Objective/EKs/Skill

2.1 Intro to Biodiversity

LEARNING OBJECTIVE

ERT-2.A

Explain levels of biodiversity and their importance to ecosystems.

SUGGESTED SKILL

Concept Explanation

1.A

Describe environmental concepts and processes.

ESSENTIAL KNOWLEDGE

ERT-2.A.1

Biodiversity in an ecosystem includes genetic, species, and habitat diversity.

ERT-2.A.2

The more genetically diverse a population is, the better it can respond to environmental stressors. Additionally, a population bottleneck can lead to a loss of genetic diversity.

ERT-2.A.3

Ecosystems that have a larger number of species are more likely to recover from disruptions.

ERT-2.A.4

Loss of habitat leads to a loss of specialist species, followed by a loss of generalist species. It also leads to reduced numbers of species that have large territorial requirements.

ERT-2.A.5

Species richness refers to the number of different species found in an ecosystem.

Biodiversity Basics

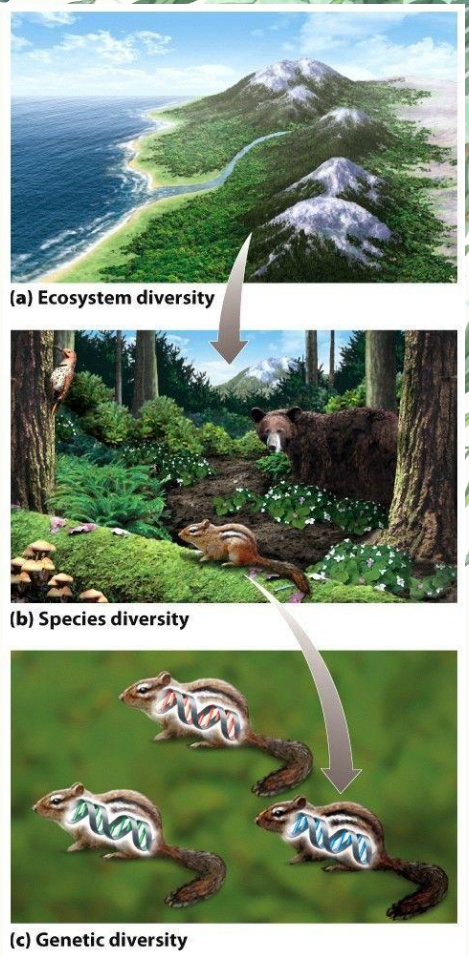
Diversity of life forms in an ecosystem; measured on 3 different levels:

Ecosystem diversity: the number of diff. habitats available in a given area

Species diversity: the number of diff. species in an ecosystem and the balance or evenness of the pop. sizes of all species in the ecosystem

Genetic diversity: how different the genes are of individuals within a population (group of the same species)

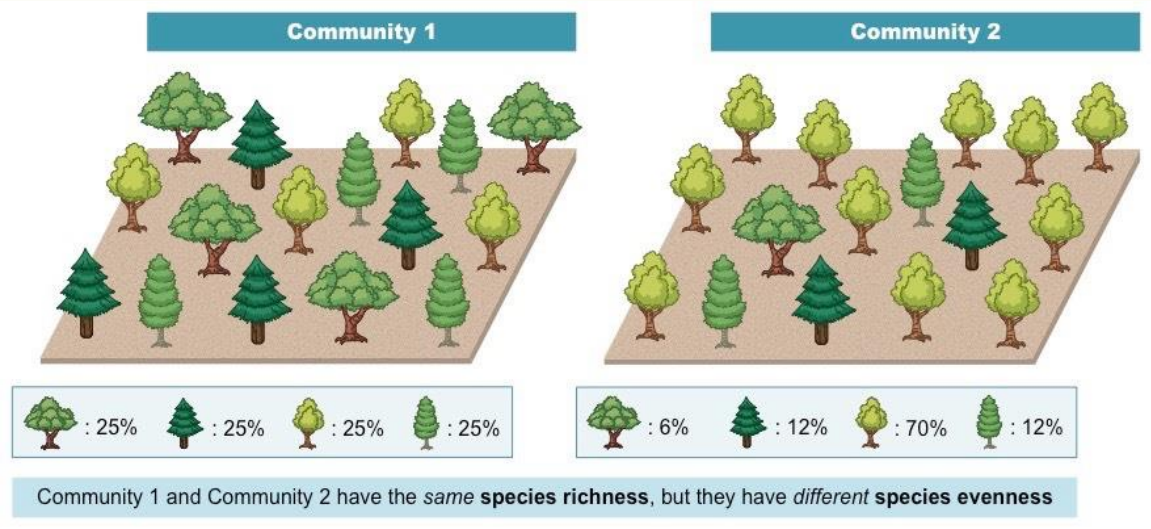
Higher biodiversity = higher ecosystem/ population health



Species Richness & Evenness

Richness (r) is just the total number of different species found in an ecosystem

Evenness is a measure of how all of the individual organisms in an ecosystem are balanced between the different species

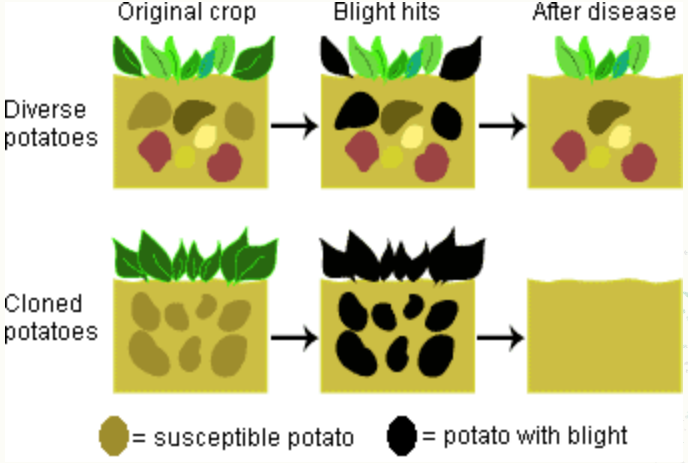


High (r) is generally a good sign of ecosystem health (more species means more quality resources like H_2O & soil)

Evenness indicates if there are one or two dominant species, or if pop. sizes are well balanced

Genetic Diversity is Beneficial

Genetic diversity = measure of how different the genomes (set of genes) are of the individuals within a population of a given species



There is genetic diversity in all pops. because random mutations in copying of DNA & recombination of chromosomes in sex cells of parents leads to new gene combinations & new traits in offspring

The more genetic diversity in a pop. the better the population can respond to env. Stressors like drought, disease, or famine

More gen. div. = higher chance that some of the individuals in a pop. have traits that allow them to survive the env. stressor

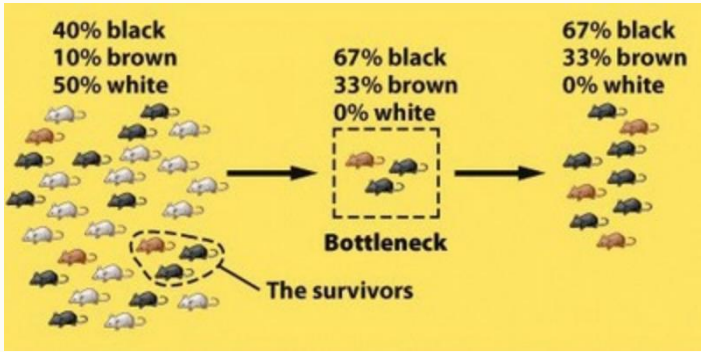
Bottleneck Event

An env. disturbance (natural disaster/human hab. destruction) that drastically reduces pop. size & kills organisms regardless of their genome

Surviving pop. is smaller and because individuals died randomly, it doesn't represent the genetic diversity of the original pop.

