MAMMOTH SCIENCE

EST 2022

PUBLISHING

Ecological Succession & Adaptation

- *Define the components of an ecosystem using appropriate terminology.*
- *Define ecological succession and distinguish between primary and secondary succession. (Remembering)*
- *Identify the pioneer species involved in primary succession and describe how they help create soil.*
- *Compare and contrast primary and secondary succession, including the differences in the types of organisms involved and the time scales of the processes.*
- *Evaluate the factors that can influence the rate and direction of ecological succession in different ecosystems, such as climate, topography, and disturbance history. (Evaluating)*
- *Predict the types of species that are likely to colonize an area during different stages of succession and explain why.*
- *Analyze how human activities such as deforestation and urbanization can disrupt ecological succession and evaluate the potential consequences for ecosystem stability.*
- *Evaluate the potential of ecological succession to mitigate the impacts of climate change on ecosystems, using evidence and scientific reasoning.*
- *Define natural selection and explain how it leads to adaptations in populations over time.*
- *Identify examples of physical and behavioral adaptations that organisms have developed in response to specific environmental pressures, such as predators or temperature extremes.*
- *Evaluate the role of adaptations in enabling species to survive and thrive in changing environments, and predict the potential consequences of failing to adapt to environmental change.*
- *Describe the different types of environmental change and their effects on biodiversity using real-world examples.*
- *Analyze how changes in biodiversity can impact ecosystem stability and explain how natural selection and adaptations in species can overcome environmental changes.*

MAMMOTH
SCIENCE

Menu

Introduction to Ecosystems

Characteristics of Ecosystems

Biogeochemical Cycles - Water Cycles

Water Cycle Explained

Carbon Cycle

Carbon Cycle - Explained

Nitrogen Cycle

MAMMOTH
SCIENCE

Menu

Nitrification / Denitrification

Nitrogen Cycle - Explained

Introduction to Ecological Succession

Ecological Succession - Explained

Primary Succession

Primary Succession - Explained

Secondary Succession

MAMMOTH
SCIENCE

Menu

Secondary Succession - Explained

Mechanisms of Succession

Human Impacts

Human Impacts - Explained

Evolution for Selection

Climate change & Ecosystems

Adaptation

Natural Selection & Change

Introduction to Ecosystems

I. Introduction to Ecosystems

B. Definition of an ecosystem - An ecosystem is a community of living organisms and their abiotic (non-living) environment that interact with one another.

C. Basic principles of ecology - Principles of ecology include the interactions between living (**biotic**) and non-living (**abiotic**) components of an ecosystem, energy flow, nutrient cycling, and the impact of disturbances on ecosystems.

4. **Biotic** - all living components of an ecosystem: organisms, producers, consumers, bacteria, decomposers
5. **Abiotic** - all nonliving things in an ecosystem: rocks, soil, water, air, minerals, etc..

Characteristics of an Ecosystem

A. Ecosystem stability and sustainability

2. Characteristics of stable ecosystems - Stable ecosystems have:

c. high **biodiversity**

d. balanced **nutrient** cycling

e. and a **resilience** to **environmental disturbances**.

f. A **balanced** nutrient **cycling** ensures that the **input** and **output** of **nutrients** in the ecosystem are relatively **equal**, while **high biodiversity** refers to the **variety** of **species** and genetic **diversity** within an ecosystem.

7. Factors that impact ecosystem stability - Factors that impact ecosystem stability include:

h. changes in **biotic** and **abiotic** factors

i. loss of **biodiversity**,

j. and **climate change**.

11. The importance of biodiversity for ecosystem stability - Biodiversity is critical for ecosystem stability because it supports ecosystem services:

l. such as pollination and nutrient cycling.

m. Loss of biodiversity can lead to a reduction in ecosystem services and can make ecosystems more vulnerable to environmental disturbances.

