Unit 6: Populations - Study Guide

Presentation #1: Carrying Capacity, Forest Carrying Capacity Lab, Rabbit Gizmo

Vocabulary:

1. Carrying capacity - **the maximum number of individuals of a species that an environment can support**

2. Population - **a group of individuals of the same species living in the same area at the same time**

3. Limiting Factor - **anything that restricts population size**

4. Overshoot - **when a population briefly exceeds its carrying capacity**

Questions:

5. A **7,906 hectare** forest in Virginia is dominated by large **water oak trees** with an average diameter of 60 cm. Each of these trees produces about **10.1 kg of acorns per year**. The forest has a density of **25 oak trees per hectare**, and deer rely heavily on acorns for food. Each deer: Eats **3 kg of food per day and** gets **75% of its diet from acorns.** However, not all acorns are available—**only 85% reach the ground**, because other animals eat the rest.
    a. How many kilograms of acorns are produced per hectare per year?

    Equation to Use: (acorns per tree) × (trees per hectare)

    10.1 kg acorns per tree x 25 trees per hectare

    252.5 kg of acorns

    b. How many kilograms of acorns does one deer need per year?

    Equation to Use: (acorns per day) x (percent of diet) x (365 days per year)

    3 kg of acorns x 0.75 x 365

    821.25 kg acorns per year

    c. Based on acorn production, how many deer can one hectare support (general carrying capacity)?

    Equation to Use: (total acorns per hectare) / (acorns needed per deer per year)

    252.5 kg per hectare / 821.25 kg per deer

    0.307 deer per hectare

    d. What is the true carrying capacity per hectare, accounting for the fact that only 85% of acorns reach the ground?

    Equation to Use: (deer per hectare) x (percent of available acorns)

    0.307 deer per hectare x 0.85

    0.26 deer per hectare

    e. How many deer can the entire forest support for one year?

    Equation to Use: (deer per hectare) x (total hectares in forest)

    0.26 deer per hectare x 7,906 hectares

    2055.56 (you can't have half of a deer so round) → 2056 deer in the forest

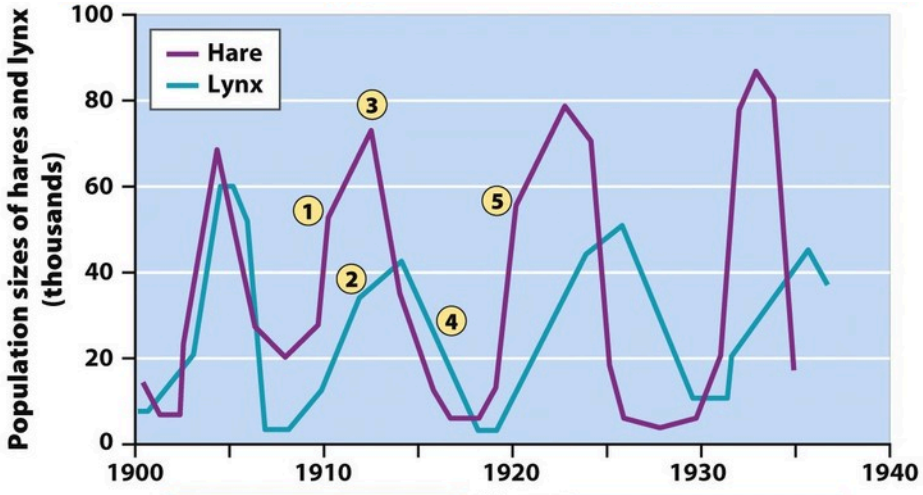
6. The removal of predators from the Kaibab Plateau resulted in the deer population exploding as their top predators no longer limited the population. Unfortunately, the deer population massively overshot the carrying capacity. Predict what will happen and why? What will be the main limiting factor now that predators have been removed?
   The main limiting factor will be food availability, as a massive population of deer overgraze the forest/plateau. This will create a strong competition for food, and as a result, many deer will die. The population will likely crash after a massive overshoot of the carrying capacity.

7. Does carrying capacity change over time? If so, why?
   Carrying capacity does change over time because it is dependent upon the resources that the environment can provide (and that changes).

8. What factors determine the carrying capacity of an ecosystem?
   Carrying capacity is determined by the availability of resources and environmental conditions.
   - **Examples of resources: Water, food, space/shelter, nutrients/energy**
   - **Examples of conditions: competition, predation, disease and parasites, climate/weather**

   Note that some conditions, such as competition and climate/weather affect resource availability.

9. Explain the predator-prey relationship and how their population sizes change in regards to one another. A graph of this is shown below as an aid to your explanation.



A predator-prey relationship is when one organism (predator) hunts and eats another organism (prey), like wolves (predator) and deer (prey).

Their populations are closely connected and tend to follow a pattern:
- ➢ **Prey population increases → More food is available for predators**
- ➢ **Predator population increases → More predators eat more prey**
- ➢ **Prey population decreases → Too many predators reduce the prey population**
- ➢ **Predator population decreases → Less food (prey) causes predator numbers to drop**
- ➢ **Cycle repeats**

This creates a cycle where predator and prey populations rise and fall over time.

