

Forest Types

Indian Flora- composition and Endemism

The Indian Flora consists of :-

- 30,000 species belonging to 174 order
- 6000 species of ferns and pteridophytes
- 11,124 species of Dicotyledons belonging to 1831 genera
- Largest family of flowering plant in India – Orchidaceae with 1700 species

- 10 dominant families of India flora are –
 - Orchidaceae, Leguminosae, Poaceae, Rubiaceae, Euphorbiaceae, Acanthaceae, Asteraceae, Cyperaceae, Labiatae and Urticaceae
 - Monocotyledons are dominant in India
 - 100 species of Bamboos
 - 25 species of conifers
 - **Endemic Flora of India**
 - **47% dicot endemic to India**
 - **Highest number of Endemism of dicots in Himalayas**

Major Ecosystems of the World

- The seas
- Estuaries & Sea shores
- Streams & rivers
- Lake & Ponds
- Freshwater marshes
- Deserts
- Tundras
- Grassland
- Mountains
- Mangroves
- Coral Reefs
- Forests

Ecosystem of India

■ Mountains

- Eastern Himalayas
- Western Himalayas
- Trai Himalayas

■ Desert

- Thar
- Rann of Kutch

contd.

- **Grasslands**
 - Wetlands- *Freshwater, Brackish Water*
- **Estuaries**
- **Mangroves**
- **Coral Reefs**
- **Marine**
- **Islands**
- **Western Ghats**
- **Eastern Ghats**
- **Deccan Peninsula**

Botanical Regions/ Ecological zones of India

India is divided into a number of botanical regions by Clarke (1898), Hooker (1907) and Chatterjee (1939)

As per C.B. Clarke (1898)

- 1) West Himalayas
- 2) Indian Deserta
- 3) Malabaria
- 4) Ceylon (no more part of India)
- 5) Coromandalia

6) Gangetic plain

7) East Himalaya

8) Assam

9) Ava

10) Pegu

11) Malaya Peninsula

As per J.D. Hooker (1907)

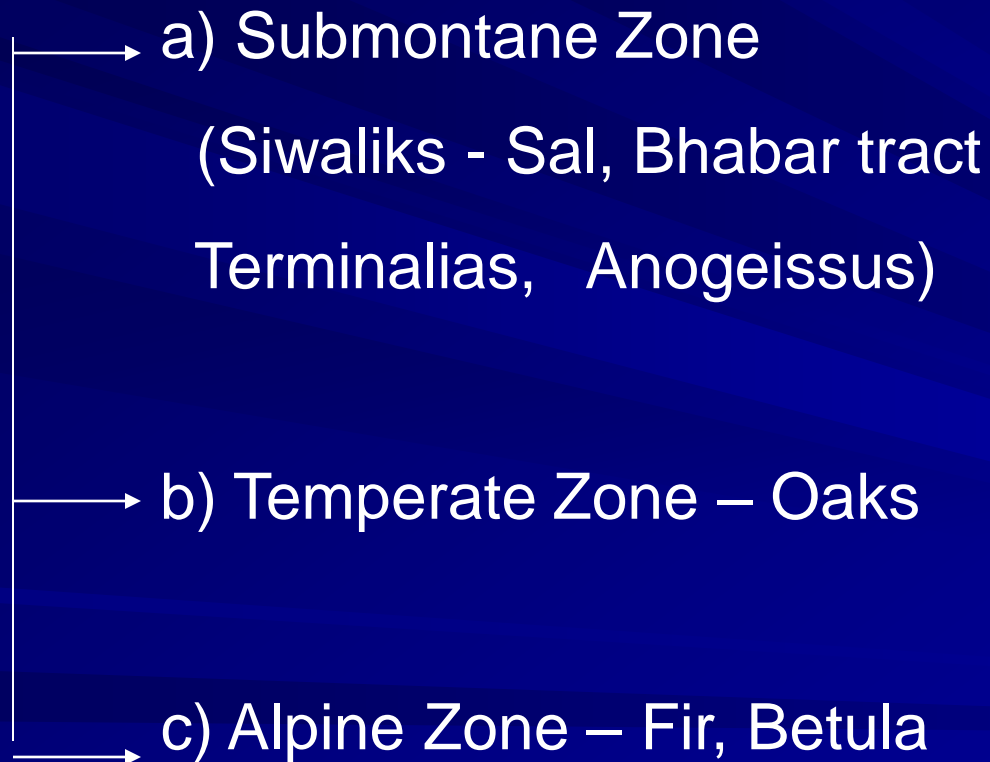
- 1) Eastern Himalaya
- 2) Western Himalaya
- 3) Indus Plain
- 4) Gangetic Plain
- 5) Malabar
- 6) Deccan
- 7) Ceylon & Maldives
- 8) Burma
- 9) Malaya Peninsula

As per D. Chatterjee (1939)

- 1) Deccan
- 2) Malabar
- 3) Indus Plain
- 4) Gangetic Plain
- 5) Assam
- 6) Eastern Himalaya
- 7) Central Himalaya
- 8) Western Himalaya
- 9) Upper Burma
- 10) Lower Burma

1. Western Himalayas

- Comprising of Himalayan mountains from Kumaon to Kashmir.



2. Eastern Himalayas

Consists of humid region from Sikkim eastward.



3. Indus Plain

- Consists of parts of Punjab, Rajputana, Kutch and Delhi
- Acacia, Prosipis, Tecomela, Anogeissus,

4. Gangatic Plain

- Consists of UP, parts of Delhi, Bihar, Orissa, Bengal
- Sal, Terminalia, Bauhinia, Eugenia, Mangroves of Surderban

5. Central India

- Consists of Vindhyan (present MP, Chattisgarh), parts of Maharashtra, UP
- Teak, Madhuca, Terminalia, Bauhinia

6. West Coast of Malabar

- High rainfall area, Luxuriant vegetation, tropical evergreen or rain forest
- From Cape camorin to parts of Gujarat in north
- Cedrela, Dipterocarpus, Hopea, Mesua, Sterculia, Calophyllum, Artocarpus, Vitex, Teak, Xylia, Adina, Climbers, Bamboos, Sholas in Nilgiris, Palani and Anaimalai hills, Mangroves, Orchids and ferns.

7. Decean

- Major of Peninsular India (Satpura Range)
- Teak, Hardwickia, Boswellia, Red Sandars in cuddepah, Anogeissus, Acacia, Euphorbia.

8. Assam

- Brahmaputra Valley, Nagaland, Manipur and Lushai
- High rainfall, Luxuriant vegetation
- Artocarpus, Michelia, Ficus, Mesus, Vatica, Sterculia, Morus, Bamboos, Alnus, Betula, Magnolia, Pyrus, Pine forest.

9. Andamans

- Mangroves, evergreen, semi evergreen and deciduous forests
- Evergreen forests—Dipterocarpus, Terminalia, Lagerstroemia

Recognized Botanical areas of India

1. Western Himalayas
2. Eastern Himalayas
3. Indus plains and Western deserts
4. Gangetic plains
5. Central India
6. Western coast
7. Deccan plateau
8. North east India
9. Andaman & Nicobar

Theories to explain the discontinuous distribution of some Indian Forest trees

- Main (5) theories to explain reason for discontinuous distribution of Forest tree species :-
 - 1) Himalaya glaciation theory
 - 2) Southern route across Indian Ocean theory
 - 3) Deccan trap theory
 - 4) Continuous Range Theory
 - 5) Satpura Range theory

1.Himalayan glaciation theory

- During Pleistocene period , glaciation in Himalaya lowered temperature throughout country.
- Medlicott (1879) suggested that occurrence of Himalaya plants and animals on higher ranges of Southern India be due to retreat of species in first place towards the equator, and subsequent, as the temperature increased, to higher parts of hills,
- As per this theory glaciation influences vegetation by changing ecological conditions of the environment.

2.Southern route across Indian Ocean Theory

- This theory postulates the occurrence of a land connection between India, Australia and India and Newzealand.

3.Deccan Trap theory

- Occurrence of similar genera of birds in South India and Malayan peninsula led to postulation of the theory of Deccan traps theory.

4. Continuous Range Theory

- As per Hora (1949), the
- Localities at which species are found at present must have at one time, formed of a continuous range of distribution of the species

5. Satpura Hypothesis

- 1) Continuity of Vindhya – Satpura ranges with Assam Himalaya in east and Western ghats in west.
 - 2) 5000 to 6000 feet elevation of Vindhya, Satpura range and the northern section of western ghats.
 - 3) Continuity of an ecological belt of mountains with rainfall of 100 inches or above and consequently tropical evergreen forest between the Assam Himalayas and mountains of Ceylon via Vindhya – Satpura trend and Western ghats.
 - 4) Dispersal of fauna from east to west and consequent changes in topography necessary therefore.
- This concept explains presence of Malayan flora and fauna in peninsular India and Ceylon.

World flora

1. Malayan

2. European & Mediterranean

3. African (Indo – African)

4. Tibetan & Siberian

5. Chinese & Japanese

■ No Indian Flora is recognized as a specific one.

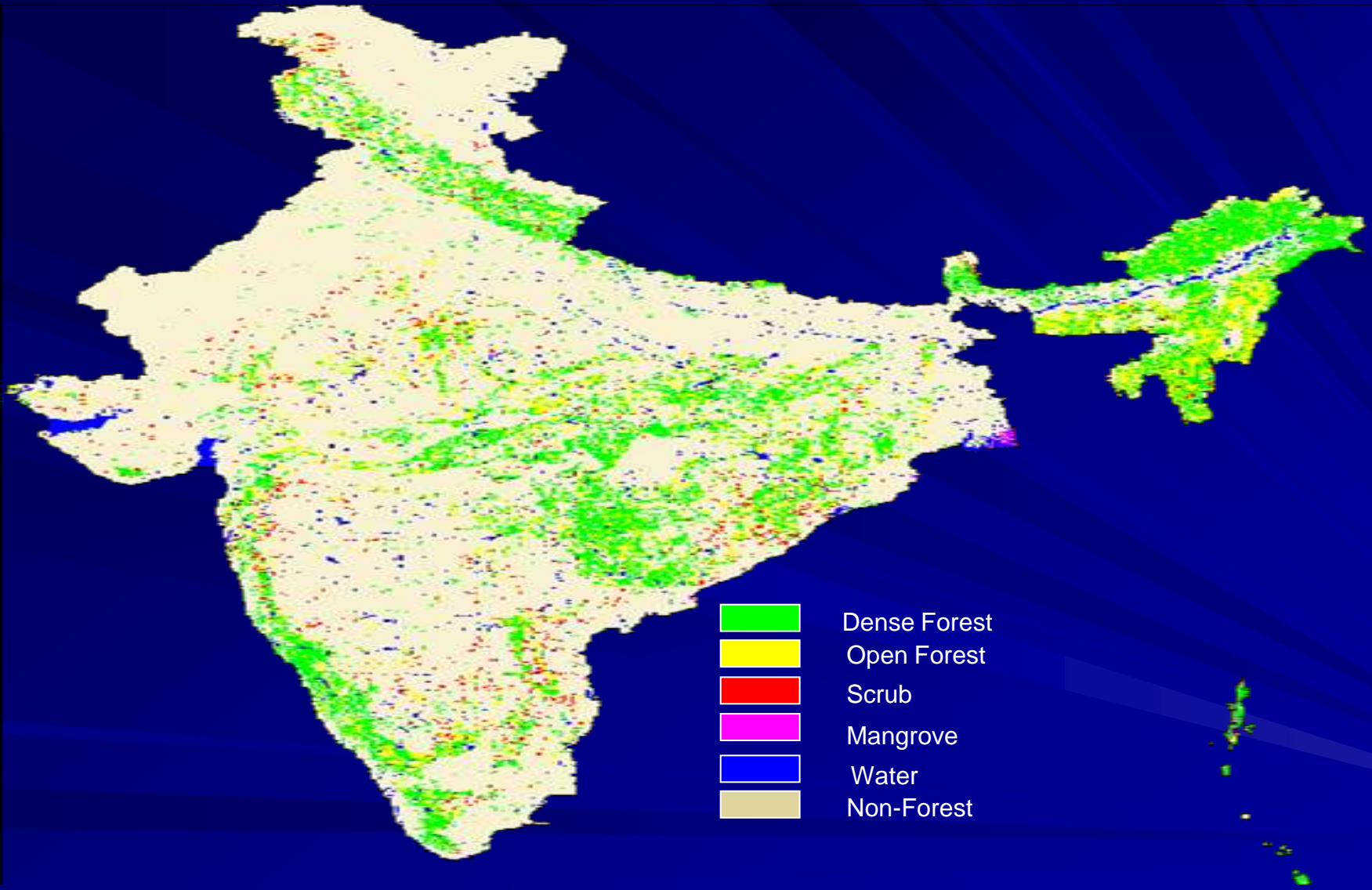
■ All the Indian Flora can be identified with world
flora

