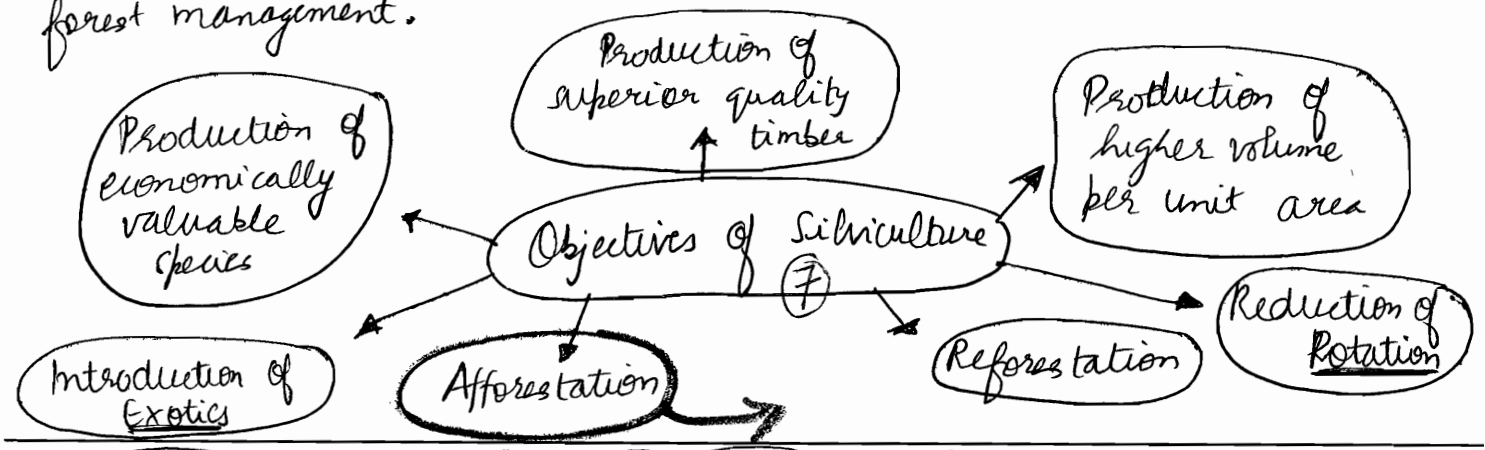
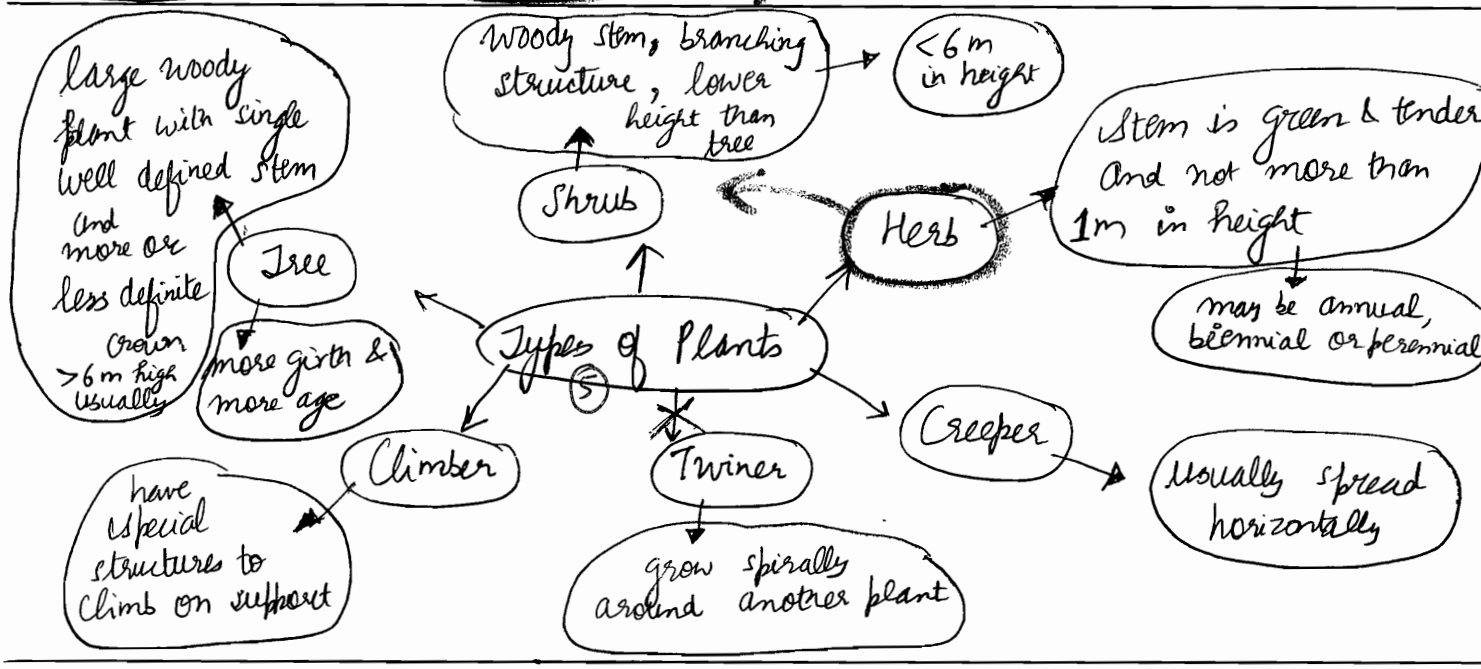
CHAPTER-1
SILVICULTURE

Silviculture is the branch of forestry that deals with establishment, development, care and reproduction of stands of timber. It includes various other forest sciences including forest protection (1), mensuration (2), utilization (3), forest economics (4) and forest management (5).





- Seed → Seedling → Sapling → Pole → Tree
- Natural forest uninfluenced by human activity is called **Virgin Forest.** Although nature is capable of maintaining forests object of study of silviculture & its practice is purely economic ie to produce more useful & valuable forests than nature would do & that too in a shorter time.
- **Rotation**: The planned number of years between regeneration of a crop & its final felling.
- **Exotic**: Not native to the area; opposite: indigenous

⊙ Regeneration : to renew a forest crop by natural or artificial means.

Types of Forestry

Multi-Use Forestry
Simultaneous use of a forest area for 2 or more purposes

Protection Forestry
protection of land over which forest is situated
protection of land at a distance against wind & water erosion
Reducing hazards of flood damage
Amelioration of adverse climatic effects

Commercial Forestry
producing timber & other product as business enterprise
if aim is to meet requirement of a particular industry, its called INDUSTRIAL FORESTRY
eg. Pulp-Mill, Chemical-Plant

Intensive Forestry
Objective of obtaining the maximum in volume & quality of products per unit area through best techniques of silviculture

Social Forestry
Farm Forestry
Agro Forestry
Recreation or Aesthetic Forestry
Extension Forestry
along roads
Shelterbelts
Railway tracks or dividers

Crown

Mode of Branching
Angle of bronching
Cedrus Deodara
Old deodar $\theta \approx 90°$
Size & no. of branches

Shape & Size
big crowns : open tree
small crown : dense forest
Cylindrical
Conical eg. Pine
Spherical eg. Azadirachta Indica

Crown development
expansion of crown measured as crown length & crown width

Leaf Colour
bright
pale
lower part slightly pale
Autumn Tint : colour change before falling

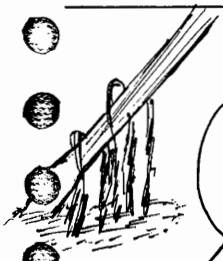
Leaf Shedding
deciduous eg. Acacia Catechu (khair)
evergreen eg. Mangifera Indica

Leaf Size & Texture
More rain ⇒ broader leaves
soft & membraneous textured leaves are easily decomposed in soil

Catechu

Stem defect

- buttress
- fluting
  - Irregular swelling and complicated structure on the bole just above the basal swell.
- forked; more than 1 leader
- epicormic branch
  - branches originating from dormant buds on a clear pole due to adverse conditions like excessive light, drought, fire or suppression
- tapering



Adventitious Roots

Roots produced from parts of the plant other than radicle, like stems, branches etc.

- Prop Roots → Banyan Tree
  - support thick branches
- Stilt Roots
  - eg. Rhizophora Mangrove
  - flying buttress
- Pneumatophores : Breathing roots
  - eg. swamp trees
  - Spike like upward projection of roots

Mycorrhiza

- Type
  - Combination of two
    - Ectendotrophic
  - Endotrophic
    - fungus penetrates cell wall
  - Ectotrophic
    - fungus does not penetrate cell wall
- Occurence
  - Eucalyptus, India
  - Shorea Robusta
    - Sal, M.P., India
- What
  - Sometimes rootlets, instead of being covered by roothairs are found to be invaded by non-pathogenic soil fungi. Composite structures so formed are called Mycorrhiza
- Importance
  - Absorbs soil moisture by ↑ area of absorbing surface
  - Helps in absorption of minerals P, Cu, Fe
  - Fixes N_2 from raw humus
- Introduction
  - natural, eg. in India
  - artificial : especially important for exotic species

Lignotubers

- Food Storage
- Why
  - Regeneration
    - They bear numerous buds which can produce shoots if tree is cut or burnt or injured
- What
  - Underground swellings found mainly in Eucalyptus
  - Modification of Stem

Root Nodules

What → Small Nodules in roots of certain plants containing bacteria (Rhizobium) in large numbers

Spread → Bacteria present in soil, enters root through root hair. It reaches inner cortex, active cell division takes place resulting in formation of nodule

Symbiosis → Bacteria living in nodule (not those in soil) help to fix atmospheric N_2 into nitrates & ammonia

Symbiosis → Plant provides, in return carbohydrates to bacteria

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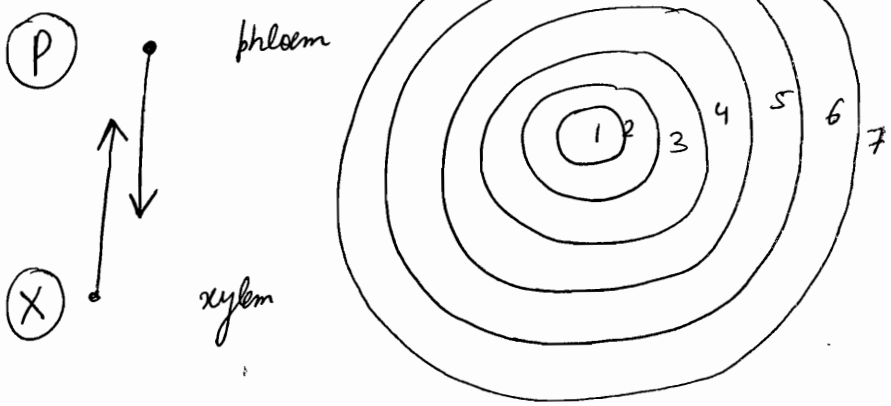


1. Pith
2. Xylem (अंदर ही होगा ताकि पानी बाहर leak न कर जाए)
3. Phloem
4. Sclerenchyma
5. Cortex
6. Epidermis
7. Periderm (Bark)

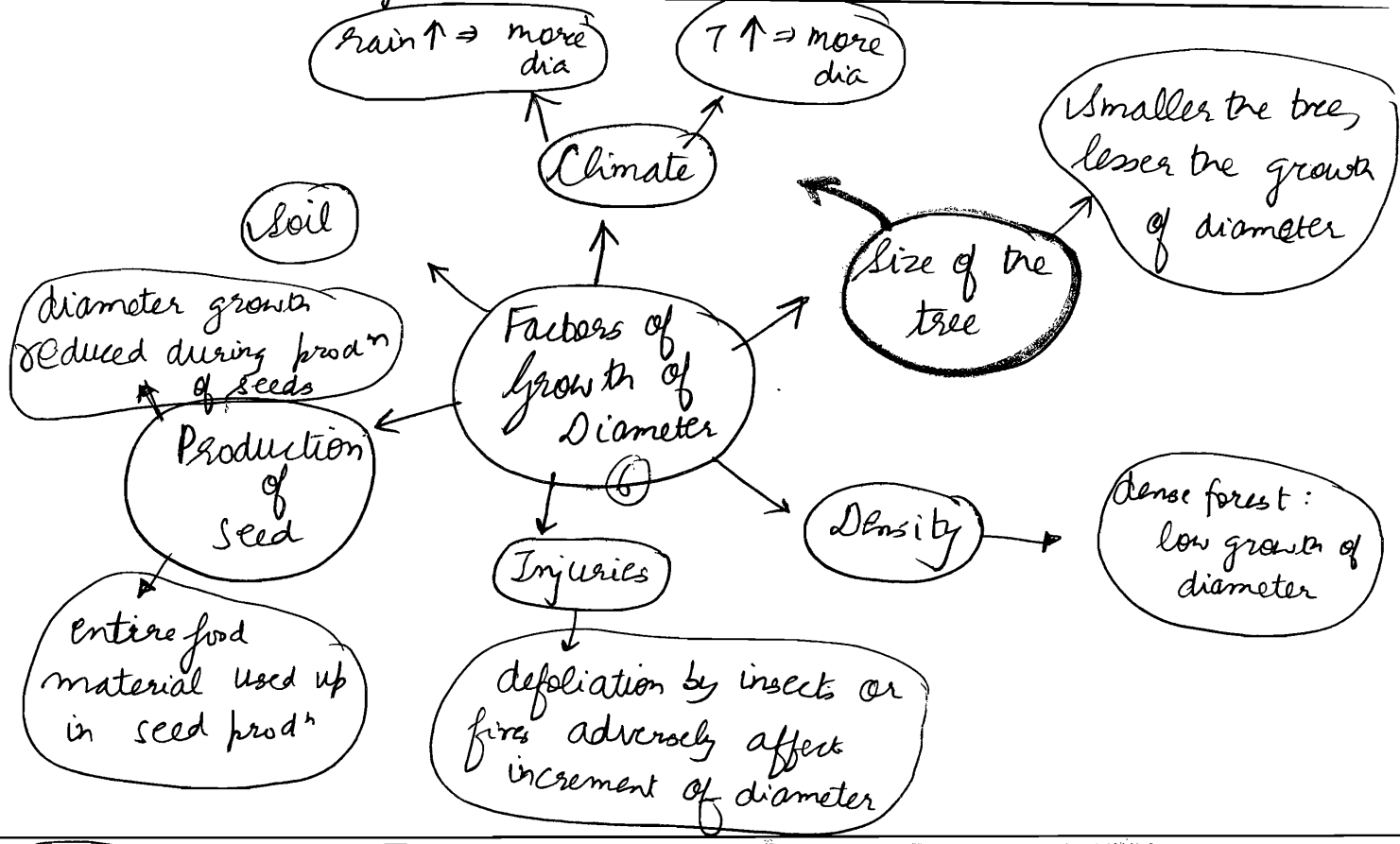
Sclerenchyma : source of hemp, flax or jute. Its the supporting tissue in plants

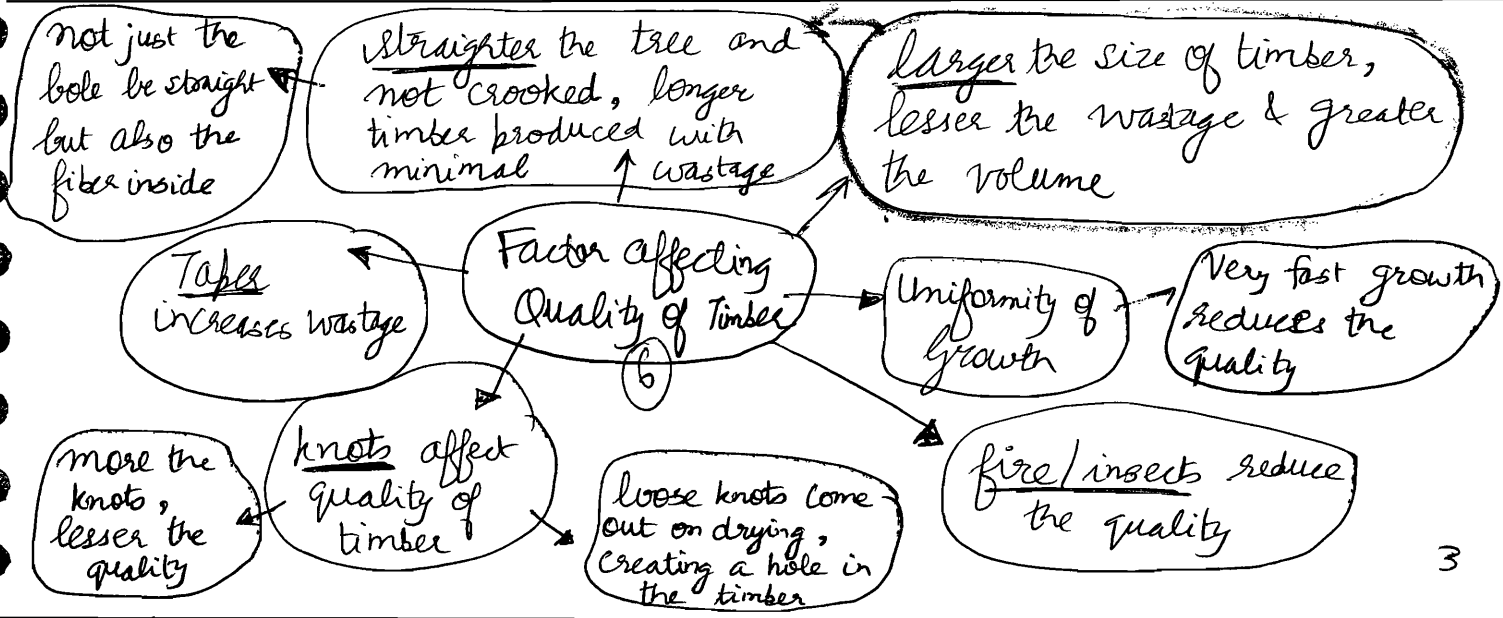
Cortex : transportation of materials into the central cylinder of root through diffusion. Also stores food in form of starch.

- Growth : increase in size of roots and stem
  development : formation of new organs like branches, lateral roots
- Phenology : science that deals with the time of appearance of characteristic periodic events (leaf shedding etc.) in the life cycle of organisms in nature.
- Meristematic Cells : capacity to divide & give rise to new cells. Important for growth & development.

○ **Annual Rings** : Growth in plants is not uniform throughout the year. Generally the periods of rapid growth are preceded by and followed by periods of slow growth, thereby creating difference between wood formed during the two periods, resulting in formation of annual rings.

Age of tree at time of felling = [No. of rings counted on stump + No. of years plant took to grow to stump height]

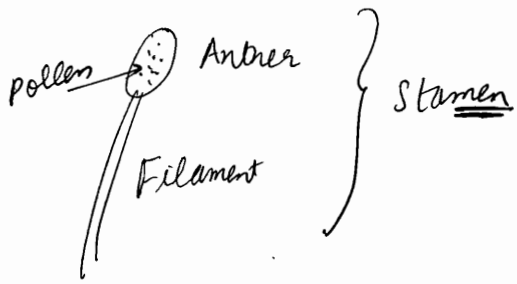


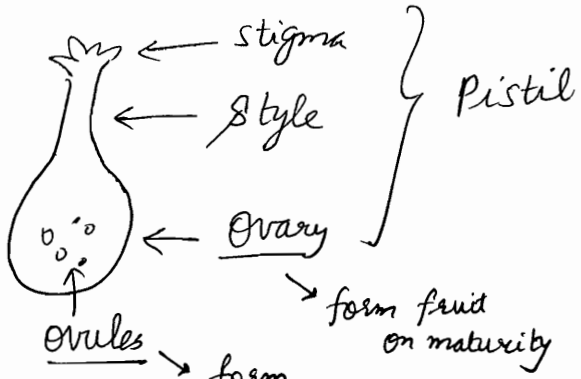


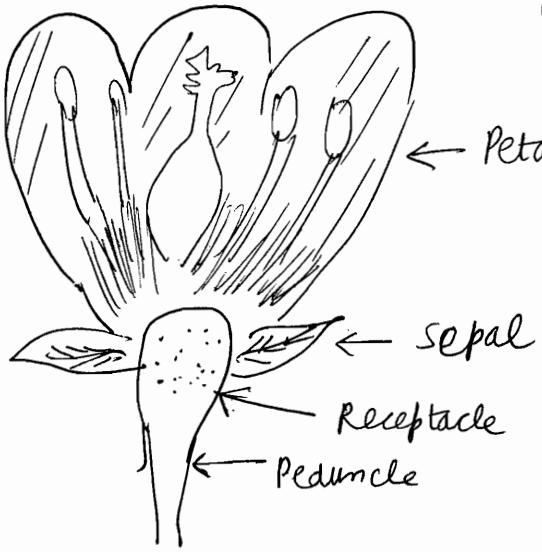
⊙ Growth in volume depends on : (1) growth in height
(2) growth in diameter
(3) taper (less taper ⇒ high volume)

⊙ **Reproduction** is that vital process by which tree species perpetuate themselves by reproducing new independent members of their own species. Reproduction in trees is of two types : Sexual and Vegetative.

- Bisexual flowers : both sexes in 1 flower i.e. stamen & pistil
- Unisexual flowers : single sex on 1 flower



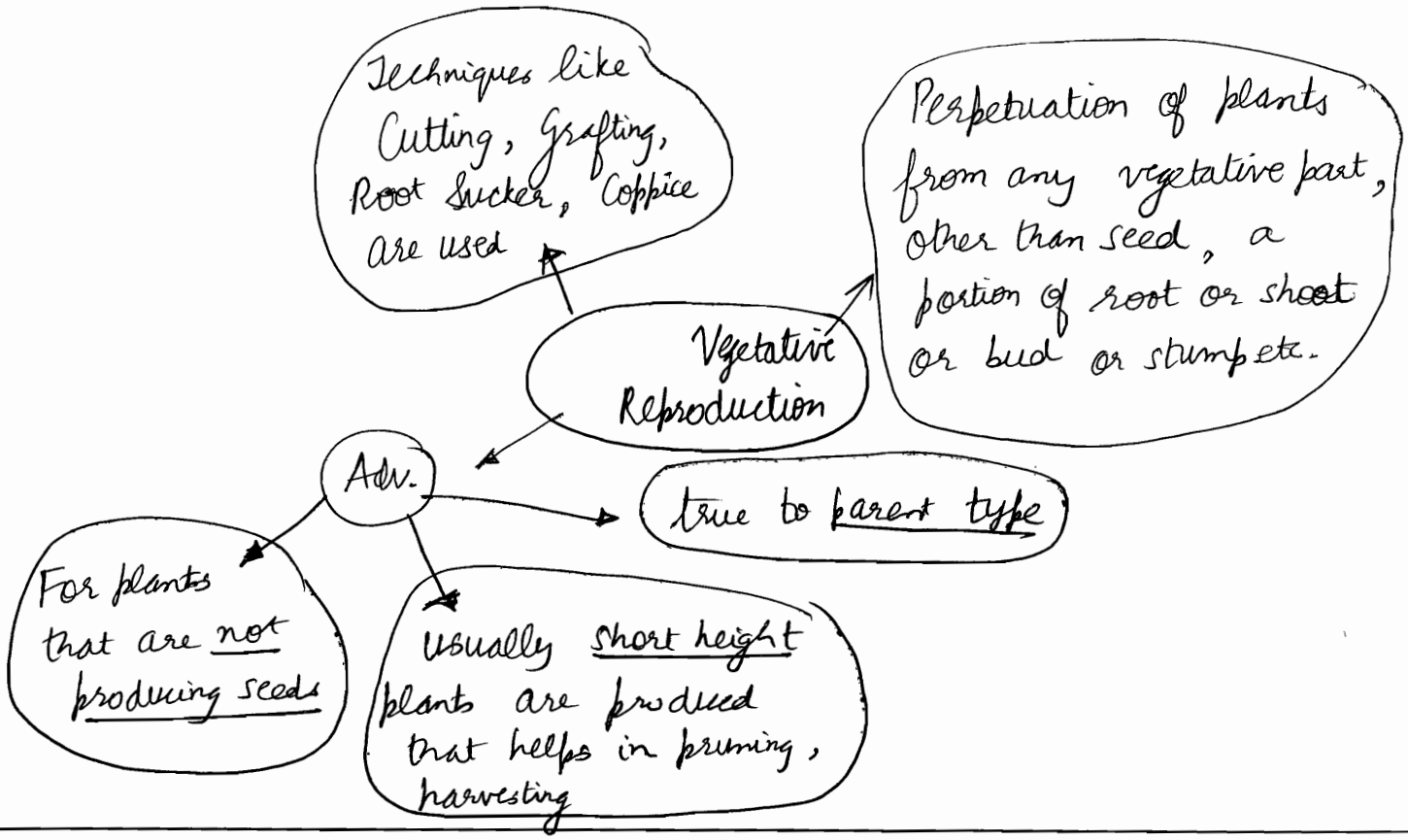




Plant (Flower) Morphology

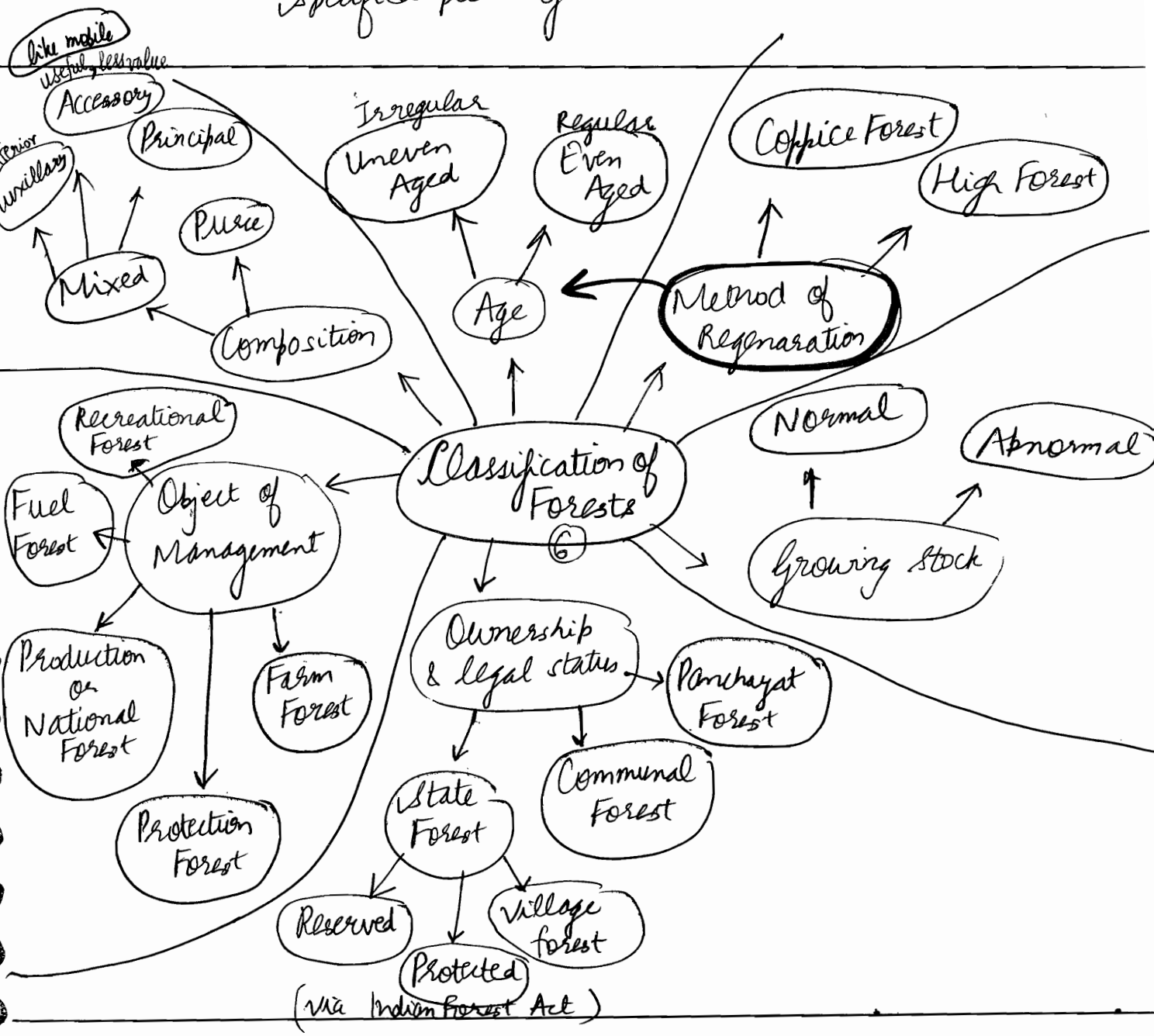
- Unisexual
  - Dioecious (male & female flowers may be on different individuals or plants) — 2 plants viz.
  - Monoecious (male & female flowers on same individual or plant) — viz. 1 plant
- Polygamous : Have both unisexual & bisexual flowers.

