Biology
Population Ecology

Population Ecology

1.

Main Idea: Population is a group of individuals of the same species living in the same general area.

Main Idea: To study populations start by examining their density (how many), their dispersion (how they are spaced) and their demographics (how they change over time).

* The next step is to find reasons for the above.

What type of factors do you predict may play a role in a populations density, dispersion and demographics?

POPULATION CHARACTERISTICS

Density and Dispersion

- *density:* number of individuals per unit area

- *dispersion:* pattern of spacing among individuals within the boundaries of of the population

Density Dynamics

- rarely can you simply count all the individuals in a population

- most the time it is impossible or impractical to count all the individuals

  - in these cases scientists use a variety of sampling techniques to estimate the population's size

    - Mark and Recapture Method is commonly used

Mark and Recapture Method

- *Application:* it is not possible or practical to count the number of individuals per unit area

- *Technique:*

  - 1. capture a random sample

  - 2. tag and release

  - 3. wait for some time to past (days or weeks)

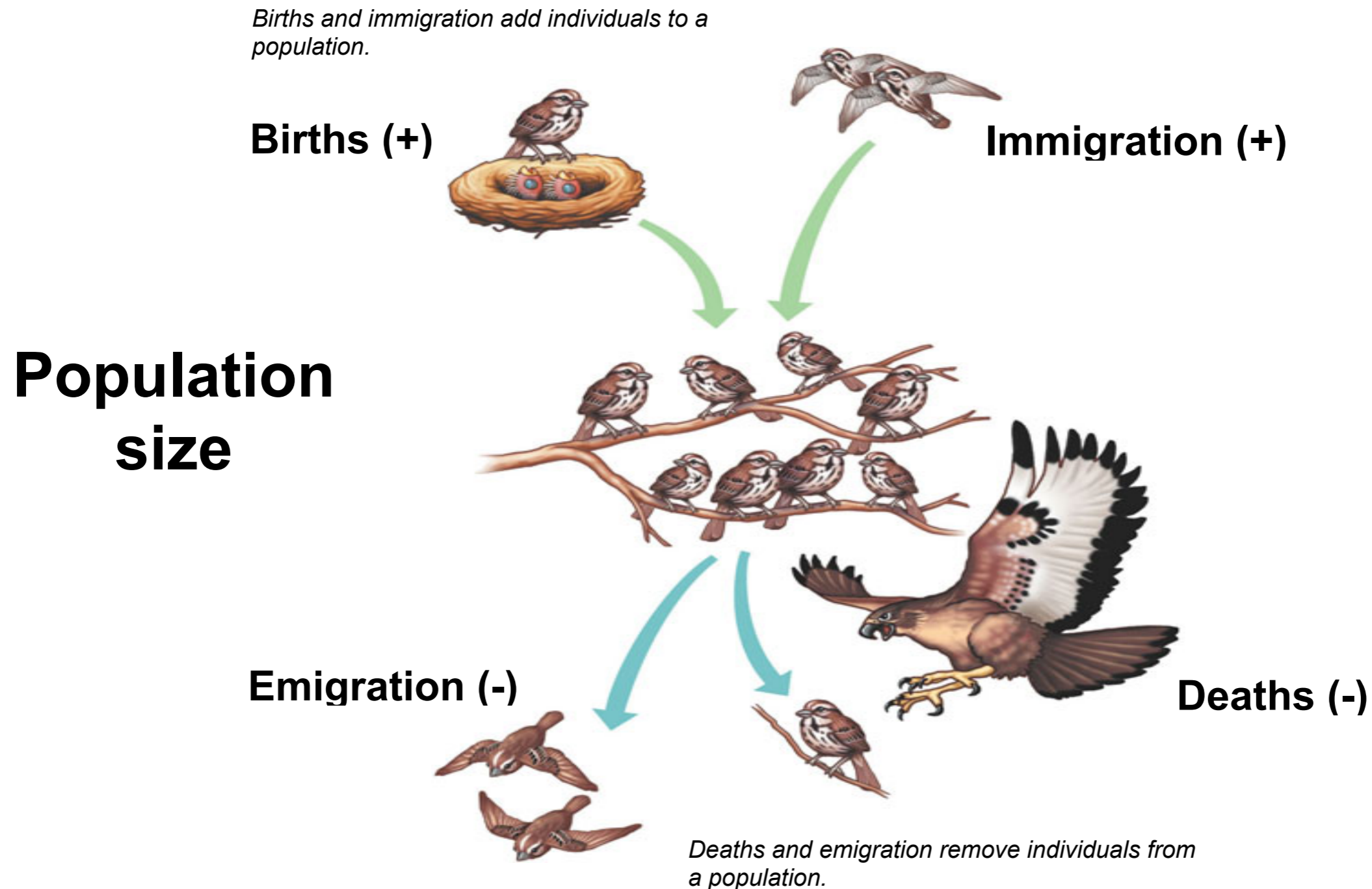 - 4. capture a second sample

  - 5. solve for N

$$\frac{x}{n} = \frac{s}{N} \quad \text{thus} \quad N = \frac{sn}{x}$$

where x= marked recaptures, n= second sample total, s= first sample total, N= estimated pop. size

Three Important Assumptions are made. *First... all marked or unmarked have the same probability of being caught. Second... the marked have remixed with the entire population. Third... no individuals are born, die, immigrate or emigrate during time frame between the two samplings.*

Density Dynamics (continued)

- density is changing all the time as a result of any or all of the four factors below


Births and immigration add individuals to a population.

Births (+)

Immigration (+)

Population size

Emigration (-)

Deaths (-)

Deaths and emigration remove individuals from a population.

