DP IB Environmental Systems & Societies (ESS): SL

Your notes

2.5 Zonation, Succession & Change in Ecosystems

Contents

Zonation

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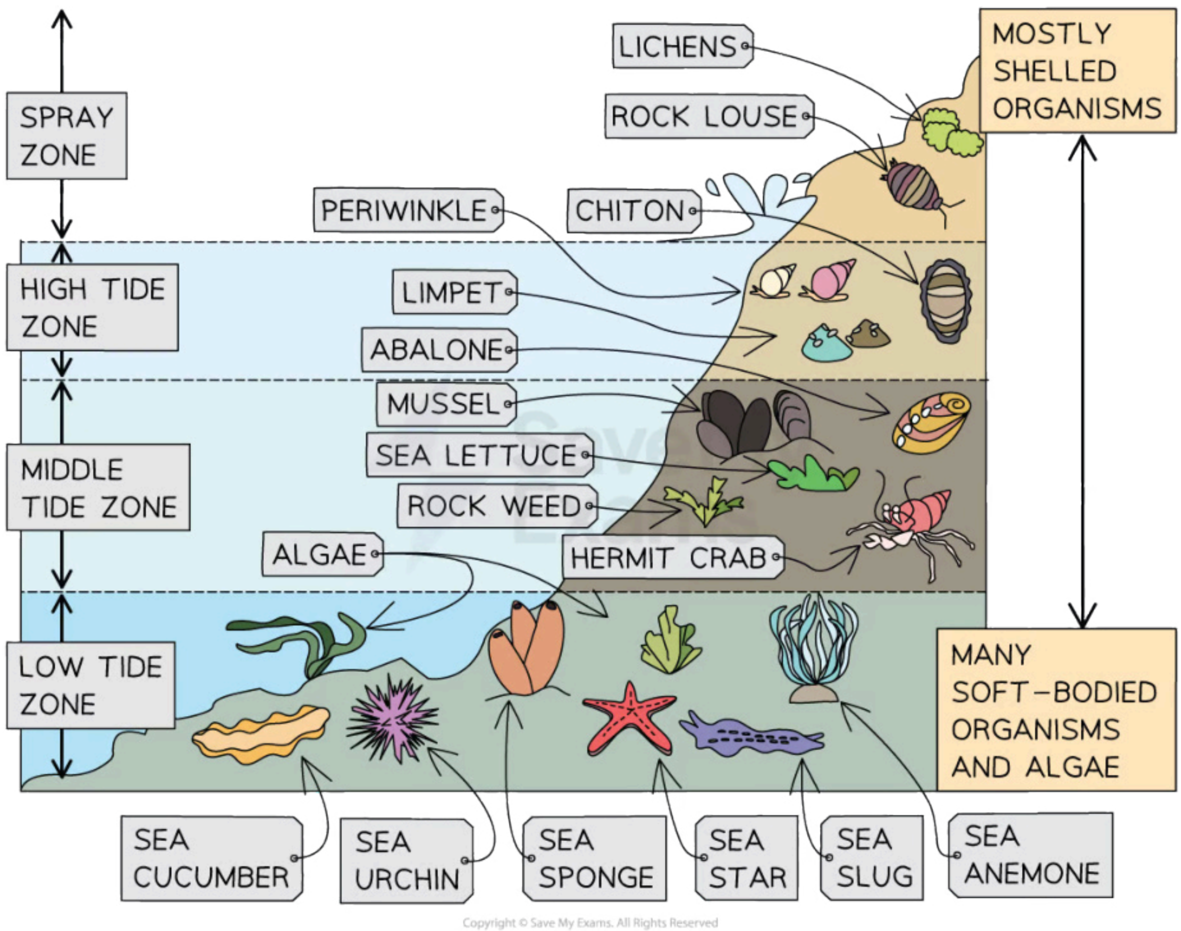
Zonation

