Green Foundation Ireland

Education Module for Transition Year Students

Biodiversity

Teacher's Resource

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TABLE OF CONTENTS

	PAGES
INTRODUCTION	2
SESSION 1: **Introduction to biodiversity and concepts**	3 – 5
SESSION 2: **Measuring biodiversity**	6 – 7
SESSION 3: **Value of biodiversity**	8 – 9
SESSION 4: **Threats facing biodiversity**	10 – 12
SESSION 5: **Conservation methods and policy**	13
SESSION 6: **Biodiversity careers and future**	14
ABOUT GREEN FOUNDATION IRELAND	15

INTRODUCTION

This is the Teacher's Resource document for the Green Foundation Ireland's Transition Year Module on Biodiversity, to be used in conjunction with the Lesson Plan document and Work Sheets. In this document are definitions, explanations, discussion points, facts and experimental set-up instructions to assist a teacher in delivering this module. Regarding the definitions provided, it is up to the educator whether they wish to provide the definitions directly to students, or to direct the students to research the terms themselves and use this resource to ensure the research is consistent.

Please note that the videos and links present within this document are not owned by Green Foundation Ireland, and are merely suggestions of audio-visual aids which can be shown in class to reinforce learning, can be suggested to students, or can be viewed by teachers to familiarise themselves with, or learn more about, the topics explored in this module.

Photographs of the topics discussed in this module are not provided here, for copyright reasons. However, teachers are encouraged to source photographs from the internet to demonstrate to classes, as a visual aid to reinforce learning.

This module encourages students to research and present information in the form of one-class projects to encourage engagement and self-directed learning. On that basis, access to computers would be of benefit, but are not essential.

SESSION 1: Introduction to biodiversity and concepts

Biodiversity is defined as the total of all the different kinds of life found in an area, including both plants and animals, as well as other organisms.

- **Genetic biodiversity** is the biological variation that occurs between members of a species. It can be described as a gene pool. These include both variability that can be directly observed, such as colour, size and pattern, as well as those that cannot be directly observed, such as variability in enzymes. Genetic diversity is of particular value in adapting to environmental change. An example of this is that a range of several different colour patterns within a community of an animal may aid them in camouflaging in a new environment. As such, large genetic diversity within a species helps the long-term survival of a species.
- **Species biodiversity** refers to the diversity of different animal and plant species in an area. As will be discussed in detail in the following weeks, biodiversity in an area provides many benefits to people, animals and the systems themselves.
- **Ecosystem biodiversity** refers to the variation between different ecosystems. The organisms that exist in an ecosystem are dependent on many abiotic (non-living) factors, such as moisture level, salinity, temperature, soil type, etc, as well as biotic (living) factors, such as predation, availability of prey/plants, etc.

An ecosystem is defined in the convention on biological diversity as *"a complex of living organisms and the abiotic environment with which they interact in a specified location".* It is a system that comprises many types of organisms, climatic conditions, and their interactions with the landscape.

Ecosystem engineers are defined as species that creates or changes a habitat. They have a large impact on the animals and plants that can inhabit an area. Examples include beavers, which create dams, and thus change the flow of rivers in an area. Mussels aggregate into mussel beds, creating more complex surfaces. Trees create treetop habitats, shaded areas, and root systems.

Ecosystem engineers create more **habitat heterogeneity** of habitats in an area, and thus more niches in which several species can live. Heterogeneity refers to how different sections of an area are. As an example, a flat field has many points which are relatively similar, whereas a rocky beach has tide pools, sandy areas and rocky surfaces, each of which contains different organisms.

Biodiversity hotspots as explained here are regions that contain high levels of species diversity, including **endemic species**, those found only in one area of the world. There are 36 regions defined as biodiversity hotspots on earth, and they comprise just 2.5% of the earth's surface. This video summarises information on a biodiversity hotspot in the Galapagos Islands.

Generalist species are those that are adapted to variation in an environment and can thrive in a wide variety of settings, such as corvids (crows) which can live in both rural and urban environments. **Specialist species** are those that evolved to thrive in one specific environment, such as koalas, which eat only eucalyptus. Therefore, koalas can only survive naturally in an environment where eucalyptus grows. In general, climate change and human activity is expected to favour generalist species, which can adapt to survive in more urbanised environments.

Redundancy within an ecosystem describes when multiple organisms fulfil the same "role" within a food web.

- In a system with only one herbivore, that species allows the food web to function, as it transfers energy from the plant matter to carnivorous animals. If it were to disappear, the carnivorous animals would die off, having no food supply. Additionally, it keeps plant species from overgrowing. Consider that with only one herbivore species in an area, if it were to go extinct, the system would collapse. However, if multiple herbivore species exist in that area, one species going extinct or moving from the area would not cause collapse, as other species would still fulfil that role. As such, an environment with more biodiversity is more **resilient**.

