BIODIVERSITY: IMPACTS, REMEDIATION AND SIGNIFICANCE

Dr. Subbulakshmi Ganesan
Amit Kumar

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CHAPTER 1

INTRODUCTION TO BIODIVERSITY

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The diversity of animals, flora, fungi, and even micro-organisms like bacteria that make up our natural environment are all included in what is known as biodiversity. These many species and critters collaborate in complicated web-like ecosystems to keep things in balance and sustain life. Everything in nature that humans need for survival, including food, fresh water, medicines, and shelter, is supported by biodiversity. Across the spectrum of biodiversity metrics, present rates of change and loss are many orders of magnitude higher than historical rates and don't seem to be slowing down. Declines in biodiversity are seen on broad scales across the biogeographic regions and ecosystems (biomes) of the whole inhabited planet. The mass extinctions of organisms including well groupings of species are high and rising (medium confidence), while at the local level, habitats and populations are often observed to be declining[1], [2].

Almost all of Earth's ecosystems have undergone dramatic change as a result of human activity. In the 30 years after 1950, more land was turned to farmland than in the 150 years between 1700 and 1850. The capacity of reservoirs to retain water quadrupled between 1960 and 2000, and as a consequence, rivers now hold three to six times as much water as major dams do. In nations where enough statistics are available, around 35% of mangroves have disappeared in the previous two decades (encompassing about half of the total mangrove area). Around 20% of coral reefs worldwide have been destroyed, while another 20% have undergone degradation. Although developing nations are now seeing the most rapid changes in their ecosystems, industrialised nations have traditionally gone through similar transitions.

Most biomes have seen significant modification. Nine out of the fourteen worldwide biomes have between 20% and 50% of their area converted to agriculture. However, before 1950, temperate grasslands, temperate broadleaf forests, and Mediterranean woodlands all saw 55% or more conversion. Tropical dry forests were the most impacted by agriculture between 1950 and 1990. Boreal woods and tundra are the biomes least impacted by farming. While cultivated areas provide a variety of provisioning services including grains, fruits, and meat), they often result in a decline in the surrounding natural biodiversity. Over the last century at least, rates of human conversion have been consistent throughout biomes. For instance, up until 1950, the natural habitat cover of boreal forests had been drastically reduced, and only a little percentage more has been lost since then. The temperate grasslands biome, on the other hand, had lost over 70% of its original cover by 1950 and another 15.4% since then. The Mediterranean forests and temperate broadleaf forests seem to be the only two biomes that deviate from this trend. By 1950, both had lost the bulk of their natural habitats, but since then, just 2.5% more habitat has been lost. Many of the world's oldest cities and also most significant accompanying sustainable agriculture may be found in these biomes (Europe, the United States, the Mediterranean basin, and China. It's probable that by 1950, the biomes' best agricultural land had already been developed[3], [4]s.

Humans have accelerated the pace of species extinction by up to three orders of magnitude during the last few hundred years. This estimate is only of moderate confidence since it is difficult to record the ultimate extinction of extremely rare species, there are delays between the influence of a dangerous event and the subsequent extinction, and the amount of extinctions of undescribed taxa are unknown. The most conclusive data, based on the known species' extinctions during the last 100 years, shows that extinction rates are around 100 times higher than those typical of species found in the fossil record. A thousand to ten thousand times greater extinction rates than those seen among ancient lineages are predicted by other, less precise predictions, some of which forecast extinction of species hundreds of years in the future. Based on the IUCN Red List, between 12% and 52% of species within higher taxa that have undergone extensive research are in danger of becoming extinct. Less than 10% of the identified species have had their conservation status evaluated. Birds make up 12% of the species that are endangered out of those that are. Mammals and conifers that have 23% and 25% of their species endangered, respectively, show largely comparable patterns of threat. Although evidence is much more restricted, the scenario for amphibians seems to be similar, with 32% being endangered. With 52% of their species worldwide imperilled, cycads have a substantially greater percentage of threatened species. The taxonomic groups that depend most heavily on freshwater environments tended to have the largest percentage of vulnerable species, according to regional evaluations. The conservation status of threatened species continues to deteriorate, and the areas with the greatest species richness often have the highest danger rates[5], [6].

The biomes with intermediary degrees of habitat alteration have the highest density of threatened animals. Low-diversity biomes (like the tundra and the boreal forest) contain few species, are not particularly threatened, and have undergone minimal change. The diversity of severely converted temperate ecosystems was lower than that of tropical biomes, and many species that were susceptible to conversions could already be extinct. The majority of endangered vertebrates are located in the high-diversity, somewhat altered tropical biomes. Most species in a variety of higher taxa are now under decline. The majority of organisms according to studies on amphibians across the world, African mammals, agricultural birds, British butterflies, Caribbean corals, waterbirds, and fisheries species, are shrinking in range or quantity. The majority of the time, rising patterns in species may be linked to management actions like reserve protection, the eradication of dangers like over-exploitation, or the fact that the species in question tends to flourish in landscapes controlled by humans. The Living Planet Index, a collective indicator of changes in species populations, leverages published information on patterns in the natural populations of several wild species to pinpoint broad trends in species abundance. Although more representative sample would increase its dependability, all patterns are in decline, with freshwater environments showing the greatest rate.

Globally, genetic diversity has decreased, especially in domesticated animals. As a consequence of the Green Revolution, there's been a major change in the pattern of intra-species variety in growers' landscapes and agricultural systems since 1960. A significant decline in the genetic variety of domestic plants and animals has resulted from the expansion of agricultural economies, specialisation among plant breeders, and harmonising impacts of globalisation. The preservation of genetic variety in gene banks has somewhat countered the losses of crop genetic variation that occur on farms. Due to very low populations, a third of the 6,500 varieties of domesticated animals are in danger of becoming extinct. Along with the loss of distinct populations and species, these events have also caused the extinction of the distinctive genetic diversity that was present in those populations and species. This loss lessens overall fitness and ability for adaptation, and it diminishes the chances of recovery for species whose numbers have been drastically decreased[7], [8].

Worldwide, the net rate of transformation of certain ecologies has started to slow, and in some areas, natural systems are bringing it back to even more natural states primarily as a result of slower rates of land conversion to agriculture. However, in some cases, these patterns represent the fact that there is little habitat left for further conversion. Broadly speaking, since the limited amount of land suited for intensive agriculture continues to dwindle, chances for future growth of cultivation are dwindling in many parts of the globe. The need for intensive agriculture is being lessened by improved agricultural production. Since 1950, farmland lands have stabilised in North America, dropped in Europe, and even declined in China. Since 1960, the former Soviet Union's cropland lands have shrunk. In the 1990s, the amount of forest cover in temperate and boreal zones rose by around 3 million hectares each year, albeit nearly half of this growth was made up of tropical forests.

Biodiversity Loss

The loss of biological variety is caused by both the global extinction of many species and the local decline and extinction of species in a particular region. Depending on whether the environmental deterioration that causes the loss is reversible via ecological restoration or ecological resilience or is in fact permanent, the latter phenomena may be either temporary or permanent (e.g. through land loss). Human actions that go beyond the bounds of the earth are causing the present global extinction, also known as the sixth mass extinction or the Anthropocene extinction that has so far been proved irreversible. The loss of biodiversity often negates the ecological benefits of biodiversity. Particularly decreasing biodiversity affects ecosystem services, which ultimately endanger food security in the short term but may also have longer-term effects on human health.

Since decades, worldwide environmental groups have fought to stop the loss of biodiversity; public health experts have included it into the One Health approach to public health practise; and increasingly, international policy is taking biodiversity preservation into consideration. For instance, the UN Convention on Biological Diversity is focused on stopping the loss of biodiversity and actively conserving natural spaces. Sustainable Development Goals 15 (Life on Land) and 14 (Life below Water) now represent the worldwide commitment and objectives for this endeavour. The majority of these initiatives, according to the United Nations Environment Programme report on "Making Peace with Nature," published in 2020, did not succeed in achieving their global objectives[9], [10].

Global biodiversity loss is happening at a pace that is predicted to continue increasing in the future years, with estimates ranging from 100 to 1000 times greater than the background extinction rate (which occurs naturally). Scientists have declared a current biodiversity crisis in both terrestrial and marine ecosystems as a result of these fast increasing extinction patterns that affect many animal species, such as primates, birds, amphibians, reptiles, and ray-finned fishes. The species richness and its temporal change may be used to calculate locally constrained loss rates. Raw counts could not be as environmentally significant as relative or absolute abundances. Numerous biodiversity indices have been created, taking into consideration the relative frequencies. The primary characteristics along which diversity may be quantified are thought to be smoothness and diversity in addition to richness.

The precise classification of the observation's geographical and temporal scope is crucial for all diversity measurements. As a subject's complexity rises and the related geographical and temporal scales increase, definitions tend to become less exact. The idea of biodiversity itself may be broken down into numerous scales or subcategories. Longer monitoring intervals are often considered to be advantageous to loss estimations, however the issue of net loss in limited places is frequently a topic of discussion.

Latitudinal variations in species diversity should also be taken into consideration when comparing rates across various geographical areas. More species were officially designated as rare, endangered, or threatened in 2006. Additionally, scientists believe that millions more species are at risk but have not been officially recognised. Nearly 37,400 out of 134,400 species, or roughly 28 percent, are now classified as endangered with extinction according to the IUCN Red List criteria, up from 16,119 threatened species in 2006. According to a 2019 study that was published in Frontiers in Ecology and the Environment and that polled over 3,000 experts, "global habitat destruction and its affects may be higher than previously thought," and that "since the year 1500, approximately 30% of lifeforms have been worldwide attacked or driven extirpated,"

Causes

The term "biodiversity" refers to the variety of life on Earth in all of its manifestations, such as the genetic diversity of species and the interactions between these many lifeforms. Nevertheless, since the turn of the 20th century, consequences brought on by the loss of biodiversity as a result of human conduct have become increasingly serious and pervasive. The fundamental causes of this reduction, according to leading scientists and the seminal IPBES Global Analysis Report on Biodiversity and Ecosystem Services, are overpopulation and excessive consumption. Habitat destruction, pollution, and resource overuse are some examples of human drivers of biodiversity loss.

Types of Losses

Disappearance of Terrestrial Invertebrates

Articles of primary concern are declining pollinator numbers, declining insect populations, and The Windshield Phenomenon. Several articles in 2017 detailed the substantial decline in absolute insect biomass and species during a 27-year span in Germany and North America. The authors point to additional agrochemicals and neonicotinoids as potential causes of the drop.

Bird Deaths

Neonicotinoids, a particular kind of insecticide, are likely responsible for the demise of several bird species. According to a research supported by BirdLife International, 8 bird species may be extinct or in risk of becoming extinct, while 51 bird species are currently under threat. Trapping and poaching for the exotic pet trade are responsible for about 30% of extinction. Due to the loss of both their habitat and their food supply, deforestation brought on by excessive logging and agriculture may be the cause of the next mass extinction of birds. "As soon as the ecosystem is gone, they're gone too," said researcher Luisa Arnedo.

Loss of Freshwater Species

On the surface of the globe, freshwater habitats including marshes, deltas, and rivers account for 1% of the total area. Freshwater ecosystems are significant despite making up a small section of the planet since around one-third of all vertebrate species call these types of environments home. Two times as quickly as other species, like those found on land or in the ocean, freshwater species are now in decline. As a result of this fast decrease, 27% of the 29,500 freshwater-dependent species are now included on the IUCN Red List. Freshwater species are rapidly decreasing because of the inadequate mechanisms in place that don't safeguard their biodiversity.

Decline of Native Species Richness

More than 75% of the terrestrial biomes have undergone "anthropogenic biome" transformation due to human alteration of plant diversity in local settings. This is shown by the replacement and overexploitation of native species by agricultural practises. According to models, there has been a "significant net human alteration" in the species richness of around half of the biosphere. A third of tree species are in danger of becoming extinct, scientists have warned in a follow-up publication to their 2020 research. They illustrate how this would substantially disrupt the world's ecosystem and how it may be avoided with "rapid interventions." According to their findings, "Large-scale extinction of tree species would lead to severe biodiversity losses in other species groups and drastically change the cycle of carbon, water, and nutrients in the world's ecosystems" and "diminish the subsistence of billions."

Decline of Marine Species Abundance

Any living thing that lives in the ocean is included in the term "marine biodiversity," which also refers to the myriad intricate interactions that exist within marine ecosystems. Compared to marine ecosystems on a global scale, marine communities are more understood on a local and regional level. Around 240,000 marine species were known as of 2018, although many more have yet to be identified. Estimates vary from 178,000 to 10 million oceanic species. Considering the paucity of information on the majority of marine species, it is possible that a lot of "strange" species that have been absent from the ocean for decades already have vanished or are silently approaching extinction.

Impacts of Biodiversity Loss

Environmental Consequences of Biodiversity Loss

The stability and effective operation of the ecosystem are also under risk from biodiversity loss. Even though all environments may, to some extent, adapt to the stressors brought on by declines in biodiversity, the complexity of an ecosystem is reduced when fewer or no longer fulfil the functions that formerly were done by several biotic interactions or people. Ecosystem characteristics, ecosystem kinds, and possible community change routes may all have an impact on how species loss or composition manifests itself and its repercussions. The consequences of species loss were comparable to many other significant drivers of environmental change, including ozone pollution, acidic deposits on forestry, and eutrophication, at greater levels of extinction.

Finally, throughout time, consequences are also observed on human requirements including the production of food, breathable air, and freshwater. For instance, research over the last two decades has shown that ecosystems with more biological diversity are more productive. Due to the extremely high rates of contemporary extinctions brought on by habitat loss, overfishing, and other human-caused environmental changes, there has been an increase in fear that nature's capacity to supply essential services including nourishment, safe drinking water, and a stable environment may be compromised. One-fifth of all nations are at danger of ecological collapse due to manmade habitat degradation and rising animal loss, according to a Swiss Re research published in October 2020.

Influence on Food Production and Agriculture

Driver interactions often make the consequences on biodiversity for food and agriculture worse (BFA). According to reports, factors like as urbanisation, trade, economics, and consumer trends have a significant impact on food systems, usually having detrimental effects on BFA and the ecosystem services it offers. However, it is also claimed that these factors provide opportunity for improving the sustainability of food systems, for instance, by creating markets for goods that support biodiversity. The consequence of an ecosystems has a significant impact on a person's health. A significant influence on human health also results from biodiversity loss. Humans are able to have a stable system of soils and the ability to possess the genetic components necessary to produce food thanks to biodiversity. Although these assertions are debatable, many activists and academics have argued that plant patent protection and the decline in agricultural biodiversity are related.

Public health

The loss of biodiversity affects human health in a number of ways. One such effect is the extinction of therapeutic plants. Around 70 to 80 percent of people globally exclusively utilise plant-based medicine as their main source of healthcare, demonstrating the widespread usage of plants for therapeutic reasons. Particularly prevalent in underdeveloped nations is this reliance on plants for medical reasons. Searching for novel herbal remedies that could be effective in treating sickness benefits from local knowledge of medicinal plants. Villages and communities that have long-term residence in a particular region produce, disseminate, and use extensive knowledge about the region's medical resources. Identification of the active components utilised in ethnopharmacy and their incorporation into contemporary medications have benefited from formal scientific approaches. To avoid putting species at risk, it is crucial that medicinal resources be maintained properly since they are marketed on a worldwide scale. Changes to local ecosystems may have an indirect effect on the local economy and society (such as availability to food and clean water). Thereby having an effect on people's health.

The human commensal microbiota and its ability to modulate immunity may be negatively impacted by decreased human interaction with the natural environment and biodiversity, according to the biodiversity hypothesis. The idea is supported by the finding that two important socio-ecological trends the decline in biodiversity and the rise in inflammatory diseases are intertwined.

As scientific knowledge on the negative effects of biodiversity loss on global health grows, the importance of biodiversity to human health is emerging as a worldwide political problem. Given that many of the expected health hazards of climate change are tied to alterations in biodiversity, this problem and the latter are closely related (e.g. changes in populations and distribution of disease vectors, scarcity of fresh water, impacts on agricultural biodiversity and food resources etc.). According to a research project co-authored by Felicia Keesing, an ecologist at Bard College, and Drew Harvell, associate director for Environment of the Atkinson Center for a Sustainable Future (ACSF) at Cornell University, the species that boost transmission of pathogens, like that of West Nile Virus, Lyme disease, and Hantavirus, often seem to be individuals who survive. This is due to the organisms most probable to dwindle are those that mitigates against transmission of infectious diseases.

Future human health is further hampered by the world's scarcity of drinking water and rising demand for it. The failure of organisations supporting the preservation of water resources and the success of water providers in increasing supply are both contributing factors to the issue. While the availability of clean water is more widely distributed, it is still uneven in several areas of the globe. Only 71% of the world's population, according to the World Health Organization, utilised a drinking-water service that was securely regulated. Nutritional well-being and food security, contagious illness, medical research and pharmaceutical resources, as well as psychological and social health are some of the health concerns impacted by diversity. Additionally, it is well recognised that biodiversity plays a significant part in post-disaster rescue and recovery operations as well as in lowering catastrophe risk. Loss of connection between people and nature is a result of habitat fragmentation and urbanisation. Furthermore, particularly in metropolitan areas, immunological non-communicable illnesses have increased in prevalence during the last several decades.

Effect of biodiversity on nourishment

Through its impact on global food production, biodiversity plays a critical role in human nutrition by guaranteeing soil fertility and providing the genetic resources for all crops, animals, and marine creatures that are collected for food. Access to a sufficient supply of a range of healthy foods is a key factor in determining health. Food production is an ecosystem function, and there are multiple degrees of connection between nutrition and biodiversity, including the species in the ecosystem and the genetic variety within them. The availability of micronutrients in the diet may be significantly impacted by the nutritional makeup of different meals as well as between types, cultivars, and breeds of the same food. High biodiversity levels need the preservation of wholesome local diets with acceptable average food consumption.

When food production is increased and intensified by irrigation, fertiliser usage, pesticide application, or the introduction of new crop types and cropping patterns, biodiversity is impacted, which has an effect on the world's nutritional status and public health. Communities' vulnerabilities often increase as a result of habitat simplification, species extinction, and species succession as a result of the environment's susceptibility to disease.

Threats to Biodiversity

In addition, scientists believe that millions more species are at risk but have not yet been officially identified. In 2006, several species were legally categorised as rare, threatened, or endangered. 16,119 out of the 40,177 species that were evaluated utilizing the IUCN Red List criteria are now classified as being at risk of becoming extinct. Loss of habitat, introduced species, overexploitation (intense fishing and hunting pressures), pollutants, and climate change are the five primary causes of biodiversity loss. Jared Diamond talks on the "Evil Quartet" of introduced species, habitat loss, overkill, and subsequent extinction events. The abbreviation HIPPO, which stands for habitat destruction, introduced species, pollutants, population overcrowding, and overexploitation, is preferred by Edward O. Wilson.

The IUCN categories as the most direct risks to conservation.

Construction of homes and businesses

1. Housing and urban areas, including towns, cities, suburbs, communities, vacation houses, industrial and commercial districts, offices, schools, and hospitals (manufacturing plants, shopping centers, office parks, military bases, power plants, train & shipyards, airports).
2. Tourist and leisure destinations (campgrounds, parks, sports fields, golf courses, skiing).

Farming endeavours

1. Agriculture (crop farms, ranches, plantations, vineyards, orchards).
2. Aquatic farming (artificial algal beds, seeded shellfish beds, hatchery salmon, fish ponds on farms, shrimp or finfish aquaculture).

Energy production and mining

Energy production and mining include non-renewable energy production (gas and oil drilling) as well as generation of renewable energy (wind, solar, geothermal, and tidal farms).

Service and transportation routes

1. Service arteries (phone & electrical wires, gas & oil pipelines, aqueducts).
2. Transportation arteries (shipping lanes, railroads, roads, and flight paths).
3. Encounters with traffic in the hallways.
4. Related mishaps and tragedies (fire, electrocution, oil spills).

Uses of biological resources

1. Poaching (fur, trophy, and bush meat); (pest control and predator control, superstitions).
2. Plants destruction or annihilation (battling timber disease, free-range livestock foraging, orchid collection, human consumption).
3. Logging or collecting wood (clear-cutting or selective, charcoal production, firewood collection).
4. angling (whaling, trawling, seaweed or live coral or egg collection).

Human interventions and activities that change, damage, or otherwise interfere with environments and species' ability to behave naturally

1. Outdoor recreation (birdwatchers, hikers, mountain bikes, whale-watching, dive boats, ultralight aircraft, snowmobiles, jet-skis, motorboats, off-road vehicles, and skiers),
2. War, civil unrest, and military drills (minefields, armed conflict, tanks & other military defoliation, vehicles, training ranges & exercises, munitions testing).
3. Unlawful actions (vandalism, immigration, smuggling).

Natural system alterations

1. The extinction or emergence of fire (unsuitable fire management, controlled burns, escaped agricultural and campfires, arson).
2. Water administration (dam construction & operation, wetland filling, surface water diversion, groundwater pumping).
3. Additional alterations (lawn cultivation, shoreline rip-rap, land reclamation projects, beach maintenance and structure, tree-thinning in parks).
4. Eliminating or minimising human upkeep (reduction in controlled burns, mowing meadows, lack of indigenous management of key ecosystems, ceasing supplemental feeding of condors).

Problematic genes, diseases, and invasive species

1. Introduced species (household pets & feral horses, kudzu, Miconia tree, zebra mussels, overview for bio-control).
2. Unwanted native species (over-abundant native kangaroo or deer, over-abundant algae due to loss of native grazing fish, locust-type plagues).
3. Inserted genetic information (pesticide-resistant crops, genetically improved pests for bio-control, genetically altered salmon or trees, escaped hatchery salmon, restoration projects using non-local seed stock).
4. Microbes and pathogens (plague distressing rabbits or rodents, chestnut blight or Dutch elm disease, Chytrid fungus affecting amphibians outside of Africa).

Sewage pollution (untreated sewage, releases from poorly functioning sewage treatment plants, sediment or oil from roads, pit latrines, septic tanks, pesticides and fertilisers from lawns and golf courses, road salt).

1. Industrial and military waste (leakage from fuel tanks, arsenic from gold mining, toxic chemicals from factories, mine tailings, illegal dumping of chemicals, PCBs in river sediments).
2. Effluents from forestry and agriculture (nutrient loading from fertiliser run-off, herbicide run-off, manure from feedlots, nutrients from aquaculture, soil erosion).
3. Trash and solid waste (municipal waste, litter & dumped possessions, flotsam & jetsam from recreational boats, waste that entangles wildlife, construction debris).
4. Airborne contaminants (acid rain, smog from vehicle emissions, excess nitrogen deposition, radioactive fallout, wind dispersion of pollutants or sediments from farm fields, smoke from forest fires or wood stoves).
5. surplus energy (noise from airplanes or highways, sonar from submarines that disturbs whales, atmospheric radiation from ozone holes, beach lights disorienting turtles, lamps attracting insects, heated water from power plants).

Disastrous Geological Occurrences

Volcanic eruptions, earthquakes, avalanches, landslides, avalanches, and gas emissions.

Changing Climate

1. Impairment of the ecosystem.
2. Modifications to geochemical regimes (changes in atmospheric CO2 affecting plant growth, ocean acidification, loss of sediment leading to broad-scale subsidence).
3. Alterations in temperature regimes (such as variations in ocean temperatures, cold snaps, heat waves, and melting of sea ice and glaciers).
4. Modifications to the hydrological and precipitation regimes (loss of snow cover, rain timing, droughts, amplified rigorousness of floods).
5. Adverse weather conditions (dust storms, ice blizzards or storms, hailstorms, cyclones, hurricanes, tropical storms, thunderstorms, tornadoes, erosion of beaches during storms).

Biodiversity Challenges in Urban Areas

Converging the requirements of the world population with urban biodiversity preservation is one of today's biggest societal concerns. Currently, half of the world's population resides in urban areas, and by 2030, that number is expected to double. The relationship between biological variety and humans nowadays is mostly based on urban activity. Given the total transformation in its biological process to make room for urban areas, the separation of the natural environment was caused by the urbanisation of the terrain. An important collection of ecosystem services (such as water supply, local climate management, flood management, air purification, groundwater replenishment, and recreation) are provided to the world population by the environments which are found near cities, in particularly green areas and bodies of water. Ecosystem processes that are vital to human health and welfare are supported by biodiversity. Nevertheless, biodiversity is disappearing at an unheard-of pace, endangering everyone's health and happiness. Human health and biodiversity are now under added danger from expanding urbanisation. Rising climatic stresses are also felt in urban areas, which are caused by both local urban heat island effects and advances in climate change globally. Cities have more surfaces with thermal and structural qualities that increase heat retention and reduce heat dissipation; less vegetated surfaces, that aid in cooling; and more heat emissions brought on by human activity, like air conditioning or congestion. By 2030, there will be 5.2 billion people living in urban areas, increasing the size of the world's metropolitan area to 1.9 million km2, thus action is required to lower future hazards by creating liveable, healthy cities for both people and the environment. Urban regions may experience lessening climatic and health challenges thanks to nature-based solutions. While solid and implementable evidence is required to operationalize health-promoting interventions, new coalitions between the World Health Organization (WHO) and the Convention on Biological Diversity (CBD) are recognising the possibility of linking health, climate, and biodiversity objectives. Extreme shifts in land and sea use, as well as excessive exploitation of natural resources, have resulted in an unprecedented amount of biodiversity loss during the last 50 years. In a society that is growing more and more urbanised, natural ecosystems are being converted to urban areas at an alarming pace. Cities have traditionally been a threat to natural species and ecosystems, but they might also be a part of the solution.

Motives for fostering urban biodiversity

Ensure that natural ecosystems are healthy

Maintained green areas and water bodies provide crucial ecological activities. By creating linear parks and green corridors that connect green spaces across the city, cities can retain sustainable biodiversity and protect these crucial ecosystems.

Boost quality of the air

Due to the widespread use of fossil fuels in transportation, air quality is a problem on a global scale and a major concern for many local governments. Biodiversity may help to improve air quality and reduce the incidence of respiratory diseases like asthma by extracting carbon dioxide from the atmosphere and creating oxygen.

Ensure that freshwater in reservoirs and aquifers is both more plentiful and of better quality.

By safeguarding animals there, cities may reduce their dependence on asphalt and increase permeable stretches. Rainwater may do this and finally find its way to aquifers and reservoirs. Furthermore, roots act as a natural filter to reduce the quantity of silt and other pollutants that reach reservoirs.

Prevent landslides and lessen erosion risk

Direct rain and strong winds can easily harm degraded areas where vegetation has been lost. These weather events exacerbate the risk of landslides by weakening slopes, moving silt, and deteriorating the soil through leaching. By preserving biodiversity in vulnerable areas, we reduce these effects and increase soil quality and stability.

Reduce the likelihood of severe events.

The ability to govern the climate depends on biodiversity. While the roots of the plants allow for more water entry into the soil and help in its retention of moisture over time, the evaporation of the leaves encourages the formation of rain clouds and increases air humidity. These factors, along with a number of others, could decrease the effects of disastrous events like fires, earthquakes, and floods.

Encourage wholesome urban food systems

Several animals, mostly insects like bees, are responsible for pollination. As a consequence of this procedure, fruits, seeds, and other items that are edible to both people and wild animals will be created. Pollination ensures the sustainability of agroforestry, green belts, and urban gardens essential components of feeding the enormous population that lives in cities.

Control harmful animals and prevent sickness

We maintain trophic chains by protecting biodiversity. Predatory animals can manage the number of creatures that pose a threat to human health in this manner. For instance, skunks are recognized to feed on scorpions, while fish are recognized to eat mosquito larvae.

Enhance thermal comfort

Biodiversity encourages softer temperatures and higher air humidity, assuring thermal conditions and a stronger feeling of wellbeing. This is particularly true of trees with leafy tops.

Encourage health and high quality of life

We are aware that social interaction and outdoor recreation are crucial to human growth and health. Cities may provide safe and healthy venues for social and leisure functions by maintaining biodiversity. Promote awareness of living in harmony with other species. At the moment, cities are home to more than 50% of the world's population. Additionally, choices that have a direct bearing on our everyday life are made in this setting. In order to emphasise the value of biodiversity for human well-being, it is crucial to foster an environment in which it coexists peacefully.

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CHAPTER 2

HUMANS AND BIODIVERSITY

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Out of the 13 million species that scientists believe there to be in total, around 1.75 million plant, animal, and microbial species have been recognised. These species' services support the carefully balanced natural cycles which maintain the planet livable for people and support our way of existence in a variety of ways, from giving us food and medicines to lessening the effects of natural catastrophes like floods. By a principle known as functional redundancy, that argues that the more organisms there really are, the more niches are filled, and therefore the more production of the ecosystem, biodiversity is positively connected with ecological productivity. Thus, the biodiversity that underlies these abundant natural resources must be protected if people are to continue enjoying their benefits. The survival of this biodiversity is in the best interests of humanity[1], [2].

Economic Advantages

All living things need nourishment to live. Although just a few species are consumed by humans, many, many additional species are necessary for these species to survive. Agricultural practises like crop rotation and mixed cropping have also been utilised for thousands of years to boost yield. This calls for a wide variety of species. Furthermore, crop populations with genetic diversity are considerably more likely to survive catastrophes like disease. The whole harvest of spinach that has been contaminated with the E. coli pathogen must be thrown away. Since non-resistant creatures are normally chosen against, pests may withstand insecticides. As a result, newer herbicides and pesticides need to be developed frequently. Pests are developing more pesticide resistance at a quicker pace than remedies can be created. Many organic farms have discovered, nevertheless, that pests are always successfully managed by their natural predators. By boosting production and preserving output, biodiversity benefits agriculture in this manner[3], [4].

The environment also offers both conventional and contemporary remedies. An estimated 50–70,000 plant species are harvested by humans globally. Various ailments are treated by certain tribes in South Africa using the organs or fats of 32 different animals. On the other hand, fewer than 1% of Amazonian trees have undergone testing, despite the fact that 25% of Western medications come from the Amazon Rainforest. Hundreds of therapeutic options may vanish if a larger portion of the Amazon is devastated. Even medications that can be created in a lab are often initially found in natural resources. For example, cone shells often employ contains, a large collection of over 50,000 distinct types of venom, to immobilise and kill their prey. Nevertheless, more than 100 distinct contains have recently been discovered by scientists, and they have the possibility to be used as therapies for a wide range of conditions, including cancer and rheumatoid arthritis.

The ecosystem also offers wood for fuel, building materials, and paper. This gasoline has certain non-renewable components. This is dependent on the carbon cycle, wherein carbon is moved from the atmosphere throughout photosynthesis to breakdown via the ecosystem. Fabrics, in particular, may benefit from the usage of natural fibres. Our apparel is most often made of cotton. Since it has been domesticated for 7,000 years, it is now simple to combine it with different fibres to give it unique qualities. A large portion of the fundamental essentials of food, drink, clothing, and shelter are provided by biodiversity. It is projected that the annual cost of natural services and products is over 33 trillion US dollars. For comparison, the GDP of the European Union was 14.82 trillion USD in 2010 whereas the GDP of the United States was just 14.66 trillion USD[5], [6].

Biodiversity aids in regulating the weather, lowering electricity costs and averting widespread harm. The environmental group American Forests claims that, based on the location, type, scale, and health of the trees, air conditioner costs in homes and businesses may be cut by 15% to 50%. Wetlands and woodlands, that retain and supply water, can efficiently regulate droughts and floods. In Vietnam, the cost of establishing and maintaining 12,000 hectares of mangroves is US$1.1 million, while the country yearly saves US$7.3 million on dike expenses. Wetlands and forests also play a role as in detoxifying of water, which reduces the cost of water filtration by billions of dollars. Management of water purification operations in the Catskills watershed in New York cost 305 billion USD, which is 507 billion USD less than the expected cost of a filter facility. Additionally, the natural habitat may reduce temperatures, stop soil and coastline erosion, and shield against winds. Due to the large heat capacity of water, the seas, for example, play a significant role in temperature and climate management. Global changes in rainfall and climate patterns are influenced by El Nio and La Nia, the cyclical warming and cooling of the eastern tropical Pacific. Forecasts of these trends, which become worse as human activities contribute to climate change, might save losses of up to $8 billion USD.

Additionally, a multiplicity of employment, from farmers to park guards, are produced by a diversity of biodiversity. For the United States, the pharmaceutical and personal care industries, that depend on chemicals derived from various living forms, brought in a combined 652 billion USD in 2006. According to the International Union for the Conservation of Nature, 500 million people worldwide rely on coral reefs for their food, storm protection, and employment. These resources alone are estimated to be worth over 375 billion USD annually. The most probable alternatives use of the regions, massive cow ranching, would cost almost three times more than the protected areas of the Amazon. Additionally, it has been calculated that designating 20–30% of the seas as Marine Protected Areas might lead to the creation of 1 million employment while maintaining an annual marine fish harvest of $70-80 billion USD. Approximately 77 billion USD are contributed by ecotourism to the world economy. Therefore, it is essential to preserve the locations that draw visitors because of their beauty. Over two-thirds of tourists from the United States, Australia, and Britain, as well as 90 percent of passengers from that country, believe that hotels have a duty to actively safeguard the environment[7], [8].

Social Advantages

The aesthetic value of biodiversity is its most well-known advantage. Homes and other structures are decorated with a wide range of plants. This has the potential to be a significant tourist draw as well, generating income and employment. The Great Barrier Reef receives over 1.6 million visitors each year. In addition, a lot of intellectuals, like impressionist painters, look to their surroundings for inspiration. Since the dawn of civilisation, there has been a connection between the environment and society. There is evidence of domesticated dogs dating back 12,000 years in Iraq; people have tamed animals for both labour and recreation. From medicines to tribal rites, many civilizations have strong, enduring ties to the ground. Research on biodiversity is also of utmost importance. Bioengineering organs from tissues that might be implanted into a patient's body, looking for novel cancer treatments, and enhancing human nutrition are a few examples of study that depends on biodiversity. The options are almost limitless. For instance, researchers have shown that adding metals to spider silk may make it more durable. This kind of study might lead to the creation of brand-new technology. Even while there is still much to learn, it is clear that without access to natural resources, humanity would be unable to survive. Researchers at the Massachusetts Institute of Technology and the Woods Hole Oceanographic Institute collaborated to develop an underwater robot that can do backflips and fast twists in a busy environment. This robot might be employed to examine choppy coasts. Stephen Lichet, the principal investigator on the study, did this by watching a 500-pound sea turtle walk about at the New England Aquarium. Without a grasp of the many natural processes that make up the Earth, society has reached a point where further advancement is impossible. Consequently, for a large range of natural systems to exist and flourish, biodiversity is necessary. Everything in the ecosystem is interconnected. These processes are susceptible to serious malfunctions brought on by a single link in the chain. The pieces must be conserved in order to keep the whole, thus we must preserve them all in order to protect those who are most essential to us.

Diminishing Rainforests

The largest contributor to forest degradation is the ever-increasing human population and consumption, which results from the immense quantities of resources, goods, and services we get from it. Since half of them have been destroyed in the past century, the remaining rainforests may completely vanish within your lifetime if things continue in this direction. If these forests, the creatures that live there, and the people who depend on them are to survive, something must be done. In actuality, deforestation is thought to be the second largest cause of climate change, contributing between 18 and 25 percent of global carbon dioxide emissions each year (behind the whole global transportation industry). Direct human causes of deforestation include the timber industry, farming, livestock grazing, mining, oil drilling, and dam building[9], [10].

Logging

Deforestation is said to be caused by logging in second place. Large trees like mahogany and teak are felled by timber corporations and sold to other nations for use in furniture production. Charcoal is often produced from smaller trees. The most valuable trees are chosen for timber while the less value ones are left for wood chipping when large sections of rainforest are taken down all at once (clean felling). See the impact of forest roads under "Oil Companies" for further information on how the roads built to cut and remove the wood often cause additional harm.

Unsustainable Farming

A large portion of the fruits, grains, and pulses we import from tropical nations were cultivated in regions where tropical rainforests formerly predominated. The trees are removed to make place for large plantations that grow crops including bananas, palm oil, pineapples, sugar cane, tea, and coffee. Similar to cattle ranching, farming requires clearing additional rainforest after a few years to create place for new plantings since the soil cannot sustain crops for a lengthy amount of time.

Livestock Farming

In order to create room for cattle rearing, which provides meat to the rest of the globe, many rainforests in Central and South America have been burned. According to estimates, 200 square feet of rainforest are lost for every pound of beef produced. Without the feeding of the woods, the cleared land cannot be used for very long. The land quickly dries up, forcing the cow farmers to leave a path of devastation as they move on to establish new livestock pastures.

Mining

Rainforests should be removed in order to access the subsurface because of the need for minerals and metals including oil, aluminium, copper, gold, and diamonds. Oil, aluminium, copper, gold, and diamonds are just a few minerals and metals that are in great need from wealthy nations and are often discovered in the soil underneath rainforests. As a result, the forest must be removed in order to extract them. When gold is mixed with dirt and trash, for instance, it is separated from the two using mercury. When separating the waste from the minerals, toxic chemicals are sometimes used. These materials often get up in rivers, where they contaminate the water supplies that residents depend on, kill fish, and alter the ecosystem of the waterway.

Energy Corporations

The quest for new oil reserves by oil firms has a significant negative impact on rainforests. Large highways are often constructed through virgin woods in order to construct pipelines and extract the oil. This encourages people to live in formerly untouched woods and begin slash-and-burn farming or more timber harvesting for sale or charcoal production. Once in place, the oil pipes that carry the oil sometimes burst, spewing tonnes of oil into the nearby forest, causing animal deaths and tainting community water sources.

Dams

Large corporations and the World Bank make financial investments in developing nations to construct dams for the purpose of generating power. Although it may entail flooding enormous tracts of rainforest, this is often seen as a renewable source of "clean" energy. Because the submerged forest slowly rots and turns reservoir water acidic, dams constructed in rainforest regions often have a limited lifespan. This causes the turbines to corrode over time.

Save Rainforests

The speed of the devastation is proof that earlier efforts to conserve the rainforests were unsuccessful. In many regions where forests have been locked off as immovable parks and reserves, illegal loggers and developers have not been deterred from clearing forests, and neither have the quality of life or economic prospects for rural poor people improved. Corruption has only exacerbated the situation. The problem with the typical park preservation method is that it doesn't provide enough financial incentives for caring for and preserving the forest, which is necessary to sustain wildlands in developing countries. The existence of forests as healthy ecosystems will be preserved if it can be shown that they have true economic worth. Locals and the government must see financial advantages in order to justify the costs of maintaining parks and sacrificing money from commercial activities within the protected area.

There are political and societal causes as well as economic ones for clearing rainforests. Poor farmers only attempting to make a livelihood on marginal lands account for a significant amount of deforestation. Beyond conversion for subsistence agriculture, significant worldwide contributions to deforestation include logging, clearing for cow grazing, and commercial agriculture. Land-clearing agricultural fires often spread beyond of farmed areas and into deteriorated rainforest sections.

Ecosystem rehabilitation and restoration

Bemoaning the extensive deforestation of the past is pointless. Currently, the focus is on how to effectively use previously cleared land so that it can sustain profitable activities for both the present and the future. We cannot expect rainforests to continue to operate as fully functioning systems and to meet our requirements without enhancing the wellbeing of people who live in and near forests. It is crucial that decision-makers consider both the more logical exploitation of previously cleared and degraded regions as well as the change of existing natural ecosystems when tackling environmental issues in nations with rainforests. We must boost and maintain the productivity of farms, pastures, plantations, and scrub land in addition to reintroducing species and ecosystems to damaged areas in order to reduce future forest loss. We may lessen the need to destroy more forest by eliminating inefficient land-use behaviours, consolidating benefits on previously cleared areas, and upgrading already developed fields.

Supporting Initiatives to Protect the Rainforest

Programs for sustainable development and conservation will not be free. Even nations that currently receive large amounts of money from international donors struggle to successfully make such efforts last over time. Since handouts are inherently unsustainable and might promote reliance, supporting these efforts could need more innovative sources of money to be genuinely effective.

Agriculture that is sustainable in rain forests

The destiny of the forests ultimately lies in the hands of the local population when looking for a "solution" to the destruction of tropical rainforests, whether it be via debt-for-nature swaps, extractive reserves, selective logging, ecotourism, or another tactic. While some may argue that limiting economic development would "save" rainforests, it is important to remember that parks and reserves won't last until local populations are convinced that conserving is in their financial best interest.

Ecotourism in the Rainforest

Ecotourism is one of the most important ways for poor nations to make money while protecting their rainforests. Eco-tourists fork over money to see a nation's natural splendour, not the devastation brought on by short-term exploitation. Forest preservation has a financial worth thanks to money that is invested in the neighbourhood economy. The government and locals both recognise how crucial it is to preserve the forest. Additionally, a lot of visitors are prepared to donate money and pay park admission fees directly toward preservation.

The Business Sector

Finding solutions for businesses to continue to be lucrative without destroying the environment will be a key factor in saving the rainforests. These companies must provide employment that protect the environment rather than harm it if we respect our forests. If working for these firms is the only option available to local residents to support their families' needs for food, shelter, and clothing, we cannot properly expect them to reject the opportunity.

Environmental and Economic Advantages of Biodiversity

Biological pest management, plant pollination, soil formation, crop and livestock genetics, organic sewage disposal, nitrogen fixation, and medications all depend on protecting biodiversity. Microbes & plants work together to circulate nutrients through the environment and breakdown organic wastes and chemical contaminants. For instance:

Bees and butterflies are two examples of pollinators that have a substantial positive impact on the ecology and economy of agricultural and natural environments. They also increase the variety and productivity of food crops. One-third of the food produced worldwide is dependent either directly or indirectly on insect pollination. Insects pollinate around 130 of the crops grown in the United States. Pollinator food supplies, nesting locations, and mating sites are negatively impacted by habitat loss and fragmentation, leading to sharp decreases in wild pollinator populations.

In the United States, 6 million tonnes of food items, including big and small animals, maple syrup, almonds, blueberries, and algae, are derived from terrestrial wild biota. The 6 billion tonnes of food are worth $57 million and boost the national economy by $3 billion (1995 calculations).

A possible target for bio treatment and bioremediation, about 75% (by weight) of the 100,000 chemicals discharged into the environment may be broken down by living organisms. The yearly savings from employing bioremediation to clean up chemical pollution throughout the globe instead of the other methods physical, chemical, and thermal amount to $135 billion (1997 calculation). For bio treatment and bioremediation to persist and become more successful, soil and water biodiversity must be preserved.

The sustainability of the agricultural, forestry, and natural ecosystems on which people rely depends on biodiversity, but due to human activities, particularly the development of natural areas, there is a 1,000–10,000 fold increase in the rate of extinction of species. The authors project that biodiversity improves the US economy by $319 billion year and the global economy by $2,928 billion annually (1997 calculation).

Conservation of Biodiversity and Reduction of Poverty

The preservation of biodiversity and the fight against poverty are two issues that affect the whole world. However, since biodiversity is often a public benefit, it receives little to no consideration in national economies. The question "which groups of the (differentiated) poor rely, in what sorts of ways, on distinct parts of biological diversity?" is the main concern of this essay. It emphasises biodiversity as a source of sustenance and revenue for the underprivileged and as a safeguard against their further slipping into poverty. Community timber enterprises, non-timber forest products, protected area jobs, mangrove restoration, fish spill over, nature-based tourism, payments for environmental services, grasslands management, agroforestry, and agro-biodiversity conservation are ten conservation mechanisms that can help the rural poor reduce their poverty.

These links come with warnings. For their daily needs, the poor rely disproportionately on biodiversity, and in certain cases, protecting biodiversity may help people escape poverty. However, the impoverished often appreciate comparatively low-quality or inferior commodities more than others, while the more wealthy frequently push the poor aside in their quest of goods with greater commercial value. Even while conservation measures don't always lend themselves to poverty interventions, the scope of poverty reduction may be modest. Focusing just on the financial rewards of biodiversity protection and ignoring the potential to address fundamental human needs is too restrictive. Additionally, although biodiversity (which serves as the basis for biomass) may be more important in the long run than biomass in the short run.

Keeping Biodiversity Safe in Agricultural and Forestry Systems

A diversified natural biota's activity is essential for both excellent agricultural output and human health. The fight to stop biodiversity loss has become more serious in recent years, but it has not kept up with the expansion of human activity. Pesticides are an annual $20 billion industry globally. The amount of pest management provided by parasites and predators seen in natural ecosystems, however, is thought to be 5–10 times more. Crop losses from pests in agriculture and forestry would be catastrophic without the presence of natural enemies, and the expense of chemical pest management would skyrocket.

A wide variety of bacteria fix atmospheric nitrogen for use by crops and forests. Nitrogen-fixing microorganisms provide an estimated $7 billion in nitrogen to US agriculture annually and 90 million tonnes of nitrogen worth roughly $50 billion to agriculture globally.

Biodiversity's Effects on the Development and Spread of Infectious Diseases

The spread of illness is accelerated by a decrease in biodiversity. This, according to researchers, may be because certain species are better at containing the spread of diseases. As an example, species with low rates of reproduction or high investment in immunity often experience greater impacts from biodiversity losses than species with high reproduction rates or low investment in immunity (and would consequently be more likely disease hosts). Lyme disease is one of 12 illnesses from various ecosystems throughout the globe that are examined in the research. The white-footed mouse is the most prevalent host species, the best host for the Lyme bacteria, and the best host for immature tick vectors in eastern North America. The majority of ticks that try to feed on Virginia opossums are killed because they are poor hosts for the virus. However, despite the fact that mice are common in many low-diversity forest fragments and degraded forests, Virginia opossums do not live there. A decline in biodiversity is accompanied by a decline in the species that has the greatest ability to fend against illness.

It could be assumed that a decline in biodiversity that causes an increase in disease transmission will result in higher medical costs, growing the immediacy of the requirement for local, regional, and international efforts to preserve eco systems and the bio - diversity they encompass. This is true even though the study does not debate costs linked to a rise rate of disease transmission.

Financial Arguments for Preserving Wild Nature

Examining the benefit: cost ratio of expenditures in habitat protection is crucial due to the ongoing loss of natural habitats and biodiversity. There is growing evidence that environmental preservation produces greater economic gains than habitat modification. A successful worldwide programme for the preservation of surviving wild nature, according to the authors, would have a benefit to cost ratio of at least 100:1.

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CHAPTER 3

VALUE OF BIODIVERSITY

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Climate change already has resulted in extinctions of species, an uptick in illness, a decrease in ecological systems, and a habitat destruction. The environment is the area where biodiversity has the greatest influence. Ecosystems that are flourishing support the Earth's natural processes. Without the species that sustain them, operations like soil aeration, water purification, pest management, and other functions would not be feasible. These processes may be severely damaged by interruptions. We are now experiencing the sixth mass extinction on a global scale, and every day, more and more critically important species are disappearing. For instance, the populations of insects, birds, amphibians, and mammals are all declining quickly. The Lake Erie Allegheny Partnership for Biodiversity (LEAP) claims that comparable biodiversity loss is occurring right here in Cleveland. The issue is so pervasive that it is included as one of the biggest risks to society this year in the World Economic Forum's newly published Global Risks Report 2020[1], [2].