- Zonation refers to the gradual change in the composition of species and communities across a landscape, based on a gradient of environmental factors such as:
  - Elevation (altitude)
  - Latitude
  - Tidal level
  - Soil horizons
  - Distance from water source
  - Temperature
  - Moisture
  - Light
- As these factors change, the species present in an ecosystem also change
  - This leads to distinct **zones** or bands of organisms that can be observed in the ecosystem
  - This process occurs due to the **interactions** between the physical environment (abiotic factors) and the biological components (biotic factors) of an ecosystem
- An example of zonation can be observed in a **rocky intertidal zone**
  - Here, the physical and biological characteristics of the ecosystem change gradually from the high tide mark to the low tide mark
    - At the highest point (sometimes referred to as the spray zone), the zone is usually dry and dominated by lichen and other hardy plants that can withstand long periods of exposure to air and sunlight
    - In the high tide zone, the environment becomes more hospitable for other organisms such as barnacles, mussels, chitons, limpets and sea snails that can attach themselves to the rocks and withstand waves
    - Further down towards the low tide zone, the environment becomes even more favourable for marine organisms such as sea stars, anemones, and sea urchins that require the constant presence of water



An example of zonation in a rocky intertidal zone

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Transects

- Transects can be used to measure biotic and abiotic factors along an environmental gradient
  - This data can be used to determine the variables that affect the distribution of a species

Worked Example

Investigate changes in the distribution of a species along an environmental gradient.

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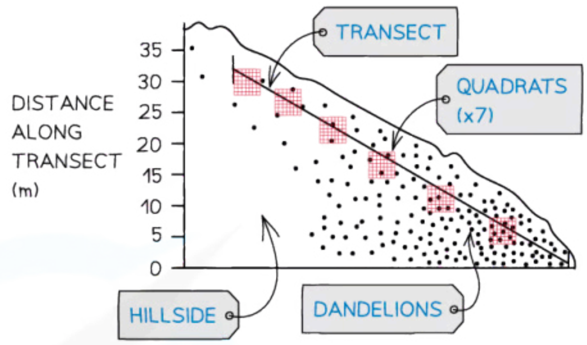
INVESTIGATING THE EFFECT OF A FACTOR ON THE DISTRIBUTION OF A SPECIES METHOD

1 SET YOUR TRANSECT UP THROUGH THE AREA YOU ARE INVESTIGATING. IN THIS CASE, A 30 m TAPE MEASURE IS PLACED UP A HILLSIDE. PLACE A QUADRAT AT EQUAL INTERVALS (e.g. EVERY 5 m) ALONG THE TRANSECT.



2 RECORD THE NUMBER OF YOUR CHOSEN PLANT SPECIES INSIDE EACH QUADRAT. RECORD YOUR ABIOTIC FACTOR (e.g. ALTITUDE) AT EACH QUADRAT. RECORD YOUR RESULTS IN A TABLE.

Distance along transect (m)	Number of dandelions	Altitude (m)
0	84	2
5	66	4
10	62	6
15	45	8
20	30	10
25	30	12
30	13	14