Bottleneck events reduce genetic diversity

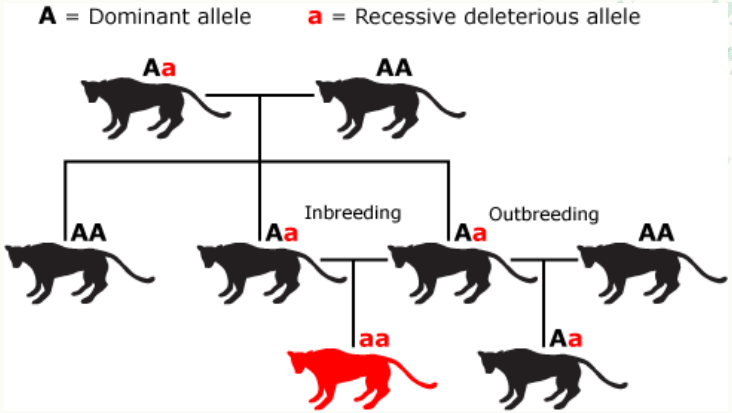
Because the pop. is smaller & less genetically diverse, it's even more vulnerable to future env. disturbances



Inbreeding Depression

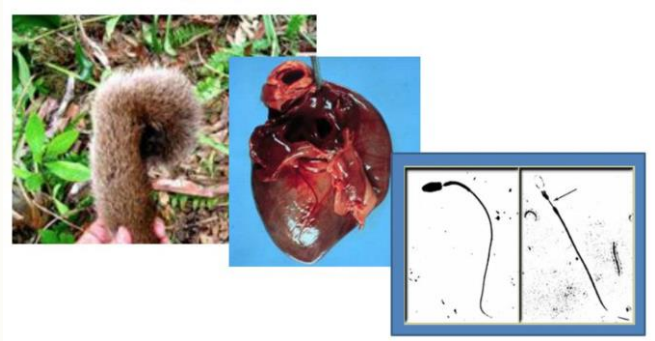
Inbreeding is when organisms mate with closely related “family” members

- Leads to higher chance of offspring having harmful genetic mutations because they’re getting similar genotypes from both parents



Smaller populations are more likely to experience inbreeding (difficult to find non-related mate)

Ex: Florida panther pop. decreased down to 30 in 1900s due to hunting & hab. loss. Inbreeding depression = kinked tails, heart defects, low sperm count, undescended testicles (saved in 95’ by pumas from Texas)



Ecosystem Resilience

Resilience = the ability of an ecosystem to return to its original conditions after a major disturbance (wind storm, fire, flood, clear-cutting, etc.)

Higher species diversity = higher ecosystem resilience

High sp. div means more plant species to repopulate disturbed ground, anchor soil, and provide food & habitat for animal species

(a)

(b)

Practice FRQ 2.1

SUGGESTED SKILL

Concept Explanation

1.A

Describe environmental concepts and processes.

Describe one of the three levels of biodiversity.

Explain how high biodiversity at the level you described is beneficial to ecosystems.

LEARNING OBJECTIVE

ERT-2.B

Describe ecosystem services.

ERT-2.C

Describe the results of human disruptions to ecosystem services.

ESSENTIAL KNOWLEDGE

ERT-2.B.1

There are four categories of ecosystem g, regulating, cultural,

SUGGESTED SKILL

Concept Explanation

1.B

Explain environmental concepts and processes.

ties can disrupt ecosystem services, potentially resulting in economic and ecological consequences.

2.2 Eco$y$tem $ervices

SUGGESTED SKILL

Concept Explanation

1.B

Explain environmental concepts and processes.

Objective/EKs/Skill

LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
ERT-2.B Describe ecosystem services.	**ERT-2.B.1** There are four categories of ecosystem services: provisioning, regulating, cultural, and supporting.
ERT-2.C Describe the results of human disruptions to ecosystem services.	**ERT-2.C.1** Anthropogenic activities can disrupt ecosystem services, potentially resulting in economic and ecological consequences.

Ecosystem Services = $$$

Goods and services provided by natural ecosystems that are beneficial to humans (often monetarily of life-sustaining)

Provisioning

Goods taken directly from ecosystems or made from nat. resources (wood, paper, food)

Regulating

Nat. ecosystems regulate climate/air quality, reducing storm damage & healthcare costs

Supporting

Nat. ecosystems support processes we do ourselves, making them cheaper & easier(bees pollinate crops)

Cultural

Money generate by recreation (parks, camping, tours) or scientific knowledge

Humans Disrupt Ecosystem Services

Human activities disrupt the ability of ecosystems to function, which decreases the value of ecosystem services they provide

This has ecological (natural) and economic (money-based) consequences

Examples

- Clearing land for ag./cities removes trees that store CO_2 (more CO_2 in atm. = more CC = more storm damage & crop failure)
- Overfishing leads to fish pop. collapse (lost fishing jobs and lower fish sales in the future)

Provisioning Services

Goods/products directly provided to humans for sale/use by ecosystems

Ex: Fish, hunting animals, lumber (wood for furniture/buildings) naturally grown foods like berries, seeds, wild grains, honey

Goods/products that are made from natural resources that ecosystems provide

Ex: paper, medicine, rubber

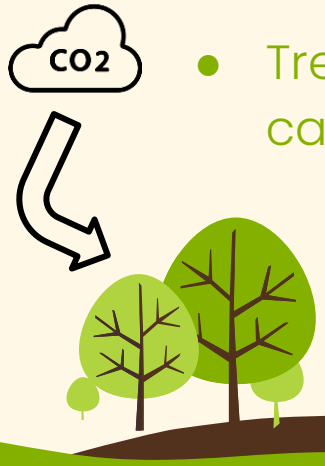
Disrupted by overharvesting, water pollution, clearing land for ag/urbanization

Regulating Services

Benefit provided by ecosystem processes that moderate natural conditions like climate and air quality

Examples

- Trees in a forest sequester (store) CO_2 through photosynthesis which reduces rate of climate change & lessens damage caused by rising sea level & reduces crop failure from drought
- Trees filter air by absorbing air pollutants which reduces health care costs for treating diseases like asthma and bronchitis



Disrupted by deforestation

Supporting Services

Natural ecosystems support processes we do ourselves, making them less costly and easier for us

Examples

- Wetland plant roots filter pollutants, leading to cleaner groundwater that we don't have to pay as much to purify with expensive water treatment plants
- Bees & other insects pollinate our ag. Crops, leading to more crop production & higher profits

Disrupted by pollinator hab. loss & filling in wetlands for development

Cultural Services

Revenue from recreational activities (hunting/fishing licenses, park fees, tourism-related spending) & profits from scientific discoveries made in ecosystems (health/ag./educational knowledge)

Examples

- Beautiful landscapes draw tourists who pay to enter parks, spend money at local stores/restaurants, or camping fees
- Fishermen pay for fishing licenses to catch fish in clean rivers
- Scientists learn about plant compounds that can lead to creation of new medicines which are sold for profit

Disrupted by deforestation, pollution, urbanization

SUGGESTED SKILL

Concept Explanation

1.B

Explain environmental concepts and processes.

Practice FRQ 2.2

Describe an ecosystem service that intact forest ecosystems provide for humans.

Identify one human activity that could degrade this ecosystem service and **explain** how the activity decreases the value of the ecosystem service.

LEARNING OBJECTIVE

ERT-2.D

Describe island biogeography.

ESSENTIAL KNOWLEDGE

ERT-2.D.1

Island biogeography is the study of the ecological relationships and distribution of organisms on islands, and of these organisms' community structures.

SUGGESTED SKILL

Concept Explanation

1.A

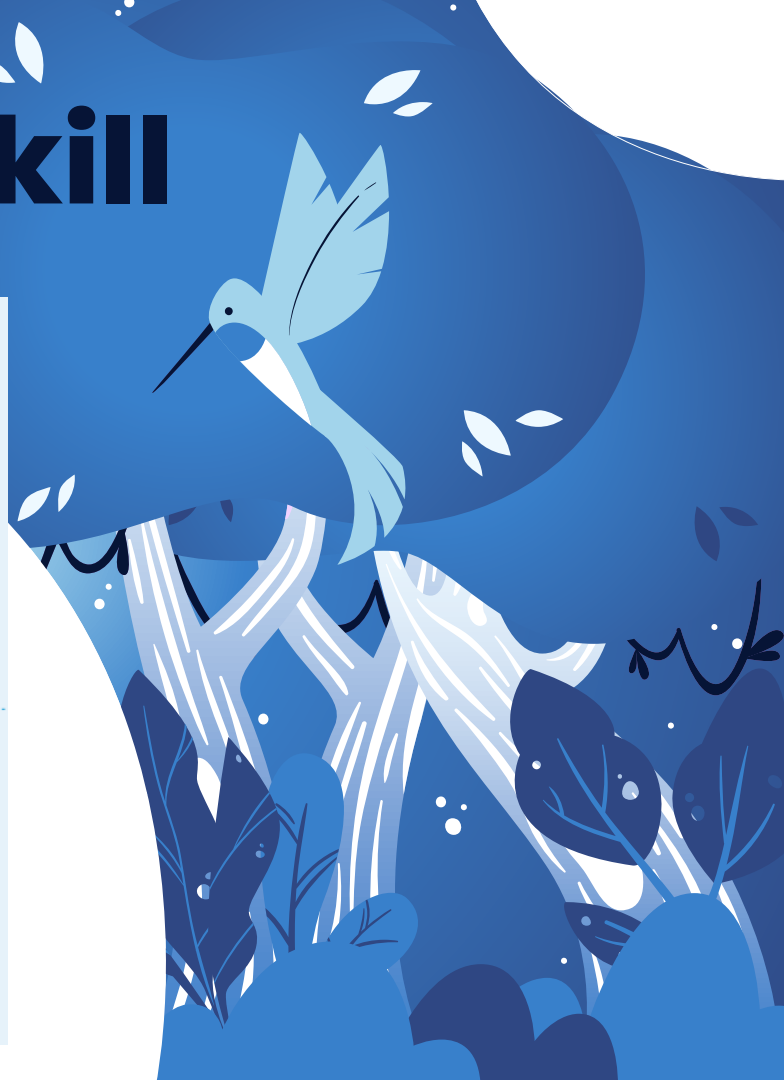
Describe environmental concepts and processes.

ve been colonized in the past by new riving from elsewhere.

nd species have evolved to be s versus generalists because of the sources, such as food and territory, slands. The long-term survival of s may be jeopardized if and when pecies, typically generalists, are introduced and outcompete the specialists.

