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# TAXONOMICAL FLORA OF INDIA

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**ABSTRACT:** The flora of India is one of the richest in the world due to the wide range of climate, topology and habitat in the country. There are estimated to be over 18,000 species of flowering plants in India, which constitute some 6-7 percent of the total plant species in the world. India is home to more than 50,000 species of plants, including a variety of endemics. The use of plants as a source of medicines has been an integral part of life in India from the earliest times. There are more than 3000 Indian plant species officially documented as possessing into eight main floristic regions : Western Himalayas, Eastern Himalayas, Assam, Indus plain, Ganges plain, the Deccan, Malabar and the Andaman Islands.[1]

**KEYWORDS-**flora, India, taxonomical, rich, plants, endemics, species

## I. INTRODUCTION

In 1992, around 7,43,534 km<sup>2</sup> of land in the country was under forests of which 92 percent belongs to the government. Only 22.7 percent is forested compared to the recommended 33 percent of the National Forest Policy Resolution 1952. The majority of it are broad-leaved deciduous trees which comprise one-sixth *sal* and one-tenth teak. Coniferous types are found in the northern high altitude regions and comprise pines, junipers and *deodars*.<sup>[2]</sup> India's forest cover ranges from the tropical rainforest of the Andaman Islands, Western Ghats, and Northeast India to the coniferous forest of the Himalaya. Between these extremes lie the *sal*-dominated moist deciduous forest of eastern India; teak-dominated dry deciduous forest of central and southern India; and the babul-dominated thorn forest of the central Deccan and western Gangetic plain. Pine, fir, spruce, cedar, larch and cypress are the timber-yielding plants widely prevalent throughout the hilly regions of India.

The Western Himalayas refers to the western half of the Himalayas, in northwestern India and northern Pakistan. Four of the five tributaries of the Indus River in Punjab (Beas, Chenab, Jhelum, and Ravi) rise in the Western Himalayas; while the fifth, the Sutlej cuts through the range after rising in Tibet.

Included within the Western Himalayas are the Zaskar Range, the Pir Panjal Range, and the Dhauladhar Range, and western parts of the Sivalik Range and the Great Himalayas. The highest point is Nanga Parbat (26,660 feet or 8,126 metres), at the northwestern end of the region.

Flora

- Northwestern Himalayan alpine shrub and meadows
- Western Himalayan alpine shrub and meadows
- Western Himalayan broadleaf forests
- Western Himalayan subalpine conifer forests

The Eastern Himalayas extend from eastern Nepal across Northeast India, Bhutan, the Tibet Autonomous Region to Yunnan in China and northern Myanmar. The climate of this region is influenced by the monsoon of South Asia from June to September.<sup>[1]</sup> It is a biodiversity hotspot, with notable biocultural diversity.<sup>[2][3]</sup>

Agriculture

Agricultural conditions vary throughout the region. In the highlands the soil is morainic, and the hill slopes are cut by the locals into successive steps or terraces only a few meters broad, thus preventing water run-off and allowing spring crops to thrive. The region's economy relied mostly on shifting cultivation agriculture, supplemented by hunting, fishing and barter trade. Agriculture does not produce sufficient yields to meet local needs. The region's economy remained stagnant and at subsistence levels for centuries due to the lack of capital, investor access, or entrepreneurial knowledge. Inhabitants also relied heavily on wild and semi-cultivated species for food and herbal medicines.<sup>[2]</sup>



Assam is a state in northeastern India, south of the eastern Himalayas along the Brahmaputra and Barak River valleys. Assam covers an area of 78,438 km<sup>2</sup> (30,285 sq mi). The state is bordered by Bhutan and Arunachal Pradesh to the north; Nagaland and Manipur to the east; Meghalaya, Tripura, Mizoram and Bangladesh to the south; and West Bengal to the west via the Siliguri Corridor, a 22-kilometre-wide (14 mi) strip of land that connects the state to the rest of India. Assamese and Boro are the official languages of Assam, while Bengali is an additional official language in the Barak Valley.

