Key Stage 5 Worksheet

Earth LIVE Lessons: Why Wetlands Are Nature's Superheroes

What is it about?

In this video, Dr Christian Dunn, a Senior Lecturer in the School of Natural Sciences at Bangor University, explains why wetland ecosystems are so important for the planet. Dunn discusses the high levels of biodiversity that these ecosystems support and their ability to clean water, prevent flooding and help reduce climate change by capturing carbon.

Watch the video here:
youtu.be/0ZerSvkvpKQ

Open file in your web browser to click on the links.

What are wetlands?

There are many different types of wetlands, including ponds, rivers, lakes, mangrove forests, swamps, bogs and fens. Fens (which get their water from different sources) and bogs (which only receive water from rainfall) are both peatlands, whereas marshes and swamps (forested marshes) are mineral soil-based wetlands. A common feature of all of these habitats is that they form a boundary between truly terrestrial (land) and truly aquatic (or marine) environments. Wetlands are generally divided into two types: coastal, which are saline, and inland, freshwater wetlands.

Wetlands provide a significant number of valuable **ecosystem services** for people, including:

- Provision of food (e.g. fish and rice) and building materials (e.g. timber from willow and mangroves)
- Flood protection
- Carbon sequestration
- Water purification
- Tourism and leisure opportunities
- Fisheries support
- Storm protection

What are wetlands continued...

Ecosystem services are functions of natural habitats that are useful for humans, which also include services such as pollination and the production of oxygen by photosynthetic organisms. Ecosystem services are often assigned an economic value to try to ensure that the loss of natural ecosystems is not disregarded in financial planning, providing an incentive for their protection. For example, the total economic value of ecosystem services in the United States of America is believed to be around 46 trillion US dollars every year!

Why are wetlands so important?

1. Biodiversity

Wetlands are among the most biodiverse environments on the planet. They support a wide range of bacteria, invertebrates, fungi, plants and animals, including water birds, fish, amphibians, reptiles such as snakes and alligators, and mammals such as water voles, beavers, river dolphins and otters.

According to the **IUCN's Freshwater Biodiversity Unit**, 126,000 species rely on freshwater wetlands alone, including 25% of vertebrates, even though these habitats cover less than 1% of the Earth's surface. It is estimated that 15,000 species of fish, 4,300 species of amphibians and 5,600 species of dragonflies and damselflies rely on freshwater wetlands.

Jonathan Wilkins, Creative Commons.

The roots of a mangrove tree (Prado, Brazil), amongst which fish fry are protected from larger marine predators.

One of the reasons for the high biodiversity of wetlands is that they are not just home to the species that are specifically adapted to live in them, such as fish. They will also be visited by more generalist species that are adapted to a terrestrial or marine environment.

Mangroves, for example, act as nursery grounds for many marine species, providing a safe place for fish to spawn. This relates to one of the ecosystem services that mangroves provide in terms of fisheries support, and it has been observed that when mangrove forests are cleared, local fisheries begin catching fewer and smaller fish. When mangroves are present, the fish fry (juvenile fish that have recently hatched from eggs) are protected from marine predators which are too large to swim between the raised roots. This protection allows them to safely reach maturity before swimming out to sea, increasing the number of mature fish in the population, boosting fisheries and supporting other animals higher up the marine food web.

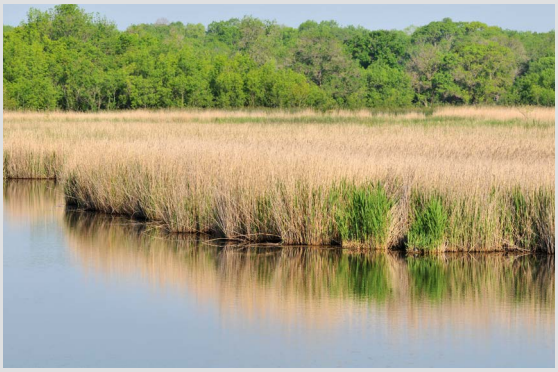
Why are wetlands so important continued...

Many species are specifically adapted to live in mangrove forests, including the mangrove trees themselves. These trees have **pneumatophores**, specialised aerial roots that protrude from the water to extract oxygen from the air, aerating the roots to enable respiration to occur. The water they grow in has a high salt content. Some mangrove species are adapted to excrete salt from their leaves, and others filter out up to 90% of the salt as it enters via their roots.