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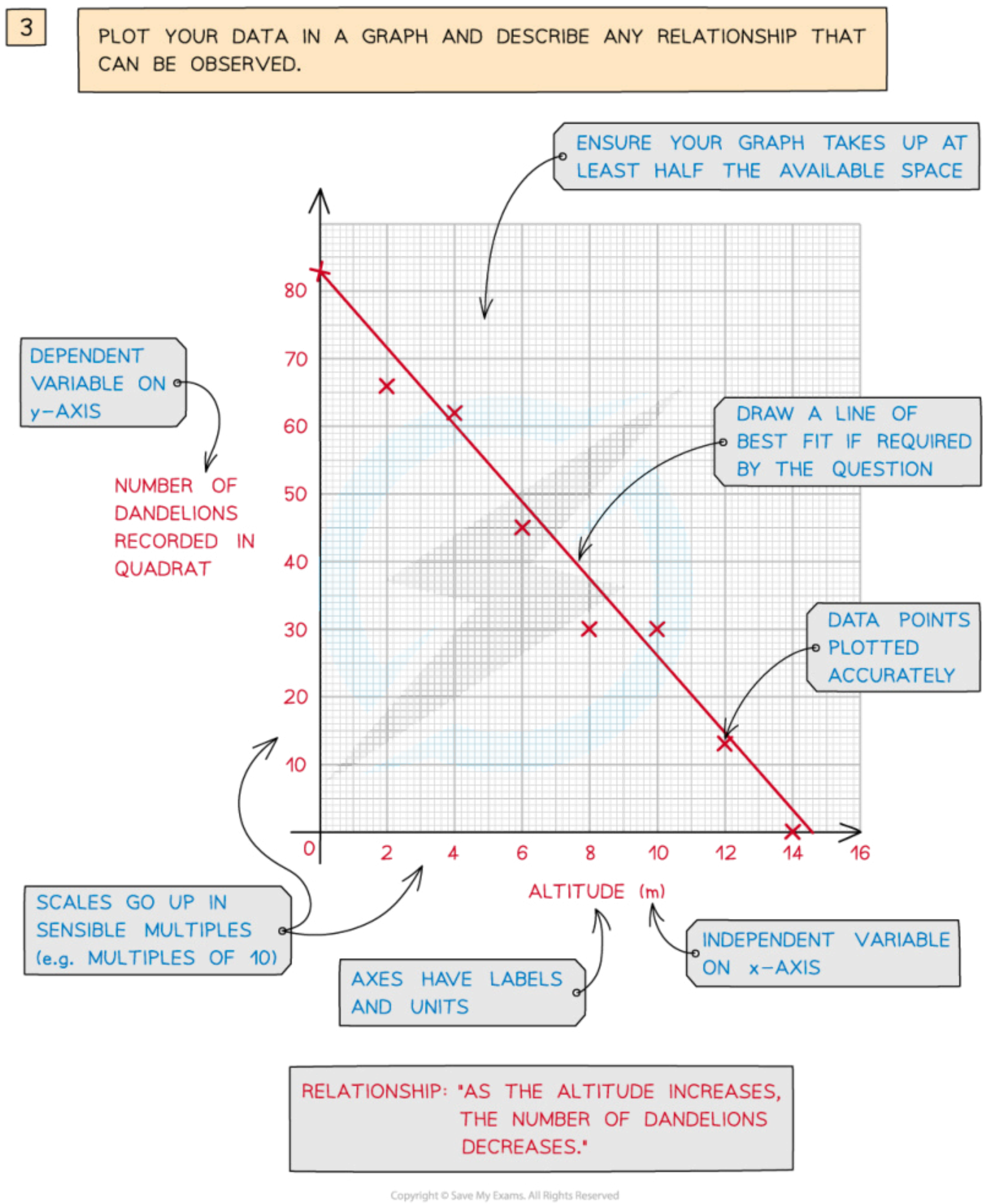


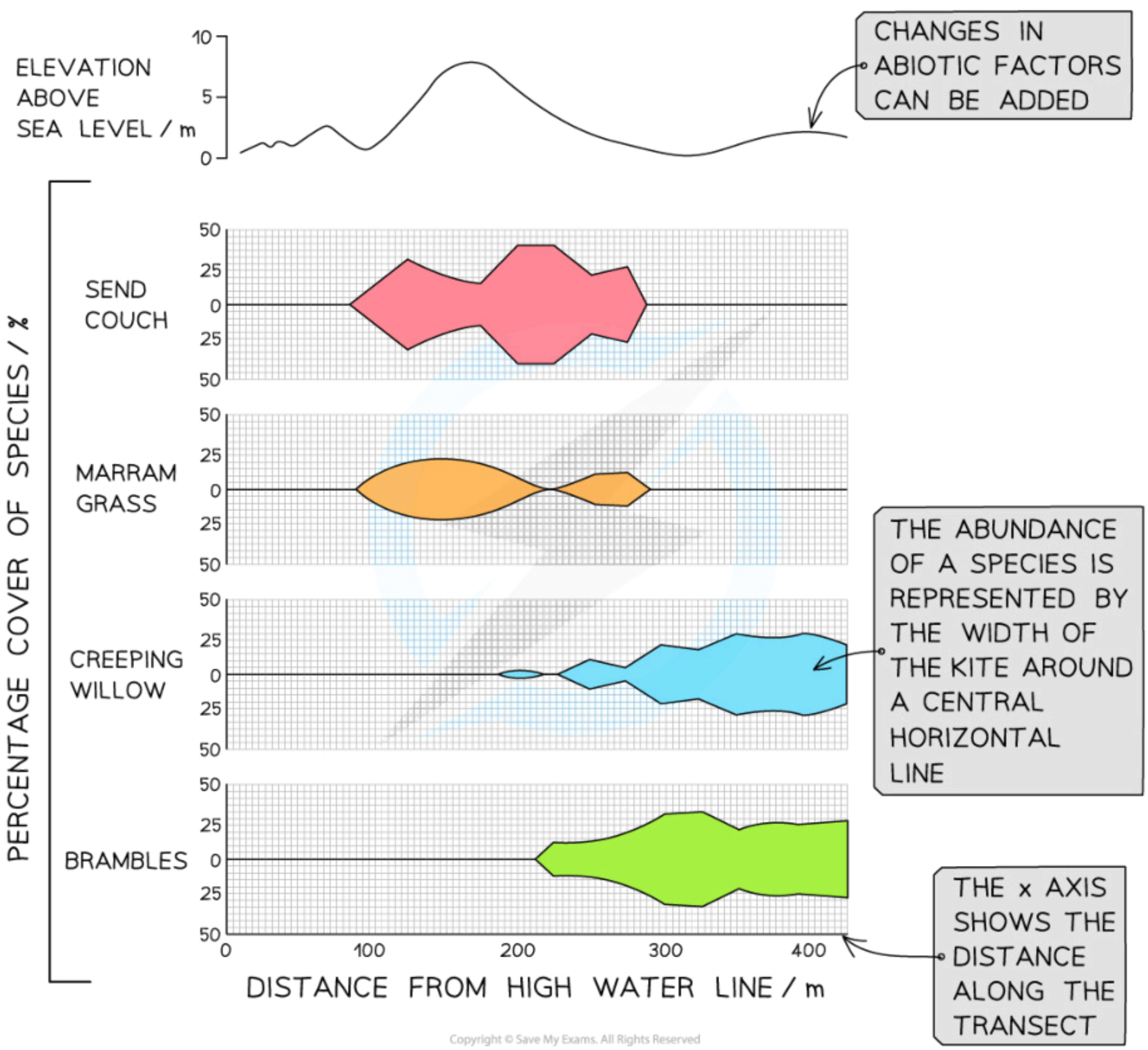
How to investigate the effect of an ecological factor on the number of plants across a survey area