R-Selection and K-Selection are terms which describe the strategy regarding number of offspring that an animal has. These strategies do not oppose each other, and co-exist in most environments. While the theory has been debated and does not hold true in all environs, their description is a useful way to understand different life strategies of animals.

- **R-selection** is the strategy wherein an animal produces large numbers of offspring with lower parental care. The strategy here is that by having several offspring, it can be ensured that at least some will make it to maturity. Rats and insects are good examples of this. Typically, R-strategist species have rapid gestation periods.
- **K-selection** is the strategy wherein an animal produces a small number of offspring and puts particular care into their protection and raising. The idea is that by focussing much effort on a small number of offspring, it can be ensured that they will make it to maturity. Elephants and humans are good examples of this. Typically, K-selected species have relatively long gestation periods.

Within nature, species may interact with each other in myriad ways. A number of terms are used to categorise and describe these symbiotic interactions:

- **Mutualism** describes a relationship between two species where both benefit from the interaction. Examples of this include clownfish and sea anemones, wherein clownfish gain shelter and protection from predators, while anemones are cleaned of parasites and gain protection from other fish.

- **Commensalism** describes a relationship in which one organism benefits, while the other is neither helped nor hindered. An example of this is the relationship between whales and barnacles, wherein barnacles receive transport and protection, while the whale is largely unaffected.
- **Predation and herbivory** refer to interactions where one organism hunts or consumes another as food.
- **Parasitism** refers to one organism benefits from a living host while harming it in the process. Ticks feed on other animals whilst draining their blood and potentially conferring diseases. Parasites can be **endoparasites** (which exist inside the body, like tapeworms) and **ectoparasites** (which exist outside of the body, like ticks).
- **Competition** is a concept with which the class may already be familiar. It refers to when two organisms compete over the same resource, be it food, mates, or territory. Competition can be **intraspecific** competition, wherein members of the same species compete over a mate, for example, or **interspecific** competition, wherein members of different species compete, an example of which being lions and hyenas competing over food sources. Additionally, competition can be categorised into interference competition and exploitation competition.
    - **Interference competition** occurs when one species directly interacts with another preventing them from accessing a resource, such as chasing another away from a food source.
    - **Exploitation competition** is an indirect method of competition wherein no direct interaction occurs, and one animal simply removes all of a resource such as a food from the area, impacting the other species' survival.
    - **Apparent competition** is a slightly more complex concept that occurs when two species who do not compete for resources impact each other's populations. An example of this is two species who are prey for the same predator. A decrease in population of one prey species would create an impact on the second, in that the predator species would rely more on that species for food.

SESSION 2: Measuring biodiversity

Species richness is simply the number of different species identified within a defined region. This is calculated via sampling studies.

Species evenness describes the relative proportions of species in a defined region. When all species exist in an area are present in roughly the same amount, evenness is high. In an environment where the number of one species massively outnumbers others, evenness is low. This diagram in *Nature Education* demonstrates this difference.

Alpha diversity measures the species diversity within a community on a local scale. It is often expressed simply as the species richness or number of species in an area.

Beta diversity is the ratio between alpha and gamma diversity, which enables quantification of how much the local diversity varies between communities in a region. It measures how different the species composition is between local sites within a larger area.

Gamma diversity measures the diversity across a very large scale. Essentially, gamma diversity is species richness over a much larger area than alpha.

- For example, on a beach system, rock pools, sand and open water would each be counted for alpha diversity. Beta diversity measures the overlap between these areas (does the open water share many species with the sand?) and the gamma diversity would be the total number of species existing in the whole beach system.

This video demonstrates the concept and calculation of alpha, beta and gamma biodiversity.

Methods to measure biodiversity you may not be familiar with include:

- **Kick sampling** is a method used in running water to examine insect species in particular. A net is held downstream of the sampling site, and the substrate of the river is kicked, capturing disturbed insects in the net. **Sweep sampling** is the process of sweeping a net through the water column and examining captured organisms.
- **Mark-Recapture methods** are those in which specimens of one species from an environment are marked upon being captured and then released. At a later date, specimens of that same species are captured, and the proportion of previously marked to unmarked animals are used to estimate the total population in the area. It can be assumed that the percentage of marked animals upon recapture is the same percentage that the originally marked number is of the whole population. This video demonstrates the methodology.