2.3
Theory of Island Biogeography

Objective/EKs/Skill



LEARNING OBJECTIVE

ERT-2.D

Describe island biogeography.

SUGGESTED SKILL

Concept Explanation

1.A

Describe environmental concepts and processes.

ESSENTIAL KNOWLEDGE

ERT-2.D.1

Island biogeography is the study of the ecological relationships and distribution of organisms on islands, and of these organisms' community structures.

ERT-2.D.2

Islands have been colonized in the past by new species arriving from elsewhere.

ERT-2.E

Describe the role of island biogeography in evolution.

ERT-2.E.1

Many island species have evolved to be specialists versus generalists because of the limited resources, such as food and territory, on most islands. The long-term survival of specialists may be jeopardized if and when invasive species, typically generalists, are introduced and outcompete the specialists.

Island Biogeography

Study of ecological relationships & community structure on islands

- Islands can be actual islands in a body of water or figurative habitat islands such as central park in New York City or National Parks (nat. habitats surrounded by human developed land)

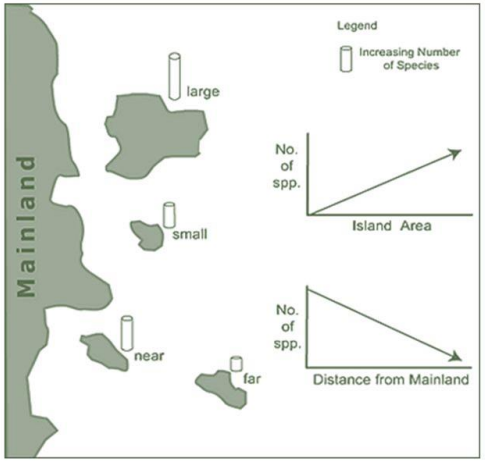
Two basic “rules” or observations of Island Biogeography

Larger Islands support more total species

- The larger the island, the greater the ecosystem diversity
- Greater ecosystem diversity = more food & hab. resources
- More niches, or “roles” organisms can play in the ecosystem

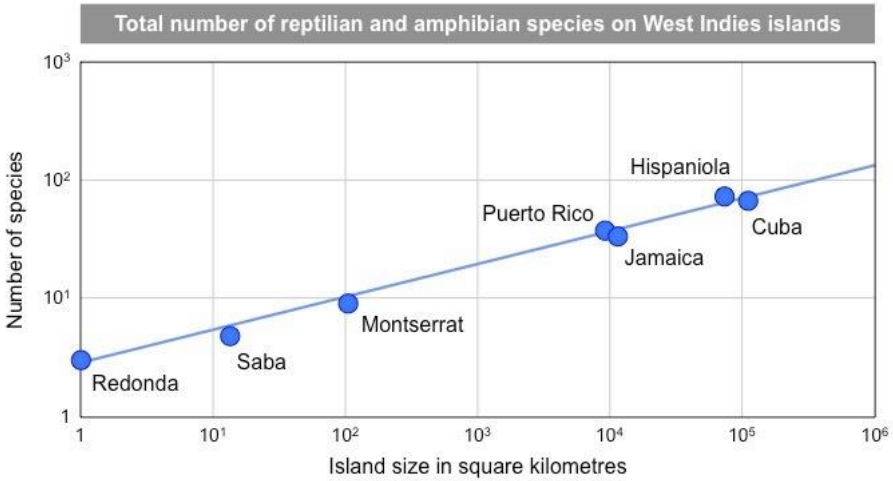
Islands closer to the “mainland” support more species

- Easier for colonizing organisms to get to island from mainland
- More colonizing organisms = more genetic diversity in new pop.



Larger Islands Support More Species

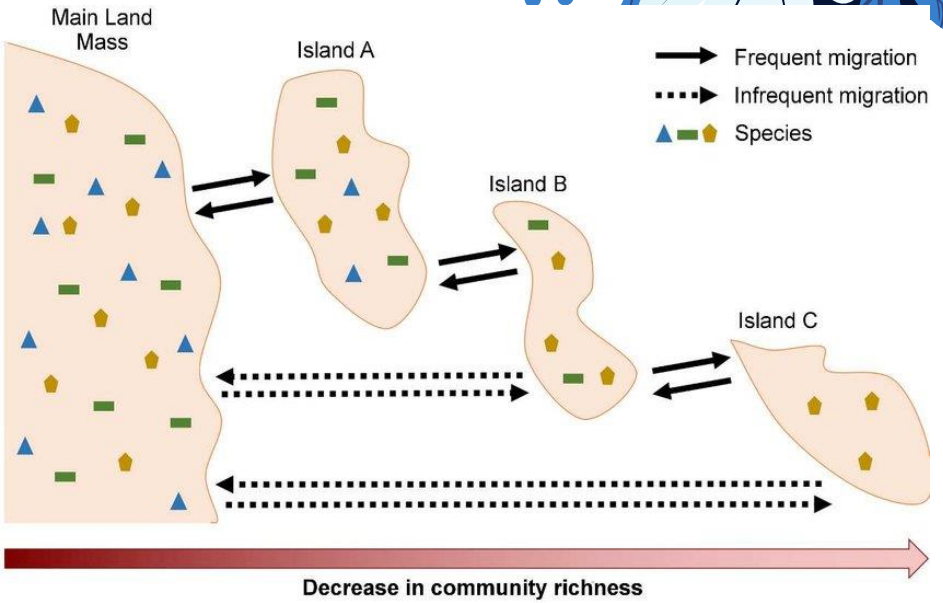
- Larger islands =
  - higher ecosystem diversity
  - More available “niches” or roles
    - Ex: all the different food sources available to birds on Galapagos
  - Larger pop. sizes (more genetically diverse and more resistant to env. disturbance)
  - Lower extinction rate (species less likely to die off)
- Positive correlation between island size & species richness



