

# Topic 7: Genetics, Populations, Evolution and Ecosystems

## Ecosystems

### Ecology definitions

You need to be able to understand and define the following keywords which can be used to describe different groups within the environment:

- **Population:** all the members of a single species which live in the same area
- **Habitat:** the area in which an organism lives
- **Community:** all the populations of different species which interact together in the same habitat
- **Ecosystem:** a community of organisms and the non-living components of their environment (i.e. both the biotic and abiotic factors). Ecosystems can range in size from very small to extremely big.

For example, if you live in England then you are a member of the UK population (members of the *Homo sapien* species living in the same area) and your habitat is the specific area in which you live (such as the city of London). The community would be the interaction of humans with their pets and the animals and plants which we buy from the supermarket to consume. The ecosystem in which we live is all of those things, together with non-living factors such as the weather.

### Niche

Within a habitat, different organisms each occupy a particular **niche**. A niche is the **role** that an organism plays in the ecosystem and includes its **biotic (living) interactions**, such as the food it eats and the predators which it needs to hide from, as well as its **abiotic (non-living) interactions**, such as the gases which it breathes or the sunlight it absorbs. Within the same habitat, different organisms will have different niches. If two different species try to occupy the same niche, one will be **out-competed** by the other until only one species survives. To increase their chances of survival, organisms will be **adapted** to the niche that they occupy.

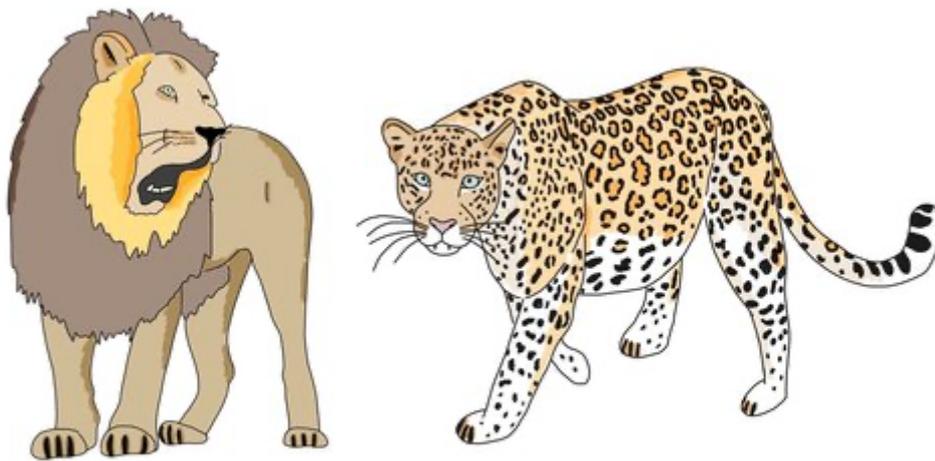
For example, the niche that gorillas occupy includes the fruits and bamboo shoots which they eat, the oxygen they inhale, the carbon dioxide they exhale and the trees that they use for shelter.

## Factors which affect population size

The **abundance** (or **population size**) is defined as the **number of individuals of one species in a particular area**. It depends on both **abiotic** (non-living) and **biotic** (living) factors.

**Abiotic factors**, such as **light intensity** and **water availability**, affect population size because when these conditions are ideal then organisms can **grow and reproduce successfully**. When these conditions fluctuate (e.g. if the temperature is too cold), the organisms in that habitat cannot grow as efficiently. More energy will be spent maintaining body temperature which means less energy will be available for growth and reproduction.

**Biotic factors** also affect species abundance. These include **interspecific competition**, **intraspecific competition** and **predation**.



INTERSPECIFIC COMPETITION

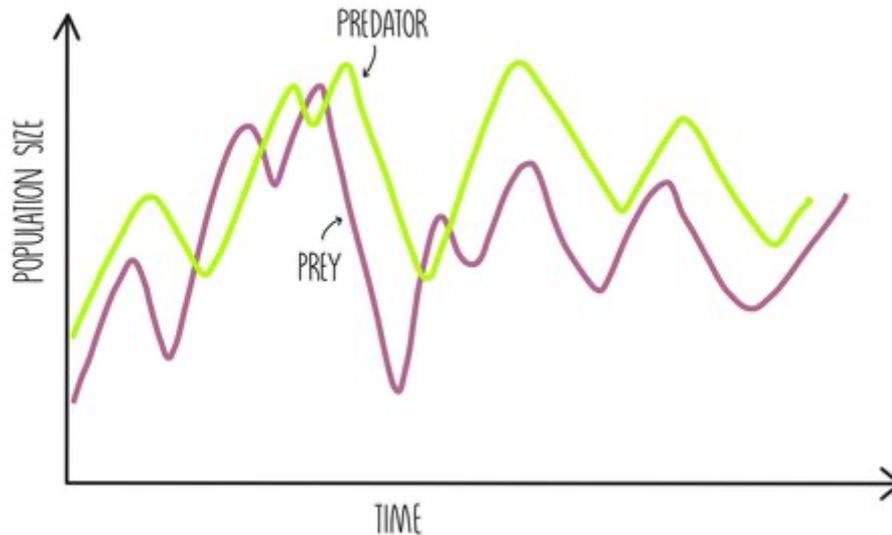
**Interspecific competition** describes competition for the same resources between **different species**. Interspecific competition means that **resources** have to be **shared** between the different species so there will be less available to both. This means both species will have less energy for growth and reproduction, so population numbers of both species will decrease. For example, leopards and lions show interspecific competition since they both feed on the same prey.



