Unit 3 - Populations

LEARNING OBJECTIVE

ERT-3.A

Identify differences between generalist and specialist species.

ESSENTIAL KNOWLEDGE

ERT-3.A.1

Specialist species tend to be advantaged in habitats that remain constant, while generalist species tend to be advantaged in habitats that are changing.

SUGGESTED SKILL

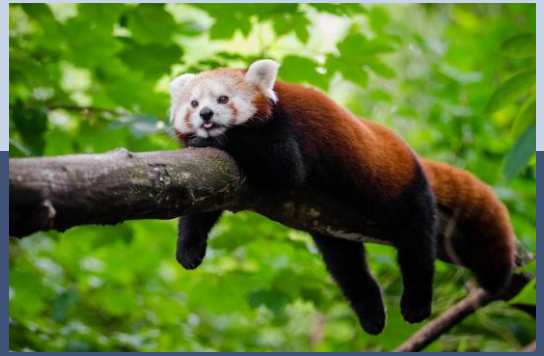
Concept Explanation

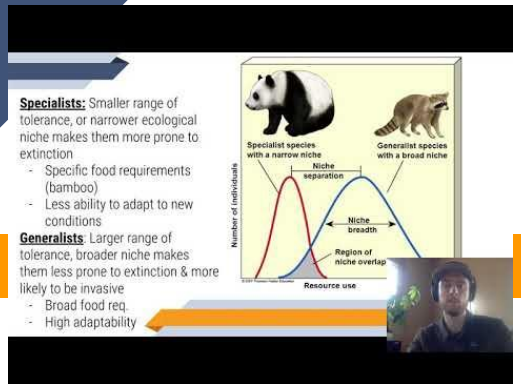
1.B

Explain environmental concepts and processes.

3.1

Specialist vs. Generalist Species



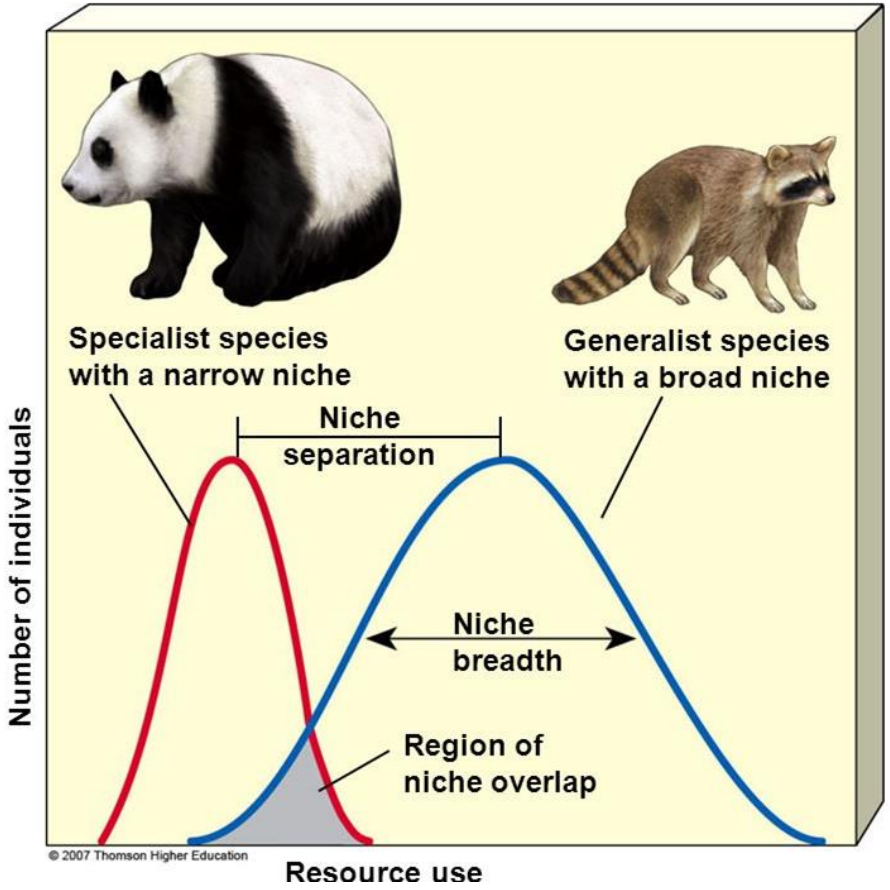


Specialists: Smaller range of tolerance, or narrower ecological niche makes them more prone to extinction

- Specific food requirements (bamboo)
- Less ability to adapt to new conditions

Generalists: Larger range of tolerance, broader niche makes them less prone to extinction & more likely to be invasive

- Broad food req.
- High adaptability



Specialists

narrow niche

less adaptable because of specialized needs

more likely to become extinct

use a specific set of resources

easily affected by changing conditions

have an advantage when conditions are more constant

Generalists

broad niche

adaptable to many environments

less likely to become extinct

use a variety of resources

high range of tolerance

have an advantage when conditions change

SUGGESTED SKILL

Concept Explanation

1.B

Explain environmental concepts and processes.

“ **Identify** ONE characteristic of specialist species and **explain** how that characteristic makes them more likely to become extinct than generalist specie

3.2 K-selected & r-selected species

Objectives, EKs, and Skills

LEARNING OBJECTIVE

ERT-3.B

Identify differences between K- and r-selected species.

SUGGESTED SKILL

Data Analysis

5.A

Describe patterns or trends in data.

ESSENTIAL KNOWLEDGE

ERT-3.B.1

K-selected species tend to be large, have few offspring per reproduction event, live in stable environments, expend significant energy for each offspring, mature after many years of extended youth and parental care, have long life spans/life expectancy, and reproduce more than once in their lifetime. Competition for resources in K-selected species' habitats is usually relatively high.

ERT-3.B.2

r-selected species tend to be small, have many offspring, expend or invest minimal energy for each offspring, mature early, have short life spans, and may reproduce only once in their lifetime. Competition for resources in r-selected species' habitats is typically relatively low.

ERT-3.B.3

Biotic potential refers to the maximum reproductive rate of a population in ideal conditions.

ESSENTIAL KNOWLEDGE

ERT-3.B.4

Many species have reproductive strategies that are not uniquely r-selected or K-selected, or they change in different conditions at different times.

ERT-3.B.5

K-selected species are typically more adversely affected by invasive species than r-selected species, which are minimally affected by invasive species. Most invasive species are r-selected species.

Quality vs. Quantity

K-selected - “quality”

- Few offspring, heavy parental care to protect them
- Generally have fewer reproductive events than r-strategists
  - **Ex: most mammals, birds**
- Long lifespan, long time to sexual maturity = low biotic potential = slow pop. growth rate
  - More likely to be disrupted by env. change or invasives

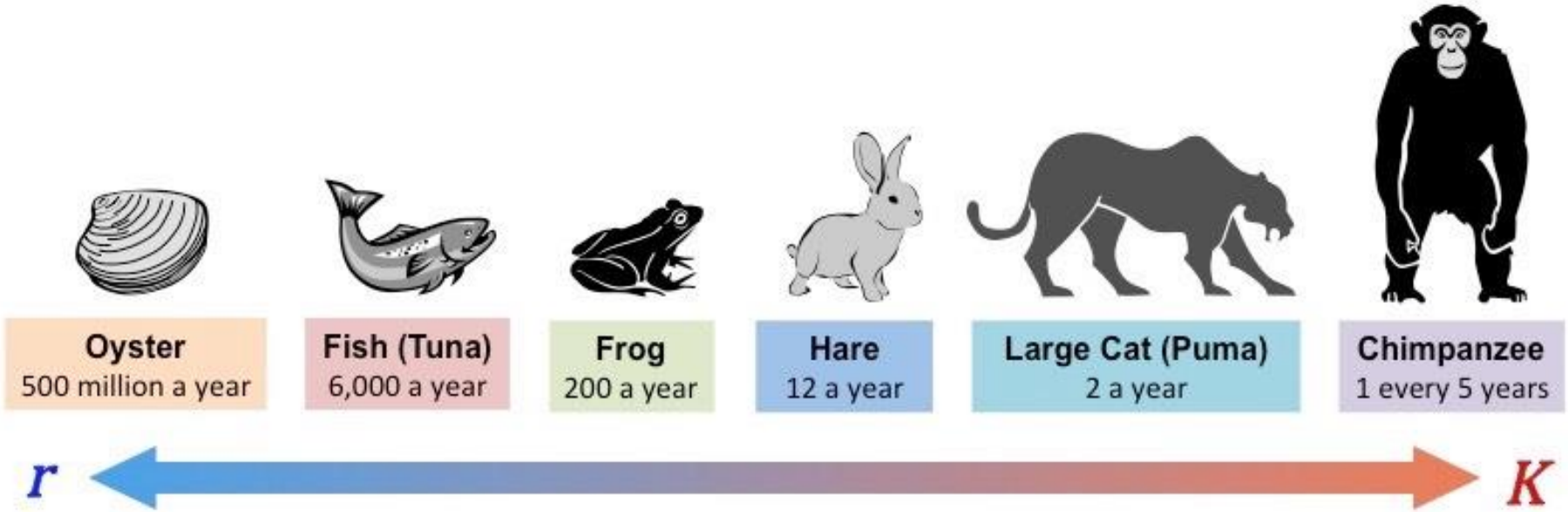
R-selected - “quantity”

- Many offspring, little to no care
- May reproduce only once, but generally reproduce many times throughout lifespan
  - **Ex: insects, fish, plants**
- Shorter lifespan, quick to sexual maturity = high biotic potential = high pop. growth rate
  - More likely to be invasive
  - Better suited for rapidly changing env. conditions

TABLE 6.1 Traits of *K*-selected and *r*-selected species

Trait	*K*-selected species	*r*-selected species
Life span	Long	Short
Time to reproductive maturity	Long	Short
Number of reproductive events	Few	Many
Number of offspring	Few	Many
Size of offspring	Large	Small
Parental care	Present	Absent
Population growth rate	Slow	Fast
Population regulation independent	Density dependent	Density
Population dynamics	Stable, near carrying capacity	Highly variable

Traits or characteristics of r-selected & K-selected species



It's a Spectrum

Spectrum of Parental Care

K-selected

- Low biotic potential (rep. rate) = hard for pop. to recover after a disturbance (env. change)
- High parental care means death of parent = death of offspring
- Invasives (usually r) outcompete for resources with high biotic potential & rapid pop. growth
- Less likely to adapt & more likely to go extinct

R-selected

- High biotic potential (rep. rate) = more rapid pop. recovery after disturbance
- Low parental care means death of parent doesn't impact offspring
- Not as impacted by invasive species since their pop. grow quickly
  - More likely to **be** the invasive
- Larger pop. & faster generation time = higher chance of adaptation & lower chance of extinction

Invasiveness & Disturbances

SUGGESTED SKILL

Concept Explanation

1.B

Explain environmental concepts and processes.

“ **Identify** ONE characteristic of an r-selected species that could increase the likelihood of the r-selected species becoming a more successful invasive species than K-selected sp

SUGGESTED SKILL

Data Analysis

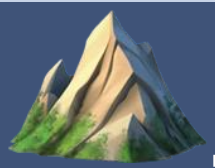
5.A

Describe patterns or trends in data.

Native Unionid and Zebra Mussel Density in the Hudson River

Year	Zebra Mussel $(\text{Density}/\text{meters}^2)$	Unionid Mussel $(\text{Density}/\text{meters}^2)$
1991	0	8
1997	3,250	2
2003	2,500	2
2009	2,000	2
2015	2,750	3

Describe the relationship between Zebra Mussel and Unionid Mussel population density in the Hudson River



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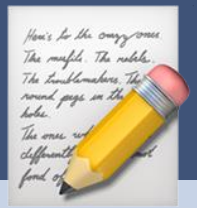

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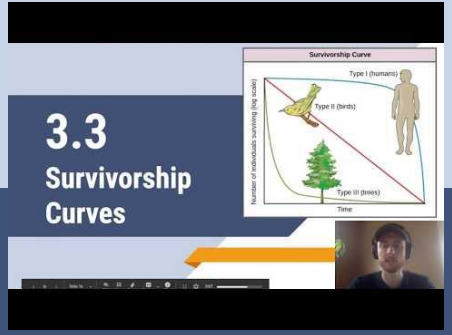
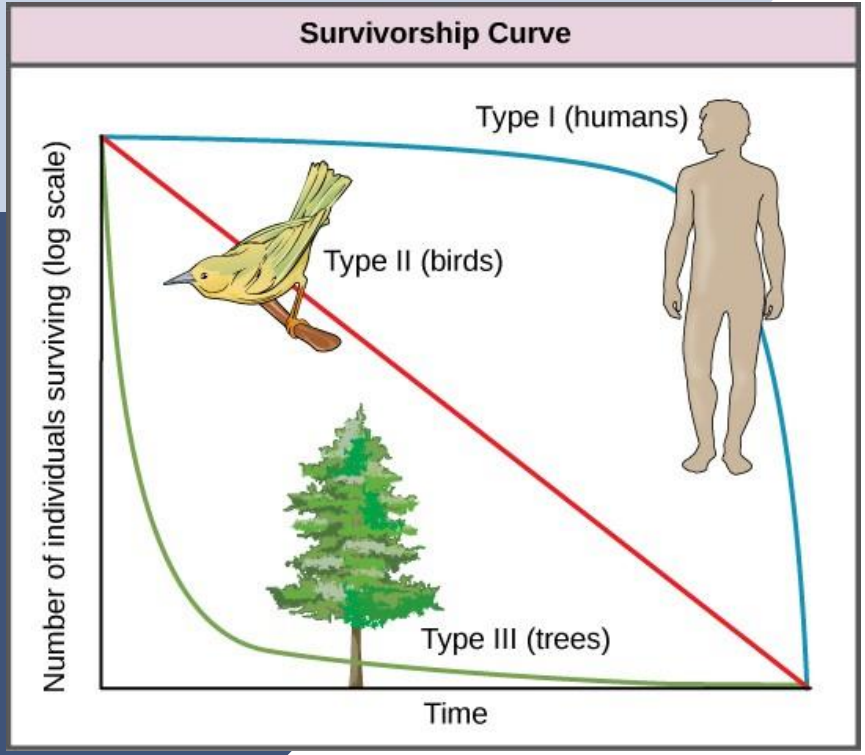


3.3 Survivorship Curves



Objectives, EKs, and Skills

LEARNING OBJECTIVE

ERT-3.C

Explain survivorship curves.

