CONSERVATION AND MANAGEMENT OF NATURAL RESOURCES

(Biol. 451)

A DISTANCE LEARNING MODULE PREPARED

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MODULE INTERODUCTION

This course deals with Conservation and Management of Natural Resources. Conservation and management are two intricately linked terminologies. he livelihood of humanity is based on the sustainable use of natural resources. To achieve such use of natural resources, students as future biologists and potential conservation experts have to study the various principles of natural resource management. Thus, the course would enable learners to be aware of the types and importance of natural resources and their conservation.

While conservation, as a part of human history, might have been around for thousands of years, it appeared as a discipline only in the 1980s, specifically, at the First International Conference on Conservation Biology at San Diego Wild Animal Park. For the record, the Society for Conservation Biology originated about 5 PM on May 8, 1985, in Ann Arbor, Michigan (USA) at the conclusion of the Second Conference on Conservation Biology (Van Dyke, 2008). This was at the University of Michigan, USA.

It should be noted that the ones who are responsible for the exploitation are the ones who initiated the discipline itself. After the birth of this society, conservation started gaining momentum. By 2006, membership had climbed to over 11,000 worldwide; the discipline boasted a number of undergraduate textbooks. After three decades of its birth, conservation biology has become an inevitable evil for human being, since human being has never practiced conservation in its history.

The fact that people lived with nature in harmony in the past does not mean conservation. The only reason to live together with nature was that it could not extract much from nature by its existing technologies. Genuine conservation can occur only when humans knowingly use resources at less than maximum sustainable rates, or forego the use of some resources altogether.

This kind of conservation is motivated by appreciating an intrinsic value of the resource itself or from the desire to provide a long-term supply of the resources for others, including others still to come in future generations. These motivations are not mutually exclusive, and they are primarily ethical in nature. Throughout history, human beings have shown themselves to have the ability to embrace both motives, but often have lacked the will to do so. In fact, humans have shown the opposite capacities for intensely selfish motives to get as much of a resource as they can for their own needs and pleasures. The history of conservation is a history of ethical conflict as well as scientific discovery.

Conservation has benefits for humans, but it requires restraint and incurs costs. Conservation that involves neither restraint nor cost is not conservation. If one is careless in defining conservation, it is easy to make historical generalizations that are not true. One false historical generalization is that people with little technology are good conservationists and people with high levels of technology are not. Another is that nomadic hunter-gatherer societies conserve the environment and agricultural societies degrade it. This kind of thinking distorts an accurate interpretation of the historical context of conservation.

Throughout the world, early human societies in Europe, Asia, Africa, Australia, and the Americas radically affected their physical environment and the species it contained. They began to “manage” ecosystems even with little technological development, primarily through the use of fire. All early peoples used fire, with this single tool changed landscapes, exterminated species, and created cultivatable areas.

The rise of the Industrial Revolution created a massive extraction of natural resources that finally included indigenous Africans as natural resource by the brand name called “Slaves”. Not knowing Africans are their ancestors; Western Europeans and Americans traded with human beings and exploited their labor. Later when that was not as such profitable, they directed their greed towards land ownership and market expansion. The root source of nature exploitation comes from international trade rather than subsistence living. International trade is the soul and spirit of capitalism without which it cannot survive.

Even though, the Industrial Revolution was started in England in the 17^{th} century, and Europeans started extracting as much resources as they could throughout the colonial era, the colonized nations showed their ambition of much extraction in the same way as the westerners that they are attracting the so-called "investors" until this day. In the absence of prudent conservation strategy, the cost of exploitation and environmental pollution may be unbearable for developing countries like Ethiopia.

This course is designed to provide an introduction to the area of conservation biology. It will include an examination of the historical and ethical background underpinning the current conservation movement; the types of natural resources. The course focuses on the values of biodiversity and ecosystem services, and threats on biodiversity due to human impacts.

Furthermore, ecological concepts that are utilized in conservation management practices and conservation status in Ethiopia will be examined. The role of international conventions, national policy and institutions in implementing conservations and the future directions of conservation biology will be discussed.

This module is divided into units and sub units. Each unit is followed by self-evaluation questions and field exercises. Answers to self-evaluation questions are found in the texts of each unit. Field exercises help you realize what conservation means and exposes you to the real world of, at least, your own environment. You should plan your time and answer each question. Some exercises require small filed trip around your community. Such exercises require that you report the findings of your observation to your instructor at distant. It is important if you substantiate your findings by pictures. If you are unable to get pictures that does not count against you. You are at your own pace and we wish you good luck.

MODULE LEARNING OUTCOMES

On successful completion of the Module, students will be able to:

- describe the basic concepts of conservation biology.
- discuss the history of conservation biology.
- enumerate the types of natural resources, global biodiversity and its importance.
- identify the threats to biodiversity and natural resources and seek solutions to the problem.
- describe methods for the conservation and management of natural resources.
- discuss the role of governments and other institutions in conservation endeavors.

UNIT 1

Under this unit to two topics will be covered. These topics are

1. Concepts and definitions in conservation and management of natural resources;
2. The need to conserve natural resources.

UNIT LEARNING OUTCOMES

On successful completion of the Module, students will be able to

- define basic terminologies frequently used in conservation and management of natural resources.
- discuss why natural resources should be conserved

INTRODUCTION

Every discipline has some specific terms of communication. Some terminologies pertain explicitly to some disciplines and need to be specifically explained. Conservation and Management of Natural Resources has also some terms which may not be specific to it but worth explanation. In this Unit, basic definitions of some of the terminologies used in conservation are explained.

1.1. CONCEPTS AND DEFINITIONS IN CONSERVATION AND MANAGEMENT OF NATURAL RESOURCES

Conservation:- The protection, preservation, management, or restoration of wildlife and of natural resources such as forests, soil, and water". In some conservation Biology Textbooks, it is defined as "applied science of maintaining earth's biological diversity; a crisis discipline focused on saving life on earth" (e.g., Hunter, Jr. and Gibbs, 2007).

Manage - "to be in charge or control" while "management" is "the act or art of managing: the act or supervising of a business". The business in our case is "natural resources conservation and management".

Resources - Any property of the physical environment, such as minerals, or natural vegetation, which humans can use to satisfy their needs. Technically speaking, a property only becomes a resource when it is exploitable by humans; by this definition, climate may be considered as a natural resource, especially for countries dependent on tourism. Natural resources may be classified as renewable and non-renewable." They will be dealt with in unit 2.

Conservation Biology - is a relatively new interdisciplinary[1] subject dealing with crises imposed on nature by human beings or other agents. It is the application of science to conservation problems, addresses the biology of *species*, *communities*, and *ecosystems* that are perturbed, directly or indirectly, either by human activities or by other agents. Its goal is *to provide principles and tools for preserving biological diversity*. Although crisis oriented, conservation biology is concerned with the long-term viability of whole systems.

It should be noted that *conservation* and *preservation* are two different and interrelated terms:

Conservation – is using *sparingly* while preservation **–** is maintaining *as is*.

Conservation biology differs from most other biological sciences in one important way: It is often a *crisis discipline*. Its relation to biology, particularly ecology, is analogous to that of

[1] **Interdisciplinary -** involves the combining of two or more academic disciplines into one activity.

surgery to physiology and war to political science. In crisis disciplines, one must act before knowing all the facts; crisis disciplines are thus a mixture of science and art, and their pursuit requires intuition (using one's six senses) as well as information.

A conservation biologist may have to make decisions or recommendations about design and management before he or she is completely comfortable with the theoretical and empirical bases of the analysis. The whole haste is about saving the species, since extinction is irreversible.

Conservation biologists are often consulted for advice by government agencies and private organizations on several problems. Such problems include ecological and health consequences of chemical pollution; the introduction of exotic species; artificially produced strains of existing organisms; the sites and sizes of national parks; the definition of minimum conditions for viable populations of particular target species; the frequencies and kinds of management practices in existing refuges and managed wild lands, and the ecological effects of development.

Conservation biology shares certain characteristics with other crisis-oriented disciplines such as cancer biology as shown in Fig. 1.

The figure shows the interdependence of science on each other and even the social sciences. The best example of the interdependence of conservation science with the social science is on the decision making of the size and nature of national parks throughout the world. The size and nature of national parks must take into consideration the impact of the park on indigenous culture, economy, and wellbeing among others.

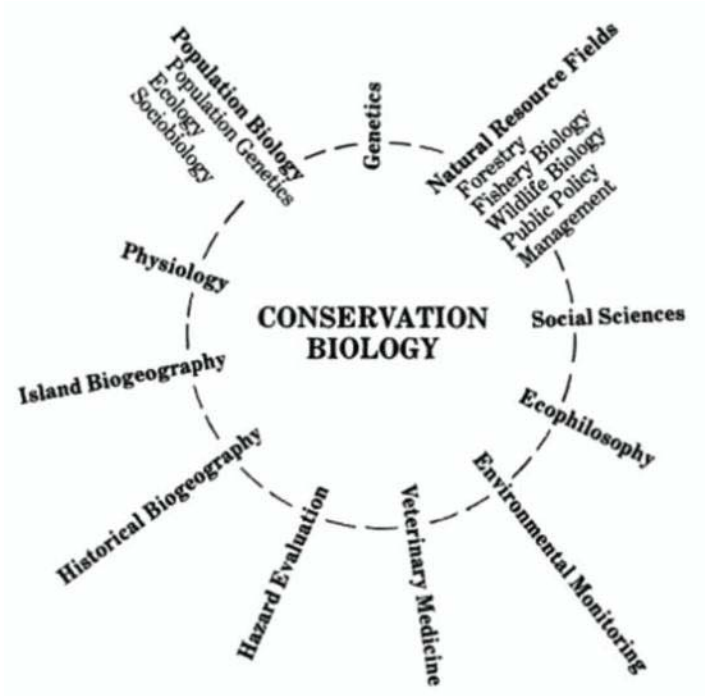


Figure 1 Illustration of relationships of conservation biology to other disciplines. The dashed line indicates the artificial nature of the borders between disciplines and between "basic" and "applied" sciences (Modified from Soulé, 1985).

1.1. THE NEED TO CONSERVE NATURAL RESOURCES.

The need to conserve natural resources can be viewed from two perspectives: 1) Classical reasons 2) contemporary reasons.

1.2.1. CLASSICAL REASONS AS TO WHY NATURE SHOULD BE CONSERVED

II. CONSERVATION IS A COMPONENT OF SOCIETY’S CULTURE

It was noted by Plato “*…so to say, the skeleton of a body wasted by disease; the rich, soft soil has been carried off and only the bare framework of the district left. …*”.

Mosses in the Bible understood the importance of conservation: "*...in the seventh year the land is to have a Sabbath rest, a Sabbath to the Lord. Do not sow your fields or prune your vineyards. Do not reap what grows of itself or harvest the grapes of your untended vines. The land is to have a year of rest.* (The Bible, Leviticus 25:4–5, New International Version). Conservation is sustainable use of natural resources. That is using sparingly so that it will last for tomorrow and also for other people and creatures. In the Holy Quran God commanded with regard to the people of Thamud and their camel, **"***And tell them that the water shall be shared between them…*" (Quran 54:28) and the Prophet said: **"***Muslims are to share in these three things: water, pasture, and fire*.**" (**Byagader *et al*., 2006).

Over exploitation of soil, water and pasture results in desertification. In Ethiopia, this tradition, which is called scientifically "fallowing", is practiced. In every tradition, there is some sort of conservation issue even though people do not practice it in an organized way.

Human societies have always benefited from the use of natural resources, but conservation was initiated when such societies began to think about resource use for future generations. When human societies begin to think of themselves as trans-generational, they also begin to think of how to use resources in a way that is ***environmentally sustainable***. But in order for resource use to be sustained, the natural processes and functions that produced the resource whether clean water, fertile soil, good crops, timber, or abundant game, must continue to function properly, and therefore must be *conserved* over time.

III. CONSERVATION IS AN EXPRESSION OF PRIVILEGE

Efforts in conservation are originated not from ethics or good will of people but imposed by punishments. In Europe, royalties have kept some forests as reserves for their own recreation and hunting grounds. This has been also practiced in ancient China.

In western societies, cultural expressions of conservation advanced from preservation by prohibition to active manipulation and management of natural resources. In Europe, wealthy individuals employed gamekeepers, whose function was to ensure an abundance of favored species for hunting. Gamekeepers accomplished this, in part, by keeping out what they call vagrants and poachers, but also through such activities as killing predators, introducing and relocating game animals to increase their densities, and even manipulating habitat. Such activities did not achieve a consistent approach to conservation because they operated within established social boundaries of class, rank, and economic status characteristic of feudal societies and aristocracies. Sometimes their long-term effects were exactly the opposite of "conservation." In the United Kingdom, killing game, cutting trees, or even trespassing in royal reserves was a serious offense, and violators often were deported to Australia, which the British originally used as a penal colony. Ironically, this practice helped to create a strong anti-conservation sentiment there. As some historian noted "the idea of game laws was anathema to many Australians. The abundance of Australian fauna suggested that it should be the everyone's right to kill animals without hindrance. Thus, "because Australia was a free and expanding young society, it would reject the notion of conservation of fauna as a hated relic of the feudal past from the Old Country".

In Ethiopia, the Derg Regime used to evict people in the park by military force with no compensation and sometimes by burning their hut to ground. Such harsh treatments brewed in the hurt of the local people a sense of sentiment. When the Derg Regime was deposed in 1983, using a short period of power vacuum, the local people rushed into the park and went committed killing spree of wild lives in revenge to the regimes past treatment. This was the case at the Bale Mountains National Park, which left dozens of Mountain Nyala and related herbivores in ruins.

IV. CONSERVATION AS RIGHT RELATIONSHIP WITH NATURE – THE ARCADIAN VISION

According to the Greece mythology, a city in Greece, Arcadia is the domain of the Forest God called by the name Pan. Arcadia's renowned beauty, as well as the presence of spiritual beings, gave it a reputation as an earthly paradise. Its human inhabitants were known for their simple, pastoral way of life, living in harmony with nature.