■ Assam – Malayan element -

Dipterocarpus

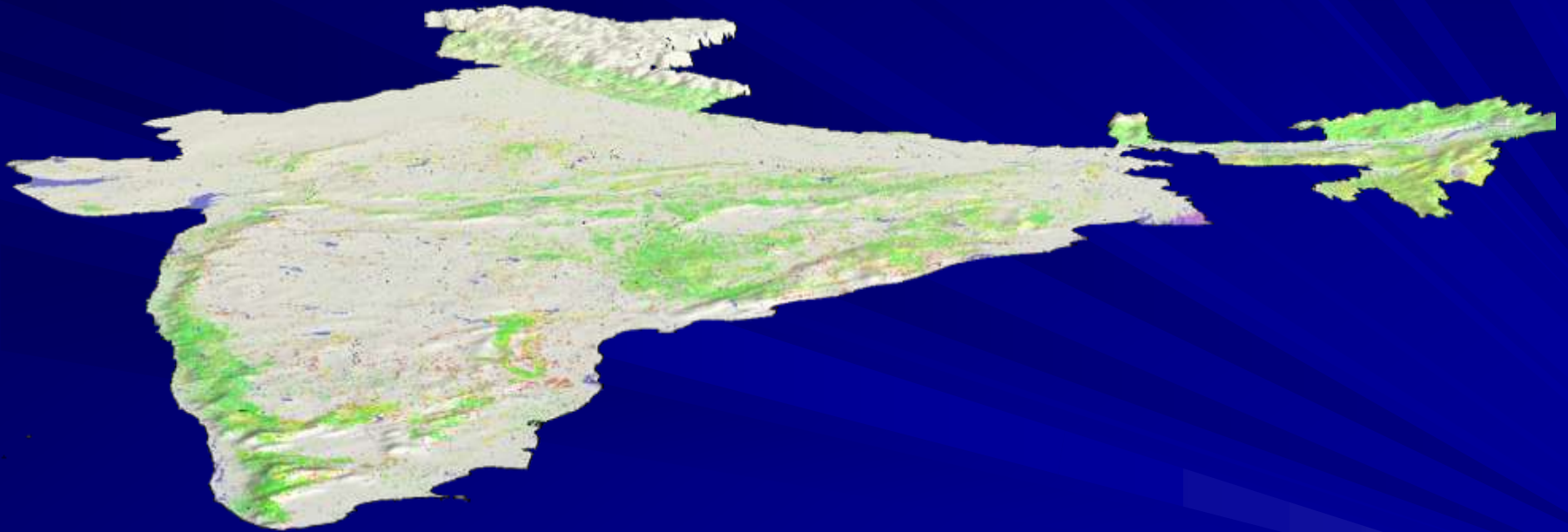
- Tibetan – alpine and sub alpine
- Sino- Japanese – oak, Rhododendron

Forests of India



Perspective view of India

Forest Cover Draped over Digital elevation Model



Forest Types

- Climatic variation
- Great diversity in plants & animals
- Geographical location
- Microclimatic variation
- 12 mega biodiversity
- 1929 - champion- silviculturist in FRI
- 1935- compilation of silviculture in 5 volumes;
- Classified the forests of India into different types
- 1965 – S.K. Seth – revised

Forest type – definition

- A unit of vegetation having a structure and form, good enough to differentiate it from another such units.

❖ Factors

1. Climate

- Tropical – very hot, no winter
- Sub-tropical – hot, cool winter
- Temperate – warm summer, severe winter

2. Altitude

3. Rainfall

4. Coastal & mountains

5. Radiation

6. Wind & topography

7. Soil

➤ Classification

- **Vegetation – plant community – webb, beard, fosberg etal**
- **Climate, temperature, moisture– koppen, shanberg etal**
- **Based on eco system – vegetation and abiotic**
- **Champion and seth classification commonly used in India**
- **5 – major groups, 16 – groups, 28 – sub groups**
- **227 types**

- Five major groups
- Tropical
- Sub tropical
- Montane temperate
- Sub alpine
- Alpine

➤ Tropical – 7 groups

- Wet evergreen
- Semi evergreen
- Moist deciduous
- Litoral & swamp
- Dry deciduous
- Thorn
- Dry evergreen

Moist

Dry

- Montane sub tropical- 3 groups
 - Broad leaved, pine, Dry Evergreen

- Monotone Temperate – 3 groups
 - Wet, moist, Dry

- Sub alpine – 1 group

- Alpine scrub – 2 group
 - Moist, Dry

- Nomenclature basis
- Climatic climax –C
- Edaphic climax –E
- Primary sere – 1S
- Secondary sere – 2S
- Tropical swamp – TS
- Fresh water swamps - FS

Classification of India Vegetation

- The best known complete classification of Indian vegetation is that of Champion (1938) modified in 1968
- This classification is based mainly on climatic feature of vegetation and is admittedly preliminary
- Climate paints the general picture, details of vegetation relates to their factor of habitat eg. edaphic factors etc.

- In champion system of classification
 - I. Tropical means no winter, no frost.
 - II. Sub-tropical means winter definite but not severe.
 - III. Temperate means frost rare winter pronounced with frost and some snow.
 - IV. Alpine means winter severe with much snow.

Classification of forest types

- **H.G. Champion and S.K. Seth (1968) classification of forests types is based on ecosystem.** This system is exclusively used in **forest management** and planning.
- **Champion & Seth divided forest vegetation of country into four major groups corresponding to four temperature based climate zone viz.,**
 - (i) Tropical**
 - (ii) Sub – tropical**
 - (iii) Temperate**
 - (iv) Alpine**

- Further division into **16 types** groups on the basis of **rainfall and morphological feature of vegetation.**
- Groups were divided into **subgroup and finally 221 ecologically stable** vegetation types were identified by them.

Classification continued..

- Champion & Seth suggested that Poly climax theory would fit the fact better than Mono climax and follow **Poly climax theory** in his classification.
- Reason for classification:- Classification should be available as standard of reference for researcher and forester.

- **Forest Types** defined by Champion & Seth as unit of vegetation which possesses (Broad) characteristic in physiognomy and structure sufficiently pronounced to permit of its differentiation from such unit.
- This is irrespective of physiographic, edaphic, or biotic factors. It is selected in first place subjectively from the ever varying cover of vegetation, with boundaries arbitrarily imposed on what are in fact gradual changes.

Classification continued..

- **The importance is placed on main tree layer or on the most emergent vegetation.**
- Distinction based on shrub and ground flora have necessarily been given a subordinate place.

- Major type groups are subdivided into types on a geographic basis since, a recognizable type group varies somewhat with locality owing to differences in floristic and minor variation in climate and site occurring with each group type.
- Units which are clearly associated with a definite site factor and differ appreciably from the prevalent type of surrounding area are referred **Edaphic type (E)**.

- In Edaphic type no exclusive emphasis is intended on special physical or chemical property of soil. On the other hand distinctive feature of site like micro-topographic, micro-climate, moisture, drainage factor effecting vegetation determining distinct vegetation were considered and (Climate factor) like **term wet, moist and dry** has been used while distinguishing various types with distinguishable vegetation.
- Taxonomic term have been excluded from the name of types whenever possible but certain species like bamboo, palms, pines, etc., which were dominant species have been used.

Contd

- In sub types genus, specific name of conspicuous dominant e.g. Mesua, Ban Oak etc., have been used.
- In plant communities, “**Plant Association**” has been defined as – the largest floristic unit consisting of a definite assemblage of species (usually with definite dominants and a definite habitat) and as being characterized by its definite floristic composition, life form, structure and habitat.

Classification of forest types as per Champion & Seth (1968)

(A) Tropical group has seven types

1.	West Evergreen Forests	Dense tall forest, 45 metres or even more high, entirely evergreen or nearly so. No species occurs gregariously. No individual species forms more than 1% of the upper canopy.	Dipterocarpus, Ar-tocarpus, Hopea, Dysoxylum, and Mesua.
2.	Semi-Evergreen Forest	Dominants include deciduous species but evergreen predominate. The general canopy is typically less dense than the true evergreen	Dipterocarpus, Ar-tocarpus, Terminalia, Albizzia, and Phoebea.

3.	Moist Deciduous Forest	Dominants mainly deciduous but sub-dominant and lower canopy largely evergreen. Canopy rarely dense and even but over 25 metres high.	Tectona grandis (teak) in south, Shorea robusta (sa) in north, Albizzia, Terminalia, Lagerstroemia, Gmelian, Pterocarpus and Dalbergia.
4.	Dry Deciduous Forest	Entirely deciduous or nearly so. Top canopy rather light and rarely over 25 metres high, usually 8-20 metres.	Teak in south, sal in north, Anogeissus, Terminalia, Madhuca and Diospyros.

5.	Littoral and swamp	Mainly evergreen, or varying density and height, but always associated predominantly with wetness	
6.	Thorn Forest	Deciduous with low thorny trees. Canopy more or less broken. Height under 10 metres.	Prosopis, Acacia, Calotropis, Salvadora and Euphorbia.
7.	Dry Evergreen Forest	Hard leaved evergreen trees predominate with some deciduous emergents, often dense, but usually under 20 metres high.	Manikara and Mimusops.

