REVIEW OF LITERATURE

A) Introduction :

The word 'Forest' is derived from Latin word, 'foris' meaning, outside, the reference being to village boundary or fence, and must have included all uncultivated and uninhabited land. Forestry has been defined as the theory and practice of scientific management of forests, including their creation when necessary, for the continuous provision of produce and services. It is important for us to remember that from many points of view, animal life is completely dependent on the maintenance of the proper balance in inanimate life. Through the process of photosynthesis, through chlorophyll, the green leaf is able to prepare the ingredients which are the basis not only of its own metabolism, but of the nourishment of animate life. So far science has not been able to invent any physical, chemical or mechanical process which can compare with this wonderful process. On this process depend the continued fertility of the earth, the maintenance of climate with the correct balance of gases, particularly the oxygen and CO_2 cycles, in the atmosphere, plus the nourishment of animals and human.

The numerous measures taken recently in our country

for conservation of forests, control of population and education of our masses on these subjects are well known e.g.

a) Establishment of biosphere reserves, forest reserves, National Parks and wild life sanctuaries.
b) Control of population by family planning giving incentives by State and Central Government, and
c) Organising seminars, observing wild life preservation weeks, etc.

The large variety of economic plants such as, medicinal and aromatic plants, fibre and pulp yielding plants and other minor forest products of the region can largely contribute to economic amelioration of the peoples living in or near the forests. In the following pages, therefore, a brief account of such economically important plants is given :

1. Medicinal and aromatic plants :

a) There are a number of medicinal plants available in the forests of N.E. India. A few of these plants have a great demand in the market e.g. *Gaultheria fragrantissima*, *Solanum khasianum*, *Lycopodium clavatum*, *Coptis teeta*, *Rauvolfia serpentina*, *Dioscorea prazeri*, *Valeriana wallichii*, *Mahonia nepatensis*, *Berberis asiatica* and *Gynocardia odorata*.

The medicinal plant industry in our country is not very

organised at present, but considerable work is in hand at Botanical Survey of India, Central Council for Research in Indian medicine and Homoeopathy, Central Indian Medicinal Plant organisation and the Regional Research Laboratories.

There are number of other plants, important for edible and non-edible oils. Some of the edible oil yielding plants are Lindera neesiana, Diploknema butyracea and Rhus griffithii. The seeds are used by the local people for extraction, of oil. The food value and yield are to be estimated and analysed in the laboratory.

2. Fibre and pulp yielding plants :

Region of Assam, Kerala, Madhya Pradesh and that of Maharashtra are rich in bamboo forests or other pulp yielding plants.

3. Other minor forest products :

In addition to these forest products there are number of other commercially valuable products derived from forest vegetation. Wide variety of other products that come from forests are rubber, cocoa, and quinine. The bark of many tree species contains a number of commercially important products, including fibre, cork and extractives such as tannins, waxes, and substances with medicinal properties. Tannins are

obtained from wood, bark, leaves and fruits while dyes are obtained from wood, bark and leaves.

Different type of oils such as tung oil, wal-nut oil, turpentine oil, conifer leaf oil and eucalyptus oil are also obtained from a variety of plants. Number of fruits are used for various purposes e.g. pecans, pinyon or pine "Nuts". Vegetable fibres, match boxes, katth and cutch, lac and shellach are some of the other economically important products obtainable from forests. Sandlewood used for fragrant oil is known all over the world since ancient times.

B) Forest Types of the World (Brief Account) :

Forests are plant communities which have closed canopy of trees beneath which may be other smaller trees, shrubs and a ground layer of herbs. Forests are the climax vegetation over about 40% (4,500 million hectares or 11,115 million acres) of the world's land surface, although man has substantially altered them or entirely removed them from vast areas. Different types of forests are found in different climates and there are striking convergences in forest structure and general appearance between different continents, where the same type of forests occur, although composed of different species. Physiological causes such as response to water stress or mineral defficiency are also involved.

1. Tropical Rain Forest (formation-type Pluviilig nosa) :

In the tropics and sub-tropics, evergreen tropical rain forests occupy about 1000 million hectares (2,500 million acres) in the wettest climates. They occur in three great blocks centered around Amazonia, the Guineacongo region of Africa and the Malay Archipelago, the later extending from the Western Ghats of India to the west, high islands of the pacific. There is also an isolated small zone in eastern Madagascar and the Mascarenes. Tropical rain forests are the most complex and species rich communities in the world. They occur in the best conditions for plant life, with no dry or cold season to interrupt growth. The biggest trees average 30-45 m (100-150 ft) in height, although some reach 60 m (200 ft). The tallest trees commonly occur as isolated emergents standing head and shoulder's above a continuous canopy. Shrubs and herbs are rare. Climbers (lianas) and epiphytes are common in a great diversity of forms and species. Stranglers, which start life as epiphytes but then send down roots and ultimately engulf and kill the host tree, are prominent saprophytes and parasites occur, including in the eastern rain forests, Raffesia, which has the largest flowers in the world. Both flora and fauna are exceedingly rich. For example, the rain forests of the Malay peninsula have total flora of about 8,000 species of vascular plants including about 2,500 tree species, which is

some six to seven times greater than the flora of England and Wales of equal area.

The absence of any dry or cold season unfavourable for plant growth is believed to be an important contributory factor to floristic richness. Important also is the structural complexity of the rain forest, which provides numerous niches. Many botanists believe that it was in tropical rain forests that flowering plants evolved. Today, they certainly contain the greatest concentration of "primitive" groups. The richest and most complex forests occur on moderately moist sites. Southeast Asia is richer than Latin America. Africa is much poorer, for example as many species of palm are found on Singapore island as on the entire continent of Africa. Away from the optimum, the vegetation structure becomes simpler and there are fewer different species, for example swamps and on mountains one of the most strikingly distinctive low land rain forest types is so-called heath forest.found in South America and Kerangas of Borneo. Heath forest is of low stature, small leaved (microphyllous) and very dense, with a uniform canopy top of high albedo (reflectivity). Its physiognomy is believed to be an adaptation to water stress, and mineral deficiency. In the eastern tropics this structure and physiognomy is also found in upper montane rain forest and several similar species occur in both.

2. Dry (Seasonal) Tropical Forests :

As the rain fall drops below 2,000 mm (80 inches) and distinct dry season becomes increasingly prominent, tropical rain forests change to various kinds of seasonal forest. At first, although the species composition alters, the genera and families present remain much the same as in the tropical rain forest, and only the taller trees are deciduous. Leaf sheding and flowering become synchronized and correlated with climatic seasonality. These forests are of much simpler structure and with fewer woody species than in the rain forests, often only a few being dominant. Semi-ever green seasonal forest grades into deciduous seasonal forest (formation type Hiemiliansoa). In the strongly seasonal dry tropics, where the dry season is approximately five months, in the so called "Mansoon forests" of India and Burma for example, the sal (Shorea robusta) and teak (Tectona grandis) form major stands.

With lower annual rain fall (down to about 500 nm or 20 inches) and a dry season, extending to about seven months (four to five months virtually without rain), the tree cover becomes more open as the forests are gradually replaced by woodland, scrub or grassland. The savanna forest in these areas is characterized by the often deep rooting and the flattened crowns of numerous trees and shrubs. Many of the dominants also have small leaves and, except in Australia, are

thorny. In all climates with a marked dry season fire is an important factor controlling the structure and species composition of the vegetation.

In progressively drier climates, the total amount of moisture becomes more important than length of dry season. Soil factors interact, especially physical ones, consequently, these monsoon and savanna forests can form a mosaic pattern with more closed, moisture-loving (hygrophillous), prominently evergreen, so-called gallery forests, which occur along water course. Seasonally dry tropical forests are extensive in all three continents. The flora is rich, with many fire resistant herbs (including bulb-forming geophytes) and grasses in the drier and more open types. Such forests support on rich fauna including the spectracular big game of East Africa.

3. Sclorophyllous Forests (Formation-type Durilignosa) :

By no means, all climatic zones with an unfavourable growing season support deciduous forest. Evergreen forest may occur as well and this is seen, for example, in the zonal woodlands of mediterranean climates, in which the summers are hot and dry, and the winters warm and wet, due to cyclonic rain. Annual rain fall is 500-1,000 mm (20-40 inches) but irregular, and there are prolonged periods of low relative humidity. There is no really cold season and spring is the

main growing and flowering season. The mediterranean basin has been the centre of civilization from ancient times, and deforestation, cultivation, grazing and soil erosion have destroyed most of the original forests. The original zonal vegetation was a comparatively open, evergreen forest, dominated by a canopy of the holm oak (Quercus ilex). 15-18 m (50-60 ft) tall, often interspersed with the Aleppo pine (Pinus halepensis) for example, with shrubs and herbs beneath, where by a dense shrub vegetation called maquis which is very rich in species, including many geophytes. 'Maquis' is subject to fire and becomes degraded by excessive grazing and buring to open garigue. Many species are adapted to mediterranean climatic conditions by the possession of small, leathery sclerophyllous, evergreen leaves which minimize water loss during dry periods. Other species are deciduous in dry periods. Other common drought-resistant plants (xerophytes) in mediterranean area are the Malacophyllous plants. These differ from sclerophyllous by the absence of thick cell walls (so the leaves are not hard) and usually do not have such deep roots or a high heat resistance of the protoplasm; like sclerophyllus, they lose water slowly when the stomata are shut and hence are highly resistant to dessication, Cistus, Rosmarinus, Lavandula and Thymus are the examples.

Similar vegetation occur in central and southern

California, where the dominants again are evergreen oaks (e.g. Quercus engelmannii), often intermingled with Pinus sabiniana, for example. In the southern Hemisphere, Sclerophyll forests occur in Chile, where only remnants persist, the Cape of South Africa, where the flora is extremely rich, especially with members of the family Ericaceae and Southern and Western Australia, where the genus Eucalyptus and members of the families Epacridaceae and proteaceae predominate to give a distinctive appearance to the vegetation. The area occupied by dry seasonal sclerophyllous forests of all kinds is 1,400 million hectare (3,500 million acres).

4. Warm Temperate Evergreen Forests :

In many parts of the world, a progression from the tropics to higher latitudes is accompanied, not by the development of a hot, dry season, but by a cool winter, which results in a distinctive series of forest types. Warm temperate forests which total 100 million hectares (247 million acres) in area, are found mainly on the eastern sea boards of the continents, exposed to monsoon or trade winds, rainfall is plentiful 1,500-3,000 mm (60-120 inches) and well distributed throughout the year, In Southeast Asia, China, Korea and Southern Japan, Eastern Australia and Southern Brazil there is continuous gradation with increasing latitude from wet tropical to subtropical to warm temperate conditions. It is very difficult

to distinguish zones in these evergreen forests. They are rich in tree species, especially broad-leaved evergreens, which characterize the most widely recognised formation - type, warm temperate evergreen rain forest. Some conifers are often present and where they become important an evergreen mixed forest formation type can be recognized. Epiphytes and climbers are prominent, but less so than in the tropical rain forest, plank butterises are absent. Some trees are deciduous, giving marked seasonal differences in appearance. Leaf size decreases with latitude. Plants reproducing by spores (cryptogams) are abundant on the ground and on tree trunks. Bamboos are common in some types, as are tree-ferns. There are marked similarities with montane tropical rain forests in structure, physiognomy and families represented. The climate, however, has a marked annual rhythm, whereas the montane tropics have a greater diurnal than annual climatic range. The general appearance varies with different regions and there is a complete change in flora from low to high latitudes. In Australia, it has been shown that tropical communities extend farthest south on best soils and moistest sites.