- **Environmental DNA or EDNA** can be sampled to better understand the species living in an area. Animals shed DNA in hair, faeces and skin, and DNA can be picked up from this to confirm their presence in the same way that DNA is sampled for at crime scenes. This is a particularly non-invasive method of surveying for wildlife in an area, but obviously DNA testing of environmental samples is beyond the scope of secondary school class groups. This video demonstrates the methodology as used to identify the presence of lynx cats.
- **Indicator species** are defined by Encyclopaedia Britanica as a species *"that serves as a measure of the environmental conditions that exist in a given locale".* As an example, mayfly and stonefly larvae are very sensitive to pollution and cannot survive in waters that have been significantly impacted. As such, a survey that finds these creatures living within a river system indicates that the river is relatively free of pollution.

As demonstrated here, in Irish rivers, the following species can be used to estimate pollution level. The highest should be taken as the result, as the lower order species can be found in a range of habitats.

- Stonefly and mayfly *(plecoptera* and *ephemeroptera)* larvae denote a relatively pristine environment as they are very sensitive to pollution.
- Caddieflies *(trichoptera)* are indicative of moderate water quality, with mild sensitivity to pollution.
- Waterlice *(asellidae)* and leeches are quite tolerant, and therefore their presence without the others is indicative of more polluter water bodies.

Similarly, lichens can be used as indicator species for air quality:

- Bushy lichens are sensitive, and this indicate nonpolluted air.
- Leafy lichens are moderately sensitive, and thus indicative of moderate air pollution.
- Crusty lichens are tolerant of air pollution, and thus indicative of more polluted air.

SESSION 3: Value of biodiversity

The value of biodiversity can be examined through multiple lenses, primarily **anthropocentric** and **ecocentric**. The lens through which one sees the topic will largely come down to personal values, but it should be encouraged that members of the class discuss and come to understand each point of view.

- The **anthropocentric** view sees the value of biodiversity as the value which it can provide to human well-being. In this sense, biodiversity is valued not for its own sake, but because biodiversity can provide value to humans in the form of ecosystem services.
- The **ecocentric** view emphasises the inherent right to exist for other organisms. This view holds that the natural world should be given the opportunity to flourish, irrespective of what value it can provide to human life, and that humans do not necessarily have the right to exploit it for their benefit.

Regardless of one's personal viewpoint, the science agrees that biodiversity is necessary to continued human survival and fulfilment and, thus, protecting and recognising the value of biodiversity is essential.

Ecosystem services, as per the American National Wildlife Federation, are defined as *"an ecosystem service is any positive benefit that wildlife or ecosystems provide to people. The benefits can be direct or indirect – small or large".* One of the simplest examples is trees creating oxygen. A directly profitable example of ecosystem services is the pollination of crops by wild insects. Without the activity of these insects, fruits and seeds would not develop on crops. Ecosystem services take place in both terrestrial and aquatic ecosystems and can be classified into several categories, as demonstrated by NatureScot:

- Provisioning: water supply, materials, food and drink, natural medicines.
- Regulating: pollination, carbon storage, erosion control.
- Cultural: tourism, physical and mental well-being, recreation.
- Supportive: nutrient cycling, hosting of wildlife, maintenance of soil and water.

Carbon sequestration is a significant ecosystem service in battling climate change. It is the process of removing carbon dioxide from the atmosphere, primarily via its absorption by plants during photosynthesis. As such, CO_2 is then "stored" in the form of plant biomass. This video demonstrates the value of carbon sequestration.

- Home gardening can be geared towards carbon sequestration. Soil in particular has a significant potential for carbon capture. Methods include:
    - Planting more woody trees and shrubs, especially a mix of long-lived and quick-growing varieties.
    - Increasing soil carbon levels by adding mulches, compost and biochar.
    - Digging less to avoid CO_2 lost to the atmosphere.

Biodiversity loss has negative implications for humans in numerous ways:

- Biodiversity loss increases the risk of **zoonotic disease** (diseases crossing the barrier between animals and humans, an example of which being COVID-19). Another example is the loss of mammal numbers in the USA which causes ticks to seek human hosts, increasing the number of Lyme Disease cases.
- The loss of biodiversity affects the entire natural food web. Negative impacts on pollinator populations can substantially threaten **food security**. Furthermore, disruptions to higher trophic levels in the food chain reduce natural regulation of pest and parasite species that damage crops, which may result in considerable declines in agricultural productivity. When natural nutrient cycling and soil formation are compromised, soil fertility diminishes, further increasing risks to food security.
- Natural systems also serve as repositories of chemical and genetic information that serve humanity as **genetic resources**. Treatment options for several important diseases such as cancer are derived from natural remedies. With the loss of biodiversity, future potential for medical innovation is significantly limited.
- **Ecosystem services** such as water filtration, carbon sequestration and many other processes on which humans rely are impacted by biodiversity loss, and human attempts to artificially replace those services are costly and uncertain.
- Nature and natural landscapes have also been demonstrated to have **positive impacts on human mental and physical health**. As such, degradation of natural systems will reduce the capacity for human wellness.