- **Regeneration** : Renewal of a forest crop by natural or artificial means.
- **Increment** : increase in girth ($2\pi r$), diameter, basal area, height, volume, quality or value of individual trees or crops during a given period
- **Canopy** : Cover of branches and foliage formed by crowns of trees in a forest. Closed canopy is the one in which crowns touch each other.



- **Forest** is defined as a plant community predominantly of trees and other woody vegetation, usually with a closed canopy
- **Stand** is defined as an aggregation of trees occupying a specific area, uniform in composition (species), age, arrangement & condition. Unit of silviculture is a stand.
- **Yield** : material that a forest can yield annually (or periodically) in perpetuity.
- **High Forest** : Crop of trees originated from seeds.
- **Coppice Forest** : forests derived mainly from coppice shoots or root suckers.
- **Selection Forest** : Uneven aged crop containing, theoretically, all age groups of trees. Managed under selection system.
- **Composition** : Various species that form a forest crop & their proportion in it.

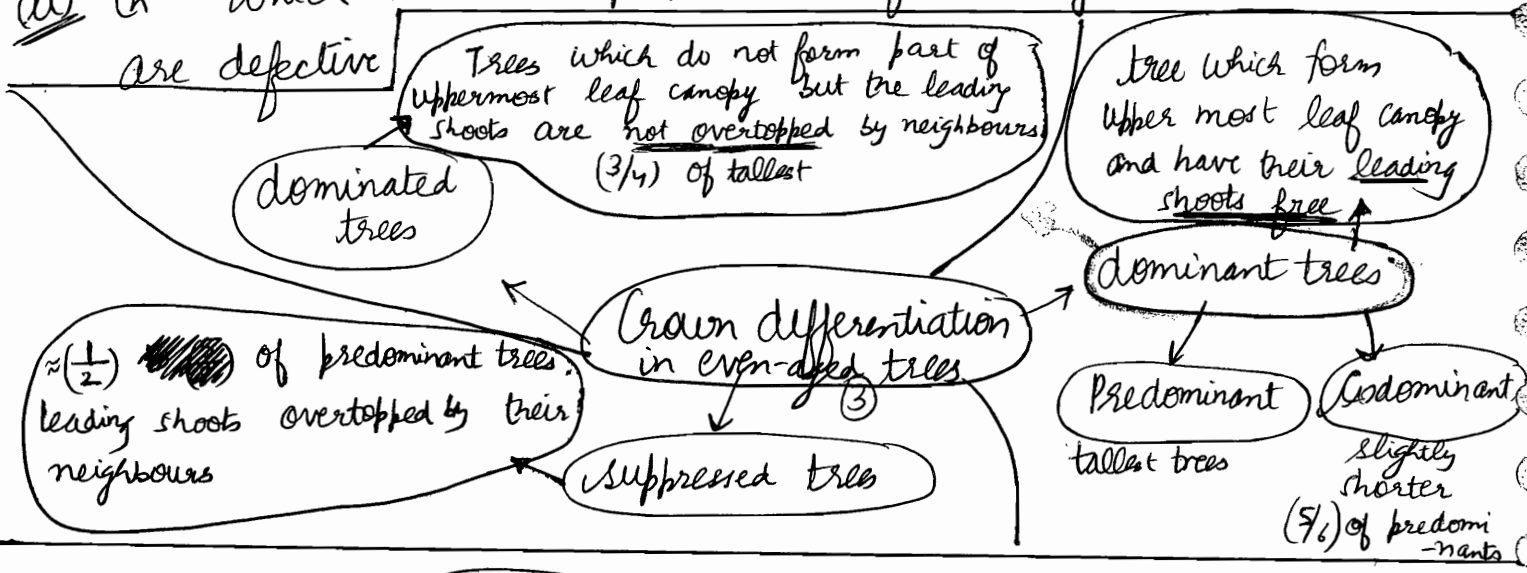
- Reserved forests are highly sacrosanct.
  Reserved : list of do's
  Protected : list of dont's
- **Growing Stock** : Sum (by number ~~or~~ volume) of all the trees growing in the forest or a specified part of it.



- **Normal Forest** : Benchmark forest acting as standard of comparison
  A forest which, for a given site & objects of management, is ideally constituted as regards (i) Growing stock (ii) Age class distribution and (iii) Increment and from which annual removal of produce, equal to increment,

can be continued indefinitely without affecting future yields.

Abnormal Forest : Forest in which, as compared to an acceptable standard, (i) the quantity of material in the growing stock is in deficit or in excess or (ii) in which relative proportions of the age or size classes are defective



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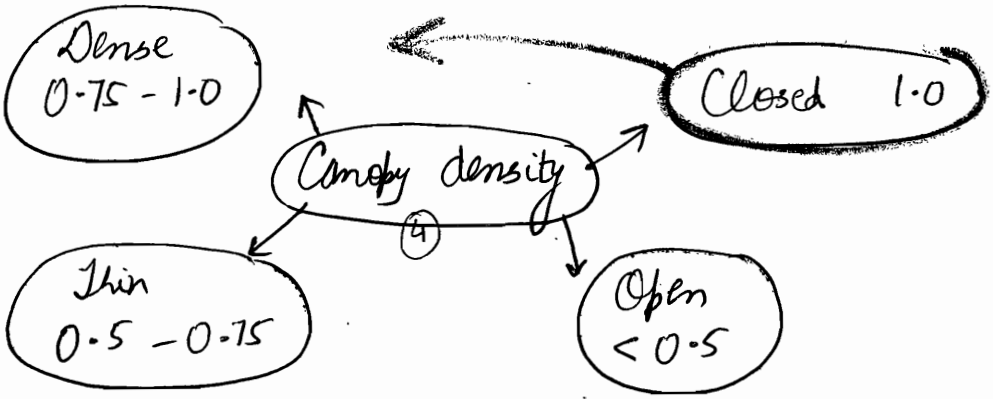
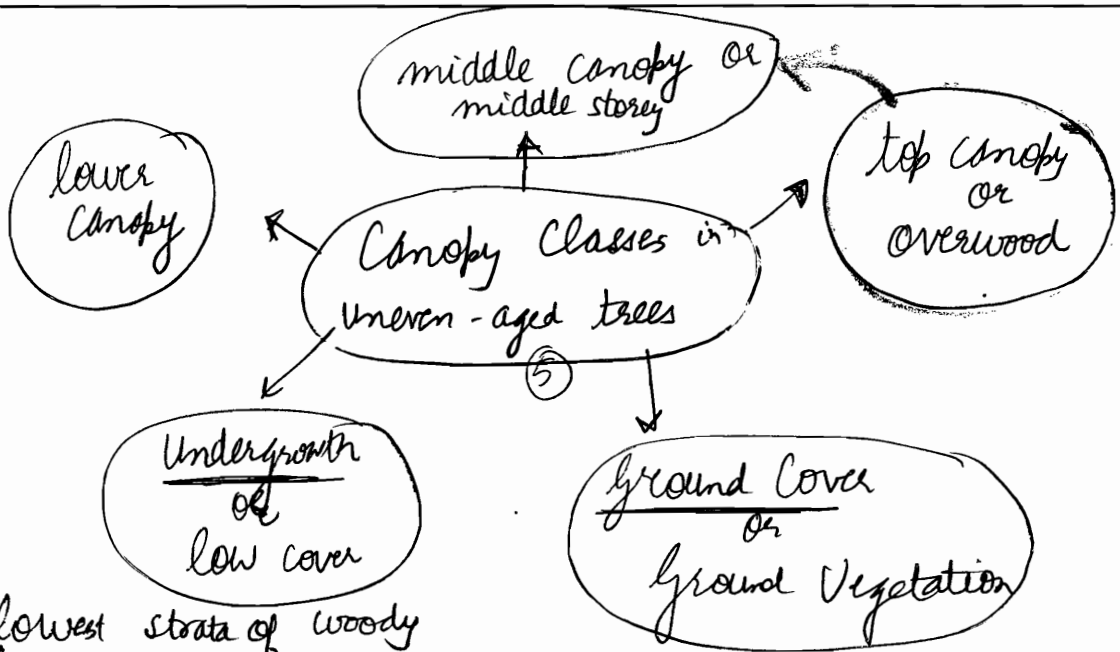
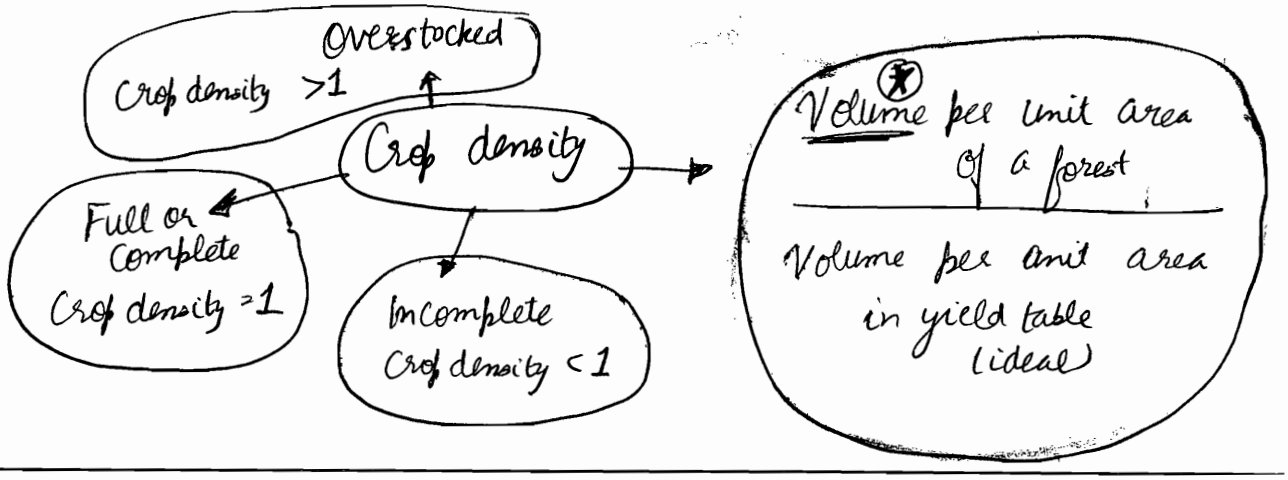
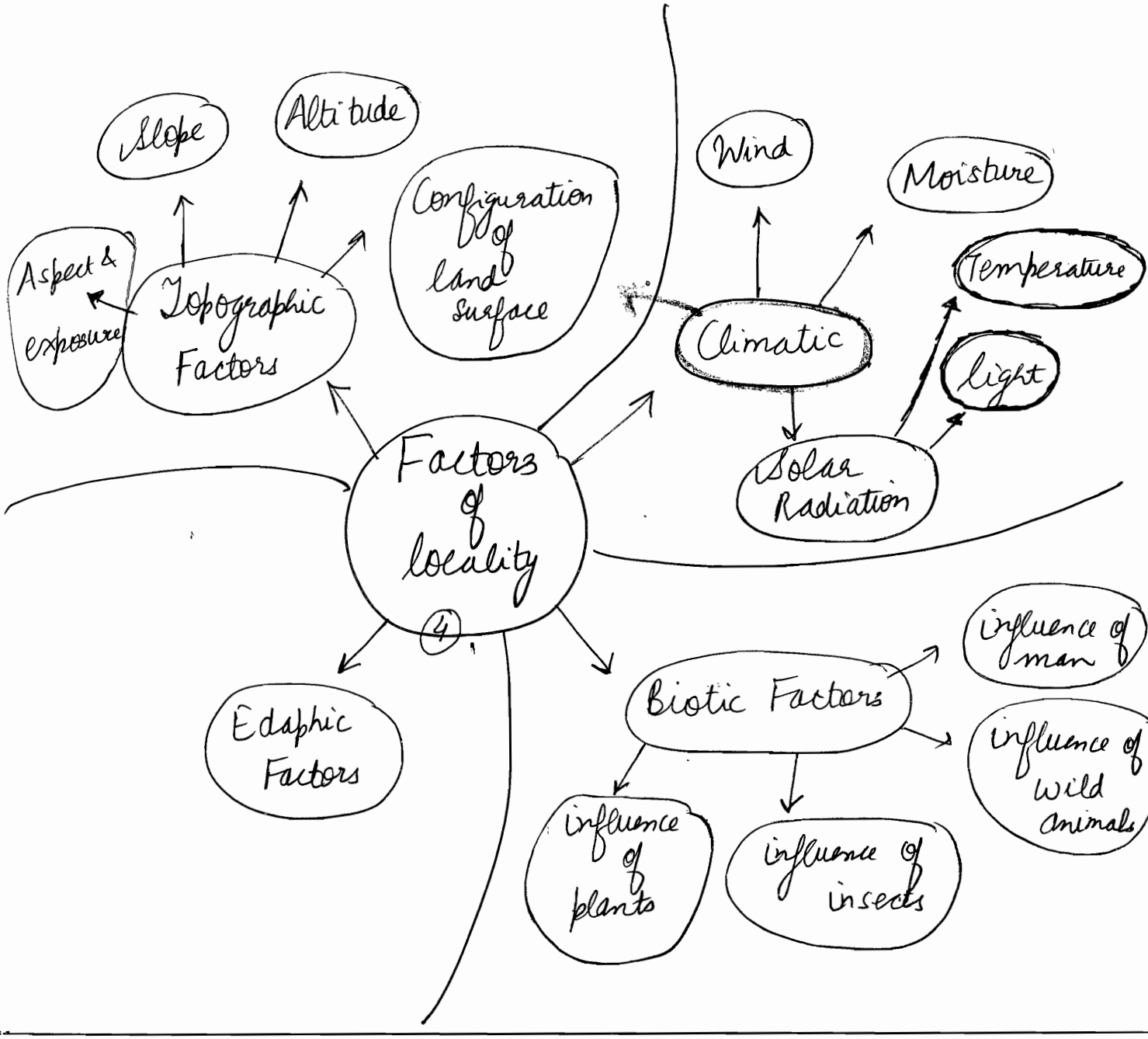
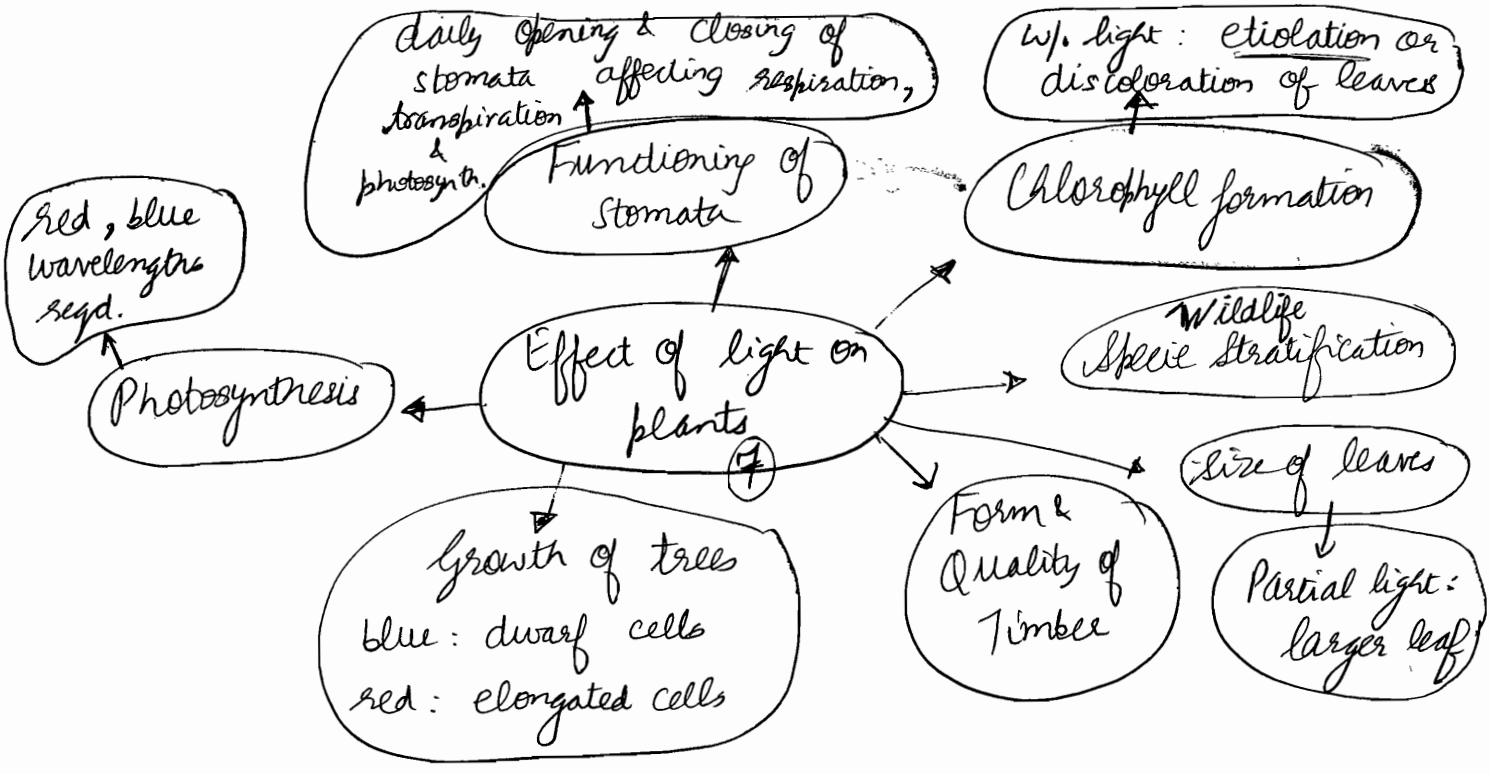








⊙ Energy received from sun
- 1% UV
- 39% Visible light
- 60% IR



- duration of light for which plant is exposed is called **Photoperiod**. (रात की)
- **Elongation of the trees** mainly occur between sunset & sunrise bcoz the low intensities of light & IR radiation tend to stimulate height growth.
- **Light required for photosynthesis** is very low (usually 2% of light falling on well-illuminated leaves). Therefore even in dense forest light is sufficient for photosynthesis. But in case of very-dense forests, light intensity may be so low that photosynthesis gains may not be able to balance the loss due to respiration.
- **Light effect on growth** depends on quality, duration & intensity.

Quality : normal but small plants in blue light.
elongation of cells in red light.

Duration : growth, breaking of dormancy, shedding of leaves, flowering are all affected by photoperiod.

Intensity : (1) Amount of dry matter produced by plants increases with increasing light intensity upto a certain maximum & then decreases.

② High Intensity favours root growth more than shoot growth. As such light conditions increase transpiration excessively, the stems remain short & develop smaller leaves. (leaves exposed to full light are smaller than those in partial light)

③ Extremely low Intensity of light also retards the growth. In such condition, even flowering does not take place.

⊙ Effect of light on Quality of Timber

① Height is retarded in extremely light intense condition. Tree growing in a little shade are usually taller.

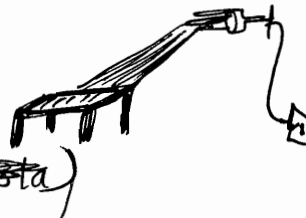
② Deficiency of light due to shading effect of upper branches is responsible for death of lower branches, resulting in long boles. The regulation of light, therefore, a powerful tool of forester to regulate "form" of trees & quality of timber

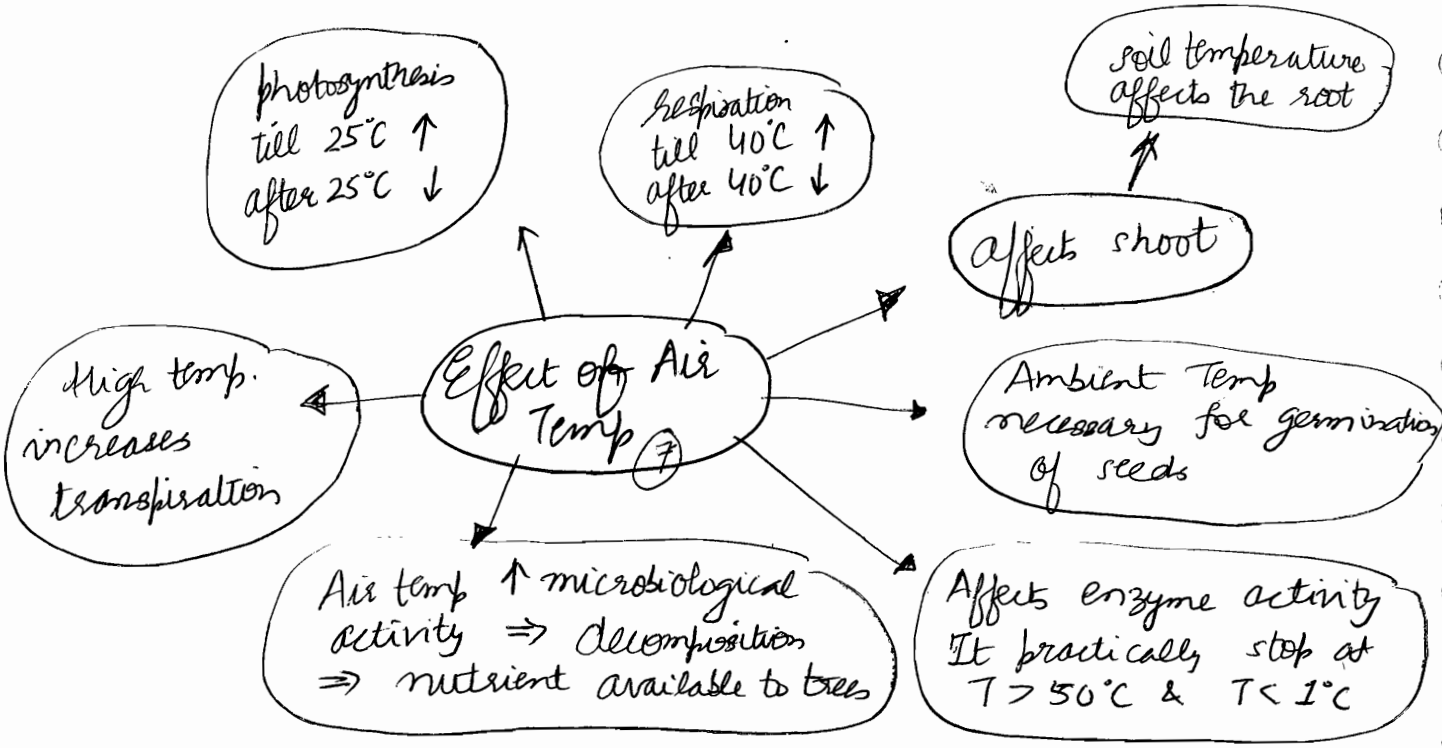
↓

light results in formation of relatively large crown ⇒ rapid growth. At the end of rotation, crops are opened up heavily to allow selected remaining trees to put on rapid diameter increment. This is known as "light increment".