The temperate rain forests are mainly dominated by species of Nothofagus, Ceratopetalum (coach wood) or Dryphora. In Northest Australia the conifers Agathi, bunya (Araucaria bidwilli) and the hoop pine (Araucaria canninghamii) become

prominent. Similar forests, dominated by a variety of broad-leaved evergreens, including species of Nothofagus, cover much of New Zealand the conifers, predominantly Dacrydium, Podocarpus and the famous Kauripine (Agathis australis), entering the canopy in the northern half of the south coast have suitably moist sites for this type of forest, here Podocarpus provides the coniferous component. In South America, the "Valdivian Rain Forest", largely found west of the Andes in central southern chile, is rich in broad-leaved evergreens including Laurelia, Drimys etc. with which coniferous communities dominated by Araucaria and Fitzroya are inter-mingled.

In North America, the Warm-temperate forests are relatively poorly developed because cold air masses move south as far as the Gulf of Mexico, but they are found near the coast from Louisiana, Florida and Georgia to North Carolina. The tree flora is rich, including evergreen oak (Quercus), a few palms, the evergreen Magnolia (M.grandiflora) and some climbers. Bald cypress (Taxodium distichum) swamps occur in wet areas and fire-climax pine (Pinus) forests are found on dry sands. In California, north of 36°, the coastal strip is moist from summer fogs which results from cool onshore ocean currents. Forest of the giant red wood (Sequoia sempervirens) occur. Further north on the same coast there are magnificant forests of western hemlock (Tsuga heterophylla), Western red Cedar

(Thuja plicata) and Douglas fir (Pseudosuga menziessii). Although broad-leaved trees are not prominent in these forests, they are usually considered to be temperate evergreen rain forests rather than boreal coniferous forests, which occur further north.

In Eurasia, temperate rain forest only occupies extensive areas in Southern Japan and Southern China, where numerous species of evergreen oaks (Quercus) and Magnolias abound, together with some admixture of pines. This type of vegetation occurs around the Black sea and includes the species-rich Tertiary-relict colchic forest (with Rhododendron, Laurus, Ilex, Quercus, etc.) of Transcaucasia, which lies in a region where the summers are mild and wet enough for tea cultivation to have replaced. Most of the zonal forest, it extends east wards as far as the shores of the Caspian Sea.

5. Summer Deciduous Forests (Formation-type Aestilignosa) :

These are perhaps the most intensively studied forests of all. Their total area is 800 million hectares (2,000 million acres). They formerly covered most of Western Europe and are still extensive in North America. They are virtually restricted to the Northern Hemisphere (apart from an area along the southern Andes and in Tierra del Fuego). Leaf fall is an adaption to the marked but not very prolonged cold season when water is unavailable or restricted (by contrast with the tropics where it is

an adaptation to drought). Annual rainfall is 700-1,500 mm (30-60 inches). Evergreen broad-leaved trees cannot resist cold or winter drought and in western Europe, ivy (Hedera helix) and holly (Ilex aquifolium) are both Atalantic species absent further east where winters are more severe Rhododendron and Vaccinium, also evergreen, by contrast, survive winter cold below a snow covering. These forests are found on the eastern of North America and Asia between the warm temperate forests and cold or arid temperate regions. In North America, they extend North to the Great Lakes and upper reaches of the Gulf of St.Lawrence, and west of the Mississippi. In Asia, they occur in northern Japan and on the adjacent part of the continent. They are also found on the western edge of Eurasia in Europe, north of the Mediterranean zone and where Gulf stream causes winter rains to be replaced by evenly distributed rain fall or rain with a summer maximum, and where the cold season is relatively short.

The temperate deciduous forest zone of western Europe is one of the most populous regions of the world because the climatic conditions also favour prosperous agriculture and grazing, and only tiny fragments of the forest remain, with virtually none in virgin condition. In England, for example, many woods are situated on the site of primeval forest, and there has been continuous forest cover since the last Ice Age.

However, their structure and relative abundance of different species are strongly influenced by many centuries of human interference. Floristically, the Western European forests are poorer than the others due to extinction in the pleistocene ice ages. Beech (Fagus), Oak(Quercus), lime (Tilia) and ash (Fraxinus) are locally dominant in the single tree layer. In wet places, alder (Alnus) and willow (Salix) become common. There is a single shrub layer in which hazel (Corylus), field maple (Acer) and hawthorn (Cratagus) are common, and a herb layer. There are few climbers and only cryptogamic epiphytes. The trees flower early, commonly before the leaves open, and most are wind-pollinated; this allows a long period for fruits to form and ripe before the onset of winter. The early spring temporal niche is succeeded by spring one, occupied by other herbs, e.g. wood sorrel (Oxalis), which flower at the time of leaf flush. In Asia and North America, there are more genera and species in both tree and shrub layers, including magnolias, numerous maples (Acer), tulip tree (Liriodendron), buckeye (Aesculus) and hickory (Carya), as well as temperate outliers of such tropical families as the staphyleaceae. The summer deciduous forests of southernmost south America, on the other hand, are dominated by only two Nothofagus species, N.pumilio and N.antarctica, which shed their leaves in winter.

6. Boreal Forest (Formation-type Aciculilignosa) :

The boreal, coniferous forest occurs to the north of temperate deciduous forest in regions with colder and longer winters, with which it is linked by a belt of mixed deciduous coniferous forest. It lies mainly between 45°N and 70°N and is very extensive (1,500 million hectares, 3,700 million acres). The main dominants are conifers with xeromorphic needle leaves, which are more resistant to winter cold and drought than broad-leaved trees, such trees can commence photosynthesis immediately after conditions permit in spring, so are better adapted to exploit regions where the growing season is short. To maintain growth, deciduous trees need about 120 days per year with a mean temperature over 10°C (50°F), while conifers can manage with 30 days, although there are differences between species. The narrow, conical, monopodial tree-form with droopping branches is adaptive to regions of high snow fall. These forests have only a poorly developed shrub and herb layer, shade is dense, decay of falling leaves is slow, so that undecomposed litter covers much of the surface, and the climate is worse. Spruces (Picea), firs (Abies), pines (Pinus) and larches (Larix) dominate in different places. The northern most forest in the world is in eastern Siberia at 70°N, 105°E. It is dominated by a larch, Larix gmelinii (L.dahurica), which is highly productive in the very short summer, and one of the few deciduous conifers, losing its needles each winter.

At its northern limit, the boreal forest merges into taiga, which is open park land having scattered groves of trees and a ground cover dominated by lichens and heath plants. Here, in addition to the conifers, various species of Betula (birch) may also be present. Proceeding northward, the trees become smaller and the woodland becomes more and more open, until finally taiga is replaced by open tundra. In the most northerly areas of taiga the only trees which can survive are larch and birch. Although heath species and lichens are the most abundant plants in the ground cover, mosses, sedges, dwarf willow (Salix) and dwarf birch are also fairly common. Lichens are an important constituent of the taiga, grazed upon by herds of reindeer; in fact, certain species of lichen are commonly known as reindeer mosses.

There is no comparable belt of coniferous forest in the southern Hemisphere, where indeed there is no land mass at the appropriate latitudes. On north temperate mountains, a coniferous forest zone commonly occurs above the deciduous broad-leaved forest, reaching upto the tree line.

C. Forest types in India :

The better defined and more stable units of forest vegetation are referred to as 'Forest Types'. They are distinguished in forestry mainly for the purpose of management and

therefore, the degree of sub-division depends on the intensity of treatment, a particular type has to receive, for purpose of it's regeneration and tending. In delimiting types, emphasis is laid on the most emergent vegetation namely the main tree layers and their important constituents from the economic view point. Thus the most complex variable wet tropical evergreen forest with luxuriant vegetation of big and small trees, shrubs, herbs, climbers, parasites, etc. of numerous species, which is not valuable, is referred to as a single type, on the other hand, the tropical deciduous forests though comparatively open and with but a few species have been distinguished into moist, semi-moist, dry arid, etc. types because the methods of regeneration and tending differ for each of these types of valuable forests. The main factors which define forest types are climatic edapic and biotic. Of climatic factors the most important are temperature, moisture and seasonal variation, provided adequate moisture is available, the temperature shows itself in the luxurient growth of the forest in height, density, variety of species and rate of growth. At higher elevation with increasing cold, winter deciduous species become more prevalent and further higher up vegetation degenerates into scrub with evergreen hard leaved species such as Rhododendrons. If moisture conditions are less favourable with higher temperature, the vegetation gets stunted, sparce and consists of a few species most of which

are summer deciduous and have other xerophytic adaptations such as small leaves, thick bark etc.

Champion and Seth (1963) have differentiated 16 climatic forest types, in India.

The general composition and distribution of the types are described below. The map (Fig.1) shows their distribution diagramatically.

1. Tropical Wet Evergreen Forests :

It is a lofty, very dense, multi layered forest with mesophytic evergreens, 45 m or more high with a large number of species, epiphytes numerous, climbers few found along the western face of the Western Ghats and in a strip running South West from upper Assam through Cachar, and in Andamans.

Ex. : i) Ranni, Kerala 1000 m.

Important spp. : Mesua, White cedar, Calophyllum, Toon, Dhup, Pakguium, Hopea, Jamun, Canes etc.

Ex. : ii) Cachar, Assam.

Important spp. : Gurjan, Chaplash, Jamun, Mesua, Agar Muli, Bamboo etc.

2. Tropical Semi Evergreen Forests :

It is a closed high forest, with large dominants, some deciduous, with the tendency to gregariousness, many species,

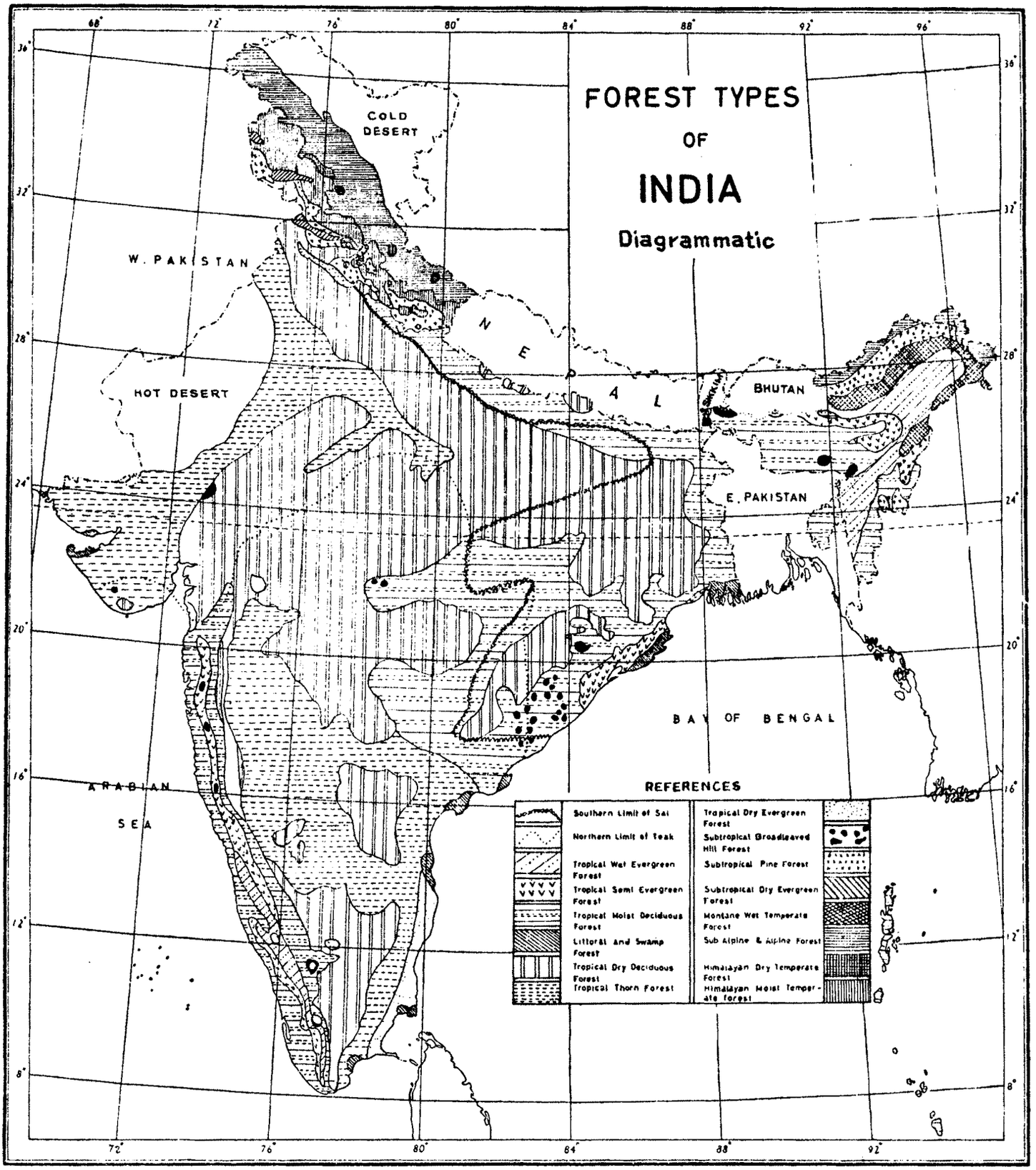
FOREST TYPES
OF
INDIA
Diagrammatic
COLD DESERT
W. PAKISTAN
HOT DESERT
NEPAL
BHUTAN
E. PAKISTAN
BAY OF BENGAL
ARABIAN SEA
REFERENCES
Southern Limit of Sal
Northern Limit of Teak
Tropical Wet Evergreen Forest
Tropical Semi Evergreen Forest
Tropical Moist Deciduous Forest
Littoral And Swamp Forest
Tropical Dry Deciduous Forest
Tropical Thorn Forest
Tropical Dry Evergreen Forest
Subtropical Broadleaved Hill Forest
Subtropical Pine Forest
Subtropical Dry Evergreen Forest
Montane Wet Temperate Forest
Sub Alpine & Alpine Forest
Himalayan Dry Temperate Forest
Himalayan Moist Temperate forest