SUGGESTED SKILL

Data Analysis

5.C

Explain patterns and trends in data to draw conclusions.

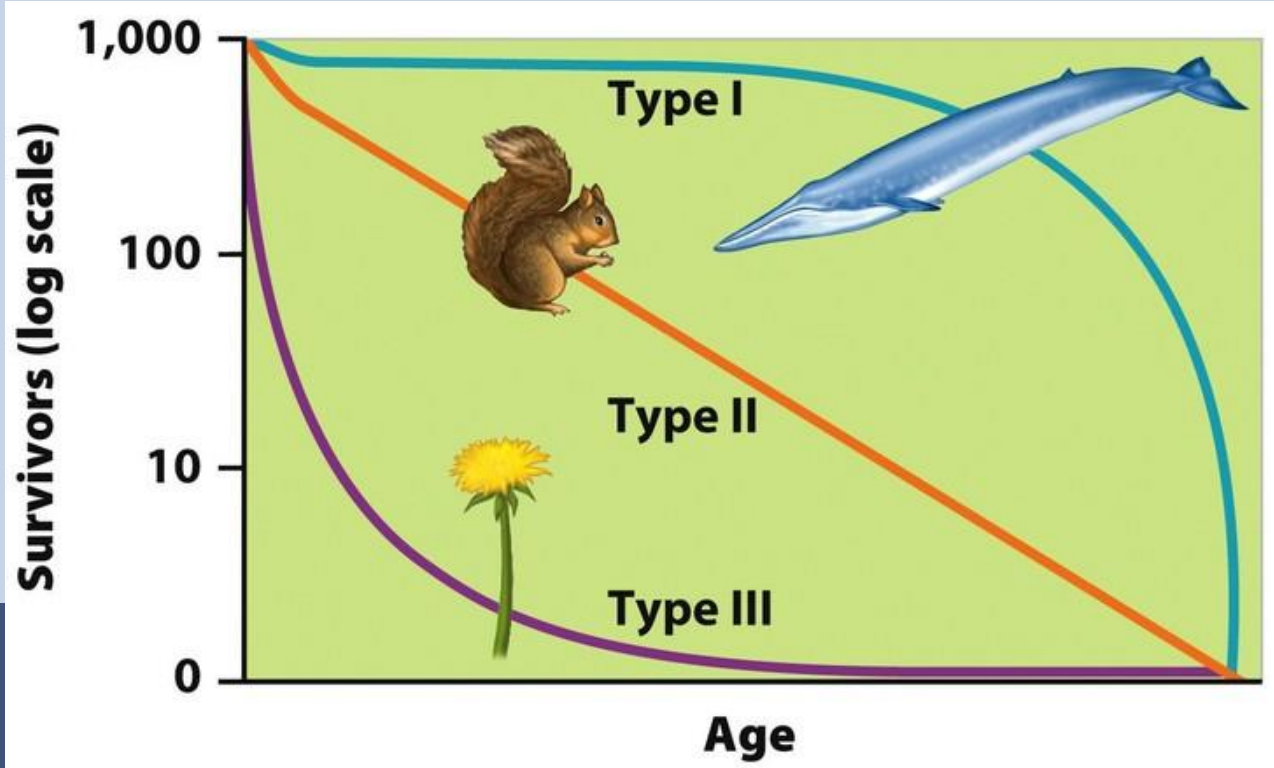
ESSENTIAL KNOWLEDGE

ERT-3.C.1

A survivorship curve is a line that displays the relative survival rates of a cohort—a group of individuals of the same age—in a population, from birth to the maximum age reached by any one cohort member. There are Type I, Type II, and Type III curves.

ERT-3.C.2

Survivorship curves differ for K-selected and r-selected species, with K-selected species typically following a Type I or Type II curve and r-selected species following a Type III curve.



- Faster drop in line = quicker die-off of individuals
- Slower drop in line = longer avg. lifespan

Survivorship Curve: line that shows survival rate of a cohort (group of same-aged individuals) in a pop. from birth to death

Type I, II, and III

Type I (mostly K-selected)

- High survivorship early in life due to high parental care
- High survivorship in mid life due to large size & defensive behavior
- Rapid decrease in survivorship in late life as old age sets in
  - **Ex: most mammals**

Type II (in between r & K)

- Steadily decreasing survivorship throughout life

Type III (mostly r-selected)

- High mortality (low survivorship) early in life due to little to no parental care
- Few make it to midlife; slow, steady decline in survivorship in mid life
- Even fewer make it to adulthood; slow decline in survivorship in old age
- **Ex: insects, fish, plants**

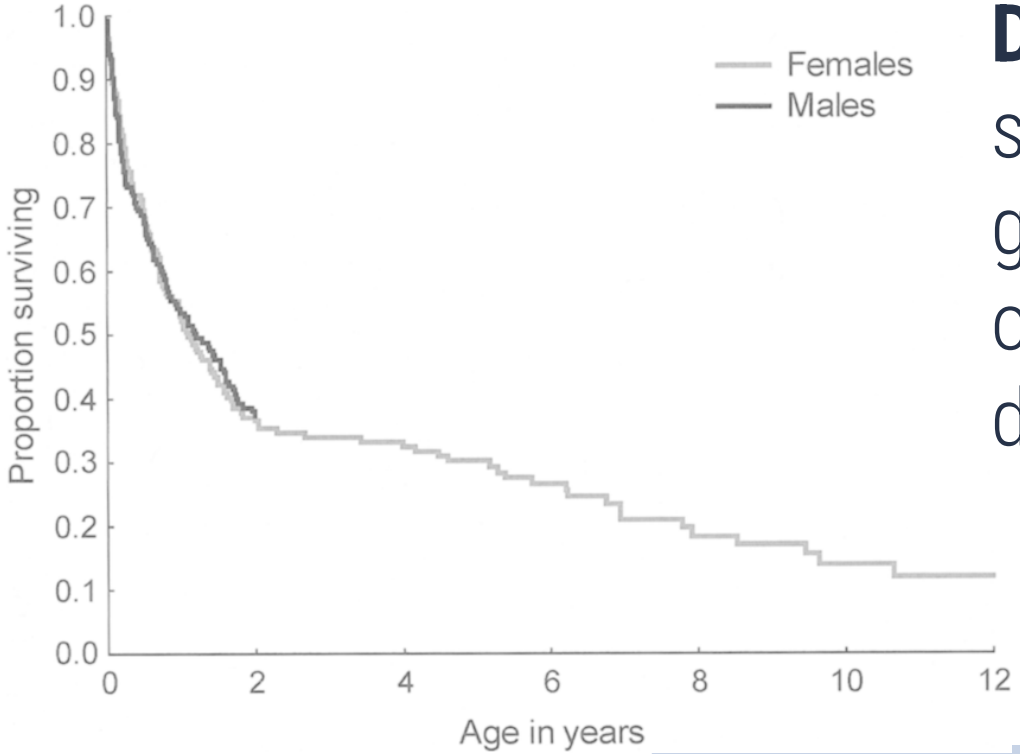
FRQ Practice 3.3

SUGGESTED SKILL

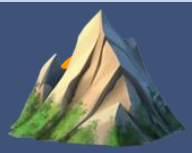
Data Analysis

5.A

Describe patterns or trends in data.



Describe the trend in survivorship shown in this graph. **Justify** which type of survivorship curve these data represent.



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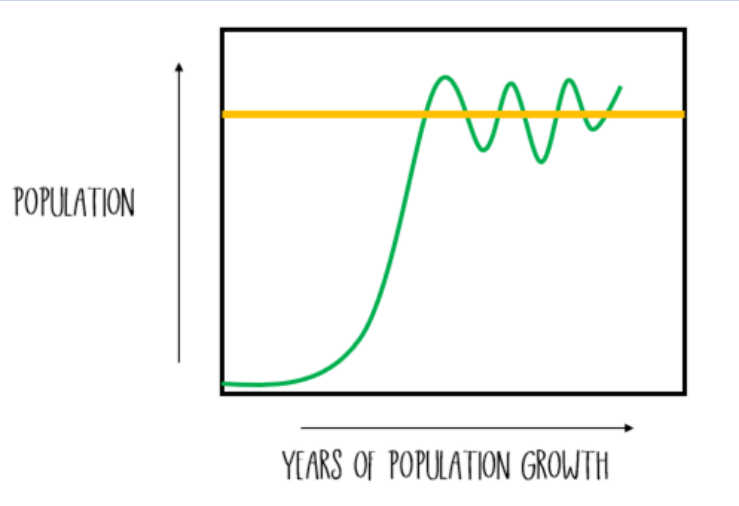
3.4
Carrying Capacity



Objectives, EKs, and Skills

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
ERT-3.D Describe carrying capacity.	**ERT-3.D.1** When a population exceeds its carrying capacity (carrying capacity can be denoted as K), overshoot occurs. There are environmental impacts of population overshoot, including resource depletion.
ERT-3.E Describe the impact of carrying capacity on ecosystems.	**ERT-3.E.1** A major ecological effect of population overshoot is dieback of the population (often severe to catastrophic) because the lack of available resources leads to famine, disease, and/or conflict.

SUGGESTED SKILL

Data Analysis

5.E

Explain what the data implies or illustrates about environmental issues.

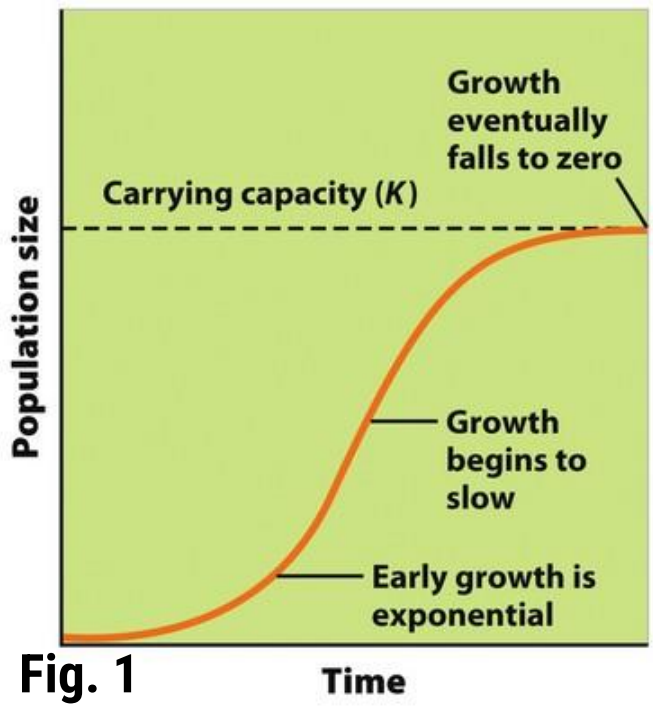


Fig. 1

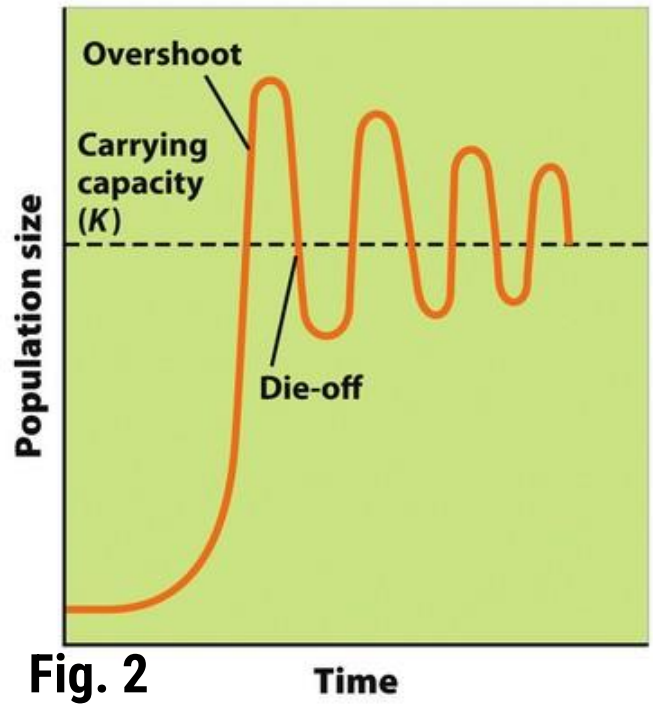


Fig. 2

- ★ Fig. 1 is theoretical
- ★ Fig. 2 is more realistic
- ★ Pop. briefly "overshoots" (k) and then die-off happens