(b)Sub-Tropical Group has three type groups :

8.	Sub-tropical. Broad Leaved Hill Forest	Broad-leaved, largely evergreen high forest.	Calophyllum, Cinnamomum. Castanopsis, Schima and Michelia.
9.	Sub-tropical Pine Forest	Pine associations predominate.	Pinus roxburghii (in west) and Pinus insularis (in east)
10.	Sub-tropical Dry Evergreen Forest	Low xerophytic forest and scrub	Olea cuspidata and Acacia madesta.

(C) Temperate Forest comprise three type groups:

10	Montane Wet Temperate Forest	Evergreen forest mainly oaks and conifers.	Cedrus deodara (Deodar), Abies pindrow (Fir), Quercus (Oak), Picea smithiana (Spruce).
12	Himalayan Dry Temperate Forest	Open coniferous forest with sparse xerophytic undergrowth.	Pinus wallichiana, Pinus gerardiana and Quercus ilex in West, and Picea spinulosa, Pinus wallichiana and Betula in east.
13	Himalayan moist temperate		

(D) Alpine has 3 types:

13.	Sub-Alpine Forest	Stunted deciduous or evergreen forest usually in close formation, with or without conifers.	<i>Picea smithiana</i> and <i>Abies spectabilis</i> in west, and <i>Abies densa</i> and <i>Betula utilis</i> in east.
14.	Moist Alpine Scrub	Low but often dense scrub.	<i>Betula utilis</i> and <i>Rhododendron camanulatum</i> .
15.	Dry Alpine Scrub	Xerophytic scrub in open formation.	<i>Juniperus communis</i> and <i>Juniperus wallichiana</i> in west, and <i>Juniperus recurva</i> in east. ⁵¹

- **The following seven type-groups are recognized:-
TROPICAL FORESTS**

1.	Wet evergreen forests	Dense tall forest, entirely evergreen or nearly so.
2.	Semi-evergreen forests	Dominants include deciduous species but evergreen predominate.
3.	Moist deciduous forests	Dominates mainly deciduous but sub-dominants and lower storeys largely evergreen. Top canopy rarely dense and even, but over 25 m. high.
4.	Littoral and swamp forests	Mainly evergreen, or varying density and height, but always associated predominantly with wetness.

5	Dry deciduous forests	Entirely deciduous or nearly so. Top canopy rather light and rarely over 25 m. high, usually 8-20 m.
6.	Thorn forests	Deciduous with low thorny trees and xerophytes predominating. Canopy more or less broken. Height under 10 m.
7.	Dry evergreen forests	Hard leaved evergreen trees predominate with some deciduous emergents, often dense, but usually under 20 m. high.

Edaphic Pre – climaxes Types

A.	Littoral Forests	On coastal sand, usually seral to 1 or 2 and somewhat resembling 2.
B.	Tidal swamp forests	On estuarine, seral to any of the other types.
C.	Freshwater swamp forests	On wet alluvium seral to 1-3 or 5 and resembling 2.
D.	Seasonal swamp forests	On wet alluvium in which the seasonal submersion is the dominant influence although the soil may become relatively dry for part of the year.
E.	Riverain fringing forests	Along stream sides where subsoil water is available throughout the year.

MONTANE SUBTROPICAL FORESTS

1.	Subtropical broadleaved forests	(Southern and Northern forms). Broad-leaved largely evergreen high forest.
2.	Subtropical pine forests	Pine association predominate.
3.	Subtropical evergreen forests by	Low xerophytic forest and scrub.

MONTANE TEMPERATE FORESTS

1.	Montane wet temperate forests	Evergreen forest without conifers.
2.	Himalayan moist temperate forests	Evergreen forest, mainly sclerophyllous oaks and conifers.
3.	Himalayan dry temperate forests	Open coniferous forest with sparse xerophytic undergrowth.

SUB-ALPINE FORESTS

1.	Sub-alpine forests	Stunted deciduous or evergreen forest usually in close formation with or without conifers
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ALPINE SCRUB

1.	Moist alpine scrub	Low but often dense scrub.
2.	Dry alpine scrub	Xerophytic shrubs in open formation.

Burtt Davy's classification for tropical vegetation (1938)

1. Davy classification is for India & Burma Vegetation.
2. His main unit of vegetation is formation types, to be made up of a number of associations.
3. Formations are group of plants, such as a forest meadows, that has a fixed physiognomic characters and is considered to be stable.
4. Formation are of two kinds-
 - (a) Climatic formation controlled by climate over large area and may or may not be climax.

- (b) Edaphic formations, as controlled by some feature of the soil in small areas, in discontinuous patches.
- Edaphic formations are subordinate to climatic climax and since they remain more or less stable, as long as the particular edaphic environment remains.
 - They are necessarily seral to the climatic climax they are called edaphic climaxes as they do not show a proof of rapid changes.

5. Burt Davy classify formations types into:-

(i) Wood land – formations which have dominate tree plants. Commonly found in India.

(ii) Grassland – grassy formation mostly devoid of tree and shrub.

- This formation is absent in India as Indian grasslands are all seral being biotic or bio-edaphic communities.

(iii) Desert – vegetation type of stunted tree or shrub unit, annual or perennial herbs.

- This is also not found in India as climatic climax.
- Indian deserts are bio-edaphic or biotic.

(iv) Tropical woodlands – 2 types

(i) Moist woodlands

(ii) Dry woodlands

Limitation of champion's classification

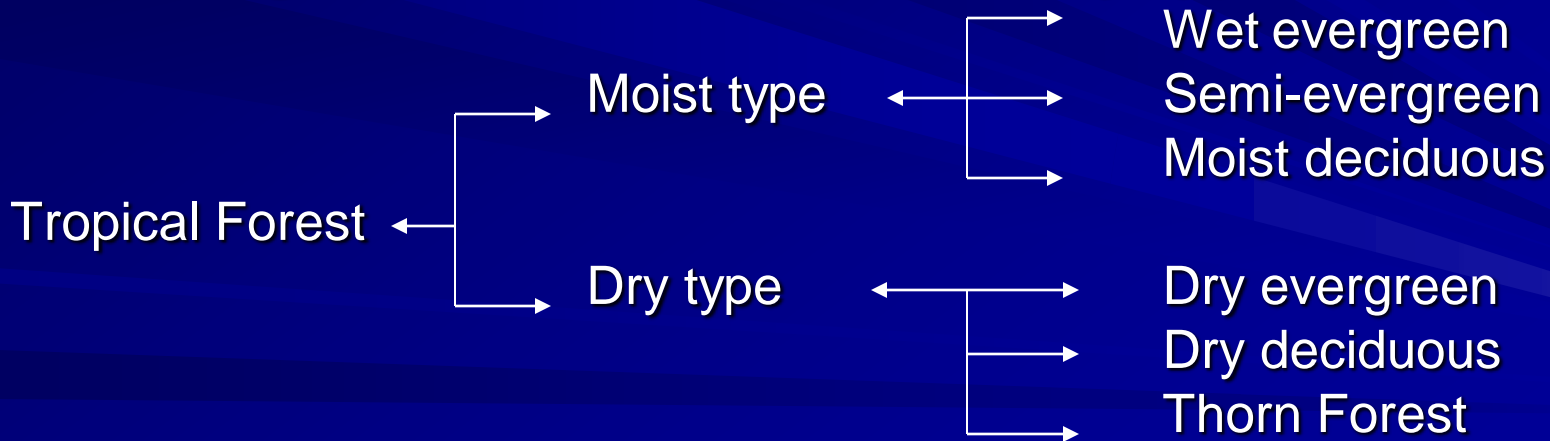
1. Latitudinal differences in vegetation witnessed in Europe is not visible in India.
2. Some types considered by champion as climatic are really edaphic or biotic or both
 - Forest developed in N.E. in shifting cultivation area.
3. Rainfall pattern and its effect on soil development in Himalaya gives impression of wet climate and moist temperate forest is not humid and they may be classed with tropical types.
4. Tropical forest of India is different from other countries in composition.

Limitation of champion's classification

5. Some of Himalayan forests and Nilgiris - shown as montane temperate which has been objected by Burtt Davy (1938) who classified them as tropical vegetation.
6. Edaphic climate used by champion like Beach forest, Tidal forest, Swamp forest, riverian forest are pre-climaxes or sub climaxes as per Burtt Davy.
7. Biotic influences has been neglected by champion like Shifting cultivation, fire, grazing which has influenced vegetation to great extent.

Tropical Forest of India

- Tropical Forests developed over most of country excepting **Himalayas** and **hills of Peninsular India above 3000 feet altitude**.
- Depending on dominant tree species, climatic factor and rainfall tropical forest are distinguished into moist and dry types.



(1) Moist Tropical Wet evergreen Forests

- Typically **rain forest of India** with rainfall above 2500 mm.
- Consists of **very tall trees**
- Usually above 150 ft. (50 mt.) forming dense canopy with luxuriant ground vegetation.
- Andamans, Western coasts, North Kanara, Anaimalai, Coorg, Assam.
- These forests are **climatic climax**.

(1) Moist Tropical Wet evergreen Forests contd..

- Forests are generally not differentiated into various strata because of growth pattern.
- Palms, canes, climbers are in abundance.
- Grasses are absent in these forests. Bamboos are present.
- Cane brakes usually replace High forests along streams.
- Trees have smooth bark and plank buttresses.
- Epiphytes are in abundance.

Succession in Moist Tropical wet evergreen forests



Champion recognizes cane brakes, wet bamboo brake, tihal, Riverian Forests as edaphic community.

