

الجمهورية الجزائرية الديمقراطية الشعبية
People's Democratic Republic of Algeria
وزارة التعليم العالي والبحث العلمي
Ministry of higher education and scientific research
معهد علوم الطبيعة والحياة
Nature and Life Sciences Institute
قسم العلوم البيولوجية والفلاحية
Department of Biological and Agricultural Sciences



Sylviculture

Dr. Y. Torche

Anno 2025/2026

Course Sheet

☞ **Course:** Silviculture

☞ **Teaching Unit:** Discovery Unit

☞ **Semester:** 5th Semester

- Credits: 02
- Coefficient: 02

☞ **Target student**

- **3rd grade license, Corp production**

☞ **Weekly Teaching Hours:**

- 1h30 Lecture (14 weeks)

☞ **Assessment:** Final exam

☞ **For any information, you can contact the course coordinator:**

- **By email:** torche.yacine@yahoo.fr
- **At the SNV Institute on Sundays from 11:00 AM to 12:00 PM**

Course Objectives and prerequisites

☞ Objectives

The **Silviculture module** is introduced in the **agronomy undergraduate program** to provide students with basic concepts in general silviculture, such as **forest ecosystems, dendrology, reforestation, and regeneration methods**, among others.

These concepts form the **fundamental principles** required to develop a **management plan within a natural (forest) environment**.

☞ Prerequisites

To achieve the objectives of the Silviculture module, the following prerequisites are generally required:

1. Basic knowledge in plant biology – understanding plant anatomy, physiology, and reproduction.
2. Introduction to ecology – concepts of ecosystems, biodiversity, and ecological interactions.
3. General agronomy principles – soil–plant relationships, environmental factors affecting growth.
4. Basic geography and climatology – knowledge of climate types, topography, and their effects on vegetation.
5. Introduction to forest sciences or natural resource management – basic understanding of forest types and uses.

Summary

1. Concept of trees: The Forest.....	6
1.1 Definition	6
1.2 <i>Types of Forests</i>	6
1.2.1 Primary Forests.....	6
1.2.2 Secondary Forests	6
1.2.3 Natural Forests	6
1.2.4 Artificial Forests	6
1.3 <i>Importance of Forests</i>	6
1.3.1 Economic Importance.....	6
1.3.2 Ecological Importance.....	7
1.3.3 Social Importance	7
1.3.4 Cultural Importance	7
1.4 <i>Ecological Succession</i>	7
1.4.1 Primary Succession.....	7
1.4.2 Secondary Succession	8
1.5 <i>Forests area and reforestation rates</i>	9
1.5.1 Tropical regions	11
1.5.2 Subtropical forests	11
1.5.3 The boreal region.....	11
1.5.4 Forests in temperate regions.....	11
1.5.2 <i>Human impact</i>	11
1.5.3 <i>Planting versus natural regeneration</i>	11
1.6 <i>Degradation of Mediterranean Forests</i>	12
1.6.1 Characteristics of Mediterranean Forests	12
1.6.2 Definition of Forest Degradation.....	12
1.6.3 Causes of Degradation.....	12
1.6.4 Indicators of Forest Degradation	12
1.6.5 Indicators of Mediterranean Forest Degradation.....	12
1.7 <i>Forest stratification</i>	13
1.7.1 Layers of a forest	13
1.7.2 Importance of stratification.....	14
2. Forest ecology	15
2.1 <i>Forest Ecology</i>	15
2.2 <i>Forest Ecosystems Across Biomes (Tropical, Temperate, Boreal)</i>	16
2.3 <i>Major Factors Influencing Forest Ecosystems</i>	18
3. Forest dendrology	20

3.1 Introduction to Dendrology.....	20
3.2 Forest Species Categories	20
3.3 Morphological Features for Tree Identification	24
3.4 Main Forest Species in Algeria.....	26
4. Silviculture in Natural Forests	29
4.1 Silviculture.....	29
4.1.1 Definition.....	29
4.1.2 Objectives	30
4.2 Forest Stands	30
4.3 Qualitative Study of Forest Stands	31
4.4 Quantitative Study of Forest Stands	32
4.5 Silvicultural system.....	34
4.6 Silvicultural Regimes.....	36
4.6.1 High Forest (Futaie):.....	36
4.6.2 Coppice (Taillis):	37
4.6.3 Mixed regime, Coppice with Standards (Taillis sous Futaie):	37
4.6.4 Determinate factors for regime choice	37
4.6.5 Transitional Treatments	38
4.7 Improvement Operations.....	38
4.7.1 Thinning:.....	38
4.7.2 Cleaning and Liberation:	39
4.7.3 Pruning:	39
4.7.4 Sanitation and Salvage Cutting:	39
4.8 Regeneration Methods.....	40

1. Concept of trees: The Forest

1.1 Definition

Several definitions exist at this level:

A forest is a natural environment where a multitude of plant and animal species coexist. They all depend on each other, as well as on the forest itself, for survival.