INTRASPECIFIC COMPETITION

**Intraspecific competition** describes competition for the same resources between the **same species**. When resources are abundant, the population size increases. This increases intraspecific competition since resources will need to be shared between more organisms, which cause population size to decrease. This pattern causes population numbers to **fluctuate** around the carrying capacity (the maximum number of organisms that an ecosystem can support).

**Predation** affects the abundance of the prey species and vice versa. Whenever the population size of prey increases, this causes the population size of the predator species to increase because more food is available. The increase in the predator population causes a decrease in the prey population because there are more predators to feed on the prey. This causes a drop in the prey population size, which reduces the food availability for the predators, which in turn leads to a reduction in the predator population.



Population sizes tend to fluctuate around a certain level, called the **carrying capacity**. The carrying capacity is the maximum stable population size that an ecosystem can support. It varies in response to abiotic factors (e.g. water availability) and biotic factors (competition and predation).

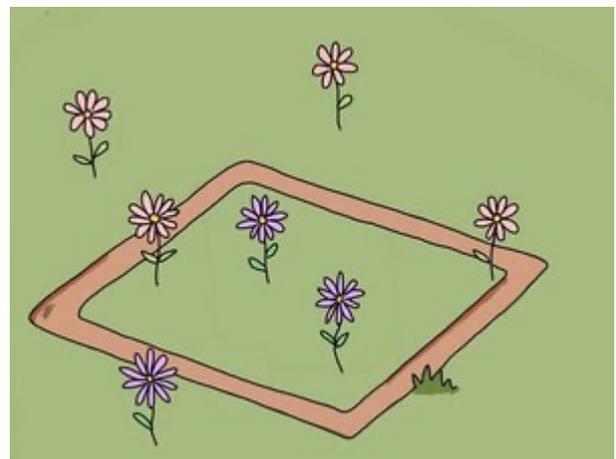
## Investigating population size

### Random and systematic sampling

Measuring the population size of a species by trying to count all of the individuals in the habitat would not only be pretty tricky but also considerably time-consuming. To save time, ecologists take a **sample** of the habitat and use that to **estimate** the size of the population in the whole habitat.

For species which don't move, such as plants, **quadrats** are typically used. It is important that quadrats are placed **randomly** within the habitat to

**avoid bias**. This can be done by using a tape measure to plot out the habitat as a grid and using a **random number generator** to plot coordinates. A **large number** of quadrats will be randomly placed throughout the habitat to ensure the data collected is **reliable**.



Sometimes it may be better to place the quadrats non-randomly - this is called **systematic sampling**. For example quadrats can be placed one next to each other along a **transect** (see below). Systematic sampling is needed wherever there is an **environmental gradient** i.e. the abiotic factors change gradually from one end of the sample to the other.

## Using transects

To see how the **distribution** of different species changes along a habitat, we use something called a **transect**, which is essentially a line placed from one part of the habitat to another. There are three different ways of using transects:

1. **Line transect** - a tape measure is placed along the line and any species which touch the tape measure will be recorded.
2. **Belt transect** - quadrats are placed along the transect one after another, so that each quadrat is touching
3. **Interrupted transect** - quadrats are placed at regular intervals along the transect

## Mark-release-recapture

For mobile organisms, the mark-release-recapture method is a better way of estimating population size. Here's how you do it:

- Capture a sample of the population using traps.
- Mark the organisms in a way that doesn't cause it harm or make it more noticeable to predators.
- Release the sample and allow them to redistribute themselves in the habitat.
- Once a sufficient amount of time has passed for the organisms to become redistributed, set up the traps again and capture a second sample.
- Count the number of individuals in your second sample and then count how many of those are marked.
- Use the formula to estimate population size:

$$\text{POPULATION SIZE} = \frac{\text{NO. CAPTURED IN SAMPLE 1} \times \text{NO. CAPTURED IN SAMPLE 2}}{\text{NO. IN SAMPLE 2 WITH MARKS}}$$

The mark-release-recapture method makes the following **assumptions**:

- The marking technique does not reduce the organism's chances of survival (i.e. due to ink toxicity or increased visibility to predators).
- The mark has not washed away or worn off.
- No organisms have died between capturing the first and second samples.
- There is no migration in or out of the population.