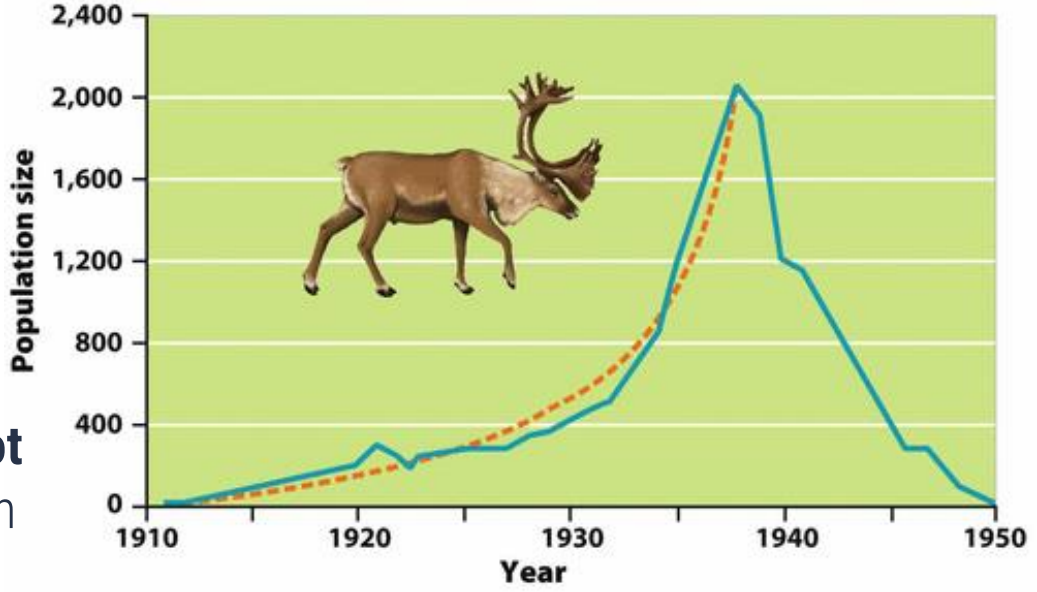
Carrying Capacity (k): the max. Number of individuals in a pop. that an ecosystem can support (based on limiting resources)

Carrying Capacity (k)

- Highest pop. size an ecosystem can support based on limiting resources:
  - Food
  - Water
  - Habitat (nesting sites, space)
- **Overshoot**: when a population briefly exceeds carrying capacity
  - *Ex: deer breed in fall, give birth all at once in spring; sudden spike in pop. = overshoot*
- **Consequence of overshoot**: resource depletion *ex: overgrazing in deer*
- **Die-off**: sharp decrease in pop. size when resource depletion (overshoot) leads to many individuals dying
  - *Ex: many deer starve with too many new fawns feeding in spring*

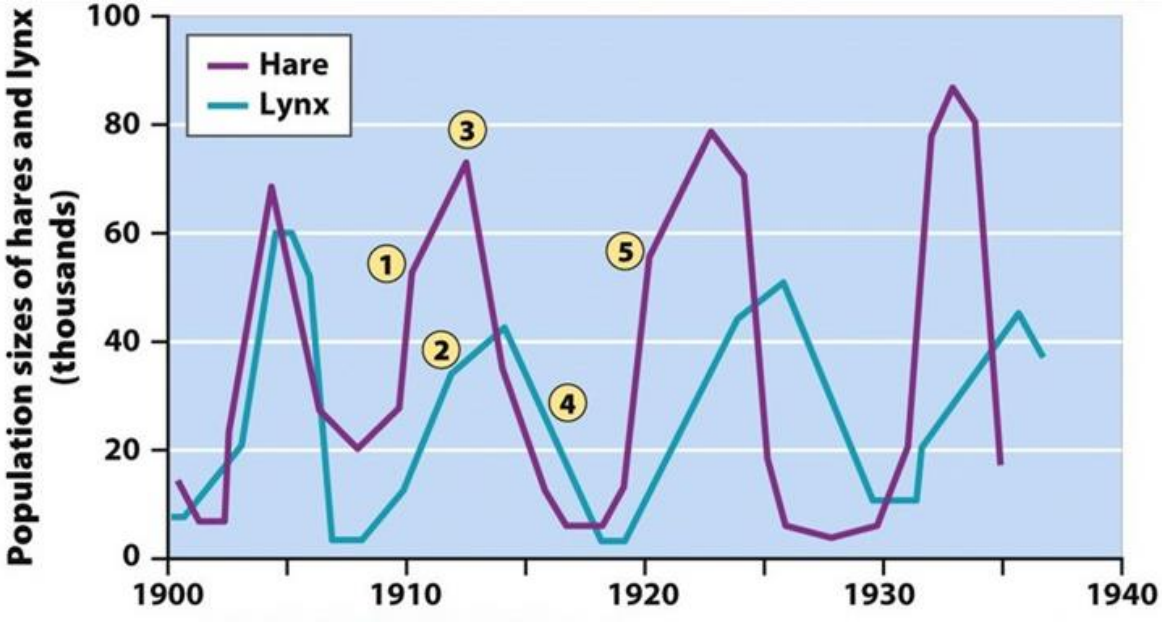
Die-off Example

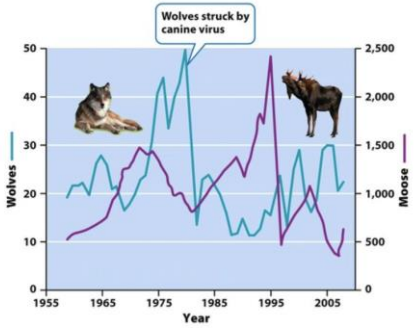
- **Reindeer of St. Paul Island**
  - 25 introduced in 1910
  - Growth was gradual (10'-30'), then exponential (30'-37')
  - **Carrying capacity** was **overshot**
  - Sharp **die-off** lead to pop. crash as food resource (lichen) were severely depleted
- *Real pops. don't always fluctuate around carrying capacity. If resource depletion is severe enough, total pop. crash can occur*



Predator-Prey

1. Hare pop. increase due to low predator pop. (lynx)
2. Lynx pop. increase due to increase in food (hare)
3. Increasing lynx pop. limits hare pop; leads to die-off
4. Hare die-off decreases lynx food source, leading to die-off
5. Hare pop. increase due to low predator pop. (lynx)





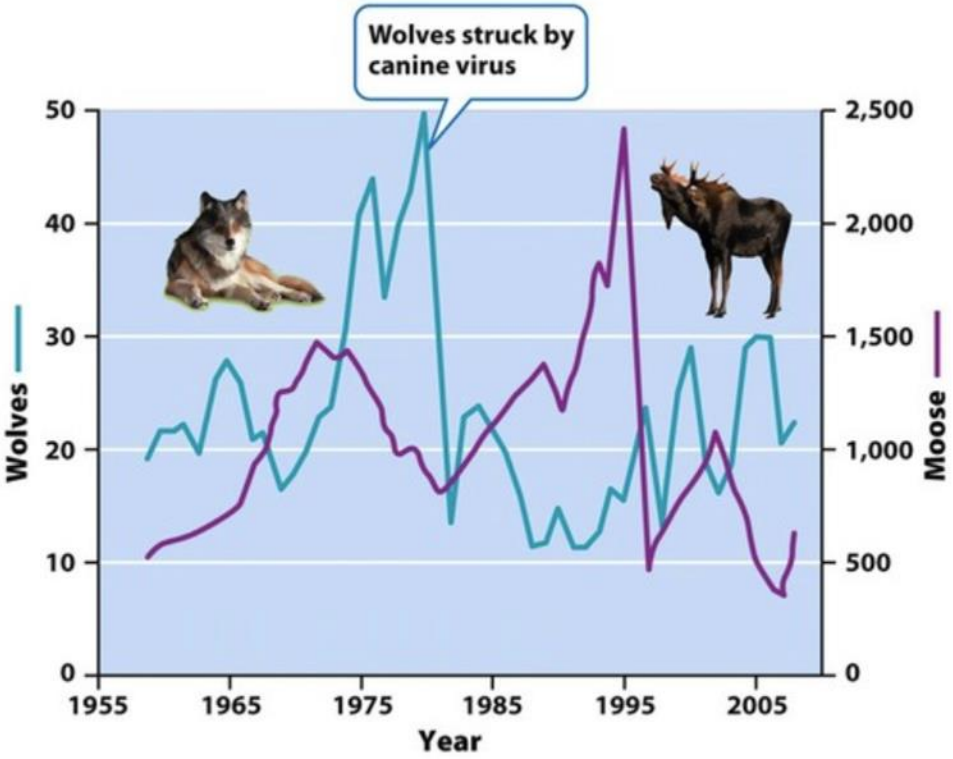
FRQ Practice 3.4

SUGGESTED SKILL

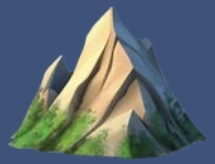
Data Analysis

5.E

Explain what the data implies or illustrates about environmental issues.



Explain the impact that the canine virus had on the moose population based on the graph.



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3.5
Pop. Growth & Resource Availability

Objectives, EKs, and Skills

LEARNING OBJECTIVE

ERT-3.F

Explain how resource availability affects population growth.

ESSENTIAL KNOWLEDGE

ERT-3.F.1

Population growth is limited by environmental factors, especially by the available resources and space.

ERT-3.F.2

Resource availability and the total resource base are limited and finite over all scales of time.

ERT-3.F.3

When the resources needed by a population for growth are abundant, population growth usually accelerates.

ERT-3.F.4

When the resource base of a population shrinks, the increased potential for unequal distribution of resources will ultimately result in increased mortality, decreased fecundity, or both, resulting in population growth declining to, or below, carrying capacity.

SUGGESTED SKILL

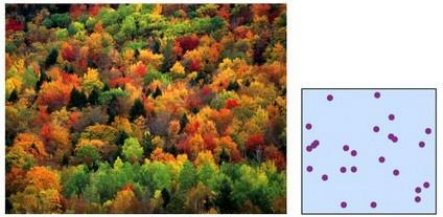
Mathematical Routines

6.B

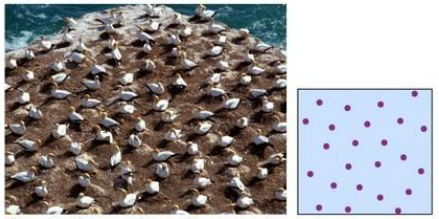
Apply appropriate mathematical relationships to solve a problem, with work shown (e.g., dimensional analysis).

Pop. Characteristics

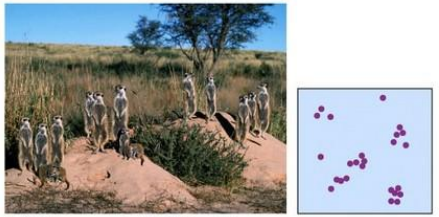
- **Size (N)**: total # of individuals in a given area at a given time
  - Larger = safer from pop. decline
- **Density:** # of individuals/area
  - *Ex: (12 panthers/km^2)*
  - High density = higher competition, possibility for disease outbreak, possibility of depleting food source
- **Distribution:** how individuals in pop. are spaced out compared to each other
  - Random (trees)
  - Uniform (territorial animals)
  - Clumped (herd/group animals)



(a) Random distribution



(b) Uniform distribution

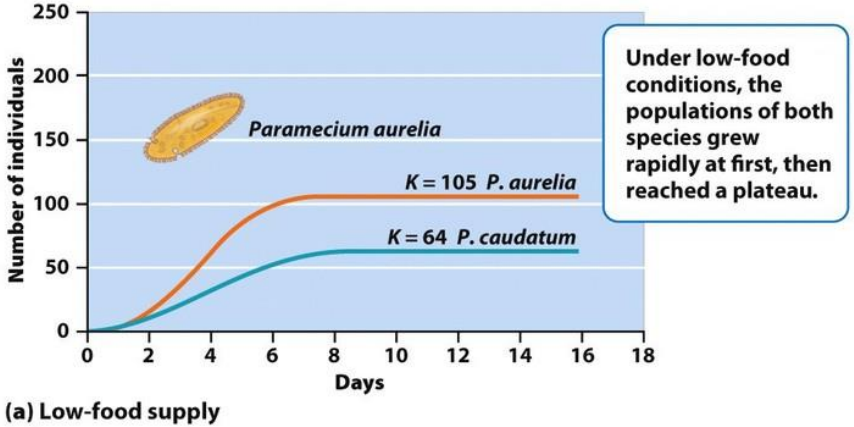


(c) Clumped distribution

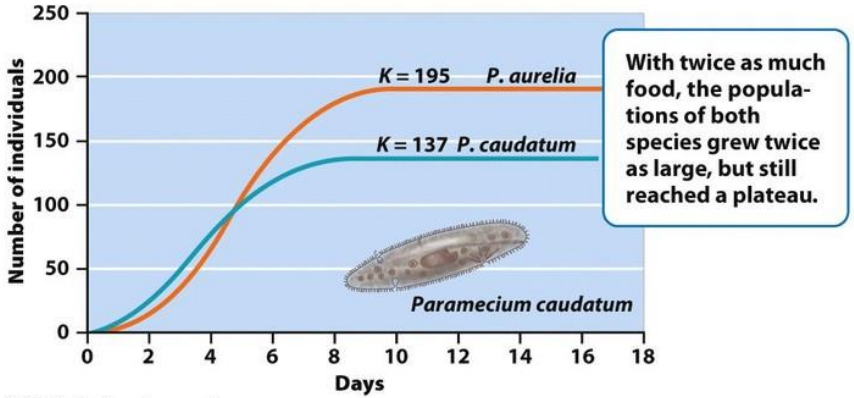
Pop. Characteristics & Growth Factors

- **Sex Ratio**: ratio of males to females. Closer to 50:50, the more ideal for breeding (usually)
  - Die-off or bottleneck effect can lead to skewed sex ratio (not enough females) limiting pop. growth
- **Density-Dependent Factors:** factors that influence pop. growth based on size:
  - Ex: food, competition for habitat, water, light, even disease
  - All of these things limit pop. growth based on their size; aka - small pop. don't experience these, large do
- **Density-Independent Factors:** factors that influence pop. growth **independent** of their size
  - Ex: natural disasters (flood, hurricane, tornado, fire)
  - It doesn't matter how big or small a pop. is, natural disasters limit them both

