

Biodiversity: an introduction

Workshop background document for capacity building in the framework of the Life+ supported project, European Capitals of Biodiversity.

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Table of Contents

1. Background	5
1.1 Objectives and expected outcomes	5
1.2 Target audiences	5
2. Basic Theory	5
2.1 Definition of biodiversity	5
2.2. Types of biodiversity	6
2.3 Gaining and losing biodiversity	6
2.3.1 Island Biogeography	6
2.3.2 Measuring diversity	7
2.3.4 Gaining Biodiversity	8
2.3.5 Losing Diversity	9
3. Abundance and Composition	9
4. The Stability and Functioning of Ecosystems	10
4.1 Diversity and Ecosystem Functions	11
5. Patterns in Space	12
6. Biodiversity Patterns in Time	12
7. How many species are there?	13
7.1 Biodiversity in Europe	13
7.2 Biodiversity in your country	14
7.3 Biodiversity in your municipality	14
8. Why conserve biodiversity?	14
8.1 The importance of biodiversity	14
8.2 The Benefits of Biodiversity	15
8.2.1 Biological Resources	15
8.2.2 Ecosystem Services	15
8.2.3 Social Benefits	16
8.2.4 Economic Benefits	16
8.3 Benefits of urban biodiversity	17
8.3.1 Environmental	17
8.3.2 Economic benefits	17
8.3.3 Social benefits	19
8.4 Motivations for Conserving Urban Biodiversity	19

9. Global biodiversity trends	21
9.1 The IUCN Red List.....	21
9.2 WWF's Living Planet Index	23
10. What threatens our biodiversity?	24
10.1 Humans have extensively altered the global environment.....	24
10.1.1 Habitat loss and fragmentation.....	24
10.1.2 Invasive alien species	24
10.1.3 Pollution	25
10.1.4 Climate change	25
10.1.5 Over-exploitation of natural resources	25
10.1.6 Human populations	25
10.1.7 Single crop agriculture:	26
10.2 Local trends and drivers of biodiversity loss	26
11. Biodiversity Law and Policies	26
12. Glossary	26
13. References	26

1. Background

In the framework of the LIFE+ supported project, *European Capitals of Biodiversity*, this background document has been prepared by IUCN to support a series of capacity building workshops for municipal staff in France, Germany, Hungary, Slovakia and Spain. This module covers the basic theory, trends, and benefits of biodiversity. Its objectives and target audiences are as follows.

This document was updated with project examples taken from all European Capital of Biodiversity competitions. This update was done By Deutsche Umwelthilfe (DUH) after the end of all competitions.

1.1 Objectives and expected outcomes

In undertaking this module, participants should:

- Develop a working knowledge of the main biodiversity theories;
- Comprehend the social, economic and environmental benefits of biodiversity with a focus on urban biodiversity;
- Gain an understanding of the key issues and major trends concerning biodiversity; and
- Heighten their awareness of the major threats to biodiversity and drivers of biodiversity loss.

1.2 Target audiences

- Local and regional decision makers;
- City and regional managers;
- Heads of departments;
- Interested council members;
- Municipality staff with responsibilities in the field of urban planning, strategic nature protection, environmental management and municipal services, who wish to refresh their knowledge;

2. Basic Theory

2.1 Definition of biodiversity

The word “biodiversity” is simply a contraction of the term, “biological diversity”. The United Nations Convention on Biological Diversity defines biological diversity as:

"Biological diversity" means the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.

2.2. Types of biodiversity

Biodiversity is a generic term that can be related to many environments and species, for example, forests, freshwater, marine and temperate environments, the soil, crop plants, domestic animals, wild species and micro-organisms.

Biodiversity can be classified at the following three distinct levels:

1. **Genetic diversity** describes the variation within a particular species;
2. **Species diversity** describes the variation between different species; and
3. **Ecosystem diversity** describes the variation within and between different ecosystems of the world, comprising habitats, the species that they contain and the processes and interactions occurring between the biological and physical components.

Taxonomically isolated species are of particular importance as they have more unique genetic structures. Such species are often endemic meaning that they are only found in one specific area. In general, their extinction would incur a greater loss for global biodiversity than the extinction of a normal species.

2.3 Gaining and losing biodiversity

Since life began some 3.8 billion years ago, global biodiversity has of course increased, albeit with several mass extinctions en-route. The current mass extinction is human-generated and the greatest since that which claimed the dinosaurs. At the local scale, biodiversity is more prone to large fluctuations at shorter time-scales. To understand the processes of losing and gaining biodiversity, it helps to understand the theory of island biogeography and how biodiversity is measured. These topics are covered below.

2.3.1 Island Biogeography

The theory of island biogeography, developed by MacArthur and Wilson (1967), applies to the patterns of diversity found on islands. In it, islands (including lakes, isolated patches of habitat, peninsulas, bays and other partially isolated areas) start out empty of species, which arrive from a large area, known as the mainland and from adjacent islands.

The greater the distance between the island and the mainland, the lower is the probability that a species will colonise that island. Also, the smaller the island is, the smaller the residing populations are and thus the greater their vulnerabilities to extinction. So in effect, the number of residing species on any given island is determined by the rate at which new species arrive and old species go extinct. Figure 1 illustrates these principles.