SESSION 4: Threats to biodiversity

The different causes of biodiversity loss are numerous and interconnected, and this resource will attempt to cover some major drivers in an accessible way. Threats to biodiversity exist on both the local and global level.

- **Climate change** refers to long-term changes in earth's climate, including both weather patterns and temperatures. **Anthropogenic climate change** refers to climate change that results from human activities. Climate change is intertwined with, and a major cause of, biodiversity loss. Destruction of ecosystems as part of logging, mining, and land-clearing for farming releases CO_2 into the atmosphere. Ocean warming and soil disturbance also release more CO_2.
    - As the ocean warms, it can hold less CO_2, meaning that warming of oceans releases more CO_2 creating a **feedback loop**.
- **Deforestation** refers to the clearing of forested land. Human history has trended towards the large-scale deforestation of the planet. According to National Geographic in 2,000 years, western Europe has fallen from 80% forest cover to just 34%. Deforestation can happen for a number of reasons, including urbanisation, agriculture and logging. Agriculture is a major driver of deforestation worldwide, with the felling of forested areas to clear land for farmland. Climate change also causes deforestation, as it leads to extreme weather events, such as floods, droughts and forest fires.
- **Habitat fragmentation** as described here refers to the breaking up of larger contiguous habitats into smaller areas. This causes numerous issues for wildlife, such as loss of breeding or feeding sites, loss of genetic diversity in a community, exposure to dangerous human-occupied areas, or disruption of migration pathways. It can be caused by human construction, but also by natural causes.
- **Overfishing** refers to when more fish are caught than can be replaced by the population. This causes long-term destruction of fish populations, with many ramifications on the marine ecosystem. Ireland in particular is responsible for a significant amount of European overfishing, according to Birdwatch Ireland. Overfishing also has significant negative impacts on coral reef systems.
    - Overfishing places pressure on seabird populations, as their food source is reduced.
    - **Bycatch** refers to non-target species that are caught in fishing equipment, not intended to be consumed as food. Sea turtle and dolphin species are commonly killed via bycatch.
- **Ocean acidification** causes disruption to marine food webs due to weakening the calcium carbonate of shells and the skeletons of corals.

- **Pollution** is defined by the National Geographic magazine as *"the introduction of harmful materials into the environment".* Pollution takes several forms: air, soil, water, light and noise pollution.
    - **Light pollution** is the damage caused by artificial lighting to wildlife, in particular nocturnal animal species such as bats. Artificial lighting causes disruption to the activity of many species, such as migration patterns, navigation, and breeding rituals.
    - **Fast fashion** refers to the rapid production of low-quality clothing in an attempt to follow current fashion trends. This type of clothing is generally considered cheap and non-durable, meaning that it is worn only a few times before it is discarded, creating a large volume of waste that pollutes the environment. This is in addition to the environmental footprint of creating large quantities of clothing.
- **Invasive alien species** are species that do not naturally occur in an area, but have been introduced due to human activities. A species becomes invasive when it thrives and proliferates in an area to an extent that it outcompetes other native species, or directly impacts native species to the point that they negatively impact their populations. Invasive alien species can be introduced in a variety of ways, intentional or unintentional:
    - **Intentional methods** include horticultural or pet trades. Rhododendron was introduced to Ireland as an ornamental species but has since spread widely throughout Ireland (Killarney National Park is one example of Rhododendron proliferation).
    - **Unintentional methods** include accidental transport of species, such as carriage in the shipping of products, or in ballast water. Zebra mussels were likely introduced to Irish waters on the hulls of ships and boats, and due to their rapid reproduction, have caused a decline of native mussel species, as well as causing issues for humans such as blocking water pipes.
    - **Factors that make a species invasive** include:
        - **Lack of natural predators** in an area means that the ecosystem cannot be rebalanced by native species hunting the invasive alien species.
        - **Rapid reproduction and growth rates** allow the species to rapidly proliferate in an area.
        - **Effective dispersal** in the case of plants means that the invasive species can rapidly cover a wide area, creating a firm foothold which is hard to remove, and allowing it to further colonise new areas.

- **Tolerance for varying conditions** means that changes in the environment do not disturb a species, and with the advent of climate change, may mean that it is more resilient than native species, meaning it may colonise areas previously inhabited by native species.