Based on this mythology European artists transformed the legend into a reality and conservation came into a cinema advocating its importance. Poetry works by different authors admire the beauty of nature but failed since time immemorial to bring conservation to practice.

If simple pastoral life could bring such a beauty as depicted in the above mythology, Ethiopia could have been the Garden of Eden. Pastoral life by itself does not mean living in friendly terms with nature since overgrazing proved to be one of nature's enemies.

V. CONSERVATION AS KNOWLEDGE – THE INVITATION TO STUDY AND APPRECIATE NATURE

For any healthy mind, nature is to be enjoyed for its own sake, and that an attitude of simplicity and humility were the prerequisites for such enjoyment. The beauty of nature is felt in the soul of an individual who watches it silently and thinks the architecture within it. Many of Ethiopian traditional songs and proverbs admire the beauty of nature. Can you sing one of them?

People try to compare the beauty of their loved ones with the wild flowers. Even though the purpose of those poems and songs are not for conservation, it indicates that the beauty of nature is compelling and that it needs to be conserved.

VI. CONSERVATION TO SAVE SPECIES – ORIGINS OF THE FIRST CONSERVATION ORGANIZATIONS

The first conservation organization called *“The Association for the Protection of Sea Birds (APSB)”* was established in Great Britain in 1868. The formation of the APSB marked the beginning of the establishment of societies to protect specific plants and animals. The formation of the British Royal Society for the Protection of Birds (BRSPB) followed in 1889. In the United States, the BRSPB was preceded by the formation of the American Ornithologists Union in 1883 and the National Audubon Society in 1886. Although the formation of the APSB marked the beginning of species specific conservation efforts through organized conservation advocacy, a second major form of conservation was the creation of parks and nature preserves from existing landscapes. This action radically affected and transformed the world creating a model for land- and ecosystem-based conservation that was imitated throughout the world. This was the concept of the modern National Parks.

VII. CONSERVATION AS PRESERVATION OF LANDSCAPE

In Europe, centuries of human impact on the natural landscape left few areas unchanged by human presence, and unaffected areas that remained were often small and remote. There was little opportunity to establish large areas for conservation purposes, so reserves set aside for species or habitat protections were small. The first nature reserve and one still in existence today, was the Karpfstock, a mountain in Switzerland where the Canton (Council) of Glaus forbade hunting by anyone in 1576.

Similar visions were accepted by the United States and the first park in the US, “The Yellow Stone National Park” was established legally on March 1, 1872. In 1916, the United States enacted as a legal procedure to establish parks in its law. Today, much of the worldwide effort in conservation biology rest on the legitimacy of designing and establishing conservation reserves, on the assumption that such reserves are an important part of national and cultural heritage. Such a foundational premise of conservation is now so familiar that it is taken for granted. In truth, the idea of landscape scale conservation reserves, first expressed in the US concept of the National Park, is a radical and recent concept. It created an enduring paradigm for conservation throughout the world, and was widely exported as a model for other countries. The ***Yellowstone Model***, however, was strongly influenced by North American landscape characteristics, as well as by perspectives and prejudices of US culture. Park formation usually involves relocating residents that may trigger other questions.

1.2. CONTEMPORARY REASONS AS TO WHY NATURE SHOULD BE CONSERVED

2. **Human population growth -** Resources are limited but human need and greed is unlimited. Not only the human need but also the human population is growing. The current world population of close to 7 billion is projected to reach 10.1 billion in the next ninety years, reaching 9.3 billion by the middle of this century, according to the medium variant of the *2010 Revision* of *World Population Prospects*. The fertility rates of the world population were categorized into three variants: low fertility variant, medium fertility variant and high fertility variant countries. Current fertility levels vary markedly among countries. Today, 42 per cent of the world's population lives in low-fertility countries, that is, countries where women are not having enough children to ensure that, on average, each woman is replaced by a daughter who survives to the age of procreation. Another 40 per cent lives in intermediate-fertility countries where each woman is having, on average, between 1 and 1.5 daughters, and the remaining 18 per cent lives in high-fertility countries where the average woman has more than 1.5 daughters. Ethiopia is one of the high fertility countries. Its

growth rate by the year between 2005 to 2010 was 2.212. One should note that not an inch of land can be added since the earth is not growing and so the resources in it. If population growth goes on unchecked for good, the population of Ethiopia will be more than 150 million by 2050. This increase has a significant effect on population density per km^2 and also resources distribution. Not only that Ethiopia's economy is on the rise but also Ethiopia is exerting strong effort on the resource exploitation. Ethiopia's real GDP growth for 2011/2012 was 7 percent according to the IMF This means that Ethiopia is exerting strong natural resources exploitation at a rate proportional to its GDP growth. History has shown that mechanized resource exploitation has a consequence of environmental pollution and degradation in the absence of strict environmental regulations.

3. **Deforestation** - Well over half the world's tropical forests are believed to have been lost, and deforestation is considered to be a critical problem throughout the developing world. The processes of overgrazing and desertification have greatly increased, resulting in dramatic spread of deserts or desert like conditions, accelerated loss of agricultural lands, degradation of most of the world's rangelands, and untold human suffering.
4. **Over exploitation** - Over fishing, pollution, and conversion of estuarine habitats have notably altered the world's marine habitats. Around 90% of the world's larger predatory fi sh have been lost to over fishing with drastic—and, in some cases, probably irreversible—changes to their ecosystems.
5. **Extinction** - Biodiversity conservation has become recognized as a global environmental problem. The International community has recognized that loss of biodiversity is an international concern. It is believed that 99% of the world's living things are extinct. These extinctions were caused as a result of natural causes. Previous extinctions were also the

result of mass extinctions during the last 5 episodes. The current (sixth extinction episode) is purely anthropogenic. That is humans are driving the very animals and plants that helped them survive on earth to extinction. An in-depth explanation of this topic is found in Chivian and Bernstein (2008).

6. **Chemical pollution –** Residues of pesticides, fertilizers, mining by-products, factory emissions, city waste products, etc affect the environments thousands of kilometers away from sources. The best example of environmental disasters is that of gold mines which use the so called *Dirty Gold Mining Process.* These are open pit and heap leaching methods. Two-thirds of newly mined gold comes from open-pit mining rather than the more expensive alternative of underground shaft mines. In open-pit mining, companies must remove vast amounts of rock and materials and blast the entire site, some times leveling mountains. This leads to the destruction of the environment at the mine site, damage to the surrounding ecosystem, and the opening up of vast craters. Open-pit mines produce eight to ten times as much waste rubble as underground mines. Gold is commonly extracted from the ore through a technique called "heap leaching." The ore containing the gold is crushed, piled into heaps, and sprayed with cyanide, which trickles down through the ore and bonds with the gold. The resulting gold-cyanide solution is collected at the base of the heap and pumped to a mill, where the gold and cyanide are chemically separated. The cyanide is then stored in artificial ponds for reuse. Each bout of leaching takes a few months, after which the heaps receive a layer of fresh ore. Given the scale and duration of these operations, contamination of the surrounding environment with cyanide is almost inevitable. In Ethiopia are the methods used to mine Gold by companies. The student is encouraged to read about the metal mining industries from literature (e.g., Earthworks and Oxfam America, 2004).

The residues of pesticides, for example, are found in terrestrial and aquatic organisms around the world, often many thousands of miles from where they were originally applied. Thousands of new chemicals are released into the environment each year, mostly with unknown impacts.

7. **Climate change-** With increasing energy needs throughout the world, the combustion of fossil fuels has accelerated, leading to a host of local, regional, and global problems. Production of CO_2 and other greenhouse gases is causing global warming which presents humans with the most daunting environmental challenge in history. It has already led to climate and weather changes, loss of glaciers, changes in biodiversity, and alterations in terrestrial and aquatic ecosystems worldwide, especially at high altitudes and high latitudes. Even though, third world countries are not responsible to much of green house gases, it does not mean they do not contribute to the problem by burning down forests, deforestation and overgrazing.
8. **Development projects –** Environmental impacts of development projects are many. Such projects, particularly, those involving lumbering, resettlement, or displacement of people have had numerous environmental impacts, leading to deforestation, loss of critical habitats and biodiversity. Some multinational corporations, having the power to silence governments and institutions, are able to do the environmental impact assessment (EIA) by themselves. A serious problem is the lack of Ethiopian accredited environmental impact assessment institutions that can do the job. They are the ‘developers’ and the ‘assessors’ and Ethiopian scholars have little say in the EIA of development projects in Ethiopia. Moreover, the final documents are not publicly available for Ethiopian scholars even to comment.

9. **Invasive species** - invasive species are challenging the world, particularly, the developing world. Invasive species of plants and animals have the power to spread and replace native species at an alarming rate. In Ethiopia several species of invasive species are present. *Prosopis juliflora*, is replacing native vegetation and expanding to the nearby areas. Imagine, when this species enters the Awash National Park. Grasslands will be covered, native vegetation will be evaded and animals which live in this park will be endangered. *P. juliflora,* a Mesquite, is a shrub or small tree in the Fabaceae family. It is native to Mexico, South America and the Caribbean. It has become established as an invasive weed in Africa, Asia, Australia and elsewhere.
10. **Political biases towards – "*feeding the poor*"** – Many decisions remain economy-driven and do not take into account science-based insights. It is often neglected that the necessary trade-off between protection and the need of '*feeding the poor*' is biased by short-term goals, which in the long run have an adverse effect (Strumbauer, 2005). In general policy makers in poor countries are short sighted by the very near problem "*poverty*" that is portrayed in front of their face, forgetting the greater danger (*biodiversity loss*) behind the curtain. For example, even though neat laws are on the paper, the environmental impact assessment issues are of little importance for poor African countries.
11. **Armed conflicts –** armed conflicts are the main cause of biodiversity loss in areas where the wealth of natural resources itself created armed conflicts. Such countries in Africa include Angola, the Democratic Republic Congo, Liberia, Sierra Leone and Sudan. In these countries where there are armed conflicts, it is difficult to enforce laws and even attempt to conserve nature. In such countries animals are killed, forests are burned down and yet no accountability.

1.3. SELF EVALUATION QUESTIONS

1. Explain the term “Conservation”.
2. What is Conservation Biology?
3. How does conservation Biology differ from other biological science fields?
4. Why is Conservation Biology considered as an interdisciplinary subject?
5. Identify the two terms “conservation” and “preservation”.
6. From classical perspective, list why we should we conserve nature?
7. Explain how “a penal colony” of Britain created a strong anti-conservation sentiment in Australia? Are there cases in Ethiopia where forcefully protecting nature created anti-conservation sentiment?
8. List contemporary reasons for conserving nature. Why do you think these problems are considered “contemporary”?
9. What is the difference between “over exploitation” and “sustainable use”?
10. When do development projects become a threat to biodiversity?
11. There is a notion that “*the poor cannot conserve nature*”. Discuss this situation, taking the case of Ethiopia in context.

1.4. FIELD EXERCISES

1. In your own culture, where you live, are there conservation practices that exist culturally which are in use by the community? Consult community elders and write a report to your instructor.
2. Take a short field trip around your community. Look at the natural environment or farmland. Do you see any sign of conservation practices such as soil conservation; forest

conservation; water conservation; wildlife conservation etc. Take at least one of them as an example and write a short report in two pages on the conservation practice you observed. If it is possible, take a picture and insert a picture of the conservation practice in the mail.

3. Try to find in your area a development project such as gold mine, floriculture industry, dairy farm, or any kind of such developments and observe how they treat the waste product out of their factory. Write a report to your instructor. If possible, get a picture of the treatment plant or any event that shows a threat to biodiversity. This report contains five points.

UNIT 2 TYPES OF NATURAL RESOURCES

UNIT INTRODUCTION

Under this unit, you will be introduced to types of natural resources. Natural resources are classified according to their ability to naturally replenish themselves or not.

UNIT OBJECTIVE

After successful completion of the unit, the student will be able to:

1. define natural resources.
2. classify natural resources.
3. explain the role of natural resources in the country's production function.

2.1. CLASSIFICATION OF NATURAL RESOURCES

The world Trade Organization (WTO) defines Natural Resources as: "stocks of materials that exist in the natural environment that is both scarce and economically useful in production or consumption, either in their raw state or after a minimal amount of processing".

A useful definition should not only identify the nature of natural resources but also distinguish what is and what is not a natural resource. Under the above criteria, it is clear that manufactured goods such as automobiles and computers would not be considered resources, since both are subject to more than a minimal amount of processing. For example, while most agricultural goods including food are primary products, we do not classify them as natural resources for a number of reasons. This is because; their production requires other natural resources as inputs, particularly land and water but also various types of fertilizer. More importantly, agricultural products are cultivated rather than extracted from the natural environment.

Natural resources can be thought of as natural capital assets, distinct from physical and human capital in that they are not created by human activity. Natural capital may be a potentially important input in a country's "production function" – that is, Y = f (K, L, N), where "Y" is output, "K" is capital, "L" is labor and "N" is natural resources. It is important to distinguish between natural resources as factors of production and natural resources as goods that can be traded internationally. For instance, minerals, oil, and various other materials can be extracted and enter into trade.

In general natural resources are classified into two major groups based on whether they are exhaustible or not within reasonable human generations.

2.1. RENEWABLE NATURAL RESOURCES

Renewable resources are by definition resources that have a continuing process of renewal and supply in nature. The renewal of some of these resources (living organisms) may be affected by human beings, while others (solar radiation, wind, tides) are principally not influenced by human activity. The renewable resources are commonly named "flow resources", as it is possible to maintain use indefinitely, provided the production (the flow) continues.

One characteristic of the renewable resources is that the rate of production or the supply may vary considerably. Therefore, the possibilities for storing and transferring of resources for use in a future period together with conditions influencing the natural production are important criteria for the sub-division of this class of resources. Based on these criteria one may distinguish between three sub-classes of renewable resources. One should notice that a particular resource might be stored for one particular use. For other uses this possibility may not exist.