The forest is a complex ecosystem characterized by strong interactions among its components. For example, birds require trees to build their nests, while earthworms aerate the soil, enabling tree roots to develop.

The forest provides a large quantity of raw materials of varying qualities, such as firewood, industrial wood (particle board, pulpwood, poles), and timber (for carpentry, construction, and furniture).

According to the FAO:

A forest is an area covering at least 5,000 m², with trees capable of reaching more than 5 meters in height at maturity in situ, a canopy cover of more than 10%, and a width of at least 20 meters. Deforested or regenerating sites are still classified as forests even if their canopy cover is below 10% at the time of inventory.

1.2 Types of Forests

1.2.1 Primary Forests

Forests composed of native species with no clearly visible human intervention, where ecological processes remain essentially undisturbed.

1.2.2 Secondary Forests

Forests regenerated after the disappearance of primary forests, due to natural phenomena or human activities such as agriculture or livestock grazing. These forests often differ significantly in structure and species composition compared to primary forests. Secondary vegetation is generally unstable and represents successive stages.

1.2.3 Natural Forests

Forests composed of native species that have regenerated naturally, but where traces of human activity are clearly visible.

1.2.4 Artificial Forests

Forests established through planting, seeding, or assisted natural regeneration, often including native species.

1.3 Importance of Forests

Forests play multiple roles, which have varied over time and differ across geographical regions. Their significance is linked to the degree of social and economic development.

1.3.1 Economic Importance

☞ Production of wood forest products (WFPs): timber.

- ☞ Production of non-wood forest products (NWFPs): cork, mushrooms, bark, aromatic and medicinal plants (AMPs), forage, and compost.

1.3.2 Ecological Importance

- ☞ Improvement and restoration of soils.
- ☞ Hydrological regulation and protection of slopes from erosion.
- ☞ Conservation of forest plant and animal species.
- ☞ Carbon storage.

1.3.3 Social Importance

- ☞ Spaces for leisure and recreation.

1.3.4 Cultural Importance

- ☞ Study of vegetation behavior in relation to their environment.
- ☞ Study of vegetation taxonomy.
- ☞ Study of ecological relationships among plant communities.
- ☞ Study of stand growth and site productivity.

1.4 Ecological Succession

Ecological succession is the natural evolutionary process through which ecosystems develop from an initial stage to a more stable final stage, referred to as the climax. At this point, the ecosystem reaches a state of dynamic equilibrium, where energy and resources are used primarily to maintain balance.

There are two types of ecological succession:

- Primary succession
- Secondary succession

1.4.1 Primary Succession

Primary succession represents the silvigenetic cycle, a series of successive changes in species composition. It begins with pioneer species and evolves toward the climax stage, which may take up to 70 years or more.

Development of a new community in a previously barren environment without vegetation.

1.4.1.1 Bare Soil

The beginning of forest formation on sterile land (sand dunes, volcanic rock, bare soil). The first species are pioneers, adapted to harsh conditions.

1.4.1.2 Moss Stage

Lasting up to five years, this stage involves the formation of a layer of lichens, mosses, and other autotrophic organisms (pioneers) that extract nutrients from rocks and create an initial soil layer. Ferns later enrich the soil.

1.4.1.3 Perennial Grass Stage

Fast-growing monocotyledonous plants (order Poales) establish. They provide habitat for insects and animals, requiring little humus. Herbaceous plants dominate at this stage.

1.4.1.4 Shrub Stage

Woody plants under 4 meters in height (shrubs, small bushes, sub-shrubs) dominate, generally after about 20 years.

1.4.1.5 Fast-Growing Tree Stage

Tree species colonize rapidly, adapting better than shrubs in disturbed areas (around 40 years).

1.4.1.6 Climax Stage

The climax stage represents the ideal equilibrium between soil and vegetation. This state is stable, occurring after about 70 years or more, and is generally only found in natural ecosystems with little or no human intervention.