Additionally, biodiversity provides civilization with certain seldom recognised inherent advantages. Meditation makes use of the awareness of natural beauty as a technique. And several cultures and faiths honour the intrinsic worth of life and base their moral principles on respect for the variety of the natural world. Biodiversity offers practical economic rewards in addition to intellectual ones. There is undoubtedly much to be argued about the expanding market prospects offered to businesses with an environmental focus. Tourism is also boosted by providing exclusive vacation places with fauna that is unmatched elsewhere. The national and international economy would suffer severe losses without biodiversity. On the other hand, coordinated measures to safeguard it would provide enormous benefits[3], [4].

Significant causes of biodiversity loss include:

Weather extremes Coastal or oceanic heat waves, wildfires, and drought. Temperature fluctuations or precipitation, sea-level rise, and the melting of snow and ice are examples of changing average circumstances. The main danger to biodiversity over the next century will be climate change, which will exacerbate other threats and make ecosystems lesser resistant. Ecosystems may adjust to local seasonality, water supply, and temperature under a stable climate. The essential circumstances for ecosystems and organisms to survive are altered by a changing climate, which causes changes in the distribution of species and the composition of ecosystems. Ecosystems may eventually reach tipping points due to climate change, which are boundaries that, if crossed, result in permanent loss. Physical barriers that prevent species from migrating through certain areas put them at greater danger of local extinction[5], [6].

Metrics for investing

How can investors monitor the effect of their portfolios on biodiversity? Utilizing issuers' reductions in carbon dioxide emissions and their equivalents, it is manageably simple to track if and how an investment is affecting climate change mitigation. Depending on the targeted impact, tracking the effectiveness of biodiversity programmes is more difficult and requires a variety of indicators. Investors may monitor either progress toward improving biodiversity or decreasing risks to biodiversity.

Increased biodiversity

A combination of machine learning and satellites or lidar (light detection and range, similar to radar employing lasers) technology is being used in technological innovations for monitoring ecosystems and land use. These make it possible to monitor global ecosystem health and deforestation in mangrove forests, on land, and elsewhere. With the use of sensors, satellite data, and output metrics, sustainable agriculture may increase productivity per unit of land or water while also enhancing the health of the surrounding environment. Additionally, new capital arrangements and accounting records are being created. They want to integrate ecosystems into "nature asset firms" that are centred on disclosing their measurements for ecosystem services. The effect and value of these businesses, as well as their natural carbon sequestration and financials, would be evaluated scientifically for the reporting[7], [8].

Minimising Dangers to Biodiversity

Another concrete approach to monitor an investment's long-term effect on biodiversity is to check to see whether it is lessening risks to it. To determine the operational effect of a firm or a government agency, pollution and waste might be monitored. This may apply to runoff and fertiliser usage in agriculture. The manufacture of plastic poses a serious threat to several industries. Only 8% of the plastics that have been produced up to this point have been recycled, while 24% are still in use.

Impact may biodiversity concerns have on investors

Continued biodiversity loss poses a serious threat to not just the environment but also to the stability of the economy. The Network of Central Banks and Supervisors for Greening the Financial System is one organisation that has taken notice of the problem. According to a statement they just issued, biodiversity loss might have serious microeconomic effects. Risks that are important for financial stability might arise from failing to take into consideration, mitigate, and adjust to their consequences. Biodiversity loss presents the financial system with two significant hazards, similar to those posed by climate change.

Biological risk

Risks related to the loss of ecosystem services, including those that regulate the climate, the water supply, illness, recreation, tourism, and human health. These observable biological harms are brought on by the changing natural environment via the dangers shown in Exhibit 2 (such the physical hazards of climate change).

Biodiversity Transition Risks:

Risks related to the shift to a low-impact economy are referred to as biodiversity transition risks. These might change investment criteria and corporate procedures, which would devalue certain assets. There have already been international pledges made to tackle climate change and protect biodiversity. Several nations signed "30 x 30" promises in the run-up to COP26, the yearly United Nations climate conference, in 2020. These pledges call for the conservation of 30% of their lands and waterways by 2030. More than 100 nations came to an agreement in 2020 to stop and halt deforestation by 2030.

A different gathering, the Group of 7 summit in June 2020, resulted in the adoption of the 2030 Nature Compact by the participating nations. It involves animal trading prohibition, stopping deforestation, minimising marine debris, and practising conservation. Additionally, delegates at the fifth United Nations Environment Assembly (UNEA-5) in Nairobi in March came to an agreement to limit plastic waste with the aim of creating an international treaty by 2024.

These agreements will probably encourage countries to adopt national strategies to increase biodiversity and reduce plastics. The biological and biodiversity transition risks will materialise as a result of international treaties, necessitating the search for measures to track biodiversity action by investors. New investment possibilities may arise from businesses whose goals include enhancing biodiversity health or reducing detrimental effects on it[9]–[11].

Monitoring and Protection of Biodiversity

There are several purposes for biodiversity monitoring. Feedback on the effectiveness of conservation efforts is provided by observing protected species' population numbers in their protected zones. An early warning system for farmers or medical services may benefit from tracking the spread of hazardous invasive species or contagious organisms. Population management systems may be optimised thanks to monitoring systems at gaming farms. These are but a few instances of the many uses available. The list that follows shows many monitoring strategies in a more organised manner as an answer to very fundamental queries or motives:

Independent observation

At first appearance, this method of only observing appears to have little scientific value since no hypothesis is evaluated. On the other hand, we cannot be certain that all significant factors and processes contributing to the alteration of biodiversity have been found. We should nonetheless give unexpected new insights some thought.

An early warning system

Changes in biodiversity may have significant effects on how well ecosystems work and how resources are used. Rarely do such changes adhere to linear connections. Negative and positive feedback mechanisms both exist. When thresholds are crossed, transitions from one meta-stabile stage of a systems into some other new phase may occur abruptly. Single actions may also trigger cascades of secondary effects (e.g. state of an ecosystem, size of a population or area of distribution). An observation system should thus function as an advance warning mechanism that enables action to be done before irreparable harm has occurred.

Changes in biodiversity indicators

It often demands significant time and human inputs to observe a big number of characteristics and processes, which resources are frequently lacking. An alternate approach is the observation or measurement of a small number of distinct characteristics and/or numbers that may serve as indicators for certain system attributes or states. In the context of normative institutional activities, such indicators could also be used to measure progress toward specific goals.

Causality method

If the assessment of such possible driving factors (for example, particular meteorological changes, specific land use practises), is incorporated into the observing system, then observation of the kind and degree of changes inside a specific ecosystem might enable determination of the change's drivers. All of the methods are appropriate for determining the impacts of climate change and/or other drivers, as well as for analysing the function of various drivers.

Process analysis

The dynamics of biocoenosis and populations must be thoroughly studied if observation is to be used to further scientific knowledge of the causes and changes that occur.

Biodiversity Protection

In order to gather assets for environmental sustainability, biodiversity must be protected and managed. Three key goals of biodiversity protection are as follows:

1. To maintain the variety of species.
2. Sustainable use of ecosystems and species
3. To protect vital ecological processes and systems that sustain life.

Methods used to conserve biodiversity

The term "biodiversity" describes the diversity of life on earth. There are many methods to preserve it:

1. *In-situ* Conservation
2. *Ex-situ* Conservation

In-situ Conservation

The preservation of species in their native environment is referred to as in-situ conservation of biodiversity. The natural ecology is preserved and safeguarded using this technique. The benefits of in-situ conservation are many. The following are crucial benefits of in-situ conservation:

1. It is a practical and affordable way to preserve biodiversity.
2. Many different living things may be preserved at once.

The organisms may develop more effectively and are more readily able to adapt to various environmental situations since they are in a natural ecosystem.National parks, animal sanctuaries, and biosphere reserves are a few protected locations where in-situ conservation is practised.

National Parks:

The government keeps a tiny amount of reserves. Its limits are well defined, and human activities like grazing, reforestation, habitat development, and farming are not permitted. Kanha National Park and Manipur National Park are two examples.

Wildlife Sanctuaries

These are the only places on earth where wild animals may be found. Human activities like logging, farming, gathering woods and other forest products are permitted here as long as they don't get in the way of the conservation initiative. Additionally, vacationers go to these locations.

Biological Reserves

Biosphere reserves are versatile protected regions where native wildlife, local customs, and cultivated flora and animals are all safeguarded. Activities like tourism and research are allowed here.

Ex-situ Conservation:

Raising and maintaining endangered species in man-made habitats like zoos, nurseries, botanical gardens, gene banks, etc. is known as ex-situ conservation of biodiversity. Less creatures are competing with one another for food, water, and available space.

1. The benefits of ex-situ conservation are as follows:
2. The animals are given more time and opportunities for reproducing.
3. It is possible to return the captive-bred species to the wild.
4. It is possible to apply genetic approaches to protect threatened species.

Science and Biodiversity

Conservationists take a variety of steps to save the enormously complex biodiversity of our world, including finding individual creatures, tracking their migrations, detecting and tracking species of plants and animals evaluating their environment, and combating poaching.Sixth great extinction event. Researchers have given this moniker to the alarming extinction of species that the planet is now experiencing. But unlike the five previous ones, which were brought on by catastrophic occurrences like asteroid crashes, this one is brought on by human activity. According to the most recent living Planet Report, which was created by WWF and more than 50 experts from across the world, the number of animals worldwide declined by 60% between 1970 and 2014.

According to the research, three-quarters of the planet's land is being utilised for agriculture, industry, and urbanisation, which is the primary cause of this extinction of species. With 300 creatures being "driven into extinction" as a result of human-caused slaughter for food, toxic waste comes in second. This is unfortunate in and of itself, but it also poses a danger to the health of both the present and upcoming populations since a healthy environment is essential to our ability to survive.Conservation activities are essential if we want to halt the speed of this alarming development. Technology like Unmanned Aerial Vehicles (UAVs), Internet of Things (IoT) sensors, crowdsourcing, and machine learning have recently boosted conservation.

Drones

Drones, sometimes referred to as unmanned aerial vehicles, have emerged as a powerful friend for environmentalists. Indeed, by offering overhead views of vast regions that might sometimes be difficult to reach, they can aid in the monitoring of species. Drone technology is the wave of the future because of how it is built. Environmentalists have already begun employing air monitoring drones, even though many academics are concentrating on how to improve these functions. This method is exceptional for data collecting, including topographic data and samples of air conditioning systems.For instance, efforts to lessen deforestation currently make use of drones. Around 26 billion trees are lost to urbanisation and mining each year, having a substantial negative influence on resources, hunger, and several other concerns. In farming, drones may be used to sow seeds as well as analyse map data. Deforestation can be stopped and potential recovery can be calculated.

Drones Contribute to Environmental Protection

Drones and the environment are connected by a short, straight path. Drone technology offers access and viewpoint that some individuals are unable to get on their own. The UAVs demonstrate the value of this relationship by helping the environment in a variety of ways.

Animal protection

Management of the ecosystem now includes tracking the travel of animals between various geographical areas. By guiding animals as needed, drones safeguard wildlife and natural environments.Additionally, drone sensors can monitor and report on wild animal populations that are in danger of extinction. Animals may be tracked by drones, and reports can be generated. These procedures take place with little danger to the individual or team involved, enabling wildlife to proceed without interruption and for monitoring and care to be provided.

Discovery of climate change

Drones may, at their most basic level, collect data using visual evidence. By using this photographic data, the effects of climate change are closely documented. Drone-pictured imagery may display changes in ecosystems, coastlines, the extent of forests, and other features.

Information Gathering

Drones are quite helpful for gathering data. They are used by Compound Services for several purposes, including air quality tests and environmental control. In a variety of businesses that need monitoring systems, a drone may be a useful tool. We are able to make better informed judgments because to the capacity to gather data. A drone may identify locations that are ideal for setting up dykes, creating shelters, and growing useful plants and commodities. Although they were previously seen as a vision of the future, drones are now a reality. Drones primarily record, monitor, and take images of what is going on in our surroundings.

Internet of Things

The "things" that make up the Internet of Things are sensor-equipped gadgets that can collect data, process it locally to variable degrees, and then connect to the internet to send it somewhere for processing and/or storage. By the end of 2019, there will be around 9.5 billion linked IoT (Internet of Thing) devices globally, according to the most recent projection from research company IoT Analytics.

There are many different ways to link IoT devices to the internet, including wired networks, wireless local area networks, low-power wide-area wireless networks (LPWAN), Bluetooth, wi-fi, and cellular (including, increasingly, 5G). Use examples include monitoring what is left of the natural world, where satellite communication will become more crucial. Other use cases include "smart" homes and workplaces, industries, cities, transportation networks, and many other locations in between.While IoT is already extensively employed in agriculture (see our recent piece on the Future of Farming) and smart home applications, it has also saved the lives of many endangered animals. IoT is used to monitor animals and deter poachers from injuring them as poaching increases globally elephants, rhinos, lions, pangolins, and other famous African species may potentially become extinct within our lifetimes.

Crowdsourcing

While sensors and drones may give useful data for tracking animals, crowdsourcing is a growing practise that is advancing conservation efforts and assisting researchers.A system for enabling the coordination of social action to achieve specified objectives is the pooling of resources, knowledge, or efforts from people to carry out specific tasks. Human culture has traditionally experienced this phenomena, and probably one of the most well-known early instances of crowdfunding was the creation of the Statue of Liberty's pedestal.

Crowdfunding is generally the process of obtaining money directly or indirectly from a large number of people, sometimes referred to as "the crowd" in this context. In this context, donors are often people, but they might also be other actors, including businesses Large non-governmental organisations (NGOs) and other players have traditionally raised money for conservation via direct crowdfunding, in which they ask their supporters for donations directly. In contrast, indirect crowdfunding uses a middleman, in this example a crowdfunding website, to connect the crowd and the fundraiser.

Restoration of Biodiversity

Obviously, preservation is essential to the preservation of variety. However, it is also evident that preservation is not a sufficient approach on its own to protect variety. Preservation can only, at most, preserve what already exists. We need more than that in a world of transition. In the end, we need a mechanism to not only preserve what we already have but also reconstruct everything that has been changed, damaged, or even destroyed.

Definition

While ecological restoration is the activity or process that restoration practitioners actually undertake, restoration ecology is the academic study of the process. According to the Society for Ecological Restoration, "ecological restoration" is a deliberate action that starts or hastens an ecosystem's recovery with regard to its sustainability, health, and integrity. [10] Erosion control, reforestation, removal of invasive species and weeds, revegetation of disturbed areas, daylighting of streams, the reintroduction of native species (preferably native species with local adaptation), and habitat and range improvement for targeted species are just a few of the projects that fall under the broad category of ecological restoration. Many academics believe that local people must be involved in ecological restoration; they refer to this process as "social-ecological restoration."

Restoration-related ecological research has mostly concentrated on community ecology and ecosystem ecology, with an emphasis on plants. However, reintroducing animals into the wild, a popular practise in conservation biology, is basically restoration. Restoration ecology, which gained popularity in the second half of the 20th century, is today recognised as a science and is researched at numerous research facilities. Knowledge of restoration research and practise is being advanced through international organisations and magazines like the Society for Ecological Restoration (est. 1988) and its journals Ecological Restoration (est. 1981) and Restoration Ecology (est. 1993). The quantity of books and academic papers on ecological restoration has increased significantly during the 1990s. A considerable endeavour has been made to clearly relate the science and practise of restoration with ecological theory. In fact, ecological restoration may serve as a real-world test of our comprehension of ecology. On the other hand, unsuccessful ecological restoration attempts might highlight ecological knowledge gaps.

Principles supporting restoration

Disturbance

There are many distinct grades and degrees of severity for disturbance events, and some are inherent to every ecosystem. Events that cause disturbances may modify soil characteristics, nitrogen cycle, and species composition. Severe weather damage, fire, floods, treefalls, and even volcanic eruptions are examples of natural calamities. Natural habitats and/or biological processes may be altered or destroyed as a result of anthropogenic (human-caused) disturbances, such as clearing land for agriculture (like damming rivers for flood control).

Humans may also alter natural cyclical and disruptive phenomena (like suppression of wildfires and prevention of periodic flooding). A restoration project's objective might be to start or hasten an ecosystem's recovery after a disruption. Restoration efforts might also be made to bring back natural disturbance patterns.

Genetics

Genetic factors are often taken into account in restoration attempts. Locally sourced plants (or animals) are more likely to be successfully adapted to the target ecology. Utilizing animals or plant materials (such as seeds or cuttings) gathered from nearby sources may thereby improve the likelihood of successful establishment. A significant number of unique plants or animals may aid in ensuring genetic diversity in the populations that have been reintroduced. It is believed that genetic variety is essential for preserving populations' capacity for change and recovery from shocks.

Succession

Ecological succession is the process through which a disturbed ecosystem's biological community composition—the number and distribution of various species—recovers over time. After eliminating a source of disturbance, passive restoration simply entails allowing natural succession to take place in an ecosystem. A prime example of passive restoration is the return of deciduous woods in the eastern United States after agriculture was abandoned. Accelerating the process or making an effort to alter the successional trajectory are both examples of active restoration. For instance, mining tailings would need so much time to passively recover that active restoration is often necessary.

Theory of Community Assembly

According to the hypothesis of community assembly, comparable places may generate diverse biological communities based on the timing of the entrance of various species. Sites may not always recover during restoration toward a targeted or expected collection of species or ecological services. When establishing certain biological communities or preventing the invasion of weeds or pests, restoration practitioners may want to take the composition of seed mixes, planting order, and planting year into account.

Geographic Ecology

A number of topics from landscape ecology are used in restoration. Because they are often remote and tiny, restored areas are particularly vulnerable to challenges brought on by habitat fragmentation. When continuous habitat regions become separated due to natural or human factors, this is known as habitat fragmentation (for example, building roads through a forest). Small, isolated areas of favourable habitat are often produced as a result of fragmentation. Fewer species and smaller populations are supported by smaller environments, which puts them at higher danger of local extinction due to inbreeding. According to the notion of island biogeography, populations are more likely to survive in huge habitat patches that are linked to other populations in favourable settings. According to this notion, the area between habitat patches, or the matrix, is uniform and hostile. Oceanic islands, which are specks of the habitat of terrestrial animals surrounded by unusable sea, are the most typical illustrations of this notion. The traditional dichotomy of friendly vs hostile environment has lately been changed to take into account the presence of many habitat patch types that are juxtaposed to create a patch mosaic. These various areas of the mosaic may provide a more friendly or less hospitable environment for the species, groups, and ecosystem services that restoration efforts are aiming to restore.

By increasing the number of edge habitat and lowering the distances between edges, fragmentation may also enhance harmful edge effects, which are consequences of one habitat on a neighbouring habitat. Invasive weeds, for instance, are more prevalent near forest margins, making tiny forest fragments (that have more edge habitat) more susceptible to invasion. Through the creation or restoration of links, restoration initiatives often aim to increase connectivity between habitat areas in fragmented landscapes. Corridors and stepping stones are two examples of links that are often utilised to increase connectedness. The relatively short, linear stretches of habitat known as corridors connect otherwise isolated habitat regions. Small, disconnected habitat patches that are near enough to one another to permit mobility across the terrain are called stepping stones.

Application

A multi-stage technique, imposed restoration could include any or all of the following phases:

Evaluating the location: To decide what sort of operations will be required, a detailed evaluation of the present circumstances at the restoration site is vital. The causes of ecological disruption and strategies for halting or reversing them are determined in this stage.Setting project objectives Practitioners may go to reference locations (similar, neighbouring settings in their natural state) and/or use historical documents that describe the pre-disturbance community to select objectives for the recovered society. Goals could also take into account which species will thrive in the current or future environment.

Eliminating causes of disturbance: In order for restoration to be effective, it may be necessary to eliminate sources of disruption. Examples include ending mining, farming, and erosion-causing practises, banning livestock from riparian zones, eliminating hazardous substances from soils or sediment, and eliminating invasive foreign species.

Process/cycle restoration: Restoring crucial ecological activities, like normal flood or fire regimes, might sometimes be sufficient to rebuild an ecosystem's integrity. Native animals and plants that already have developed to withstand or need natural disturbance regimens may do so in these situations without the intervention of professionals.

Rehabilitating substrates may refer to any action taken to correct damaged soil chemistry or texture, or to reestablish hydrological patterns or water quality.Restoring vegetation: Restoration initiatives often entail the land being directly replanted with vegetation. Typically, natural plants that are compatible with the local environment are chosen for planting. In order to guarantee genetic diversity, seeds or cuttings are often gathered from a range of sources within a local area. Seeds or seedlings may be used to plant vegetation.

Observing the restoration site throughout time is essential to assessing if objectives are being accomplished and may help guide administration choices in the future. Observations conducted at the site can suggest that further steps, such routine weed eradication, are required to guarantee the project's long-term viability. Restoration initiatives should ultimately result in a self-sustaining environment that doesn't need further human intervention.Nearly every kind of environment in the globe has been the focus of restoration efforts, but the environments most negatively damaged by human activity, such as wetlands, grasslands/rangelands, riparian regions, and tropical forests, have received special attention.

Alternatives to Increase Biodiversity

Recently, there has been a lot of focus on tropical deforestation and the resulting loss of biological diversity in tropical rain forests. Because the factors causing tropical deforestation are multifaceted, no one solution will be enough to mitigate their consequences. The issue has been recognised, but the best biological principles must be used in any remedies, and they must also make sense in the social and economic environment. Tropical biology research institutions cannot directly address economic and social issues, but addressing these issues requires a knowledge of how the biological system works. Some unique alternatives to destruction were discovered throughout the quest.

Lower the Mortality of Eggs and Hatchlings

Previously a diverse reptile, it has been coveted for its protein content for more than 7,000 years. Due to habitat degradation from slash-and-burn farming, pasture conversion of wooded areas, increasing use of biocides, and unrestricted hunting, the animal population is currently dramatically declining.Over 95% of captive hatching attempts have been successful thanks to developed techniques. Additionally, yearling survival is very nearly 100%. Hatchlings kept in captivity acquire weight twice as quickly as wild ones thanks to a low-cost, high-protein feed. Both captive and wild females preferred an artificial nest made to make egg harvest easier over nests they built themselves. The generation of a certain number of young and their controlled proliferation in captivity are ensured by developed techniques.

Breeding in Captivity

The technique of keeping plants or animals in confined spaces, such as zoos, botanical gardens, as well as other conservation institutions, is known as captive breeding, sometimes known as captive propagation. It is sometimes used to support species that are under danger from human activities including climate change, loss of habitat, fragmentation, excessive fishing or hunting, pollution, predation, illness, and parasitism. Relatively little is understood about the circumstances necessary for effective breeding in many species. The effectiveness of a captive breeding effort may depend on knowledge of a species' reproductive biology. A captive breeding programme may sometimes be able to prevent the extinction of a species, but for this to happen, breeders must take into account a variety of elements, such as genetic, ecological, behavioural, and ethical considerations. Most effective initiatives enlist the collaboration and coordination of several entities.

At least 10,000 years ago, when the first humans domesticated animals like goats and plants like wheat, captive breeding practises got their start. These customs grew in scope with the emergence of the earliest zoos, which were originally royal menageries like the one at Hierakonpolis, Egypt's Predynastic Period capital. Only in the 1960s did the first real captive breeding projects get off the ground. These initiatives, like the Phoenix Zoo's 1962 Arabian Oryx breeding programme, were aimed at reintroducing these animals to the wild. Under the Nixon Administration's Endangered Species Act of 1973, which was centred on preserving biodiversity through saving endangered species and their habitats, these initiatives were extended. Since then, research and conservation have been held in zoos, such the Institute for Conservation Research at the San Diego Zoo, which was established in 1975 and extended in 2009, which has aided in the success of conservation efforts for species like the Hawaiian Crow.

Forests Gardening

Agroforestry and low-maintenance plant-based food production system based on woodland ecosystems, forest gardening includes fruit and nut trees, shrubs, herbs, vines, and perennial vegetables that produce crops that are directly beneficial to people. These may be put together to grow in a series of strata using companion planting to create a forest environment. In tropical regions, forest gardening is a primitive means of ensuring food. Robert Hart first used the phrase "forest gardening" in the 1980s after modifying the concepts for use in temperate climes. Since ancient times, hunters and gatherers may have had an impact on forests. In Europe, for instance, Mesolithic people may have brought with them preferred trees like hazel. The world's oldest and most robust agroecosystem is likely the forest garden system. They developed in the ancient era among riverbanks covered in vegetation and in the soggy foothills of monsoon areas. Families gradually enhanced their surrounding environment by identifying, protecting, and enhancing helpful tree and vine species while eradicating unwanted ones. Later, the best foreign plants were chosen and added to the gardens. In the 1930s, a Smithsonian archaeologist discovered First Nation towns in Alaska that had forest gardens full of plants, berries, nuts, and stone fruit. Forest gardens are still prevalent in the tropics and are called by a variety of names, including: home gardens in Kerala, south India; Nepal; Zambia; Zimbabwe; Tanzania; Kandyan forest gardens; and huertos familiares, or "family orchards," in Mexico. These are also known as agroforests, and the name "shrub garden" is used when the wood components are short-statured. For the local community, forest gardens have been shown to be a substantial source of income and food security. In the 1980s, Robert Hart modified forest gardening to the temperate environment of the United Kingdom. Martin Crawford from the Agroforestry Research Trust and other permaculturists including Graham Bell, Patrick Whitefield, Dave Jacke, and Geoff Lawton further extended his views.

Wildlife control

The practise of managing interactions among and between wildlife, its habitats, and humans in order to accomplish certain outcomes is known as wildlife management. The finest available research is used in an effort to strike a balance between the requirements of humans and animals. Wildlife conservation, gamekeeping, and pest control are all examples of wildlife management. To get the greatest outcomes, wildlife management integrates fields like mathematics, chemistry, biology, ecology, climatology, and geography. Wildlife management tries to stop the decline in the biodiversity of the planet, by taking into account environmental factors including physical topography, pedology, and hydrology, as well as biological concepts like carrying capacity, disturbance, and succession. Although rewilding is becoming more popular, most wildlife biologists are focused on habitat preservation and enhancement. Reforestation, insect management, nitrification and denitrification, irrigation, coppicing, and hedge-laying are some examples of techniques.

Gamekeeping, which includes the killing of other creatures that occupy the same niche as game or predators to maintain a large population of more lucrative species, such as pheasants brought into forest, is the management or control of wildlife for the welfare of game. Aldo Leopold, one of the forerunners of wildlife management as a science, described it as "the art of making land yield continuous yearly harvests of wild animals for recreational use" in his 1933 book Game Management. Controlling actual or imagined pests may be done for the protection of humans, animals, farmers, gamekeepers, or other interests. In the US, governmental organisations often adopt wildlife management strategies to enforce laws like the Endangered Species Act.

Several organisations, including government agencies like the Forestry Commission, nonprofits like the RSPB and The Wildlife Trusts, as well as contractors and gamekeepers who are employed privately, manage wildlife in the United Kingdom. Additionally, laws protecting animals have been established, including the 1981 Wildlife and Countryside Act. In order to increase the conservation value of their farms, the UK government also provides farmers with subsidies under the Countryside Stewardship Scheme.

Policies to Protect Biodiversity

The largest danger to the planet's biodiversity is, ironically, the species that depends on it most: humans. One of the biggest issues facing mankind is halting biodiversity loss, which is the decline or extinction of the variety of living things that occupy the world. Ecosystems and the organisms that make them up suffer from soil contamination and changes in their usage brought on by actions like deforestation.

Primary Reasons for deforestation are:

Industry Agriculture

Approximately 85% of global deforestation is caused by industrial agriculture, which you may find on your dinner plate. Deforestation is mostly caused by the production of livestock, particularly cattle, although soy and palm oil plantations are also significant contributors.

Forest Logging

To satisfy the enormous worldwide need for wood and other wood products, some 380,000 hectares of forest are chopped down each year, which is responsible for about 60% of degradation.

Minecraft

Mining is becoming more prevalent in tropical forests as a result of the rising demand for minerals. Additionally, since large-scale mining is a labor-intensive, industrial activity, it calls for the construction of a vast infrastructure, which only serves to accelerate the deterioration.

Improvement and Structure

Large tracts of forest are removed to make room for the establishment of towns and settlements as the tide of human population increase sweeps the continent. These communities also provide more infrastructure and growth.

Change in Climate

Deforestation is mostly caused by climate change. Millions of hectares of forest are destroyed each year by extreme weather conditions like wildfires, floods, and severe storms, and their severity is only becoming worse due to global warming. However, the problems don't end there because after the final fire has been extinguished, the doors are left wide open for pests, illnesses, and alien species to move in and decimate what is left.

Five Ways to Reduce Deforestation

Give locals more power

Industrialized countries are now prescribing what people in developing countries can and cannot do with their own forests since they have benefited from deforestation in their own countries and now have the advantage of hindsight.

Transfer land control to native people

Offering indigenous people ownership of the land is one of the most effective ways to stop deforestation, according to research.

Make supply networks more disciplined

Forests and agriculture may live together, but this is not the norm. In actuality, the main reason for deforestation is the removal of trees for farming. Seven products are responsible for the bulk of this destruction: cattle, soy (which is mostly used as animal feed), palm oil, wood fibre, cocoa, coffee, and rubber.

Reduce your intake of beef (and meat generally)

Residents may also contribute by consuming less meat. Aresearch found that a 20% decrease in worldwide beef consumption may cut the pace of deforestation in half.

Pick governments that value forests.

Making educated choices at the grocery store is beneficial, but voting is where it really matters most for the environment.

Policies:

The major goal of the policies is to protect the area and integrity of the woods and to keep an ecological balance necessary for all species of flora and wildlife to survive. "Sovereign national rights over biological resources" are granted by international accords like the Convention on Biological Diversity (not property). By signing the accords, nations pledge to "conserve biodiversity," "create resources for sustainability," and "share the advantages" that come from using these resources. Countries with a diversified biosphere that permit bioprospecting or the collecting of natural goods demand a portion of the rewards rather than letting the person or organisation that finds or uses the resource to keep all of the rewards for themselves. When these rules are not adhered to, bioprospecting might turn into a kind of biopiracy. Access and Benefit Sharing Agreements, as they are more often called, may provide a foundation for sovereignty concepts (ABAs). In order to determine which resources will be exploited and for what purposes, as well as to come to an equitable agreement on benefit sharing, the Convention on Biodiversity requires informed consent between the source nation and the collector.

Union of Europe

The European Union released its 2030 Biodiversity Strategy in May 2020. The European Union's plan to combat climate change must include the biodiversity policy. A significant portion of the 25% of the European budget that will be allocated to combating climate change will go toward restoring biodiversity and using natural remedies.

The following goals are part of the EU Biodiversity Strategy for 2030:

1. Protect 30% of the water and 30% of the land, including Old-growth forests.
2. By 2030, plant 3 billion trees.
3. Make at least 25,000 kilometres of rivers flow-free by restoring them.
4. Cut down on pesticide usage by 50% by 2030.
5. Expand organic agriculture. According to the related EU initiative From Farm to Fork, the goal is for 25% of EU agriculture to be organic by 2030.
6. Increase agricultural biodiversity.
7. Donate €20 billion annually to the problem and incorporate it into company operations.

About 50% of the world's GDP is reliant on nature. Numerous economic sectors in Europe that produce billions of euros annually rely on nature. There are between €200 and €300 billion in annual benefits from Natura 2000 in Europe alone.

Laws at the Federal Level

Some political and legal judgments consider biodiversity:

1. Law and ecosystems have a long-standing interaction that has an impact on biodiversity. Private and public property rights are involved. Along with certain rights and obligations, it might specify how vulnerable ecosystems should be protected (for example, fishing and hunting rights).
2. More current legislation relates to species. It lists the species that need to be conserved because they might face extinction. One effort to solve the "legal and species" dilemma is the U.S. Endangered Species Act.
3. The laws governing gene pools are barely a century or so old.

Although techniques for domesticating and breeding plants are not new, improvements in genetic engineering have resulted in stricter regulations on the sale of GMOs, gene patents, and process patents. Governments struggle to choose between, say, focusing on creatures and species or genes and genomes.The use of biodiversity as a legal criteria has not yet received universal support. According to Bosselman, the remaining areas of scientific ambiguity lead to intolerable administrative waste and increase litigation without advancing preservation aims, hence biodiversity should not be employed as a legal criteria. In order to preserve its biological variety, India approved the Biological Diversity Act in 2002. The Act also stipulates procedures for the fair distribution of gains from the use of conventional biological resources and expertise.

The significance of biodiversity is crucial because without it, life on earth could not exist. The availability of many species, including those of plants, animals, and microbes, as well as their frequencies on our planet, makes biodiversity important. Since it promotes community stability and enhanced production, a high degree of biodiversity is often seen as advantageous and desirable.

Problems and Future Prospects

There are parts of natural science that need attention but have not yet been covered, without concentrating on the economic, social, and political issues that are crucial to current issues and future prospects:

Species Diversity

Understanding the relative abundance of various species may help us understand how a community works. Data on species abundances may provide insight into less obvious features of a community, such competition and predation, and are reasonably simple to gather. For instance, the fact that two species co-occur often but never at high concentrations (i.e., when one species is abundant, is the other sparse) shows that both species are in competition with one another. Because communities can include a variety of species with drastically varying abundance patterns, comparing species abundance across communities may be challenging. To handle this complexity, species abundance curves—where the number of species is plotted against their abundance are utilised. They enable comparisons of how different communities vary in their organisational structures by compressing the information on species abundances. Contrasting trends in species abundance may also point to variations in the structure of communities.

Barriers like huge rivers, seas, oceans, mountains, and deserts promote variety by allowing allopatric speciation, which allows separate evolution on each side of the barrier. Species that cross the natural boundaries that would ordinarily keep them restrained are referred to as invading species. Without boundaries, these species invade new areas, often displacing native species by taking over their niches or using the resources that would otherwise support them.

Since at least the turn of the century, there have been more species invasions. Humans are moving species around more and more (on purpose and accidentally). In other instances, the invaders are seriously altering and harming their new environments (e.g.: zebra mussels and the emerald ash borer in the Great Lakes region and the lion fish along the North American Atlantic coast). According to some data, invading species are more competitive in their new environments because they are less likely to be disturbed by pathogens. While some contend that diversified ecosystems are more robust and able to fend off invading plants and animals, others describe conflicting research that sometimes suggests that species-rich communities house numerous native and foreign species at the same time. Is it true that invading species lead to extinctions? Numerous studies note invading species' impact on native species but do not mention extinctions. Invasive species seem to boost regional diversity (i.e., alpha diversity), which slows down diversity turnover (i.e.: beta diversity). Even some of the sneakiest invaders (such as Dutch elm disease, emerald ash borer, and chestnut blight in North America) have not led to the extinction of their host species, which may result in a reduction in overall gamma diversity. Regional biodiversity homogeneity, population decrease, and extirpation are far more frequent. By importing invasive species for food and other uses, human actions have often been the cause of their overcoming their boundaries. Therefore, animals are now able to move to new locations thanks to human activities on time periods that are substantially shorter than those previously needed for a species to expand its range.

Both invasive and intentionally introduced species do not exist in equal numbers. In certain instances, like the zebra mussel invasion, the US waters were unintentionally invaded. Others, like mongooses in Hawaii, purposefully but ineffectively introduce the subject (nocturnal rats were not vulnerable to the diurnal mongoose). In some instances, such as the introduction of oil palms in Indonesia and Malaysia, the gains are enormous economically, but they are accompanied by expensive unforeseen effects.

Unintentionally harming a species that relies on the species that it replaces is another risk associated with introduced species. Eastern European Prunus spinosa leaves in Belgium significantly earlier than its Western European equivalents, interfering with the Thecla betulae butterfly's feeding habits (which feeds on the leaves). When new species are introduced, it often renders endemic and other native species incapable of surviving because they cannot compete with the foreign species. Exotic creatures may be parasites, predators, or they may outcompete native species for resources like water, light, and nutrients.

Currently, a number of nations have imported so many alien species, especially agricultural and decorative plants that it's possible that their native flora and wildlife are now outnumbered. For instance, the biodiversity in certain places has been endangered by the introduction of kudzu from Southeast Asia to Canada and the United States. Effective strategies to reduce climate change are provided by nature.

Wildlife Smuggling

Although pollution, deforestation, loss of natural habitats, and climate change are all dangers to animal and plant species, wildlife trafficking considerably worsens the issue by poaching, harvesting, or depleting large numbers of already endangered or at-risk species. The consequences of trafficking in animals, animal parts, and plants extend well beyond the affected species and affect human livelihoods, biodiversity, and government.

Industry Leather

Before you can purchase an animal's skin at your neighbourhood shop as a leather jacket, a pair of boots, or a purse, it must go through a number of processes. Cattle sourcing (raising and killing cattle), leather tanning (making leather from unprocessed animal skin), and leather processing make up the complete process (turning leather into goods). A significant portion of the leather business has been relocated to nations that don't give a damn about labour rights, the environment, or animal welfare because of our need for inexpensive leather.

Overpopulation of People

As of mid-2017, there were around 7.6 billion people on Earth (almost one billion more than in 2005), and that number is expected to rise to 11.1 billion by the year 2100. "It is self-evident that the tremendous expansion in human population over the 20th century has had greater influence on biodiversity than any other single cause," Sir David King, a former senior scientific advisor to the UK government, said in response to a parliamentary investigation. The pace of global human population growth will likely have a significant impact on the loss of pristine biodiverse land, at least until the middle of the twenty first century.

Leading scientists have stated that population increase and growth, together with excessive consumption, are important contributors to the decline in biodiversity and the deterioration of the soil. According to the 2019 IPBES Global Assessment Report on Biodiversity and Ecosystem Services, overconsumption and human population increase are the major causes of species reduction, as well as scientists Paul R. Ehrlich and Stuart Pimm. E. O. Wilson said that the "pattern of human population expansion in the 20th century was more bacterial than primate," supporting his claim that the increase in human population had severely harmed the biodiversity of the world. He said, "We and the rest of life cannot afford another 100 years like that." When Homo sapiens reached a population of six billion, he said, "Their biomass surpassed that of any other big land dwelling animal species that had ever lived by almost 100 times."

The World Wildlife Fund said in 2020 that the world's human population now surpasses the planet's biocapacity, and that to satisfy our present needs, 1.56 Earths' worth of biocapacity would be needed. According to the 2014 research, if everyone on the globe had the Footprint of a normal Qatari citizen, we would need 4.8 Earths, and if everybody lived like a typical American, we would require 3.9 Earths.The keyword 'biodiversity' has become commonplace as a shorthand for 'biological diversity' during the previous decade. When the Conventions on Biological Diversity (CBD) was established, it put biodiversity firmly on the world agenda (Figure 3.1).

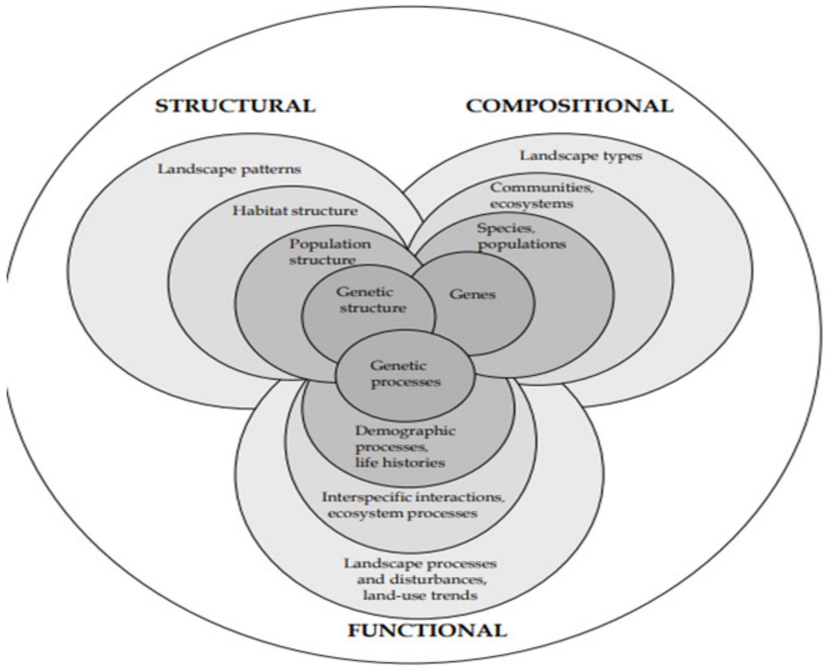

Figure 3.1 Represents the Compositional, structural and functional biodiversity.

The UK biodiversity process

Implementing the CBD goals in the UK should improve and widen the scope of current wildlife policy and law. The present strategy prioritises the protection of ecosystems and species inside protected areas. Appendix 1 summarises the essential provisions of current policy and law. The necessity to establish and execute a national biodiversity plan has dominated implementation of the Convention's responsibilities in the United Kingdom, as it has everywhere throughout the globe. The primary goal of these national plans is to identify priority sectors required to achieve the CBD's goals. A group of six UK volunteer conservation organisations created the discussion paper Biodiversity Challenge: an agenda for restoration in the UK in 1993 (Wynne et al, 1993) (a second version was issued in 1995). (Wynne et al, 1995). This paper, billed as "a plan for action from the volunteer conservation sector," was created to assist the UK government in developing a national biodiversity strategy. The UK Biodiversity Action Plan (UK BAP) was announced in January 1994 (HM Government, 1994) with the general goal:

The UK Biodiversity Group compiled a list of Conservation Concern Species that fall into one or more of the following categories:

1. Threatened endemic and other globally threatened species.
2. Species where the UK has more than 25% of the world or appropriate biogeographical population.
3. Species where numbers or range have refused by more than 25% in the last 25 years.
4. In some cases, where the species is found in fewer than 15 ten km squares in the UK.

Priority Species have been designated for certain species on the list of Species of Conservation Concern. These are internationally threatened species and/or species that are quickly falling in the UK, i.e. by more than 50% in the previous 25 years. All Priority Species (nearly 450 species) and 35 habitat types have now received costed action plans (Habitat Action Plans (HAPs) and Species Action Plans (SAPs)) or conservation statements (Habitat

Statements (HSs) and Species Statements (SS)). The plans' aims and suggestions are intended to be suitable through 2010.

In addition to these national-level activities, the UK BAP is being carried out via a variety of local biodiversity planning (LBAPs) targeting key habitats and species. To guide its conservation activities and offer a framework for the LBAP process, English Nature has created a Natural Areas approach4. Many LBAPs, both regional and local authority, are at various stages of development; for example, Hampshire, Kent, the South West, and Mendip District have published Action Plans, while Bradford City Metropolitan Council and Surrey are in the process of developing plans. These national and local strategic plan are essential references and information sources for any EIA.

Existing Government advice on nature conservation and planning6 does not address interactions with the UK biodiversity process directly. Indeed, only the Natural Heritage Planning Guidance in Scotland (NPPG 14) explicitly mentions the UK and LBAPs, stating that "planning authorities can make an important contribution to the achievement of biodiversity targets by adopting policies that promote and afford protection to species and habitats identified as priorities in LBAPs" (SOED, 1999). Further government advice is needed on this topic, particularly on how much weight the UK and LBAPs should be given in the planning system. Such guidelines might be integrated into upgraded versions of current nature conservation planning guidance, such as the proposed updates of PPG 9 and TAN 5.

Biodiversity is not referenced expressly in UK EIA regulation. This may be explained in part by the historical date of the EIA and the CBD. The EU EIA Directive was agreed upon before to the CBD in 1985. Neither the EIA Directive nor the EIA Amendment Directive (approved in 1997) address biodiversity directly. Yet, the EIA Directive's preamble mentions the necessity to analyse the "environmental consequences of a project...to guarantee the conservation of species diversity and the reproductive potential of the ecosystem as a fundamental resource for life" (CEC, 1985). Furthermore, because the EIA Directive requires the identification, description, and assessment of direct and indirect effects of a project on flora and fauna, as well as the interaction between these and soil, water, air, climate, and the landscape, it is clear that biodiversity is an integral part of EIA.

Some components of biodiversity, such as endangered species and habitat loss, are addressed in most EIA studies where they are relevant, but EIAs are less likely to address other aspects of biodiversity, such as diversity at the genetic and ecosystem levels, diversity of non-threatened species, diversity within species, and functional components of biodiversity. So, it seems that components of biodiversity that are currently protected (protected areas or status) are more likely to be included in EIA than components that have less popular status but may be crucial to the long-term productivity of ecosystems and biodiversity maintenance.

Biodiversity different to ecology and nature conservation

The word 'biodiversity' is used both as a broad political phrase (as a shorthand for the world's living life support systems) and in a more scientific and technical meaning, as defined by Noss (1990) and reflected in the definition selected for the purposes of this advice.The word biodiversity is being used to refer to a broader notion that will give new momentum for nature conservation in the form of a new framework and financing. Significantly, it also contains the notion of sustainable use as a major component of, and instrument for, the conservation of biodiversity.The more realistic approach stresses the need of comprehending the many layers of biological entities, the various scales at which they work, the linkages they offer, and the activities they perform. In this regard, it refocuses ecology and nature conservation ideas away from a typical species-based approach and towards a more holistic approach that explicitly addresses entire ecosystems and landscape/bioregional scales.

Guidance in biodiversity

The purpose of this advice is to increase the consideration of biodiversity in road EIAs. It combines components of existing best practises in ecological impact assessment with recommendations for a systematic approach to tackling biodiversity concerns in road EIAs. A major purpose and guiding principles for biodiversity offer the backdrop for the evaluation. The advice takes into account biodiversity problems important to each step of the EIA process, such as:

Screening: What biodiversity issues should prompt an EIA for a road?

Scoping: Which options should be considered? What activities could have an influence on biodiversity? What aspects of biodiversity could be harmed?

Baseline circumstances: Good sources of biodiversity background information. What fresh polls should be conducted? What criteria should be used to assess the relative significance of various biodiversity elements?

Impact prediction and evaluation: Which impact prediction methodologies are suitable for predicting biodiversity impacts? What factors should be considered when determining the degree of biodiversity impacts? What standards should be used to assess the importance of biodiversity impacts?

Mitigation and enhancement: What mitigation/enhancement measures should be taken into account?

EIS development: How should biodiversity data be presented?

Decision-making: Taking into account the biodiversity data contained in the EIS.

Biodiversity monitoring and ecological management plans - Which aspects of biodiversity should be tracked? What data sources may this monitoring data be supplied into? Should a strategy for environmental management be developed? The use of the systematic recommendations provided in the following sections should enhance the consideration of biodiversity concerns in road EIAs/EISs.

The EIA Directive makes no mention of monitoring. Furthermore, post-project monitoring is likely to be the weakest link in present EIA practise. Nonetheless, the inclusion of monitoring programmes is critical to offer a 'feed-back loop' allowing assessment of the EIS forecasts, judging the performance of mitigation measures, and identifying and correcting post development issues. Monitoring may give significant information to be used in future EIAs and for enhancing the scientific foundation of EIAs in general, in addition to these 'project-specific' advantages.

