DEMOCRATIC AND POPULAR REPUBLIC OF ALGERIA
MINISTRY OF HIGHER EDUCATION AND SCIENTIFIC RESEARCH

Nour Bachir El Bayadh University Center

Institute of Natural and Life Sciences

Department of Ecology and Environment

"Handout"

"COURSE: Structure, and Functioning of Ecosystems: Characterization and Preservation."

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SYLLABUS

Structure, and Functioning of Ecosystems: Characterization and Preservation.

HOURS VOLUME

Teaching Unit	VHS	VHS Weekly				Coeff	Crédits
	14-16 weeks	C	TD	TP	Autres		
UE Fundamentals							
Structure, and Functioning of Ecosystems: Characterization and Preservation	67h30	3h	1h30	-	82h30	03	06

Teaching Objectives:

Knowledge of the heterogeneity and diversity of Mediterranean ecosystems and their characteristics (climatic, biogeographical, floristic, and genetic).

Recommended Prerequisites:

Plant Biology, Ecology, and Bioclimatology.

.

Table of Contents

Introduction

Chapter 01: Terrestrial Ecosystem

1- The tropical forest
2-1- Location of tropical fores
3- Forest layers
4- Canope Layer
5- Base layer
6- Functional diversity of Mediterranean ecosystems Mediterranean environments
7- The Desert
7-1- Desert Features
7-2- Deserts have all the same characteristics
7-3- Absolute desert
8- Deserts classified according to their humidity
9- Physical characteristics of the desert Biome
10-- Precipitation and climate
11- Animal life
12- Geographic characteristics
1- Temperate grasslands, savannas and shrublands
1-2- Status
1-2- Flora
2- Climatic conditions and vegetative period
3- Sol
4- Wildlife
1- temperate forest
1-2- The characteristics of the temperate forest
1-3- temperate forest variety
1-4- Temperate forest structure
3- Tall trees
1- Boreal Forest
1-2- Characteristics of climate and vegetation
1- The tundra
1-2- Plants and fungi
1- Steppe ecosystems
1-2- Distribution of various steppes in temperate and tropical latitudes
1-3- The rainfall
1-4- The soils
1-5- Soils and vegetation formations in Algeria
1-6- Ecosystem Structure
Chapter 02: The structures
1- The structures
2- Low and high species diversity
3- Species Assemblages
3-1- Description of species associations
4- Search for explanatory hypotheses
5- Taxonomic Diversity
6- diversity index
7- molecular ecology
7-1- Insert A new discipline for the study of ecosystem diversity: molecular ecology

1- Ecosystem complexity and interaction (notions and theorem)
1-2- General theories of systems
1-3- The complexity
2- Bifurcation
3- cellular automata
4- The notion of self-organized criticality
5- the concept of “self-organized criticality
6- General theory of systems
6-1- The elements depend on each other in their functioning and their evolutions
7- Isotropie/ anisotropie
8- Spatio temporal contraction
8-1- cow dung
8-2- The individual in his habitat
9- ecological factors and adaptation of living beings
Chapter 03: Structure of food chains.
1- Structure of food chains
1-1- Relationships between producers (autotrophies) and their dependence on nutrients and light or chemical energy
2-1-. Food Chain
2-2- biosphere: terrestrial and aquatic
2-2-1-. Food Web
3- Primary or autotrophic producers
-1- Consumers (Heterotrophies) who are linked to producers
3-2- Consumers of fresh matter
3-3- Consumers of dead animals
3-4- Decomposers that recycle and mineralize organic matter
3-5- Different types of food chains
3-5-1- Predator chains
3-5-2- Chains of parasites
3-5-3- Detritivorous chains
4- Functioning of ecosystems
4-1- Energy flow at biosphere level
4-2- Production
4-2-1- Primary production:
4-2-1-1- Net primary production (NPP)
4-2-1-2- Primary production of biomass
4-2-1-3- Secondary biomass production
4-3- Productivity
4-3- Productivity
4-3-1 -Biomass production or productivity
4-3-2- Gross productivity
4-3-3- Net Productivity
4-3-4- Secondary productivity
5- Description of diagram of material cycles and energy storage in an ecosystem
Bibliographic References

LIST OF TABLES :

1. **Table 1:** Deserts have all the same characteristics.
2. **Table 2:** The characteristics of the temperate forest.
3. **Table 3:** Characteristic of The Tundra.

LIST OF FIGURES:

1. **Fig. 01:** Physical characteristics of coniferous forest
2. **Fig. 02:** a- Ferns b- Canopy Layer
3. **Fig. 03:** Leaflet of a three-year-old conifer.
4. **Fig. 04 :** *d-Honeysuckles (genus Lonicera),a-et-e- (Cornus mas), Acer spicatum,b- Acer spicatum*
5. **Fig. 05:** forbs.
6. **Fig. 06:** Agropyrum
7. **Fig. 07:** Tulipa suaveolens, T. sylvestrisHyacinthella pallasiana, H. leucophaea Paeonia tenuifolia Adonis vernalis, A. wolgensis Pulsatilla sp).
8. **Fig. 08:** Andropogon
9. **Fig. 09:** Chernozem
10. **Fig. 10:** Loess doll
11. **Fig. 11:** temperate forest
12. **Fig. 12:** Deciduous trees
13. **Fig. 13:** The tundra .
14. **Fig. 14:** Map of the world's biomes
15. **Fig. 15:** Aerial view of tundra during summer.
16. **Fig. 16:** Northern lights are common at night in the tundra
17. **Fig. 17:** Sedges (Cyperaceae)
18. **Fig. 18:** Distribution of various steppes in temperate and tropical latitudes.
19. **Fig. 19:** Land use map of the steppe
20. **Fig. 20:** Distribution of rangelands by group of plant formations (ANAT, 2003)
21. **Fig. 21**: a-Carex curvula, b-Caricion curvulae
22. **Fig. 22:** the percentage of individuals from distinct species
23. **Fig. 23:** simple local rule and the result (complex) of the repeated application of this rule on a grid of cells
24. **Fig 24:** concept of "self-organized criticality"
25. **Fig. 25 :** Schematic Diagram of an Ecosystem
26. **Fig. 26 :** Interaction System Organizational Chart
27. **Fig. 27 :** "transitive closure of an interaction network."
28. **Fig. 28:** Example of food chain.
29. **Fig. 29:** General scheme of the two fundamental types of food chains in the
30. **Fig. 30:** Trophic Network Representation
31. **Fig. 31:** Overall structure of a food chain
32. **Fig. 32:** Energy flow through a food web (Faurie et al., 2012).
33. **Fig. 33:** Biomass at different levels of a food chain
34. **Fig. 34:** A diagram illustrating the hierarchical structure from molecules to the biosphere.
35. **Fig. 35:** An illustration of energy flow in an ecosystem.
36. **Fig. 36:** A diagram of material cycles and energy storage in an ecosystem
37. **Fig. 37:** Nutrient Recycling

1-The tropical Forest :

It is the richest biome on our planet. The abundant rains combined with the high heat constituted this ecosystem with the very diversified vegetation. These three strata combined (which do not lose their leaves in the year) let pass almost no solar radiation, which leaves very little displacement to shrub, herbaceous and muscinal species which are very reduced.

There are also many climbing plants. The fauna is rich and diverse, it is an essentially arboreal fauna (and pluristratified) because the resources are abundant. The soil is very poor and fragile. The organic debris on the soil is very quickly decomposed and the minerals extracted are quickly reused by the superficial roots of the trees or leached by rain to the groundwater. Therefore, the soil contains few nutrients and is therefore very fragile.

2-1-Location of tropical forest:

Fig 01: Physical characteristics of coniferous forest.

Coniferous forests are biomes of coniferous or evergreen trees. The boreal or taiga *forest* is the largest coniferous forest in the world, extending over the entire northern hemisphere of the tundra of Canada and Alaska in North Asia and Europe.

Coniferous forests consist of three layers of vegetation: the canopy, shrubs and soil layers. Each layer houses the specific species of plant life that create the coniferous biome.The canopy is the upper floor of the forest

3-Forest layers:

The coniferous forest, like all forests, exists in the canopy layers on the forest floor. Large conifers, such as pine, spruce and hemlock, create the cover of a conifer biome. These trees *withstand the extreme temperatures* of the northern hemisphere. Small deciduous trees and shrubs form the shrub layer of the forest, while *ferns, mosses and tolerant acid wildflowers form the soil layer. Each layer is home to wildlife that cannot exist elsewhere.*

4-Canope Layer:

The trees of the canopy are conifers, which are a highly sought after wood in construction as well as furniture making. Clear-cutting of coniferous trees causes ecological disasters such as landslides and wildlife extinction. As forest fires devastate coniferous forests, the heat of the fire is needed for a new life begins.

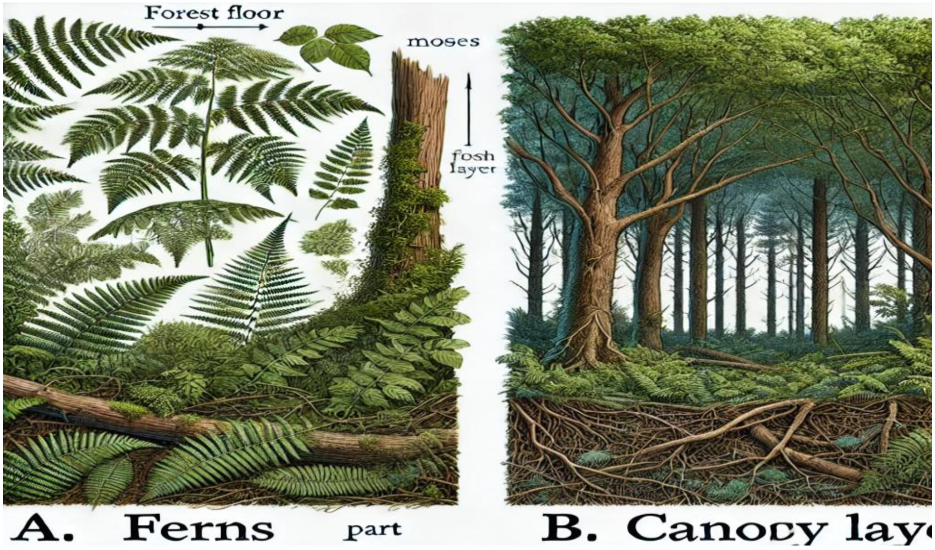

Fig 02: a- Ferns b- Canopy Layer

Coniferous species like redwood must have extreme heat to open their pods. Envergont house and feeding many birds and small animals in the forest.

3-Shrub layer:

Long-billed hazel, spiked maple, honeysuckle and dogwood are some of the shrubs that grow in acidic soil under conifers. These shrubs provide food for small herbivores who live in the forest. They are tolerant of shade. Mountain laurel and rhododendrons exhibit beautiful floral arrangements in coniferous forests in areas like the Blue Ridge Mountains, where moderate temperatures allow for longer periods of growth.Blueberries and sheep laurels grow under conifers in the taiga. Long-billed hazel

Fig. 03: Leaflet of a three-year-old conifer..

a) b)

c) d)

e)

Fig 04 : *d-Honeysuckles (genus Lonicera),a-et-e- (Cornus mas), Acer spicatum,b- Acer spicatum*

5-Base layer

The soil of coniferous forest teams with life. Mosses and lichens that date back to prehistoric times grow due to the profusion, dark and humid environment found in the forest soil. Ferns and wildflowers grow in the acidic soil of evergreen forests. In the bogs of the taiga, cranberries, small orchids and carnivorous plants thrive. Nepenthes, also known as insectivorous plants, discourage insect population growth. Many plants of this layer have healing properties that the natives used in medicine.

6-Functional diversity of Mediterranean ecosystems Mediterranean environments:

Are, by definition, characterized by a strong seasonal (seasonal) variation. For different vegetation types, species grouping criteria may be based on strategies used for survival during the adverse period. Established under cold temperate conditions, the classification of biological types of **Raunkiaer (1934)** is based on ***the location of renovation buds relative to the soil surface.***

- Renovation buds can be located: below the soil surface (in the soil), they are the geophytes; at ground level, and therefore half hidden: these are the hemiicryptophytes; at 25-30 cm height from the ground surface, these are the chamephytes; at a height greater than 25-30 cm above the soil surface, these are the phanerophytes;

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Under arid climate, species whose only source of water is atmospheric, adopt two major strategies in the face of summer drought (Evenari et al., 1975): arido-active species (persistent or perennial) maintain photosynthetic activity even at very low levels during periods of severe drought; they are mostly phanerophytes and chamephytes and some hemiicryptophytes and geophytes.

Their main reaction to seasonal dry conditions is a dimophism of the foliage which ensures a decrease of the transpirant surface); arido-passive (ephemeral) species cease all metabolic activity and include, in arid environments, therophytes, many hemiicryptophytes, geophytes or even some chamephytes (Helianthemum virgatum).

7-The Desert:

7-1-Desert Features:

There are several kinds of deserts: the absolute desert in which nothing grows, the cold desert and the hot desert. The desert is an extremely dry environment with very little rainfall. The desert is an arid environment that is not without vegetation. The conditions are very difficult, but some plants have adapted and with them some animal species. The largest desert in the world is a warm African desert, the Sahara, which is 9,000,000 km2.

7-2-Deserts have all the same characteristics:

Little rain, rainfall is very scarce. In some areas it doesn't rain for several years in a row. There's a big difference in temperature between day and night.

The soil is poor. ;Water evaporation is more important than precipitation.The vegetation is low and rare, it is mainly composed of succulents and succulents.The fauna is weak, rare and consists mainly of small animals: insects, small rodents, arachnids and birds.

Table 1 : Deserts have all the same characteristics.

characteristics	Description
Climate	Extremely arid with very low annual rainfall (less than 250 mm per year).
Temperature	Wide temperature ranges, with hot days and cold nights. Some deserts have extremely high daytime temperatures.
Vegetation	Sparse vegetation adapted to drought, such as cacti, succulents, and xerophytes.
Soil	Poor in organic matter, sandy or rocky, often with high mineral content.
Water Sources	Scarce, often limited to oases or temporary water bodies formed by rare rains.
Animal Life	Adapted to extreme conditions, includes reptiles, insects, small mammals, and birds.
Adaptations	Both plants and animals have evolved to conserve water and tolerate extreme temperatures.
Human Activity	Limited, often focused on nomadic herding, mining, and limited agriculture where water is available.

Encyclopaedia Britannica - Desert: Britannica Deserts

7-3-Absolute desert:

In the absolute desert there is no vegetation. The only area on land with no vegetation is the ice cap. There are no life forms. As the ice recedes, the tundra appears.

8-Deserts classified according to their humidity:

Deserts are classified according to their humidity. The lower the humidity, the more difficult the living conditions will be in the desert.

The absolute desert is so cold that water is present in the form of ice, so it is totally unusable for life. The largest deserts in the world:

- ✓ Sahara in Africa 9,000,000 km2.
- ✓ Gobi Desert in Asia 1,125,000 km2.
- ✓ Kalahari Desert in Africa 580,000 km^2.
- ✓ Large sand desert in Australia 414,000 km2.
- ✓ Karakum in Asia 350,000 km2.
- ✓ Taklamakan shamo in Asia 344,000 km2.
- ✓ Namib Desert in Africa 310,000 km2.

9-Physical characteristics of the desert Biome:

A biome is an ecosystem that includes specific characteristics related to temperature, climate, plant and animal life. A desert is just one of the eight main biomes on the planet. Although some of the Earth's biomes are remarkably similar to each other, some have very distinct appearances and characteristics. A desert is a biome that is hugely different from the other seven.

10--Precipitation and climate:

The desert climate is hot and dry. The main reason for this hot climate is that deserts are tropical biomes and are exposed to direct sunlight almost. The amount of rain in the desert varies slightly from desert to desert, but on average, the measurements of desert precipitation about 1 inch per year.

11-Animal life:

You might expect a desert to be a place where the life of the plant exists little. However, there are thousands of plants that thrive in a desert biome. The two most numerous are the ocotillo, a flowering plant, and the Saguaro cactus. Desert plants generally have shallow but extensive root systems. Desert plants also have water storage capacity or have evolved so that their water demand is relatively low.

12-Geographic characteristics:

Most geographical features in the desert include only sand or rocks and gravel. Vegetation, well diversified, is afraid. Although there are sand dunes that appear as hills, the lie of the land is flat. A water-rich ecosystem that can be found in the desert is called an oasis. An oasis is fed by underwater streams and occurs in an area low enough for groundwater to be exploited often.

1-Temperate grasslands, savannas and shrublands:

Grasslands, savannas and temperate shrublands form a terrestrial biome that groups the temperate grasslands that can be called steppe, pampa or veld depending on where they are located. The natural landscape is that of an immense expanse of grass whose trees are most often completely absent, except along waterways.

1-2-Status:

This group covers vast areas (plains) often located in the heart of many continental areas with extremely large latitudes. In the northern hemisphere, in Eurasia. The North American prairie corresponds to the central United States and Canada, east of the Rocky Mountains. The Argentine pampa represents the biome in the southern hemisphere.

1-2-Flora:

Grassland plant formation is composed primarily of ***annual herbaceous plants***, including the perennial Poaceae (or grass) family, whose rhizomes, bulbs or tubers can persist for many years, often between ten and twenty years.

- Their surface apparatus has the appearance of a continuous formation of jointed grasses that grow in the form of clumps or sod plates.
- These grasses belong to a small number of genera, about a dozen, whose distribution depends on ***differences in temperature and precipitation***. Some are from the cold temperate zone such as Agropyrum, Poa, Stipa; Others come from subtropical spaces such as Andropogon, Bouteloua, *Panicum.*

Fig 05 : forbs.

Fig. 06 : Agropyrum

Many dicotyledon plants, such as Compositae, Labiiae (sage, mints) and Legumes, etc., also grow among grasses. They are grouped in the United States under the name of «forbs». These plants can survive by sinking their taproots deeper than grasses, up to three or four metres underground instead of one or two.

2-Climatic conditions and vegetative period:

These ecosystems are characterized by a temperate climate with low to moderate rainfall. Grassland is established in regions with a continental climate characterized by a cold winter - four months below 0°C, daily frosts for eight months, eleven months - hot summers with 21°C. Precipitation.

