

trees not only releases stored carbon (driving climate change) but also fragments habitats and interrupts water and nutrient cycles.

- Liu et al. (2021) report that selective logging and deforestation have significantly lowered canopy cover and soil protection, thereby reducing forest resilience. Habitat loss forces forest species into smaller fragments, often reducing biodiversity and enabling invasive species. Deforestation also alters the regional climate and hydrology (e.g. reducing rainfall). In short, land-use change converts dynamic forest ecosystems into degraded landscapes or agricultural lands, fundamentally altering ecosystem services.
- **Other Human Impacts:** Beyond deforestation, numerous human actions influence forests. These include overharvesting of timber or non-timber forest products, pollution (acid rain, ozone, nitrogen deposition) that stresses vegetation, road-building and fragmentation, and introduction of invasive species. For example, Loreau (2010) lists overexploitation of resources and biotic homogenization as major pressures on ecosystems. Changes in fire management (suppression or excess burning) can also disrupt natural disturbance regimes. Each of these factors – alone and in combination – can lead to nutrient imbalances, soil degradation, and altered species interactions. Collectively, they increase forest vulnerability by compounding the effects of climate change and biodiversity loss.

In summary, current research shows that forest ecosystems are increasingly affected by global changes. Climate change and its feedbacks, combined with habitat destruction and biodiversity loss, are pushing many forests into new regimes. Understanding these drivers and their interactions (a central goal of forest ecology) is critical for predicting and managing forest change in the Anthropocene.

3. Forest dendrology

3.1 Introduction to Dendrology

Def. –Dendrology (also called **xylology** or forest dendrology) is the scientific study of **woody plants** – trees, shrubs and lianas – with an emphasis on their taxonomy, characteristics and uses.

As a specialized branch of systematic botany and forestry, dendrology focuses on identifying and classifying forest trees and other woody species. Historically it also encompassed the natural history of trees in a region, but today ecological aspects (e.g. tree-environment interactions) are treated separately under ecology.

In practice, dendrologists use morphological keys (based on leaves, bark, buds, fruits, etc.) to distinguish species. This knowledge is **vital for forestry and conservation** – for example, selecting the best tree species for timber or reforestation, recognizing invasive species, and protecting rare or endangered trees. In short, dendrology provides the foundational tree identification skills and taxonomic framework used in forestry, ecology and natural resource management.

3.2 Forest Species Categories

Forest plants are often classified by their origin and behavior in an ecosystem. Key categories include:

- **Native (indigenous) species** – species occurring in a region **within their natural range and dispersal potential**. These have not been introduced by humans. Native trees form the historic vegetation of an area and are generally well adapted to local conditions. For example, the holm oak (*Quercus ilex*) and Aleppo pine (*Pinus halepensis*) are native to Algerian Mediterranean forests. Native species contribute to stable ecosystems and often support local wildlife. (They may sometimes be called “historic” if introduced long ago and now widely accepted as part of the flora).



- **Endemic species** – native species **found only in a limited area** or single region. Endemics have very restricted ranges and high conservation value. For example, the Numidian fir (*Abies numidica*) is endemic to the Babors Mountains of Algeria, the Atlas cedar (*Cedrus atlantica*) occurs only in the Atlas highlands of Algeria and Morocco and the Afares Oak (*Quercus afares*) in Northeast Algeria and West Tunisia. Because endemics occur nowhere else, they often fill unique ecological niches, but are vulnerable to habitat loss or climate change (any threat in their small range puts them at risk).



- **Exotic (non-native) species** – species introduced (intentionally or accidentally) **outside their natural range**. An “alien” species may be foreign to the continent or country. For example, eucalyptus trees (*Eucalyptus spp.*) from Australia have been planted in North Africa. By definition, exotic species live in habitats they could not reach without human help. Their ecological roles vary: some integrate without much impact, while others can affect native ecosystems. Exotics that establish self-sustaining populations are sometimes called **naturalized**.



- **Naturalized species** – exotics that have become **established and reproduce on their own** in a new region. They “go wild” without ongoing human planting. For instance, ornamental pines or acacias planted around Algerian towns may escape cultivation and form small forests. A naturalized species may fill vacant niches or change community structure, but in itself is not necessarily harmful. It becomes a management concern only if it spreads aggressively.



Eucalyptus sideroxylon, l'eucalyptus à écorce de fer, Ironbark rouge ou mugga (Foret Tipaza)

- **Invasive species** – non-native species that **spread rapidly and cause harm** to native ecosystems, economy or human health. Invasives often outcompete local plants or animals, alter habitats, and reduce biodiversity. For example, in many regions invasive trees or shrubs form dense thickets that crowd out native saplings. Invasives may also change fire regimes, hydrology or nutrient cycles.