The need for monitoring

Monitoring techniques should be devised throughout the study's prediction and mitigation phases, and biodiversity data gained via monitoring should be incorporated in global data services such as the CHM and BCISmonitoring is critical for understanding the consequences of a project and assessing the degree of implementation as well as the success or failure of mitigation measures When the success of mitigation is uncertain or failure might have far-reaching consequences, it may be necessary to monitor mitigation measures so that they can be modified or altered if they are insufficiently successful.

The systematic observation and measuring of ecosystems to determine their features and changes through time is referred to as ecological monitoring goes into great length on the basics of ecological monitoring. It is critical that the monitoring programme be adequately organised. Preferably, the monitoring programme will involve monitoring throughout all project phases (pre-construction, during construction, and after the road is operational). It is critical that standard data gathering techniques/methods be utilised (and made apparent) so that the data may be used for comparison reasons. A good monitoring programme will be organised to answer clearly stated questions, will allow for repeatability and control, and will have established suitable timing and frequency in connection to the biodiversity factors being assessed and the nature of the proposed/implemented road project. To be credible, a quality control process for reviewing monitoring data that is independent is required. For instance, a Conservation/Monitoring Group comprised of interested parties such as the local planning, the developer, consultants, consultees, and so on.

U.S. Interest in Biodiversity Conservation

The US government's high priority for biodiversity conservation of the Foreign Assistance Act, which directs USAID and other appropriate international organisations to make a special effort to continue and increase assistance for sound wildlife habitat management and plant conservation programmes. Biodiversity conservation is intimately linked to other US overseas development programmes as well as significant US national interests such as national security, economic prosperity, law enforcement and emergency response, and health and demographic challenges. Conflicts over limited and critical natural resources, for example, may cause tremendous stress, sparking insurgencies, ethnic confrontations, and mass migration in certain circumstances.

Enabling local governments and populations to manage natural resources provides a chance to develop more successful democracies and fair societies while also ensuring that intact ecosystems continue to deliver the environmental services on which people rely.The Global Summit on Sustainable Development in 2002 and the World Conservation Union's (IUCN) World Parks Congress in 2003 both emphasised these and other connections. The World Summit highlighted the critical role of biodiversity in environmental services, human health, economic prosperity, and human security. Poverty, weak governance, and political instability were identified as important limiting factors in accomplishing biodiversity protection. The World Parks Congress also underlined the need of addressing challenges such as inadequate governance, war, and poverty in order to conserve biodiversity. Such connections are vital in many USAID initiatives, because interconnections between conservation and development efforts are mutually beneficial.

USAID’s Strengths in Biodiversity Conservation

One of USAID's strengths is its ability to connect biodiversity with development. Although biodiversity is a global resource, it is also an important local resource, offering watershed protection, pollinator refuge, direct economic possibilities, and local cultural requirements. USAID excels in integrating conservation efforts with other sectors and development programmes such as economic growth, agriculture, natural resource management, population, health, and democracy and governance. These activities address numerous environmental and development concerns at the same time, making many biodiversity conservation programmes more sustainable. In Madagascar, the mission's activities in biodiversity conservation and sustainable management of environmental services are closely connected with the provision of improved health services such as clean drinking water and sanitation in protected area buffer zones.

The Agency's innovative collaborations with other conservation groups are vital to programme success. USAID initiatives are carried out in collaboration with a wide range of partners, including governments, non-governmental organisations (NGOs), and corporate groups. In this approach, Agency initiatives assist governments and local groups create in-country capacity, therefore contributing to both civil society building and conservation aims.

History of USAID Funding for Biodiversity Protection

For almost 30 years, USAID has financed biodiversity protection activities. The Agency's help for biodiversity conservation started in the 1970s, with missions devoting limited sums of money mostly towards natural forest protection. USAID collaborated with the Department of State to assist the United States Strategy Conference on Tropical Deforestation in 1978. In 1981, the Agency supported the United States Strategic Conference on Biological Diversity. 3 Immediately after the second meeting, USAID's Office of Science and Technology's Environment Division was reorganised as the Office of Forestry, Environment, and Natural Resources inside the newly formed Science and Technology Bureau. From 1982 and 1985, the new office collaborated with the U.S. Department of Interior to establish a federal interagency working group on biodiversity protection. The biodiversity conference and working group activities led in greater attention to biodiversity conservation concerns among US federal agencies, non-governmental organisations (NGOs), and Congress. Sections 118 and 119 of the Foreign Aid Act were enacted in 1986, and the first Biodiversity Conservation direction of $1 million was included in the FY 1986 Appropriations Act. At the conclusion of fiscal year 1986, the first Tropical Forestry and Biodiversity Report to Congress was submitted.

Throughout the 1970s and early 1980s, most biodiversity conservation operations were carried out as parts of bigger projects or as minor conservation grants. Programs centred on conservation in protected areas, while some programmes started assisting conservation in forest areas outside of protected areas as early as the 1980s. For example, in 1980, the Agency initiated a pilot project in Niger focusing on natural forest management, where a community-based natural forest management programme boosted vegetative regeneration without introducing alien species.

Through several programmes, including the Biodiversity Support Program, the Innovative Science Research, Technical Support project, and the Pacific Islands Marine Resources project, USAID began to provide biodiversity research grants that encouraged innovation and the development and testing of novel approaches in the late 1980s and 1990s. These research projects conducted analyses to discover the best successful conservation techniques and created a slew of ideas and tools for conservationists. As a result, the Agency's focus switched from fundamental research to more applied programming.

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CHAPTER 4

CURRENT AND FUTURE TRENDS IN USA ID'S BIODIVERSITY CONSERVATION PROGRAMS

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The present variety of biodiversity conservation projects is built on foundations and methodologies created in the 1990s. Programs are becoming more landscape-oriented, with an emphasis on ecoregional planning. They prioritise natural system conservation, believing that protecting threatened species is best accomplished by limiting the destruction of natural ecosystems. Conservation in coastal, marine, freshwater, and wetland environments is also becoming more prominent in programmes. Outside of forest settings, the Agency actively supports conservation activities in over 25 nations.Learning from the Biodiversity Programm and other conservation initiatives that emphasise a threat-based approach. This method emphasises the need of identifying important risks to conservation, prioritising these concerns, and developing efforts to mitigate them. The threats-based approach emphasises that human activities causes biodiversity loss and that risks are best addressed and minimised when all stakeholders collaborate to establish long-term solutions. Although the Integrated Environment and Development Plans were beginning to address the human component of conservation, many development and conservation aspects had already been implemented[1], [2].

Tendency towards combining conservation efforts across industries. Conservation, for example, is being linked to the population and health sectors. Many mission conservation activities are currently being sponsored within the Economic Growth and Democracy and Governance programmes. Given the Agency's conservation programmes' diverse cross-sector topics, such as community-based conservation, sustainable natural resource use, economic incentives for conservation, conservation finance, and policy development and reform, these cross-sector connections are becoming increasingly possible. Cross-sector collaboration enables the attainment of objectives in different sectors at the same time.Increasingly, USAID initiatives are tackling challenges in environmental governance that create incentives or eliminate obstacles for local people to maintain biodiversity and other natural resources. Several mission initiatives include decentralisation and devolution of natural resource management and biodiversity protection duties to local governments and people. Several of these initiatives also stress the need of equality in the sharing of conservation benefits[3], [4].

Moreover, USAID biodiversity conservation programmes encourage methods that stress institutional improvement of national and local governments and non-governmental organisations (NGOs), improved stakeholder engagement, local participation, and openness in programme execution. This emphasis has sparked an increased interest in collaborating with indigenous groups as well as multinational enterprises with logging and mining concessions in high biodiversity regions.Apart from the trends mentioned above, USAID is committed to additional long-term support for programmes. Several of the programmes discussed in this study have been supported for as long as 10 years, which was unusual in the 1980s.

The Agency encourages self-sustaining finance solutions that involve and go beyond private sector investment in ecotourism. For example, programmes are increasingly seeking solutions through new forms of private-sector involvement (as illustrated on page 15 with the Global Development Alliances), the creation of conservation concessions, and payment for ecosystem services such as carbon sequestration and water quality and quantity. Endowments are increasingly being financed with monies created via debt-for-nature swaps. USAID is also looking at funding assistance for ex-situ conservation, especially where it complements in-situ conservation efforts and when measurement is involved[5], [6].

USAID in National and International Environmental Fora and Policy Reform

A policy environment that encourages conservation while discouraging unsustainable or damaging actions is required for effective natural resource management. Although most of USAID's biodiversity conservation work is done at the site level, the Agency also supports policy debates within host nations, across countries, and at the international level.USAID promotes site-based biodiversity conservation via institutional and policy transformation at the national level. Policy reforms in partner countries have included the establishment and strengthening of parks and wildlife conservation departments, the establishment of national protected area systems, the establishment of protected area management structures, and the development of national environmental action plans. The Agency has also aided host nations in developing, implementing, and publicising policies that encourage biodiversity protection on private properties. In several partner nations, USAID has promoted the decentralisation and devolution of natural resource management rights and duties to local communities.

This report's programme descriptions give concrete examples of national policy improvements. In Namibia, for example, USAID assisted community groups in gaining legal recognition and rights to natural resources. This has enhanced local responsibility and ownership of natural resources, including animals, providing incentives to manage them sustainably. In Paraguay, the mission promotes decentralisation of natural resource management to local towns and strives to build local institutions so that forests and protected areas may be managed successfully. USAID assisted the Dominican Republic's Secretariat of Environment and Natural Resources in drafting a biodiversity legislation for submission to the Dominican Legislature. In the Philippines, the Agency assisted the national government in negotiating TFCA agreements with the US, encouraging conservation initiatives while reducing foreign debt.As a consequence of policy measures supporting decentralisation, L. Lartigue Community Forestry Agents in Guinea are empowered to manage local natural resources[7]–[9].

In addition to assisting host countries with policy reform, the Agency participates in international fora, treaties, and conventions pertaining to biodiversity conservation, such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the Convention to Combat Desertification, the United Nations Framework Convention on Climate Change, the Ramsar Convention on Wetlands, and the Convention on Biological Diversity (see Box 1). The Agency assists nations in meeting their duties under international environmental treaties to which they are party via its programmes and operations. At the same time, USAID offers scientific, policy, and technical support fora, as well as inter-agency conversations that shape US views in international negotiations. USAID assists U.S. government agencies in understanding the ramifications of the United States' stance in the developing countries.

The Agency is a member of national and international working groups that provide information to national and international conventions, as well as conservation-related procedures. For example, the Agency is an active participant in the International Coral Reef Initiative, a collaboration of states, international organisations, and non-governmental organisations aimed at reducing the destruction of coral reef ecosystems. USAID advocates coral reef-related policy in international fora as a member of the initiative's Coordination and Planning Committee. The Agency and the United States State Department co-chair the International Working Group and oversee the United States Coral Reef Task Force.

International Treaties

The United States is a signatory to a number of international environmental treaties. With its purpose and centrally financed programmes and operations, USAID promotes the aims of international and national environmental accords.

Among the specific agreements are:

The UN Convention to Combat Desertification (CCD) is an international treaty that tackles land degradation issues in the world's arid, semi-arid, and dry sub-humid forests and savannahs. To combat land degradation, the Convention advocates for a bottom-up participatory approach. Several of USAID's community-based natural resource management projects directly complement the aims and objectives of the Convention. The United States ratified the Convention in 2000. Additional information may be found at http://www.unccd.int.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an international agreement between states to guarantee that international commerce does not harm the existence of wild animals and plants. The Convention has been in effect for over three decades. Currently, the Agreement protects over 30,000 species of flora and wildlife, with about 1,000 recognised as having the highest level of protection. The United States ratified the Convention in 1974.

The United Nations Framework Convention on Climate Change (UNFCCC) serves as the focal point for worldwide efforts to counteract global warming. Established in 1992 at the Rio Summit, the Agreement seeks to stabilise greenhouse gas concentrations in the atmosphere at a level that would preclude hazardous human influence with the climate system.The Ramsar Convention on Wetlands (Ramsar) is an intergovernmental convention signed at Ramsar, Iran, in 1971 that offers a framework for national action and international cooperation for the protection and judicious use of wetlands and their resources. The United States is one of the Convention's 138 signatories.

The United Nations Convention on Biological Diversity (CBD) was established during the United Nations Conference on Environment and Development in 1992. The three basic purposes of the Convention are: the protection of biodiversity, sustainable use of the components of biodiversity, and sharing the benefits emerging from the commercial and other use of genetic resources in a fair and equitable manner. The Convention is legally binding, and nations who sign up must follow its rules, such as reporting on what has been done to implement the agreement and the efficacy of these actions. The United States signed the deal in 1993 but has yet to ratify it.It has been approved by almost all USAID-assisted nations. USAID strives to assist nations in carrying out their National Action Plans.

The activities of USAID support the Executive Order's international charge to assess the United States' role in the international trade of coral reef species, develop strategies for mitigating the negative impacts of trade, develop and implement activities for the protection and sustainable use of coral reef resources worldwide, and implement the International Coral

Reef Initiative's Framework for Action through expanded collaboration with the initiative's partners. Moreover, the Task Force's International Working Group provides opportunity to coordinate US government policies and activities that support coral reef conservation and best management practises.

USAID is a member of the National Invasive Species Council, an inter-departmental council of eleven federal agencies that provides national leadership on invasive species and aids in the coordination and implementation of complementary and effective federal efforts to combat the spread of invasive species.

Many USAID missions are involved in invasive species identification, removal, and mitigation efforts. USAID funded efforts to assist governments in managing invasive species via a series of country studies and coordination conferences in Africa, South and Southeast Asia, and the Pacific.The Agency funds initiatives and programmes that help raise awareness of certain biodiversity issues in international forums. For example, in FY 2003, USAID funding for the Lake Basin Management Project and LakeNet helped to promote awareness of the significance of lakes, their freshwater resources, and biodiversity at the World Water Conference. 8 In addition, in FY 2003, USAID financed the attendance of developing-country representatives to the 5th IUCN World Parks Conference on Protected Areas, which was held in Durban, South Africa. The IUCN Congress, held every 10 years, analyses the condition of protected areas and sets the agenda for the following decade. The 2003 Congress, headlined "Benefits Beyond Borders," addressed gaps in protected area systems by identifying under-represented ecosystems, developing instruments to increase management effectiveness, pursuing alternative legal arrangements, supporting sustainable conservation funding, and forming collaborations. The statement to the Convention on Biological Diversity, which included suggestions for future steps to meet the Convention's goals, was a major contribution of the 2003 Congress. A considerable percentage of the Congress' proposals and calls to action included indigenous peoples, community-conserved regions, local governance challenges, conservation funding, poverty concerns, and the spiritual and cultural aspects of protected areas.

Partnerships for Conservation: the Global Development Alliance

The private sector is becoming an increasingly significant component of resource transfers to developing countries. In the 1970s, the United States provided 30% of its resources to the undeveloped world through private sources, while 70% came from government development aid. Now, 80 percent of resource transfers from the United States to the developing world are private, with the remaining 20 percent being public. The Global Development Alliance (GDA) is a system that aims to increase the effect of foreign aid by combining public and private sector resources and NGOs via public-private partnerships.There are significant potential for conservationists, industry, and local governments to collaborate on future development that benefits all stakeholders and the environment. On biodiversity challenges, USAID has been able to communicate effectively with industrial and agricultural partners. The Agency financed more than 15 biodiversity-related collaborations in fiscal year 2003. USAID contributed roughly $22.3 million to these collaborations. Non-USAID partners, such as private companies, contributed more than $100 million to some of these relationships. Examples from the Asia and Near East Bureau, Bulgaria, Brazil, the Central American Regional programme, Guinea, Madagascar, Malawi, Nepal, and Tanzania are also included in the descriptions of their particular regions in this study.

The Illegal Logging Coalition in Indonesia fights illicit logging and supports sustainable forest harvesting. This partnership was developed by USAID's Indonesia mission, the Asia and Near East Bureau, and shops such as The Home Depot, IKEA, and Carrefour in collaboration with the Indonesian government and local and international NGOs.The alliance, coordinated by The Nature Conservancy and World Wildlife Fund-Indonesia, aims to increase the supply of Indonesian wood products from well-managed forests, demonstrate practical ways to distinguish between legal and illegal wood supplies, strengthen market signals to combat illegal logging, and restrict access to financing and investments for companies engaged in destructive or illegal logging. The coalition has gained agreements from the Indonesian government, concessionaires, and pulp and paper firms to cease logging in high biodiversity regions. Notable locations include Sumatra's Tesso Nilo, which has the greatest amount of plant biodiversity in the world, and East Kalimantan, which is home to the region's last viable population of orangutans. Corporate partners and the conservation community have more than quadrupled USAID's commitment to the alliance (over the course of the project).

The Atlantic Forest Alliance works in Brazil to conserve and restore biodiversity in the Brazilian Atlantic forest area. USAID has collaborated with the Instituto BioAtlantica, a collaboration of Conservation International, Aracruz Cellulose, DuPont Brasil, Petrobras, and Veracel, to support conservation measures implemented by private companies on significant land holdings. Plant nurseries are being established, native tree species are being reforested, and formal protected areas are being linked with forest reserves on private property. Moreover, the partnership will create and test a protected area system for privately owned lands, with the goal of safeguarding and restoring 80,000 or more hectares of private property in the Central Atlantic Forest corridor. The collaboration will guarantee that important ecosystem services are supplied to local people and landowners in the future. During the course of the project, the Brazilian pulp and paper sector will contribute five times the Agency's contributions to the alliance.

The Conservation in the Congo Basin initiative in Central Africa aims to promote community-based conservation that is suited to the particular ecological and socio-political features of Congo Basin forest dependent populations. The Jane Goodall Institute has teamed with USAID to bring together Congo Basin African governments, local communities, bilateral and multilateral funding agencies, the commercial sector, foreign foundations, and other conservation Organizations. Beginning with the Democratic Republic of the Congo, the programme will identify pilot locations in Central Africa with exceptional primate habitat and develop community-based conservation campaigns to enhance health, education, economic growth, improved natural resource management, and wildlife conservation. The initiative has received funding from USAID's Bureau for Global Health and the's Global Alliance. Further funds are being sought from the commercial sector, conservation Organisations, and other foundations.

Africa has the world's highest concentration of big animals, the world's second largest tropical rainforest, and key desert, wetlands, and coral reef habitats. These various environments sustain a broad range of flora and wildlife, including over 50,000 plant species, 1,000 animal species, and 1,500 bird species. The richness and variety of ecosystems is critical to the lives of rural Africans, an estimated 70% of whom rely on natural resources.In recognition of the critical significance of natural assets and biological diversity in Africa, USAID funded biodiversity conservation programmes in more than 25 countries throughout the continent in FY 2003, totaling more than $42 million.

The Congo Basin Forest Partnership (CBFP), a collaboration of 29 governmental and international organisations announced by Secretary of State Colin Powell at the Sustainable Development Summit, which took place in Johannesburg, South Africa in 2002, resulted in an impressive increase in funding for the region in FY 2003.USAID committed $15 million to the cooperation via its Central African Regional Environment Program (CARPE). The program's operations seek to enhance the management of the region's forests and protected areas, as well as to establish sustainable livelihoods for the Basin's 60 million residents. Moreover, with USAID assistance, some nations in the area, most notably Namibia and Madagascar, introduced innovative community-based initiatives to enhance natural resource management and protect biodiversity.

Patterns of Biodiversity
Latitudinal gradients:

Plant and animal variety is not homogeneous across the earth, but rather has an uneven distribution. There are intriguing patterns in diversity for many groups of animals or plants, the most well-known being the latitudinal gradient in richness. In general, as we travel farther from the equator and towards the poles, species diversity declines.The tropics (latitudinal range of 23.5° N to 23.5° S) have more species than temperate or polar environments, with very few exceptions. Colombia has approximately 1,400 bird species near the equator, whereas New York has 105 species at 41° N and Greenland has just 56 species at 71° N. India, having majority of its land area in the tropical latitudes, boasts more than 1,200 species of birds. A tropical forest like Equador contains up to ten times the number of vascular plant species as a temperate forest like the Midwest of the United States. The mostly tropical Amazonian rain forest in South America boasts the largest biodiversity on the planet, with over 40,000 plant species, 3,000 fish species, 1,300 bird species, 427 mammals, 427 amphibians, 378 reptiles, and over 1,25,000 invertebrates. Experts believe that there are at least two million bug species waiting to be identified and described in these rain forests.

What is it about the tropics that accounts for their increased biological diversity? Various hypotheses have been proposed by ecologists and evolutionary biologists, some of which are as follows: (a) Speciation is generally a function of time; unlike temperate regions that have been subjected to frequent glaciations in the past, tropical latitudes have remained relatively undisturbed for millions of years and thus have had a long evolutionary time for species diversification; and (b) Tropical environments, unlike temperate ones, are less seasonal, relatively more constant and predictable. Such consistent settings foster niche specialisation and increase species variety; and (c) More solar energy is accessible in the tropics, which adds to increased production; this, in turn, could contribute indirectly to greater diversity.

Species-Area relationships

Alexander von Humboldt, the great German naturalist and geographer, observed that within a region, species richness increased with increasing explored area, but only up to a point. Indeed, the relationship between species richness and area for a wide range of taxa (angiosperm plants, birds, bats, and freshwater fishes) is a rectangular hyperbola. The relationship is a straight line on a logarithmic scale, as described by the equation $\log S = \log C + Z \log A$, where S denotes species richness.

Where;

A= Area

Z = line slope (regression coefficient)

C is the Y-intercept

Ecologists have unearthed that the value of Z is in the range of 0.1 to 0.2, regardless of taxonomic group or region (the slopes of the regression line are remarkably similar for plants in Britain, birds in California, and mollusks in New York state.

Loss of Biodiversity

Our planet's biological riches is fast dwindling, and the accusing finger plainly points to human activity. Human colonisation of the tropical Pacific Islands is thought to have resulted in the loss of over 2,000 species of native birds. The IUCN Red List (2004) records the extinction of 784 species in the previous 500 years (containing 338 vertebrates, 359 invertebrates, and 87 plants). Recent extinctions include the dodo (Mauritius), quagga (Africa), thylacine (Australia), Steller's Sea Cow (Russia), and three tiger subspecies (Bali, Javan, and Caspian). In the previous two decades alone, 27 species have been extinct. According to BIOLOGY, extinctions among taxa are not random; certain groups, such as amphibians, seem to be more sensitive to extinction. The fact that more than 15,500 species are threatened with extinction adds to the bleak picture of extinction. At the moment, 12% of all bird species, 23% of all mammal species, 32% of all amphibian species, and 31% of all gymnosperm species are threatened with extinction.

An examination of the history of life on Earth via fossil records reveals that large-scale extinctions such as the one we are presently seeing occurred earlier, even before people emerged on the scene. There have been five events of mass extinction of species during the lengthy time (> 3 billion years) from the creation and diversity of life on Earth. What distinguishes the current 'Sixth Extinction' from earlier episodes? The difference is in the rates; contemporary species extinction rates are projected to be 100 to 1,000 times quicker than pre-human eras, and our actions are to blame. Ecologists warn that if current trends continue, almost half of all species will be extinct over the next 100 years.In general, a region's loss of biodiversity may result in (a) decreased plant output, (b) less tolerance to environmental perturbations such as drought, and (c) greater variability in some ecosystem processes such as crop production, water usage, and pest and disease cycles.

Causes of biodiversity losses

Habitat loss and fragmentation

This is the most significant cause of animal and plant extinction. Tropical rain forests are the most severe instances of habitat loss. These rain forests, which once covered more than 14% of the earth's land area, today cover less than 6%. They are being demolished at a rapid pace. The Amazon rain forest (known as the "lungs of the earth"), which is home to millions of species, is being chopped and cleared for soya bean cultivation or converted to grasslands for beef cattle ranching. Apart from complete loss, pollution's deterioration of many ecosystems endangers the existence of numerous species. When huge ecosystems are fragmented into tiny pieces as a result of numerous human activities, mammals and birds that need wide territories, as well as some species with migratory tendencies, suffer, resulting in population decreases. (ii) Excessive exploitation.

Alien species invasions: When alien species are introduced, whether accidentally or on purpose, some of them become invasive and cause the decrease or extinction of indigenous species. The introduction of Nile perch into Lake Victoria in east Africa finally led to the demise of an ecologically unique assemblage of over 200 species of cichlid fish in the lake. You must be aware of the environmental harm and danger that exotic weed species such as carrot grass (Parthenium), Lantana, and water hyacinth represent to our native species

(Eicchornia). The recent illegal import of the African catfish Carcass characteristics for aquaculture reasons presents a danger to our rivers' indigenous catfishes.

Co-extinctions: When a species falls extinct, the plant and animal species that are obligately connected with it also go extinct. As a host types of fish becomes extinct, so does its unique array of parasites. Another example is a coevolved plant-pollinator symbiotic association in which the extinction of one always results in the extinction of the other.

Conserve Biodiversity

There are several reasons for this, some apparent, others not so obvious, but all equally significant. They may be classified as narrowly utilitarian, generally utilitarian, or ethical. The narrow utilitarian arguments for biodiversity conservation are self-evident; humans derive numerous direct economic benefits from naturefood (cereals, pulses, fruits), firewood, fibre, construction material, industrial products (tannins, lubricants, dyes, resins, perfumes), and medicinal products. More than 25% of the pharmaceuticals now on the market are derived from plants, and 25,000 plant species contribute to the traditional medicines utilised by indigenous peoples across the globe. Nobody knows how many more medicinally valuable plants exist in tropical rain forests that have yet to be discovered.

Nations endowed with high biodiversity might expect to gain huge advantages from increased investment in 'bioprospecting' (exploring molecular, genetic, and species-level variety for products of commercial relevance). According to the generally utilitarian argument, biodiversity plays a significant role in many of the ecological services that nature delivers.The Amazon jungle is believed to create 20% of the total oxygen in the earth's atmosphere via photosynthesis.In situ conservation- Faced with the struggle between development and conservation, many countries believe that conserving all of their biological riches is idealistic and economically unfeasible. The number of species waiting to be rescued from extinction always greatly outnumbers the conservation resources available. Eminent environmentalists have tackled this issue on a worldwide scale. They highlighted for utmost conservation specific 'biodiversity hotspots' locations with very high levels of species richness and endemism (species unique to that region and not found anywhere else). Originally 25 biodiversity hotspots were found but later nine more have been added to the list, bringing the total number of biodiversity hotspots in the globe to 34.

These hotspots are also areas of rapid habitat loss. Three of these hotspots, the Western Ghats and Sri Lanka, Indo-Burma, and Himalaya cover our country's high biodiversity areas.While all of the biodiversity hotspots together comprise less than 2% of the earth's surface area, the number of species they collectively harbour is quite large, and stringent conservation of these hotspots might cut ongoing mass extinctions by over 30%.Ecologically distinct and biodiversity-rich areas in India are constitutionally protected as biosphere reserves, national parks, and sanctuaries. There are presently 14 biosphere reserves, 90 national parks, and 448 wildlife sanctuaries in India. India has a long history of religious and cultural traditions emphasising environmental conservation. Several civilizations set aside areas of forest, and all the trees and creatures inside were revered and protected. Similar holy groves may be found in Meghalaya's Khasi and Jaintia Hills, Rajasthan's Aravalli Hills, Karnataka and Maharashtra's Western Ghat regions, and Madhya Pradesh's Sarguja, Chanda, and Bastar districts. The holy groves of Meghalaya are the final refuges for a huge number of rare and vulnerable flora.

Conservation in situ- Endangered animals and plants are removed from their native habitats and put in specific settings where they may be preserved and cared for. This function is served by zoological parks, botanical gardens, and animal safari parks. Several creatures have gone extinct in the wild but are nonetheless kept alive in zoological parks. Ex situ conservation has gone beyond the confinement of vulnerable species in cages in recent years. Cryopreservation techniques may now keep imperilled species' gametes viable and fertile for extended periods of time, eggs can be fertilised in vitro, and plants can be reproduced utilising tissue culture procedures. Seed banks can store seeds from many genetic strains of economically relevant plants for extended periods of time.

Biodiversity has no political bounds, hence its protection is the duty of all countries. The landmark Convention on Biological Diversity ('The Earth Summit') in Rio de Janeiro in 1992 urged all governments to adopt suitable actions for biodiversity protection and sustainable use of its benefits. Following this, at the World Summit on Sustainable Development in 2002 in Johannesburg, South Africa, 190 nations promised to achieve a substantial decrease in the present pace of biodiversity loss at the global, regional, and local levels by 2010.

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CHAPTER 5

THE NATURAL LONGEVITY OF SPECIES

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Species of higher creatures, such as ammonites or fishes, show remarkable stable lifespan. As a consequence, the likelihood that a particular species will go extinct in a given amount of time after splitting apart from other species may be approached as a constant, and the frequency of species remaining can be approximated as a constant.Species of higher creatures, such as ammonites or fishes, show remarkable stable lifespan. As a result, the probability that a given species will become extinct after splitting off from other species can be approximated as a constant, so that the frequency of species surviving through time falls off as an exponential decay function; in other words, the percentage (but not the absolute number) of species going extinct in each period of time remains constant. These regularities, such as they are, have been disrupted throughout the last 250 million years by catastrophic extinction events that have lately occurred. It is expected that this will happen every 26 million years (Raup and Sepkoski, 1984)[1], [2].

Due of the relative abundance of fossils in shallow marine sediments, the lifetime of fish and invertebrate species may frequently be established with a reasonable degree of certainty. Throughout the Paleozoic and Mesozoic eras, most organisms lived for 1 to 10 million years on average: 6 million for echinoderms, 1.9 million for graptolites, 1.2 to 2 million for ammonites, and so on (Raup, 1981, 1984).These estimations are highly intriguing and informative, but as palaeontologists have been cautious to point out, they have some significant limits. For starters, terrestrial creatures are significantly less well known, there have been few estimations, and hence alternative survival patterns may have happened (although Cenozoic flowering plants seem to fall within the 1- to 10-million-year range). Most significantly, many creatures on islands and other confined environments, such as lakes, streams, and mountain peaks, are so uncommon or local that they might come and go in a short period of time without leaving any remains. Another significant challenge is the occurrence of sibling species, which are reproductively separated populations that are so similar to closely related species that they are difficult or impossible to differentiate using standard anatomical features. In fossil form, such things were seldom identified. All of these factors imply that estimations of the lifetime of species should be used with extreme care to groups with a limited fossil record[3], [4].

Rain Forests as Centres of Diversity

In recent years, evolutionary biologists and environmentalists have devoted considerable attention to tropical rain forests for two primary reasons. Second, although occupying just 7% of the Earth's geographical area, these habitats are home to more than half of the world's biota. Second, the woodlands are being destroyed at such a rapid rate that they will mostly disappear during the next century, wiping off a billion of species. Numerous species-rich biomes are under danger, most notably tropical coral reefs, geologically ancient lakes, and coastal wetlands. Each deserves special attention in its own right, but for the time being, the habitats serve as a paradigm for the larger global challenge. Closed tropical forests, also known as tropical rain forests, have a relatively compact overhead of mostly broad-leaved evergreen trees.

Annual rainfall of 100 cm or more is required to support the ecosystem. In the top canopy, there are usually two or more levels of trees and bushes. Since very little sunlight reaches the forest floor, the vegetation is thin and human people may easily stroll through it.Rain forests have a legendary level of species variety. Every tropical scientist has a favourite case study. I recently retrieved 43 species of ants belonging to 26 genera from a single leguminous tree in Peru's Tambopata Reserve, about equivalent to the whole ant biodiversity of the British Isles (Wilson, 1987). Peter Ashton discovered 700 tree species in 10 chosen 1-hectare plots in Borneo, the same number as in all of North America (Ashton, Arnold Arboretum, personal communication, 1987). It is not uncommon for a single kilometre of forest in Central or South America to include hundreds of bird species and thousands of butterfly, beetle, and other insect species[5], [6].

Tropical rain forests, despite their incredible riches, are among the most vulnerable of all environments. They thrive in so-called wet deserts, which have an unappealing soil foundation washed away by strong storms. Tropical red and yellow earths, which are often acidic and deficient in nutrients, cover two-thirds of the forest surface. High quantities of iron and aluminium generate insoluble compounds with phosphorus, reducing phosphorus availability to plants. Calcium and potassium are quickly leached from the soil once their compounds are dissolved by rain. Hardly 0.1% of nutrients filter deeper than 5 cm into the soil surface (NRC, 1982). Forsyth and Miyata provide an outstanding public explanation of rain forest ecology (1984).

Despite the 150 million years since its formation, the mostly dicotyledonous flora has developed to become dense and towering. At any one moment, the majority of nonatmospheric carbon and critical nutrients are locked up in plant tissue. As a result, the litter and humus on the ground is sparse in comparison to the dense mats seen in northern temperate woods. Patches of bare dirt may be seen here and there. There is evidence of fast disintegration by dense colonies of termites and fungus at every turn. When a forest is chopped and burnt, the ash and decaying plants produce enough nutrients to sustain fresh herbaceous and shrubby growth for two or three years. Then these materials degrade to levels lower than those required to ensure healthy agricultural crop development without the use of artificial supplements[7], [8].

The fragility of the seeds of the component woody species also limits rain forest renewal. Most species' seeds germinate within a few days or weeks, severely restricting their capacity to spread over the stripped terrain into optimal growth places. As a consequence, most grow and die in the clearings' hot, infertile soil (Gomez-Pompa et al., 1972). Monitoring of logged areas suggests that recovery of a mature forest might take decades. To provide an anecdotal example, the forest at Angkor dates back to the fall of the Khmer city in 1431, yet it is still structurally distinct from a climax forest today, 556 years later. In truth, the process of rain forest regeneration is so long in general that few extrapolations have been achieved; restoration may never occur spontaneously in certain areas with the highest combined damage and sterility.

Around 40% of the ground that may sustain tropical closed forest is currently devoid of it, owing mostly to human intervention. According to estimates from the Food and Agriculture Organization and the United Nations Environment Programme, by the late 1970s, 7.6 million hectares, or about 1% of total cover, had been permanently cleared or converted to the shifting-cultivation cycle. The total annual area is 76,000 square kilometres (27,000 square miles), which is larger than the state of West Virginia or the whole nation of Costa Rica. In essence, the vast majority of this land is being permanently removed, that is, reduced to a condition where natural regeneration will be very difficult, if not impossible. This estimate of forest cover loss is similar to that proposed by tropical biologist Norman Rawlings in the mid-1970s, which was often criticised by scientists and environmentalists as overstated and alarming. The confirmation of this early prediction should serve as a warning to always take such apocalyptic scenarios seriously, even if they are based on insufficient data[9], [10].

A straight-line extrapolation from the first of these numbers, with equally absolute yearly increments of forest-cover reduction, yields 2135 A.D. as the year when all remaining rain forest will be either clear-cut or severely disturbed, with the former being more likely. This coincides with the World Bank's prediction that the human population would peak at 11 billion people in 2150. (The World Bank, 1984). Moreover, the ongoing increase in human population suggests that a straight line estimate is much too cautious. Population pressures in the Third World will almost definitely continue to increase deforestation in the next decades unless heroic conservation and resource management measures are implemented.Another reason to conclude that the numbers for forest cover reduction provide an overly optimistic image of the danger to biological diversity. Deforestation has been quicker in several local regions with high levels of endemicity than in the general average.

Madagascar, home to some of the world's most unique flora and animals, has already lost 93% of its forest cover. The Atlantic coastal forest of Brazil, which enthralled Darwin as a young man upon his arrival in 1832 ("wonder, surprise, and profound devotion, fill and elevate the intellect"), is now 99% gone. The woods of many of Polynesia's and the Caribbean's smaller islands are in far worse shape, if not completely vanished.Around 40% of the area capable of supporting tropical closed forest is now devoid of it mostly as a result of human activity. According to estimations from the, by the late 1970s, 7.6 from the Food and Agriculture Organization and the United Nations Environment Programme Millions of hectares, or approximately 1% of total land cover, are permanently removed or transformed into the cycle of changing cultivation. The total area is 76,000 square kilometres. (27,000 square miles) each year, which is larger than the whole state of West Virginia or the entire nation.

Costa Rican. In fact, the majority of this area is being permanently removed, that is, converted to a barren wasteland situation in which natural replanting will be very difficult, if not impossible Melilo and colleagues (1985). This estimate of forest cover reduction is similar to that given by the tropical scientist Norman Myers in the mid-1970s, an opinion that was widely accepted at the time Scientists and environmentalists have criticised the report as excessive and alarming the acquittal. This early perspective should serve as a warning to constantly consider such apocalypse possibilities. Even if they are based on inadequate information, they should be taken seriously.

A straight-line extrapolation from the first of these numbers, with the same absolute values.

Annual increments of forest-cover reduction result in the year 2135 A.D. as the year when all the remaining rain forest will be either clear-cut or severely disturbed, with the former being more likely. By chance, this is close to the date (2150) on which the World Bank estimates the human population. The population will reach 11 billion individuals (The World Bank, 1984). Indeed, the continual growth in human population suggests that a straight line estimate is much too conservative. Population pressures in the Third World will undoubtedly continue to intensify deforestation in the following decades unless dramatic conservation efforts are performed as well as resource management.

Another reason to suspect that the numbers for forest cover reduction are too high more upbeat view of the danger to biological variety. Several communities have high levels of Because of endemicity, deforestation has been quicker than the global average. Madagascar, home to some of the world's most diverse floras and faunas, has Already, 93% of its forest cover has been destroyed. Brazil's Atlantic coastal forest, which is so captivated Darwin as a young man upon his arrival in 1832 ("wonder, surprise, and magnificent") the dedication, filling and elevating the mind"), is 99% gone. In far worse shape in fact, several of Polynesia's smaller islands and their forests have been mostly destroyed Caribbean.

Optical Forests and Their Species

There is compelling evidence that we are in the early stages of an extinction crisis. That is, we are seeing a mass extinction event, defined as a rapid and significant drop in the number and variety of ecologically distinct groups of animals over the planet. Extinction has, of course, been an aspect of existence since the origin of animals about 4 billion years ago. Just a few millions of all species that have ever lived, potentially half a billion or more, survive. Yet, the natural background rate of extinction during the last 600 million years, the era of significant life, has been on the order of one species every year or so. Today's rate is very certainly hundreds, if not thousands, of times greater (Ehrlich and Ehrlich, 1981; Myers, 1986; Raven, 1987; Soulé, 1986; Western and Pearl, in press; Wilson, 1987). Moreover, although previous extinctions were caused by natural processes, Human sapiens is now the almost exclusive cause, eradicating whole ecosystems and entire populations of species in record time. Everything happens in the blink of an evolutionary eye. While these forests comprise just 7% of the Earth's land area, it is believed that they contain at least 50% of all species (perhaps a significantly greater amount. Nevertheless, they are depleting faster than any other natural zone.

Tropical Forests

There is also widespread agreement that between 76,000 and 92,000 square kilometres are lost each year, with at least another 100,000 square kilometres severely affected. These deforestation rates are based on data from the late 1970s; the rates have risen somewhat since then. This translates to around 1% of the biome becoming deforested each year and more than another 1% being substantially damaged. Remote-sensing surveys, which are totally objective and methodical in nature, are the primary source of information. By 1980, there had remote-sensing data covering around 65% of the biome, which has since increased to 82%. In all nations where remote-sensing data has just recently been accessible notably, Indonesia, Burma, India, Nigeria, Gabon, Guatemala, Honduras, and Peru we find that deforestation is worse than government agencies had previously estimated.

Tropical deforestation is far from a linear process. Some locations are being hit harder than others, and some will fare better than others. Except for two large remnant blocs in the Zaire basin and the southern half of Brazilian Amazonia, plus two much smaller blocs in Papua New Guinea and the Guyana Shield of northern South America, there may be little left of the biome in primary status with a full complement of species by the end of the century or shortly thereafter. These relict biome sectors may survive for many decades more, but they are unlikely to survive past the middle of the next century, owing to the massive increase in the number of small-scale growers. Fast population expansion in small-scale cultivator communities happens mostly via immigration rather than natural increase, i.e., the phenomenon of the shifted cultivator. Consider the situation of Rondonia, a state in the southern section of Brazil's Amazonia, as an example of what ultrarapid development rates may already impose on tropical forests. Between 1975 and 1986, the population increased from 111,000 to well over 1 million, a 10-fold rise in less than ten years. Around 1,250 square kilometres of woodland were removed in 1975. This area had increased to more than 10,000 square kilometres by 1982, and to over 17,000 square kilometres by late 1985.

This widespread clearance and degradation of forest ecosystems is by far the leading cause of extinction of species. Sadly, we have no method of knowing the true present rate of extinction, and we can only make educated guesses. Yet, we may make significant judgements by looking at species counts before to deforestation and then employing island biogeography analytic approaches. Let us quickly analyse three specific regions to acquire an understanding of the extent and magnitude of current extinctions: the wooded expanses of western Ecuador, Atlantic-coast Brazil, and Madagascar. Each of these places has, or has had, very high densities of species with high degrees of endemism. Western Ecuador is said to have formerly had between 8,000 and 10,000 plant species, with an endemism rate of 40 to 60%. (Gentry, 1986). We may confidently assume, based on extensive inventories in sample plots, that there are at least 10 to 30 species of animal for every one plant species.

Biofuels production

Organic wastes may be biochemically transformed into biofuels like biogas and ethanol, which can be used for heating or as fuel to combustion engines and cogenerators that generate power and heat. Biogas, a byproduct of anaerobic organic matter decomposition, has been proposed as an alternative energy source. Anaerobic breakdown occurs when there is no oxygen present. The biogas is mostly composed of methane (about 65 percent), carbon dioxide (30 percent), and trace quantities of ammonia, hydrogen sulphide, and other gases. The energy in biogas is mostly derived from methane (CH_4), which has a calorific value of 1,012 BTU/ft3 (or 9,005 kcal/m3) at 15.5 °C and 1 atmosphere pressure, or 211 kcal/g molecular weight, which is comparable to 13 kcal/g. The estimated specific heat of biogas is 500-700 BTU/ft3 (4,450-6,230 kcal/m3).The biogas generated by small-scale biogas digesters (1-5 m3) located at individual residences or agricultural areas is mostly utilised for family cooking, heating, and lighting. Biogas generated by anaerobic sludge digestion is widely utilised as fuel for boilers and internal combustion engines in big wastewater treatment facilities. Hot water from heating boilers may be utilised to heat digesters and/or buildings. The biogas-fueled combustion engines may be utilised for wastewater pumping as well as other purposes at the treatment facilities or nearby.

While dirty, the slurry or effluent from methane digesters is rich in nutrients and a great fertiliser. The usual procedure is to dry the slurry before spreading it over land. While little research has been done, it can be utilised as fertiliser in fish ponds. The processing and reuse of slurry in biogas digesters poses possible health risks. Before to reuse, it needs be further processed, such as by lengthy drying or composting. Ethanol (C_2H_5OH) may be made from three kinds of organic materials: sugarcane and molasses (which include sugar); cassava, maize, and potato (which provide carbs); and wood or agricultural leftovers (containing cellulose). Except for those that include sugar, these organic components must first be transformed into sugar, then yeast fermented into ethanol, and then distilled to separate water and other fermented products from ethanol. Ethanol has a calorific value of 7.13 kcal/g or 29.26 kJoule/g.

Aqua cultural reuses

The generation of micro-algae (single-cell protein), aquatic macrophytes, and fish are the three primary forms of aquaculture reuses of organic wastes in hot regions. Normally, wastewater is used in high-rate photosynthetic ponds for microalgal production. While the algal cells generated during wastewater treatment contain around 50% protein, their tiny size, often less than 10 m, has created significant challenges for the present harvesting procedures, which are currently not commercially feasible. Aquatic macrophytes such as duckweed, water lettuce, and water hyacinth thrive in contaminated waterways and may be harvested for use as animal feed additions or compost fertiliser.

Organic wastes may be reused in fish culture in three ways: by fertilising fish ponds with human or animal manure, growing fish in effluent-fertilized fish ponds, or rearing fish directly in waste stabilisation ponds. Fish farming is seen to offer significant promise for poor nations since it is easy to harvest and has a high market value. To protect public health in nations where fish are bred on trash, it is critical to maintain high cleanliness at all stages of fish handling and processing, and to guarantee that fish is ingested only after it has been thoroughly cooked.

Chitin and chitosan are non-toxic, biodegradable polymers with similar chemical structures and molecular weights. They are a nitrogenous polysaccharide extracted from the shells of crustaceans such as shrimp and crabs. Chitin is an insoluble in water linear chain of acetyl glucosamine groups. Chitosin is made by removing the acetyl group (CH_3-CO) from chitin molecules (a process known as deacetylation). Chitosan is cationic, soluble in most diluted acids, and capable of forming gel, granules, fibres, and surface coatings.Chitin and chitosan have several uses in the environmental, culinary, cosmetic, and pharmaceutical industries. They've been used to treat wastewater, as well as food additives, disinfectants, and soil conditioners. Chitin and chitosan are utilised as ingredients in the production of a variety of cosmetic and pharmaceutical goods.

Indirect reuse of wastewater

When wastewater is discharged into rivers or streams, it may initiate a self-purification process in which microbial activities (mostly those of bacteria) breakdown and stabilise the organic components in the wastewater. As a result, river water may be reused in agriculture or as a source of water supply for settlements downstream at a station downstream and sufficiently distant from the place of wastewater discharge.

Pollution occurs when the organic waste load is moderate and the microorganisms in waste breakdown need little DO. When there is a larger organic waste load (type 2 pollution), the bacteria need more oxygen, resulting in a bigger DO sag and, as a result, a longer recovery time or distance of flow before the DO can return to normal. Category 3 pollution occurs when there is an overabundance of organic material in the stream, resulting in anaerobic conditions (zero DO concentration). This is harmful to aquatic life; the recovery period for DO pollution will be substantially longer than for kinds 1 and 2 pollution. While DO is an indication of stream recovery after pollution discharge, additional criteria such as pathogen and hazardous chemical concentrations should be considered when reusing stream water (Figure 5.1)

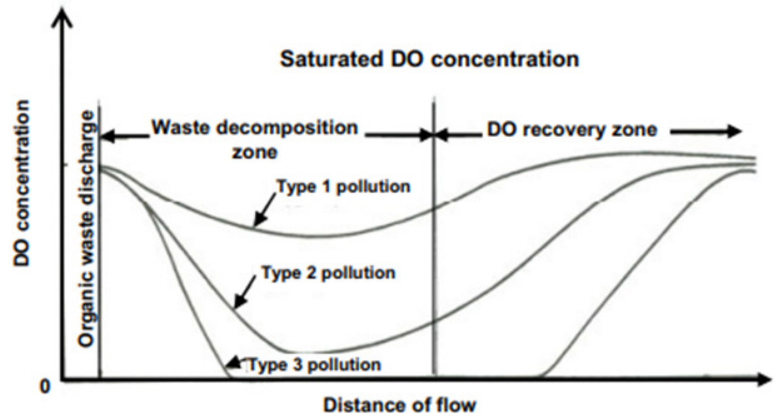

Figure 5.1 the sag profile in polluted stream

Integrated and Alternative Technologies

The aforementioned technologies may be used separately or in conjunction with one another, depending on local circumstances. To make the most use of resources, consider integrating several waste recycling systems in which waste from one operation serves as raw material for another. Animal, human, and agricultural wastes are all utilised to create food, fuel, and fertilisers in these integrated systems. To reduce external energy inputs and increase self-sufficiency, the conversion processes are integrated and balanced. The following are some of the benefits of an integrated system (NAS 1981):

1. Greater resource use,
2. Higher yields,
3. Extended harvest period based on diverse goods,
4. Marketable excess, and
5. Improved self-sufficiency

Feasibility and Social Acceptance of Waste Recycling

A trash recycling scheme's viability is determined not just by technical and economic factors, but also by social, cultural, public health, and institutional issues. While trash recycling has been effectively implemented in many countries (both developed and developing), a huge percentage of individuals still lack awareness and disregard the advantages of garbage recycling systems. Trash recycling should not be limited to generating food or electricity. Unquantifiable advantages from pollution management and public health improvement should be included when determining the cost-effectiveness of a rubbish recycling project. Since human excreta and animal manure might include dangerous bacteria, recycling these organic wastes must be done with extreme caution; the public health elements of any waste recycling method must also be considered.