Assam is known for Assam tea and Assam silk. The state was the first site for oil drilling in Asia.<sup>[11]</sup> Assam is home to the one-horned Indian rhinoceros, along with the wild water buffalo, pygmy hog, tiger and various species of Asiatic birds, and provides one of the last wild habitats for the Asian elephant. The Assamese economy is aided by wildlife tourism to Kaziranga National Park and Manas National Park, which are World Heritage Sites. Dibru-Saikhowa National Park is famed for its feral horses. Sal tree forests are found in the state which, as a result of abundant rainfall, look green all year round. Assam receives more rainfall than most parts of India; this rain feeds the Brahmaputra River, whose tributaries and oxbow lakes provide the region with a distinctive hydro-geomorphic environment.

#### Flora

Assam is remarkably rich in Orchid species and the Foxtail orchid is the state flower of Assam.<sup>[73]</sup> The recently established Kaziranga National Orchid and Biodiversity Park boasts more than 500 of the estimated 1,314 orchid species found in India.

The Indus is a transboundary river of Asia and a trans-Himalayan river of South and Central Asia.<sup>[6]</sup> The 3,120 km (1,940 mi)<sup>[3]</sup> river rises in mountain springs northeast of Mount Kailash in Western Tibet, flows northwest through the disputed region of Kashmir,<sup>[7]</sup> bends sharply to the left after the Nanga Parbat massif, and flows south-by-southwest through Pakistan, before emptying into the Arabian Sea near the port city of Karachi.<sup>[1][8]</sup>

The river has a total drainage area of circa 1,120,000 km<sup>2</sup> (430,000 sq mi).<sup>[3]</sup> Its estimated annual flow is around 243 km<sup>3</sup> (58 cu mi), making it one of the 50 largest rivers in the world in terms of average annual flow.<sup>[9]</sup> Its left-bank tributary in Ladakh is the Zaskar River, and its left-bank tributary in the plains is the Panjnad River which is formed by the successive confluences of the five Punjab rivers, namely the Chenab, Jhelum, Ravi, Beas, and Sutlej rivers. Its principal right-bank tributaries are the Shyok, Gilgit, Kabul, Kurram, and Gomal rivers. Beginning in a mountain spring and fed with glaciers and rivers in the Himalayan, Karakoram, and Hindu Kush ranges, the river supports the ecosystems of temperate forests, plains, and arid countryside.

The northern part of the Indus Valley, with its tributaries, forms the Punjab region of South Asia, while the lower course of the river ends in a large delta in the southern Sindh province of Pakistan. The river has historically been important to many cultures of the region. The 3rd millennium BCE saw the rise of Indus Valley Civilisation, a major urban civilization of the Bronze Age. During the 2nd millennium BCE, the Punjab region was mentioned in the Rigveda hymns as *Sapta Sindhu* and in the Avesta religious texts as *Saptha Hindu* (both terms meaning "seven rivers"). Early historical kingdoms that arose in the Indus Valley include Gandhāra, and the Ror dynasty of Sauvīra. The Indus River came into the knowledge of the Western world early in the classical period, when King Darius of Persia sent his Greek subject Scylax of Caryanda to explore the river, c. 515 BCE.

## II. DISCUSSION

The Ganges in Bangladesh: Padma<sup>[6][7][8]</sup> is a trans-boundary river of Asia which flows through India and Bangladesh. The 2,525 km (1,569 mi) river rises in the western Himalayas in the Indian state of Uttarakhand. It flows south and east through the Gangetic plain of North India, receiving the right-bank tributary, the Yamuna, which also rises in the western Indian Himalayas, and several left-bank tributaries from Nepal that account for the bulk of its flow.<sup>[9][10]</sup> In West Bengal state, India, a feeder canal taking off from its right bank diverts 50% of its flow southwards, artificially connecting it to the Hooghly river. The Ganges continues into Bangladesh, its name changing to the Padma. It is then joined by the Jamuna, the lower stream of the Brahmaputra, and eventually the Meghna, forming the major estuary of the Ganges Delta, and emptying into the Bay of Bengal. The Ganges-Brahmaputra-Meghna system is the second largest river on earth by discharge.<sup>[11][12]</sup>

The main stem of the Ganges begins at the town of Devprayag,<sup>[1]</sup> at the confluence of the Alaknanda, which is the source stream in hydrology on account of its greater length, and the Bhagirathi, which is considered the source stream in Hindu Mythology.