Patterns of Dispersion

Clumped: most common, increases breeding success, acquisition of food and provides safety in numbers
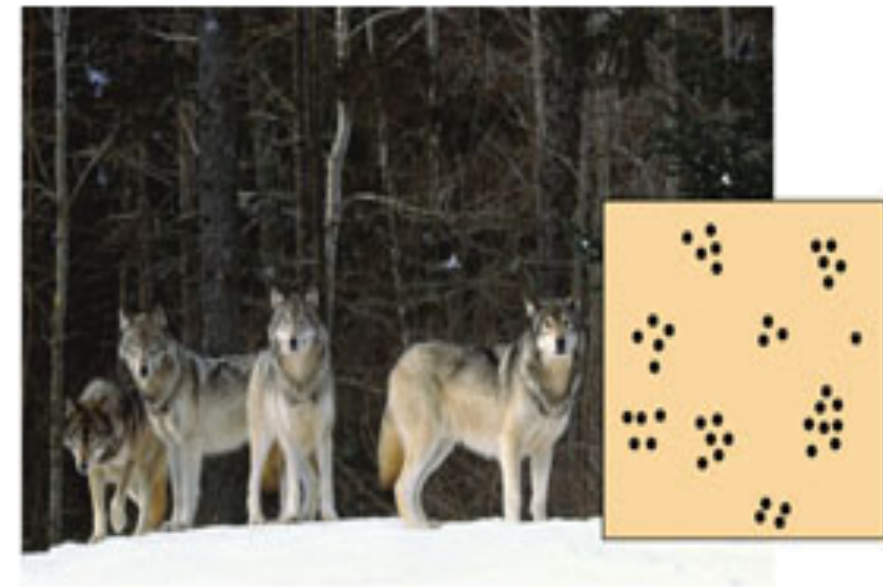
Uniform: rare, direct interactions and competition for limited resources result in this spacing
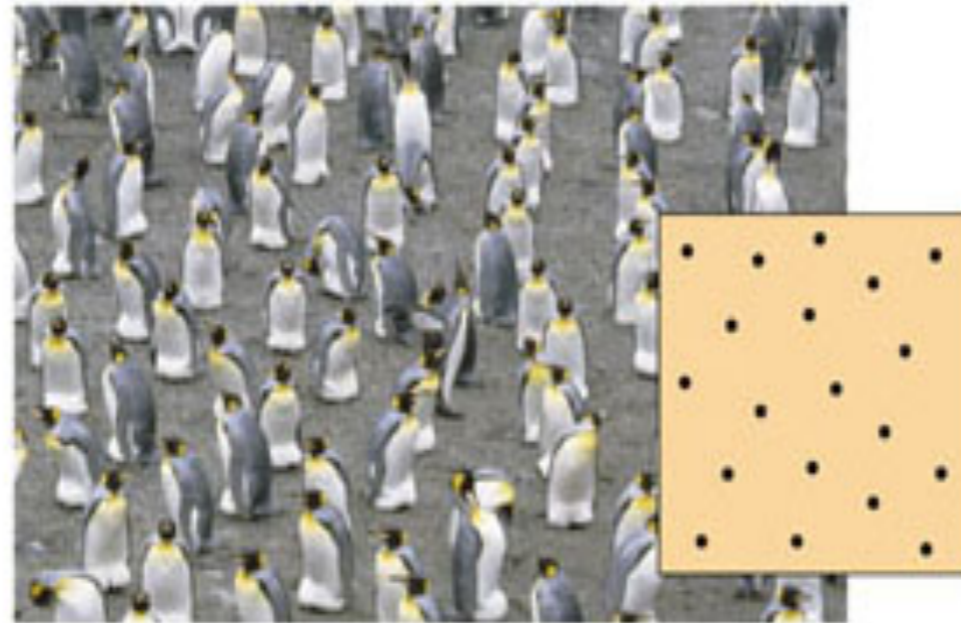
Random: not as common as one might suspect, there is usually an absence of strong attractions / repulsions or the key environmental factors are relatively constant / abundant

Demographics

- the study of vital statistics of a population and how they change over time

    - we will focus on *birth rates* and *death rates*

        - to simplify we will ignore *immigration* and *emigration*

Survivorship Curves (death rates)

- graphic representation of life table data

- plots the proportion or numbers in a cohort still alive at each age

- there are three general types of curves

- in reality curves are more complex and most species fall in between these three general curves

- Reproduction is the biological imperative! **What are the strategies behind type I and type III curves?**