Institutional support and collaboration from multiple governmental entities in trash recycling programme marketing, training, and maintenance/monitoring are also required for success. Since the success of any programme is heavily dependent on public approval, the communities and individuals affected should be made aware of the trash recycling programmes that will be implemented, their methods, and the benefits and downsides. Stone (1976) performed a public opinion poll in ten towns in Southern California, USA, to investigate the acceptance of water reuse. Public attitudes are generally favourable for lower contact uses (such as irrigating parks/golf courses, factory cooling, toilet flushing, and scenic lakes); additionally, treatment costs are generally low due to the requirement for a lesser degree of treatment, and adverse effects on public health are minimised. Reusing wastewater for body contact applications (such as boating/fishing, beaches, bathing, and washing) elicited more neutral or negative opinions, while human consumptive reuses (such as food canning, cooking, and drinking) were not acceptable to those polled.

According to a recent research by Metcalf et al. (2006), irrigation using recovered water has become prevalent in Florida, USA, and demand for reclaimed water is strongest during the dry season. Tampa, Florida's modern wastewater treatment facility now generates 190,000 - 227,000 m^3 /day of recovered water, with the flow rate predicted to climb to 265,000 m^3/day during the next 20 years. The use of recovered water for agriculture and stream augmentation is estimated to offset about 98,400 m^3 of potable water per day. About 30,300 m^3 of recovered water per day will be made available for natural system restoration and aquifer replenishment.

In poor nations, assessing public approval for wastewater reuse has not been done or is done seldom, if at all. Since numerous nations, like China, India, and Indonesia, have been recycling either human or animal waste for millennia, and because of their socioeconomic restrictions, societal acceptance for wastewater reuses should be higher than in Western countries. Schouw (2003) discovered that recycling human waste nutrients via composting restrooms and irrigation of septic effluents is socially acceptable in southern Thailand. Composting toilets for excreta treatment and waste stabilisation ponds for sullage treatment (wastewater from kitchens, bathrooms, and laundry) were deemed the most ecologically practicable.

Characteristics of organic wastes

Human Wastes

Excreta is a mixture of faeces and urine that is usually of human origin. It becomes household sewage or wastewater when it is diluted with flushing water or other grey water (such as from washing, bathing, and cleaning activities). Another sort of human waste is solid waste, which refers to solid or semi-solid wastes that are thrown as worthless or undesired. It contains food wastes, trash, ashes, and residues, among other things; in this instance, the food wastes, which are largely organic, are recyclable.

The amount and type of human excreta, wastewater, and solid waste varies greatly depending on variables such as food consumption, socioeconomic conditions, weather, and water availability. As a result, generic data from the literature may not be easily relevant to a given example, and field inquiry at the real location is advised whenever feasible prior to the commencement of facility design.

Human excreta

Certain European and North American cities produce between 100 and 200 g (wet weight) of faeces per capita per day, whereas poor nations produce between 130 and 520 g (wet weight) per day. Most individuals generate between 1 and 1.3 kilogramme of pee per day, depending on how much they drink and the weather. The water content of faeces varies with faecal amount, ranging from 70 to 85%. Human faeces and urine composition the solid matter in faeces is primarily organic, but its carbon/nitrogen (C/N) ratio is only 6-10 which is lower than the ideal C/N ratio of 20-30 necessary for efficient biological treatment. If composting and/or anaerobic digestion are to be used for excreta treatment, extra organic materials with a high C content must be added to increase the C/N ratio. Trash (food waste), rice straw, water hyacinth, and leaves are examples of readily accessible C compounds that are mixed with excreta. A person generally excretes 25 to 30 g of BOD_5 per day via excreta excretion.

Excreta is typically handled on-site by techniques such as septic tanks, cesspools, or pit latrines in locations where sewerage systems are not accessible. Septage or sludge created in septic tanks and cesspools must be collected on a regular basis (approximately once every 1-5 years) so that it does not overflow from the tanks and block the soakage pits or drainage trenches (soakage pit and/or drainage trench).Organic waste trenches are units where septic tank/cesspool overflow drains into and seeps into the surrounding soil, where soil microorganism's biodegrade its organic content). The most effective way to remove septage is to utilise a vacuum tanker (size 3-10 m3) outfitted with a pump and a flexible suction line. If vacuum tankers are not accessible, the septage must be gathered manually using a shovel and buckets; in this situation, the worker doing the septage emptying may be exposed to disease transmission from the septage, and the technique is deemed unsanitary and unsanitary.

Waste water

Sewerage systems in affluent cities and many cities in developing nations transport wastewater from houses and buildings to central treatment facilities. This wastewater is a mixture of excreta, flushing water, and other grey water or sullage, and it is highly diluted depending on per capita water use. According to White (1977), the amount of water consumed varies from a few L per person per day to around 25 L for rural users without tap connections or standpipes. Consumption ranges from 15-90 L for households with a single tap to 30-300 L for households with several taps.

Animal Wastes

The volume and nature of animal waste (faeces and urine) excreted per unit of time varies greatly as well. They are affected by a variety of variables, including the animal's total live weight (TLW), species, size and age, diet and water consumption, climate, and management approaches, among others. Measurements and sampling should be gathered at the farm site or (if the farm is not constructed) at comparable locations for the design of facilities for animal waste collection and treatment. Taiganides (1978) proposes that the basic guideline values should be utilised for planning purposes. Younger animals produce more waste every unit pf TLW than older animals.

Agro-Industrial Wastewaters

Tapioca industry

Tapioca, commonly known as cassava or manioc, is cultivated in almost every tropical region on the planet. The plant's root contains roughly 20% starch in a cellulose matrix. Tapioca starch is particularly popular for sizing sheet or fibres, and it is also utilised in the culinary business. Pellets, chips, and flour are all made from tapioca. Pellet manufacturing has been continuously expanding due to increased demand for pellets as animal feeds from European nations (Unkulvasapaul 1975).Pellets and chips are not made with water and hence do not pollute the environment. Tapioca flour, on the opposite hand, necessitates a considerable amount of water, and the resultant wastewaters are very polluting. To process one tonne of input root, about 5 to 10 m3 of water is utilised, or around 30 to 50 m3 of water is used per tonne of starch produced. The resulting wastewaters are biological in origin and vary greatly in amount and quality. They have high BOD_5 and SS readings, as well as a low pH and little nutrients.

Tapioca processing of the highest quality

To prevent starch degradation, roots should be processed within 24 hours after arrival to the facility. The sand on the roots is first removed by dry rasping in a rotating drum and the peel is then removed by mechanical tumbling in a wash basin, from which the root washwater is obtained. The roots are then mechanically crushed, releasing the starch granules from the cellulose matrix that surrounds them. The majority of the cellulose material is extracted by centrifugation in a jet extractor and subsequently through continuous centrifugation. If the cellulose material or pulp is fresh, it is sold as chicken feed; otherwise, it is dewatered, dried, and sold as animal feed. Following initial centrifugation, the starch milk is grinded through a sequence of three sieves decreasing in pore size to help in separating the starch from the minimal quantity of pulp remaining. The recovered pulp is returned to the jet extractor, and the refined starch milk is sent to a second centrifuge, which produces wastewater and a more concentrated starch. The product is spray dried and packaged after being dewatered to a paste-like consistency in a basket centrifuge.

Second grade tapioca process

Second-grade tapioca facilities are labor-intensive, with basic procedures and limited automation. They are usually modest private-enterprise businesses.\a typical process flow diagram. The roots are washed in a wooden tank with spinning paddles, which removes sand and clay bits as well as some peel. The cleaned roots are fed into the rasper before being filtered through nylon mesh supported by a big cylindrical drum. The pulp is progressively pulled off and collected for dewatering once the starch is sprayed through. After that, the starch milk is discharged into big concrete settling basins. The supernatant is decanted after 24 hours of settling. The bottom surface of the starch cake is cleaned, and the starch is suspended and pumped to something like a second sedimentation basin. The excess is decanted after 24 hours and the surface is washed again. The starch is then extracted in huge cakey pieces and placed to dry on a heated concrete surface.The starch is packaged after drying. The first and second settling basins' supernatant and surface wash waters are emptied or directed to a third settling basin. If a third settling basin is provided, the supernatant and surface wash waters are allowed to settle for 24 hours before being decanted and released. The bottom sediment is dredged about every two months; the material is suspended twice more, as previously described, and the starch recovered is sold as a lower-grade starch.

Tapioca starch wastewater characteristics

The combined wastewater from tapioca starch manufacturing is mostly made of root wash water and either starch supernatant separated by centrifugation from sedimentation basins or separator wastewater, depending on whether a second-grade or first-grade starch plant is being examined. In Thailand, first- and second-grade industries typically process 200 and 30 tonnes of tapioca root per day, respectively, and emit wastewater with unit mass emission rates. Root wash water comprises a high concentration of settleable materials, mostly sand and clay particles from raw roots. The combined waste has an acidic pH ranging from 3.8 to 5.2 due to the inclusion of sulphuric acid during the extraction process as well as the release of some prussic acid by the tapioca root.

Tapioca starch wastewaters are highly organic yet contain modest levels of nitrogen and phosphorus. The settling separator waste has a soluble BOD_5 to soluble COD ratio of 0.6 - 0.8, suggesting that it is biologically degradable. For this organic waste, biological treatment techniques are expected to be the most cost-effective. The high BOD_5 and COD concentrations indicate that anaerobic biological processes, as the first-stage treatment, will be successful for organic reduction, and biofuel byproducts such as CH_4 gas may be used to generate energy.

Palm oil industry

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Extraction Process

The extraction proceed a generic process flow diagram of a palm oil mill. The freshly cut fruit bunches, supplied to the mill, are first put in cages set on rails and driven immediately into a horizontal steriliser where steam is used to heat the fruits to roughly 140 °C at a pressure of 2.5 - 3.5 kg/cm^2 (35-45 psi) for 50 to 75 min. The goal of this treatment is to deactivate the enzymes that break down oil into free fatty acids and release the fruits from the stalks. The sterilised bunches are then placed into a rotary-drum threshing or stripping machine, where the fruit is separated from bunches. The empty bunches fall onto a conveyor belt and are burned into ash, but the loose fruits are turned into a homogeneous greasy mush by a succession of rotating arms (digester). The digestion mash is then put through a press to extract crude oil (at this point, nuts must not be cracked). The nuts and fresh fibre are then separated, and the nuts are broken to generate kernels for sale. Typically, the crushed fibre and portion of the shells are burned as fuel in the steam-raising boiler. The crude oil, which is a combination of oil, water, and fine solid particulates, is pushed through a vibrating screen to remove the solids. This process often includes the addition of hot water. The oil is separated by gravity in a clarity tank, and the oily sludge sinks at the bottom. Prior to being pumped into a storage tank, the clarified oil is further refined in a vacuum drier. After straining and desanding, the oil sludge is centrifuged to collect the oil, which is then returned to the clarifier. The sludge is released into an oil trap, where it is heated with steam before being sent to a waste treatment plant to recover further oil.

Sugar cane industry

The initial stage in raw sugar manufacturing is juice extraction, which is accomplished by crushing the cane between a series of rollers under pressure. Sprays of water or thin juice are focused on the blanket of bagasse (fibrous component of the cane) as it exits from each mill unit to leach off sugar. The last bagasse from the last roller comprises unextracted sugar, woody fibre, and 40-50% water. This is utilised as a fuel or as a raw material in the making of wallboard and paper. The extracted juice is acidic, turbid, and dark green in hue. It is heated and treated with chemicals like as lime, sulphur dioxide, carbon dioxide, and phosphate for clarity. This treatment has the effect of precipitating suspended particles and certain contaminants, as well as colour removal, which are allowed to settle before the clear juice is filtered via vacuum filters. The filter press juice is either returned to the clarifying process or goes straight to clarified juice. The press cake is either dumped or returned to the fields as fertiliser. During mashing, enzymatic reactions occur in the combination of finely crushed malt and hot water, converting starch into sugar and dextrins and protein in amino acids and polypeptides. Sweet wort is the soluble result of mashing, which is then boiled with hops in a metal pot. Boiling kills the enzymes while extracting resins from the hops to provide bitterness. The wort is subsequently cooled in the cool-ship, yeast is introduced, and the carbohydrates present are transformed into alcohol and CO_2 during the fermentation process. The yeast uses the nitrogenous substance and phosphates in the wort for growth and fermentation. Before ever being bottled or canned, the beer is held in lager tanks for a length of time before being filtered and pasteurised.

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CHAPTER 6

WASTEWATER SOURCES AND CHARACTERISTICS

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Washing from cool ships, lager tanks, and fermentation tanks are all sources of wastewater with high levels of suspended and dissolved particles. These wastewaters include excessive concentrations of beer, malt, and yeast, which have a very high COD, often reaching 20,000 mg/L, accounting for around 10% of the total waste released. Brewery wastewaters are typically amber in colour and have a rich grainy malt aroma.\ Brewery wastewaters have been shown to be heavily polluted with soluble organics, to be deficient in nutrients and pH, and to be very hot.

Characteristics of slaughter house and meat-packing wastes

Slaughterhouse and meat-packing house effluents are often extensively contaminated with solids, floatable matter (fat), blood, manure, and a wide range of proteinaceous substances. The composition is heavily influenced by the kind of manufacturing and facilities. Lairage, killing, hide removal or dehairing, paunch handling, rendering, trimming, processing, and clean-up activities generate the majority of waste. The concentrations of BOD5 and solids in plant effluent are affected by in-plant water consumption control, by-product recovery, waste separation at the source, and plant management.The first factor in wastewater disposal is water usage. Abattoir wastewater output ranges from 5 to 15 m3 per tonne live weight. A typical discharge in the poultry business is between 10 and 55 L per bird (Brolls and Broughton 1981). In terms of BOD5, average loads from abattoirs and meat processing in the UK are 6-12 kg/ton live weight, with a concentration of 1,000 - 3,000 mg/L. The effluent from chicken packing is typically half the strength of slaughterhouse wastewater, with a BOD5 level of 13-23 kg/1,000 birds (Brolls and Broughton 1981)[1], [2].

Unit activities generate waste

The comparatively clean water used in chilling, condensing, and concentrating accounts for a large portion of overall waste flows from several commodities, particularly citrus. Water separation for reuse is used to some degree and should become almost ubiquitous. Washing tomatoes, skinning potatoes, peeling peaches, washing potatoes, cutting corn, cutting and pitting peaches, washing corn, and blanching corn are all examples of huge waste flows. These methods produce a large amount of BOD_5. Citrus by-product recovery creates a significant quantity of BOD_5 and SS. Peeling potatoes, chopping maize, and washing tomatoes are all high in SS.

Cleaner Production

Cleaner production (CP) is the ongoing application of a comprehensive preventative environmental management systems to processes, goods, and services in order to improve overall efficiency. CP may be used to processes in every business, to goods, and to a variety of societal functions. For an agro-industrial process, for example, CP derives from saving raw materials, water, and energy; removing toxic and hazardous raw materials; and minimising the amount and toxicity of all emission and wastes at sources throughout the manufacturing process. For an agricultural production product, CP strives to decrease the environmental, health, and safety implications of the product across its full life cycle, from the gathering of raw materials through production and usage, and finally disposal. CP for services entails integrating environmental issues into service design and delivery[3], [4].

Planning and organization

When one or a few people in the firm get interested in cleaner manufacturing, planning and organisation begin. If management has taken a deliberate choice to take action, a CP evaluation may be begun. According to the experiences of an increasing number of firms, the following aspects are critical for the effective launch of a CP programme:

Committee of management: To promote cooperation and involvement, plant management must set the environment for CP activities. Management committee may be expressed in environmental policy declarations; nevertheless, the actual conduct of the management is at least as significant as written pronouncements. To begin, coordinate, and manage CP operations, a CP project team must be formed.

Employee involvement: Although management should set the tone, whether or whether strong CP possibilities are discovered is primarily based on employee engagement. Workers, particularly those engaged in daily operations and maintenance on the shop floor, often understand why wastes and emissions are created and are frequently able to provide solutions[5], [6].

Cost awareness: Accurate cost information may persuade management and people alike that producing better can save or gain money. Regrettably, many businesses, particularly small and medium-sized businesses, are unaware of how much money is being squandered. Normally, only the fees levied by external garbage contractors are included. Real waste costs might be far higher.

Source reduction addresses the challenges associated with trash processing and disposal by preventing waste creation. A broad range of facilities may implement waste-reduction measures. Several source reduction strategies include changes in procedural and organisational actions rather than changes in technology. As a result, these alternatives tend to impact the management element of production and do not often need major money and time commitments.

Implementation and continuation

Create a cleaner production plan: the CP measures are arranged based on the estimated implementation dates. In addition, the person or department in charge of the execution should be indicated. Adopt viable cleaner production methods: The amount of work required to execute different cleaner production measures varies greatly. Basic CP measures (such as excellent housekeeping) are simple to apply. Nevertheless, the emphasis should be on complicated CP measures that need a significant investment (high cost option) and comprehensive planning, such as equipment installation and finance requirements. The installation of gear need monitoring in order to ensure that the new facilities are used to their full potential.

Monitor cleaner production development: Straightforward indicators should be utilised to track CP progress and keep management and other interested parties informed on a regular basis. The technique of measuring must be carefully chosen. It might be based on changes in waste (and/or emission) amounts, resource usage (including energy consumption), or profitability. Changes in manufacturing output and/or product mix should be considered when evaluating monitoring data.

Maintain cleaner manufacturing: The continued use of the cleaner manufacturing idea may need fundamental modifications in the company's structure and management system. The essential aspects are: integration with the company's technological growth, effective waste generation responsibility, and staff participation. Preventive maintenance schedules, the use of environmental parameters (such as energy and resource usage) in the procurement of new equipment, or the incorporation of CP into long-term development and study plans might all be examples of integration into technological development. Staff education, frequent chances for two-way internal communication, and employee award programmes may all help to increase employee participation[7], [8].

Waste recycling

A substance is considered "recycled" if it has been utilised, repurposed, or recovered. Recycling through use and/or reuse entails returning waste material to the original process as a replacement for an input material or to another process as an input material. Recycling via reclamation is the process of treating garbage in order to recover a valuable resource or regenerate it. Recycling processes might be carried out on-site or in an off-site facility dedicated to garbage recycling. Waste recycling may be a highly cost-effective waste management option. This alternative may aid in the elimination of waste disposal expenses, the reduction of raw material costs, and the generation of revenue from salable waste.

Composting

The biological decomposition and stabilisation of organic substrates under conditions that allow the development of thermophilic temperature of biologically produced heat, with a final product that is sufficiently stable for storage and application to land without adverse environmental effects. Composting is also defined as a regulated aerobic process carried out by successive microbial populations that combine mesophilic and thermophilic activity, resulting in the creation of carbon dioxide, water, minerals, and stable organic waste.

Composting is often used for solid and semi-solid organic wastes with solid contents more than 5%, such as nightsoil, sludge, livestock manure, agricultural leftovers, and municipal garbage. The breakdown of organic wastes in the presence of oxygen (air) is known as aerobic composting; the end products of biological metabolism are carbon dioxide (CO_2), NH_3, water, and heat. Anaerobic composting is the breakdown of organic wastes in the absence of oxygen; the end products include methane (CH_4), CO_2, NH_3, and trace quantities of other gases, as well as other low-energy compounds organic acids with a high molecular weight. During the maturation or curing phase, nitrifying bacteria oxidise NH_3 to produce nitrate (NO_3). Aerobic composting has become a favoured approach for stabilising huge volumes of organic wastes because it may release more heat energy, resulting in a faster breakdown rate. Anaerobic composting is a lengthy process that may create unpleasant aromas due to intermediary metabolites such as mercaptans and sulphides. Anaerobic composting may yield temperatures close to or at thermophilic levels, depending on the techniques used. Anaerobic burial has found certain uses in many rural parts of developing nations for waste stabilisation produced by families and farmers due to its simplicity[9], [10].

In contrast to wastewater treatment, the words "aerobic" and "anaerobic" in composting have relative meanings. They merely identify which circumstances dominate the process. Since compost materials are heterogeneous and heavy in nature, there is always "anaerobic" composting in a compost heap, which is rare in "aerobic" composting but plentiful in "anaerobic" composting; and vice versa. Certain composting techniques, such as those used in rural China, are aerobic at first and then turn anaerobic as the composting process progresses. With technology as the key, composting may be categorised into 'mechanical' and 'non-mechanical' processes, or 'on-site' and 'off-site' processes. Composting may also be classified according to its mode of operation, which is either batch or continuous or semi-continuous. Composting may be classified into two types based on temperature:'mesophilic' composting (temperatures in the compost heap between 25-40°C) and 'thermophilic' composting (temperatures between 50-65°C).

Objectives, Benefits and Limitations of Composting

The following are the primary uses and benefits of composting:

1. Stabilization of waste. The biological activities that occur during composting transform putrescible organic wastes into stable, mostly inorganic forms that would cause minimal pollution if dumped onto land or into a water stream.

2. Pathogen eradication. The waste heat created by composting may reach a temperature of around 60 °C, which is adequate to inactivate most harmful bacteria, viruses, and helminthic eggs if sustained for at least one day. As a result, composted goods may be disposed of safely on land or utilised as fertilizers/soil conditioners. The impact of time and temperature on the die-off of selected pathogens in nightsoil and sludge. The shorter the period necessary for pathogen die-off, the higher the temperature.

3. Land and nutrient reclamation. The nutrients (N, P, K) contained in trash are often in complex organic forms that are difficult for crops to absorb. Following composting, these nutrients would be inorganic forms suited for crop absorption, such as NO3 - and PO4 -3. The use of composed goods as fertiliser on land lowers nutrient loss due to leaching because inorganic nutrients are mostly in insoluble forms that are less prone to leach than soluble forms of uncomposted wastes. Moreover, the soil tilth is enhanced, allowing for greater root development and, as a result, increased nutrient accessibility (Golueke 1982). Compost applied to unproductive soils will ultimately improve soil quality, allowing hitherto unusable areas to be restored.

One significant disadvantage of composting is the process's unpredictability in supplying desired nutrient availability and pathogen die-offs. Since the qualities of organic wastes may vary substantially from batch to batch, with time, environment, and style of operation, the properties of composted products will likewise vary. Because of the diverse character of the materials in compost heaps, temperature distribution is frequently uneven, resulting in partial inactivation of pathogens contained in decomposed materials. Some composting constraints are related to socioeconomic considerations. Handling nightsoil during composting, for example, might be unattractive, unaesthetic, and odorous. Most farmers continue to choose chemical fertilisers because they are relatively inexpensive and deliver consistent crop production outcomes in the near term.

Drying of sludge. Since human excreta, animal manure, and sludge include around 80-95% water, the expenses of sludge collection, transportation, and disposal are high. Sludge drying by composting is an option in which the wasted heat created by the composting process evaporates the water present in the sludge.

Biochemical Reactions

Organic wastes suitable for composting range from very heterogeneous materials found in municipal garbage and sludge to almost homogenous wastes produced by food processing companies. The biochemical breakdown of these wastes is a complicated process that involves multiple stages and routes. Protein degradation, for example, involves the following pathways:

Proteins, peptides, amino acids, ammonium compounds, bacterial protoplasm, and atmospheric nitrogen or ammonia are all components.

In the case of carbohydrates:

Carbohydrates, simple sugars, organic acids, CO_2, and bacterial protoplasm are all examples of compounds.

The specific intricacies of the metabolic changes that occur throughout the complicated composting processes are yet unknown. The following stages may be recognised in composting operations based on temperature trends (Figure 6.1):

1. The latent phase, which refers to the time required for microorganisms to acclimatise and colonise in the compost heap's new habitat.
2. The growth phase is distinguished by the increase of biologically generated temperature to the mesophilic level.
3. Thermophilic phase, in which the temperature rises its maximum.

This is the most efficient time for waste stabilisation and pathogen killing. Equations 2.1 and 2.3, for aerobic and anaerobic composting, respectively, may reflect this biological process.

Maturation phase, during which the temperature drops to mesophilic and, as a result, ambient levels. A secondary fermentation occurs that is gradual and promotes humification, that is, the transformation of certain complex organics to humic colloids that are tightly connected with minerals (iron, calcium, nitrogen, and so on) and, eventually, to humus. Nitrification reactions occur when ammonia, a by-product of waste stabilisation as stated in Equations 2.1 and 2.3, is physiologically oxidised to create nitrite (NO^{2-}) and then nitrate (NO_3^-), as follows:

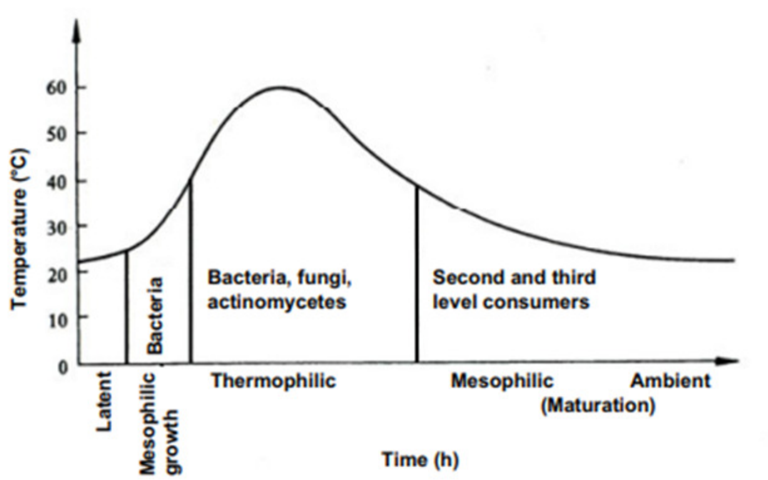

Figure 6.1The patterns of temperature and microbial growth in compost piles.

Biological Succession

Composting is a biological process that converts organic wastes into stable humus via the action of complex organisms found in the trash. They include microorganisms like bacteria, fungus, and protozoa, as well as invertebrates like nematodes, earthworms, mites, and other creatures. The first level consumers, such as bacteria, fungus (moulds), and actinomycetes, breakdown organic wastes. Bacterial responses are primarily responsible for waste stabilisation. The first bacteria to arise are mesophilic bacteria. After that, as the temperature increases, thermophilic bacteria arise and colonise all regions of the compost heap. After 5-10 days of composting, thermophilic fungi normally begin to develop. As the temperature rises over 65-70°C, fungi, actinomycetes, and most bacteria become dormant, and only spore-forming bacteria may grow. When the temperature rises in the last phases. Bacillus spp., in particular, play an important role in the breakdown of proteins and other carbohydrate molecules (Strom 1985). Despite being restricted to the outer layers of compost piles and becoming active only later in the composting process, fungi and actinomycetes play an important role in decomposing cellulose, lignins, and other more resistant materials that are attacked after the readily decomposed materials have been utilised. Streptomyces and Thermoactinomyces are the most frequent actinomycetes, whereas Aspergillus is the most common fungus (Strom 1985).After these steps, the first level consumers, such as mites, beetles, nematodes, protozoa, and rotifers, provide food for the second level consumers. Second level consumers are preyed upon by third level consumers such as arachnids, rove beetles, and ants.

Environmental Requirements

The groups of organisms that occupy and stabilise organic wastes determine the success of a composting process. Any process failure might be caused by uneven chemical and physical variables in the compost heaps that are adverse to microbial development. The primary environmental factors required to be adequately managed in the operation of composting processes are as follows:

Nutrient balance

The carbon/nitrogen (C/N) ratio is the most critical nutritional characteristic. Phosphorus (P) is the second most important element, followed by sulphur (S), calcium (Ca), and trace amounts of numerous other elements. According to Alexander (1961), about 20-40% of the C substrate in organic wastes (compost feed) is finally incorporated into new various microorganisms in composting, with the remaining being transformed to CO_2 in energy-producing activities. These cells, on the other hand, contain around 50% C and 5% N by dry weight, or a C/N ratio of about 10/1. If 30% of the C substrate is turned into microbial cells, the initial C/N ratio of the compost feed should be modified to 30/1 to provide a balanced substrate percentage of cell development. As a result, the demand for N in the compost feed is 2 - 4% of the original C, implying that a C/N ratio range of roughly 20/l - 40/1 is optimal for biological processes. The C/N ratios of different wastes. Other wastes, with the exception of horse manure and potato tops, should have their C/N ratios corrected to the optimal value of 25/1 before composting. In reality, the following considerations make precise computation and modification of the ideal C/N ratio problematic.

Particle size and structural support of compost pile

Composting materials should have as tiny a particle size as feasible to allow for effective aeration (in the case of aerobic composting) and to be quickly digested by bacteria, fungi, and actinomycetes. Municipal solid trash and agricultural leftovers, such as aquatic weeds and fibres, should thus be shredded into tiny pieces before composting. Fine solid particles appropriate for microbial breakdown are often found in nightsoil, sludge, and animal dung. Other materials, such as organic supplements and/or bulking materials, must be added to these wastes, however, in order to increase the C/N ratio, give structural support for compost pile, and generate void spaces in the case of aerobic composting. Organic additives are materials that are added to the composting feed to enhance the amount of degradable organic C, decrease bulk weight, and increase air spaces in the compost mixture; examples include sawdust, rice straw, peat, rice hulls, and household garbage. Bulking elements may be organic or inorganic of significant size to offer structural support and retain air space in the compost mixture when added to sludge. Dried water hyacinth (Eicchornia crassipes) and rice straw, shred into tiny (2-3 cm long) pieces, were found to be appropriate as organic additions and bulking materials for nightsoil composting.

Moisture control

The compost mixture's moisture content must be optimal for microbial degradation of organic waste. Since water is required for nutrient solubilization and cell protoplasm, moisture levels below 20% may seriously impair the biological process. Too-high moisture level will induce leaching of nutrients and pathogens from the compost pile. Too much water in aerobic composting will restrict air passages, leading the compost pile to turn anaerobic. A moisture level of 50-70% (average 60%) is ideal for composting and should be maintained during active bacterial interactions, such as mesophilic and thermophilic development.While nightsoil, sludge, and animal manure often have moisture levels greater than the ideal value of 60%, the addition of organic amendments and bulking materials may assist lower moisture content to some extent. Most agricultural leftovers, on the other hand, have moisture levels less than 60%, and some water must be provided during the composting process of these wastes. For batch operation of composting, the moisture level of the compost mixture may be adjusted by adding water to the compost heaps one or two times daily. The moisture content should be maintained at the optimal level until the thermophilic stage is through, as demonstrated by the drop in temperature in the composting process and the appearance of second- and third-level consumers.

Aeration requirements

Aerobic composting requires enough aeration to supply enough oxygen for aerobic bacteria to stable organic wastes. This is performed by non-mechanical ways such as stirring the compost piles on a regular basis, inserting perforated bamboo rods into the compost piles, or lowering compost heaps from to the floor. Forced-air aeration, in which air is blasted via perforated pipes and orifices into the compost heaps, is a more efficient mechanical method.Since non-mechanical aeration cannot provide enough oxygen to the microbes, aerobic conditions occur only on the compost heap's outer surface, while facultative or anaerobic conditions are present inside. As a result, the composting rate is sluggish, necessitating a longer composting interval. The volume or rate of air flow must be correctly adjusted while utilising mechanical aeration. Too much aeration is wasteful and may result in heat dissipation from the compost heaps, while no enough aeration can result in anaerobic conditions inside the compost piles.

Temperature and Ph

The biologically produced heat created inside a composting mass is crucial for two reasons:

1. To enhance the pace of decomposition.
2. To produce a material that is microbiologically' safe' for usage.

Composting

Compost temperatures over 60-65 °C, or the thermophilic range, are known to considerably limit the rate of biodegradation in compost heaps. According to a recent study that used compost samples from a full-scale composting factory, the ideal temperature for composting, as determined by microbial activity (incorporation of [14C] acetate), was consistently lower than 55°C (McKinley et al. 1985). Most harmful germs, on the other hand, are successfully inactivated at temperatures exceeding 50°C. Therefore the main objective is to regulate compost pile temperatures such that they optimum both organic material decomposition and pathogen inactivation (about 55°C). Temperature may be adjusted by adjusting aeration and moisture content, as well as using screened compost as an insulating cover for compost heaps.

The kinds and species of microorganisms that thrive in compost heaps are influenced by temperature patterns. In composting, mesophilic temperature (25-45°C) develops initially, followed by thermophilic temperature (50-65°C). Most organic substrates will have been stabilised by this point, resulting in a temperature drop to mesophilic and, finally, ambient levels. In many situations, the thermophilic temperature may reach 55-65°C and remain for many days, effectively inactivating microorganisms. Aerobic composting typically occurs at a neutral pH and seldom experiences significant pH decrease or increase. Due to the synthesis of volatile fatty acids, a minor pH decrease may occur after a few days of anaerobic composting. Following this time, the pH returns to neutral as the acids are transformed to methane and carbon dioxide by the reactions of biogas bacteria.

Composting Maturity

There are several parameters for determining the maturity or completion of a composting process. In general, a composted product should have a low organic content, have inactivated pathogens, and not continue additional fermentation when dumped on land. Several methods for determining the degree of compost stabilisation are as follows:

1. Temperature decrease towards the conclusion of batch composting.
2. Reduction in compost organic content as evaluated by volatile solid (VS) content. Chemical oxygen demand (COD), percent carbon content, and C/N ratio.
3. The presence of certain elements like nitrate and the lack of others like ammonia.
4. Lack of insect attraction or larval growth in the finished product.

Absence of offensive odour

When composted materials are to be applied to crops because public health is a concern, another crucial criteria to consider is the time necessary for pathogen die-offs during composting pathogen die-off and the public health issues associated with composting.Since compost materials often include some biologically resistant chemicals, total stabilisation may not be accomplished during composting. The time necessary to achieve a sufficient level of composting would be determined by the environmental parameters. Aerobic composting typically takes 10-30 days under ideal circumstances, however anaerobic composting might take 45 to 100 days. Compost maturation or curing times may be similar to those needed for organic stability. Several firms have created mechanical composting reactors that promise to generate adequate compost in a short amount of time, such as 24 hours. These reactors, however, are both costly and complex to run, and the composted materials generally need further time for curing or nitrification.

It should be observed that the temperature pattern and biological succession generated in the compost heaps in batch composting are comparable to those depicted. Since batch composting involves both trash stabilisation and curing, the composted product is appropriate for use in agriculture or agriculture.The continuous decomposing process is generally aerobic, with a semicontinuous plug-flow movement of composting materials via a reactor structure, and reactor contents with constant thermophilic temperatures. The material is translocated through the structure as part of both the tumbling motion in a giant spinning drum, by the action of augers thrust through the mass, or by gravity, depending on the individual design.

Several techniques may supply the gas exchange by driving air through the bulk. The residence duration in the reactor ranges from 1 to 10 days, with 5 days being the most common. The material displaced from the continuous stage is physiologically stabilised. It should be further treated during the curing stage to enable for nitrification and to make the composting products appropriate for agricultural reuse. Sludge dewatering or drying may be accomplished by composting. The nitrification processes are not required in this situation, and the composted products from continuous reactors may be disposed of in sanitary landfills or reused in non-agricultural activities.

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CHAPTER 7

COMPOSTING SYSTEMS AND DESIGN CRITERIA

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Composting systems will be classified as on-site and off-site procedures. On-site systems decompose organic wastes where they are generated, such as at home or in toilets; the composting process is typically uncontrolled and occurs organically. Off-site methods include the collection and shipment of organic wastes to central treatment facilities for composting; the composting process is generally regulated manually or automatically.

1. On-site composting
2. Aerobic composting toilets

Lindstrom pioneered these sorts of composting toilets, known as the'multrum,' and they were first commercialised roughly 20 years ago (Rybczynski et al. 1978). The multrum is a watertight container with a sloping bottom. Human excreta (without flushing water) is introduced at the top end of the container, and combined with organic skitchen and garden wastes, injected lower down, to enhance the C/N ratio. To improve aeration, air ducts and a vent pipe are supplied. The composted material settles towards the bottom and is retrieved on a regular basis.The container is relatively huge, with a lengthy decomposition time of up to 4 years (3 x 1 x 1 m: length x width x height). The air ducts also assist to dissipate humidity and reduce smells, and the sloping bottom allows for the continuing use of a single container by separating new and decomposing items. The biopic composting toilet is another Meldrum adaptation that contains a gravel soakage pit to treat and disposed of the liquid waste included in the excreta[1], [2].

Public Health Aspects of Composting

Die-offs of primary pathogens

The two most critical criteria responsible for pathogen die-offs during composting are time and temperature. It should be emphasised that pathogens are seldom completely inactivated in a compost pile. Several factors contribute to this, including:

1. The heterogeneous nature of the compost components, which may form clumps with pathogens and shield them from being completely exposed to thermophilic temperatures.
2. The uneven temperature distribution in the compost heaps. Unless regularly mixed, the exterior surfaces of a compost heap often have a lower temperature than the core, resulting in a poorer effectiveness of pathogen death.

Pathogens are partially inactivated. Composting only partly inactivates several pathogens such as sporeforming bacteria, cysts, and helminthes ova. They may re-grow and re-infect if exposed to a suitable environment, such as damp conditions in agricultural fields. Many studies found that composting reduced bacteria total coliforms, faecal coliforms, and faecal streptococci and viruses by several orders of magnitude. Higher inactivation rates were seen with the BARC system, with various bacteria, including Salmonella, being undetectable after 10 days of composting and F2 bacteriophages being undetectable after 15-20 days[3], [4].

Health risks from secondary pathogens

Contact or inhalation of air having a high density of secondary pathogen spores may endanger the health of compost workers and consumers. An epidemiological research was undertaken on compost employees at nine sludge composting companies in the United States to assess the possible health risks

Compost employees face a greater health risk than non-compost workers; nose and throat cultures positive for fungal pathogens were more prevalent in these compost workers than in others. Since Aspergillus fumigatus may cause severe infections in the lungs and other human body parts, suitable precautions must be taken to prevent spore absorption.

Utilization of Composted Products

Compost has been utilised as a) fertiliser, b) soil conditioner, c) aquaculture feed, d) landfill waste, and e) horticultural medium on parks, ornamental and recreational areas, and highway right-of-ways. To remove metals, glass, and other elements from the compost that may be unpleasant in its usage, screening, grinding, or a combination of comparable techniques should be used. Compost does not need to be completed or processed further for certain applications, such as soil remediation and reclamation. A coarse grind is enough for basic agriculture/aquaculture, while a finer grind is required for horticulture and luxury gardening. Compost that is intended to be used as fertiliser or soil is often blended with chemical fertilisers to make its nutrient content acceptable for crop development[5], [6].

Utilization as fertilizer and soil conditioner

Compost may increase overall soil fertility by adding organic matter and plant nutrients, as well as changing the pH of the soil. The long-term impact on soil fertility is also critical. As a consequence, soil erosion may be decreased, water retention capacity increased, soil structure improved, and plants can be developed fast.The use of composted municipal wastes as fertilisers and soil conditioners will be determined by three major factors:

a. Socioeconomic factors.
b. Product quality and Responses of soil and plants.

Production of an energy source

Production of an energy source

The most tangible advantage of biogas technology is the generation of an energy resource (biogas) from the anaerobic digestion of organic wastes. Biogas production in rural regions may provide various benefits, including reduced demand for power, coal, oil, and firewood, as well as savings on administrative and distribution costs. Organic materials necessary for biogas generation are plentiful and cheaply accessible. Reduced demand for firewood protects the forest and advances afforestation activities.

Nutrient reclamation

the nutrients (N, P, and K) in waste are often in complex organic forms that are difficult for crops to absorb. At least 50% of the nitrogen present after digestion is as dissolved ammonia, which may be nitrified to create nitrate when given to crops (Equation 3.5) or is easily accessible to crops.As a result, digestion raises the availability of urea in organic wastes over the normal range of 30-60%. During digestion, the phosphate and potash levels are not reduced, and their availability of roughly 50% and 80%, respectively, is not altered. Anaerobic digestion does not remove or degrade nutrients from household and agricultural waste, but rather makes them more accessible to plants. The biogas digester sludge, in addition to being used as a fertiliser, also functions as a soil conditioner, increasing the physical attributes of the soil. The use of digester effluent to unproductive soils would ultimately enhance soil quality, or the unproductive areas may be restored.

Pathogen inactivation

The trash is stored without atmosphere for a lengthy period of time (15-50 days) at about 35°C throughout the digesting process. These circumstances are adequate to render several harmful bacteria, viruses, protozoa, and helminth ova inactive.] Yet, there are certain disadvantages to biogas technology. As compared to other options, such as burning, biogas generation is the sole significant benefit of this approach. Additional benefits, such as waste stability and pathogen inactivation, are better met by composting a comparison of biogas technology vs composting is detailed[7], [8].

Environmental Requirements for Anaerobic Digestion6

Anaerobic processes in a digester may begin fast if a good inoculum or seed, such as digested sludge, is present. At start-up or acclimation, a suitable amount of seed material should be fed to the initial concentration feed material, e.g. at least 50%. Throughout a three or four-week period, the seed volume may be gradually lowered while the fraction of influent feed is increased.At the conclusion of this time, the influent feed may be delivered directly to the digester to help anaerobic bacteria proliferate. The feed material's solid composition should be about 5-10%, with the remainder being water. Anaerobic digestion, like any other biological process, is a multi-parameter regulated process, with each individual component having overall influence over the process either by their own impact on the system or interaction with other factors.

Temperature, as well as its daily and seasonal variations, have a significant impact on the rate of gas generation. In general, two temperature ranges are considered in methane generation. They are mesophilic (25-40°C) and thermophilic (50-65°C). The rate of methane generation rises with temperature, but there is a notable pause in the climb about 45°C, since this temperature favours neither mesophilic nor thermophilic germs. Yet, no definitive relationship can be shown other than an increase in the rate of gas generation (within specific restrictions).At 10°C, gas output drops dramatically; hence, operation below this temperature is not advised owing to reduced gas production (among other technical issues). At 30 - 35°C, the digester needs a significant quantity of electricity for digestion heating, making the operation economically untenable.

pH and alkalinity

In anaerobic digesters, the operational pH range should be between 6.6 and 7.6, with the ideal range being 7 to 7.2. Although acid-forming bacteria may withstand pH values as low as 5.5, methanogenic bacteria are hindered at such low pH levels. If a digester produces too much gas (volume / time), the pH might go below 6.6.

Temperature (degrees Celsius)

160 Organic waste recycling: innovation and management of volatile fatty acid buildup. This kind of buildup may develop when the organic loading rates are overly high and/or poisonous compounds are present in the digester, all of which hinder the methanogenic bacteria. When the rate of CH4 synthesis slows owing to a reduction in pH in an anaerobic digester caused by the deposition of volatile fatty acids or an increase in H_2 partial pressure, appropriate steps should be implemented immediately. In general, the digester should be stopped feeding to let the methanogens to use the accumulated volatile fatty acids and H_2 at their own speed. After

the ideal gas production rates are restored, the digester may be loaded normally again. Also, the pH of the digester must be corrected to neutrality by adding lime or other basic minerals. The digester generally has a high buffering capability if the alkalinity of the digester slurry is kept between 2,500 and 5,000 mg/L[9], [10].

Nutrient concentration

The majority of the material in this field has come from investigations of rumen bacteria. The majority of rumen bacteria get their energy from anaerobic carbohydrate fermentation. Nitrogen is essential for cell structure.It is essential to combine the raw materials in compliance with an appropriate C/N ratio to ensure regular biogas production. Bacteria consume carbon at a rate 25 to 30 times quicker than they consume nitrogen. As a result, at this C/N ratio (25-30/l), the digester is projected to run at peak gas output, equivalent to that necessary for composting other components such as P, Na, K, and Ca are also mentioned as being important in gas generation. Nonetheless, the C/N ratio is regarded as the most important element. Yet, these agricultural leftovers may cause issues because they float to the top and create a hard layer of scum on the slurry surface within the digester.

Loadings

Organic loading (kg COD or volatile solids (VS)/m3 -day) and hydraulic loading (retention time) are two ways to represent this phrase (HRT). A large organic loading would often result in excessive phospholipid fatty acid formation in the digester (sour condition), lowering the pH and negatively damaging the methanogenic bacteria. A low organic loading will not yield enough biogas for other applications and will increase the digester capacity needlessly. Since organic materials feeding anaerobic digesters are semi-solid, organic loads to a digester is easily read in terms of VS.

Distinguishes between two kinds of anaerobic digesters: dispersed-growth digesters (those that use dispersed-growth bacteria) and attached-growth digesters (those employing attached-growth bacteria).The optimal organic loadings for dispersed-growth digesters have been reported to be 1-4 kilogramme VS/(m3 -day) and 1-6 kg COD/(m3 -day) for anaerobic filters and upflow sludge blanket digesters, respectively (Barnet et al. 1978 and Brown and Tata 1985).

HRT has a similarly strong influence on digester performance. An HRT that is too short will not provide anaerobic microorganisms, particularly methane-forming bacteria, and the time to digest the wastes. An HRT that is too lengthy may result in an excessive build-up of digested particles in the digester and the development of a digester that is too big in size. An ideal HRT, like organic loadings, is determined by the properties of influent feed ingredients and the ambient conditions in the digesters. The ideal HRT for dispersed-growth digesters is 10-60 days, whereas for attachedgrowth digesters it is 1-10 and 0.5-6 days for anaerobic filters and up-flow sludge blanket digesters, respectively.

According to the data shown above, attached-growth digesters can function at larger organic loadings or with shorter HRT than dispersed-growth digesters. This benefit is due to the nature of connected bacteria, which adhere to the medium and/or remain in the digester for extended periods of time. They are consequently present in large quantities in the digesters, are not readily washed out/overflowed in the biogas slurry, and are well adapted to the incoming wastes. To improve process efficiency or achieve greater loading rates, scattered growth digesters may have a portion of their slurry fed back to them in order to retain more functional biomass and enhance solids retention time.

Presence of toxic compounds

Accumulation of volatile fatty acids, H_2, and undissociated ammonia are typically related with digester failure in the anaerobic breakdown of biological wastes such as human excreta, animal manure, and other agricultural leftovers. Methanogenic bacteria are also inhibited by the presence of molecular oxygen. Inhibition produced by high quantities of some ions may be counterbalanced by certain other ions (antagonistic ions), but it can also be exacerbated by others (synergistic ions). Organic wastes containing the inhibitors specified should be or before or diluted such that their concentrations are lower than the inhibitory concentrations before being fed to anaerobic digesters.