Renewable Resources without Storage Possibilities: - include solar radiation, wind, tide and scenery. These are the most typical flow resources. The flow from these resources may be increasing, decreasing or constant. Present use of the flows does not diminish future flows, and if flow continues, use can be maintained forever. No possibility exists for substitution of the flow from one time period to that of another period. That means the yield from this type of resources cannot be stored. If it is not used when available, it is lost.

Renewable Resources Capable of being Stored:- The production from this class of resources may be stored; however, the production is independent of the quantity stored. One typical resource of this category is rainfall used for pproduction of hydroelectric power. Precipitation can be stored in dams, and when storage takes place, the stored flow may be treated as a stock that can be used in a future period. However, the water stored in dams does not significantly influence the amount of rainfall.

Renewable Resources with Augmentable Stock: - This class of resources comprises the biological resources that are by definition all living beings. The availability of a reproducible stock is the main characteristic of these resources. For some resources the production is directly related to the size of the stock (fish, volume of trees). Thus human action may influence the flow from these resources. A "critical zone" for renewal may exist for these resources. By "critical zone" is meant a more or less clearly defined level below which the decrease in production from the resource cannot be reversed. Certain species of animals may be exterminated if the stock falls below a certain minimum. Wildlife resources are grouped under this. That is why controlled hunting and timber production are necessary to exercise.

Earth Surface Resources: - The permanency of their quantitative properties, such as size, shape, location and exposure, typifies this category of resources. Depending on composition and use their qualitative properties may differ considerably. The important resources of this category are land, atmosphere and hydrosphere. Although the physical stock of these resources is limited, the services they provide can be maintained forever.

As an example the services provided by a given area of land, whether they are for agricultural production, amenities or housing, can be obtained in future irrespective of to-day's use, provided that the quality of the resource is maintained. However, degradation in the quality of the services these resources provide may cause serious problems. A decrease in the productivity of land may be reversed cheaply if it results from depletion of plant nutrients. Pollution of water reservoirs and air may be more costly to reverse. The concepts of critical zones and irreversibility are also important for these types of resources. Multiple use is another relevant issue.

2.2. NON-RENEWABLE NATURAL RESOURCES

The non-renewable resources are those types of resources whose physical quantity does not increase significantly with time. That means the rate of renewal is so slow as to be negligible. The non-renewable resources are often defined as "stock resources". The total supply of the resource is limited in quantity, and each rate of use diminishes some future rate of use (Figure 2).

One main characteristic of this category of resources is the possibilities for substituting resource use between different time periods. An increased use in one period diminishes the quantity available in another period. To which degree future use is sacrificed is closely related to then possibility for re-use or recycling of the resource. Thus, this will be the criterion for dividing this group of resources into sub-classes.

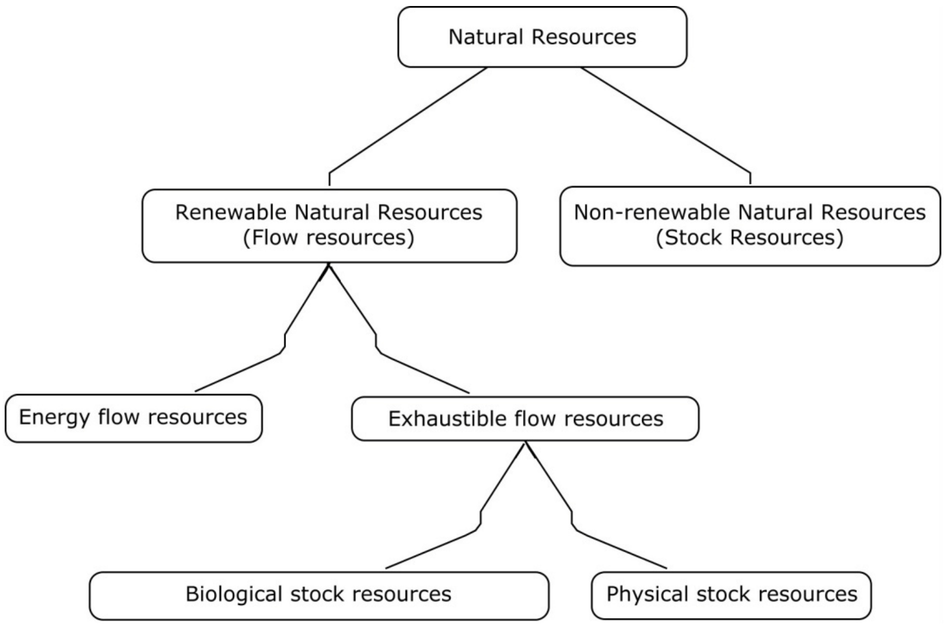


Figure 2 Illustration showing classification of natural resources.

Exhaustible Stock Resources: - These resources are generally of a geological nature. Utilisation of one unit of the resource implies its total destruction and thereby it is completely lost for future use. Examples are coal, oil and gas used for energy purposes.

Recyclable Stock Resources: - These resources are again typical geological resources with definitive stock. However, for these resources it is important to take into consideration the possibility of reusing the material once used. Therefore, in this case utilisation of one unit of the resource does not imply that it is totally and permanently lost. The material from the resource is locked in a particular use in a certain period, from which a process of industrial recycling can release it, and thus be available for another use. Typical resources of this category are metal ores like iron, lead and copper.

UNIT 2 SELF EVALUATION QUESTINS

1. Define natural resources.
2. Classify natural resources.
3. Sketch natural resources using concept diagram.
4. What is the difference between exhaustible stock resources and recyclable stock resources?
5. In the production function of a country Y = f (K, L, N), what for “N” stands? Why is it so important for the economic growth of a country?

UNIT 3 BIODIVERSITY

UNIT INTRODUCTION

The central concept in conservation biology is specifying what to conserve. Biodiversity answers this question. In this unit, you will investigate the essence of biodiversity; levels of biodiversity; the species concept; the fundamental unit of conservation and how to maintain biodiversity.

UNIT OBJECTIVES

After successful completion of this unit the student will be able to:

1. define biodiversity.
2. list the seven species concepts.

3. identify the working definition of the species concept.

4. explain the three scopes of biodiversity.

5. Comprehend reserve design techniques.

3.1. WHAT IS BIODIVERSITY

In unit 1, the term biological diversity was briefly explained. In this unit, it will be dealt with in detail. "Biodiversity" is a contracted form of "Biological diversity" and is becoming popular among conservation biologists. Biodiversity has a broad definition. The so called the "The Convention", otherwise, known as the Convention on Biological Diversity (CBD), Article 2 (SCBD, 1993) defines biological diversity as:

"*the variability among living organisms from all sources including, inter alia*[2], *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*."

An important concept in biological diversity is that it is continuous. That is all the levels of organization are dependent on each other. In this definition and in all other definitions, biodiversity lies in the species concept; but what is a species? There are at least seven definitions of species from different schools of thought (Table 2). This definition complicates the concept of conservation since conservation depends on the meaning of what to conserve.

[2] *Inter alia* = among others

Table 1 the species concept and its definition.

Species concept	Definition
Biological species	A group of interbreeding natural populations that do not successfully mate or reproduce with other such groups (and, some would add, which occupy a specific niche)
Cohesion species	The smallest group of cohesive individuals that share intrinsic cohesive mechanisms (e.g. interbreeding ability, niche)
Ecological species	A lineage which occupies an adaptive zone different in some way from that of any other lineage in its range and which evolves separately from all lineages outside its range
Evolutionary species	A single lineage of ancestor–descendant populations which is distinct from other such lineages and which has its own evolutionary tendencies and historical fate
Morphological species	The smallest natural populations permanently separated from each other by a distinct discontinuity in heritable characteristics (e.g. morphology, behaviour, biochemistry)
Phylogenetic species	The smallest group of organisms that is diagnostically distinct from other such clusters and within which there is parental pattern of ancestry and descent
Recognition species	A group of organisms that recognize each other for the purpose of mating and fertilization

The species concept that is given in Table 1 has both strength and difficulties. The strength and difficulties are indicated in Table 2

Table 2 Species concepts their practical application, strength and/or weakness..

Species concept	Practical application	Strengths/weaknesses
Biological	Difficult	Popular, irrelevant to asexual organisms, complicated by natural hybridization, polyploidy, etc.
Cohesion	Difficult	Cohesion is difficult to recognize
Ecological	Difficult	Adaptive zones difficult to define, assumes two species cannot occupy same niche for even a short period
Evolutionary	Difficult	Criteria vague and difficult to observe
Morphological	Common	Morphological criteria may not reflect actual links that hold organisms together into a natural unit
Phylogenetic	Increasing	Will give rise to recognition of many more species than more traditional concepts
Recognition	Difficult	Determining if a feature is used to recognize potential mates is difficult or impossible in many populations

3.2. SCOPES OF BIODIVERSITY

The three building blocks of biodiversity are "*Genetic Diversity*", "*Species Diversity*" and "*Ecosystem Diversity*". These are the levels of biodiversity. The three levels are closely related and the higher hierarchies contain the lower ones. For example, biomes are the elements of biogeographic realms. Levels of biodiversity are shown in Table 2.

Table 3 Elements of biodiversity (focusing on those levels that are most commonly used).

Genetic diversity	Ecological diversity	Species diversity (Organismal Diversity)
Populations	Biogeographic realms	Domains of Kingdoms
Individuals	Bioms	Phyla

Chromosomes	Provinces	Families
Genes	Ecoregions	Genera
Nucleotides	Ecosystems	Species
	Habitats	Subspecies
	Populations	Populations
		Individuals

3.2.1. GENETIC DIVERSITY

Genetic diversity encompasses the components of the genetic coding that structures organisms (*nucleotides, genes, chromosomes*) and variation in the genetic make-ups between individuals within a population and between populations. This is the raw material on which evolutionary processes act. Perhaps the most basic measure of genetic diversity is genome size - *the amount of DNA (Deoxyribonucleic acid) in one copy of a species' chromosomes (also called the C-value)*. This can vary enormously, with published eukaryote genome sizes ranging between 0.0023 pg (picograms) in the parasitic microsporidium, *Encephalitozoon intestinalis* and 1400 pg in the free-living amoeba, *Chaos chaos*. These translate into estimates of 2.2 million and 1369 billion base pairs (the nucleotides on opposing DNA strands), respectively. Thus, even at this level the scale of biodiversity is overwhelming. Cell size tends to increase with genome size. Humans have a genome size of 3.5 pg (3.4 billion base pairs).

There is strong conservatism of some genes across much of the diversity of life. The differences in genetic composition of species give us indications of their relatedness, and thus important information as to how the history and variety of life developed. Genes are packaged into chromosomes. The number of chromosomes per somatic cell varies between 2 to 1260 from the smallest organism studied to the largest one, respectively.

Within a species, genetic diversity is commonly measured in terms of allelic diversity (average number of alleles [3] per locus), gene diversity (heterozygosity across loci), or nucleotide differences. Large populations tend to have more genetic diversity than small ones, more stable populations more than those that wildly fluctuate, and populations at the center of a species' geographic range often have more genetic diversity than those at the periphery. Such variation can have a variety of population-level influences, including on productivity/ biomass, fitness components, behavior, and responses to disturbance, as well as influences on species diversity and ecosystem processes

3.2.2. SPECIES DIVERSITY (ORGANISIMAL DIVERSITY)

Species diversity encompasses the full taxonomic hierarchy and its components, from individuals upwards to populations, subspecies and species, genera, families, phyla, and beyond to kingdoms and domains. Measures of species diversity thus include some of the most familiar expressions of biodiversity, such as the numbers of species (i.e., species richness). Starting at the lowest level of organismal diversity, little is known about how many individual organisms there are at any one time, although this is arguably an important measure of the quantity and variety of life (given that, even if sometimes only in small ways, most individuals differ from one another). Nonetheless, the numbers must be extraordinary. The global number of prokaryotes has been estimated to be 4 - 6 x 10^{30} cells - many million times more than there are stars in the visible universe - with a production rate of 1.7 x 10^{30} cells per annum. The numbers of protists is estimated at 10^4-10^7 individuals per m^2..

[3] One member of a pair (or any of the series) of genes occupying a specific spot on a chromosome (called locus) that controls the same trait. For example, a pair of alleles controlling the same trait, i.e. eye color: one allele codes for blue eyes, another allele for brown eyes.

Impoverished habitats have been estimated to have 10^5 individual nematodes per m^2, and more productive habitats 10^6 - 10^7 per m^2, possibly with an upper limit of 10^8 per m^2; 10^{19} has been suggested as a conservative estimate of the global number of individuals of free-living nematodes. By contrast, it has been estimated that globally there may be less than 10^{11} breeding birds at any one time, fewer than 17 for every person on the planet.

Individual organisms can be grouped into relatively independent populations of a species on the basis of limited gene flow and some level of genetic differentiation (as well as on ecological criteria).

The population is a particularly important element of biodiversity for two major reasons:

1. it provides an important link between the different groups of elements of biodiversity (Table 2.1).
2. it is the scale at which most sensible linkages between biodiversity and the provision of *ecosystem services* are considered (See Section 2.2.3) .

Estimates of the density of such populations and the average geographic range sizes of species suggest a total of about 220 distinct populations per eukaryote species (Hughes et al. 1997). Multiplying this by a range of estimates of the extant numbers of species, gives a global total of 1.1 to 6.6 x 10^9 populations, one or fewer for every person on the planet. The accuracy of this figure is essentially unknown, with major uncertainties at each step of the calculation.

3.2.3. ECOLOGICAL DIVERSITY

Ecoregions are large areal units containing geographically distinct species assemblages and experiencing geographically distinct environmental conditions. Careful mapping schemes have identified 867 terrestrial ecoregions (Table 3). Some workers have identified 14 terrestrial biomes, some of which at least will be very familiar where ever in the world one resides (tropical

& subtropical moist broadleaf forests; tropical & subtropical dry broadleaf forests; tropical & subtropical coniferous forests; temperate broadleaf & mixed forests; temperate coniferous forests; boreal forest/taiga; tropical & subtropical grasslands, savannas & shrub lands; temperate grasslands, savannas & shrub lands; flooded grasslands & savannas; montane grasslands & shrublands; tundra; Mediterranean forests, woodlands & scrub; deserts & xeric shrub lands; mangroves).