- **Predator populations lag behind prey populations (they increase *after* prey increases).**
- **This relationship helps keep ecosystems balanced and prevents populations from exceeding carrying capacity.**

Presentation #2: Population Growth and Resource Availability, Rabbit Gizmo

Vocabulary:

10. Density-dependent limiting factor - **limiting factors that depend on population size (effects become stronger as the population becomes more crowded)**

11. Density-independent limiting factor - **limiting factors that affect populations regardless of size**

Questions:

12. Describe the four population characteristics.
    - **Size: total # of individuals in a population**
    - **Density: # of individuals/area (how crowded the population is)**
    - **Distribution: how individuals of the population are spaced out compared to each other**
    - **Sex ratio: ratio of males to females**

13. Macaroni penguins have a much larger population size compared to other species. Numbering up to 100,000 individuals, the breeding colonies of the macaroni penguin are among the largest and densest of all penguin species. However, their nests are always spread out quite evenly, showing a uniform distribution. The sex ratio of the breeding colonies tends to fall around 44.4-58.3% male, with an average of 51.6%). What can you infer about the population knowing these population characteristics (*Hint: you should have one inference/answer per characteristic).*
    - **Population size: A large population size suggests that the population is safer than most when it comes to the threat of population decline**
    - **Population density: As breeding colonies are quite dense, the population likely will experience increased competition and probability of disease outbreak**
    - **Distribution: A uniform distribution suggests territorial or antagonistic (they fight) relationships between nesting individuals.**
    - **Sex ratio: With an average of 51.6% males across breeding groups, there is a pretty ideal ratio to ensure breeding of all individuals.**

14. In the table below are a list of limiting factors (both density-dependent and density-independent). Please highlight the density-dependent factors in yellow.

Food	Climate	Weather	Forest Fire	Competition
Natural Disaster	Disease	Space/Shelter	Parasites	Finding a Mate
Water	Pollution	Predation	Waste Buildup	Drought

Presentation #3: Survivorship Curves

Vocabulary:

15. Survivorship curve - **graphs that show how many individuals in a population survive at each age**
16. K-selected species - **organisms that exhibit low reproductive rates and lower mortality rates**
17. R-selected species - **organisms that exhibit high reproductive rates and high mortality rates**

Questions:

18. Describe the traits of the survivorship curve, characteristics of organisms, and examples of each of the three types of survivorship curves. Use the table below.

Survivorship Type	***Type 1***	***Type 2***	***Type 3***
Traits	- High survival early and middle life - Most individuals live to old age - Low death rate until late in life	- Constant death rate throughout life - Equal chance of dying at any age	- Very high death rate early in life - Few individuals survive to adulthood
Characteristics of Organisms	- Produce few offspring - Provide a lot of parental care - Offspring have high chance of survival	- Produce moderate number of offspring - Provide some parental care	- Produce many offspring - Provide little to no parental care - Survivors live long once past early stage
Example Organisms	- Humans - Elephants - Many larger organisms	- Birds - squirrels - Some reptiles	- Fish - Insects - Plants

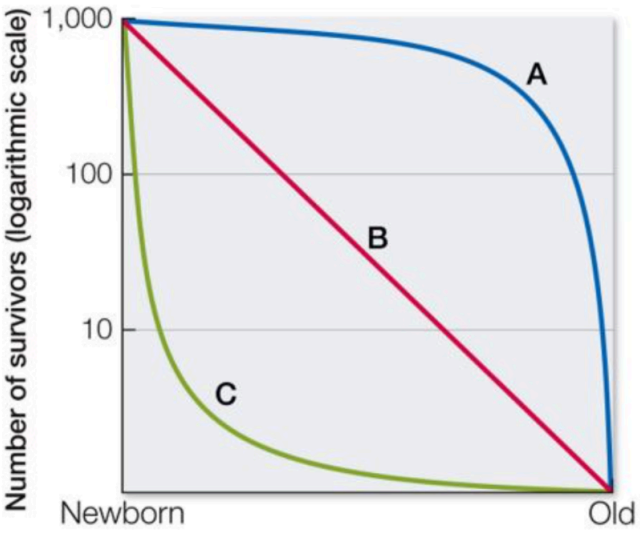
Quick Summary

Type	Offspring	Parental Care	Survival Pattern
Type I	Few	High	Live long, die old
Type II	Moderate	Some	Constant death rate
Type III	Many	Little/None	Many die young

Memory Tip

- **Type I = “Invest a lot” → Few babies, high survival**
- **Type II = “In between” → steady survival**
- **Type III = “Quantity over quality” → many babies, low survival**

19. Please label curves A, B, and C with the correct number of survivorship curves.



Curve A: Type I

Curve B: Type II

Curve C: Type III

20. How do the terms r-selected species and K-selected species relate to population size and growth?

r = refers to the growth rate of a population (how fast a population grows)