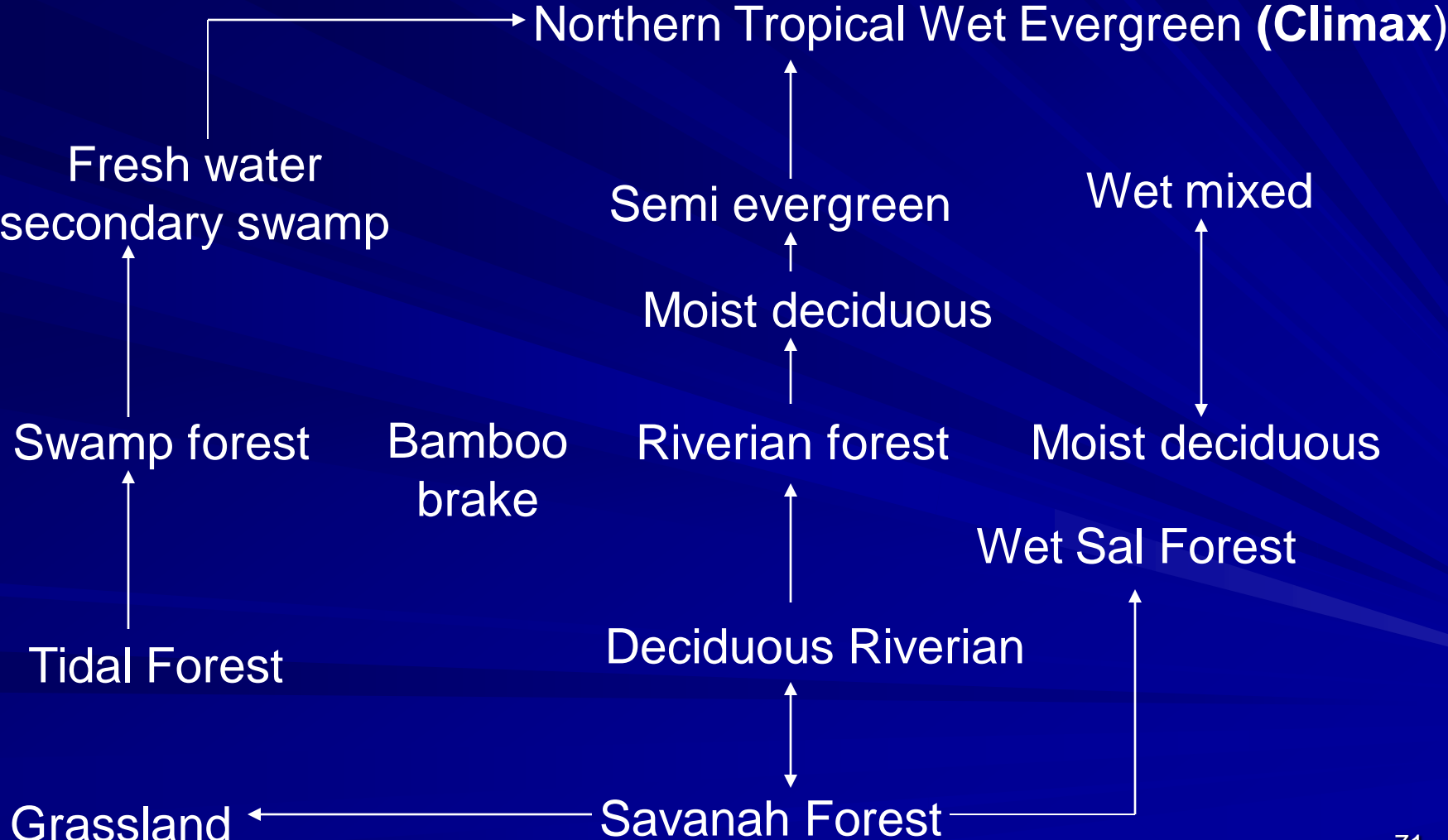
3) As per champion **evergreen** type is **truly climax**.

- Deciduous types are degraded which changes to evergreen climax through semi evergreen communities when biotic factors are excluded.
- He consider **semi evergreen or deciduous type as bio-edaphic** communities.
- Further **riverian, beach, tidal, swamp as seral stages**.
- The seral stages are bio-edaphic in nature and get preserved. Hence they are called Edaphic types.

4) Puri recognizes following formations in moist wet evergreen forest:-

- a) Dipterocarpus – Mesua – Michelia
- b) Cinnamomum – Mesua – Michelia
- c) Mesua (as post climax) in Balipare
- d) Bischofia – Dillenia
- e) Shorea – Dillenia - Lagerstroemia

5) As per champion succession in Northern Tropical wet evergreen forest are :-



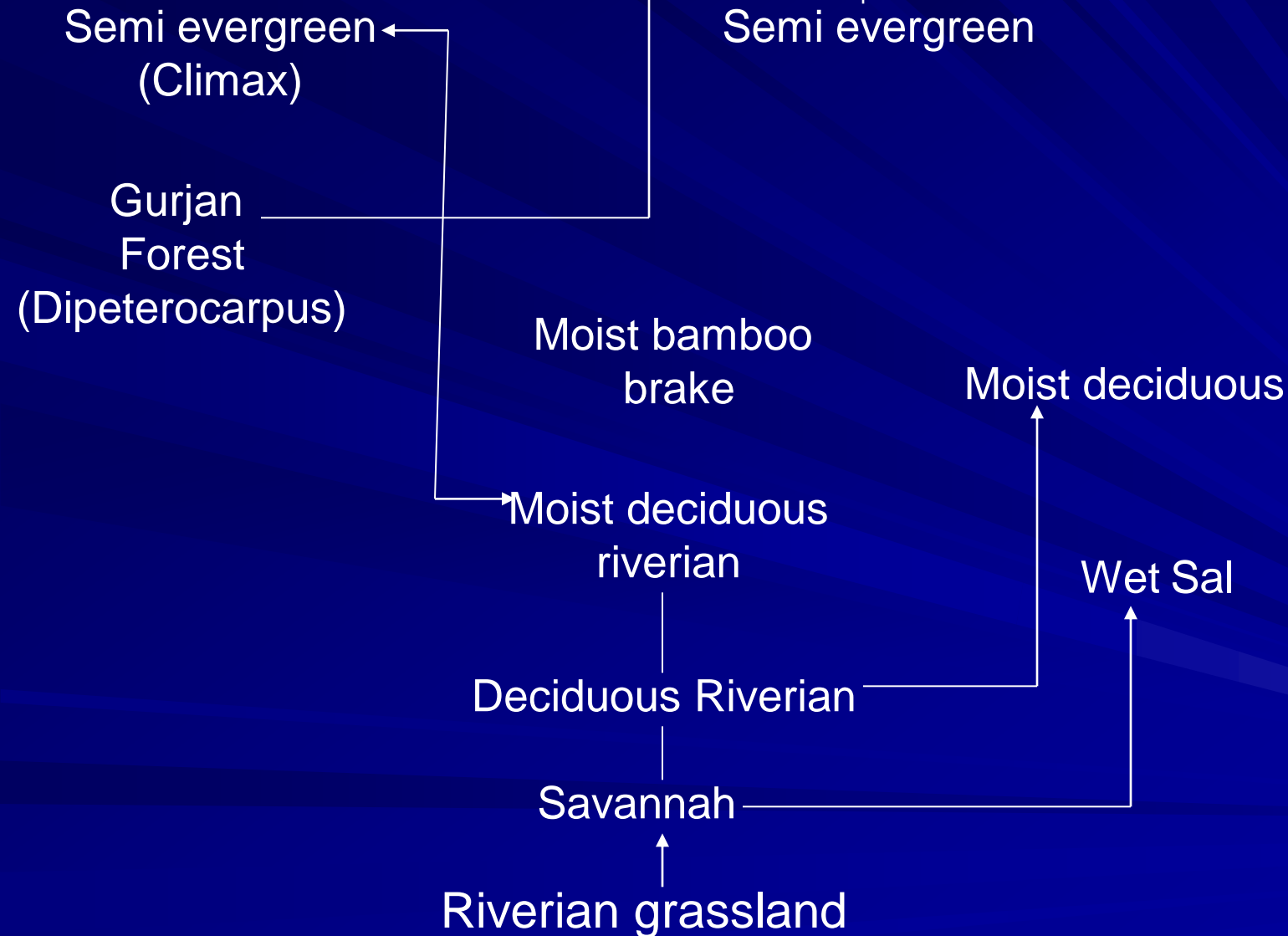
2. Moist Tropical Semi Evergreen Forest

- This is **intermediate** between tropical evergreen and tropical moist deciduous forest type.
- Have **deciduous** and **evergreen** tree both
- Undergrowth evergreen, climber and bamboo present.
- **Climax occurs in Western ghats.**
- Common species are Xylia, Terminalia, Dipterocarpus, Hopea, with evergreen species in middle canopy.

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■ Succession as per champion are-

Tropical wet evergreen (Climax)



Tropical moist Deciduous Forest

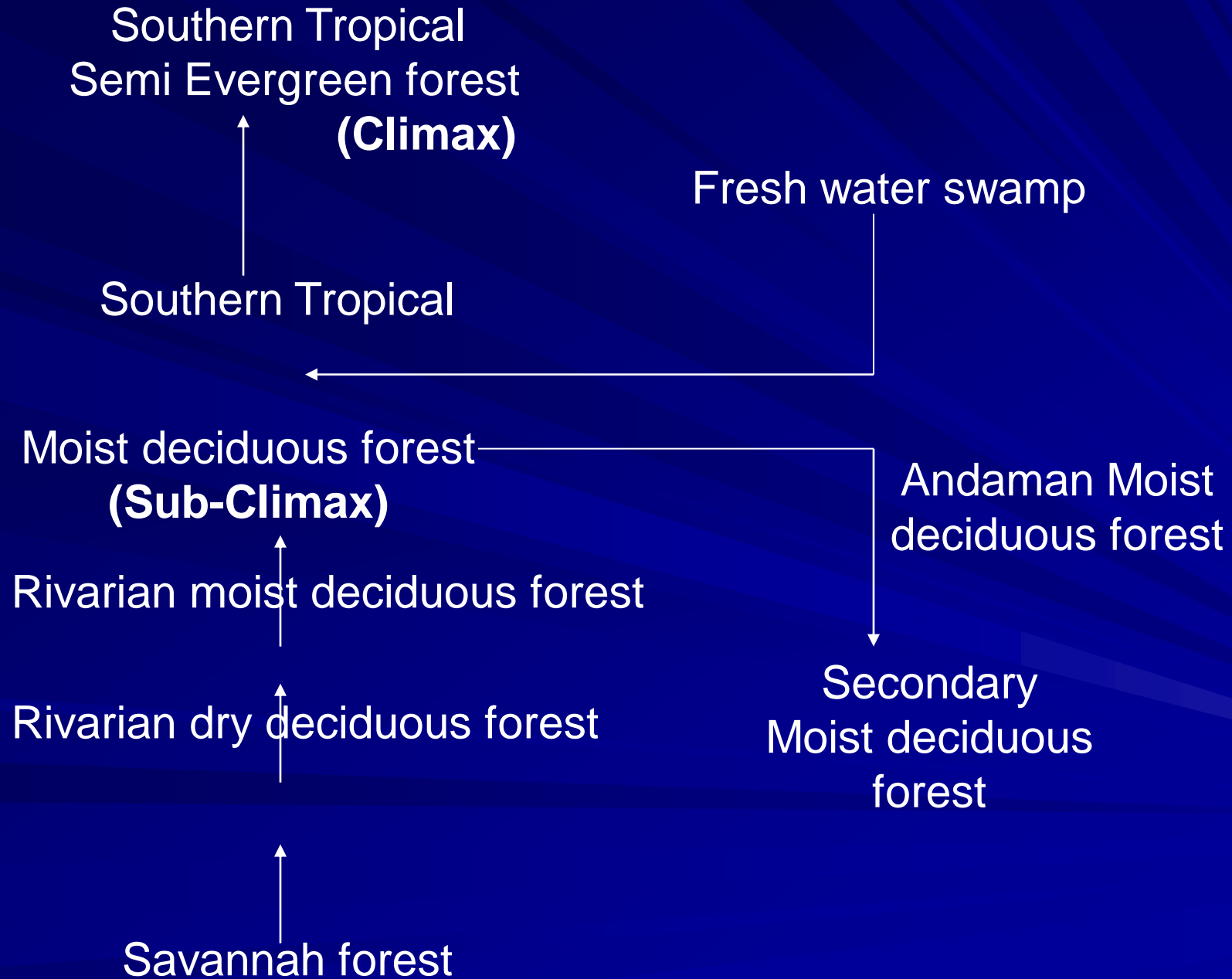
- In moist deciduous forest species remains deciduous only for **short time** and number of evergreen dominantes are also present
- The **evergreen** are mostly in under storey and general nature of forest is **deciduous**.