The Ganges is a lifeline to millions of people who live in its basin and depend on it for their daily needs.<sup>[13][14]</sup> It has been important historically, with many former provincial or imperial capitals such as Pataliputra,<sup>[15]</sup> Kannauj,<sup>[15]</sup> Sonargaon, Dhaka, Bikrampur, Kara, Munger, Kashi, Patna, Hajipur, Delhi, Bhagalpur, Murshidabad, Baharampur, Kampilya, and Kolkata located on its banks or the banks of tributaries and connected waterways. The river is home to approximately 140 species of fish, 90 species of amphibians, and also reptiles and mammals, including critically endangered species such as the gharial and South Asian river dolphin.<sup>[16]</sup> The Ganges is the most sacred river to Hindus.<sup>[17]</sup> It is worshipped as the goddess *Ganga* in Hinduism.<sup>[18]</sup>

The Ganges is threatened by severe pollution. This poses a danger not only to humans but also to animals. The levels of fecal coliform bacteria from human waste in the river near Varanasi are more than a hundred times the Indian government's official limit.<sup>[16]</sup> The Ganga Action Plan, an environmental initiative to clean up the river, has been considered a failure<sup>[a][b][19]</sup> which is variously attributed to corruption, a lack of will in the government, poor technical expertise,<sup>[c]</sup> poor environmental planning<sup>[d]</sup> and a lack of support from religious authorities.<sup>[e]</sup>

#### Economy

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The Ganges Basin with its fertile soil is instrumental to the agricultural economies of India and Bangladesh. The Ganges and its tributaries provide a perennial source of irrigation to a large area. Chief crops cultivated in the area include rice, sugarcane, lentils, oil seeds, potatoes, and wheat. Along the banks of the river, the presence of swamps and lakes provides a rich growing area for crops such as legumes, chillies, mustard, sesame, sugarcane, and jute. There are also many fishing opportunities along the river, though it remains highly polluted. Also, the major industrial towns of Unnao and Kanpur, situated on the banks of the river with the predominance of tanning industries add to the pollution.<sup>[114]</sup>

The large Deccan Plateau of the Indian Subcontinent is located between the Western Ghats and the Eastern Ghats, and is loosely defined as the peninsular region between these ranges that is south of the Narmada river. To the north, it is bounded by the Satpura and Vindhya Ranges.

A rocky terrain marked by boulders, its elevation ranges between 100 and 1,000 metres (330 and 3,280 ft), with an average of about 600 metres (2,000 ft).<sup>[2]</sup> It is sloping generally eastward. Thus, its principal rivers—the Godavari, Krishna, and Kaveri (Cauvery)—flow eastward from the Western Ghats to the Bay of Bengal. The plateau is drier than the coastal region of southern India and is arid in places.

It produced some of the major dynasties in Indian history, including the Pallavas, Satavahana, Vakataka, Chalukya, and Rashtrakuta dynasties, Chanakya dynasties also the Western Chalukya Empire, the Kadambas, the Yadava dynasty, the Kakatiya Empire, the Musunuri Nayakas regime, the Vijayanagara and the Maratha empires, as well as the Muslim Bahmani Sultanate, Deccan Sultanates, and the Nizam of Hyderabad.

The plateau is drained by the Godavari River taking a southeasterly course; by the Krishna River, which divides the peneplain into two regions; and by the Pennai Aaru River flowing in a northerly direction. The plateau's forests are moist deciduous, dry deciduous, and tropical thorn.

Most of the population of the region is engaged in agriculture; cereals, oilseeds, cotton, and pulses (legumes) are the major crops. There are multipurpose irrigation and hydroelectric-power projects, including the Pochampad, Bhaira Vanitippa, and Upper Pennai Aaru. Well known Industries are cotton textiles, sugar, foodstuffs, tobacco, paper, machine tools, and pharmaceuticals. Cottage industries are forest-based (timber, firewood, charcoal, bamboo products) and mineral-based (asbestos, coal, chromite, iron ore, mica, and kyanite).