Ex. of Density-Dependent Factor

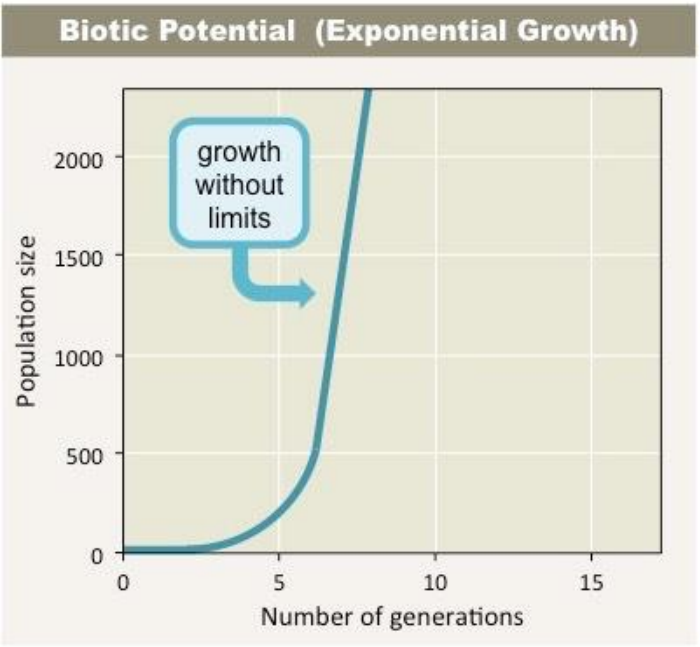


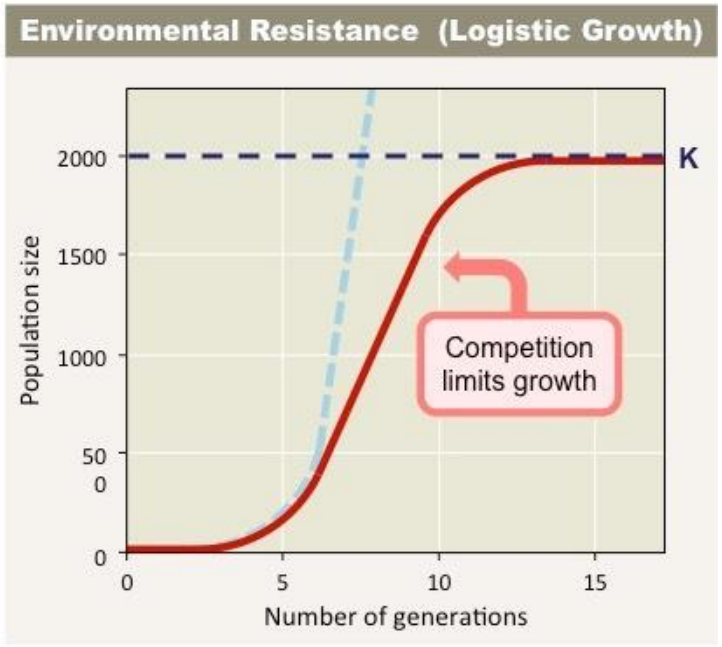
(a) Low-food supply



(b) High-food supply

- **Food** is a density dependent factor. (also a limiting resource)
  - When twice as much food was added to the dish, both species increased **carrying capacity** by about 2x





Biotic potential = exponential growth

Logistic growth = initial rapid growth, then limiting factors limit pop. to K

- **Biotic Potential** = max. potential growth rate, with no limiting resources
  - May occur initially, but limiting resources (competition, food, disease, predators) slow growth, & eventually limit pop. to carrying capacity (k)

Calculating Population Change

- **Population Size = (Immigrations + births) - (immigrations + deaths)**
  - **Ex:** An elk pop. of 52 elk has 19 births and 6 deaths in a season, and 5 new elk immigrate to the herd and 0 elk emigrate from the heart

(19+5) - (6+0) = + 18 elk

52 + 18 = 70 elk

FRQ Practice 3.5

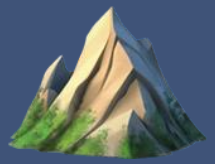
SUGGESTED SKILL

Mathematical Routines

6.B

Apply appropriate mathematical relationships to solve a problem, with work shown (e.g., dimensional analysis).

Calculate the percent change in the population size of a 14 wolf pack that experiences 5 deaths, 3 births, and 4 new wolves released into the pack from a nearby wildlife sanctuary.



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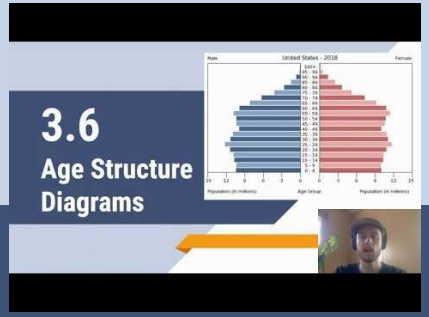
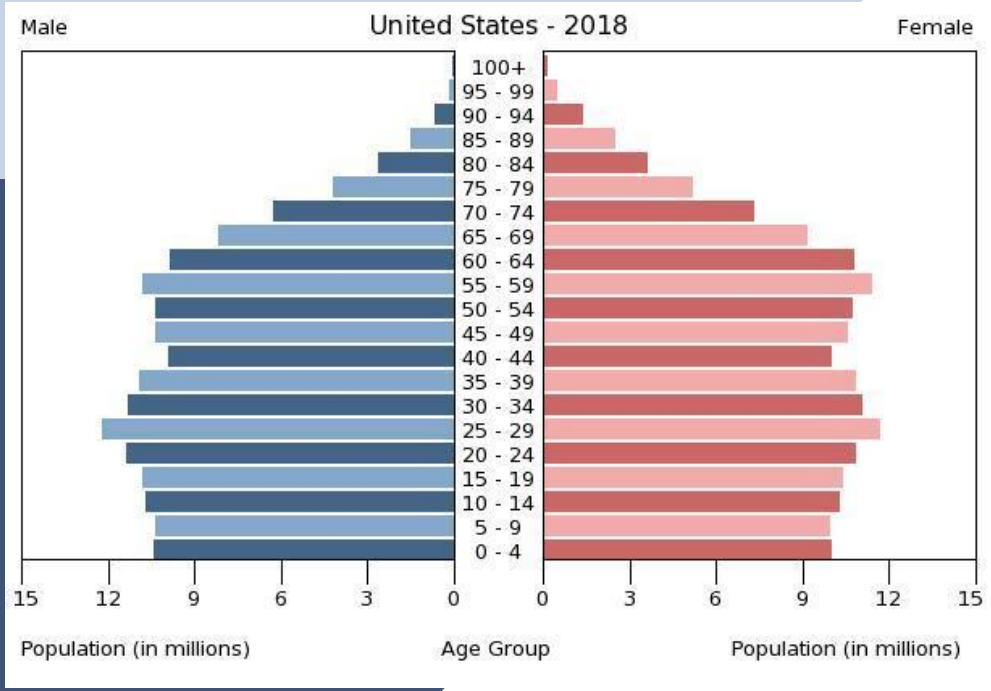
#WriteLikeAScholar



3.6 Age Structure Diagrams



Objectives, EKs, and Skills

LEARNING OBJECTIVE

EIN-1.A

Explain age structure diagrams.

ESSENTIAL KNOWLEDGE

EIN-1.A.1

Population growth rates can be interpreted from age structure diagrams by the shape of the structure.

EIN-1.A.2

A rapidly growing population will, as a rule, have a higher proportion of younger people compared to stable or declining populations.

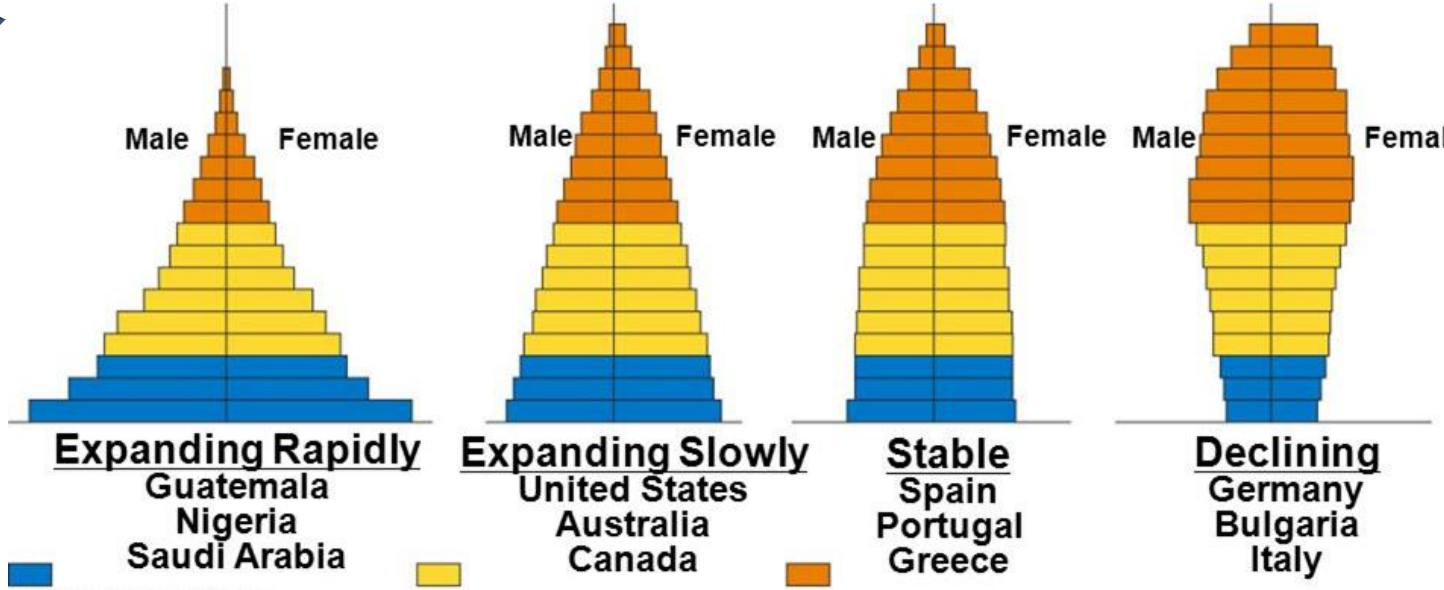
SUGGESTED SKILL

Data Analysis

5.C

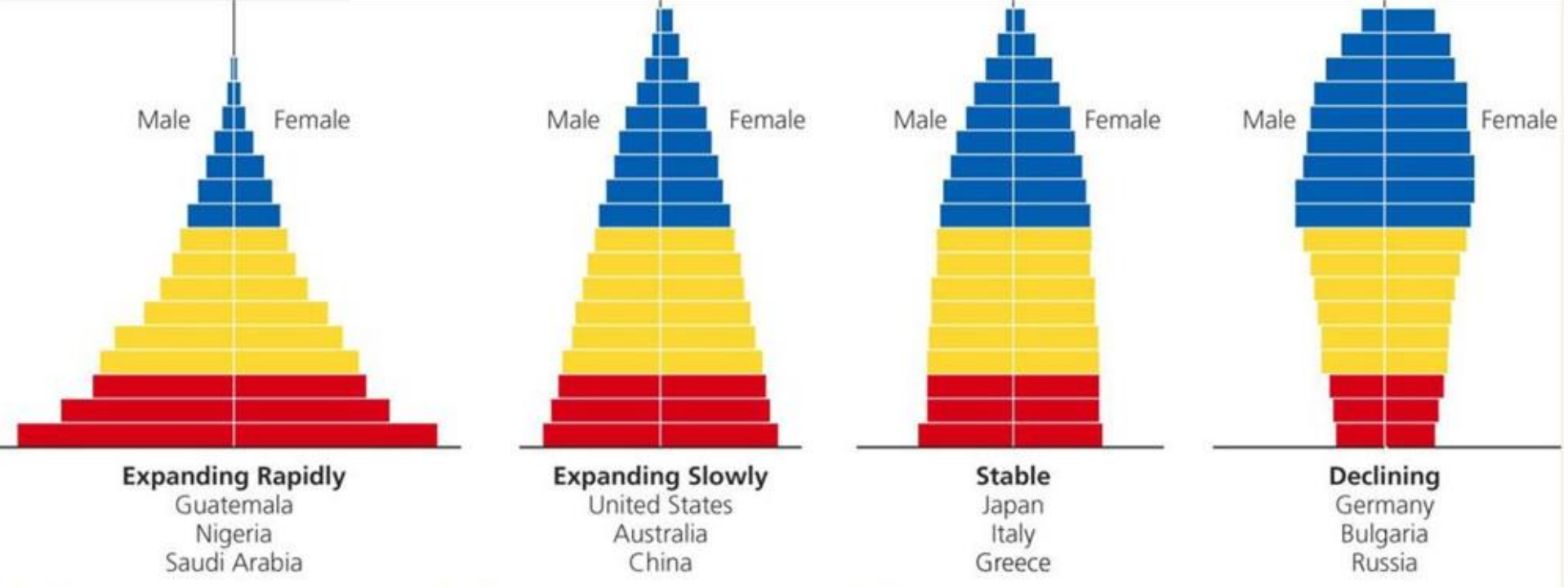
Explain patterns and trends in data to draw conclusions.