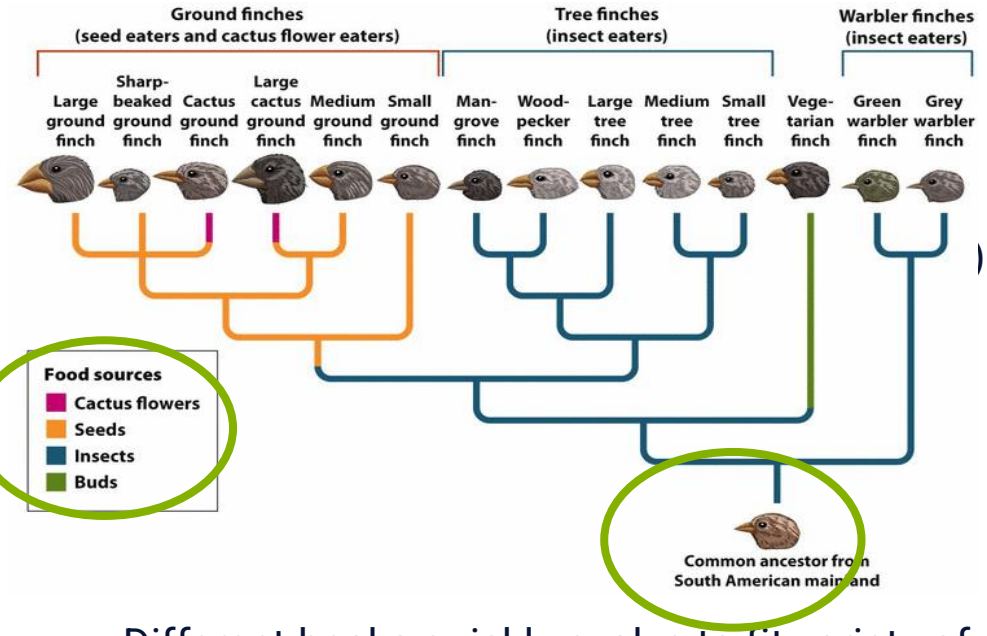
Distance to Mainland

Closer to mainland = higher species richness

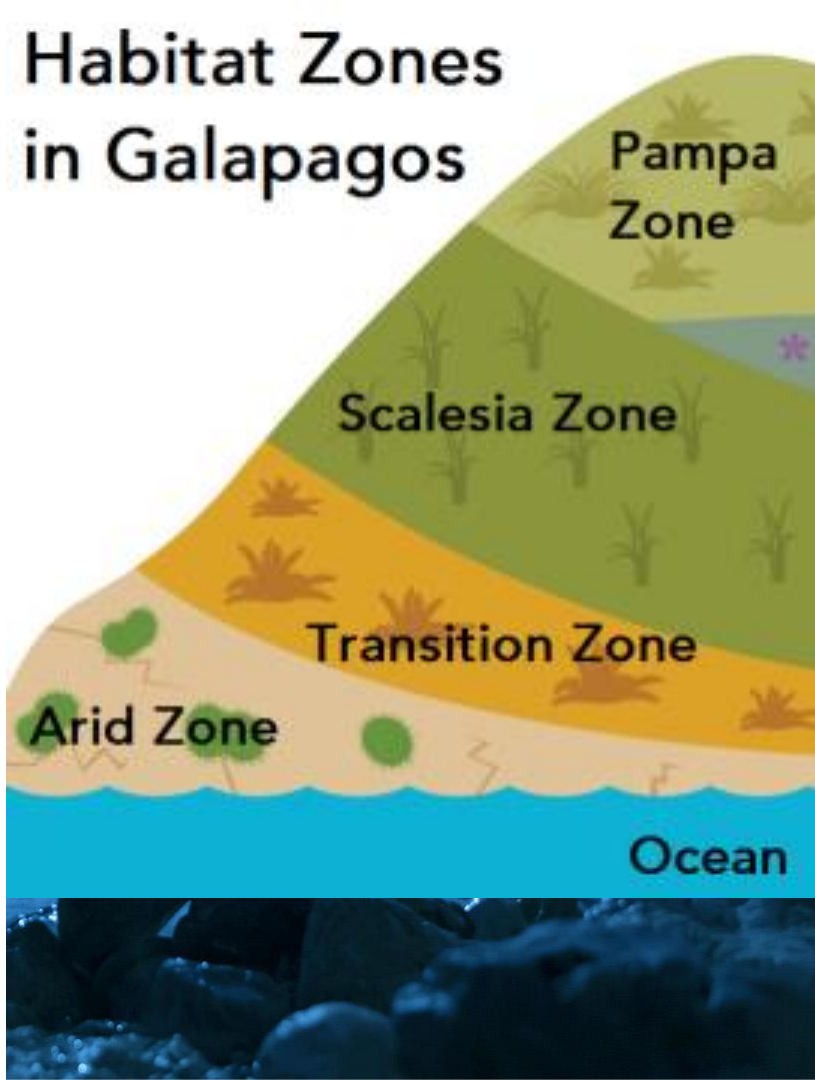
- Easier for more species to migrate to island from mainland (swim/fly)
- More continual migration of individuals to the island habitat
    - Frequent migration brings more genetic diversity & larger pop. size
- Inverse relationship between island distance from mainland & species richness
    - The further away from mainland, the fewer species



Evolution on Islands



- Different beaks quickly evolve to fit variety of different food sources on Island
  - Single colonizing species from mainland quickly evolves to many slightly different species to adapt to new island cond.



Practice FRQ 2.3

SUGGESTED SKILL

Concept Explanation

1.A

Describe environmental concepts and processes.

- **Describe** the processes of colonizing an island habitat.
- **Describe** how the island's distance from the mainland influences the number of species that will colonize the island habitat.

2.4 Ecological Tolerance

Objective/EKs/Skill

LEARNING OBJECTIVE

ERT-2.F

Describe ecological tolerance.

SUGGESTED SKILL

Text Analysis

3.A

Identify the author's claim.

ESSENTIAL KNOWLEDGE

ERT-2.F.1

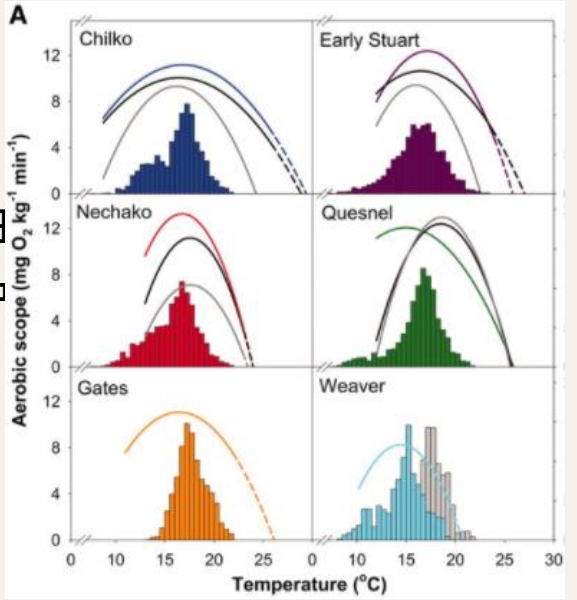
Ecological tolerance refers to the range of conditions, such as temperature, salinity, flow rate, and sunlight that an organism can endure before injury or death results.

ERT-2.F.2

Ecological tolerance can apply to individuals and to species.

Ecological Range of Tolerance

- **Range of conditions such as temperature, salinity, pH that an organism can endure before injury or death**
- **Species and individual organisms both have a range for all the different environmental conditions of their habitat**



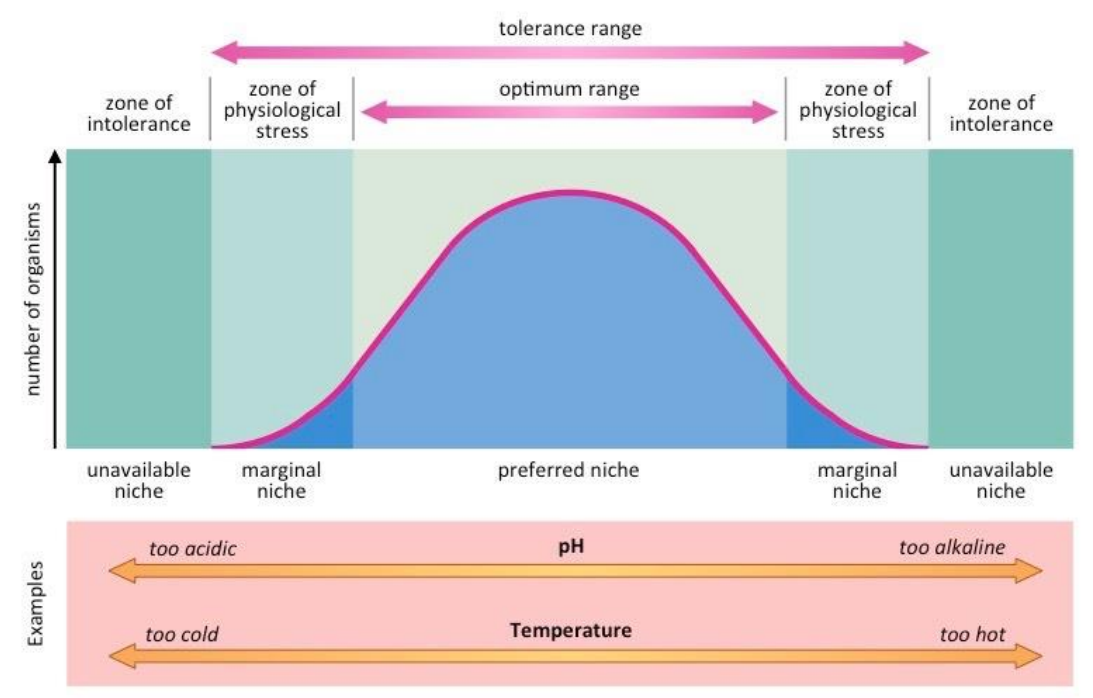
Ex: Salmon have a basic range of tolerance for temperature from 6° to 22° C. But some individual salmon have adaptations that give them a range of tolerance that is outside the basic range for the species.