While not a direct threat to biodiversity, **greenwashing** is a concept students should be aware of, as it can mask the more damaging effects of other loss drivers discussed here and it is important to maintain a critical eye on marketing materials for products and services. It is defined here by the Rainforest Alliance as the process of *"making false or misleading claims about the environmental benefits of a product or practice".*

SESSION 5: Conservation methods and policy

Conservation is defined as mission-oriented work to protect and restore biodiversity.

- **In-situ conservation** means working to protect species in their natural habitat, such as the preservation of parks or protected areas.
- **Ex-situ conservation** is when work is done to preserve the species outside of their natural habitat, such as captive breeding or translocation.

Environmental Impact Assessments, as defined here by Planning Permission Ireland, are studies that *"identify and assess the environmental effects of proposed developments before decisions are made. It covers a wide range of environmental factors, including biodiversity, water, air and soil quality, and cultural heritage".* Environmental Impact Assessments allow foresight into potential harms, as well as allowing positives and negatives for a project to be considered before it is approved. Most developments legally require an Environmental Impact Assessment before being approved. Mitigation measures are also identified for if the project is to go ahead.

- An example would be a proposed bypass road through a semi-forested area. Negative impacts may include felling of trees, disturbance and loss of topsoil due to wind or water erosion, increased air pollution impacting flora and fauna, potential killing of animals in road collisions, and light pollution impacting animals.
- Mitigation measures may include replanting of trees, building of wildlife passages to avoid road crossings, and using low-luminosity lighting to avoid light pollution.

Natura 2000 sites are those designated within the EU Birds Directive and the EU Habitats Directive. **Special Areas of Conservation** are established for animals under the EU Habitats Directive, while **Special Protection Areas** are established specifically for the protection of birds under the EU Birds Directive. The Birds Directive outlines 197 threatened species for which protective measures are to be put in place.

Wildlife corridors are strips of natural land that connects two natural areas, across roads, farmland, or residential areas, allowing animals to move between them. This can help to prevent the negative impacts of fragmentation.

SESSION 6: Biodiversity careers and future

There are a wide range of careers in biodiversity advocacy to suit a wide range of interests and skill sets. Some are listed below.

Ecologists are scientists who study the interactions between animals, plants and their environment. They are often involved in observation and fieldwork studies, examining environments, performing data analysis, conservation and management, remediation, education and outreach. They may work mainly in the field or in the lab. **Restoration ecologists** specifically help to restore and remediate damaged ecosystems.

In addition to ecologists, there are several specific fields that relate to conservation:

- **Marine biologists** are those who specifically study or work in marine systems.
- **Botanists** study plants, including their role in ecosystems, their conservation and environmental management.
- **Climate scientists** analyse data on changes in the atmosphere, temperature, weather, and use models to predict current or future environmental conditions and humanity's impact on them.

Conservation rangers are civil servants who maintain an assigned geographic area, and enforce laws that protect biodiversity. Their work is a combination of both office and fieldwork, and often requires significant amounts of travel. Their tasks can be very diverse, including maintenance, law enforcement, managing conservation work, environmental surveying, and public queries. As such, this is a varied and interesting career, as demonstrated in this video.

Environmental policymakers are experts who combine understanding of biology, economics and politics. Their role involves creating laws, guidelines and regulations put in place to safeguard the environment against degradation and to protect biodiversity. They may create laws relating to pollution, land use and resource management, among other things. They may work for government bodies, enacting legislation, or for corporations, creating policies committing to environmental stewardship. With no fieldwork, this career would suit someone who prefers office work and has an interest in policy and law.

Science communicators make scientific data and biodiversity issues accessible to the public through creating informative media. This role involves processing data and presentation, potentially including aspects of writing, graphic design, public speaking, or content generation. As such, this is an occupation that combines scientific understanding with creativity and good communication skills.

The future of conservation work is a field set to be of increasing importance and funding in the future, due to the numerous issues facing biodiversity and our increased recognition of its importance. There are a wide variety of occupations within the field to suit the preferences of any person who wants to undertake this essential work.

About Green Foundation Ireland

Green Foundation Ireland aims, through education, to inspire the public to work towards a sustainable society for Ireland.

Green Foundation Ireland (GFI) is an independent registered charity which promotes education for sustainability in Ireland. It is affiliated to the Green European Foundation (GEF).

GFI aims, through education, to create public support for a sustainable society and economy in Ireland and elsewhere. We aim to engage with both the arts and sciences to create a new environmental narrative that promotes action to conserve and protect life on earth.

For more information about what Green Foundation Ireland does, or if you would like to contribute to our work in any way, please contact us at:

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