At a yet coarser spatial resolution, terrestrial and aquatic systems can be divided into biogeographic realms. Terrestrially, eight such realms are typically recognized, Australasia, Antarctic, Afrotropic, Indo-Malaya, Nearctic, Neotropic, Oceania and Palearctic (Figure 4).

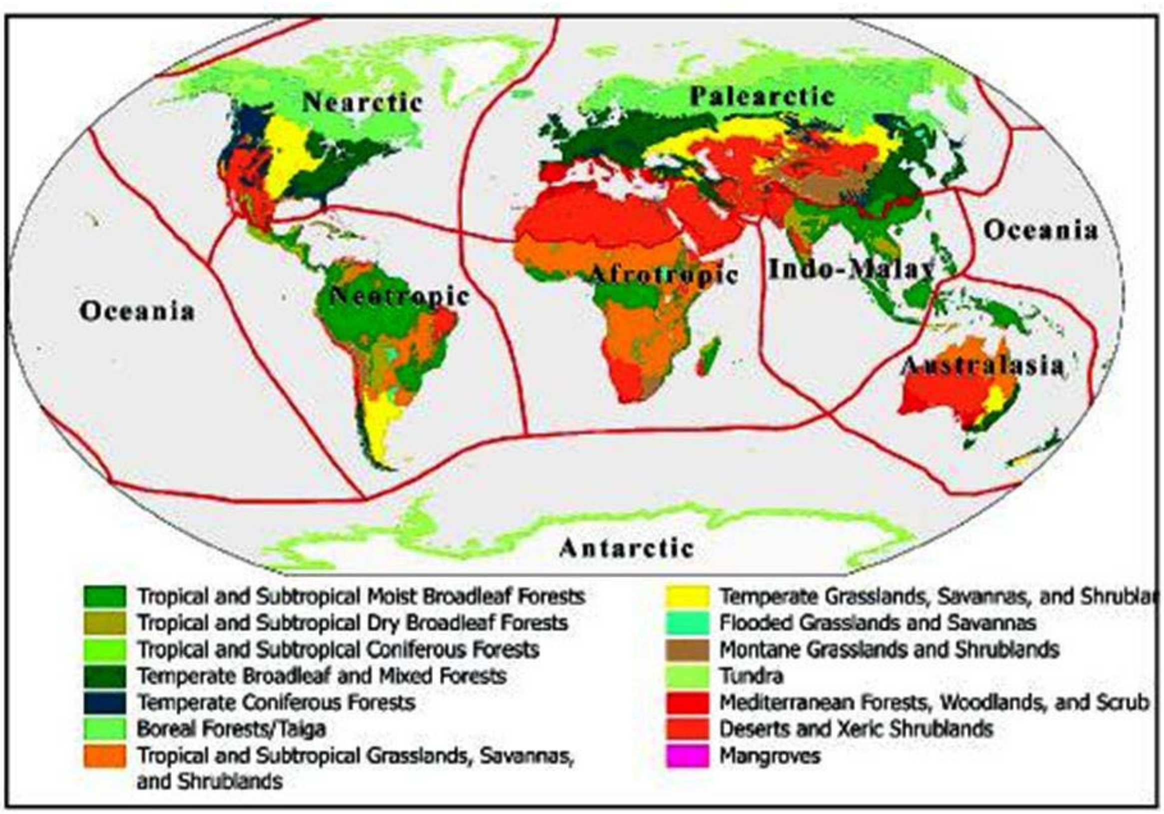


Figure 3 ***The ecoregions are categorized within 14 biomes and eight biogeographic realms.***

Ecoregions can in turn be grouped into biomes, global-scale biogeographic regions distinguished by unique collections of species assemblages and ecosystems.

Ecological diversity is arguably also the least satisfactory of the groups of elements of biodiversity. There are two reasons.

1. whilst these elements clearly constitute useful ways of breaking up continua of phenomena, they are difficult to distinguish without recourse to what ultimately constitute some essentially arbitrary rules. For example, whilst it is helpful to be able to label different habitat types, it is not always obvious precisely where one should end and another begins, because no such beginnings and endings really exist. In consequence, numerous schemes have been developed for distinguishing between many elements of ecological diversity, often with wide variation in the numbers of entities recognized for a given element.
2. some of the elements of ecological diversity clearly have both abiotic and biotic components (e.g. ecosystems, ecoregions, biomes), and yet biodiversity is defined as the variety of life.

3.3. MAINTAINING BIODIVERSITY

This unit explores strategies conservationists employ to protect natural ecosystems (i.e. ecosystems that are little changed by people) by establishing and managing reserves. Most conservationists also recognize that protecting some exemplary natural ecosystems is not enough. We must look beyond the boundaries of reserves to the ecosystems that form the larger matrix, in which reserves are imbedded, especially those semi-natural ecosystems in which we can integrate management for biodiversity and management for commodities such as timber, livestock, and fisheries.

The idea that some places should be protected from the usual range of human uses goes back at least 3000 years to Ikhnaton, king of Egypt, and probably earlier to sacred mountains and groves unrecorded by history. It is hard to know why such places were selected for protection and exactly what types of protection were enacted. In this chapter we will consider three contemporary issues regarding protecting ecosystems: selecting particular ecosystems to be protected; designing a reserve for those ecosystems; and managing a reserve after it is established. Natural places protected from most human activities may have many names: parks, refuges, sanctuaries, wilderness areas, preserves, and more (Table 5). Sometimes, these different names reflect different management goals and strategies, and, sometimes, they simply reflect the ambiguity of language. We will use “reserve” as a generic term for areas in which natural ecosystems are protected from most forms of human use; “protected area” is another common generic term.

TABLE 4 THE UNITED NATIONS RECOGNIZES SEVEN TYPES OF PROTECTED AREAS (LOCKE AND DEARDEN, 2005).

Category	Description
Ia Strict Nature Reserve	Protected area managed for science
Ib Wilderness Area	Protected area managed mainly for wilderness protection
II National Park	Protected area managed mainly for ecosystem protection and recreation
III Natural Monument	Protected area managed mainly for conservation of specific natural features
IV Habitat/Species Management Area	Protected area mainly for conservation through management intervention
V Protected Landscape/Seascape	Protected area managed mainly for landscape/seascape conservation and recreation
VI Managed Resource Protected Area	Protected area managed mainly for the sustainable use of natural ecosystems

3.3.1. RESERVE SELECTION

Traditionally, the selection of reserves has been driven by aesthetics and recreation because people love to visit spectacular places or wild life in accessible areas such as the Serengeti, Bale Mountains, or Awash national Park.

The objectives of reserve selection vary from country to country but the assumption is that most species, known and unknown will be protected if a reserve system contains a complete array of the region's ecosystems.

An ecosystem is selected to be a reserve if it is

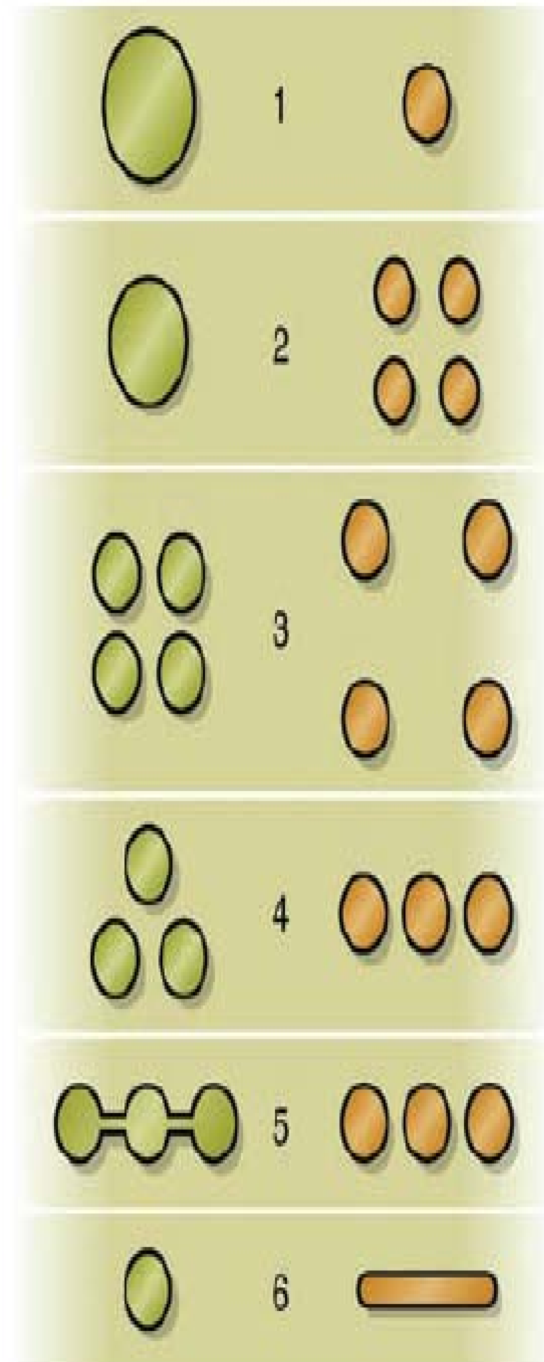
1. irreplaceable as a Center of Species Diversity;
2. if protecting a complete set of all ecosystems that belong to a certain region will protect most – but not all species (ecosystem and environment surrogate approach);

3. if it fills the gap by gap analysis (Usually there is an existing set of reserves and they must undertake a process called "gap analysis" to identify holes in the existing network, which is often unbalanced and incomplete from the perspective of biodiversity conservation);
4. If the size of an ecosystem can encompass home range of protected species;
5. If it satisfies logistic issues (feasibility of creating a reserve in an area under imminent threa).

3.6.1. RESERVE DESIGN

Reserve selection is inevitably followed by reserve design: deciding how large the reserve should be, where its boundaries should lie, and other issues. Many ideas about reserve design is based on an analogy between reserves and islands. Based on Island Biogeography concept, six designs can be employed.

Table 5 Schematic representations of design principles for nature reserves. In each pair the design on the left will probably have a lower extinction rate and thus may have higher species diversity.

<table>
<tr><th>Definitions</th><th>Left</th><th>Right</th></tr>
<tr><td>
1. A large reserve will hold more species than a small reserve because of the species–area relationships
2. A single large reserve is preferable to several small reserves of equal total area, assuming they all represent the same ecosystem type.
3. If it is necessary to have multiple small reserves, they should be close to one another to minimize isolation.
4. Arranging small reserves in a cluster, as opposed to a linear fashion, will also facilitate movement among the reserves.
5. Connecting the reserves with corridors will make dispersal easier for many species.
By making reserves as circular as possible, dispersal within the reserve will be enhanced, and the negative effects of edges will be minimized.
</td><td colspan="2">
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In designing the reserve, the following criteria need to be taken into account:

1. Reserve size - Conservationists prefer large reserves to small reserves for two main reasons:
    i. Large reserves will, on average, contain a wider range of environmental conditions and thus more species than small reserves. Additionally, some species will be absent from small reserves because they require large home ranges (e.g. large carnivores), or simply because they live at low densities and by chance alone are unlikely to be in a small reserve (e.g. many rare plants). In both cases, these are species that are likely to be high priorities for conservation.
    ii. large reserves are more secure and easier to manage (at least per unit area) than small reserves for three reasons:
        a. Large reserves have relatively large populations that are less likely to become extinct
        b. large reserves have a relatively shorter edge than small reserves and thus are less susceptible to external disturbances such as invasions of exotic species and poachers ; and
        c. Large reserves are less vulnerable to a catastrophic event such as a volcanic eruption, hurricane, or oil spill, or fire because most catastrophes cannot disturb an entire reserve if it is large enough.

All three of these factors, especially the second one (b), makes large reserves easier and cheaper to manage per unit area. There are also efficiencies of scale in supporting the management infrastructure of a large reserve (e.g. almost every reserve, large or small, needs a headquarters building).

2. Landscape context – It should be noted that reserves are not an island for the boundaries of reserves are permeable and many things move across them. Air and water pollution, invasive exotics, livestock, and poachers are some of the negative factors that can encroach on reserves from outside. One obvious idea is to design reserves so that they will be buffered from the most harmful human activities by being imbedded in a matrix of semi-natural ecosystems such as native forests managed for production of large trees. Dense human populations (some of whom might be poachers) and incompatible land uses such as intensive agriculture would be kept at a distance from the reserve. Reserves are easier to buffer if they are circular, because a circle has less edge per unit area than any other shape.
3. Connectivity – reserves should be completely surrounded by carefully managed semi-natural ecosystems through which species could easily move from reserve to reserve. Four basic kinds of movement need to be maintained:
    - The daily movements most animals make among the patches of preferred habitat that comprise their home range.
    - The annual migrations many animals make between winter and summer ranges, or dry season and wet season ranges. The length of these movements vary from a few hundred meters for some amphibians and insects to thousands of kilometers for some birds and marine animals.
    - The dispersal movements that young animals and plants (the latter usually as seeds, spores, or pollen) make away from their parents. Dispersal movements

are vital to keeping the organisms of a reserve “connected” with conspecifics living elsewhere.

- The range shifts that species make in response to climate change, moving back and forth across continents at time scales measured in thousands of years

No refuges are large enough to accommodate continental-scale movements, but conservationists have considered linking reserves with continental scale corridors, or at least having reserves arranged as stepping-stones across a continent. Naturally, the design of a connection should depend on the kinds of organisms and the types of movements it was intended to accommodate.

3.4. ECOSYSTEM SERVICES

3.4.1. WHAT ARE ECOSYSTEM SERVICES?

The services of ecological systems and the natural capital stocks that produce them are critical to the functioning of the Earth's life-support system. They contribute to human welfare, both directly and indirectly, and therefore represent part of the total economic value of the planet. The student is encouraged to read about ecosystem functions and services in Costanza et al. (1997).

Ecosystem services are defined as “the benefits people obtain from ecosystems”. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, and other nonmaterial benefits.