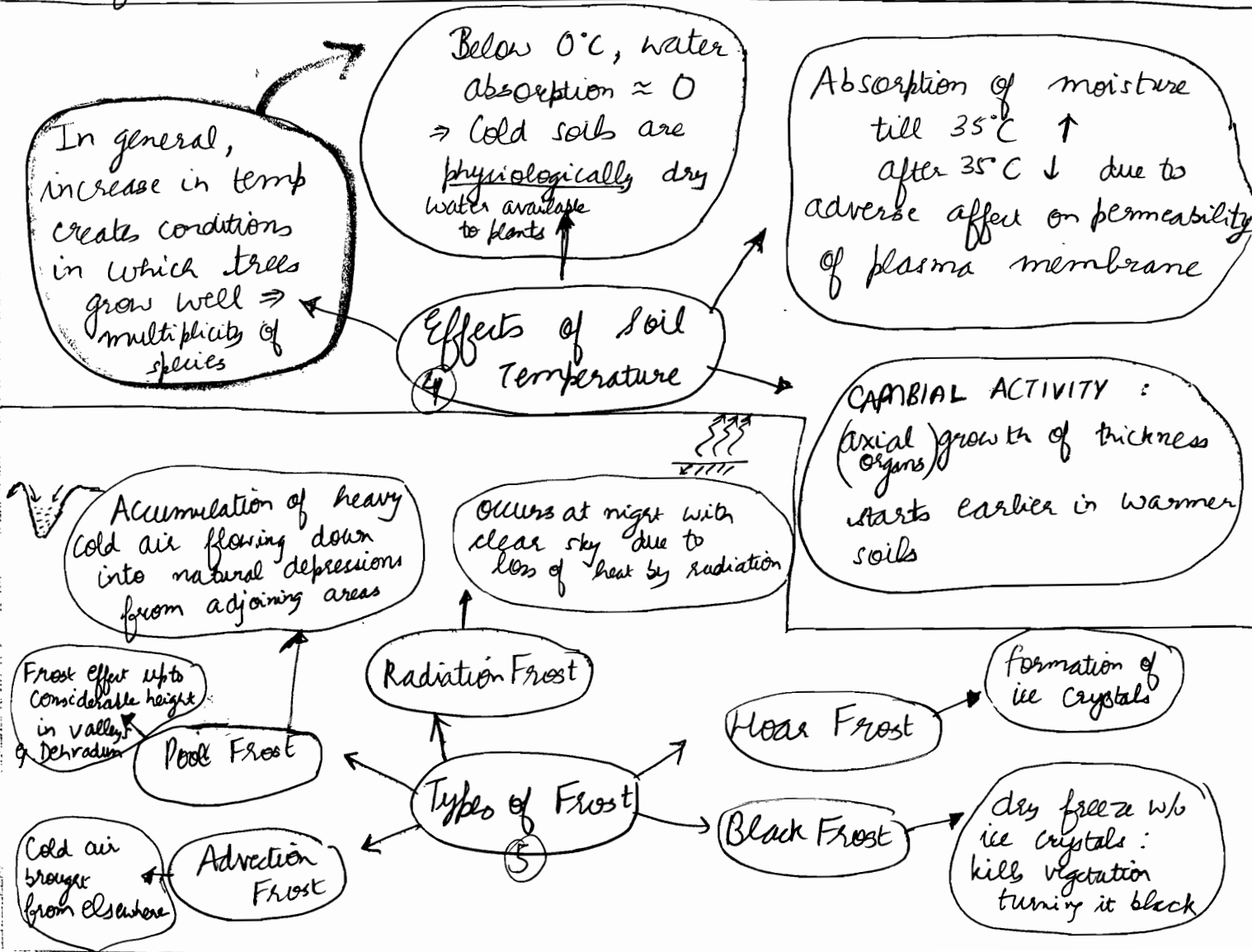
⊙ Different canopies receive different amount of light, thereby, resulting in **stratification of species** in different canopies according to requirement of light.

⊙ Trees → Light demander (Teak ~~Robusta~~ OR ~~Sal~~)
→ Shade Bearer (Santanum Album OR SANDALWOOD)
→ Shade demander





⊙ How to write : Though photosynthesis takes place under a wide range of temperature, varying with species & locality, increase in temperature upto 25°C, increases photosynthesis, after which it decreases sharply.




Damage of Frost
Frost heaving
Soil moisture frozen ⇒ volume increase
⇒ Soil heaved up along with plants
⇒ roots gets dislodged. When ice melts, particles of soil fall away from root ⇒ root exposed and plants fall over & dies
Killing of young plants or their parts
Common in Eastern Slopes in India
Eg. Shola Forest in Nilgiri
frost @ night ⇒ freezing of soil moisture ⇒ direct sun light in morning ⇒ transpiration but no water ⇒ death
Damage to cells
Water in inter cellular spaces freezes ⇒ withdraws water from cells
In severe frost, ice formed within cell wall ⇒ disrupts cell structure due to mechanical stress
Injuries to Crown & boles
Frost Cracks
moisture in wood freezes ⇒ shrinkage of wood after melting
outer layer of wood shrinks more rapidly than inner layer ⇒ Cracks in stem. Usually occur at base of stem
Formation of Cankers
Pinus Roxburghi or Chir : resistant or frost hardy
Azadirachta Indica or Neem : damaged due to frost ⇒ Frost Tender
Frost Resistance
External Factors
Temp
Depends on Season: Plants can withstand frost in winter but not out of season
Rapid fall of temp. is more injurious than gradual fall
Frost hardiness increases if plant is gradually exposed to increasingly low temp before winter starts
Light
Lesser the duration of light ⇒ more frost hardiness
less photoperiod ⇒ less growth ⇒ reserve carbohydrate converts to sugar ⇒ ↑ resistance
Mineral Nutrition
Nitrogen ⇒ Boosts growth ⇒ reduce frost hardiness
Internal Factors
Size of Cell
Smaller cell ⇒ frost hardy
Water conten
lower the water content ⇒ frost hardy
Osmotic or solute concentration
higher O.C. ⇒ frost har
Water binding colloids
⇒ greater the colloids ⇒ frost hardy
reduces amount of water that can be frozen
making internal ice formation less likely
reducing the amount of water that can be removed on external ice formation
frost hardy

Source of water of streams

Acts as blanket, prevents further drop in temp ⇒ protects seedling from excessive cold & frost

Benefits of Snow (3)

Influence distribution of deodar (Cedrus Deodara) as snow is essential for natural regeneration of Deodar

Harms of Snow (5)

Mechanical bending of stems of trees: accumulation of snow on uphill side ⇒ poles bend outwards ⇒ the portion of maximum diameter (base) gets wasted

Breaking of branches & top of trees

Sliding slow uproots trees

Shortens period of vegetative growth

Harms due to Cold (*)

- damage to cells
- less microbial activity
- physiologically dry
- Cambial activity ↓

Optimum temp. for photosynthesis (25°C) is lower than that for respiration (40°C) ⇒ @ higher temp depletion of food ⇒ susceptible to fungi attack

Maximum limit of temp for physiological activities. Above 50°C, death of plants due to coagulation of proteins

Effect of excessively high Temp. (5)

Deficiency of moisture & heating of soil surface

Excessive transpiration ⇒ desiccation of tissues

Cracks in stem due to excessive shrinkage of outer tissue

Small leaf area

Thick cuticle

Efficient conducting system

Drought Hardiness (6)

Reduction in number of stomata

Shedding of leaves

Increased resistance of protoplasm to dehydration

Drought Hardy: Acacia Nilotica or Babul (नीला BABUL)

Drought Sensitive: MANGO or MANGIFERA INDICA

⊛ dry month :- < 5 cm of rainfall

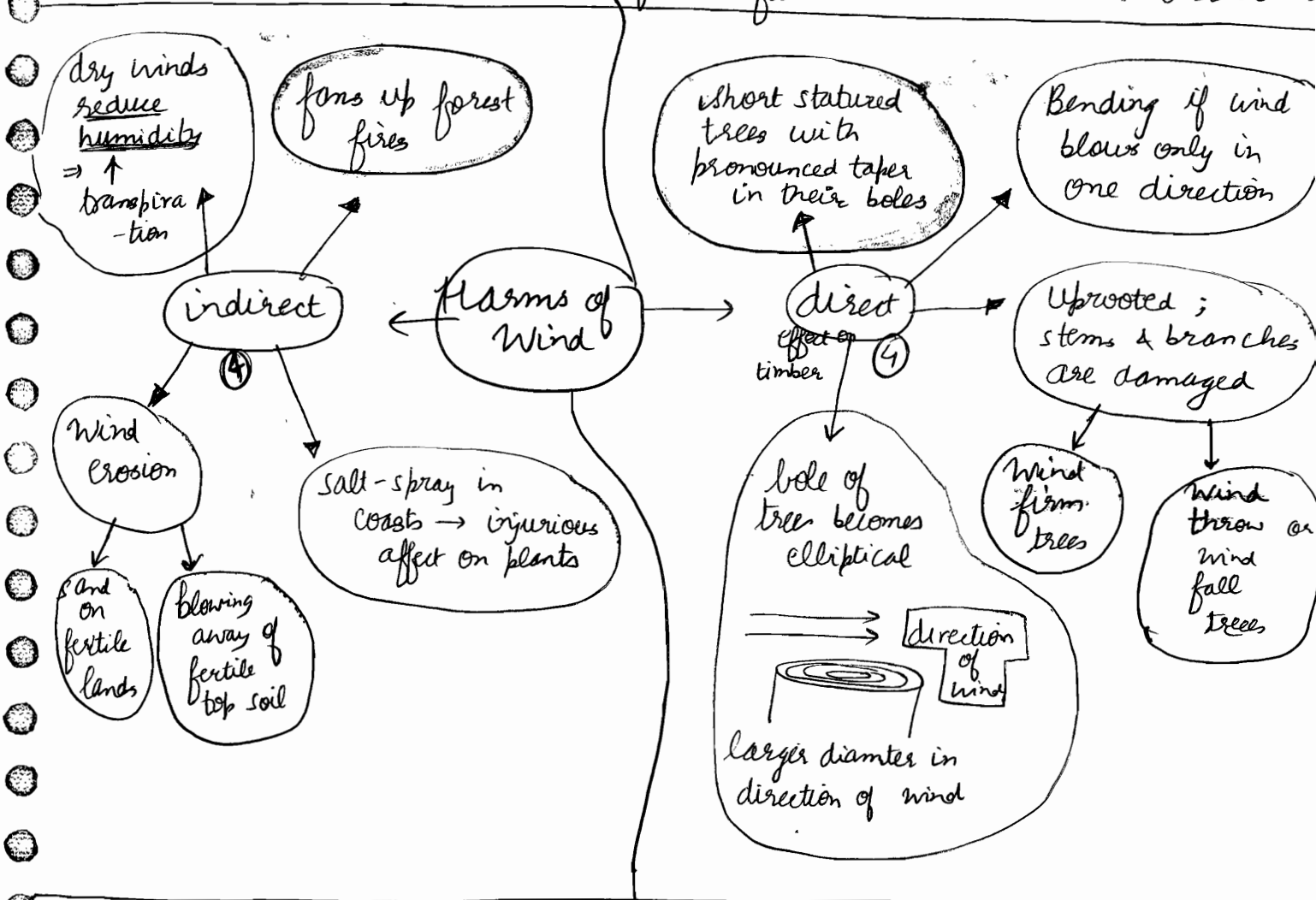
less there are dry months ⇒ more luxuriant fore

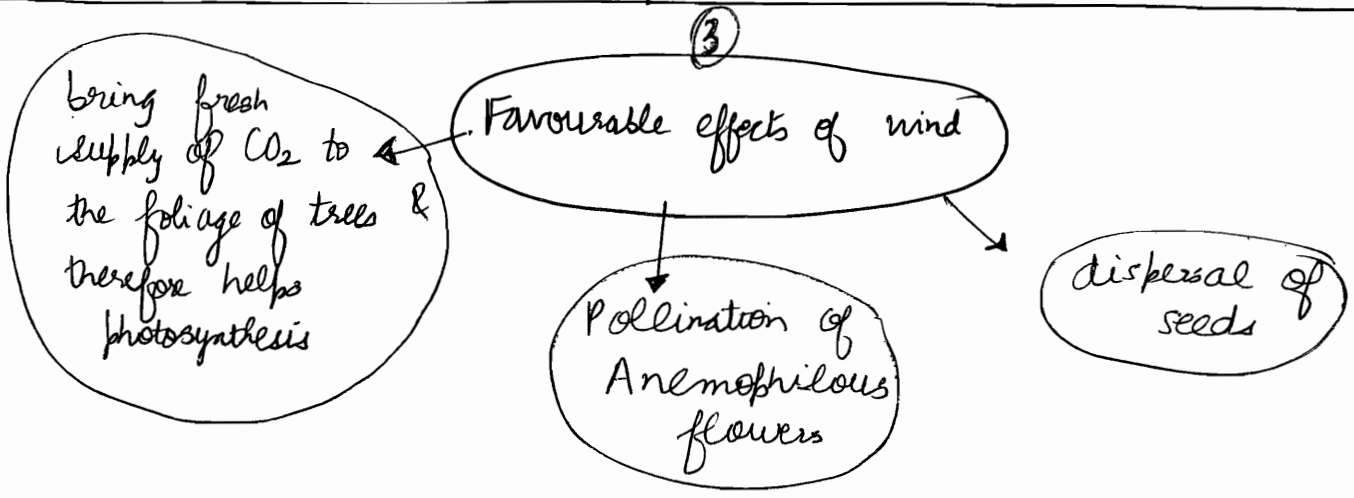
rainy day :- > 0·25 cm of rainfall

rainfall intensity :- rate of rainfall . Important for afforestation work & water conservation works

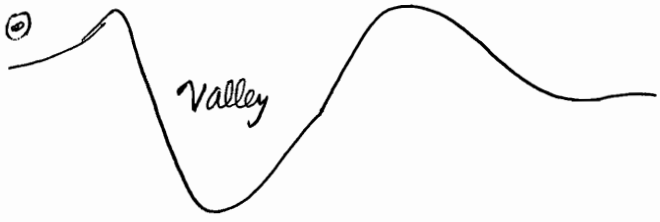
10 cm of rainfall in 24 hours : Ok.

10 cm of rainfall in 2 hours : destruction



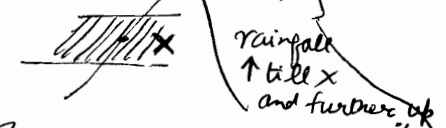


Bioclimate : Climate defined by modified or adjusted climatic factors eg. Temp. Efficiency Index, Precipitation Effectiveness } Thornth.



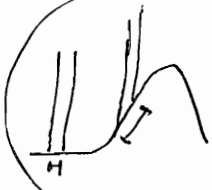
- **Valleys** have high range of temperature. Summers hotter due to radiation from hills & winters colder too due to shade. Hence prime example of effect of Configuration of land surface

Effect of Altitude

- Air gets rarer at altitude
  ⇒ less absorption of radiation
  ⇒ fall in temperature
- Solar Radiation increases due to low scattering
  ⇒ if high intensity of radiation ⇒ dwarfing effect on shoot & growth of root is favoured
- 

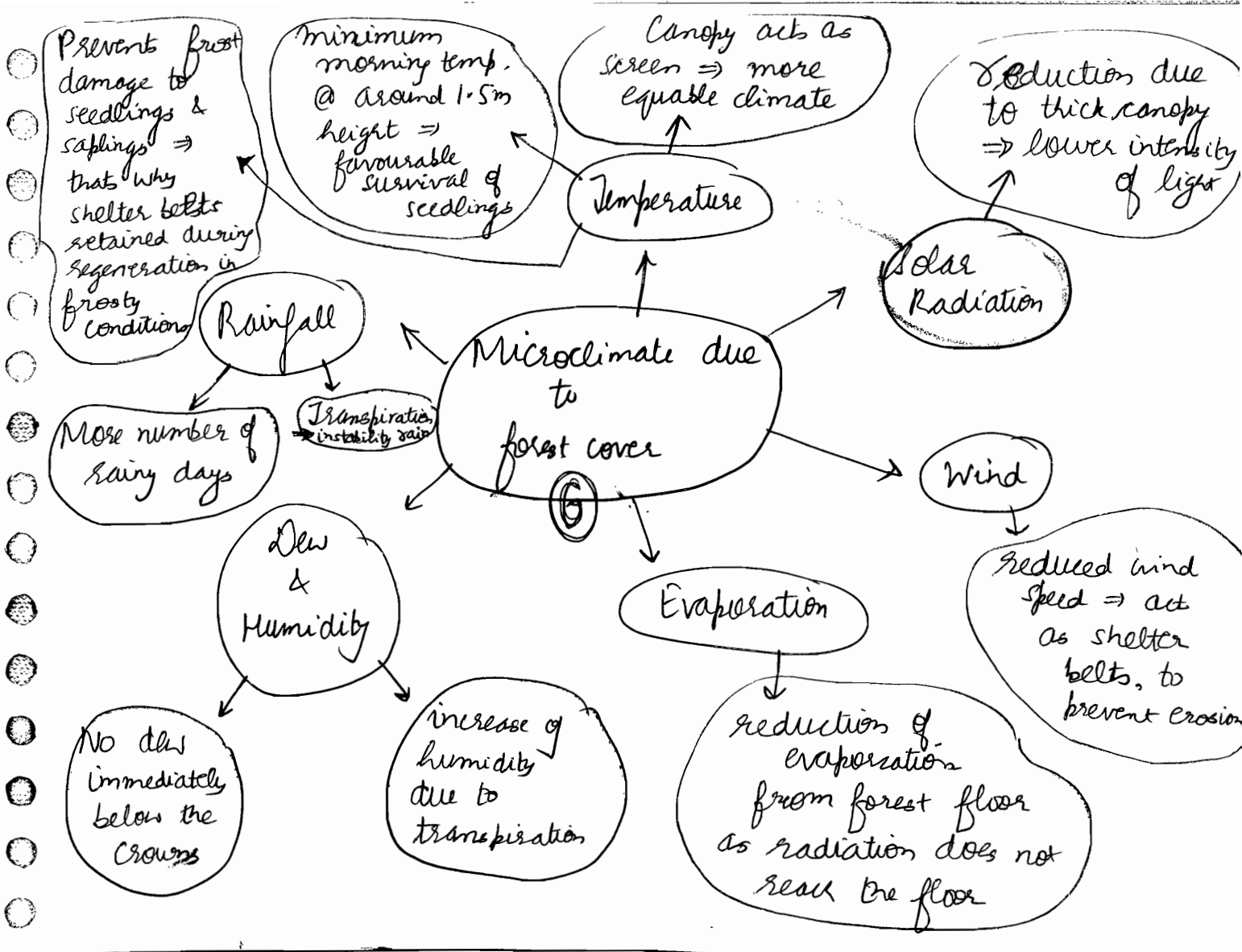
  Zone of maximum precipitation ≈ 1200 m in Himalayas
- Tree line in Himalayas ≈ 4000 m
  Snow line ≈ 5000 m

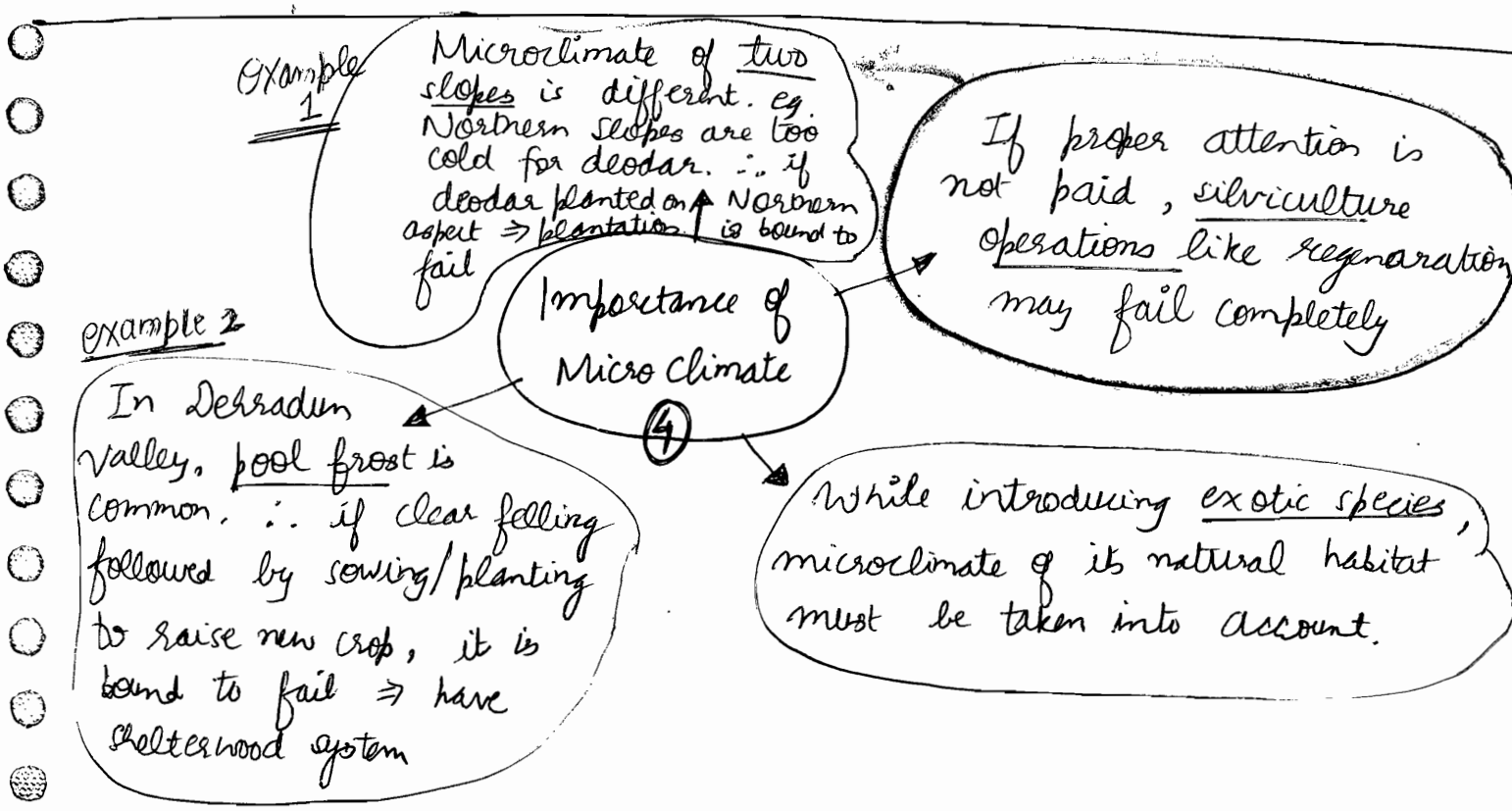
Effect of slope

- 

  Reduction of intensity of insolation
- better drainage
- more run off
- immature soil
- More erosion
- less depth of soil
- low humus content as top soil erodes

Microclimate :- Climate due to localized conditions


Microclimate due to forest cover
6
Temperature
Prevents frost damage to seedlings & saplings ⇒ that why shelter belts retained during regeneration in frosty conditions
Minimum morning temp. @ around 1.5m height ⇒ favourable survival of seedlings
Canopy acts as screen ⇒ more equable climate
Reduction due to thick canopy ⇒ lower intensity of light
Solar Radiation
Rainfall
More number of rainy days
Transpiration → instability rain
Wind
Reduced wind speed ⇒ act as shelter belts, to prevent erosion
Dew & Humidity
No dew immediately below the crowns
Increase of humidity due to transpiration
Evaporation
reduction of evaporation from forest floor as radiation does not reach the floor


Importance of Micro Climate
4
Example 1
Microclimate of two slopes is different. eg. Northern slopes are too cold for deodar. ∴ if deodar planted on Northern aspect ⇒ plantation is bound to fail
If proper attention is not paid, silviculture operations like regeneration may fail completely
example 2
In Dehradun valley, pool frost is common. ∴ if clear felling followed by sowing/planting to raise new crop, it is bound to fail ⇒ have shelterwood system
While introducing exotic species, microclimate of its natural habitat must be taken into account.

