**MODULE 8**

**BIODIVERSITY**

**INTRODUCTION**

Biodiversity is the variation and richness of life at a particular scale. Humans are part of a complex system and interdependent web of life and we are trying to understand our place in it. Most of us have realized how dependent we are on biodiversity for most, if not all, our needs, and that a significant loss of biodiversity could seriously undermine our long-term well-being, be it intellectual, physical, emotional, and economic. In this module, you are going to learn the basic concepts of biodiversity and some of the important roles that biodiversity play.

It has been estimated by biologists that species extinction has fast accelerated in the last fifty years to up to 1,000 times more than normal. Species become extinct even before they are discovered and named. The first Earth Summit in 1992 in Rio de Janeiro concluded that human activities were fast destroying ecosystems through loss of biodiversity at alarming rates (Cardinale et al., 2012). Since this summit, there was an increase in desire to understand biodiversity loss and its impact on ecosystems. People became keen to know how biodiversity loss affects the supply of goods and services. Many international research endeavors were established and hundreds of experiments conducted around the world.

The reduction in biodiversity is brought about by extinction or displacement of species. Over time, the rate of extinction speeds up and its effects are felt dramatically in tropical ecosystems (OpenStax, 2013). Natural causes and changes in environmental conditions brought about by human activities have been attributed to as the drivers of biodiversity loss. Because the ecosystem provides living beings with essential resources, biodiversity loss threatens the continuity of life. The losses of biodiversity at the local level have a collective direct impact at the global scenario.

Module 8 explains what biodiversity is, what causes biodiversity, and why we should care about it. This module presents the areas on Earth where biodiversity is rapidly dwindling, including our very own country, the Philippines. It will also examine some drivers of biodiversity loss: population growth, habitat loss, and climate change. The immediate subsequent effects to be studied are threats to food and energy security, unavailability of clean water, and damage to social relationships. It is undeniable that biodiversity loss is a clear and present danger to ecosystems.

**LEARNING OUTCOMES**

On successful completion of the module you should be able to:

* Describe the biodiversity concept;
* Explain the importance and attributes of biodiversity; and,
* Discuss why biodiversity is distributed as such, and why there are biodiversity hotspots;
* Articulate the causes of biodiversity loss;
* Identify the specific problems brought about by biodiversity loss in your community; and,
* Participate in community discussions on biodiversity loss.

**8.1 LEVELS OF BIODIVERSITY**

**ACTIVITY 8-1 (G1)**

Watch a 3-minute video\* on Biodiversity produced by Vancouver Film School. Familiarize yourself with the different biodiversity concepts, as these are the same concepts that we would be discussing in class.

\*Source of video: https://www.youtube.com/watch?v=L5ELFfbQAXU&t=7s

**GUIDE QUESTIONS**

1. How many ecological regions does the Earth have?
2. Which group of living organisms are the most numerous?
3. What would happen to a species with a diverse gene pool compared with a species with a less diverse gene pool in terms of chances of survival when threatened by disease? Why?
4. What are some of the benefits we get from biodiversity?
5. Of the 80,000 species of plants that are potentially edible, how many do we actually eat?

Coined by Walter Rozen of the National Research Council/National Academy of Sciences (NRC/NAS) in 1985, the term biodiversity was first used in 1988 in a publication by Edward O. Wilson. The term encompasses the total richness and variety of life on earth. According to the Convention on Biological Diversity (CBD), biological diversity or biodiversity means the variability among living organisms from the land, the seas, and other aquatic ecosystems, and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems. It has three levels:

* Genetic diversity
* Species diversity
* Ecosystem diversity

***Genetic diversity*** is the sum total of information contained in the genes of species of plants, animals, and microorganisms. This also includes genetic variation between distinct populations of the same species or variation within a population. Genetic diversity plays a very important role in the survival and adaptability of a species to changing environmental conditions. Variations in the gene enable changes to occur in the organisms’ morphoanatomy or physiology between generations, that are important requisites in adaptation and survival. Vulnerability of populations to diseases increases with decreasing genetic diversity.

***Species diversity*** refers to the variety of species, including their abundance, distribution and functions or interactions within a given spatial context, which can be a geographical region/location/ecosystem. The two main factors taken into account, when measuring species diversity, are richness and evenness. *Richness* is a measure of the number of different kinds of organisms present in a particular area regardless of scale, such as the number of organisms living in a spoonful of soil, or on a large scale as the whole earth. However, diversity depends not only on richness, but also on evenness. *Evenness* compares the similarity of the population size of each of the species present. Some habitats or ecosystems have high species diversity, such as coral reefs or tropical forests. Other habitats, like high altitude lakes, deserts, or the deep sea house lower species diversity. These ecosystems, as they evolved through time, have produced an emergent property composed of a unique set of species which carry out the important functions of the ecosystem.

**ACTIVITY 8-2 (G2)**

Compare 2 communities in terms of species richness and evenness and fill-up the table below (you may add as many rows as necessary). Which is more diverse? Why? (Your teacher may show you illustrations or pictures of 2 land communities or 2 aquatic communities, or may bring you to the field to observe 2 communities)

|  |  |  |  |
| --- | --- | --- | --- |
| Community A | | Community B | |
| Organism name | No. of individuals | Organism name | No. of individuals |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
|  |  |  |  |
| Total richness | Total no. | Total richness | Total no. |

***Ecosystem diversity*** refers to the distribution and abundance of habitats, biotic communities, and ecological processes in the biosphere. Presence of variety of habitats also supports a different set of species exhibiting different genetic variations in that region/space.