Due to genetic biodiversity

Makes populations of salmon more resistant to disturbances, like global warming

Ecological Range of Tolerance - Zones

- **Optimal range**: range where organisms survive, grow, and reproduce
- **Zone of physiological stress**: range where organisms survive, but experience some stress such as infertility, lack of growth, decreased activity, etc.



- **Zone of intolerance**: range where the organism will die

  Ex: thermal shock, suffocation, lack of food/water/oxygen

FRQ Writing Tips

On FRQs about human activities or natural events that cause environmental disturbance, connect answer to ecological range of tolerance

If possible, connect human activity to climate change

- (electricity generation, transportation, agriculture) all release CO_2 which causes climate change and global warming
  - Global warming shifts temperature outside the range of tolerance for many tree species, causing their populations to decline

OR

  - Global warming warms the ocean, shifting temperature outside range of tolerance for many fish species causing die-offs

FRQ Writing Tips

Try to connect a shift in range of tolerance to a specific kind of physiological stress

Ex: suffocation, thermal shock, lack of water/food/nutrients/oxygen

- Global warming warms the ocean, shifting temperature outside range of tolerance for many fish species. Since global warming increases ocean temperature and warm water holds less oxygen, fish may **suffocate due to lack of oxygen**.

- Global warming warm can increase droughts. With increased droughts, rainfall patterns may shift outside the range of tolerance for many plant species. Without enough rainfall, these species may suffer population decline as their **roots are unable to absorb enough water from the soil.**

Practice FRQ 2.4

SUGGESTED SKILL

Text Analysis

3.A

Identify the author's claim.

Chinook salmon are important members of freshwater and ocean food webs. Salmon transport nutrients from the ocean to freshwater habitats. Traces of nutrients from salmon can be found in everything from trees to bears! Salmon also support sport and commercial fisheries, and are used for ceremonial purposes by Native Americans. Climate change poses a threat to salmon populations by warming the waters of streams and rivers where they reproduce. To maintain healthy populations, salmon rely on cold, freshwater habitats and may go extinct as temperatures rise in coming decades. Warm temperatures can cause large salmon die-offs. However, some salmon individuals have higher **thermal tolerance**, or the ability to withstand and live in warm temperatures. These individuals may be better able to survive when water temperatures rise.

Salmon individuals with certain gene variants that give them higher thermal tolerance may be better able to survive in warmer waters. Scientists want to know whether there is a genetic basis for the variation observed in salmon's thermal tolerance. If differences in certain genes control variation in thermal tolerance, scientists can identify the location on the genome responsible for this very important adaptation. Once identified, management agencies could then screen for these genes in populations of Chinook salmon in order to identify individuals that could better survive in a future warmer environment. Hatchery programs could also breed thermally tolerant fish in an attempt to preserve this important fish species.

2.5 Natural Disruptions to Ecosystems

Natural Disturbances

- A natural event that disrupts the structure and or function of an ecosystem

  Ex: Tornados, hurricanes, asteroids, forest fires, drought

- Natural disturbances can be even greater than human disruptions
  - Can occur on periodic, episodic, or random time frames

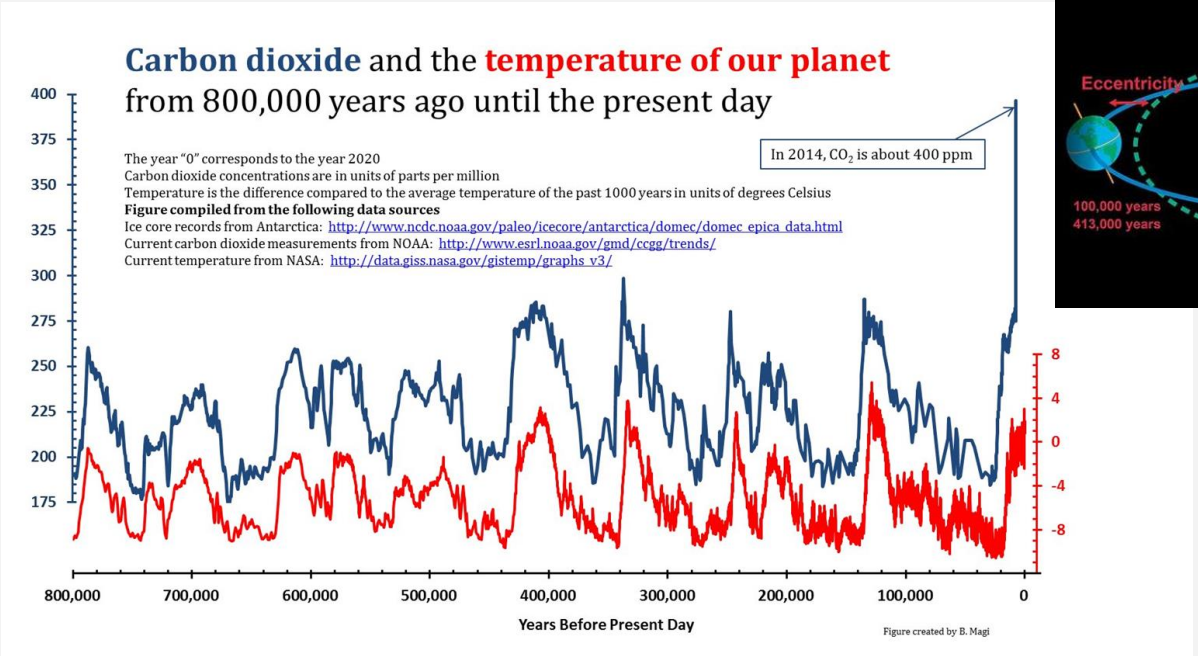
  Periodic: occurs with regular frequency (ex: dry-wet seasons)

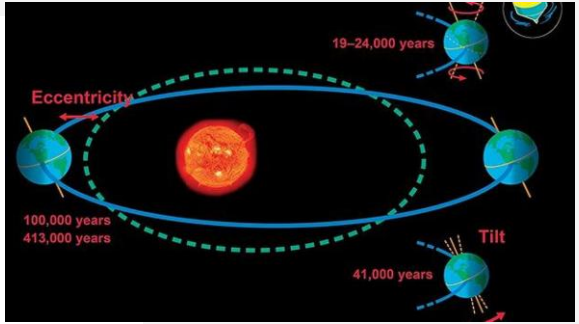
  Episodic: occasional events with irregular frequency (ex: hurricanes, droughts, fires)

  Random: no regular frequency (volcanoes, earthquakes, and asteroids)

Natural Climate Change

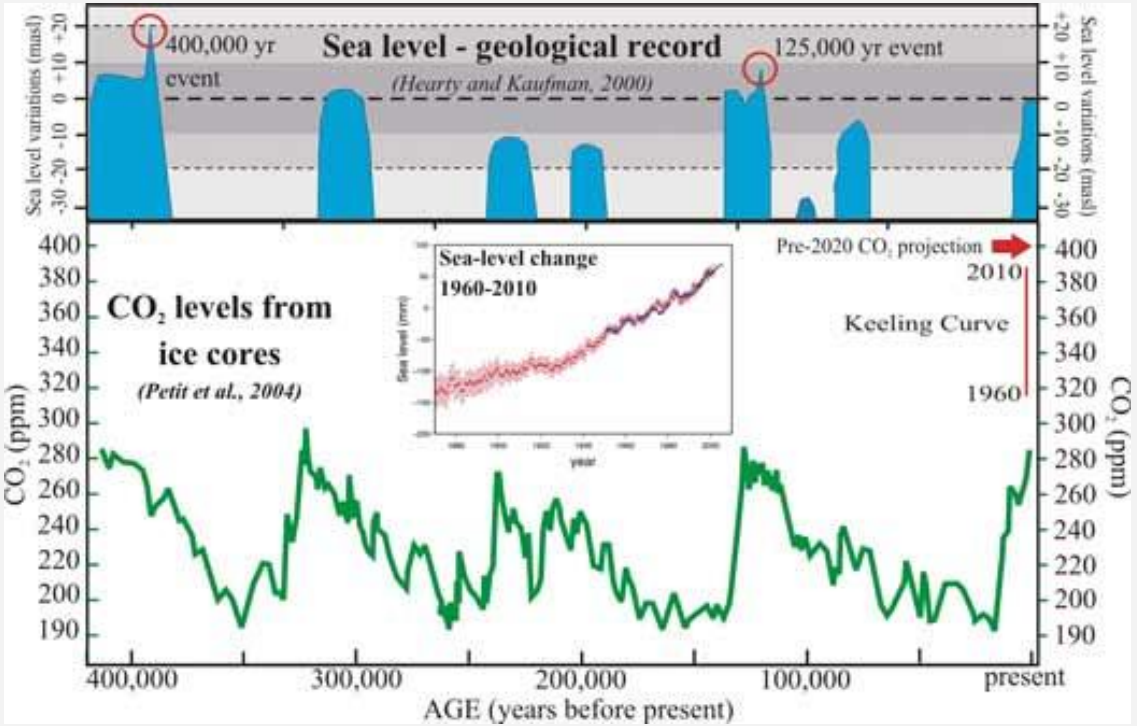
- Earth's climate has varied over geologic time for numerous reasons
  - Ex: Slight changes in earth's orbit & tilt cause mini ice ages & warmer periods as earth shifts slightly closer to & further from sun