Fig. 1

buttressed trunks frequent, bark thicker and rougher and canopy less dense than in previous type, climbers heavy, bamboos less prevalent, epiphytes abundant occurs in the western coast, Assam, lower slopes of Eastern Himalayas, Orissa and in Andamans.

Ex. : i) Palghat, Kerala

Important spp. : Aini, Semul, Gutel, Mundani, Hopea, Benteak, Kadam, Irul, Laurel, Rosewood, Mesua, Thorny, Bamboo etc.

Ex. : ii) Kalimpong, W.Bengal

Important spp. : Bonsum, White cedar, Indian chestnut, Litsea Mango, Champa etc.

3. Tropical Moist Deciduous Forests :

It has irregular top storey of predominantly deciduous species 40 m or more high heavily buttressed trees, definite second storey of many species with some evergreens, fairly complete shrubby under growth with patches of bamboos, climbers, heavy including canes, Occurs throughout Andamans, Moister part of U.P., M.P., Gujarat, Maharashtra, Mysore and Kerala.

Ex. : i) Andamans.

Important spp. : Padauk, White chuglam, Badam, Dhup, Chikrasi, Kokko.

Ex. : ii) Allapalli, Maharashtra.

Important spp. : Teak, Laurel, Irul, Dhaman, Rosewood, Amla, Kusum, Garari common bamboo etc.

Ex. : iii) Dehra Dun, Uttar Pradesh.

Important spp. : Sal, Lendi, Haldu, Jamun, Mahul, Litsea, etc.

4. Littoral and Swamp Forest :

It is mainly of evergreen species of varying density and height, always associated with wetness, littoral forests are found all along the coast and the swamp forests in the deltas of bigger rivers.

Ex. : Sunderbans, West Bengal.

Important spp. : Sundri, Bruguiera, Sonneratia, Agar, Bhendi, Keora, Nipa etc.

5. Tropical Dry Deciduous Forest :

This type of forest has upper canopy closed though rather uneven, composed of a mixture of a few species practically all deciduous during the dry season, some for several months, upto 20 m. high, some species tend to predominate over selected areas but most non-gregarious, lower canopy almost entirely deciduous, shrub present but enough light reaches the forest floor to permit growth of grass, bamboos present unless exterminated by over cutting but not luxuriant, climbers few but some

large and woody, epiphytes and ferns inconspicuous, occurs in an irregular wide strip running NS from the foot of the Himalayas to cape comorin except in Rajasthan, Western Ghats and Bengal.

Ex. : Betul, Madhya Pradesh.

Important spp. : Teak, Axlewood, Tendu, Bijasal, Rosewood, Amaltas, Haldu, Kasi, Bel, Common-bamboo etc.

Ex. : ii) Cuddapah, Andhra Pradesh -

Important spp. : Red sanders, Axlewood, Anjan, Harra, Stainwood, Papra, Achar etc.

Ex. : iii) Ramnagar, Uttar Pradesh.

Important spp. : Sal, Axelwood, Achar, Khair, Ghont Bel etc.

6. <u>Tropical Thorn Forest</u> :

It is an open, low, pronouncedly exerophytic forest, Thorney leguminous species predominate, trees with short boles and low branches, an ill-defined lower storey of smaller trees and shrubs, spiny and with xerophytic characteristics, climbers few. This type grows in a large strip in South Panjab, Rajasthan, Upper Gangetic plains, the Deccan Plateau and the lower peninsular India.

Ex. : i) Solapur, Maharashtra.

Important spp. : Khair, Reunjha, Axlewood, Neem, Sandlewood, Nirmali, Dhaman etc.

Ex. : ii) Jaipur, Rajasthan.

Important spp. : Acacia senegal, Reunjha, Khejra, Kanjur, Neem, Palas, Ak, etc.

7. Tropical Dry Evergreen Forest :

It is a low forest, upto 12 m high with complete canopy, mostly of coriaceous leaved evergreen trees of short bloes, no canopy layer differentiation, bamboos rare or absent, grass not conspicuous is restricted to a small area of Karnatak Coast which receives some summer rain also.

Ex. : Sriharikota, Andhra Pradesh

Important spp. : Khirni, Jamun, Kokko, Ritha, Tamarind, Neem, Machkund, Toddy palm, Gamari, Canes etc.

8. Sub-Tropical Broad leaved Hill Forest :

It is a lusuriant forest, evergreen species predominating, limited to the lower slopes of Himalayas in Bengal and Assam and other hill ranges such as Khasi, Nilgiri and Mahabaleshwar.

Ex. : Trivandrum, Kerala.

Important spp. : Jamun, Machilus, Meliosma, Elaeocarpus, Celtis, etc.

9. Sub-Tropical Pine Forest :

It is practically a pure association of chirpine, considerably influenced by periodical fires, no underwood, few shrubs.

It is found throughout the whole length of North West Himalayas between 1000-1800 m. It is absent in Kashmir due to weakened South West Monsoon. In Khasi, Manipur and Naga Hills khasya pine occurs at similar altitudes.

Ex. : Maharpali, Uttar Pradesh.

Important spp. : Chir, Jamun, Oak, Rhododendron etc.

10. Sub-Tropical Dry Evergreen Forest :

It is a low, practically scrub forest having small evergreen stunted trees and shrubs including thorny species, herbs and grasses appear in monsoon. It is met with in the Bhabar, the Siwaliks and Western Himalayas upto about 1000 m.

Important spp. : Olive, Acacia modesta, Pistacia etc.

11. Montane Wet Temperate Forest :

It is a closed evergreen forest. Trees mostly short-boled and branchy attaining large girth, height rarely 6 m; crowns dense and rounded leaves coriaceous, red when young, branches clothed with mosses, ferns and other epiphytes, woody climbers common. It is found in the higher hills of Madras and Kerala from 150 m upwards and in Eastern Himalayas on the higher hills of Bengal, Assam and NEFA from 1800 to 3000.

Ex. : Kalimpong, West Bengal.

Important spp. : Machilus, Cinnamomum, Litsea, Magnolia, Chilauni chestunut, Birch etc.

12. Himalayan Moist Temperate Forest :

It is a coniferous forest, mostly pure, 30 to 50 m high with varying under wood mostly evergreen, mosses and ferns grow freely on trees. It extends along the entire length of the Himalayas between the pine and the alpine forests in Kashmir, Himachal Pradesh, Punjab, U.P., Darjeeling and Sikkim between 1500 to 3300 m.

Ex. : i) Chakrata, Uttar Pradesh

Important spp. : Oak, Fir, Sprue, Deodar, Cletis, Chestnut, Maple etc.

Ex. : ii) Sutlej valley, Himachal Pradesh.

Important spp. : Spruce, Deodar, Fir, Kail, Oak, Yew, Maple, Birch etc.

13. Himalayan Dry Temperate Forest :

It is predominantly coniferous forest with xerophytic shrubs, hardly epiphytes and climbers. It is found in the inner ranges of the Himalayas where South West Monsoon is very feeble, precipitation below 100 mm. mostly snow; in Ladakh Lahoul, Chamba, Bashahr, Garhwal and Sikkim.

Ex. : U.Bashahr, Himachal Pradesh.

Important spp. : Chilgoza, Deodar, Oak, Maple, Ash, Geltis, Parrotia, Olive etc.

14. Sub-Alpine Forest :

It has a dense growth of small crooked trees or large shrubs with coniferous overwood, mostly fir and birch, conifers 30 m. high, broad leaved trees 10 m. high. It occurs at the upper limit of tree forest in the Himalayas adjoining alpine scrub and grasslands.

Ex. : Kulu, Punjab.

Important spp. : Fir, Kail, Spruce, Rhododendron, Plum, Yew etc.

15. Moist Alpine Scrub :

It shows a low evergreen dense growth of Rhododendron and Birch. Mosses and ferns are on the ground with alpine shrubs and flowering herbs. It occurs along the entire length of the Himalayas above 3000 m.

Ex. : Kumaun, Uttar Pradesh 3000 m.

Important spp. : Birch, Rhododendron, Berberis, Honey, Suckle, etc.

16. Dry Alpine Scrub :

It has the upper most limit of Xerophytic scrub with dwarf shrubs, over about 3,500 meters.

Ex. : High Himalayas over 4000 m.

Important spp. : Juniper, Artemesia, Potentilla etc.

D) Forestry in India :

In any rational land use plan for a country, forests have an important place. They perform a number of functions including ecological, recreational and economic (as discussed at the beginning). Therefore, in a country like India, forests are expected to play different roles in varied climatic and topographical zones.

1. Area under Forests :

Out of a total of 326,809 thousand hectares of geographical area in India, forests cover 75,351 thousand hectares, just a 23 percent of the total. While the norm for forests varies according to the terrian, 33 per cent is recommended by 1951 Forest Policy Resolution for the country as a whole. The suggested norm for hill areas is 60 per cent and for plains 20 per cent. The statewise distribution of existing forest area is shown in (Fig.2).

It is seen that a little less than one-forth of the country's forest area is in Madhya Pradesh. Next at distance are Andhra Pradesh, Maharashtra and Uttar Pradesh with about 10, 9 and 6.4 percent respectively. The shares of Jammu and Kashmir and Kerala, which otherwise grow better species, are 4.5 and 1.8 percent respectively. The optimum percentage of area under forests in each of the states has been worked out.