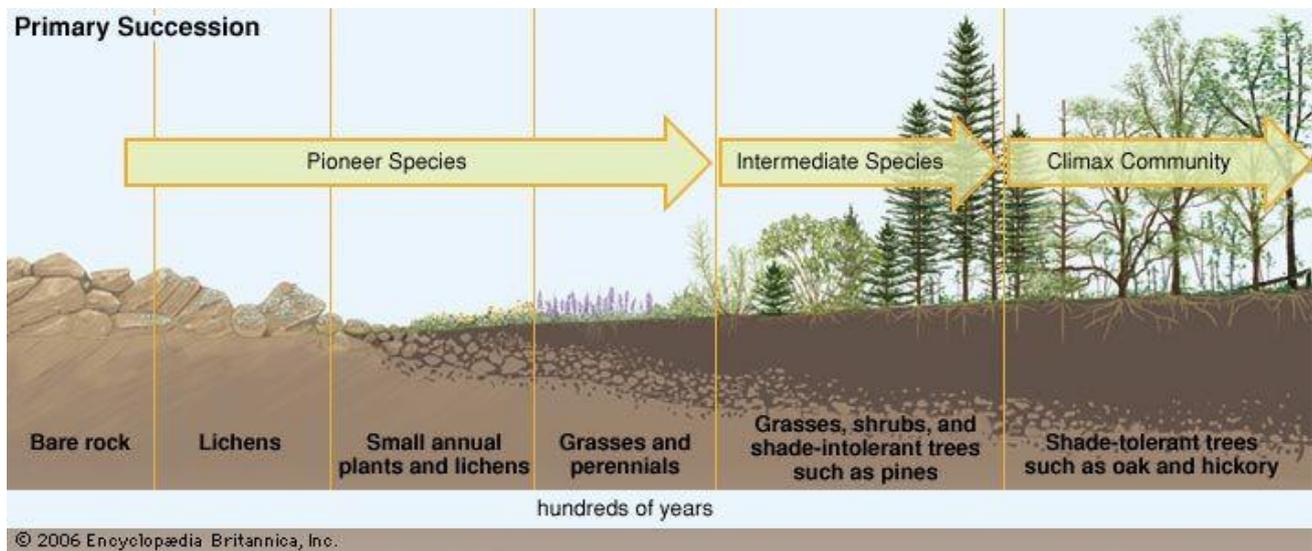


Fig 1. Primary succession begins in barren areas, such as on bare rock exposed by a retreating glacier. The first inhabitants are lichens, mosses, fungi, or microorganisms—those that can survive in such an environment. Over hundreds of years these “pioneer species” convert the rock into soil that can support simple plants such as grasses. These grasses further modify the soil, which is then colonized by other types of plants. Each successive stage modifies the habitat by altering the amount of shade and the composition of the soil. The final stage of succession is a climax community, which is a very stable stage that can endure for hundreds of years. *Encyclopædia Britannica, Inc.*

1.4.2 Secondary Succession

Secondary succession occurs when a climax community or an established ecosystem is disturbed by ecological events such as wildfires, storms, or other disturbances, but the soil still retains nutrients. Because the soil is already present, the regeneration process is faster. This phenomenon is called a **paraclimax**.

- **Example:** The destruction of the Mediterranean climax forest leads to paraclimax forms such as **maquis** and **garrigue**, which are forms of Mediterranean forest degradation.

1.4.2.1 Stages of secondary succession:

1. A climax forest in equilibrium.
2. Disturbance (e.g., wildfire).

3. Destruction of the forest canopy.
4. Soil left exposed, but still containing nutrients.
5. Pioneer grasses and pyrophytic species (e.g., Montpellier cistus) colonize.
6. Shrubs and young trees recolonize the area.
7. Fast-growing conifers and shade-tolerant hardwoods reestablish undergrowth.
8. Restoration of an ecosystem similar to the original, until the next disturbance.

Note on pyrophytic species: Recurrent fires promote the spread of plants adapted to fire (e.g., cork oak), which either resist fire or regenerate through vegetative reproduction such as **coppicing** and **root suckering**.