Representing results

- The results of an investigation into the distribution and abundance of organisms can be represented visually using a type of graph known as a kite diagram
- Kite diagrams can show both **distribution** and **abundance**

- The distribution of a species along a transect can be shown by its position along a central horizontal line in each section of a kite diagram
- Each section represents a **different species**
- The distance along the transect is given on the x-axis, to which the horizontal line is parallel
- The abundance of a species can be shown by the **width** of the '**kite**' around the central horizontal line
- The shape is referred to as a kite because it extends an **equal distance** on each side of the central horizontal line

- Additional sections can be added to a kite diagram to show the changes in abiotic factors at different points along a transect e.g. the height above sea level or the pH of soil



Kite diagrams can be used to provide a visual representation of both abundance and distribution of species, as well as changes to abiotic factors such as elevation

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Succession

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Succession

- Ecosystems are **dynamic**, meaning that they are constantly changing
- Ecosystems change from being very simple to being relatively complex
  - This process is known as **succession**
  - During succession, the **biotic** conditions (i.e. the living factors) and the **abiotic** conditions (i.e. the non-living factors) **change over time**
- **Primary succession** is the process that occurs when newly formed or newly exposed land (with **no species present**) is gradually **colonised** (inhabited) by an increasing number of species
- This new uninhabited land can be created in several ways. For example:
  - The magma from erupting volcanoes cools and often leads to the formation of new rock surfaces or even new rocky islands in the sea
  - Another way new land can be exposed is by sea-level dropping or the drying up of a lake, leaving areas of bare rock
  - When glaciers retreat, they also leave bare rock or moraines
- Primary succession does not only occur on bare rock—any barren terrain that is slowly being colonised by living species is undergoing succession. For example:
  - Sand dunes in coastal areas
    - Marram grasses are the pioneer species in these environments as they have deep roots to access water that other plants can't reach
    - They are also able to tolerate the salty environment i.e. the high concentrations of sodium and calcium ions caused by sea spray
- **Secondary succession** is a very similar process but happens on bare soil where there has been a pre-existing community, such as:
  - An agricultural field that has stopped being used
  - A forest area after an intense forest fire

The stages of succession

- A **seral community** (also known as a **sere**) is a temporary and intermediate stage in the ecological succession of an ecosystem