#### Economy

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The Deccan plateau is very rich in minerals and precious stones.<sup>[24]</sup> The plateau's mineral wealth led many lowland rulers, including those of the Mauryan (4th–2nd century BCE) and Gupta (4th–6th century CE) dynasties, to fight over it.<sup>[25]</sup> Major minerals found here include coal, iron ore, asbestos, chromite, mica, and kyanite. Since March 2011, large deposits of uranium have been discovered in the Tummalapalle belt and in the Bhima basin at Gogi in Karnataka. The Tummalapalle belt uranium reserve promises to be one of the top 20 uranium reserve discoveries of the world.<sup>[26][27][28]</sup>

Low rainfall made farming difficult until the introduction of irrigation. Currently, the area under cultivation is quite low, ranging from 60% in Maharashtra to about 10% in Western Ghats.<sup>[29]</sup> Except in developed areas of certain river valleys, double-cropping is rare. Rice is the predominant crop in high-rainfall areas and sorghum in low-rainfall areas. Other crops of significance include cotton, tobacco, oilseeds, and sugar cane. Coffee, tea, coconuts, areca, black



pepper, rubber, cashew nuts, cassava, and cardamom are widely grown on plantations in the Nilgiri Hills and on the western slopes of the Western Ghats. Cultivation of *Jatropha* has recently received more attention due to the *Jatropha* incentives in India.

The Malabar Coast is the southwestern coast of the Indian subcontinent, generally referring to the coastline of Western coast of India from Konkan to Kanyakumari. Geographically, it comprises the wettest regions of South India including coastal part of Goa, Karnataka, Kerala and Tamil Nadu.

Kuttanad, which is the point of least elevation in India, lies on the Malabar Coast. Kuttanad, also known as *The Rice Bowl of Kerala*, has the lowest altitude in India, and is one of the few places in the world where cultivation takes place below sea level.<sup>[3][4]</sup>

The region parallel to the Malabar Coast gently slopes from the eastern highland of Western Ghats ranges to the western coastal lowland. The moisture-laden winds of the Southwest monsoon, on reaching the southernmost point of the Indian subcontinent, because of its topography, divides into two branches; the "Arabian Sea Branch" and the "Bay of Bengal Branch".<sup>[5]</sup> The "Arabian Sea Branch" of the Southwest monsoon first hits the Western Ghats,<sup>[6]</sup> making Kerala the first state in India to receive rain from the Southwest monsoon.<sup>[7][8]</sup> The Malabar Coast is a source of biodiversity in India.

The Andaman Islands are an archipelago in the northeastern Indian Ocean about 130 km (81 mi) southwest off the coasts of Myanmar's Ayeyarwady Region. Together with the Nicobar Islands to their south, the Andamans serve as a maritime boundary between the Bay of Bengal to the west and the Andaman Sea to the east. Most of the islands are part of the Andaman and Nicobar Islands, a Union Territory of India, while the Coco Islands and Preparis Island are part of the Yangon Region of Myanmar.

The Andaman Islands are home to the Andamanese, a group of indigenous people that includes a number of tribes, including the Jarawa and Sentinelese.<sup>[1]</sup> While some of the islands can be visited with permits, entry to others, including North Sentinel Island, is banned by law. The Sentinelese are generally hostile to visitors and have had little contact with any other people. The government protects their right to privacy.<sup>[2]</sup>

#### Flora

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The Middle Andamans harbour mostly moist deciduous forests. North Andamans is characterised by the wet evergreen type, with plenty of woody climbers.

The natural vegetation of the Andamans is tropical forest, with mangroves on the coast. The rainforests are similar in composition to those of the west coast of Burma. Most of the forests are evergreen, but there are areas of deciduous forest on North Andaman, Middle Andaman, Baratang and parts of South Andaman Island. The South Andaman forests have a profuse growth of epiphytic vegetation, mostly ferns and orchids.

The Andaman forests are largely unspoiled, despite logging and the demands of the fast-growing population driven by immigration from the Indian mainland. There are protected areas on Little Andaman, Narcondam, North Andaman and South Andaman, but these are mainly aimed at preserving the coast and the marine wildlife rather than the rainforests.<sup>[36]</sup> Threats to wildlife come from introduced species including rats, dogs, cats and the elephants of Interview Island and North Andaman.

Scientists discovered a new species of green algae species in the Andaman archipelago, naming it *Acetabularia jalakanyakae*. "Jalakanyakae" is a Sanskrit word that means "mermaid".<sup>[37]</sup>

#### Timber

Andaman forests contain 200 or more timber producing species of trees, out of which about 30 varieties are considered to be commercial. Major commercial timber species are Gurjan (*Dipterocarpus* spp.) and Padauk (*Pterocarpus dalbergioides*). The following ornamental woods are noted for their pronounced grain formation:

- Marble wood (*Diospyros marmorata*)
- Padauk (*Pterocarpus dalbergioides*)
- Silver grey (a special formation of wood in white utkarsh)
- Chooi (*Sageraea elliptica*)
- Kokko (*Albizia lebbek*)



Padauk wood is sturdier than teak and is widely used for furniture making.