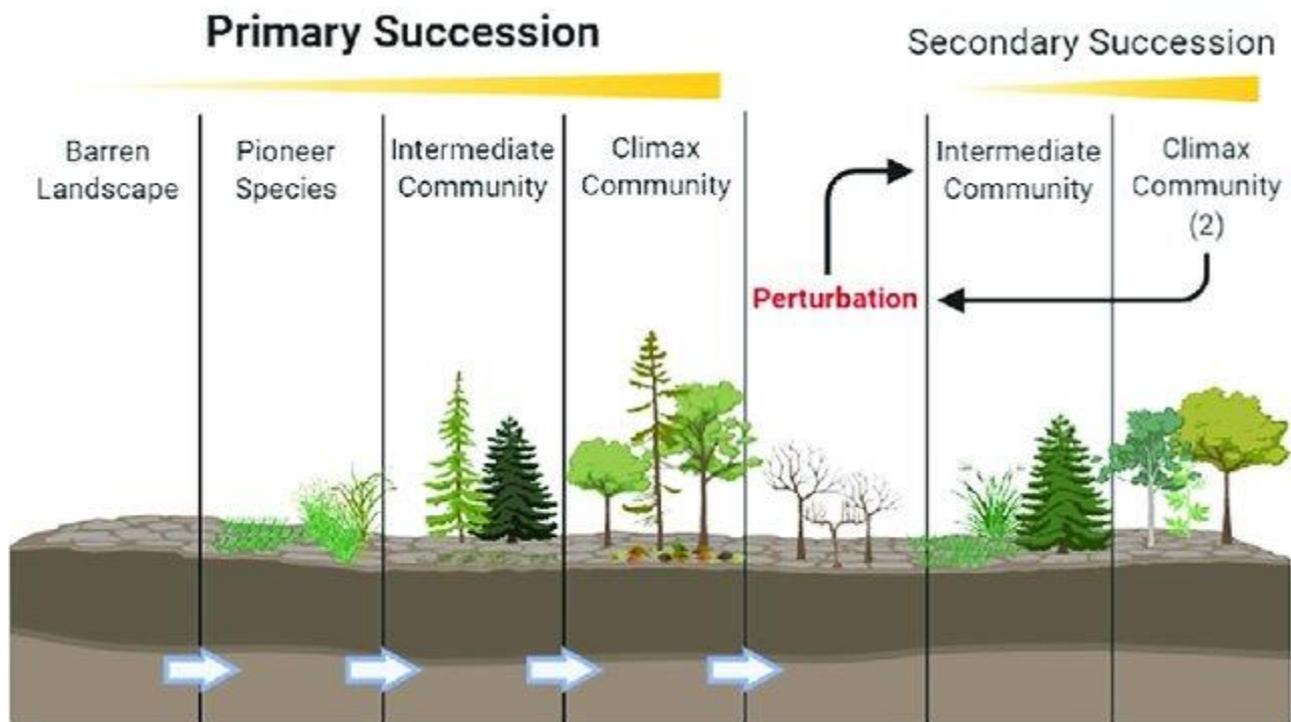
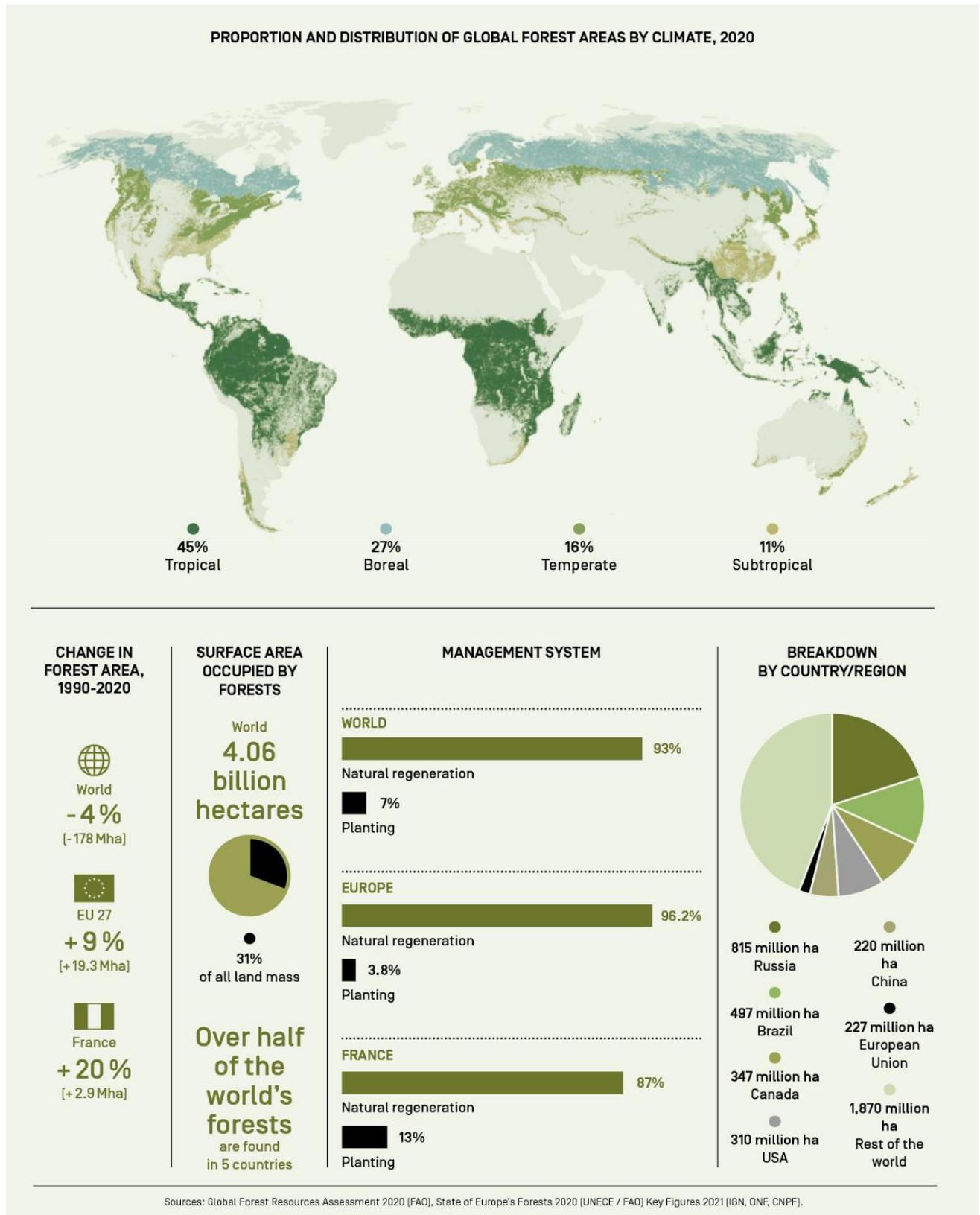