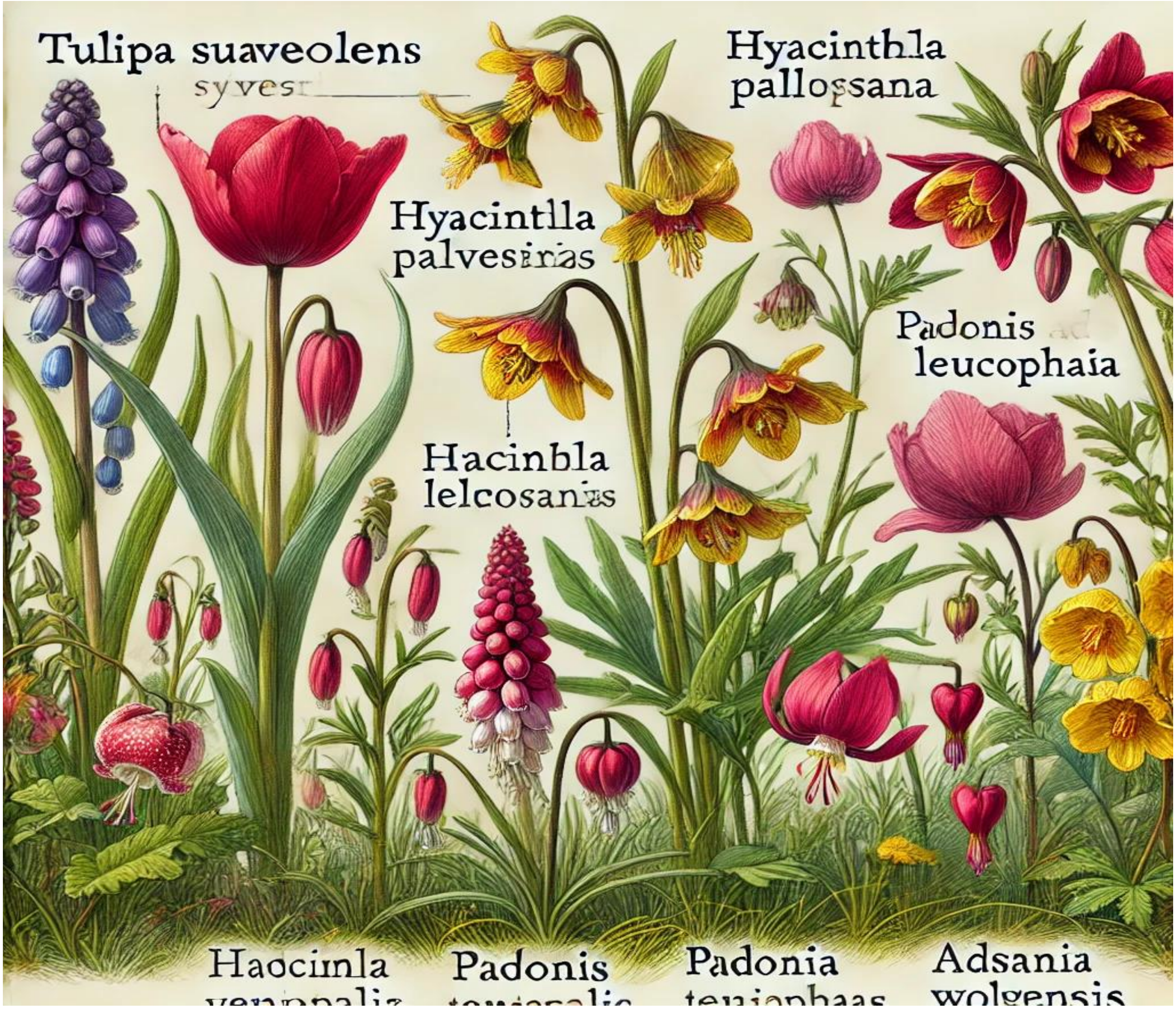
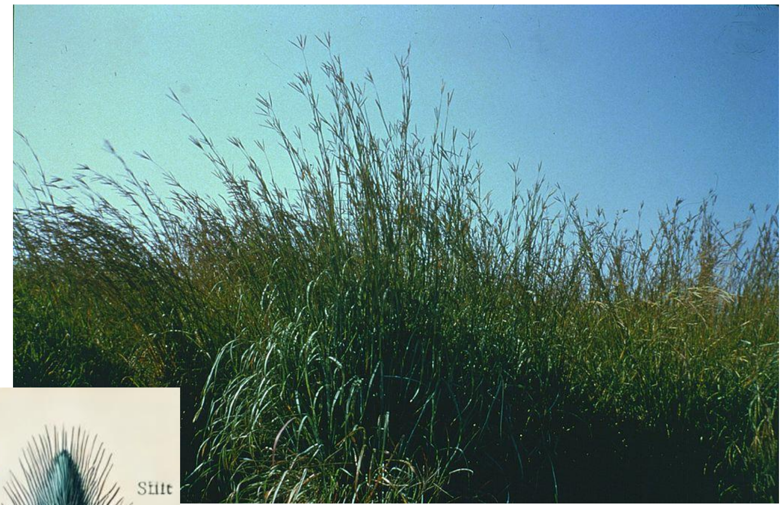
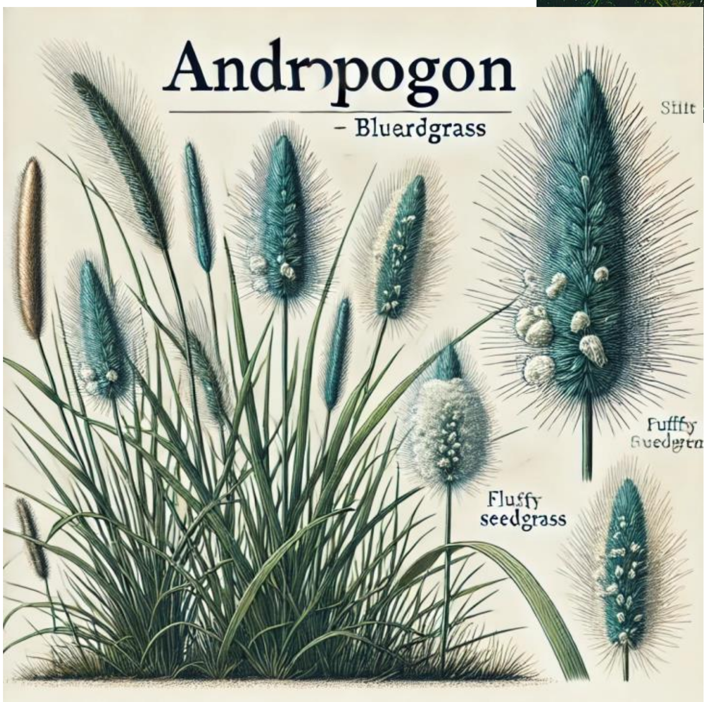


Fig 07: *Tulipa suaveolens, T. sylvestrisHyacinthella pallasiana, H. leucophaea, Paeonia tenuifolia Adonis vernalis, A. wolgensis Pulsatilla sp*).

The vegetative period is therefore relatively short and the appearance of the meadow changes considerably with the seasons. In winter, the surface apparatus of the grasses is parched, the meadow has a dull, gray, sad appearance. In the continental regions, the night radiation is intense, the negative temperatures (from 2°C to 20°C on average, sometimes much less in absolute), the soil freezes for several tens of centimeters but the rhizomes and bulbs resist well to these difficult conditions





Source : *Missouri Botanical Garden - Andropogon Species: Missouri Botanical Garden*

Fig 08: Andropogon (commonly known in the United States as broomsedge, or “broom straw”) is a genus of herbaceous plants in the Poaceae family. It can reach a height of 1.50 m and one draws from its stem an ochre dye, From the first heat, in spring, after the melting of the snow and the thaw, the soils having a reserve of water, the vernal and vernal plants develop quickly and bloom. The meadow is thus covered with flowers.

In the Pontian steppe, for example, it is a festival of iris (*Iris pumila*), tulips (*Tulipa suaveolens, T. sylvestris*), hyacinths (*Hyacinthella pallasiana, H. leucophaea*), peonies (*Paeonia tenuifolia*), adonis (*Adonis vernalis, A. wolgensis*), golden buds, anemones (*Pulsatilla sp*)etc.

The grasses of the dominant species (such as Andropogon or Stipa) develop more slowly and gradually overwhelm the other grasses to form a dense green and homogeneous mass.

Many inflorescences of annual and biennial plants with higher stems appear in turn, mixing with the releases of the year of rhizomatous and perennial plants.

Where there has been no movement of herbivore herds to consume the grasses, the grassland turns into high brush, but otherwise, if the movement of herbivores is significant, a clean lawn appearance will be maintained. In summer, water from showers is absorbed immediately by the leaves and roots and is insufficient to compensate for perspiration.

The herbs thus dry up gradually after allowing the underground organisms to accumulate reserves. The seeds ripen before being released. In case of droughts, frequent from year to year, the ***risk of prairie fires becomes high in this season, and their frequency more or less plays an important role in the opening of the environment and the absence of afforestation.***

Many plants promote fairly regular fires of their aerial parts, drying or sometimes producing flammable species, thus maintaining an open biotope that is favorable to them.

In autumn, the meadow is adorned with various shades, red, yellow, brown... Some rainwater seeps into the soil, evaporation is reduced in this season due to cooler temperatures and the soil is not yet frozen.

The vigour and density of herbaceous vegetation must obviously be related to the abundance of annual rainfall. When the latter are greater than 500 mm, the meadow is formed of tall grass whose height can exceed 2 meters. When on the contrary, they are weak (between 300 and 400 mm), the grasses are shorter (less than 0.50 m) and the proportion of annual grasses increases. Xerophile bushes, sagebrush begin to appear and the herbaceous carpet becomes discontinuous, in fact one passes from the meadow to the sagebrush steppe.

3-Sol:

The typical prairie soil is chernozem, that is, the black earth found mainly in southern Russia and Ukraine where annual rainfall varies between 350 and 400 mm. This chernozem is perfect for the type of plant formation that is grassland because:

It is balanced. There are few or no excessive downward movements that would cause leaching from the upper horizons, or dangerous upwelling to the surface leading to ***superficial concretions***;

It is rich in humified organic matter due to the abundance of plant debris provided by the prairie;nodules) or on a rocky surface (crusts, coatings), or from a point of water flow (concretions in karst environment), of biochemical (eg algal concretion) or chemical (eg ferruginous concretion or limestone concretion in caves). Concretization is the process leading to concretionsit is calcimorphic, that is, there is saturation of the absorbing complex due to the high nitrogen content and grass base. The pH is about 7 to 8, the C/N ratio is between 8 and 10;

It is deep, well aerated, thanks to the dense network of roots and the action of burrowing animals, rodents that represent 3/4 of the Ukrainian fauna, earthworms that digest a large part of humus.*The C/N ratio or carbon-to-nitrogen mass ratio is an indicator that allows to judge the degree of evolution of organic matter, that is, its ability to decompose more or less quickly in the soil.*

Fig 09: Chernozem; type soil in southwest Russia. is a humus rich soil type. The term chernozem is also found in some texts

Fig10: Loess doll: limestone concretion in the loess (location: Geispolsheim).

A concretion (from the Latin concrescere, «become solid») is the thickening by accumulation of matter, often in successive layers, around a nucleus (globular concretion,

4-Wildlife

The great American prairie was inhabited by millions of North American bison that once fed the Native Americans.Grassland grasses provide important feeding opportunities for birds. Some insects such as grasshoppers and butterflies are particularly abundant and diverse. Many species of rodents are subservient to these ecosystems and play an important role

An organism, population or species is considered to be inferred when the entity is highly dependent (but not necessarily mandatory) on one or more environmental factors. But there used to be large herds of herbivores, which, depending on the vegetative period, had to make large migrations in search of their food. The steppes of southern Russia and northern Kazakhstan were the cradle of the domestication of the horse by man.

- Even in the early 19th century, large herds of bison (50 to 70 million) moved across the prairie of North America. Their mass destruction, which almost led to their extinction, was only one episode in the development of the prairie.

Fig11: temperate forest

1-temperate forest: There are several varieties of temperate forest:

The temperate forest is the most widespread biome on earth. The temperate forest is also called the mixed forest. Temperate forest is found in Europe, Asia and America. The temperate forest is composed mainly of deciduous trees called: deciduous deciduous.

Temperate forest is also called temperate deciduous forest. The deciduous forest has four distinct seasons: summer, autumn, spring and winter.

1-2-The characteristics of the temperate forest:

Table 02 : The characteristics of the temperate forest

Characteristic	Description
Climate	Moderate climate with four distinct seasons: spring, summer, autumn, and winter.
Temperature	Average annual temperature ranges from -30°C to 30°C (-22°F to 86°F).
Precipitation	High annual rainfall, typically between 75 cm and 150 cm (29.5 in to 59 in).
Vegetation	Dominated by broadleaf deciduous trees (e.g., oaks, maples) and evergreen conifers (e.g., pines).
Soil	Rich, fertile soil with high organic matter content.
Biodiversity	High biodiversity with a variety of plant species, insects, birds, mammals, and microorganisms.
Human Impact	Often subjected to logging, agriculture, and urban development.

University of California Museum of Paleontology - Temperate Forest: UCMP Temperate Forest

- The temperate forest is characterized by:
- Alternating seasons: spring, summer, autumn and winter.
- Deciduous trees: the temperate forest is essentially composed of deciduous trees.
- Mild and temperate temperatures.
- Sufficient and regular rainfall.
- Rich and fertile soil due to falling leaves.
- The herbaceous richness of the undergrowth

1-3- temperate forest variety:

The type of tree is determined by the influence of the oceanic, continental or mixed climate. Forests exposed to the oceanic climate will mainly be oak forests, while beech will be the dominant species in continental forests. The forests of Asia and America offer a greater variety of species whether for trees or undergrowth species. For example, France has 5 species of oaks while some American states have 19! Primary forest has been severely degraded in Europe by human agriculture.

1-4-Temperate forest structure:

- ✓ The temperate forest is structured vertically, regardless of its geographical location. From the ground up to the sky we find:
- ✓ The foams.
- ✓ The herbaceous and the bulbous.
- ✓ The bushes and shrubs.
- ✓ Growing trees in the shade.

3-Tall trees:

Temperate forests are forests located in temperate climates especially in the northern hemisphere where there are the most land areas but also in the southern hemisphere. There are mainly two types of forests: evergreen temperate forests where it is found in coniferous forests; temperate deciduous forests.

Unlike tropical forests, these forests have a lower level of diversity of forest species where it can be found sometimes less than five species per massif (oak, fir, beech in particular). This lower level of biodiversity is also due to forest degradation resulting from overuse since the beginning of humanity.

These forest areas have been particularly inhabited by man since prehistoric times. The mild climate and the agronomic richness of their soils have led to very significant forest conversions. It is in these areas that primary forests or those with a high level of naturalness have declined or disappeared the most. The Taiga coniferous forests of Canada or Russia are the largest terrestrial biomes.

They are thus often particularly fragmented by roads, agricultural areas and various infrastructures.

In addition to this fragmentation, mono-specific plantations have also replaced natural forest and wildlife. Large mammals such as wolves, bears, wolverines, and lynxes have become very rare.

Wet or rainy alluvial forests have often been destroyed or heavily drained. These forests are also victims of the scarcity of dead wood, which no longer allows many species of invertebrates to live there. They are very simplified and most often suffer from too low a level of biodiversity.

The services provided by temperate forests, whose appearance and life change strongly with the seasons, are numerous, as for tropical forests: great landscape importance, carbon sinks, restoration, or soil protection.

- **An intermediary: Temperate** forests are, in many ways, an intermediary between other terrestrial biomes. In fact, the word temperate means what is not extreme. It is warmer and more diverse than in the boreal forests. However, the climate is less hot and there is less diversity compared to humid forests. Temperate forests are wetter than deserts but drier than rainforests. This is because temperate forests are located in areas with a mild climate.

We find especially mild climates around the middle latitudes. Many animals and plants in temperate forests in South America and Australia resemble those in temperate forests in the northern hemisphere, but they are not related. Temperate forests receive about 75 to 150 cm of rainfall per year. Temperatures are typically between -29°C and 32°C.

- **The changes of season** :There are four seasons in temperate forests: spring, summer, winter and fall. Because they are located in the middle latitudes of the Earth – neither too far north nor too far south – their climate is mild.

Summers are hot but not as hot as in the deserts further south, and plants and trees can continue to grow. There are snowy winters but not as cold as those of the boreal forests, and during which many plants are dormant and many animals migrate or hibernate.

Temperate forests can be subdivided but the two main types are deciduous and coniferous forests. Deciduous forests have deciduous trees like maples, which lose their leaves during the winter. Coniferous forests have many conifers such as lodgepole pines, which keep their needles (special leaves) throughout the year. In general, coniferous forests receive less water than deciduous forests and grow more slowly. In the United States, forests in the west are often temperate and those in the east are mostly deciduous.

Fig12: Deciduous trees, like the one from which the red oak leaf comes (left), lose their leaves each winter. Conifers keep their needles (right) all winter. Images by Ed Uebel and Mats Halldin.

1-Boreal Forest:

It is a forest dominated by conifers with discreet presence of deciduous trees. In Europe, consisting of deciduous (birch) and coniferous trees, it extends from the Baltic to the Urals. Spruces are the dominant conifers forming a dense and dark forest. Beyond the Urals, larch replaces spruce and it clears as it goes east until it becomes a very clear formation, a kind of steppe in the mountains of the Far East. On the Chinese border, along the Amur, the taiga becomes denser and more varied.

Boreal Forest The most common alternative name is Taiga and a rarer but used by some European authors when talking about Canada’s boreal forest, is the Hudson Forest. Here, the term Taiga will be used in a more specific sense, namely an incredibly open boreal forest.

The boreal forests are confined to the Northern Hemisphere. In North America, the forest is a continuous vegetation belt stretching across the continent and spanning more than 101 latitude. Its northern limit is defined by transition to the treeless tundra; this limit extends from about 681 N in Alaska to 581 N on the west coast of Hudson Bay, and it reaches the Labrador coast at about 581 N (Larsen, 1980).

In Fennoscandia it ranges from 561 N to 691 N (Esseen et al., 1997), with the northern limit fringing the northern coast of Norway. Across Russia, except for a small border, the northern boundary more or less follows the Arctic coast. In parts of Siberia the boundary is up to 500 km inland (Larsen, 1980).

The southern limits of the boreal forest are more difficult to define because the boundaries are rarely sharp. In more oceanic areas the forest is bounded to the south by broad-leaved deciduous forest, and in continental areas transition is to parkland, dry grasslands, and semideserts. For example, in western Canada the southern transition is to subalpine forest, in central Canada it is to prairie grasslands, and in easterly regions it is to mixed deciduous forest.

Climate There are strong relationships between the climate and the soils of the boreal regions. The characteristic nature of the climate to a large extent dictates the nature of the soils, including the permafrost, and these ultimately determine the plants and animals that live there.

Temperature In more general terms, Elliott-Fisk (1988) describes the climate as cool, humid microthermal, with very cold winters of 7–9 months allowing persistence of snow cover during all but the brief (3 or 4 months), relatively cool summer season. For more than 6 months of the year, the mean temperature is below 0 1C and net radiation is negative. Maximum summer temperatures generally reach the low 20s and winter minimums in the 50s. However, yearly variation can be extreme such as in Verkhoyansk (30 1C in summer and 70 1C in winter), but these extremes are moderated near the coast, for example, in Umea˚, Sweden (Figure 2).

Precipitation Generally, the boreal zone is characterized by having a high proportion of the annual precipitation falling as snow. Throughout most of the boreal forest annual precipitation is low, varying between 250 and 1000 mm. There are extremes, however, with Fort Yukon in Alaska and Verkhoyansk in Siberia each recording 180 mm annually. Some areas of western Norway with up to 2000 mm of precipitation annually have been classified as boreal rain forest. Because of low temperatures and short growing seasons, evaporation rates are low and drought is uncommon. When drought does occur, forest fires can ravage vast areas of boreal forest.