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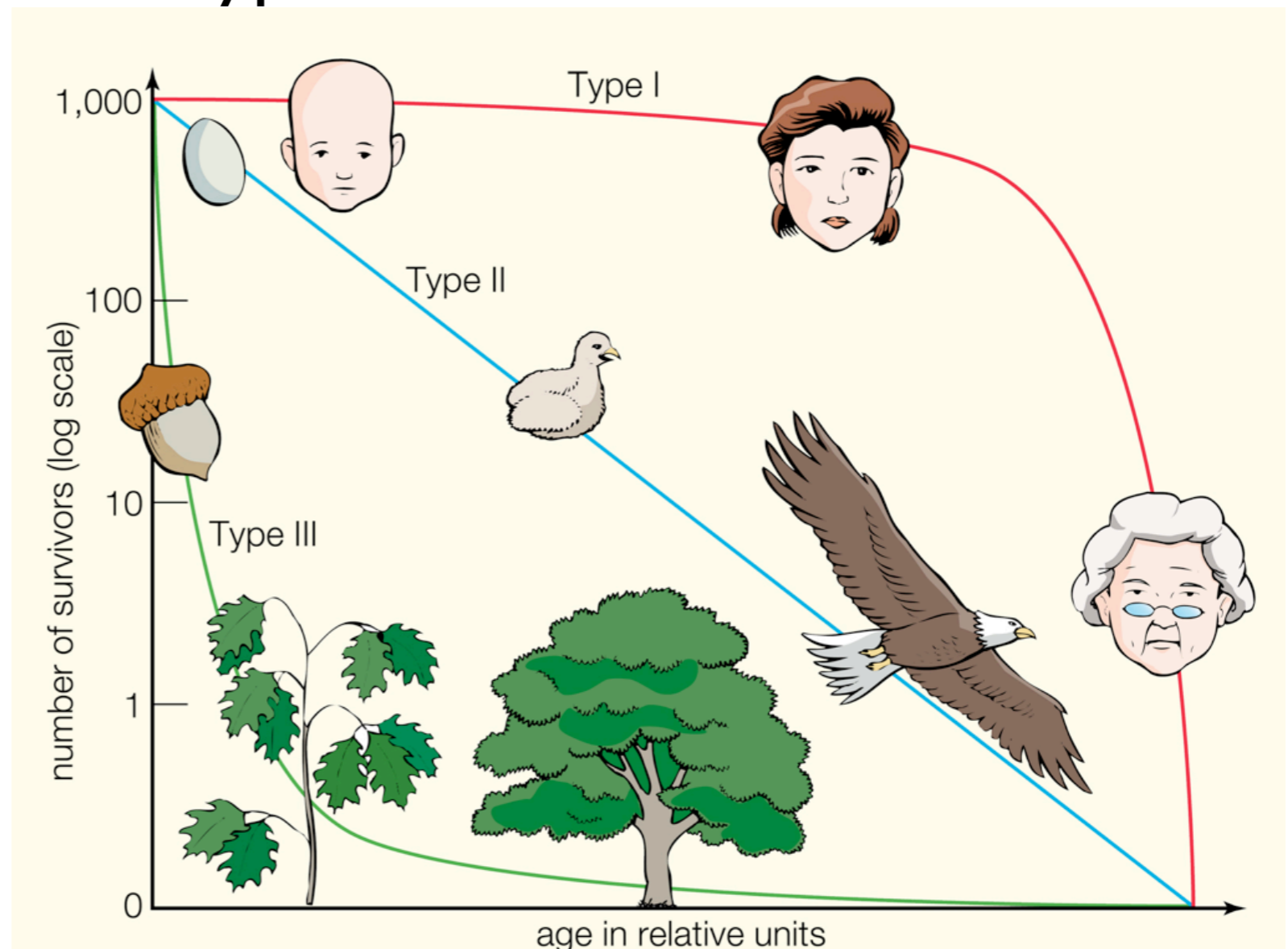
Reproductive Rates (birth rates)

- collect data on the reproductive output as it varies with age

  - *reproductive tables* or fertility schedule is an age specific summary of reproductive rates in a population

    - usually focuses on females because only they produce offspring

  - plots this reproductive data will help illustrate and describe reproductive patterns in the population

  - reproductive tables and patterns vary considerably by species

Population Ecology

II.

Main Idea: All species have the potential to increase their population size greatly under ideal conditions.

Main Idea: Exponential growth describes a population growing at its maximum potential under ideal conditions

What type of factors do you think constitute "ideal conditions"?

EXPONENTIAL MODEL

- *Bacteria* have a fast rate of intrinsic growth

- A population of bacteria doubles every 20 minutes.

  - 1 becomes 2 in 20 minutes, 2 become 4 in another 20 minutes

  - at this rate bacteria would cover the earth's surface at a depth of 30 cm in just 36 hours

- *Elephants* have a slow rate of intrinsic growth

- An elephant may produce only 6 offspring in a 100 years time

  - still in 750 years, a pair of elephants could give rise to a population that exceeds 19 million

Exponential Growth

- Reproduction at the physiological capacity (maximum)

  - "graphed" **exponential growth** takes on a "**J**" shaped curve

  - this type of growth is rare in the real world,it does/can occur where populations are rebounding or have been recently introduced into a new environment
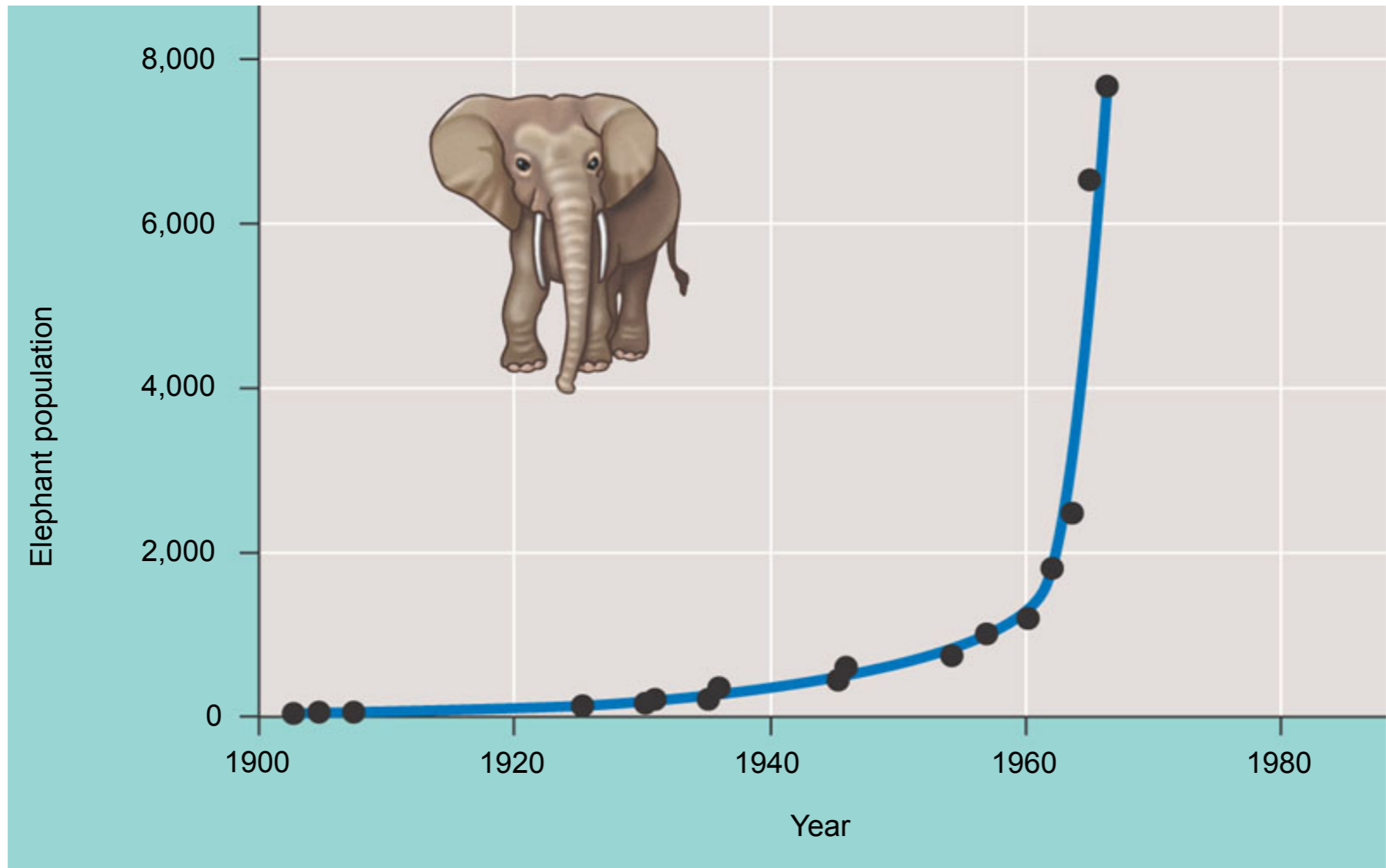
Population Ecology