Natural Climate Change

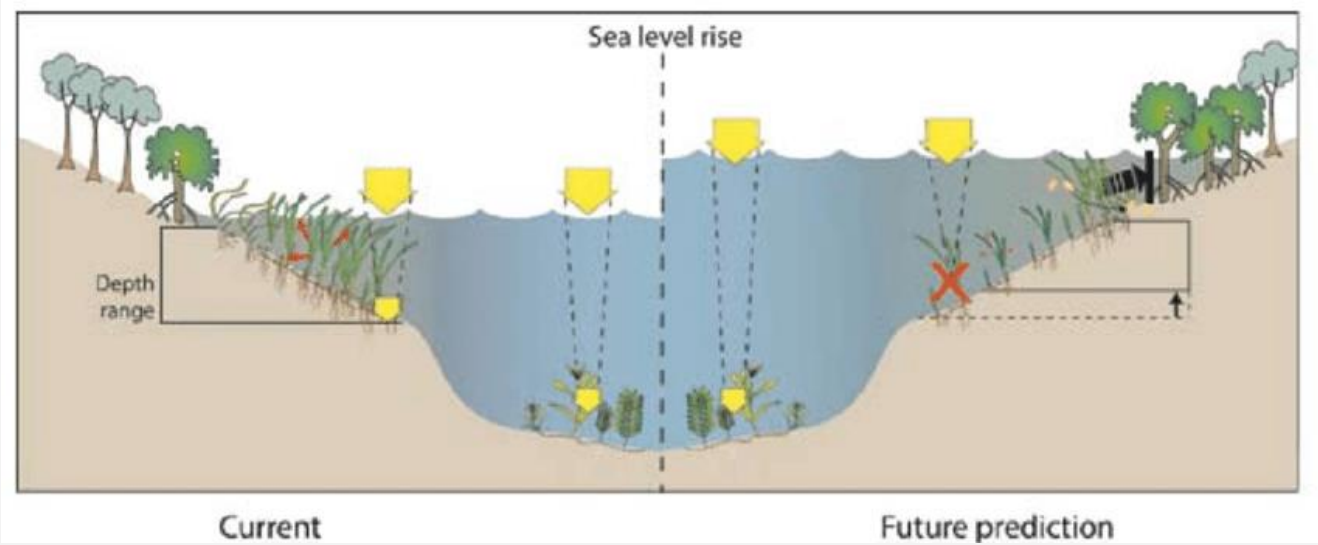
- Sea level has varied over geological time as glacial ice on earth melts & forms



Env. Change = Hab. Disruption

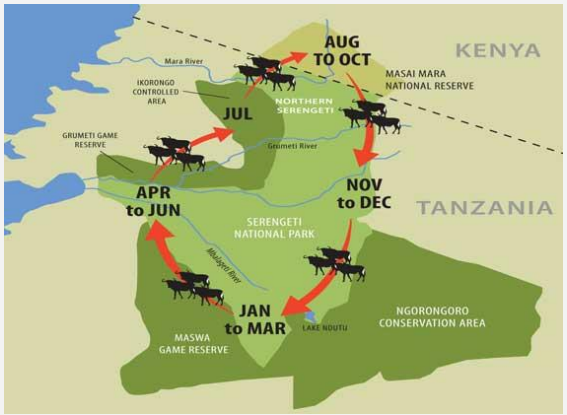
- Major environmental disturbances result in widespread habitat changes and or loss

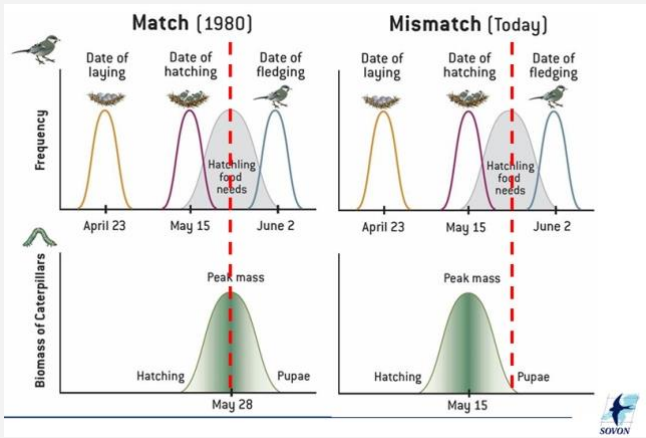
  Ex: Rising sea level floods coastal & estuary habitats



Migration

- Wildlife may migrate to a new habitat as the result of natural disruptions
  - Ex: wildebeests migrating to follow rain patterns of African savanna
    - Ocean species moving further north as water temperature warms
    - Bird migration & breeding shifting earlier as insect hatching shifts earlier with warming climate





Practice FRQ 2.5

SUGGESTED SKILL

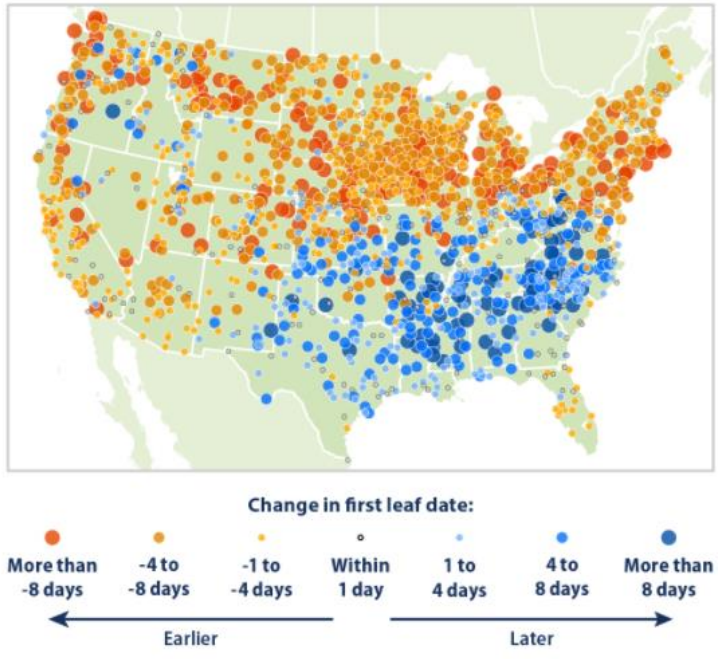
Data Analysis

5.A

Describe patterns or trends in data.

Describe the relationship between latitude and change in first leaf date depicted in the graph. **Explain** why you think this relationship exists.

Figure 2. Change in First Leaf Date Between 1951–1960 and 2006–2015



2.6 Adaptations

Objective/EKS/Skill

LEARNING OBJECTIVE

ERT-2.H

Describe how organisms adapt to their environment.

SUGGESTED SKILL

Data Analysis

5.B

Describe relationships among variables in data represented.

ESSENTIAL KNOWLEDGE

ERT-2.H.1

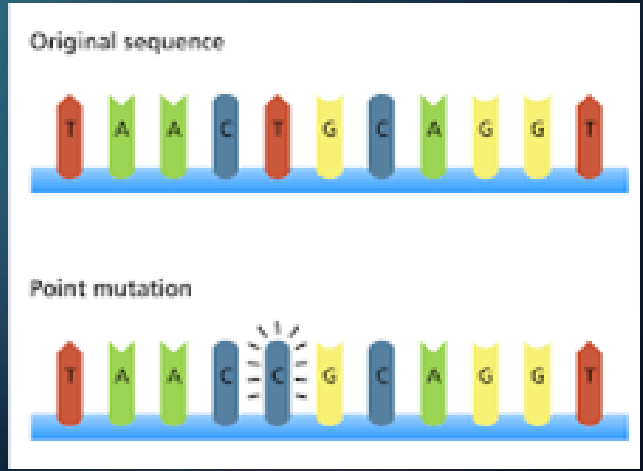
Organisms adapt to their environment over time, both in short- and long-term scales, via incremental changes at the genetic level.