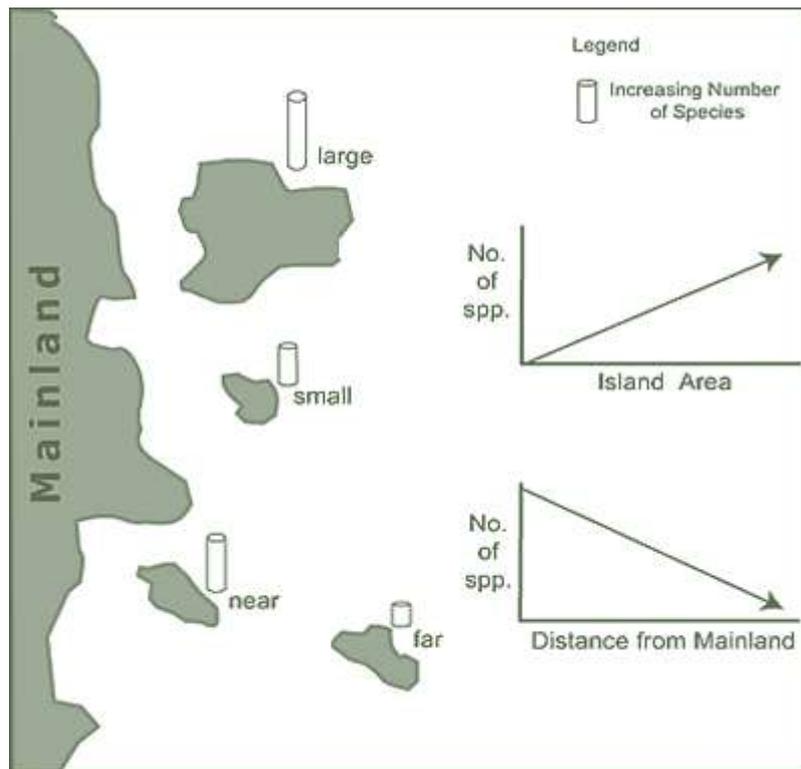


Figure 1. Island biogeography (image from: www.on.ec.gc.ca/wildlife/ecogifts/biog-e.html).

This theory is based on a number of assumptions. For example, it considers all species to be equal which, of course, is not the case in reality. Nevertheless, the theory can be successfully employed to predict the number of species on an island.

2.3.2 Measuring diversity

Quantifying biodiversity is difficult as it has many components that cannot be conveyed in a single number. Three common methods exist:

1. **Numbers:** The number of species in a particular area, the number of alleles in a locus, or indeed the number of taxonomic or functional groups in an ecosystem, all provide reasonable but incomplete indications of biodiversity. An inadequacy of this method is the difficulty of standardising measures at different scales.
2. **Evenness:** At the species level, this method measures the extent to which individuals are evenly distributed among species. Indices (e.g. Shannon-Weaver and Simpson indices) are used to reflect the species number and evenness in a single value.
3. **Difference:** This method takes account of the evolutionary distances between different units. This method considers a number of closely related species to comprise lower diversity than the same number of distantly related species. Measurements of difference include disparity and trait diversity.

2.3.4 Gaining Biodiversity

Mutations

Mutations alter the genetic makeup of organisms and in doing so, increase genetic diversity. Mutations can be inherited by the offspring of an individual and may or may not be expressed as traits. This is a relatively slow process but ultimately the only way in which diversity is truly created.

Speciation

This process predominantly affects species level diversity, in that it leads to the creation of novel species. Speciation arises via three different ways: geographical isolation, competition, and polyploidy.

1. **Geographical isolation** results from the division of a population into two or more separate sub-populations usually caused by natural phenomena e.g. the rise of a new mountain chain or the lowering of a lake's water levels. Sub-populations may diverge to become separate species if, over time, they adapt to their separate environments or randomly mutate to a sufficient extent.
2. **Competition:** When a new exploitable resource becomes available, individuals within a given population may benefit from choosing to specialise on only one resource (i.e. either the new or the original resource). Speciation can arise when the offspring of parents that specialise on the same resource are more viable than the hybrid offspring of parents that specialise on different resources.
3. **Polyploidy:** This process occurs mainly in plants. When diploid species (species that inherit two copies of each chromosome – one from each parent) have, by errors at the cellular level, too many chromosomes and as such cannot produce functional offspring with other individuals of their own species, they may self fertilise to produce polyploid species.

Immigration

Immigration is the influx of biological resources into a given area, thereby increasing biodiversity initially. Immigration rate depends on the size and location of the area in question, as well as the capacity of the area to accommodate and support additional species. High immigration rates may help to sustain otherwise unviable populations. The aforementioned theory of island biogeography sheds light on how such factors affect immigration. It should be noted that whilst immigration enhances biodiversity initially, the introduction of some species, notably invasive alien species, can drastically disrupt and degrade ecosystems and biodiversity.

Succession

Succession is the process through which an area gains species as successive communities modify their immediate environment and are replaced by better adapted communities until an endpoint, called the climax community, is reached. Succession may begin with the colonisation of bare rock by pioneer species. Different regions have different local climax communities e.g. tundra of the north, grasslands of prairies or the rainforests of the tropics. As succession progresses, local biodiversity generally increases.

2.3.5 Losing Diversity

Extinction

Over 99% of the species that ever existed are now extinct due to natural processes. Genes that fail to be inherited by the next generation may also go extinct. Ecosystems may go extinct if the species that constitute them are lost.

Extirpation

Species can also go locally extinct (whilst continuing to exist elsewhere); in which case, they are said to be extirpated. The same can happen to genes e.g. when particular alleles are lost in one population but maintained in another.

Competition

By altering the abundances of a species, competition directly affects both the evenness and genetic makeup of a community, and thus can affect biodiversity. In some cases, dominant species may competitively exclude other species resulting in the extirpation or even extinction of weaker species.

Disturbances

Intermediate levels of disturbance can enhance biodiversity but extremes can reduce it. Too much disturbance promotes early successional stages which usually have impoverished biodiversity. Too little disturbance and climax communities will be easily reached largely excluding the species found at earlier successional stages.

Bottlenecks

When many individuals in a population die, the remaining survivors carry only a fraction of the genetic diversity that originally existed. The population size typically recovers much faster than its genetic diversity does and thus the population has a shallower gene pool than before. The shallower gene pool reduces the population's ability to respond to altered conditions.

3. Abundance and Composition

Diversity is affected by changes in the relative numbers of individuals in species. This section considers the abundance of individuals and composition of communities.

Trade-offs

Species must make trade-offs between different traits that confer different abilities. Examples of such trade-offs include: competitiveness vs. offspring dispersal; growth vs. survival; aquatic locomotion vs. terrestrial locomotion; thriving in average stable conditions vs. being able to take advantage of sudden pulses of resources etc.

Variable Environments

Environments vary both spatially and temporally. As environmental variation increases, new niches become available which can accommodate more species.

Niches

The niche of a species is a region in a multi-dimensional space of environmental factors that affect the welfare of that species (Hutchinson 1957). Species tend to use niches in which they can avoid competition. If the niches of two species are too similar then one species will competitively exclude the other.