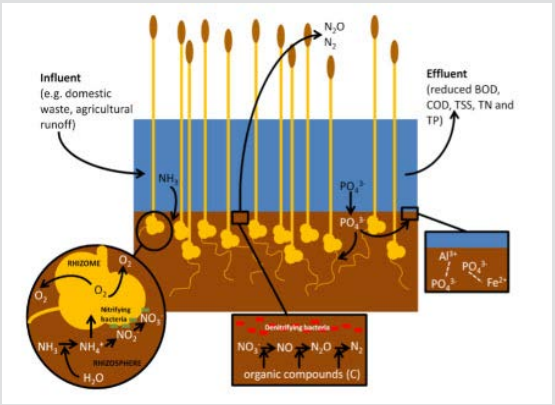
2. Cleaning water

Just as the kidneys filter waste from our blood, wetlands are sometimes described as the landscape's kidneys, purifying water by **filtering out microbes**, including harmful pathogens such as Giardia, and pollutants. This includes run-off from agricultural fields. This water run-off can be high in nitrates and phosphates from fertilisers, and can therefore cause **eutrophication** of waterways, whereby an excess of nutrients in the water triggers the growth of algal blooms. These algal blooms coat the surface of the water, preventing sunlight from penetrating, which can be harmful to the aquatic plants growing beneath the surface of the water. When the algae and aquatic plants die, they are decomposed by microbes in the water which consume oxygen during the decomposition process, depleting it from the water. This can lead to the creation of "**dead zones**", where oxygen levels are too low for organisms to survive.

Some wetlands, such as reed beds, are so good at cleaning water that people create "constructed wetlands" and pass contaminated water through them in order to clean it. This approach is used, for example, to treat sewage in off-grid systems and to complete the purification of water discharged from a water treatment plant. An example of this is the Welsh Water Llanelli wastewater treatment plant, which discharges into the extensive reed beds of the Wildfowl and Wetland Trust (WWT) **Llanelli Wetland Centre** nature reserve.



Reed bed



Removal of pollutants in a constructed reed bed. The reeds are hollow, transporting oxygen from the air into their roots to provide an aerobic environment for nitrifying bacteria inside the plants' rhizomes, which convert ammonia to nitrate and nitrite. Denitrifying bacteria convert nitrate into nitrous oxide and nitrogen gas, which is emitted into the atmosphere. Metal ions in the soil form a complex with phosphate ions, removing them from the water. Nitrates and phosphates are also directly taken up by the reeds through the roots. Having passed through the reed bed,the effluent water has a much lower level of pollutants, as measured by tests including **Biological Oxygen Demand** (BOD), **Chemical Oxygen Demand** (COD), Total Suspended Solids (TSS), Total Nitrogen (TN) and Total Phosphorous (TP).

Why are wetlands so important continued...

3. Storm and flood protection

You might not expect wetlands, which are full of water, to be able to **help prevent flooding**. However, healthy wetlands can act like a giant sponge, absorbing and slowing down excess water during storms.

Beavers are an especially helpful wetland species when it comes to flood protection as **the dams they build** are not solid, so some of the water in the river system is able to trickle through. When there is heavy rain, the volume of water held by the river increases, along with the speed of flow. However, once this water reaches the beavers' dam, the water slows down and the volume able to pass through is reduced. Beavers are classed as "**ecosystem engineers**", species which significantly modify, create, or maintain an ecosystem. Human engineers have been inspired by beavers' dams and now build "leaky" dams like this around areas that need protection from flooding - but beavers do this job for free!

In the 1940s and early 1950s in Iowa in the USA, beavers were causing problems in some areas due to their high population density, so some were moved to new areas. Some of these areas were very remote, so a creative strategy was devised to transport the beavers to these areas. The beavers were captured, placed in crates and **parachuted into remote areas**!

As well as providing protection from flooding, some wetlands provide protection from storms. Mangrove forests are able to absorb much of the energy of tsunamis, protecting coastal villages. When the huge Indian Ocean tsunami occurred, **research revealed** that those areas with intact mangrove forests suffered much less destruction than those where the mangrove forests had been cleared. Other coastal wetlands such as **saltmarshes** can reduce the energy of waves, absorb huge volumes of water and help to prevent erosion.

4. Carbon sequestration and climate control

Like all plants, wetland plants take in carbon dioxide via **photosynthesis**. However, in certain types of wetlands, their ability to capture carbon goes beyond this. In these wetlands, called **peatlands**, when the plants die they don't completely decompose (which would release carbon dioxide into the atmosphere), but instead partially decompose to form peat, in which the carbon remains locked up and stored.