Ecological impacts: Invasive plants typically **compete with and displace native species**, reduce habitat quality, and may increase fire danger. (For example, the giant reed *Arundo donax* can outcompete riparian vegetation and is highly flammable) Many invasives exhibit explosive population growth with little natural control. You can read this article for more information about invasive species in Algeria (<http://s614510234.onlinehome.fr/wp-content/uploads/2020/08/Meddour-Sahar-Fried-2020-Botany-Letters.pdf>)

Examples: *Prosopis juliflora* (mesquite) and prickly pear cactus (*Opuntia ficus-indica*) – both introduced in Algeria – have become invasive by forming dense stands that reduce pasture and biodiversity. By contrast, native oaks and pines maintain local food webs and soil stability.



The list below summarizes these categories:

- **Native:** *Occurring naturally (within dispersal range)*. E.g. *Quercus ilex*, *Pinus halepensis* in Algeria.
- **Endemic:** *Native but only found in one area*. E.g. Numidian fir (*Abies numidica*) in NE Algeria; Atlas cedar (*Cedrus atlantica*) in the Maghreb
- **Exotic (alien):** *Introduced from elsewhere*. E.g. Australian eucalyptus (*Eucalyptus globulus*), Mexican prickly pear (*Opuntia*).
- **Naturalized:** *Introduced but now self-sustaining*. E.g. ornamental pines or acacias that now reproduce in Algerian foothills.
- **Invasive:** *Harmful, spreading alien*. E.g. *Prosopis juliflora* forming dense woodland; invasive weeds that outcompete natives.

Each group plays different ecological roles: natives/endemic sustain traditional ecosystems; exotics may provide new services or pests; invasives often degrade habitats and must be managed to protect native forests.

3.3 Morphological Features for Tree Identification

In dendrology, **morphological characteristics** – observable physical traits – are essential for identifying tree species in the field. Key features include:

- a) **Leaves and needles:** The simplest starting point. Observe whether leaves are simple or compound, their shape (ovate, lobed, needle-like, etc.), margin (smooth, serrated, spiny) and arrangement on the twig (alternate, opposite, or whorled). For example, *Pinus*



halepensis has two long needles per bundle (a trait of the pine family), whereas cork oak (*Quercus suber*) has broad evergreen leaves. Leaf texture and color (e.g. glossy vs. dull, dark green vs. grey-green) also help distinguish species. Seasonal changes (deciduous leaves) are noted when present.

- b) **Bark:** The bark's texture, color and pattern are distinctive in many species. Some trees have smooth bark (e.g. beech) versus rough, fissured bark (e.g. many oaks and pines). Cork oak's thick, deeply furrowed, corky bark is obvious, while Aleppo pine has reddish-brown scaly bark. Bark clues are invaluable in winter when no leaves are available. Dendrologists note bark color bands, peeling plates, lenticels (horizontal lines on young bark), and even sap characteristics.



- c) **Buds and twigs:** In winter, buds (the undeveloped shoot tips or leaves) become key. Twigs may have an alternate or opposite arrangement; buds may be terminal (at twig ends) or lateral (along twig sides). Bud scales (flat, pointed, hairy) are often species-specific. For instance, *Cedrus atlantica* has clustered buds (like its needles), while many oaks have single buds at twig ends. Observing twigs and buds helps distinguish similar species when foliage is absent.



- d) **Fruits, cones and flowers:** When present, reproductive structures are diagnostic. Note fruit type (acorns, samaras, nuts, berries) or cone shape and size in conifers. Example: Atlas cedar bears barrel-shaped woody cones; cork oak has acorns with a broad cup. Flower or cone arrangement (solitary vs. clustered) and timing (spring vs. fall) also aid ID. Field keys often include fruit traits because they are highly species-specific.



- e) **Branching form and overall habit:** The tree's shape (columnar, spreading, umbrella-like) and branching pattern (whorled branches like pines, or uniform branching) can help at a distance. For example, *Pinus pinea* (stone pine) forms a distinctive flat-topped canopy, whereas holm oak is a broad round tree. Habitat and tree size give further clues (e.g. a conifer at alpine tree line vs. a warm-climate species lowland).



Dendrology courses teach that **combining these traits** (often via an identification key) leads to a reliable ID. A classic field rule is: start with leaves (most obvious), then confirm with bark and fruit. Precise use of morphological characters is crucial for taxonomy: botanists use leaf arrangement, flower structure, wood anatomy, etc. to define genera and species. In fieldwork, careful observation of these characters allows foresters and ecologists to quickly identify timber and monitor forest composition.