ERT-2.H.2

Environmental changes, either sudden or gradual, may threaten a species' survival, requiring individuals to alter behaviors, move, or perish.

Fitness & Adaptation

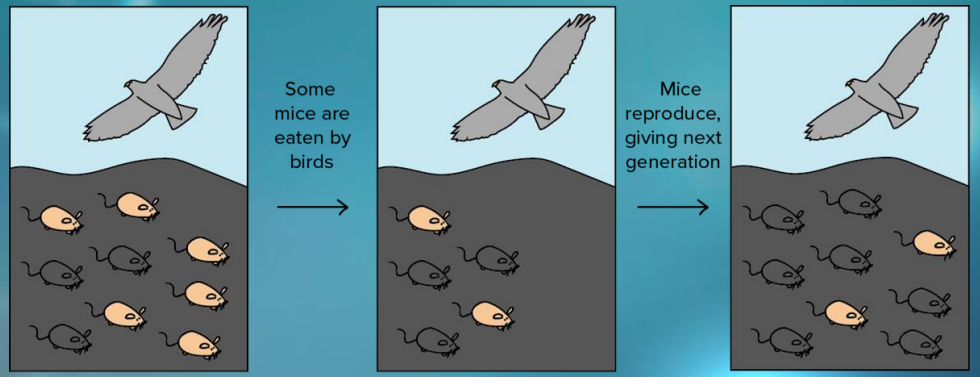
- All populations have some genetic diversity, or variability in genomes of individuals; Genetic diversity exists because:
  - Random mutations while DNA is being copied create new traits
  - Crossing over in parent chromosomes creates new combinations of genes (and therefore traits)
- **Adaptation:** a new trait that increases an organism's **fitness** (ability to survive and reproduce)



Adaptation & Natural Selection

Natural selection: organisms that are better adapted to their env. survive and reproduce more offspring

- Individuals with adaptations pass them on to offspring & individuals without adaptations die off, which leads to the entire population having the adaptation over time (evolution)

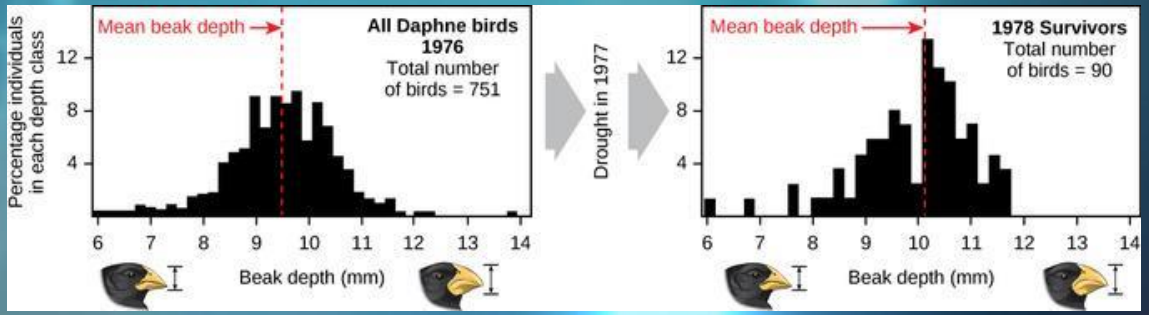


- **Selective pressure/force:** the environmental condition that kills individuals without the adaptation

Predation (hawk) = selective pressure

Environmental Change & Evolution

- The environment an organism lives in determines which traits are adaptations
  - As environments change, different traits may become adaptations & old traits may become disadvantages
  - **Ex:** a drought can kill off finches with smaller beaks, making larger beaks for cracking harder seeds an adaptation



Pace of Evolution

- **The more rapidly an env. changes, the less likely a species in the env. will be to adapt to those changes**
  - If the pace of env. change is too rapid, many species may migrate out of the env. or die-off completely
  - Ex: if the ocean warms too quickly, many species of fish may not be able to migrate before they run out of oxygen and suffocate
- **The more genetic diversity in a population, the better they're able to adapt to env. change (higher chance that some individuals have good mutations)**

The longer the lifespan of the organism, the slower the rate of evolution

- Ex: bacteria & viruses can adapt and evolve in days
  - Humans evolution = thousands-mil. years

Practice FRQ 2.6

Daphne Island Beak Size (mm)	Santa Cruz Island Beak Size (mm)
9.55	10.05
8.70	9.74
9.62	10.27
9.22	9.81
8.79	10.46
9.61	10.24
9.02	10.02
7.85	10.30
9.01	10.43
8.26	10.52

This data table shows the beak size of 20 finches from two different islands in the Galapagos.

Describe the difference in beak size between the two islands. **Make a claim** about the reason for this difference in beak size.

SUGGESTED SKILL

Data Analysis

5.B

Describe relationships among variables in data represented.

2.7
Ecological Succession

Objectives/EKs/Skill

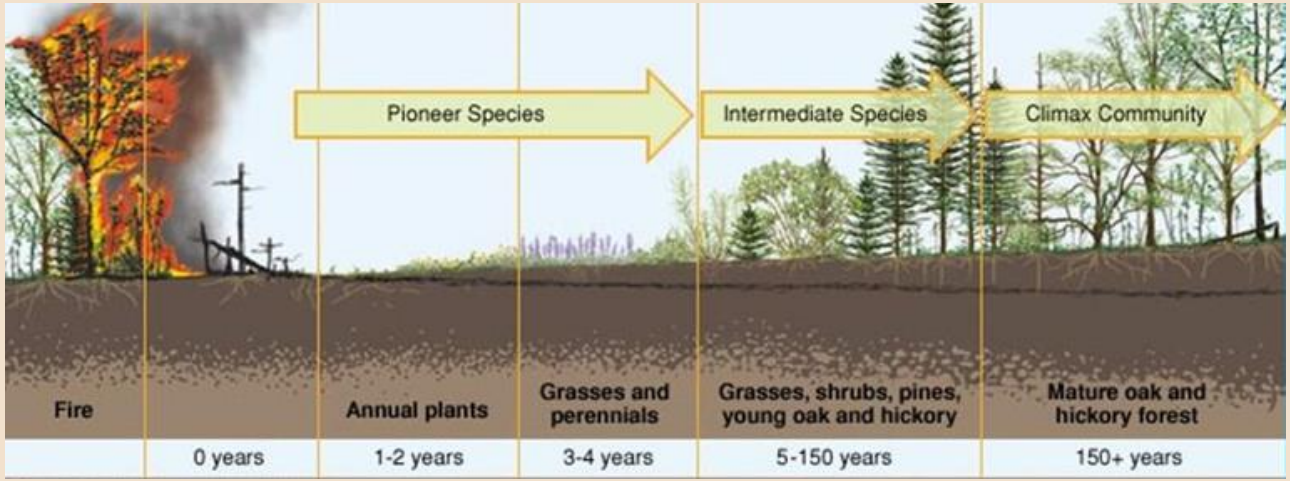
LEARNING OBJECTIVE	ESSENTIAL KNOWLEDGE
ERT-2.I Describe ecological succession. **SUGGESTED SKILL** *Data Analysis* **5.C** Explain patterns and trends in data to draw conclusions.	**ERT-2.I.1** There are two main types of ecological succession: primary and secondary succession. **ERT-2.I.2** A keystone species in an ecosystem is a species whose activities have a particularly significant role in determining community structure. **ERT-2.I.3** An indicator species is a plant or animal that, by its presence, abundance, scarcity, or chemical composition, demonstrates that some distinctive aspect of the character or quality of an ecosystem is present.
ERT-2.J Describe the effect of ecological succession on ecosystems.	**ERT-2.J.1** Pioneer members of an early successional species commonly move into unoccupied habitat and over time adapt to its particular conditions, which may result in the origin of new species. **ERT-2.J.2** Succession in a disturbed ecosystem will affect the total biomass, species richness, and net productivity over time.