The way in which niches are filled with biota is known as “niche packing”. The number of species that fit into an ecosystem and the abundance of each species is determined by both the allocation of resources to different species and the way that those species fit into their respective niches e.g. whether additional species invade occupied niches or only unused ones, and whether the size of the niche affects the likelihood of invasions.

Keystone Species

Species with ecosystem roles that are disproportionately important relative to their abundance are known as keystone species. The niches and interactions of such species affect their ecosystem as a whole. Changes in the abundance and distribution of keystone species can thus have profound effects on the status of other species and indeed the pertaining ecosystem.

Catastrophes

Catastrophes disturb ecosystems resulting in earlier successional stages and the altered abundance and composition of species. The presence of species from earlier successional stages in an otherwise late successional ecosystem increases diversity.

Chance

Composition and abundance are also affected by chance events. For instance, the order in which different plant species colonise a new island can considerably affect which tree species will become dominant. The loss of one species can result in the loss of other species that depend on it, even if the dependent species are otherwise successful and well-adapted. Naturally varying climatic conditions also impact upon the success of different species.

4. The Stability and Functioning of Ecosystems

Ecological functions involve "ecological and evolutionary processes, including gene flow, disturbance, and nutrient cycling" (Noss 1990). The ecological functioning of biodiversity itself is a complex field.

Functional Types and Functional Equivalence: Species performing similar ecosystem functions can be grouped into functional types. Functionally equivalent species are considered to compete with one another but, if examined in finer detail are usually found to occupy slightly different niche spaces that allow them to coexist. For example different herbivores may be regarded as functionally equivalent but may in fact feed on different plant species or even different parts of the same plant. Species of different functional types (e.g. carnivores and herbivores) tend not to compete over resources.

Functional Diversity: The functional diversity of an ecosystem is determined by both the diversity of functional types and the number of functionally equivalent species in each functional type. Usually, high functional diversity creates stability in an ecosystem because functional diversity increases the ability of the ecosystem to cope with environmental change.

4.1 Diversity and Ecosystem Functions

There are numerous theories about how species richness affects the functioning and stability of ecosystems (e.g. Rivet hypothesis, Redundancy hypothesis etc.). Despite some conflict between these theories, it is generally accepted that, in most cases, increasing the number of species confers an increase in the number ecosystem functions.

The relationship between diversity and stability is still a hotly debated issue, but the current general consensus is that increased diversity does enhance the resistance and resilience of ecosystems and thus increase stability. This is due to several reasons:

1. **Insurance effect:** Increases in the number of species broadens the range of conditions that at least some species can survive in. This increases the chance that in light of a disturbance, vital ecosystem functions will be upheld or at least promptly restored.
2. **Averaging effect:** This is a statistical effect due to the summing of random variables. If all species have differential responses to environmental change, then the averaging of these responses will produce a more temporally stable ecosystem if there are more species in that ecosystem (Doak *et al.* 1998).
3. **Negative covariance effect:** Increases in diversity tend to heighten the competition for resources. In a diverse and competitive environment, the decline of one species may be offset by the gains of another, which helps to maintain ecosystem functions.
4. **Resistance to invasion:** Diverse communities tend to utilise a greater range of available niches, thus reducing the vacancy for invading species to fill. Also, in diverse communities, the impact of an invading species on ecosystem properties or processes is generally lower.
5. **Resistance to disease:** Diversity helps to thwart the transmission and prevalence of disease, by lowering the proportion of susceptible species to a particular disease and widening the distance between infectious individuals or populations.

Food web structure affects stability too. Food webs with strong links (i.e. with species which are highly dependent on other species) are less stable than those with weak links, as the stronger the link, the greater the ecosystem repercussions of population changes in a given species.

The relationship between biodiversity and ecosystem stability has high socio-economic relevance. The ecosystem services upon which humans depend so heavily are upheld by biodiversity.

5. Patterns in Space

Latitude

With few exceptions, species diversity decreases poleward from the tropics. This is thought to be due to the facts that relative to the tropics, the poles receive less solar energy, endure greater climatic variation, and are frequently ravaged by glaciers.

Area

With all else being equal, larger areas usually harbour greater biodiversity although this trend is not linear – the rate of finding additional species slows down with increasing area. Species-area curves can be used to predict the species richness in an area being studied. Compared with smaller areas, large areas can accommodate larger samples of biodiversity, encompass a wider range of habitats, and according to the aforementioned island biogeography theory, experience lower extinction rates and higher immigration rates.

Altitude and depth

As altitude increases, temperatures drop, seasonal variability increases, and areas shrink, all of which contribute to a fall in biodiversity. In marine environments however, the greatest biodiversity is found on the seabed, at least until a certain depth, beyond which the ocean floor has impoverished biodiversity.

Habitat diversity

The greater the habitat heterogeneity of an area, the greater the number of different niches and thus the greater the total number of species.

Hot spots

Areas that have exceptionally high biodiversity, especially biodiversity that is rare or scientifically unusual are termed, hotspots. Hotspots are typically afforded high protection and subjected to strong conservation efforts, as many species can be effectively protected with the same measures.

Productivity

The relationship between productivity and biodiversity is a disputed issue. Productive areas generally harbour more species, but only up to a certain point. At extremely high levels of productivity, only a few species begin to dominate, thereby excluding other species and impoverishing biodiversity.

6. Biodiversity Patterns in Time

Seasons

The biomass and number of individuals in a given area vary considerably between seasons as offspring are born, bee numbers proliferate then diminish, trees lose and regain their leaves, and annual plants flourish before receding to seeds. Despite such changes the actual diversity of species present remains fairly constant, with any fluctuations being largely attributable to migratory species.

Succession

The aforementioned process of succession tends to increase diversity, at least until the climax community is reached. Within a large late-successional community, small perturbations can increase the species richness by creating patches of varying successional stages with different species.

Ice ages

Over multi-millennial time scales ice ages create large scale disturbances to ecosystems that are very slow to recover. The last ice age peaked around 20 000 years ago.

Evolutionary time

Over billions of years, biodiversity has increased, albeit entailing several mass extinctions. In evolutionary time-scales, new species commonly arise, but new groups at higher taxonomic classification (e.g. class, phylum etc.) rarely arise.

7. How many species are there?

It is important to bear in mind that only 1.7-2 million of the 5 to 30 million species that are thought to exist on Earth have been identified so far (Greenfacts 2009). In this section we will outline biodiversity in Europe before discussing local biodiversity.