Mixing

The mixing of digester slurry is necessary to improve interaction between anaerobic bacteria and incoming organic wastes, resulting in increased biogas generation. It helps to prevent/break up scum development at the slurry surface by reducing solids settling or buildup of digested particles at the bottom of the digester. Manual mixing of the digester's slurry is possible for small-scale digesters. Mixing in large-scale digesters may be accomplished mechanically by stirring and circulation of the gas and or digested slurry.

Modes of Operation and Types of Biogas

There are several kinds of anaerobic digesters used for research, pilot plant evaluations, and real field application. Their design, materials, system performance, pricing, and so on all vary greatly. Operationally, air must be excluded from the digester's content, and adequate volume must be given inside the digester for biological processes to occur. The major ways of digester operation may be divided into three categories:

Modes of operation

Batch processing

In this mode of operation, the digester is completely loaded with organic matter and seed inoculum, sealed, and the decomposition process is allowed to continue for an extended period of time until gas production decreases to a low rate (duration of process varies based on regional temperature swings, type of substrate, etc.). It is then unloaded, leaving 10-20% as seed, then reloaded, and operation continues. In this sort of operation the gas output is predicted to be unstable and the production rate ranging from high to low, and digestion failures owing to shock load is not unusual. This style of operation, on the other hand, is suited for treating vast amounts of organic materials at regular intervals. If a consistent supply of gas is required, different gas holders may be required.

Semi-continuous operation

This entails feeding the digester more often. Feeding is normally done once or twice a day. The digested organic materials is also eliminated at regular intervals. When there is a consistent flow of organic materials, this form of operation is appropriate. The digester capacity must be big enough to function as both a reactor and a gas storage tank. Typically, total gas generation per unit organic weight the organic materials added is high. This kind of plant accounts for the majority of the active biogas plants in the field.

Continuous operation

This way of operation involves continuous feeding and removal of organic materials. The quantity of material to be digested in the digester is maintained constant by overflow or pumping. It has been employed in the treatment of low solid concentration liquid wastes or organic wastes. Continuous operation is strongly reliant on external energy inputs for pumping und mixing, and so has limited utility in locations where energy resources are scarce.It should be noted, however, that the seed inoculum is injected at the beginning of the anaerobic digestion process (start-up), and genuine operation begins after the microbial population establishes itself and the gas output + proportion of methane gas in total gas production stabilise. The animal dung itself works as seed inoculum in the field application of anaerobic digestion, and the process may attain stability within 20-30 days of operation (depending upon temperature, digester size and type of substrate).

Types of digesters

Dispersed-growth digesters

The gas storage space in this sort of digester is right above the reactor's digesting contents. The digester's volume is the sum of the slurry and gas volumes. This sort of small-capacity digester (6-12 m3) is appropriate for a single household or a group of families. The largest sizes (50 m3) are intended for communal gas needs. The top, sides, and bottom of the reactors are made of either in-situ bricks or precast concrete. Lime clay is used for the intake orifice and the displacement tank. Both the top and bottom are hemispherical and connected by straight sides. If the digester is made of bricks, the interior surface is coated with numerous thin layers of mortar to keep water and gas out (Figure 7.1).

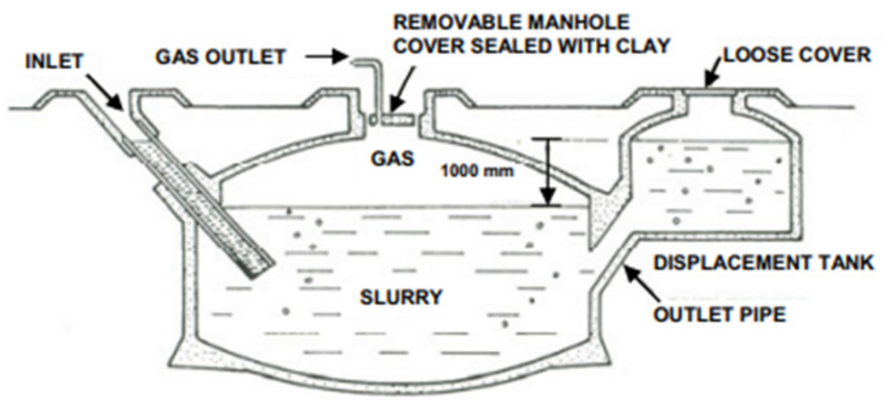

Figure 7.1 Fixed-dome digester.

The gas storage space in this sort of digester is right above the reactor's digesting contents. The digester's volume is the sum of the slurry and gas volumes. This sort of small-capacity digester (6-12 m3) is appropriate for a single household or a group of families. The largest sizes (50 m3) are intended for communal gas needs. The top, sides, and bottom of the reactors are made of either in-situ bricks or precast concrete. Lime clay is used for the intake orifice and the displacement tank. Both the top and bottom are hemispherical and connected by straight sides. If the digester is made of bricks, the interior surface is coated with numerous thin layers of mortar to keep water and gas out.

Depending on availability and C/N ratios, typical feed for these digesters is a combination of animal dung, nightsoil, water hyacinth, and agricultural leftovers. The rate of gas generation is stated to be 0.15 - 0.2m3 /day per m3 of digester capacity, although it may be as high as 0.3-0.4m3 /day per m3 of digester capacity in tropical locations. Mixing of the digester contents is performed by feeding of the influent materials and extraction of effluent slurry.an improvement in the mixing efficiency of the digester contents. The plastic rope is pulled back and forth at the input and output of the digester, causing the plastic blades to churn the slurry and allow greater interaction between the organic waste and the anaerobic bacteria. This type of mixing avoids both the intake and outflow pipes from becoming clogged and the build-up of digested wastes in the digestion chamber.

Ethanol Production

The principles of producing ethanol (C_2H_5OH) from organic wastes and other biomass, such as molasses, sugarcane, cassava, and maize. Ethanol is a liquid fuel that is being produced in numerous nations as an alternative energy source owing to the rising price of oil. Since these organic materials have significant BOD concentrations, fermenting them to make liquid fuel would offer an economic return while also helping to reduce environmental concerns that may arise if they were incorrectly disposed of to the water, land environment.

The ethanol yields from four kinds of biomass feedstock materials are compared in Molasses and maize have comparatively high ethanol outputs of 280 and 310 L/ton, respectively, but sugarcane has the maximum ethanol production of 3,500 - 4,000 L/ton dependent on land area (ha-yr). The basic ethanol manufacturing process, which shows that carbohydrates in starch-containing biomass (such as cassava and maize) must first be biochemically transformed into simple sugars ($C_6H_{12}O_6$) by alpha-amylase and gluco-amylase enzymes.

Sugars are subsequently biochemically transformed to ethanol by the yeast Saccharomyces cerevisiae processes. In theory, 1 g of $C_6H_{12}O_6$ can yield roughly 0.5 g of C_2H_5OH, making sugarcane one of the most appealing biomass feedstock for ethanol synthesis from an economic and technological standpoint. Not only is sugar readily transformed by yeast into ethanol, but the sugar production process also yields bagasse, which can be burned to create heat and steam for the ethanol fermentation and evaporation processes. Molasses derived from the sugar producing process and containing predominantly $C_6H_{12}O_6$ may be readily transformed to C_2H_5OH through the yeast reaction.

Flocculation and flotation

Flocculation is the process of forming flocculent materials by gradual mixing such that their sizes are big and heavy enough to settle in a sedimentation tank. In the treatment of water and wastewater, flocculation is usually followed by coagulation, in which coagulant ingredients such as copper, lime, ferric chloride, or polymers are added singly or in combination and quickly mixed to improve floc formation. Flotation is a physical process in which solid particles float to the water's surface due to buoyant forces (such as dissolved-air flotation or foam flotation), and the floating particles may be skimmed off the water's surface, leaving the clear liquid in the flotation tank's bottom area. The use of coagulation prior to flotation is intended to benefit solids removal since floating particles will be bigger in size, simpler to entrap or absorb tiny bubbles, and buoyed up by dissolved air, allowing them to be successfully skimmed off the water body.

Coagulation-flocculation

Based on the evidence presented above, it seems that coagulation may improve the effectiveness of solids removal by flocculation or flotation. For algal flocculation using alum as a coagulant, a pH range of 6.0-6.8 (6.5 optimal) provided high algal removal efficiency (Golueke and Oswald 1965). Batallones and McGarry (1970) discovered the same result when they investigated the jar test using a rapid mixing speed of 100 rpm for 60 seconds for coagulation and a final slow mixing speed of 80 rpm for 3 minutes for flocculation.

They discovered that the most effective alum dosage for algal flocculation was between 75 and 100 mg/L, while Golueke and Oswald (1965) discovered that the alum dose was 70 mg/L. Several polyelectrolytes or polymers, in addition to alum, may be utilised as coagulant aid materials. Since algal cells operate as a negative charge, only cationic polyelectrolytes should be employed in algal flocculation. Batallones and McGarry (1970) discovered that harvesting by alum alone at algal concentrations below 30 mg/L was fairly costly and advised using alum in conjunction with some cationic polyelectrolyte to decrease the chemical cost. They found that if a polyelectrolyte (Purifloc-C31) was used to help alum, the most cost-effective dosages were 40 mg/L alum plus 2-4 mg/L Purifloc-C31.

The efficacy of coagulation-flocculation is widely recognised to be dependent on numerous environmental conditions like as pH, alkalinity, temperature, and turbidity, among others. To pick the proper HRAP water, laboratory or pilot-scale research on each HRAP water should be done whenever feasible (Figure 7.2).

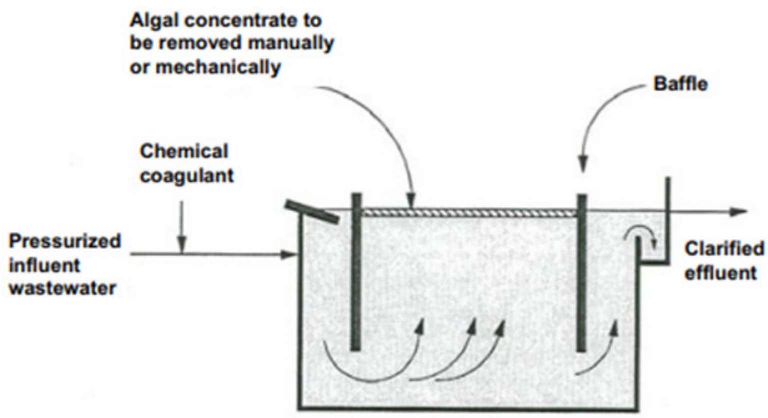

Figure 7.2 represents Coagulation-flocculation

Dissolved-air flotation (DAF)

Algal cells have a propensity to float to the water's top owing to the emission of supersaturated oxygen gas during the photosynthetic cycle. DAF is often used to help algal cells float more efficiently. In DAF systems, air is dissolved in water under several atmospheres of pressure, and the pressure is eventually released to atmospheric pressure in the flotation tank. In small-scale operations, some or all of the influent flow is pressured and coagulant ingredients such as alum are added. The cleared effluent is generally recycled to mix with both the influent feed before being discharged into the flotation tank for large-scale operation and to optimise system performance. The recycled effluent is pressured and semi-saturated with air in this example before being combined with the external tank influent water.

The air/solids ratio, dissolved air pressure, flotation period, type and dosage of coagulant aids, and pH of the water all influence DAF efficiency. Several firms in Europe and the United States of America create different kinds of DAF units for full-scale use. McGarry and Durrani (1970) performed DAF studies on HRAP water and discovered that an algal concentration of 8% was reached in the overflow effluent at alum doses of 125-145 mg/L, pH = 5-7, air pressure = 35-50 psi gauge (2.4-3.4 atmospheric pressures), and floating duration = 6-10 min.

Auto flocculation

The precipitation of algae and other particulate debris in a pond when the pH increases to a very alkaline level is referred to as autoflocculation. This phenomena is connected to the chemical composition of the water, namely the existence of calcium and magnesium carbonates. When the algae remove CO2, the pH increases to the point where precipitation of magnesium hydroxides and calcium carbonate occurs, resulting in the elimination of particulate debris.

Sukenik and Shelef (1984) discovered that the correct amounts of calcium and orthophosphate ions in the medium are necessary for autoflocculation. The culture medium (or HRAP water) should include 0.1-0.2 mM orthophosphate and 1.0-2.5 mM calcium to achieve autoflocculation within the pH range of 8.5-9.0. The flocculating agent is calcium phosphate precipitates, which react with the negatively charged surface of the algae to induce aggregation and flocculation. To remove the precipitated algal cells, another non-agitated basin must be used, or mechanical aeration must be stopped for a few hours daily if cell precipitation is to occur in the HRAP. The precipitated cells may be removed at night or early in the morning when photosynthetic activity is low and algae cells do not climb to the water's top.

Since it does not need complicated mechanical equipment or operation, autoflocculation looks to be a very straightforward way of algae harvesting. Nevertheless, its efficacy in microalgae removal is often lower than the aforementioned approaches, and it necessitates a vast area for settling basin building. Also, to get the high pH values in HRAP water, a particularly warm and clear day is necessary; this situation does not occur all year in most areas.

Biological harvesting

Herbivorous fish (fish that feed on phytoplankton) and other microeconomic consume the unicellular algae growing in HRAP. The cultivation of herbivorous fish in algal pond water to feed on the algae is an appealing method of producing. The protein biomass in fish tissue. Fish, on the other hand, cannot efficiently graze all of the algal cells and will release fish excrement, leading the pond water to still retain significant levels of algal content and organic matter.

Utilization of Waste-Grown Algae

If algae can be given to animals (pigs, chicken, and fish, for example), and these animals are utilised as food for humans, the direct use of algae as a human dietary supplement may be superfluous. Hintz et al. (1966) found that waste-grown algae (Chlorella and Scenedesmus) were 73% digestible when given to ruminant animals like cattle and sheep, but only 54% digestible when fed to pigs. Ruminant digestible energy content was 2.6 kcal per g algae.

These algae were proven to give enough protein to complement barley for pigs. Alfafa-algae pellets produced greater weight increases in lambs than alfafa pellets alone. Algae are generally unpalatable to most animals, however this may be addressed by pelletizing the processed algae with the animal's regular diet, such as steam barley in the case of cattle. Because of the high protein and other useful material contents, waste-grown algae seem to have promise as a livestock feed described the use of waste-grown algae as herbivorous fish diet (Tilapia). Based on 3-month growth periods in ambient, tropical circumstances, extrapolated fish outputs reaching 20 tons/(ha-year) were produced in the 4m3 concrete pond system. A linear connection was found between fish yields and mean algal concentration in fish ponds, with an algal content of 70 mg/L in pond water deemed sufficient to support optimal fish development. Higher algal concentrations were not advised since they might result in zero concentration of dissolved oxygen in the early morning hours.

Algae for fertilizer

Algae may be utilised as fertiliser in agriculture, either directly or indirectly. Algae is cultivated in HRAP and then watered to crops in direct usage. This process is easier, but it takes longer since the algal cells must first disintegrate in the soil. In terms of indirect usage, algae is gathered, decomposed, and then put as fertiliser to soil. The application of algal-laden water to crops should be done with careful concern for public health and guidelines. Since algae can fix nitrogen from the atmosphere, they play a vital function in agriculture. During four years, rice fields infected with the nitrogen-fixing algal *Tolypothrix tenvis* produced 128% more harvest than uninoculated fields. In addition, the plant from the infected field had 8.4 kg N/ha more than the plant from the uninoculated field. Moreover, employing algae as fertiliser improves soil water retention, which benefits crop output.

Public health risks

The production of waste-grown algae poses certain public health issues owing to: Contamination of pathogens often found in raw garbage; and deposition of heavy metals and other hazardous substances in algal cells. Pathogen die-off in algal ponds may occur as a result of ultraviolet radiation, algal toxins generated by algae cells, competition with other microorganisms, restrictive conditions such as high pH during photosynthesis, and sedimentation with sludge, as in reality, however, pathogens are never completely removed since they might be preserved by self-shading of algal and clumping with sewage particles.

Edwards et al. discovered a one-order-of-magnitude reduction in microbe eradication in their HRAP unit in Thailand. Bacterial densities in HRAP effluents ranged from 1.0x105 to 1.3x1010, 1.6x105 to 2.4x106, and 7.0x104 to 9.2x105 no. /100 mL for standard plate count bacteria, total coliforms, and faecal coliforms, respectively. This HRAP effluent, is not suited for unlimited irrigation (e.g., irrigation of food crops), but it may be utilised for restricted irrigation, such as irrigation of trees and other industrial crops. Those working in HRAP units should be cautious of occupational hazards. Contamination is a real danger for these individuals, especially during algae harvesting, which might transfer diseases to other people by carrying them on their bodies or clothing. The potential of ingesting infections while working cannot be ruled out.

Another negative impact on public health is the likelihood of algal contamination with hazardous chemicals and heavy metals. Heavy metals and pesticides may be accumulated in algae via the bioaccumulation process, causing an influence on other consumers in the food chain through bio magnification Toxic chemicals in algae are likely to be more concentrated than in wastewater dumped into the pond. To minimise such concerns, wastewater should be treated to the permitted concentration of heavy metals and other harmful chemicals before being fed into HRAP. The presence and quantities of these chemicals in waste-grown algae used for human or animal feed should really be evaluated on a regular basis.

Acceptance by the general public

Unprocessed freshwater algae have a strong odour and flavour that is comparable to that found in eutrophicated natural environments. Algal texture is also slimy and unappealing, making direct food usage for humans and animals difficult (except for herbivorous fish). As a consequence, converting algal biomass into dietically acceptable forms or appealing material (such as pelletization) is critical, and some promising findings on using pelletized algae as animal feed have been reported. Given the findings on the acceptability and nutritional content of waste grown algae, the potential of their immediate usage as a human protein supplement remains unlikely. Although the strain Spirulina appears to have the potential to be used as human or animal feed, the main issue is that, whereas species control in terrestrial crops is relatively simple in order to grow the best suited species, it is nearly impossible to control algal speciation in outdoor HRAP cultures (Goldman 1979a). HRAP and waste-grown algae seem to be used only to solve certain environmental concerns, such as wastewater treatment and other applications. These constraints include the top limit in algal production of 30-40 g/(m2 -day), algal harvesting economics, and algal cell properties, which are essential considerations in defining the applicability of HRAP to a specific context. Acceptance by the general public

Pathogens

Bacteria, parasites, and viruses are the pathogens of concern in land treatment systems. The principal avenues of concern include groundwater pollution, internal or external crop contamination, and transfer to grazing animals and humans as well as off-site transfer by aerosols or runoff. There is no evidence of parasite disease transmission from wastewater application in land treatment systems because parasite cysts and eggs generally settle out during pre-application treatment or in storage ponds. Nevertheless, if the land treatment area is open to the public, there is a risk of human infection from parasite illnesses. It has been discovered that Ascaris ova may survive in soil for an extended length of time, and examinations at a site in France confirmed the existence of ascaris ova in soil.

Concerns about agricultural contamination centre mostly on surface contamination, followed by pathogen persistence until ingested by humans or animals, or internal plant infection via the roots. Pathogen survival times on leaf and fruit crops, are often shorter than the growth periods of the majority of these plants (Strauss 1986). But, in soil, the survival of viruses, Salmonellae bacteria, and Ascaris eggs may outlast crop development As a result, viable pathogens are more likely to be discovered on root crops and soil than on leaf crops. Human or animal illness can be reduced by implementing preventive measures such as restricting the eating of raw vegetables produced on land treatment sites and allowing two weeks or more after wastewater application before allowing animals to graze. This allows sunlight to eliminate the majority of faecal bacteria and viruses. Since temperature and time have a substantial impact on pathogen die-of.

Land treatment of sludge

Land treatment of sludge has become a solution that many towns across the world are considering. It has the benefit of recycling nutrients back to the soil at a minimal cost, as well as restoring fields that have been ruined by strip mining, deforestation, and overuse of inorganic fertilisers. Before being applied to land, sludge is usually stabilised by anaerobic digestion or other acceptable processes. This type of stabilisation avoids objectionable odours and insect issues. The nutrients and water given by irrigating with digester boost grain and forage crop yield. Because of its high humus concentration, organic matter in digested sludge accumulates in soils and imparts beneficial qualities. The word "biosolid" refers to sludge solids that are appropriate for beneficial land application or digestion to create compost and/or biofuels. Sludge output in the United States was predicted to be 7.6 million dry tonnes in 2005, and this figure is expected to rise to 8.3 million dry tonnes by 2010 (U.S. EPA 1999).

Large wastewater treatment plants

In 2005, the total annual output of sewage sludge in the 15 original European Union nations was projected to be 10.7 million tonnes of dry matter (www.mapa.es/app); this sludge is disposed of as follows: 29% is utilised in agriculture; 45% is dealt of on supervised garbage dumps; 7% is incinerated; and 19% is released into the sea. Statistics on sludge formation in underdeveloped nations are scarce because most cities lack suitable sewerage networks for transporting wastewater to central treatment plants. Nonetheless, it is estimated that each individual produces 25-40 kg of dry sludge per year, or around 800 kg of wet muck (95% water content) each year.

Sludge land application systems are classified into four types:

1. Agricultural use: Sludge is utilised as a fertiliser nutrient source and/or soil amendment.
2. Forest utilisation: Sludge is utilised to increase the productivity of forests.
3. Reclamation of disturbed land: Sludge is used to recover disturbed ground, such as strip mined areas for re-vegetation, or to rehabilitate coastal land.
4. Land disposal: For the primary objective of sludge disposal, sludge is given to soils, regardless of the vegetation. Crop productivity and soil improvement are secondary considerations.

The physical properties of several forms of sludge:

Well-digested sludge is non-addictive and perfectly acceptable for land application. Some varieties of sludge are typically poorly stabilised and emit disagreeable odours. Typical chemical compositions of raw and processed sewage. Although digested sludge has a lower percentage of volatile solids and protein than raw sludge, the former has a higher nutritional value (N, P, and K). The nutritional content of numerous types of sludge in the United States, indicating the viability of employing this sludge in agricultural production and land restoration. Several towns may provide their sludge to farmers at almost no cost, resulting in huge cost savings for both the farmers and the municipality that generates the sludge. Nevertheless, the expense of sludge transit from a treatment facility to a land application location, as well as correct sludge application to land might be too expensive in some situations.

Genetic diversity

Because of the huge number of combinations available in the genes that give each individual distinct features, each member of each animal or plant species differs greatly from other individuals in its genetic composition. As an example, each human person is distinct from the others. This genetic variety is required for a species' reproductive population to be healthy. As the number or breeding individuals is limited, genetic dissimilarity decreases and in-breeding develops. This can eventually lead to the extinction of the organism. Wild species variety serves as the "gene pool" from which our crops and domesticated animals have evolved over thousands of years. Now, the diversity of nature's abundance is being expanded by employing wild cousins of crop plants to develop new types of more profitable crops and better domestic animals. Modern biotechnology manipulates DNA to create improved medications and a wide range of industrial items.

Species diversity

The number of plant and animal species present in a region defines its species variety. This variety may be seen in both natural and agricultural habitats. Some locations have a greater diversity of species than others. Wild, undisturbed tropical forests offer far more species diversity than plantations maintained for wood production by the Forest Service. A forestland ecosystem supplies a wide range of non-wood items on which local communities rely, including fruit, fuel wood, fodder, fibre, gum, resin, and medicines. Timber plantations do not supply the wide range of items required for local use. The financially sustainable benefits from non-wood forest products are considered to be larger in the long run than the returns from cutting a forest for its timber. As a result, the value of a natural forest, with all of its species richness, is far larger than that of a planted. Contemporary intensive agricultural ecosystems have a lesser crop variety than old agropastoral farming systems that planted many crops.

Now, conservation experts have identified and classified around 1.8 million species on the planet. Nonetheless, numerous new species are being discovered, particularly among blooming plants and insects. Diversity 'hotspots' are areas that are rich in species variety. India is one of the world's 15 countries with the greatest diversity of species.

Ecosystem diversity

There are many diverse ecosystems on the planet, each with its own set of distinct interconnected species based on environmental characteristics. The variety of ecosystems can be defined for a single geographical region or a political body such as a country, state, or taluka. Landscapes like forests, grasslands, deserts, mountains, and so on, as well as aquatic ecosystems such as rivers, lakes, and the sea, are examples of distinct ecosystems. Man-made regions, such as cropland or grazing pastures, can also be found in each region.When an ecosystem is referred to as 'natural,' it is mostly undisturbed by human activity, and it is referred to as ‘modified,' when it is converted to various sorts of usage, such as agriculture or urban areas. Wilderness places have the most natural ecosystems. When natural ecosystems are abused or mistreated, their productivity declines and they are said to be degraded. India has an extraordinarily diverse ecology. The Origins of Biodiversity and Evolution: The beginnings of life on Earth three and a half billion years ago remain unknown. Life most likely began as a result of organic reactions in the Earth's primordial waters. Other scenarios have been proposed, such as life originating in a muddy ooze or life being seeded from outer space. After life established itself on the planet, it progressively began to diversify.

Unicellular unspecialized organisms developed into sophisticated multicellular plants and animals over time. The ability of living creatures to adapt to shifts in their surroundings is referred to as evolution. Therefore, abiotic events in nature, including as climatic and atmospheric upheavals, recurrent glaciations, continental drift, and the construction of geographical barriers, separated various groups of plants and animals and led to the emergence of new species over millions of years.

The majority of organisms appear to have a life span of several million years. Their capacity to adapt to subtle changes in their environment, as well as interactions with newly generated species, results in groupings of interconnected creatures that continue to evolve together. Examples include food chains, prey-predator partnerships, parasitism (total reliance on another species), commensalism (a cooperation advantageous to both species), and so on. The behavioural patterns of the many species that comprise a community of species connect them through their breeding biology, eating habits, migrations, and so on. As old species died extinct as a result of geological upheavals, these left behind vacant 'niches' in the ecosystem, which pushed current species to fill them by forming new species. Throughout Earth's history, there have been periods of huge extinctions followed by eras of species origination. Despite the fact that these continually resulted in a significant drop in the number of species, the variety of life was restored each time by progressively increasing the number of species on Earth. This took millions of years, though, because evolution is an extremely sluggish process. So, when man appeared on the scene about 2.5 billion years ago, the globe was more diverse than ever before. But, in recent years, extinctions caused by modern man's actions have occurred at such a quick pace that nature has had little opportunity to generate new species. The Earth is losing species at a faster rate than ever before. Modern man is so quickly changing the variety of life at any and all three organisational levels, genetic, species, and environment. This is a huge loss for future generations that will come after us.

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CHAPTER 8

BIOGEOGRAPHIC CLASSIFICATION OF INDIA

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Based on the topography, climate, and pattern of vegetation visible, as well as the populations of mammals, birds, reptiles, groups are more likely, insects, and other invertebrates that reside in them, our nation may be neatly classified into various primary sections. Each of these regions has a unique ecology, including forests, grasslands, lakes, rivers, marshes, mountains, and hills, each with its own plant and animal species.

The Biogeographic Zones of India

1. Ladakh's chilly mountainous snow-covered Trans Himalayan area.
2. Kashmir, Himachal Pradesh, Uttarakhand, Assam, and other North Eastern states' Himalayan peaks and valleys.
3. The Terai, a lowland where rivers from the Himalayas descend into the plains.
4. The plains of the Gangetic and Bhramaputra rivers.
5. Rajasthan's Thar Desert.
6. Gujarat, Maharashtra, Andra Pradesh, Karnataka, and Tamil Nadu have semi-arid grassland regions on the Deccan plateau.
7. India's Northeastern States,
8. Maharashtra, Karnataka, and Kerala's Western Ghats.
9. The islands of the Andaman and Nicobar Islands are number nine.
10. The lengthy western and eastern coastal strip, which includes sandy beaches, woodlands, and mangroves.

Value of Biodiversity

Environmental services provided by species and ecosystems are critical on a global, regional, and local scale. Important services include the production of oxygen, the reduction of carbon dioxide, the maintenance of the water cycle, and the protection of soil. The world is increasingly aware that biodiversity loss leads to global climate change. Forests are the primary mechanism for converting CO_2 into carbon and oxygen. The 'greenhouse effect' is exacerbated by the loss of forest cover, as well as the increased emission of gases such as carbon dioxide as a result of industrialisation. Global warming is floating ice caps, leading in a rise in sea level that would drown the world's low-lying communities. It is producing significant atmospheric changes, resulting in higher temperatures, severe droughts in some regions, and unexpected floods in others.Biological diversity is also necessary for the preservation of ecological processes such as nutrient fixation and recycling, soil formation, circulation and cleansing of air and water, global life support (plants absorb CO_2 and emit O_2), maintaining water balance within ecosystems, watershed protection, maintaining stream and river flows throughout the year, erosion control, and local flood reduction[1], [2].

Food, clothes, shelter, energy, and medicines are all resources that are directly or indirectly related to the biological diversity existing in the biosphere.This is particularly visible in tribal societies that gather forest resources or fisherfolk who capture fish in marine or freshwater habitats. Others, such as agricultural communities, exploit biodiversity to cultivate foods that are environmentally friendly. The majority of commodities and services used by urban societies are derived indirectly from natural ecosystems[3], [4].

It has become clear that the preservation of biological resources is critical for human well-being and long-term survival. This diversity of living species found in the wilderness, as well as in our crops and cattle, plays an important part in human ‘development. The preservation of 'biodiversity' is thus an essential component of any plan aimed at increasing the value of human existence.

Consumptive use value

Local communities' direct use of timber, food, fire wood, and fodder. The ecosystem's biodiversity supplies forest residents with all of their daily requirements, including food, construction materials, fodder, medicines, and a range of other items. They understand the properties and many applications of wood from various tree species, and they harvest a great variety of native fruits, roots, and plant material that they utilise as food, construction material, or medicine. Fishermen rely heavily on fish and know where to go to collect them, as well as other edible water creatures and plants.

Productive use value

The biotechnologist explores biorich environments to 'prospect' for prospective genetic traits in plants or animals that can be exploited to generate better crop types for farming and plantation operations, or to develop better livestock. Biological variety, according to the pharmacist, is the raw material from which novel medications may be identified from animal or plant sources. To industrialists, biodiversity provides a valuable resource for developing new goods. For agricultural scientists, biodiversity in crop plant wild relatives provides the foundation for generating superior crops.

With careful breeding, genetic variety allows scientists and farmers to generate superior crops and domestic animals. Initially, this was accomplished by intentionally selecting or fertilizing crops in order to obtain a more productive or disease-resistant type. Nowadays, this is progressively being accomplished through genetic engineering, which involves choosing genes from one plant and putting them into another. Biotechnology is being used to generate new crop types (cultivars) by using genetic material discovered in wild relatives of agricultural plants[5], [6].

Even now, new plant and animal species are being found in the wild. Hence, these wild species serve as the foundation for the advancement of human existence, and their extinction represents a significant economic loss to humanity. Just a small percentage of the known species have been studied for their food value, medicinal or economic potential.Whereas previous cultures with a limited population and less resources protected biodiversity as a life-sustaining resource, modern man has rapidly depleted it, even to the point of irreversible loss due to extinction of numerous species. Besides from the local consumption or sale of biodiversity goods, there is also the societal element, in which affluent civilizations utilise an increasing amount of resources. Traditional cultures that viewed biodiversity as a resource and recognised that its depletion would be a huge loss to their community have helped to conserve it to a large extent[6], [7].

Biodiversity's consumptive and productive worth is inextricably related to social problems in traditional societies. 'Ecosystem people' cherish biodiversity as a source of income as well as for cultural and religious reasons. Traditional agricultural methods grew a diverse range of crops, allowing a wide range of produce to be grown and distributed throughout the year and acting as insurance against crop failure. Farmers have recently begun to obtain economic incentives to plant cash crops for national or international markets rather than for local purposes. As a result, there are local food shortages, unemployment (cash crops are typically mechanised), landlessness, and greater vulnerability to drought and floods.

Ethical and moral values

The imperative of conserving all forms of life underpins ethical ideals connected to biodiversity protection. All kinds of life on Earth have the right to exist. Man is simply a minor member of the Earth's vast family of creatures. Don't plants and animals have the same right as humans to live and exist on our planet, which is essentially an inhabited spaceship?

Apart from the economic value of biodiversity conservation, there are various cultural, moral, and ethical considerations linked with the sacredness of all forms of life. Many generations of Indian culture have maintained nature through local customs. This has been an essential aspect of many of our nations' old thinking. In our country, tribal people have kept a vast number of holy groves or 'deorais' in different states. These holy forests, which surround old sacred places and temples, serve as wild plant gene banks.

Aesthetic value

Another incentive to maintain biodiversity is to gain knowledge and appreciation for its presence. It is essential as a tourist attraction, in addition to hunting wildlife for food. Biodiversity is a fantastic and beautiful part of nature. Listen to the birds while sitting in the woods. Watch a spider spin a sophisticated web. Look at a fish feeding. It's breath-taking and interesting.For thousands of years, symbols from wild creatures such as the Hindu lion, the Buddhist elephant, and deities such as Lord Ganesh, as well as the vehicles of various deities that are animals, have been worshipped. Valmiki opens his epic narrative with a couplet about a hunter accidentally killing a crane. For generations, the 'Tulsi' has been put at our doorway[8]–[10].

The worth of an option

Option value refers to keeping future possibilities open for utilisation. It is hard to foresee which of our species or conventional agricultural and domestic animal kinds will be extremely useful in the future. To continue improving crops and domestic livestock, we must return to crop plant and animal wild ancestors. Consequently, biodiversity preservation must include historic strains already present in crops and domestic animals.

Biodiversity at Global, National and Local Levels

There are about 1.8 million species recognised and catalogued by scientists worldwide. Scientists believe that the number of plant and animal species on Earth might range from 1.5 to 20 billion! As a result, the vast majority of species have yet to be found.The majority of the world's bio-rich nations are in the South, which are developing countries. In contrast, the vast majority of countries capable of utilising biodiversity are located in the Northern hemisphere, in the economically developed globe. Yet, these countries have low amounts of biodiversity.

Hence the industrialised world has come to endorse the view that biodiversity must be regarded to be a 'global resource'. But, if biodiversity is designated as a "common property resource" to be shared by all nations, there is no reason to rule out oil, uranium, or even intellectual and technological skills as global assets. India's sovereignty over its ecological variety cannot be jeopardised unless the world changes its mind about sharing all forms of natural resources.South American nations such as Brazil and South East Asian countries such as Malaysia and Indonesia have more diversities than India. Yet, the species found in these nations differ from ours. As a result, preserving our own biodiversity as a key economic resource is critical. While few other'mega diversity nations' have mastered the technology to utilise their species for biotechnology and genetic engineering, India can.The significance of biologically rich natural spaces is gradually being recognised across the world as unfathomable. Such locations are protected and supported by international agreements such as the World Heritage Convention. India has signed the treaty and designated numerous protected areas as World Heritage sites. They include Manas on the Bhutan-India border, Kaziranga in Assam, Bharatpur in Uttar Pradesh, Nandadevi in the Alps, and the Sunderbans in West Bengal's Ganges delta.India has also joined the Convention on International Trade in Endangered Species (CITES), which aims to decrease the use of endangered species of plants and animals by regulating trade in their products and in the pet trade.

India as a Mega Diversity Nation

Geological occurrences on India's landmass have created conditions for extraordinary levels of ecological diversity. Over 70 million years ago, a break in the one enormous continent resulted in the emergence of northern and southern continents, with India forming part of Gondwanaland - the southern landmass, along with Africa, Australia, and the Antarctic. Subsequent tectonic events moved India northward over the equator, bringing it into contact with the Northern Eurasian continent. As the intervening shallow Tethis Sea dried up, flora and animals from both Europe and the Far East came into India before the Himalayas formed. The final inflow came from Africa, with Ethiopian species suited to the Savannas and semi-arid environments.Hence, India's unique geographical location between three major centres of biological evolution and species radiation is responsible for our diverse biodiversity.

Among the biologically diverse nations, India ranks among the top 10 or 15 for the diversity of its flora and animals, most of which cannot be found elsewhere. India contains 350 distinct animal species (ranked ninth in the world), 1,200 bird species (ranked eighth in the world), 453 reptile species (ranked fifth in the world), and 45,000 plant species, the majority of which are angiosperms (fifteenth in the world). Ferns and orchids, in particular, have a high species variety (1022 species) (1082 species). In India, 50,000 insect species have been identified, including 13,000 butterflies and moths. The number of undiscovered species is thought to be several times larger.

Apart from the enormous variety of Indian wild flora and animals, there is also a wide range of produced crops and domestic cattle varieties. This is the outcome of several thousand years of civilizations growing and flourishing in the Indian subcontinent. Traditional cultivars comprised 30,000 to 50,000 kinds of rice, as well as a variety of cereals, vegetables, and fruits. Cultivar variety is greatest in the high rainfall areas of the Central Highlands, Eastern Ghats, Northern Himalayas, and North-Eastern highlands. Around 34,000 grains and 22,000 pulses cultivated in India have been gathered by gene banks. India contains 27 indigenous cow breeds, 40 sheep types, 22 goat breeds, and 8 buffalo breeds.

Hotspots of Biodiversity

The biodiversity of the Earth is divided into ecological zones. The earth has over a thousand main ecoregions. 200 of these are believed to be the richest, rarest, and most unusual natural places on the planet. These territories are known as the Global 200.It is believed that 50,000 endemic plants, accounting for 20% of global plant life, are found in only 18 'hot spots' throughout the planet. Mega diversity nations are countries that have a comparatively high share of these hotspots of diversity.The rate at which species are becoming extinct in our country remains unknown. That is quite likely to be exceedingly high, given our wilderness areas are fast diminishing. Our internationally recognised national "hot spots" include the forests of the North-East and the Western Ghats, which are among the world's most biodiverse locations. The Andaman and Nicobar Islands are highly rich in biodiversity, with several subspecies of various animals and birds evolving.

A considerable fraction of the endemic species, or those found exclusively in India, are concentrated in these three locations. The Andaman and Nicobar Islands alone include about 2200 blooming plant species and 120 fern species. The Northeast is home to 85 (63%) of India's 135 land mammal genera. There are 1,500 indigenous plant species in the Northeast. The Western Ghats are home to a large number of amphibian and reptile species, particularly snakes, as well as 1,500 indigenous plant species.Coral reefs encircle the Andaman and Nicobar Islands, the Lakshadweep Islands, and the Gulf regions of Gujarat and Tamil Nadu in Indian seas. They have almost as many species as tropical evergreen forests!

Threats to biodiversity

Most of these natural habitats are being overused or abused by humans. Because of this 'unsustainable' resource usage, previously fruitful woods and meadows have been transformed into deserts and wasteland across the planet. Mangroves have been destroyed for fuelwood and prawn farming, resulting in a reduction in the environment required for marine fish spawning. Wetlands have been drained in order to expand agricultural land. These changes will have serious economic consequences in the long run.

There are around 1.8 million species of plants and animals, both large and little, known to science today. Yet, the number of species is likely to be multiplied by at least ten. Plants, insects, and other kinds of life previously unknown to science are constantly being discovered in the world's 'hotspots' of variety. Regrettably, with the current pace of extinction, around 25% of the world's species will become extinct quite quickly. This might happen at a pace of 10 to 20 thousand species every year, which is a thousand to ten thousand times quicker than the natural rate! Human activity has the potential to eliminate 25% of the world's species within the next twenty or thirty years. Human population expansion, industrialisation, and changes in land-use patterns are all contributing to this mass extinction. Extinction rates will be highest in 'biorich' environments such as tropical forests, wetlands, and coral reefs. Rapid human population increase and short-term economic development are important factors to the fast worldwide degradation of biodiversity.

Human activity has so far had the greatest impact on island flora and fauna with high endemism in small isolated regions surrounded by sea, leading to the extinction of many island plants and animals (the dodo is a notable example). Man's introduction of organisms from one place into another also causes habitat loss, upsetting the equilibrium in existing ecosystems. Several native species have been wiped off as a result of intentionally or unintentionally imported organisms (Eupatorium, Lantana, Hyacinth, Congress grass, or Parthenium).

Species extinction happens as a result of the degradation of natural ecosystems, whether for conversion to agriculture or industry, over-extraction of their resources, or pollution of air, water, and soil. Forests and grasslands in India are constantly being converted to agricultural land. Encroachments have been frequently legalised. Similarly, natural wetland systems have been drained to make way for croplands, leading in the extinction of aquatic species. Grasslands that were formerly sustainably exploited by a relatively small number of humans and their cattle have either been converted to other uses or have been destroyed by overgrazing.

When excessive firewood is extracted from the forest by lopping tree branches, the forest canopy is opened up, affecting local biodiversity. Since seedlings are frequently trampled by foraging cattle, forest regrowth is slowed.

Human population growth on the outskirts of our Protected Areas degrades forest ecosystems. This is an important feature to consider when assessing the ecosystem's quality. Frequent fires caused by local grazers to boost grass growth eventually decrease regeneration and reduce plant species diversity. This burden cannot be reduced without alternative sources of feed.

Another issue threatening forest biodiversity is the introduction of exotic weeds that are not native to the area. In India, common examples are lantana plants, Eupatorium shrubs, and 'congress' grass. They have been brought from other countries and have infested significant areas of our natural woods. These weeds proliferate at the expense of indigenous undergrowth species. Though not well investigated, the influence on the diversity in insect, bird, and other animal species is extremely clear.

Many ancient agricultural practises have emerged in our nation over numerous generations

Two such techniques include slash and burn cultivation in the Himalayas and 'rab' cultivation in the Western Ghats, which involves the lopping of tree limbs to function as a wood-ash fertiliser. These were sustainable agricultural systems when the human population in these locations was minimal. Regrettably, these places now contain a huge population of people who rely heavily on forest agriculture. These practises are no longer viable and are contributing to the loss of forest biodiversity.Overfishing, particularly trawling, is causing major loss of fish supplies. Off the coast of Orissa, turtles are being slaughtered. A unique whale shark, a critically endangered species, is being slaughtered off the coastline of Gujarat.

Poaching: Particular dangers to certain species are associated with significant economic rewards. Tiger skin and bones, elephant ivory, rhino horns, and must deer scent are all widely utilised in other countries. Bears are slaughtered for their gallbladders. On the beaches of Chennai and Kanyakumari, corals and shells are also harvested for export or sale. A wide range of wild plants with true or doubtful medical benefit are being overharvested. Plants typically gathered include Rauvolfia, Nuxvomica, Datura, and others. Orchids, ferns, and moss are among the garden flora in this collection.

Endangered and Endemic Species of India

To appreciate India's rare and endangered species, it is necessary to first grasp the country's diverse plant and animal species. Among the well-known species, some are threatened by human activities. The country's endangered species are classified as Vulnerable, Rare, Indeterminate, and Threatened. Some species are only found in India, making them endemic or confined to our nation. A few of these may have a very limited range and are considered extremely endemic.Many species of plants and animals in the nation are currently restricted to only one or two Protected Areas. Among the most endangered animals include well-known species such as the tiger, elephant, and rhinoceros. The Indian wild ass, Hangul or Kashmir deer, Golden langur, pygmy hog, and a slew of others are among the lesser-known large animals isolated to a specific place. There are also some endangered bird species, including the Siberian crane, Great Indian Bustard, Florican, and various birds of prey. Vultures, which were widespread a decade ago, have recently vanished and are now critically endangered. Some reptile and amphibian species are also endangered. Numerous invertebrates, including many species that live on our coral reefs, are also endangered.Several plant species are becoming increasingly endangered as a result of changes in their ecosystems caused by human activities. Apart from big trees, shrubs, and climbers that are particularly habitat specific and hence endangered, habitat loss threatens thousands of tiny herbs. Many orchids are yet another threatened plant species.

Several plants are endangered by overharvesting as components in pharmaceuticals. The Wildlife Protection Act was enacted in India to safeguard endangered animals. This comprises listings of plants and animals classified by the threat to their survival. We know very little about our country's species variety. We know relatively little about a few of groups. Most of us are only aware of the situation of a few prominent huge mammals, but we must recognise the threat to lesser-known plant and animal species. We need to develop solutions to help future generations conserve our magnificent biodiversity.

Conservation of Biodiversity

Biodiversity at all levels, genetic species, and entire ecosystems can be best conserved in situ by reserving a sufficient representation of wildness as 'Protected Areas'. There should be a network of National Parks and Wildlife Sanctuaries, with each diverse habitat represented. A network like this would protect a region's whole diversity of life. Before, significant animal species such as tigers, lions, elephants, and deer were designated as national parks and sanctuaries in India. The goal of these regions should be increased to include the preservation of reasonably intact natural ecosystems where biological variety may be conserved, ranging from minuscule unicellular creatures and plants to huge trees and big mammals.

Therefore, species cannot be protected separately since they are all interdependent. As a result, the entire ecology must be safeguarded. The biologist's point of view is concerned with places that are relatively rich in species, or with uncommon, threatened, or endangered species, or with 'endemic' species that are not found elsewhere. Because rare genera are present only in a small region, they are easily wiped out by human activities. Such habitats must be given special consideration since their biodiversity is unique to the region. Elephants, for example, require different types of habitat to eat in at different times of the year.

They like open grasslands after rains because the fresh grass shoots are very nutritious. Once the meadows dry, the elephants travel into the forest to graze on tree leaves. A Reserved Area designed to safeguard elephants must thus be large enough and6 feature a varied range of habitat types to sustain a full complement of interconnected species.India's Wildlife Sanctuaries and National Parks: India has 589 Protected Areas, 89 of which are National Parks and 500 of which are Wildlife Sanctuaries. They contain a wide range of ecosystems and habitats. Some have been established to safeguard critically endangered species of wild flora and animals occurring nowhere else on the planet.

The Great Himalayan National Park is the greatest refuge in this environment and one of the last remaining habitats for the majestic snow leopard. Dachigam Sanctuary is the only area where you may see the endangered Hangul or Kashmir stag. There are various sanctuaries in the Terai region, the most notable of which being Kaziranga National Park, which features elephants, wild buffalo, gaur, wild boar, swamp deer, and hog deer in huge numbers, as well as tiger and leopard. It has a diverse bird population, including ducks, geese, pelicans, and storks. In addition to the Terai species mentioned above, the Manas Sanctuary is home to the extremely rare golden langur and the extremely uncommon pygmy hog, the world's smallest wild pig. The florican is exclusively found in a few untouched meadows in Terai reserves. There are numerous Protected Areas in Madhya Pradesh's sal woods. Kanha provides an excellent opportunity to watch wild tigers on the back of an elephant. It is the only Protected Area where a subspecies of Barasingha may be found.

Bharatpur is one of the world's most well-known aquatic bird sanctuaries. There are thousands of ducks, geese, herons, and some other wading species here. This is the sole habitat of the extremely rare Siberian crane, which migrates to India each winter. In the last two decades, the 30 or 40 Siberian cranes have been reduced to 2 or 3. Cranes were not sighted in 2002-3, and it is probable that this exquisite bird may never return to India.