**8.2 BIODIVERSITY ATTRIBUTES AND ECOSYSTEMS PROCESSES**

Each of the three levels of biodiversity discussed in the first section, can be described further in terms of composition, structure, and function.

***Compositional biodiversity*** describes the type of elements and the number of representatives present at each level (genes, species and habitat) in an area. Examples can be genetic composition of populations, identity and relative abundances of species in a natural community, and kinds of habitats and communities distributed across the landscape.

***Structural biodiversity*** describes the variety of arrangement of these components, i.e. variety of ways in which different habitats, species or genes are arranged over space or time. Example of spatial biodiversity can be the vertical layering of trees in a forest, or the horizontal patchiness of vegetation. Temporal fluctuations in the environmental factors also regulate the biodiversity of a specific space. An example for the importance of time in relation to biodiversity is the dependency of estuarine fish feeding and breeding patterns on water availability or changing water temperature as the tide changes, as well as seasonal flooding events. These temporal fluctuations support different species over different seasons/timescales and have a critical influence on ecosystem dynamics.

***Functional biodiversity*** is the variety of biological processes, functions or characteristics of a particular ecosystem/area. These variety of processes (climatic, geologic, hydrologic, ecological, and evolutionary) which occur due to the interaction of different species with each other and with their physical environment generate biodiversity and continuously change it. This can be manifested for instance in nutrient cycling, pollinations, predation, parasitism, germination etc. An example of functional biodiversity is the balance in the number of filter feeders in an ecosystem compared to the number of grazers. Functional biodiversity is thought to be one of the main factors determining the long‐term stability and resiliency of an ecosystem.

Biodiversity at all forms, levels, structure, and function provides many anthropocentric, as well as, ecocentric benefits to humankind. Anthropocentric benefits from biodiversity include the many potentials for different lifeforms to provide information necessary for science, materials that are useful to humans, and all other recreational, medical, or consumptive benefits. Hence, the anthropocentric nature of humans choosing to protect a certain species or ecosystem, just in case, it turns out to be useful. Ecosystem services are the services that ecosystems perform for humanity. Animals, plants, and other living component of every ecosystem do many things for humans such as purifying water and air, pollinating crops, stabilizing soil, maintaining a proper heat balance in the atmosphere, and cycling critical nutrients. These services can also be viewed from an economic context. For example, the damage brought about by typhoon Yolanda to a coastal community in Cebu could have been very costly had it not been for the mangrove forests in the area providing the “services” of absorbing and slowing down the strong winds and waves.

Ecocentric benefits are based on the intrinsic value of biodiversity which is beyond any potential human uses. Just knowing that a healthy and vibrant coral reef system or a tropical forest is present can already be fulfilling in itself (even if you may never have actually visited it or has directly benefited from it), hence may feel the need to protect these so that future generations will be able to appreciate these as well.

**Required readings:**

Biodiversity BC. 2007. *Ecological concepts, principles and application to conservation*. Retrieved 12 Jan 2018, from http://www.biodiversitybc.org/EN/main/where/131.html

**Other references:**

Franco, J. L. d. A. 2013. The concept of biodiversity and the history of conservation biology: from wilderness preservation to biodiversity conservation. História 32(2). http://dx.doi.org/10.1590/S0101-90742013000200003

Santos, R. 2016, July 20. *Meet 3 animals that tell us about the health of the Philippines’ forests*. Chemonics. Retrieved 13 Jan 2018, from blog posted at https://www.chemonics.com/meet-3-animals-that-tell-us-about-the-health-of-the-philippines-vanishing-forests/

Tubbataha Youth Ambassador. 2014. *Module 1: ecology & biodiversity basics*. Retrieved 08 Jan 2018, from http://tubbatahareef.org/wordpress/wp-content/uploads/2014/09/Module-One-Ecology-and-Biodiversity-Basics2.pdf

**8.3 MEASURING AND MONITORING BIODIVERSITY USING SURROGATE SPECIES**

The many values biodiversity brings and could bring to humankind has compelled us to take steps in its conservation. There are many ways to measure and monitor biodiversity. The most ideal would be to measure actual processes such as rates of productivity, pollination rates and patterns, species interaction, etc. However, this would be very tedious and time consuming. A simpler and quicker approach is the use of surrogate species that can represent a broader set of species and/or habitats to support conservation or management strategies. Various surrogate approaches had been chosen on the basis of taxonomy, habitat, life-history features, or other ecological functions.

***Keystone species*** play essential community roles and their impact on the community or ecosystem are much larger relative to its abundance, and more influential than expected. Their impact becomes apparent once they are removed from an ecosystem. Without the keystone species, an ecosystem would dramatically differ or would even cease to exist altogether because no other species would be able to fill its ecological niche or role, allowing new and possibly invasive species to populate the habitat. An example would be tropical figs which bear fruits during off fruiting season. Without them, many animals would starve to death during periods of fruit scarcity.

***Umbrella species*** require such large areas of habitat that their protection might automatically protect a large number of naturally co-occurring species in several ecosystems and habitats. Monitoring this one species and ensuring its continued success also mean the maintenance of high quality habitat for the other species in the area. Since animals identified as umbrella species usually require large home ranges that cover different habitat types, protecting these species effectively protects many habitat types and the many species that depend on those habitats. Most of the umbrella species are listed as endangered or threatened on the International Union for Conservation of Nature (IUCN) Red List. Marine turtles are a very good example of an umbrella species for the ocean ecosystems. For land ecosystems, the Philippine Eagle can be considered as an umbrella species since it requires a large home range.