1. **Southern Tropical moist deciduous forest** are distributed in West coast of Kanara, Coorg, Wynad, Nilambor, Part of M.P., Anadammans. This type include **Teak forest of India.**

- Important species are **Teak, Dalbergia, Cedrela toona, Terminalia tomentosa, Adina, Bombax, Sterculia**
- **Bamboo in abundance**

•Succession pattern in Southern Tropical moist deciduous forest as per champion



- As per champion **Tropical moist deciduous forest** is in subclimax to tropical Semi-evergreen type. Champion also consider **tropical moist deciduous** type in late **seral stage** of fresh water swamp forest, riverian dry and riverian moist deciduous type.
- As per clement, **swamp and riverian type** is **edaphic** type as they are influenced by edaphic feature than the climate.

Teak forest of India

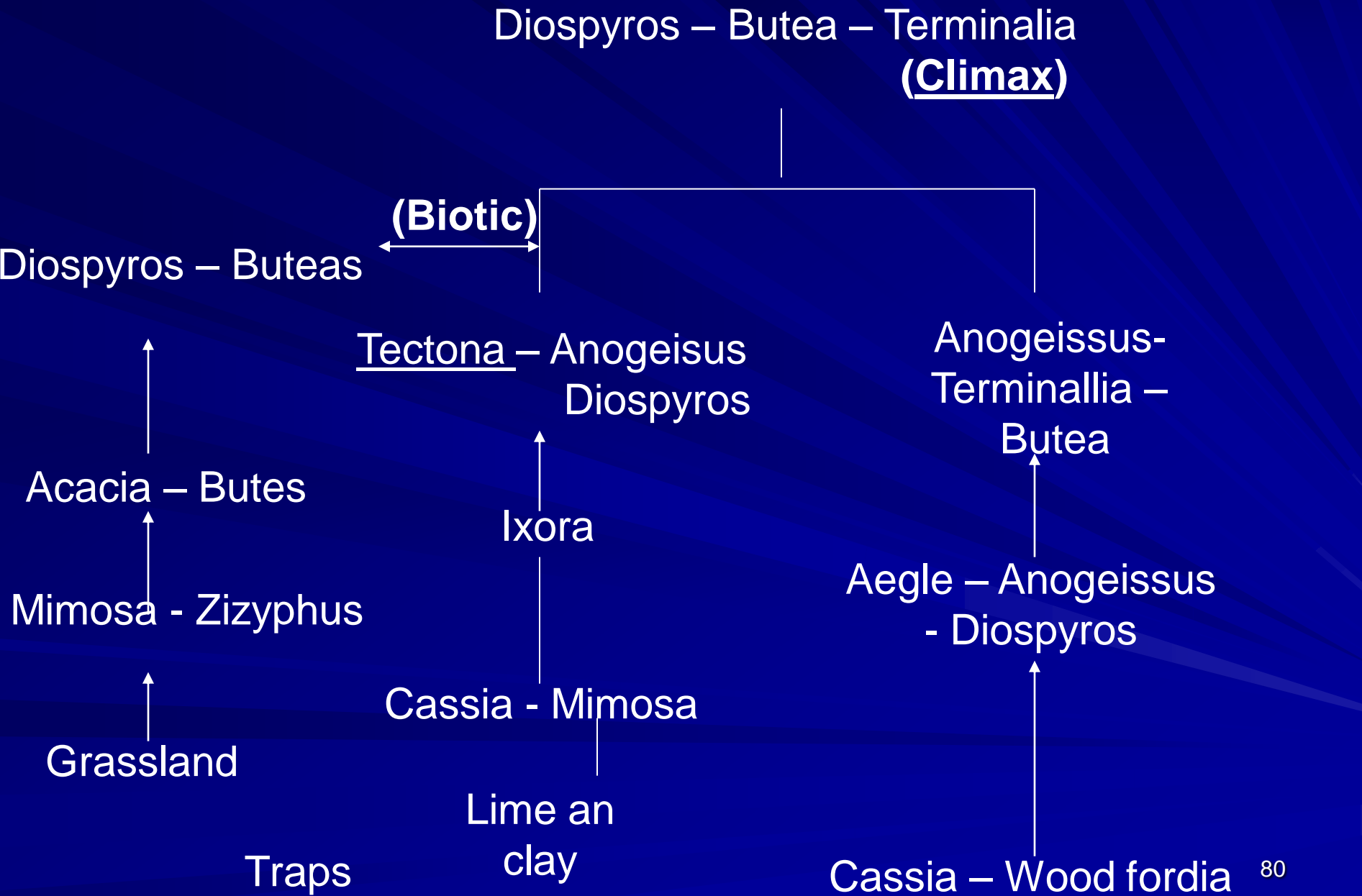
- Distribution of teak has correlation with presence of calcium content in rock and soil (Puri 1951). Soil phosphate also regulates abundance of teak.
- Teak is best developed on deep alluvial Soil forming pure patches (Champion). It avoid crystalline rock and sterile sand stone and laterite.
- Widely distributed in M.P., Maharashtra, Gujarat, Karnataka and U.P, UAA

Teak forest of India

- Common associate Terminalia tomentosa,
T. Belleirca Lagerstroemia parviflora,
Anogeissus latifolia, Delbergia latifolia,
Pterocarpus marsupium, Gmelian arbores.
- The common bamboo associate is
Dendrocalamum strictus.

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■ Succession of forest communities in teak forest Mishra and Joshi in Sagar forest of M.P.



Butea – Termianalia – Tectona – Eugenia
(Post Climax)



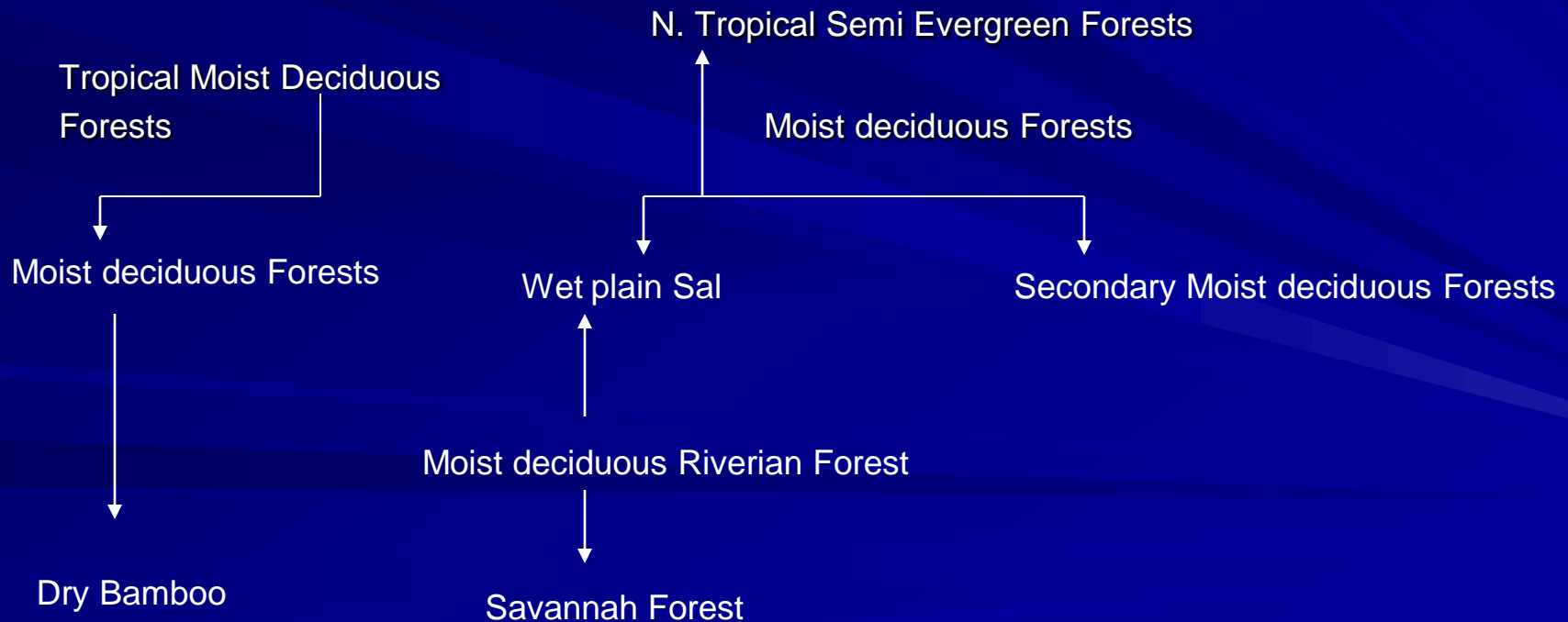
Woodfordia - Anona
Streams

Sandal Forest

- South Indian and part of M.P
- Lalitpur district of UP – Bar- plantations
- Semi evergreen type which changes in deciduous type.
- Semi parasite in initial stages
- Associate of Sandal, *Diospyros montana*, *Zizyphus*, *Cassia fistula*, *Albizzia*.
- Prefer hot climate, grows in poor and gravelly soil in scrub forest.

Northern Tropical Deciduous Forests

- UP, Bihar, Orissa, M.P, WB, Assam
- Includes most important species Sal
- Sal is gregarious species forming pure patches of Sal forest .
- Succession in Northern Tropical Moist deciduous forests are:-



Continued

■ Sal is dominant species and climax vegetation except in moist Forest of Bengal & Assam where they represent probably seral communities.

■ Quality of Sal :-

UP	-	III or IV
Bengal	-	I or III
Assam	-	II or III (Easter Bhabar – I)
Bihar, Orissa	-	II or III
MP	-	III or IV

Contd

- After study by Troup (1921), Champion (1933), Mooney (1941), Hewetson (1954), Puri (1951) **ecological status of Sal is not clear as whether it is climax? Champion consider that in some part of Bihar & Orissa only it is climax.**
- As per Puri **Sal in Central Province is edaphic. association Shorea – Eugenia. Further Shorea – Anogeissus latifolia_ is an unstable seral community.**
- As per Puri Sal in Kanha is **post climax.**

Montane Sub -Tropical Forests

- Intermediate between tropical and temperate forests.

- Montane Sub tropical Forests



Contd

- 1) **Southern subtropical forests e.g.**
 - Mahabaleshwar Forest
 - Subtropical Forest of Coorg.
 - Subtropical Forest of Central India (Bastar)
- 2) **Northern subtropical wet forest e.g.**
 - Eastern Himalaya (Kalimpong, Darjeeling, Assam Valley, Aka hills in Assam)
 - Subtropical Pine forest (Mussoorie) Chir pine forest of Garhwal Himalaya, Kangra, Mandi.
 - As per Coventry (1929) **Olive Forest (*Olea cuspidata*) and mixed forest are climax in subtropical dry evergreen forest.**

Temperate Forest of India

- Champion uses the term temperate forests that occurs on mountains either in South India above 5000 ft. or in Himalayas above 5000ft.
- The term temperate is used, though climate is not typically humid as found in true temperate forests in Northern Hemisphere.
- Burtt Davy classify them as tropical forest.