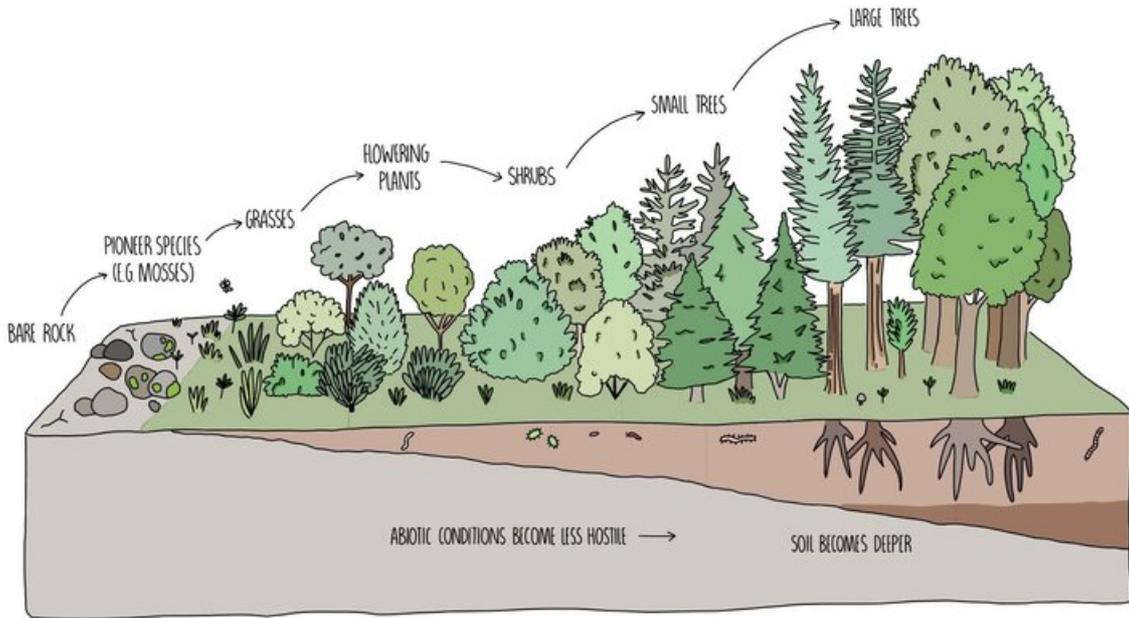
- The first sample have become fully distributed in the habitat before the second sample was taken.

## Succession

Succession describes the **change in an ecological community over time**, from a relatively sparse landscape to a stable community of several different plants and animals. There are two types of succession: **primary** and **secondary**. **Primary succession** is when an ecological community develops in the **absence of soil** (i.e. from bare rock). This may happen after a volcanic eruption which results in the formation of new rock or if the sea level lowers and exposes new land.

**Secondary succession** is when an ecological community develops from a barren landscape in which **soil is present**. Secondary succession may happen after a forest fire, for example. Succession occurs in the following stages:

- The first organisms to colonise an ecosystem are **pioneer species**, which includes things like moss, lichen and marram grass. There is no soil to begin with, therefore nothing to absorb water. This means that the pioneer species are **specially adapted** live in **dry, hostile conditions**.
- When the pioneer organisms **die and decompose**, they form a basic soil called **humus**. This makes the environment **less hostile** and **changes the abiotic conditions**. As soil forms and more water becomes available, **other plant life** will be able to survive here.
- As those plants die and decompose, the **soil becomes deeper and thicker**. Larger plants, such as shrubs can now survive and **biodiversity increases**. The organisms which are best adapted to the changing ecosystem will **out-compete** and **replace** those which are less adapted.
- Eventually, a **stable** community of plant and animal life is formed - this is called the **climax community**. The ecosystem is now supporting the largest and most complex community possible and the ecosystem stops changing significantly.



## Conservation

When succession takes place, organisms that are present at the earlier stages are absent from the climax community. This may be because the habitat is no longer available or they have been out-competed by other species. Conservation of habitats (and the organisms they support) often involves the **management of succession**, preventing the formation of the climax community and preserving certain habitats.

Succession can be controlled by:

- **Grazing livestock** - sheep and cattle grazing can prevent a climax community forming because tree seedlings can't grow properly.
- **Controlled fires** – after a fire, the pioneer species (these are the species to be conserved) are the first to grow back. By the time other species begin to take over, they will be removed by the next controlled fire.

There is often a **conflict** between **conservation** and **human needs**. For example, endangered animals may encroach on farmland and hunt local livestock. This poses an economic problem for the farmers, who may be tempted to retaliate by killing the animals. In such areas, conservationists may work with the local people to explain the importance of conservation, while helping to reduce conflict between their need to make a living and preserving biodiversity.

Conservation can take place in different ways:

- **Fishing quotas** – these place limits on the number of fish that are legally allowed to be caught, preventing population sizes from falling excessively.
- **Protecting land** – areas can be made into national parks and nature reserves. This restricts farming and development on the land and protects habitats.
- **Captive breeding** – endangered species can be bred in captivity (e.g. zoos) then returned to the wild.
- **Seedbanks** – these hold a collection of seeds from a variety of different plant species. If plants become extinct, the seeds can be used to reintroduce the plants into their native habitats.