Peatlands are the world's most important **terrestrial store of carbon**. Peatlands contain at least twice as much carbon as the world's forests, but take up a small fraction of the space, around 3% of the Earth's surface. Many rainforests are also peat swamps, so carbon is stored both in the trees and in the soil, so these habitats are the best of all for carbon sequestration.

The process of peat formation helps to remove carbon dioxide from the atmosphere and store (sequester) it in the soil, reducing levels of atmospheric carbon dioxide and therefore helping to reduce climate change.

Threats to and conservation of wetlands

Although wetlands are home to such a large proportion of the world's biodiversity, and provide essential ecosystem services to people, unfortunately they are threatened. Many wetlands have been degraded or lost completely, having been dug up or drained, for example to use the land for development or to extract peat to use in compost. This peat took thousands of years to create and is so important for carbon sequestration that there are many campaigns from organisations such as **Plantlife** to encourage gardeners to only buy peat-free compost.

Wetlands have not been highly valued in the past, and in many cases now are still seen as "wasted" land, which is then drained to use for construction. Mangroves are threatened by deforestation for timber. Climate change is also affecting where certain types of wetlands are able to exist.

As a result of these and other threats, a large proportion of wetland species are now threatened with extinction, as shown below in the data from the **IUCN**.

Wetland species under threat

- Waterbirds - Of the 1,138 waterbird populations whose trends are known, 41% are in decline.
- Wetland-dependent mammals - 38% of the fresh water-dependent species that have been assessed are globally threatened.
- Fresh water fish - 33% of the world's fresh water fish species have been assessed as threatened.
- Amphibians - 26% of the world's fresh water amphibian species are considered threatened.
  - At least 42% of all amphibian species assessed are declining in population; less than 1% of species show population increases.

Source: IUCN Red List of Threatened Species, BirdLife International, Wetlands International

Beavers became extinct in the UK during the 16th century, when they were heavily hunted for their pelts and meat. **Beavers have now been reintroduced** into some parts of the UK. Many other species have also become extinct in the UK, including grazing animals such as the European bison. As a result, substantial habitat management needs to be carried out to maintain wetland ecosystems in the UK, otherwise, by the process of natural **succession**, these areas would over time become wet woodlands and eventually woodlands. Without regular cutting, some species, such as reeds, come to dominate a wetland environment, reducing the level of biodiversity. **Conservation grazing** is a useful management technique, which involves moving herds of farm animals such as cattle and sheep onto wetland areas. This replicates the effects of the large herds of herbivores that are now extinct in the UK, keeping vegetation levels under control and maintaining different microhabitats suited to a wide range of species.

New wetlands are now being created to try to offset some of those that have been lost over the centuries. It is even possible to create a small wetland, such as a pond, in a garden. Organisations like the Wildfowl and Wetlands Trust (WWT) create and manage large scale wetland reserves, including **Steart Marshes**, which was formed by intentionally breaching the sea wall to restore saltmarsh for flood protection and to support biodiversity.

Find out more!

- Explore how mangroves are adapted to survive in a saline environment **here**.
- Explore how other plants and animals are adapted to survive in swamps **here**.
- Discover more about the ecosystem services provided by wetlands that help to sustain life on Earth **here**.
- Find out more about the threats to wetlands **here**.
- Learn how to create a miniature wetland in your own garden **here**.
- Protecting wetlands to benefit from their ecosystem services can be much more cost effective than allowing them to be drained or degraded. New York City has saved an estimated 10 billion US dollars by protecting and restoring wetlands for purifying water rather than building water treatment plants. Find out more **here**.
- Discover more about the construction and management of reed beds from **The Wildlife Trusts.**
- Find out more about how peat is formed and how peatlands help to sequester carbon in a report from Natural England **here** and from the IUCN's peatland programme **here.**

Questions

Interactive: Click on box to start typing

Name three ecosystem services provided by wetlands.

Flood protection, cleaning water and providing food (e.g. fish and rice).

Describe two specific adaptations of mangrove trees.

Mangroves have aerial roots called pneumatophores, which extract oxygen from the air to allow respiration to happen in the roots. They can also excrete the salt they take up through their roots from the saline water they grow in through their leaves.

How do reeds create an aerobic environment for denitrifying bacteria in their roots?

Reeds are hollow like a tube, so they can transport oxygen from the air down to their roots.