Human beings depend directly or indirectly on ecosystem services for their survival. However, the services ecosystems provide to human beings are usually unnoticed and taken for granted. It is only few decades ago that recognition of ecosystem services came to the science arena. Ecosystem services are the product of ecosystem functions without which the later is difficult to explain.

In their broad definition, ecosystem services are simply ‘‘the benefits people obtain from ecosystems’’. This definition includes both the benefits people perceive, and those they do not. Benefits are anything that people value and both perceive and are ‘‘willing to pay’’ for in some real or contingent sense. Ecosystem functions refer variously to the habitat, biological or system properties or processes of ecosystems. Ecosystem goods (such as food) and services (such as waste assimilation) represent the benefits human opulations derive, directly or indirectly, from ecosystem functions. In its simplified form ecosystem goods and services together can be referred to as ecosystem services.

Ecosystem functions are

A large number of functions and services can be identified. Some ecosystem services and functions are shown in Table 6.

Table 6 Some examples of ecosystem services and functions

	Ecosystem services	Ecosystem functions	examples
1	Gas regulation	Regulation of atmospheric chemical composition	CO_2/O_2 balance, O_2 for UV protection and SO_x levels
2	Climate regulation	Regulation of global temperature and other biologically mediated climatic processes at global or local levels	Green house gas regulation, Dimethyl Sulfide production affecting cloud formation
3	Disturbance regulation	Capacitance, damping and integrity of ecosystem response to environmental fluctuations	Storm protection, flood control, drought recovery and other aspects of habitat response to environmental variability mainly controlled by vegetation structuring
4	Water regulation	Regulation of hydrological flows	Provisioning of water for agricultural (such as irrigation) or industrial (such as milling)

			processes or transportation
5	Water supply	Storage and retention of water	Provisioning of water by watersheds, reservoirs and aquifers.
6	Erosion control and sediment retention	Retention of soil within an ecosystem	Prevention of loss of soil by wind, runoff, or other removal processes, storage of stilt in lakes and wetlands.
7	Soil formation	Soil formation processes	Weathering of rock and the accumulation of organic Material
8	Nutrient cycling	Storage, internal cycling, processing and acquisition of nutrients	Nitrogen fixation, N, P and other elemental or nutrient Cycles
9	Pollination	Movement of floral gametes	Provisioning of pollinators for the reproduction of plant Populations
10	Biological control	Trophic dynamic regulations of population	Keystone predator control of prey species, reduction of herbivory by top predator

How can the ecosystem services be valued? Valuation of ecosystem services is based on, either directly or indirectly, on attempts to estimate the 'willingness-to-pay' of individuals for ecosystem services. For example, if ecological services provided a $50 increment to the timber productivity of a forest, then the beneficiaries of this service should be willing to pay up to $50 for it. In addition to timber production, if the forest offered non-marketed, aesthetic, existence, and conservation values of $70, those receiving this nonmarket benefit should be willing to pay up to $70 for it. The total value of ecological services would be $120, but the contribution to the money economy of ecological services would be $50, the amount that actually passes through markets.

UNIT 3- SELF EVALUATION QUESTIONS

1. What is biodiversity?
2. Which species concept is currently widely accepted?
3. Discuss in brief scopes of biodiversity.
4. Explain steps in reserve design.
5. Why do some media outlets criticize Ethiopian parks as “paper parks”?

FIELD EXERCISE

Prepare the following materials:

- Sickle
- Hoe
- Biodegradable bag or compact sac
- Measuring tape or stick
- Pencil
- White paper

Personnel:

- One field assistant

On a sunny day morning, with your filed assistant, take the materials; get out to the field near your town or compound. Select an area covered with grass or small bush, which is not recently disturbed by humans or animals. Measure exactly a 1-m^2 area. Harvest the grass piece by piece near its root and rub the grass off every organism you found into the bag you made until you completely finish the grass. Gather all fallen leaves and decomposing organic matter above the soil using a hoe and collect all organisms you found into the bag. Identify the organisms into species 1, species 2, species 3 etc. You should not know the exact species name but you should detect at least that each organism belong to different species. After identifying each species just release them to the nearby grass. How many species did you count? If you answer this question, you just arrived that one of the most prominent biodiversity measures, “species richness”. Your answer should be no. of species per m^2. Species richness is the number of species per unit given area. You can repeat another day fro a different place and compare the biodiversity of grass dwelling invertebrates.

UNIT 4 THREATS TO BIODIVERSITY

4.1. EXTINCTION

Evolutionary biologists are confident that, as death is the inevitable fate of every individual, extinction is the fate of every species. In fact, the fossil record indicates that of all the species that have ever lived on earth, about 99.9% have gone extinct. It is also reasonable to assume that those that are extant now will eventually meet the same fate. Although extinction is inevitable, it does take different forms. A species may disappear because it evolves into a similar, but distinct, new species or it may disappear into an evolutionary dead end. A few creatures have persisted nearly unchanged for such long periods that they are popularly called living fossils; for example, the horseshoe crab, genus *Limulus*, has changed little in 190 million years. A more typical "life span" is a million years or so. (Average life spans in the fossil record are closer to four million years, but the fossil record is probably biased toward widespread, successful species with longer life spans, and life spans across all species are probably somewhat shorter. Although species have been falling to extinction throughout the 3.5-billion-year history of life on earth, extinction's clock has not run smoothly. There have been at least five periods when huge numbers of species have vanished, leaving behind a greatly impoverished biota. Concern that we may be in the midst of another spasm of extinctions – one of our own making – is, of course, the catalyst behind conservation biology. Before examining the evidence for a human-induced extinction spasm and its likely mechanisms, we need some understanding of the episodes of mass extinction that preceded our arrival on the scene.

The world has experienced five mass extinctions and currently experiencing the sixth one.

During the last five extinction episodes species have recovered, but it took them millions of years to do so. Once species extinction happens, that means no human generation may have the chance of seeing it back.

The current extinction is different from the previous one in that it is human induced. Since thousands of species remain unknown to science it is difficult to note exactly the number of species becoming extinct each day. However with some constraints, it is possible to document some recent extinctions. The most comprehensive list, compiled by the World Conservation Monitoring Centre, lists 90 species of plants and 726 animals that probably have become extinct, at least in the wild, since 1600. It is undoubtedly incomplete for all groups, extremely so for invertebrates. It does not even attempt to list extinct fungi, algae, bacteria, and other microbes. Because many such obscure organisms are part of a highly coevolved interspecific relationship with better known "higher" plants and animals (as parasites, pathogens, etc.), the number of "coendangered" species is likely many times that of documented endangered and extinct species. Since the number of species is proportional to the size of the ecosystem they occupy, habitat degradation stands first as the main cause of current species extinction.

4.2. CLIMATE CHANGE

Scientists believe that the earth is experiencing a significant change in climate now because of human-induced changes in atmospheric concentrations of CO2, and that these changes are stressing the earth's biota. In a changing climate, the species has two options: either to adapt or to perish. The easiest way for a species to adapt to climate change is to shift its geographic range to a new area that has appropriate climate. The simplest response would be moving toward the poles during warming periods and toward the equator during cooling periods. This also can be changing attitude.

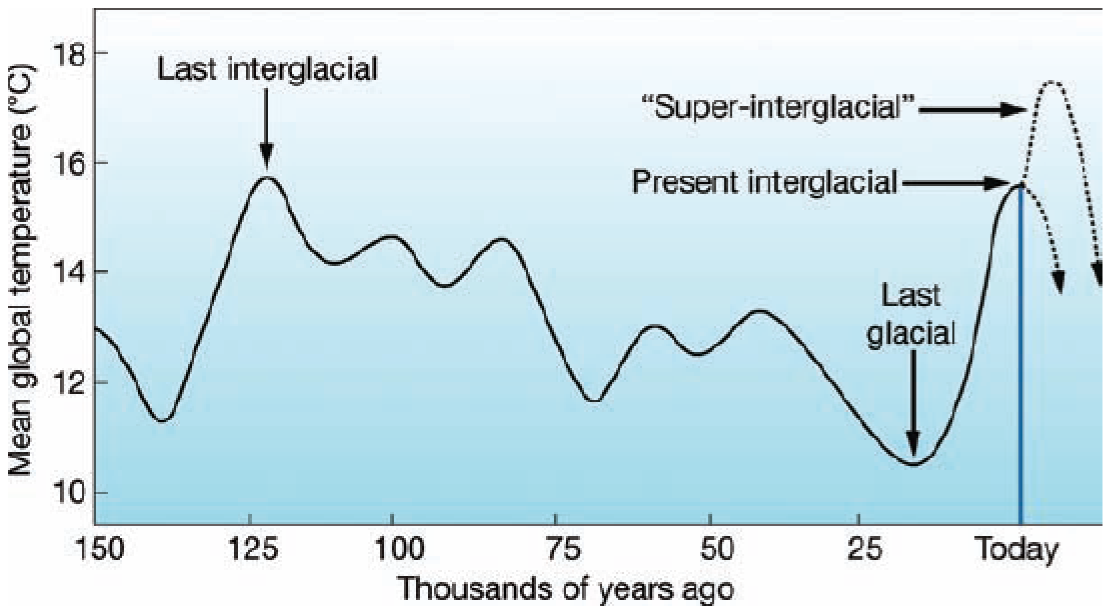

FIGURE 4 GLOBAL MEAN TEMPERATURE OF THE LAST 150,000 YEARS. THE TERM INTERGLACIAL REFERS TO A COMPARATIVELY SHORT PERIOD OF WARMTH DURING AN OVERALL PERIOD OF GLACIATIONS.

4.3. ECOSYSTEM DEGRADATION BY HUMANS (ANTHROPOGENIC IMPACTS)

Habitat degradation is the process by which habitat quality for a given species is diminished: for example, when contaminants reduce a species' ability to reproduce in an area. When habitat quality is so low that the environment is no longer usable by a given species, then *habitat* loss has occurred.

Ecosystem degradation occurs when alterations to an ecosystem degrade or destroy habitat for many of the species that constitute the ecosystem. For example, when warm water from a power plant increases the temperature of a river, causing many temperature-sensitive species to disappear, this is ecosystem degradation by a conservation biologist's definition. In contrast, an ecosystem ecologist might focus on changes in ecosystem function such as a reduction in productivity, rather than on structural attributes such as the abundance and diversity of biota. *Ecosystem loss* occurs when the changes to an ecosystem are so profound and when so many species, particularly those that dominate the ecosystem, are lost that the ecosystem is converted to another type. Deforestation and draining wetlands are just two of many processes that destroy ecosystems.

Human beings can destroy ecosystems by several ways. Some of the ways are the following:

4.3.1. CONTAMINATION (POLLUTION)

One might define a pollutant or contaminant as a substance that is where we do not want it to be. This suggests that substances often do not stay where we put them; they move. There are three main media that can move pollutants – air, water, and living organisms. Note that there is overlap among these media; for example, acid rain begins as air pollutants and ends up contaminating a lake or causing increased concentrations of heavy metals in biota. Pesticides can be distributed by air or water, but we will focus on those that move from organism to organism in a food web.

4.3.2. ROADS, DAMS, AND OTHER STRUCTURES

The most ubiquitous structures created by people are roads, and while roads facilitate the movement of people, they can also serve as impediments to the movements of many animals. Some roads have curbs or lane dividers that are an absolute barrier to small, flightless animals such as amphibians, small reptiles, and various invertebrates. In Ethiopia there are studies done concerning road killings but it is estimated that the roda through the Awash National Park, The Bale Mountains National Park and many other preserves kill hundreds of animals each year.

A second major problem associated with roads is the access they provide to people who may overexploit organisms or destroy whole ecosystems. The roads penetrating formerly remote areas of tropical forest, allowing access by poachers who overexploit game populations and settlers who raze the tropical forests, are a particularly lamentable example of this phenomenon.

Roads may also provide access to exotic organisms that can disrupt native. Usually, these will be species carried, intentionally or not, by people traveling along the highway. Sometimes, exotic species will move along the road by themselves. In particular, weedy exotic plants seem to use the disturbed ground of roadsides to invade a landscape. Finally, roads have a variety of physical and chemical attributes that are likely to affect adjacent aquatic and terrestrial ecosystems. These include various substances such as dust, sediment, salt, heavy metals, hydrocarbons; a sunny, windy, warm microclimate; blocking surface water runoff etc. One of the most annoying physical aspects of roads for human observers – traffic noise – was found to reduce bird population densities in a band hundreds of meters.

Worldwide, over 45,000 large dams (>15 meters high) have affected most of the world's major river systems. The damming of streams and rivers destroys many aquatic ecosystems, flooding ecosystems upstream of the dam and changing water flows to downstream ecosystems. We will return to these issues in a later section; here the focus will be on the barrier effects of dams. Many animals move up and down rivers during the course of a year, or during their life cycle, searching for the best places to forage or breed. Some of them can fly or walk around dams (otters, mayflies, etc.), but for totally aquatic species dams can be very significant barriers. Moving downstream, these animals are likely to be churned to death or at least highly stressed in turbines. Moving upstream, they encounter an insurmountable wall that may or may not have a fish ladder around it, and even fish ladders work for only a portion of the population. The reservoir behind a dam may also impede movement, especially if it has been stocked with exotic, predatory fish. Of course, fish are the best known victims of dams, especially anadromous fish such as salmon that move long distances between riverine spawning areas and marine foraging areas. Dispersal rates of water dispersed plants also face the same fate.

Some landscapes are dissected by barriers specifically designed to inhibit the movement of animals. Notably, rangeland fences stretch huge distances, controlling the movement of both livestock and large wild mammals and sometimes severing seasonal migrations. For example, in Botswana, thousands of kilometers of fences have been erected to isolate livestock from wild ungulates that might harbor diseases. These fences have had catastrophic consequences for native ungulates, especially wildebeest, which must migrate to access water during dry seasons.

4.3.3. UNREGULATED FARMING STYLE (CAUSE OF SOIL EROSION)

Soil errosin has determintal effect on soil microorganism and top soil. Once the top soil is lost soil loses its f ertility. Loss of fertility means loss of grass, crop and all necessary services that plants provide to the system.