Vegetation The boreal forest is the most continuous and extensive forest in the world. The North American and Eurasian forests are remarkably uniform in their appearance throughout their range, both in their physiognomic structure and in species composition. Typically, there is a simple canopy layer (15–20 m high) in which numerical dominance is maintained nearly everywhere by coniferous tree species belonging to four genera: spruce (Picea), pine (Pinus), fir (Abies), and larch (Larix) . Species of juniper (Juniperus), cedar (Thuja), and hemlock (Tsuga) also occur.

Next is a shrub layer (typically 1 or 2 m tall) supporting mainly broad-leaved deciduous species that are also frequently present as successional components of the forest; deciduous species rarely achieve dominance, except in some postfire successions and in the mountain birch forest in Fennoscandia. Generally, the deciduous species belong to the genera willow (Salix), birch (Betula), poplar (Populus), and alder (Alnus). The herb layer typically is poorly developed, but it is enmeshed in a welldeveloped ground layer of mosses, liverworts, and lichens. Despite the uniformity of appearance, the tree species are unique to a particular continent, i.e., there are no circumboreal trees.

The species making up the shrub layer and ground layer may be more wide ranging, and many of the mosses and lichens are circumboreal. Bryophytes and lichens are typically a more common component of the forest floor vegetation than vascular plants. Bryophytes usually dominate on mesic and moist sites and their diversity in boreal forest is higher than in most temperate or tropical forests. Lichens also contribute significantly to diversity in boreal forests, especially on drier and northern sites, and particularly in the ground layer of pine heaths and on rocky ground.

Because there are few species of trees, the boreal forest gives an impression of monotony, but this is misleading even though they are floristically impoverished compared to most other vegetation formations of the earth. Nevertheless, these forests are a complex mosaic of different plant communities, and they caused Cumming et al. (1996) to title their paper ‘‘Boreal Mixedwood Forests May Have No ‘Representative’ Areas.’’ Some of the tree species are widely distributed (e.g., Picea glauca and P. mariana), but many other boreal species have more limited ranges, resulting in local and regional changes to forest composition. Throughout the North American boreal forest, a vegetation group dominated by P. glauca (sometimes codominated by Abies balsamea, A. bifolia, Betula papyrifera, or Populus tremuloides) is typically the climax community in relatively dry areas. A second group dominated by P. mariana occurs where soils are wetter, such as in bogs and muskegs.

Picea mariana is not strictly characteristic of wet areas because it also flourishes after fire. In the European forests the Scots pine (Pinus sylvestris) is frequently dominant on drier soils and the Norway spruce (Picea abies) occurs on moister sites. Although there are no abrupt transitions in the vegetation, changes in the dominant tree species, in the subdominant shrubs, and in the herbaceous layers can be detected.

Various attempts have been made to survey and describe latitudinal and longitudinal gradients, based primarily on climatic distinctions, and to describe the associated vegetation assemblages. For example, Larsen (1980) described seven regions in the boreal forest of North America, and Rowe (1972) described 35 regions. However, rather than describe each of these, we focus on some of the recent classifications.

Closed Forests The closed forest dominates vast areas of the southern boreal forest, and it occurs on a wide range of soil types and topographies. These forests have a closed crown with a moist, deeply shaded floor. The spruce–feathermoss community is characteristic of this zone, with either white or black spruce dominant.

The P. mariana–feathermoss forests have a uniform, moderately dense tree stratum, with an almost continuous ground cover of bryophytes. In contrast, the P. glauca forests are more irregular and open, having an understory of broad-leaved shrubs and herbs and a patchy bryophyte distribution. The most common moss in the black spruce forests is Pleurozium schreberi, whereas Hylocomium splendens is more characteristic of the white spruce and mixed woodlands.

Lichen Woodland These forests are more open with a discontinuous shrub layer and abundant lichens. The transition from the southern closed forests to these lichen woodlands is usually smooth or mosaiclike but can sometimes be quite abrupt as in northern Manitoba and

Saskatchewan. In some cases, a Western Stereocaulon paschale- and an Eastern Cladonia stellaris-dominated woodland have been identified.

Picea mariana and P. glauca are the dominant trees in these forests, with P. glauca declining to the north. Because these forests are more open, light penetration to ground level is much greater than in closed forests. Although these trees may be as tall (but less dense) as those in closed forests, the additional light promotes branching to ground level.

The additional light often promotes a discontinuous layer of health plants such as crowberry (Empetrum nigrum) and bilberry (Vaccinium myrtillus). Forest–Tundra Ecotone Here, there are scattered and isolated trees, often deformed or prostrate, in a tundra landscape. Although this type of forest is located north of the limit of continuous forest, it is still considered boreal forest.

The ecotone is more than 300 km wide in Quebec, up to 225 km wide in Central Canada, and it narrows at both its eastern and western ends. A Longitudinal Classification There is a remarkable similarity between the vegetation of the boreal forests in eastern North America and that in eastern Asia, with many identical or closely allied genera and sometimes species.

These forests contain many different species, whereas those of the Euro-Siberian region contain few. Of all the tree species in the North American boreal forest, only P. glauca extends from the Bering Straits across Alaska and Canada to Newfoundland. Picea mariana, usually found only on poor or wet soils, is found at the timberline toward the Arctic, and Larix laridna is found in the continental regions. Only two species, P. sylvestris and P. abies, are of any real importance in the boreal zone of Europe.

Only in eastern regions of Europe is P. abies replaced by the closely related Picea obovata, whereas additional species are being added to the forest in Siberia (Abies sibirica, Larix sibirica, and Pinus sibirica; Table 1). Moving east, spruce gradually declines from the forest until it is entirely absent in eastern Siberia. Peinado et al. (1998) analyzed the vegetation of the North American boreal forests.

They identified three major sections and classified them as eight major groups. The three sections coincide well with La Roi’s (1967) classification for the same regions. Qian et al. (1998) examined longitudinal patterns of plant diversity in the North American boreal forests, focusing specifically on the southern closed forests. The central section has a higher species and genera diversity than the western and eastern sections.

White spruce forests are always more diverse than black spruce forests; this is a reflection of the diversity of herbaceous plants and bryophytes and not the diversity of woody plants.

The diversity of white spruce forests is rather similar between western and eastern sections, but the diversity of black spruce forests is much higher in the west than in the east . The diversity of bryophytes is remarkably consistent across the continent, but again there are more bryophytes in white spruce than in black spruce forests . Animals The boreal forest is home to many animals. It is the winter home of the migratory caribou and reindeer and the permanent home of many others.

The wolf and lynx are the major predators of the boreal forest. Some of the best examples of population cycles in animals are described from the boreal forest regions; for example, lynx (Lynx canadensis), snowshoe hares (Lepus americanus), arctic ground squirrels (Spermophylus parryi), red squirrel (Tamiasciurus hudsonius), and boreal red-backed vole (Clethrionomys rutilus) in northern Canada and microtine rodents, owls, capercaillie (Tetrao urogallus), black grouse (Tetrao tetrix), mountain hare (Lepus timidus), and red fox (Vulpes vulpes) in Eurasia.

The causal relationships of these cycles have not been fully explained but many of the North American examples are synchronized with the snowshoe hare cycle, and Eurasian examples are synchronized with microtine rodent cycles. In North America, other inhabitants of the boreal forest include moose, black bear, grizzly bear, deer, wolverine, coyote, marten, beaver, porcupine, sable, voles of the genus Microtus, chipmunks, shrews, and bats.

Typical animals of the boreal forest vary slightly more from location to location than do the plants. The moose which browse on willow, birch, alder, and water plants, and the beaver which feeds on aspen, are widespread. Many birds also inhabit the boreal forest; for example, great horned owl, goshawk, spruce grouse, ruffed grouse, nuthatchers, juncos, and warblers. Brown bears inhabit the boreal forest in Eurasia.

In the boreal zone of Eurasia, the diversity of mammalian herbivores is highest in the interior of the continent and declines to the east. Across Eurasia, species richness of mammalian herbivores is positively correlated to warm climate, the number of hardwood species, and the area of the boreal forest. Across North America, species richness of mammalian herbivores increases as the length of the growing season and the number of coniferous tree species increase .

Given this information, it appears that indirect measures of primary productivity as well as the number of tree species can accurately predict species richness of mammalian herbivores. Bird diversity decreases from west to east across both the North American boreal forests and the Eurasian boreal forests. In Fennoscandia the diversity of forest birds decreases northwards; in Finland, this occurs only in pine forests and not in spruce.

It seems that the boreal forests of Canada, and possibly Russia, differ from those in northern Fennoscandia in that small herbivore biomasses reach much higher levels and are dominated by species of hare rather than voles. In addition, the densities of many fewer species in the boreal forests of Canada are correlated with the dominant herbivore relative to the situation in Fennoscandia. Tree death and decaying wood provide a variety of habitats for an enormous number of invertebrates. For example, in Sweden approximately 1000 species of beetle are dependent on dead trees.

The most diverse fauna on snags is found during the first 2 years after the tree has died. Spruce logs have a more diverse invertebrate fauna than pine, but many invertebrates can inhabit both. Four typical stages in the succession of invertebrates on spruce logs in boreal forests have been described. Initial colonization is by bark beetles and other primary cambial eaters along with their associated parasitoids, predators, and detritivores. Subsequent stages have been described in detail by Esseen et al. (1997).

Conservation In both Canada and Russia, vast areas of boreal forest are being cut annually, and the situation is worse in Fennoscandia. Although wood cutting is the biggest danger to biodiversity, there are additional threats from mining, pollution, road building, and dam construction. Clear-cutting vast areas of forest has profoundly altered the landscape structure in northern Sweden and in central Canada, resulting in habitat loss, habitat alteration, and fragmentation.

Clearly, this will have mostly negative influences on both animal and plant biodiversity, even though some species will benefit in the short-term, i.e., weedy species such as Epilobium angustifolium, Deschampsia flexuosa, and Calamagrostis purpurea that are adapted to fire and other disturbances. Few data are available on the long-term effects of clear-cutting in the boreal forest, but studies from other forests suggest that herb communities do not recover in logging cycles of 40–150 years.

Rotational cutting and clear-cutting will inevitably influence, or eliminate, natural fire regimes and will lead to changes in tree species composition and forest structure, a general reduction in stage age, and reduced input from coarse woody debris (Esseen et al., 1997), all of which will have profound impacts on the natural biodiversity of the boreal forest. Biodiversity must be preserved at all scales from the genetic variation within a population to heterogeneity occurring at the landscape level.

There are two major approaches to preserving biodiversity in these areas: (1) sustainable management and (2) reserves of natural areas. The first approach is more applicable to areas that are already subject to intense management such as Fennoscandia, whereas the second approach can be applied where vast, relatively untouched areas still exist such as in parts of Canada and Russia.

Sustainable Management To maintain biodiversity, we must also preserve or simulate the processes, mostly natural disturbances that produced the heterogeneity in the first place. Microscale heterogeneity may be enhanced by gap disturbance and by coarse woody debris. Larger scale heterogeneity may be enhanced by fire or insect outbreak. The management of forests itself may have effects on biodiversity, where species dependent on continuous forest cover (bryophytes, lichens, fungi) and carabids are negatively affected by management, but vascular plants positively affected (Paillet et al., 2010).

The emulation of natural disturbance in management techniques has been proposed as promising new technique for sustainable forest management, but the lack of consistent views on the meaning of the emulation of natural disturbance raises concerns about its use in policy making (Klenk et al., 2008). Reserves of Natural Areas Reserves alone are not sufficient to conserve biodiversity in forests, but any such initiative for maintaining biodiversity in the boreal forest should include at least four components: 1. Large areas representative of southern closed-canopy forest, lichen woodland, the forest–tundra ecotone and each of the longitudinal elements within these must be protected. 2. In selecting these areas, attention must be given to the animal inhabitants, their abundance or rarity, and their migratory behavior, if any. 3. The minimum reserve size should be large enough to incorporate natural disturbance and maintain ecological processes. 4. The decision-making process should consider the ‘‘floating reserve’’ strategy (Cumming et al., 1996) in which portions of a protected area could be periodically replaced in response to aging of components, unexpected large-scale disturbance, or refinements in conservation objectives.

Although much of the world's boreal forest still remains intact with little impact from man, the impact from man has been immense in many areas. In the new millennium, there will continue to be an increasing demand on the world's resources, including the boreal forests. Indeed, man's impact has already been substantial in Fennoscandia (less than 5% of the boreal forest remains in a natural or seminatural state) and is increasing in the North American forests.

It is tempting to argue that these forests are the world's largest vegetation type, occupying vast areas (approximately 14 million km2) and account for approximately 12% of the world's biomass, so the incursion of man is likely to have little impact. As described in this article, although the boreal forest is less diverse than most of the other world's vegetation types, it is nevertheless a complex mosaic of patches with changing species composition both longitudinally and latitudinally, with no representative areas, and home to many species of mammals, birds, and other animals.

1-2-Characteristics of climate and vegetation:

The cold continental climate in short summer is typical of this type of forest; the annual average temperature is 0°C with a five-month freeze; rainfall ranges from 400 to 800 mm and is distributed fairly regularly throughout the year (Köppen-Geiger Dfc climate). The floristic composition is relatively poor, with predominance of monospecic formations.

specific. Woody species mainly belong to conifers, spruce, pine, fir and larch (Picea, Pinus, Abies, Larix) and to northern deciduous, birch, poplar, alder (Betula, Populus, Alnus). Boreal larch forest Known as the eastern Siberian deciduous forest, some authors simply equate this forest with the boreal forest. The unique characteristics of climate and vegetation justify a particular type of forest

climate and vegetationThe coldest temperatures in the world for an inhabited continent, up to -90°C, which led to the designation of the Cold Pole for the Oymyakon region in eastern Siberia (Köppen-Geiger Dfd climate). Larch (Larix) is the only tree genus that tolerates such a medium, and Dahuria larch (Larix dahurica) is predominant. The deciduous character of larch, the presence of permafrost over 6 Mkm 2 , reaching 500 m deep, and the low species diversity gives this forest a physiognomy that clearly distinguishes it from the typical boreal forest.3.5.3 Mixed boreal forest This forest is commonly called Mixed forest or Mixed forest. Climate and vegetation characteristicsThis forest has a milder climate than the average of the forests of the boreal forest biome, growing at low altitudes often near warm sea currents, large lakes, rivers and rivers (climate Dfb de Köppen-Geiger). It is characterized by a mixture of leafy species such as oaks (Quercus), beeches (Fagus), maples (Acer) and conifers

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Fig13: The tundra • **World Wildlife Fund** - Tundra: WWF Tundra.

1. The Tundra

2. Characteristics

The tundra is a unique biome characterized by its cold climate, low biodiversity, and specific adaptations by plants and animals to survive harsh conditions

Table 03: Characteristic of The Tundra

Characteristic	Description
Climate	Extremely cold with long winters and short, cool summers.
Temperature	Average annual temperature ranges from -34°C to 12°C (-30°F to 54°F).
Precipitation	Low annual precipitation, usually less than 25 cm (10 in), mostly in the form of snow.
Vegetation	Low-growing plants such as mosses, lichens, grasses, and dwarf shrubs.
Soil	Permafrost (permanently frozen ground) is a defining feature, leading to poor drainage and shallow root systems.
Biodiversity	Low biodiversity with few species of plants and animals, adapted to the cold and nutrient-poor environment.

Key Plant and Animal Species

Plants: Arctic moss, caribou moss, bearberry, and various sedges.

Animals: Arctic fox, caribou, lemmings, snowy owl, and musk ox.

1. Overall View of the Tundra

An illustration showing the tundra landscape with low-growing vegetation, patches of snow, and frozen ground. Include typical tundra plants like mosses and dwarf shrubs. Show some tundra wildlife such as an arctic fox and a caribou.

2. Seasonal Changes

An illustration depicting the tundra in different seasons:

Winter: Snow-covered ground, bare vegetation.

Summer: Melting snow, blooming flowers, and active wildlife.

3. Biodiversity

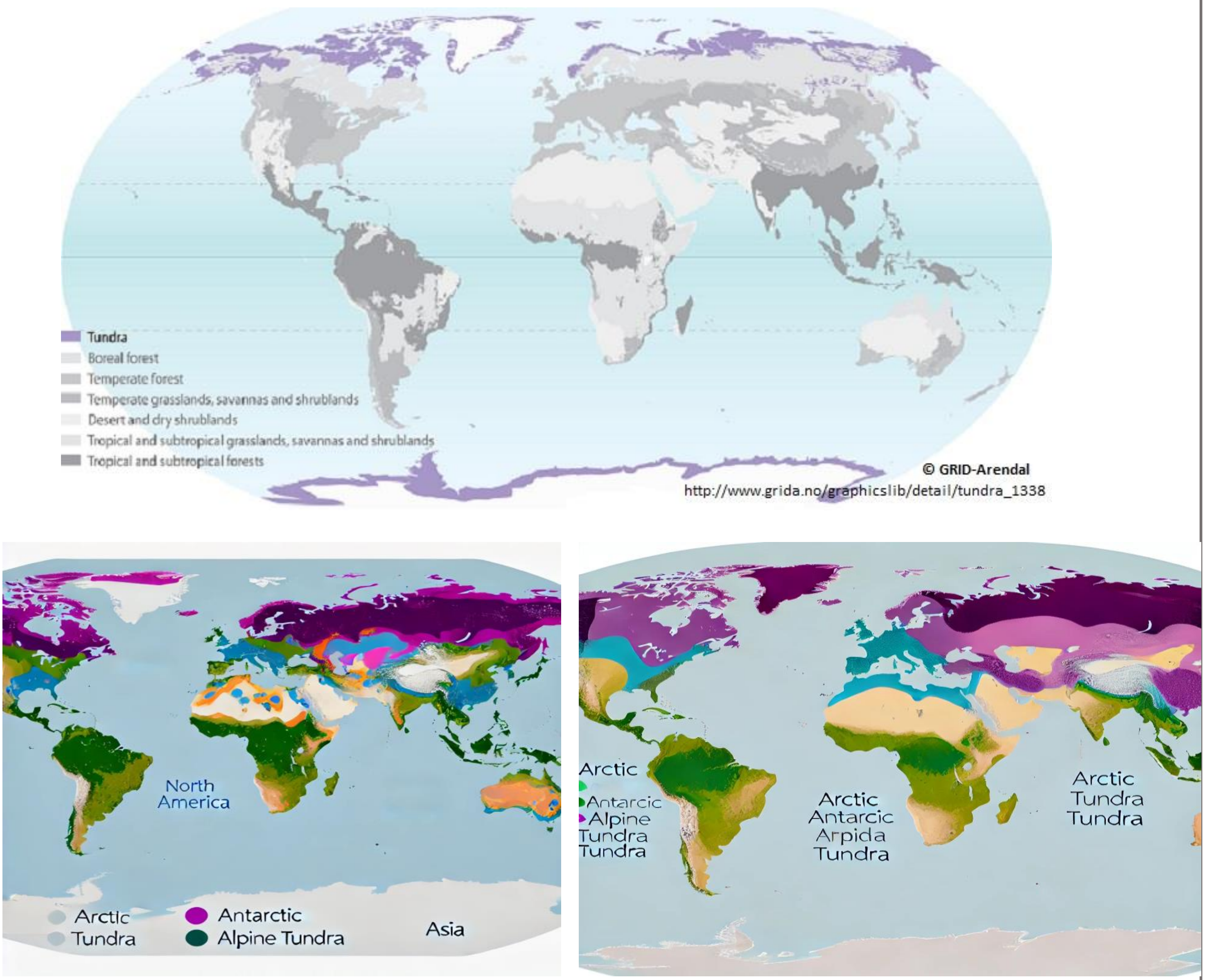
A detailed illustration showing the biodiversity of the tundra, including:

Plants: Various mosses, lichens, and dwarf shrubs.