Age Cohorts

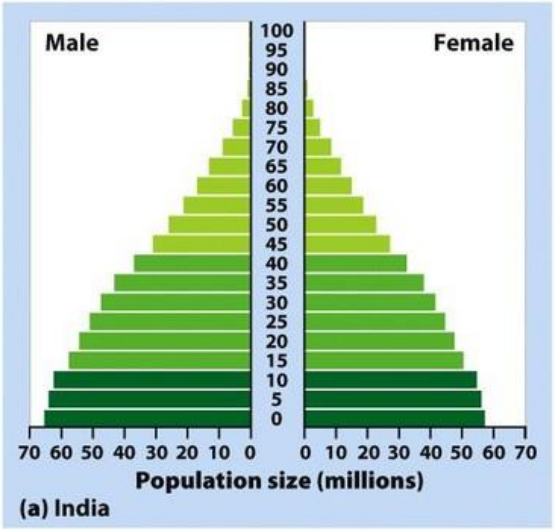


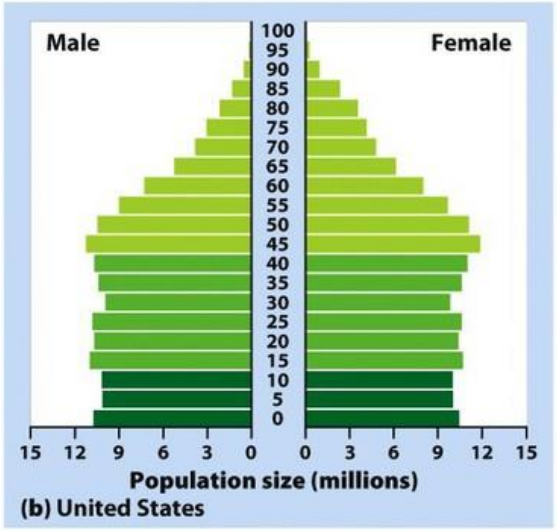
Age cohorts & growth = groups of similarly aged individuals

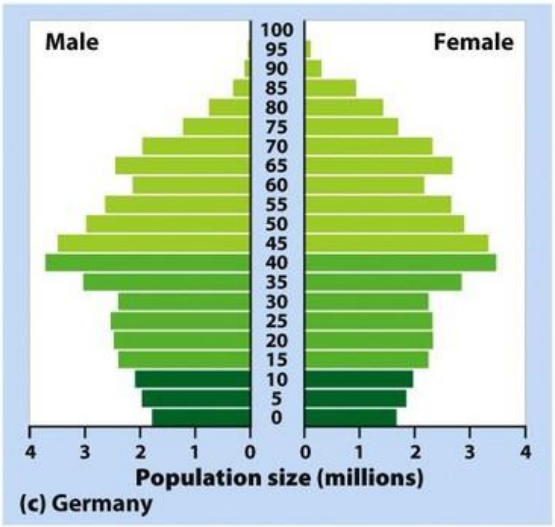
- 0-14 = **prereproductive**; 15 - 44 = **reproductive age**; 45 + = **post reproductive**
- Size difference between 0-14 & 15-44 indicates growth rate
  - **Larger 0-14 cohort** = current & future growth
  - **Roughly equal 0-14 & 15-44** = slight growth/stable
  - **Larger 15-44** = pop. decline

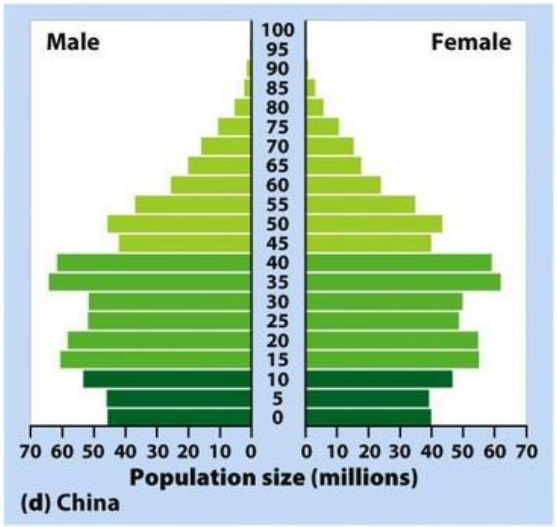


- **Extreme Pyramid shape** = rapid growth
- **Less extreme pyramid =** slow, stable growth
- **House =** stable, little to no growth
- **Narrowest @ base** = declining pop.









Practice Reading Diagrams

Highest to Lowest Growth Rate

India > US > China > Germany

Number of 0-14 Individuals

- India = 360 million
- US = 62 million
- Germany = 11.5 million
- China = 270 million

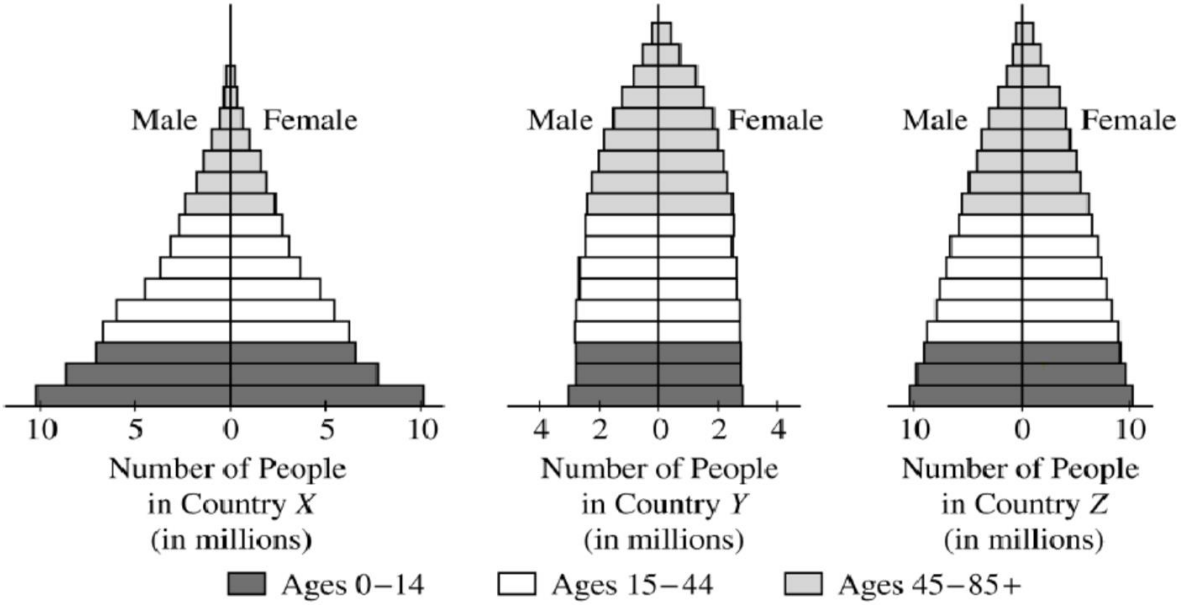
FRQ Practice 3.6

SUGGESTED SKILL

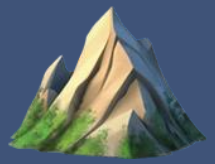
Data Analysis

5.C

Explain patterns and trends in data to draw conclusions.



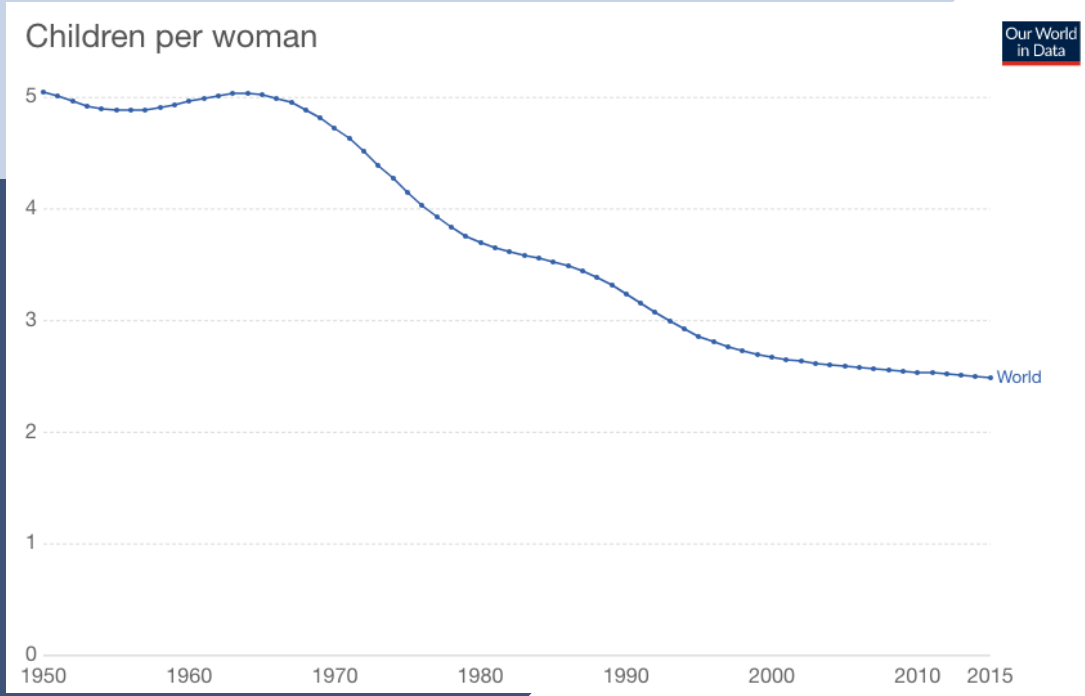
Identify the country with the slowest pop. growth rate and **explain** your answer



#ThinkLikeAMountain

#WriteLikeAScholar

3.7 Total Fertility Rate (TFR)



Objectives, EKs, and Skills

LEARNING OBJECTIVE

EIN-1.B

Explain factors that affect total fertility rate in human populations.

ESSENTIAL KNOWLEDGE

EIN-1.B.1

Total fertility rate (TFR) is affected by the age at which females have their first child, educational opportunities for females, access to family planning, and government acts and policies.

EIN-1.B.2

If fertility rate is at replacement levels, a population is considered relatively stable.

EIN-1.B.3

Factors associated with infant mortality rates include whether mothers have access to good healthcare and nutrition. Changes in these factors can lead to changes in infant mortality rates over time.

SUGGESTED SKILL

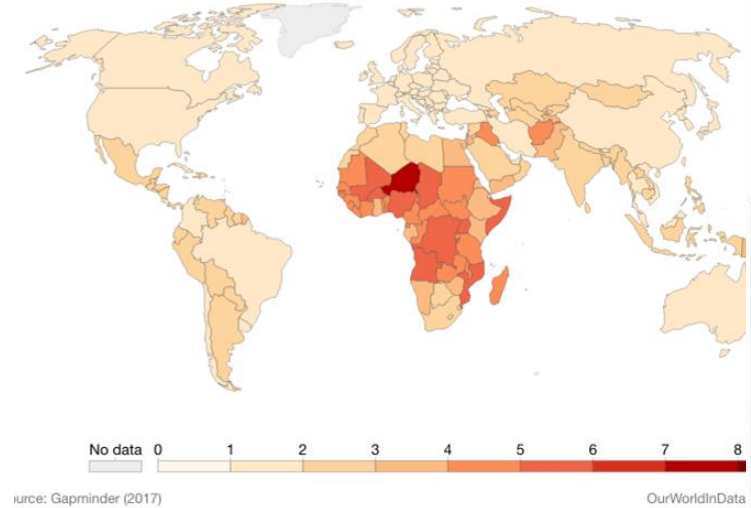
Data Analysis

5.A

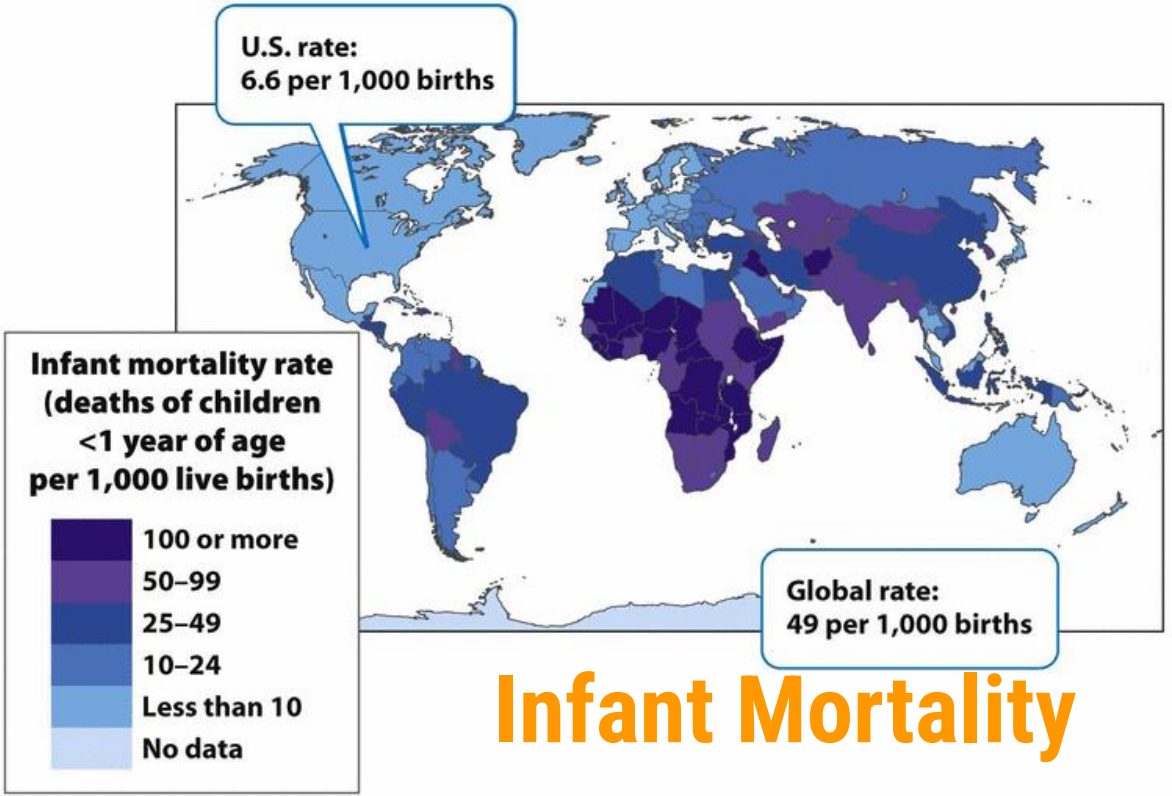
Describe patterns or trends in data.