How does a reed bed reduce water pollution caused by run-off from agricultural fields?

Run-off from agricultural fields contains high levels of nutrients (nitrates and phosphates) washed off by the rain, which can pollute water bodies. As the water flows through the reed bed, the reeds absorb these nutrients from the water through their roots. Phosphates can also become trapped in the soil by bonding to metal ions, and nitrates are processed by denitrifying bacteria living in association with the reeds, converting them to atmospheric nitrogen gas.

How do peatlands help to mitigate climate change?

Plants take up carbon dioxide when they are alive for photosynthesis, and then the carbon is stored in their structures. In peatlands, when the plants die they don't fully decompose, which would release the carbon dioxide back into the atmosphere. Instead, they partially decompose to form carbon-rich peat, which traps the carbon in the ground.

What are some of the main threats to wetlands?

Wetlands are threatened by drainage and destruction for development, digging up peat for compost, deforestation (mangroves) and climate change.

Exercise

Conduct more research into the ecosystem services of wetlands and, where the information is available, the economic values attributed to them. Write a report presenting a case to your local council to preserve a wetland environment of your choice, rather than draining the wetland to provide land for a housing development. Provide detail about all of the ecosystem services provided by the wetland and how these benefit people living in the area.

For teachers and home schoolers

Links to Science in the National curriculum for Wales (KS5)

https://www.wjec.co.uk/media/gcgjtvqj/wjec-gce-biology-spec-from-2015.pdf

AS Biology: Biodiversity and Physiology of Body Systems – All organisms are related through their evolutionary history [(h) biodiversity as the number and variety of organisms found within a specified geographic region] – the high diversity of species found in wetland environments and the reasons for this.

AS Biology: Biodiversity and Physiology of Body Systems - All organisms are related through their evolutionary history [(n) the different types of adaptations of organisms to their environment including anatomical, physiological and behavioural adaptations] – the adaptations of mangrove trees to living in a saline environment, for example the excretion of salt through the leaves and filtering through the roots.

A2 Biology: Energy, Homeostasis and the Environment – Population size and ecosystems [(e) the concept of ecosystems, including that ecosystems range in size from very large to very small, (g) the concepts of habitat and community] – wetland environments as examples of ecosystems comprising communities of many different interdependent species interacting with the abiotic components of an environment at the boundary between terrestrial and aquatic.

A2 Biology: Energy, Homeostasis and the Environment – Population size and ecosystems [(i) the principles of succession as illustrated by the colonisation of bare rock to form woodland] – Wetlands as an example that, in the absence of certain species, can quickly succumb to natural succession to form woodland, unless proper management is conducted.

A2 Biology: Energy, Homeostasis and the Environment – Population size and ecosystems [(n) the role of bacteria in the nitrogen cycle and the significance of nitrates in producing proteins and nucleic acids, (p) the process of eutrophication and algal blooms and that drainage has adverse effects on habitats] – the role of reed beds and constructed wetlands, including nitrifying bacteria in the root nodules and denitrifying bacteria in the soil, in removing excess nitrates and phosphates from the water to reduce eutrophication.

A2 Biology: Energy, Homeostasis and the Environment – Human impact on the environment [(a) the reasons for species becoming endangered and causes of extinction, (d) the increased human pressures on the environment including the need to achieve sustainability by changes in human attitudes and making informed choices] – the threats to wetlands and examples of endangered wetland species, and the use of economic valuation of ecosystem services as a step towards sustainable management.

https://www.wjec.co.uk/media/wijlspii/wjec-gce-geography-spec-from-2016-e.pdf

A2 Geography: 4.2.3 Biodiversity Under Threat [Threats to biodiversity from direct action and indirect action operating at a range of scales from local to global, Ecosystems at greatest risk including tropical rainforests, coral reefs and wetlands] – the threats to wetlands that can result it in a decrease in biodiversity (including through lack of management, causing some species to dominate).

A2 Geography: 4.2.4 Conserving Biodiversity [Strategies to conserve biodiversity including a range from total protection through no access to sustainable use] – establishment of wetland reserves and practical land management techniques to maintain biodiversity in wetlands, including conservation grazing and manual cutting.

A2 Geography: 4.2.5 Ecosystems at a local scale [Succession of one ecosystem] – the process of succession that occurs in UK wetlands in the absence of, for example, large grazing animals, resulting in development of wet woodland and ultimately woodland.

Swansea University Science for Schools Scheme

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