Animals: Birds, mammals, and insects adapted to the cold environment.

Arctic tundra is the biome that extends from the edge of the taiga (or boreal forest), or forest boundary, to the permanent ice sheets closer to the North Pole or the Arctic Ocean. It is made up of a variety of landscapes, from extensive lowlands to imposing mountains. Often considered a barren and rocky biome, the tundra surrounds the pole and dominates in the arctic and subarctic regions.

- In Canada, the Arctic tundra is found in the Yukon, Northwest Territories, Nunavut, northeastern Manitoba, northern Ontario, northern Quebec and northern Labrador. In the



rest of the world, it is found in Alaska, Greenland, Russia, Iceland and part of Scandinavia.

The physical characteristics of the tundra are low temperatures (mean winter temperature is -34°C, mean summer is -34°C

Fig 14: *Map of the world's biomes, with arctic, antarctic and alpine tundra in purple. Arctic tundra occurs at the northern tip of North America, Europe and Asia.*

between 3°C and 12°C), low precipitation (15 to 25 centimetres including melted snow, which is drier than most deserts)strong winds and no sunlight for up to 163 days per year in the northernmost regions. These conditions create a harsh climate. The growing period is short, with only 50-60 days per year when temperatures are high enough for plants to grow. Biodiversity is also low compared to many other biomes, as few species are able to adapt to survive in the tundra. Given the low temperatures, the soil is very slow to form.

It has a thin layer of 25 to 100 centimetres, called an active layer, composed of soil that goes through an annual cycle of freezing and thawing. Below this layer is permafrost, which remains permanently frozen.

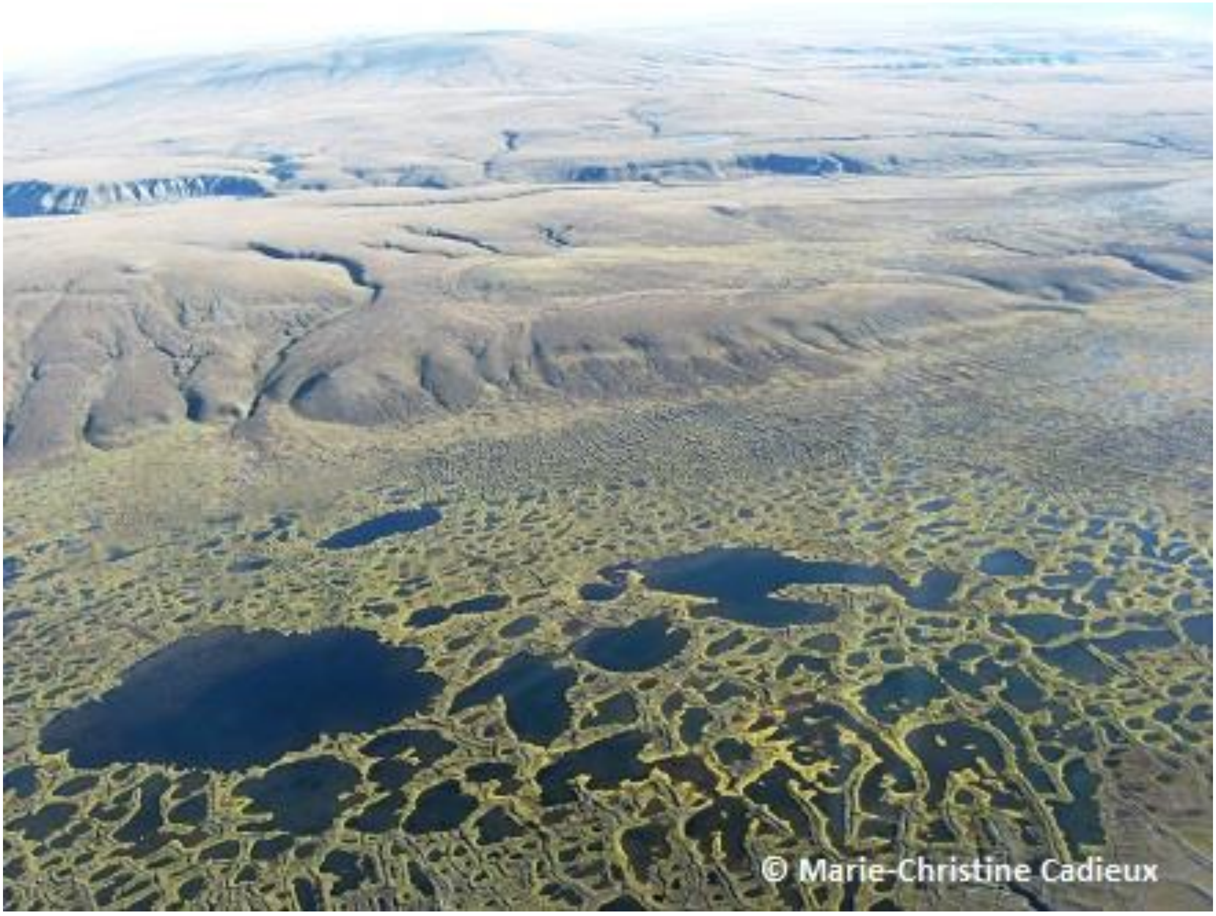


Fig 15: Aerial view of tundra during summer.

Tundra winters are long, dark and cold. Snowfall is low and most of the ground surface is covered with compacted, dense and hard snow. In some areas, high winds can create thick snow banks that harden sharply. In summer, snow and soil layers above permafrost in the active layer melt, creating and feeding a vast network of lakes, streams, rivers and wetlands.

Fig 16: *Northern lights are common at night in the tundra*

Fig 17: *Sedges (Cyperaceae)*

Waterlogged soil and 24 hours of sunlight stimulate rapid plant growth; at the lower latitudes of the tundra, at its southern end, dense and lush vegetation mats can even develop. This gives beautiful scenery and provides food for wildlife that lives in the Arctic year-round or migrates there to enjoy the abundance of food suddenly available in summer.

1-2-Plants and fungi:

Nearly 2000 species of plants, mainly mosses, sedges, grasses and flowering plants, form the vegetation of the tundra. Species diversity gradually decreases from the treeline to the permanent ice caps further north. Because of climate, permafrost and short summers, some tree species such as birch and willow form ground cover – they grow horizontally, not upwards, in this biome. This horizontal growth also helps plants to take advantage of the insulating snow cover during the winter as they become covered with it.

Tundra plants need to grow quickly for the short time allowed by temperature and light. Summer is short-lived but very colourful; Many beautiful plants, such as the Broadleaf Spike-primrose and Mountain Dryad, are in bloom at this time. As the sunshines 24 hours a day in summer above the Arctic Circle, some plants can grow and develop very quickly while being subjected to indirect lighting, unlike plants found in other biomes further south.

- *Sedges* (Cyperaceae*) are monocotyledons, as are true grasses (*Poaceae*). This last family includes many cultivated plants such as wheat, barley, rye, oats and corn, as well as important weeds such as field vulpin, dung, annual pasturin, or wind-toy agrostide. Graminicides are available to effectively control these weeds. On the other hand, it is more difficult to fight the ugliness which invades in an ever more problematic way the agricultural and vegetable surfaces. The stalk section of the uglies is generally triangular and leaves are arranged in three rows 120° apart. The individual flowers are tiny. The ugliness has attracted attention in Switzerland as a result of the increasing spread of the edible tigernut (Cyperus esculentus L.).*

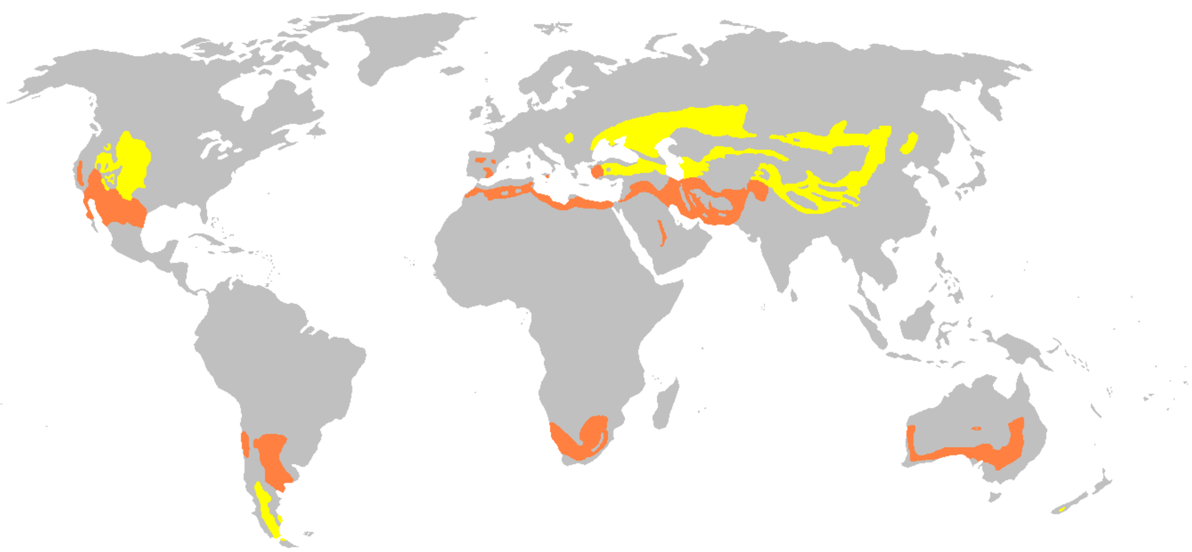


Fig18: Distribution of various steppes in temperate and tropical latitudes.

1-Steppe ecosystems:

1-2-Distribution of various steppes in temperate and tropical latitudes.

Steppe ecosystems have an essentially pastoral vocation**. *They are now experiencing a strong trend of degradation which results in the reduction of biological potential and the breakdown of ecological and socio-economic balances.***

characterize the environment, both phytoecologically (flora, vegetation, bioclimate) and edaphically (soil); more particularly, with an annual rainfall of 200 to 400 mm/year and a cold semi-arid bioclimate (sensu Emberger).

these steppe ecosystems have an essentially pastoral vocation. They are now experiencing a strong trend of degradation which results in the reduction of biological potential and the breakdown of ecological and socio-economic balances.

Over the past two decades, steppe ecosystems have been marked by intense degradation affecting vegetation cover, biodiversity and soil. At the beginning of this degradation, the most noticeable changes are those that affect some dominant perennial plants that print the physiognomy of these courses

The climate of the steppe is characterized by low rainfall (100 to 450 mm per year) and high thermal amplitudes. This rainfall is not only low but irregular. It has very significant spatio-temporal variations and precipitation often falls in the form of violent rains (showers). A dry and hot summer season alternates with a rainy and cool, if not cold, winter season.

The vegetation is the reflection of the environmental conditions especially climatic. Thus, as DJELLOULI (1981) reports, one of the concerns of phytogeographics and climatologists and researchers; by studying available climate data, expressions that can best and comprehensively translate the combination of climate variables influencing plant life.

The bioclimatic diversity of the steppe is characterized by three major constraints:

1. Aridity partly in the hot season;

2. A harsh winter;

- 3. Climate variability from month to month and year to year.

1-3-The rainfall :

- The average annual rainfall (100 to 400 mm/ year) and its distribution is irregular in space and time, the effectiveness of this rainfall varies according to its importance, its distribution and according to the edaphic substrate and the state of the course

1-4-The soils:

The distribution of steppe soils corresponds to a complex mosaic from the pedological point of view. Soils are generally shallow calcimagnesic and subject to highly visible runoff LABADI, (1998). This is due to a silty layer called glacage film that prevents water from entering the soil. Moreover, they are poor in organic matter POUGET, (1980), which favors the phenomena of water and wind erosion.

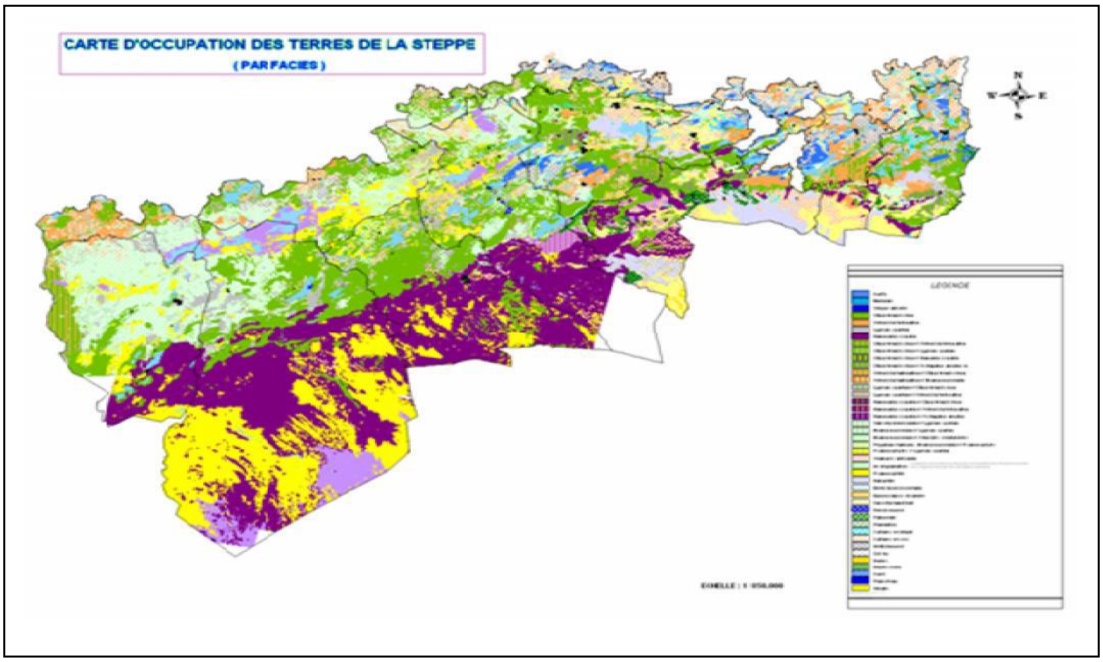


Fig19: Land use map of the steppe

1-5-Soils and vegetation formations in Algeria :

It is commonly called Algerian steppe a territory of 20 million hectares that includes 15 million hectares of steppe proper and 5 million hectares of cultivated land, unmaking, forests, and unproductive land.

- The steppe itself, generally unsuitable for cultivation and arboriculture, is found on shallow soils and poor in organic matter, characterized by a high sensitivity to erosion and degradation.

The distribution of steppe soils corresponds to a complex mosaic from a pedological point of view. The soils are generally shallow calcimagnesic, and subject to very visible runoff Labadi, (1998). This is due to a silty layer called the glaze film, which prevents water penetration into the soil. In addition, they are poor in organic matter Pouget, (1980), which favors water and wind erosion phenomena.

II -4-Main plant formations

The vegetation cover of steppe zones is dominated by four types of plant formations: esparto steppes (*Stipa tenacissima)*, white wormwood steppes (*Artemisia herba alba*) with high fodder value considered to be the best rangelands, sparte steppes (*Lygeum*

spartum) of little pastoral interest and remt steppes (*Arthrophytum scoparium*), which are also of lesser pastoral interest.

II -4-1-Wild mugwort: (*Artemisia herba alba*)

Sagebrush rangelands cover an average area of around 3 million hectares.

(*Figure 2*). They are located in cool arid and semi-arid zones, with rainfall ranging from 100 to 300 mm, often on more or less deep crusts, but with an icy surface film (Djebaili et al., 1989). Primary production varies from 500 to 4500 kg DM/ha/year, depending on the degree of degradation. Annual production can be estimated at 500 kg MS/ha, which corresponds to a pastoral productivity of 150 to 200 UF/ha/year.

II -4-2-Sparrow: (*Lygeum spartum*)

These rangelands cover an area of around 2 million hectares**.** They are located in cool semi-arid and especially cool or cold arid zones, often on more or less deep limestone crusts, but with a film of glaze on the surface (ibid.). Their productivity ranges from 300 to 500 kg DM/ha/year, in terms of UF, while parched rangelands are less productive, estimated at 150 UF/ha/year, according to Nedjraoui (1981).The same findings were made by Ouaffai et al; (2001), in trials intheDjelfa; with Lygeum spartum dry matter productivity in the order of 818 Kg DM/h, i.e. an energy yield of 168 UFL/ha. In fact, this species is only a very poor pasture, with an energy value of 0.20UFl/KgMs (ibid.), and is only grazed during the rhizome aerial budding period (March-April). Lepeyronie, (1982).

-Xerophytic grasses

These grasses can adapt to drought by having females that can curl or fold, their epidermis scarified and their stomata located in grooves. These species generally form large, dense clumps. Examples include *Stipatenacissima* (Alfa), *Ampelodesmos mauritanicus* (Diss) and *Lygeum spartum* (Snegh, or Sparta), arid-active plants, well adapted to dry conditions.