Fig 2. Model of ecological succession describing the stages of primary succession (left) that occurs through pioneer species which colonize an initially uninhabited landscape from an environmental reservoir secondary succession (right) that occurs through locally resident species following a perturbation that disrupts the normal steady state and results in the form of a stable, but different climax community. As the perturbations, however minor, are constantly occurring, even a relatively "steady-state" community is constantly in a dynamic state of flux, and moving toward a desired equilibrium, which may never be truly reached. The image was created with BioRender.

1.5 Forests area and reforestation rates

Around the world, forests are home to 73,300 species of trees, each with differing needs and abilities to adapt: some prefer a temperate climate, while others withstand extreme heat or cold or can thrive in unaccommodating soils that lack water or contain salt. Because they determine the structure and functioning of these ecosystems and influence the biodiversity that develops in them, trees are classified as 'keystone' species (INRAE).

Forest cover around the globe is primarily the result of past and present climate conditions that define the five major forest types: boreal, polar, temperate, subtropical and tropical (INRAE).



1.5.1 Tropical regions

Receive heavy rainfall during certain periods or throughout the year. Forested landscapes in this region are highly dense and diverse. Examples include the lush cover found in the Amazon (including French Guiana) and South-East Asia, and the drier forests of the Congo Basin.

1.5.2 Subtropical forests

With a warmer climate (22°C minimum average) and contrasted seasons, range significantly, from mangroves to pine forests and savannas, in Mexico, the Mediterranean Basin, the centre of Australia and in southern China and Japan.

1.5.3 The boreal region

It is a region populated with mainly coniferous and birch forests, or “taiga”, that withstand harsh winters and temperatures (between –20 °C and –60 °C) and tolerate a contrasted day-length period from season to season. These landscapes are found in Canada, Russia, Scandinavian countries and in France in the Saint-Pierre-et-Miquelon archipelago. In polar regions, summer temperatures, below 10°C, are too low to allow for tree growth.

1.5.4 Forests in temperate regions

With less extreme temperatures and rainfall, levels are populated with deciduous and coniferous trees. Concentrations of certain species are determined by altitude, the presence of waterways, and the nature of forest soils. These forests are more common in the northern hemisphere from North America to Europe, as well as in southern Australia and South America.