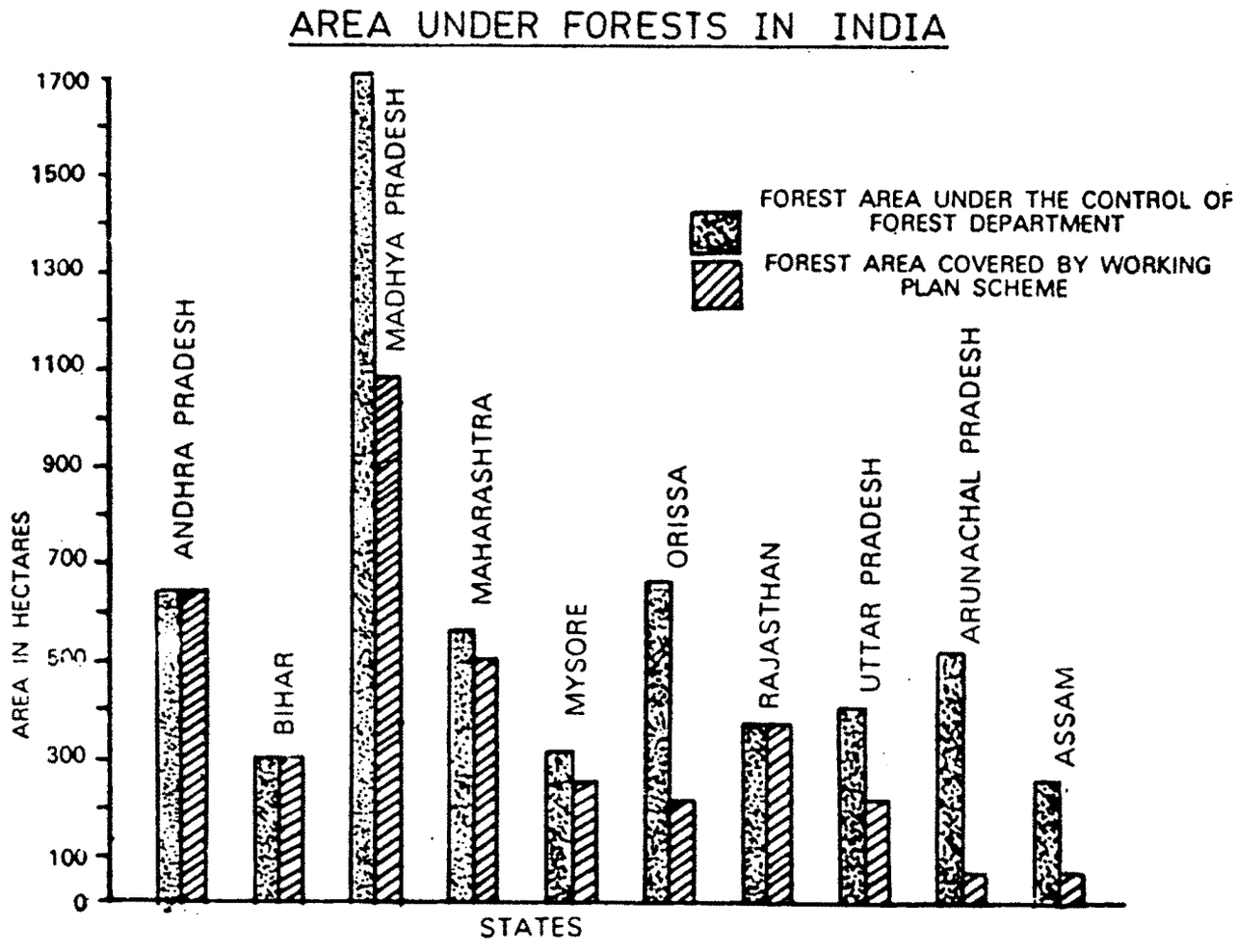
AREA UNDER FORESTS IN INDIA
AREA IN HECTARES
1700
1500
1300
1100
900
700
500
300
100
0
ANDHRA PRADESH
BIHAR
MADHYA PRADESH
MAHARASHTRA
MYSORE
ORISSA
RAJASTHAN
UTTAR PRADESH
ARUNACHAL PRADESH
ASSAM
FOREST AREA UNDER THE CONTROL OF FOREST DEPARTMENT
FOREST AREA COVERED BY WORKING PLAN SCHEME
STATES

Fig. 2

In India, coniferous species cover 3,765 thousand hectares and the remaining area is stocked with broad-leaved species. By economic accessibility, the currently exploitable area is 63-64 percent, and as it was expected, it might rise to 84 per cent by the end of the sixth five year plan.

Madhya Pradesh has the maximum area (3119 thousand hectares) under teak, followed by Maharashtra (1404 thousand hectares), Gujarath (1176 thousand hectares) and Karnataka (1000 thousand hectares). These four states account for about 92 per cent of the area under teak in the country. Sal is predominantly found in Madhya Pradesh and Bihar. These two states account for 80 percent of the total area under sal. Conifers grow largely in higher altitudes of Himachal Pradesh, Jammu and Kashmir and Uttar Pradesh. Another important species spread out in the length and breadth of the country with heavy concentrations in Assam, Tripura, Maharashtra, Madhya Pradesh, Karnataka and Orissa are mostly bamboos, some sabai grass and small quantities of conifers. Bamboos occur in untrapped forests. Such forests should be opened up. Similarly, coniferous wood available in the Himalayas should be exploited by the introduction of improved method of logging and extraction.

2. <u>Value of Forest Produce</u> :

The income from India's forest land, when contrasted

with that in some other countries of the world is dismally low. But it has a regional factor as well. In 1970-71 in terms of value of forest produce, the share of Madhya Pradesh is the highest at about 14.7 per cent of the total of the country. Andhra Pradesh with about 13 per cent comes next and Jammu and Kashmir with 12.3 per cent is third. Among the remaining states, forests play a significant role in the state economics of Maharashtra, Karnataka, Uttar Pradesh and Himachal Pradesh. About 79 per cent of the value of forest produce in the country comes from major forest produce, and the remaining from minor produce. The five states, Madhya Pradesh, Jammu and Kashmir, Himachal Pradesh, Andhra Pradesh and Uttar Pradesh contributed as much as 64 per cent of the total value of forest produce in the country, suggesting the present and potential role of forests and forest based industries in these areas. Compaired to major produce, minor produce was relatively dispersed. Madhya Pradesh heads the list with 22.8 per cent of the total value. Next comes Karnataka with about 15 per cent and Maharashtra stands third with 12 per cent.

3. Man-made Forests :

Man-made forests comprise just about 2 per cent of the total forest area in the country, and those are a good deal concentrated in southern and south-eastern states of Karnataka and Tamil Nadu. The main species grown are teak and eucalyptus.

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Bamboo and sissoo plantations have been taken up largely in the northern region, the important states in this respect being Uttar Pradesh and Bihar.

4. Government Policy (Ministry of Forestry) :

Interestingly, India which has one of the best Forest Research Institutes in the tropical countries, has not given adequate attention to the economic aspects of the forestry. Independent India announced its Forest Policy statement in 1952, but even afterwards there has not been a proper socio-economic perspectives for forest development. Currently the country faces a virtual pulp paper and newsprint famine.

a) The First Five Year Plan :

The first Five Year Plan (1951-56) showed maximum concern about rehabilitation of the forest area, which had been over-exploited either to meet the second world war needs, or unintelligently destroyed by the quiting zamindars at the time of abolition of the zamindari system. Little effort was made to help stabilise soil in highly eroded areas through aforestation. In response to the forest policy of 1952, the 'Vana Mahotsava' was inaugurated to create enthusiasm in the popular mind for the preservation of forests and planting of new trees. The central Board of Forestry was asked to indicate the proportion of area that ought to be

under forests, and that after taking note of the nature of terrain and the principle of proper land use in states. Man-made forests were raised over an area of about 50,000 hectares.

b) The Second Five Year Plan :

In the second (1956-61) and third plan (1961-66) the programmes of consolidation of areas under forests were continued. Additionally, construction of forest roads and economic plantations received more emphasis. To improve the quality of forest products, plantations of industrially and commercially valuable species were undertaken. New plantations of match wood and industrial timber were undertaken over an area of 164,000 hectares.

c) The Third Five Year Plan :

The target for new plantations was fixed at an all time high figures of 280,000 hectares. To avoid wastages, better techniques of timber extraction and of proper seasoning and preservation treatment were recommended. The Central Government provided cent per cent assistance for raising plantations under 'quick growing species' which were intended primarily to meet the needs of pulp and paper mills.

d) The Fourth Five Year Plan :

The physical targets of the fourth plan (1969-74) were

(1) Planting of quick growing species covering 2.87 lakh hectares, (2) Planting of economic species like teak, semal and sissoo over 3.39 lakh hectares and (3) developing plantations over 2 lakh hectares under the scheme of rehabilitation of degraded forests. It was also proposed to take up waste lands continuous to the forests in large blocks of 20 hectares and above for fuel wood plantations.

Even by the end of the fourth plan, the man made forests might have not covered even 2 percent of the forest area in India. In contrast, the proportion of man-made forests in England was then 100 per cent, and in Japan 40 per cent.

e) The Fifth Five Year Plan :

The primary objective of the Fifth Plan (1974-79) was to initiate measure for increasing production of industrial wood. In this connection, it was intended to the limited experience of institutional financing gathered during the Fourth plan and to have a shef of projects for various states. The second important objective was to develop the much needed farm forestry and improvement of degraded forests to increase the fuel and timber supply in the rural areas. The need for data base with respect to forests had been pointedly stressed, and a large scale project had already been formulated in the states of Uttar Pradesh, Maharashtra and Madhya Pradesh. These

projects were extended to other states, namely Bihar, West Bengal, Kerala, Karnataka, Meghalaya, Andaman and Nicobar Islands etc. and two world Bank teams recently visited the country examining some of these projects. It was believed that only such projects can give spur to man-made forests, and it is only through them that one can economically justify massive investiments in clear felling plantations and tending of forest produce.

In India, specially forest area, growing stocks, increment and potentail increment, present, cut and wood availability in the country by main species. The plan has discussed the present pattern of utilisation of timber and forest based industries, particularly paper, news print, rayon pulp, wood panel products and various minor forest products. The projections of demand for forest products by 1985 were considered, along with the likely gap, which was expected and the methods of meeting the same.

Detailed cost-benefit studies were suggested, as also the project formulations in the forestry sector. The creation of large scale man-made forests was proposed to increase the forest productivity.

f) <u>The Sixth Five Year Plan</u> :

According to the Sixth Plan (1980-85), forest policy

has to fulfil three sets of needs : Ecological security; Fuel, fodder and other domestic needs of the population; and the needs of village, small-scale and large-scale industries. In conformity with the objectives, the major area of thrust was on the promotion of a peoples forestry movement. An important aspect, which was stated, requires a closer attention in the coming years on employment generation through forestry activities.

The sixth plan also laid special emphasis on interdependence of tribal economy and forest development. The primary emphasis was on maintaining a proper environmental balance and the conservation of natural resources, specially on the conservation of gene resources. Revenue hunting was not the object, considering the vital value of forests for environmental conservation. Social forestry programmes comprising of mixed plantations on waste-lands, and reforestation of degraded forests and raising of shelter-belts were envisaged. A new centrally sponsored scheme of social forestry including rural fuel wood plantations and farm forestry had been introduced in 100 selected districts. An important part of strategy was to grow fuel wood as near as possible to the consumption points. Another object was that the entire contractor agency should be eliminated from forest working in all the states during the sixth plan period. The pre-investment

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survey of Forest Resources was converted into a fuel-fledged forest survey of India. People's participation in forestry was the special aim, besides programmes for tree for every child, creation of an eco-development force specially for the West Himalayan Region and agro-forestry programmes.

The sixth plan also said that the large scale deforestation in recent decades has rendered the sensitive catchment areas in the Himalayas and other hills, particularly vulnerable to soil erosion. It goes on to say that no more than about 12 per cent of the country's land surface is actually under adequate tree cover, as against the target of 33 per cent prescribed by the National Forest Policy of 1952. The programmes were modest until the fourth plan. But during the Fifth Plan period and subsequently there was a substantial increase in the rate of planting. It was seen that the average expenditure per hectare of plantation was about Rs.100 per ha. in the First Plan which rose to about Rs.2000 per ha. during 1979-80. This was due, apart from the rising cost of labour and material, to the adoption of more standard techniques including better protective measures.