There are burr wood and buttress root formations in Andaman Padauk. The largest piece of buttress known from Andaman was a dining table of 13 ft × 7 ft (4.0 m × 2.1 m). The largest piece of burr wood was again a dining table for eight.

The Rudraksha (*Elaeocarpus sphaericus*) and aromatic Dhoop-resin trees also are found here.

### III. RESULTS

In botany and horticulture, deciduous plants, including trees, shrubs and herbaceous perennials, are those that lose all of their leaves for part of the year.<sup>[6]</sup> This process is called abscission.<sup>[7]</sup> In some cases leaf loss coincides with winter—namely in temperate or polar climates.<sup>[8]</sup> In other parts of the world, including tropical, subtropical, and arid regions, plants lose their leaves during the dry season or other seasons, depending on variations in rainfall.

The converse of deciduous is evergreen, where foliage is shed on a different schedule from deciduous plants, therefore appearing to remain green year round because not all the leaves are shed at the same time.<sup>[9]</sup> Plants that are intermediate may be called semi-deciduous; they lose old foliage as new growth begins.<sup>[10]</sup> Other plants are semi-evergreen and lose their leaves before the next growing season, retaining some during winter or dry periods.<sup>[11]</sup>

Many deciduous plants flower during the period when they are leafless, as this increases the effectiveness of pollination. The absence of leaves improves wind transmission of pollen for wind-pollinated plants and increases the visibility of the flowers to insects in insect-pollinated plants. This strategy is not without risks, as the flowers can be damaged by frost or, in dry season regions, result in water stress on the plant.

Spring leafout and fall leaf drop are triggered by a combination of daylight and air temperatures. The exact conditions required will vary with the species, but generally more cold-tolerant genera such as *Salix* will leave out earlier and lose their leaves later, while genera such as *Fraxinus* and *Juglans* can only grow in warm, frost-free conditions so they need at least 13 hours of daylight and air temperatures of around 70 °F (21 °C) to leaf out. They will be among the earliest trees to lose their leaves in fall. In sub-Arctic climates such as Alaska, leaves begin turning colors as early as August. However, for most temperate regions it takes place in late September through early November and in subtropical climates such as the southern US, it may be November into December.

Leaf drop or abscission involves complex physiological signals and changes within plants. When leafout is completed (marked by the transition from bright green spring leaves to dark green summer ones) the chlorophyll level in the leaves remains stable until cool temperatures arrive in autumn. When autumn arrives and the days are shorter or when plants are drought-stressed,<sup>[12]</sup> the chlorophyll steadily breaks down, allowing other pigments present in the leaf to become apparent and resulting in non-green colored foliage. The brightest leaf colors are produced when days grow short and nights are cool, but remain above freezing.<sup>[13]</sup> These other pigments include carotenoids that are yellow, brown, and orange. Anthocyanin pigments produce red and purple colors, though they are not always present in the leaves. Rather, they are produced in the foliage in late summer, when sugars are trapped in the leaves after the process of abscission begins. Parts of the world that have showy displays of bright autumn colors are limited to locations where days become short and nights are cool. The New England region of the United States and southeastern Canada tend to produce particularly good autumn colors for this reason, with Europe producing generally poorer colors due to the humid maritime climate and lower overall species diversity. It is also a factor that the continental United States and southern Canada are at a lower latitude than northern Europe, so the sun during the fall months is higher and stronger. This combination of strong sun and cool temperatures leads to more intense fall colors. The Southern United States also has poor fall colors due to warm temperatures during the fall months and the Western United States as it has more evergreen and fewer deciduous plants, combined with the West Coast and its maritime climate. Most of the Southern Hemisphere lacks deciduous plants due to its milder winters and smaller landmass, most of which is nearer the equator with only far southern South America and the south island of New Zealand producing distinct fall colors.