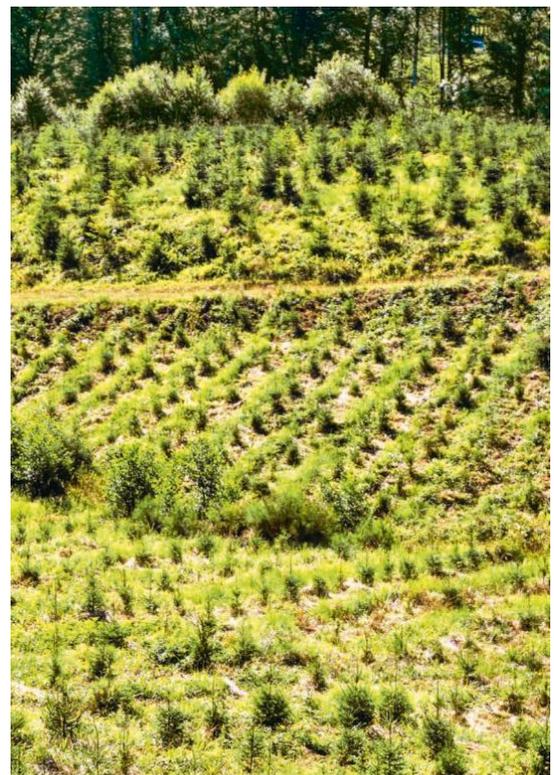
1.5.2 Human impact

Over time, forest areas in general have been more or less managed and directly or indirectly affected by human activity, making them socio-ecosystems. At times, they have been badly damaged by humans in the interest of farming, cities, transportation infrastructure and the activities of a continuously growing population.

World forest cover has diminished by 20% in the space of a century. Deforestation, in which forests are converted into other uses (farming, in particular), has decreased somewhat in the last 30 years. It occurs unevenly: forests in the northern hemisphere are generally expanding, and those in the south are shrinking. It should be pointed out that since 2010; deforestation is more widespread in Africa than in South America.

1.5.3 Planting versus natural regeneration

A “naturally regenerated forest” is one in which canopy coverage grows back independently after a fire or cutting. The FAO estimates that 54% of the world’s forests are subject to a long-term management plan, registered and periodically studied. Practices vary significantly from region to region. 96% of forests in Europe fall into this



category, 59% in North America, 24% in Africa and 19% in South America.

One-third of all naturally regenerated cover today is classified as primary forest by the FAO. In this type of forest, human activity has no visible impact on its ecosystem. The European Union considers that 2.2% of its forests fall under this category. Primary forests do not exist in metropolitan France, but a recent study by the LESSEM research unit in Grenoble estimates that 3% of the country's forests have not been harvested for fifty years or more.

1.6 Degradation of Mediterranean Forests

Mixed pine plantation in Futeau (Meuse department).

1.6.1 Characteristics of Mediterranean Forests

The Mediterranean climate is marked by a **summer water deficit** and cold winters, leading to long dry periods that can last up to six months (as illustrated by **Emberger's ombrothermic diagram**).

Mediterranean forests and shrublands are highly exposed to wildfire risk due to the flammable nature of many tree and shrub species, with some exceptions like the Atlas cedar and Moroccan fir, which grow in colder, snowy zones. These climatic conditions make Mediterranean ecosystems highly vulnerable to disturbances.

Additionally, Mediterranean forests play a vital **protective role**, as the region's hydrology and steep slopes promote erosion. Forest conservation is therefore a critical priority.

Despite their relatively low productivity, Mediterranean forests are inhabited by human populations who rely on them for livelihood. These forests are **multifunctional**, providing both goods and ecosystem services to local communities and the state (see Table 1).

1.6.2 Definition of Forest Degradation

Forest degradation is defined as the **reduction in the forest's capacity to provide goods and services**.

1.6.3 Causes of Degradation

- Climate change
- Wildfires
- Overexploitation
- Erosion

1.6.4 Indicators of Forest Degradation

Three indicators are commonly used to assess degradation:

1. Reduction in biomass (standing stock or stored carbon).
2. Reduction in biodiversity (loss of species or habitats).
3. Soil loss, as indicated by decreased cover, depth, and fertility.

1.6.5 Indicators of Mediterranean Forest Degradation

Two typical vegetation formations illustrate degradation in Mediterranean ecosystems:

1.6.5.1 Maquis

- Tall shrubland (3–10 m in height), usually dense, dominated by **Ericaceae** and **Cistaceae**.

- Results from regression of Mediterranean forest cover, often due to fire or overgrazing.
- Grows on acidic or siliceous soils.
- Typically associated with more humid zones.



1.6.5.2 Garrigue

- Low, open shrubland (<2 m), dominated by shrubs, small bushes, and sub-shrubs.
- Arises from degradation of Mediterranean forests, typically through fire or overgrazing.
- Found mostly on **calcareous soils**.
- Characteristic of drier, more arid climates.

1.7 Forest stratification

Forest stratification is the vertical layering of a forest into distinct zones based on plant height, which creates different microclimates and niches for various species. This arrangement is determined by factors like light availability, leading to layers such as the emergent, canopy, shrub, and ground layers, each supporting unique communities of plants and animals. The process increases overall forest biodiversity by providing diverse habitats and reducing competition among different plant and animal species.