***Indicator species*** are species that set a benchmark against which comparisons can be made after a period of time whether conservation interventions are applied or not. They are sensitive to certain changes in the environmental factors hence are only found in environments where these factors are optimal. However, unlike umbrella species, indicator species may work well only in a particular habitat or ecosystem. The sub clover *Trifolium subterraneum* is used as a biological indicator to the presence of ozone as it displays visible damage to leaves (chlorotic and necrotic spots) at low levels of ozone. In the Philippines, the presence of the giant golden crown flying fox, one of the largest bats in the world, indicates a healthy forest and good forest regeneration. The flying foxes roost on trees in dipterocarp forests in very large colonies hence their presence means the forest holds a reliable number of dipterocarp trees. They also serve as pollinators of fruit trees in the forest. The bat indulges in fruits that typically grow in the forest. Spitting the seeds from the fruits helps in the pollination process.

***Flagship species*** are popular, charismatic species that serve as symbols and rallying points to stimulate conservation awareness and action. They serve to act as an ambassador, icon or symbol for a defined habitat, issue, campaign or environmental cause. Focusing on, and achieving conservation of that species, the status of many other species which share its habitat, or are vulnerable to the same threats, may also be improved. Flagship species may or may not be keystone species and may or may not be good indicators of ecosystem health. In the Philippines, a local government unit in Mindoro has adopted the Mindoro ‘Tariktik’ as the municipality’s flagship species in its conservation campaigns. Meanwhile the Haribon Foundation uses the Philippine Eagle as an expression of the urgency to protect and conserve our natural resources.

**Required readings:**

Tubbataha Youth Ambassador. 2014. *Module 1: ecology & biodiversity basics*. Retrieved 08 Jan 2018, from http://tubbatahareef.org/wordpress/wp-content/uploads/2014/09/Module-One-Ecology-and-Biodiversity-Basics2.pdf

Andelman, S.J., and W.F. Fagan. 2000. Umbrellas and flagships: Efficient conservation surrogates or expensive mistakes? PNAS 97(11):5954-5959. doi: 10.1073/pnas.100126797

**Other references:**

Lambeck, R.J. 1997. Focal species: A multi-species umbrella for nature conservation. Conservation Biology11:849-856.

National Geographic. n.d. *Keystone species*. 1996-2018 National Geographic Society. Retrieved 13 January 2018, from https://www.nationalgeographic.org/encyclopedia/keystone-species/

World Wide Fund for Nature (WWF). 2017. Global Species Programme: how WWF classifies species. *Know your flagship, keystone, priority and indicator species*. Retrieved 13 Jan 2018, from http://wwf.panda.org/about\_our\_earth/species/flagship\_keystone\_indicator\_ definition/

**8.4 BIODIVERSITY HOTSPOTS**

A biodiversity hotspot is a place on Earth that is both biologically rich and deeply threatened due to habitat loss by human activity. According to Conservation International, to qualify as a biodiversity hotspot, a region must meet two strict criteria. One, it must have a high percentage of plant life found nowhere else in the world which amounts to at least 1,500 endemic vascular plants (less than 0.5% of the world’s total). Second, it must have 30% or less of its original natural vegetation. In 2005, a total of 34 biodiversity hotspots were recognized based on the work of around 400 specialists. A description of the 34 hotspots is in http://www.cnrs.fr/inee/recherche/fichiers/ Biodiversite\_hotspots.pdf. In 2011, researchers from the Commonwealth Scientific and Industrial Research Organization (CSIRO) working with Conservation International identified the Forests of East Australia as the 35th hotspot. In February 2016, the North American Coastal Plain became the Earth's 36th hotspot.

Although these 36 hotspots represent less than 3% of the Earth’s land surface, they hold more than 50% of the world’s endemic vascular plant species, and nearly 43% of endemic land vertebrates (a combination of bird, mammal, reptile, and amphibian species).

The top 10 biodiversity hotspots in the world where biodiversity is richest and most threatened:

1. Atlantic Forest of tropical South America
2. Cape Floristic Region, South Africa
3. Cerrado, Brazil
4. Coastal Forests of Eastern Africa
5. Himalaya
6. Indo-Burma
7. Madrean Pine-Oak Woodlands, Mexico and Southern US
8. Mesoamerica
9. Polynesia-Micronesia
10. Philippines

The biodiversity hotspot concept highlights the close link between biodiversity and conservation. The concept, suggested in 1988 by Norman Myers, originally arose due to the growing concern among ecologists and environmentalists about the rapid loss of endemic species and habitat. On a broader perspective, it covers not only endemism at the species level, but at the genetic and ecosystem levels in any area or region with exceptionally high biodiversity. The hotspot concept has become a tool in setting conservation priorities by helping stakeholders decide for cost-effective strategies to preserve biodiversity. This tool was applied originally in terrestrial ecosystems but somehow has been extended to marine ecosystems as well. Endemism means that a gene, a species, or an ecosystem is only found or only lives in a particular region of the world, hence the loss of its kind means that it is lost forever.

To ensure that the largest percentage of endemic species are protected, it is important to know where species are found and understand the underlying factors that led to this non-random distribution of species. The complex pattern of biodiversity distribution is determined by climate, geology and the evolutionary history of the planet. These patterns are called "ecoregions" or "large unit of land or water containing a geographically distinct assemblage of species, natural communities, and environmental conditions." A generalized biogeographical map of where biodiversity is distributed in the world is found in https://fpe.ph/biodiversity.html/view/life-all-around-the-distribution-of-biodiversity (FPE, 2018). Meanwhile, an in-depth description of the world’s ecoregions is found in https://www.worldwildlife.org/biomes (WWF, 2018).