4.3.4. ILLEGAL USE OF FIRE (ARSON)

Unmanaged, intense and frequent fire has devastating effect on species and ecosystem. This is particularly true in nature preserves and natural forests that harbor several species.

4.4.4. DEFORESTATION

Deforestation may be the most important direct threat to biodiversity for three reasons:

1. Forests cover less than 6% of the earth’s total surface area.
2. Forests are habitat for a majority of the earth’s known species.

3. Forests are being lost faster than they are growing.

Deforestation in Ethiopia exists for five important reasons:

1. Poverty – people cut trees for their livelihoods as a means of income. If they have alternative income sources, they may not do it at a magnitude they are doing it now.
2. Lack of alternative energy sources: – most Ethiopian households use fire to cook food. Alternative energy source will certainly curb this problem.
3. Lack of alternative construction material:– Households in Ethiopia still use wood for construction. Such woods come from natural forests. Commercial tree farms and alternative construction materials such as rock, soil, and metal may solve the problem.
4. Lack of awareness: – Most people in Ethiopia do not have sufficient knowledge of how deforestation can cause climate change, soil erosion, pollution and the like.
5. Overgrazing – rural Ethiopia, particularly, the pastoralist community believes in the numbers of livestock than the quality. Such large number of livestock contributes to severe overgrazing, particularly, on the high lands.

4.4.4. DESERTIFICATION

Overgrazing and cultivation of the same land for generations is causing desertification. Sub-Saharan Africa suffers from the natural expansion of the Sahara to its nearby landscapes each year. Overgrazing and activities that destroy trees all contribute to the expansion of the desert regime.

4.4.5. DRAINING THE WETLANDS

Filling- a wet depression with material until the surface of the water table is well below ground is an obvious way to turn a wet ecosystem into a dry one.

Draining- involves digging ditches that allow the water to drain away. It changes an ecosystem for of wetland organisms to an inhospitable ground.

Dredging- involves digging up the bottom of a water body – the mud and a host of mud dwelling creatures – and depositing the material elsewhere, often in a wetland that someone wants filled.

Channelizing- rivers and streams means making them straighter, wider, and deeper and replacing riparian (shoreline) vegetation with banks of stone or concrete. This conversion from a complex of natural riverine communities to a barren canal may meet engineering objectives, usually flood control, but is obviously an environmental calamity. Sometimes canals are dug to connect separate water bodies; these can become conduits that allow the mixing of formerly isolated biota. E.g., turning of River Modjo to a lake called Babogaya in Bishoftu area changed the entire biota of the lake.

4.4.6. FRAGMENTATION

The process by which a natural landscape is broken up into small parcels of natural ecosystems, isolated from one another in a matrix of lands dominated by human activities, is called *fragmentation*. In highly fragmented landscapes, it is difficult for individuals (usually juvenile animals, seeds, or spores) to disperse to another suitable patch of habitat. Fragmentation has several negative consequences on species survival.

5. OVER EXPLOITATION

The early overexploitation can be exemplified by the arrival of the white man on the undiscovered continents such as Africa, North America, Latin America, and other parts of the world. The colonial era exemplifies the over killing of the American Bison, the Extinction of the African Moa and several others. This may be because of the advent of guns and the ignorance of conservation.

Currently, the two forms of overexploitation that receive the most attention from conservationists are overfishing and the so-called “bush meat” trade. Overfishing does not attract adequate public scrutiny for many reasons including: (1) people are not very sympathetic to fish; (2) most fishing happens at sea, beyond sight and often beyond national boundaries; and (3) the total harvest across all fisheries has only recently started to decline.

The term “bush meat” can be widely construed to cover any wild animal used for human food, but in the lexicon of conservation it is used primarily when describing the overexploitation of animals in tropical terrestrial ecosystems, especially in forests, and especially in West and Central Africa. The range of animals involved is enormous – from crabs to gorillas – but mammals dominate especially rodents, ungulates, and primates. Of course people have been hunting and eating wild animals in tropical forests for millennia, but the rate of exploitation has clearly become unsustainable in recent decades as the density of people has grown and as exploitation has been driven by commercial enterprises rather than local, subsistence consumption. With urban populations mushrooming and roads reaching farther and farther into formerly remote areas the market for bush meat is enormous. Importantly, bush meat overexploitation carries profound risks for people as well as wild animals; notably loss of a supply of protein and exposure to **zoonotic** diseases. There are several types of exploitations: commercial exploitation, subsistence exploitation, recreational exploitation, incidental exploitation that is also called as by-catch by anglers.

Overexploitation is removing more individuals than they are reproduced and thus exposing them to extinction in the end. Overexploitation has an unbalanced effect on age, sex, genetic structure, and ecosystem structure.

Indirect Exploitation - The term "indirect exploitation" could be used to cover a wide set of human activities that indirectly kill other organisms: the roads, fences, antennas, and so forth.

UNIT 5 CONSERVATION BIOLOGY

In Unit 1 you were briefly introduced to the concepts of Conservation Biology. In this unit you will be exposed to the guiding principles of Conservation Biology; world views about conservation Biology; its brief History and the ethics within it.

Conservation biology is a cross-disciplinary subject lying between biological and natural resource sciences. Conservation biology differs from basic biological sciences as it reaches beyond biology into disciplines such as economics, social work, law, education, politics, philosophy and other subjects that shape the human world. Conservation biology differs from the traditional resource conservation as it conserves the entire systems and all their biological components and processes but not only motivated to conserve those resources useful for human.

Few decades ago, maintaining biological diversity was considered as only saving the endangered species from extinction, overshadowed by soil and water conservation, and related disciplines. However, as many of the species are at risk, at present Conservation Biology extended to genes, species, and ecosystem focusing on saving life on earth.

There are three guiding principles that serve as working paradigms for conservation biology. A paradigm is the family of theories that under grid a discipline. These three principles are so basic for conservation practice.

Principle 1. Evolutionary change – Evolution is the basis for understanding all biology that unites all biology. The processes of evolutionary change are the ground rules for how the living world operates.

Principle 2. Dynamic ecology – ecological systems are dynamic and non-equilibrial; change must be part of conservation. Communities have their own interactions that are important for the ecological dynamicity. Change at some level in the community is acceptable. Ecosystems are open systems with fluxes of species, materials, and energy.

Principle 3. Human presence – Humans are and will continue to be part of both natural and degraded ecological systems, and their presence must be included in the conservation planning.

5.2. History of conservation biology

The global effort to conserve and protect natural environment is a recent phenomenon. However, the efforts to conserve economically important natural resources have a long history. Environmental destruction is associated with human history. Even Aristotle has also commented on the destruction of forest habitats by humans.

Conservation biology draws on religious and philosophical traditions. European scientists in the eighteenth and nineteenth centuries reacted to the destruction of forests and water pollution in their colonies by proposing some regulations. The decline and extinction of species in Europe led to the establishment of the first nature reserves and an active popular interest in conservation.

Since the end of the nineteenth and twentieth century, conservation began to become an important goal for many nations. The aim was broadened from efforts that protect important game species to the whole biodiversity both within nations and across the globe.

Thousands of species are going extinct as result of human activities due to the exponential human population growth and consumption of natural resources. Thus a field of conservation biology developed over the last 40 years as a response of the scientific community due to this crisis.

5.1. CONSERVATION ETHICS

Ethics is the study of right and wrong actions based on normative premises and logical argument. Morals reflect the predominant feelings of a culture, about ethical issues. Conservation ethics is an ethics of resource use, allocation, and protection.

There are several views of environmental ethics.

1. **Anthropocentrisom** (human chauvinism): found in two forms:
    a. the sole value assumption - the belief that (of all earthly creatures) humans alone are morally significant because they alone possess the characteristics which bestow moral significance;
    b. the greater value assumption - the belief that humans are more significant, morally speaking, than any other creatures, because they possess in a greater degree the characteristics which bestow moral significance.

According to this view only humans have significant value; meaning humans should not care directly about the non-human entities. All environmental responsibilities derived from human interest alone; and nature has value only when humans utilize it.

2. **Biocentrism** (life-centered ethics)**:** the contrary of anthropocentric view; a view that attributes moral value to living systems generally. Bicentrism is "an attitude of respect to

nature" which involves a moral commitment to live one's life in a way that respects the welfare and inhernet worth of all other organism.

3. **Ecocentrism** (ecosystem centered ethics): Ecocentric ethics moves from individualistic to holistic approaches to environmental ethics. It assesses that our ethical duties are not to individuals but to the ecosystem as a whole. Whether a particular organism has value and, if so, its degree of value depends on its role in the larger system.
4. **Deep Ecology –** is a type of biocentrism but with a strong social emphasis. Deep ecology embraces biocentrism but focuses much of its attention on social issues. It asserts, for example, that the life style of persons in affluent nations must be dramatically changed and that the human population of earth should be greatly reduced. Deep ecologists are critical of globalization as well as, arguing for decentralization in the political and economic spheres and for increased respect for cultural diversity.
5. **Ecopheminism** – is an approach to environmental ethics that is human centered but that endeavors to construe "human" in a feminist (or at least gender neutral) rather than a patriarchial sense. Another version of ecopheminism rejects anthropocentrism and argues that operession of woman is systematically linked – in our social structures and our ways of thinking – to the oppression of nature. According to this aaproach, sexism and naturalism are so tightly connected that women will not be able to achieve genuine equality until nature itself is recognized as an equal.

In general some ethical theories hold that only individual things – whether humans person, animals, or plants – can have inherent value. These are individualistic theories. Anthropocentrism is an example. Other theories contend that it is only the system or community of individuals – for example, the entire ecosystem or "the land community"- that have inherent value. These are holistic theories. Some ethical theories such as biocentrism, assert that inherent value can be had in only one degree or quantity – that whatever has from either a free market or a socialist perspective, for example, or which special attention to questions of race or class or gender. In every case, however, the presumption is that human behaviors that degrade the environment are rooted in the social and economic and political structures that surround the behavior.

The way we treat things depend on its value. Something with greater value is handled very carefully. For example, a 100 g gold is handled more carefully than a 100 kilogram corn. Some things are valuable because of the ways in which they can be used or the benefits that they provide. Imagine a gold ring for your beloved one and a quintal of corn that you. What kind of value a thing has affects the way we consider our behavior towards it. If a thing has an instrumental value (extrinsic value) (like computers, cups, glasses etc), it can be harmed, but it cannot be wronged. How I treat it will depend only on my consideration of its value to me and to others. But if a thing has inherent value (like a human person), it can be wronged. How I treat it depends not only on my consideration of its value to me and the others but above all on a consideration of how my behavior will affect it: how, for example, my behavior is fair, decent, respectful and so forth.

The most important questions of different environmental ethics theories attempt to answer is: “Which things in the world around us have inherent value? That is which things deserve moral consideration not only because of their value but also for their own sake? If we prefer to discuss moral questions in the popular language of “rights,” this question becomes, which things have rights? This debate leads to animal rights, and all sorts of rights moment.

Conservation biology rests on a number of underlying assumptions that are accepted by most conservation biologists. These assumptions cannot be proved or disproved, and accepting all of them is not a requirement by the conservation biologists.

These assumptions represent a set of ethical and ideological statements that help for conservation.

1. The diversity of organisms is good – The general public interest is high on the biodiversity as seen by millions of visitors.
2. The untimely extinction of populations and species is bad - The extinction of species by human impact is increasing.
3. Ecological complexity is good - The complex ecological interrelationships in different species in a natural habitat are good.
4. Evolution is good – Evolutionary adaptation lead to formation of new specie that increases biological diversity.
5. Biological diversity has intrinsic value – species have value regardless of their economic, scientific, or aesthetic value to humans.

6. CONSERVATION PLANNING IN THEORY AND PRACTICE

6.1. CONSERVATION PRIORITY SETTING

There are three criteria for the global conservation priority setting: vulnerability, irreplaceability and representativeness. The three criteria can be explained as follows:

VULNERABILITY - Vulnerability (or threat, endangerment) refers to the likelihood that an area's biodiversity will be disturbed or lost to current or future threatening processes. The presented approaches measure vulnerability by quantifying either the extent of remaining natural habitat or the degree of human impact in an area. In a more indirect way, they also consider an area as vulnerable if it contains globally threatened species according to the IUCN Red List of Threatened Species (Fig.). In addition, some approaches rely on expert knowledge or intuition to define vulnerability.

IRREPLACEABILITY- Irreplaceability (or uniqueness, rarity) is the importance of an area in contributing

to a specific set of conservation targets. While vulnerability has a temporal dimension, e.g., sites with low vulnerability will retain options for conservation in the future, irreplaceability refers to the degree to which geographic (or spatial) options for conservation will be lost if that particular site is lost. Irreplaceability is measured by considering the species richness and endemism of the area, or according to the importance of an area for a particular species, such as restricted-range species or congregatory species, e.g., colony-breeding birds. Measures for irreplaceability that include ecosystem and/or habitat characteristics are less common. With the main emphasis on species richness and endemism, the "centres of plant diversity" also consider some additional criteria, namely having an important gene pool of plants of value to humans, a diverse range of habitat types and a significant proportion of species adapted to special edaphic conditions.

REPRESENTATIVENESS - refers to the need for protected areas to represent, or sample, the full variety of habitat types, species assemblages, ecological processes or other natural features that are characteristic for a given region. By definition, representativeness is a very ambiguous riterion because it strongly depends on the ecological target selected and on the geographic unit considered. It can be measured, e.g., in relation to broad, fairly homogeneous biogeographic regions (last of the wild), in relation to characteristic habitat and ecosystem features within each biogeographic region or in relation to national boundaries (megadiversity countries). Other approaches do not define geographic units, but instead measure representativeness according to the species richness of plants (centers of plant diversity) or birds (Endemic Bird Areas, EBAs). A crucial issue is when representativeness is achieved, i.e., how many ecosystems adequately represent all global ecosystems and which number of species is representative of the global species pool (e.g., megadiversity countries).