7.1 Biodiversity in Europe

Biodiversity in Europe is distributed heterogeneously. Northern Europe has relatively impoverished biodiversity, whilst the Mediterranean region and Eastern Europe harbour Europe's richest biodiversity, with numerous endemic plant species too. The Mediterranean Sea is Europe's marine biodiversity hotspot.

Approximately 200 000 animal and plant species are found in Europe. Intensive agricultural practices, heavy industrialisation and high population densities have impoverished much of the EU's biodiversity, particularly in Western Europe. 335 vertebrate species are at risk of extinction, including the Iberian lynx, brown bear and all of our sea mammals. Around 38% of our bird species, 45% of our butterfly species and 5% of our mollusc species are also threatened. Our fish stocks are in dire states, with over 80% facing collapse or of unknown status. 800 plant species occurring in Europe are threatened with global extinction and already 64 of our endemic plant species have gone extinct in the wild. Domestic animals have also suffered with nearly 100 breeds becoming extinct in recent times and a further 30% of surviving breeds at risk of extinction. (European Commission 2005)

Our ecosystems are also in peril. Over half of the EU's wetlands have disappeared and only a small fraction of its once extensive forest remains. Ancient and semi-natural woodlands continue to shrink and degrade as do species rich agricultural habitats. Most of Europe's marine ecosystems are severely disrupted.

Box 1. Bird diversity in Szentes, Hungarian Capital of Biodiversity 2011

Best practice from the European Capitals of Biodiversity competitions

Szentes is located in the southern part of the Hungarian Great Plains. Surrounded by two rivers, the city is particularly rich in various bird species. The Kurca river, which divides the town into two parts, provides ideal habitats for water and reed birds. A rich vegetation along the riverbanks provides habitat for species like *Tachybaptus ruficollis*, *Ixobrychus minutus*, *Rallus aquaticus*, *Porzana porzana*, *Acrocephalus palustris*. Furthermore, due to thermic activities the Kurca river does not freeze in winter, which makes the area an excellent resting and wintering site for rare domestic and migratory bird species, such as *Phalacrocorax pygmeus*, *Bucephala clangula*, *Tringa ochropus* and *Alcedo atthis*. At the Thermal Lake (122 hectare), which is 5 kilometres from town, ornithologists have observed 172 bird species of which 60 species are resident birds. Some notable examples are: *Phalacrocorax pygmeus*, *Tadorna tadorna*, *Aythya marila*, *Clangula hyemalis*, *Haliaeetus albicilla*. The lake can be accessed from town on a scenic bicycle-path, providing many bird watching opportunities.

Scattered mosaic areas of sodic and grass meadows cover large extent from the north-east to the south-east of the town. Some well-connected part, called the Cserebökény Pustas are a protected area and have belonged to the Körös-Maros National Park since 1997. Almost 200 bird species have been identified in the area of which 15 are highly protected. Significant migrating birds are: *Buteo rufinus*, *Buteo lagopus*, *Falco peregrinus*, *Pluvialis apricaria*, *Carduelis flavirostris* and *Plectrophenax nivalis*.

Further details on the city of Szentes can be found at: www.szentes.hu

7.2 Biodiversity in your country

(National Partner please contribute details of your country's biodiversity)

7.3 Biodiversity in your municipality (interactive session)

This session provides an opportunity to gauge the knowledge of the municipal staff and liven up the workshop.

Possible discussion topics:

- Biodiversity present in your municipality;
- Locally iconic species and habitats;
- Observable changes to biodiversity in living memory.

8. Why conserve biodiversity?

8.1 The importance of biodiversity

Biodiversity confers to humanity, vast provisions termed, 'ecosystem services'. These services regulate the climate, purify the air and water, fertilise soils and decompose wastes. They supply us with the tools and requirements for developing medicines, fuels, fibres and construction materials, and they inspire us to develop

some of the world's most useful technologies, a practice known as biomimicry. Indeed, there are valuable scientific, educational, aesthetic and spiritual attributes of biodiversity that strongly merit conservation for the benefit of future generations. In effect, biodiversity underpins human health and economic prosperity.

As previously discussed, a variety of species covering a variety of structural and functional roles engenders some resistance and resilience to natural systems.

8.2 The Benefits of Biodiversity

The benefits of biodiversity conservation can be categorised as follows:

8.2.1 Biological Resources

- **Food:** 5 000 different plant species have been used as food for humans but today less than 20 feed the majority of the world's population, with only 3 or 4 carbohydrate crops dominating our calorific intake.
- **Pharmaceutical resources:** 118 of the world's top 150 prescription drugs are derived from biological resources, mainly plants e.g. Aspirin from willow trees; quinine from quina trees; and taxol from Pacific yews. Many animal extracts have also been found to have medicinal properties e.g. certain snake venoms are the basis for substances which enables blood clots to form; and Caribbean sponges can be used to combat rejection of organ transplants.
- **Agriculture:** The genetic diversity of crops and livestock is important in defending those assets from the effects of diseases and pests. Insects pollinate crops; earthworms aerate soil; many amphibians prey upon agricultural pests like slugs; ladybirds control aphid numbers; and passerine birds control caterpillars.
- **Population reservoirs:** Healthy ecosystems can support commercially valuable environmental benefits e.g. natural areas can provide spawning grounds for lucrative fish species.
- **Resources not yet identified:** Only a small fraction of the total number of species have been described, with the proportion of species that has been tested for useful properties being even smaller. Under-utilised food crops may become important in the future and bioprospecting activities will unearth novel medicines.
- **Wood products:** Throughout the world, wood is relied upon as a source of fuel, construction material, furniture and paper.
- **Pets and ornamental plants:** Certain organisms are used for aesthetic purposes.
- **Agents for crop improvement or biological control:** In some cases, biological resources have been shown to offer more sustainable alternatives to chemical fertilisers and pesticides.

8.2.2 Ecosystem Services

- **Protection of water resources:** Vegetation plays a vital role in hydrological cycles, including cloud formation, water purification, and the regulation of flows.