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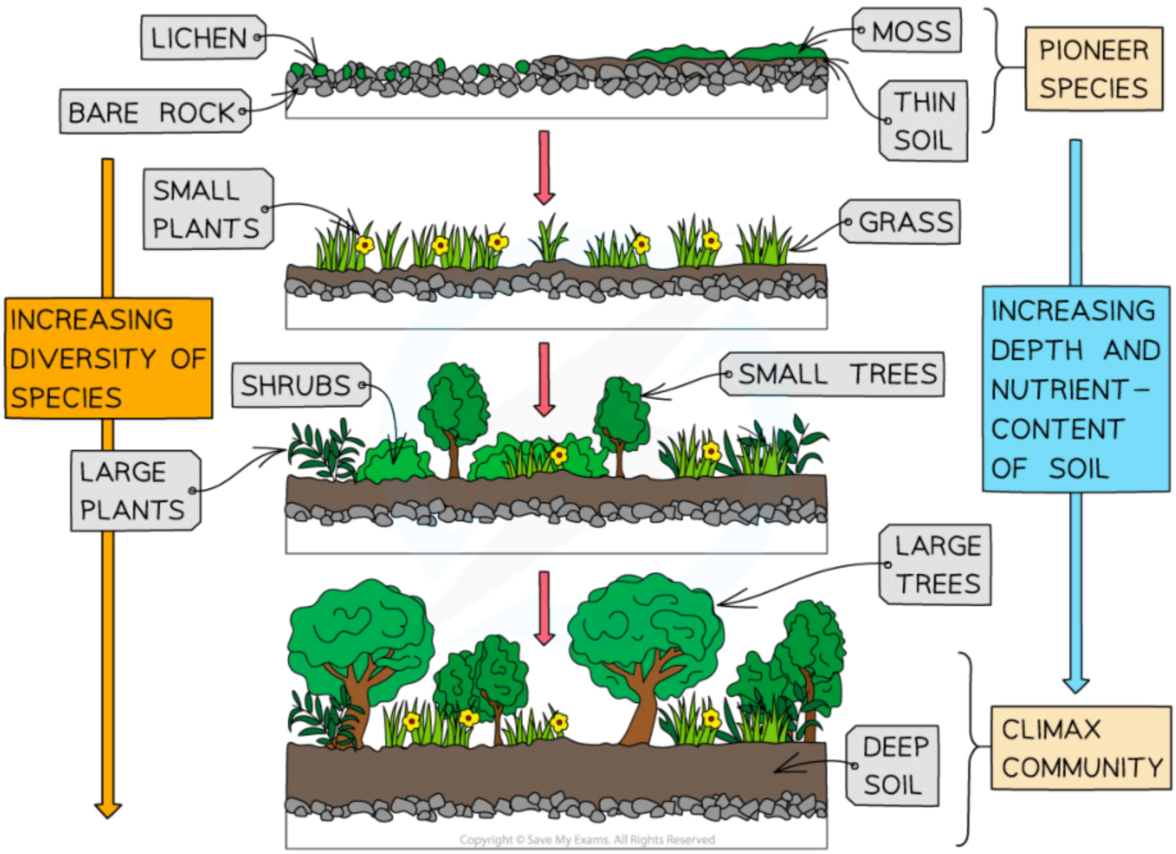
  - Each seral community, in succession, causes changes in **environmental conditions**
  - These changes allow the next community to **replace it** (e.g. through competition) until a stable climax community is reached
- First, seeds and spores carried by the wind land on the exposed rock and start to grow
  - These first species to colonise the new land (often moss and lichens) are known as **pioneer species**
  - As these pioneer species die and decompose, the dead organic matter (humus) forms a **basic soil**
- Seeds of small plants and grasses, sometimes also carried in the wind or transported other ways (e.g. in bird faeces), land on this basic soil and begin to grow (these smaller plants are adapted to survive in shallow, relatively nutrient-poor soils)
  - As these small plants and shrubs die and decompose, the new soil becomes **deeper** and more **nutrient-rich**
  - The roots of these small plants and shrubs also form a **network** that helps to **hold the soil** in place and prevent it from being washed away
- Larger plants and shrubs, as well as small trees that require deeper, more nutrient-rich soil, can now begin to grow
  - These larger plants and small trees also require more water, which can be stored in deeper soils
- Finally, the soil is sufficiently deep, contains enough nutrients and can hold enough water to support the growth of **large trees**
  - These final species to colonise the new land become the **dominant species** of the now relatively complex ecosystem
  - The final community formed, containing all the different plant and animal species that have now colonised the new land, is known as the **climax community**