Accumulation of salts in soil (7)

- movement of soluble salts to the surface to be deposited there on evaporation of water
- Excess of evaporation compared to precipitation
- Carbonates, Chlorides, Sulphates of Sodium, Calcium & Magnesium
- High water table
- Periodic flooding with sea water
- Presence of impervious layer in the sub soil preventing downward movement of water
- Basin shaped topography
- Excess canal irrigation w/o provision for sub-soil drainage

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Pan Formation (6)

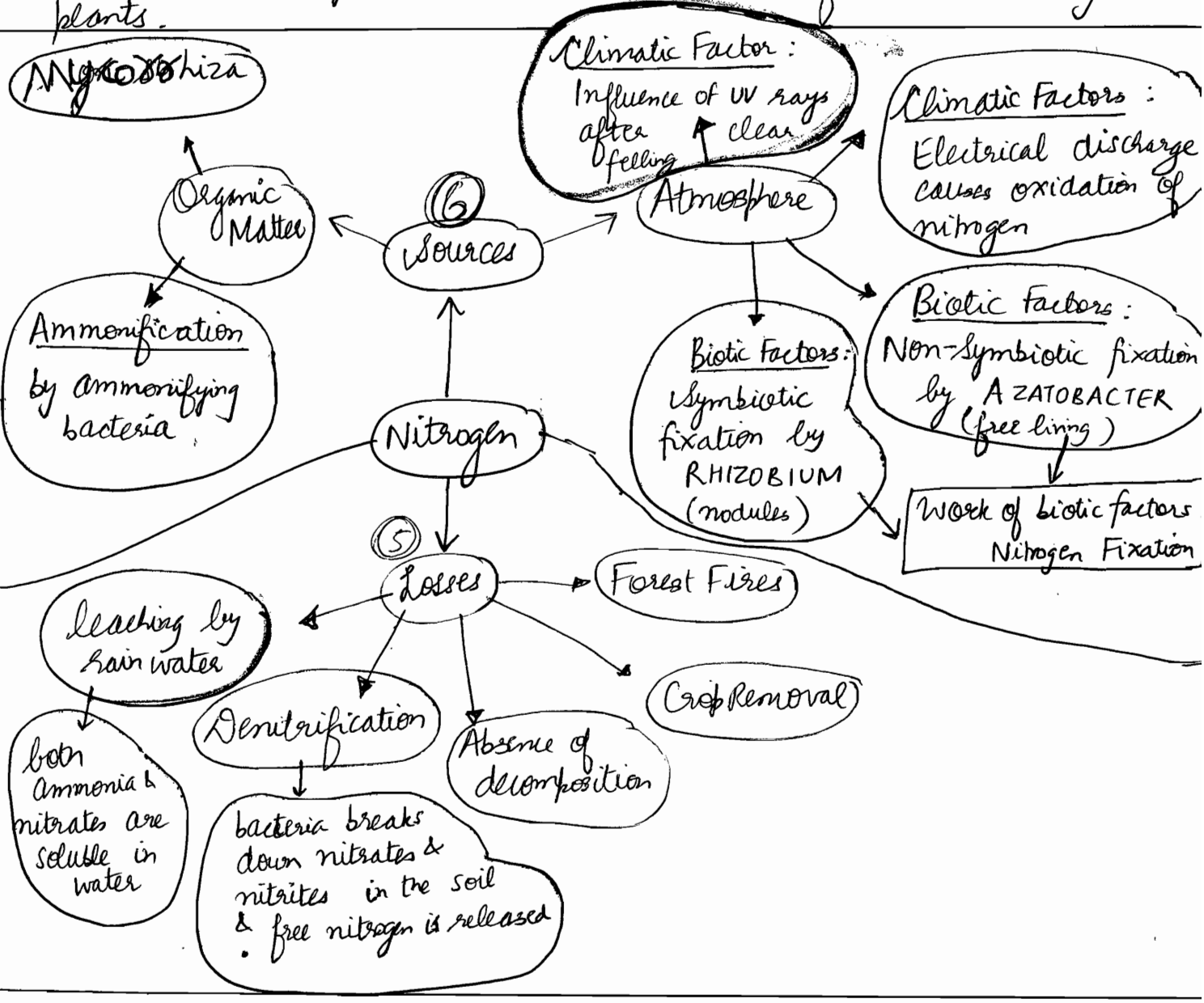
Pan is defined as a compacted or cemented soil horizon in which cementation is due to iron hydroxides, organic material, silica or other substances

- Podsolic iron pan
  - Iron & Aluminium Sesquioxides
- Lateritic iron pan
  - Latosols or Laterization
- Silican Pan
  - In latosols, intensive leaching of silica & deposition in lower layers
- Kankar Pan
  - Alluvial soils of UP lime is precipitated in soil below
- Clay Pan
  - Mechanical compaction of layer of clayey soil due to use of heavy machines
  - ∴ called Plough Pan

- leaves of broad leaved plants decompose faster than needles ⇒ more humus
- Poorly drained soils have higher organic content ⇒ more humus
- Lopping : removal of green leaves by village for cattle fodder
  Removal of dry leaves for bedding of cattle sheds.

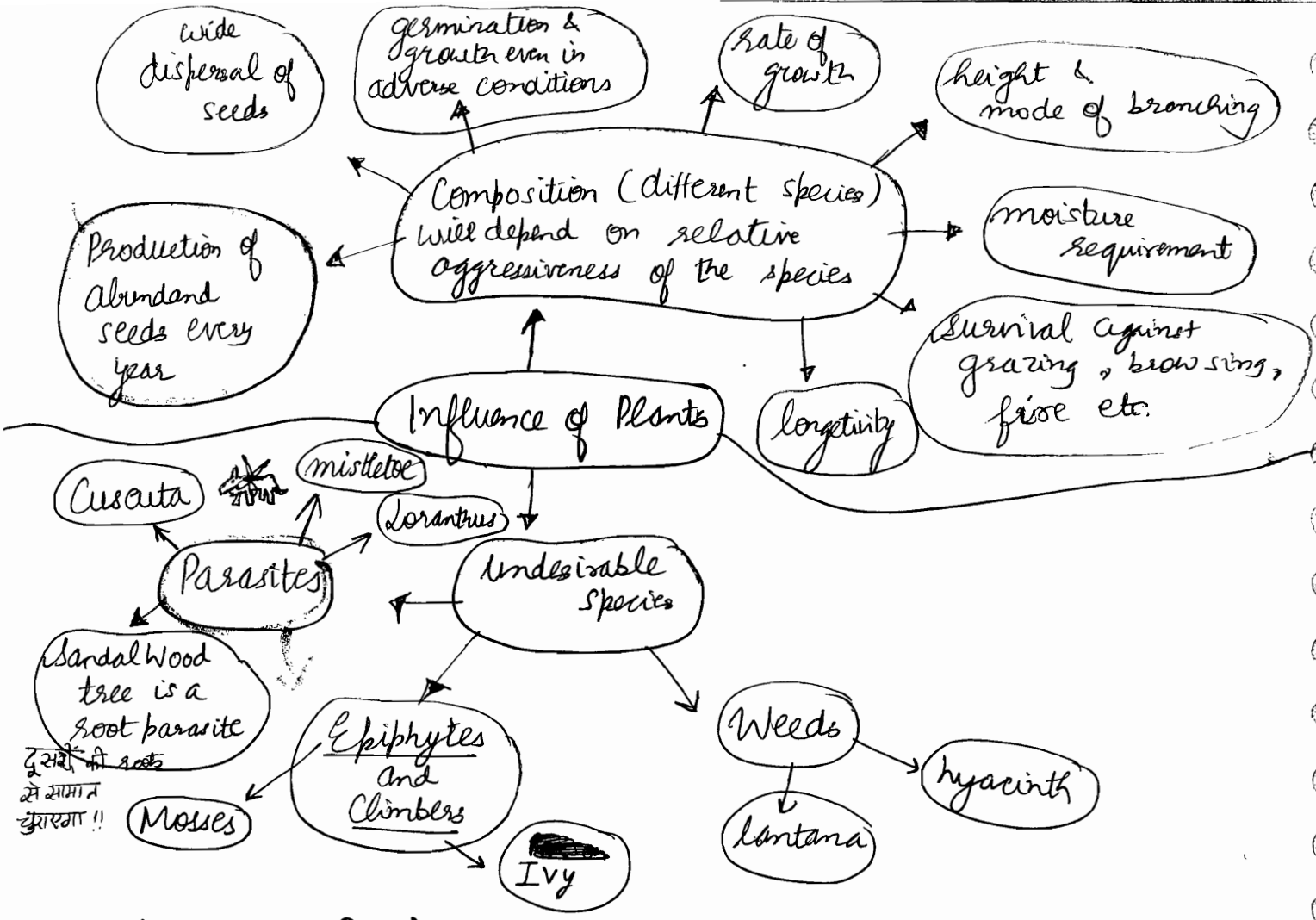
humus improves physical properties of soil : improves (1) structure, water holding (2) capacity. Makes sandy (3) soils more cohesive ⇒ ↑ retention of moisture. Makes clayey (4) soils more permeable to water.

also improves chemical properties by returning (5) minerals to soils, ↑ nitrogenous (6) content of soil. It is colloidal (7) in nature and therefore increases cation exchange capacity ⇒ helps absorption of nutrients by plants.



(*) Nitrate production is an index of soil fertility. If nitrification of soil is insufficient, soil may be unsuitable for regeneration.

Certain tree species accelerate the nitrification of humus. Eg. leaves of broad-leaved trees in temperate Himalayas help in nitrification of humus. ∴ For natural regeneration of conifers, some broad-leaved trees are also mixed.



(*) उतने examples लिखने पर ही Number मिलेंगे !!

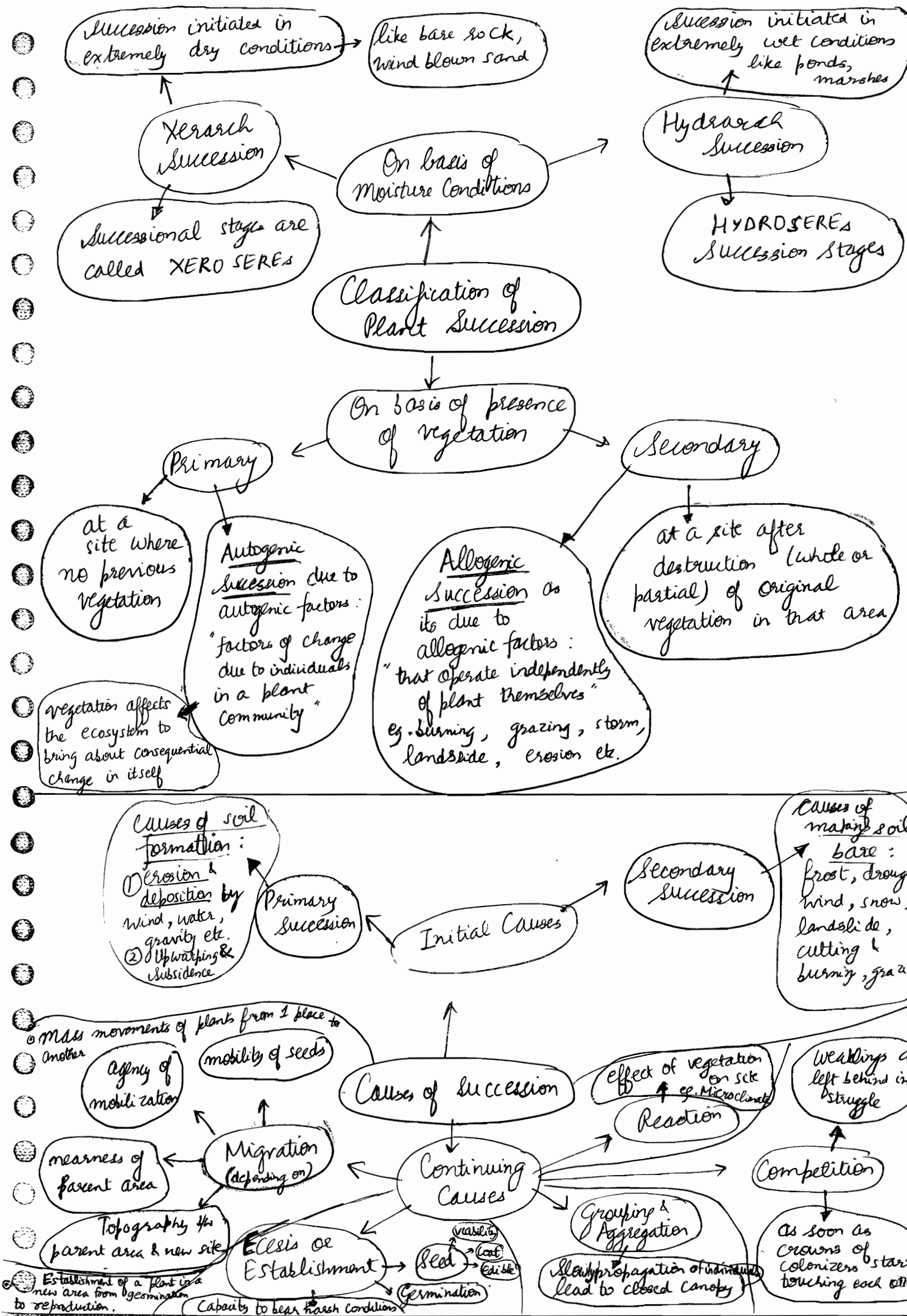
- ⊙ Parasites have a modified root, called HAUSTORIA that penetrate the host plant & connects to xylem, phloem or both.
- ⊙ large woody climbers called liana : damage timber (grooves)
  kill saplings
  bend the trees.
  restrict diameter growth
- ⊙ Lantana coppices so well that efforts to eradicate it have completely failed. Obstruction in regeneration of Sal.
- ⊙ Sal Borer : makes tunnel in timber of sal trees & in case of heavy attack, kills the tree.
  eg. in MP & UP, many trees were killed.

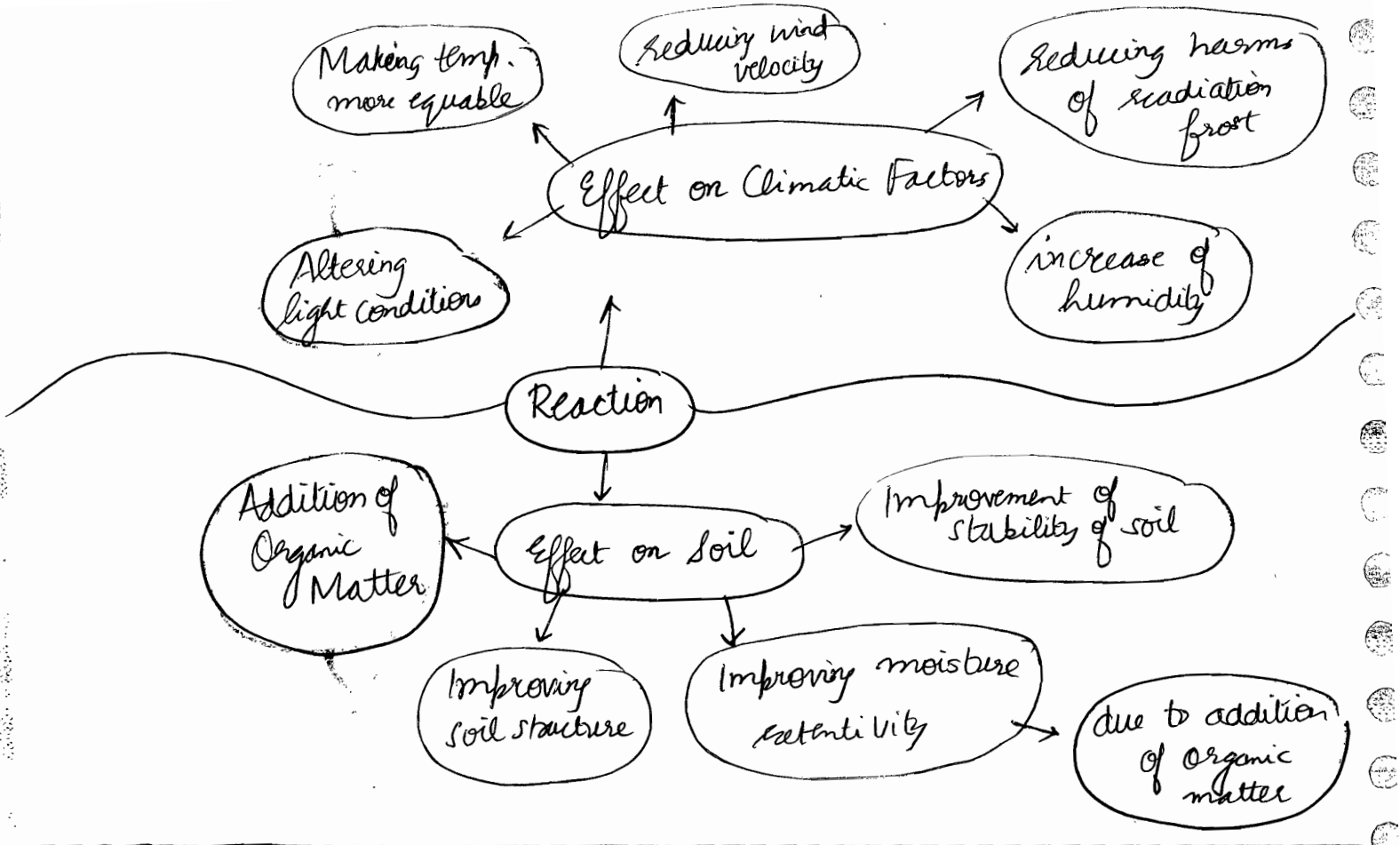
But insects do help eg in Pollination (Entomophilous)

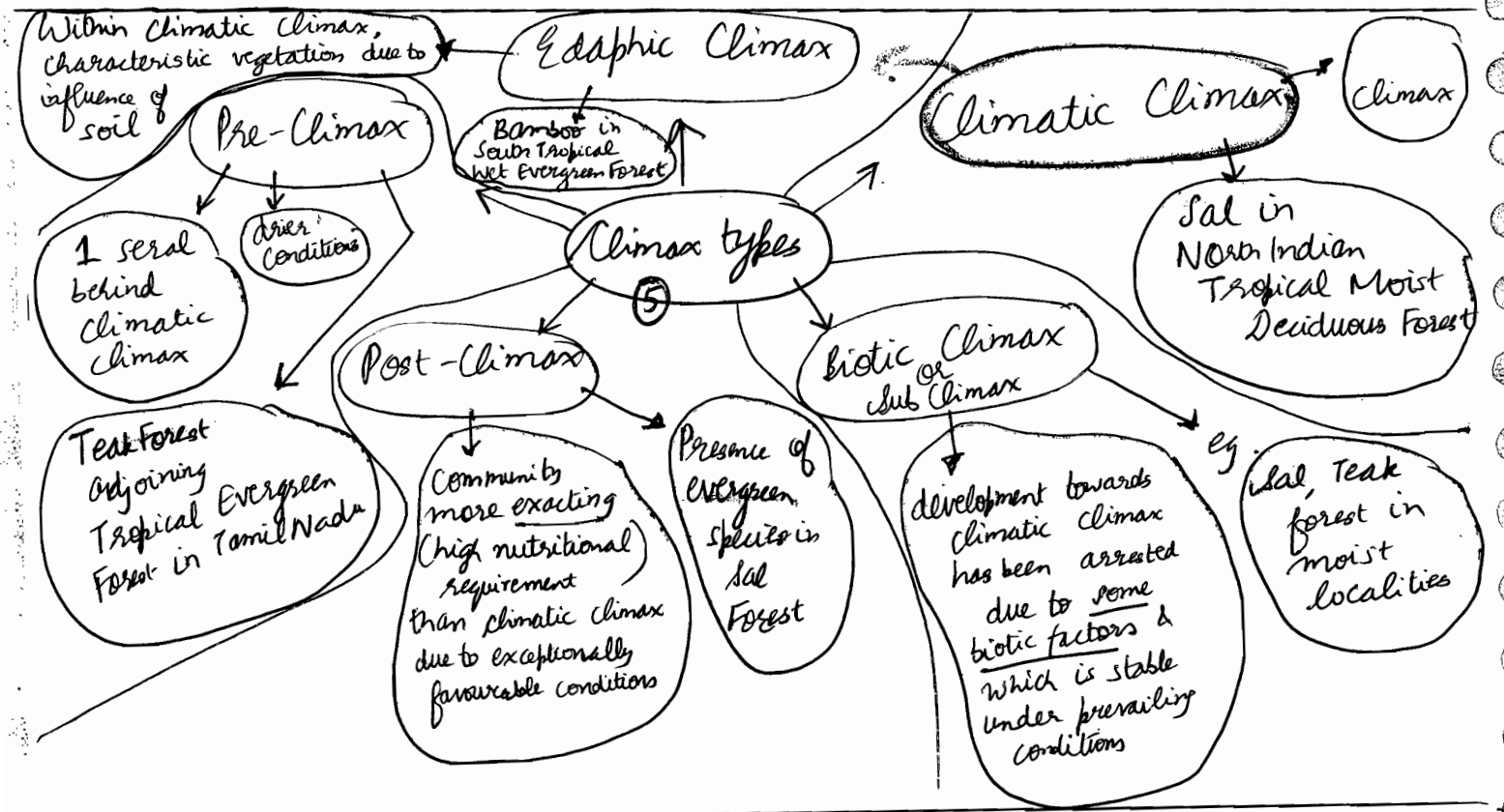
- ⊙ Severe defoliation by certain insects harms the trees due to reduced photosynthesis, respiration & transpiration.

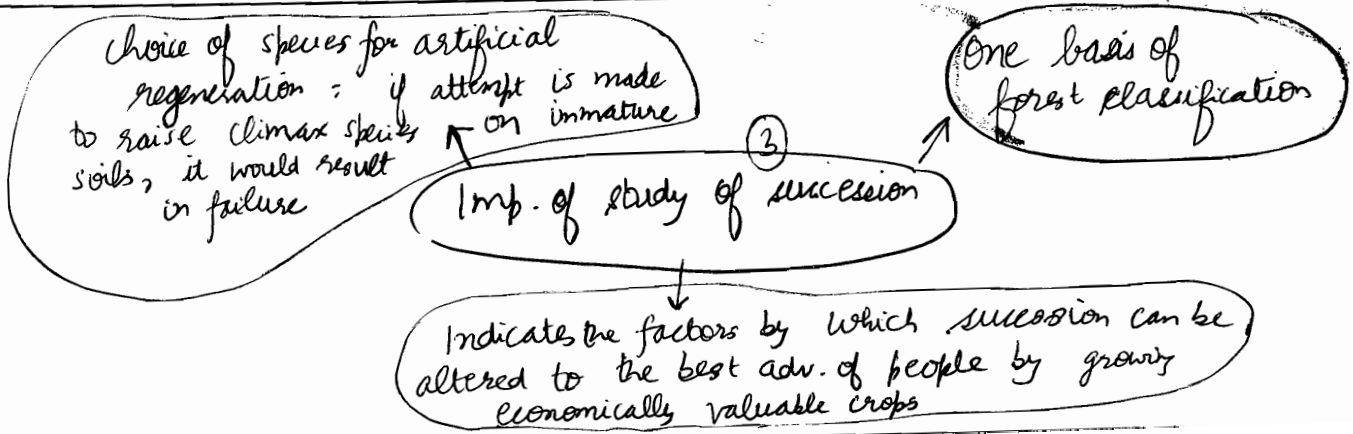

Wild Animal's influence
7
Elephants trample young seedlings
Porcupines destroy seedling of Bamboo & khair
Adverse effect on Sal regeneration by Cheetal, Sambhar & Nilgai (herbivores)
Pollination & dispersal
Removal of bark increases infection chances
Monkeys & langurs: damage to fruits
Pigs dig up & eat bamboo rhizomes
Black Bears strip-off barks of deodar, spruce & pine in Himalayan Conifers to lick the sap beneath the bark
Effect of Man & domesticated animals
6
Repeated lopping weakens the trees & it becomes prone to diseases
leaf fodder
lopping
removal of leaves
Fire
deforestation & denudation
Such trees easily attacked by insects
↓ photosynthesis
Removal of dry leaves
as bedding for cattle
Nutrient loss
Protective cushion lost ⇓ more run off
Collection of flowers & fruits
Natural regeneration difficult
Grazing
Fire
4
adv. of controlled fire
Hazard reduction
burns inflammable material
Clearance of site for artificial regen.
clearing weeds, grasses, shrubs & felling refuse
↑ bacterial activity
Improvement of soil & undergrowth conditions for regen.
Reduce density of undergrowth & make conditions suitable for natural regen.
heat treatment of seeds break dormancy
Even if not burnt down, growth of trees is affected
Trees with thick bark are less affected
damage to trees
Saplings are most affected
Summer Fire is more dangerous than winter fire
5
damage due to uncontrolled fire
ecological balance disturbed
damage to fauna
damage to regeneration
young regeneration is completely burnt down
damage to soil
soil is laid bare to action of wind, rain, sun
soil becomes compact & impervious
damage to productive power of forest
evergreen forest degenerates to inferior deciduous forest
Valuable specie disappear. Fire hardy species grow

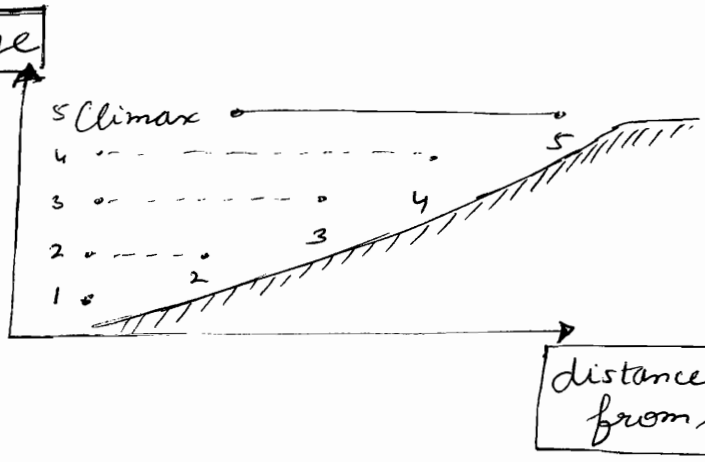
- Soil Texture : Clay → Silt → Sand → Gravel
  Soil Structure : Single grained → Crumby → Granular → blocky or nutty
- Like fire, grazing is a good servant but bad master.
- Goat is most damaging ; stands up on hindlegs & eats up everything.
- Camel due to height, is very destructive. Camel is an animal of deserts & it creates a desert wherever it goes.
- Browsing : Feeding on twigs or shoot, with or without attached leaves of shrubs, trees or woody climbers.
- Pruning, Lopping : Cutting of branches of a tree for improvement of tree timber, or to produce better shoots.