The New 20 Point Programme :

A significant step forward in forestry was the inclusion of afforestation and forestry including farm forestry in the new 20 point Economic Programme of the Prime Minister.

Item 12 of the programme lays down that afforestation and forestry including farm forestry will be vigorously pursued. This step has boosted the planting programme. A hitherto some what neglected subject is beginning to get attention and its importance in nation building is recognised. For proper targeting and monitoring at the National level it is necessary to know precisely what each of the items of the programme includes.

I) Afforestation means the total number of tree seedlings of forest or horticultural importance, planted by government departments or individuals or institutions, in government community or private land, raised under any scheme.

II) Social Forestry includes plantations raised in community lands, wastelands, marginal lands, roadsides, canal sides and railway sides and also the plantations raised on degraded forests near habitations. It is expressed as area planted in hectares.

III) Farm forestry includes the seedlings planted by farmers and others in and around their fields, compounds etc. The number of seedlings distributed to public through government agencies or from private nurseries is the index of this item.

In pursuance of the inclusion of these items in the programme, definite targets were fixed during 1982-83 and

1983-84. The progress of planting and survivals was monitored by adopting a suitable reporting system and field checking mechanism. During 1982-83 the targets were exceeded in all the three items. The targets for 1983-84 were set at nearly 20 percent above those of 1982-83, which according to government statistics, have been exceeded. It is clear that the inclusion of the items in the 20 Point Programme has given them much needed boost.

In forest plantation, planning has to be done at least a year in advance, as plants have to be raised in nurseries and digging of pits has to be done months ahead of the planting season to allow the soil to weather properly. The targets for 1984-85 have also, therefore, been worked out.

The country targets set out are :

I)	Afforestation	:	25 crore seedlings,
II)	Social Forestry	:	450 lakh ha. to be planted.
III)	Farm Forestry	:	12,000 lakh seedlings to be supplied to the public.

The National Remote Sensing Agency (NRSA) did mapping of forest cover of India through visual interpretation of Satellite Imagery (Land Sat NSS) for the period 1972-75 and 1980-82 on 1:1 million scale. The study led to the conclusion that the forest cover in the country had gone down from 16.89%

(of the total geographical area) during 1972-75 to 14.10% during 1980-82. The Forest Survey of India (FSI) also carried out a similar study for the period 1982-83 and concluded that the extent of forest cover was 19.7% as against 14.10%, worked out by the NRSA. Leaving aside the wide discrepancy in the two figures, it is quite certain that the area under forests is diminishing day by day inspite of the advancement in the number of five year plans. This certainly is a serious matter as far as the welfare of human is considered. Thus, it can be said that a day has come to think over the problem quite seriously. With this view in mind we must put all our efforts in Indian forestry. It is necessary now to undertake various studies in forestry to understand the problems and difficulties encountered in successful forestry.

To study the behaviour of various forest trees, it is highly essential to understand the natural pattern of their growth and development. To tackle this aspect one should undertake the studies to understand the physiology of these plants. With this view in mind the present studies have been undertaken.

E) <u>Silviculture</u> :

Without going into technical hair-splitting, it may be said that where as silvics deals with the theory of the growth

of forests, silviculture is the practice of growing forest crops in a desired pattern namely the methods of regenerating and tending it.

1. Natural Regeneration :

To secure natural regeneration of the desired species at the proper time, it is necessary to study the ecological conditions obtaining on the forest floor and to alter them to such an extent that regeneration is induced and then it survives and gets established. The manner in which natural regeneration of important species is obtained is briefly described below.

In the moist teak forests, which contain a large number of other mesophilous species in the upper canopy, a dense lower storey, as also a thick cover of grasses and shrubs, natural regeneration of teak does not come up. The same is the case with very dry, almost pure stands of teak. Here the soil is practically devoid of humus due to annual fires, it has also become very hard due to unrestricted grazing and tamping by live stock. By careful manipulation of canopy over a series of years viz., by opening it up in the moist and closing it in the dry forests, suitable conditions can be brought about, after which fallen teak seed germinates naturally. The semi-moist forests of Betulin Madhya Pradesh are being regenerated

in this way.

In Uttar Pradesh, after experiments extending over a series of years, an elaborate technique has been evolved to induce natural regeneration of sal. It consists of fencing the area to keep out deer and domestic animals and then making 'pepper-pot' openings in the cannopy. The forest is also fire protected and shrub cutting is carried out to free individual sal seedlings that come up. After a number of years a full crop of seedlings is obtained. After this the canopy is gradually removed so that the seedlings grow to a size when they cannot be killed back by forest. On the whole, this is a very long and expensive process. Perhaps it would be better to obtain artificial regeneration by the Taungya method or else to plant another species which is more valuable and fast growing.

In the Deodar forests of Manali in Punjab, regeneration is being obtained under the shelter-wood compartment system on the Shankaracharya Hill in Srinagar where Deodar was introduced artificially, it is now regenerating naturally.

2. <u>Artificial Regeneration</u> :

When a forest is under-stocked, or contains many malformed trees of several species only a few of which are utilisable timber and these are slow growing, or when on clear felling the existing growth, a new crop of the desired species

does not come up naturally, the forest is regenerated artificially. Some times seed of valuable species is broad cast in the the forest if there is a reasonable chance of its germination and the seedling getting established. In Madhya Pradesh in certain mixed forests of inferior species, teak seed was broad cast or dibbed at regular intervals before the monsoon. After a few years some teak plants were noticed. When these grew up and seeded, the proportion of teak steadily increased. Today teak is the predominant species and is naturally regenerating in these forests. In certain forests in Maharashtra teak is introduced by sowing or planting it in patches called rabs, after the fallen debris is burnt and the ashes are spread uniformly. Proportion of desirable species can also be successfully increased by under planting. Bamboos have thus been introduced in certain forests.

Teak seed from genetically superior mother trees is collected and sown on nursery beds about March. If the seed is abdurate as in the dry teak forest, where it has a hard seed coat, it is pre-treated by alternate drying and wetting after which it readily germinates on sowing. When the seedlings have developed two leaves, they are picked out on transplant bed, 7.5 cm x 7.5 cm, side shaded, watered and weeded regularly.

In Kashmir, plantations are being raised of Deodar,

Willow, etc. In Himachal pradesh attempts are being made to create plantations of silver fir. The latest development is the creation of large scale plantations of Eucalyptus tereticornis from Mysore which has been found to be very fast growing and which succeeds in a variety of climates from sea coast to an elevation of 2500 m. and in places with rain fall ranging from 750 mm to 3500 mm. Large plantations have been created in Mysore, Kerala, Uttar Pradesh, etc.

The main advantages claimed for artificial regeneration are quicker and surer results, more uniform and adequate stocking certainly of regulating the composition of the crop, concentration of work, rapid early growth and better returns on outlay. On the other hand it temporarily expose the soil, is more expensive, and requires a larger labour force. Ordinarily, natural regeneration is preferred when it can be obtained with reasonable expendition certaintly and cost. Only when this is not possible or change of species is considered desirable, artificial regeneration is restored to. The choice of species for artificial regeneration depends on its site suitability and the object of management.

3. Thinning :

After a forest has been regenerated, the principle tree species and other vegetation begin to compete for growing space and a struggle for existence sets in tending the species

proposed to be grown, thus becomes necessary. This consists of hygienic operations, such as weeding, cleaning and climber cutting as distinct from site ameliorative operations such as soil working, trenching, manuring, burning etc.

When plants of the principle species reach the sapling stage, competition intersets in, and fellings are needed to reduce congestion. The best stems are retained and given the optimum freedom for development. This operation is called thinning.

4. Silvicultural System :

Prof. Troup (1921), the doyen of Indian silviculturists, defined this as a system of forest management applied with due consideration for the silvicultural requirements of the species and aiming at the attainment of the normal forest and the establishment of regeneration to the normal extent. The regeneration may be natural, that is, from seedlings or from coppice or may have been obtained artificially by planting. The silvicultural system adopted depends on the requirements of the species, the intensity of demand and the development of communications. Forests in remote areas containing many species, only a few of which in large sizes can be economically extracted are worked under what is called the 'Selection System'.

In certain cases, it is considered desirable to work

the forest to produce both, fuel wood which is best grown as coppice, and some timber and poles. Such forests are worked under a system called the coppice with 'Standards System'. Under this system, species utilisable only a fuel or as stakes are worked on a short rotation. Mixed deciduous forests of M.P. vary greatly in quality, composition, size and density. Only a few species are utilisable as timber, some only as poles and others as fuel. Certain species yield economic products such as fruit, tanning material, etc. for instance Mahua, Mango, Amaltus, etc. certain trees are needed for protecting soil or preventing forest damage to young crops. Similarly, the well grown pipal and banyan trees are retained to provide shelter and food to birds. In such forests the classical system of CWS in which the standards are only of timber species and occur uniformly distributed, the forests are better stocked with well-formed trees and more, the site quality has also improved.

F) Physiological Studies in Tree Sepcies :

Growth of a tree begins with germination of its most important, propogule, the seed. However, the chance that an individual seed will actually become a mature tree is very slim indeed. The stage of greatest mortality risk are those of the ungerminated embryo in the seed and of recently germinated seedlings. Under natural conditions remarkable

high losses of seeds are traceble to lack of seed viability, seed dormancy, and injury or consumption of seed by fungi, insects and various higher animals. But if a seed should germinate the plant is subjected throughout its existence to possible attacks by various organisms and to environmental stresses. Many trees which survive the dangerous seed germination and seedling development stages also fail to reach maturity because of increasing competition among plants.

A mature woody plant consists of vegetative (leaves, stems and roots) and reproductive organs (flowers, fruits and seeds). A woody plant like all other multicellular organisms, grows by accumulating new cells. Whereas meristematic cells remain alive and functional throughout the life of a perennial woody plant, most of its other cells have a relatively brief life span. Many living tissues such as leaves, flowers, fruits and young roots are shed periodically and other persistent tissue eventually die. Hence, a massive old tree consists of an accumulation of dead cells numbering in the billions, and a very small percentage of living cells which carry on its vital metabolic activities.

Like higher plants in general, fruit trees, have a specific requirement for sixteen nutrient elements, but all plants do not require these elements in the same amounts, at the same stage of growth, or in the same ratios. The tree

is very different from the annual plant in that it contains large reserves of the plant nutrients.

Assuming normal temperatures and water and oxygen tensions in the soil, nutrient uptake is related in general to nutrient supply but, under similar conditions, nutrient uptake by trees may be modified considerably by the type of root stock. In apple, root stock effects are most marked on the cations calcium, magnesium and potassium (Avent, 1957; Whitfield, 1963).

The essential mineral elements classified as macro-nutrients usually are required in available amounts exceeding 1 ppm. Whereas micro-nutrients are needed in very much smaller amounts, often less than 1 ppm. The macronutrients include nitrogen, phosphorus, potassium, calcium, magnesium and sulfur. Important micronutrients are boron, iron, manganese, zinc, copper, molybdenum and chlorine. Mineral elements have several important physiological functions in plants. They serve as -

i) constituents of plant tissues (e.g. calcium in cell walls, nitrogen and sulfur in proteins, magnesium in chlorophyll),

ii) catalysts (e.g. iron, manganese, copper and zinc as activators of enzymes),

iii) buffers (e.g. Phosphate buffer system),

iv) controllers of permeability (monovalent ions increase permeability of cell membranes and calcium and other divalent ions decrease permeability),

v) osmotic regulators,

vi) antagonists (one element can reverse the action of another one),

vii) toxic agents (aluminium and mercury are toxic and some essential micronutrients are toxic if present in more quantities).

1. Macronutrients :

a) Nitrogen :

This element is an important constituent of proteins and of the chlorophyll molecule. It also occurs in purines, alkaloids, and vitamins. Demands for nitrogen by trees are very high and response to lack of nitrogen probably is the most wide spread form of mineral deficiency in trees. Nitrogen deficiency in trees is associated with reduction in shoot growth and pale leaf colour. The symptoms usually are noticeable over the entire crown and individual leaves also show a uniformly pale colour. Nitrogen deficiency also occurs commonly in many forest trees and in nurseries.

b) Phosphorus :

Trees require phosphorus in relatively large amounts. Phosphorus is a part of nucleoproteins and phospholipids. The high energy bonds of phosphate groups are important in energy transfer.