1.7.1 Layers of a forest

a) **Emergent layer:**

The tops of the tallest trees that extend above the main canopy.

b) **Canopy layer:**

The dense, upper layer formed by the crowns of the tallest trees, which receives the most direct sunlight.

c) **Subcanopy layer:**

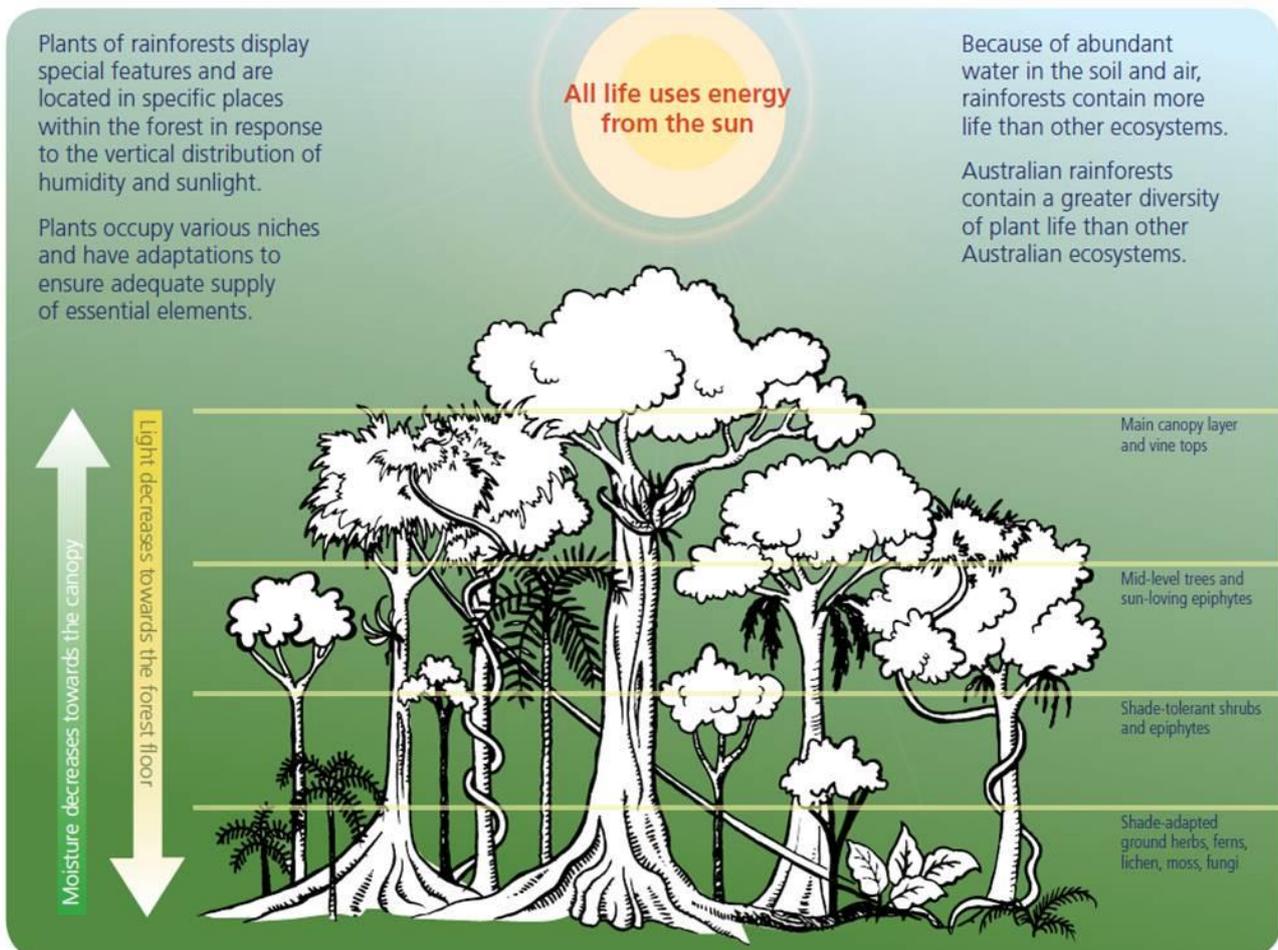
The layer below the canopy, comprised of smaller trees and saplings that are adapted to lower light conditions.

d) **Shrub layer:**

A layer of shrubs and young trees that receive very little sunlight. Plants here often have large, dark green leaves to capture maximum light.

e) **Forest floor (ground layer):**

The lowest layer, consisting of ground vegetation like herbs, mosses, and grasses, and leaf litter. This area receives the least amount of light.



