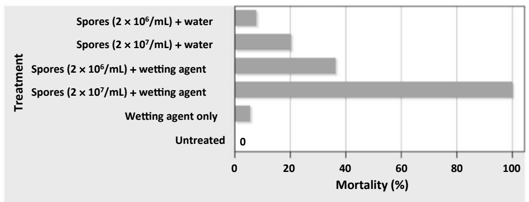
The Process of Science: Can Biological Control Defeat Kudzu?

- **Observation**: The fungus *Myrothecium verrucaria* causes severe disease in other weeds belonging to the same family as kudzu.
- **Question**: Will the application of fungal spores of *M. verrucaria* control an established stand of kudzu in a natural setting?
- **Hypothesis**: *M. verrucaria* treatment that was effective in small outdoor plantings would also be most effective in a natural setting.

The Process of Science: Can Biological Control Defeat Kudzu?

- **Prediction**: The greatest kudzu mortality would result from the treatment that sprayed the highest concentration of spores in combination with a wetting agent.
- **Results**: The hypothesis was supported by the data, as indicated in the following table.

Figure 19.18



Integrated Pest Management

- Agricultural operations create their own highly managed ecosystems that
  - have genetically similar individuals (a monoculture),
  - are planted in close proximity to each other, and
  - function as a "banquet" for
    - plant-eating animals,
    - pathogenic bacteria, and
    - viruses.

Integrated Pest Management

- Like invasive species, most crop pests
  - have an opportunistic life history pattern and
  - can cause extensive crop damage.

Integrated Pest Management

– Pesticides may
- result in pesticide-resistant pests,
- kill the pest and their natural predators, and
- kill pollinators.

Integrated Pest Management

– Integrated pest management (IPM)
- tolerates a low level of pests instead of total eradication,
- produces a sustainable control of agricultural pests, and
- uses a combination of
  – biological methods,
  – chemical methods, and
  – cultural methods.

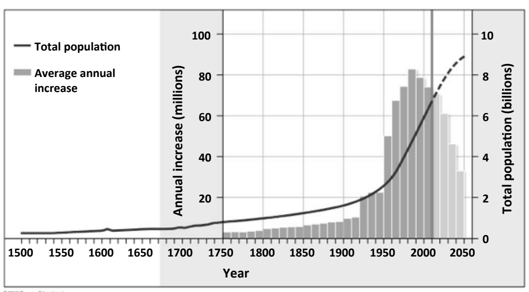
Integrated Pest Management

– IPM methods include
- using pest-resistant varieties of crops,
- using mixed-species plantings, and
- rotating crops to deprive the pest of a dependable food source.

HUMAN POPULATION GROWTH
The History of Human Population Growth

- From 2,000 to 500 years ago (in 1500),
  - mortality was high,
  - births and deaths were about equal, and
  - the world population held steady at about 300 million.

Figure 19.21



The History of Human Population Growth

- Worldwide population growth rates reflect a mosaic of the changes occurring in different countries.
  - In the most developed nations, the overall growth rates are near zero.
  - In the developing world,
    - death rates have dropped and
    - high birth rates persist.

Age Structures

- Age structures help predict a population's future growth.
- The following figure shows the estimated and projected age structures of Mexico's population in
  - 1985,
  - 2010, and
  - 2035.

Figure 19.22