Himalayan Moist Temperate Forest

- Characterized by **Oaks and conifers** in north western parts.
- In Himalayas **Oaks** are predominates on **southern** scrap slopes and conifers
- **Mixed Oak - conifers** forests are the characteristic of **northern dip slopes**.

- **Luxuriance** of ground flora is dependent on intensity of **grazing and soil moisture**.
- Tree branches are covered by mosses, especially in Oak Forest.
- There are very few grasses.
- Indian temperate forests occurs on mountains above **5000 ft.** altitude.

Main Types of forests in the western and the eastern Himalayas.

Western Himalayas

Eastern Himalayas

Broad leaved forest.

Rhododendron campanulatum, *Betula utilis*, on sheet rock and thin dry moraine.

Q. semecarpifolia on scarp slope of schists and stablised scree masses with a dry head.

Q. Dilatala on flood plains of fine granite or scree masses with wet head.

Coniferous forest.

Abies webbiana on moraines. *Junipers* on sheet rock.

Abies pindrow on moraines or dip slope of schists, etc. *Pinus excelsa* on scrap slope of schist or rearly seral stages on moraines.

Abies pindrow, *Picea morinda*, *Cedrus deodara* on flood plain deposits, dry or moist.

Coniferous forest.

—

Abies densa on glacial moraine s.

Picea spinulosa, *Tsuga brunonia*.

Broad leaved forest.

Rhododendron spp., *Betula utilis* on sheet rocks.

Q. pachyphylla on stabilized soils mainly developed *in situ*.

Q. pachyphylla, *Q. lamellosa*, on well developed soils.

Main Types of forests in the western and the eastern Himalayas.

Western Himalayas

Eastern Himalayas

Broad leaved forest.

Q. Incana on quartzite, schists, limestone, scree and flood plain deposits, also in the Siwaliks on sandstone.

Q. Ilex on granite or other rocks in inner valleys.

Coniferous forest.

Cedrus deodara on abandoned cultivation, dip slopes of schists, dip slopes of schists, *Pinns excelsa* on scarp slopes, *Pinus roxburghii* on quartzite, sandstone, also the Siwaliks.

Pinus geradiana on flood plain deposits, abandoned cultivation in inner valleys.

Coniferous forest.

Tsuga brunonia

A little *Pinus roxburghii* on quartzite *P. khasya*, etc.

Broad leaved forest.

Q. lamellosa,
Q. lineata.

Southern Wet Temperate Forests

- These forests are developed in Nilgiris, Anaimalai, Palani and Tirunelveli above 5000 ft. and popularly called “Sholas”.
- **Sholas are evergreen forests of close canopy with tree having 50 to 60 ft. height.**
- Tree trunks are covered with epiphytic ferns mosses and climbers.
- **Canopy in the forest are not differentiated into layers.**
- Shola develops on shelter sites of steep slopes.

- Common species in shola forest are Hopes, Balanocarpus, Artocarpus, Bombax, Eleocarpus, Myristica etc.
- **As per Rangnathan (1938) Sholas are distinct climatic climax.**
- **Champion (1938) also recognizes shola as climatic climax**
- Rhododendron arboreum is very common in Nilgiris. This is very common species in Himalayas, hence it supports **Satpura Hypothesis.**

Northern Wet Temperate Forest

- Northern Wet temperate Forest are developed in East Himalayas (also in Assam) at altitude of 6000 – 9000 feet.
- There are number of deciduous species in these forest.
- **Oaks** forms gregarious patches.
- Magnolia, Acer are common features in these forest.

- Snow ranges constitute alpine vegetation but outer Himalayas between 6000 to 12000 feet has temperate vegetation.
- Altitudinal zonation are :-
 - (a) **Machilus – Michelia** (6000 – 7000 feet)
 - (b) **Quercus** (7000 – 9000 feet)
 - (c) **Rhododendron arboreum** (above 9000 feet)
 - (d) **Abies, Juniperus, Betula** (Above 13,000 ft.)

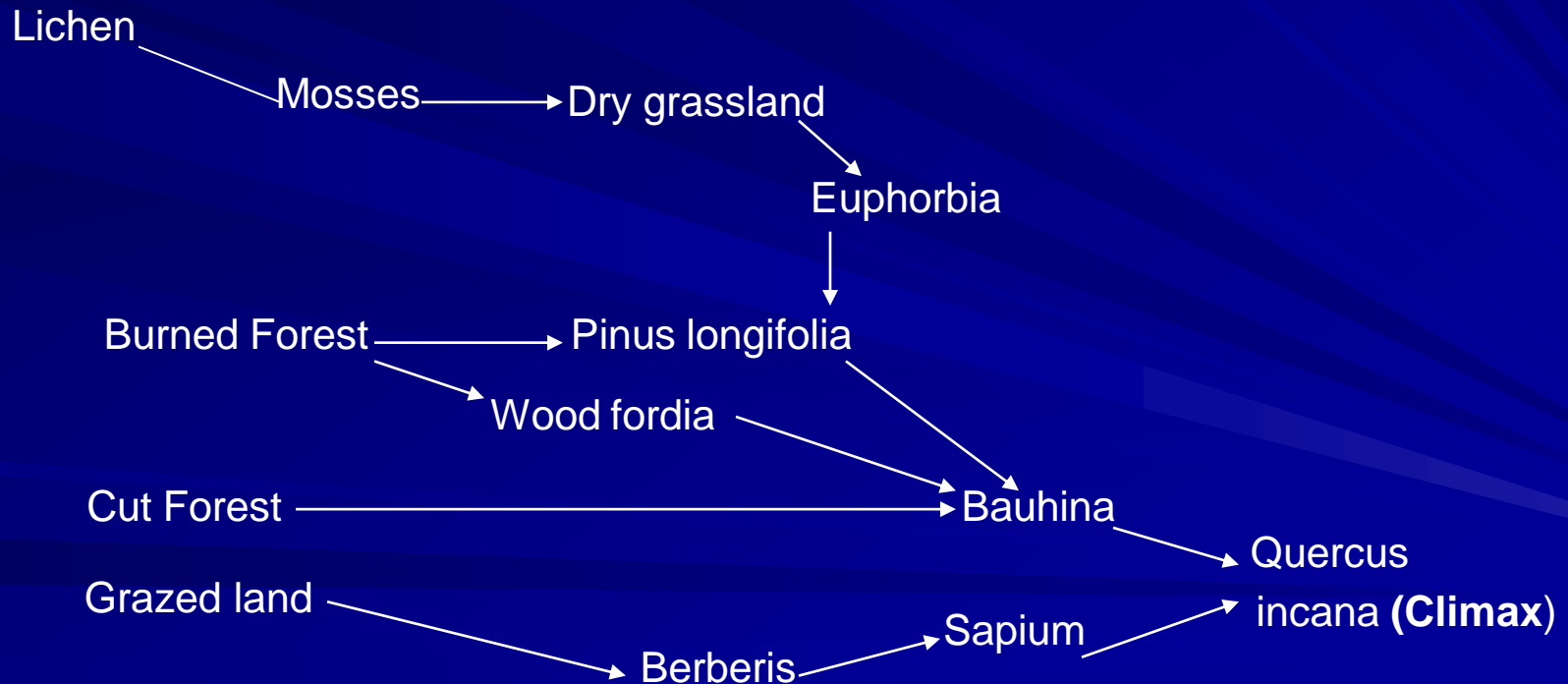
Succession in Temperate Forest

- **Cedrus deodara is an edaphic community and not climax (Champion 1938)**
- **Pinus roxburghii is an edaphic climax on quartzite.**

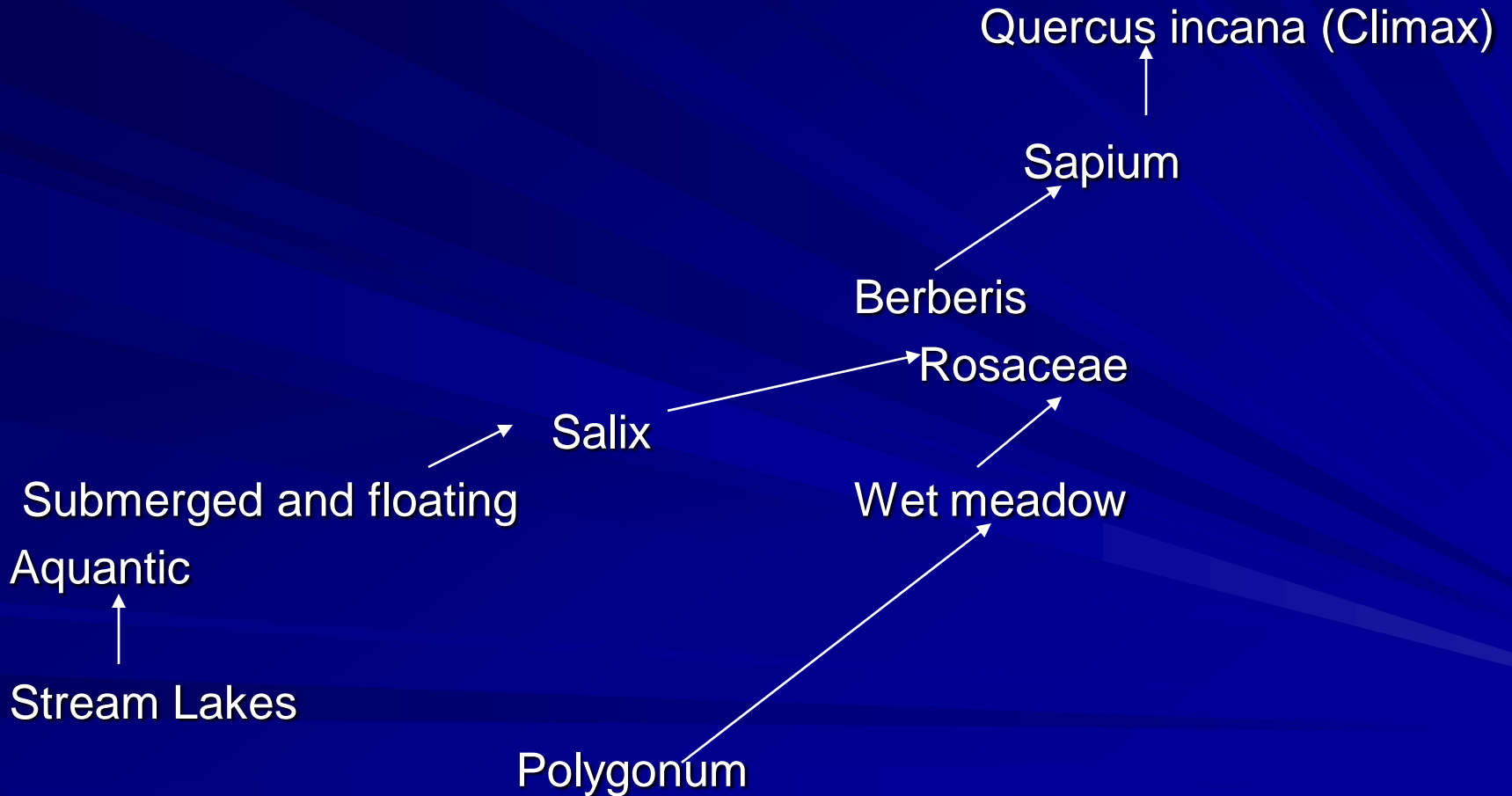
Succession in Temperate Forest

- As per Kenyon (1921) succession in Kumaon Himalaya are two types:-

(a) Xerarth succession



(b) Hydrach Succession



Contd.....