Meyer and Tukey (1965) demonstrated the importance of phosphorus reserve to shoot growth in *Taxus* and *Forsythia*. More than three fourths of the phosphorus in the new growth of *Taxus* and more than half of the phosphorus in new growth of *Forsythia*, came from reserves. Application of phosphorus during one growing season increased the reserve content and greatly stimulated growth during the next year.

A deficiency of phosphorus is very uncommon in fruit trees. When it does occur, however, the young leaves and shoots develop a purple colour along the margins of leaves and lower sides of the major veins. Deficiency symptoms are most obvious early in the summer and they tend to be reduced later as absorption of phosphorus by roots increases.

c) Potassium :

Trees require potassium in large amounts. Potassium appears to catalyze cellular reactions and a deficiency of it impedes nitrogen metabolism and translocation of carbohydrates. When deficiencies occur potassium moves from older tissue to

growing points. Hence, deficiencies are most obvious in older tissue. Luxury consumption without apparent injury to trees occurs commonly.

Potassium deficiency occurs commonly in forest trees, with symptoms varying greatly among species. For examples, potassium deficient Prunus serotina leaves had bright red margins, those of Betula populifoia had chlorotic margins and those of Acer rubrum were uniformly chlorotic (Walker, 1956).

d) Magnesium :

As magnesium is a constituent of the chlorophyll molecule a deficiency would be expected to cause chlorosis. Magnesium is also important in certain enzyme systems. Magnesium is rather mobile in plants and when deficiencies occur it may move from old to young growing tissues.

e) Calcium :

The precise role of calcium in trees is vague. It appears to be involved in nitrogen metabolism and affects membrane permeability. It occurs together with pectates in cell walls.

Calcium deficiency in broad leaved trees causes shoot dieback and inward rolling of leaves. In fruit trees leaf margins may have thin chlorotic margins with some spotting and brown scorching.

Calcium is most important in tree nutrition largely because, when it is abundent,it decreases availability of other elements causing "lime-induced chlorosis". Low uptake of manganese or iron is commonly attributed to excess calcium but absorption of other elements is also impeded. For example, lime-induced potassium deficiency has been described in Picea (Bjorkman, 1953) and iron deficiency in Fagus (Day, 1946). The most severe lime-induced chlorosis occurs on fine textured poorly aerated and cold soils where conditions do not favour mineral uptake.

2. Micronutrients :

Most symptoms of micronutrients deficiency are specific for species, yet the same deficiency does not cause the same symptoms in different species. If two or more micronutrients are deficient the symptoms may not be typical for either element, as one may obscure the effect of the other.

a) Boron :

A deficiency of boron in fruit trees has been documented. According to Stone (1968), symptoms of boron deficiency include chlorosis, reduced leaf size, resetting, dieback of shoots, much branched roots and multiple buds.

b) Iron :

This element appears to be a part of an enzyme system

involved in chlorophyll synthesis. It also occurs in hydroxyperoxidases and cytochrome oxidase. Iron deficiency occurs commonly in fruit trees and angiosperm and gymnosperm forest trees.

c) Manganese :

Like iron, manganese is associated with chlorophyll formation. It is also involved in activation of enzyme systems. Manganese deficiency has been reported in several gymnosperms.

d) Copper :

This element is a constituent of such enzymes as ascorbic acid oxidase and tryosinase. As copper is required in very small quantities, deficiencies in fruit and forest trees are uncommon.

e) Zinc :

This element is involved in synthesis of tryptophane, a precursor of indole acetic acid. Zinc deficiency is not very common in fruit trees or broad leaved forest trees.

f) Molybdenum :

Deficiencies of molybdenum occur in citrus, otherwise they are rare in orchard and forest trees. Except in nitrogen fixing species, the requirement for molybdenum is very low, usually less than 1 ppm.

Several investigators have provided an important role of nutritional factors in correlative growth inhibition. Gregory and Veale (1957), for example, believed the degree of apical dominance was dependent on nitrogen and carbohydrate supplies. Their view was that under deficiency conditions lateral buds were inhibited. At low nitrogen levels there was not enough nitrogen to maintain activity in more than one meristem.

Kozlowski and Winget (1964) noted that a supply of reserves from the old needles of Pinus resinosa was necessary early in the growing season to maintain dominance of terminal leader over lateral branches. Such data suggested that auxin-directed translocation might redistribute nutrients from storage tissues to young growing tissues and exert a role in correlative inhibition of lateral buds.

Wareing et al. (1968) studied the mechanism involving changes in photosynthetic activity of leaves as source-sink relations were altered. When trees were partially defoliated the remaining leaves became greener and larger. Further more, the total protein content increased. Their conclusion is based on the assumption that photosynthesis is commonly limited by the supply of RuBP-carboxylase, an assumption questioned by some investigators. Changes in the rate of photosynthesis with leaf age are associated with anatomical

and physiological alternations increase during leaf expansion is related to development of internal leaf structure and stomata, synthesis of chlorophyll, decrease in diffusion resistance, increase in rate of photosynthetic phosphorylation, increase in protein synthesis, in RuBP carboxylase activity and an abrupt decrease in mitochondrial respiration.

In very young tree leaves total CO_2 uptake is low, reflecting the small amounts of mesophyll and chlorophyll. Photosynthesis then increases progressively in the growing leaf until maximum photosynthetic capacity usually is attained near the time of completion of most rapid growth with further aging, photosynthesis generally decreases until abscission occurs. Typical patterns of changes in photosynthesis with aging of leaves of deciduous species were shown by Richardson (1957). In Acer saccharinum, for example, photosynthesis in very young leaves was low, some what higher in half expanded leaves and the highest when the leaves were fully expanded.

It is clear that the photosynthetic capacity or potential is only one of many plant characteristics which determine ultimate production or yield. As such, however, we would accept C_4 dominated systems to be more productive in habits where their potential can be realized. Monteith's (1978) recent evaluation of production data and review of

earlier comparisons confirm higher short-term maximum rates for C_4 crops in their environments compared to C_3 crops in more temperate zones.

Difference in leaf photosynthetic rates do exist not only in well-known cases of herbaceous plants but also in trees, which are all C_3 plants. In the study on the photosynthetic rate of trees in a low land rainforest of peninsular Malaysia, Koyama (1978) found remarkable differences among the species tested in the rates of net photosynthesis of sun leaves at light saturation. Typical large trees of the top layer of undisturbed forest stand, such as Dipterocarpus spp. and Shorea spp. had rates of 10 to 15 mg CO_2 dm^{-2} (leaf area) h^{-1} which are approximately equivalent to those of temperate trees (Larcher, 1980). On the other hand, higher rates ranging between 20 and 25 mg CO_2 dm^{-2} h^{-1} were obtained in such small pionear trees as Macaranga hypoleuca, Mallotus paniculatus and Glochidion spp. These species are the ecological equivalents of the American Cecropia spp. also known for their high photosynthetic rates. These species grow very rapidly, although they are very short-lived and have light wood of little economic value. Growing in the same habitat, the evergreen forests almost always prove to be more productive than deciduous forest (Ovington 1962; Kira, 1975). Summarizing the above ground net production data in Japanese forests, Kira (1976), arrived at an average production rate of

11.15 ± 3.75 tonnes $ha^{-1}yr^{-1}$ (mean of 88 stands) for boreal and sub-alpine coniferous forests, while the corresponding average for cool, temperate deciduous broad leaved forests was 8.74 ± 3.47 tonnes ha^{-1} yr^{-1} (55 stands). The evergreeness of the former forest type appears to be advantageous for its primary production in spite of the thermal climate being less favourable than that of the cool, temperate zone. The length of growing season for deciduous trees is substantially shortened. This is probably the reason for the higher productivity of evergreen forests. The same relationship may also exist between drought deciduous and evergreen forests in the tropic as well as among herbaceous canopies.

The maximum net production rate for C_3 canopies of 40 to 50 tonnes ha^{-1} yr^{-1} is most probably, reached by plantations of so called 'fast growing trees' in the tropics through few exact estimates are available. Corresponding maxima for C_4 canopies are twice as large; for example 96 tonnes ha^{-1} yr^{-1} in Pennisetum purpureum (Puertokico) and 78 tonnes ha^{-1} yr^{-1} in sugarcane (Hawaii). However, this does not mean that C_4 canopies are always highly productive. Certain C_3 plants such as sunflower are often as productive as C_4 plants. In some cases genetic differences in other physiological characters than photosynthetic pathways may become more important.

Carbohydrates are of special importance because they are the direct products of photosynthesis and therefore, the basic organic substance from which other organic compounds found in plant are synthesized. They are the chief constituents of cell wall. They form the starting point for the synthesis of fats and proteins, while learge amount are oxidised in respiration. Soluble carbohydrates increase the asmotic pressure of the cell sap. Quantitatively they are the most important consituents of trees. The carbohydrates include sugars, polysaccharides and compound carbohydrates. Many of the carbohydrates found in plants are less stable once supposed but actually are continually undergoing conversion from one form to another or synthesis of fats, protein and other non-carbohydrates. Sugars must be translocated from leaves to roots if these parts are to grow and function properly. All the various growing regions of the plant including root, stem, cambium, fruit and seed compete for the products of photosynthesis. The success in competition seems to vary with age and growth.

Although growth requires large amount of available carbohydrates, several lines of evidence show that cessation of shoot expansion generally is not due primarily to carbohydrate deficiency. Both stored carbohydrates and products of current photosynthesis are used in shoot growth. The quantity and propertions of reserve and currently produced

carbohydrates are used in internode elongation. Kozolowski and Clasusem (1966) presented evidence for use of considerable current photosynthates during shoot expansion of heterophyllous species, Betula papyrifera.

The carbohydrates formed by photosynthesis have several possible roles. A very large fraction is used in growth, being translocated to the stem and root tips, the cambium and reproductive structures, where it is converted into new protoplasm. Another fraction is accumulated as reserve food and eventually is used in growth. A considerable amount of carbohydrate is oxidized in respiration, releasing the energy needed in the synthetic process associated with growth.

Some carbohydrates are lost by leaching and volatilization from leaves and by exudation from roots. According to Tukey (1970), as much as 800 Kg of carbohydrates per hectare may be lost annually by leaching from leaves of apple trees. The relative proportions of carbohydrates used in growth of the crown, stem and root system varies with plant age. Both reserve and currently produced carbohydrates are used in growth. Carbohydrates reserve in both roots and shoot are depleted by translocation to growing tissues. The various carbohydrate reserves that are close to the site of utilization. Because various parts of trees grow at different times of the year, the utilization of carbohydrates is

extremely variable over the tree axis. During years of heavy fruiting or seed production, a very large percentage of the carbohydrate supply is diverted from vegetative to reproductive growth.

Proteins are the principle organic constituents of protoplasm. They are exceedingly complex nitrogenous substances of high molecular weight which differ from one another in shape, size, surface properties, and even in function. They all, however, have in common the fact they are built up from amino acids, are amphoteric, and have colloidal properties. Proteins possess basic-NH_2 and acidic,-COOH, groups and are positively charged at pH values below the critical "neutral" value, known as the 'isoelectric point' and negatively charged at pH values above the isoelectric point.

In a living plant, proteins are in a dynamic state and are constantly being broken down and reformed, but the total amount of protein may remain constant over considerable periods of time. Protein synthesis occur most energetically in cells of meristematic regions where cell division occurs and in storage organs where protein is accumulated, as in endosperms of seeds. Protein synthesis takes place in ribosomes in the cytoplasm.