III.

Main Idea: Conditions are rarely ideal and as such the environment can support a limited number of individuals
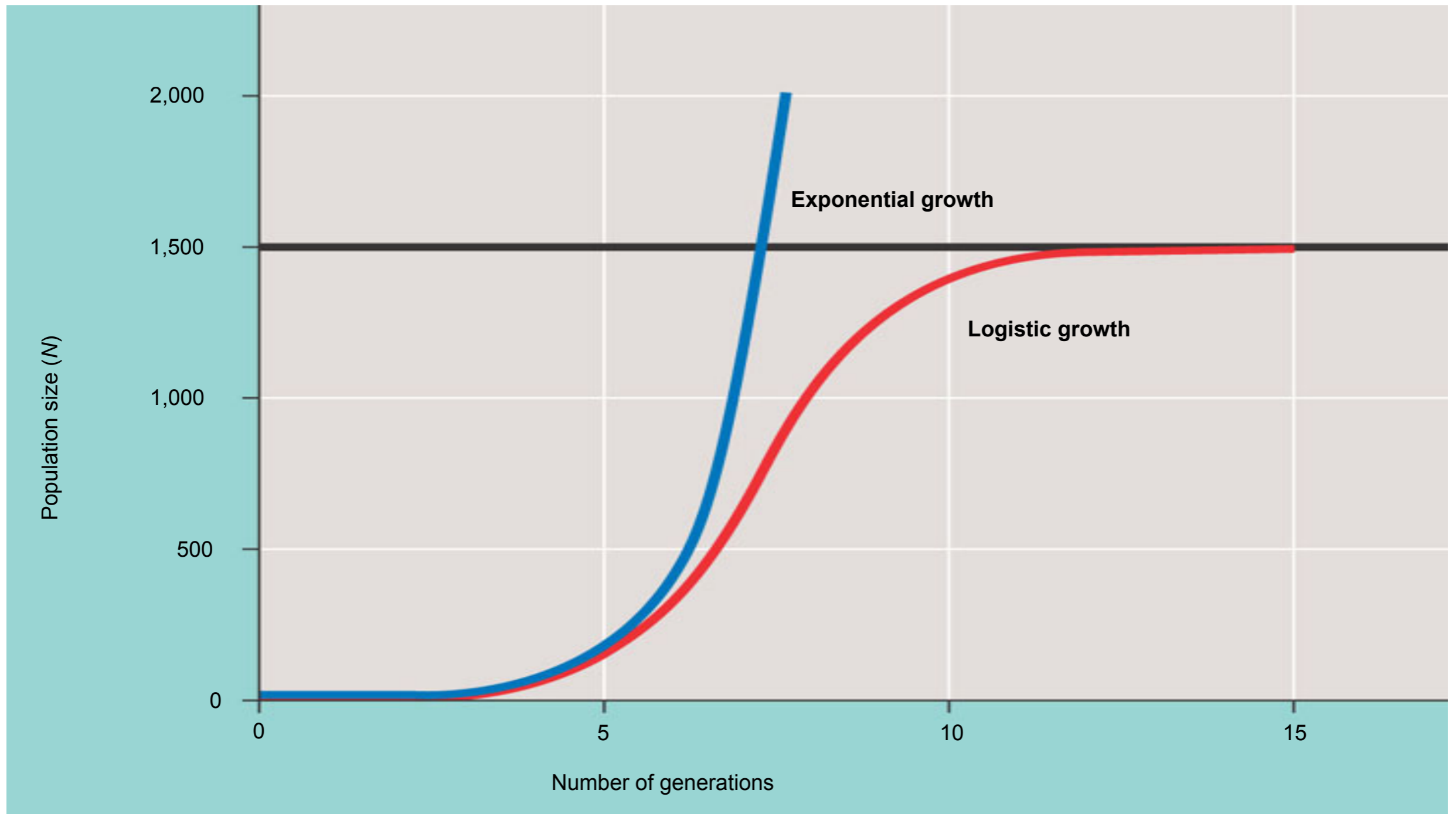
Main Idea: The maximum number of individuals that the environment can sustain is its carrying capacity.

Main Idea: Population growth rate decreases as a population approaches its carrying capacity.

Can you think of any limiting factors?

Logistic Growth Model

- "graphed" **logistic growth** takes on a "**S**" shaped curve

Logistic Growth in Real Populations

- Logistic Model

    - Many populations fluctuate greatly, making it difficult to establish an accurate carrying capacity

    - **This model is a starting point for more complex ones!**

Population Ecology

IV.

Main Idea: The "purpose of life" is pass genes into the future.