TFR & Infant Mortality

- **Total Fertility Rate (TFR)**: avg. number of children a woman in a population will bear throughout her lifetime
  - Higher TFR = higher birth rate, higher pop. growth rate (generally)
- **Replacement Level Fertility:** the TFR required to offset deaths in a pop. and keep pop. size stable
  - About 2.1 in developed countries (replace mom & dad)
  - Higher in less developed countries due to higher infant mortality
- **Infant Mortality Rate (IMR):** number of deaths of children under 1 year per 1,000 people in a pop.
  - Higher in less developed countries due to lack of access to: health care, clean water, enough food
- Higher IMR = higher TFR, due to families having replacement children

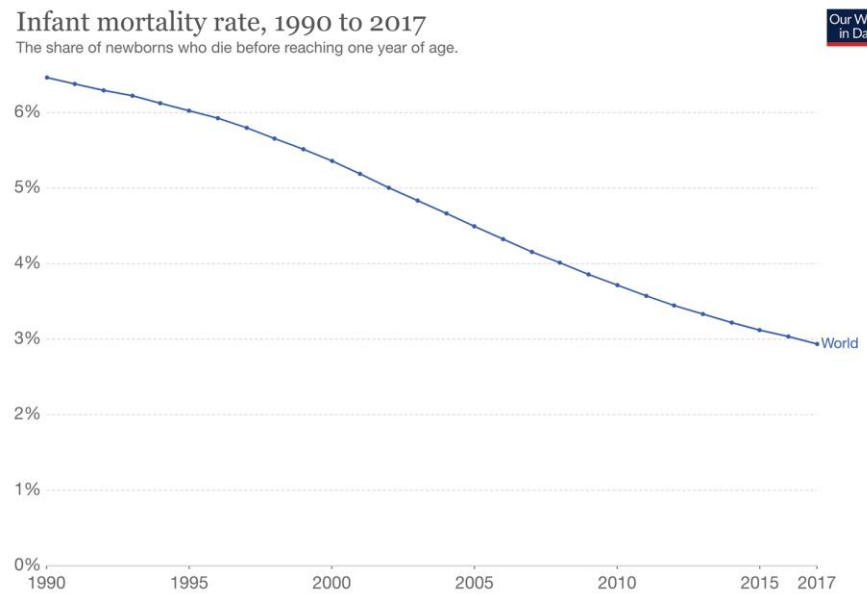


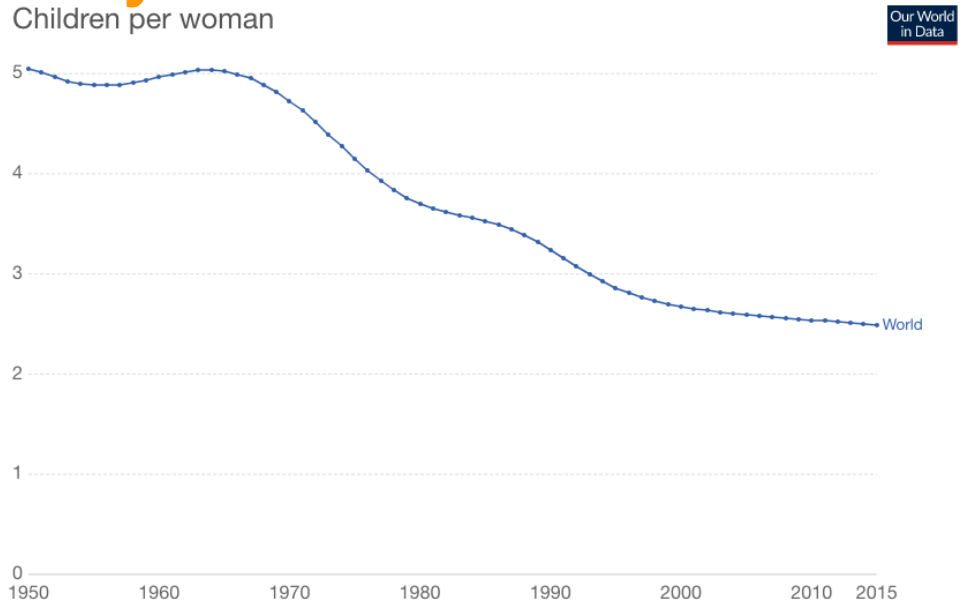
Global TFR



Infant Mortality

Infant Mortality & TFR





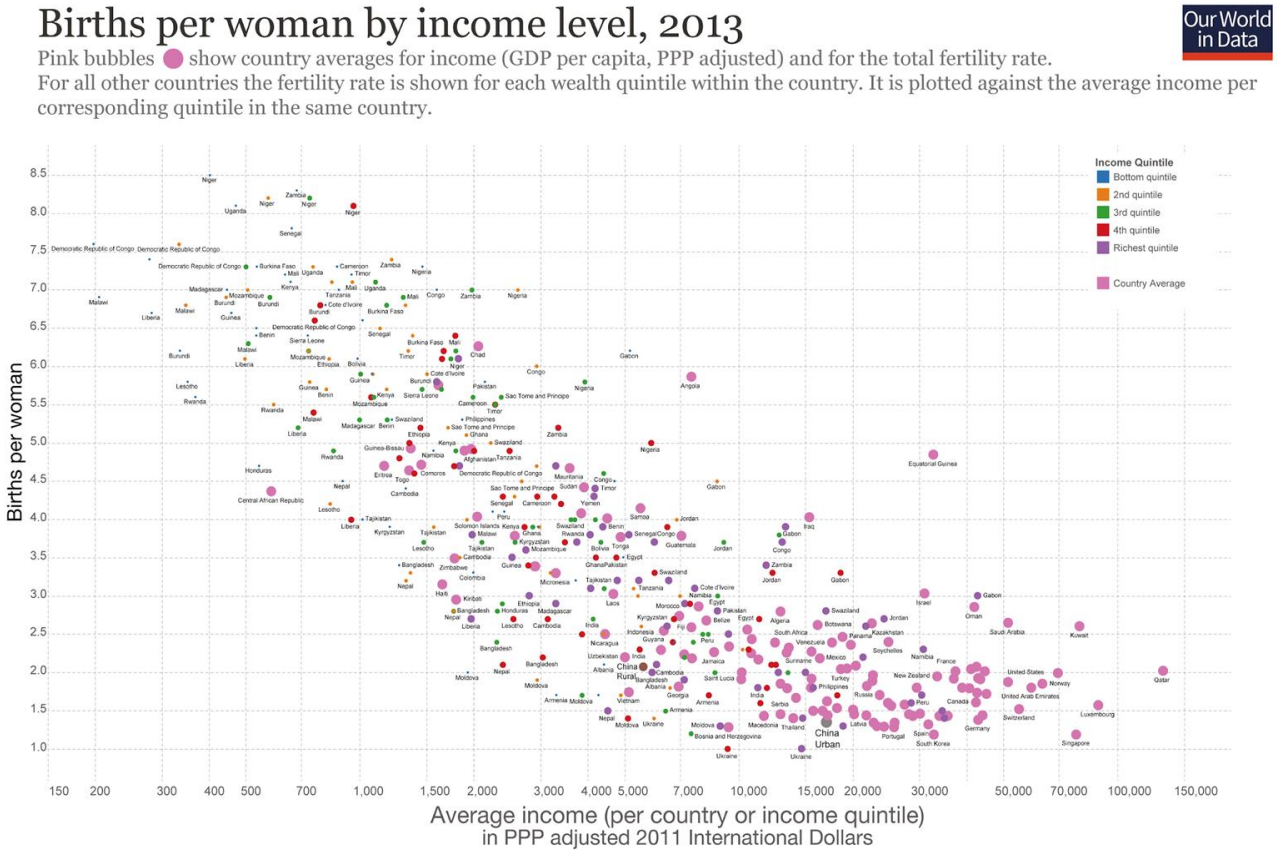
Factors in IMR Decline

- Access to clean water
- Access to healthcare (hospitals, vaccines, vitamins & supplements for moms & babies)
- More reliable food supply

Factors That Affect TFR

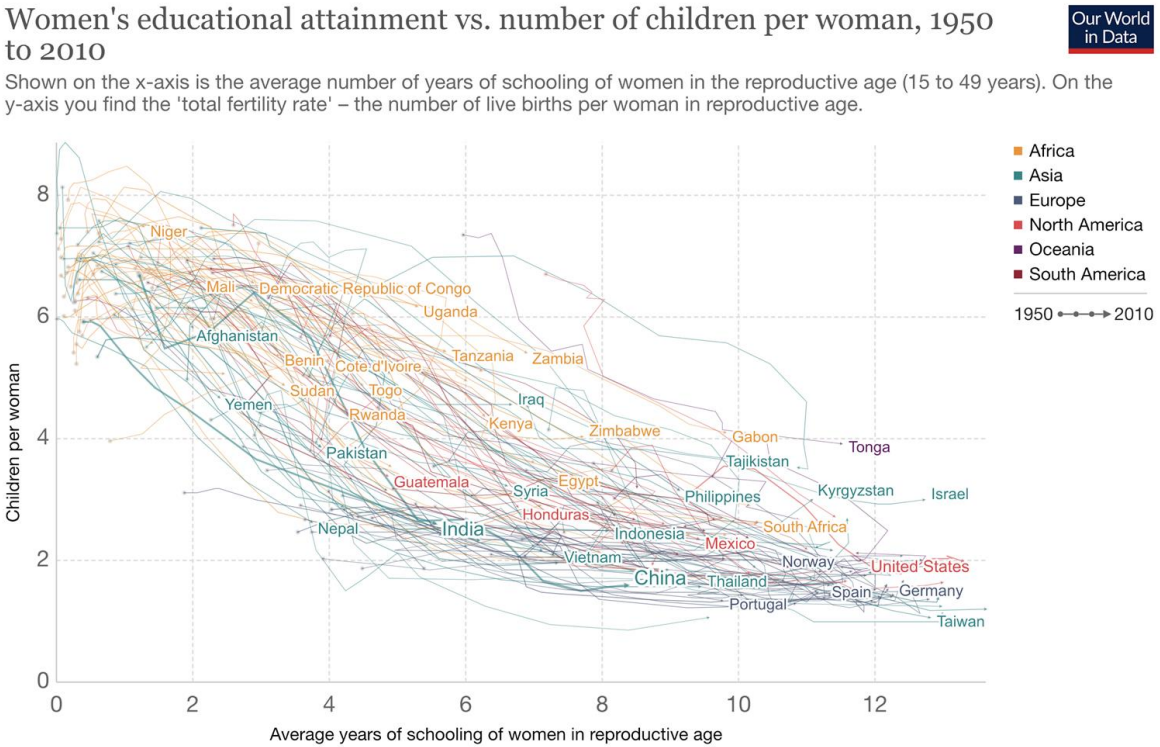
- **Development (Affluence)**: more developed, or wealthy nations have a lower TFR than less developed nations
  - More educational access for women
  - More econ. opportunity for women
  - Higher access to family planning education & contraceptives
  - Later age of first pregnancy
  - Less need for children to provide income through agricultural labor
- **Gov. Policy:** can play a huge role in fertility by coercive (forceful) or noncoercive (encouraging) policies
  - Forced or vol. sterilization
  - China's 1 (now 2) child policy
  - Tax incentives to have fewer children
  - Microcredits or loans to women without children to start businesses

Affluence & TFR



- More access to contraceptives & family planning
- Ed./econ. opportunities require time, leaving less for raising children
- Lower IMR = lower TFR

Female Education & TFR



Source: Our World In Data (2017), UN Population Division (2017 Revision), Population (Gapminder, HYDE(2016) & UN (2019))
OurWorldInData.org/fertility-rate • CC BY

- More education = fewer unplanned pregnancies
- More education = more job. opportunities for women
  - Alternative to marrying young

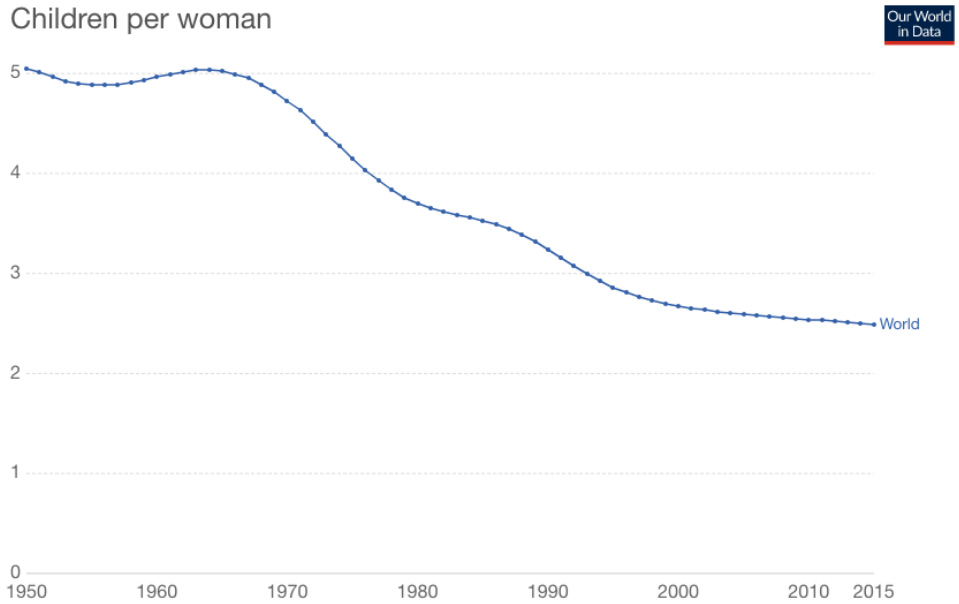
FRQ Practice 3.7

SUGGESTED SKILL

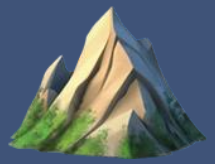
Data Analysis

5.A

Describe patterns or trends in data.