- **Soil formation and protection:** Vegetation and soil microbes help to create and maintain soil structure and retain moisture and nutrient levels.
- **Nutrient storage and recycling:** Biodiversity plays a critical role in the cycling of nutrients between the atmosphere and soil. Microorganisms replenish the soil's nutrients by decomposing organic wastes whilst plants uptake those nutrients and form the basis of food chains.
- **Pollution break down and absorption:** Pollution is detrimental to ecosystems although some microorganisms and higher life forms can breakdown and assimilate pollutants. Wetlands are particularly effective in this respect.
- **Contribution to climate stability:** Natural areas influence the climate by affecting, inter alia, transpiration (release of water vapour via plants into the atmosphere) rates and surface albedo (the fraction of reflected solar irradiance).
- **Recovery after unpredictable events:** Fires, floods, storms and other perturbations disrupt ecosystems. Healthy ecosystems tend to recover better than degraded systems.

8.2.3 Social Benefits

- **Research and education:** Natural areas provide us with excellent living libraries for improving our understanding of biodiversity and helping us to utilise it sustainably.
- **Recreation and tourism:** Biodiversity is a focal point for tourism and recreational pursuits such as hiking, photography, wildlife watching etc.
- **Cultural values:** Human societies have evolved as part of the biodiversity around them and so certain aspects of biodiversity have profound significance in many cultures. Biodiversity provides inspirational, aesthetic, spiritual and educational stimulation for cultures the world over.

8.2.4 Economic Benefits

All three of the above categories of biodiversity benefits have huge direct and indirect economic values although such values are often difficult to quantify. Forestry, fisheries, agriculture, tourism and recreational sports are multi-billion pound industries which depend heavily on biodiversity.

Most worthy of note is *The Economics of Ecosystems and Biodiversity* (TEEB) which is a major international study that aims to highlight the value of the global economic benefits of biodiversity and the growing costs of biodiversity loss and ecosystem degradation. The study draws together expertise from the fields of science, economics and policy to enable practical actions moving forward. For more information visit: www.teebweb.org.

According to the TEEB study, damage to global ecosystem services and biodiversity is acute and accelerating. In the last century we have lost 35% of mangroves, 40% of forests and 50% of wetlands. 60% of ecosystem services have been degraded in fifty years. Species loss is 100 to 1,000 times than in geological times and will get worse with climate change. 80% of the world's fisheries are fully- or over-exploited.

Critical thresholds are being passed: for example, coral reefs risk collapse if CO₂ emissions are not urgently reduced.

Ecosystem damage carries costs for business and society: the number of sectors benefiting from natural capital represents a far larger share of the economy than many policy-makers appreciate. Failure to halt biodiversity loss on land may cost \$500 billion by 2010 (estimated value of ecosystem services that would have been provided if biodiversity had been maintained at 2000 levels). At sea, unsustainable fishing reduces potential fisheries output by an estimated \$50 billion/year. Another obvious example is the pharmaceutical industry: 25-50% of the sector's turnover (about US\$ 650 billion/year) is derived from genetic resources. Ecotourism is also fast-growing sector which generates significant employment and is now worth around US\$ 100 billion/year.

8.3 Benefits of urban biodiversity

With the majority of the world's population now living in urban areas and urban sprawl continuously encroaching into natural areas, urban biodiversity conservation has been receiving increasing attention of late. Petersen *et al.* (2003) identified the following benefits of urban biodiversity:

8.3.1 Environmental

- Ecosystem services
 - Provisioning services: Local residents can grow fruit and vegetables and in their allotments and gardens.
 - Regulating services: Water runoff, water purification, disease, pollination, climate.
 - Cultural services: Spiritual, aesthetic, religious, ecotourism, cultural.
 - Supporting services for all three of above: soil formation, nutrient cycling, and primary production.

8.3.2 Economic benefits

- Attraction of high quality professionals to peaceful green neighbourhoods.
- Increased job satisfaction, reduced work pressure, reduced incidence of headaches and other ailments, and ultimately increased productivity, for employees with physical and visual access to green spaces (Relf 2009).
- Greening business districts has been shown to improve customers' perceptions of those districts, thereby enhancing business activities (Project Evergreen 2009).
- Green civic areas may help to attract tourists to an area, bringing associated economic benefits.
- Increased retail activity – Retail areas that have flowers and greenery are thought to be more enticing to shoppers (Hauer 2006).

- Increased property prices – in Finland, it was found that properties dropped an average of 5.9% in price for every km from the nearest forested area and that properties with forest views were, on average, 4.9% more expensive than homes with otherwise similar characteristics (Tirväinen 1997; 2000).
- Trees help to thwart storm runoff thereby reducing the necessary scale and costs of flood defenses and urban drainage systems.
- Decreased air conditioning costs – vegetation can help to regulate temperatures, keeping buildings warmer in winter and cooler in summer.
- Inspiration for creative thinking e.g. technological bio-mimicry.

Additionally, the TEEB study is now attempting to quantify the direct contribution of ecosystems services to our economy, which have been so far underestimated or disregarded. Please see www.teebweb.org for more information.

Box 2. Semi-natural meadows inside the city, Zvolen, Slovakia

Best practice from the European Capitals of Biodiversity competitions

In 1994 a new church was built in Zvolen, on top of a cone-shaped hill. The church and the adjacent rectory building are mainly surrounded by spontaneously established vegetation (semi-abandoned meadows). At one side of the hill, a newly created Square of the Cyril and Methodius now forms a new center of the adjacent town district, which is made up mostly from prefabricated or similarly densely built housing estates.

The church hill is one of the few areas in the city with a well-preserved nature - with remnants of species-rich semi-natural grasslands. Therefore, this location is classified as an "urban bio-center" in the Landscape ecological plan of the town of Zvolen and therefore the area should retain its natural character.

Within the project this measures has been made at the area:

- Planting ornamental trees in the immediate surroundings of the church, based on a detailed plan of the garden architect;
- Selective removal of shrubs, weed cutting, increase of mowing intervals, and restoration of grassland;
- Planting the lime trees along walking tracks and in small groups of trees in open areas;
- Removal of soil dumps and establishment of grassland in their places; and
- Two mowings a year at carefully chosen times in order to maintain species diversity: three flowering periods are ensured by mowing after the first flowering in spring, with a second flowering period after that, and a third after the second mowing in late summer.