Main Idea: In order to do this successfully life must first *survive* and then *reproduce*.

Main Idea: *Natural selection* has favored certain *life histories* over others. Think of these *life histories* as strategies for reproductive success.

Do you think that the perfect life history exists today? If not will it exist in the future? Why or Why not?

LIFE HISTORY TRAITS

- traits that influence an organisms survival and reproduction

- entails 4 main variables

  - *WHEN* reproduction begins

    - (age of 1st reproductive attempt or age of maturity)

  - *HOW OFTEN* they reproduce

    - (once in their life or multiple times throughout)

  - *HOW MANY* offspring they produce

    - (per reproductive attempt or cycle)

  - *PARENTAL CARE* they provide

    - (can range from no care at all to years of extensive care)

Evolution of Life History Diversity

- Nature has selected the most successful reproductive strategies over time

  - Like all adaptations there are "Trade Offs"

  - Like all adaptations there is No Conscious Choice reflected in an organisms development, behavior, physiology or structure

How is a peacocks tail an example of a "trade off"?

- Many life histories exist but looking at Two opposing extremes helps us to better understand all of the different life histories

- There two ideal and opposing life strategies

  - This is the "Quantity Strategy"!

  - It is commonly favored/found in species who live in

    - 1.)harsh and unpredictable environments,

    - 2.)species with high infant mortality and

    - 3.)species who are preyed upon

      - Ex. salmon, squid, arachnids, grain crops

- This is the "Quality Strategy"!

- It is commonly favored/found in species who live in

  - 1.) dependable environments with plenty of resources,

  - 2.)species who live near their carrying capacity

  - 3.)species who are involved in intense competition for resources

    - Ex. all birds, most mammals, reptiles, fish

In reality most life histories are intermediate and specific to each species situation
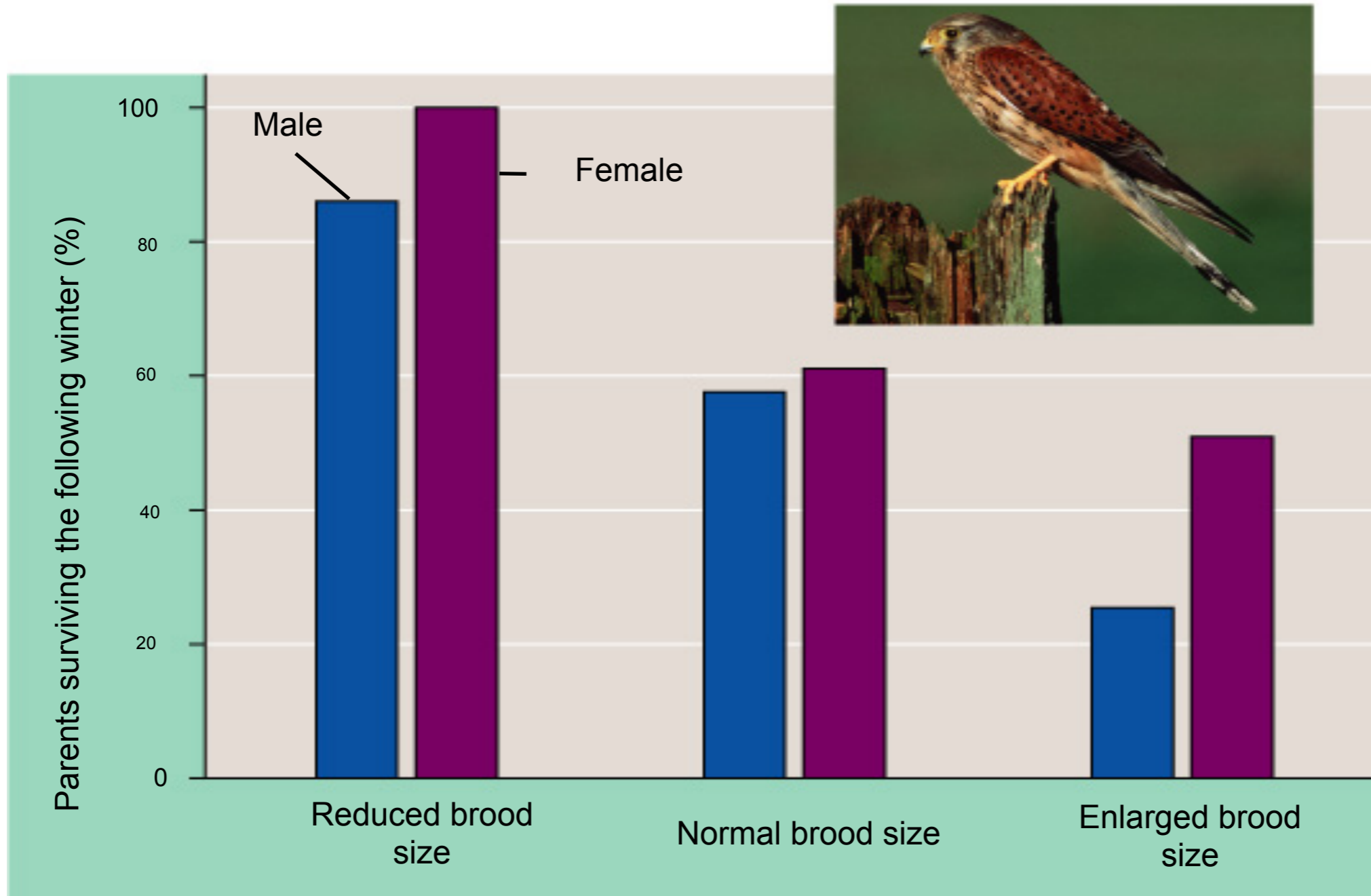
Trade Offs (Cost/Benefit Analysis)

- There is an indirect relationship between the number of offspring and parental care.