Biochemical Cycles - Water Cycle

II. Cycling of Matter and Flow of Energy in Ecosystems

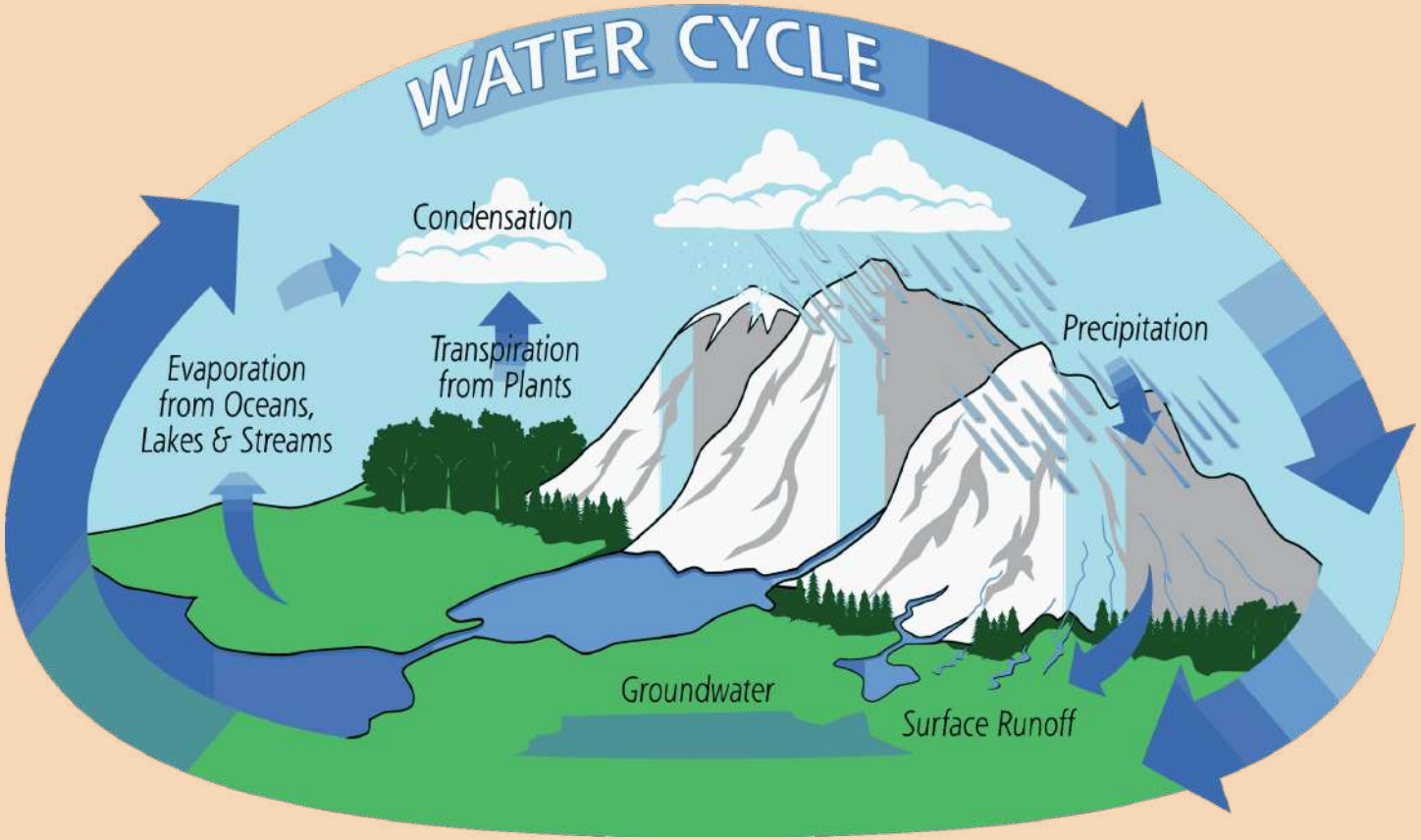
A. Overview of Biogeochemical Cycles

2. Water cycle - The water cycle describes the movement of water between the atmosphere, land, and oceans through processes such as:

- **c) evaporation** - liquid to gas
- **d) condensation**- gas to liquid vapor - cloud formation
- **e) precipitation** - water in any form falling from clouds
- **f) transpiration**: water vapor given off by plants - stoma and guard cells
- **g) runoff** : some water is absorbed by the ground, the rest runs into surface water
- **h) infiltration** - water absorbed by the ground
- **i) surface water & groundwater** - water on the surface: lakes, river, oceans. Groundwater: underground aquifers

- *The water cycle is critical for the distribution of water resources and the survival of aquatic and terrestrial organisms.*

Water Cycle - Explained



(2013, January 31). *NASA | Earth's Water Cycle*. Youtube. Retrieved March 31, 2023, from https://youtu.be/oaDkph9yQBs