3.4 Main Forest Species in Algeria

Algeria's forests span Mediterranean and mountain zones and host a mix of conifers and broad-leaved trees. Major species include:

✚ ***Pinus halepensis*** (Aleppo pine) – *Pinus halepensis*. A drought-tolerant, resinous pine with bundles of 2 long needles (6–12 cm). Bark is orange-brown and scaly; cones are egg-shaped. Ecologically, it is a pioneer in semi-arid zones and dominates reforestation (the “green dam” project). It occupies the *largest forest area* in Algeria, especially the interior Tell Atlas (Ouarsenis, Tlemcen, Saïda) and coastal belts. It tolerates ~350 mm annual rain and poor soils. Uses: valued for timber, resin and erosion control. Conservation status: globally LC, but vulnerable to wildfires and the pine processionary caterpillar.



✚ ***Cedrus atlantica*** (Atlas cedar) – *Cedrus atlantica* (French: *Cèdre de l'Atlas*). A large evergreen conifer with flat, broad crown. Needles are in clusters of 20–30, silvery-green; cones are large and barrel-shaped. Grows at high altitude (1,400–2,800 m) in humid, cool Atlas conditions. Found in discrete forests of the Algerian Tell Atlas (Aurès, Blida, Djurdjura, Belezma, Ouarsenis). Role: forms pure or mixed cedar forests; these are biodiversity hotspots and source of durable timber. Conservation: **Endangered** – overexploited for wood and decimated by grazing, fire and drought. Threats include goat browsing and bark beetles. Uses: valued for its strong aromatic wood (historically in construction) and essential oils distilled from foliage.



- ✚ ***Quercus suber*** (cork oak) – *Quercus suber*. A medium evergreen oak with thick, deeply fissured corky bark (harvested for cork) and glossy oval leaves (6–11 cm) with shallow lobes. It produces acorns ~2 cm long. Habitat: humid-subhumid Mediterranean zones on acidic (non-calcareous) soils. In Algeria it is *rare and scattered*, confined to the northeast (El-Kala, Kherrata, Guelma, Souk Ahras). Ecologically it forms open cork forests and woodlands. Uses: cork harvest (bark is regrown), firewood and charcoal. It is relatively slow-growing. Conservation: not globally threatened (LC), but Algerian stands are limited in extent.



- ✚ ***Quercus ilex*** (holm oak, holly oak) – *Quercus ilex*. A tough evergreen oak with small, leathery, dark-green leaves (often spiny on young trees) and a rounded crown. Acorns are small (~1–2 cm). It forms dense, drought-resistant forests. According to Algerian vegetation surveys, holm-oak forests occur on dry limestone hills and cover much of northern Algeria (and even into the Saharan Atlas). They are usually low (≤ 10 m) semi-evergreen forests. Role: typical Mediterranean woodland, providing acorns for wildlife and grazing. Holm oak is not endangered (LC) and widely used in reforestation and as a soil stabilizer.



✚ **Abies numidica** (Numidian or Algerian fir) – *Abies numidica*. A rare fir with flat needles and upright conical cones. It is **endemic** to Algeria, found only on two mountains (Jebel Babor and Tababor in the Aurès) algerianativeplants.net. It grows at very high altitude in humid forests (above ~1,500 m). Conservation: **Critically Endangered** (IUCN) due to its tiny range and overcutting. Its ecological role is similar to cedar, forming relict fir stands. It is protected in national parks, and also grown in arboreta outside Algeria.



✚ **Tetraclinis articulata** (Barbary thuja or thuya) – *Tetraclinis articulata*. A small evergreen conifer (cupressus family) resembling a cypress. Leaves are scale-like in opposite pairs; cones are small and globose. It thrives in arid zones (rainfall ~250–300 mm) of western Algeria. There it forms low woodlands and coppices (near Oran, Mascara, etc.) on rocky soils. Ecological role: highly xerophytic, it prevents erosion on degraded hillsides. Uses: hard, aromatic wood (traditionally prized for inlay work and craft, though Algerian populations are small). Not threatened due to its remote habitats, but populations are fragmented.