It has been globally accepted that the species is the fundamental unit of biodiversity. Conversely, mitigating or stopping species extinction can be seen as the fundamental goal of biodiversity conservation, because while all of humanity is other impacts on the Earth can be repaired, species extinction is irreversible. It is fitting, then, that maybe the oldest, best-known, and most widely used tool in the conservationist's toolbox tackles conservation planning at the species level. This is the IUCN Red List of Threatened Species (www.iucnredlist.org).

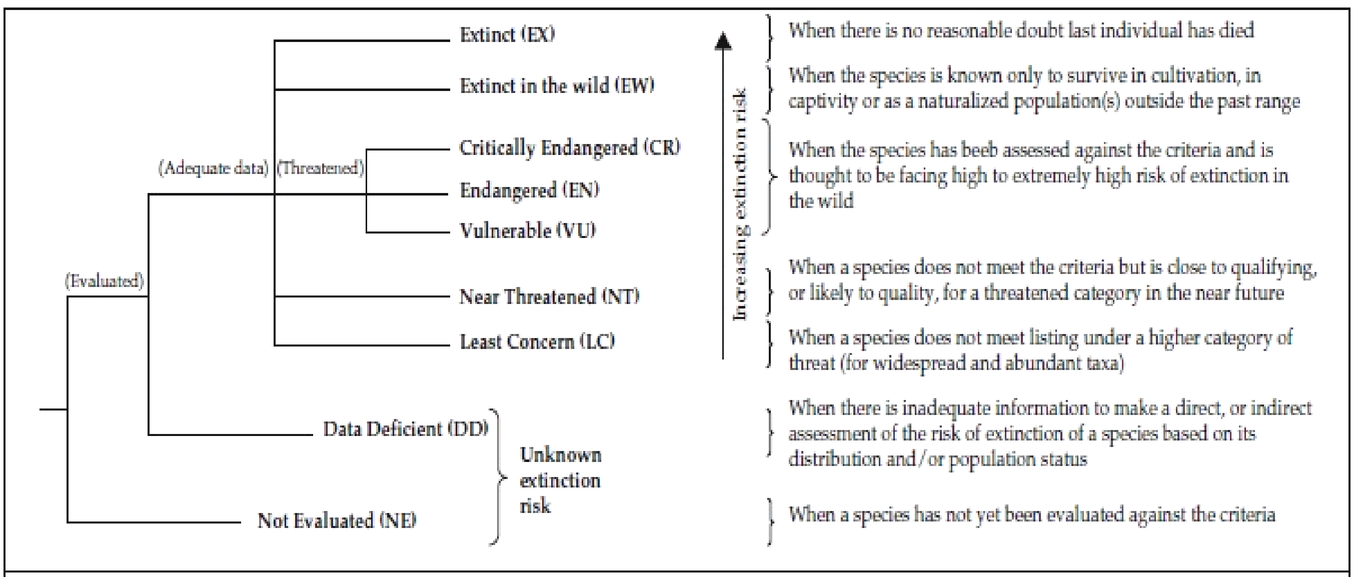

Figure 5 The IUCN Redlist category.

The IUCN category is based on the assessment of vulnerability of species in terms of extinction risk and puts them in seven categories (Fig.5). If there is no data, the species will be labeled as data deficient (DD) and not evaluated (NE) if no assessment took place.

- Whilst biodiversity can be quantified in many ways, species richness remains the most commonly used. Species counts offer several pragmatic advantages as follows.
- Species richness can be easily compared between different sites and conservation schemes.
- There already exists detailed information on species richness within many regions.
- Species represent identifiable entities that can be useful for garnering public support and leveraging conservation funds.
- Species provide a focus for policy and legislation.

Even though conservation priorities differ from region to region, the concepts are similar. There are seven steps in the setting procedure:

1. ***Identify conservation targets:*** conservation targets are the entities or features for which conservation plan or project is attempting to ensure long-term persistence. These can be communities and ecosystems, abiotic (physically or environmentally derived targets) Species: imperiled or endangered, endemic, focal, keystone species etc.

   Keystone species are species, which have a disproportionate effect on their ecosystem, due to their size or activity, and any change in their population will have correspondingly large effects on their ecosystem.

2. ***Collect information and identify information*** **–**The best regional conservation plans utilize information from all available sources, including conservation organizations, public natural resource agencies (local, state, , federal), academia, research institutions, and individual experts. In many cases, critical information necessary for development of a conservation plan may be lacking. These gaps can be filled through use of a variety of

techniques that utilize a combination of remotely sensed imagery, reconnaissance over flights, selective biological inventories, and visual display of information with a GIS to cost effectively gather biological and ecological information about an area; among these techniques are TNC's

Table 7 ***Useful categories of information for conservation planning***

Category	Type information
Land use ownership	Transportation Administrative boundaries Land cover Locations of dams and diversions Water–quality monitoring stations Hydrological flow monitoring stations Point sources for pollution
Physical	Soils Geology Climate Terrain and elevation Wave exposure Wave depth Watersheds and hydrography
Biological	Vegetation cover Wetlands Species distribution Ecoregions and bioregions Fisheries data
Socioeconomic	Population density Population trends Economic trends

3. ***Establish conservation goals*** -. Conservation goals should have two components: a representation Component that refers to the number of occurrences or percentage of each target that should be represented within conservation areas, along with some indication of how those targets should be distributed or stratified across a planning region; and a

quality component that addresses the level of viability or ecological integrity thought necessary for these targets to persist over the long term. For example, most marine studies have suggested that ecologically functional reserves will need to cover at least 20% of a planning region if the biodiversity of that region is to be fully conserved. Broader goals have been suggested for marine reserves when an additional goal is to sustain fisheries. Beyond these two components, additional criteria, such as the range wide distribution of the target relative to the planning region, can be considered in goal setting. For example, if a particular target is endemic to or largely restricted to a planning region, then goals may be set correspondingly higher than for a target that is more widely distributed across several planning regions.

4. ***Assess existing conservation areas for their biodiversity values***. This is essentially gap analysis**.** A logical early step in any planning process for conserving biodiversity is to determine what biological features are already under adequate management within existing conservation areas. The biota of many of the world's parks, refuges, wilderness areas, marine protected areas, and nature reserves have been poorly inventoried, in part because of the perception that these areas are already "protected" and that survey funds would be better spent on areas yet to be designated for conservation management. Nevertheless, interviews with resource experts for these protected areas often reveal considerable information on the status and distribution of biodiversity and the need to devote greater management attention to the conservation of this diversity. Remote-sensing imagery of vegetation cover for these areas can also be useful in assessing the status and distribution of community and ecosystem-level targets. Given the limited fund

available for new conservation areas, it is especially important to determine which conservation targets are already within existing conservation areas and the degree to which these areas are being appropriately managed for these targets. The final step in this framework, identifying priority conservation areas (step 7), will use this information as one of the criteria for setting priorities.

5. ***Evaluate the ability of conservation targets to persist:-*** A practical approach for evaluating the ability of species, community, and ecosystem-level targets to persist is to use a qualitative ranking system that employs three criteria: size, condition, and landscape context.

- ***Size*** is a measure of the area or abundance of a conservation target's occurrence. At the species level, size takes into account the area of occupancy and the number of individuals. For communities or ecosystems, size relates to the area needed to ensure survival from large-scale natural disturbances; it has been referred to as the *minimum dynamic area*. In the case of reserve, minimum dynamic reserve is defined as the minimum reserve area required incorporating natural disturbance and maintaining ecological processes.
- ***Condition*** is an integrated measure of the composition, structure, and biotic interactions that characterize the occurrence of conservation target. For example, this factor would include information on the reproduction and age structure of a population, the canopy or understory structure of a community, or any of several biotic interactions such as predation and disease. In assessing condition, it is often helpful to examine the extent of anthropogenic impacts (e.g., habitat fragmentation and degradation, introduction of

exotic species) and the presence or absence of biological legacies—critical features of communities and ecosystems that take generations to develop (e.g., fallen logs and rotting wood in old-growth forests).

- ***Landscape context*** is an integrated measure of two factors: intactness of dominant ecological processes that help maintain conservation targets (e.g., natural hydrological flow and fire regimes) and connectivity, which allows species to disperse, migrate, and otherwise move to adjacent habitats to meet life cycle needs. In practice, planners have often found it adequate for their purposes to rate each occurrence of a conservation target, for each of these three criteria, as "very good,""good,""fair," or "poor." Occurrences of those targets that receive an overall fair or poor rating are generally excluded from further consideration in the planning process. Because of the scarcity of information on minimum dynamic areas and disturbance regimes for many communities and ecosystems, much work remains to make these criteria operational for conservation targets above the species level. This is very critical for countries such as Ethiopia.

6. ***Assemble a portfolio of conservation area:-*** Following the collection and mapping of data on conservation targets and assessment of the conditions for persistence, the next step is identification of a set of potential conservation areas, including areas that do not have acceptable levels of viability and integrity but which may be restored in the future. Planning teams should have a substantial amount of information on conservation targets, ratings of persistence or suitability, land ownership and management, and other ancillary data sets. Because of the relative complexity of the task, there are a number of advantages to using computerized algorithms with GIS as a tool to aid the identification of

conservation areas. An algorithm is a step-by-step problem-solving procedure, usually a computational process defined by stipulations written into a computer program. In the case of biodiversity conservation, site or area selection methods and algorithms are used as a tool to design networks of conservation areas employing biogeographic principles.

The final task in assembling a portfolio of conservation areas is consideration of the overall configuration or design of the portfolio. Collectively, these principles lead to an emphasis on selecting landscape-scale conservation areas.

7. ***Identify priority conservation areas:-*** Use the criteria of existing protection, conservation value, threat, feasibility, and leverage. action, while others are not. Therefore, a final step in this planning framework is to set priorities for action among the portfolio of potential conservation areas. Priority setting can use: degree of existing protection, conservation value, threat, feasibility, and leverage. "Degree of protection" refers to how well or the extent to which conservation targets are already represented within the existing set of conservation areas in an ecoregion (step 4). Higher priority is given to areas with targets that are not already well represented. The conservation value of an area is based on the number of conservation targets, the diversity of these targets (e.g., terrestrial and aquatic), and their predicted ability to persist over the long term. Areas with more conservation targets (step 1) and higher persistence or suitability ratings (step 5) are assigned a higher priority. Conservation areas that face critical threats are assigned a higher priority than those that are not imperiled; the greater the degree of threat, the higher the priority. Feasibility refers to an organization's capacity to gain protection for an area (through land acquisition, for example) and to secure sufficient funding, staff, and strategies to abate critical threats. Finally, leverage is the ability to

take conservation action at one area and thereby effect observation action at other areas. In practice, a qualitative rank of high, medium, or low is assigned for each criterion (see Groves et al. 2000 for definitions of qualitative ranks) for ach potential conservation area. These criteria rankings are summed for the conservation areas, each of which is assigned an overall priority rank. As with any qualitative ranking scheme, results should be used in setting priorities in conjunction with the sound judgment and personal knowledge of conservation areas by members of the planning team and other experts.

6.2. CONSERVATION APPROACHES

In general, there are three conservation approaches. They are proactive, reactive and representative.

Proactive approaches prioritize areas of low vulnerability that still harbor large and undisturbed ecosystems. They recommend starting conservation activities before a region is actually threatened such as the remaining pristine rainforests of the Amazon and the Congo basin.

In contrast, reactive approaches prioritize areas of high vulnerability and, mostly, of high irreplaceability, e.g., the unique and severely threatened natural ecosystems of Madagascar. The underlying principle is that conservation measures are most crucial in those regions on earth which are rich in biodiversity and under immediate threat of destruction.

Representative approaches have the objective to highlight all regions considered important for conserving a representative part of the world’s biodiversity. Sites are primarily selected for their high degree of irreplaceability without considering site vulnerability. While there is a shared understanding of what vulnerability, irreplaceability and representativeness mean in a descriptive sense, the quantitative characterization of these terms is not as straightforward and is based on a number of different measures and indicators.

Most of the presented approaches screen the planet for conservation priorities by applying a predefined set of ecological criteria and generate so-called global conservation priority templates.

6.3. IN SITU CONSERVATION

In the wild, or in-situ, conservation is defined as "the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings, and in the case of domesticated or cultivated species, in the surroundings where they have developed their nstinctive properties." Essentially, this definition translates to conserving species in their natural environments so that they can exist naturally. Examples include national parks, protected areas, nature reserves and sanctuaries. Primarily, such areas are designed to protect some species either which are endangered, or which are key stone species or some charismatic mammals such as elephants and lions. Can you mention such some in situ conservation sites in Ethiopia?

6.4. EX SITU CONSERVATION

In captivity, or "ex-situ," conservation is defined as "the conservation of biological diversity outside their natural habitats." Essentially, this definition translates to conserving species outside their natural environments, usually in zoos, aquaria, botanical gardens and arboreta, and in gene banks. Good examples in Ethiopia are the Gullele Botanical garden and the gene bank at the Institute of Biodiversity.

6.5. HABIATA RESTORATION

6.6. RESTORING DEGRADED ECOSYSTEMS

6.7. COMBATING DESERTIFICATION

Definition:

Desertification defined by the UNEP: is "*land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities*".

Most of the endangered dry land regions lie near the world's five main desert areas:

- The Sonoran Desert of northwest Mexico and its continuation into the southwest United States;
- The Atacama Desert, a thin coastal strip in South America between the Andes and the Pacific Ocean;

- A large desert area running eastward from the Atlantic Ocean to China, including the ***Sahara desert***, the Arabian Desert, the deserts of Iran and the former Soviet Union, the Great Indian Desert (Thar) in Rajasthan, and the Takla-makan and Gobi Deserts in China and Mongolia;
- The Kalahari Desert in southern Africa; and
- Most of Australia.

