ECOSYSTEMS

Content Statements:

D4.2.1 Stability as a property of natural ecosystems

D4.2.2 Requirements for stability in ecosystems

D4.2.3 Deforestation of Amazon rainforest as an example of a tipping point in ecosystem stability

D4.2.4 Use of a model to investigate the effect of variables on ecosystem stability

D4.2.5 Role of keystone species in the stability of ecosystems

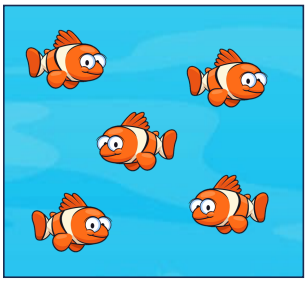
D4.2.6 Assessing sustainability of resource harvesting from natural ecosystems

D4.2.7 Factors affecting the sustainability of agriculture

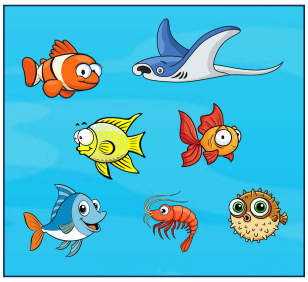
D4.2.11 Restoration of natural processes in ecosystems by rewilding

ECOSYSTEMS

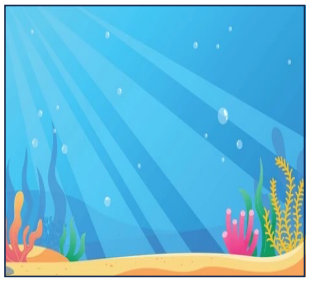
An ecosystem consists of all the interactions between a group of organisms (community) and their abiotic environment (habitat). Ecosystems can vary in size or complexity (ponds and oceans are both ecosystems) and can show continuity over long periods (ecosystems that are stable can persist for millions of years).



Population
Group of same species



Community
Group of populations



Habitat
Abiotic environment

Ecosystem
Habitat *and* community

ECOSYSTEM STABILITY

An ecosystem is considered to be stable if it is capable of maintaining its ecological functions under changing conditions or during disturbances. There are four factors that must be present for an ecosystem to remain stable under changing conditions:

- **Recycling of nutrients** (decomposers maintain a supply of chemical elements)
- **Abiotic conditions** (key climatic variables must remain within tolerance levels)
- **Genetic diversity** (high levels of diversity allow populations to adapt to change)
- **Energy supply** (constant energy supply must be made available for metabolism)

HINT: RAGE

MESOCOSMS

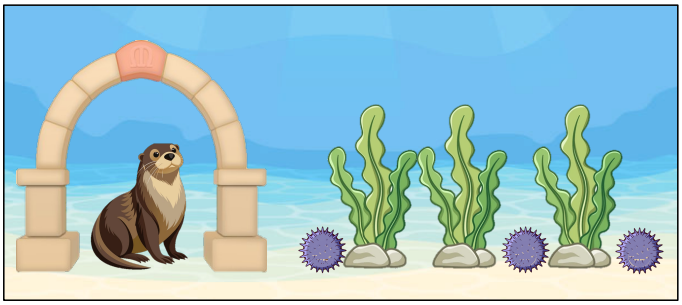
Mesocosms are enclosed environments that allow a part of the natural environment to be observed under **controlled conditions**. Within a laboratory, mesocosms can be set up with a single factor altered to assess its effect on ecosystem stability. Mesocosms are typically set up in sealed glass vessels to prevent the entry and exit of matter, while still allowing for external energy transfer. Terrariums and aquariums are examples.

KEYSTONE SPECIES

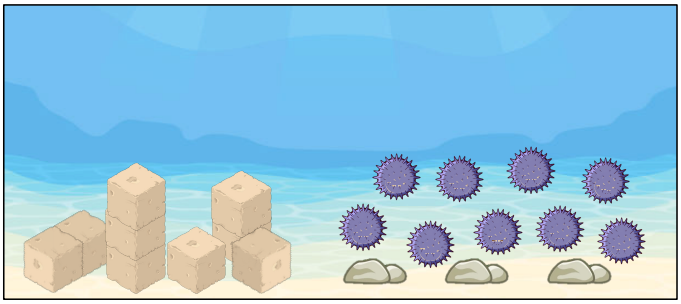
A keystone species is a species that has a disproportionately large impact on the environment relative to its abundance. They fundamentally support the ecosystem and prevent it from collapsing (like a keystone in an arch). These species don't have to occupy the highest trophic level and influence ecosystems in many ways:

- **Predators** – exert top-down pressure on lower trophic levels to prevent a monopolisation of resources
- **Mutualists** – exert bottom-up control by supporting the life-cycle of other organisms in the community
- **Engineers** – refashion the environment in a manner that promotes the survival of several other species

Examples of keystone species include **sea otters** (which prevent habitat destruction by feeding on the sea urchins that eat kelp), **honey bees** (pollinate flowering plants to ensure the continuation of these species) and **beavers** (who build dams that allow other species to thrive under the new environmental conditions).



Keystone species: Sea otters feed on sea urchins



Overpopulation of sea urchins destroys kelp numbers

SUSTAINABILITY

In ecology, sustainability is the capacity for biological systems to remain diverse and productive indefinitely. A **sustainable yield** refers to the amount of a natural resource that can be taken from an ecosystem without reducing the base stock (in other words, rate of harvesting is *lower* than the rate of resource replacement).