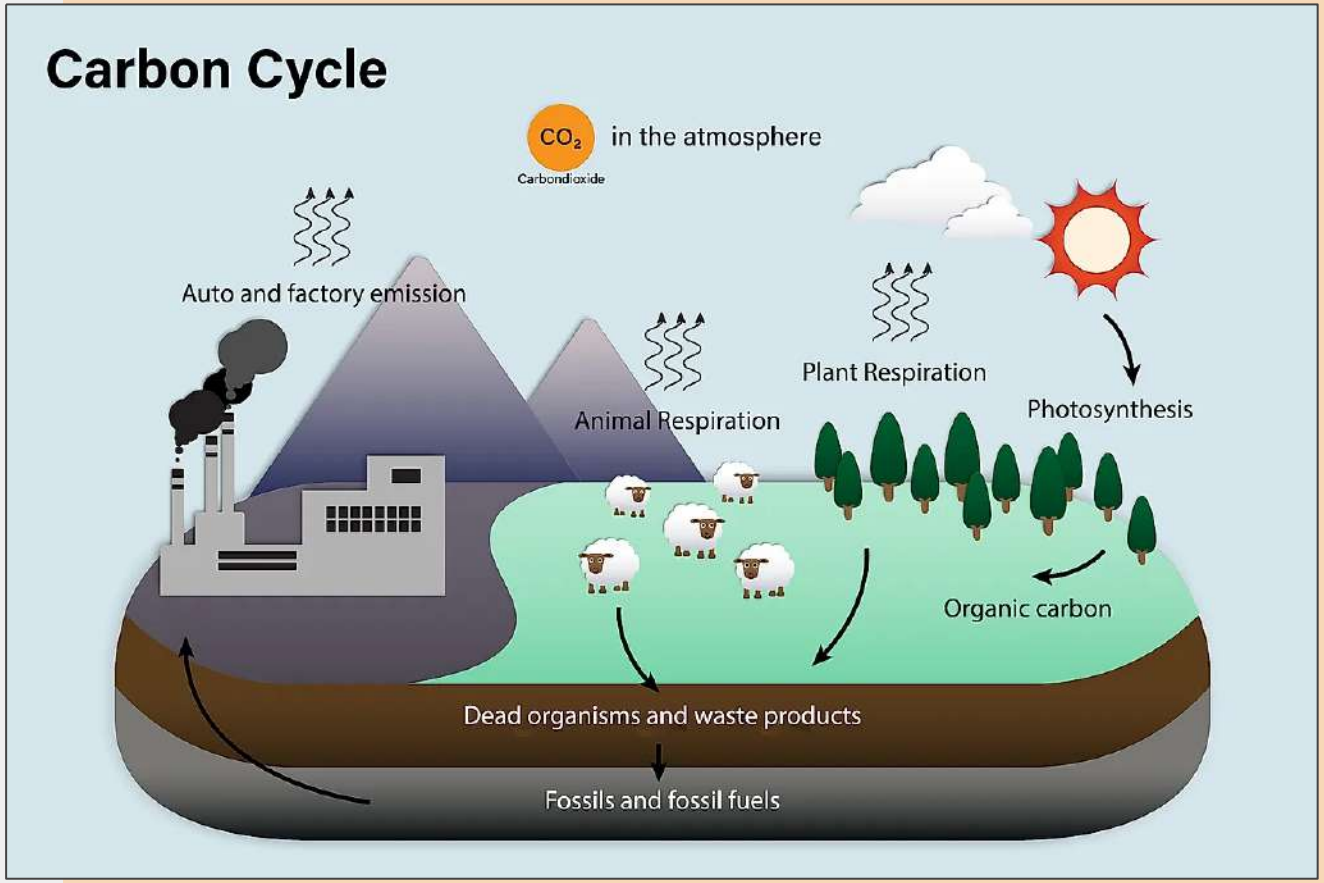
Carbon Cycle

1. **Carbon cycle** - The carbon cycle describes the movement of carbon between living organisms, the atmosphere, and the geosphere through processes such as:
   - **b) photosynthesis** - autotrophs, producers, plants, taking in Carbon Dioxide (CO_2), converting solar, radiant, or light energy to a product in the form of chemical energy: Glucose (carbohydrate)
   - **c) respiration** - autotrophs and heterotrophs taking in glucose and converting to cellular energy in the form of ATP (Adenosine Triphosphate), producing Carbon Dioxide
   - **d) decomposition** - when organisms die, they undergo the decomposition process, breaking down in base elements - Carbon being the most essential
   - **e) combustion** - the burning of fossil fuels: oil, coal, natural gas, produces CO_2

- *The carbon cycle is critical for the regulation of atmospheric CO_2 concentrations and the survival of photosynthetic organisms.*

Carbon Cycle - Explained

(2013, January 31). *NASA | Carbon All Around Us*. Youtube. Retrieved March 31, 2023, from https://youtu.be/Qu5uQqiLnUQ



Nitrogen Cycles

1. **Nitrogen cycle** - The nitrogen cycle describes the movement of nitrogen between the atmosphere, living organisms, and the soil through processes such:
   b) as **nitrogen fixation**,
   c) nitrification, and
   d) denitrification.

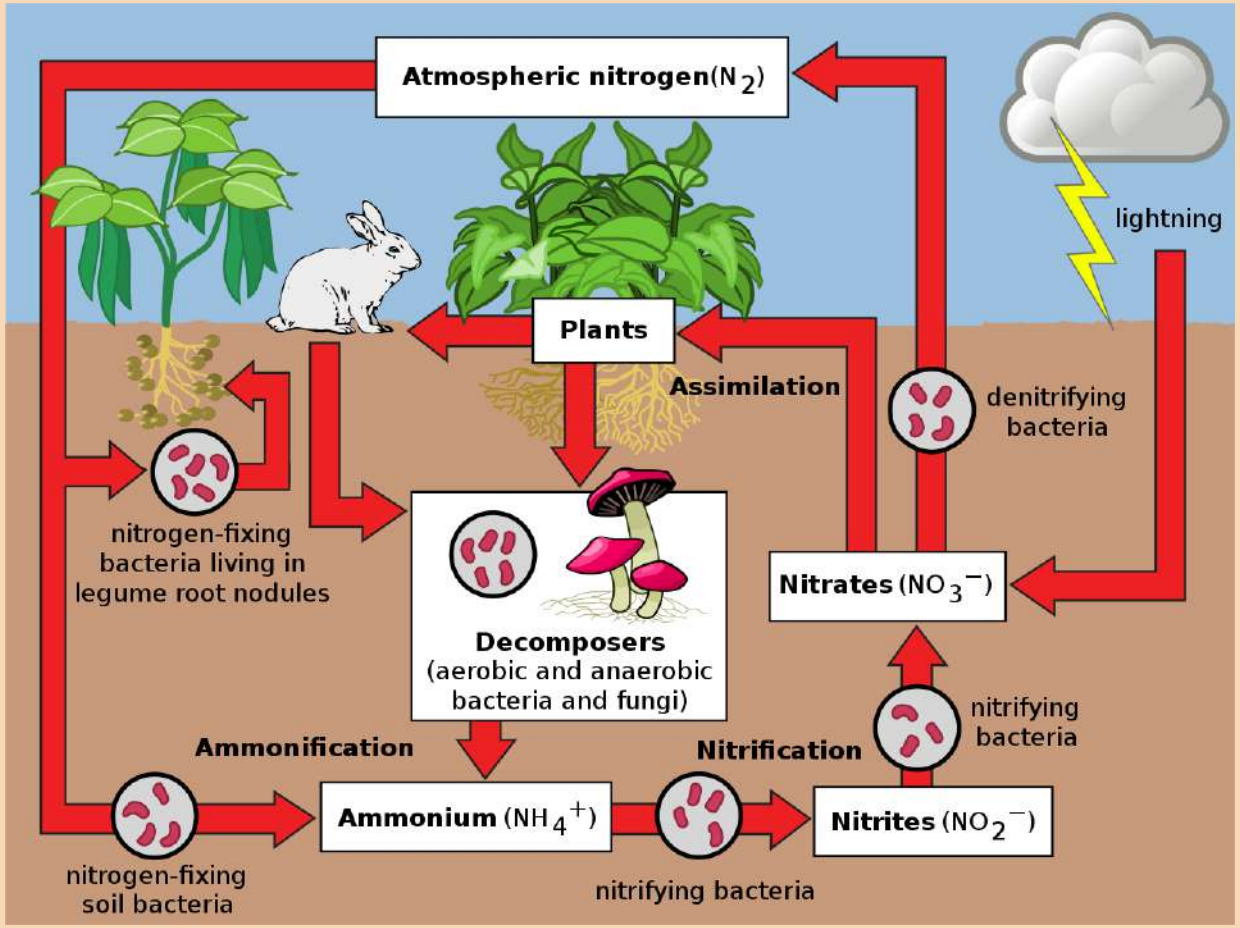
      5) Nitrogen fixation: *Nitrogen fixation is the process by which atmospheric nitrogen gas (N2) is **converted** into a **usable** form of **nitrogen**, such as ammonia (NH3) or nitrate (NO3-).*