Further details on Zvolen can be found at: www.zvolen.sk

8.3.3 Social benefits

- Human well-being
 - Psychological benefits of exposure to nature have been shown to increase with biological complexity (Fuller *et al.* 2007).
 - Recovery times of hospital patients were found to be much faster for those with window views onto natural areas (Ulrich 1984).
 - General health benefits include:
 - Enhanced social interaction
 - Eased mental fatigue
 - Opportunities for reflection

In Australia, 2000, Parks Victoria launched its *Healthy Parks, Healthy People* programme, which aims to promote and realise the potential for parks to contribute to healthy communities. Maller *et al.* (2009) note that “recent research shows that ‘green nature’, such as parks, can reduce crime, foster psychological wellbeing, reduce stress, boost immunity, enhance productivity, and promote healing. In fact, the positive effects on human health, particularly in urban environments, cannot be over-stated.” The Healthy Parks, Healthy People initiative has spread to Canada, USA, New Zealand and the UK, forging partnerships with reputable health organisations that add credibility to the campaign by legitimising the link between a healthy park system and a healthy society through the authority of the medical profession.

For more information, please visit <http://www.parkweb.vic.gov.au/1grants.cfm>

- Leisure activities
 - Sport and exercise, playing, picnics, recreation, relaxation, gardening, social events like concerts, recovery from work stress.

8.4 Motivations for Conserving Urban Biodiversity

Dearborn and Kark (2009) identify seven key motivations for conserving urban biodiversity.

1. **To preserve important local biodiversity in an urbanizing environment.** Some important remnant habitats harbouring important species can be found in urban areas.
2. **To create stepping stones or corridors for natural populations.** Urban natural habitat patches can help some species to navigate across otherwise impassable urban areas and uphold their trans-urban ecological linkages.

3. **To understand and facilitate species' responses to environmental change.** The altered physical environments of cities provide insightful mediums in which to study species.
4. **To connect people with nature and provide environmental education.** Many urbanites rarely access rural areas and would be severely disconnected from nature in the absence of urban biodiversity. Furthermore, cities are centres of power and so it is important that decision-makers are exposed to biodiversity in order to develop compassion for it.
5. **To provide ecosystem services.** See above.
6. **To fulfill ethical responsibilities.** Urban natural areas allow urbanites who feel a sense of moral obligation to participate in nature conservation to do so easily.
7. **To improve human well-being.** See above.

Additionally, a growing consensus is now emerging on the economic motivation to protect biodiversity and ecosystems because of their direct contribution to our economy.

Box 3. Differentiated management of gardens and parks, Paris, France

Best practice from the European Capitals of Biodiversity competitions

The gardens of Paris are scattered in a compact urban context. Under the technical lead of the garden management department, a differentiated management of these green spaces was set up in 2007. An independent organization will eventually audit and certify greens spaces where the specific management is applied.

The differentiated management implies principles such as:

- Generalizing best practices aiming at a respectful care of both environment and people
- Adapting management to gardens' specificities and use
- Encouraging landscape, vegetation and animal diversity
- Emphasizing the historical and cultural identity of each garden.

The upkeep methods are categorized for each green space element (trees, shrubs, lawn/meadows, flowers, minerals and water). Each category is differentiated according to management goal, aesthetic aspect, usage and biodiversity. The gardeners' constant aim is to enhance the gardens' inheritance and public use while working towards reducing pollution and increasing biodiversity. A detailed technical folder helps spreading the necessary practices and knowledge. A specific folder for each garden enables a consistent implementation of the upkeep. The differentiated management and related subjects such as composting, alternatives to chemical pest control, or water management are taught in specific training sessions for the gardeners.

Further details on Paris can be found at: www.paris.fr

9. Global biodiversity trends

All of the Earth's ecosystems have been disrupted to a some extent by anthropogenic forces. Already 35% of mangroves and 20% of coral reefs have been destroyed. In particular, over the last few decades, the following land areas have been subjected to severe degradation:

- the Amazon basin and Southeast Asia (deforestation and expansion of croplands);
- Asia (land degradation in drylands); and
- Bangladesh, Indus Valley, parts of Middle East and Central Asia, and the Great Lakes region of Eastern Africa.

Land conversion for agriculture and other uses has continued at a steady pace over the last century, shrinking forests and fragmenting habitats.

Extinction is a natural process although current extinction rates far exceed the rate at which biodiversity is being generated. It is thought that over the course of the last century, due to human pressures, extinction rates were at least 100 times higher than the natural rates would have been.

9.1 The IUCN Red List

The global conservation statuses of thousands of species are documented in the IUCN Red List. The extinction risks of the assessed species are evaluated based upon a set of precise criteria that are relevant to all species and all regions of the world. By drawing the attention of the public and policy-makers to the poor status of many iconic species, the Red List helps to motivate the international community to better address conservation issues.

Based on criteria including the rate of decline, population size, geographical distribution, and degree of fragmentation, species are classified into the following categories:

- **Extinct (EX)** - No individuals remaining.
- **Extinct in the Wild (EW)** - Known only to survive in captivity, or as a naturalized population outside its historic range.
- **Threatened:**
 - **Critically Endangered (CR)** - Extremely high risk of extinction in the wild.
 - **Endangered (EN)** - High risk of extinction in the wild.
 - **Vulnerable (VU)** - High risk of endangerment in the wild.
- **Near Threatened (NT)** - Likely to become endangered in the near future.
- **Least Concern (LC)** - Lowest risk. Does not qualify for a more at risk category. Widespread and abundant taxa are included in this category.
- **Data Deficient (DD)** - Not enough data to make an assessment of its risk of extinction.
- **Not Evaluated (NE)** - Has not yet been evaluated against the criteria.

The term ‘threatened’ refers to a grouping of the three categories: Critically Endangered, Endangered, and Vulnerable.

The category of every species is re-evaluated every 5-10 years through a process of peer reviewing in the IUCN Species Survival Commission Specialist Groups.

The 2008 Red List confirmed the current extinction crisis and warned that nearly a quarter of all mammals are “at risk of disappearing forever”. For different taxonomic groups, figure 2 shows the proportions of threatened species based upon the 2008 Red List.