There are some other areas of major concern:

- In Africa, 66 per cent of the total land area is arid or semi-arid; in North America, the figure is 34 per cent.
- About 40 per cent of the continental United States is considered vulnerable to desertification by the US Bureau of Land Management. At least 40 per cent of Texas pasture land is already too parched for grazing.
- Dry lands cover more than a third of the earth's total land surface, while deserts account for about 7 per cent. Activities to counter desertification focus on preventing the creation of "desert-like conditions" in dry land areas.
- The Roman Empire's breadbasket in North Africa, which once contained 600 cities, is now a desert.
- The Ogaden, Southern Ethiopian territories, Northern and North Eastern Lowlands are also prone to desertification.

Drought often triggers desertification, but human activities are usually the most significant causes. Over-cultivation exhausts the soil. Overgrazing removes vegetation that prevents soil erosion. Trees that bind the soil together are cut for lumber or firewood for heating and cooking. Poorly drained irrigation turns cropland salty, decertifying 500,000 hectares annually, about the same amount of soil that is newly irrigated each year.

Significant underlying causes include social and economic factors in developing countries, such as poverty, high population growth rates, unequal land distribution, refugee flows, modernization that disrupts traditional farming practices, and government policies that encourage the growing of cash crops on marginal land to pay off foreign debts.

Life on earth depends on the layer of soil that is the source of nutrients for plants, crops, forests, animals and people. Without it, ultimately none can survive. Although topsoil takes a long time to build up, if mistreated it can vanish in just a few seasons due to erosion by wind and water.

The United Nations Convention to Combat Desertification in Those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa, the Convention's full name, was adopted on 17 June 1994 and opened for signature in Paris in October that year. As of 14 January 1997, the Convention (CCD) had been ratified by 60 countries. It entered into force on 26 December 1996. Ethiopia is signatory to this convention.

Agenda 21 of the United Nations Environment program focuses on the following topics to combat desertification:

a. Strengthening the knowledge base and developing information and monitoring systems for regions prone to desertification and drought, including the economic and social aspects of these ecosystems;

b. Combating land degradation through, inter alia, intensified soil conservation, afforestation and reforestation activities;

c. Developing and strengthening integrated development programs for the eradication of poverty and promotion of alternative livelihood systems in areas prone to desertification;

d. Developing comprehensive anti-desertification programs and integrating them into national development plans and national environmental planning;

e. Developing comprehensive drought preparedness and drought-relief schemes, including self-help arrangements, for drought-prone areas and designing programs to cope with environmental refugees;

f. Encouraging and promoting popular participation and environmental education, focusing on desertification control and management of the effects of drought.

6.8. SALINE HABITAT RECLAMMATION

Saline soils cover about 380–995Mha of the Earth's land surface and of these, 62% are saline-sodic or sodic soils. Sodicity is due to sodium (Na^+) accumulation in the soil. Accumulation of excess sodium (Na^+) in the soil causes the changes in soil exchangeable and solution ions and soil pH, destabilization of soil structure, deterioration of soil hydraulic properties, increases susceptibility to crusting and imbalances of plant-available nutrients in the soils.

Soil salinity and sodicity is becoming more and more serious due to climate drying and human activities including overgrazing.

Owing to hydrolyzation of salts, plants growing on the soil suffer not only from sodium toxicity, but also from high pH stress caused by Na_2CO_3 and $NaHCO_3$. Thus agricultural productivities in most of arid and semiarid regions in the world are threatened by the occurrence of salts.

Reclamation of sodic soil requires removal of part or most of the exchangeable sodium, improvement of the soil physical structure, and lowering of pH value.

Soil amendments, such as gypsum or calcium chloride, were commonly used as a supply of soluble calcium for the replacement of exchangeable sodium. Other substances like sulphuric acid, sulphur, coal fly ash, and byproduct from flue gas desulfurization (coal combustion coal products).

The exchange reaction between gypsum and soil's exchangeable Na^+ depended on the contact of gypsum with soil particles and rate of removal of Na^+ from the soil solution. In most cases, fine gypsum was used because they dissolve more rapidly in water than indirectly (chemically or biologically) made the relatively insoluble indigenous calcium carbonate found in sodic soils available for replacement of sodium and improvement of soil physical structure can be used. For best results, after gypsum application, soluble Na^+ should be leached out of the root zone using good quality water so that the reaction proceeds in the forward direction.

The effects of gypsum are limited to shallow depth and shortage of good quality water in most of arid and semi-arid regions where water is scarce.

Recently, biological methods using special plants were being sought for more results. The following biological methods are in use to reclaim saline soils apart from chemical methods mentioned above:

1. Farm yard manure application;
2. Salt tolerant grass revegetation;
3. Laboratory culture and addition of Vesicular-Arbuscular Mycorrhizae (fungi).
4. Leaching with groundwater and growing rice (if applicable);

6.9. FUTURE DIRECTIONS IN CONSERVATION BIOLOGY

Conservation biology is winning some battles but losing the war.

Battles won:

1. The magnitude of the crisis facing wild populations and places has been better documented;
2. threats to individual species and habitats elucidated;
3. priority areas systematically identified; and
4. remedial interventions proposed and in many cases put into practice.

Battles lost:

1. global rates of loss of populations and biomes reach approximately between 0.5 and 1% each year;
2. threats from unsustainable consumption, population growth, and greenhouse gas emissions continue to rise.

Future directions of conservation biology will be mainly about:

1. Improving our understanding of how ecosystems change in response to anthropogenic pressures;
2. trying to conserve ecological and evolutionary processes;
3. Putting conservation plans into practice;
4. documenting and understanding the benefits of natural systems for human well-being;
5. Mainstreaming conservation into the everyday decisions of the business and public sectors;
6. monitoring and communicating the changing state of nature;
7. assessing and improving the success of conservation interventions;
8. tackling the major threats of overexploitation, habitat loss, climate change, and the spread of alien invasive species;
9. building overarching, spatially explicit models of wild nature - how wild nature is generated and maintained, and how it affects and is in turn affected by people;
10. reconnecting people and nature.

7. THE ROLE OF GOVERNMENTS AND OTHER INSTITUTIONS IN CONSERVATION

By the powers vested in them by the people, governments have the mandate and power to set policies, regulations and laws.

Accordingly, governments can shape conservation in many was. Some of them include:

1. Developing and enforcing environmental regulations – usually governments set regulations but reluctant or unwilling to enforce.
2. Conserving publicly owned resources.

a. maintaining a well trained staff of governmental natural-resource managers who directly manage publicly owned lands and waters;
b. issuing long-term leases to individuals and corporations (e.g. leasing land for afforestation) that are designed to ensure sound conservation;
c. working with local communities to conserve natural resources that are legally owned by the national government, but that are, practically speaking, owned by local communities that have a long tradition of using the resource.

3. Encouraging conservation through economic policy:- Governments profoundly affect the economics of both individuals and corporations through many mechanisms.
4. **Supporting environmental education and research.** Most of the world's schools are public institutions; therefore governments assume a major responsibility for providing students with the education they need to be responsible citizens. Clearly, this includes education that encourages students to be careful stewards of the earth.

7.1. INTERNATIONAL CONVENTIONS

International cinventions have became important in the wake of the the 21st century as countries recognized the importntnce of international collaborations to conserve natural resources that are commonly owned by two or more countries. Such resources include, marine resources, Tranboundary Resources such as migratory animals and Transboundary Rivers.

The following are among the major international treaties throughout the world. Ethiopia has signed and ratified most of them. The years in the brackets are years of establishment of each organization.

- **The Convention on International Trade in Endangered Species of Wild Fauna and Flora** (CITES) (1973) (www.cites.org) controls international trade in endangered species of plants and animals whether they are alive or dead, whole organisms, or materials derived from organisms. Species listed in their Appendix I cannot be traded internationally for commercial purposes. International trade in their Appendix II species is regulated and monitored.
- **The Convention on the Conservation of Migratory Species of Wild Animals** (1979) protects wild animals that migrate across international borders through international agreements.
- **The International Convention for the Regulation of Whaling** (1946) establishes the International Whaling Commission (www.ourworld.compuserve.com/homepages/iwcoffice/) to regulate whaling.
- **The Convention on the Conservation of Antarctic Marine Living Resources** (1980) protects the integrity of the ecosystems surrounding Antarctica and conserves marine living resources there.
- **The Convention Concerning the Protection of World Cultural and Natural Heritage** (1972) establishes a system of World Heritage Sites that are protected for their natural and cultural values. UNESCO's have established another international system of reserves called Biosphere Reserves.

- **Man and the Biosphere Programme** to demonstrate the integration of rural development and environmental protection.
- **The Convention on Wetlands of International Importance, Especially as Waterfowl Habitat** (1971) (often known as the Ramsar Convention because it was signed in Ramsar, Iran); promotes protection of wetland resources in general and establishes a system of Wetlands of International Importance.
- **The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter** (1972); prohibits the ocean dumping of some pollutants and regulates others.
- **The United Nations Convention on the Law of the Sea** (1982) (www.un.org/Depts/los/index.htm); establishes a comprehensive legal framework for oceans, including regulation of marine pollution and harvesting natural resources.
- **The Protocol on Substances that Deplete the Ozone Layer** (1987)- requires reduction in emissions of chlorofluorocarbons and halons that deplete the ozone.
- **The Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space, and Under Water** (1963) prohibits tests that could distribute radioactive debris across international boundaries.

The following five documents were signed by heads of state at the United Nations Conference of Environment and Development (UNCED) (www.unep.org/unep/partners/un/unced/home.htm) in 1992; the first two are binding treaties.

- **The Convention on Biodiversity** (www.biodiv.org) - This convention's objectives are "the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources." (This last item has proven contentious, at least in the United States, because it attempts to establish a mechanism by which nations that are the site of origin for a species or gene would benefit financially if this species or gene were developed into a marketable product (e.g. a new medicine) in another country. The treaty has been signed and ratified by 188 nations but not by the United States.)

- **The Convention on Climate Change** (www.unfcc.org) requires stabilization of the concentrations of carbon dioxide, methane, and other greenhouse gases to avoid interfering with the earth's climate. The Kyoto Protocol is the latest manifestation of this convention, but it still has not been ratified.
- **The Statements on Forest Principles**. A formal treaty on sustainable management of forests could not be negotiated, in large part because industrialized nations insisted that it apply only to tropical forests. A nonbinding statement of 17 principles was signed.
- **The Rio Declaration** promotes general principles to guide nations in their programs for development and environmental protection.
- **Agenda 21 -** describes environmental problems, associated issues such as health and poverty, and puts forth a series of action plans. These cover the legal, technical, financial, and institutional aspects of tackling a host of problems such as deforestation, desertification, atmospheric pollution, and so on. The difficult part of Agenda 21 was determining how to pay for its estimated cost of $600 billion per year.
- **The Framework for Action on Biodiversity and Ecosystem Management -** derived from the World Summit on Sustainable Development (the Johannesburg Summit 2002) outlines concrete steps toward implementing the vision outlined in the Rio Declaration.

- **The Durban Accord: Action Plan -** resulted from the Fifth World Parks Congress in 2003 and placed protected areas on the global sustainable development and biodiversity agenda by articulating the following six desired outcomes:
    1. global system of protected areas linked to surrounding landscapes and seascapes achieved;
    2. improved effectiveness of protected areas management in place;
    3. empowerment of indigenous peoples and local communities achieved;
    4. significantly greater support for protected areas from other constituencies agreed;
    5. new forms of governance, recognizing traditional forms of great value for conservation, implemented; and
    6. increased resources for protected areas secured.

7.2. NATIONAL LAWS AND CONVENTIONS

Concerning biodiversity and conservation, Ethiopia has its own laws and policies. These laws and policies are located at the websites of organizations such as the Ethiopian Environment Protection Agency (www.epa.org.et) , the Ethiopian Wild life Conservation Authority (www.ewca.gov.et), the Ethiopian Biodiversity Conservation Authority (www.ibc.org.et) and in a more organized way at a website called www.chilot.me

7.2.1. ETHIOPIAN ENVIRONMENTAL LAWS:

a. **Article 44 of the Constitution of the Federal Democratic Republic of Ethiopia-** under subtitle "Environmental Rights states": *"All persons have the right to live in a healthy environment*". Even though this is a short statement about environment, it serves as an master law in the protection of environments in the territory of the country.

b. **Proclamation No.541/2007 –** This proclamation is a proclamation to provide for the development conservation and utilization of wildlife of Ethiopia.

It was stated that the objectives of the proclamation are:

1. to conserve, manage, develop and properly utilize the wildlife resources of Ethiopia;
2. to create conditions necessary for discharging government obligations assumed under treaties regarding the conservation, development, and utilization of wildlife;
3. to promote wildlife-based tourism and to encourage private investment.

c. **Proclamation No. 575/2008 –** this is a proclamation to provide for the establishment of the Ethiopian wildlife development and conservation authority

It was stated that the objectives of the Authority shall be to ensure the development, conservation, and sustainable utilization of the country's wildlife resource.

Several other laws were formulated and ratified for the safe guard of the environment and allow sustainable development in the country. Few of these laws in addition to the above include:

d. **Council of Ministers Regulations No. 163/2008**

e. Environmental Organs Establishment Proclamation (295/ 2002)

f. Impact Assessment proclamation (299/2002),

g. Pollution Control Proclamation (300/2002).

h. The Environmental Policy of Ethiopia [EPE], which emanated from the Conservation Strategy of Ethiopia, constitutes ten-sectoral and ten cross -sectoral policy pronouncements. The sectoral and cross-sectoral policy elements of the environment policy of Ethiopia are:

1. Soil Husbandries and Sustainable Agriculture
2. Forest, Woodland and Tree Resources
3. Genetic, Species and Ecosystem Biodiversity
4. Water Resources
5. Energy Resource
6. Mineral Resources
7. Human Settlements, Urban Environment and Environmental Health
8. Control of Hazardous Materials and Pollution from Industrial Waste
9. Atmospheric Pollution and Climate Change
10. Cultural and Natural Heritage
11. Population and the Environment
12. Community Participation and the Environment
13. Tenure and Access Rights to Land and Natural Resources
14. Land Use Plan
15. Social and Gender Issues
16. Environmental Economics
17. Environmental Information System
18. Environmental Research
19. Environmental Impact Assessment (EIA)
20. Environmental Education and Awareness

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