- 4) As per Osmaston (1922) temperate vegetation in Garhwal area are:-
 - (a) Pinus – Cedrus formation on dry and arid zones
 - (b) Quercus – Abies formation in moist zone

Pinus – Cedrus formation is a secondary succession and in seral community in Garhwal.
- 5) As per Coventry (1929) temperate vegetation in Himalayas.
 - (i) Blue Pine (*Pinus excelsa*)
 - (ii) Deodar
 - (iii) Mixed forest of Walnut, Chest nut, Prunus
 - (iv) Oak forests of *Quercus diletata*.

4) As per Osmaston (1922) temperate vegetation in Garhwal area are:-

In temperate region :-

- Picea (Spruce)
- Silver Fir (Abies pindrow)
- Mixed broad leaves
- Oak (Quercus semicarpifolia)

Contd

- 6) Mohan & Puri (1939) – **Conifers are seral stages and not climax vegetation** and **climax is Oak forest** in those area. They are bio-edaphic community and represents secondary succession and tend to develop into a stable pure Oak community if adverse biotic influences are removed.
- 7) Due to intense biotic interference pure blue pine and pasture land have developed.

Succession in *Quercus incana* zone

- 1) In ban Oak zone pure ***Quercus incana*** is the **stable climax community**.
- 2) *Pinus excelsa*, *Picea smithiana*, *Pinus roxburghii* invades this area forming mixed **conifer Oak** community which represents **secondary succession**.
 - This would have developed into **climax Oak forest**, if biotic factor is excluded.
- 3) Places where *Q. incana* has been lopped heavily, secondary scrub of wet or dry type develops.
- 4) ***Pinus roxburghii*** on quartzite formation is either progressive to **Oak climax**.

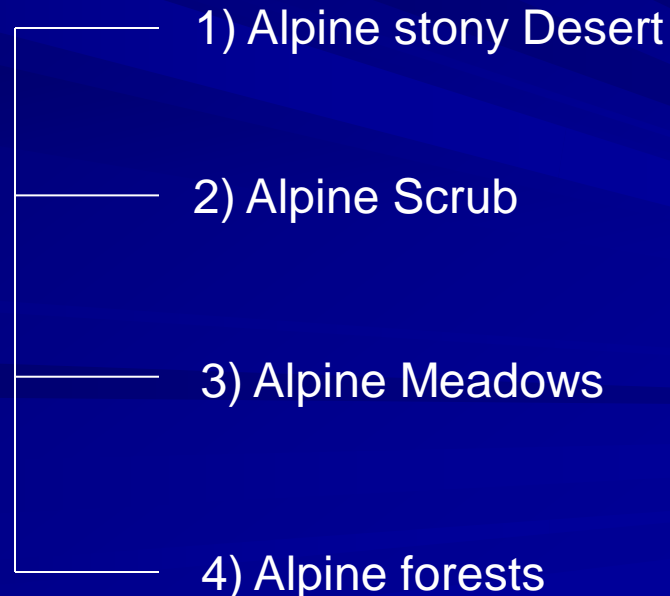
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- 5) Mohan & Puri (1955) have recognized following forest communities in climax in Himalayas.
 - (a) **Quercus - ilex** in inner dry valley of Sutlej
 - (b) **Cedrus deodara – Quercus- ilex** on deposits of granite in Sutlej valley.
 - (c) **Quercus- ilex scrub** in heavily felled rocky area.
 - (d) **Quercus– Pinus gerardiana – Quercus- ilex** in grassy valley of Sutlej.
 - (e) **Cedrus deodara – P. gerardiana – Quercus** near Purbani flood plains (HP)

Alpine vegetation in India (Evaluation and Ecological Status)

- Occurs above 10,000 ft. altitude in Himalayan mountains.
- Other species is climatic climax while alpine meadows status is doubtful.

Alpine Vegetation



1.) Alpine Stony Deserts

- Occurs little below snow between 12000 – 14000 feet
- Species found are lichens like Saxifraga
- No record of flowering plant

2.) Alpine Scrub

- 10,000 – 12,000 ft.
- Rhododendron, Junipers, dwarf willow (Salix)-very common.
- Berberis, Poa, Polygouum, Acer, Picea, Tsuga, Abies,
Juniperus, Betula.

3.) Alpine Meadows

- Above alpine scrub zone are alpine meadows
- Herbaceous alpine vegetation
- With increasing altitude, some plant, show reduction in size
- Chenopodium album (8-9 feet in plain while 1 or 2 inch at 14000 feet)

- Many plants become larger, bearing large flower at high altitude like Anemone rivularis
- In case of Euphorbia tibetica flower bud or fertile shoot are replaced by vegetative shoot above 10,000 feet
- In Rhododendron lepidotum above 12000 feet in Sikkim area, flower bud is replaced by a tuft of red leaves.
- Many polypoids are recorded in alpine habitat.

- The species common are Anemone, Ranunculus,
- Delphinium, Aconitum, Saxifraga, Epilobium, Morina, Geranium in Kashmir Valley and other parts of Himalayas.
- Alpine plants usually have few annuals and the perennials have a long tap root with woody root stock
- Remain alive during unfavorable season, they have hairy leave of small size and cushion shaped ,flowering carpet line structure.

4) Alpine Forest

- Alpine forests of Himalays are classified by champion and seth into two climax types
Alpine fir – birch forest and Birch
Rhododendron forests
- (1) Alpine –birch forests – dominant tree *Abies*,
Pinus excelsa
 - Second storey – Betula, Quercus semi
carpifolia, Pyrus, accuparis,
 - Scrub layer is of Rhododendron
 - Ground layer is of Smilax, Strobilanthes,
Polygonum

(5) Birch – Rhododendron forests

- In Birch – Rhododendron forest Betula is only tree species
- Except Quercus semicarpifolia which may be present in some places.
- Second story – Rhododendron
- Shrub storey – Berberis, Lonilera
- Ground flora - Primula

Ecological status and successional relationship in Alpine vegetation

- In Alpine vegetating following distinct type can be recognized in Himalayas.
- (1) Stoney deserts – developed on rock substrata having vegetation of lichens eg. Saxifragas, Sedum, Androsace. Plants are cushion shaped and it appear that this type is climatic climax at these altitudes.
- (2) Alpine scrub – Two types alpine scrubs recognized by champion viz. moist and Dry types.
- In moist type Rhododendron predominant and developed on schists or other rock which do not have high calcium. This appears to be climatic climax but seems to be controlled by edaphic feature and nature of underlying rock than by climate

Ecological status and successional relationship in Alpine vegetation contd.

- In dry type is dominated by Junipers which are developed on limestone rock. This type also seem to be edaphic community.
- Hence in moist type Rhododendron and dry type Junipers can not be called climatic climax with certainty.

(3) Alpine meadows – developed on two types of habitats viz glacial moraines and other types of soil in situ or transported by glacial nalas. Both are degraded from alpine forest and are bio-edaphic communities.

(4) Alpine forests – Alpine forests are two types based on there habitat

(a) Silver fir- Birch community developed in glacial moraines and has preponderance of mixture of broad leaved species. Silver fir is in abundance and have Pinus excelsa as colony.

- Champion advocate this as climatic climax.
- Puri (1939) consider this as edaphic community, which may not reach climax stage as long as moisture available from glaciers.
- H.P. Mohan (CCF) consider Betula as climatic climax of this habitat.

(b) Birch – Rhododendron community develop on rocky substrata.

– Champion consider this as bio-edaphic and not climatic climax.

– Preference of Quercus semicarpifolia indicates that climax of such community would be Q. Semi carpifolia.

Edaphic Forest in India

- Edaphic controlled forest communities are well represented in India.
- The main soil factor for development of vegetation in India is **moisture content through minerals and plant food like nitrogen and phosphorus.**
- Edaphic type – **Mangroves, Swamp, riverian.**

(1) Riverian Forest

- (i) Lagerstroemia – Terminalia along large river new alluvium.
- (ii) Bombax – Albizzia forest on river bank open type.
- (iii) Acacia – Dalbergia on bank of river where water goes under
- (iv) Pterospermum – Terminalia on river bank of upper Assam, well drained near alluvium.
- (v) Terminalia – Pholebe low land river bank.
- (vi) Cane brakes in evergreen & semi evergreen
- (vii) Bamboo brakes in Northern Moist Forest

Continued

- (viii) Khair – Sissu forest in newly sandy or gravelly alluvium in Punjab, UP, Bihar, WB, Assam and Doon Valley.
- (ix) Aegle (Aegle marmelos) forest in drier Gangetic plains.
- (x) Southern wet bamboo brakes on streams or on badly drained hollow in Southern tropical wet evergreen forest of South India.
- (xi) Inundation babul forest in Central India.
- (xii) Pinus roxburghii on quartzite and riverian soil in Parbati Valley, Kullu.

(2) Mangrove Forest

- Found in deltas of Chief river system i.e. Ganga, Brahmaputra, and Indus.
- On alluvial deposits of tidal inundation.
- (a) Beach forests of Andamans, Sunderbans along Sea-face in WB,
- Orissa, TN, Karnataka, Kerala, Maharashtra.
- Common species of Mangrove – Bruguiera, Rhizophora, Avicennia, Ceriops,
- Avicennia- kakinada- Andhra Pradesh- natural regeneration – water borne seeds

(b) Tidal Forest in deltas of Gangas and Brahmputra

■ Champion classify tidal forest into :-

- (1) Low mangrove forest e.g. river delta of east-coast.**
- (2) Tree mangrove forest e.g. river delta of east cost-
Andamans,Sunderbans**
- (3) Salt water Heritiera forest like river delta with
blackish water.**
- (4) Fresh water Heritiera forest like delta of Ganges.**

(b) Tidal Forest in deltas of Ganges and Brahmaputra - contd.