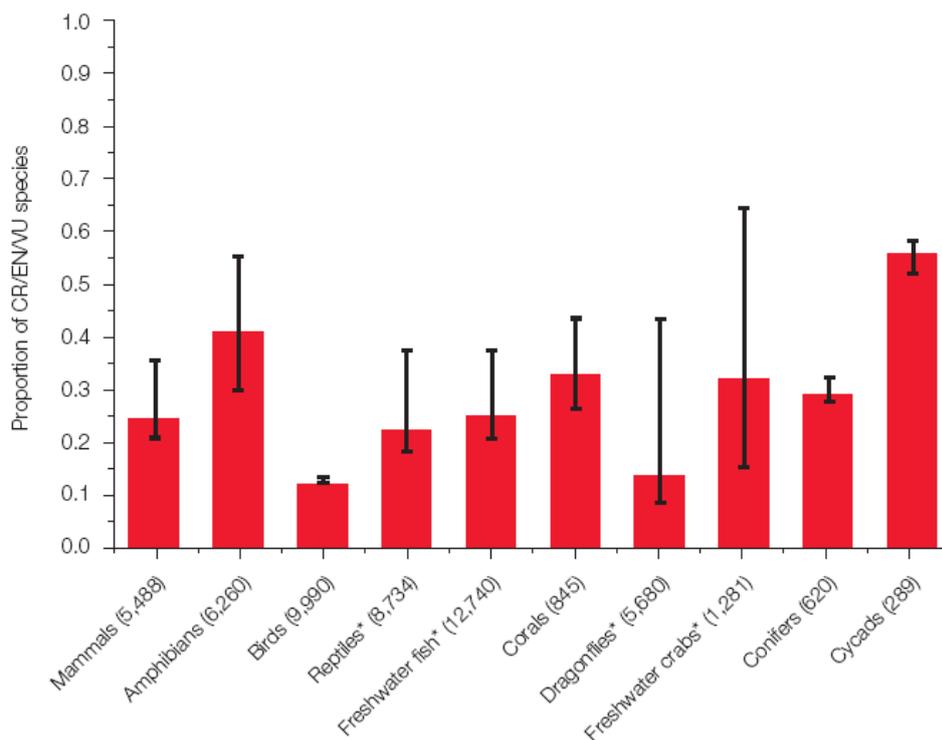


Figure 2. Proportion of species threatened with extinction in different taxonomic groups. Asterisks indicate those groups in which estimates are derived from a randomized sampling approach. The estimates assume that Data Deficient species are equally threatened as non-Data Deficient species; error bars show minimum and maximum estimates if all Data Deficient species are Least Concern or threatened, respectively. Numbers on the horizontal axis indicate the total number of described species in each group. Corals include only warm water reef-building species. (Vié *et al.* 2009)

The sharp population declines of many species groups including amphibians, African mammals, and birds in agricultural lands, have greatly retracted the geographical range of these species.

Box 4.: Bat protection, Ratekau, Germany

Best practice from the European Capitals of Biodiversity competitions

Bats are a typically urban animal species. They sleep, breed and spend the winter in church towers, roofs or other building structures and hunt in gardens and parks at night. In the small town of Ratekau in the North of Germany, both private house owners and the local authority have embraced bat conservation. Bat boxes have been installed on all public buildings to give bats resting places during the day and to raise their offspring. The new school building and the fire brigade were planned and constructed in a bat-friendly from the beginning. In 2011, over 60 bat boxes were available for the nocturnal animals on public buildings alone. The authorities advise and support house owners who want to renovate their houses or who discover nursery roosts in their attics. Furthermore, the town has bought five old bunkers in the nearby forest, which were no longer used by the German armed forces, and together with young people turned them into wintering grounds for bats. An old pump station was also refurbished as a bat home in winter.

The measures have been successful: regular monitoring shows that all bunkers and the pump station have been populated by Natterer's Bats (*Myotis nattereri*) and Brown Long-eared Bats (*Plecotus auritus*). Pond Bats (*Myotis dasycneme*), a regionally endangered species, have also been discovered. In a private home, a nursery roost of no less than 150 individuals was once found. More projects are being developed to ensure that Ratekau remains a bat-friendly township in the future.

Further details on Ratekau can be found at: www.ratekau.de

9.2 WWF's Living Planet Index

WWF's Living Planet Index tracks trends in the abundance of 1 313 wild vertebrate species. As shown in figure 3, the index has fallen by around 30% since 1970.

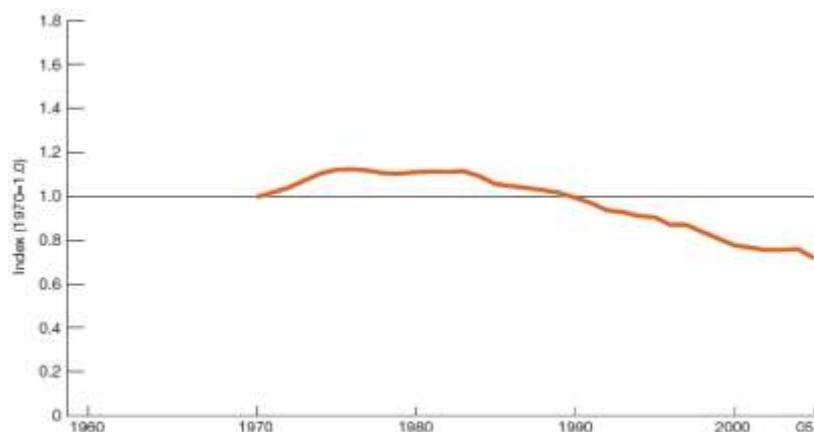


Figure 3. Living Planet Index 1970-2005 (WWF 2008).

Intensive agriculture, augmented with specialization by plant breeders and the homogenizing effects of globalization have greatly impaired the genetic diversity of domesticated plants and animals. A third of the world's 6 500 domestic breeds are now threatened with extinction.