Halophyte course

They cover around 1 million hectares Djebaili et al, (1989). The most common dominant species include many Chenopodiaceae, the main species being *Atriplexhalimus* and *Solsola veimiculata*. Atriplexes present a double interest, as they can constitute a surprisingly significant fodder reserve for livestock feed. Ouaffai et al (2000) (Figure 3)

Biotic characteristics and adaptations

Pastoral resources in arid and semi-arid zones develop certain adaptive traits to cope with climatic and edaphic constraints, enabling them to save and make optimal use of rainwater. According to Aidoud (1989), Xerophytic adaptive traits can be broken down as follows: - at the individual or population level (Morphology and anatomy; Physiology ; -Specific phenology) and at the community level: Competition and spatial distribution; Sym - phenology; Biological and phytogeographical spectrum;

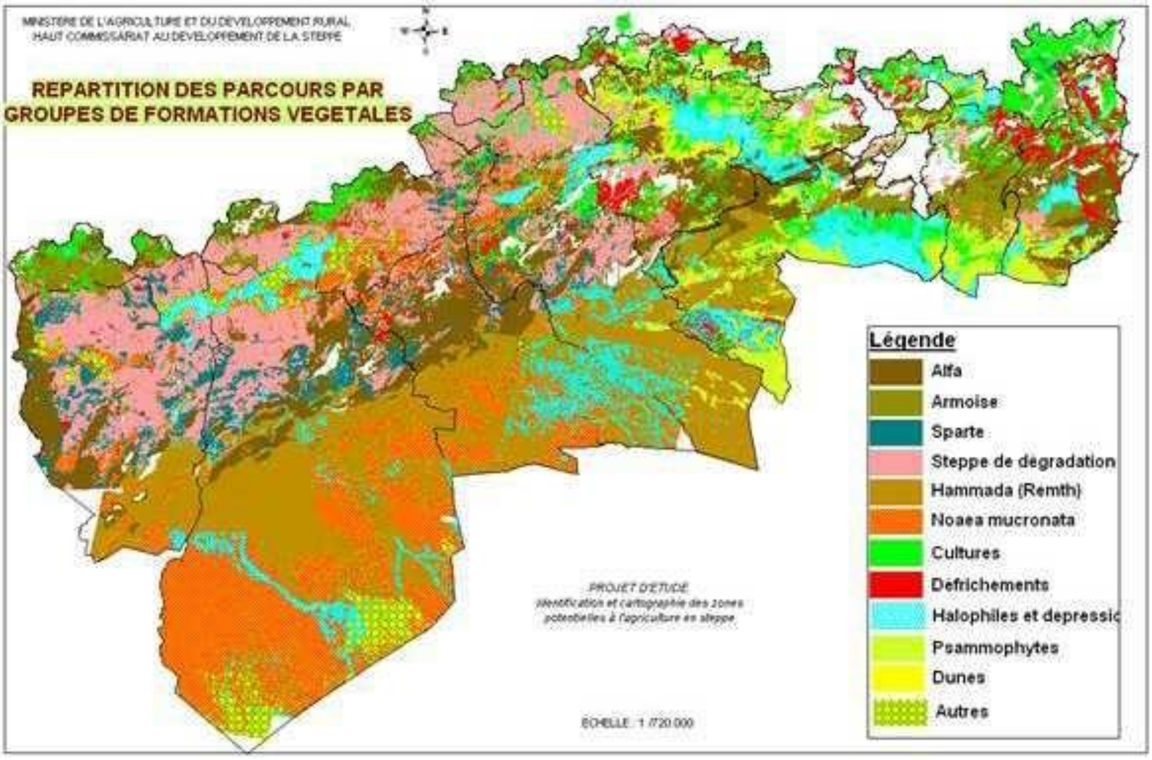
Therophytes: (short-cycle annuals)

The seeds germinate at the start of the winter rains, flower in the spring and reach maturity before the onset of the summer dry season. They dry out and spend the summer as resting seeds:-Spring annuals, whose active life takes place in winter and early spring (many grasses, crucifers and papilionaceous plants); - Biennials, which are generally fairly hardy grasses that, in their first year, produce only a rosette of leaves. In the second year, they flower, bear fruit and die (as in the case of many Borraginaceae).This biological type is included in the category of mayflies (arido-passives), which escape stress.

Geophytes: (plants with bulbs or rhizomes)

These are perennial plants which, like the previous ones, only show their full development during the rainy period in summer, after having first stored nutrients in their underground reserve organs, which can live for a long time in the form of bulbs or rhizomes. Pouget (1980) reports that the presence of bulbs and rhizomes in most geophytes represents a good adaptation to long periods of winter cold and summer drought, without the need to develop a considerable root system. According to Floret and Pontanier (1982), geophytes are included in the category of passive ephemerals.

Figure 3: Distribution of rangelands by group of plant formations (ANAT, 2003)


MINISTERE DE L'AGRICULTURE ET DU DEVELOPPEMENT RURAL
HAUT COMMISSARIAT AU DEVELOPPEMENT DE LA STEPPE
REPARTITION DES PARCOURS PAR GROUPES DE FORMATIONS VEGETALES
Légende
Alfa
Armoise
Sparte
Steppe de dégradation
Hammada (Remth)
Noaea mucronata
Cultures
Defrichements
Halophiles et depressic
Psammophytes
Dunes
Autres
PROJET D'ETUDE
Identification et cartographie des zones potentielles à l'agriculture en steppe
ECHELLE : 1 /720 000

The Chméphytes

These woody, perennial plants protect themselves from the cold or drying wind by their low height above ground (less than 0.25 m). According to Evenari et al. (1975), chamephytes belong to the category of perennials (arido - active), which maintain their green organs and thus a certain photosynthetic activity during the dry period. This biological type also includes thorny shrubs (thorny xerophytes). Spiny shrubs are the result of the transformation of various organs (stems, leaves), often accompanying a spherical plant habit or a dense cushion-like form, such as *Noaea mucronata*.

II -5-4-Fatty plants (or succulents)

They adapt to summer drought thanks to the water reserves they have accumulated in their leaves or fleshy stems. Examples include opuntia and Zygophyllumcornutum (Bougriba

Chapter 03: Ecosystem Structure

1-The structures

In this Chapter, we will indicate the most common ways of describing biocenonoses or communities, consisting first of specifying, in terms of composition, the assemblages of species that constitute them; then assign them a degree of taxonomic or special diversity that will allow us to compare qualitatively different assemblies.

The idea of "ecosystem" arises from the realization that species that coexist in the natural environment exhibit interactive dynamics and, at the same time, interact collectively with the surrounding physical environment that conditions them, and at the same time, they change. The whole then forms a «system»

The evidence was first that **the species of a natural settlement were not associated at random with their encounters. Many regular assemblages** have been gradually described, called **species associations, or communities, or biocenonoses** (names that we will consider equivalent, sometimes promoted as natural biological units, almost «super-species».

Each of these associations occupies a particular physico-chemical environment, quality of biotope , which conditions its existence and is at the same time transformed by it. Thus Tansley developed in 1935 the ecosystem by the symbolic addition: «ecosystem = biocoenosis + biotope» by proposing the alternative formula: «ecosystem = biocoenosis biotope»

The sign denoting a symbolic tensor product, or set of interactions between all elements of the biocenonosis and all elements of its environment. the tensor product is a convenient way to encode multilinear objects.

2-Low and high species diversity:

Comparing between them the assemblages, or the transient states tending towards one of the assemblages listed, it appeared that beyond the simple lists of species, they could be characterized and interclassified using quantitative taxonomic diversity descriptors.

They will then settle, regardless of their ***particular composition***, along a gradient joining the simplest stands, including a single abundant species and a small number of rare accompanying species the «speciesfic diversity» is then very low), and ***complex associations*** involving many species of not equal but comparable abundances, always accompanied by rare species, sometimes in large numbers (high «specic diversity»).

3-Species Assemblages :

3-1-Description of species associations:

By seeking to order and classify their inventories, observers find that their work is made easier by the existence of recurring associations of species, ***which can be recognized and***

compared. In fact, a proven specialist in a stand category can determine, based on a list of species:

- – whether the presence of this or that species is “normal” or “aberrant” for the site and ambient conditions;
- – if such association, observed, of several species indicates a ***transient or (sub)***deteriorating state of *the stand, or if it denotes a particular character of the environment (for example a state of pollution, or the devastation of a certain important factor, etc.).*
- Species associations are often characteristic of a biotope character association; the concept of “indicator association” then complements that of “indicator species”.
- These associations have been identified mainly in two main areas: terrestrial vegetation and marine **macrobenthos**.

benthos are all aquatic organisms (marine or freshwater) living near the seabed

This is no coincidence: this material lends itself easily to this type of approach. On the one hand, the associations or their differences are well visible in the field, possibly after a rough sampling, and the biotope/biocoenosis relationships are often easy to highlight.

On the other hand, these stands are fixes and perennial: one can return to the field some time after a first observation, and find the same association or, on the contrary, note its changes (which is much more difficult for example for plankton, too mobile, or for large animals moving often)

The study of the specific associations observed in the vegetation has given rise to a branch of ecology called «phytosociology», for the details of which we refer to botany manuals. We qualify then «phytocoenoses» the recurrent associations of species (as we call «entomocœnoses» those of insect species).

Each “coenosis” is characterized by:

– a limited list of characteristic species, which are the most regularly represented (not always the most abundant!);

– a “procession” of accompanying species, often inventoried at the same time as the previous ones, but whose presence is not mandatory to establish the association;

– a list of occasional, even accidental species.

This way of describing vegetation has been pushed very far, following in particular the work of Braun-Blanquet. The so-called «Montpellier-Zurich» European School once undertook ***an exhaustive inventory of these associations***, initially in temperate climates, then (with much more difficultés, because associations are less permanent) in tropical regions.

This inventory project was accompanied by a doctrine to consider these associations as permanent entities, although possibly evolving. just like cash. A nomenclature similar to the Linnean nomenclature used for genera and species was established to designate them, the Latin name of an association evoking the species or the two most characteristic species.

Two types of species have been distinguished: Linnaean species or large species, whose characters are very clear and apparent, and Jordanian species or small species whose differential characters are sometimes difficult.

It led to a hierarchical classification where «associations» are grouped into «alliances», these in «orders», then in «classes». For example, the herbaceous “association” Caricetum curvulae alpinum described in the Maritime Alps is described by the characteristic species Carex curvula and a few others.

It is part of the Caricion curvulae alliance, which is included in the Caricetalia curvulae order (alliances, orders and classes with their own lists of species, common to the subcategories they include).

Another axiom is that, under natural conditions, each vegetation evolves and tends towards a deinitive (often forest) state called climax an axiom means an unproven proposition, used as the basis of a mathematical reasoning or theory.

a)-

b)-

Fig21: a-Carex curvula, b-Caricion curvulae

Indeed, plant associations are a reality, and their consideration often makes it possible ***to judge the state of a biotope***, its biological potential ***and deficiencies***, its ***state of maturation, degradation, or regeneration after aggression, of a stand. The description of phytocoenoses remains one of the important elements of ecosystem description.***

However, recent work applied to more complex cases (in particular using mathematical methods ,have led to new paradigms. Intermediate states have been identified , and a school of thought, known as "continuum", has emerged, according to which variations in faunal

Caricetalia curvulae

composition would be progressive in space, and that consequently the separations described within stands would be arbitrary.

However, the controversy between the biocoenotic hypothesis and the continuum hypothesis seems outdated today. The precise conclusions made possible by numerical methods confirm both visions. Except in the case of sudden changes in the environment, changes in living stands are never completely abrupt but simply faster in some circumstances than in others.

Moreover, at the level of a rapid change of community, that is to say at the level of an interface between two very distinct communities, one notices not only a rapid biocoenotic transition as well as certain mixtures of elements, but also the appearance of new elements, interface-specific.

One is thus led to develop interface communities or ecotones (concept, moreover, ancient), sometimes more important for the functioning of the global ecosystem than regular settlements on both sides.

Nevertheless, even mathematically, the search for associations and their classification are only a first step. There is still:

– look for reason for recurring cash pools,

– assess the consequences on the functioning of the “functional diversity” ecosystem

The development of biocenonoses has received renewed momentum with the *methods of Data Analysis, allowing* the objective establishment and classification of species groups from quantitative inventories.

These methods mainly include factor analysis and numerical taxonomy, The inventories suggesting these intermediate situations had probably not escaped the first researchers. But they had been interpreted as mixtures due to imperfection of sampling, or as transient states of an evolutionary community: they did not contradict the biocenonotic axiom.

It is remarkable that quantitative, systematic and objective methods have largely confirmed species groups and classifications established by the more intuitive methods of precursors. The global vision of the latter proceeded from many years of work in the field.

Recent numerical methods both corroborate previous work, and provide a tool to continue it – and perhaps even more so, to apply it to more complex cases, such as tropical vegetation, where intuition had quickly shown its limits.

4-Search for explanatory hypotheses:

We discuss here the «factorial ecology», pillar if there is classical ecology The simplest of the explanatory hypotheses, given the evidence of species associations, is that of a community of specific requirements and tolerances affecting the physico-chemical factors of the biotope. Any biocoenosis would correspond, in this vision (at least in the stage final of evolution of the biocoenosis) to a biotope well developed, of which it would constitute a «signature».

In continental environments, this biotope is typically characterized by attributes specific to the atmosphere and soil, in other words by climatic (and/or microclimatic) factors respectively:, and edaphic factors: . For aquatic environments, hydrological factors are added: factors of the «hydroclimate», content of water in dissolved substances, degree of water agitation, etc.

- We will recognize, for example, «communities of Mediterranean climate», «communities of calcareous soil», and in oceanography «communities of warm coastal water», «communities of facies beaten by waves» etc.

- ***One more degree in the analysis of communities leads to the recognition of communities indicating the deficiency or excess of a trace element in the soil, or indicators of a form or degree of pollution.***
- The «biotic factors»We group under this term all the determining interactions between living species, whether strong or weak (activities of the species strongly or weakly correlated with each other), direct or indirect (indirect, notably via immediate or delayed environmental transformation.

These interactions obviously occur in the permanence of associations: species live together not only because they can, but often because it is necessary for them. It is common for the presence of one species to be understood only based on the presence of a number of others (many examples. On the other hand, certain proximities are non-viable (notion of amensalism).

The composition of a natural association of species is, therefore, at least as much as a community of environmental requirements (other related ecologies), a set of mutual influences.

The relationships of phoresia, symbiosis, etc., are often described because of their biological interest, and their obvious necessity for the system. However, there are few examples of communities where all interactions have been inventoried to explain the association.

The problem is indeed inextricable complicated, so many, diverse and sometimes unsuspected interactions between distinct species. The few analyses available in the ecological literature relate to very simple systems (and even, for them to become such, simplified), or to real subsystems, the least of which is already complex.

- For example, macroscopic plants in the same community were found to communicate chemically through their common mycorrhizae, but in general the descriptions never go exhaustively from microorganisms to macroorganisms.

- Another approach is to «short-circuit» the detailed analysis, and to try to identify the global properties of a complex system.

To proceed in this way seems to replace the search for the causes with those of the consequences. But in reality, phenomena acting at different hierarchical levels, both «causes» and «consequences», insofar as the insertion of an element in an organized system modifies its properties,

The two visions are complementary. The second is the basis of an ecosystem theory, which is still incomplete today but whose axes are beginning to appear,

In Enfin, taking into account the historical aspect in the "explanation of a current association" means taking into account some previous events. These have acted on the ecosystem either for long periods of time, or sporadically in the form of impulses and bifurcations that we mentioned in .As well as environmental conditions and interactions between living species, the state of a community of species is also a history – and in particular that of its disturbances and human interventions.

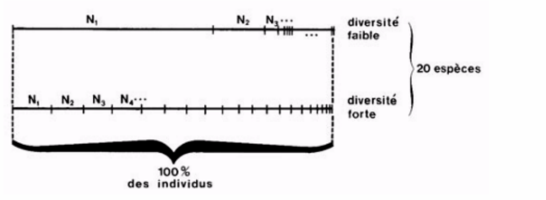
However, we will not be able to specify the implications until we have discussed the evolution of ecosystems,

5-Taxonomic Diversity:

The diversity of the elements of a community is a «quality» that can be observed from the outset. It covers, in fact, two aspects: (i) the number of categories identified at the same taxonomic level. In current practice, species are most often counted (we will then speak of special diversity); but one may as well count only genders or even families .

The regularity of the numerical distribution of taxa in the inventory. This distribution is called more or less «regular» or «irregular» depending on whether the different taxa show similar or disparate abundances.

The second concept seems more elaborate than the first. However, it corresponds to a common intuition. If one of the S species in a territory, or a very small number of them, represents the majority of the number of individuals, the other species being rare, we feel the species assemblage as “little different.”



Représentations des répartitions en pourcentages des individus d'espèces distinctes, pour le même nombre total (20) d'espèces, dans deux types de communautés, l'une très diversifiée, l'autre peu. En haut : diversité et régularité faibles. En bas : diversité et régularité élevées.

Fig. 22: *the percentage of individuals from distinct species.*

If on the contrary the assemblage includes many species of ***average abundance, each of them being quite frequently encountered, we declare it «well diversifiée»***

1 . Each of the situations can be graphically symbolized by the sharing of a straight segment, whose length represents the totality of the individuals observed, in as many sub-segments as species inventoried, length proportional to the proportions of individuals in each. The

representation is even clearer if the sub-segments are classified in order of decreasing species frequencies (Figure).

6-diversity index:

An index based on a hypothetical model of the distribution of individuals in species: the Gleason diversity index A first idea, intuitive enough, ***to assign a measure to the specific diversity – a measure taking into account both the number of species present and the "regularity" – is dictated by the census process itself.***

Depending on the rate at which the number of species surveyed increases as the number of individuals examined *increases*, diversity will be felt as large or small. If large, the species list grows **rapidly; if it is low,** it will require ***a significant sampling or observation effort to increase the number of species identified*** by including rare species (the rarer a species, the greater the average observation effort to meet it).

7-molecular ecology :

- 1. It should be noted that molecular ecology is currently opening up prospects for renewing the concept of diversity (Insert)Representations of the percentage distributions of individuals of distinct species, for the same total number (20) of species, in two types of communities, one very diverse, the other little. Top: low diversity and regularity. Bottom: high diversity and regularity.

7-1-Insert A new discipline for the study of ecosystem diversity: molecular ecology:

- Access to taxonomic diversity begins by identifying taxa at a certain level (species, genus, family, etc.).vIf this indispensable work is in some cases relatively easy, based on visible morphological criteria, it becomes very difficile and very long for organisms of small size and without very marked external characters (for example the meioffauna of marine sediments). For even smaller groups (bacteria and viruses in particular), morphological criteria are not relevant.

New approaches, combining modern detection and counting techniques, and the possibilities offered by molecular biology, allow for about fifteen years (especially in the field of biological oceanography) to understand the taxonomic diversity of these organisms

Among the examples of use of these techniques, those from the marine environment show to what extent they have lifted an important barrier, and have thus made it possible to reconsider the vision that one could have of the functioning of certain marine ecosystems.

In the 1980s, tiny photosynthetic procaryotes (nano- and picoplankton) were discovered in oligotrophic ocean environments, using the technique of flux cytometry (a technique for measuring at high frequency the diffusion and fluorescence of isolated cells, thus counting them with great precision).

This discovery called into question the description of the functioning of these media in terms of production, regeneration and flux of matter.

- These techniques were then coupled with the use of afin DNA markers to detect and characterize picoplankton, bacteria and viruses. The next step was to develop taxonomic probes to distinguish a taxon of Alga or Bacterium thanks to its ribosomal RNA sequence (RNA 18S in Eukaryotes, RNA 16S in Prokaryotes), chosen because it is present in all living beings except Viruses.

We thus determine the place of an organism vis-à-vis phylogenetically close organisms. This technique makes it possible today, from DNA extracted from natural samples (thus without going through the cultivation of selected groups), to sequence the target gene in order to directly determine the picoplankton diversity present in the seawater sample. It is then possible to take into account, in the analysis of the ecosystem, the diversity of biological compartments. One of the founding articles of the use of this approach in oceanography is by Giovanni et al. (1990).