1.7.2 Importance of stratification

a) **Increases biodiversity:**

Stratification creates more niches, or specialized roles, for different organisms, which increases the number of species a forest can support.

b) **Reduces competition:**

By dividing resources like light, the layers prevent different plant species from competing with each other at the same height.

c) **Influences microclimates:**

The layers create different environmental conditions. For example, the canopy filters sunlight, leading to cooler, more humid conditions in the lower layers.

d) **Affects nutrient distribution:**

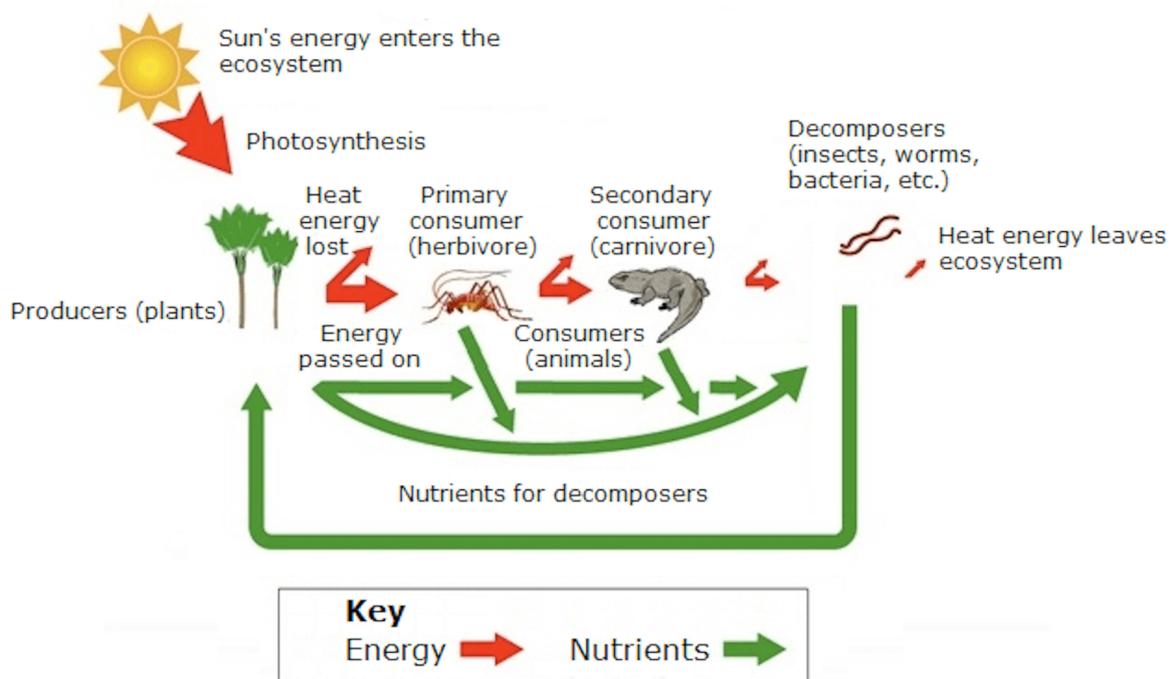
Different layers can have different physical and chemical properties, affecting how precipitation and nutrients are distributed and cycled through the forest.

2. Forest ecology

☞ Reminder

In ecology, an **ecosystem** is broadly defined as a biotic community together with its physical environment, functioning as a unit through the flow of energy and cycling of materials. For example, Yu et al. (2021) describe an ecosystem as “a fundamental organizational unit of the biosphere in which biological communities interact with their non-biological environment through energy flows and material cycles”. Likewise, Loreau (2010) defines an ecosystem as “the entire system of biotic and abiotic components that interact in some place,” emphasizing that an ecosystem includes all plants, animals, microbes, soils, water, atmosphere and other factors linked by ecological processes.

A simple ecosystem



© The University of Waikato Te Whare Wānanga o Waikato | www.sciencelearn.org.nz

In practice, ecosystems are dynamic systems: solar energy enters via photosynthesis, nutrients are recycled through food webs and decomposition, and the structure of the community can change over time (succession). This definition applies at many scales (from a pond to a forest to a desert), but always involves the key features of living communities interacting with their abiotic surroundings under the laws of ecology.

2.1 Forest Ecology

Forest ecology is the subfield of ecology that focuses on forest ecosystems – that is, on communities of trees and associated plants, animals, microbes, and their abiotic environment. It seeks to understand