The hotspot concept, although very effective in driving biodiversity conservation efforts especially in terms of international funding, tends to leave out the huge expanses of the cold places in the planet dubbed as biodiversity “coldspots.” To know more on the limitations of the hotspot concept and the need to take a look at important “coldspots”, go to https://raxional.com/conserving-biodiversity-coldspots/.

The global authority on the conservation status of the natural world is the International Union for Conservation of Nature (IUCN). The IUCN Red List Categories and Criteria are intended for an easily understood system of identifying and classifying endemic species at high risk of being lost forever. The resulting list could be used as one of the basis in setting priorities for conservation measures for their protection. Currently, there are nine (9) categories set by the IUCN namely:

* Extinct (EX) – a taxon is Extinct “when there is no reasonable doubt that the last individual has died”
* Extinct in the wild (EW) – a taxon is Extinct in the Wild “when it is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range”
* Critically endangered (CR) – a taxon is Critically Endangered “when the best available evidence (severe population decline, very small population, very small geographic area occupied, or if the calculated probability of extinction during the next 10 years of **>50%**) indicates that it is facing an extremely high risk of extinction in the wild”
* Endangered (EN) – a taxon is Endangered “when the best available evidence (large population decline, small population, small geographic area occupied, or if the calculated probability of extinction during the next 20 years is **>20%**) indicates that it is considered to be facing a very high risk of extinction in the wild”
* Vulnerable (VU) – a taxon is Vulnerable “when the best available evidence (large population decline, small population, small geographic area occupied, or if the calculated probability of extinction during the next 20 years is **at least 10%**) indicates that it is considered to be facing a very high risk of extinction in the wild”
* Near threatened (NT) – a taxon is Near Threatened “when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future”
* Least concern (LC) – a taxon is Least Concern “when it has been evaluated against the criteria and does not qualify for Critically Endangered, Endangered, Vulnerable or Near Threatened. Widespread and abundant taxa are included in this category”
* Data deficient (DD) – a taxon is Data Deficient “when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status”
* Not evaluated (NE) – a taxon is Not Evaluated “when it is has not yet been evaluated against the criteria”

**The Philippines** is considered one of the 17 mega-diverse countries in the world when it comes to variety of ecosystems, species and genetic resources. Many of the islands in the archipelago are believed to have a very high degree of endemism. The country is home to more than 52,177 described species, more than half of which is found nowhere else in the world. The geographic and ecological characteristics of the country that allow it to support such a well-distributed diversity of species and high endemism include: tropical location, a highly heterogeneous and complex topography, isolation created by separate islands, and rugged topography. The details of these characteristics are in https://fpe.ph/biodiversity.html/view/life-all-around-the-distribution-of-biodiversity (FPE, 2018). However, the country is also considered a biodiversity hotspot because we are continually destroying our important resources, which in turn has magnified the effects of natural disasters such as earthquakes and typhoons. The following tables reflect the status of the biodiversity in the country (DENR-BMB, 2016).

**WILD FLORA**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **POLICIES** | **CR\*** | **EN\*** | **VU\*** | **OTS\*** | **TOTAL NO. OF THREATENED SPECIES** |
| DAO 2007-01 | 99 | 187 | 176 | 64 | **526** |
| DAO 2017-11 | 179 | 254 | 406 | 145 | **984** |

**WILD FAUNA/ANIMALS**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **TAXONOMIC GROUP** | **NO. OF SPECIES** | **NO. OF ENDEMIC SPECIES** | **NO. OF THREATENED SPECIES** **(DAO 2004-15) and CITES 2015** | | | | |
| **CR\*** | **EN\*** | **VU\*** | **OTS\*** | **TOTAL NO. OF THREATENED SPECIES** |
| Terrestrial Mammals | 207 | 133 | 8 | 12 | 17 | 5 | **42** |
| Birds | 691 | 239 |  |  |  |  |  |
| Reptiles | 419 | 241 | 5 | 16 | 4 | 4 | **29** |
| Amphibians | 120 | 98 | - | 4 | 10 | - | **14** |
| **TOTAL** | **1,437** | **711** |  |  |  |  |  |

 \* Conservation Status: *CR - Critically Endangered EN - Endangered     Vu - Vulnerable    OTS - Other Threatened Species*

**ACTIVITY 8-3 (G3)**

Watch a 9-minute video\* on Philippine Biodiversity by Biodiversity Management Bureau, DENR. Then answer the guide questions that follow.

\*Source https://www.youtube.com/watch?v=2F2KzjTzi9Q&t=25s

**GUIDE QUESTIONS**

1. What are some of the Philippine endemic species shown in the video?
2. How long is the Philippine coastline?
3. What are the marine ecosystems shown in the film?
4. What 3 aspects of our needs does biodiversity contribute to?
5. In what way does biodiversity prevent the Earth from overheating?
6. What will happen to biodiversity if we continue with our destruction of the environment and the overexploitation of resources?
7. How can we help protect and conserve our biodiversity?

**Required readings:**

Marchese, C. 2015. Biodiversity hotspots: A shortcut for a more complicated concept. GlobalEcology and Conservation 3:297-309.