- **R-species reproduce to maximize the growth rate (many offspring which overshoots carrying capacity and results in most of them dying)**

K = refers to the carrying capacity (maximum population an environment can support)

- **K-species reproduce in low numbers to keep the population stable (not exceed carrying capacity)**

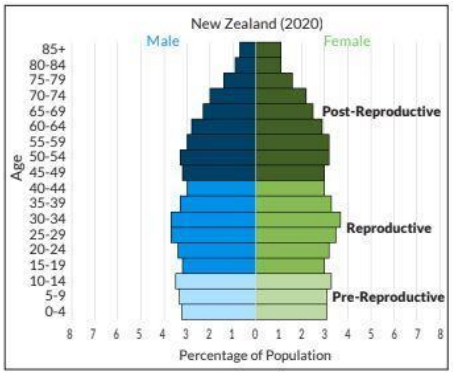
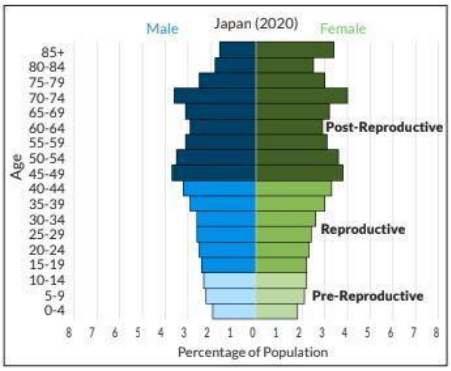
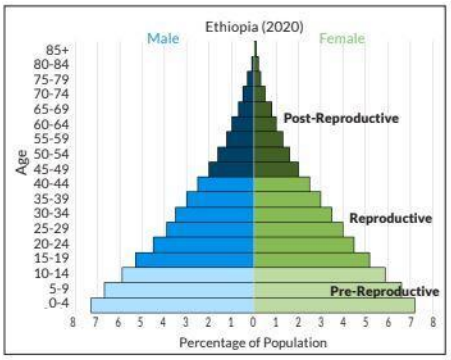
Age Structure Diagram Activity

Vocabulary:

21. Age Structure Diagram - **A graph that shows the number of males and females in different age groups in a population**

Questions:

22. Please identify whether the following age structures are expanding, stable, or diminishing.

		
Stable	**Diminishing**	**Expanding**

a. How would you expect the population has changed over the last six years for each of the nations listed above?
   - **New Zealand (stable): The population has remained largely unchanged**
   - **Japan (diminishing): The population has decreased in size**
   - **Ethiopia (expanding): The population has increased in size**

23. What factors can contribute/lead to the various types of age structures in a population?
   - **Expanding:**
     - **High birth rates**
     - **Limited access to education**
     - **Limited access to birth control**
     - **Lower life expectancy**
     - **Higher poverty rates/agricultural economies (need more workers)**
   - **Stable:**
     - **Balanced birth rates and death rates**
     - **Access to health can and family planning**
     - **High education levels**
     - **Urban lifestyles**
   - **Diminishing:**
     - **Very low birth rates**
     - **High cost of living**
     - **Women delaying or choosing not to have children**
     - **Access to careers and education**
     - **Aging population**

[Demographic Transition Model Doodle Notes](), [Demographic Transitions Activity]()

Vocabulary:

24. Demographic transition - **A model that shows how a country's population changes over time as it develops**

25. Stage 1: Preindustrial - **A stage with high birth rates and high death rates, resulting in little or no population growth**

26. Stage 2: Transitional - **A stage where death rates drop quickly but birth rates remain high, causing rapid population growth**

27. Stage 3: Industrial - **A stage where birth rates begin to decline, and population growth starts to slow**

28. Stage 4: Post-industrial - **A stage with low birth rates and low death rates, resulting in stable or declining population growth**

Questions:

29. Please describe how population growth changes as a population moves through the stages of demographic transition. Analyze birth rates, death rates, and factors that influence both.

Demographic Stage	Stage 1	Stage 2	Stage 3	Stage 4
Overall Growth	Low Growth	Rapid Growth	Growth rate continuously slows	No growth or declining
Birth Rate & Influencing Factors	High Families have many children for labor	High Still agricultural so there is a need for children	Decreasing Urbanization, education, higher cost of raising kids, women working, access to birth control	Low High education levels, women delaying birth, career focus, high cost of living
Death Rate & Influencing Factors	High Little medical care, poor sanitation, high disease rates, food shortages	Rapidly decreasing Improved medicine, better sanitation, increased food	Low Good or better medicine, sanitation, resource availability	Low Advanced healthcare, medicine, sanitation, resource availability

30. What type of age structure diagram would you associate with each phase of demographic transition?
    Stage 1: Preindustrial - Expanding (narrow pyramid shape)
    Stage 2: Transitional - Expanding (wide pyramid shape)
    Stage 3: Industrial - Expanding (narrowing pyramid shape over time)
    Stage 4: Post-industrial - Stable or declining (rectangular shape or inverse pyramid)