The Thar Desert National Park protects wildlife in the Thar Desert. Several black buck, neelgai, and chinkara may be spotted here. These dry areas are home to the Great Indian Bustard. Until around 3 or 4 years ago, Ranthambor was the most well-known refuge for watching tigers in the wild. Poachers have killed several tigers since then. Elephant Project: Proj6ect Elephant was established in 1992 to secure the long-term survival of a sustainable elephant population in its native habitats in north and north eastern India, as well as in south India. It is now being adopted in 12 states. Despite this, our elephant populations are under jeopardy as their habitat shrinks and human activities hinder their migration pathways.

Undergraduate Environmental Studies Courses

The Great and Little Ranns of Kutch have been designated as sanctuaries to safeguard the extremely uncommon wild ass, flamingo, star tortoise, and desert fox. The Gir Sanctuary in Gujarat safeguards the sole remaining population of the beautiful Asiatic lion. Large herds of chital, sambhar, and nilgai live in this thorn and deciduous forest.The Western Ghats and its accompanying hill ranges are home to some of the most varied forest types in the country. The Malabar giant squirrel, the flying squirrel, and a variety of hill birds, as well as various species of amphibians, reptiles, and insects, are just a few examples of critically vulnerable species. These areas are also rich in indigenous plant life. In Maharashtra, sanctuaries like as Bhimashankar, Koyana, Chandoli, and Radhanagari retain this rich flora, as do Bandipur, Bhadra, Dandeli, Nagarhole, and others in Karnataka, and Eraviculum, Perambiculum, Periyar, and Silent Valley in Kerala.

The magnificent forest Sanctuaries of the Nilgiri Hills safeguard some of the remaining enclaves of Indian elephants in South India. Bandipur, Madhumalai, Wynad, and Bhadra are a few examples. During the previous decade, a huge proportion of this region's big tusker elephants have been cruelly slaughtered for their ivory. There are now relatively few of these wonderful creatures left in these forests.Chilka Lake and Cape Calimere are two notable sanctuaries dedicated to the protection of coastal habitats. The Sunderbans safeguard India's biggest mangrove delta. Gujarat's Marine National Park preserves shallow marine regions, islands, coral reefs, and vast mudflats. To protect the Andaman and Nicobar Islands' unique island ecosystems, over a hundred Protected Areas have been established.

The need for an Integrated Protected Area System (IPAS)

To be effective, Protected Areas must be developed in every biogeographic region. Very vulnerable ecosystems, places with high species diversity, or locations with high endemism must be represented in greater numbers. Protected Areas must also be connected with one another by creating corridors between nearby areas wherever feasible to allow species to travel between them.With a fast rising human demographic, it is difficult to set aside more and more territory to develop Reserved Areas in our country. The need to offer more land for agricultural and other purposes has been a growing source of concern in land and resource management. This is a significant hurdle to the establishment of additional Protected Areas.Having said that, there is an essential need to expand our Reserved Areas in order to conserve our extremely diverse biological richness. Most of the natural wildness has already changed dramatically.

Remaining regions with high levels of species diversity, endemism, or endangered flora and animals must be designated as National Parks and Wildlife Sanctuaries. Additional sites can be designated as Community Conserved Areas, which are administered by local residents.

According to the International Union for Conservation of Nature and Natural Resources, if biodiversity is to be protected in the long run, at least 10% of all ecosystems must be designated as Protected Areas. In 2004, India's 589 Protected Areas accounted for barely 5% of its total geographical area. Nevertheless, most of land comprises plantations of sal or teak, which were established for lumber in the past and hence have a low level of 'naturalness' and variety. Only a few excellent meadows remain in our nation that have been designated as Protected Areas. Some are topsoil erosion wastelands in locations where grasses formerly flourished.

Most of these locations have minimal biological value and require careful management to return to a more 'natural' condition with their full complement of flora and animals. Just a few wetlands have already been designated as National Parks. They necessitate improved management.A primary approach for reducing the consequences of the PAs on biodiversity should be to offer a sustainable supply of resources for the local people who live nearby. A Protected Area restricts their conventional grazing techniques as well as their access to fuelwood supplies. These resources must be made available by developing them in buffer zones. Fuel wood plantations and appropriate grassland management in regions outside Reserved Areas can assist lessen strain on wildlife habitat in the Conservation Area. Management must guarantee that the presence of the PA provides a tangible economic benefit to the local community.

Engaging local people in Protected Area administration and establishing visitor amenities that promote local revenue production helps to include their support for the Protected Area.An essential feature of PA management is a properly crafted management plan that includes a 'ecodevelopment' component aiming at providing a supply of fuel wood, fodder, and alternate income production for local residents. Outside of our present network of PAs, some plant and animal species live without protection. Because notifying additional PAs without impacting people's life is impractical, alternative measures such as Community Reserves or Community Conserved Areas must be developed. They should be managed by locals in order to conserve biodiversity while utilising the area's resources in an equitable and sustainable manner. A Community Constantly replenished Area must have specified conservation goals that may be met without jeopardising the area's utility.

Ex-situ conservation

The greatest way to conserve a species is to safeguard its natural habitat and all of the other species that reside there. This is known as in-situ conservation, which involves the preservation of a species in its natural habitat through the establishment of National Parks and Wildlife Sanctuaries. Nonetheless, there are times when an endangered species is so near to extinction that unless other measures are used, the species will be pushed to extinction. This method is known as ex-situ conservation, which means preserving a species outside of its native habitat in a highly regulated environment, like as a nature park for plants or a zoological park for animals, where experts may multiply the species under artificially managed conditions. Yet, administering a Protected Area is more expensive than breeding projects for rare flora and animals.

Another method of conserving a plant is to save its germ plasm in a gene bank so that it can be used in the future if necessary. This is considerably more costly. When an animal is on the verge of extinction, it must be carefully reproduced to prevent inbreeding from weakening the genetic makeup. Breeding with the exact same stock might result in poorly suited offspring or even the inability to produce enough offspring. Contemporary breeding operations are carried out in zoos that meet all of the animals' demands, including cages that mimic their natural environments.

There may also be a need to artificially aid breeding. While most zoos are designed to give visitors with a visual experience of seeing a wild animal up close as well as knowledge about the species, a contemporary zoo must go beyond these tasks by reproducing endangered animals as a conservation effort.

Ex situ conservation projects for all three of India's crocodile species have been successful. This has been a huge success. Another recent achievement was the breeding of the extremely uncommon pygmy hog at the Gauhati Zoo. The rare Manipur brow antlered deer has been successfully produced in the Delhi Zoo. The most crucial phase in a successful breeding effort, however, is the restoration of a species into its natural environment. This necessitates the rehabilitation of deteriorated habitat as well as the eradication of other reasons such as poaching, disturbance, or other man-made impacts that have been the major cause of the species' population decline.

Conservation of cultivars and livestock breeds:

Action of cultivars and livestock breeds: Until roughly 50 years ago, there were an estimated thirty thousand kinds of rice farmed in India. Just a couple of these are still farmed now. The germ plasm of these early forms of rice was used to generate the new varieties that are presently being grown all over the world. If all of the old types become extinct, it will be impossible to generate new disease-resistant rice varieties in the future. Many strains have been saved in gene banks. Nevertheless, this is both costly and unsafe. Helping farmers to cultivate numerous indigenous types is thus a crucial matter for humanity's future. There are currently about 34 thousand grains and 22 thousand pulses in gene bank collections.

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CHAPTER 9

LOSS OF BIODIVERSITY AND CAUSES

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Species extinction is a natural process that happens without human involvement since all species have a finite lifespan throughout geological time. Extinctions induced directly or indirectly by people are happening at a pace considerably above any acceptable estimate of background rates of extinction, and they must be growing to the degree that these extinctions are connected with habitat disruption. It is difficult to quantify species extinction rates, and it is hard to forecast future rates with precision.Documenting definitive species extinctions is only feasible under certain conditions, such as when a known species is easily observable and has a well-defined range that can be inspected regularly. Interestingly, the majority of known extinctions occur in species that are easy to record and inhabit areas that can be easily inventoried. The high number of extinct species on oceanic islands is not only a result of poor recordkeeping, but island species are more vulnerable to extinction as a result of human activity[1], [2].

The majority of global extinction rates are calculated by extrapolating observed and expected rates of habitat loss and estimates of species richness in various ecosystems.These two estimations are evaluated in light of an island biogeography principle that argues that the size of a region and its species complement have a predictable connection. Fewer species can survive in a number of tiny habitat pieces than in the original unfragmented environment, which can lead to species extinction. These estimations are fraught with uncertainty, and forecasts of present and future extinction rates should be evaluated with extreme caution. The quest of greater precision in estimating global extinction rates is unimportant. It is more crucial to appreciate in broad terms the extent to which unmonitored populations and species are vulnerable to fragmentation and extinction[3], [4].

In terms of overall global diversity, biodiversity loss in the form of domesticated animal breeds and plant varieties is minor, but genetic erosion in these populations is of particular human concern because it has implications for food supply and the sustainability of locally adapted agricultural practises.For the same reason, the loss of wild relatives of agricultural or wood species is of particular concern to domesticated populations. These genetic resources may not only underpin the productivity of local agricultural systems, but they may also provide the foundation for traits (disease resistance, nutritional value, hardiness, and so on) that are of global importance in intensive systems and will become even more important in the context of future climate change. The loss of variety in agricultural gene pools is difficult to quantify, but it may be measured indirectly by the rising share of world farmland devoted to high-yielding, but genetically homogenous, cultivars. Genetic modification of organisms, variations, or cultivars for food production, medicines, and other items, which has alarmed some governments but not others, may also contribute to biodiversity loss[5], [6].

Humans either actively eliminate species via hunting, collecting, and persecution, or indirectly through habitat loss and change. Overhunting is likely the most evident direct cause of animal extinction, although it is unquestionably far less important than the indirect effects of habitat alteration in terms of total biodiversity loss. Hunting selectively impacts the targeted species as well as plant and animal species whose populations are then influenced either adversely or positively, and hence has significant consequences for natural resource management. The same processes are likely to reduce genetic diversity in a hunted population. The genetic variety represented by agricultural plant or livestock populations is likewise expected to reduce as a result of mass production, as intended economies of scale need high levels of homogeneity[7], [8].

Persistent human activity will impact the relative abundance of species, perhaps leading to extinction in severe circumstances. This may occur as a consequence of the habitat becoming unsuitable for the species (e.g., clear-cutting of forests or severe pollution of rivers) or as a result of the habitat being fragmented (discussed earlier). Fragmentation is the process through which previously continuous populations of a species are divided into tiny sub-populations. If these are sufficiently modest, random processes result in increasing odds of extinction in a relatively short period of time. Changes in global temperature and weather patterns are expected to cause major changes in natural habitats during the next century. These will result in dramatically increased extinction rates.

Maintaining Biodiversity

The sustainable management of viable populations of species or populations in situ or ex situ is the preservation of biological diversity. The preservation of a large amount of the world's biological variety appears to be only possible by keeping organisms in their natural condition and within their present range. This enables for continued adaptability of wild populations through natural evolutionary processes and, in theory, the continuation of present use patterns. To be successful, such upkeep nearly always necessitates improved management through integrated, community-based protection of protected areas.

Conservation biologists have battled with the issue of biodiversity maintenance in extremely varied settings such as rain forests over the last thirty years. Analytical tools (neural-net models) that allow us to recreate previous distributions of forest types allow us to forecast past contractions and expansions of forest forms, as well as the chance of refugia surviving climatic change. Pollen samples from Brazil, for example, rejected modelling assumptions that savanna grasslands should have existed, whereas tropical and temperate forests were present. Some scholars have argued against the Pleistocene refugia concept (Haffer, 1969) for the Amazon area, citing evidence of a lack of rain forest fragmentation at that time period. There is a substantial association between diversity patterns and purported rain forest refugia in both species and genetic diversity in the biogeographical zones of the Australian wet tropics. Yet, rather than allopatric speciation in the Pleistocene, this appears to have been produced by variable extinction rates in various sized refugia. Others have underlined the need of focusing on the Pliocene or earlier, because most tropical species radiations happened before the Pleistocene[9], [10].

The local-determination theory of wildlife populations (Rosenzweig, 1995) has also been disputed, which expects comparable species diversity in similar settings. Net plant taxon diversification was substantially higher in Asia than those in North America for genera that are found on both continents. Deeper insights into the impacts of current ecology on an area's local diversity may be aided by evaluating the relative ages of clades, which might establish species proliferation rates between areas, thereby furthering the dispute over local vs regional diversity. They also used phylogenies of bird species to verify the taxon cycle theory, and discovered that older species' lineages had more restricted ranges, lower habitat breadth, and more fragmented distributions, and were closer to extinction than younger species.

In attempts to conserve biodiversity, conserving genetic dissimilarity is frequently a greater priority than retaining genes with significant similarity. Recent research indicates that genetic difference in mammals grows from the headwaters to the mouth as a river widens, creating a stronger barrier among populations on different banks; this impact promotes species variety through allopatric speciation. The phylogeny of headwater species is basic, and shared haplotypes exist exclusively in the headwaters; this discovery contributes to Wallace's riverine diversification theory in the Amazon basin.

What geographical regions to conserve in order to sustain the most biological variety is a major question in the design of effective conservation projects. Myers originated the term biodiversity hotspot, which most usually refers to areas of high species richness. GAP analysis is used to find gaps in existing protected area networks; it use algorithms to pick the smallest number of grid cells that include unprotected species. Balmford and Long employed rarity and endemicity to establish hotspots in bird conservation, while species richness and endemism were used to rank nations. Hotspots are sometimes characterised as places having the highest concentration of endangered species.

For determining conservation priorities, it is assumed that indicator groups (for example, birds, animals, and plants) are strong predictors of biological diversity in general. Another concern is how to best interpret biodiversity data in order to produce reliable and meaningful studies that will influence conservation choices. On a wide scale, there is some agreement between avian diversity across continents and insect diversity, as well as endemism patterns among species; however, at a smaller geographic scale, this agreement begins to break down. The richness of genera and families is an excellent predictor of the richness of species at a finer level.Unfortunately, species richness is not an effective indicator for identifying conservation hotspots since it excludes uncommon species, however as the sample region for hotspots expands, more rare species are included as a simple function of arithmetic progression. Rarity and endemicity are efficient indices for picking the fewest number of locations, but they are less beneficial in identifying conservation objectives when compared to complementarity criteria.

Complementarity is an excellent conservation measure in which the species complement of a reserve or region is recognised and then additional sites that contribute the largest number of new species are sought; this is similar to the portfolio strategy. Another strategy for selecting the best choice of sites is restricted to short datasets and does not yield the highest conservation gain for the fewest extra sites. Obviously, integrating an ecological portfolio strategy with an assessment of richness or endemism would be useful, but different methodologies are required depending on the conservation aim and data availability.

Classifying Biodiversity

There are two schools of thought on biodiversity: those who think it is a state and those who feel it is a measure of the state. Most writers describe biodiversity as a condition or characteristic. Some definitions of biodiversity restricted the attribute's scope to explicit, measurable dimensions or metrics, such as "biodiversity is the quantity or "the number and relative abundance. This focus on quantitative, operational definitions of biodiversity (as well as critiques of non-quantitative definitions) may indicate a future change in the term's categorization from an attribute to a measure of an attribute.

Biodiversity Characteristics

Another approach to define a phrase is to enumerate its traits, attributes, qualities, and pieces. Noss (1990) identified three key characteristics of biodiversity: composition, organisation, and function.The identity and richness of biotic components, as well as the relative quantity (e.g., abundance, cover, biomass), are addressed in composition. Genes, organisms, family units, populations, age classes, species and other taxonomic categories, trophic levels of animals (e.g., herbivores, predators), animal guilds and assemblages, plant communities, and interacting assemblages of plants, animals, and microorganisms are all biotic components of ecosystems (i.e., biotic communities).

The many vertical and horizontal components of a community or landscape, as well as the organisational levels of plant and animal populations and assemblages, are referred to as structural features of biodiversity. Horizontal structure in a landscape consists of the size, form, spatial arrangement, and juxtaposition of distinct plant communities; vertical structure consists of the leaf density and height of different vegetation layers (Noss, 1990). Population, age, and trophic structure, as well as other layers of community organisation, may all be referred to as structure.

The addition of structure in the definition of biodiversity creates connections with other concepts such as habitat diversity and the plant community idea, for both of which vegetation structure is a key distinguishing factor. Most definitions of biodiversity may have omitted structure since the term came from the concept of ecological diversity, which largely focused on species variety. Curiously, it was argued 20 years ago that assessments of diversity should not exclude structural diversity, despite the fact that the word is most often employed in connection to species diversity. Variety may also relate to the breadth of niches and the structural complexity of ecosystems. Herbivory, predation, parasitism, mortality, production, vegetative succession, nutrient cycling and energy transfer via biotic communities, colonisation and extinction, genetic drift, and mutation comprise the third component of biodiversity. Biotic 388 the identity and quantity of distinct kinds of processes, as well as the rate, at which each process works, may be addressed in terms of Biodiversity, Definition Of Processes.

Several biogeographic scales exhibit diversity of biotic components and processes, ranging from microsites and larger-scale landscape features to regional landscapes, biomes, continents, hemispheres, and the whole biosphere. While these are sizes at which biodiversity may be seen, they are not necessarily biodiversity scales since many of them incorporate abiotic (e.g., geological) aspects. Individual organisms, populations, species, and assemblages (e.g., guilds and plant communities) may also be seen at numerous organism-based scales, as can biogeographical scales.

Biological Resource Asset and Management Objectives

The contextual changes in biodiversity definition are determined by the usage of the biological resource asset (or bioasset), and hence the asset management purpose. Biological resource values include direct and indirect use, as well as choice and non-use values.

They may be further categorised for the purposes of analysing prospective application as follows:

Values of principal extractive products for direct use. In the case of terrestrial and marine systems, this would primarily involve forestry for wood and commercial fishing. Large non-local enterprises often spend heavily in capital equipment to extract these goods, which are then transported and marketed in well-developed markets distant from their original source.

These are naturally or semi-naturally occurring items that need labour-intensive collecting or harvesting operations, which are often performed by locals. Rattan, fuelwood, seaweed, wild foods, specialty fisheries, aquarium fish, and therapeutic plants are among examples. They may be gathered for sale, barter, or personal consumption.

Direct usage values need just a tiny quantity of biological material to be extracted for ex situ investigation or storage. Extraction of material to biological inventories, germplasm banks, and industrial research is included. Extraction is often carried out during short or extended expeditions that cover broad regions in order to obtain representative samples of biological material.

Non-extractive direct use values that often need significant on-site involvement of the user with the resource. This includes ecotourism, leisure, on-site research, and other key "non-consumptive" activities that take place primarily in protected areas. These events are distinguished by the need to provide participants with food, accommodation, and transportation.

Indirect usage values accumulated on-site. The key characteristic of these values is that they support or safeguard the fundamental operation of the protected area. Nutrient cycling, soil stability in erosion-prone locations, coastal zone stabilisation, and biological support to local ecosystems are some examples. Because of their nature, the value of these on-site operations is likely to be a component of all of the area's other direct and non-use values.

Indirect usage values that accumulate away from the location. The value of these functions, such as watershed protection, natural ecosystems protected as national parks in generating income from tourism activities, protection of fisheries' nurseries and subsistence fisheries, and climate regulation, may be very large or very small, depending on their relative importance in supporting or protecting off-site economic activity.

The values of the options. While option values may be connected with any use value, they are examined only when they have the potential to be significant in association with a certain kind of product or service. Values that are not in use. Some values, such as stewardship, ethics, cultural belief, and aesthetics, occur at a distance from the resource and need no extraction or physical engagement with the resource by definition.

The preceding numbers are only tangentially connected to biological diversity. That is, a certain degree of species richness is necessary for these tasks, but there is not always a straight relationship between ecological value and variety. Consequently, whereas mangrove ecosystems have significantly less variety than nearby lowland terrestrial forests, they are expected to be of equivalent value in terms of resources. The savannas of eastern and southern Africa, which are important for tourist income generation, are less diversified than the wet forests of same nations, which have significantly less tourism potential.

The Precautionary Principle

Humans now utilise a comparatively tiny fraction of the world's biological variety. There are several more possible, but unexplored, optional, and nonuser benefits of biodiversity. These characteristics encourage a cautious approach to biological diversity preservation. In this scenario, the precautionary principle contends that efforts should be done to avoid additional biodiversity loss and possibly irreversible effects before all biological concerns are addressed. Yet, in order to conserve biodiversity, the predicted costs of protecting and maintaining it must surpass any potential benefits.

If species are to be treated as a resource and their maintenance to be cost-effective, conservation should focus on species-rich systems and places, as well as species known to be helpful or thought to have a high possibility of being beneficial. Hence, biodiversity and its protection would be determined only on the basis of operational or cost-benefit considerations. This bioasset viewpoint on biodiversity would therefore be based on economic rather than biological grounds.

Biodiversity has been noted as being vital for ecosystem health, medical benefit, agricultural reasons, as well as aesthetic and recreational value. According to Noss (1990), an operational definition is one that is sensitive to real-world management and regulatory concerns, and such a definition is unlikely to be found for biodiversity. In a similar vein, Angermeier (1994) mentioned an operational definition, while Hunter (1996) indicated that a quantitative definition is required for monitoring biodiversity and establishing management strategies. Other scholars, on the other hand, argue that the mismatch between the two aspects is largely too responsible for the uncertainty regarding how biodiversity notions may be actually applied.

Implications of Variations in the Definition

The requirement for an unambiguous and exact definition of biodiversity that is scientifically sound and globally applicable is crucial for guiding the creation of future policies and programmes, as well as making key choices in the present. Such a definition does not yet exist. As a notion, biodiversity is simultaneously widespread and beneficial, specific and perplexing; as a result, it is regularly reinterpreted on practically every occasion. One of the numerous reasons for this state of things is that the definition of biodiversity influences national and regional research and conservation management aims, as well as international financing priorities. A timber extraction or non-timber forest product programme that conserves species richness (i.e., the number of species) at the price of genetic diversity might be readily promoted. Likewise, a present research initiative aimed at stimulating or expanding the range of tropical tree species not already traded in order to relieve pressure on over-exploited species may be erroneous. As foresters increase the number of species they take and pick only the best and most mature individuals, they may remove the most productive and healthiest genetic stock, which may lead to greater genetic as well as species poverty.

Apart from the previously discussed principal definitions of biodiversity, such as the highest number of species (i.e., species richness) and the highest level of species endemicity (called critical faunas analysis), interpretations of pure or applied definitions are becoming more common within the vocabulary of conservation and biodiversity utilisation when determining biodiversity management priorities. National biodiversity programmes that maintain "biodiversity portfolios" are examples; biodiversity defined as flagship or keystone species diversity is another; viability modelling (population viability analysis) defining the species' populations to be prioritised is another; population analysis defining sustainability and thus defining a species' status is another; and projects that focus on the feasibility of integrating the targeted species, assemblages, or ecosystems with the needs of local hum Although a country's conservation policy may be driven by more pressing needs such as family planning, education, politics, internal conflict, financial planning and investment, and individual vested interests, current policy and decisions are also based on the aforementioned biodiversity bases rather than strict academic lines. Endemicity and species richness are helpful beginning points for setting global priorities, but the urgency of a specific conservation intervention cannot be appraised without knowledge on the likelihood of extinction obtained by viability modelling or population analysis.

Moreover, with an increased focus on integrating local people into conservation efforts to save long-term expenditures and offer a more permanent foundation for people and their natural environment, the potential for 390 The importance of biodiversity for community-based conservation and sustainable usage cannot be overstated. Since most projects would need national or foreign finance, the ecological value of a region in comparison to others using an ecosystem diversity (or portfolio) approach will be a crucial selection factor.The existence of a flagship or keystone species will also help to raise cash. Obviously, political expediency or sheer chance may enter the picture, and scientists have yet to clarify whether genetic diversity should be employed as the primary metric. In the lack of viable means for assessing these biodiversity features, they must remain speculative goals for the time being.

The many methods to biodiversity conservation recommended are not only dictated by the available techniques, but are also indicative of the underlying beliefs. The evolutionary method is mostly the domain of biologists, and it is concerned with the preservation of variety as an unqualified goal unfettered by economics. The necessity for conservation and the applications of biodiversity the resource-based argument are used to "sell" the idea to decision-makers and policymakers. The objective of ecological sustainability and the conservation strategies for attaining it will be attainable when these components come together. Since the term biodiversity has become so officially invested, its meaning will continue to play an important role in conservation planning and public policy.

Value of Biodiversity

The business usefulness, ecological services, social и aesthetic worth of biodiversity are considerable. Innumerable ways, we gain from other creatures. Sometimes we comprehend and appreciate the worth of an organism only after it has died. A very little, inconsequential, and seemingly worthless creature may serve a critical function in the ecological balance of the environment or be a possible source of some vital treatment for terrible illnesses such as cancer or AIDS. McNeely et al. in 1990 defined the numerous applications of biodiversity or biodiversity value as follows:

Consumptive use value:

These are direct use values for biodiversity products that can be gathered and eaten directly, for example, fuel, food, pharmaceuticals, fibre, and so forth.

Food:

Humans eat a wide variety of wild plants as food. Around 80,000 edible plant species have been identified in the wild. Around 90% of today's food crops have been domesticated from wild tropical plants. Even today, our agricultural experts employ existing wild plant species that are closely related to our crop plants to generate new resilient strains. Wild cousins are often more tolerable and hardy. A significant number of wild animals provide us with sustenance.

Medicines and medicines:

Plants or plant extracts are used to treat around 75% of the world's population. Penicillin, a wonder medication used as an antibiotic, is produced from the fungus Penicillium. Tetracyclin is also derived from bacteria. Quinine, a malaria treatment, is derived from the bark of the Cinchona tree, while Digitalin, a heart-healthy remedy, is derived from the foxglove (Digitalis). Recently, two anticancer medicines, vinblastin and vincristine, were isolated from the Periwinkle (Catharanthus) plant.

It contains anticancer alkaloids

Several marine species are thought to have anti-cancer qualities that have yet to be thoroughly investigated.

Fuel: For centuries, our woods have been utilised for fuel wood. Coal, petroleum, and natural gas are all petrified results of biodiversity. Individually harvested firewood is not often sold, but rather eaten directly by tribals and local people, and hence comes under the category of consumptive value.

Values of productive use: These are the values that may be used commercially when the product is advertised and sold. It might contain timber or wild gene resources that scientists can employ to introduce desired qualities into crops and domesticated animals. Animal items such as elephant tusks, musk from musk deer, silk from silkworm, wool from sheep, fir from numerous animals, lac from lac insects, and so on are all exchanged in the market. Several businesses rely on biodiversity's productive use values, such as the paper and pulp industry, plywood industry, railway sleeper industry, silk industry, textile industry, ivory-works, leather industry, pearl industry, and so on.

Despite an international restriction on trading in goods derived from endangered species, smuggled fur, skin, horns, tusks, live specimens, and other items worth millions of dollars are traded each year. The greatest biodiversity hubs are developing nations in Asia, Africa, and South America, and wild life items are smuggled and sold in enormous numbers to certain wealthier western countries, as well as China and Hong Kong, where export of cat skins and snake skins is a thriving industry.

Social Values: These are values related with people's social lives, conventions, religion, and psycho-spiritual components. Several plants, such as Tulsi (holy basil), Peepal, Mango, Lotus, and Bael, are regarded holy and sacred in our land. These plants' leaves, fruits, or blooms are utilised in worship, or the plant itself is venerated. The indigenous people are inextricably related to the forest's natural life.

Their social lives, music, dances, and rituals are all centred on the animals. Several animals, such as the cow, snake, bull, peacock, and owl, have a vital role in our psycho-spiritual arena and so have specific social significance. Consequently, biodiversity has various social values in different communities.

Ethical value: This is also called as existence value at times

It raises ethical concerns, such as the preservation of all life. It is founded on the philosophy of Live and Let Live. If our species is to survive, we must safeguard all biodiversity, since biodiversity is vital. The ethical value implies that we may or may not utilise a species, but just knowing that it exists in nature provides us pleasure. When we find that a passenger pegion or dodo is no longer alive, we all feel sad. We are not directly getting anything from the kangaroo, zebra, or giraffe, but we all believe that these animals should live in nature. This suggests that each species has an ethical worth or an existence value.

Aesthetic worth: The aesthetic value of biodiversity is high. Nobody wants to see wide areas of desolate country devoid of visible life. People travel long distances and pay a lot of money to visit wilderness regions where they can appreciate the aesthetic value of biodiversity, and this sort of tourism is now known as eco-tourism. The idea of willingness to pay for such eco-tourism provides us with a monetary approximation for the aesthetic worth of biodiversity.Ecotourism is predicted to produce around $12 billion in income each year, almost equivalent to the aesthetic value of biodiversity.

Option values: These are the biodiversity potentials that are currently unknown and must be researched. There is a chance that a possible treatment for AIDS or cancer exists in the depths of a marine habitat or a tropical jungle. So, the benefit of knowing that there are biological resources on this biosphere that may one day prove to be an effective alternative for anything essential in the future is known as option value. Hence, the choice value of biodiversity implies that any species may eventually prove to be a miracle species. Biodiversity is like a valuable gift from nature given to humans. We must not make the mistake of losing these gifts before even opening them. The choice value also includes the value of visiting locations with a diverse flora and fauna, or especially certain endemic, uncommon, or endangered species.

Ecosystem service value:

A non-consumptive use value connected to ecosystem self-maintenance and numerous key ecosystem services has recently been acknowledged. It refers to ecosystem services such as soil erosion prevention, flood prevention, soil fertility maintenance, nutrient cycling, nitrogen fixation, water cycling, and their function as carbon sinks, pollution absorption, and mitigation of the hazard of global warming, among others. Various types of biodiversity value clearly show that ecosystems, species, and genetic variety all have immense potential, and that a fall in biodiversity would result in massive economic, ecological, and socio-cultural losses.

Global Biodiversity

During the Rio de Janeiro Earth Summit, it became clear that there is a rising need to know and scientifically identify the vast majority of species that are currently unknown on our planet. Around 1.5 million species are reported to date, which is either 15% or 2% of the total amount. Every year, tropical deforestation reduces biodiversity by half a percent. Mapping biodiversity has therefore been correctly identified as an emergency effort in order to plan its protection and practical application in a prudent way.

The earth's terrestrial biodiversity is best defined as biomes, which are the major biological units found in various geographic locations and are called for the dominating flora, such as tropical rainforests, tall grass prairies, savannas, deserts, tundra, and so on. Millions of species of plants, birds, animals, insects, and mammals live in the tropical rainforests. They are the world's biggest repository of biodiversity. Several of these species evolved in highly specialised niches throughout time, making them more susceptible to extinction once their native habitat or niche is lost. These rainforests contain between 50 and 80% of the world's biodiversity. More than one-fourth of the world's prescription medications are derived from tropical forest plants. 70% of the 3000 plants identified as sources of cancer Biodiversity and its Conservation 105 fighting compounds by the National Cancer Research Institute came from tropical rain forests. Recently, an extract from one of Cameroon's creeping vines was shown to be efficient in inhibiting the reproduction of the AIDS virus. It is worth noting that the ordinary Neem tree, so widespread in tropical India and recognised for its therapeutic virtues, has recently gained popularity in western temperate nations.

Tropical woods are home to an estimated 1,25,000 blooming plant species. Nevertheless, we only know only 1-3% of these species. Needless to say, we must do all possible to conserve our tropical rainforests. The Quiet Valley in Kerala is India's sole tropical rain forest location. You may remember the Silent Valley Hydropower Project, which was scrapped mostly because it threatened our sole tropical rain forest species. Temperate woods contain substantially less richness, but the species are much well documented. Worldwide, over 1,70,000 flowering plants, 30,000 vertebrates, and approximately 2,50,000 additional groupings of species have been described. The challenge of characterising the remaining species, which might number anywhere from 8 million to 100 million, is enormous. It is fascinating to note that marine biodiversity is much greater than terrestrial biodiversity, despite the fact that it is still less recognised and characterised. The biological variety of estuaries, coastal seas, and oceans is astounding. The sea is the cradle of all known animal phyla. 34 of the 35 known phyla of multicellular creatures are marine, with 16 being entirely marine.

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CHAPTER 10

HOT SPOTS ANDCONFLICTS BETWEEN MAN AND WILDLIFE

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Hot spots of biodiversity are areas with a high species richness as well as a high species endemism. Myers popularised the word (1988). On a worldwide scale, there are 25 such biodiversity hotspots, two of which are found in India, namely the Eastern Himalayas and the Western Ghats. These hotspots, which occupy less than 2% of the world's land surface, have been determined to hold around 50% of the terrestrial biodiversity. According to Myers et al. (2000), a hotspot is defined as having at least 0.5% of its plant species as endemic.In these hotspots, around 40% of terrestrial plant species and 25% of vertebrate species are endemic. The Mediterranean has the second largest number of indigenous plant species after the tropical rain forests (Mittermeier). These hotspots are mostly found in the Western Amazon, Madagascar, North and East Borneo, North Eastern Australia, West Africa, and the Brazilian Atlantic forests. These are locations with significant variety and endemism that are also endangered by human activity. More than a billion people (about one-sixth of the world's population) reside in these places, the vast majority of whom are impoverished. Any actions to safeguard these hotspots must take into account human settlements and tribal problems. Previously, 12 worldwide hotspots were discovered. Myers et al. (2000) later identified 25 hot sites, two of these hotspots are located in India and extend into neighbouring countries: the Indo-Burma area (encompassing the Eastern Himalayas) and the Western Ghats-Sri Lanka region. Indian hotspots are not only rich in floral diversity and rare plant species, but also in reptiles, amphibians, swallow-tailed butterflies, and certain mammals[1], [2].

Eastern Himalayas: They have a highly diversified terrain that encourages species diversity and endemism. Sikkim has several deep and semi-isolated valleys that are exceptionally rich in indigenous plant species. Sikkim has over 4250 plant species, 60% of which are indigenous, spread across an area of 7298 Km2.

The Eastern Himalayas' forest cover has shrunk to around one-third of its original extent. Some species, such as the parasitic angiosperm Sapria himalayana, have only been seen twice in this area in the previous 70 years. According to recent research, North East India, together with its adjoining territories of Burma and the Chinese provinces of Yunnan and Schezwan, is a dynamic hub of organic development and the birthplace of flowering plants. 30% of the world's documented flora is native to India, with 35,000 of them found in the Himalayas.

Western Ghats: It is a 17,000 km2 forest strip across Maharashtra, Karnataka, Tamil Nadu, and Kerala that contains 40% of all indigenous plant species. The Western Ghats are home to 62% of all amphibians and 50% of all lizards. Forest tracts up to 500 m elevation, which occupy 20% of the forest area, are evergreen, whereas those between 500 and 1500 m are semievergreen. Agastyamalai Hills and Silent Valleythe New Amambalam Reserve Basin are the key diversity hotspots. According to reports, just 6.8% of the original woods remain now, while the rest have been deforested or destroyed, which is reason for considerable concern since it implies we have already lost a significant percentage of the biodiversity. While the hotspots are distinguished by endemism, a few species are shared by both hotspots in India.

Ternstroemia japonica, Rhododendron, and Hypericum are among the common flora, while the common fauna includes the laughing thrush, Fairy blue bird, lizard hawk, and others, suggesting their same geological origin[3], [4].

Threats to Biodiversity

Extinction The extinction of a species is a normal evolutionary process. The world has undergone cataclysmic extinctions throughout its geologic history. Species have died out and been replaced by others throughout evolution. Yet, considering the huge expanse of time spanning 444 million years, the pace of species extinction in the ancient past has been a sluggish process. Extinction has grown especially rapid in recent years of human civilisation. The human effect on the environment has been so severe in this century that thousands of species and types are being extinct on an annual basis. According to E.O. Wilson, a prominent biologist, the rate of extinction is 10,000 species every year, or 27 per day! This astonishing statistic raises concerns about the significant harm to biodiversity. The pace of extinction has increased considerably during the past 150 years. If current trends continue, we will lose one-third to two-thirds of our existing biodiversity by the middle of the twenty-first century.

Loss of Habitat

The single most important cause of biodiversity loss is the destruction and loss of natural habitat. During the last 10,000 years, billions of hectares of forest and grassland have been destroyed for conversion to agriculture, pastures, residential areas, or construction projects. Many of species died as a result of the loss of their natural habitat in these natural woods and grasslands. Wetlands have suffered severe harm due to the misconception that they are worthless ecosystems. Now, the distinctive rich biodiversity of wetlands, estuaries, and mangroves is under the most severe danger. Wetlands are being destroyed as a result of draining, filling, and pollution, resulting in massive biodiversity loss. Habitat fragmentation occurs when habitat is lost in stages, causing the habitat to be fragmented into tiny and dispersed parts. Many wild animals, such as bears and huge cats, need extensive territory to survive. They are severely endangered since they exclusively reproduce in the interiors of the woods. Several songbirds are becoming extinct as a result of habitat fragmentation.

Tropical forests are also rapidly disappearing in our nation, at a pace of roughly 0.6% each year. At present rates of forest habitat loss, it is projected that 20-25% of the world's flora will be destroyed within a few years. Human activity is also threatening marine biodiversity by destroying the delicate breeding and feeding sites of our oceanic aquatic life on a vast scale[5], [6].

Poaching

Another harm to wildlife is the drug activity of wildlife items obtained by killing forbidden endangered species, sometimes known as poaching. Notwithstanding an international restriction on commerce in goods derived from endangered species, animal items such as furs, skins, horns, tusks, live specimens, and herbal preparations are smuggled. Continues to be worth millions of dollars every year. The emerging countries of Asia, South America, and Africa are the greatest sources of biodiversity and animals. The wealthy nations of Europe and North America, as well as several prosperous Asian countries such as Japan, Taiwan, and Hong Kong, are the biggest importers of wild life goods or wild life itself. The trade in such wild life items is very profitable for poachers who simply hunt these forbidden animals and transport them to other nations through a mafia. Elephant tusks may cost up to $100 per kilogramme; a leopard fur garment can cost up to $100,000 in Japan; and bird catchers can earn up to $10,000 for a rare hyacinth macaw, a gorgeous coloured bird from Brazil. The worst aspect of the tale is that for every live chicken that enters the market, around 50 other animals are captured and slaughtered. If you want to collect unique flora, fish, or birds, make sure you don't go for endangered or wild-caught species. This will assist to prevent future decrease of these species. Likewise, do not buy a fur coat, handbag, or bag, or anything made of crocodile or python skin. You will undoubtedly contribute to the preservation of biodiversity by doing so.

Conflicts between Man and Wildlife

We spoke about how important it is to conserve and protect our animals. But, there are occasions when wildlife causes enormous harm and danger to humans, and it becomes very difficult for the forest department to appease the injured villages and garner local support for animal protection. Cases of man-animal conflict continue to emerge in numerous areas throughout our nation. Elephants have murdered 195 people in Sambalpur, Orissa, in the previous five years. In revenge, the villagers slaughtered 98 elephants and severely wounded 30 others. Several instances of killing of elephants in the border regions of Kote-Chamarajanagar belt in Mysore have been reported recently. The man-elephant conflict in this area arose as a result of elephants wreaking havoc on farmers' cotton and sugarcane crops. The distressed locals electrocute the elephants and occasionally conceal explosives in the sugarcane fields, which detonate when the elephants enter. Locals, in fact, murder more people than poachers. In early 2004, a man-eating tiger was alleged to have killed 16 Nepalese individuals and one four-year-old kid within the Royal Chitwan National Park[7], [8].

National Park located 240 kilometres south-west of Kathmandu. The Park, which is known for its animal conservation efforts, has turned into a horror zone for the inhabitants. Such contradicting scenarios have been observed from the border areas of our country's Corbett, Dudhwa, Palamau, and Ranthambore National Parks. In June 2004, two persons were murdered by leopards in Powai, Mumbai. The leopards from the Sanjay Gandhi National Park in Mumbai have murdered 14 people in 19 incidents since January, causing alarm among local residents.

Man-animal conflict causes include

The following are the underlying reasons of these conflicts:

Due to dwindling forest cover, tigers, elephants, rhinos, and bears are forced to travel outside the forest and attack people or other animals. Human expansion into forest regions causes conflict between humans and animals, maybe because it is a matter of survival for both. Animals that are sick, weak, or wounded have a proclivity to attack humans. In addition, if the mother tigress believes her newborn cubs are in danger, she will attack the human. The major issue is that once a tiger has tasted human flesh, it will not eat any other animal.

At the same time, tracking and culling the man-eating tiger is very tough, and many innocent tigers are killed in the process. Before, when bamboo leaves, elephants' favourite staple food, were unavailable, forest departments would produce paddy, sugarcane, and other crops inside the sanctuaries. Animals are now leaving the forest in search of food owing to a lack of such techniques. It should be remembered that an adult elephant requires 2 quintals of green feed and 150 kg of clean water each day, and if they are not available, the animal would wander.

The people often install electric wire around their ripe agricultural fields. Elephants get harmed, suffer in anguish, and become angry. Formerly, there were wild-life corridors by which wild animals would move periodically in groups to neighbouring locations. The route of wildlife has been disturbed due to the construction of human settlements in these corridors, and the animals have attacked the towns.

The monetary compensation that the government provides in lieu of agricultural loss is insufficient. A farmer in Mysore receives Rs. 400/- per quintal of estimated production, whereas the market price is Rs. 2400/- per quintal[9], [10].

Remedial Measures to Curb the Conflict

1. The Tiger Conservation Project (TCP) has made plans to make cars, tranquillizer guns, binoculars, and radio sets, among other things, ready to cope with any impending risk.
2. An adequate crop compensation and livestock compensation programme, as well as considerable financial compensation for human life loss, must be established.
3. Solar-powered fence, as well as electric current-proof ditches, should be installed to keep animals from wandering into fields.
4. Cropping patterns along forest boundaries should be modified, and appropriate food, fruit, and water should be made accessible to elephants inside forest zones.
5. Wildlife corridors should be established to allow large animals to migrate in large numbers under adverse weather conditions. Elephant corridors need around 300 km2 of land for their seasonal travel.
6. During the months of April and May at Similipal Sanctuary, Orissa, there is a ceremony of wild animal hunting in which the forest is burned to flush out the animals. People's huge hunting has reduced tiger prey, causing them to emerge from the jungle in search of food. There is now a WWF-TCP effort in Orissa to end the Akhand Shikar ceremony.

Endangered Species of India6

The International Union for the Conservation of Nature and Natural Resources (IUCN) produces the Red Data Book, which contains a list of endangered plant and animal species. The red data is a warning signal for endangered species that, if not protected, are likely to go extinct in the near future. Over 450 plant species in India have been listed as endangered, threatened, or unusual. An estimated 150 animals and 150 bird species are threatened, while an unknown number of bug species are endangered. It may not be directly relevant here to provide a comprehensive list of our country's endangered flora and animals.

Endemic Species of India

Since India has two biodiversity hotspots, it contains a considerable number of endemic species. Around 7000 of our country's 47,000 plant species are indigenous. Consequently, the Indian subcontinent includes around 62% indigenous flora, which is mostly limited to the Himalayas, Khasi Hills, and Western Ghats. Orchids and species such as Sapria himalayana, Uvaria lurida, Nepenthes khasiana, Pedicularis perroter, and others are among the notable indigenous flora. Plate V depicts several indigenous plant species.A huge proportion of our country's 81,000 animal species are indigenous. The Western Ghats are especially rich in amphibians (frogs, toads, and so forth) and reptiles (lizards, crocodiles etc.). The Western Ghats are home to 62% of all amphibians and 50% of all lizards. Among of our country's most significant endemic species are monitor lizards (Varanus), reticulated pythons, Indian Salamanders, and Viviparous toads (Nectophryne).

Biodiversity matter

Since biodiversity supplies food for people, it serves as the basis for all of our food industry and associated services. This food comes in the shape of vegetables, fruit, nuts, meat, and food additives such as food colourants, flavouring, and preservatives. These can come from either wild or cultivated sources, but for the vast majority of the world's population, the latter is obviously more prevalent in 1997, global agriculture provided 95% of all plant and animal protein and 99% of all energy consumed by humans; United Nations Development Programme et al. 2000. Agriculture's development and subsequent advances allowed the human population to grow from a worldwide total of probably 4 million hunter-gatherers to the current 6 billion people (Cohen 1995). Despite the fact that current agricultural technology allows one person to be fed with food produced on 2000 m2, disparities imply that part of the human population is fat, while much is malnourished or at or near the threshold of hunger.

About 12,500 of the 300,000 or more species of flowering plants are considered edible to humans, however occasional usage may include a substantially higher number (Rapoport & Drausal 2001). For food, over 200 plant species have been domesticated. Yet, at the moment, more than 75% of the human population's food supply (in terms of calorie consumption) is supplied directly or indirectly from only 12 plant species (bananas/plantains, beans, cassava, maize, millet, potatoes, rice, sorghum, soybean, sugar cane, sweet potatoes, wheat).

In 1996-98, the total yield of 93 important food crops was 2.7 billion tonnes (2.07 billion tonnes of cereals and 0.64 billion tonnes of roots and tubers; United Nations Development Programme et al. 2000). In 1994, the total number of wheat stalks cultivated topped 450 trillion, which was most likely a record at the time. The variety of animals used for food is more difficult to count, but once again, although a broad range of species is eaten or offers products for consumption (e.g. milk), the majority of consumption is centred on just a tiny number of these species. Insects (moths, beetles, wasps, and bees), crustaceans (lobsters, crabs, shrimp), mollusks (bivalves, gastropods, squid), echinoderms (sea urchins, sea cucumbers), and vertebrates are among the animals used directly or indirectly (fish, amphibians, reptiles, birds, mammals). Just a few figures show the vast scale of the exploitation: (i) 3.39 billion livestock are maintained worldwide (1.33 billion cattle, 1.76 billion sheep and goats, 0.12 billion equines, 0.18 billion buffaloes and camels; United Nations Development Programme et al. 2000); (ii) average global annual meat production for 1996-98 was 215 million tonnes (United Nations Development Programme et al. 2000); and (iii) global fish.

Whether it is plants or animals, the variety of creatures exploited for food remains relatively limited in comparison to their entire diversity, leaving great room for additional exploitation (although the characteristics necessary for domestication may be exhibited by a surprisingly small proportion of species; Diamond 2002). This gap is being closed primarily through the use of wild species and varieties to supply genes for the improvement of cultivated and domesticated species (increasing yields, tolerances, vigour, and disease resistance); industrialscale agriculture has resulted in the loss of much of the previous local genetic variation in crops and livestock, which has been replaced by uniform varieties over often vast areas. Moreover, extending the genetic basis of certain food species may be the only way to preserve our heavy dependence on them. Some of the most important genetic material may be found in wild populations of animals exploited for food, or in near relatives.

In addition to supplying nutrition, biodiversity serves other critical direct functions in preserving human health. Natural products have long been acknowledged as a valuable source of therapeutically effective medications, with over 60% of the world's human population relying nearly totally on plant medicine for basic health care (Harvey 2000). Furthermore, nine of the top 20 non-protein drugs in 1999 were derived, directly or indirectly, from natural products, with annual sales totaling more than US$16 billion simvastatin, lovastatin, enalapril, pravastatin, atorvastatin, augmentin, ciprofloxacin, clarithromycin, cyclosporin; Harvey 2000.