  - producing more offspring puts more genes into the future but the provisions will have to go down as time and resources are limited thus quality is sacrificed

  - producing less allows for better provision but less offspring means less genes going into the future thus quantity is sacrificed

Bottom Line...Selective Pressures influence the number and size of offspring along with the extent of care given.

Researchers in the Netherlands studied the effects of parental caregiving in European kestrels over 5 years. The researchers transferred chicks among nests to produce reduced broods (three or four chicks), normal broods (five or six), and enlarged broods (seven or eight). They then measured the percentage of male and female parent birds that survived the following winter. (Both males and females provide care for chicks.)

Male

Female

Parents surviving the following winter (%)

100

80

60

40

20

0

Reduced brood size

Normal brood size

Enlarged brood size

CONCLUSION   The lower survival rates of kestrels with larger broods indicate that caring for more offspring

Trade Offs (Cost/Benefit Analysis)

- There may be a relationship between the life history of a species its and population's density in the logistic growth model.

  - Species living near their carrying capacity are called *K-selected*

    - Living near "K" results in extensive competition for the limited resources

    - These species tend to be found in stable and relatively constant environments

    - As a result "quality" gametes/offspring are favored to better compete

      - This usually means more energy has to be put into each gamete/offspring thus they tend to be *larger* and *fewer* in number

        - for example consider coconuts and dandelions

Trade Offs (Cost/Benefit Analysis)

- There may be a relationship between the life history of a species its and population's density.

  - Species whose numbers are not near their carrying capacity are called *r-selected*

    - Species not yet living near "K" are able to reproduce at or near their maximum intrinsic rate "r" because competition is less

    - As a result "quantity" trumps quality, species are more successful generating a *high number* of *smaller* gametes/offspring to increase their chances for success

      - These species are often found in very unpredictable environments where resources fluctuate dramatically

Can you think any examples of K-selected or r-selected traits? What does K and r represent in logistic growth?

REGULATION OF POPULATION GROWTH

A. Population Change Over Time

- *Once again will simplify matters by ignoring immigration and emigration or assume they cancel each other out!*

- A factor that does not effect birth rates and death rates as the population becomes more dense is said to be *density independent.*

- Should birth rates and death rates change as population size change then those factors are said to be *density dependent.*

Density Dependent Population Regulation

- *Density Dependent Factors.*

  - Competition
  - Predation
  - Disease

  - Territoriality
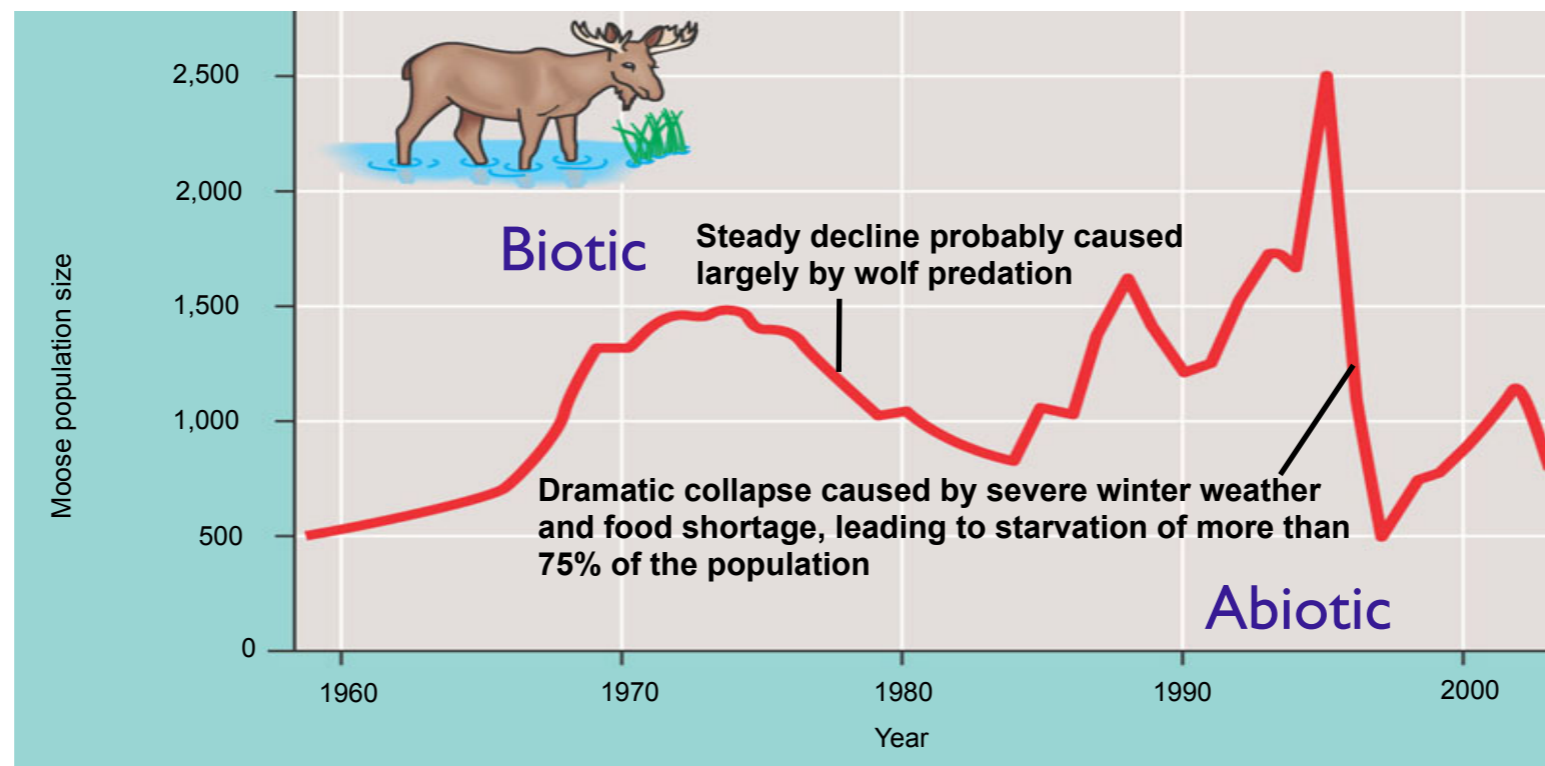 - Toxic Waste
  - Intrinsic Factors

Propose how each of these might regulate population growth as density increases. Can you provide examples?