- (5) Osmotic and suction pressure of mangrove species rise from roots towards the leaves.**
- The osmotic pressure of mangrove plant is very high as compared to other plant, plant do not experience any difficulty in absorption of water.**
- The plant absorb salt in sea water which increases osmotic pressure of cell sap.**
- (5) Succession of vegetation in mangrove swamp depends on disintegration of rock, soil salinity, soil humidity and biotic factor.**

(3) Terrestrial Edaphic forest communities

- (i) Moist sal in north Indian moist deciduous forest.
- (ii) Terminalia tomentosa in sal in north Indian moist deciduous on heavy clayey soil in valleys.
- (iii) Eastern Himalayan moist deciduous forest in foot hill of Himalaya in Bengal and Assam.
- (iv) Wet plain sal in terai Bhabhar.
- (v) Bamboo brakes in moist hill forest of Assam.
- (vi) Moist deciduous sal forest in Shivalik clay inter bedded with conglomerate.
- (vii) Sal forest on red clayey soil in Central India.
- (viii) Dipterocarpus in Western ghats.
- (ix) Teak on basaltic soil in Penninsular India.

Contd

- (x) Coastal sal of Ganjam (Orissa).**
- (xi) Xylia xylocarpa in western Semi-evergreen forest.**
- (xii) Acacia catachu in Deccan.**
- (xiii) Bamboo brakes in moist temperate forest of Himalaya.**
- (xiv) Blue pine in drier track of Kashmir and HP.**
- (xv) Chir pine on Shivalik conglomerate.**
- (xvi) Chir pine on Shivalik Sand stone.**
- (xvii) Abies on glacial moraines in Himalaya.**
- (xviii) Deodar forest in flood plain deposits above 4000 – 10,000 feet in Himalayan river.**

Biotic Forests of India

- **The secondary succession that started as a result of biotic interference**
- **Like forest clearing for agriculture, pasturing and habitation.**
- **Examples of biotic forest of India**
 - (1) **Tropical moist deciduous forest of Dhuanalī (Orissa).**
 - (2) **Southern thorn forest in part of MP, Mah, TN.**
 - (3) **Thorn forest of Satpudas.**
 - (4) **Semi desert vegetation of Anaimalai Hill.**
 - (5) **Euphorbia scrub of Deccan, Rajasthan & Cutch.**
 - (6) **scrubby vegetation of Kathiawar (Gir, Girnar).**
 - (7) **Scrubby vegetation of Dwarka.**

Contd

- (8) Thorny scrub jungle of kutch.
- (9) Dry deciduous scrub of UP, Bihar, Orissa.
- (10) Lower Blue pine in HP.
- (11) Scrub Oak in temperate belt of Himalayas
- (12) Open pasture with **Pinus excelsa** in Himalayan region.
- (13) Degenerate Quercus scrub in Himalaya.
- (14) Nilgiris sub tropical hill Savanah.
- (15) Desert vegetation of India.

Grassland vegetation of India

- Nearly all grassland in India owes its origin to one or other kind of interference of the natural forest vegetation by man.
- The favourable climate for the development of grassland as a climax unit would be frequent rainfall.
- Even if of a small amount, and a sufficient warmth and moisture during growing season.
- Since both these factors are not present in India, grassland vegetation changes to other types of forests, under natural conditions.

Grassland vegetation of India -contd.

- Sometimes biotic and edaphic factors of habitat helps in perpetuation of grassland over extensive area in India like Nilgiris, alpine meadows, savannahs and grassy plains which are biotic or bio-edaphic and seral in nature and are comparatively stable under the existing factor of the habitat.

Contd

- The grassland of India may be classified under following (3) types:-
 - 1) **Xerophilous, grassland** e.g. dry regions of north west India under semi desert condition.
 - 2) **Mesophilous grassland** (called Savannah) are grassy blanks in moist deciduous forests (Saccharum munja, Vateria) alpine meadows in Himalaya, Nilgiris meadow.
 - 3) **Hygrophilous grassland** (wet Savannah) e.g. densely stocked with Erianthus elephantinus and Saccharum arundinaceum, Phragmites on wetter side.

As per ICAR, Indian grassland are (8) types:-

Grass land	Soil type
Sehima – Dichanthium	Black soil
Dichanthium	Sandy soil
Phragmites – Saccharum	Marshy areas
Bothriochloa	Paddy tract and high rainfall belt
Cymbopogon	Low Hill
Arundinella	High Mountains
Deyeuxia – Arundinella	mixed temperate climate
Deschampsia – Deyenxia	Alpine Temperate climate

Ecological Status of Grassland

- According to Ranganathan, grassland in Nilgiris and Anaimalai Hills are **probable climatic climax**.
- Low riverian swampy grassland – **Edaphic climax**.
- Dry riverian grassland – **Transition stage**
- Site of severe forest fire – **Transition stage**
- **Retrogression stages** of grassland in forests are – Typical minor blank in forest, grassland due to repeated fire, grassland due to overgrazing, grassland due to over felling.

Bio-edaphic forest of India

- **Partly controlled by soil features and partly by the action of man and domesticated animals.**
- **Status is seral stage and called bio-edaphic community.**
- **Bio-edaphic forest –**
 - 1) **Anogeissus pendula forest in Aravali Hills of Rajasthan, Jhansi.**
 - 2) **Gangetic Saline scrub in Gangetic plain.**
 - 3) **Dry bamboo brakes in Siwalik.**
 - 4) **Hardwickia forest in Peninsular India (hard gravelly soil over trap)**

Bio-edaphic forest of India- contd..

- 5) Boswellia forest in Deccan trap in Vindhyan granite and gneiss in central India.
- 6) Butea forest in badly drained soil in black cotton soil in valley where forest fire occurs like in Vindhyan Range
- 7) Babul forest in Black Cotton alluvial soil.
- 8) Laterite thorn forest in west coast (Acacia sundra)

Why Forest Ecology for foresters ?

(Applications of Forest Ecology)

- 1) Forest Ecology is related to silviculture, forest biology, forest mycology, forest genetics, forest entomology and others.
- 2) Application in working plan
 - Selection of silvicultural system.
 - Andamans Paddock (Chengappa canopy lifting system).
 - Development of grassland in Kaziranga National Park, Kanha National Park.
 - Succession study in Brahmaputra Valley.
 - Ecology of *Phoenix paludosa* in river beds.
 - Bamboo regeneration and flowering problem.

- Afforestation of eroded sites, ravines, sand dunes etc.,
- Possible seral retrogression in different types of forest in Bihar as a result of fire (Harazibagh) and excessive grazing (Palamu).
- Sal regeneration problem in UP, MP.
- Problem of eradication of Lantana from mixed teak forest.
- Regeneration and protection of shola forests in Nilgiris.
- Protection of meadows in Nilgiris.
- Regeneration of Sandal & Red Sanders.
- Secondary succession in coniferous forest in Kulu; after grazing.
- Succession in ravine areas.

Forest types – species – at a glance

➤ Tropical

- Southern

- Northern

- Southern – Andamans, Kerala, Karnataka, Western coast, M.P., A.P., Maharashtra

- Northern – NE, Assam, Bengal & Orissa

- Montane subtropical - Southern & Northern
- Nilgiris, Mt. Abu, Himalayas upto 1800 mts.
NE, Manipur, Shiwalik, Bhabhar, J&K
- Montane Temperate
- Higher hills of TN, Kerala, Eastern Himalayas (1800-3000 mts), Bengal, Assam, Arunachal Pradesh, UAA, HP, J&K
- Sub-alpine – 2900-3500 mts of Himalaya
- Alpine scrub – above 3500 mts. of Himalayas.

➤ Major species found in various forest types

- Tropical wet evergreen – Dipterocarpus, shorea (Sal), Artocarpus, Mangifera, (Mango) Syzygium (Jamun), cane, Bamboo, Palm
- Tropical Semi evergreen – Dipterocarpus, Hopea, Terminalia (Arjun, Harra, Bahera), Syzygium (Jamun), Mellotus, Diospyrous (Tendu)
Bamboosa Arundanasea

- Tropical Dry evergreen (TN, Andhra, Bay of Bengal Coast)
- Acacia, Albizia, Ziziphus, Syzigium (Jamun), Azhadaricta (Neem), Tamarindus (Imli), Diospyrous (Tendu)

- Moist deciduous –(Andamans, South India, Assam).
- Pterocarpus
Terminalia (Arjun, Harra, Bahera)
- Lannea Coromandalica
- Cinnamomum
- Bamboos
- Murayya
- Mellotus

➤ Nilambur, Wynaad, Dangs of Gujarat-
Teak Forest- composition

- Teak, Grewia, Adina Cardifolia, Lagerstromia
- Terminalia, Dalbergia latifolia (Rose wood)
- Dendro Calamus – (Bamboo)
- Pterocarpus, Bambax ceiba, Madhuca (Mahua)

➤ Sal & Teak

- Sal, Lagerstromia, Mellotus, Terminalia, Anogoiessus Latifolia (Kardhai) , Adina, Syzigium (Jamun), Albizia, Bombax (Semul), Diospyros (Tendu), Pterocarpus Marsupium .

➤ Dry deciduous

■ MP, Gujarat, Maharashtra, AP, TN, Karnataka.

■ Teak

■ T. Tomentosa, Anogeissus Latifolia

(Kardhai), Diospyros (Tendu), Sterculia

Urens (Gum), Lannea

- Shorea (Sal)
- Adina, Terminalia, Acacia catechu
(Khair), Bosewellia Serrata, Buchania,
Bombax, Aegel (bel), Hardwickia (Basket
making), Dendrocalamus

➤ Littoral & Swamp

- Casuarina equisetifolia (Fuel wood)
- Pongamia (Kanji)
- Erythrina
- Barringtonia
- Eugenia
- Syzigium
- Salix
- Terminalia Arjuna, T. Myriocarpa

➤ Thorn forests

- **A. Catechu (Khair)**
- **A. Nilotica (Babul)**
- **Capparis**
- **Prosopis**
- **Ziziphus**
- **Anogeissus (kardai)**
- **Salvadora,**
- **Holeptelia (Kanju)**
- **Teccomella Undulata (Marwarh Teak)**
- **Tamarix**

➤ Montane sub-tropical

- Broad leaved (hills)
- Quercus (Oak)
- Alnus
- Ilex
- Pyrus
- Prunus

➤ Montane subtropical - Pine

- Pinus roxburghi (chir)
- Terminalia
- Mallotus
- Pyrus
- Rhododendron,
- Acer oblongum
- Salix
- Magnolia

➤ Montane sub-tropical- Dry evergreen
Mainly scrubs

➤ Montane temperate- Wet

- Cinnamomun, Magnolia, Acer (maple),
Betula

➤ Montane temperate Moist

- Ban oak,
- Blue pine, (Kail)
- Cedrus deodara (Deodar)
- Rhodendron
- Moru oak,
- Abies pindrow (spruce)
- Acer
- Ilex
- Betula
- Aesculus,
- Juglans Regia (Walnut)

➤ **MONTANE TEMPERATE DRY**

■ Ladakh, Chamba, Sikkim, Arunachal Pradesh

■ Pinus gerardiana, Acer, celtis, blue pine, junipers.

➤ **Sub-alpine**

■ Dense growth of crooked trees

■ Betula, Junipers, Rhododendron, Quercus.