Conservation International. 2005. *CI facts: biodiversity hotspots*. Retrieved 13 Jan 2018, from http://www.cnrs.fr/inee/recherche/fichiers/Biodiversite\_hotspots.pdf

**Other references:**

Conservation International. n.d. *Hotspots: targeted investment in nature’s most important places*. Retrieved 13 Jan 2018, from https://www.conservation.org

Critical Ecosystem Partnership Fund (CEPF). 2017. *Hotspots defined*. Retrieved 13 Jan 2018, from https://www.cepf.net/our-work/biodiversity-hotspots/hotspots-defined

Department of Environment and Natural Resources-Biodiversity Management Bureau (DENR-BMB). 2016. *Status of the Philippine Biodiversity*. Philippines: DENR-BMB. Retrieved 31 Jan 2018, from http://bmb.gov.ph/388-protection-and-conservation-of-wildlife/facts-and-figures/786-status-of-the-philippine-biodiversity

FPE (Foundation for the Philippine Environment). 2018. Biodiversity. Life all around: the distribution of biodiversity. Foundation for the Philippine Environment, Quezon City. Retrieved 16 July 2018, from https://fpe.ph/biodiversity.html/view/life-all-around-the-distribution-of-biodiversity

International Union for Conservation of Nature (IUCN). 2001. *Categories & Criteria* (version 3.1). Gland, Switzerland: IUCN. Retrieved 31 Jan 2018, from http://www.iucnredlist.org/static/categories\_criteria\_3\_1#categories

Kareiva, P. and M. Marvier. 2003. Conserving Biodiversity Coldspots: Recent calls to direct conservation funding to the world's biodiversity hotspots may be bad investment advice. American Scientist 91(4), Jul/Aug 2003. Retrieved 16 July 2018, from https://raxional.com/conserving-biodiversity-coldspots/

WWF (World Wildlife Fund). 2018. Ecoregions. World Wildlife Fund, Washington D.C. Retrieved 16 July 2018, from https://www.worldwildlife.org/biomes

**8.5 CAUSES OF BIODIVERSITY LOSS**

**ACTIVITY 8-4 (G4)**

Read “Millenium Ecosystem Assessment (2005)”, pp. 2-10 before coming to class. (30min-1hr)

**GUIDE QUESTIONS**

1. What is biodiversity loss?
2. Why is biodiversity loss a concern?
3. What are the causes of biodiversity loss?
4. What are the risks associated with biodiversity loss?

**Required reading:**

Millenium Ecosystem Assessment. 2005. Ecosystems and human well-being: biodiversity synthesis. World Resources Institute, Washington, D.C. pp. 2-10.

**8.5.1 Population growth**

McKee et al. (2003) modeled the relationship between human population density and the number of threatened mammal and bird species by nation. They found that human population density was a key threat to the bird and mammal species depending on the ecological nature of a nation. In short, the density of people is a key factor to species threat (Fig. 1). It was further suggested that regulating human population growth is a key component to biodiversity management and conservation.

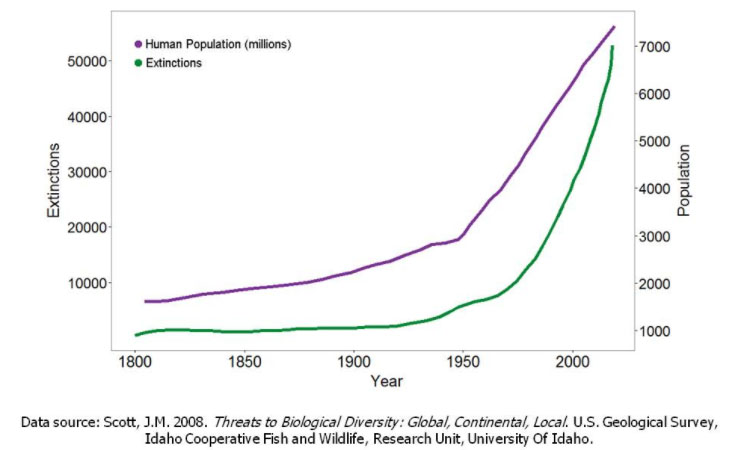


Fig. 1. Relationship between human population increase and species extinction.

**Readings/References:**

McKee, J. K., P. W. Sciulli, C. D. Fooce, and T. A. Waite. 2004. Forecasting Biodiversity Threats Due to Human Population Growth. Biological Conservation 115(1):161-164.

Population Action International (PAI). 2011. Why population matters to biodiversity. Washington, D.C., USA. 4p.

**8.5.2 Habitat loss**

***8.5.2.a. Deforestation***

According to National Geographic (2017), agriculture is a major cause of deforestation when farmers clear pristine forests to make room for the cultivation of agricultural crops. Logging operations to produce paper and building materials are responsible for the loss of thousands of trees. Logs may also be lost to new developments such as new housing and commercial areas as well as new roads that lead to remote areas. Deforestation not only cause species reduction or loss but contributes to climate change as well. The loss of trees cause water to return more quickly to the water cycle. The absence of trees also contributes to global warming because trees absorb greenhouse gases.

**Suggested Readings/References:**

National Geographic. 2017. Deforestation. https://www.nationalgeographic.com/environment/global-warming/deforestation/

***8.5.2.b. Loss of mangrove species***

Mangroves are also highly threatened by habitat destruction due to agricultural and commercial expansion. Climate change threatens mangrove species when temperatures and se levels rise. The most affected in low areas or upstream in tidal estuaries are *Brownlowia tersa*, *Bruguiera sexangula*, *Nypa fruticans*, *Phoenix paludosa*, *Lumnitzera racemosa*, *Lumnitzera littorea*, *Sonneratia caseolaris*, *Sonneratia lanceolate*, *and Xylocarpus granatum* (Polidoro et al., 2010). Mangroves are also threatened by overharvesting for domestic uses such as for firewood. Where mangrove diversity is highest (Indo-Malay Philippine Archipelago), loss of area is also highest (FAO, 2007).