Succession is the process of ecosystem change over time, beginning with newly formed or newly exposed land

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Changes occurring during succession

- As the the structure and species composition of an ecosystem changes during succession, so do the patterns of energy flow, productivity, species diversity and nutrient cycling that ecosystem

1. **Energy flow:**
   - During the early stages of succession, the energy flow in the ecosystem is relatively low
   - This is because there are only a few species present and most of the energy is used to build biomass
   - As the ecosystem becomes more complex, energy flow increases
2. **Productivity:**
   - During the early stages of succession, gross productivity and net productivity are low because there are only a few species present

- This means the ecosystem's overall gain in energy and biomass per unit area per unit time is relatively small
- As the ecosystem becomes more complex, gross productivity and net productivity increase

3. **Species diversity:**
   - Diversity refers to the number of species present in an ecosystem
   - During the early stages of succession, diversity is low because there are only a few species present
   - As the ecosystem becomes more complex, diversity increases because there are more niches available
   - This means more species are able to coexist within the same habitats in the ecosystem
4. **Nutrient cycling:**
   - Nutrient cycling refers to the movement of nutrients through an ecosystem
   - During the early stages of succession, nutrient cycling is relatively simple
   - This is because there are only a few species present and abiotic processes dominate nutrient cycling
   - As the ecosystem becomes more complex, nutrient cycling becomes more complex
   - This is because there are more species present and each species has unique nutrient requirements and cycling processes

Examiner Tips and Tricks

You could be presented with an example of succession other than the ones provided here. As long as you understand the principles of the stages of succession, you should be able to apply your knowledge to any example that an exam question might throw at you.

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Resilience & Stability of Ecosystems

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Resilience & Stability of Ecosystems

- An ecosystem's capacity to tolerate disturbances and maintain equilibrium depends on its diversity and resilience
  - Diversity refers to the variety of species, genetic variations, habitats and ecological functions within an ecosystem
  - Resilience refers to the ability of an ecosystem to recover after a disturbance
    - High resilience = ecosystem quickly returns to its original state after disturbance
    - Low resilience = ecosystem takes a long time to recover or does not fully recover after disturbance
- Greater diversity often means greater resilience—two main reasons for this include:
  - Species redundancy:
    - Multiple species perform similar roles, so if one species is lost, others can fill its ecological role
  - Genetic variation:
    - More genetic diversity within a species can help it adapt to changing conditions

Human impacts on succession

- Human activities can divert the progression of succession to an alternative stable state by modifying the ecosystem through various activities, such as:
  - Burning
  - Agriculture
  - Grazing pressure
  - Resource use (such as deforestation)
- These activities can have both **direct** and **indirect** impacts on the ecosystem
  - They lead to changes in the biotic and abiotic components, ultimately altering the course of ecological succession within the ecosystem
    - For example, controlled fires are often used to clear land for agricultural purposes or to manage the spread of wildfires

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- However, fire can have serious negative effects on the ecosystem by killing off plants, reducing soil fertility and altering nutrient cycles
- Similarly, agriculture and grazing can cause soil erosion, loss of vegetation cover and changes in nutrient cycling
- This can, in turn, affect the composition of the species in the ecosystem

Human activities often simplify ecosystems, rendering them unstable (Photo by Randy Fath on Unsplash)

- These activities, which divert the progression of succession, may be temporary or permanent, depending upon the resilience of the ecosystem
  - If the human disturbance is mild and the ecosystem is highly resilient, it may be able to recover and return to its original state
  - If the disturbance is severe and the ecosystem is less resilient, the ecosystem will be **permanently changed**
    - This eventually leads to a new stable state with a different set of species and ecological interactions

- This is one reason why it is so important to carefully consider the environmental impacts of human activities in order to minimise their negative effects on the ecosystem
  - It is essential to protect natural ecological processes, such as succession

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Case Study

Human disturbances to succession in tropical rainforests

- Even highly resilient ecosystems like tropical rainforests can shift to alternative stable states under enough human pressure

1. **Deforestation and agriculture:**
   - Trees removed to create grazing land
   - Reduces habitat complexity and leads to biodiversity loss
   - Disrupts nutrient cycling and changes the hydrological cycle
   - Causes soil erosion and loss of topsoil, leading to lower soil fertility
   - Results in decreased primary productivity
   - Can trigger the process of desertification
2. **Mining:**
   - It involves the removal of topsoil and vegetation
   - Leads to soil erosion and landslides
   - Chemicals used in mining can pollute water sources
   - Water pollution negatively impacts aquatic life within the ecosystem.