      *vi) This process is usually carried out by certain **bacteria** or other **organisms** that have the ability to convert N2 into a form that can be **used** by **plants** and other **organisms**.*

Nitrification / Denitrification

2. **Nitrification**: ***Nitrification*** *is the process by which* ***ammonia*** *(NH3) is converted into* ***nitrite*** *(NO2-) and then into* ***nitrate*** *(NO3-)* ***by*** *certain types of* ***bacteria****.*
   i) *This process is important because it helps to make* ***nitrogen*** *available to* ***plants*** *and other* ***organisms*** *in a form that they can use.*
2. **Denitrification**: ***Denitrification*** *is the process by which* ***nitrate*** *(NO3-) is converted back into atmospheric* ***nitrogen*** *gas (N2) by certain* ***bacteria****.*
   i) *This process is important because it helps to reduce the amount of* ***nitrogen*** *available in the* ***ecosystem*** *and prevent* ***excess*** *nitrogen from* ***causing*** *environmental* ***problems*** *such as* ***eutrophication****. Denitrification typically occurs in environments where oxygen is limited, such as wetlands or soil that is waterlogged.*
      - *The nitrogen cycle is critical for the survival of nitrogen-fixing bacteria and the availability of nitrogen for plant growth.*

Nitrogen Cycle - Explained



(2018, February 1). *NOVA: Earth From Space | Lightning Produces Nitrates.* Youtube. Retrieved March 31, 2023, from https://youtu.be/qiea_iObetI

Introduction to Ecological Succession

III. Introduction to Ecological Succession

A. **Definition of ecological succession:** The process by which an ecological community undergoes changes in species composition over time.

B. **Importance of studying ecological succession:** Understanding how ecosystems change over time can help us predict and manage their responses to environmental stressors, including climate change.

C. **Historical background on the study of ecological succession:**

4. Early Ecological Studies

e. Frederic Clements

6) Developed the idea of a climax community

7) Proposed the theory of succession

b. Henry Cowles

1) Conducted research on plant succession in sand dunes

2) Introduced the concept of primary and secondary succession

2. Later Ecological Studies

a. Eugene Odum

2) Developed the concept of a "steady-state" ecosystem

3) Introduced the idea of ecological succession as a process of energy flow

b. Robert Whittaker

1. Introduced the concept of species diversity and richness
2. Developed the "gradient analysis" approach to study succession

3. Current Ecological Studies

d. F. Stuart Chapin

5) Conducted research on boreal forest succession

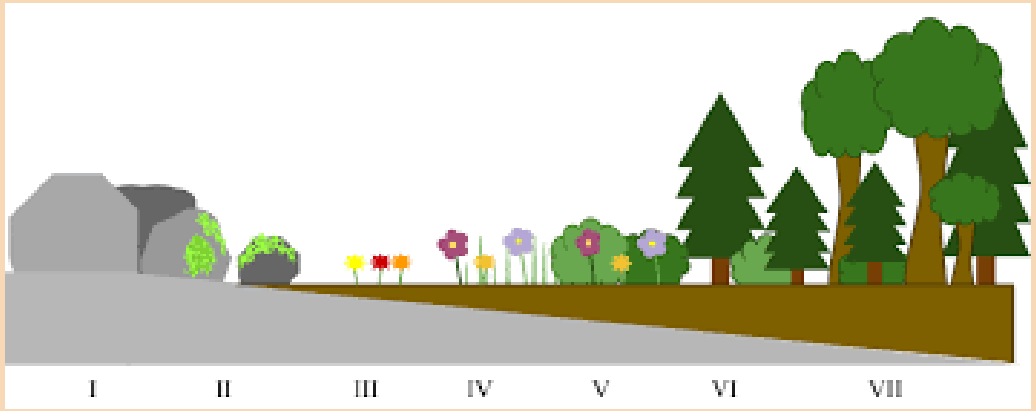
6) Introduced the concept of resilience and regime shifts