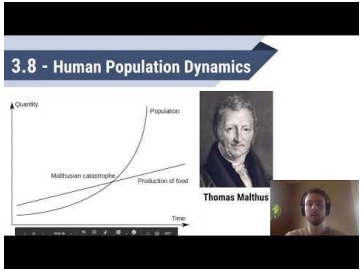
Identify and **discuss** TWO of the causes for the trend in worldwide TFR.

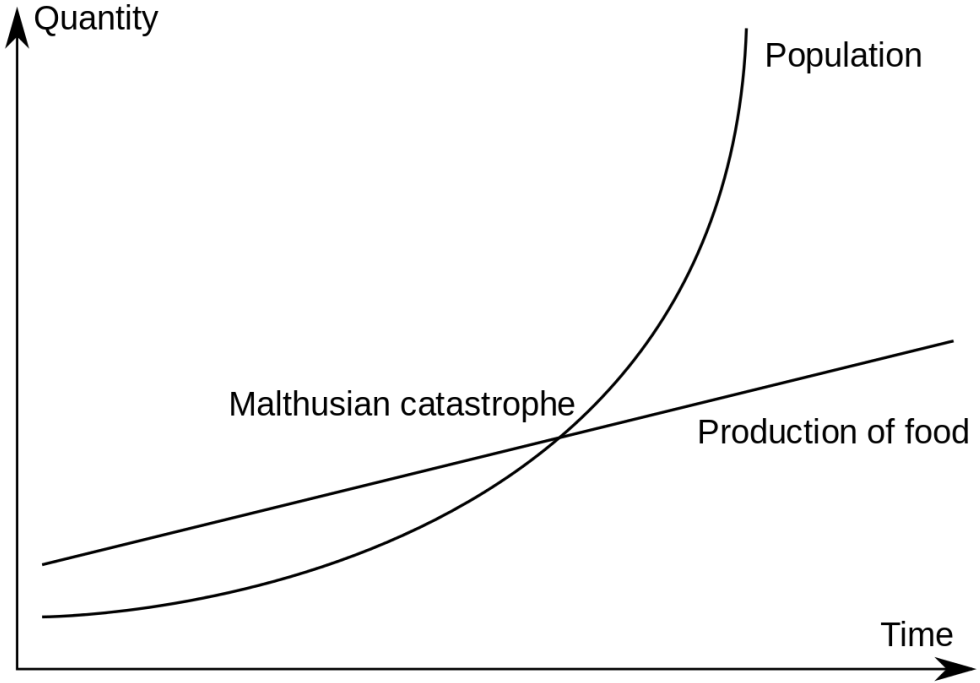


#ThinkLikeAMountain

#WriteLikeAScholar

3.8 - Human Population Dynamics





Thomas Malthus

Objectives, EKs, and Skills

LEARNING OBJECTIVE

EIN-1.C.1

Explain how human populations experience growth and decline.

ESSENTIAL KNOWLEDGE

EIN-1.C.1

Birth rates, infant mortality rates, and overall death rates, access to family planning, access to good nutrition, access to education, and postponement of marriage all affect whether a human population is growing or declining.

EIN-1.C.2

Factors limiting global human population include the Earth's carrying capacity and the basic factors that limit human population growth as set forth by Malthusian theory.

EIN-1.C.3

Population growth can be affected by both density-independent factors, such as major storms, fires, heat waves, or droughts, and density-dependent factors, such as access to clean water and air, food availability, disease transmission, or territory size.

EIN-1.C.4

The rule of 70 states that dividing the number 70 by the percentage population growth rate approximates the population's doubling time.

SUGGESTED SKILL

Environmental Solutions

7.A

Describe environmental problems.

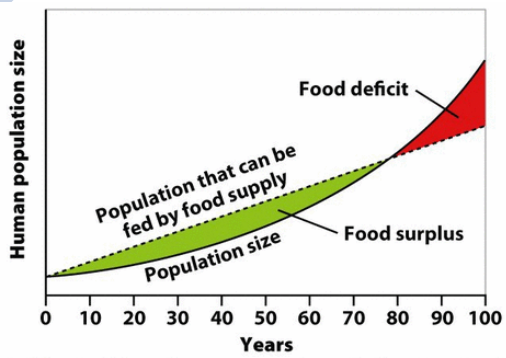
Does Earth Have a Human Carrying Capacity?

Malthusian theory (what Malthus theorized):

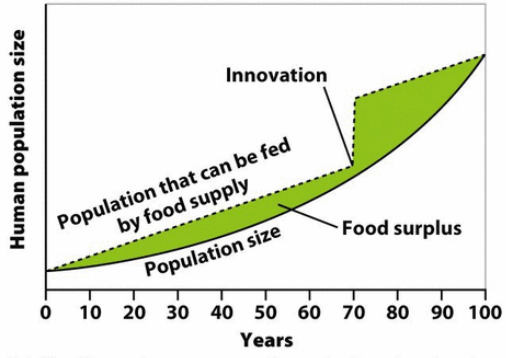
- Earth has a human carrying capacity, probably based on food production
- Human population growth is happening faster than growth of food production
- Humans will reach a carrying capacity limited by food

Technological Advancement

- Humans can alter earth's carrying capacity with tech. Innovation
  - Ex: synthetic fixation of Nitrogen in 1918 leads to synthetic fertilizer, dramatically increasing food supply

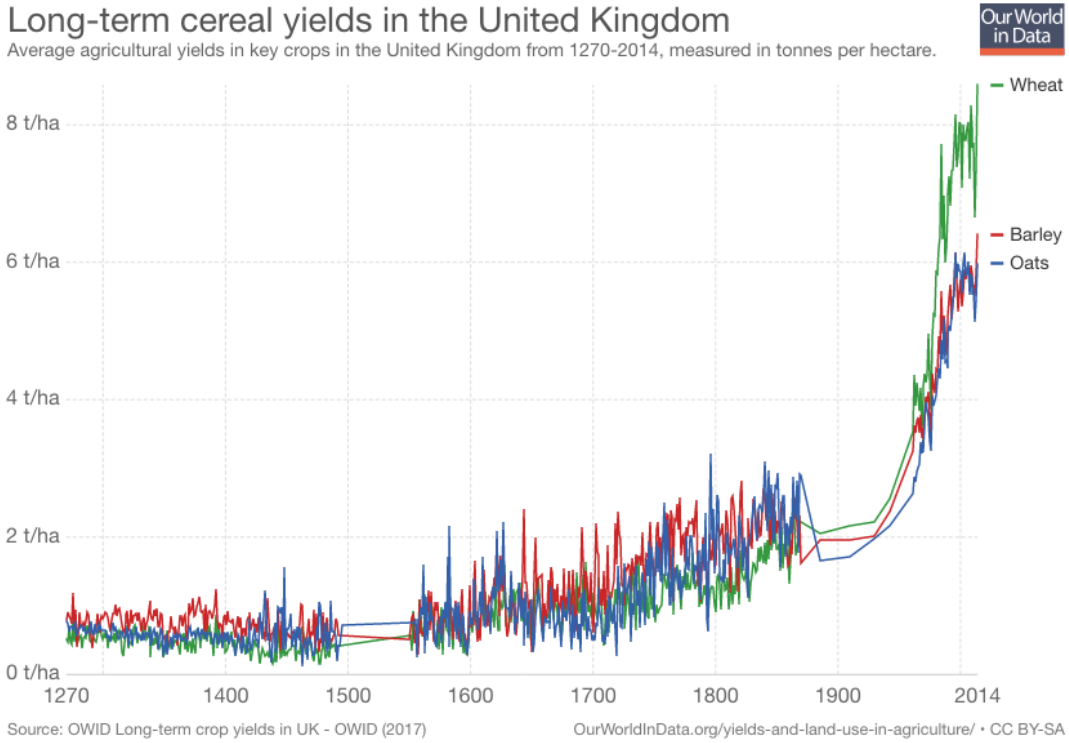


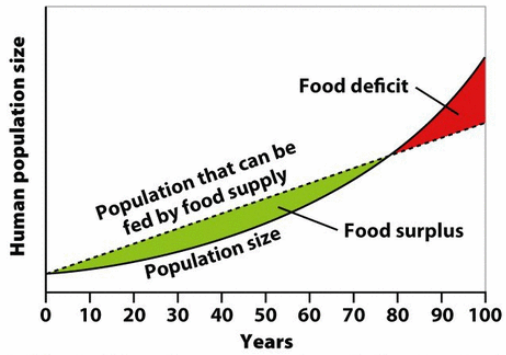
(a) No significant improvement in agricultural technology



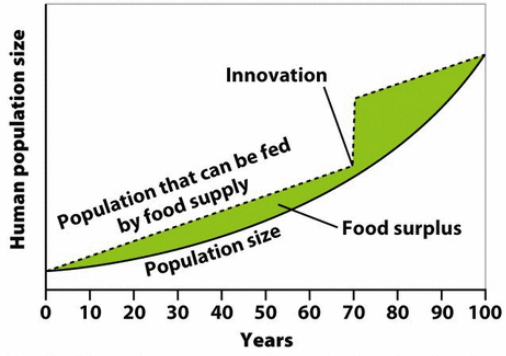
(b) Significant improvement in agricultural technology

Exponential Increase in Food Supply





(a) No significant improvement in agricultural technology



(b) Significant improvement in agricultural technology

Birth Rate, Death Rate, and Growth

- **Growth Rate (r) =** % increase in a population (usually per year)
  - Ex: a growth rate of 5% for a population of 100 means they grow to 105
- **Crude Birth Rate & Crude Death Rate (CBR & CDR)**
  - Births & deaths per 1,000 people in a pop.
    - Ex: Global CBR = 20 & CDR = 8
  - **Calculating Growth Rate (r)**

$$\text{Global population growth rate} = \frac{[\text{CBR} - \text{CDR}]}{10}$$

$$= \frac{[20 - 8]}{10}$$

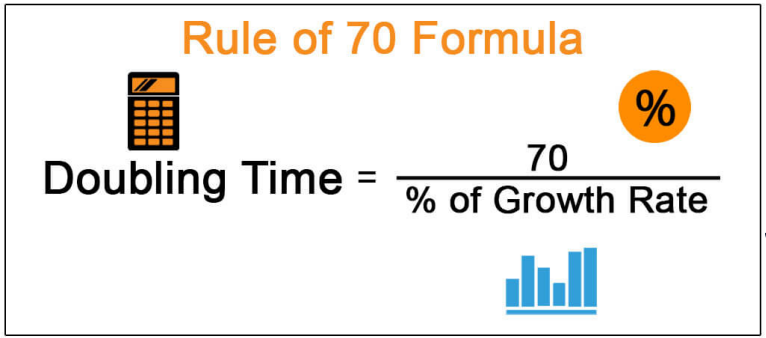
Divide by 10 because CDR & CDR are per 1,000 and growth rate is % or per 100

$$= 1.2 \text{ percent}$$

Growth rate always expressed as %

Doubling Time (Rule of 70)

- **Rule of 70:** The time it takes (in years) for a population to double is equal to 70 divided by the growth rate



1.2%

ears

Global pop. will double in 58.3 years

Calculating Population Change

- **Practice Problem:** A country has a CDR of 9 and a CBR of 18.
  - Calculate the annual growth rate, and the doubling time

- **Solution**: (18-9)/10 = 9/10 = **0.9% growth rate**

  70/0.9% = **77.77 years to double**

Factors Affecting Human Pop. Growth

- **Factors that increase pop. growth**
  - Higher TFR ⟶ higher birth rate
  - High infant mortality rate can drive up TFR (replacement children)
  - High immigration level
  - Increased access to clean water & healthcare (decrease death rate)

$$\text{Global population growth rate} = \frac{[\text{CBR} - \text{CDR}]}{10}$$

- **Factors that decrease population growth rate**
  - *High death rate*
  - *High infant mortality rate*
  - Increased development (education & affluence)
  - Increased education for women
  - Delayed age of first child
  - Postponement of marriage age

Standard of Living Indicators

- **Standard of Living**
  - What the quality of life is like for people of a country based
- **Gross Domestic Product (GDP) = key economic indicator of standard of living**
  - Total value of the goods & services produced
  - Per capita GDP is total GDP/total population
- **Life expectancy = key health indicator of standard of living**
  - Average age a person will live to in a given country
  - Increases with access to clean water, health care, stable food sources