Succession initiated in extremely dry conditions
like bare rock, wind blown sand
Succession initiated in extremely wet conditions like ponds, marshes
Xerarch Succession
On basis of Moisture Conditions
Hydrarch Succession
Successional stage are called XEROSERES
HYDROSERES Succession Stages
Classification of Plant Succession
On basis of presence of vegetation
Primary
Secondary
at a site where no previous vegetation
Autogenic Succession due to autogenic factors: "factors of change due to individuals in a plant community"
Allogenic Succession as its due to allogenic factors: "that operate independently of plant themselves" eg. burning, grazing, storm, landslide, erosion etc.
at a site after destruction (whole or partial) of original vegetation in that area
vegetation affects the ecosystem to bring about consequential change in itself
Causes of soil Formation:
① Erosion & deposition by wind, water, gravity etc.
② Upwarping & subsidence
Primary Succession
Initial Causes
Secondary Succession
Causes of making soil bare: frost, drought, wind, snow, landslide, cutting & burning, grazing
Mass movements of plants from 1 place to another
Agency of mobilization
mobility of seeds
Causes of Succession
effect of vegetation on site eg. Microclimate
Reaction
Weaklings a left behind in struggle
nearness of parent area
Migration (depending on)
Continuing Causes
Competition
Topography b/w parent area & new site
Ecesis or Establishment
Seed
viability
Coat
Edible
Germination
Grouping & Aggregation
As soon as crowns of colonizers start touching each other
Establishment of a plant in a new area from germination to reproduction.
Capacity to bear harsh conditions
Slow propagation of individuals lead to closed canopy


Making temp. more equable
Reducing wind velocity
Reducing harms of radiation frost
Effect on Climatic Factors
Altering light condition
increase of humidity
Reaction
Addition of Organic Matter
Effect on Soil
Improvement of stability of soil
Improving soil structure
Improving moisture retentivity
due to addition of organic matter


Within Climatic Climax, characteristic vegetation due to influence of soil
Edaphic Climax
Pre-Climax
Bamboo in South Tropical Wet Evergreen Forest
Climatic Climax
Climax
1 seral behind Climatic climax
drier conditions
Climax types
5
Sal in North Indian Tropical Moist Deciduous Forest
Post-Climax
biotic Climax or Sub Climax
Teak Forest adjoining Tropical Evergreen Forest in Tamil Nadu
Community more exacting (high nutritional requirement than climatic climax due to exceptionally favourable conditions
Presence of evergreen species in Sal Forest
development towards climatic climax has been arrested due to some biotic factors & which is stable under prevailing conditions
eg
Sal, Teak forest in moist localities

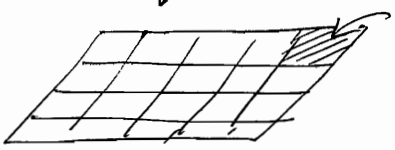

Choice of species for artificial regeneration : if attempt is made to raise climax species on immature soils, it would result in failure
One basis of forest classification
Imp. of study of succession
3
Indicates the factors by which succession can be altered to the best adv. of people by growing economically valuable crops

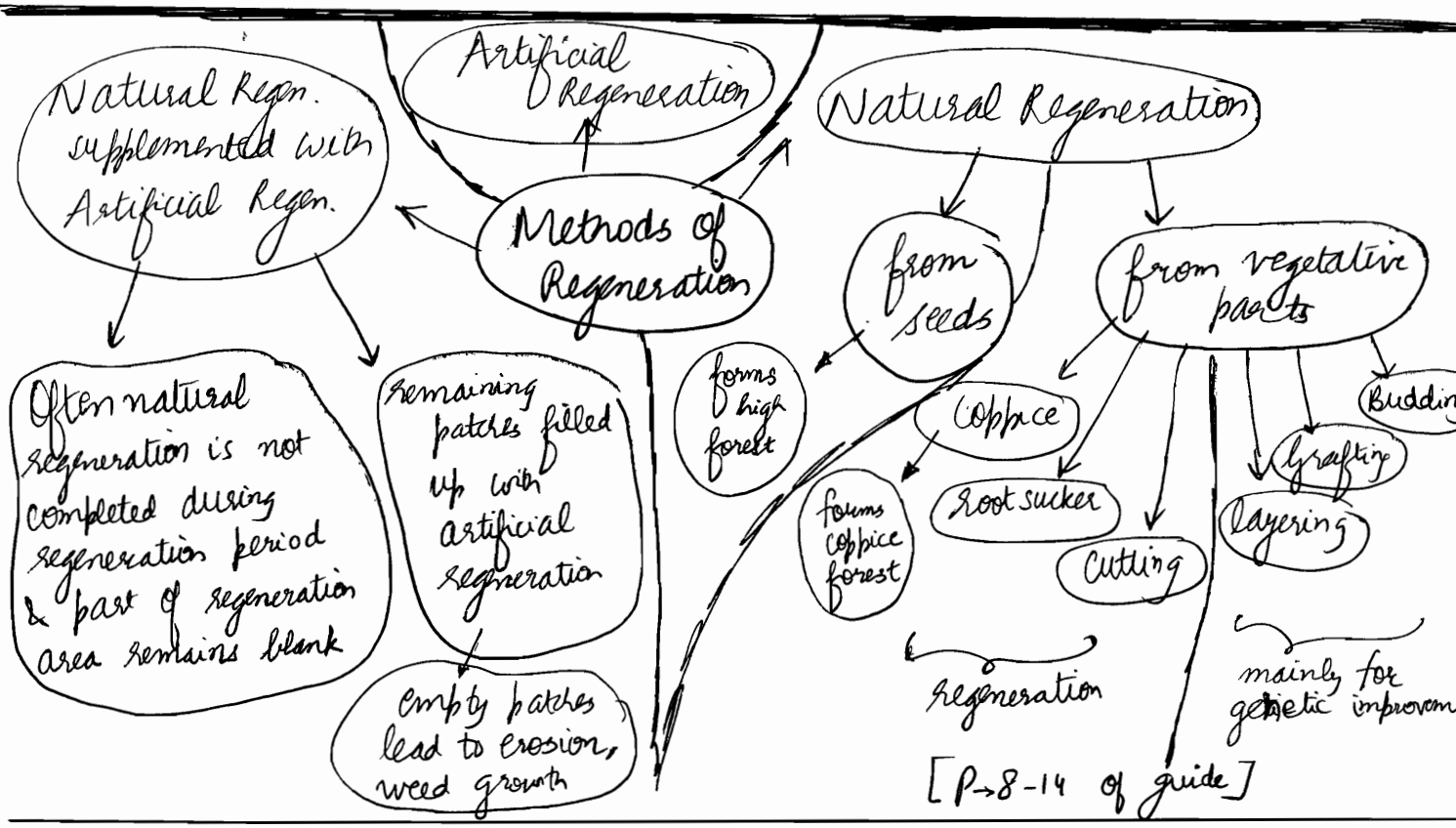


⊙ It's not possible to see all stages of succession in the same place as development of vegetation takes place in 1000s of years. However if there is gradual rise of land from river bank to mature high land various stages of succession can be seen.

⊛ **Pole** is a tree that is larger than sapling size, but not yet of a merchantable timber size.

⊛ **Quadrat** A small, typically rectangular, plot used in ecology & forestry, to isolate a standard unit of area for study of the distribution of an item over a large area.





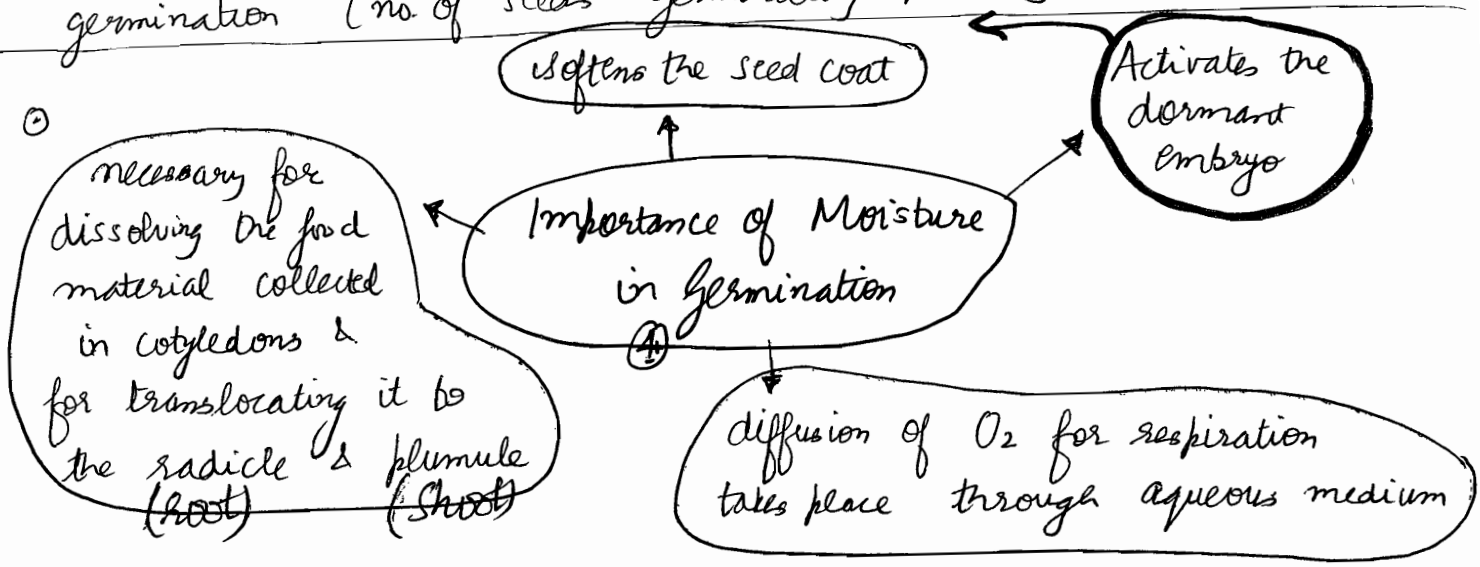
[P→8-14 of guide]

⊙ For producing root suckers, circular trenches are dug with radius of 3 m around isolated trees so that their roots are severed & root suckers produced, which, with tending, could develop into trees. But such trees are liable to wind-throw & poor in growth. ∴ this method is less favoured.

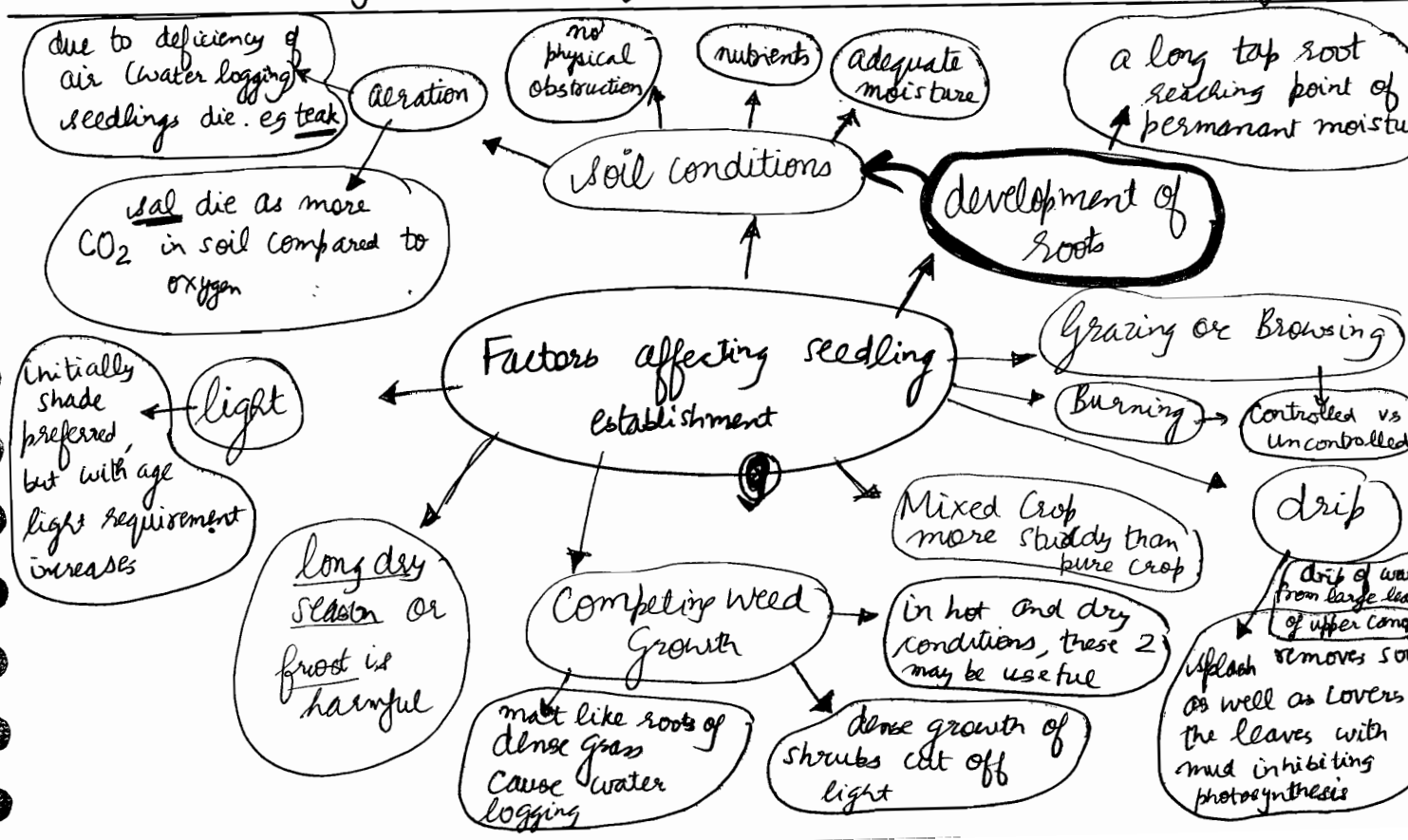
⊙ After-Ripening : Even if embryo is full developed, sometimes seeds do not germinate b'coz embryo is not chemically ready for germination. They generally germinate after they have undergone a process of after-ripening.

⊙ Viability is the Potential Capacity of a seed to germinate. Some seeds lose their viability soon while others retain their viability for a year or more.

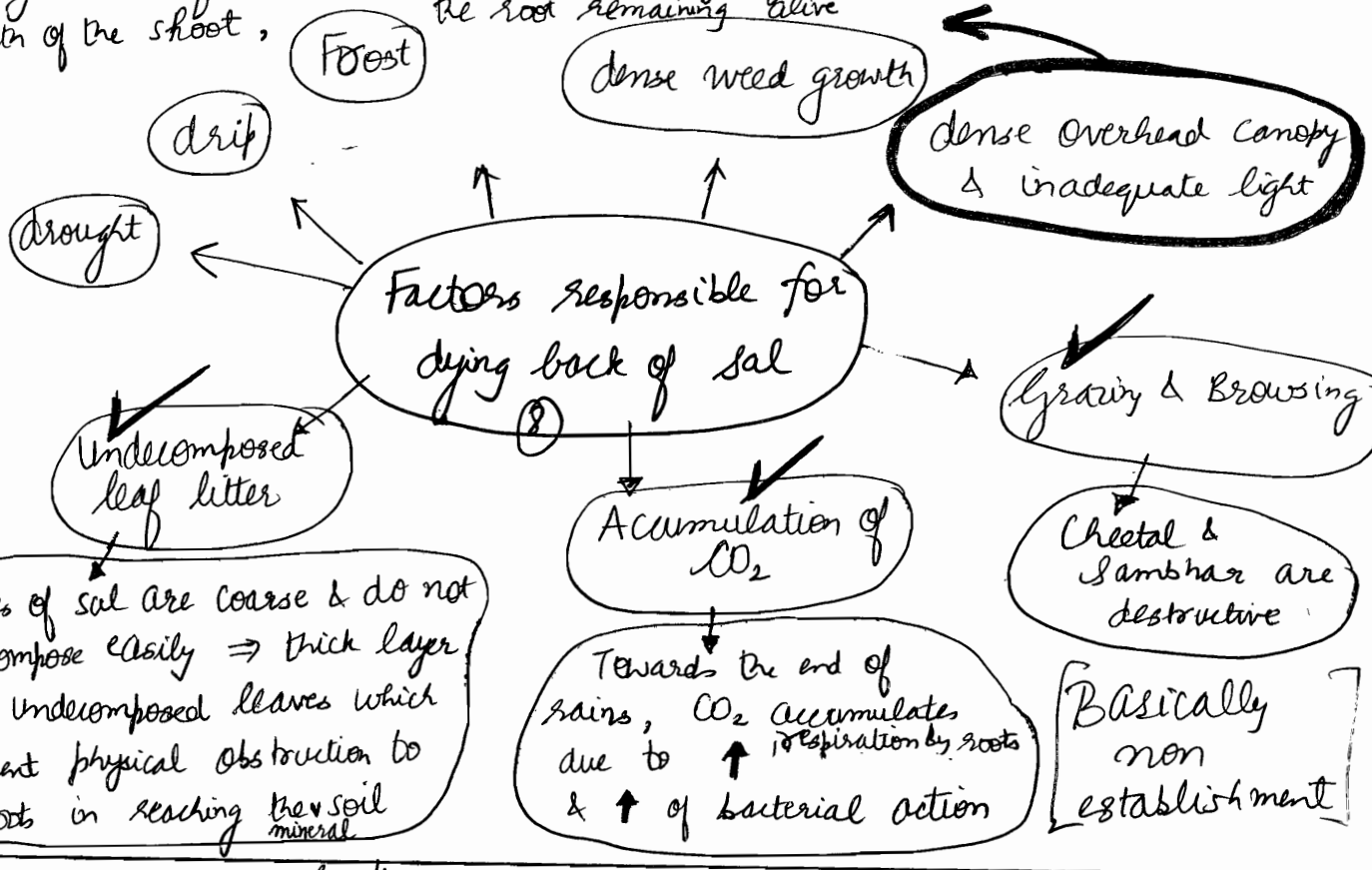
- **Germinative Capacity** : %, by number of seeds, in a given sample that actually germinate, irrespective of time.
- **Germinative Energy** : %, by number of seeds, in a given sample that germinate within a given period of time. This time is usually taken as the time when the rate of germination (no. of seeds germinating per day) reaches its peak.



- In germinating seed, O_2 is very important for respiration. Therefore, seeds buried in the deeper layers of soils often remain dormant for want of O_2. Even if it germinates, seed is not able to push plumules through the soil.
- Within a range, the higher the temp. the better the germinat

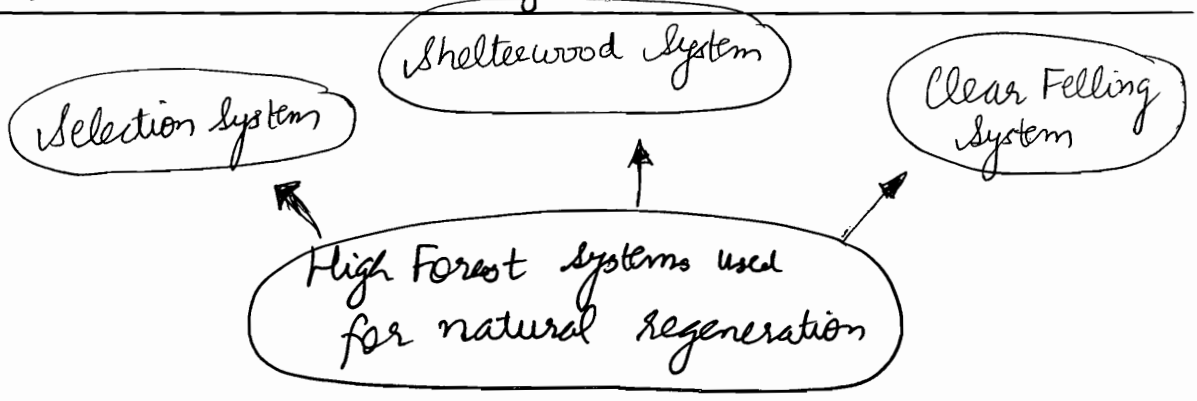


⊙ dying back refers to the backward dying from the tip of the plant. Usually the root remaining alive
death of the shoot,



⊙ In the Sandy area, the first tree species to come are [illegible] & Sissu but they do not regenerate under their own canopy. This is b'coz the moisture & fertility improves, overhead light reduces & diurnal range decreases.
उदाहरण for regeneration

⊙ [illegible] regenerate freely in nature but they form pure "crops", their regeneration becomes a problem. This is because they require natural grazing & fire for their survival. In controlled "scientific" environment, conditions become too moist & evergreen shrubs come up.

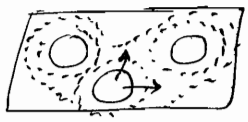


⊙ Seeding Felling (t_1) → Secondary Fellings → Final felling (t_2)

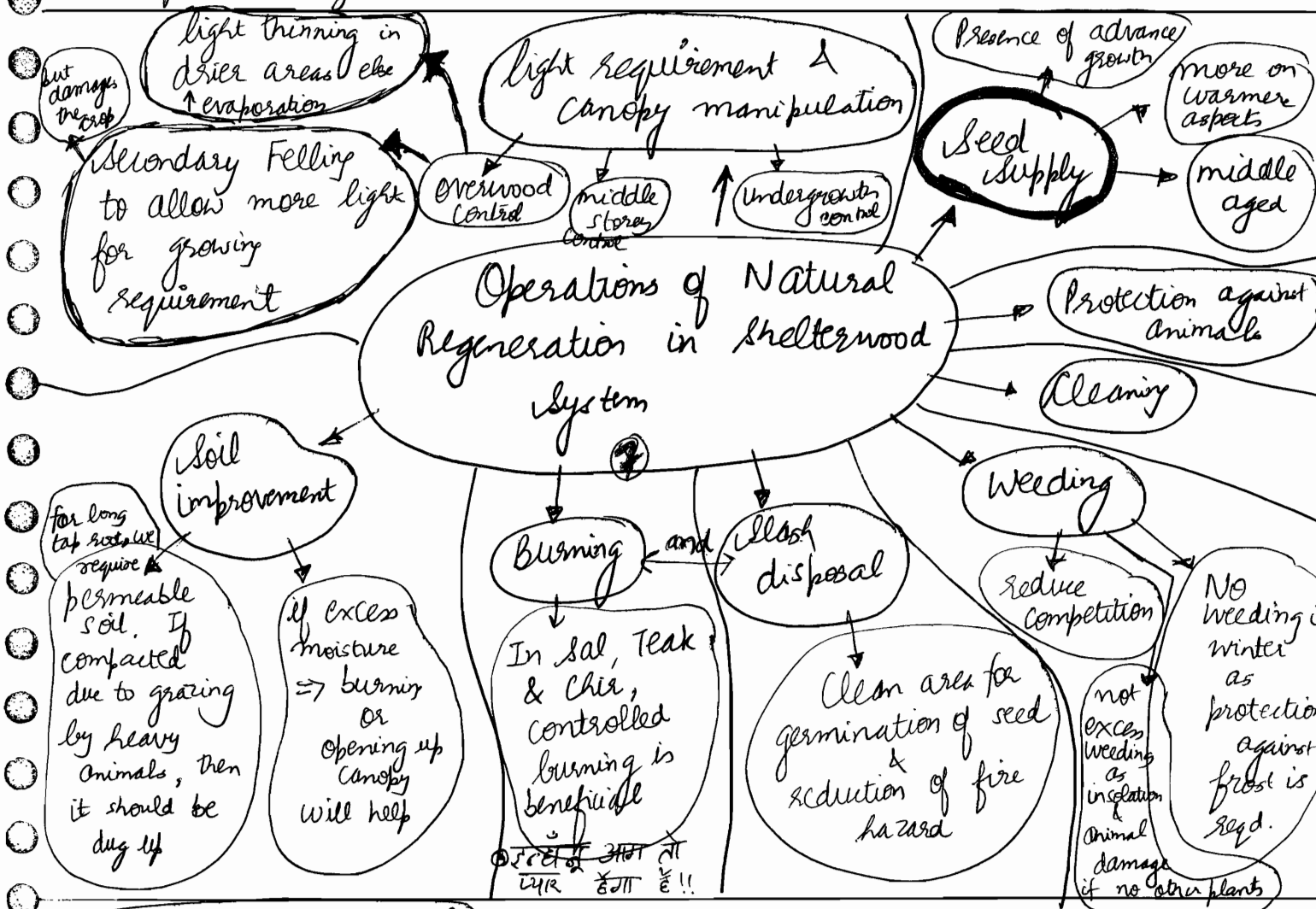
$t_2 - t_1$: regeneration interval (determines the age uniformity)

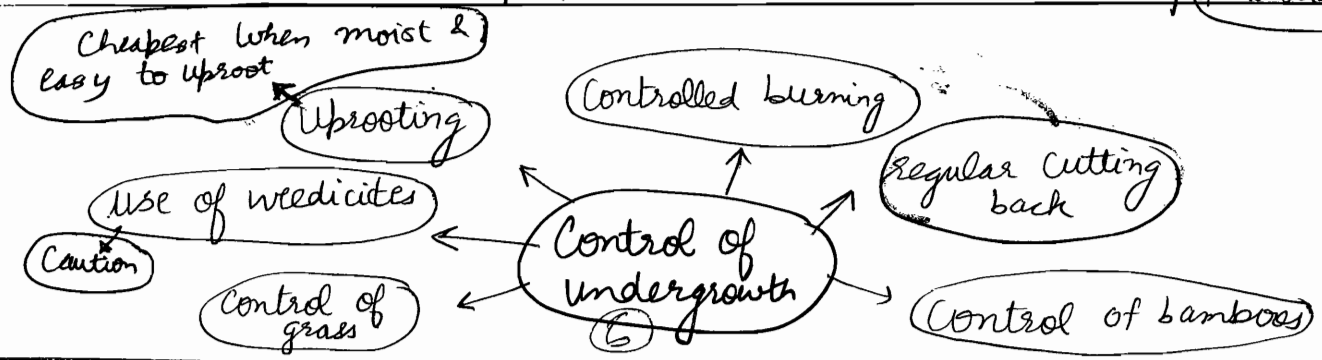
- Well-distributed small gaps over the whole compartment,
  ⇒ regeneration comes up uniformly : UNIFORM SHELTERWOOD System

- If seeding felling is done in groups, regeneration also comes up in groups : GROUP SHELTERWOOD System.



- If advance growth (seedlings, saplings and poles of species of the overwood, that have become established naturally in forest, before regeneration fellings are started) is retained (to make up deficiency of natural regeneration), resulting crop is irregular : IRREGULAR SHELTER WOOD SYSTEM.