Population Dynamics

Regardless the mechanism most populations fluctuate to some extent or another. The reasons may be complex and often involve both biotic and abiotic factors.

1. Stability and Fluctuation

- Biotic & Abiotic Factors.

  - ↓harsh weather, ↓parasites, ↕ food availability, etc.

Biotic

Steady decline probably caused largely by wolf predation

Dramatic collapse caused by severe winter weather and food shortage, leading to starvation of more than 75% of the population

Abiotic

Moose population size — Year

THE HUMAN POPULATION

Name that tune?   "Times They are a Changing" By: Bob Dylan

THE HUMAN POPULATION

- Human population has exploded over the last few centuries

A. Human Population

- Nearly 80 million people are added to the earth each year at the current rate

- 200,000 are added each day this equivalent to the city of Richmond, Virginia

- Growth rate has decreased over the last few decades, it has departed from true exponential growth

- Likely this change is a result of voluntary population control (China) and diseases (AIDS)

- http://www.poodwaddle.com/clocks/worldclock/

THE HUMAN POPULATION

- **Year 1 Population 200 million**
- **1650 500 million**
- **1804 1 billion**
- **1927 2 billion**
- **1960 3 billion**
- **1975 4 billion**
- **1999 6 billion**
- **2006 6.5 billion**
- **2012 7 billion**
  - **projections:** 2020 7.6 billion
    - 2030 8.2 billion
    - 2040 8.8 billion
    - 2050 9.2 billion

Global Human Carrying Capacity

- Are we approaching it? Have we already surpassed it?

Estimates of Human Carrying Capacity

- Average estimates between 10-15 billion

- Range from less than 1 billion to more than 1 trillion

  - 3 Methods of estimation

    - 1. *math/computer*: models from logistic curve principles

    - 2. *land*: amount of habitable land vs population density

   - 3. *single limiting factors*: food, water, farmland

Global Human Carrying Capacity

- Are we approaching it? Have we already surpassed it?

Limits on Human Population Size

Ecological Footprints- *the aggregate land and water area required by each person, city or nation to produce all the resources it consumes and to absorb all the waste it generates.*

- Calculations suggest 1.7-2 hectares per person or roughly 2-4 acres

- Anyone with a footprint above 2 hectares is using an unsustainable share of earth's resources

  - The average american has a footprint of 10 hectares!

  - An american use 30X more energy than the a typical person from central Africa
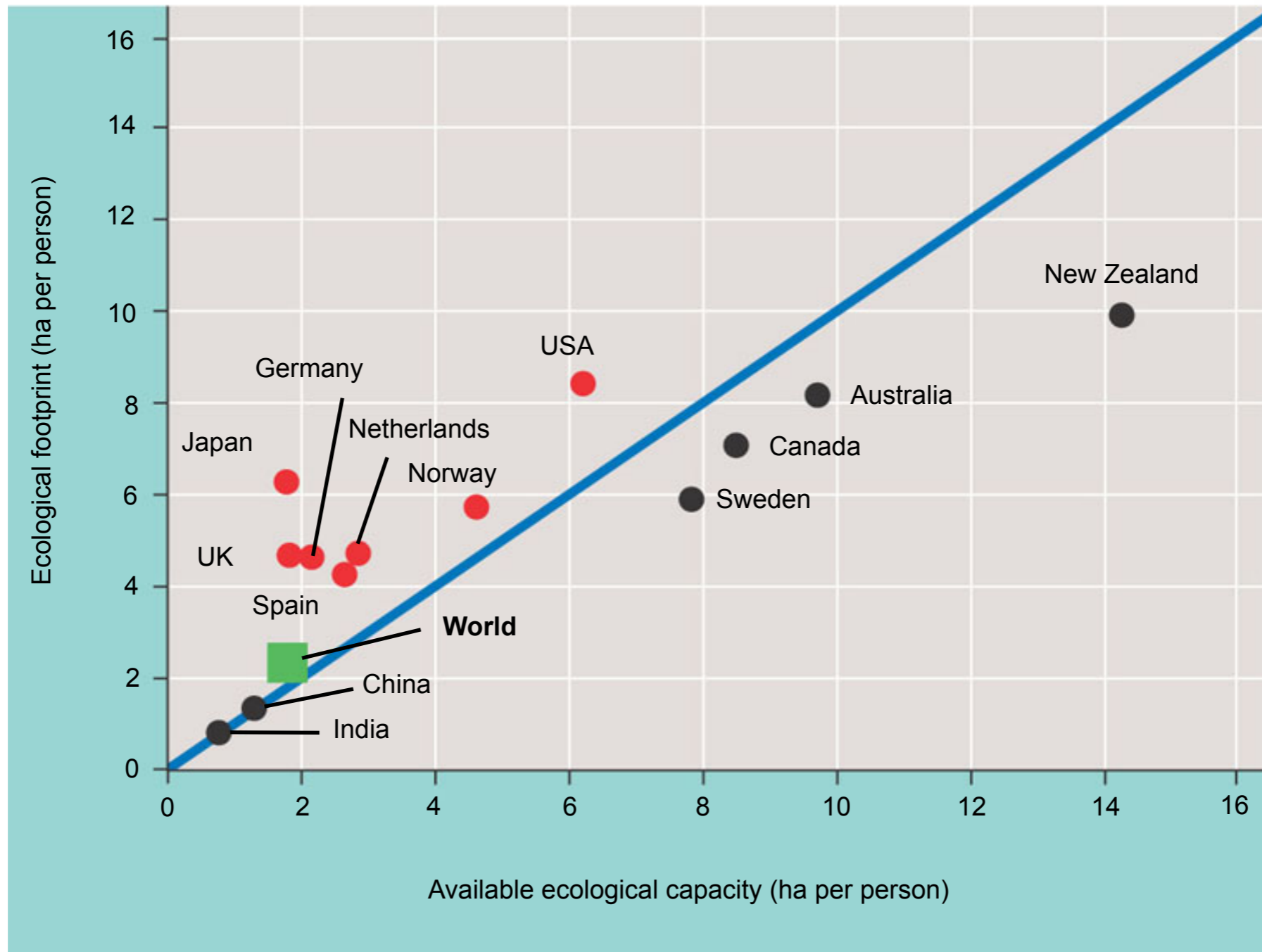
Ultimately the combination of resource use per person and population density will determine our global ecological footprint.