High GDP & life expectancy are both indicators of development & low pop. growth

FRQ Practice 3.8

SUGGESTED SKILL

Environmental Solutions

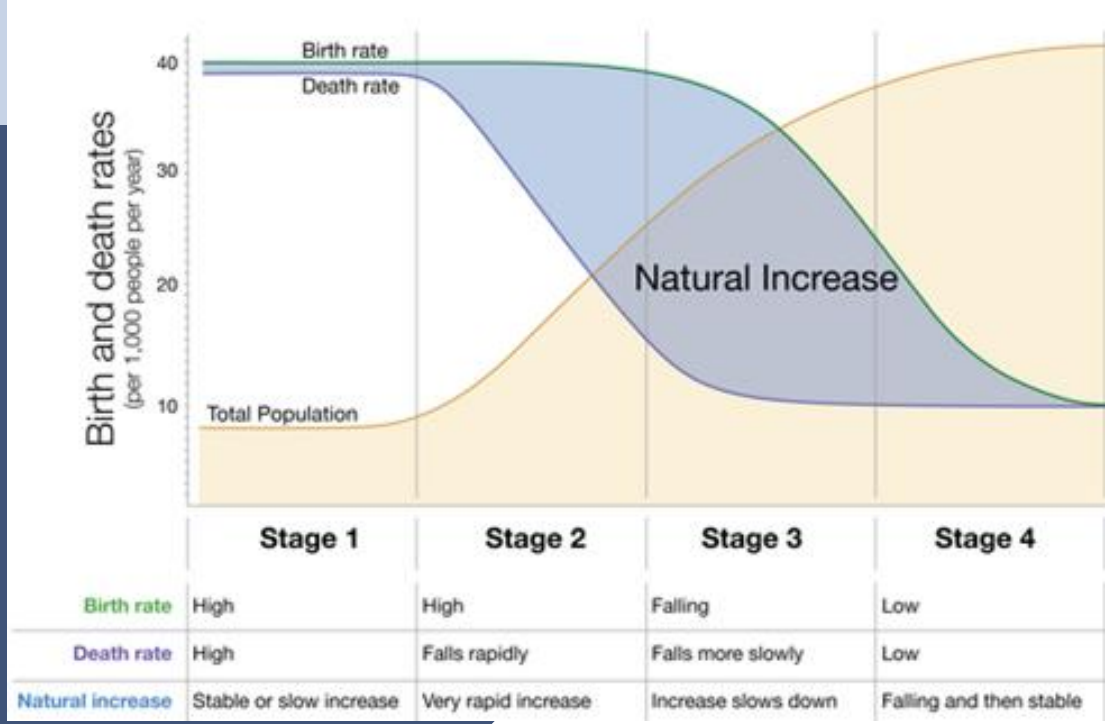
7.A

Describe environmental problems.

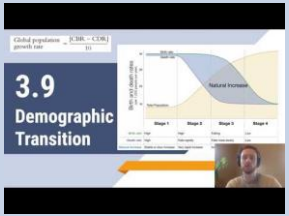
Describe one human activity related to a rapidly growing human population that is having an impact on biodiversity. **Propose a solution** a government could take to slow population growth.

$$\text{Global population growth rate} = \frac{[\text{CBR} - \text{CDR}]}{10}$$

3.9 Demographic Transition



	Stage 1	Stage 2	Stage 3	Stage 4
Birth rate	High	High	Falling	Low
Death rate	High	Falls rapidly	Falls more slowly	Low
Natural increase	Stable or slow increase	Very rapid increase	Increase slows down	Falling and then stable



Objectives, EKs, and Skills

LEARNING OBJECTIVE

EIN-1.D

Define the demographic transition.

ESSENTIAL KNOWLEDGE

EIN-1.D.1

The demographic transition refers to the transition from high to lower birth and death rates in a country or region as development occurs and that country moves from a pre-industrial to an industrialized economic system. This transition is typically demonstrated through a four-stage demographic transition model (DTM).

EIN-1.D.2

Characteristics of developing countries include higher infant mortality rates and more children in the workforce than developed countries.

SUGGESTED SKILL

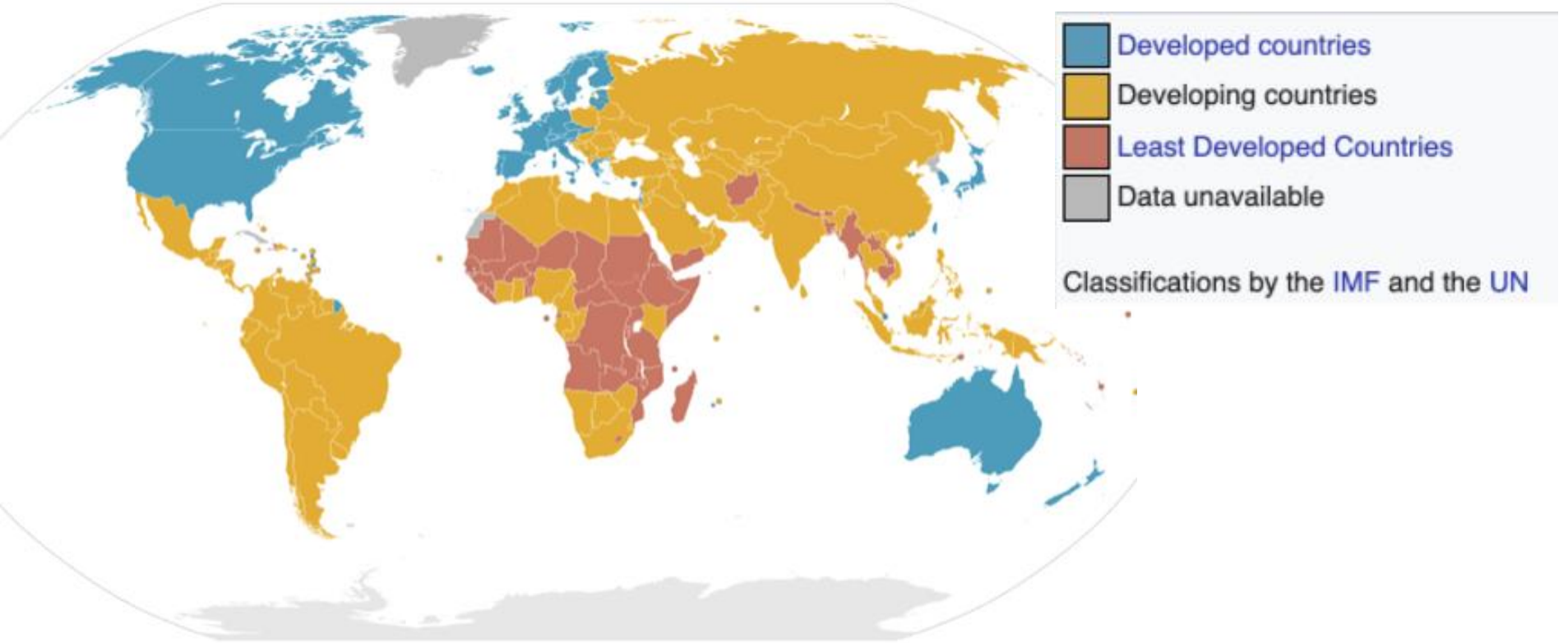
Concept Explanation

1.C

Explain environmental concepts, processes, or models in applied contexts.

Industrialization

- **Industrialization:** the process of economic and social transition from an agrarian (farming) economy to an industrial one (manufacturing based)
- **Pre-industrialized/Less developed**
  - A country that has not yet made the agrarian to industrial transition
  - Typically very poor (low GDP)
  - Typically high death rate & high infant mortality
  - High TFR for replacement children & agricultural labor
- **Industrializing/developing**
  - part way through this transition
  - Decreasing death rate & IMR
  - Rising GDP
- **Industrialized/developed:** completed the transition
  - Very low DR & IMR
  - Very High GDP
  - Low TFR



Development Status

Stage 1 - Preindustrial

- High IMR & high death rate due to lack of access to clean water, stable food supply, and healthcare
- High TFR due to lack of access to:
  - Ed. for women
  - Contraceptives/family planning
- Need for child agricultural labor
- **Little to no growth due to high CBR & CDR balancing each other out**

Ex: Virtually no country is in phase 1

Stage 2 - Industrializing/Developing

- Modernizations brings access to clean water, healthcare, stable food supply
  - IMR & CDR decline
- TFR remains high due to
  - Lack of ed. for women & contraceptives/family planning
  - Need for child agricultural labor
  - Generational lag (takes time for ed. & societal change to spread
- **Rapid growth, due to high CBR and declining CDR**

- **Econ./societal Indicators**
  - Low per capita GDP
  - Shorter life-expectancy
  - High infant mortality
  - High TFR
  - Low literacy rate & school life expectancy for girls

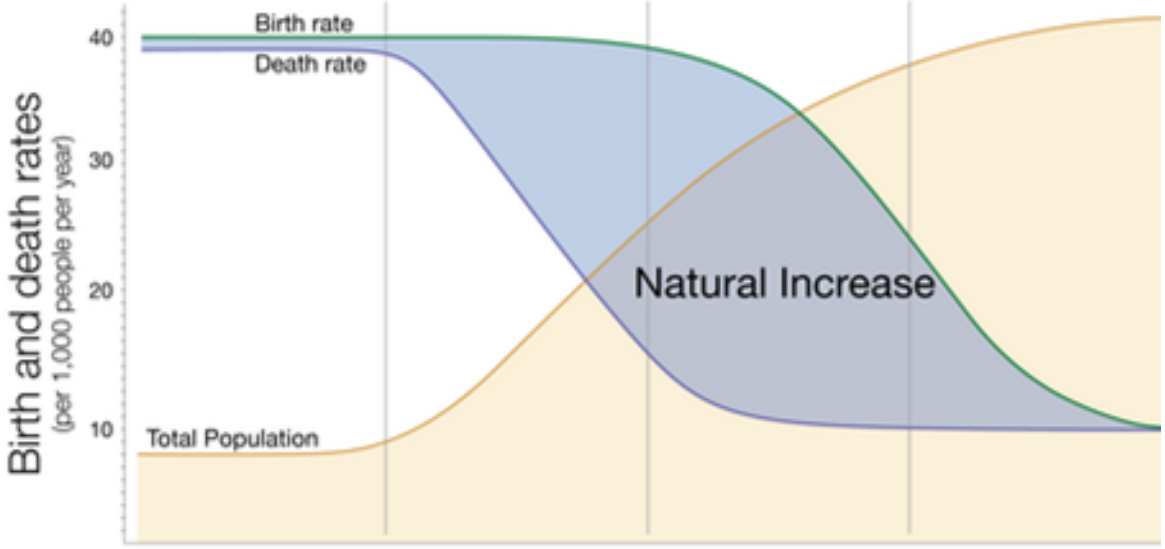
Stage 3 - Developed/Industrialized

- Modernized economy and society increase family income, so TFR declines significantly due to
  - More ed. opportunities for women
  - Delayed age of marriage & first child to focus on ed./career
  - Access to family planning & contraceptives
- **Slowing growth rate as CBR drops closer to CDR**
- **Econ./societal Indicators**
  - High per capita GDP
  - Long life-expectancy
  - Low infant mortality
  - TFR, near replacement level (2.1)
  - High literacy rate & school life expectancy for all

Stage 4 - Post-Industrialized/Highly Developed

- Highly modernized countries that are very affluent
  - TFR declines even further as families become more wealthy and spend even more time on educational & career pursuits
  - Increased wealth & education brings even more prevalent use of family planning & contraception
- **CBR drops lower that CDR & growth becomes negative(pop. decline)**

- **Econ./Societal Indicators**
  - Very high per capita GDP
  - Longest life-expectancy
  - TFR, below replacement level (2.1)
  - Highest contraceptive use rates



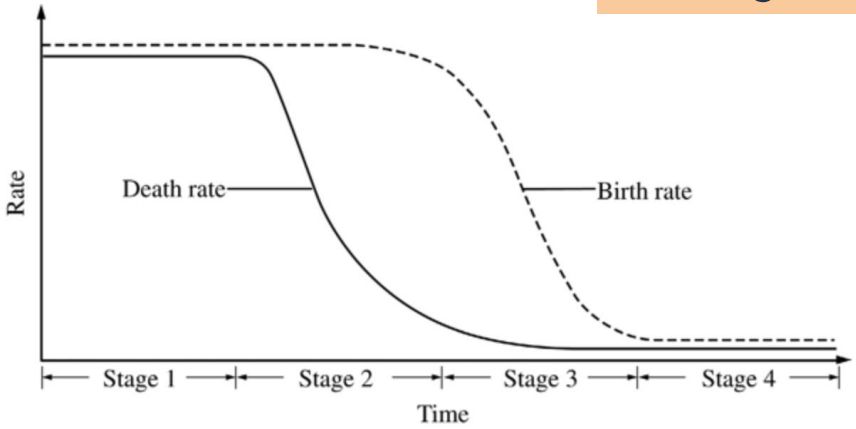
	Stage 1	Stage 2	Stage 3	Stage 4
Birth rate	High	High	Falling	Low
Death rate	High	Falls rapidly	Falls more slowly	Low
Natural increase	Stable or slow increase	Very rapid increase	Increase slows down	Falling and then stable
Population Pyramid				

Stages & Development

- 1 = pre-industrial
- 2 = developing
- 3= Developed
- 4 = Highly developed

$$\text{Global population growth rate} = \frac{[\text{CBR} - \text{CDR}]}{10}$$

FRQ Practice 3.9



SUGGESTED SKILL

Concept Explanation

1.C

Explain environmental concepts, processes, or models in applied contexts.

Identify the stage of this graph in which population grows the fastest and **explain** why this is the case. Besides population growth rate, **describe** one economic or societal indicator of a country in this phase.