The beginnings of leaf drop starts when an abscission layer is formed between the leaf petiole and the stem. This layer is formed in the spring during active new growth of the leaf; it consists of layers of cells that can separate from each other. The cells are sensitive to a plant hormone called auxin that is produced by the leaf and other parts of the plant. When auxin coming from the leaf is produced at a rate consistent with that from the body of the plant, the cells of the abscission layer remain connected; in autumn, or when under stress, the auxin flow from the leaf decreases or stops, triggering cellular elongation within the abscission layer. The elongation of these cells break the connection between the different cell layers, allowing the leaf to break away from the plant. It also forms a layer that seals the break, so the plant does not lose sap.



Some trees, particularly oaks and beeches, exhibit a behavior known as "marcescence" whereby dead leaves are not shed in the fall and remain on the tree until being blown off by the weather. This is caused by incomplete development of the abscission layer. It is mainly seen in the seedling and sapling stage, although mature trees may have marcescence of leaves on the lower branches.

A number of deciduous plants remove nitrogen and carbon from the foliage before they are shed and store them in the form of proteins in the vacuoles of parenchyma cells in the roots and the inner bark. In the spring, these proteins are used as a nitrogen source during the growth of new leaves or flowers.<sup>[14]</sup>

Conifers are a group of cone-bearing seed plants, a subset of gymnosperms. Scientifically, they make up the division Pinophyta also known as Coniferophyta or Coniferae. The division contains a single extant class, Pinopsida. All extant conifers are perennial woody plants with secondary growth<sup>[a]</sup>. The great majority are trees, though a few are shrubs. Examples include cedars, Douglas-firs, cypresses, firs, junipers, kauri, larches, pines, hemlocks, redwoods, spruces, and yews.<sup>[1]</sup> The division Pinophyta contains seven families, 60 to 65 genera, and more than 600 living species.<sup>[2]:205[3]</sup>

Although the total number of species is relatively small, conifers are ecologically important. They are the dominant plants over large areas of land, most notably the taiga of the Northern Hemisphere,<sup>[1]</sup> but also in similar cool climates in mountains further south. Boreal conifers have many wintertime adaptations. The narrow conical shape of northern conifers, and their downward-drooping limbs, help them shed snow. Many of them seasonally alter their biochemistry to make them more resistant to freezing. While tropical rainforests have more biodiversity and turnover, the immense conifer forests of the world represent the largest terrestrial carbon sink. Conifers are of great economic value for softwood lumber and paper production.<sup>[1]</sup>

Deserts and xeric shrublands are a biome defined by the World Wide Fund for Nature.<sup>[1]</sup> Deserts and xeric (ancient Greek *xēros*, "dry") shrublands form the largest terrestrial biome, covering 19% of Earth's land surface area.<sup>[2]</sup> Ecoregions in this habitat type vary greatly in the amount of annual rainfall they receive, usually less than 250 millimetres (10 in) annually except in the margins. Generally evaporation exceeds rainfall in these ecoregions. Temperature variability is also diverse in these lands. Many deserts, such as the Sahara, are hot year-round, but others, such as East Asia's Gobi, become quite cold during the winter.<sup>[1]</sup>

Temperature extremes are a characteristic of most deserts. High daytime temperatures give way to cold nights because there is no insulation provided by humidity and cloud cover. The diversity of climatic conditions, though quite harsh, supports a rich array of habitats. Many of these habitats are ephemeral in nature, reflecting the paucity and seasonality of available water.<sup>[1]</sup> Woody-stemmed shrubs and plants characterize vegetation in these regions. Above all, these plants have evolved to minimize water loss. Animal biodiversity is equally well adapted and quite diverse.<sup>[1]</sup>

#### IV. CONCLUSIONS

Plants are grouped into floras based on region (floristic regions), period, special environment, or climate. Regions can be distinct habitats like mountain vs. flatland. Floras can mean plant life of a historic era as in fossil flora. Lastly, floras may be subdivided by special environments:

- Native flora. The native and indigenous flora of an area.
- Agricultural and horticultural flora (garden flora). The plants that are deliberately grown by humans.
- Weed flora. Traditionally this classification was applied to plants regarded as undesirable and studied in efforts to control or eradicate them. Today the designation is less often used as a classification of plant life since it includes three different types of plants: weedy species, invasive species (that may or may not be weedy), and native and introduced non-weedy species that are agriculturally undesirable. Many native plants previously considered weeds have been shown to be beneficial or even necessary to various ecosystems.

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