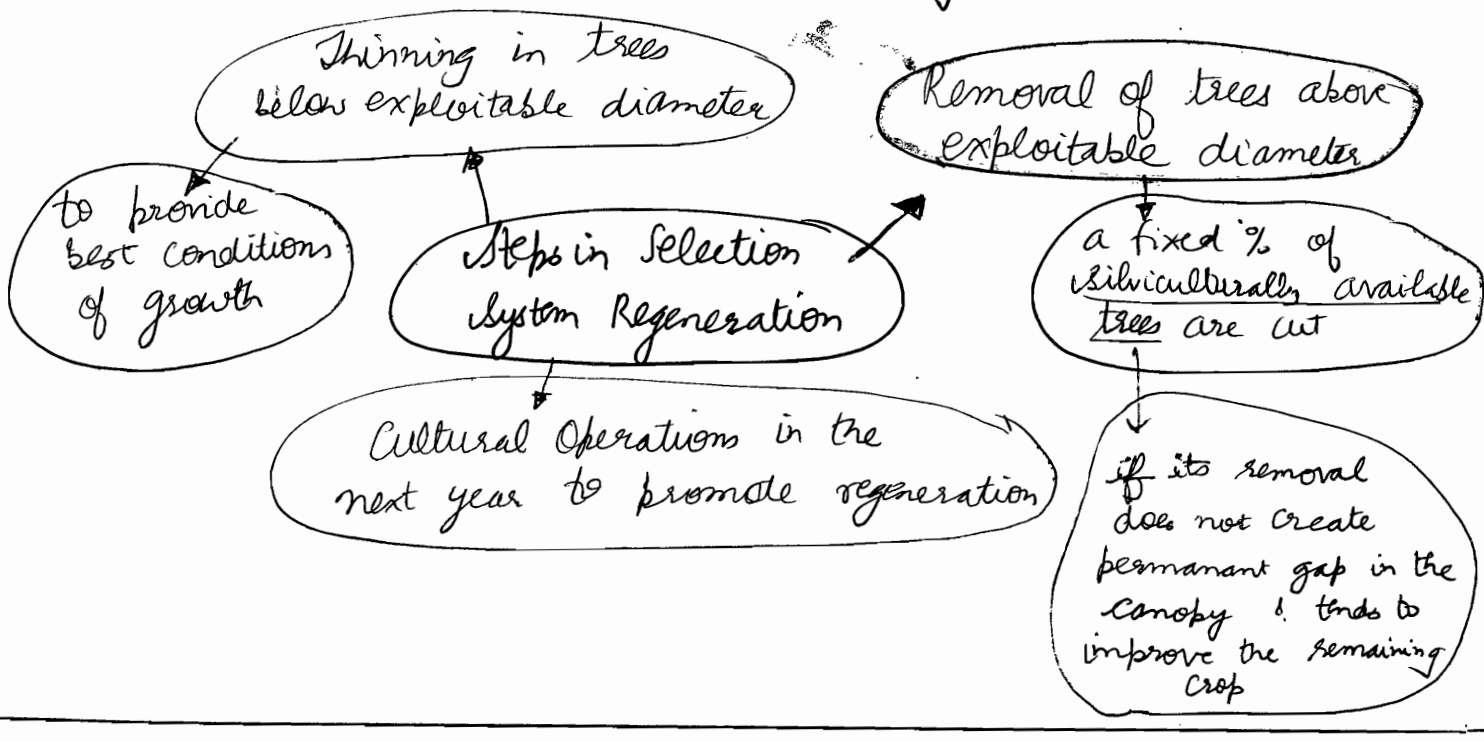
- Too long fencing period ↔ increased cost of maintenance
  antagonizes people whose grazing rights have been suppressed.

  Too short fencing period → defeat the purpose for which fence was put up.

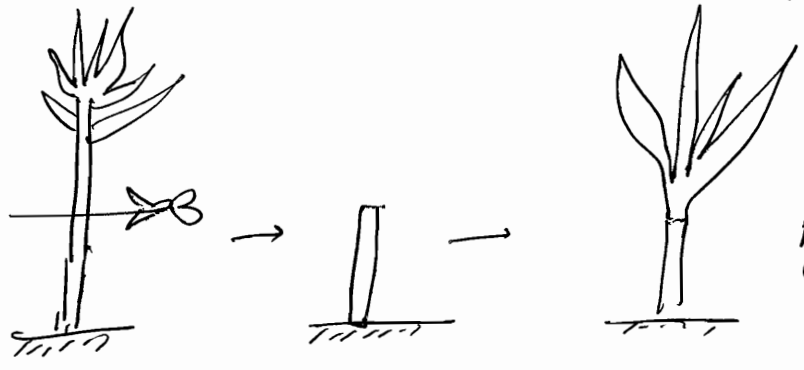
- In **Selection System**, mature crop is removed either as single trees or in small groups over the whole of felling series (a forest area forming a part of a working cycle) and therefore resultant crop is always irregular.

  Follows nature in which mature trees keep on dying & they are regenerated.

  Often, trees are felled where saplings & poles of main species are there to take the place of mature trees.



Pollarding



→ stem of a tree is cut off at a height beyond the reach of browsing animals with the object of producing a crown of new shoots.

(★) Note that we already know 7 general points of Natural Regeneration

Natural Regeneration of Conifers (Chir / Fir / Deodar / Spruce)

(1) All trees other than seed bearers are removed.

(2) Seed bearers are retained on the upper portion of slopes.

(3) After felling, slash is collected away from seed bearer & burnt in winter.

(4) Area is continued to be control burnt till a good seedling crop is obtained from a good seed year.

(5) After seedling comes up, protection against burning & grazing.

(6) Weeding & Shrub cutting is done.

(7) When seedlings are established, grazing is allowed (reduces fire hazard) and seed bearers are removed. Usually when regeneration ≈ 6m high on gentler slopes & 9m high on steeper slopes.

(8) In fire prone areas some seed bearers are kept.

Natural Regeneration of deciduous (Sal / Teak)

(1) Top canopy : No seeding felling is required in a normally thinned mature stand as enough gaps exist in canopy

(2) Middle storey : Low branching & dense-foliage should be heavily thinned. Light crowned species should be retained.

(3) Thorough soil working should be done in the year preceding the good seed-year.

(4) Deficiency in natural seed fall should be made up by broadcasting seeds.

(5) Controlled burning is done to stimule regeneration.

(6) From the beginning, fencing should be done with game-proof fence (protection from wild animals)

(7) Weeding & shrub cutting annually for 1st 3 years.

(8) When enough seedling reach woody stage, top canopy may be further opened up, to stimulate growth of woody regeneration.

Natural Regeneration of Evergreen Trees

(Andamans Canopy lifting Shelterwood System) (Andaman evergreen & deciduous)

(1) Extraction of commercial timber from regeneration area, by removing all saleable trees above a prescribed g.b.h (girth @ breast height)

(2) Canopy lifting: After the extraction of timber, canopy lifting done by: ① Felling all low poles (<10m) and ② girdling trees of 10-20 m not needed as seed bearers. Or commercially afterwards. Aim is to have adequate light filtered through the canopy.

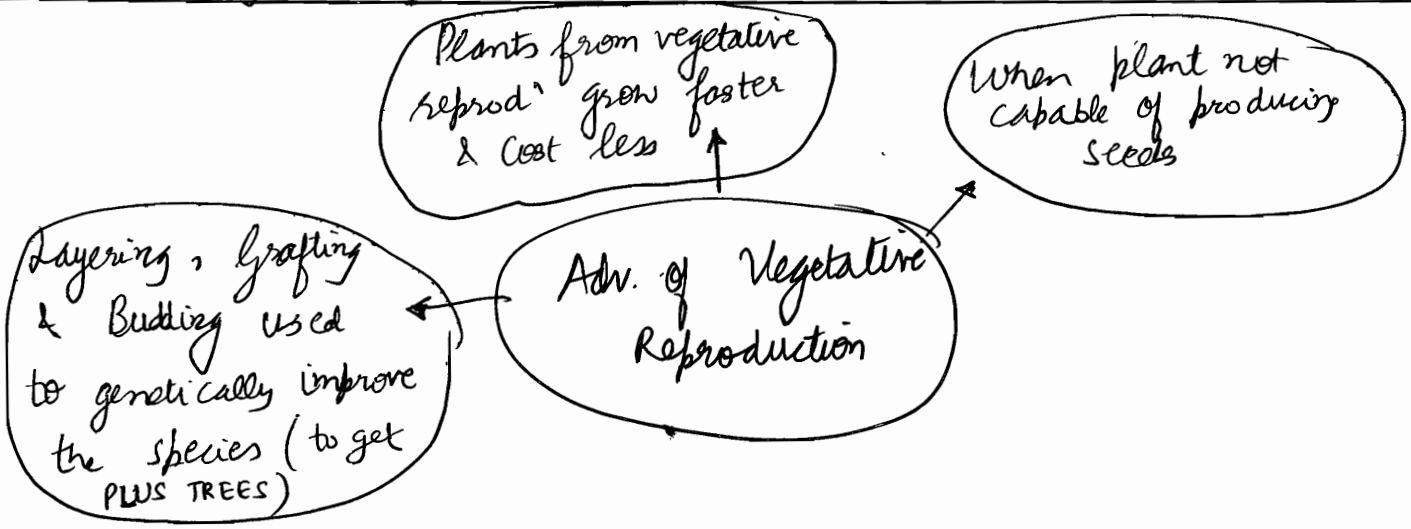
(3) Controlled burning.

(4) Seed Broadcasting where seed bearers or advance growth is insufficient.

(5) Weeding after rains

(6) Cleaning and Climber cutting.

(7) Thinning

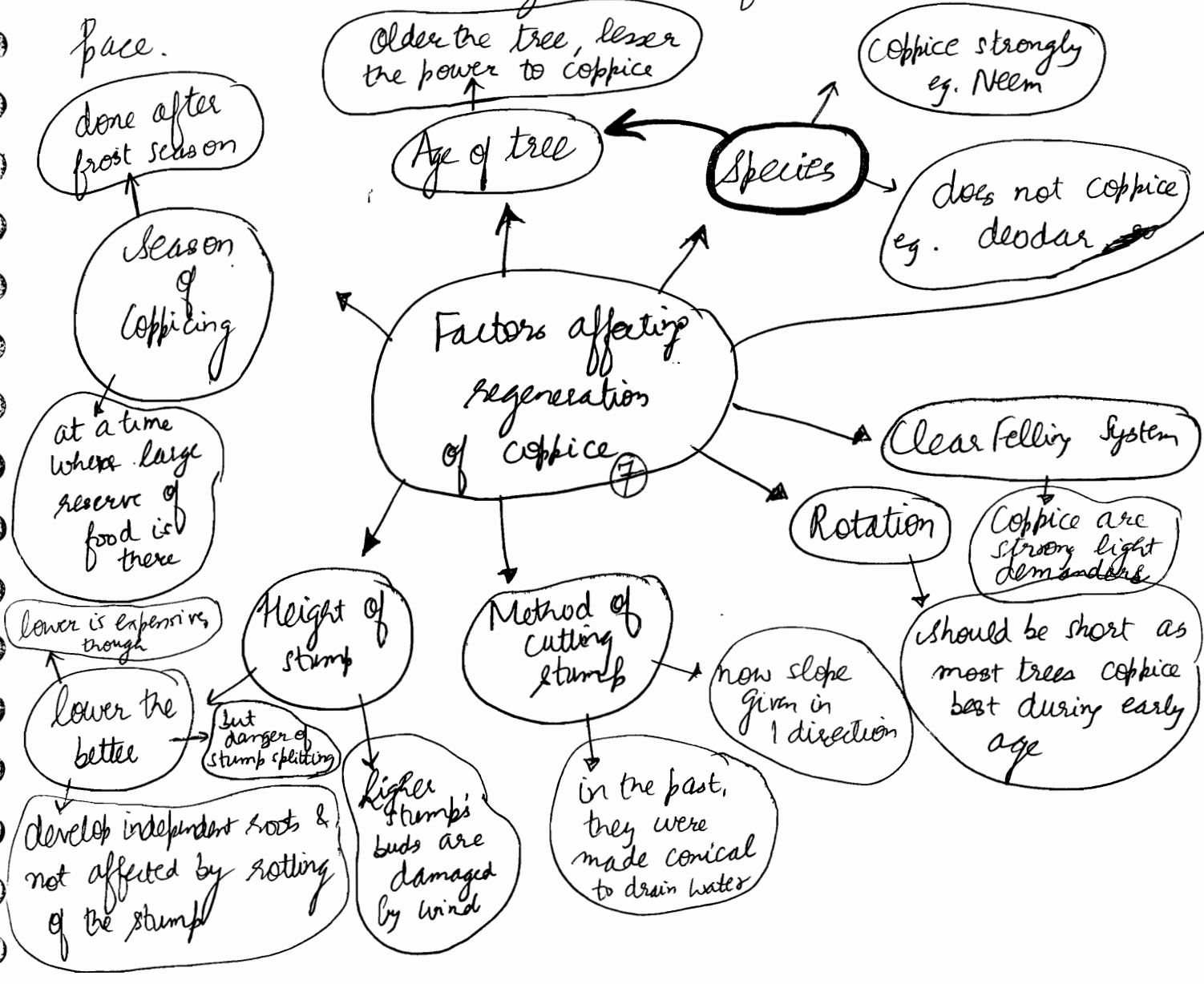


⊙ **Coppice shoot** refers to the shoot arising from an adventitious bud at the base of a woody plant that has been cut near the ground.

Types of Coppice

① Stool Coppice : Copping arising from living stump, either from base of stump or from top. Former are better, as the latter are liable to ↑ rotting (be damaged by the) of upper portion of stump as well as by wind.

② Seedling Coppice : Arising from base of the seedling that has been cut or burnt back. done in sal & teak. Done when natural regeneration fails to progress at good pace.



- Trees cannot keep on indefinitely coppicing and they die after sometimes. ∴ in every coppice, some stools do not coppice, hence mortality can be made up by encouraging seedling regeneration, supplemented with sowing or planting.

⊙ Usually each stool produces several coppice shoots. To develop good poles, shoots should be reduced to 2 or 3 in second year and after developing further, it should be reduced to 1 shoot.

Simple Coppice System

(1) Applicable to species that coppice strongly. As youngers trees coppice profusely, coppice rotation is kept short between 20 - 40 years.

(2) All trees are clear-felled with no shelterwood.

(3) Tending Operations : initially limited to 2 shoots and then 1 shoot.

(4) Natural seedlings allowed to grow alongside.

(5) Blanks are regenarated by sowing or planting.

Coppice - with - standard System

(1) Part of crop retained to form uneven aged overwood. Resultant crop is 2 storeyed :- Upper storey : Standard Standings
Lower storey : Coppice crop

(2) Standards are of wind-firm valuable species.

(3) Standards occupy $(\frac{1}{3})$ to $\frac{1}{2})$ of area of canopy, & this space is equally divided into standards of all age class.

(4) After selecting standards, rest of the crop is clear felled.

(5) < (3), (4), (5) points of simple Coppice >

(6)

(7)

Coppice - with - reserves System

(1) Well grown saplings & poles are retained, to form part of the new crop.

(2) Reservation is done with object of providing protection against frost & erosion, supplying seed and protecting valuable species.

(3) Felling varies from clear felling to no-felling. Regeneration of area is both by coppice as well as saplings and poles grown from seeds.

(4) < 3, 4, 5 points of simple coppice >

(5)

(6)

- Cultural Operations are performed in the years following the regeneration fellings :
  - → to remove after-effects of felling
  - → to improve conditions of growth for regeneration.

- Includes
  - Subsidiary felling
  - Weeding
  - Cleaning
  - climber cutting
  - Unremunerative Improvement Felling
  - thinning
  - girdling/poisoning of unwanted growth
  - Controlled burning

Cultural Operation

(1) Carried out for
- → benefit of forest crop
- → complete regeneration
- → minimize ill effects of felling

∴ Broader scope

(2) One of their objectives

(3) Includes controlled burning.

(4) does not include pruning

(5) Carried out only after felling

(6) Only associated with natural regeneration

Tending

(1) Carried out for benefit of forest crop.

(2) Not aim @ obtaining natural regeneration

(3) does not include controlled burning

(4) includes pruning

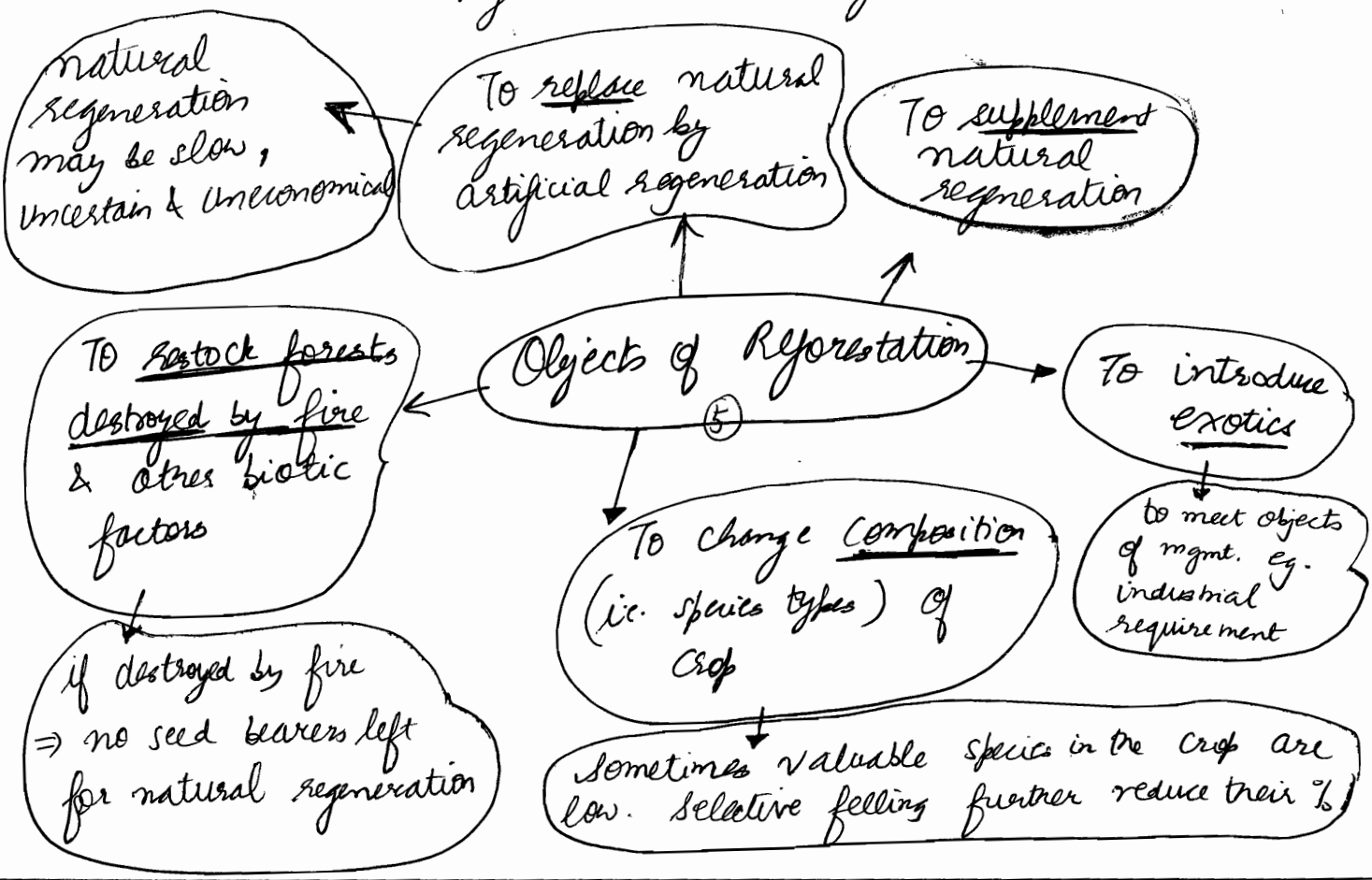
(5) Carried out regularly & periodically.

(6) Carried out for both natural & artificial regeneration.

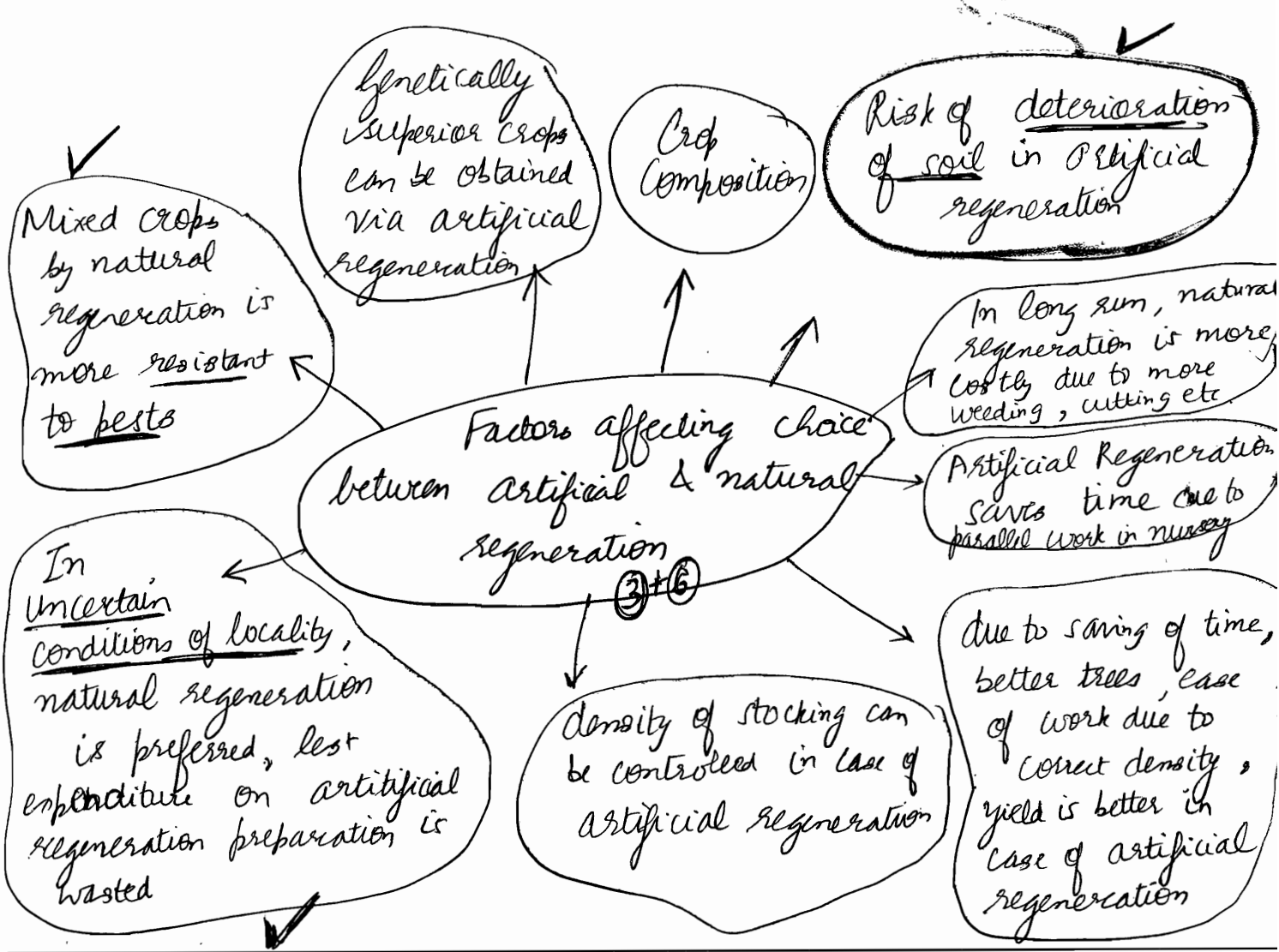
Artificial Regeneration is defined as the renewal of a forest crop by sowing, planting or other artificial means. It also refers to the crop so obtained. It has 2 major aims:

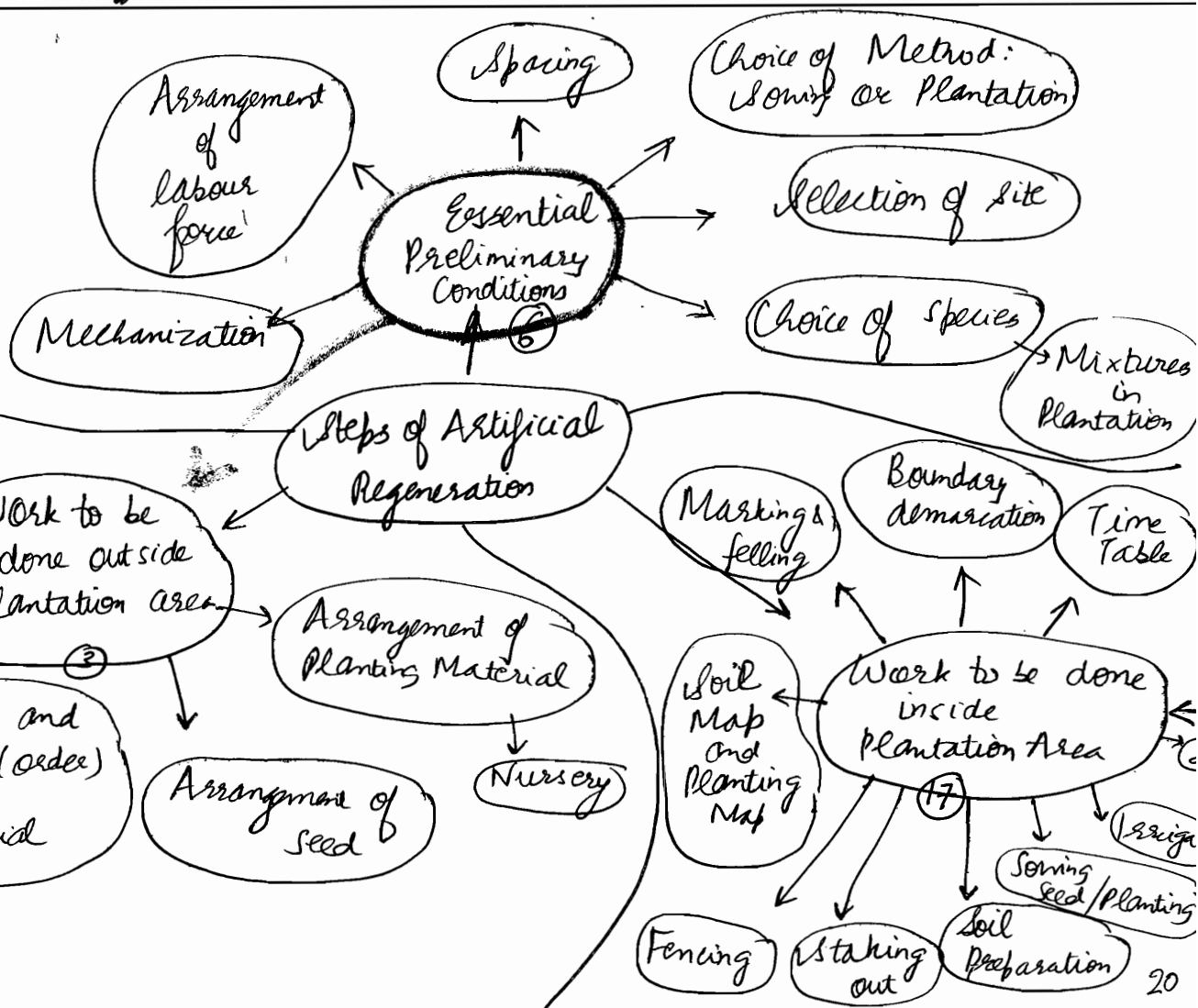
(1) **Reforestation**: Restocking of a felled woodland by artificial means.