b. B. Peter Vitousek

1) Conducted research on nutrient cycling and successional changes in Hawaii

2) Emphasized the role of human impacts on ecological succession

Ecological Succession - Explained



Biophilia (2023, March 31). *Succession Explained: UntamedScience #4*. Youtube. Retrieved March 31, 2023, from https://youtu.be/qiea_iObetI

Primary Succession

A. Different types of ecological succession:

2. **Primary** succession
3. **Secondary** succession
   - *which differ in terms of the starting point for ecological change (i.e., bare rock vs. disturbed soil).*

d. Primary Succession

5) **Definition of primary succession:** Ecological succession that occurs on bare rock or other surfaces with no existing soil.
6) **Pioneer species involved in primary succession:** The first organisms to colonize a bare surface, typically lichens or mosses that break down rock and create soil.
7) **Factors affecting primary succession:** Physical factors such as climate and topography, as well as biological factors such as the availability of propagules (i.e., spores or seeds).

Primary Succession - Cont'

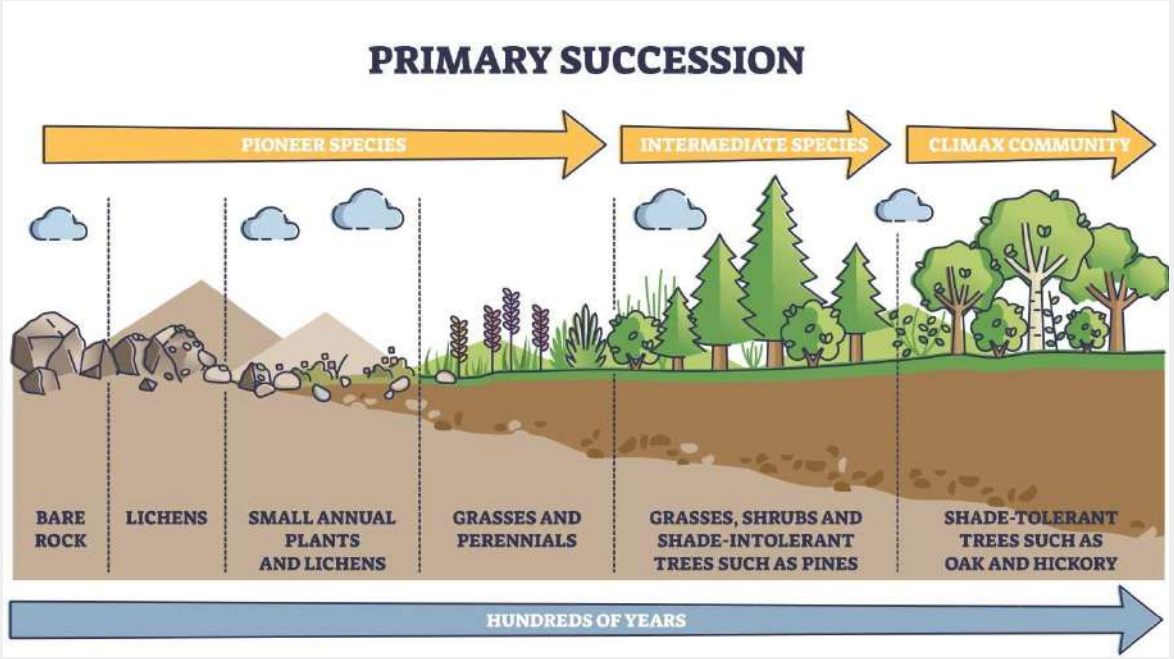
4) **Stages of primary succession:** The process by which a community changes from a bare surface to a mature ecosystem with a diverse array of species.
    a) **Bare rock or sterile ground:** This is the starting point of primary succession, where there is no soil or organic matter.
    b) **Pioneer species colonization:** The first living organisms to colonize the barren area are called pioneer species. These are typically **lichens**, **mosses**, or **algae** that can grow in harsh conditions and can **break down rock** to form **soil**.
    c) **Soil development:** Over time, the pioneer species help to create soil by breaking down rocks and adding organic matter to the surface.
    d) **Intermediate species establishment:** As the soil becomes more developed, other plant species can begin to establish themselves in the area. These are called intermediate species and can include grasses, shrubs, and small trees.
        - **Seed dispersal by** : **wind**, **water**, and **animals**
    e) **Climax community formation:** The **climax community** is the final stage of succession, where a **stable** and diverse **ecosystem** has been established. This community is made up of a **variety** of **plants** and **animals** that are well **adapted** to the **environment** and can coexist in a balanced ecosystem.

4) **Examples of primary succession in different ecosystems:** Examples include **volcanic islands**, **glacial retreats**, and **landslides**.