In the Philippines, mangrove degradation is attributed to its accessibility for use as firewood and the long history of its conversion into aquaculture (Primavera, 2000). Species affected include *Acanthus*, *Acrostichum*, *Aegiceras*, *Avicenna*, *Brownlowia*, *Bruguiera*, *Cerrops*, *Lumnitzera*, *Rhizophora*, *Sonneratia,* and *Xylocarpus* as well as *Campostemon philippinensis*, *Excoecaria agallocha*, *Heritiera lottoralis*, *Kandelia candel*, *Nypa fruticans*, *Osbornia octodonta*, *Pemphis acidula*, and *Scyphiphora hydrophyllacea* (Primavera, 2009).

**Readings/References:**

Food and Agriculture Organization (FAO). 2017. The World's Mangroves 1980-2005, FAO Forestry Paper 153. Rome: Forest Resources Division, FAO. 77p.

NASA Global Climate Change. 2017. *The consequences of climate change*. Retrieved from https://climate.nasa.gov/effects/

Polidoro, B.A., K.E. Carpenter, L. Collins, N.C. Duke, A.M. Ellison, E.J. Farnsworth, E.S. Fernando, K. Kathiresan, N.E. Koedam, S.R. Livingstone, T. Miyagi, G.E. Moore, V.N. Nam, J.E. Ong, J.H. Primavera, S.G. Salmo III, J.C. Sanciangco, S. Sukardjo, Y. Wang, and J.W.H. Yong. 2010. The Loss of Species: Mangrove Extinction Risk and Geographic Areas of Global Concern. PLOS ONE 5(4):e10095. https://doi.org/10.1371/journal.pone.0010095

Primavera, J.H. 2000. Development and conservation of Philippine mangroves: institutional issues. Ecological Economics 35:91-106.

Primavera, J.H. 2009. Field guide to Philippine mangroves. Philippine Tropical Conservation Foundation Inc.

Primavera, J., R.B. Sadaba, J. Lebata-Ramos, and J. Altamirano. 2016. Mangroves and beach forest species in the Philippines. ERDB-DENR. 256p.

***8.5.2.c. Invasive alien species (IAS)***

When a living species (animal, plant or microorganism) not commonly found in a specific location becomes dominant, it is referred to as invasive. Invasive alien species (IAS), as defined by the Convention on Biological Diversity (CBD), are “species whose introduction and/or spread outside their natural past or present distribution threatens biological diversity”. Important mechanisms for the transport of invasive species are human-related activities including ballast water of ships. Invasion is finalized when IAS are able to reproduce rapidly in their new environments. The root cause of biological invasion is actually trade, travel, and modern technology. Biological invasion has been considered as an important driver of biodiversity loss. Economic losses in agricultural and fisheries production have been attributed to biological invasion as well, including expenses related to control and eradication of these invasive species.

The IUCN through the Invasive Species Specialist Group (ISSG) runs a website that is a good source of information on invasive alien species including a search engine called the Global Invasive Species Database (GISD) where you can look for specific invasive species of your interest. The ISSG, likewise, published the World's 100 Worst Invasive Alien Species with available profiles of each species.

**Readings/References:**

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Lowe, S., M. Browne, S. Boudjelas, and M. De Poorter. 2004. *100 of the world’s worst invasive alien species: a selection from the global invasive species database*. Auckland, New Zealand: The Invasive Species. Specialist Group (ISSG) a specialist group of the Species Survival Commission (SSC) of the World Conservation Union (IUCN). 12p.

***8.5.2.d. Urbanization***

The rapid urbanization resulting mainly from the continued increase in population has resulted to a myriad of consequences to biodiversity. Although the relationship between urbanization and biodiversity is quite complex (McKinney, 2002), there is increasing evidence showing that urbanization increases habitat loss and fragmentation, along with other physical transformations as urban areas expand (Pickett and Cadenasso, 2009). Habitat destruction, considered by Fahrig (2001) as “the largest factor contributing to the current global extinction event,” brought about by the growth of cities may lead to losses in biodiversity through fragmentation or destruction of large areas of natural habitat on which many species depend. On the other hand, an increase in biodiversity could occur but at the expense of native species as they get displaced by introduced species including those that are invasive.

**Readings/References:**

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Pickett, S.T., and M.L. Cadenasso. 2009. Altered resources, disturbance, and heterogeneity: a framework for comparing urban and non-urban soils. Urban Ecosystems 12(1):23-44.

***8.5.2.e. Environmental pollution***

According to the World Wildlife Fund (WWF, 2017), humans are at risk from environmental pollution. Contamination sources include toxic chemicals from industry, excess nutrients and pesticides from farms, scattered trash from landfills, and smog in city skies.

Among all forms of pollution in Europe, nitrogen and phosphorus loading were found to be the major driver of biodiversity loss and ecosystem disfunction (Biodiversity Information System for Europe (BISE), 2017. When nitrogen rises to a certain level that exceeds the limit. This is called the ‘critical load’ and may lead to eutrophication (body of water contains excessive nutrients) that damages biodiversity (European Environment Agency (EEA), 2010). The main sources of pollutants are agriculture and transport.

**Readings/References:**

Biodiversity Information System for Europe (BISE). 2017. *Pollution*. Retrieved from https://biodiversity.europa.eu/topics/pollution

European Environment Agency (EEA). 2010. *Critical load exceedance for nitrogen*. Retrieved from https://www.eea.europa.eu/data-and-maps/indicators/critical-load-exceedance-for-nitrogen/critical-load-exceedance-for-nitrogen

World Wildlife Fund (WWF). 2017. *Pollution threats*. Retrieved from https://www.worldwildlife.org/threats/pollution

**8.5.3 Climate change**

Changes in temperature and weather conditions impact living organisms by directly affecting their number and range of habitat. Increase in the amount of greenhouse gases also severely affects biodiversity and ecosystems.