Willow trees (from which salicylic acid was first derived and of which aspirin is a simple derivative), foxglove (digitoxin), belladonna (atropine), and poppy are examples of plant species that have proved to be medicinally important (codeine).Animals are also widely used in traditional remedies (with significant international trade associated with Oriental and other customary forms of medicine), as a source of a variety of products in modern medicine (e.g. anticoagulants, coagulants, vasodilatory agents), and as models for testing potentially useful drugs or techniques.

Recent drug development examples (see Chivian 2001; Mateo et al. 2001 and references therein) include:

Taxol

Logging operations commonly abandoned the Pacific yew tree Taxus brevifolia as having little economic use. It was discovered, however, to contain the molecule taxol, which kills cancer cells in a way that other chemotherapeutic agents do not and has been demonstrated to be one of the most promising medications for the treatment of breast and ovarian cancer. It has become the best-selling anticancer agent in history, with yearly sales reaching $1 billion. The taxol molecule, which has since been found in several species, has served as the foundation for numerous more potent synthetic drugs.

Venom from cone snails

The venoms of tropical reef cone snails include a diverse range of peptide molecules. These chemicals have been shown to inhibit a wide range of ion channels, receptors, and pumps in neuromuscular systems. One calcium channel blocker, omega-conotoxin, has been shown to be a strong painkiller and to give a mechanism of keeping nerve cells alive after ischaemia (insufficient blood and oxygen supply to an organ). Its synthetic form is undergoing advanced clinical studies for the prevention of nerve cell death after coronary artery bypass surgery, brain injury and stroke, and the treatment of persistent intractable pain associated with cancer, AIDS, and peripheral neuropathies. This synthetic version has 1000 times the analgesic effectiveness of morphine but does not cause tolerance or addiction, nor does it cause a clouding of consciousness.

Drugs that inhibit acetylcholinesterase (ACE)

ACE inhibitors such as enalapril, captopril, lisinopril, and perindopril were developed from a peptide found in the venom of the fer-de-lance (Bothrops athrox or B. jararaca), a Neotropical pit viper that kills its victim by lowering blood pressure. These medications have contributed significantly to the decrease in human mortality from stroke and heart attack.

The number of species that have been studied for potential medication derivation is fairly modest. For example, while approximately 37,500 plant species had been studied phytochemically as of 1995, only approximately 14,000 had been studied for at least one type of biological activity (Verpoorte 1998), and the number studied in detail for their medicinal properties is at best in the low thousands. Despite advances in computer-assisted drug design, molecular biology, and gene therapy, there is still a pressing need for new drugs to combat drug-resistant pathogens, multidrug-resistant cancers, the emergence of new human diseases (particularly HIV/AIDS), the resurgence of older diseases such as tuberculosis, changes in disease distribution caused by increased human movement and global climate change, and conditions associated with.

Maybe the most effective approach to locate them is to take use of millions of generations of natural selection trial and error that have provided other species with the tools to live healthy lives. It has been hypothesised that one out of every 125 plant species researched has generated a significant medicine, but the possibility for discovering big novel pharmaceuticals in synthetic chemicals is on the order of one in 10,000 compounds evaluated (Dobson 1995). As a result, the quest for valuable molecules from biological material continues (probably the most visible example of what has become known as bioprospecting). In the field of cancer therapy, for example, clinical studies have been undertaken using compounds derived from tunicates or a bryozoan, as well as preclinical trials using compounds derived from a sponge and a mollusk.

Other animals may hold clues to remedies to various medical issues that humans encounter. Hence, new methods of preventing and treating osteoporosis may be discovered in bears, the only animals considered to be immune to the condition. Despite not eating, drinking, urinating, or defecating for 3-7 months, black bears Ursus americanus may birth and nurse young, preserve bone density and lean body mass, and avoid becoming ketotic or uraemic. The use of natural enemies to manage pest species is becoming more common, and it is typically seen as a more ecologically acceptable alternative to pesticides. Biocontrol programmes against hundreds of plant and insect species have been developed, with roughly 30% of weed biocontrol and 40% of insect biocontrol programmes being effective. Biological control has included the introduction of control agents. The economic benefits on biological control programmes may be enormous, with yearly advances in food or other crop output potentially surpassing the whole investment in control programmes many times over. For example, consider the cost-benefit ratio for controlling cassava mealybug. The encyrtid wasp preys on Phenacoccus manihoti. The prevalence of epidinocarsis lopezi in Africa was predicted to be 1 to 149, with yearly savings of up to $250 million.

Materials used in industry

A diverse spectrum of commercial materials, as well as templates for their synthesis, have been produced directly from biological resources. Building materials, fibres, dyes, resins, gums, adhesives, rubber, oils and waxes, agricultural chemicals (including insecticides), and scents are examples. In 1989, the overall global value of wood exports was projected to be US$6 billion, with more than 3.8 billion cubic metres collected yearly for fuel, lumber, and pulp (Kunin & Lawton 1996). The biotechnology business, which includes agricultural, food processing, industrial chemicals, and pollution control, had revenues of US$10-12 billion in the United States alone in 1993.

Several industrial materials and constructions have been inspired by biological materials (biomimicry). Thus, the Amazonian water lily Victoria amazonica inspired the Crystal Palace dome in London, termite mounds inspired air-conditioning systems, burdock seeds inspired Velcro fasteners, bats inspired the echo-sounder, and rattlesnake thermosensitive pit organ inspired infrared sensors. As with food and medicine, the potential for using a significantly higher variety of organisms for industrial materials is tremendous. Plants and other animals have previously addressed many of humanity's issues and difficulties, sometimes in very brilliant ways. The reasons why the potential for exploitation is so much bigger than is now realised are likely due to cultural factors (the devil you know) as well as ignorance about natural goods. The Biosphere 2 experiments visually showed the necessity to preserve biodiversity because of the benefits it offers. Biosphere 2 is the world's biggest closed-environment facility, including 3.15 acres of soil, air, water, plants, and animals. It cost about $200 million to design and build, and millions more to operate (annual energy investments surpassed $1 million), and it depended on vast technical resources and knowledge. Yet, it proved impossible to design a completely closed system capable of providing appropriate food, drink, and air to eight persons for two years. Unexpected environmental effects included a major drop in oxygen levels and an increase in carbon dioxide, an increase in nitrous oxide (N2O) concentrations, nutrient overloading of water systems, and the extinction of all pollinators. In summary, no system could be developed with all human technology, intellect, and infinite (relative to regular research budgets) financial resources to feed eight persons, let alone humanity, with the life-sustaining functions that natural ecosystems give for free.

People do not live in glasshouses, no matter how enormous. Nonetheless, a large share of the population lives in cities. They make extensive use of ecosystem services. Consequently, it has been calculated that the 29 major cities in the Baltic Sea region derive ecosystem support services from regions at least 500-1000 times bigger than the cities itself (Folke et al. 1997). To maintain their consumption lifestyles, average inhabitants in North America, Europe, Japan, and Australia need the biophysical output (anecological footprint) of 5-10 hectares of biophysically productive land and water.

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CHAPTER 11

BIODIVERSITY AND ECOSYSTEM FUNCTION

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The extent and direction of change in ecosystem function are unknown since individual species play complex and diverse roles.A significant number of studies (both in the laboratory and in the field) have been undertaken to discern between these possibilities, with the most frequent strategy being to establish duplicate assemblages of varying numbers of species and quantify the related ecosystem functioning.Several of these studies' designs and interpretations of their findings have been much disputed. While alternative results have been recorded, a number of tests have revealed that ecosystem functioning rises from extremely tiny to small numbers of species assemblages, with the impact declining as species numbers expand further, implying some kind of ecological equivalence across species (redundancy)[1], [2].

Three processes have been suggested to explain why biodiversity and ecosystem functioning should be linked. The sampling effect. If some of the species in a big regional pool have considerable effects on ecosystem processes, then the more species pulled from this pool to build a local assemblage, the more likely some of these highly influencing species will be included. Complementarity of two species. If species utilise resources differently, the more species in a particular assemblage, the more comprehensively the given set of resources will be used, with the behaviours of various species complementing one another.

There were three positive interactions. Raising the number of species in a particular assemblage may increase the number of mutual, facultative, or positive indirect impacts among them, improving ecosystem functioning. In actuality, all three of these systems may be active at the same time, with the study issue being to assess their proportional contribution to ecosystem function. Understanding the link between ecosystem and biodiversity functioning, on the other hand, requires further research[3], [4].

Human impacts

The most well-known and generally debated effect of human actions on biodiversity has been species extinction. Species extinction seems to have captured the public imagination, maybe because to its irreversibility and the remarkable quality of some of the species that have perished. Moreover, when evaluated in terms of species richness, species extinctions are both an evident and really valuable barometer of change in biodiversity. Humankind's effects on other species have likely endured for the majority of the 100,000-200,000 years that anatomically modern humans have lived. Although there is some disagreement on the subject, early humans may have played a significant role in the extinction of so many large-bodied species of birds and mammals, as well as other groups, during the late Pleistocene (by 10,000 years before the present (BP), all major land masses except Antarctica had been colonised, some for an extended period of time, and humans were exerting significant environmental effects). Apparently, broadly coincident with the arrival of humans in different major land masses, much of the megafauna disappeared, suggesting that they were either hunted to extinction (or perhaps close to the brink, with other factors finally tipping them over) or were brought to extinction by anthropogenic ecosystem disruption (Martin 1984, 2001; MacPhee 1999; Miller et al. 1999; Flannery 2001; R.G. Roberts et al. 2001; but see

Grayson 2001; Brook & Bowman 2002). These extinctions were very certainly accompanied by numerous more, of which we are yet uninformed because to the deficiencies of the subfossil record.

The large number of avian (and other) extinctions that followed the colonisation of tropical Pacific islands by prehistoric peoples, an expansion that began perhaps 30,000 years ago and was nearly complete by 1000 years ago, are perhaps the most graphically demonstrated effects of early human activities on the biota. The combined consequences of resource exploitation, deforestation, and the introduction of foreign species resulted in the extinction of about half of the land bird species on each island group (Milberg & Tyrberg 1993; Pimm et al. 1995b; Steadman 1995). The fraction of avifauna on selected Pacific island groups that has recently been extinct, is presently endangered, or is in imminent danger of extinction is lower where humans have been there the longest. This shows that the places that were colonised earliest had already lost the majority of the species that are susceptible to human activities , albeit the time lag between human arrival and major extinction events on oceanic islands was very varied (Steadman et al. 2002). A realistic estimate would be that an average of ten sea- or land bird species or populations were lost from each of Oceania's roughly 800 islands, for a total loss of 8000 species or populations (Steadman 1995). With one to four endemic rail species per island, 2000 rail species may have been lost alone, compared to the 133 existing species, a number of which are considered seriously vulnerable. It is not impossible to imagine that possibly half of all recent bird species have already gone extinct, at least in part as a result of human activity[5], [6].

It's tough to imagine how different the Earth's biota might have appeared if all of these animals were still alive. The variety that we currently find so astounding is, at least in terms of the vertebrates that get so much attention, a mere shadow of what it might have been if early humans had not directly and indirectly wreaked such losses.Several of these extinct and subsequently lost species undoubtedly contributed significantly to the development of ecosystems and communities linked with them, raising the issue of what completely natural assemblages might have looked like. Big animals, whether terrestrial or marine, may devour enormous amounts of vegetation or a large number of smaller species, as well as physically disrupt the ecosystem in fundamental ways. Many of these large animals have become extinct in terrestrial systems, and many are now 'ecologically extinct' in marine systems (e.g., species of large sharks and rays, turtles, manatees, and dugongs), in the sense that their numbers have been reduced to the point where they no longer have major ecological impacts.

Species extinctions did not cease with the initial era of human colonisation of the globe. There have been over 1000 reported extinctions of plant and animal species since 1600 (a period after which the availability of contemporaneous information increases substantially) Almost half of these occurred in the previous century. During the last 400 years, there has been a large increase in the rate of reported species extinctions for well-known groups of animals, with a steep surge in the 19th century correlating with European colonial expansion. A worldwide reduction in the documented rate since around 1950 may represent the expansion of conservation operations, but it is more likely owing to the development of more severe criteria for determining whether a species is really extinct (rather than merely being unrecorded). For example, the current IUCN (World Conservation Union) (1994) criteria define a species as extinct 'when there is no reasonable doubt that the last individual has died' and as extinct in the wild if the species is only known to survive in cultivation, captivity, or as a naturalised population (or populations) well outside the past range. Extensive surveys in known and/or predicted habitat, at suitable periods (diurnal, seasonal, yearly) across a taxon's historic range have failed to record an individual. As a result, substantiating an extinction takes substantial time and effort, especially when the prospective habitat for a species is wide or difficult to reach. As intriguing as the data on reported extinctions is, it is clear that it understates the real amounts of species loss.

Extinction data is heavily skewed towards higher plants, birds, and mammals, which have received more attention, and away from taxa such as fungi, lower plants, and invertebrates, which have received less attention. Most extant avian and mammal species, for example, have host-specific lice and fleas, as well as likely particular microbial symbionts in many instances. As a result, it is likely that the extinction of every bird and mammalian species has been accompanied by the extinction of at least one other species. Nonetheless, despite the detection of 128 bird and 83 mammal species extinctions, these so-called coextinctions have tended to go unrecorded. There are no extinct lice or flea species on the Hilton-Taylor 2000 Red List. Although various species may have had legitimately varied recent rates of extinction, the huge variations in the number of documented extinctions constitute an artefactual distortion (McKinney 1999).

Extinction data is heavily skewed towards islands (71.6% of mammalian species extinctions since 1500 are for island species; MacPhee & Flemming 1999) and industrialised countries. This is due, in part, to the high levels of endemism often associated with islands, as well as the longer duration of official study of developed-nation biotas. It is also because island biotas may be more vulnerable to extinction-causing processes (in the face of threatening processes, island endemic species may have no refuges), and developed-nation biotas tend to be relatively species poor and have experienced the implications of that human development (extant species may simply be those that were more resilient to extinction)[7], [8].

Extinction data is heavily skewed towards terrestrial and freshwater species and away from marine species. Few marine species have been reported as extinct. On the one hand, the lack of known extinctions of marine species may be due to the fact that they are really less likely to go extinct, maybe due to the higher contiguity of the seas compared to the continents and the resulting broader geographic ranges of marine species. On the other hand, this might be due to the difficulty of documenting extinctions in the waters.

Until adequate evidence is gathered to prove that a reported species is extinct, it is usually always presumed that it is extant. Museum collections, for example, include specimens of numerous species that have not been seen since they were obtained, or at least for many decades, but since no active search has been conducted to discover them, it is presumed that they are still alive. Many of these are presumably gone, considering that the natural environment in which they were gathered has often vanished. Diamond (1987) observed that at the time (doubtless things have changed a little since), if one followed the assumption 'extant unless proven extinct,' one bird species had recently gone extinct in the Solomon Islands, but if one followed the assumption 'extinct unless proven extant,' up to 12 species could be extinct or endangered, with the latter figure more likely to be correct.

If a species is unknown to science, its disappearance will go unnoticed. Since the vast majority of them have remained undocumented as much serious habitat degradation has occurred in locations where biological inventories were previously inadequate, it follows that many highly localised species may have died extinct without our knowledge[9], [10].

Threats to biodiversity

Species extinctions and other biodiversity reductions are caused by four major factors: (i) direct exploitation; (ii) habitat loss and degradation; (iii) introduced species; and (iv) extinction cascades. They are known as "the wicked foursome" (Diamond 1984). Although these causes are pretty well described, the patterns and speeds at which they change are less well known.

Exploitation directly

The most apparent method that people might cause species extinction is by exploiting their populations to the last individual or to such low numbers that they have a very high possibility of going extinct by coincidence. The magnitude of human exploitation of certain animals is enormous and unsustainable. Here are three instances.

Meat from the bush

Wildlife hunting is common in tropical woods, mostly for sustenance or trade (Redford 1992). Moreover, it is impossible to determine what many species' natural abundances would be in the absence of such pressure since such sites do not exist. The Brazilian Amazon, for example, is expected to devour 9.6-23.5 million reptiles, birds, and mammals every year, or 67-165 thousand tonnes (Peres 2000). Demand is rising as tropical forests become more accessible to hunters, effective human population densities rise, people grow more sedentary, traditional hunting tactics change, the meat trade becomes more commercial, and urban demand for wild meat rises. The application of mathematical models shows that this harvest is not sustainable, especially given the low yearly production rates of big animals in tropical forests. According to Fa et al. (2002), animal production rates in the Congo Basin and the Amazon Basin are around 2.1 and 1.8 million tonnes per year, respectively, with extraction rates of 4.9 and 0.15 million tonnes per year. This indicates that to offset present extraction rates, Congo Basin animals must create 93% of their body mass each year, but Amazonian mammals must produce just 4%.

Fuelwood

More than 2 billion people (about one-third of the current population) are anticipated to rely directly on biomass fuels, which include woodfuels (fuelwood, charcoal, etc.), agricultural leftovers, and dead animals (United Nations Development Programme et al. 2000). In many, mostly developing, nations, fuelwood is the major type of biomass energy. In many locations, supplies have declined dramatically in recent decades, forcing inhabitants of certain communities to travel long distances to get material. While this has been somewhat countered by worldwide tree planting programmes, woodfuel demand is expected to be 2.4-4.3 billion m3 by 2010, compared to a projected availability of 2.3-2.4 billion m3 of fuelwood and charcoal combined.

Fisheries in the sea

The 1950s and 1960s witnessed a massive increase in worldwide fishing activity, driven mostly by industrialisation, which resulted in significant increases in catches (Fig. 5.3). The Peruvian anchoveta Engraulis ringens stock dropped in 1971-72, paralleled by diminishing catches elsewhere, which intensified in the late 1980s and early 1990s when cod Gadus morhua populations off New England and eastern Canada declined. Despite this, global fishing activity expanded to the point that, by the mid-1990s, a large percentage of populations had collapsed or were being fished beyond sustainability. Since the late 1980s, reported global fisheries landings have been steadily dropping by roughly 0.7 million tonnes per year. Fisheries have progressively been 'fishing down marine food webs,' removing huge long-lived predatory fish and exploiting those at lower trophic levels. They have altered the evolutionary traits of populations by size-selective harvesting, putting the future survival of certain target species in jeopardy. Research shows that, although the impacts of overfishing may be reversible, the time required for stocks to recover may be lengthy. With the collapse of shallow-water fishery populations, more attention has been placed on deep-water fisheries, which are even more vulnerable to such consequences. In addition to the effects on target species stocks, fishing has broader consequences, including: (i) the wholesale reorganisation of remaining species assemblages as trophic interactions are disrupted; (ii) massive amounts of bycatch of non-target species that are typically simply discarded (bycatch exceeds 25 million tonnes per year); and (iii) incidental capture and killing of other species (including seabirds, turtles, sea snakes, marine mammals).

Above all, the history of human resource exploitation reminds us that populations of even initially plentiful species can be reduced to low levels amazingly quickly, and that the ease with which this may be accomplished has risen with the march of technology. Unfortunately, in the short-term, from a strictly economic standpoint, nonsustainable use can in some cases still be regarded as a viable option. From this vantage point, the optimum harvesting method for biological groups with relatively moderate growth rates (e.g., whales) may be to exploit them to extinction. When invested, the money produced by this harvest might potentially give a higher financial return than the sustainable harvest from the population (Clark 1981; Lande et al. 1994; May 1994c). Of course, this ignores both the direct and indirect use value of biological resources (which may both be critical to human population sustainability) as well as the non-use value of biological resources, both in the short and long term.

The dramatic reshaping of habitat distributions or vegetation types has been a feature of much of human history, with habitat change as a result of prehistoric populations' activities being reported on numerous occasions. Furthermore, it has been regularly shown that what were thought to be 'natural' landscapes had been significantly altered by previous human activity.On a wide scale, relative to an estimate of their extent prior to major human disturbance, forest/woodland area has decreased by 29%, steppe/savannah/grassland area has decreased by 49%, shrubland area has decreased by 74%, and tundra/hot desert/ice desert area has decreased by 14%. Cropland today accounts for 11% of the land surface, while pasture accounts for 23%. Human disturbance is visible in every biome on Earth, although it is most visible in temperate broadleaf and evergreen sclerophyllous forests. Probably the most visible evidence of such alterations comes from comparing the amount of the most diverse terrestrial habitat, tropical forest, at various eras and in different parts of the globe. The majority of such forest clearance is caused by external pressures on the environment, namely undervaluing the forest resource, which promotes liquidation of the resource.

These changes are mostly the consequence of human activities such as mining and burning fossil fuels, as well as converting forests and grasslands to agriculture and other low biomass habitats. Carbon dioxide is the most significant 'greenhouse gas,' although others, such as methane (CH4), chlorofluorocarbons (CFCs), ozone (O_3), and nitrous oxide, also contribute (N2O). Examination of air bubbles collected from Antarctic and Greenland ice cores reveals that CO2 levels in the atmosphere were relatively steady for thousands of years until about 1800, when they began to rise rapidly.

Many species' distributions are currently shifting in response to climate change, and many more are predicted to do so in the future. Additional reactions to climate change are being recorded as well. Although regional differences exist, common phenological shifts in Europe and North America include earlier bird breeding or first singing, earlier arrival of migrant birds, earlier appearance of butterflies, earlier choruses and spawning in amphibians, and earlier shooting and flowering of plants. Many of the changes to the landscape caused by people entail not only the decline of certain plant types and the increase of others, but also the fragmentation of vegetation. This results in a landscape with (typically tiny) remaining remnants of natural vegetation interspersed among agricultural and developed land.

Fragmentation causes changes in the physical environment within patches (e.g., fluxes of radiation, water, and nutrients), in part because the size of areas of vegetation influences local climate, and in part because smaller patches of vegetation have a higher ratio of edge to area, which increases the potential for penetration by, and influence from, events and processes in the surrounding landscape. Changes in edge-to-area ratios may also increase pressure from invading species as well as other direct (e.g., hunting) and indirect (e.g., pollution) human-caused impacts.

Moreover, fragmentation produces biogeographic changes, which, like its other repercussions, may have a significant impact on the number and content of the biotas in the residual patches Apart from changes in the pattern of covering of various plant types, those areas that remain may be degraded for other causes in terms of their ability to sustain populations of naturally existing species. This deterioration may manifest itself in a variety of ways, including changes in the occurrence and abundance of several components. Human activity, for example, has significantly affected the global nitrogen cycle by fixing N_2 (combining it with carbon, hydrogen, or oxygen), either intentionally (for fertiliser) or as a byproduct of other activities (fossil fuel combustion).

This activity now contributes at least as much fixed N to terrestrial ecosystems as all other natural sources combined. Increased atmospheric concentrations of the greenhouse gas N2O, increased fluxes of reactive N gases, contribution to acid rain and photochemical smog, increases in productivity of ecosystems where fixed N was scarce, resulting in losses of N and cations from soil, eutrophication of aquatic systems, and loss of biodiversity are among the consequences.The proliferation of elements that do not exist naturally exemplifies the sheer pervasiveness of such forces. Brominated flame retardants, for example, are utilised in electronic equipment such as computers and television sets, as well as textiles, automobiles, and a variety of other uses. They have been discovered in sperm whales Physeter macrocephalus, which generally remain and eat in deep water, implying that these chemicals have made their way there.

From ancient times, human activities have helped to transfer non-domesticated species to locations where they would not have naturally existed, breaking down numerous natural barriers to their spread. Leaving aside domesticated animals, the oldest known example includes the introduction of a marsupial, the grey cuscus Phalanger orientalis, to New Ireland some 19,000 years ago.

Such species transfers have occurred through a variety of means, including purposeful introduction for agriculture or sport, the transport of soil and ballast, the connecting of streams via canals, and the release or escape of pets. They represent our preferences as shoppers, travellers, growers, and so on. The number of introduced species in an area frequently increases in proportion to the size of the human population, the duration of human occupation, and the number of visitors, all of which tend to increase the levels of such activities, and thus the likelihood and frequency with which individuals of a given species arrive. The number of imported species in a region is often connected to the number of native species, most likely because the needs knowledge of species from both groups reacts to comparable causes.

Some imports have benefited human living, but most invaders have little impacts; Williamson (1996) recommends that 10% of imported invaders become established, and 10% of those established become pests as a reasonable rule of thumb. Sadly, the negative consequences may be severe, and introductions have been regarded as "one of the great historical convulsions in the world's fauna and flora". Imported species may modify nutrient regimes, fire regimes, hydrology, or energy budgets, change vegetation or habitat, and promote changes in native species abundance and distribution, eventually leading to extinction (Williamson 1996). They have therefore become key agents of global transformation, drawn from a broad range of groups. Almost half of the vulnerable species in the United States, for example, are threatened in part due to the impacts of alien species.

By predation/parasitism, introduced species have most commonly caused species extinctions. Some of the best-documented cases include the introduction of alien predators to lakes and islands, resulting in the demise of flora and animals that had no defences against them. As a result of the intentional introduction of the Nile perch Lates niloticus, a voracious predator (although other factors have also contributed; Harrison & Stiassny 1999 and references therein), a number of fish species, many of which are endemic, from the lakes of the East African Rift Valley may be extinct. Similarly, the accidental introduction of the brown tree snake Boiga irregularis to Guam around 1950 resulted in the loss of perhaps 12 species of an original fauna of 22 native birds (three pelagic species and perhaps nine forest species, some endemic to the island), the reduction of most remaining forest species to small remnant populations, and the loss of 3-5 species of an original fauna of 10-12 reptiles (Fritts & Rodda). In both circumstances, the generalist predators' catholic preferences were vital, allowing them to maintain high abundances even when one of their prey species became uncommon.

Since imported species have the potential to predate native species, biological pest management must be used with extreme care although this may be very useful in terms of economics, possible biological control agents must be thoroughly vetted to guarantee that they will not have a detrimental influence on other organisms. A significant number of instances have been reported in which enough care was not used.

By competition, introduced species may potentially cause species extinctions, at least locally. As a result, the introduction of some ant species, such as the red fire ant *Solenopsis invicta*, the Argentine ant *Linepithema humile*, and the big-headed ant *Pheidole megacephala*, has often resulted in substantial declines in native ant assemblages due to violent interactions. Similarly, the tropical alga *Caulerpa taxifolia* has grown substantially throughout the Mediterranean coast, carpeting enormous regions and eliminating numerous other species.

The economic consequences of introductions might be enormous. According to Pimentel et al. (2000), the nearly 50,000 ou pas species in the United States alone cause economic harm and control of US$137 billion each year. The net effect of species extinctions and the introduction of species into areas where they would not naturally occur is to homogenise biotas around the world, making them more similar to one another; in the worst-case scenario, we would be left with biota comprised of pests and weeds. For example, pairs of states in the continental United States today have 15.4 more fish in similar than they did before European colonisation of North America.

Extinction of one species may result in the extinction of others. Moreover, if this species supplies vital resources for others, such as specialised herbivores, parasites, or predators, or where it works as a specialist pollinator or dispersion agent, this is unavoidable. In New Zealand, for example, the huge eagle *Harpagornis moorei* probably undoubtedly preyed on the big flightless moas, and its extinction was most likely caused by the Maori hunting that led to their extinction. As evidenced by the dramatic, and often extensive, changes in floral and faunal composition that can result from changes in the abundance and occurrence of key species, more complex sets of interactions may also result in cascades of extinctions. For example, the extinction of largebodied carnivores may be accompanied by meso-predator release, in which slightly smaller predators escape previously imposed population controls and exert increased predation pressure on their prey species, reducing their abundance and possibly driving them locally or even globally extinct.

In some ways, all of the aforementioned causes of species extinction and threats to biodiversity are related. The ultimate reasons are the number of the human population, its expansion, and what has been referred to as the magnitude of the human enterprise (Fig. 5.9; Ehrlich 1995). The facts are unmistakable.

Population increase and size

In the mid-2000s, the world's human population was predicted to be at 6.1 billion people. This compares to 10,000-25,000 for the bonobo Pan paniscus, 100,000-150,000 for the chimp Pan troglodytes, 40,000-65,000 for the gorilla *Gorilla gorilla*, and about 38,500 for such orang-utan Pongo pygmaeus.

At a coarse geographical resolution, there seems to be a significant positive association between the number of species present in a region and human density. Balmford et al. (2001) demonstrated this for Sub-Saharan Africa, and it seems to occur because both species counts and population numbers exhibit similar connections with primary production, locating comparable types of places suitable for multiplication. Moreover, the human population is distributed in such a way that almost 1.1 billion people reside inside the 25 global biodiversity hotspots, which are some of the most important and vulnerable locations for other kinds of life. The population density in these hotspots is around 73 per km^2, compared to a worldwide average of 42 per km^2.

Even at relatively coarse spatial resolutions, levels of habitat loss in areas are commonly correlated with the number of people but the conflict between people and biodiversity becomes more apparent at finer spatial resolutions (here, of course, positive relationships between the number of people and species richness tend to break down quickly - highly urbanised areas may have few native species). Thus, the number of previously native scarce plant species that have not been recorded from areas of Britain since 1970 is an increasing function of human population density in those areas (Thompson & Jones 1999), and the occurrence and persistence of a number of large-bodied vertebrate species declines with human population density, even when these species are in protected areas and density is measured in the surrounding areas

First production

Humans use, co-opt, or destroy roughly 35-40% of all potential terrestrial primary productivity the net accumulation of organic carbon resulting from the surplus of fixation over respiration. 2001 for a discussion of the uncertainties in such estimates). The similar statistic for aquatic systems is 8% of primary output, while the percentage for nearshore and freshwater systems is substantially greater and comparable to that of terrestrial systems.

Energy use

Ehrlich (1995) estimates that overall power consumption by humans has increased around 7000-13,000-fold from 0.001-0.002 terawatts (1 TW = 1012 watts) to 13 TW from before the agricultural revolution to the present. In 1993, global commercial energy output was 338 exajoules (1 exajoule = 1018 joules, or about 163 million barrels of oil), 40% more than in

1973. Overall energy consumption increased by 49% to 326 exajoules in 20 years (World Resources Institute 1996).

Water

Humans consumes more than a quarter of the available 69,600 km3 yr1 of terrestrial evaporation and transpiration and more than half of the available 12,500 km3 yr1 of runoff (Postel et al. 1996). Agriculture accounts for 42% of world water usage, while industry accounts for 14%. Freshwater scarcity is increasing ecological deterioration, restricting agricultural and industrial productivity, affecting human health, and escalating international tensions.

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CHAPTER 12

CONSERVATION OF BIODIVERSITY

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Use of the term ‘biodiversity’ arose in the context of, and has remained firmly wedded to, concerns over the loss of the natural environment and its contents. The significance of this link cannot be emphasised. We relied significantly on the Convention on Biological Diversity in defining biodiversity in this work. This was not done just for the sake of convenience. It reinforces our opinion that, for better or worse, and despite its numerous shortcomings, this is the single most essential international step towards the long-term preservation of biodiversity.

The Convention represented a historic commitment by governments throughout the globe (though unfortunately, not all of them, including the United States, have ratified or even signed). It was the first times that biodiversity was thoroughly addressed in a binding global convention, the first time that genetic variation was expressly addressed, and the first time that biodiversity protection was acknowledged as a universal issue. So, having examined the main features and patterns of biodiversity (the value placed on it, and the threats to its survival we now turn to the relevant Articles contained in the Convention to provide a useful framework in which to discuss its future maintenance (as well as a valuable lesson in how such treaties are formulated). Whether or whether one considers the Convention to be of substantial importance, this gives a significant benefit[1], [2].

Larger canvas than would be attained by just focusing on concerns normally linked with the study of conservation biology. It emphasises the fact that the preservation of biodiversity impacts on many aspects of human activity and is about much more than preventing specific species from going extinct or providing nature reserves and other protected places for conservation.The focus on fair benefit sharing from the use of genetic resources reflects worries that in the past, such resources belonging to one country have been used by one or more countries with no remuneration. While most cases involve the exploitation of poor countries' genetic resources by wealthy nations, where the repercussions are most severe, the issue is more widespread. Svarstad et al., for example, describe how the hyphomycete fungus *Tolypocladium inflatum* was gathered in soil samples by a scientist during a vacation in Norway in 1969, under an open access environment. A pharmaceutical firm later created best-selling drugs based on cyclosporin A (an immunosuppressant and vital in human organ transplantation), a biochemical generated by the fungus. If there had been benefit-sharing with the originating nation (although the fungus has now been proven to be diffused across numerous countries), 2% royalties on sales would have been a plausible claim, amounting to $24.3 million in 1997 alone.

Each Contracting Party shall: (a) Develop national strategies, plans, or programmes for the conservation and sustainable use of biological diversity, or adapt existing strategies, plans, or programmes for this purpose, which shall reflect, inter alia, the measures set out in this Convention relevant to the Contracting Party concerned; and (b) Integrate, as far as possible and appropriate, the sustainability and sustainable use of biological diversity.

In summary, biodiversity conservation and sustainable usage are not anticipated to occur by chance in each country. Indeed, as the recent history of biodiversity demonstrates, they will not. Human activities are putting a strain on biodiversity, with many species facing extinction and much of the usage being unsustainable

The Convention requires States to create systems for biodiversity conservation and sustainable use, or to develop these mechanisms if they already exist. Strategies, plans, and programmes may be seen as a sequential sequence of phases in which particular suggestions are transformed into means of attaining those recommendations finishes, followed by movement on the ground. They will obviously have to be dynamic and constantly refined and developed in order to adapt to changing biodiversity situations in a certain country. These national initiatives must be effective if they are to be successful[3], [4].

Strategies, plans, and programmes will be difficult to develop since they will need to address many (maybe even all) human activities. As a result, they will need to be incorporated into policy in areas as varied as agriculture, education, employment, energy, health, industry, and transportation. If they are to be genuinely successful, strategies, plans, and programmes for protecting and exploiting a nation's biological variety must become integral to how that nation's affairs are handled.

These are subsidies that are harmful to both the economy and the environment in the long run, and include support for: (i) agriculture, which may lead to soil erosion, pollution from synthetic fertilisers and pesticides, and the release of greenhouse gases; (ii) fossil fuels and nuclear energy, which may increase pollution, smog, and global warming, as well as waste disposal issues; and (iii) road transport, which promotes pollution and excessive road-building. The scope of perverse subsidies is immense, totalling about US$1450 billion each year and often surpassing the market worth of items produced by a specific economic sector. Global subsidies to marine fisheries, for example, surpass the market worth of the fish caught. According to Myers (1998), a US citizen spends at least US$2000 in taxes each year to finance perverse subsidies and about the same amount via increasing consumer goods prices and environmental deterioration.

In compliance with Article 6, a number of nations have established national Biodiversity Strategy (general policy instruments used to identify strategic requirements) or Action Plans (practical papers that outline what has to be done and who is responsible for it) (Miller et al. 1995). The publishing of the UK Action Plan (Anon. 1994), for example, is a clear governmental reaction to its mission, principles, and goals. At their finest, such agreements may explain how the manner in which societies function will be reorganised in order to achieve biodiversity conservation and sustainable usage. More often than not, they express ambitions with no indication of how they will be accomplished, and they fail to comprehend the essential character of what must be done[5], [6].

The combination of a lack of biodiversity knowledge and the incredible diversity of life makes it difficult to identify or monitor all of the components of biodiversity that exist inside a nation's boundaries. As a result, the Article and its related Annex focus these efforts in two directions: first, on components that are thought to be vital for the conservation and sustainable use of biodiversity, and second, on actions that are anticipated to have the greatest influence on this conservation and use. Most of this will need the gathering of wholly new information, although some current data, maybe newly compiled, may be used. This will have far-reaching consequences beyond the Convention, helping to increase general knowledge of biodiversity. The last clause of will make this easier. On the basis of current knowledge alone, the ease with which states may begin to meet the obligations of this Article will vary substantially. Yet, it is critical that efforts to increase knowledge be not used as an excuse to avoid taking action in other areas. This has been a recurring issue in conservation and sustainable usage (Figure 12.1).

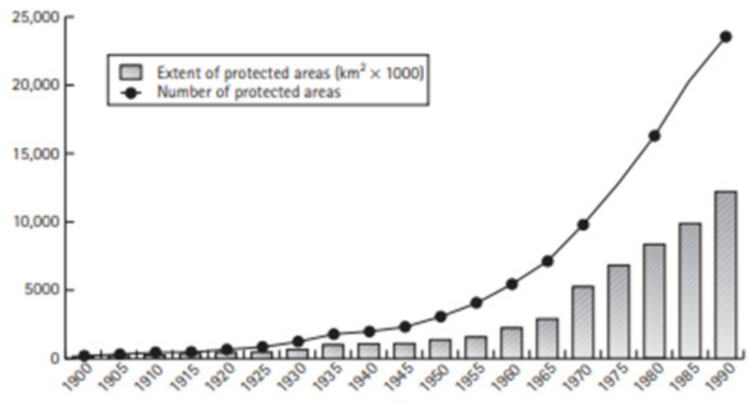

Figure 12.1 Cumulative growth in the number and extent of protected areas

Reserved area systems or networks must be constructed as a fundamental pillar of a national biodiversity conservation strategy. The IUCN (World Conservation Union) Commission on Parks and Reserved Areas recognises nearly 20,000 current protected areas distributed throughout practically all nations in the globe, spanning an estimated 13.2 million km2 marine reserves represent roughly 1.3 million km2 of this total. Nevertheless, this network has a number of serious shortcomings[7], [8].

Most protected areas are quite tiny, often much below the size necessary to sustain healthy populations of big animals. The severity of this size limitation may be mitigated if protected areas are connected by corridors, but in fact, with a few noteworthy exceptions, this has not occurred, and corridor building has both advantages and disadvantages. Possible benefits include higher immigration rates and the availability of additional or alternative refugia; potential drawbacks include enhanced transfer of fire, disease, and predators, as well as a decrease in between-population mobility.

Genetic variation has been studied extensively. While the total number of protected areas continues to grow, the average size of those proclaimed in any particular period has tended to shrink over time. Protected areas are more likely to be located on low-value lands that face less competition from alternative land uses, as well as on the borders of geopolitical units (for example, county, state, and country boundaries, where they might act as buffer zones). As a result, they do not accurately depict natural vegetation patterns or species occurrences. Simulations of the changes in species distributions that are anticipated to follow show that climate change will worsen the issue.

Many locations that have been nominally designated for conservation get no, minimal, or restricted protection in reality (and are commonly referred to as "paper parks"). Grnne Ejland in Greenland, for example, was designated a Ramsar site protected area designated under the Ramsar Convention on Wetlands of International Importance) in 1987, owing to the presence of the world's largest colony of Arctic terns Sterna paradisaea. 1950 estimates suggested 50,000-80,000 breeding pairs). This classification had little practical meaning, and by the summer of 2000, not a single breeding pair of terns had been documented as surviving. Several additional protected places' efficacy has been hotly contested[9], [10].

Finally, the amount of managerial actions will often determine this (e.g. enforcement of park boundaries, anti-poaching patrols). In many parts of the globe, funds are inadequate.

Globally, $6 billion is now spent on conservation-related protected areas (James et al. 1999, 2001). This compared to the cost of a replacement space of US$2.1 billion.

shuttle in 1991, US$6 billion paid to repair property damage caused by Hurricane Floyd in 1999, US$15 billion committed in 2002 by the UK government on a single order of fighter aircraft, and US$50 billion spent per year worldwide on dieting regimens. The current conservation network is insufficient in scope. The IUCN (1993) recommends that each country set aside at least 10% of its land area for conservation. The worldwide cost of expanding the global network of protected areas to fulfil the 15% objective has been estimated to be between $20 and $28 billion per year. In actuality, even a network spanning 15% of various areas is unlikely to be sufficient to represent all species, particularly in the tropics. For ecosystems or countries with greater levels of species richness and/or endemism, higher percentages may be necessary. The amount of terrestrial area made available for conservation may be insufficient, but the fraction of marine environment set aside for protection is significantly smaller (about 0.5% of ocean area). Nonetheless, existing evidence strongly supports the notion that designating ocean protected areas has enormous benefits for biodiversity both within and outside of those areas, and thus for exploitation. An endeavour to create a globally effective network spanning 30% of the ocean's surface would cost around US$23 billion per year in recurring expenditures, plus approximately US$6 billion per year (over 30 years) in begin costs.

The present conservation network was designed along relatively static lines, and it is ill-equipped to deal with shifts in species distributions caused by global climate change. These alterations would ordinarily result in shifts in species distributions, with expansions along certain range borders and contractions along others. Yet, when protected areas become more like islands of native forests amid a matrix of transformed ecosystems, frequently separated by significant distances, the ability of species to adapt by such migrations becomes more limited. There have been many initiatives to designate priority conservation sites, to influence thinking in the establishment of future protected areas, and to implement additional conservation measures. They are predicated on the assumptions that biodiversity is unevenly dispersed throughout the globe, that it is under greater urgent danger in certain regions than others, and that conservation resources are limited. These include techniques based on biodiversity, endemism, and threat hotspots, as well as the best examples of various habitat types, such as Birdlife International's Endemic Bird Areas and Conservation International's Hotspots.

Major Tropical Wilderness Areas of Conservation International, Frontier Forests of the World Resource Institute, Centres of Plant Diversity of the World Wide Fund for Nature and the World Conservation Union, and the World Wildlife Fund-Global USA's 200 ecoregions. More emphasis is being placed, particularly at the regional level, on optimising the complementarity across diverse fields. The extent to which areas chosen on the basis of one taxonomic group are also appropriate for the maintenance of the biodiversity of others in a region is a key issue in identifying priority conservation areas. Although there are some notable parallels, there are also substantial disparities that warn against believing that planning based on groups we know well would work for those we do not.

Regulate or manage biological resources important for the conservation of biological diversity, whether within or outside protected areas, with a view to assuring their conservation and sustainable use; Promote the protection of ecosystems, natural habitats, and the maintenance of viable populations of species in natural surroundings; and Promote environmentally sound and sustainable development in areas adjacent to protected areas with a view to furthering conservation and sustainable use of course, whether on land or in the sea, protected areas are necessary yet insufficient for biodiversity protection.

First, they are not insulated from events outside their borders, and the more deteriorated circumstances outside get, the less viable the people inside becomes. Second, they are often exposed to external dangers and mishaps, such as resource extraction and chemical pollution. Consequently, extinction rates of big animals in West African protected areas have been observed to rise with human population in the surrounding regions, likely reflecting increasing hunting pressures. Finally, protected areas will not be able to contain much biodiversity. For example, an unknown but unquestionably huge fraction of species are unrepresented inside protected areas, while large numbers of certain flagship species reside beyond their bounds; for example, 80% of Africa's elephants dwell outside protected areas. Fourth, many essential processes, such as migration and population replenishment (particularly in maritime systems), take place at considerably greater scales than those protected zones (Figure 12.2).

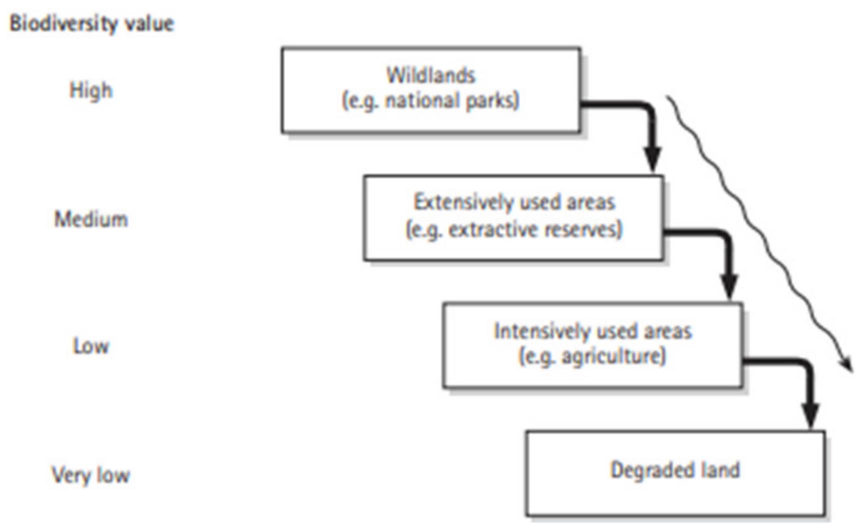

Figure 12.2 the land-use cascade

Finally, climate change may render conditions inside current protected areas unsustainable for some of the species they were designed to safeguard. As a result, these paragraphs of Article 8 require the management of biological resources both within and outside of protected areas (i.e., the general protection of ecosystems and populations wherever they occur), ensuring that development in areas adjacent to nature reserves does not undermine their ability to conserve biodiversity. There has been some effort to assess the cost of conserving biodiversity in the matrix of landscapes outside reservations.

Consequently, it has been predicted that biodiversity rehabilitation costs for the forestry industry might be US$34 billion per year, US$1 billion for freshwater, and US$14 billion for coastal and marine systems Biodiversity protection in agriculture would cost significantly more, with one estimate of US$240 billion per year, for a total yearly cost of almost US$290 billion This is a small proportion of the money now spent on misguided subsidies. The implications of alien species introduction on biodiversity and the ecosystem have previously been discussed and steps to mitigate these effects are clearly required as part of a successful conservation plan. Invasion prevention is much less expensive than invasion management once established, hence efficient quarantine procedures are critical, yet only a few governments now use them. Eradication of established introductions is sometimes possible, particularly from islands and small areas, where action can be taken early in the invasive process, where measures can be applied repeatedly over long periods of time (temptations to reduce efforts in response to initial success in reducing numeric values must be resisted), and where such campaigns have public support.

In certain situations, the typically high expenditures of eradication could prove more cost-effective than the recurring year-to-year spending of control programmes that aim only to confine the spread or lower the quantity of an alien species. Yet, in most circumstances, the later procedures tend to be the only ones that are practicable, and they may need a significant amount of dedication and care. Intuitively, support for biological variety conservation will be reduced when required modifications clash with current usage. The first of these lines recommends that Parties to the Convention reduce these conflicts, notwithstanding the fact that doing so will often be difficult, if not impossible. This raises the question of whether it is preferable to utilise smaller regions aggressively or to exploit bigger areas less intensively. Traditionally, the latter has been seen to be preferable for biodiversity conservation. Yet, data from forestry and fisheries research shows that the opposite may be true (Noble & Dirzo 1997). Yet, the long-term environmental and sustainable effects of intensive agriculture are major concerns. Locally, agricultural intensification may increase erosion, impair soil fertility, and reduce biodiversity; regionally, it can contaminate ground waters and cause eutrophication of rivers and lakes; and internationally, it can impact the atmosphere and climate

Indigenous and local communities' knowledge, inventions, and traditions may be relevant to the conservation and sustainable use of biodiversity, and that this cultural relevance should be encouraged for the benefit of its custodians. This is especially true given the intricate relationships that exist between poverty and the environment. First, the majority of biodiversity occurs at low latitudes, and there is also a decline in nation wealth (as measured by per capita gross national product, GNP) at low latitudes, implying that the majority of biodiversity occurs in nations with the fewest resources to conduct conservation and sustainable use. Second, when forests are chopped down, the poor are disproportionately affected by contaminated surroundings, the loss of fertile areas, the collapse of fisheries, and the loss of traditional supplies of food, fodder, fuel, and fibre. The poor lack the financial wherewithal to get the resources they need (food, water, etc.) from elsewhere; the rich's vast carbon impact minimises their sensitivity to local environmental deterioration. Finally, as a result, the relative consequences of variables impacting biodiversity differ between wealthier and poorer nations.