Primary Succession - Explained

evs aerl (2023, March 31). Primary succession. Youtube. Retrieved March 31, 2023, from https://youtu.be/kTuLctsNl3o

https://news.uchicago.edu/sites/default/files/styles/full_width/public/images/2021-12/primary-succession.jpg?itok=A-R386o-



Secondary Succession

b. Secondary Succession

1) **Definition of secondary succession:** Ecological succession that occurs on surfaces that have been **previously** disturbed but still contain some soil.
2) **Differences between primary and secondary succession:** Secondary succession typically occurs **faster** than primary succession because the **soil already** contains **nutrients** and a **seed** bank of **existing plant** species.
3) **Factors affecting secondary succession:** Physical and biological factors similar to those affecting primary succession, but with the added factor of the **history of disturbance** -fire, weather event, flooding
4) **Stages of secondary succession:** The process by which a community changes from a disturbed ecosystem to a mature ecosystem with a diverse array of species.
    e) **Disturbance**: Secondary succession begins with a **disturbance**, such as a **fire**, **flood**, or **human activity** that **destroys** an **existing** ecosystem.

Secondary Succession - Cont'

b) **Early colonization**: The first organisms to colonize the disturbed area are usually **annual plants** and **grasses** that can quickly establish themselves in the newly exposed soil.

c) **Shrubs and small trees**: As the soil becomes more stabilized, **shrubs** and **small trees** begin to establish themselves in the area. These species are often fast-growing and can quickly dominate the area.

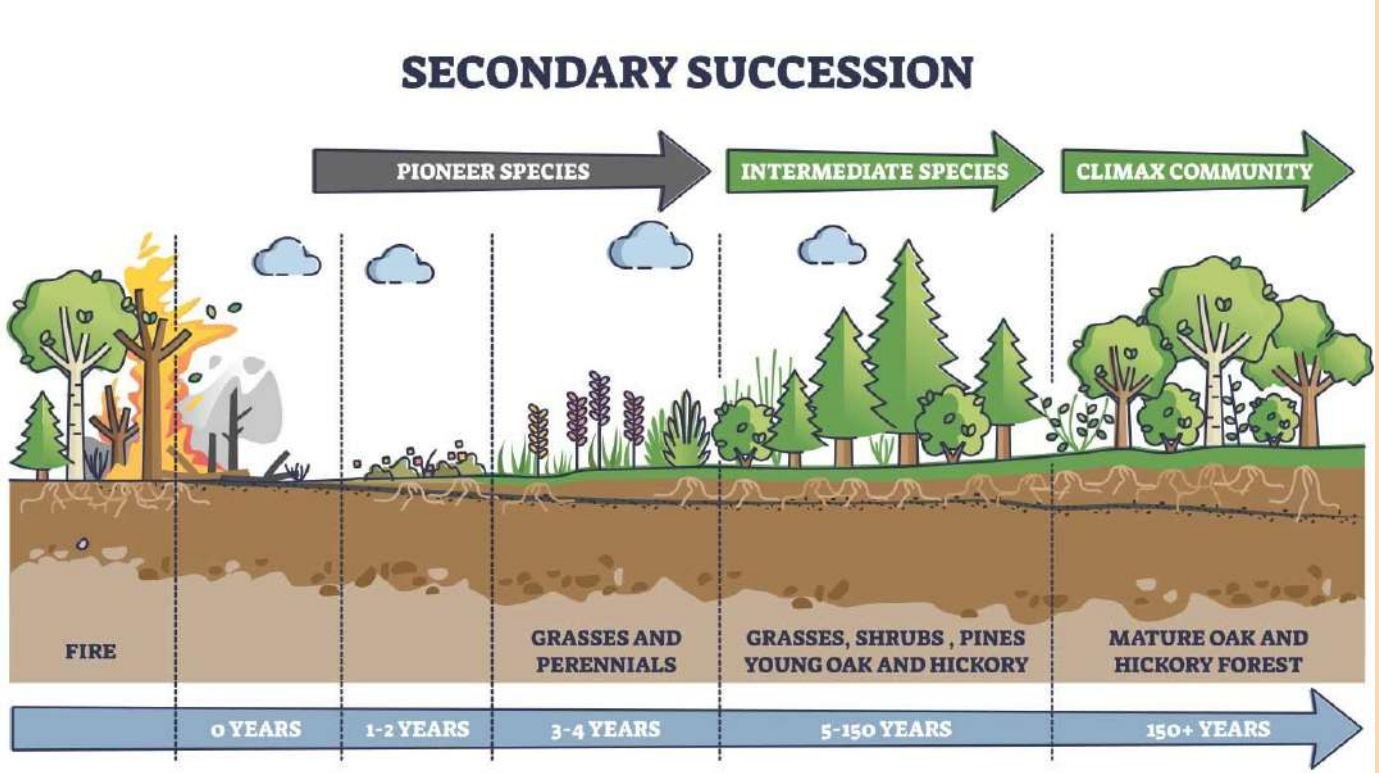
d) **Mature forest:** Over time, the **shrubs** and **small trees** give way to larger, **slower-growing trees**, which form the **canopy** of a mature **forest**. This stage may take many years to reach, depending on the environmental conditions.

e) **Climax community formation:** The **climax community** is the final stage of succession, where a stable and diverse ecosystem has been established. This community is made up of a variety of plants and animals that are well adapted to the environment and can coexist in a balanced ecosystem. In some cases, the climax community may resemble the original ecosystem, while in other cases it may be a new and different ecosystem.