1-Ecosystem complexity and interaction (notions and theorem)

1-2-General theories of systems:

The general theory of systems, applied today in virtually all fields of knowledge. we say a few words to the general theory of systems in "ecosystem", there is "system". ecology joins a current movement of thought, such that after any analysis of a set of elements, we consider the new properties that confer on this set a «**organization» of these elements among themselves**. the systemic is the logical and generic study of such sets,

1-3-The complexity:

Complexity As Edgar Morin (1990) points out, complexity appears at first glance as a kind of hole, confusion, difficulté. It cannot be defined in a simple way, as an antinomy of simplicity: complexity is a problem word and not a solution word.

What is complex is part of the experimental world, uncertainty, the inability to be certain of everything, to formulate a law, to design an absolute law. It is also logical, namely the inability to avoid contradictions

it is therefore difficile to give a single and simple definition . On the other hand, many have been proposed, varying depending on whether one approaches the structural, functional, algorithmic complexity etc., and whether one refers to the notions and concepts of information, chaos, self-organization, or even chance. Complexity systems can be ***developed by integrating these various characterizations.***

- **We will say that the latter:**
- (i) are open and dissipative systems, that is, having exchanges of energy and matter with their environment;
- (ii) are composed of a very large number of different elements;
- (iii) are based on very large numbers of nonlinear interactions, showing various response times, and performing frequent retroactive loops;
- (iv) have significant spatial and temporal heterogeneity at all scales; they have a history, and their evolution is irreversible

;(v)have a succession of levels of hierarchical organizations (called integration levels);

(vi) are therefore characterized by: emerging properties; through multi-scale interactions; by unpredictable behaviours (bifurcations), adaptive; and by self-organization;

(vii) cannot be characterized without explicit introduction of the observer.

2-Bifurcation :

- In a dynamic “system”, a qualitative change in structure that can be produced by amplifying a small internal fluctuation or by an external disturbance, when the system is in an unstable situation. **Forks are** in theory unpredictable, they lead the system to a configuration whose trajectory can be perfectly determined but is not the only possible.
- Bifurcations are characteristic of complex or evolving systems. They are frequent events at individual or local unit levels, but quite rare at meso or macro-scale in geography; ex: bifurcation produced in the evolution of a «territory» by a technical change, the discovery of a new resource or its exhaustion...

The concepts of super-system, system, sub-system, sub-sub-system… are ways to make complex systems accessible. Current research focuses on causes, mechanisms and methods. Many theoretical approaches have proved relevant, each addressing an aspect of «complexity»: since 1948,

information theory and cybernetics; more recently, theories of disasters, fractals and multifractals, chaos, cellular automata, neural networks, self-organization (including the self-organized criticality of Per Bak, 1996). Rather than contradictory, these approaches are complementary, and all fall within the framework of a systemic approach,

Cybernetics is the study of the information mechanisms of complex systems, A fractal figure is a mathematical object, such as a curve or a surface, whose structure is invariant by scaling.

3-cellular automata:

A cellular automaton consists of a regular grid of «cells» each containing a «state» chosen from a finite set and which can evolve over time. The state of a cell at time t+1 is a function of the state at time t of a finite number of cells called its «neighborhood». With each new unit of time, the same rules are applied simultaneously to all cells in the grid, producing a new «generation» of cells entirely dependent on the previous generation.

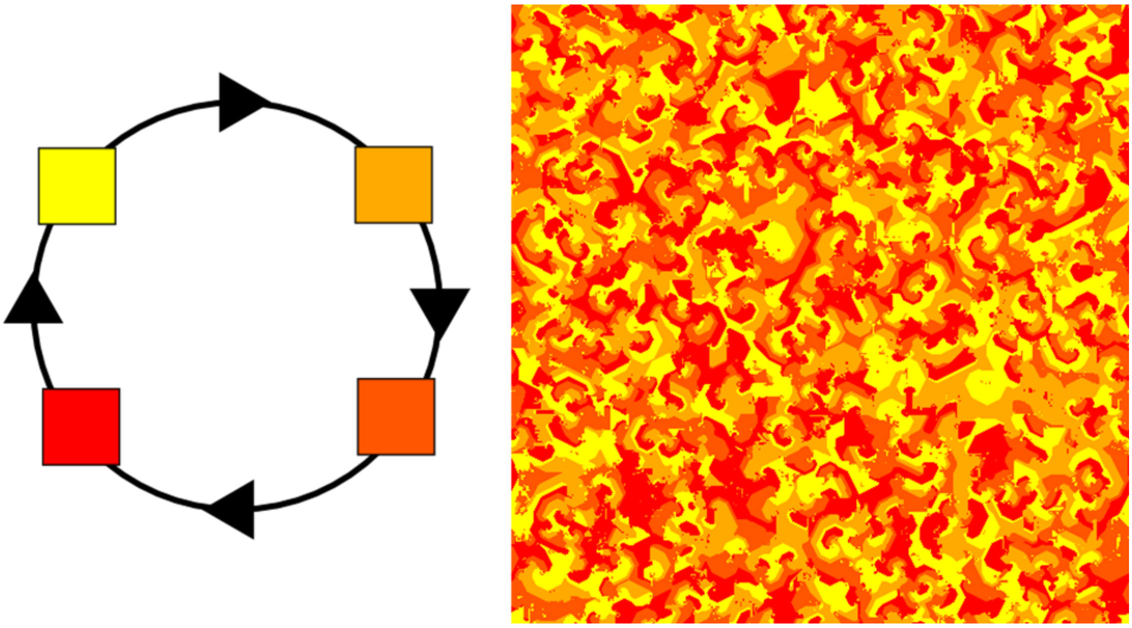


Fig 23: simple local rule and the result (complex) of the repeated application of this rule on a grid of cells

On the left, a simple local rule: a cell moves from one state (i) to the next (i+1) in the state cycle as soon as i+1 is present in at least 3 neighboring cells. On the right, the result (complex) of the repeated application of this rule on a grid of cells. This type of cellular automata was discovered by D. Griffeath.

Theory of critical self-organization

- The theory of critical self-organization is a theory of complexity that allows to study the brutal changes in the behavior of a **system.**
- This theory teaches that some systems, composed of a large number of elements in **dynamic interaction**, evolve towards a critical state, without external intervention and without control parameters. The amplification of a small internal fluctuation can lead to a critical state and cause a chain reaction leading to a **«catastrophe»** (in the sense of a change in the behavior of a system).

This theory is based on two key concepts: self-organization and criticality. Self-organization refers to the ability of elements of a system to produce and maintain a structure at the “scale” of the system without that structure appearing at the component level and without it resulting from the intervention of an external agent.

- self-organization phenomena are observed, for example, in animal societies (organisation of anthill, flight of birds),
- Agents or entities in interaction, without a previously defined common goal, will create, without knowledge and by imitation, a particular form of organization. What characterizes self-organized systems is the emergence and maintenance of a global order without there being a conductor. ***This self-organization means that the same properties cannot be observed at the micro and macroscopic levels.***

the criticality

It characterizes systems that change phase, for example the transition from water to ice, from individual panic to collective panic. In fact, the system becomes critical when all elements influence each other (vice versa). When this critical state is reached, the system may bifurcate, that is, it abruptly changes behavior to switch from one attractor to another.

- This critical state is an attractor of the «dynamic» **system** reached from different initial conditions. This critical state is called self-organized because the state of the system results from dynamic interactions between its components and not from an external disturbance. ***Self-organization is therefore a process that involves critical states.***

In the study of dynamic systems, an **attractor** (or set-limit) is a set or a space towards which a system evolves irreversibly in the absence of disturbances

4-The notion of self-organized criticality:

This theory has many complex phenomena, including the phylogenetic evolution of living species, the mechanisms triggering earthquakes, avalanches

Phylogeny **is the** study of the links between related species. Thanks to it, it is possible to trace the main stages of **the evolution** of organisms from a common ancestor and thus to classify more precisely the relationships of kinship between living beings,

To illustrate this theory, P. Bak et al. use a simple model: the sand pile. The experiment is to regularly add grains to a pile of sand. Gradually the sand forms a pile whose slope, slowly increasing, brings the pile of sand to a critical state. The addition of a grain can then cause an avalanche of any size, which means that a small internal disturbance does not necessarily imply small effects.

In a non-linear system, a small cause can indeed have a great reach. Avalanches therefore have different amplitudes which are all generated by the same initial disturbance (an additional grain of sand). While it is not possible to predict the size and timing of the avalanche, this theory tells us about all the responses of the system when it reaches the critical state.

- The self-organized critical state of a system is therefore a state where the system is globally metastable while being locally unstable. This local instability (small avalanches in the sand heap model) can generate global instability (large avalanches causing the heap to collapse) which then returns the system to a new metastable state: the sand heap has a new base.

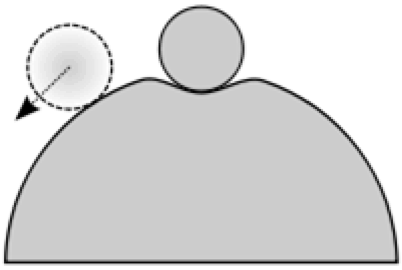


Fig 24 : *concept of "self-organized criticality"*

5-the concept of "self-organized criticality:

To describe in a unified way systems with an intrinsic stability threshold around which they spontaneously tend to maintain themselves. As long as material is provided, the system will evolve in such a way that it approaches its threshold of stability; as soon as this threshold is exceeded, the system relaxes quickly to find itself in a temporarily stable state until the next «avalanche», like the sand pile

According to P. Bak, one of the peculiarities of critical self-organized systems is to have a dual fractal, temporal and spatial signature. Thus, variables that describe the behavior of the system follow power laws and critical self-organized systems build fractal forms.

Cybernetics is the study of the information mechanisms of complex systems,

A fractal **figure** is a mathematical object, such as a curve or a surface, whose structure is invariant by scaling.

- We will have to look at ecosystems as complex systems. Do not confuse "complex" with "complicated". A complicated structure is made of many individual elements assembled; it can be «reduced», that is to say simplified and cut into its simplest elements so as to be better understood. Natural systems, on the other hand, are complex, in the sense that by reducing them they are mutilated and their intelligibility is destroyed (clarity)

6-General theory of systems:

Systems have long been studied (even if not declared) in physiology, economics, sociology, linguistics, also today in physics and chemistry. According to Hebenstreit (2002), a system is “a set of interdependent phenomena and events that are extracted from the outside world through an arbitrary intellectual process, in order to treat this whole as a whole.”

The reference to the external world, seen as an interactive environment, implies that no real system (natural or conceived by man) is isolated, but that it is itself element in a larger system, which can be called «super-system». Similarly, any "element" of the first system is itself a system, called "subsystem". The intervention of a hierarchical organization (in the sense of: made of nested levels) of the systems thus appears from their development. We will delve a little further into this fundamental aspect

- We propose below a more detailed definition, now naming «system» any set of elements, or parts or subsystems, *interconnected* by functional links (involving causalities, evolutions, movements), in such a way that three categories of properties result.

6-1-The elements depend on each other in their functioning and their evolutions:

- The set of interactive elements can be represented as “flow charts” (figures) in which:
- – the letters (capital letters) represent identical compartments or material parts (sometimes delimited in a rather arbitrary way, but as much as possible in coherence with the objective operation);

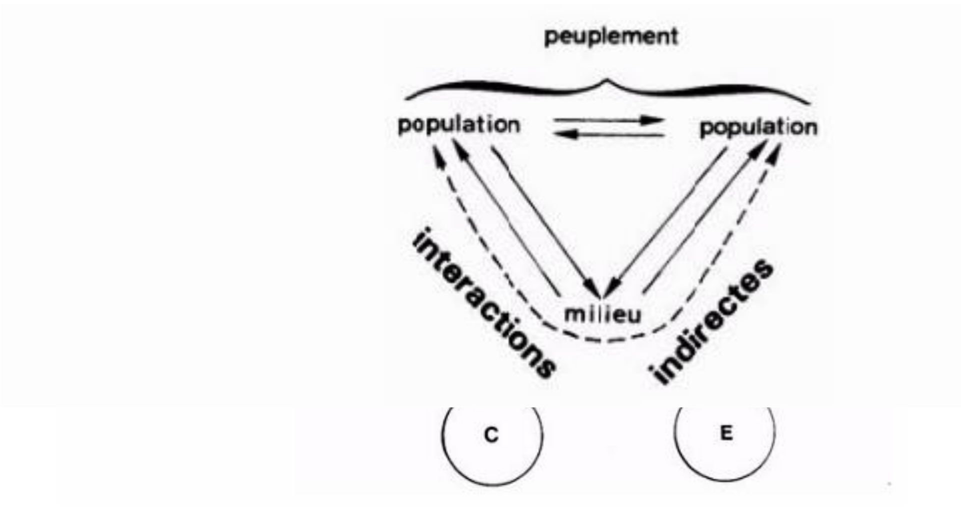


Fig. 25 : Schematic Diagram of an Ecosystem

The flèches represent direct or indirect interactions, which can be either transfers of matter and/or energy, or purely causal determinations that can be described as "transfers of information" (ids or CASH DISTRIBUTIONS (DRF)).

Matter and energy circulate in a determined direction. Concerning information, between two compartments the action can be either one-way (classical causality) or two-way (reciprocal action, circular causality, recursion sensu E. Morin). One can also make figure the action of an element on itself (self-control, self-runaway, etc.).

Fig. 26: Interaction System Organizational Chart

The word "arbitrary" can be discussed. If it is true that a system is delimited according to a certain prior image of the world, it is at least endeavoured that it best receives the real organization.

A «piece» of organism or ecosystem, delimited by an arbitrary or pragmatic approach (butcher's meat or cadastral plot of a forest), is not necessarily the relevant image of a system or subsystem.

However, a certain amount of arbitrariness is often unavoidable in the construction of models, particularly models with compartments, where a set of elements is grouped together in a «compartment» that is not discernible (for example, the phytoplankton compartment containing many species of microscopic algae)

On the other hand, based on the intensity and speed of actions, we will distinguish between "strong" and "weak" interactions (with of course intermediate degrees).

Their discrimination depends on how you measure that "strength". In general, we distinguish in this respect:(i) The degree of determination of a variable towards another, or of a compartment towards another. In terms of statistics, the "strength" of A's action towards B could, for example, be measured by the proportion of variance of B explained by the variation of A (see Frontier et al., 2001).

- In information theory (IDS), by the amount of information passing from B to A; the flèches in the organization chart then represent information flux . The “strength” may be unequal from A to B and from B to A.(ii) The lead time, which may also be unequal between the two senses. An indirect action has a longer lead time than a direct action, since it goes through intermediate phases requiring a certain amount of time. In complex systems such as ecosystems, information from a point tends to be shared between many simultaneous pathways (flèches in the large flow chart). It follows that an indirect interaction is often «weak», because diluted and shifted in time.

Nevertheless, it is sometimes of crucial importance for the ecosystem considered at a sufficient space-time scale – as when interaction involves a sustainable modification of the environment .

The theoretical approach of these networks of interaction is greatly facilitated by an already ancient mathematical tool, the Graph Theory (see for example Kauf- mann, 1970), which analyzes any network in terms of nodes and loops and makes it possible to deduce logically, from a structure, a number of properties,

It will always be possible to simplify the representation of the network by retaining only strong and/or rapid interactions – at the risk, moreover, of suppressing some indirect and long-term interactions that can be decisive.

One of the properties studied is transitivity: if A acts on B and B on C, then A acts on C (indirect interaction: transitivity does not retain the properties of force and speed of direct interactions). The transitive closure of a network is the set of direct interactions retained in a certain conceptualization of the network, supplemented by the set of indirect interactions they evoke (Fig. 0.3).

An ecosystem could be defined as the transitive closure of a network of interactions within the living settlement and between it and its biotope. Another theory used is information theory , initiated by Shannon in 1948 (see Shannon & Weaver, 1949). As stated above, the concept of quantity of information (SDI) allows, to some extent, to measure the «strength» of an interaction. According to intuition, an element A will bring a lot of information to an element B if the functioning and evolution of B depend strongly on variations of A «perceived by B».

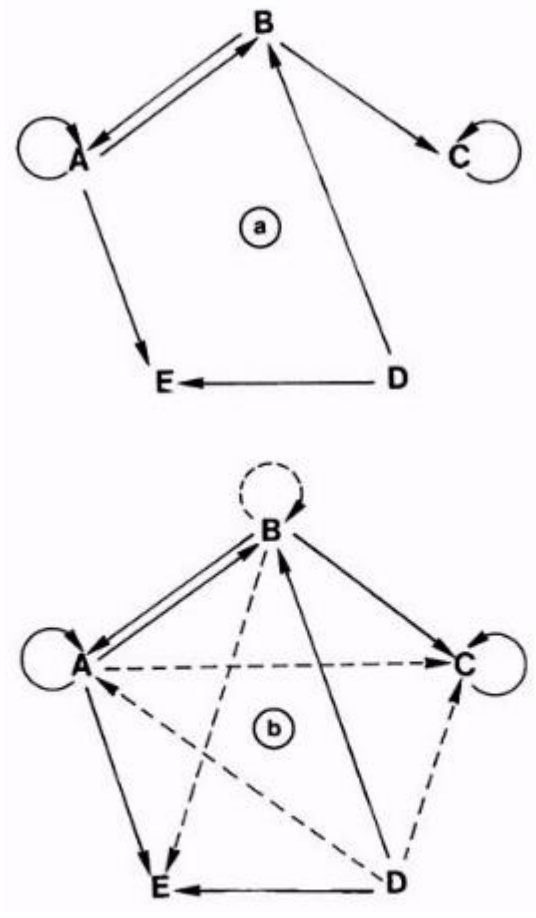


Fig. 27: "transitive closure of an interaction network."

6-2-Feedback:

Feedback is a particular form of “interaction” between elements of a system that, in the face of a parameter change, tends to trigger amplification processes or the reverse of regulation. Originally used in cybernetics, the idea of feedback is now developed in biology, economics and geography.

7-Isotropie/ anisotropie :

A medium is isotropic if its physical properties are identical in all directions. A **system** will be called isotropic if its (macroscopic) properties are invariant to a particular direction and therefore, if none of them has a directional dependence.

If only one of its properties is directional, the system ceases to be isotropic, it is anisotropic. We will also say that a physical quantity is anisotropic, or isotropic, depending on whether it depends on the direction in which it is measured. In the primitive and restricted sense of the term, isotropy and anisotropy are properties of macroscopic bodies or sets. In this general sense, time and space being physical quantities, since measurable, we often talk about their isotropy or anisotropy.

8-Spatio temporal contraction:

refers to the reduction of the time required to cross a portion of Earth’s space, through the use of innovative modes of movement that significantly reduce the speed practiced until then. The geographical space is thus minimized by the speed of movements that spread out at a certain time between the pairs of places,

8-1-cow dung :

'Cow dung is in itself a true ecosystem. The feces are quickly recycled by cohorts of Dung Beetles who soon made them disappear. When the dwellings are fresh, first settle Scarabéids with demographic strategies of type r*.

* ***Species of type r*** are poorly specialized, colonizing and well adapted to unstable environments. ***Types K,*** more specialized and competitive, devote little energy to their reproduction; they permanently replace the r types when the environment stabilizes (author's note)

This is the case for the majority of those who concentrate all their energy at their reproduction and swarm in excrement. Then other less prolific species appear as . Finally come species applying a typical demographic strategy of type K*.