During acclamation of plant tissues to cold, changes occur in the concentrations of sugars, proteins, amino acids,

nucleic acids and lipids. Various investigators have demonstrated a strong correlation between cold hardiness and soluble protein content. Changes in soluble proteins may involve an increase in water binding proteins that could decrease free cellular water. Siminovitch and Briggs (1949, 1953) found that the amount of water-soluble proteins of black locust bark increased in the autumn, with the development of hardiness, and declined in the spring. The concentration of insoluble protein did not change materially during the induction of frost hardiness.

Phenolic compounds enjoy a wide range of distribution in the plant kingdom and are particularly prominant in fruits, where they are important in determining colour and flavour. Neish (1964) has suggested that they may be originally by-products of the metabolism of aromatic amino acids.

During formation of wood a wide variety of extractive substances, including tannins, assorted dyestuffs, oils, gums, resins and salts of organic acids, accumulate in cell lumens and cell wall resulting in a dark coloured wood. Some of these substances also occur in the sapwood, but usually in smaller amounts. Extractives in heart wood sometimes exceed 30% of the total weight and increase the colour, density and durability of the wood. Extractives are formed primarily in ray parenchyma cells but they may also form in axial parenchyma.

Among the most important of the heart wood extractives are the polyphenols. These are aromatic compounds with one or more phenolic hydroxyl groups. Usually, most phenolic substances obtained from tissues with living cells occur as glycosides or esters, while polyphenols obtained from heart wood are almost exclusively found as aglycones (organic compounds, usually a phenol or alcohol, combined with the sugar portion of a glycoside). The important chemical pathways leading to formation of extractives are summarized by Hillis (1968). Factors influencing formation of phenolic compounds are discussed by Hillis *et al*. (1962).

Phenolics in addition to abscisic acid function as inhibitors in plants. The most important phenolic compound is cinnamic acid, that inhibits auxin activity. Exogenously applied monophenols increase indole acetic acid oxidase activity and the destruction of auxin, but di - and polyphenols inhibit the destruction of indole acetic acid. There are also some rather confusing data indicating that phenolics are involved in the responses of seedling to light (Leopold and Kriendemann, 1975). The flavonoids may have some role in the response of leaves to light (Thimann, 1972), and some unsaturated lactones such as coumarin have also been identified as growth inhibitors. Coumarin and protoanemonin are best known. Coumarin occurs in grasses and it is responsible for the characteristic odor of newly mown grass. It

inhibits lettuce seed germination and elongation of roots. Jacobson and Corcoran (1977) suggest that tannins are important antagonists and regulators of the gibberellins.

Naturally occuring compounds that have inhibitory effects on the seed germination and growth of neighboring of plants include phenolic acids, coumarins and quinones, terpenes essential oils, alkaloids, and organic cyanides. Allelopathic chemicals are ecologically important because they influence succession, dominance, vegetation dynamics, species diversity, structure of plant communities, and productivity (Whittaker, 1970). Terpenes or isoprenoids contain more different compounds than any other group of plant products, although the alkaloids must be nearly as numerous. The carotenoids, abscisic acid and gibbrellic acid have important physiological functions in plants and certain essential oils and oleoresins seem to be important in repelling predators or attracting pollinators. However, many of the compounds synthesized by plants, especially terpenes and alkaloids, have few known functions. It sometimes is argued that everything in an organism must have a function, but it seems improbable that every aspect of plant metabolism is equally important in the process of natural selection. It is more probable that many of these substances are merely products of synthetic processes which originated incidentally

in ancient ancestors and have persisted simply because they do not have enough negative effect on survival to have been eliminated by natural selection. On the other hand, considerable attention has been given to the possible protective function of phenolic compounds and other compounds against pathogens and insect pests.

As a tree ages it's growth changes markedly. Among the major manifestions of aging are, decrease in metabolism, reduced growth of vegetative and reproductive tissues, increase in dead branches, heart wood formation, slow would healing and changes in resistance to invasion by certain insects and fungus pathogens.

In young trees the amount of annual shoot growth increases for number of years but it attains a maximum, relatively early in the life of the tree and declines thereafter. The effects of aging on shoot growth vary with species, environmental fluctuations, and site conditions. In many tropical species young trees exhibit for less intermittency of shoot growth than do old ones. In mango (Mangifera indica), as tree ages the rate of cambial growth follows a definite trend which varies with species and also the environment. Many investigators have reported variations in root growth of trees during aging (Scholtes, 1953). Kalela (1950) showed differences in rate of root growth of Pinus and Picea at various ages. The changes in the activity of apical and lateral meristems as

tree ages are reflected in dry weight accretion. In Pinus sylvestris dry weight production of young stands with age to a maximum is at about 20 years. At the age of approximately 30 years there is a slow decline in dry weight. The decrease was accelerated after the age of 40 years. Old trees of 50 years producing only half as much dry matter as 33 years old trees.

The quantity and quality of seed produced by adult forest trees vary greatly with their age. Most trees produce greatest amount of seeds during middle age. Hence, reproductive capacity is correlated with longevity. Eventually trees reach andage at which rèproductive capacity declines. However, it is some what difficult to establish precise ages of first and optimal flowering capacity for any species because these are greatly modified by plant competition and tree vigor.

Several important anatomical changes occur during development of trees. During the first year of development there is change over from primary to secondary tissues. After the adult stage is reached, external alternations of aging trees are characterized by various internal structural changes in tree stems which influence wood quality.

The wood of young trees consists of entirely of sap wood. Although, sap wood is made up of mostly dead cells, it is physiologically important because it serves as an auvenue

for translocation of water and minerals. It's living cells also carry on metabolic process and store foods. In contrast, the dead heart wood is considered physiologically inactive. After a certain age, which varies greatly among tree species and with environment, all the living cells in the central core of the main stem and large branches die, usually darken, and lose their physiological role. The most critical change in transformation of sap wood into heart wood is death of ray and longitudinal parenchyma cells. Other changes accompanying heart wood formation include altered metabolic rates, changes in enzymatic activity starch depletion, darkening of xylem associated with deposition of extra actives, change in wood density, anatomical changes such as pit aspiration in gymnosperms and formation of tyloses in angiosperms, and changes in moisture content.

Trees are by far the oldest living thing on earth. There is wide variation, however, in the life-span of various species. Many species of trees survive less than a hundred years, but few grow for several thousand years. The oldest living plants appear to be Pinus aristata trees growing in California. Some of these were confirmed by Schulman (1958) to be well in excess of 4000 years old.

As tree ages, several changes in food, water and hormone relations occur which may contribute of anabolism to catabolism leading to a deteriorative condition. As Moller _et al_. (1954) demonstrated, the leaf area of aging trees

remains fairly constant but its total photosynthetic output declines slightly while respiratory consumption of food increases appreciably. Hence, the leaves appear to be unable to supply adequate food for the requirements of the old tree.

Increasing difficulty in translocation of food, water, minerals and harmones as distance from root to shoot increases, appear to be very important in promoting senescence. Went (1942) strongly emphasized that translocation of water to the crown became progressively difficult in aging trees and caused sufficiently water deficits in some leaves and branches to cause their death. Hence, tissue senescence is promoted by gradually decreasing availability of essential compounds. Enzymatic activity decreases as shown by an over all diminished metabolic rate. Hormone supplies tend to become limiting as the leaf mass becomes inadequate to supply the tree. Further more, as growth regulators are translocated in the assimilate stream, a decreased flow of carbohydrate from the leaves is correlated with decreased movement of hormones. At the cellular level senescence may be considered as expression of deteriorative changes involving the breakdown of structural integrity of aging tissues. According to Sacher (1957) and Varner (1961) deterioration of cell membranes may be responsible for cellular decline.

From the foregoing account, it is clear that there are number of studies in forest trees but not in the trees grown in

Indian forests. Similarly, quite a few species such as pines, Picea etc. which are common and popular in the Western world have been investigated for their physiology some what thoroughly. Indian forest trees have been only rarely investigated for their physiology, particularly for their organic and inorganic constituents. Therefore, in the present study an attempt has been made to carry out some preliminary investigations in some selected and very common and popular trees grown in our side with respect to their organic constituents. In the following pages these species have been briefly described with respect to their morphology, physiology and economic importance.

G) Tree Species Selected :

1. Sesbania grandiflora (Plate (Fig.) 3-A) :

Family - Papillionaceae

Vern - Hadga

A soft-wooded tree reaching 20-30 ft.high, with large white or red flowers, is often grown about temples and villages, but is now here indigenous. Its flowers are 2-3 inches long and very showy. Pods often reach a foot long.

In the Mekong delta of South Vietnam, fruit trees are planted in what are usually called 'home gardens'. These home gardens are modified forest ecosystems. S.grandiflora is always present as a component in these agroforestry systems,

(A)

(B)

Fig. 3 – HABIT OF *Sesbania grandiflora* (A) AND *Moringa pterygosperma* (B)

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which are known to have existed for hundreds of years.

The tender leaves, flowers and pods are eaten. Certain parts of the tree have repute in native medicine. The association of S.grandiflora and fruit trees provides the farmers with a variety of useful products. Poles for fishing, fodder for animals, edible flowers and stem wood for mushroom production. In addition, the soil is improved and the yield of fruit trees is also increased. S.grandiflora is also viewed as a source of pulp wood, this agroforestly system is very promising for rural development schemes as well. The flowers and pods are eaten in salads or a vegetable in S. Asia. A decoction of leaves is used as diuretic and laxative and a decoction of the bark is a tonic and a treatment of intenstinal worms.

2. Moringa pterygosperma (Plate (Fig.) 3-B) :

Family - Moringaceae

Vern - Shevga

A small or middle sized tree; bark corky; wood soft; root pungent; young parts tomentose, leaves usually 3-pinnate, sometimes $1\frac{1}{2}$ ft. long, rachis slender, thickened articulated at the base; pinnae and pinnules opposite, deciduous, their rachides very slender, articulated and with a gland at the articulations; ultimate leaf lets $\frac{1}{2} - \frac{3}{4}$ by $\frac{1}{4} - \frac{3}{8}$ in; the lateral elliptic, the terminal obovate and slightly larger than the lateral ones; nerves obscure; petiolules of the

lateral leaf lets 1/16 - 1/10 in., those of the terminal 1/8 - 1/4 in.long. Flowers white, in large puberulous panicles. Calyxlobes linear lanceolate reflexed, puberulous outside. Petals spathulate, veined. Stamens 5, fertile, alternating with 5-7 antherless ones; Filaments villous at the base. Ovary oblong, villous; style cylindric, pods reaching 18 inches long, 9-ribbed, Seeds 3-angled, the angles winged.

The horse radish tree or dramstick tree is found wild in the forests of the western Himalayas, but is cultivated throughout India and in many other tropical countries.

The scraped root furnishes an excellent substitute for horse radish, while the long immature pods are used in making what is known to Europeans as drumstick curry. Several parts of the tree are used in native medicine and oil called Ben oil is extracted from the seeds. The oil is highly valued by watch makers and generally as lubricant for the machinery, while perfumes hold it in high esteems from the property it possesses of absorbing and retaining fugitive odors. It seems surprising that greater trade is not done in this oil considering the number of trees that are planted throughout India. The oil which is sometimes called Gomme de Benoiele, is used by artists in mixing paints.

3. Emblica officinalis (Plate (Fig.) 4-A) :

Family - Euphorbiaceae

Vern - Avla.

A deciduous small or middle - sized tree with crooked trunk and spreading branches; bark greenish-grey, peeling off in conchoidal flakes; branchlets glabrous or finely pubescent, 4-8 in long, often deciduous. Leaves subsessile, 3/8 - 1/2 by 1/10 - 1/8 in; closely set along the branchlets, distichous, light-green, glabrous, narrowly linear, obtuse, imbricate when young having the appearance of pinnate leaves. Stipules ovate, finely acute. Flowers greenish-yellow, in axiallary fascicles on the leaf-bearing branchlets, often on the naked portion below the leaves, with fimbriate bract at the base, male flowers numerous, on short slender pedicels, sepals 6, oblong, obtuse, 1/20 in.long. Disko anthers 3 on a short central column. Female flowers few, subsessile, sepals as in the male. Disk a lacerate cup. Ovary 3-celled, styles connate at the base, irregularly twice 2-fid with acute lobes. Fruit 1/2 - 5/8 inches in diam., fleshy, globose, with 6 obscure vertical furrow, pale yellow, of three 2-seeded crustaceous cocci-seeds 6, 3-gonous.