1) **Examples of secondary succession in different ecosystems:** Examples include **abandoned** agricultural fields, **clear-cut** forests, and **areas** affected by fire or flooding.

Secondary Succession Explained

https://news.uchicago.edu/sites/default/files/styles/full_width/public/images/2021-12/secondary-succession.jpg?itok=MF0Gof2Z



WildNatureInstitute (2013, September 24). *Forests Born of Fire*. Youtube. Retrieved March 31, 2023, from https://youtu.be/1BmTq8vGAVo

Mechanisms of Ecological Succession

IV. Mechanisms of Ecological Succession

A. **Role of soil in ecological succession:** Soil provides **nutrients** and a physical **structure** that **supports** plant **growth** and **development**.

B. **Succession and the availability of nutrients:** Nutrient **availability** changes over the course of **succession** as different plant species **enter** and **leave** the community.

C. **The importance of competition in ecological succession: Competition** between **different** plant **species** can influence the **speed** and **direction** of succession.

D. **Facilitation, inhibition, and tolerance in ecological succession:** Different **species** can **affect** the **growth** of **other** species in the **community**, either **positively**, **negatively**, or **neutrally**.

5. **Facilitation**:

f. An example of **facilitation** is the relationship between legume trees and nitrogen-fixing bacteria.

7) Legume trees have root nodules that house bacteria that convert nitrogen gas into a usable form for plants.

8) When these trees die, they release nitrogen into the soil, which can be used by other plants.

9) Thus, the legume trees facilitate the growth of other plants by increasing the availability of nitrogen.

Mechanisms Cont'

1. **Inhibition:**
   b. An example of inhibition is the production of allelopathic chemicals by certain plant species.
      3) These chemicals can inhibit the growth of other plant species by reducing their germination or growth rates.
      4) An example of this is the Brazilian pepper tree, which produces allelopathic chemicals that inhibit the growth of other plants in the area.
5. **Tolerance:**
   f. An example of tolerance is the ability of some plant species to survive in harsh conditions, such as low light levels.
      7) For example, some understory plants in the rainforest have adaptations that allow them to grow in low light conditions, such as large leaves or the ability to store nutrients.
      8) These plants tolerate the low light conditions and can continue to grow even when larger trees overshadow them.

Human Impacts

V. Human Impacts on Ecological Succession

A. Human activities that disrupt ecological succession: Examples include:

2. **land use change,**
3. **invasive species,**
4. and **pollution.**

E. Mitigation and restoration of ecosystems affected by human activities: Strategies for restoring ecosystems to their previous state or promoting the growth of new communities.

6. **Restoring wetlands: Wetlands** are essential **habitats** for many **species**, but they are often **drained** or **filled** in for development. To restore wetlands, efforts can include **restoring** the **hydrology** of the area, **removing invasive** species, and **planting** native **vegetation**.
7. **Reforestation: Deforestation** is a major issue around the world, leading to **loss** of **habitat** and **biodiversity**. Reforestation involves **planting** new **trees** to restore the ecosystem and promote **biodiversity**. This can involve both natural regeneration and active reforestation efforts.

Human Impacts - Cont'

3. **Stream and river restoration:** Human activities such as **dam construction**, **agriculture**, and **urban development** can severely impact the health of streams and rivers. Restoration efforts can involve removing dams, planting vegetation along the banks, and reintroducing native fish species.
4. **Marine habitat restoration:** Human activities such as **overfishing**, **pollution**, and **climate change** can severely damage marine ecosystems. Restoration efforts can involve creating marine protected areas, restoring coral reefs, and reducing pollution.
5. **Brownfield redevelopment: Brownfields** are **abandoned** or underutilized **industrial** sites that are often **contaminated** with **pollutants**. Restoration efforts can involve cleaning up the site and transforming it into a usable space, such as a park or community garden.

Human Impacts - Explained

NatGeo (2018, October 24). *50 Years Ago, This Was a Wasteland. He Changed Everything | Short Film Showcase.* Youtube. Retrieved March 31, 2023, from https://www.youtube.com/watch?v=ZSPkcpGmflE

https://tcwp.tamu.edu/files/2015/07/4-22-15-1_cropped.jpg

Succession and Climate Change

VI. Ecological Succession and Climate Change

A. **Effects of climate change on ecological succession: Changes** in **temperature**, **precipitation**, and other **climate variables** can affect the **speed** and **direction** of ecological succession.

2. **Changes in forest succession:** As **temperatures** rise, the timing of seasonal events such as bud break and leaf fall can **change**.

c. This can affect the timing of plant **growth** and ultimately the successional **trajectory** of a forest.

d. For example, in some regions, warmer temperatures may favor faster-growing species, leading to a shift in the dominant species in a forest over time.

5. **Changes in grassland succession:** Drier conditions associated with climate change can lead to increased fire frequency in grasslands.

f. This can **disrupt** the natural **succession** of the **ecosystem**, leading to changes in the **composition** of plant and animal species.

g. For example, more fire-tolerant species may become dominant, while less tolerant species may decline.