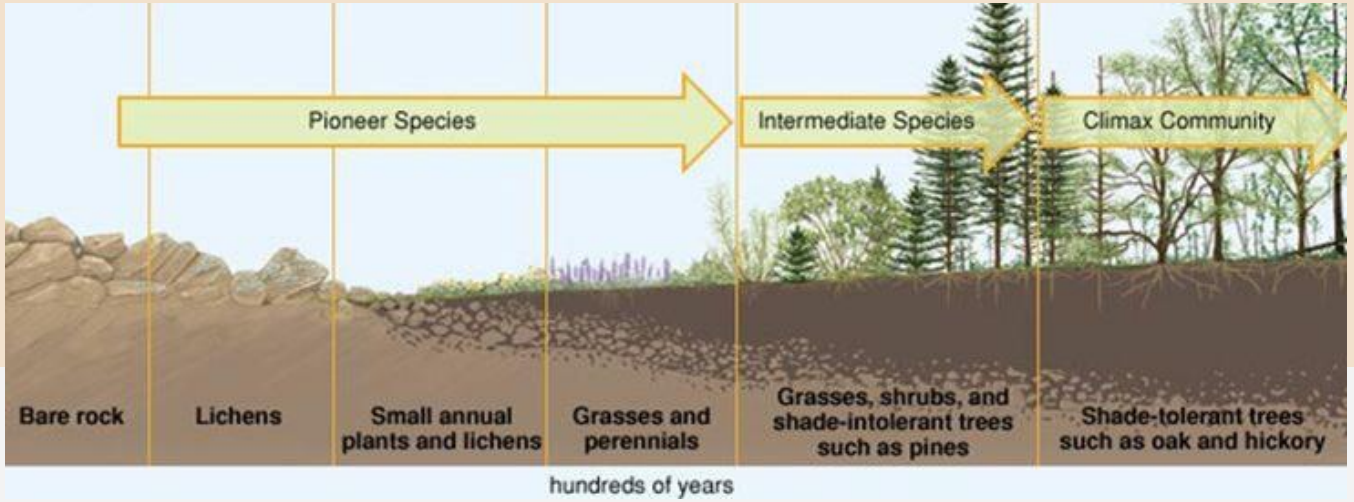
Ecological Succession

A series of predictable stages of growth that a forest goes through

Two types of succession:

- **Primary Succession**: starts from **bare rock** in an area with no previous soil formation
  - Moss & lichen spores carried by the wind grow directly on rocks, breaking them down to form soil
- **Secondary Succession**: starts from **already established soil**, in an area where a **disturbance** (fire/tornado/human land clearing) cleared out the majority of plant life
  - Grasses, sedges, wildflowers, and berry bushes have seeds dispersed by wind or animal droppings


Pioneer Species
Intermediate Species
Climax Community
Fire
Annual plants
Grasses and perennials
Grasses, shrubs, pines, young oak and hickory
Mature oak and hickory forest
0 years
1-2 years
3-4 years
5-150 years
150+ years


Pioneer Species
Intermediate Species
Climax Community
Bare rock
Lichens
Small annual plants and lichens
Grasses and perennials
Grasses, shrubs, and shade-intolerant trees such as pines
Shade-tolerant trees such as oak and hickory
hundreds of years

Stages of Succession

Stages are characterized by which types of plant species dominate the ecosystem; different species are adapted to the conditions of the different stages

- **Pioneer or early succession species** appear first, when the ground is simply bare rock, or bare soil after a disturbance
  - **Characteristics**: seeds spread by wind or animals, fast growing, tolerant of shallow soil and full sunlight
  - **Ex**: moss, lichen (bare rock) | wildflowers, raspberries, grasses/sedges

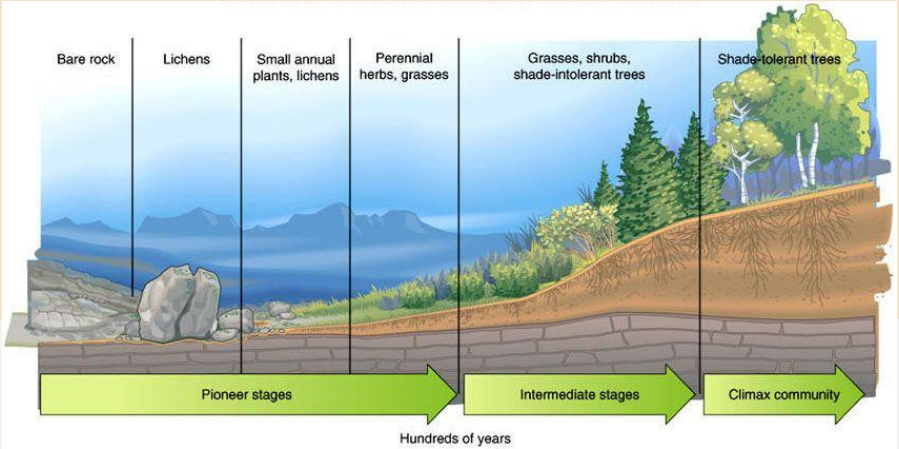
- **Mid-successional species** appear after pioneer species have helped develop deeper soil with more nutrients by their cycles of growth/death
  - **Characteristics**: relatively fast growing, larger plants that need deeper soils with more nutrients than pioneers, sun tolerant
  - **Ex**: shrubs, bushes, fast-growing trees like aspen, cherry, and pine

Stages of Succession

- **Late successional or climax community species** appear last, after soil is deepened and enriched with nutrients by cycles of growth and death by early & mid successional species

  Characteristics: large, slow-growing trees that are tolerant of shade and require deep soils for large root networks

  Ex: maples, oaks, other large trees



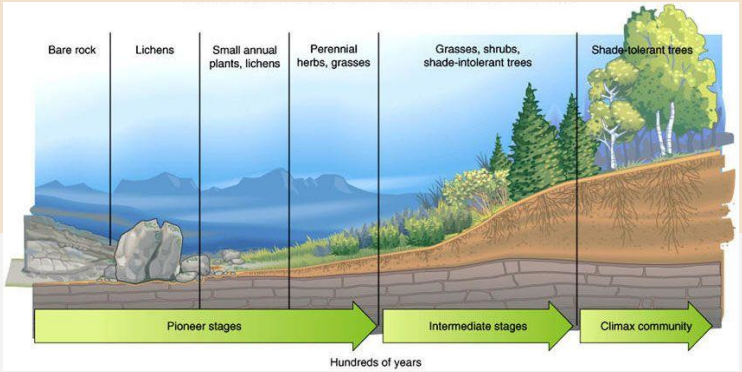
Primary Succession

Occurs in an area that hasn't previously been colonized by plants (bare rock)

Ex: volcanic rock, rock exposed after glacial retreat

Moss and lichen (spores dispersed by wind) are able to grow directly on rock by secreting acids that break down rock & release minerals containing nutrients they need (N/P/K)

Chemical weathering of rocks by moss & lichen combined with organic matter from moss & lichen dying form initial shallow soil

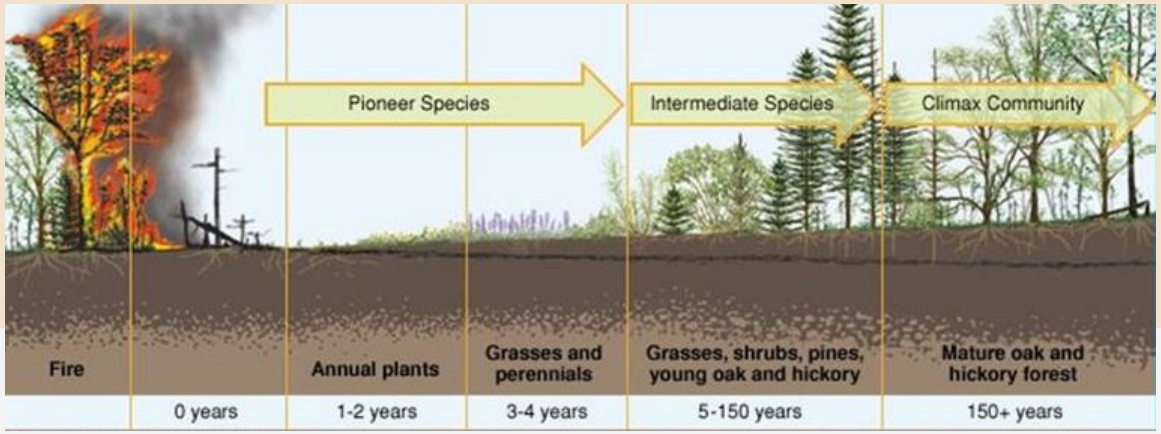


Secondary Succession

Occurs in an area that <u>already has established soil</u>, but has had most plant life removed by a <u>disturbance</u>

Pioneer species are still wind-dispersed seeds of plants that are fast-growing and sun tolerant, but grasses/wildflowers/weeds instead of moss/lichen

Soil is already established & sometimes even enriched by nutrient-rich ash from fire; overall more rapid process than primary succession



Practice FRQ 2.7

SUGGESTED SKILL
Data Analysis
5.C
Explain patterns and trends in data to draw conclusions.

Based on the graph below, **explain** whether spruce trees are an early, middle, or late successional species.