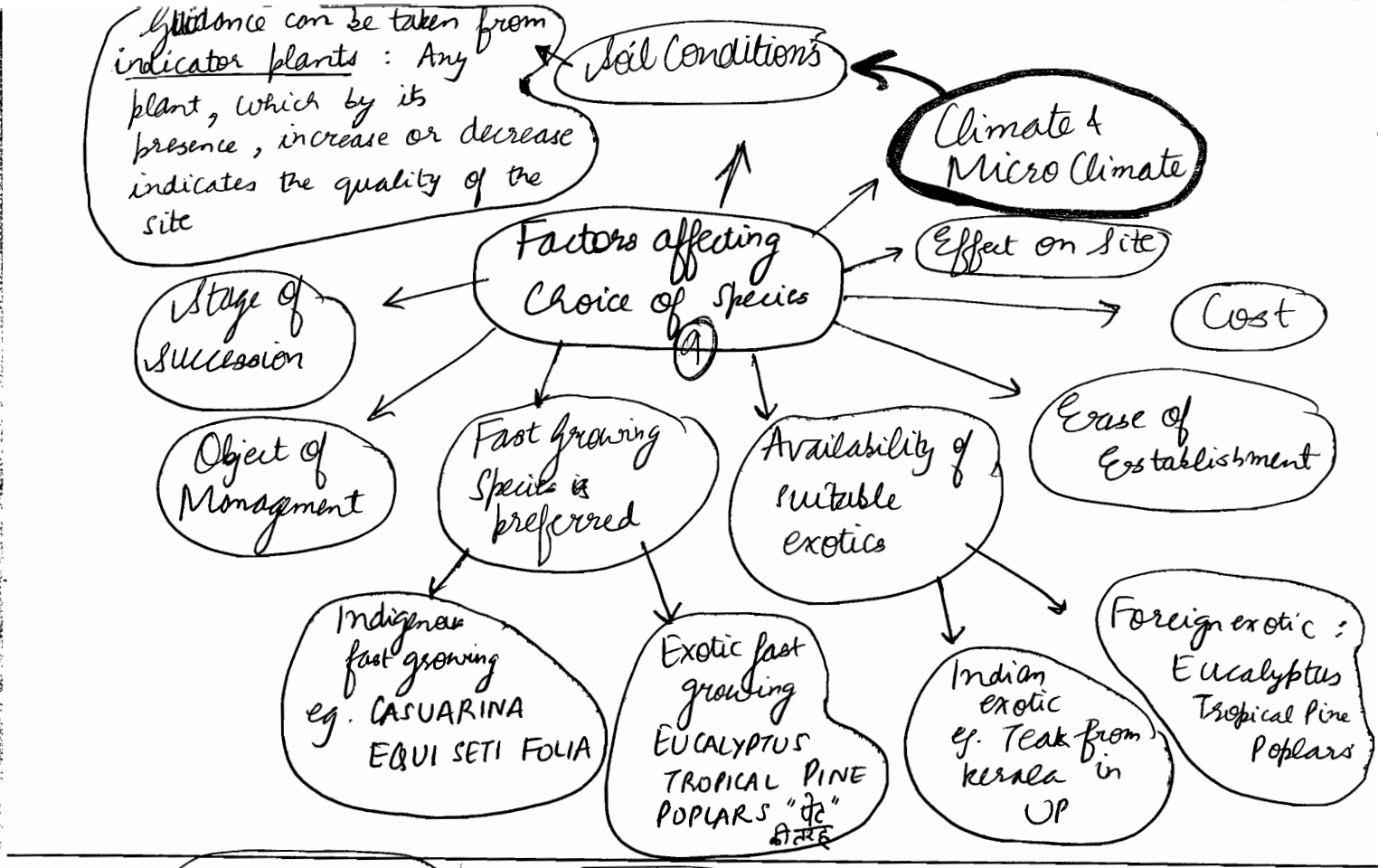
(2) **Afforestation**: Establishment of a forest by artificial means on an area from which forest vegetation has long been absent.

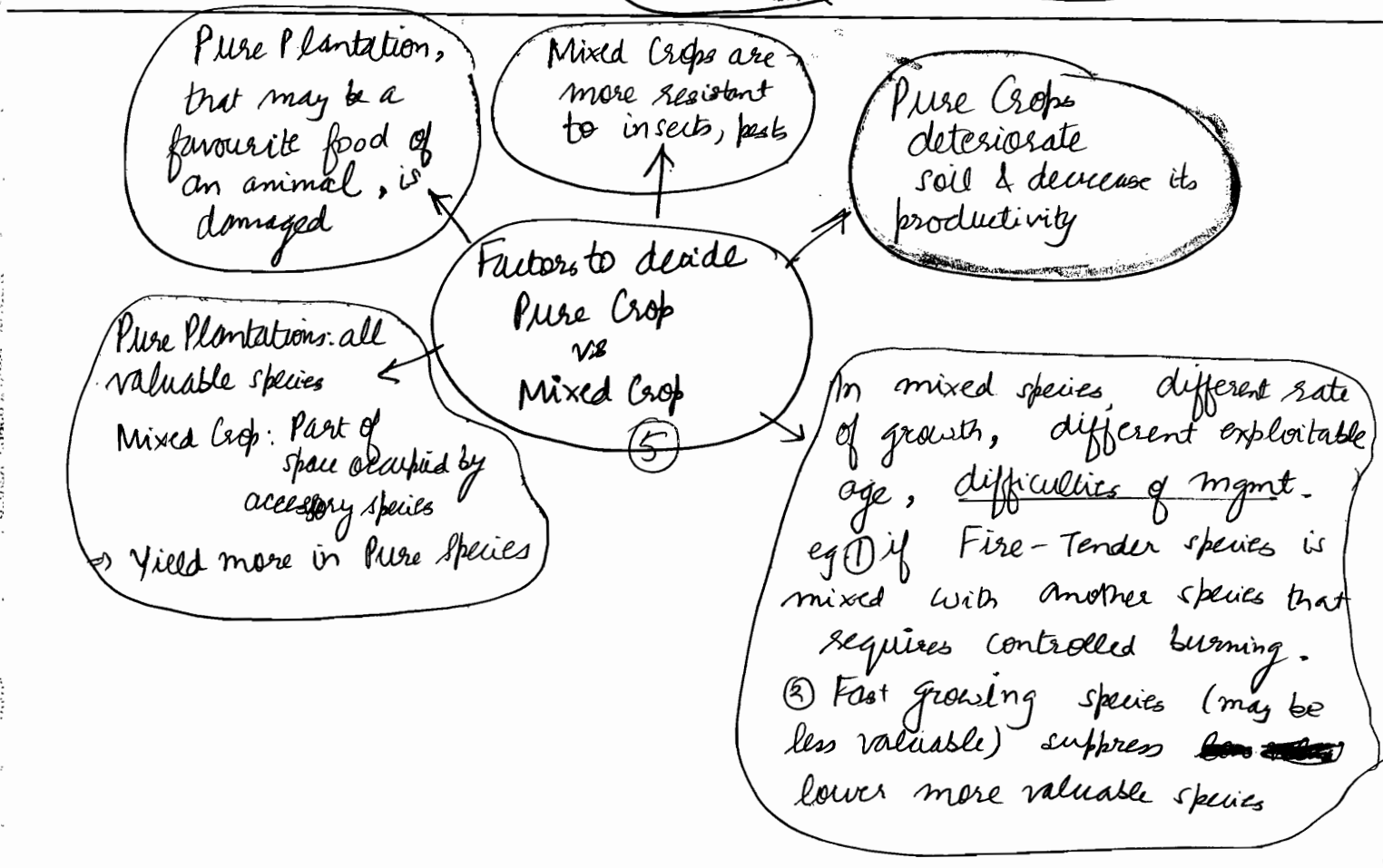


(1) Fertilizer
(2) Beating up (Casuality replacement)
(3) Nurse Crop
(4) Cover Crop
(5) Underplanting
(6) Weeding
(7) Fire & General Protection
(8) Plantation Journal


Factors affecting choice between artifical & natural regeneration
3+6
Genetically superior crops can be obtained via artificial regeneration
Crop Composition
Risk of deterioration of soil in Artificial regeneration
Mixed crops by natural regeneration is more resistant to pests
In long run, natural regeneration is more costly due to more weeding, cutting etc
Artificial Regeneration saves time due to parallel work in nursery
In Uncertain conditions of locality, natural regeneration is preferred, lest expenditure on artificial regeneration preparation is wasted
density of stocking can be controlled in case of artificial regeneration
due to saving of time, better trees, ease of work due to correct density, yield is better in case of artificial regeneration


Steps of Artificial Regeneration
Essential Preliminary Conditions
6
Spacing
Choice of Method: Sowing or Plantation
Arrangement of labour force
Selection of site
Mechanization
Choice of Species
Mixtures in Plantation
Work to be done outside plantation area
3
Arrangement of Planting Material
Estimate and indent (order) of material
Arrangement of seed
Nursery
Marking & felling
Boundary demarcation
Time Table
Soil Map and Planting Map
Work to be done inside Plantation Area
17
Irriga
Sowing seed/Planting
Fencing
Staking out
Soil preparation





⊛ Mixtures are of two types : (1) Temporary (2) Permanent

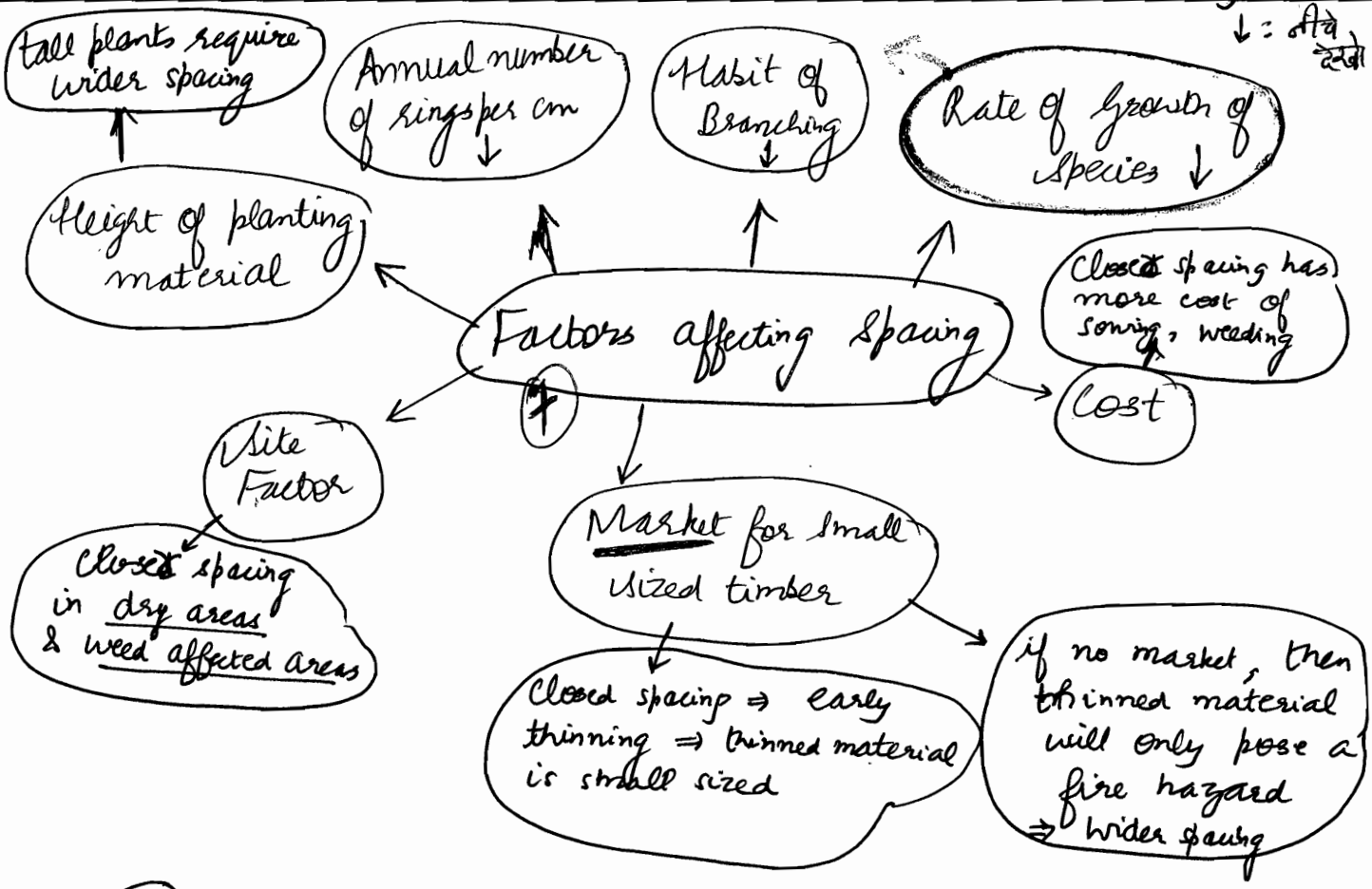
(Species mixed are removed as soon as the purpose for which they were planted is achieved)

⊙ Stake : Pole set up as a marker


Competition ⇒ height growth
Swaying ⇒ lower branches are cut off
Competition in early stage to obtain better bole form
Protection from frost, browsing or insolation
Providing additional revenue
Purpose of Temporary Mixed Species
4
Providing cover to ground & suppression of weeds
Condition of the site
infertile laterite soil
weed infested site
place where long closure is not possible
eroded soils
in poorer & difficult site, sowing is not successful eg.
Factors affecting Artificial Regeneration
Method's choice: Sowing or Plantation
4
Specie to be raised
slow growing or seeds with hard-coat are raised by planting
Availability of seed
sowing only if huge amount of seeds
Cost
sowing is comparatively cheaper
No. disadv. of broad cast sowing ⇒ Most Common type
Skilled labour for straight lines
longer time to close canopy
line sowing
Soil Preparation of whole area
more seed is req
Broad Cast Sowing
Number of unremunerative thinnings & cleaning need to be done
line
Interrupted line
Staggered interrupted line
Strip Sowing
5
kinds of sowing
Mixture of broadcast & line sowing
Each strip has more than 1 row ⇒ less chance of failure
Patch Sowing
Sowing a number of seeds in specially prepared patches
Patches should be properly staked otherwise fear of losing them in weeds
Patches act as small temporary nurseries: extra plants can be used to plant blank patches
Dibbling
sowing in shallow holes made @ definite intervals
Stake is fixed @ dibble site for easy location
Cheap method
dibbling sites remain inconspicuous & escape animal or bird damage

adv. of sowing
1. low cost & unskilled labour reqd.
2. no disturbance to root as there is no transplanting ⇒ no adverse effect on growth of plant.

disadv. of sowing
1. large quantities of seeds reqd.
2. Birds/animals may eat up the sown seeds
3. seedling mortality is heavy ⇒ uncertain success
4. Weedings have to be done for a longer period thereby making them costly.



- Lighter Wood ⇒ (Paper industry) less rings per cm ⇒ rapid diameter increment required ⇒ wider spacing
- Denser Wood ⇒ large rings per cm ⇒ less diameter increment ⇒ closer spacing
- (*) Wider spacing ⇒ more light ⇒ more growth both height wise & diameter wise
- Large number of branches reduce timber volume & decrease timber value. ∴ more branch-producing trees are spaced closely so that bole is made clean by (i) natural pruning (ii) deficient light
- Most important objective of artificial regeneration is that canopy should close soon so that soil may not deteriorate due to exposure. Therefore, fast-growing species have wider spacing and slow-growing species have closer spacing.

Adv. of wide spacing : ① Saving in seeds and plants
② less labour required
③ Cost of plantation reduced
④ less competition in early stages

Disadv. of wide spacing : ① Canopy takes long time to close leading to soil deterioration.
② If 1 plant dies ⇒ big gap in plantation ⇒ infestation with grasses & weeds
③ Trees tend to become branchy ⇒ knotty timber
④ As less number of plants ⇒ thinnings become difficult.
⑤ Wide spacing ⇒ rapid diameter increment ⇒ wider annual rings ⇒ low density & strength of wood

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⊙ Plantation in which forest crops are raised along with agricultural crops are known as **Taungyas**.

Destructive method of shifting cultivation has been changed by foresters into cheap & productive method of raising forest crops in conjunction with agricultural crops.

⊛ Clear Felling ⇒ Area given to Taungya Cultivators ⇒ They burn felling refuse & raise agricultural crop. ⇒ Along with it they raise forest plantation ⇒ After 2-3 years, they move to next area

3 types of Taungya

leased taungya
- no extra burden on forest staff
- Cost of regeneration realized from lease money
- weeds & grasses are suppressed w/o expenditure

village taungya
- shortage of labour reduced
- poor villagers get land to cultivate
- Taungya Cultivators also look after forest crop
- augment food production of country

departmental taungya
- forest staff employs daily workers

⊙ disadv. of Taungya

(1) Ploughing & Tilling of interspaces in sloping areas ↑ soil erosion

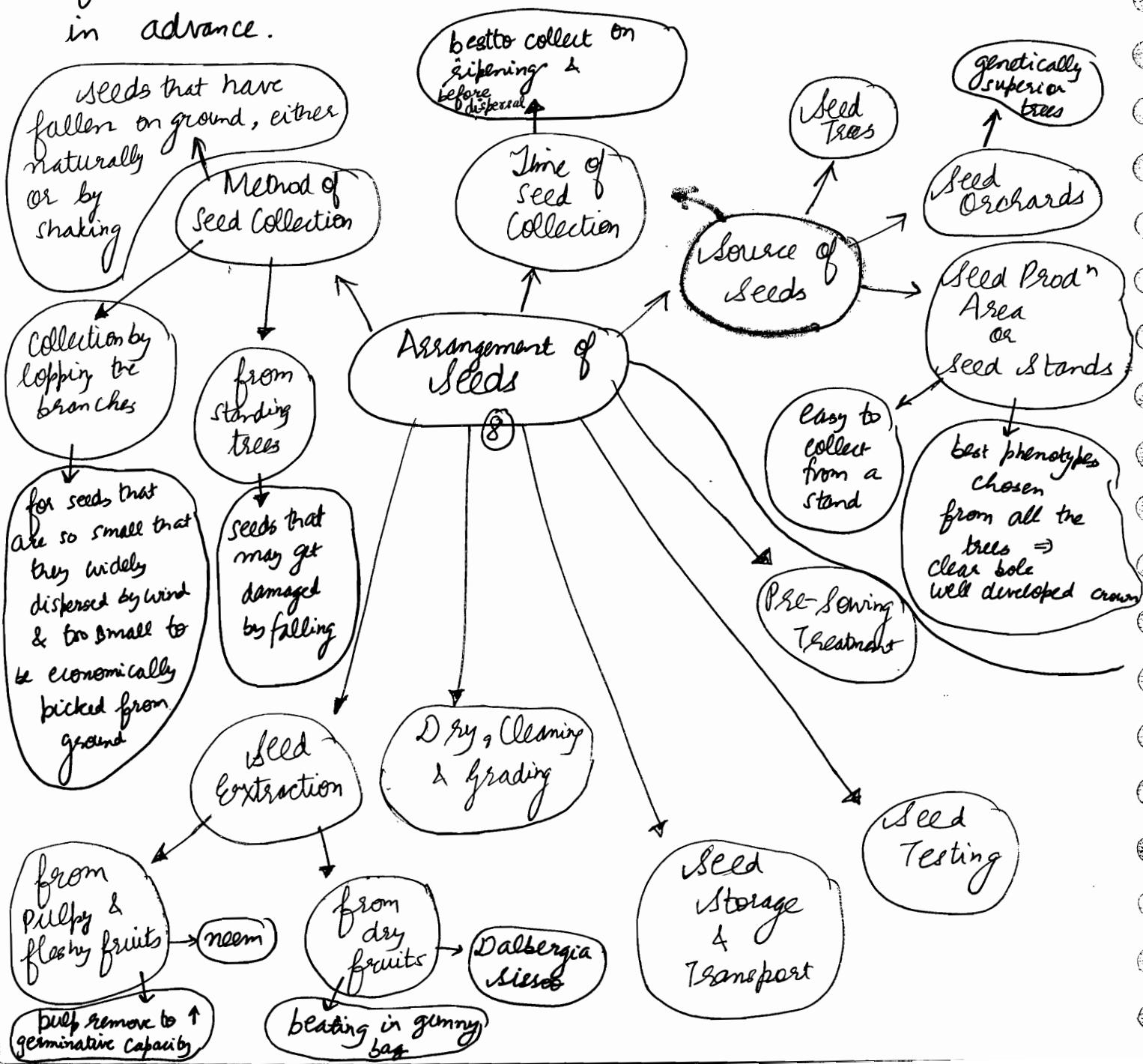
(2) Agriculture cultivation leads to loss of fertility of soil.

(3) cultivation of crops increase danger of epidemics, pests.

(4) Legal problems are created to evict them after 2–3 years. Also they start to neglect the plantation work.

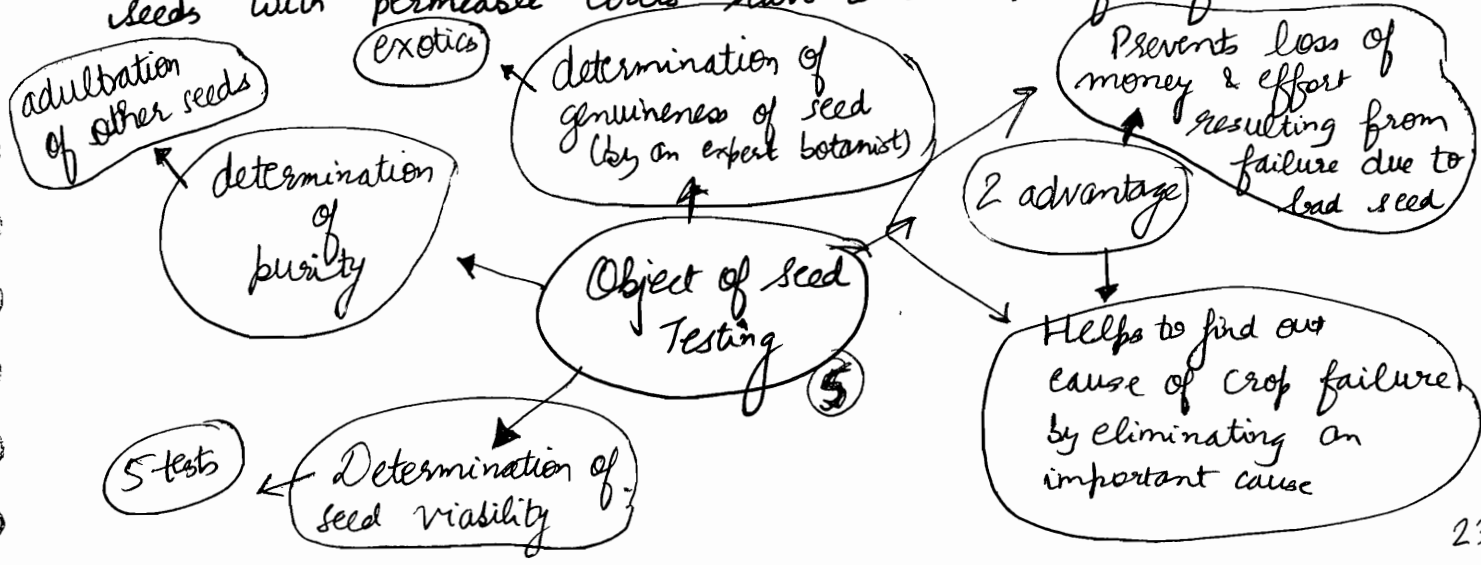
(5) Its a method of human exploitation.