Succession and Climate Change - Cont'

3. **Changes in aquatic succession:** Changes in precipitation patterns can affect the flow and nutrient levels in aquatic systems.
    a. This can affect the **successional trajectory** of aquatic ecosystems, such as lakes and ponds.
    b. *For example, increased runoff from heavy rainfall events can lead to an influx of nutrients, which can cause algal blooms and disrupt the natural succession of the ecosystem.*
4. **Changes in arctic succession:** Climate change is having a particularly strong impact on **arctic** ecosystems, where **warming** temperatures are leading to **rapid changes** in plant and animal communities.
    a. *For example, as permafrost thaws, it can release stored nutrients, leading to increased plant growth and changes in the composition of arctic vegetation*

Evolution by Selection

C. Evolution by Natural Selection

1. **Evolution** by natural selection occurs when the **frequency** of certain **traits** in a **population** changes over time due to **differential** reproductive **success.**
2. **Individuals** with **traits** that are better **adapted** to their environment ar**e more likely** to **survive** and **reproduce, passing** on those advantageous **traits** to their **offspring.**
3. Over time, this can lead to the **evolution** of **new species.**

https://ichef.bbci.co.uk/news/976/cpsprodpb/14195/production/_89852328_carbtypmating2005.jpg

Climate Change and Ecosystems

DJI Captures (2021, June 24). *Climate Change - A Short Film [4K]*. Youtube. Retrieved March 31, 2023, from https://youtu.be/jAa58N4Jlos

MAMMOTH
SCIENCE

Change and Biodiversity

VII.Environmental Change and Biodiversity

A. Types of environmental change

2. **Natural environmental change** - Natural environmental change refers to changes that occur without human influence, such as climate change and natural disasters.
3. **Anthropogenic environmental change** - Anthropogenic environmental change refers to changes that are caused by human activities, such as deforestation, pollution, and climate change.

B. Effects of environmental change on biodiversity

1. **Habitat destruction** - Environmental change can lead to habitat destruction, which can **reduce** the **biodiversity** of an ecosystem.
2. **Invasive species** - Environmental change can create new opportunities for invasive species to establish themselves in an ecosystem, which can outcompete native species and **reduce biodiversity**.
3. **Pollution** - Environmental change can also lead to pollution, which can have toxic effects on the organisms in an ecosystem and **reduce biodiversity**.

Natural Selection and Adaptations

C. Natural selection and adaptations in species

1. **Definition of natural selection** - Natural selection is the process by which **individuals** that are better **adapted** to their **environment** are more likely to **survive** and **reproduce**.
2. **Examples of adaptations in species** - Examples of adaptations in species include **camouflage**, **mimicry**, and the **development** of new **traits** to cope with environmental change.
   - **c. Camouflage**: *Many animals have evolved to have **coloration** or **patterns** that help them **blend** in with their **environment**, making them **less visible** to predators or prey. For example, the chameleon changes its skin color to match its surroundings, while the polar bear's white fur helps it blend in with the snow and ice.*
   - **d. Mimicry**: *Some animals have evolved to mimic the **appearance** or **behavior** of other **species** as a way of **avoiding predators** or **catching prey**. For example, the harmless scarlet king snake has evolved to look like the venomous coral snake, which deters predators from attacking it. Similarly, some orchids have evolved to mimic the appearance and scent of female wasps to attract male wasps as pollinators.*
   - **e. Development of new traits**: *As environments change, some species can **evolve** new **traits** that help them **cope** with the new **conditions**. For example, some fish species have evolved the ability to live in water with high levels of pollutants, while some bacteria have evolved resistance to antibiotics. Similarly, some birds have evolved longer beaks to access new food sources, such as flowers with longer nectar tubes.*

Adaptations

Getty Images TV (2018, October 24). *Mimic Octopus: Master of Disguise*. Youtube. Retrieved March 31, 2023, from https://youtu.be/Wos8kouz810

Netflix After School (2022, January 1). *Poison Dart Frogs 🐸 Life in Color with David Attenborough | Netflix After School*. Youtube. Retrieved March 31, 2023, from https://youtu.be/9TlVCXegmMw

Natural Selection and Change

1. **How natural selection can overcome environmental change** - Natural selection can enable species to adapt to changing environmental conditions and overcome environmental change.
   b. **Peppered Moths:** *Prior to the Industrial Revolution, the majority of peppered moths in the UK had a light coloration, which helped them blend in with the light-colored tree bark. However, when pollution from coal burning turned the tree bark dark, darker moths became more visible to predators and had a higher mortality rate. As a result, over time, the population shifted to a darker coloration, which helped them blend in with the new environment and survive.*
   c. **Antibiotic Resistance:** *Antibiotic-resistant bacteria are a major problem in modern medicine, but they didn't exist before humans began using antibiotics. However, when antibiotics are used to kill off bacteria, some bacteria are able to survive due to natural genetic variation. These bacteria can then reproduce and pass on their resistance to future generations, eventually leading to a population of bacteria that is resistant to the antibiotic.*
   d. **Darwin's Finches:** *In the Galapagos Islands, a group of finches have evolved to have different beak shapes and sizes based on the type of food available on their respective islands. This is an example of natural selection at work - the birds with the most advantageous beak shape for their environment are more likely to survive and reproduce, passing on their genes to future generations.*

Thank you!

Do you have any questions?

matthewsimmons@hebisd.edu
817-399-3360 x-7565