- **Bottom Line... we can only speculate on the earth's carrying capacity!**

- Perhaps **food** will be our limiting factor, perhaps **space**, perhaps **freshwater**, perhaps **nonrenewable resources** or maybe the environments ability to **absorb waste**.

This Much is True- *1. no population can grow indefinitely, 2. quality of life we choose to enjoy will effect the earth's carrying capacity.*

Unlike any other species we have the choice to achieve zero population growth through social change or allow nature to do it through plagues, limited resources, war and environmental degradation.

"Nothing in nature takes more than it needs" unknown

"...Except Humans" *Morone Jr.*

National Geographic's "Human Footprint" (first ten minutes)
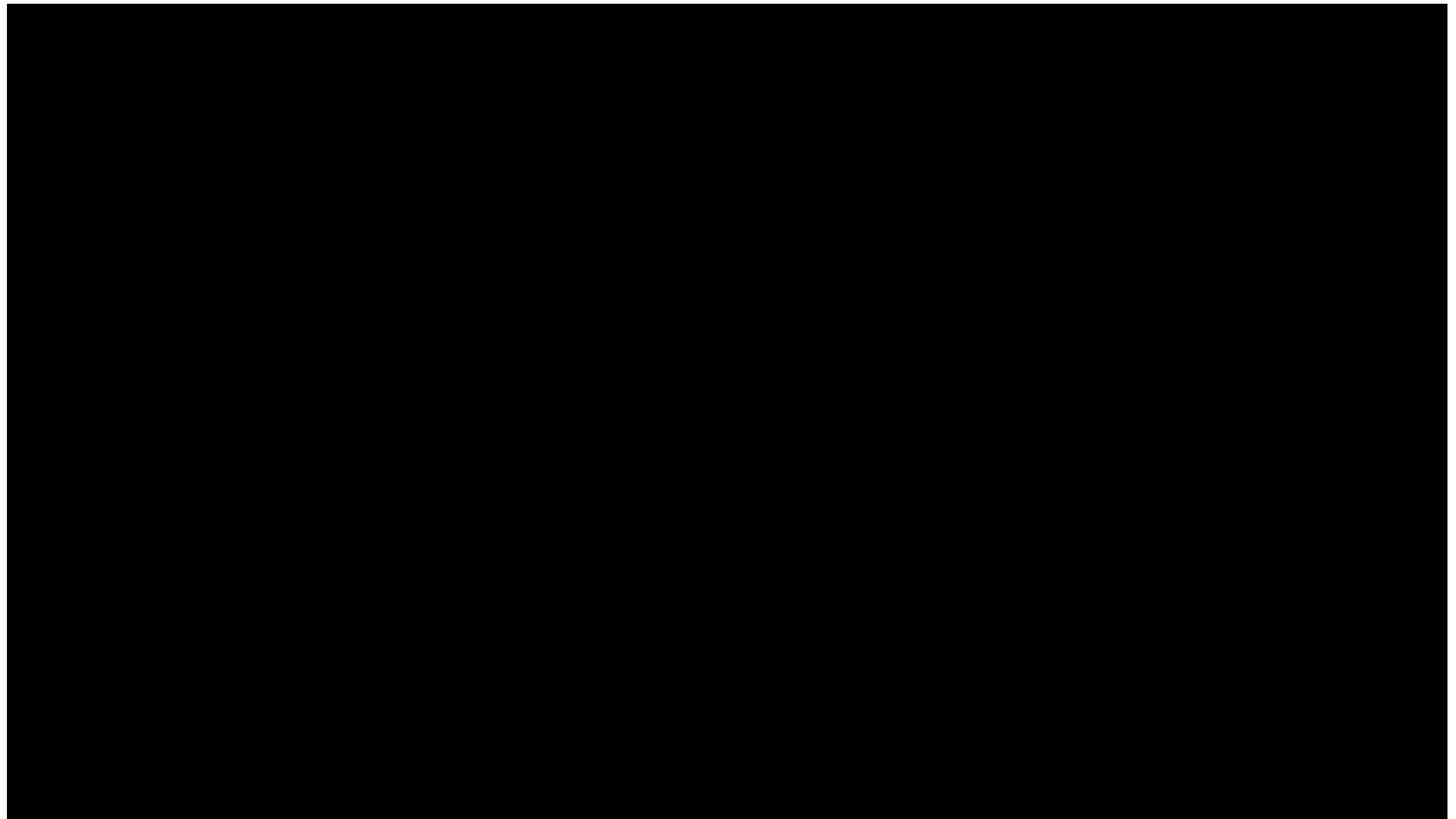
National Geographic's "Human Footprint" (last minute)

Stop and Think

Can you imagine a population where you could actually count all the individuals?

Try producing a survivorship curve from the Dall Sheep life table data.

Explain why a constant rate of increase (r max) for a population produces a growth graph that is J-shaped rather than a straight line.

Where is exponential growth more by a plant population more likely – on a newly formed volcanic island or in a mature, undisturbed rain forest? Why?

Stop and Think

Each female of a particular fish species produces millions of eggs per year. What is their likely survivorship pattern? Explain

One species of forest bird is highly territorial, while a second lives in flocks. What is each species likely pattern of dispersion? Explain