Ex-situ conservation strategies may include seed banks, sperm and ova banks, culture collections (for example, plant tissues), artificial plant propagation, and animal captive breeding. In an increasing number of cases, such facilities house more members of a specific species than exist in the wild. Ex-situ conservation costs and benefits have been hotly disputed. This is especially true for large-bodied animals (such as primates, big cats and cetaceans). The ethics of keeping individuals in captivity, whether the resources used could be deployed in other ways (e.g., for in-situ conservation), the immediate and long-term viability of both captive and wild populations, the relationship between the two (including the use and efficacy of reintroductions of species into areas where they have become extinct, and to bolster declining natural populations), and other potential benefits are key issues here. Notwithstanding one's view on these issues, ex-situ actions should take a back seat to in-situ conservation.

To live sustainably, the human population must draw on the biosphere's natural resources without diminishing the capital stock. Data shows that human exploitation of the Earth's biological production may have surpassed this capacity since the 1980s, with the world population's ecological footprint in 1999 being 1.2 times that of the whole Earth. So, issues of sustainability extend much beyond the common media attention on trading in specific commodities of great economic worth, such as mahogany wood, rhinoceros horn, tiger body parts, and elephant ivory. Simply said, most current uses of biodiversity are not sustainable (management practises have often prioritised short-term yield or economic benefit above long-term sustainability).

Controlling the degree of consumption is a huge challenge. Even though consumption is generally sustainable at low levels, it may have a major effect at greater levels. This shows the possible tradeoffs between levels of use, geographical extent of use (to acquire the same resource, low levels of use must be distributed across a larger region), and usage consequences. Such factors range from the harvest of natural tropical forest products to the establishment of genetically modified crops. In essence, the Convention suggests that sustainable usage be achieved by incorporating it into national planning. How this may be done most successfully is a complicated question, with discussion centred on the best method to trade (free market, heavily regulated, etc.).Sustainable usage need the cooperation of local peoples, and one method to do so is to maintain and promote traditional use. Yet, traditional uses that are consistent with conservation and sustainable usage must be distinguished from those that are not.

For example, the widely held assumption that 'primitive' peoples have no discernible negative influence on the environment is, to put it bluntly, a fallacy. Even when not based on historical distortions, appeals to traditional usage often represent times in which human populations were much smaller and economic exploitation did not exist (Figure 12.3).

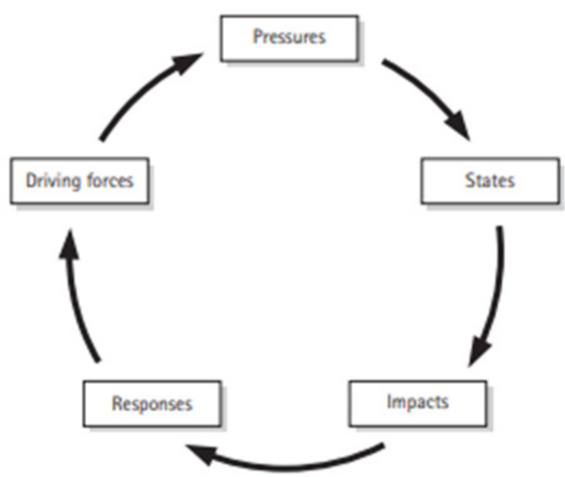

Figure 12.3The despite model adopted by the European environment agency.

A number of Convention Parties have developed Biodiversity Strategy and Action Plans. This, however, is a very simple step in reacting to its contents, but one that may get major media attention. Making the reforms needed to properly protect biodiversity and use it in a sustainable manner is significantly more challenging, and is often unappealing to politicians with short-term interests (such as re-election and personal financial advantage). A number of countries have taken minor steps in the right direction, but significant progress has been lacking.

The obvious path ahead, as used by previous treaties and accords, is to set and agree on objectives for each party to meet in order to fulfil the Convention, as well as procedures for reporting progress so that this may be thoroughly examined. Regrettably, after multiple Conferences of the Parties (CoPs) and summit meetings, such an approach has yet to be approved; at the time of writing, the most recent summit, the World Summit on Agenda 2030, was held in Johannesburg in 2002.

Unless and until significant progress is made in achieving the principles outlined in the Convention, whether through ensuring its application or through some other mechanism (individual nations could make significant progress unilaterally), biodiversity will continue to decline as a result of human activities. It is less important if this would eventually jeopardise humanity's survival rather than if it will threaten the sort of existence individuals would prefer to have. It is already doing so for us.

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CHAPTER 13

EVOLUTION OF BIODIVERSITY

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Most of today's geological terrain may be traced back to historical biodiversity, which left behind a rich fossil record. This has offered incredible insights into the evolution of life on Earth. Working with the fossil record to comprehend this past, on the other hand, is a significant limitation for three reasons. Secondly, as Darwin acknowledged while compiling evidence for his hypothesis of evolution, this record is far from flawless or even. The record is substantially better for certain eras than for others, and estimates of the number of species that have left a fossil record vary from less than one to a few percent of all those that have ever existed. Second, just a small portion of this fossil record has been collected. Finally, the record, or at least the fraction of it that has been retrieved, favours more numerous, widespread, and long-lived species, as well as certain groups of organisms over others. Soft-bodied creatures, such as jellyfish and sea anemones, are infrequently preserved and are uncommon in the fossil record, but the number of individual fossils of hard-bodied species, such as brachiopods, has been estimated to be in the billions. Several of the largest soft-bodied animal groups, such as the Platyhelminthes, have no fossil remnants (flatworms, flukes and tapeworms). The fossil record for creatures having hard body parts, such as brachiopods and molluscs, echinoderms, and vertebrates, is far from comprehensive and not usually representative: 95% of all ancient species are marine creatures, but 85% of all plants and animals known today are terrestrial. To summarise, many of the chapters of biological history recorded in the fossil record are missing, and those that have been acquired only represent a skewed piece of that history[1], [2].

The lack of a fossil record, even for particular species, is aptly shown by a group that has hard body components and is rather widely investigated, having captured the interest and imagination of people of all ages and from all walks of life: dinosaurs. While part of this group's history is recognisable to many primary/elementary school pupils, it is based on a relatively limited window on the past. As of 1990, it was thought that 900-1200 dinosaur genera had ever existed (Dodson 1990). Just 285 (336 species) of these were known from fossils, and almost half of them were known from a single specimen; complete skulls and skeletons were known from only 20% of all genera. Similarly, it has been estimated that just 7% of all known primate species are known from fossils. Although it is evident that the recorded fossil record is far from complete, it nonetheless gives a wonderful graphic history of life on Earth, with many of the important events in that history leaving their imprint in, or on, the rocks. Despite its limitations, it is nevertheless useful. It is feasible to use the fossil record to develop a knowledge of changes in biodiversity across geological time. Nonetheless, because to the aforementioned limits, it will often be required to refer to the temporal dynamics of higher taxa rather than species throughout this chapter, since they are less sensitive to the constraints. This should not be too difficult, since not only can higher taxa serve as a substitute for species counts but they also serve as a measure of biodiversity in their own right[3], [4].

Although the fossil record continues to offer the majority of insights into the evolution of biodiversity, genetic evidence is becoming more important. The comparison of molecular data for various creatures allows the development of branching trees indicating theories about their phylogenetic relatedness patterns, with organisms with more dissimilar sequences thought to have separated earlier in the evolutionary process. If assumptions regarding the pace at which molecular sequences diverge are established (a "molecular clock"), the timeframes of various evolutionary events may be approximated[5], [6].

The dates of initial emergence of groupings are not always consistent between fossil and molecular data. Molecular evidence, for example, reveals that at least six animal phyla started deep in the Precambrian, more than 400 million years (Myr) before their first appearance in the fossil record. Similarly, genomic evidence indicate that primates separated from other placental mammals around 90 Myr ago, but the earliest known fossil primates date from approximately 55 Myr ago. Since the chance of such early people being fossilised and the fossils found is minimal, the fossil record is always prone to underestimating dates of first appearance. Of fact, the correctness of first appearances inferred from molecular evidence is dependent on how the molecular divergence data is interpreted, notably on presumptions regarding the makeup and dynamics of the molecular clock. Nevertheless, when combined, fossil and molecular data present a potent mix for uncovering many of the past's mysteries, 600 Myr ago, almost 80% of the history of life had gone. None of the early fossil metazoans had hard components, and most were just a few millimetres long. There are a few tantalising glimpses of somewhat big soft-bodied metazoans in late Precambrian rocks, such as the Ediacaran fauna in Australia, which has been described as either ancestral metazoans or a similar failed metazoan attempt.

Only at the beginning of the Palaeozoic Period (early life) and in rocks from the Cambrian era (550 Myr ago) can we find the abrupt emergence of the first gigantic metazoans with hard parts (as represented by the Burgess Shale fauna from Canada, described in Gould 1989). Not only are the fossils numerous, but there is a surprising assortment of diverse body designs present, some 'experimental' (or, in retrospect, innovative) and very short-lived (300+ Myr), but others surviving and lasting until the present. It is projected that if the Cambrian boom of biodiversity had continued at its current pace, the seas would be filled by 1060 families of metazoan animals, rather than the 103 that now exist. In fact, by the end of the Cambrian period, the fossil record contains all of today's main animal groups (or phyla).

The variety in body designs presented by the various phyla conceals some significant underlying conservatism in their genetic make-up, notably in homeotic genes, which govern the expression of other genes. The Hox genes are among the most understood. Homologous Hox genes are found in almost all species. They play an important role in defining anterior/posterior regional identity. A Hox gene mutation, or the formation of even one new Hox gene, may have far-reaching morphological implications. Not unexpectedly, similar occurrences have been proposed as a mechanism for early fast evolution of body designs, resulting in a rise in phylum diversity around and before the Cambrian epoch. The relative time of the important events in Levels of gene evolution as they are placed onto a phylogenetic tree of metazoans for which data is available. Only the anterior and posterior Hox genes are found in cnidarians. The other animal phyla studied exhibit an increase of central Hox genes (with additional specialisation following the advent of moulting animals - the ecdysozoans), with echinoderms and chordates showing an expansion of posterior Hox genes. Hox genes are duplicated in vertebrates: sharks and jawless fish have more than two complexes, teleost fish have 5-7 complexes, and tetrapod's have five complexes a list of all current phyla as recognised by one authority. This is based on a higher categorization scheme of five kingdoms, while a three domain system has also been suggested (Woese et al. 1990). Some polls acknowledge higher or lower figures[7], [8].

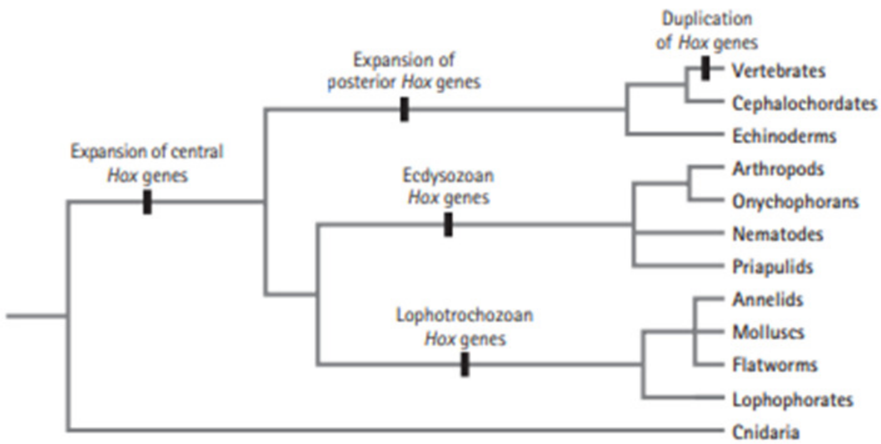

Figure 13.1 the Major events in the evolution of metazoan Hox genes

Which are minute and generally parasitic sub-organisms produced, it has been believed, from organisms' nuclear material).Also, new phyla are constantly being discovered. Several authority reported more than 20 novel bacterial divisions at the phylum, and potentially higher, level in 1998 alone. At the time of writing, the most recent discovery has been called Nanoarchaeota, containing just one species, a nano-sized hyperthermophilic microbe collected from a subsurface hot vent

According to Gould, anatomical variety peaked around the period of the Cambrian explosion in biodiversity. Animal and plant colonisation of land (440 Myr ago) and subsequent diversity trailed significantly after the advent of multicellular creatures in the waters. Hence animal life has progressed from a position of relatively few species spanning many diverse body plans in the Cambrian to now, when we observe far more species but fewer body plans.In general, there were few species throughout the Palaeozoic and early Mesozoic periods (though this has been disputed; Signor 1990). However, beginning just over 100 Myr ago, there was a gradual and significant increase in biodiversity that culminated at the end of the Tertiary and the beginning of the Quaternary (Pleistocene) with more extant species and higher taxa of animals and plants (both marine and terrestrial) than at any time before or since (Signor 1990). The human lineage descended from apes approximately 5 million years ago in Africa, the species Homo about 2 million years ago, and anatomically modern humans 100,000-200,000 years ago. We are living in the Quaternary (Holocene) epoch of declining variety, which is linked to climate change and the emergence of organised and large-scale human activities

There is no agreement on whether the journey from one species too many can be described in broad strokes by a simple mathematical model, and if so, what that model may be. Much of the issue stems from the fact that once diversification started on a large scale (from the Cambrian to the present), it was not, as previously said, continuous. Rather, there were periods of rapid growth mixed with big setbacks or periods of relative stagnation (or at least no marked directional trend in diversity). As a result, the history of biodiversity is often portrayed as one of radiations and stabilisations interrupted by major extinctions. Diversification of marine organism families occurs in three major stages (early Cambrian, Ordovician, and Mesozoic and Cenozoic), two major phases of approximate stabilisation of diversity (mid to late Cambrian, and most of the Palaeozoic), and five major mass extinctions (Late Ordovician, Late Devonian, Late Permian, Late Triassic, end-Cretaceous)

This has been described using two successive S-shaped (logistic) curves, each having an initial sluggish phase of rise, followed by a fast period, and a final gradual approach to an asymptote it has also been described with the help of an underlying exponential curve. Which varies greatly in terms of the number of families). The number of families of continental organisms and all organisms (marine and continental) are increasing in a more consistent trend. They have been described using logarithmic curves, with family numbers doubling on a regular basis within set time units. In none of these situations is there evidence of a clear long-term limit to the variety of life on Earth. If diversification continues, an ultimate ceiling would presumably be reached at some time, although it is not impossible to imagine that many more diverse species than are now existent might be crammed onto the Earth just before limit was reached.

Many models of patterns of species richness in time and space, on the other hand, assume that this richness has reached equilibrium. The number of families in each given time is equal to the number in the previous period plus the number of new ones that have arisen, less the number that have fallen extinct in the prior era. The patterns of these origins and extinctions are complicated and several studies have attempted to discover underlying regularities. The patterns seem to be influenced by both internal dynamics of the diversification process and external forces.

To a large extent, global and regional biodiversity, as well as local biodiversity, reflect broad patterns of temporal change this is both intriguing and useful since it shows that while biodiversity has expanded on a global basis, it has also increased locally. The alternative scenario would have been that biodiversity stayed about constant locally, with the worldwide increase resulting entirely from increasing differentiation between locality residents. Assuming that there is a trend of general biodiversity growth through time, the obvious question is why? The simple answer is that we don't know. External factors such as the break-up of continents and their subsequent drift (increasing the differentiation between assemblages on different continents and in different ocean basins), changing climatic conditions, and intrinsic factors such as the occupation of more and more of the potential niche space open to organisms over evolutionary time.

The overall pattern of diversification is not the result of synchronous changes in the biodiversity of all organismal component groups. Rather, some groups, in particular, experienced differential diversification. Time periods that are frequently associated with the invasion of new habitats or the aftermath of major extinction events. Furthermore, different groups varied in different ways. Some radiated quickly and later experienced a rapid decline in diversity, possibly leading to extinction. Some radiated slowly and remained with low diversity. Others continued to emit at moderate to high rates for extended periods of time.

This is evident in both terrestrial plants and vertebrate tetrapods. The dominance of primitive vascular plants among land plants gave way to pteridophytes (ferns) and lycopsids (club mosses), which in turn gave way to a predominance of gymnosperms (spore bearers), which was eventually surpassed by angiosperms (flower bearers) there is some evidence that the angiosperms continue to diversify today. The early amphibians and reptiles gave way to a number of successful reptile groups (including dinosaurs), which in turn gave way to modern amphibians and reptiles, birds, and mammals. It's tempting to interpret these successions as cases of competitive replacement or improvement, with one group being pushed out by the ascendant group's increasing number of species. However, there is no reason to believe that this interpretation is correct, and the reasons for these patterns are almost always much more complex, and associated with changing environmental conditions and the shifting opportunities that come with them.

It has been proposed that, with the exception of mass extinctions and other such disruptions, the rise and fall in diversity of different groups can be reasonably well modelled by a modification of a logistic model in which a group diversifies initially rather slowly and then more quickly, reaching a peak in richness at some point, and then declining slowly to extinction over some longer period.

Despite the relatively large number of major body plans, or phyla, only a few groups of organisms contribute much of the biodiversity at any given time, and most groups are simply not very diverse. This pattern occurs at all taxonomic levels. Thus, the majority of species are in the animalia, the majority of species in the Animalia fall under the Arthropoda, the majority of species in the Arthropoda are in the class Insecta, and the majority of species in the Insecta are in the orders Diptera (flies), Hymenoptera (ants, bees, and wasps), and Coleoptera (the beetles). Similarly, the order Rodentia (the rodents) has the greatest number of species in the class Mammalia, the majority of Rodentia species are in the family Muridae, and a large proportion of Muridae species are in the largest species in that group.

Three major explanations for this bunched pattern of diversity have been proposed. First, this could simply be an artefact of the process of classifying organisms into groups, with no biological basis. There is little evidence that this is true, because differences between many groups of organisms are clearly real and reflect their evolutionary relationships; however, humans do have a curious tendency to organise sets of different inanimate objects into a few large groups and many small ones.

Second, the patterns could simply be coincidental. A pattern in which many groups have few species and one or a few groups have a high proportion of species is most likely the result of a random speciation and extinction model. Consider the case where lineage splitting leads from one ancestral species to four descendant species and one ancestral species gives rise to two descendants at all branching points (dichotomous splitting; Fig. 2.8). At first, an ancestral species splits into two distinct species. There are two possible three-species outcomes depending on which of these two species speciates, and six possible four-species outcomes depending on which of these three species subsequently speciates. Only one-third (2/6) of these phylogenetic patterns of four species are symmetrical; an uneven distribution of species is more likely. This pattern is repeated for progressively larger and larger numbers of species (despite the fact that the possible number of evolutionary trees grows very quickly; for example, by the same set of rules, there are 87,178,291,200 possible trees giving rise to 15 species!). Indeed, models of random speciation and extinction help us understand patterns of diversification, but they are not always sufficient. Some groups continue to have far more species than would be expected by chance[9], [10].

This brings us to the third possible explanation for the observed pattern: some groups have characteristics that predispose us all to diversify disproportionately. Thus, it has been proposed that animal dispersal aided in the diversification of some vascular plant groups, that the ability to fly aided in the diversification of some insect groups, and that small body size aided in the diversification of some bird groups. Such hypotheses have proven far more difficult to test than was previously assumed, and there are numerous 'just-so' stories (a phrase used by Gould and Lewontin (1979), borrowed from Rudyard Kipling's 1902 book of the same name, to describe a clever explanation as to why a given species has a particular trait that is either untested or untestable) for why one group is more diverse than another, with no sound empirical support. Nonetheless, it appears likely that the evolution of some traits knowledge intended to present for some groups to diversify more than others.

Thus, there is hard data that the adoption of phytophagy ('plant eating') has been associated with disproportionate diversification in insect groups whereas the adoption of a carnivorous parasitic lifestyle has not been associated with disproportionate diversification. Much of the history of diversification has been characterised by specialisation in interspecific interactions, whether these interactions are based on consumption, pollination, or dispersal.

The difference in rates of speciation (adding species) and rates of extinction causes the overall pattern of temporal change in biodiversity (taking species away). The level of biodiversity will increase if species are created faster than they are extinct. When the rate of extinction equals the rate of speciation, there is an overall pattern of stability (stasis). As a result, if or when stasis in biodiversity is observed, it does not necessarily imply that nothing is happening; turnover in taxa identities over time could, and regularly will, occur. The stakes are still high. When the rate of extinction exceeds the rate of speciation, biodiversity declines, and if this continues for a long enough period of time, extinction occurs.

Life on Earth would eventually be extinguished

Over the course of Earth's history, it is estimated that more than 90% of all species (and possibly closer to 98%) have become extinct. Based on evidence from a variety of groups (both marine and underground), the best current estimate is that the average species has had a life span of around 5-10 Myr (i.e. from the time a particular species appears in the fossil record until it disappears). Raup (1994) discovered that the recorded life spans of 17,500 genera of fossil marine animals were strongly right-skewed using a higher taxonomic unit to reduce sampling problems Most genera lasted only a short time, while a few lasted an extremely long time. The true pattern is likely to be even more skewed, because the very short-lived are unlikely to be recorded in the fossil record. The pattern is likely to apply to species as well. However, no genus survived for very long in comparison to the duration of life on Earth. The longest-lived survived for about 160 Myr, or about 5% of life's history.

Some groups experience significantly higher rates of extinction than others. As a result, the estimated periods for which species in different taxonomic groups persist vary significantly Natural extinctions, in fact, tend to be taxonomically clumped, often disproportionately within species-poor communities, which may mean that more genetic diversity is lost than would be expected by chance. Extinctions caused by human activity are also common grouped (at the moment, parrots, pheasants, and lemurs are all disproportionately threatened) such variations may be due to extrinsic factors.

Thus, in the fossil record, marine groups appear to have lower extinction rates than terrestrial groups which may reflect the greater buffering of marine systems to environmental change. However, the differences may also reflect intrinsic factors that make some species more vulnerable to extinction than others, with the relationship between intrinsic species characteristics and the likelihood of extinction being fundamentally dependent on the extrinsic factors that pose a threat to continued persistence.

Extinction intensity has shifted dramatically over time, with comparatively low levels during the majority of periods and increased concentrations during the minority, and an overall right-skewed frequency distribution. The right-hand tail of this continuum is known as the mass extinctions (the other periods are known as background extinctions), though they clearly do not represent a distinct subset of periods. Although 75-95% of species alive at the time are estimated to have become extinct in these short intervals (Jablonski 1995), mass extinctions account for only about 4% of all extinctions in the last 600 Myr (Raup 1994). Their significance thus lies not in their contribution to total mass extinction events, but in the disruption they have had on biodiversity development patterns.

When levels of biodiversity recover, they frequently have a markedly different composition than those that existed prior to a mass extinction, with previously highly successful groups in terms of species richness being lost entirely or persisting in reduced numbers. Despite being the tail of a continuum, mass extinctions were not the result of a chance coincidence of extinctions of a large number of species. Indeed, the 'big five' mass species are thought to have resulted from very different causes.

Ordovician (late) (440 Myr ago)

Warm global climates during the Ordovician caused a decrease in vertical circulation in the oceans and, as a result, oxygen depletion in deep waters. Climate cooling and the beginning of glacial conditions were caused by the movement of a large amount of continental area near the South Pole. Sea levels fell, resulting in the extinction of marine, particularly deep-water, species. The end of the glaciation triggered a second wave of extinction, with rising sea levels linked to the spread of low oxygen conditions, resulting in the extinction of shallow-water groups.

Devonian (late) (360 Myr ago)

Many processes, including extra-terrestrial impact, sea-level fluctuations and the spread of low oxygen waters, climatic changes, and global cooling, have been proposed as causes of this extinction event. There is insufficient evidence to attribute the event to any of these alone, and it could have been caused by a combination of factors, although it has received considerable attention, the significance of this question may have less to do with the usefulness of the actual answer and more to do with the challenge it poses to understanding how biodiversity is distributed among different groups of organisms and across the Earth. It is one of the fundamental descriptors of life on Earth, and we should be able to provide a reasonably accurate answer.

On the surface, it appears that the best way to determine the number of extant species is to simply count them! However, the diversity of life is so great that this presents a truly daunting task, and one that has never risen high enough on humanity's agenda to be seriously considered. The question of how insurmountable the barrier would be if significant resources, technology, and ingenuity were applied. The question of biodiversity through time 39 remains unanswered. Some believe it can be accomplished in a matter of decades, but the majority are sceptical.

Given the enormity of the task, all attempts to estimate the number of extant species have used indirect measures and, as a result, have made major assumptions of one kind or another. Based on extrapolations from, five main methods have been used to estimate the number of extant species in large taxonomic groups or all groups:

Experts are being canvassed: This entails estimating overall species numbers based on the opinions of experts who have studied specific groups of species over long periods of time and have gained an understanding of the numbers that science does not know. This assumes the completely untestable assumption that these experts know these groups well enough to make reliable estimates.

Species description patterns: The total number of species in some groups has been estimated by extrapolating the cumulative number of taxonomically described species over time into the future.This assumes that past description patterns predict future patterns.

The percentage of undescribed species: This method entails estimating the total number of species based on the ratio of previously unknown to previously known species in large samples of specimens, and then extrapolating from the total number of known species. This is based on the assumption that the samples are representative.

Four areas have been thoroughly researched: Overall species numbers have been estimated globally or in very large regions by extrapolating from the few (predominantly temperate) areas where species numbers are reasonably well known. This assumes that the areas with well-known overall species numbers are representative of those without.

Groups that have been thoroughly researched: This entails estimating overall species numbers based on global numbers in well-known groups, as well as estimates of the ratio of species numbers in these groups to others in the few regions where the latter are reasonably well known. This assumes that the numbers of species in well-known and other groups remain relatively constant over time.

All of these approaches' assumptions are rarely met precisely: All of them also necessitate extrapolation beyond the bounds of available data, which statisticians always warn against. A widely quoted working estimate of extant species numbers, based on large numbers of studies, is one of around 13.5 million, with upper and lower estimates of 3.5 and 111.5 million species, respectively. Estimates for specific taxonomic groups (e.g., viruses, bacteria, fungi, nematodes, mites, insects), functional groups (e.g., parasites), and habitats or biomes continue to be fraught with uncertainty. Indeed, the relative contribution of some groups compared to others is still being debated, sometimes heatedly.

Estimated number of species

The vast majority of these organisms and thus applying classical identification techniques, as well as the unimaginable number of individuals that exist (the global number of prokaryotes is estimated to be 4-6 1030 cells, with a production rate of 1.7 1030 cells yr1; Whitman et al. 1998). The number of species estimated to exist in even small areas can vary by several orders of magnitude, depending on the method used to estimate them. Globally, it is clear that the diversity of bacteria, both in terrestrial and marine systems, may be far greater than many previously imagined.

While even very small sediment samples may contain many Protozoa species, it is becoming clear that, at least in some groups, the majority of these have large geographic ranges and that this local richness may not be indicative of high global richness. Thus, none of the 85 ciliate species discovered in an Australian volcanic crater-lake were unique to the continent. The number of extant free-living ciliate species is estimated to be around 3000, with the number of extant free-living Protozoa being around 12,000-19,000.

Fungi:

A working figure of 1.5 million fungi species has been widely cited, based primarily on extrapolation from temperate studies. On the one hand, some tropical studies indicate that this is a significant underestimate. However, it has been argued that the frequency of discovery of previously unknown species in areas where fungi are poorly studied suggests that the figure is likely an overestimation. Regardless, the discovery that just three individual plant leaves from the Neotropics supported 108 foliicolous lichen species, accounting for 25% of all taxa known from the region; lichens are a mutualistic relationship between a fungus and an alga or cyanobacterium.

Nematodes:

'If all matter in the universe except the nematodes were swept away, our world would still be dimly recognisable, and if, as disembodied spirits, we could then investigate it, we should find its mountains, hills, vales, rivers, lakes, and oceans represented by a film of nematodes,' Cobb (1914) observed. The number 1019 has been proposed as a conservative estimate of the global population of free-living nematodes (Lambshead, in press). It is unclear how this vast abundance translates into the number of species. Figures ranging from one million to one hundred million extant species have been proposed (for a review, see Lambshead, in press), but recent analyses have cast serious doubt on the more extreme upper estimates.

Mites

Mites have long been thought to be a hyperdiverse group of organisms, with studies in the tropics revealing a richness comparable to many insect taxa. Less than 50,000 mite species have been described out of an estimated total of hundreds of thousands.

Insects are an example. The total number of all species is heavily dependent on the number of extant insect species, for which estimates have varied greatly. A number of recent studies have strongly suggested that the higher estimates are unsustainable, but they remain popular in some circles. The degree of host specificity of herbivorous insects in such forests was assumed to be much higher than is actually the case, implying a fine subdivision of plant resources and thus inflating estimated numbers of insect species. The question of which order of insects is the most speciose is still being debated. The fact that the Coleoptera (beetles) are a more tropical group than some of the others would seem to support their claim, but empirical evidence is limited.

Many of these groups' species are parasites, which is a feature shared by the majority of them. This has sparked a heated debate about whether parasitism is the most common way of life on Earth, and whether the vast majority of species are parasitic rather than free-living. Given that parasites are more poorly understood than free-living species, these are critical issues in understanding the overall biodiversity of life on Earth. Given that most free-living species host many parasitic species, that some of these species are frequently host specialists, and that parasites frequently provide hosts for other parasites, the parasitic way of life is undeniably important to the global total number of species. If you're still not convinced, consider that humans alone host hundreds of parasitic species.

There is also considerable disagreement about the number of extant species in some of the better-known taxonomic groups. Thus, the widely quoted figure of c. 250,000 species of angiosperms (seed plants) appears to be a significant underestimate, with suggestions that there may be 300,000 or even more than 400,000 (Prance et al. 2000; Govaerts 2001; Bramwell 2002). While reliable figures for small areas and regions exist, global estimates are still largely based on guesswork.

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CHAPTER 14

EXTRAPOLATION AND ASSUMPTIONS ABOUT SPECIES OVERLAP IN DIFFERENT BIOGEOGRAPHIC REGIONS

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The construction of a species inventory on Earth is severely hampered by the fact that only a fraction of the total number of species has been formally taxonomically described. Even determining how large a fraction is complicated by the lack of a definitive listing of all described species and their status (e.g., whether or not they are currently considered valid species). Several attempts have been made to establish an international programme to generate such a catalogue, but these have all failed due to a lack of substantial funding. A widely quoted working estimate is that approximately 1.75 million living species have been described, accounting for approximately 13% of an estimated total number of extant species of 13.5 million, with the percentage of species in some specific groups thought to be much lower[1], [2].

There are two types of errors that can occur in lists of described species. First, the same species name may have been assigned to more than one species, a phenomenon known as homonymy. Second, more than one species name may have been assigned to the same species, a phenomenon known as synonymy. For example, two of the 59 new mammals described from the Neotropics between 1992 and 1998 were already considered synonyms of previously known species by 1997 (Patterson 2000). Most synonyms take much longer, often decades, to be recognised. The balance of these two types of errors appears to favour synonymy, with many thousands of species names thought to be synonyms. For example, 20% of extant insect species names may be synonyms, with the proportion being higher in groups that have been intensively studied, have larger geographic ranges, and exhibit conspicuous individual variation (Gaston & Mound 1993), and high proportions are also becoming apparent in some better studied or easily collected fungi and mollusc groups[3], [4].

A similar issue plagues fossil species lists, with analyses of North American fossil mammal species predicting that 24-31% of currently accepted names will be found to be invalid (Alroy 2002). This implies two things. First, the total number of species described is significantly lower than the number of currently valid species names suggests. Second, only about 13% of the estimated total number of extant species have been described. This is less clear, because estimates of global numbers of extant or fossil species based on extrapolation from lists of known species will be inflated as well by these difficulties. In fact, the situation is even more dynamic than this may appear. Recognized synonyms, for example, may be reinstated as full species names if subsequent research shows that they did, in fact, originally refer to genuinely distinct species, and not the ones previously described. Thus, in the Neotropics since 1982, 57 new mammal species have been described, 57 have been synonymized, and approximately 150 have been resurrected from previous synonymy, resulting in a net increase of approximately 150 species (Figure 14.1).

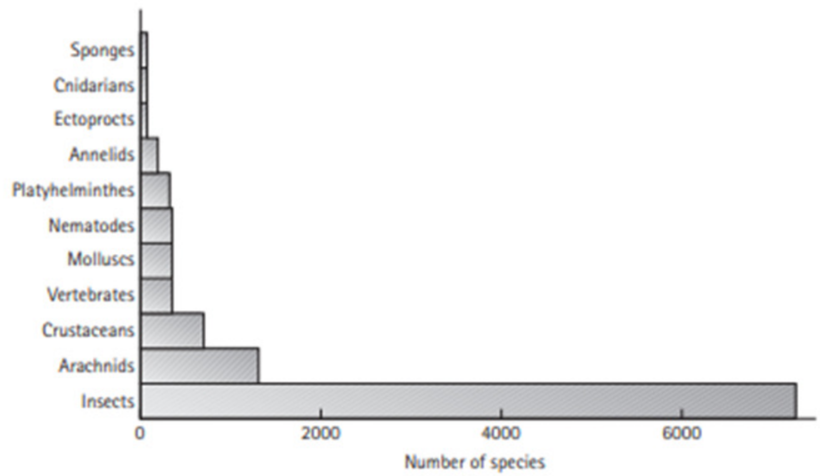

Figure 14.1: The Average number of species described per annum between 1978 and 1987 for major animal groups.

Additional species are being formally described at a rate of approximately 13,000 per year, or approximately 36 species per day (both figures based on formal published descriptions of new species); the breakdown for major animal groups. This rate has remained remarkably stable over the last several decades. However, the particular group of organisms that a taxonomist chooses to study is driven by practical concerns such as the group's importance in human affairs (e.g., agriculture, medicine) and the availability of funding for research.

As a result, the biodiversity catalogue has grown in a somewhat haphazard manner. Even within the better-studied groups, the species described are not a random subset of all species. They are larger-bodied, more abundant (locally or regionally), more widely distributed, occupy a greater number of habitats or life zones, and originate disproportionately in temperate zones (for some groups, rates of description from the tropics appear to have collapsed; see Bouchet 1997). Where a species has been formally described, this does not imply that much is known about it. For example, one estimate suggests that approximately 40% of described beetle species are known from a name, which usually reflects the Number of species. Biodiversity over time 45 is the fact that they were only captured on one occasion, often many decades ago meaning that their present status is unclear; with so many new species being discovered and described, it is inevitable that extant representatives of previously unknown major lineages will be discovered. New phyla have previously been mentioned; other recent examples include the discovery of a new order of insects and a new family of beetles[5], [6].

Typically, the cumulative number of species described in a tax on follows an S-shaped function over time, albeit only very roughly. It grows slowly at first, then rapidly, before approaching an asymptote when all of the species have been identified. Changes in the species concept that is generally used as well as variation in the number and output of taxonomists studying a group, can disrupt such a pattern, but the overall shape is reasonably robust. The full shape of the function has been revealed for well-known groups of organisms, but only the early parts have so far been attained for poorly known ones.The disparity between the number of described animal species and the estimated total number of extant species is primarily due to a lack of knowledge about small-bodied invertebrate taxa, which comprise the majority of species[7].

However, it should not be forgotten that new vertebrate species are constantly being discovered. Each year, approximately 130-160 new fish species are described. Between 1946 and 1995, 48 new bird species were discovered in Africa alone. From 1980 to mid-2002, 151 extant or recently extinct bird species were newly described globally, an average of 6-7 per year, with several others awaiting description. The vast majority of these species have been identified using traditional taxonomic methods. However, molecular studies are revealing the existence of many more bird species than morphological studies alone revealed. Many previously recognised subspecies, races, and disjunct populations have as much molecular divergence as previously recognised species, though this may not be as obvious in other ways. This has led to speculation that there may be 20,000 extant bird species, which is twice the current widely accepted number.

From 1937 to the early 1990s, sixteen new, living species of large mammals were described, an average of three per decade. These included two porpoises, four beaked whales, a wild pig (*Sus heureni*), a peccary (*Catagonus wagneri*), and four deer. There is no chance that the gap between the total number of extant species and the number of species described will be significantly narrowed in the near future. This is due to the fact that the taxonomic workforce does not exist to carry out the task. In fact, the current workforce is declining (Gaston & May 1992). In light of this dismal state of affairs, completing the task of trying to describe all species will remain a distant prospect. Rather than the current ad hoc accumulation of taxa, what is required is a planned targeting of key groupings, taxa, and geographical areas for taxonomic description in order to provide a better understanding of the important issues involved in the investigation of biodiversity and other[8], [9].

Mapping biodiversity

Biodiversity is not distributed evenly across the Earth or through the media that cover it (e.g., air, soil, water). Rather, species numbers form a richly textured surface of highs and lows, and species composition (the specific set of species) varies spatially. Attempts to comprehend the distribution of biodiversity have concentrated on identifying general spatial patterns in species richness that transcend this complexity, as well as the mechanisms that have given rise to these patterns. Inevitably, such efforts have focused on a small number of well-known taxa, particularly plants, birds, and mammals in the terrestrial realm and molluscs and fish in the marine realm. Most highly speciose groups, such as bacteria, fungi, and insects, have very little empirical data on spatial patterns in their biodiversity. We do not yet have a complete count of all the species (across all taxa) that occur in any geographic area, even if it is only of moderate size.

We do four things in this chapter. First, we will discuss the effects of spatial scale on observed levels of biodiversity. Second, we find spatial patterns in the distribution of areas with extremely high and low biodiversity. Third, we identify spatial gradients in biodiversity and the mechanisms that are thought to cause them. Finally, we discuss spatial congruence in different groups' biodiversity and the prospects for determining the big picture, which will allow further generalisations about the distribution of life on Earth to be made. This chapter distinguishes between species richness at local and regional or large spatial scales. Other people distinguish between alpha, beta, and gamma diversities, with alpha being the number of animals found within local assemblages or communities, beta being the turnover of species identities between communities, and gamma being the number of species occurring across a region.

On average, the number of species in an area increases with its size. Despite the fact that other models better fit some data sets, the relationship between species richness and area is commonly approximated as $S = cAz$ or $\log S = \log c + \log z$ where S denotes the number of species, A denotes the area, and z and c are constants (known as the Arrhenius relationship). This type of relationship typically explains more than half of the variation in species richness between different areas. The slope of the relationship, z, is usually found to be between 0.25 and 0.30.

This roughly implies that losing 90% of an area's habitat (i.e. a 10-fold reduction in its extent) will result in the extinction of 50% of the species that live exclusively in that habitat. Similarly, if 99% of the habitat is lost, 75% of the species will become extinct varies significantly depending on whether or not areas are nested (smaller areas within the confines of gradually larger ones), whether they are islands or parts of continents, their latitude, and the range of area sizes.Four primary explanations for the species-area relationship have been proposed. There may be no underlying relationship between species number and area, with the observed relationship being a statistical artefact of sample size variations associated with areas of varying sizes. Because more individuals are sampled in larger areas, more species are recorded.

The variety of habitats. Larger areas may have more species because they have more habitats and thus more opportunities for various organisms to establish and persist. Larger areas may have more habitats because they are more diverse topographically and environmentally. The dynamics of colonisation and extinction. The number of species in an area may be the result of a dynamic balance between the number of species colonising from the source pool (e.g., the mainland set of species for many islands) and those that become extinct after colonisation. The rate of colonisation is expected to decrease as the number of species increases, because there are fewer species to colonise and because the early colonisers will be those best suited to colonisation (e.g. good dispersers). Because each species has a finite probability of extinction and because negative interactions between species (competition, predation, etc.) are more likely when there are more species, the rate of extinction is hypothesised to increase with the number of species (although positive interactions may also increase, nullifying this latter effect). As a result, as the number of species in an area increases, the rate of colonisation decreases and the rate of extinction increases.

Dynamics of speciation and extinction. For very large areas, the influence of immigration on the number of species present is relatively small, and the most significant process is the balance between speciation (adding entirely new species) and extinction (removing species). The larger the area, the larger the potential geographic range sizes of the species that live there. More species will accumulate if species with larger geographic ranges have a higher probability of speciating (perhaps because barriers are more likely to subdivide their ranges) and a lower probability of extinction (because they contain more individuals and chance events are less likely to affect them all at the same time).

The importance of these various mechanisms varies with the type and size of set of areas. As a result, colonization/extinction dynamics are likely to be very important in genuine island systems, and speciation/extinction dynamics are likely to be important at the biogeographic province scale. With a few notable exceptions differences in area size have a pervasive influence on most spatial patterns in biodiversity. This must be kept in mind throughout the remainder of this chapter. Indeed, species-area relationships will be mentioned as potential explanations for a number of such patterns. However, some other spatial patterns in biodiversity, particularly those related to latitude, can obscure or even reverse the species-area relationship For example, the small tropical country of Costa Rica (51,100 km2) has at least 218 reptile species, 796 bird species, and 203 mammal species, whereas the large temperate country of Canada (9,970,610 km2) has 32 reptile species, 434 bird species, and 94 mammal species.

Local–regional richness relationships

Although smaller areas tend to have fewer species than larger areas, the species richness of a small area is not independent of the larger area in which it is embedded. Two theoretical types of relationships have been contrasted between the local richness of an assemblage and the species richness of the region in which that assemblage resides. Following a proportional sampling model, local uniqueness may be directly proportional to, but less than, regional richness (Type I).

Alternatively, as regional richness rises, local richness may reach a plateau beyond which it does not rise further, despite continued increases in regional richness (Type II). Despite some work related factors, most real processes, including marine, freshwater, and terrestrial assemblages, appear to have an underlying Type I relationship.

Regional richness explains a large proportion of the variance in local richness (> 75%), and local richness accounts for a significant proportion (> 50%) of regional richness. The observation that some spatial gradients in species richness (e.g., that with latitude) are documented both for locations and regions across those gradients supports the predominance of Type I relationships.

The preponderance of Type I relationships, particularly where habitat type has been kept constant, is supported by other evidence (e.g., the limited support for: (i) convergence of communities in equivalent environments in regions with different species count; (ii) density renumeration among species in assemblages; and (iii) invasion resistance of assemblages), implying that there are not hard limits to levels of local richness in most cases. That is, local assemblages do not appear to be saturated with species as one might expect if ecological interactions (such as competition, predation, and parasitism) limited local richness. This would be consistent with the observation that a historical limit on the number of species that can coexist on Earth has not been reached

If the majority of systems exhibit Type I local-regional richness relationships, then the regional number of species appears to be a major driver of local richness. Regional-scale phenomena are important for local-scale assemblage structure in general. A local community is formed from a regional pool of species (the pool of species in the region capable of colonising a specific site). Regional processes influence the size and structure of this pool, including the effects of the region's geophysical properties and history (its age, geology, size, and climate), as well as broad-scale ecological or evolutionary processes such as species migrations, invasions, speciation, and regional extinction. They determine the species composition, abundance, body size, and trophic formation of the pool from which local communities are formed. Regional pools, while undoubtedly important in structuring local assemblages, are perhaps best viewed as contributing to, rather than determining, local assemblage framework: local processes remain important. Understanding global patterns of biodiversity may rely on determining the relative contributions of local and regional processes.

Some argue that species-area relationships and local-regional species relationships are inextricably linked, and that the latter two are a direct consequence of the former. Mapping the sequence of biodiversity in its various forms (Whatever its causes, the relationship between local and regional biodiversity underpins the critical observation that temporal changes in global and regional species diversity tend to be reflected in local biodiversity, and vice versa). Thus, changes in the number of species in local fossil abundances can often be interpreted as indicators of larger-scale changes.

Biological realms

The oceans cover approximately 67% and land approximately 33% of the Earth's surface (511 million km2). As a result, one would expect greater biodiversity in the oceans. However, whether or not this is true is dependent on the taxonomic level under consideration. Marine systems have many more phyla than terrestrial systems. Margulis and Schwartz (1998) identified 96 phyla, with approximately 69 having marine representatives and 55 having terrestrial representatives. The greater diversity of marine systems is also true of some lower taxa, such as classes; Reaka-Kudla claims that marine systems contain 90% of all known classes. Despite the vastly larger area covered by the ocean, less than 15% of the species currently named are marine.

The extent that their proportions would change if all marine and terrestrial species were described is debatable. Nonetheless, it appears unlikely that anything resembling parity in richness would be achieved, and that marine devices are genuinely significantly poorer in terms of species numbers. Five sets of factors have been proposed to explain the disparity in diversity between land and sea. The Sea is where life began. This meant that the early diversification of form that led to the various higher taxa seen today occurred in the sea, with only some of these groups able to emerge onto land later. This, however, does not explain why there should be more species in the terrestrial realm.

Continental environments seem to be more diverse than marine environments. Although the complexities of marine environments are increasingly being recognised, this observation has long been held to be true. The heterogeneity of continental environments would have favoured higher levels of speciation on land, particularly when combined with continental drift. The latter resulted in the evolution of distinct floral and faunal assemblages on various land masses, with species from different evolutionary origins frequently filling similar roles.

The architectural complexity of the ocean-bed environment is lower than that of the terrestrial environment. Again, if correct, this would tend to promote greater levels of speciation in the terrestrial realm relative to the marine realm, though this could be argued to be offset by the oceans' greater continuous area. Herbivore patterns differ between the sea and land. Herbivores in marine environments are generalists, whereas those in terrestrial environments are specialists, often feeding on a single host-plant species and often only a portion of it. Greater specialisation allows for more speciation, but whether this is a cause or a result of high species numbers is debatable.

The body size distributions of terrestrial as well as marine species assemblages differ. Primary production, herbivory, and predation all involve smaller species in the sea than they do on land (for example, much of marine productivity is driven by massive abundances of microscopic picoplankton). Smaller-bodied species may be able to maintain the contiguousness of larger geographic ranges more easily due to larger numbers of individuals and greater dispersal abilities, potentially reducing the likelihood of allopatric speciation (genetic drift by subdivision of ancestral species distributions) in marine systems.

Land masses appear to be a likely explanation for why terrestrial systems have more species than marine systems. While freshwater systems are not typically thought to be a separate biological realm in their own right, it is instructive to compare their biodiversity to that of marine and terrestrial systems. Freshwater systems have about 55 phyla, which is slightly less than in terrestrial systems; however, the number of species is much smaller. This could simply be an area effect, with lakes and rivers covering only 1.5 million km2 (another 16 million km2 is under ice and permanent snow, and 2.6 million km2 is wetlands, soil water, and permafrost), but the high degree of habitat fragmentation, wide variation in physical as well as chemical habitat characteristics, and the limited dispersal abilities of many freshwater organisms have doubtless resulted in many species having extremely limited dispersal abilities.

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