Timber Harvesting

Softwood timber (e.g. hoop pine) is sustainably harvested at plantations within Australia. Selective felling of trees ensures there are gaps in the canopy to promote regrowth and minimises soil erosion. The trees may be selected based on age to ensure there are enough trees remaining to produce seeds. Regeneration and replanting policies ensure that logging does not outpace growth, while ground measurement techniques and spatial modelling is used to monitor and evaluate forest cover to ensure all sustainability goals are met.

1 year: Seedlings grown in greenhouses

5 years: Plant transferred to plantation

25 years: Trees are selected for logging

30 years: Wood harvests (cycle repeats)

Fishing Practices

Marine fish (e.g. bluefin tuna) are sustainably harvested from the oceans surrounding Australia. Catch sizes are limited to prevent population decline (maximum sustainable yield should be *half* the carrying capacity of the species). Fishing vessels must be registered to allow for governmental oversight and certain oceanic regions are cordoned off for biological conservation. Mesh net size restrictions prevent younger fish that are smaller in size from being captures (maintaining the potential for future reproduction). Closed seasons may also be declared to allow for uninterrupted breeding periods during which fish are able to repopulate.

Agriculture (Farming)

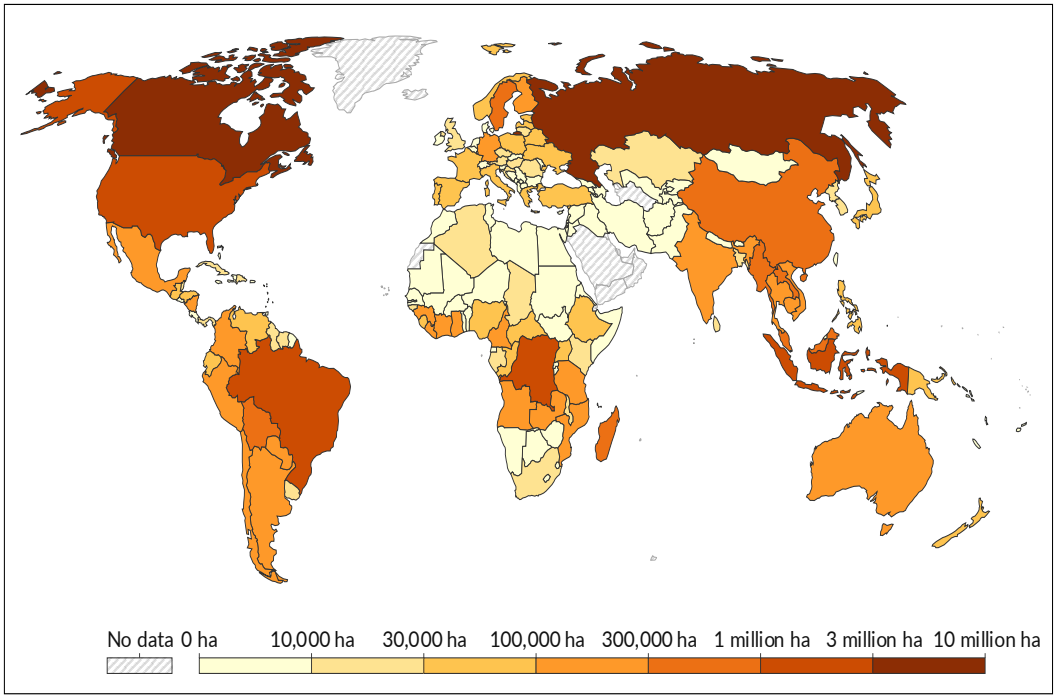
Agricultural sustainability is a complex challenge that is influenced by several factors:

- **Supply of fertilisers** – Excessive use of fertilisers can alter the composition of soil
- **Carbon footprint** – Land clearing and product transport increases CO_2 emissions
- **Agrochemical pollution** – Herbicides and pesticides may harm the native species
- **Leaching of nutrients** – Rain can wash fertilisers into waterways (eutrophication)
- **Erosion** – Removal of trees for farming makes the soil less stable (likely to erode)

HINT: SCALE

DEFORESTATION

The clearance of land for timber or agricultural use threatens the stability and sustainability of ecosystems. Deforestation alters the climatic variables in an ecosystem – including **temperature** and **rainfall**. Rainforests generate large amounts of atmospheric water vapour by transpiration. This vapour not only has a cooling effect but also influences air flow and rainfall patterns. Water vapour is also a significant greenhouse gas and hence plays an important role in regulating global temperatures. It is posited that deforestation of the Amazon rainforest could reach a **tipping point** beyond which the ecosystem is no longer stable. Removing large areas of trees will cause temperature and rainfall patterns to change. This will impact photosynthesis and nutrient cycling. It is uncertain what area of rainforest is required to maintain these vital processes.



Deforestation can be measured via the use of satellite imagery. The forest cover can be compared over a period of time and the overall extent of deforestation can be assessed by working out the percentage change over time

Image Reference:
OurWorldinData.org

REWILDING

Rewilding is the use of conservation strategies to restore ecosystems to natural conditions. This can involve:

- **Species reintroductions** – Keystone species and apex predators can control local consumer populations
- **Improving habitat connectivity** – Wildlife corridors allow organisms to access and occupy larger regions
- **Minimising human activity** – Via the legislation of exclusion zones where human activities are restricted

An example of rewilding can be seen in the restoration of the **Hinewai Reserve** in New Zealand. The reserve was once used as farmland, but is now privately owned with limited human access (e.g. bushwalking). Alien species were removed by human intervention, but now the reserve is maintained with minimal oversight.