It is distributed throughout the deciduous forest, Matheran, Konkan, Western Ghats and it is often planted, throughout tropical India. It is wild or planted in Ceylon, China, Malay, Islands.

(A)

(B)

Fig. 4 – HABIT OF *Emblica officinalis* (A) AND *Tamarindus indica* (B)

The fruit is used as a medicine, and for dyeing and tanning. It is also made into a sweet meat with sugar, and some times used as pickle. The wood is valuable for various purposes.

4. Tamarindus indica (Plate (Fig.) 4-B) :

Family - Leguminosae

Vern - Chinch.

A large tree 40-60 ft. high, branches spreading, glabrous. Leaves 2-5 in long; rachis slender, channelled; stipules linear, caducous, Leaflets subsessile, 10-20 pairs, tolerably closely set on the rachis, 1/3 - $1\frac{1}{4}$ by 1/5 - 1/3 inches, oblong, obtuse glabrous, reticulately veined. Flowers in lax few flowered racemes at the ends of the branchlets, pedicels 1/4 - 3/8 inch long, slender, articulated below the calyx, glabrous, bracts can have, 1/4 - 1/3 inch long, enclosing the buds, caducous, bracteoles small. Calyx 1/2 inch long; tube, narrowly turbinate, 1/6 inch long, segments 1/3 inch long, subequal, oblong, some what oblique, obtuse or subacute. Petals 3 (an upper and 2 lateral), 3/8 inch long, subequal obovate-oblong, yellowish with pink stripes. Stamens 3 fertile, connate nearly half their length, filaments pubescent at the base; anthers oblong. Ovary stalked; ovules 8-12 or more, style pubscent, equalling the stamens. Pods 3-8 inch long, 1 inch broad and about 3/8 inch thick, slightly curved, sub-compressed, scurfy seeds 3-12, obovate

oblong, truncate at the ends, 5/8 by 5/16 inch, compressed with a shallow oblong pit on each of the flat faces, smooth, brown, shining.

The well-known Tamarind tree is cultivated and self-sown throughout India and the Tropics generally probably indigenous in Africa.

The tree is of great value, almost all its parts being useful. Two different kinds of fruit are recognized, distinguished by their colour, namely red and brown tamarind of which the former is the most valued. Some fine specimens of the red fruited variety grow at Bijapur in the Deccan. The bitter-sweet pulp from the ripe pods is used to make drinks, chutneys, curries etc. It was used by sailors instead of limes as a source of vitamin C. The pulp is also used as a laxative. The plant is cultivated in the old and new world.

5. Azadirachta indica (Plate (Fig.) 5-A) :

Family - Meliaceae

Vern - Nim.

A large tree 40-50 ft high with a straight trunk. Leaves simply pinnate, 8-15 inch long, crowded near the ends of the branches; leaflets 9-12 subopposite, 1-3 by 1/2 - $1\frac{1}{2}$ inch; obliquely lanceolate, sometimes falcate accuminate, serrate, glabrous on both surfaces, base inequilateral, acute;

petiolules very short. Flowers white, fragrant, in branched glabrous panicles, shorter than the leaves;bracts minute, laceolate, caducous. Calyx puberulous outside, divided almost to the base; lobes rotund-ovate, minutely ciliolate. Petals 1/4 inch long, obovate-oblong, faintly puberulous outside ciliolate. Staminal-tube glabrous, a little shorter than the petals, obconic, the lancinise truncate and toothed at the apex, anthers 10, opposite the lacinise and a little shorter than them, apiculate Disk 0. Ovary glabrous, 3-celled, the cells opposite to the petals; ovules 2 in each cell, collateral, stigma 3-toothed included in the tube. Drupes the shape of an olive, 1/2-3/4 inch long, glabrous 1-seeded.

Cultivated throughout India and hot climates, self planted but no where wild and common about villages. The well-known Nim or Margosa tree. Its valuable properties attracted the notice of the Mohammedans on their arrived in India and it was named by them Azad-daracht-i-hindi from its resemblance to the persion lilac (Melia azedarach).

Dried leaves (in a bag or envelope for convenience) put in drawers and cupboards keep out moths, cockroaches etc. Another use for these 'Magic' leaves is in poultice form when they are employed to heal festered wounds. From the yellow fruit the size of a small olive, is obtained the famous Margosa oil which is so effective in the treatment of leprosy and skin

(A)

(B)

Fig. 5 – HABIT OF *Azadirachta indica* (A) AND *Acacia arabica* (B)

diseases. Leaves and fruit are both vermifugal and the latter is used as a purgative. External application of oil from the seeds is believed to cure reheumatism and it also has antiseptic properties. Bark and gum yield valuable medicines, in fact practically every part of this fine tree is of value.

Nim timber some what resembles mahogany, it is beautifully mottled, hard and heavy and is used for ship-building, cart and furniture making and has numerous other uses. Wood from old trees is so bitter that no insects will attack it. A non-drying oil (Margosa oil) is extracted from the seeds. It is used for soup-making and treat skin diseases, locally. The bark (cortex Azadirachta, Nim Bark), and leaf extract (Neem Toddy) are used as a tonic, and to reduce fevers. The leaves are also used as an antiseptic. A powder of the dried root bark is also used to reduce fevers. The leaves, pressed in the leaves of books, prevent attack by insects.

6. <u>Acacia arabica</u> (Plate (Fig.) 5-B) :

Family - Leguminosae (Sub-family - Mimosae)

Vern - Babhal.

A small tree with dark brown or black longitudinally fissured bark; branchlets slender, terete, pubescent when young leaves 2-pinnate, 2-4 inch long, stipular spines very variable, 1/4 - 2 inch long, smooth, usually whitish, straight,

sharp often absent, pinnae 4-9 pairs, 3/4 - 2 inch long, shortly stalked. Leaflets subsessile, 10-25 pairs, 1/8 - 1/4 by 1/20 - 1/12 inch, linear-oblong, obtuse glabrous or nearly so. Flowers yellow, in globose heads, peduncles axillary, in fascicles of 2-6 terete, pubescent, bracteoles 2 above the middle of the peduncle, broadly ovate, acute pubescent. Calyx campanulate, 1/20 inch long, teeth very short, corolla 1/8 inch long; lobes short, triangular, pods stalked, 3-6 by 1/2 - 5/8 inch moniliform, compressed, constricted at the sutures between the seeds, densely and persistently grey downy; seeds 8-12.

Throughout the region except in moist regions near the coast. Widely planted in the Deccan, Gujarat and Sind. Throughout the greater part of India, Ceylon, Arabica, Egypt Tropical Africa.

The well-known Babhal or Indian Gum - Arabic tree. The gum is used medically and by the calico printer and also forms a substitute for true Gum-Arabic. The bark and the pods supply a valuable tanning material. The green pods, young shoots and leaves form an excellent fodder, and are especially valuable during seasons of draught. The timber is hard and durable and extensively used for wheels, well-curbs and very largely as fuel.

7. Polyalthia longifolia (Plate (Fig.) 6-A) :

Family - Anonaceae

Vern - Asok

A tall handsome tree; young branches slender, glabrous, Leaves membranous; 3-9 by 3/4 - $1\frac{1}{2}$ inch narrowly lanceolate, tapering to a fine point, shining, both surfaces glabrous margins undulate; petoles about 1/4 inch long. Flowers $1-1\frac{1}{2}$ in. cross, yellowish-green, in fascicles or shortly peduncled umbels; pedicels slender $1-1\frac{1}{2}$ inch long, with a small, pubescent, deciduous bract about or above the middle-sepals 1/6 inch long, triangular, pubescent, the trips reflexed petals subequal, linear spreading, tapering to a point. Ripe carpels 3/4 inch long, glabrous, stalk 1/2 inch long, stout glabrous. Seeds smooth shining.

The Mast Tree is usually noticed as a loftly column, infinitely graceful with its down-ward sweeping, branchlets and shining, green foliage. This is the weeping variety P.longifolia but in the species wide spreading slender branches issue from the trunk and form a compact symmetrical crown.

The tree is at its most attractive when the new leaves are appearing; the contrast between the deep-green of the old leaves, the yellow-green of the half-grown leaves and the rusty tinge of the limp new ones being particularly striking. It is held in great esteeme by Hindus who plant it near their

(A)

(B)

Fig. 6 – HABIT OF *Polyalthia longifolia* (A) AND *Leucaena leucocephala* (B)

temples. Having light and flexible wood, the tall, straight trunks were ideally suited to making of masts in the days of sailing ships. It is straw-coloured and also used for making small articles such as pencils, boxes etc. A febrifuge is prepared from the bark and the inner bark yields as useful fibre.

Festoons of leaves are often used to make arches or are strung across doorways during religious ceremonies and leaves, in conjunction with various flowers, are frequently seen as a decoration. The tree is a native of Ceylon. There and in India the spreading form is planted in all the hot areas, usually as a roadside shade tree.

8. Leucaena leucocephala (Plate (Fig.) 6-B) :
   Family - Leguminosae (Sub-family - Mimosae)
   Vern - Su-babul

Leaves are bipinnate 15 to 25 cm long rachies pubscent pinnate 4 to 8 pairs, 5 to 10 cm long, leaflets 10 to 15 pairs, leaflet linear-oblong, acute, inequilateral, 7 to 15 cm long and 3 to 4 mm wide. The stipules are triangular, glabrous and 15 mm long. The flowers are white, 100 to 180 flowers clustered in a globular head, 2.5 to 3.0 cm in diam., solitary, axillary, long pedicelled and about 4 cm in length. The seed pods are thin flat strap shaped, accuminate, 12-18 cm long, 1.4 to 2 cm wide, usually 15 to 60 per cluster, covered with

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fine haris when young, with 15 to 25 seeds per pod, seeds are elliptic compressed, shiny brown 3-4 mm wide 6 to 8 mm long and 2 mm thick. Generally Su-babul plant may rich about 10 meters height. However, the plant characters differ according to environment and are in consistent and considerable intra specific variation exists. Though Su-babul exihibit drought resistance and an inherent ability to with stand repeated defoliation with its foliage providing high protein content and high yields, immediate research efforts are needed on agronomic aspects such as efficient method of establishment, optimum plant population and fertility management to maximise yield and on utilization aspects to determine the long term effect of feeding Su-babul on animal health. The need of the hour is productivity of lines free from mimosine.

Leucaena is native of central America originating in the mid lands of Southern Mexica, Chiapas and Yucatan. However, it (Leucaena) was introduced into India during 19th Century for various purposes. The first reference to Leucaena in the agriculture literature was in 1900, when it was mentioned in a report on work in Jawa relating to its performance as a plant for providing shade an maintaining fertility in coffee plantations according to Dijkman (1950). However, Takashashi and Ripperton (1949) reported that the first use of Leucaena as a forage in Hawii was in 1915. According to them Hawiian farmers began to broad cast Leucaena

seeds on to leaf cattle pastures and only in 1934 a farmer planted Leucaena and used plucked branches as a feed to milk animals, subsequently during second world war, research in Hawaii was explained which showed that the plant was a protein concentrate and replacement in a dairy rations.

The Leucaena leucocephala supplies fuel wood in addition to much rich in nitrogen and other plant nutrients. Thus this system, in addition to ensuring stable production with minimum soil degradation, help minimize the use of nitrogen fertilizers. L.leucocephala can also be grown as a source of in situ stakes for yams and other climbing crops.