Formation of alternative stable states

- Deforestation can transform tropical rainforests into savannas or grasslands
  - These new ecosystems are less resilient compared to rainforests
  - They have lower biodiversity and productivity
  - They have different abiotic and biotic factors from the original forest ecosystem
- These new states have lower resilience and are less capable of recovering to their original forested condition

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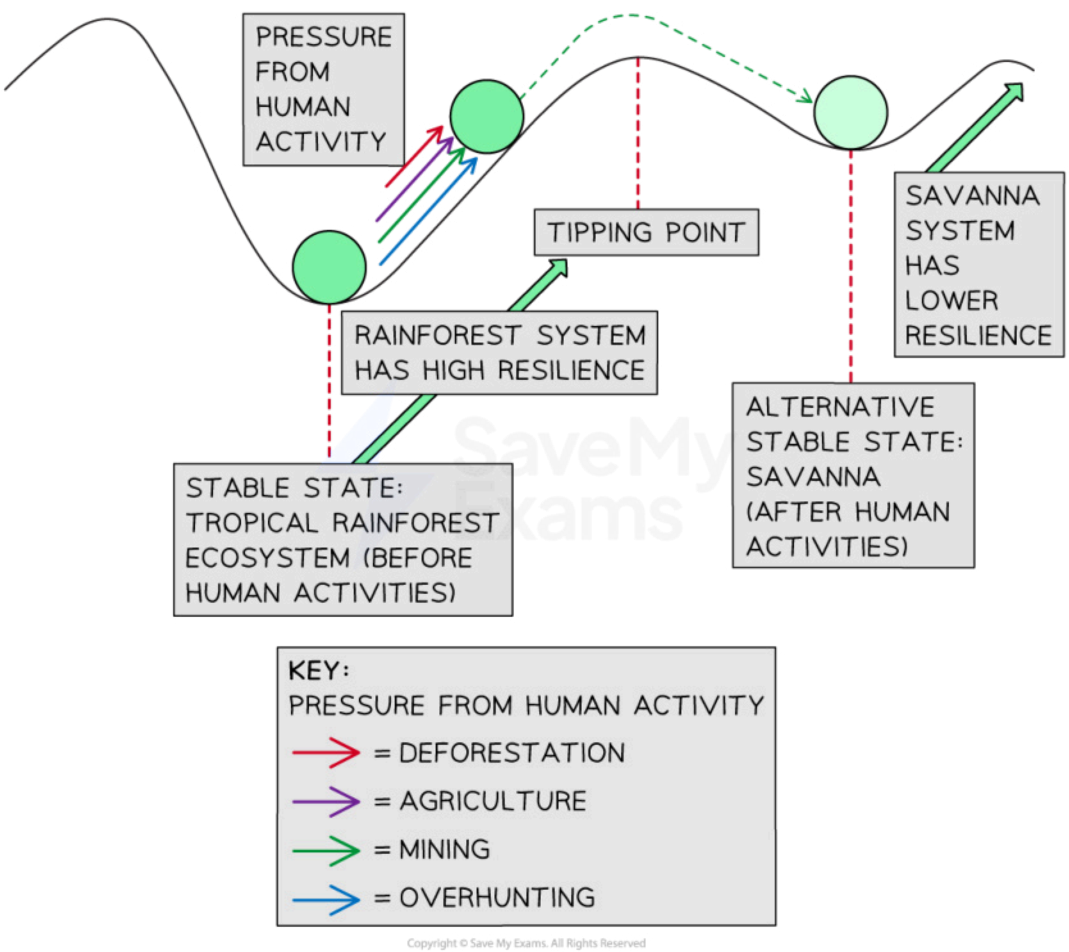

Human activities can divert the process of ecological succession and push the ecosystem towards an alternative stable state