10. What threatens our biodiversity?

10.1 Humans have extensively altered the global environment

Human's alteration of the environment has triggered the 6th major extinction event in the history of life. In just three centuries, the combustion of fossil fuels and widespread deforestation have increased atmospheric CO₂ concentrations by a third with well over half of that increase occurring in the last 50 years. This, coupled with a doubling of atmospheric CH₄ concentrations, has given rise to the most rapid climate change at least since the end of the last glaciation, 18 000 years ago. Industrial fixation of nitrogen, mainly for the production of fertilisers, has more than doubled the terrestrial fixation of gaseous nitrogen into biologically available forms. In the Earth's developed river basins, urban and agricultural run-off nutrients have intensified causing drastic ecological changes in freshwater and marine ecosystems. Around half of the world's ice free land surface has been converted into urban or agricultural land. Humans dominate a third of net primary productivity on land and harvest fish that account for 8% of ocean productivity. We utilise well over half of the world's available freshwater, and this demand is skyrocketing. We have transported organisms across geographical barriers that long kept the biotic regions of the Earth separate. (Chapin *et al.* 2000)

The unprecedented pressures that humans exert on nature are ultimately responsible for the rapid degradation and depletion of biodiversity. What follows are some of the severest anthropogenic drivers of biodiversity loss.

10.1.1 Habitat loss and fragmentation are widely regarded as the primary drivers of biodiversity loss. The clearance of native vegetation for agriculture, drainage of wetlands for development, flooding of valleys to create dams, and urban sprawl, have destroyed extensive natural areas, resulting in a loss of habitat for many species and undermining the integrity of pertaining ecosystems. As habitats shrink, so does their natural capacity to filter pollutants, detoxify water, recycle nutrients and decompose organic wastes. New constructions often increase land erosion, which in turn increases siltation in water ways. Pollution emissions are invariably exacerbated by development, which further impairs biodiversity and the functioning of ecosystems.

Human infrastructures have also fragmented habitats thereby obstructing the movement of organisms, diminishing sub-populations of wild species below critical thresholds, and severing important ecological linkages.

10.1.2 Invasive alien species constitute the second greatest threat to biodiversity worldwide. Exotic species can wreak havoc on the naturally occurring species within an ecosystem. They can dominate entire ecosystems and competitively exclude native species resulting in the degradation of biodiversity and ecosystem functioning. Exotics may prey on native species or modify and usurp their habitats. They are usually introduced accidentally, but many have been introduced intentionally. Invasive alien species are responsible for multi-billion Euro losses in the fishing, forestry and agricultural sectors. The problem is expected to worsen in the future, in line with escalating climate change, global trade and tourism. There are many examples. You can find out which invasive alien species are present in your region

by visiting the Global Invasive Species Database at: www.issg.org/database/species/search.asp?st=100ss .

10.1.3 Pollution poisons the water, soil and atmosphere and mainly arises from transport, industry, construction, extraction, power generation, agriculture and forestry. Pollutants may impact on biodiversity directly or, by unbalancing the chemical constituents of ecosystems, indirectly. Marine pollution is inflicting serious damage to coral reefs and estuarine systems throughout the world. Reductions in the plant diversity of Polish grasslands have been attributed to the effects of air pollution. Acid deposition, resulting from sulphate and nitrate emissions, has damaged many European forests and eradicated life in numerous Scandinavian lakes. Acid deposition is also known to soften birds' eggs by dissolving their calcium carbonate shells. (Naturopa 1996)

10.1.4 Climate change, resulting from increased atmospheric greenhouse gas concentrations, constitutes a profound emerging threat to biodiversity. Sea level rise and ocean acidification, changing precipitation patterns, rising global average temperatures, and increases in the frequency of extreme weather events will distort the abundance and distribution of species. Indeed a growing body of evidence suggests that such impacts are already occurring. As habitat ranges shift polewards, the species they harbour may struggle to keep pace. Many species will be deprived of the niches to which they have adapted, and risk extinction. Ecosystems will deteriorate.

10.1.5 Over-exploitation of natural resources has already led to widespread destruction of ecosystems. Biodiversity is exploited for construction materials (e.g. timber), industrial products, food, pet trade, fashion (e.g. fur), and traditional medicines (e.g. rhino horn). Although such exploitation usually entails the selective removal of a single species from an ecosystem, other species may also be harmed as is the case for fishing by-catches. Over-exploitation of natural resources leads to the exhaustion of those resources, as years of unsustainable forestry, hunting and fishing clearly testify. Overpopulation, the globalization of trade, and escalating demand for natural products are central elements of this over-exploitation.

10.1.6 Human populations are rising rapidly, confounding many of the aforementioned issues. The global population is expected to rise from 6.8 billion at present to 9 billion by 2040 with one estimate predicting it will level off at 11 billion in the 23rd century. Such overpopulation is driving an unprecedented demand for freshwater, fuel, and food. The pressures that this demand places on biodiversity and ecosystems will bear ever heavier as nations strive to increase their material wealth and improve the living standards of their burgeoning populations.

10.1.7 Single crop agriculture: Modern farming favours sub-species of crops with traits suitable for maximising profits, such as rapid growth, large fruits etc. This selection process incurs a loss of genetic diversity which renders populations more vulnerable to attacks by viruses, insects and fungi, which in turn, necessitates the increased application of ecologically-harmful pesticides.

Box 5. Genetic diversity in agriculture, Allariz, Spain

Best practice from the European Capitals of Biodiversity competitions

Since 2007, the local council has set up a host of actions aimed at recovering local varieties of corn and crop-growing areas. Through a business initiative, the young people of this township have been able to learn about traditional uses and innovate with respect to products originating from corn. In addition, every year the Festa do Millo (Corn Festival) is held to pay homage to traditional uses of corn and other new uses.

In 2000 a herd of Limia cows was introduced on common land in Penamá to recover this local breed which is in danger of extinction. A traditional ecological system has been set up to allow for the recovery of pasturelands and the cleaning of former crop-growing areas. Experiments are under way on new ways of developing pasturelands and ecological fertilisers.

These activities have made it possible to obtain a large herd of Limia cattle for producing ecological meat, thereby preventing forest fires and obtaining economic benefits for the more than 300 families who jointly own the land.;

Further details on Allariz can be found at: www.allariz.com

10.2 Local trends and drivers of biodiversity loss

(Optional interactive session)

11. Biodiversity Law and Policies

Neat summaries of all the EU's biodiversity-related legislation and policies can be found at:

http://europa.eu/legislation_summaries/environment/nature_and_biodiversity/index_en.htm

National Partners, please outline main national biodiversity policies.

12. Glossary

The European Environment Agency has created a comprehensive glossary Available from: <http://glossary.eea.europa.eu>

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