So you find the , and then they roll their dung ball to their nest. […]In Australia, where Dung Beetles specialized in dry marsupials, the introduction of Horses and Cattle, with much softer droppings, posed serious problems.

None of the indigenous coprophages was able to recycle such large, water-rich droppings. Gradually, the Australian pastures were buried under millions of dung which made them unusable and which moreover were vectors of diseases of cattle and Man. It was then necessary to resort to the contribution of European or African dung beetles […]." Extract from: C. Faurie ,5th edition, © Lavoisier, 2003.

8-2-The individual in his habitat:

It is often difficult to attribute a species to a clearly defined biocenosis. Deer, for example, share their activities between the forest ecosystem and neighbouring agrosystems. Red frogs live in the pond at the larval stage and are terrestrial at the adult stage. Conversely, interactions are frequent between different species of eco-systems:

The osprey is a terrestrial raptor with fish. To avoid artificially compartmentalizing ecological systems, it is wiser to consider an individual or group of living beings and to study the interactions between them and their environment. From this point of view, the interaction between unbiotope and a biocenosis is no longer considered, the ecological system expresses the functioning of a species in its environment called the habitat

This habitat is the geographical area where the indi-vidus of the species meet. It is characterized by certain physical etchimic conditions, but also by the presence of all other living beings.

It offers a number of resources and imposes constraints on the community. The individual as well as the interactions he establishes with the environment are natural realities

9-ecological factors and adaptation of living beings:

In an ecological system, living beings interact with their environment and are adapted to this environment. Environmental characteristics that directly affect a living being are ecological factors. They determine the survival possibilities of living beings in the environment. They can be classified into two main categories: factors related to the physical environment (abiotic factors) and those related to the action of living beings (biotic factors)

Ecological factors act in different ways:- they determine the geographical distribution of species by eliminating them or prohibiting their establishment in unfavourable areas. Climatic factors, in particular, condition the distribution of living beings according to altitude and latitude.

- ***For example,*** tropical plants cannot survive naturally in temperate regions because their seeds die when the temperature drops below 3 degrees. Another example is climate warming, which has led to a recent expansion of bird species northward and upward;- they alter the development, reproduction of species or favour the appearance of adaptive changes.
- ***For example,*** the photo-period (relative duration of day and night) sets the rates of growth and flowering of plants, but also the whole life cycle of animals (day-night rhythm, hibernation, reproduction period, etc.). Another example: some plants need an intense cooling period in winter to resume their activity in spring.

When it reaches an upper or lower limit value, an ecological factor alone can limit the chances of survival of a species. This happens even if all other conditions are favorable. This factor is limiting. Oxygen is frequently limiting for aquatic animals; In terrestrial environments, nitrogen or hu midity can be applied to plants. Between these limit values extends the tolerance interval of the species for the ecological factor under consideration.

The species has the best development for an intermediate value of this factor called optimumphysiological. For the same factor, the extent of the tolerance interval and the value of the physiological optimum vary greatly between species. It depends on the type of habitat the species are adapted to. Antarctic marine fish only survive in waters with temperatures between -2.5°C and 8°C!

Biotoperelated factorsabiotic environmental factors are mainly climate-related factors – temperature, humidity, light….– and soil factors that are related to the action of the physical and chemical characteristics of the soil.Climate also plays an essential role in soil formation and action determines the possible composition of living species of an ecosystem..

Conversely, plant formations can exert a regulatory action on the microclimate. This is particularly the case for forests and hedges; Thus, compared to open ground, a forest has a lower annual temperature and a higher night temperature, higher annual rainfall and relative humidity, lower wind speed and reduced evaporation. Hedges speed and agitation of the air, reduce temperature differences, favour rain, drain too wet soils… In aquatic environments, the main ecological factors are latemperature, currents, light, dissolved gas content (O_2 , CO_2), mineral richness (N, P…), pH and lasalinity. (texture, structure, water content, pH,richness of mineral elements), although less important than those related to climate, also have an action on the distribution of living beings.Conversely, these play an important role on soils by their mechanical or chemical action: action of roots, soil fauna and decomposers (earthworms, arthropods, fungi, bacteria, etc.). Their activity contributes to changing the structure of the soil, its porosity and water retention capacity

Factors related to biocenosis, notion of ecological optimum Biotic factors correspond to the action of living beings on others. These relationships may be between individuals of the same species (intraspecific relationships) or between individuals of different species (interspecific relationships). These living-living interactions correspond to relations of competition, exploitation or mutual aid. Most living things live in more or less organized and sustainable groups in which intraspecific relationships are expressed.

Gender mainstreaming is generally linked to sexual reproduction, it can also enable better exploitation of resources. There are even organized societies where forms of communication exist between individuals (ants, bees, monkeys, etc.). Animals of the same species can cooperate for the protection of the area, the search for food and the breeding of young. On the other hand, they may compete for food, housing, reproduction or their place in the hierarchy. In plants, competition for light, water and minerals

all these relationships have a significant impact on the abundance and distribution of individuals in an ecosystem. Thus, cooperative relationships can increase the efficiency of the exploitation of the environment (hunting in meutepar wolves, for example). On the other hand, when the population density of a species increases beyond the possibilities offered by the environment, competition criteria appear and most often result in an increase in mortality and a decrease in fertility. Competition thus allows a regulation of population density.

The main form of exploitation between different species is predation. A predator is a free organism that feeds at the expense of another called prey. The herbivore is a predator of plants, the carnivore a predator of herbivores or smaller carnivores. This relationship is an essential factor in the regulation of populations and their dynamics. Its effects over time are very variable depending on whether the predators are rather specialized (few species on their menu) or rather opportunistic (many prey species). Parasitism differs from predation in the sense that parasites, if they also use other living beings for food, do not lead a «free» life.

- They are physically linked to their host during a phase of their development. The parasite benefits from the high availability of its food resource; On the other hand, it must face a compulsory free life phase to ensure reproduction and dispersiontowards new hosts. The plant world and the animal world are full of examples of parasitism. Elm disease (due to a fungus), tapeworm, or the fluke of farmed mammals are parasitic diseases.

1-Structure of food chains.

1.1. Relationships between producers (autotrophies) and their dependence on nutrients and light or chemical energy:

The activity of any living being requires the use of a source of energy. The two main ones are light for autotrophic beings and biochemical substances (lipids, carbohydrates, ...) for heterotrophic beings, so food.

2-1-. Food Chain :

This expression refers to all plant and animal species involved in the formation of solar energy in plant tissues and then in the transfer to higher levels than the decomposition of dead matter into simple elements (**Fig. …**).

In an ecosystem, living beings depend on each other through salimentary relationships. Food chains ensure the circulation of matter and therefore the transfer of energy in biochemical form between the various organisms in the ecosystem. They respond to the general scheme:

Autotrophic organism Herbivore Carnivore 1 Carnivore 2

Fig 28: Example of food chain.

Figure 29: General scheme of the two fundamental types of food chains

2-2-biosphere: terrestrial and aquatic

The set of interconnected food chains within an ecosystem through which energy and matter circulate is called the food web.

2-2-1-. Food Web

This term refers to all the trophic relationships existing within a biocoenose between the various ecological categories of living beings constituting the latter: producers, animal consumers and decomposers. A tro phic network can also be defined as the result of the entire food chain uniting the various populations of the species that has a biocoenosis .

In aquatic ecosystems, there are usually benthic food webs, which concern the water-to-water interfacesediments from both freshwater and marine biotopes and pelagic trophic webs specific to open ocean waters as well as those in the limnetic zone of lakes.

Depending on their function in ecosystems, living beings are divided into three major categories: primary or autotrophic producers, primary and secondary or heterotrophic consumers.

Fig.30: Trophic Network Representation

I'll include a complex network of interactions between different species at various trophic levels. Here is a detailed description for the image :

1. Primary Producers: At the base, include green plants and algae.
2. Primary Consumers: Above them, include herbivores like insects, small mammals (e.g., rabbits), and zooplankton.
3. Secondary Consumers: Next level includes small carnivores and omnivores like frogs, small fish, and birds.
4. Tertiary Consumers: Above them, larger predators like snakes, large fish, and hawks.
5. Quaternary Consumers: At the top, apex predators like eagles and large carnivorous mammals (e.g., wolves).
6. Decomposers: Include fungi, bacteria, and detritivores like earthworms throughout the network, connected to all levels to show decomposition.

Each species should be connected with arrows to show the flow of energy and matter through predation, highlighting the complexity of the interactions in the network.

Here is a complex trophic network representation based on Ramade F. (2008). It illustrates the intricate interactions between various species at different trophic levels.

3- Primary or autotrophic producers:

Functional group of living beings specific to any ecosystem. All the autotrophic organisms of a biocoenose, essentially green plants in terrestrial environment, phytoplankton and macrophytes in the hydrosphere. They use solar energy to develop chemical substances from CO2, water and mineral salts; these are the first links in the food chain.

3-1-Consumers (Heterotrophies) who are linked to producers :

Consumers or heterotrophies who can only feed on sorghum materials synthesized by other living beings. First-rate consumers its lesphytophages or vegetarians. They form the second trophic level.

Higher-order consumers are zoophages or carnivores. They form the third, fourth, ... trophic level. All consumers also manufacture organic materials, so they are secondary producers.

3-2- Consumers of fresh matter :

These are:

***Primary Consumers (C1)**: Phytophages eat producers. These are general animals, called herbivores (herbivorous mammals, insects, crustaceans: shrimp), but more rarely plant parasites and green plant animals.

***Secondary consumers (C2)**: Predators of C1. These are carnivores feeding on herbivores (carnivorous mammals, raptors, insects, etc.).

***Tertiary consumers (C3)**: C2 predators. They are therefore carnivores who are also carnivores (insectivorous birds, raptors, insects, etc.).

Most often, a consumer is omnivorous and therefore belongs to several trophic levels.

C2 and C3 are either predators that capture their prey, or parasites of animals.

3-3- Consumers of dead animals

Scavengers or scavengers are species that feed on the corpses of spawned or decomposed animals. They often complete the work of carnivores. Example: Jackal, Vulture, …

3-4- Decomposers that recycle and mineralize organic matter :

Decomposers are the different organisms and microorganisms that attack corpses and excreta and break them down little by little by ensuring the gradual return to the mineral world of the elements contained in organic matter.

Saprophyte: Plant organism feeding on organic matter in the process of decomposion Exemple: Mushrooms.

Saprophage: An animal organism that feeds on organic matter during decomposition.

Example: Bacteria.

Scavenger: An invertebrate that feeds on animal and/or plant detritus or debris.

Example: Protozoa, earthworms, nematodes.

Coprophage: Animal that feeds on excrement.

Example: Dung beetle.

Primary producers, consumers and decomposers are linked by a food chain. The cyclic rate of the chain is ensured by the decomposers.

3-5- Different types of food chains:

There are three main types of linear trophic chains:

3-5-1- Predator chains :

In this chain, the number of individuals decreases from one trophic level to another, but their size increases (Elton's rule stated in 1921).

Example: (100) Producers + (3) Herbivores + (1) Carnivores.

3-5-2- Chains of parasites:

The latter proceed, in contrast to the previous ones, from large organisms to small organisms. In some cases, several individuals belonging to species that are fortdistant from the zoological point of view can thus each evolve inside the body of the other, the first being the host of the second and so on. (Elton's rule is not verified in cecas).

Example: (50) Grasses + (2) Herbivorous mammals + (80) Fleas + (150) Leptomonas.

3-5-3- Detritivorous chains:

Goes from dead organic matter to smaller (microscopic) and shady organisms (Elton's rule is not verified in this case).

Example: (1) Cadaver + (80) Nematodes + (250) Bacteria.

4-

Fig.31: Overall structure of a food chain

Functioning of ecosystems :

4-1- Energy flow at biosphere level:

The only incoming energy flow is solar radiation which is converted into living matter (biochemical energy) by phytoplankton and aquatic macrophytes thanks to the selsminery dissolved in water. This living matter and the energy it contains is then incorporated into the «food chains» of consumers: zooplankton, fishsonsherbivores and predators. Finally, the microorganisms (bacteria and fungi) contained in the water and surface layers of the sediment break down and mineralize the organic matter after the death of aquatic plants and animals.

The maximum complexity is achieved in ecosystems that result from several dozen combinations. The functioning of the ecosystem depends on that of each component keeping its properties and the general functioning that obeys its own rules. The trophic relationships that exist between the levels of a food chain result in energy transfers from one level to another.

***Flows at primary producer level (P1)**

-Some of the sunlight absorbed by the plant is dissipated as heat.

-The remainder is used for the synthesis of organic substances (Photosynthesis) and for Gross Primary Productivity (PB).

-Part of (PB) is lost for Breathing (R1).

-The remainder is Net Primary Productivity (FN).

So we can write: PB=PN+R1

-Part of (NP) is used to increase plant biomass.

-The rest of (PN) is used by the next trophic level.

***Feed at herbivorous consumer level (C1)**

-Only part of crop production is ingested by herbivores known as Parties

Ingested (PI1).

-Everything else is made available to scavengers and decomposers when plants die.

As it is not used by herbivores we will name it (NU1).

-The amount of energy ingested (Ingested Portion) (PI1) is what is actually used or

Assimilated (A1) by the herbivore (By digestion), plus what is released (Not assimilated) (NA1) in the form of excrement and waste:

I1= A1+ NA1

-The equivalent fraction (A1) is used for Secondary Productivity (PS1) and for

respiratory expenditure (R2):

A1=PS1+R2

***Feed at carnivorous consumer level (C2)**

-Only part of the energy set by primary consumers will then be used for the function of carnivorous organisms or secondary consumers. We will call it (PI2).

-Many prey will die of old age and their corpses will be delivered at the whim of the aggressors (NU2).

-Only part of the biomass consumed will be assimilated, i.e. (A2).

-All that will be eliminated by feces and various secretions will correspond to (NA2).

-As in the previous level, much of the energy set by digestion will serve the carnivores and will be eliminated in the form of respiratory losses (R3).

-If (PS2) represents the energy gained which is added to that of the existing biomass, the flux at the level of the arnivores is then the following: A2 =PS2+R3.

-The process continues in the same way if the food chain extends to levels of

supracarnivores. Given the enormous losses that occur at each trophic level, it is clear that food webs are always short.

-As for scavengers and decomposers, they are also involved in the flow of energy through the ecosystem. They are the ones who recover the energy stored in everything that is not used

(NU1, NU2, NU3,...). They derive from it all that is necessary for their metabolism and the increase of biomass, and like other consumers, lose energy by the catabolism respiratoireou fermentations.

Thus, from the sun to consumers (1st, 2nd or 3rd order), energy flows from utrophic level to trophic level, decreasing with each transfer from one chain to another. There is talk of flow (flow) of energy. The flow of energy that crosses a trophic level gives response to the totality of the energy assimilated at this level, that is to say the sum of the productivitenet and the substances lost by breathing. For primary producers, this flow is:

PB = PN+R1.

The energy flow through the trophic level of herbivores is: A1 = PS1+ R2.

The further away from the primary producer, the lower the production of living matter.

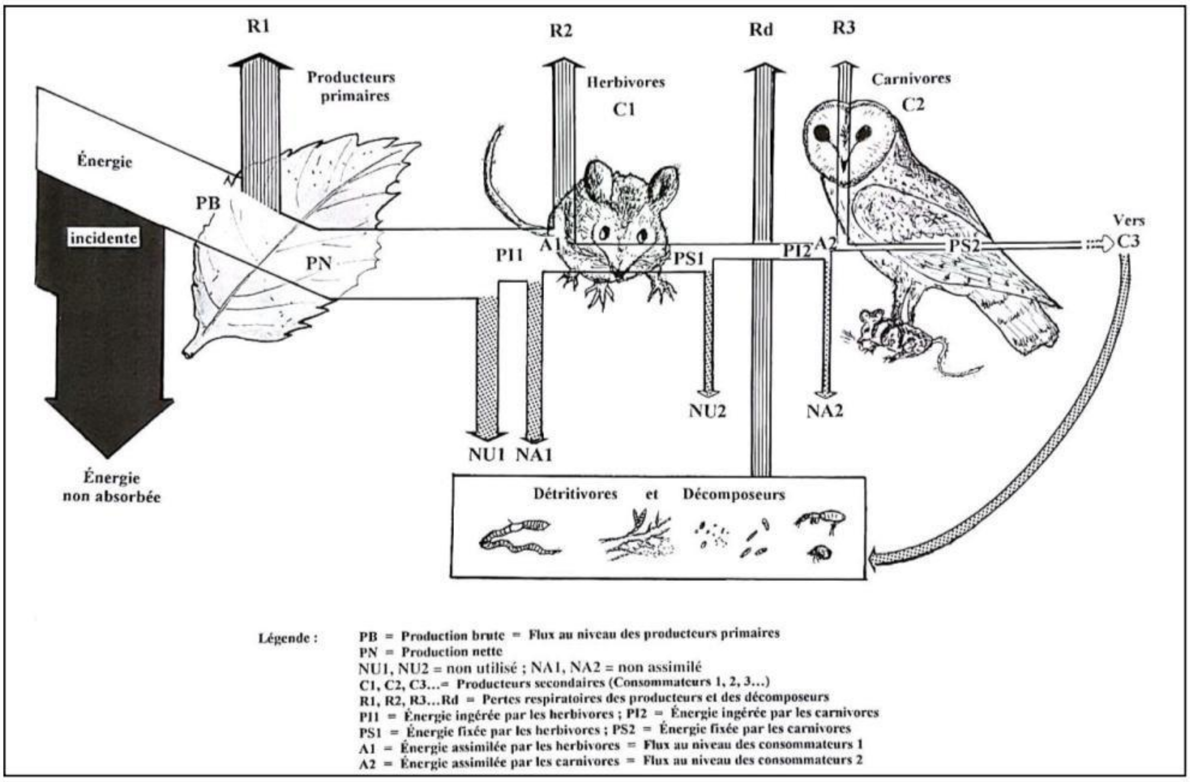


Fig.32: Energy flow through a food web (Faurie et al., 2012).

4-2-Production:

In ecology, refers to the amount of living matter (= organic matter) elaborated by one of the food chain per unit of time, surface or volume. A distinction is made between primary production (gross and net), secondary production, tertiary production and quaternary production.

4-2-1-Primary production:

Designates in ecology the production of plant organic matter (biomass), resulting from the photosynthesis, by autotrophic organisms, called primary producers. It reflects the speed at which a given amount of organic matter is formed per unit of time, from mineral matter and an energy input. It is expressed in biomass produced per unit of time and per unit of area or volume.

4-2-1-1-Net primary production (NPP):

Is determined as the energy fixed by plants minus their respiration. Primary energy nette terrestre is estimated at 110-120 x 109 tons of dry mass per year, and 50-60 x 109 tons in the seas. Although marine ecosystems cover two-thirds of the Earth's surface, they only account for one-third to half of its production. There is a latitudinal trend whereby productivity is concentrated in tropical and temperate regions and is primarily constrained by solar radiation (as a resource) and temperature (as a condition).