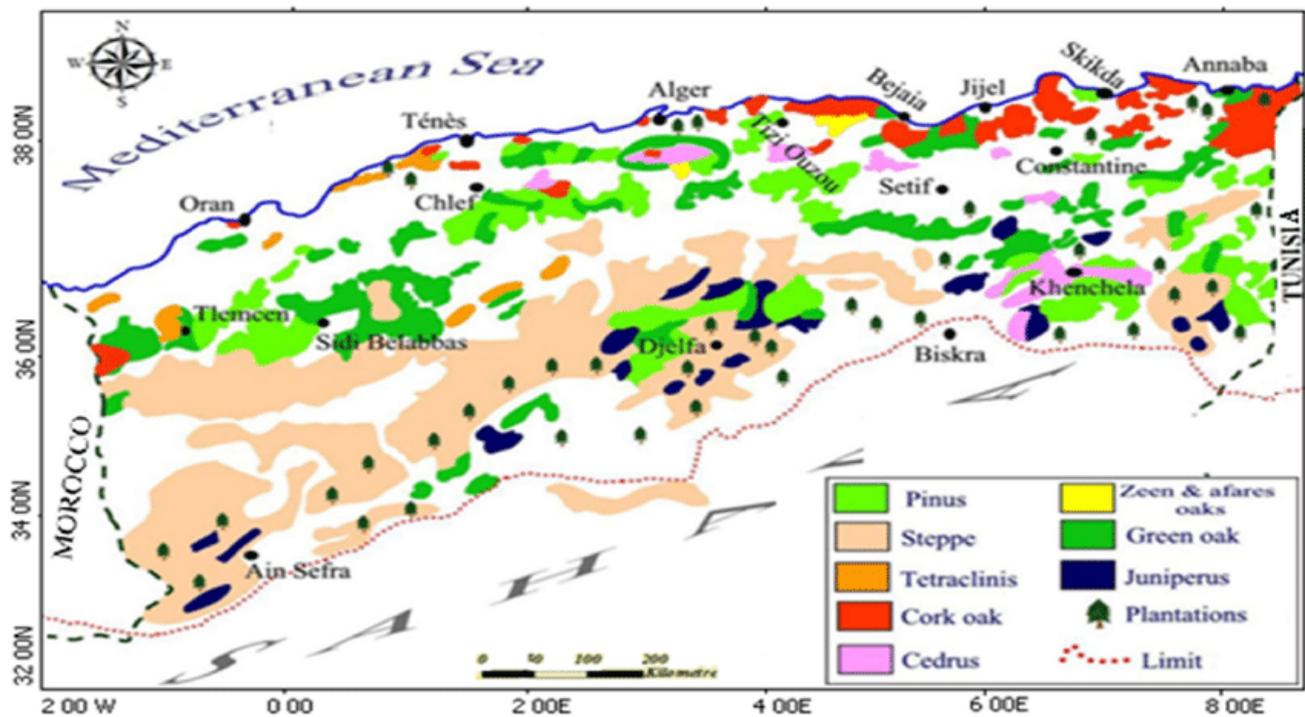
✚ **Others of note:** *Quercus canariensis* (Zeen oak) and *Quercus afares* (Afares oak) occur in humid eastern Algeria. The pine species like *Pinus pinea* (stone pine) and *Pinus pinaster* have limited local stands (the stone pine is planted along coasts).

Introduced *Eucalyptus* plantations cover ~40,000 ha in Algerian north-east, but these are managed forestry, not native.



Distribution and ecology: In general, Algerian forests follow a rainfall gradient: humid north-east (Atlas cedar and cork oak), drier west and central (Aleppo pine and holm oak), and high mountains (cedar, fir, junipers). Many of these species form mixed forests: e.g. cedar often grows with Aleppo pine and Algerian oak; cork oak co-occurs with Turkish oak (*Q. canariensis*).

Each species has specific uses: timber, resin, cork, fuelwood, or non-timber products (acorns, oils). For example, cork oak bark is harvested sustainably for wine corks, Atlas cedar wood is used in furniture, and Aleppo pine resin is distilled. Understanding their biology and status is crucial: *Cedrus atlantica* and *Abies numidica* are conservation priorities due to their limited range and declining populations, whereas *Pinus halepensis* and *Quercus ilex* remain widespread and key to Algeria's forestry efforts.



4. Silviculture in Natural Forests

4.1 Silviculture

4.1.1 Definition

Silviculture is the **art and science** of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet society's diverse needs on a sustainable basis. In practice, silviculture involves selecting and applying treatments (such as planting, thinning, or controlled burns) that shape stand development toward specific goals. It is a fundamental component of forest management, providing the tools to align forest conditions with landowner and societal objectives. Silvicultural decisions must balance **ecological**, **economic**, and **social** considerations. For example, thinning or regeneration methods are chosen not only for timber yield, but also to maintain wildlife