According to NASA Global Climate Change (2017), the Intergovernmental Panel on Climate Change (IPCC), a group of more than 1,300 scientists from the United States and other countries, predicts that increase in mean global temperature of 1-3oC may lead to advantageous outcomes in some regions but detrimental to others.

The Convention on Biological Diversity (2007) reported the following potential impacts of climate change on biodiversity:

1. Warming of polar regions will lead to the addition of freshwater to the ocean;
2. A fast-rising growth in population will force the conversion from traditional to intensive agricultural practices that may endanger wild sources of food staple;
3. Pests and diseases may hamper the plant food production;
4. Drylands which are already threatened under non-climate change conditions may lose more of the little biodiversity that is left;
5. Forest species are very prone even to small changes in temperature and precipitation;
6. Inland water ecosystems wherein 20% of species are either extinct, threatened or endangered, will be greatly impacted.
7. Island ecosystems which are small and highly dependent on coral reefs for survival are sensitive to changes in temperature;
8. Marine coastal ecosystems which are already encumbered by overharvesting and habitat loss will all the more be negatively affected.
9. Mountain ecosystems which are already under stress from increased human activities will suffer more because there is limited capacity for species to move to higher elevations in response to warming temperatures.

**Readings/References:**

Bellard, C., C. Bertelsmeier, P. Leadley, W. Thuiller, and F. Courchamp. 2012. Impacts of climate change on the future of biodiversity. Ecol Lett. 15(4):365-377. doi:10.1111/j.1461-0248.2011.01736.x

Convention on Biological Diversity (CBD). 2007. Biodiversity and Climate Change. UNEP. 48p.

NASA Global Climate Change. 2017. *The consequences of climate change*. Retrieved from https://climate.nasa.gov/effects/

**8.6. EFFECTS OF BIODIVERSITY LOSS**

**8.6.1 Threats to food security**

Biodiversity is comprised of genes and species that build valuable ecosystems which provide vital sources for agricultural production (Thrupp, 2000). Agricultural biodiversity is a prerequisite to food security. On top of genetic conservation measures, innovative agrisystems methods such as integrated pest management and soil management approaches must be adopted.

**Reading/Reference:**

Thrupp, L.A. 2000. Linking Agricultural Biodiversity and Food Security: the valuable role of agrobiodiversity for sustainable agriculture. International Affairs 76(2):283-297. DOI 10.1111/1468-2346.00133

**8.6.2. Threats to energy security**

In developing countries, the source of more than half of the energy consumed is fuel from wood. Women and children walk many kilometers to gather firewood for cooking and to heat homes (Millenium Ecosystem Assessment, 2005). Fuel from wood sometimes constitutes up to 80% of the total energy consumed in some African countries where no alternative sources of fuel is available. Because developing countries are highly populated, biodiversity loss is inevitable and consequently, energy sources are threatened. It is not possible under these conditions to reduce energy consumption unless human population is considerably reduced, too.

**8.6.3. Unavailability of clean water**

Forests and watersheds are sources of clean water. It is of utmost importance that they remain intact in pristine conditions. When forests and watersheds are disturbed by human activities, the supply of available clean water for daily human needs are made uncertain. Citing a specific example in New York City, U.S.A., Millenium Ecosystem Assessment (2005) reported that it is more cost efficient to protect the watershed to provide clean water. The city has saved $6-8B from not having to build and operate a water treatment plant.

**Reading/Reference:**

Millenium Ecosystem Assessment. 2005. Ecosystems and human well-being: biodiversity synthesis. World Resources Institute, Washington, D.C. pp. 2-10.

United Nations. 2014. International decade for action. Water for life 2005-2015. Retrieved from http://www.un.org/waterforlifedecade/scarcity.shtml

**8.6.4. Damage to social relationships**

Figure 2 shows the main drivers of biodiversity loss according to the Millenium Ecosystem Assessment (2005).

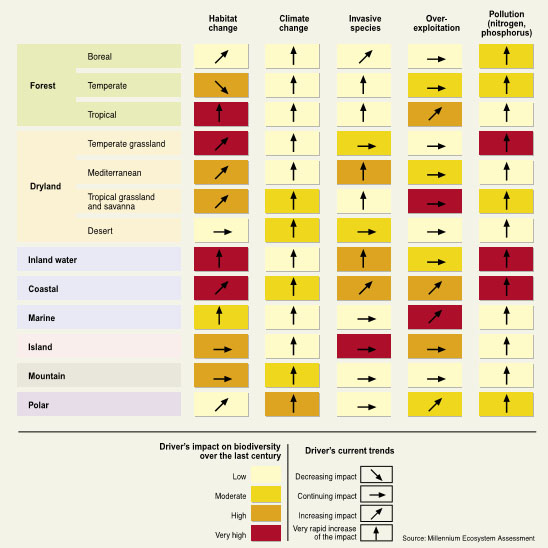


Figure 2. The main drivers of biodiversity loss.

(Source: Millenium Ecosystem Assessment, 2005)

Scarcity of resources such as fresh water is known to have been caused by factors such as land degradation and deforestation. The availability of water is limited in many parts of the world and could give rise to social and political conflicts. The United Nations (2014) predicted that a quarter of the world population or around 1.6 B people will experience economic water shortage in the 21st century.