Other factors can also limit productivity, such as availability of nutrients, water or altitude. A bias exists in the total measure because of the difficulty in measuring net primary production below ground.

Some authors distinguish production P (quantity of material produced per unit of time for a given biomass B) from productivity (production relative to a unit of biomass P/B. Conversely, the ratio B/P is the turnover or turnover rate of biomass.

4-2-1-2-Primary production of biomass:

Quantity of biomass from autotrophic organisms obtained in a given period of time, parexemple, transformation of chemical or solar energy into biomass. Most of the primary production of biomass comes from photosynthesis, by which the plants vertesconvertise solar energy, carbon dioxide and water into glucose and finally into uvaegeal tissue. Some seabed bacteria convert chemical energy into parchimiosynthesis biomass.

4-2-1-3-Secondary biomass production:

Quantity of biomass of heterotrophic organisms (consumers and decomposers) obtained during a given period of time.

4-3-Productivity:

Defined as the ratio of production over a period of time to biomass present in the area. Plants produce a certain amount of organic matter per unit of time, under the effect of photosynthesis. This quantity produced is called gross production.

-Growth rate of organisms and their populations, determined either by inorganic carbon fixation by photosynthesis or chemosynthesis, or by ingestion of prey, dissolved organic matter or particulate organic matter. -The amount of human-usable biological material that is produced at a given location. In agriculture, soil productivity is called yield, which refers to production per unit area and productivity to production per unit of work.

4-3-1-Biomass production or productivity:

Amount of biomass obtained in a given period of time or on a given surface.

4-3-2-Gross productivity:

The quantity of living matter produced per unit of time (usually one year) by a given nutrient level or by one of its constituents.

It is expressed in the amount of carbon fixed per unit of time by a given plant biomass. It is the total product of photosynthesis, that is, all the organic matter produced including the raw assimilates in respiration. This PB ensures:

- Maintenance of existing components.

- Establishment of new bodies.

- The preparation and storage of reserves.

- The creation of dissipated energy for reproduction.

4-3-3-Net Productivity:

Corresponds to gross productivity minus the amount of living matter degraded by respiratory phenomena. The net production is the apparent photosynthesis that is to say the whole of

all the tissues formed per unit of time and all the materials newly stored in all the eggs, this is the biomass difference between T1 and T2.

B2 – B1

PN = -------------------=PB - R R: Breathing.

T2 – Tl

Every living thing that makes tissue and reproduces uses a certain amount of energy:

Insure maintenance expenses.

- Allow muscular effort.
- Ensure growth.
- Build up reserves.
- the preparation of the necessary elements for the creation of a new organism (reproduction).

4-3-4-Secondary productivity

Broadly speaking, the term secondary productivity refers to the rate of accumulation of living matter

(Biomass therefore energy) at heterotrophic level: consumers and decomposers.

Finally:

- ✓ **Gross productivity (PB)**: The amount of living matter produced over a unit of time, per a given trophic level.
- ✓ **Net Productivity (NP)**: Gross productivity minus the amount of living matter degraded by trapping.

PN = PB – R.

- ✓ **Primary productivity:** Net chlorophyll autotrophic productivity.
- ✓ **Secondary productivity:** Net productivity of herbivores, carnivores and decomposers.

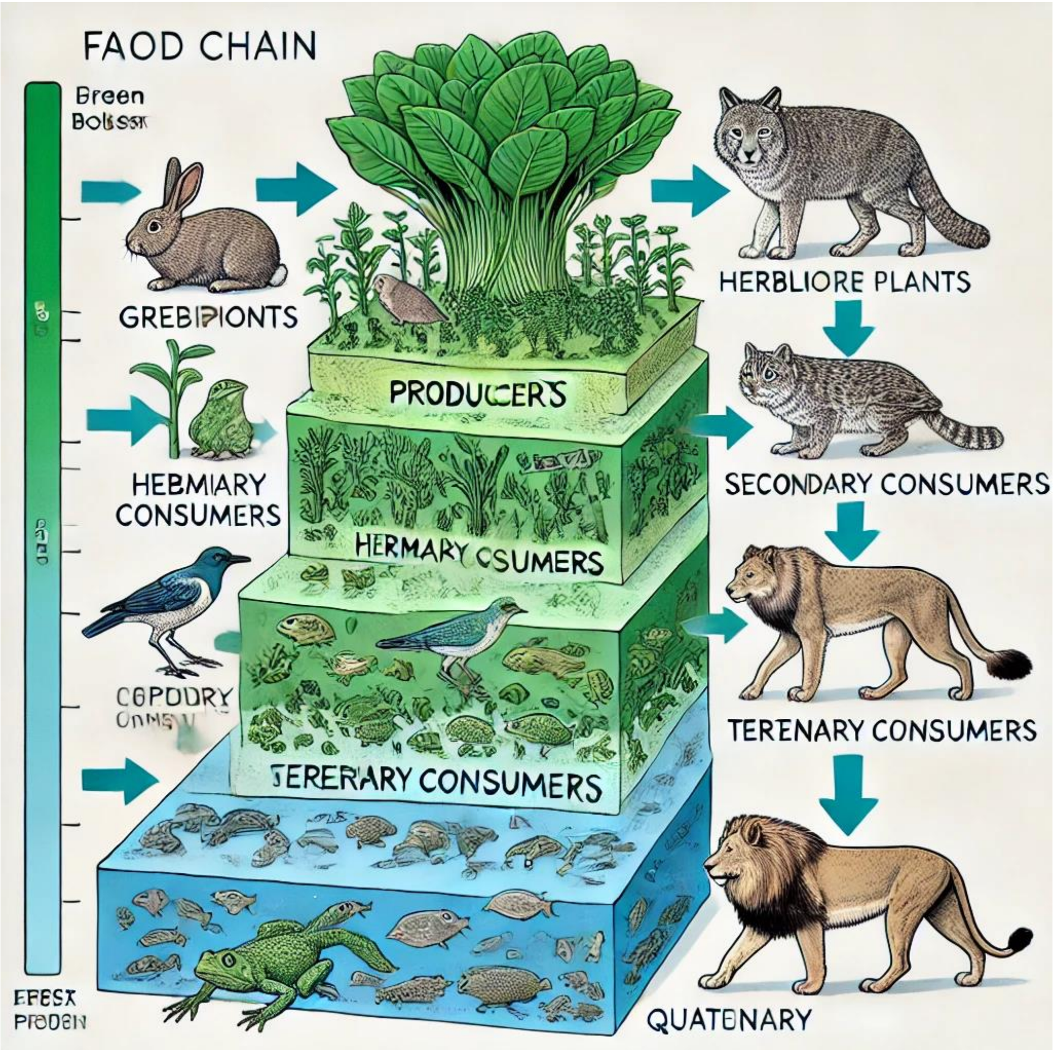


Fig33: Biomass at different levels of a food chain.

The transition from one food level to another leads to a considerable loss of material.

Structure of Ecosystems and Complex Systems

Groups – Study Facilities

Individuals: physiology, ethology

Population: collection of individuals of the same species with specific properties (density, sex-ratio, demographic structure, birth rate, mortality) – population dynamics, autoecology

Metapopulation: set of populations, more or less overlapping, exchanging individuals (immigration, emigration) and/or genes - metapopulation

Community: set of populations sharing the same space at the same time; taking into account biotic and abiotic interactions – synecology

Ecosystem: A group of communities through a flow of energy and matter -ecology

Spatially Structured Population Classification • A: Island-containing type (= well-source); the only source is the continental area where the population is persistent; wells are the islands whose populations disappear if isolated from the source(island or source-sink type)

• B: Panmic population with spot distribution(panmictic population with clumped distribution)

• C: unbalanced set of subpopulations (=metapopulation): there is too little emigration to keep the population as a whole; it is therefore on the verge of extinction (non equilibrium metapopulation)

• D: like A, but with an entache source population (garden-variety source-sink type)

• E: metapopulation (classical); subpopulations are isolated from each other (e.g. each on an island); extinction and colonization processes take place from other islands rather than from a continental area (classical metapopulation).

Properties of ecosystems and organized structures

1. The set has properties that the constituent elements do not have

An ecosystem is not just a collection of species and habitats: there are interactions between them.

2. Interactions, Self-Conservation and Regulations

All biological systems have many interactions between their constituents and between the whole and the different constituents. Biological systems also show (despite this) a tendency to self-preservation (the structure remains as it is) despite both environmental and internal fluctuations in the system.

This is a direct consequence of their structure and functioning, which is responsible for many regulations. The existence of such self-regulating systems is obviously linked to natural selection: in the absence of regulatory mechanisms, a system could not last long, so that only those who benefit from it remain.

3. Hierarchical Organization

4. Introduction

Hierarchical organization is a fundamental characteristic of complex living systems. At every level, from the simplest to the most complex, elements interlock in a cascade of systems. This hierarchical structure is essential for maintaining the stability and permanence of these systems.

5. Holarchic Systems

A hierarchical system is often referred to as holarchic, reflecting the concept of hierarchy in natural systems. Each level of this hierarchy is known as a holon. A holon is both a whole, comprising other underlying hierarchical levels, and a part of a larger whole. This concept is also used in cognitive psychology and philosophy.

6. Energy Flows and Thermodynamics

The thermodynamics of living systems, described by Prigogine et al., differs significantly from classical thermodynamics. Living systems are dissipative structures—open systems through which energy flows, keeping them far from equilibrium. This continuous energy flow is crucial for maintaining the system's structure and function over time.

Main Properties:

- **Material Cycles:** These include loops of use and recycling, and temporary energy storage (e.g., energy from chemical bonds, biomass, carbon sinks).
- **Matter Flows:** These flows generate and maintain structures, contrary to the second law of thermodynamics in closed systems, which states that structures disappear near equilibrium due to maximum entropy.

The metabolism of a cell or an ecosystem represents the constant torrent of energy that must flow through living systems to sustain them over the long term. This energy flow occurs through information transfer (chemical, visual messages, etc.) and matter transfer, without skipping levels of organization—interactions occur between successive levels.

7. Figures and Illustrations

1. **Hierarchical Organization in Living Systems:**

Fig34: A diagram illustrating the hierarchical structure from molecules to the biosphere.

- **Level 1:** Molecules and atoms.
- **Level 2:** Cells.
- **Level 3:** Tissues.
- **Level 4:** Organs.
- **Level 5:** Organ systems.
- **Level 6:** Organisms.

    - **Level 7:** Populations.
    - **Level 8:** Communities.
    - **Level 9:** Ecosystems.
    - **Level 10:** Biosphere.
  - **Caption:** Each level of organization is a holon, both a whole and a part of a larger system.

2. **Energy Flow in Living Systems:**
  - **Figure 2:** An illustration of energy flow in an ecosystem.
    - **Producers:** Plants converting solar energy into chemical energy through photosynthesis.
    - **Primary Consumers:** Herbivores consuming plants.
    - **Secondary Consumers:** Carnivores eating herbivores.
    - **Tertiary Consumers:** Apex predators.
    - **Decomposers:** Fungi and bacteria recycling nutrients.
  - **Caption:** Energy flows through different levels of the food chain, maintaining the structure and function of the ecosystem.

- **Fig 35 :** An illustration of energy flow in an ecosystem.

3. **Material Cycles and Energy Storage:**
    - **Figure 3:** A diagram of material cycles and energy storage in an ecosystem.
        - **Material Cycles:** Showing loops of nutrient recycling.
        - **Energy Storage:** Depicting energy stored in biomass and chemical bonds.
    - **Caption:** Material cycles and energy storage are crucial for the maintenance of living systems, illustrating the flow and recycling of energy and matter.

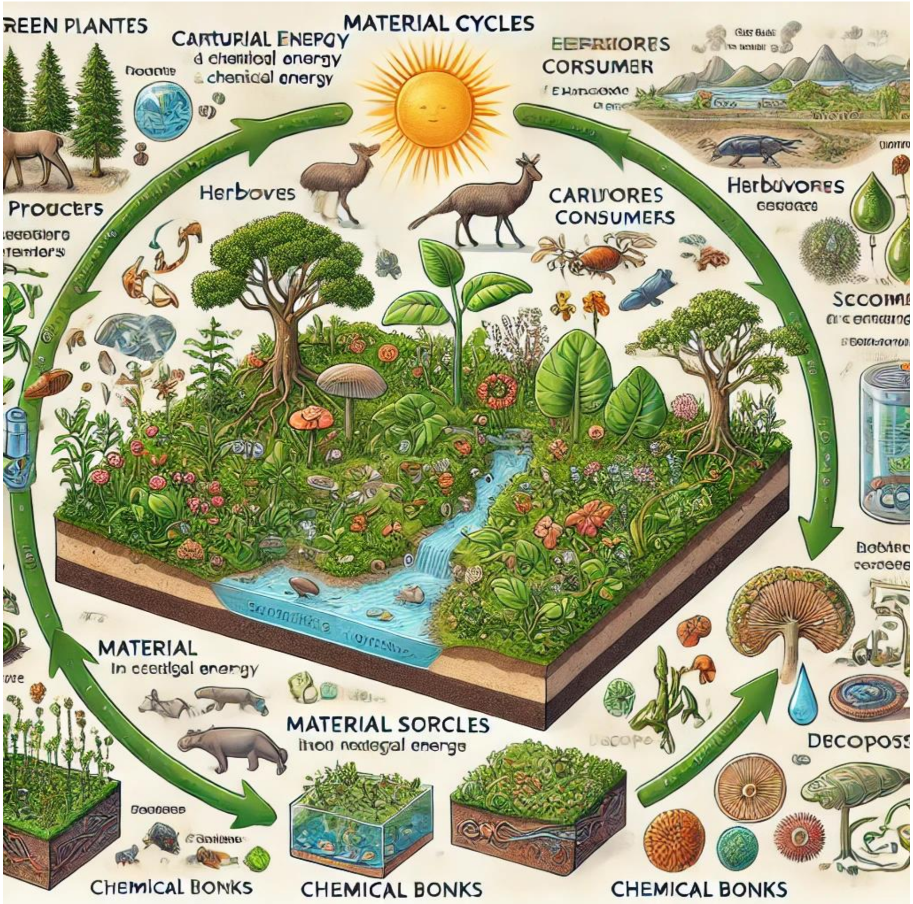


Fig 36: A diagram of material cycles and energy storage in an ecosystem

Description of diagram of material cycles and energy storage in an ecosystem : This diagram illustrates the complex interactions within an ecosystem focusing on material cycles and energy storage. The key components include:

Producers (Plants):

Capture solar energy through photosynthesis, converting it into chemical energy stored in biomass.Take up nutrients from the soil and convert them into organic matter.Primary Consumers (Herbivores):Feed on producers, obtaining energy and nutrients.Convert plant material into animal biomass and waste products.Secondary Consumers (Carnivores):Feed on herbivores, transferring energy and nutrients up the food chain.Store energy in their biomass and release waste products.Tertiary Consumers (Top Predators):Feed on other carnivores, representing the highest level in the food chain.Store energy in their biomass and contribute to the nutrient cycle through waste and decomposition.

Decomposers (Fungi and Bacteria): Break down dead organic matter, returning nutrients to the soil.Play a crucial role in recycling nutrients and maintaining soil fertility.

Material Cycles: Carbon Cycle: Involves the exchange of carbon between the atmosphere, organisms, and soil. Photosynthesis and respiration are key processes.

Nitrogen Cycle: Involves the conversion of nitrogen between various forms, including atmospheric nitrogen, ammonia, and nitrates, facilitated by soil bacteria.

Water Cycle: Involves the movement of water through evaporation, condensation, precipitation, and runoff, essential for all living organisms.

Energy Flow: Energy Storage: Occurs in biomass (plants, animals) and chemical bonds (organic molecules).Energy Transfer: Flows from producers to various consumer levels, ultimately reaching decomposers.

Nutrient Recycling: Waste products and dead organisms are decomposed, releasing nutrients back into the soil.Nutrients are then available for uptake by producers, continuing the cycle.This diagram emphasizes the interconnectedness of energy flow and nutrient cycles, highlighting the importance of each component in maintaining the balance and health of an ecosystem.Diagram (Illustration)Producers: Green plants absorbing sunlight.Primary Consumers: Herbivores like rabbits feeding on plants.Secondary Consumers: Carnivores like foxes preying on herbivores.Tertiary Consumers: Apex predators like eagles at the top.Decomposers: Fungi and bacteria breaking down organic matter.Arrows: Indicating the flow of energy and cycling of materials through the ecosystem

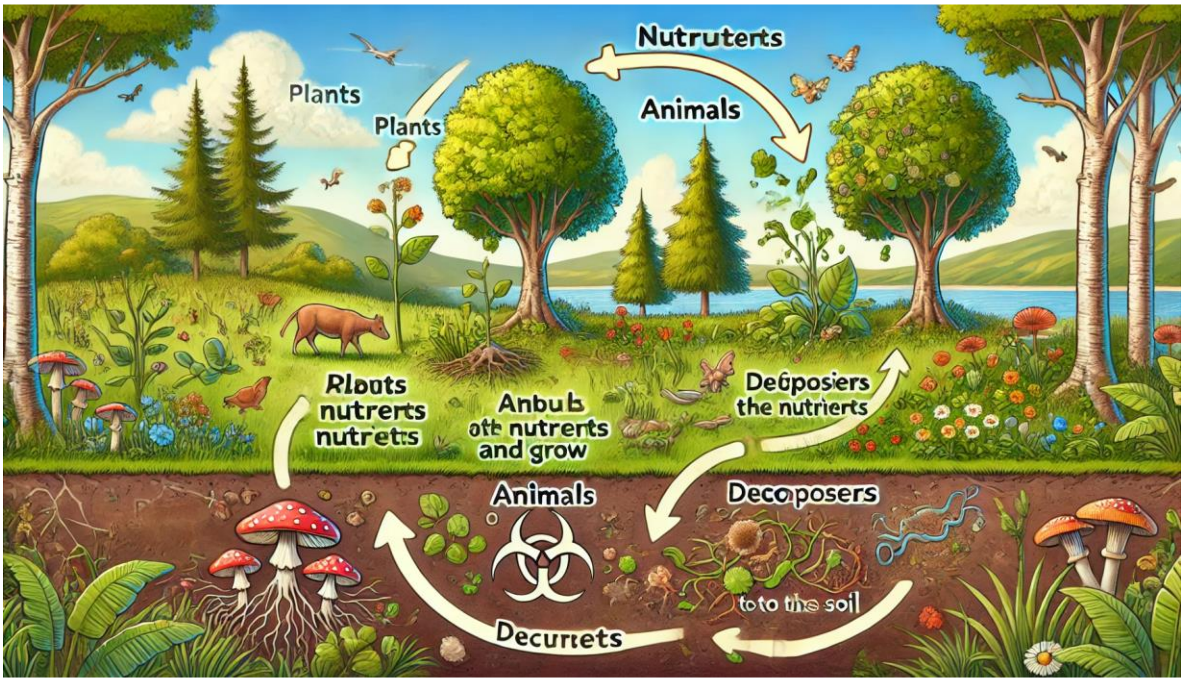


Fig 37: Nutrient Recycling

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