The availability of water in a number of regions (including the Middle East); depletion of fish stocks off the east coast of Canada; and deforestation in Brazil, Thailand and elsewhere have been (or are potential) sources of conflict.

According to Lornegan (1997), changes in atmospheric conditions brought about by global warming could potentially disrupt society where availability of strategic resources are disrupted. Land use may change a society’s ability to provide sufficient food for a rapidly increasing population.

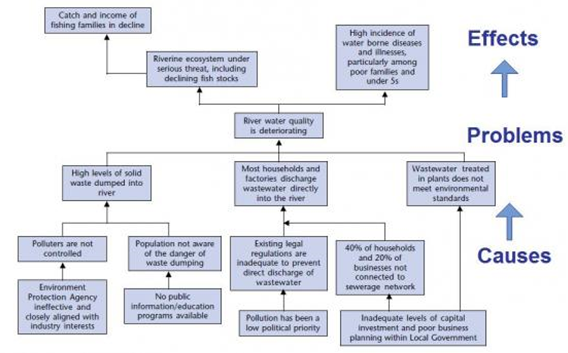
**ACTIVITY 8.4a (Groups 1-4)**

After learning about the drivers of biodiversity loss, you are now ready to apply what you learned through your critical thinking skills by building a problem tree. Identify a specific problem affecting your community. Trace the causes and effects.

Detailed instructions can be found at:

Campbell, K.L.I, C. Garforth, C. Heffernan, J. Morton, R. Paterson, C. Rymer, and M. Upton. 2006. The problem tree: analysis of the causes and effects of problems. Retrieved from https://www.sswm.info/node/2000

Below is an example of a Problem Tree tackling a specific environmental issue: Deterioration of river water quality



The teacher-in-charge together with the class will set a date for the presentation of the problem tree. A RUBRIC for the problem tree will also be presented for your guidance.

**ACTIVITY 8-6 ASSESSMENT**

Prepare an IEC material of an organism or an ecosystem within the locality showing the importance/role of the organism or the ecosystem to local biodiversity and the current and potential threats to it.

For the organism, identify this to the lowest taxonomic level possible. Identify the organism’s conservation status (refer to IUCN red list).

For the ecosystem, identify the dominant organism(s) in this ecosystem. Identify the ecosystem’s conservation status (refer to IUCN red list of ecosystems).

You have to submit your group’s chosen organism or ecosystem at an earlier date designated by your teacher to avoid duplications. You also have to identify your target audience. The teacher-in-charge will set a minimum and maximum length of time for infomercials (video format) and the date for submission of the project. A RUBRIC for the IEC material will also be presented for your guidance.

**Required reading:**

Campbell, K.L.I, C. Garforth, C. Heffernan, J. Morton, R. Paterson, C. Rymer, and M. Upton. 2006. The problem tree: analysis of the causes and effects of problems. Retrieved from https://www.sswm.info/node/2000

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Cardinale, B.J., J.E. Duffy, G. Gonzalez, D.U. Hooper, C. Perings, P. Venail, A. Narwani, G.M. Mace, D. Tilman, D.A. Wardle, A.P. Kinzig, G.C. Daily, M. Loreau, J.B. Grace, A. Larigauderie, D.S. Srivastava, and S. Naeem. 2012. Biodiversity loss and its impact on humanity. Nature 486:59-67.

Lonergan, S. (1997) Water Resources and Conflict: Examples from the Middle East. In: Gleditsch N.P. (eds) Conflict and the Environment. NATO ASI Series 2: Environment, vol 33. Springer, Dordrecht.

Millenium Ecosystem Assessment. 2005. Ecosystems and human well-being: biodiversity synthesis. World Resources Institute, Washington, D.C. pp. 2-10.

WE. 2017a. *Problem tree: investigating causes and effects*. Retrieved from https://www.we.org/ap/problemtree/

WE. 2017b. *Solution tree*. Retrieved from https://www.we.org/ap/solutiontree/

**SUMMARY**

1. Biological diversity or biodiversity means the variability among living organisms from the land, the seas, and other aquatic ecosystems, and the ecological complexes of which they are part.
2. The three levels of biodiversity are genetic, species, and ecosystem diversity.
3. The levels of biodiversity can be described further in terms of composition, structure, and function.
4. Biodiversity at all forms, levels, structure, and function provides many anthropocentric, as well as, ecocentric benefits to humankind, hence the need to protect them.
5. Conservation entails the regular measuring and monitoring of biodiversity. A simpler and quicker approach is the use of surrogate species that can represent a broader set of species and/or habitats to support conservation or management strategies. Various surrogate approaches had been chosen, such as the use of keystone, umbrella, indicator, and flagship species.
6. A biodiversity hotspot is a place on Earth that is both biologically rich (with high endemism) and deeply threatened due to habitat loss by human activity. As of February 2016, there are 36 recognized biodiversity hotspots on Earth.
7. Major causes of biodiversity loss include population growth, habitat loss, and climate change.
8. Biodiversity loss can lead to threats to food and energy security, unavailability of clean water, and damage to social relationships.

**ADDITIONAL REFERENCES**

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United Nations Educational, Scientific and Cultural Organization (UNESCO)/Convention of Biological Diversity (CBD). 2017. Biodiversity Learning Kits. Vols. 1 and 2. Paris, France: UNESCO. Retrieved 11 Jan 2018, from http://www.unesco.org/new/en/natural-sciences/special-themes/biodiversity/biodiversity-education/learning-kits/

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World Resources Institute. 1992. Root causes of biodiversity loss. New York: Oxford Press.