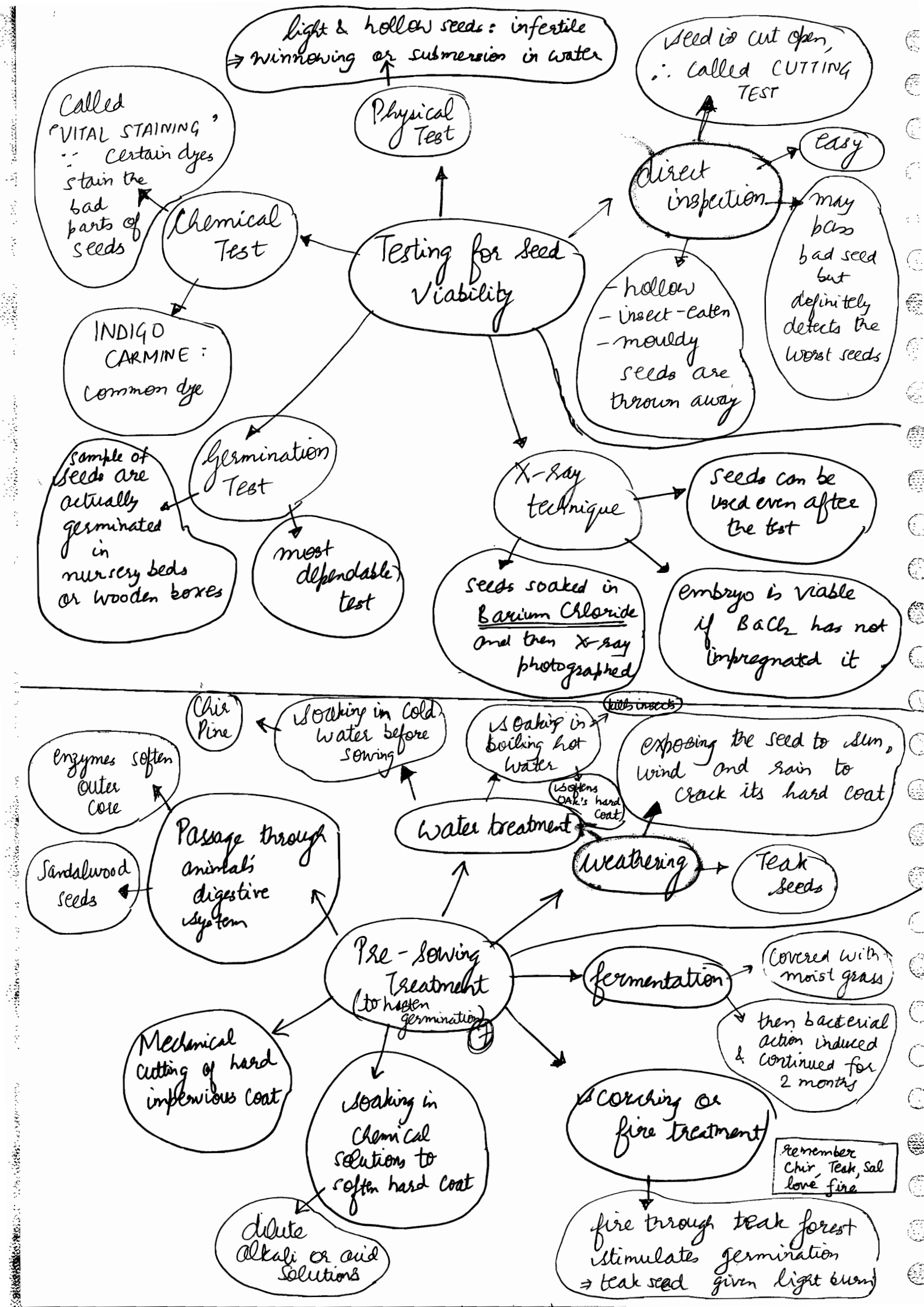
⊙ Plantation time table is very important eg. For deodar, fir and spruce, nursery has to be raised 3 to 5 years in advance.



- Cleaning of seed by : (4)
  1. Hand Picking (removal of large crap)
  2. Separation by Water (good seeds sink to bottom)
  3. Winnowing  (to remove light husk & dust)
  4. Sieving (both types of sieves, larger than seed & smaller than seed)

- For single-seeded fruits, larger the seed, better it is !!
- Ideal storage conditions are those in which respiration and transpiration is reduced to a minimum, w/o damaging the inherent vitality & strength of seed embryo.
- drying (open/shade) and storage (cold/warm condition) should ideally follow nature for any species.
  Wise to follow nature
  eg. Seeds of open deciduous forest : dried in sun
  Seeds of evergreen forest : dried in shade
  seeds that ripe in autumn & germinate in spring (Oct) (Mar) : stored in cold condition
- Seeds having a hard-coat with very slow permeability to water do not need any special precaution for storage while seeds with permeable coats have to be kept free from moisture.




Testing for Seed Viability
Physical Test
light & hollow seeds: infertile
⇒ winnowing or submersion in water
Chemical Test
Called "VITAL STAINING" ∴ certain dyes stain the bad parts of seeds
INDIGO CARMINE: common dye
direct inspection
seed is cut open, ∴ called CUTTING TEST
easy
may pass bad seed but definitely detects the worst seeds
- hollow
- insect-eaten
- mouldy
seeds are thrown away
Germination Test
most dependable test
sample of seeds are actually germinated in nursery beds or wooden boxes
X-ray technique
seeds can be used even after the test
seeds soaked in Barium Chloride and then X-ray photographed
embryo is viable if $BaCl_2$ has not impregnated it
Pre-Sowing Treatment (to hasten germination)
Passage through animal's digestive system
Sandalwood seeds
enzymes soften outer core
water treatment
Chir Pine
soaking in cold water before sowing
soaking in boiling hot water
kills insects
softens Oak's hard coat
exposing the seed to sun, wind and rain to crack its hard coat
weathering
Teak seeds
fermentation
covered with moist grass
then bacterial action induced & continued for 2 months
Mechanical cutting of hard impervious coat
soaking in chemical solutions to soften hard coat
dilute alkali or acid solutions
scorching or fire treatment
remember Chir, Teak, Sal love fire
fire through teak forest stimulates germination
⇒ teak seed given light burn

Nursery is an area where plants are raised for eventual planting out.

It has 2 types of beds :

① **Seedling Bed** : Beds in which seedlings are raised either for transplanting in other beds or for planting out.

② **Transplant Bed** : Beds in which seedlings raised in seedling beds are transplanted before planting out in forest.

✓ Nursery may be :

dry (no irrigation facility)
or
wet (irrigation facility during dry period)

✓ Nursery may be :

temporary
- ⊙ to meet requirement of a small area ⇒ smaller
- ⊙ made in newly cleared site ⇒ rich in humus ⇒ does not require manuring

or

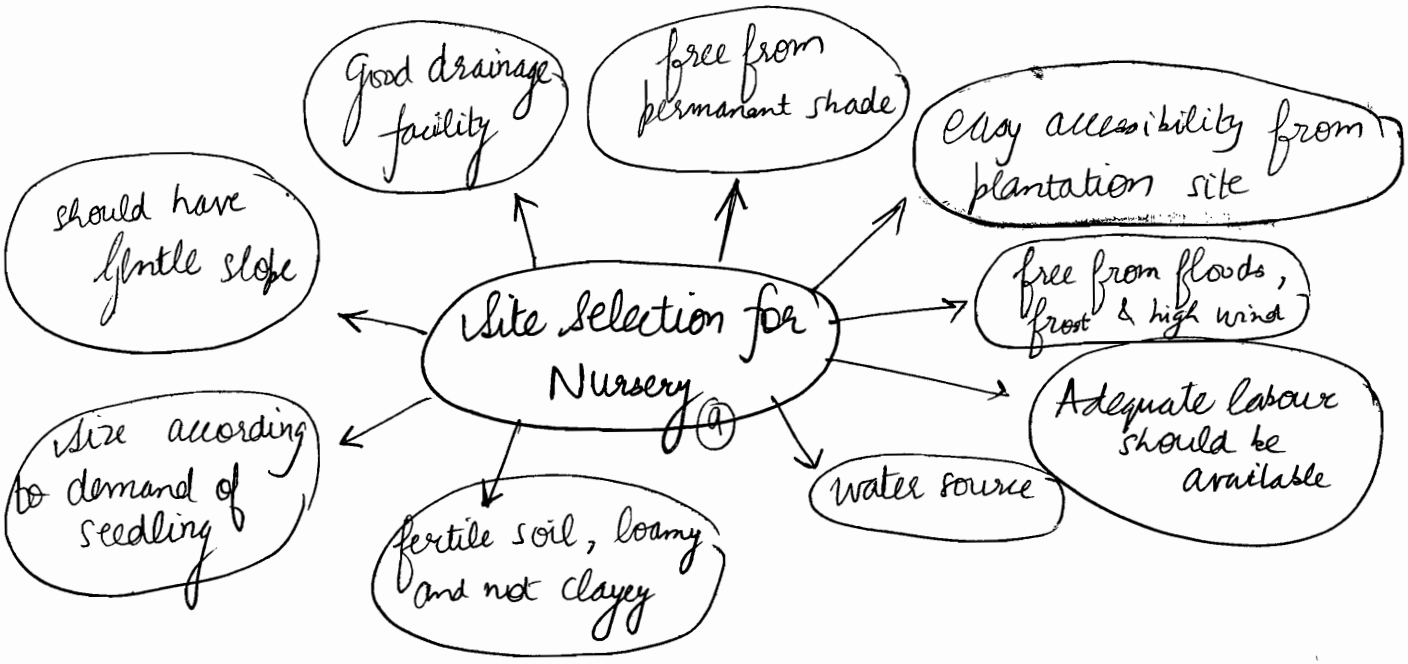
permanant
- ⊙ to supply nursery stock for a long time on a permanant basis
- ⊙ larger
- ⊙ plants are raised year after year ⇒ fertility ↓ ⇒ manured regularly
- ⊙ facilities of irrigation & shading

- testing exotics
- genetic improvement

⑥ Objects of Nursery

- Some species grow very slowly. If directly sown, they will be suppressed by weeds
- Some species do not seed every year. Annual Plantations are ensured by nursery
- Roadside Avenue Plantations depend on planting table and sturdy plants
- Direct sowings are sometimes not successful especially barren sites
- Introduction of Exotics
- Casualities in plantations & sowing. Replacement with help of nursery only

⊙ We can write points of adv. of plantation over sowing

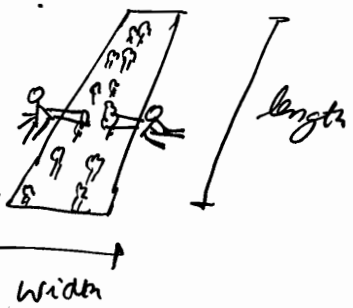


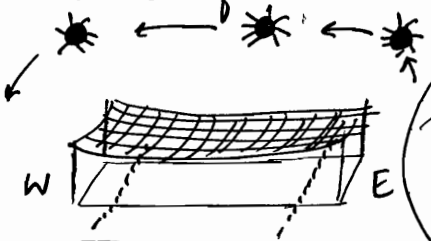
⊙ While calculating :

→ 50% more area for paths in nursery

→ 80% more seeds to account for casualities.

⊙ Width of a nursery bed should be such that it can be weeded by labour sitting on both sides of it without resting a hand or foot in it





In Hills, nurseries are made after terracing the area.

~~After~~ nursery should be divided into blocks (divided by permanent paths) which then be subdivided into nursery beds (divided by kaccha paths)

Beds should be laid with their lengths East - to - West so that they can be shaded against sun & frost without difficulty

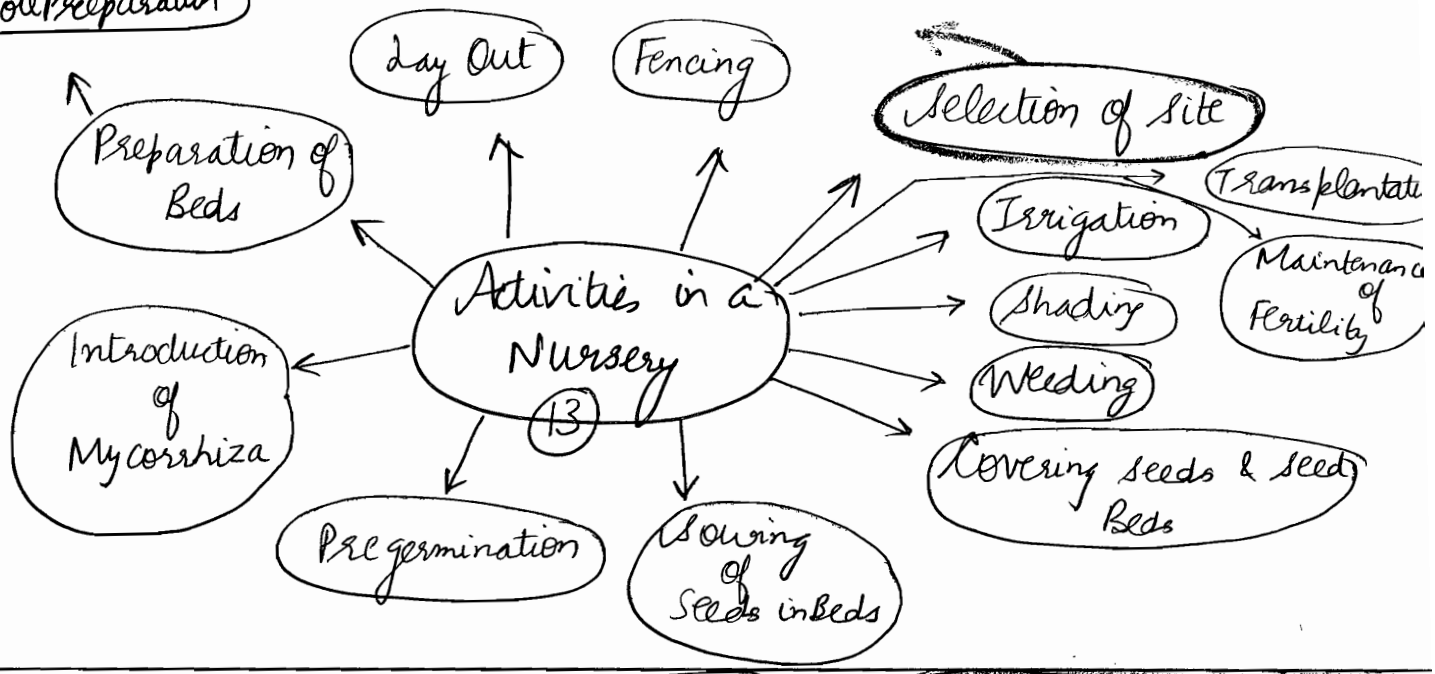
⑤ Lay Out of Nursery

For extensively mechanized plantations, there should be provision for wide roads on which trailors can ply

Each bed should have road on one side and irrigation channel on other i.e. there should be a road after every 2 beds

..... I BRB .....

Soil Preparation



- Species with slow or irregular germination (eg. Teak), its better to pregerminate seeds in trays & then sow the pregerminated seeds in nursery beds, so that germination is complete & there are no blanks in nursery

If sown very close, it results in
- poor germination
- greater mortality
- weak stock
- difficulty in weeding
- damping off

killing of young seedling by fungi that cause decay of stem/roots.

Broadcasting done for smaller seeds, its preferable to sow them into rows to avoid difficulty in weeding

Precautions while sowings seeds in nursery (4)

Even though initially seeds are sown closer, after germination, excess plants are transplanted in other beds.

Seeds should not be sown too deep as germinating shoots have to push through thick soil layer, in which process, it may die. Also not left on surface else birds will eat. Ideal depth of soil above ≈ diameter of seed

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⊛ When there is danger of birds / insects / rodents eating up seeds :

① Cover seed with repellant like → red lead (Pb_3O_4)
→ kerosene oil
→ camphor

② application of interticide in soil → ALDREX
→ DDT
→ BHC

③ use of protective covering on seed bed → thorns (deodar)

⊛ 2 precautions while weeding :

① Roots of desired seedling are not disturbed. Hold the seedlings firmly between 2 fingers of left hand while pulling out weed by right hand

② Weeding is not done when soil is wet to avoid removal of soil along with weed roots & consequent exposure of roots of desired species. (जंगलों में कर लो wet में, nursery में न करो)

⊛ 2 precautions while shading :

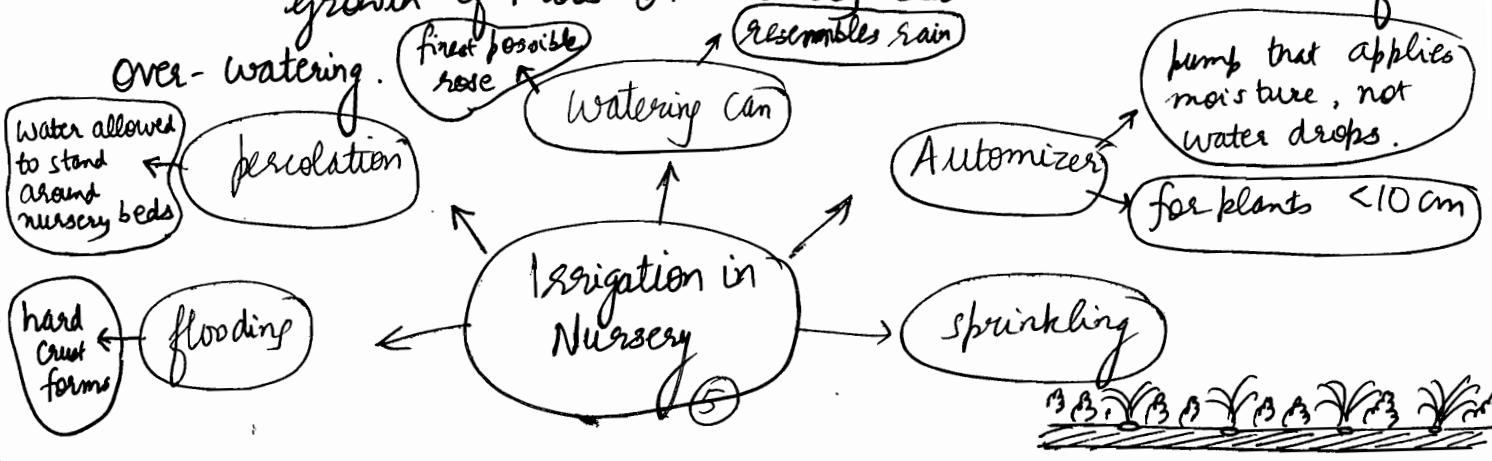
① Seedling of frost tender species require protection against morning sun in frost localities (transpiration but no water due to frozen soil) but shade

should be removed as soon as soil temperature rises, so that soil does not get chilled for want of sunlight, resulting in greater damage to seedlings.

② Plants get used to shade and its necessary to harden off the seedling before "planting out" by reducing the period of shade gradually.

- Irrigation is usually done in afternoon. But in places, where frost is feared, its done in the morning.

Growth of Moss on nursery bed is an indication of over-watering.



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nursery → plantation : Planting Out
nursery → nursery : transplantation

★ 2 reasons for transplantation

① If seedling are allowed to remain in bed (as stock is not yet of adequate height or plantation preparation is yet incomple, they develop long tap roots, making planting out difficult. Transplanta helps to create bushy roots.

② Younger seedlings are quite close together & as they grow they tend to suppress each other. Transplantation done at greater space.

→done in Deodar, Fir, Spruce

Cylindrical tubes of moss
≈ 15 cm in length
≈ 7.5 cm in diameter

Moss Cylinders

Cup made of leaves

Dona

Plants that cannot be planted out with naked roots are planted out with ball of earth but its costly & time consuming.
∴ such species are sown in some container, transported to forest in it, & then planted out with or without it. This entails minimum disturbance to roots

bamboo strips

Baskets

Nursery Plant Containers (5+1)

w/o bottom ⇒ put in field with plant

Earthen Pots

with bottom ⇒ broken up before planting

Costly, more weight ⇒ more transport cost

Poly thene Bags

for aeration & drainage, they are perforated

---

has to be prepared in tropical countries

By mixing well rotten leaf mould

Usually (1/4)th land left fallow in rotation of 4 years

By leaving the land fallow

animal dung

farmyard manure

vermicomposting

Maintenance of fertility (7)

Mixing compost

mixture of vegetable matter which has been allowed to rot, often with addition of animal material

INM

Green Manuring

turning in leguminous crop

not preferred in dry areas

By adding chemical fertilizers

Remember to add trace elements also

According to need of soil

Work to be done inside plantation area

- While demarcating the area, care should be taken to make it rectangular because irregular boundary makes it difficult & expensive to fence.
- The marked trees are auctioned with specific conditions that the contractor will remove his material & burn the debris to clean the area by a specific date. Here is where there is a lot of corruption.
- a strip of 3-6 m in width is left outside the plantation area to serve as a <u>fireline</u>.
- After clearance of the area, soil map or suitability map is made depicting tree species and the soil working required according to different soil conditions in the area.

(5) Soil Preparation

- Objects
  - to dig out roots of weeds so that weed growth is reduced
  - to improve aeration of soil
  - to enable rain water to percolate deeper so that moisture is retained during drought
  - to enable seedling to develop deep roots
- digging of soil depends on type of sowing
  - eg. strip sowing
  - patch sowing
- On slopes, trenches are made along contours
- The dug up soil is heaped up on a side of trench to weather for a month or two.
  - Crumb structure is improved. Bigger clods are broken into smaller clods
  - roots of the weeds get dried up
  - injurious insects are eaten up by birds
- level of seedbed is kept higher by building a raised heap (soil is loosed upon weathering & therefore allows heap to be built) in case of high rainfall condition or lower in low rainfall condition to collect water

(5) Type of Pit

- Ordinary pit
  - used in clayey soils
  - water storage ring
  - 50 cm
  - 30 cm
  - 30 cm
- Trench Ridge
  - Trench for water storage
  - for salt affected soils provides for leaching
- Ridge Ditch
  - Partly filled
  - On slopes
- Saucer Pit
  - for dry zones
  - 1m
- Ring Pit
  - Sandy soil
  - circular trench 20 cm away from pit

Temperate species should be sown in early spring when snow melts but it difficult, so done before snowfall → silver fir

Tropical deciduous: sow just before the rains to get maximum benefit of growth period & long tap root before the end of rainy season is develop

Time of sowing

Shortly before the time when it germinates in nature

Sowing seed (3)

depth of sowing

Quantity of seeds to be sown

- If there is danger seed being eaten up by birds, insects or rodents, it is mixed with red lead (1 kg for 10 kg seeds)

Where Monsoon does not reach eg. kashmir → Spring

most Common season: deodar → Monsoon → except W.Ghats due to very heavy r.f.

Season of Planting → Winter

Pre Monsoon → irrigation or good convectional showers

Some species do best by planting

to fill failed patches of previous years plantation

Why planting?

either grown from nursery: seedlings or natural seedlings growing in forest: wildl

inferior to nursery grown seedlings

digging them out w damaging roots is cost & difficult

Planting (6)

Size & Age of Planting Stock

Very small plants → easier to plant naked roots; difficult to handle; Cannot compete with weeds

Can't be planted with naked roots

Large or big plants → Can compete with weeds

Method of Planting

Pattern of Planting

line planting

Square Planting

Quincunx Planting

Triangular

Calculating number of plants

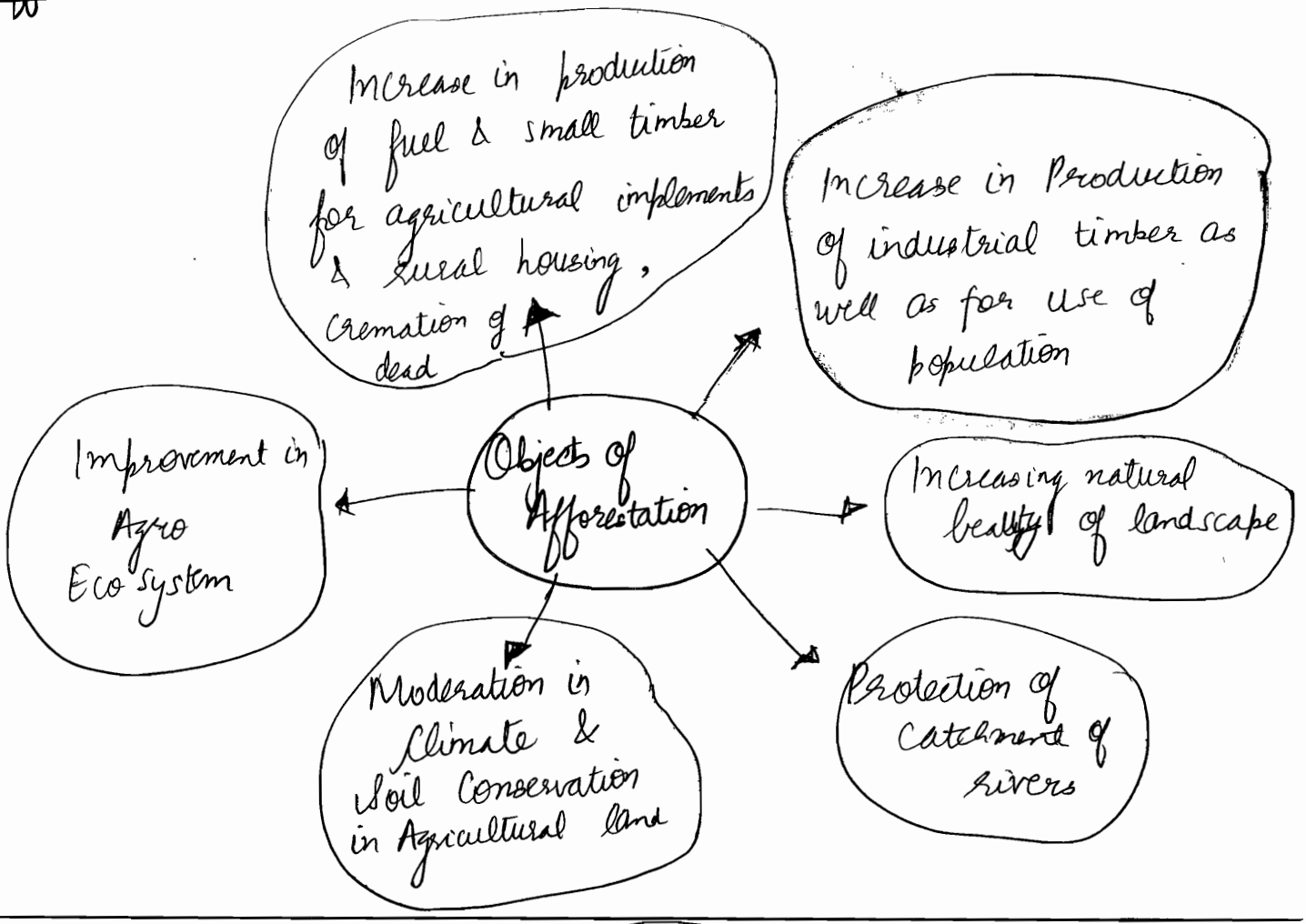
Quincun $N = \frac{2x \times 10^4}{d^2}$

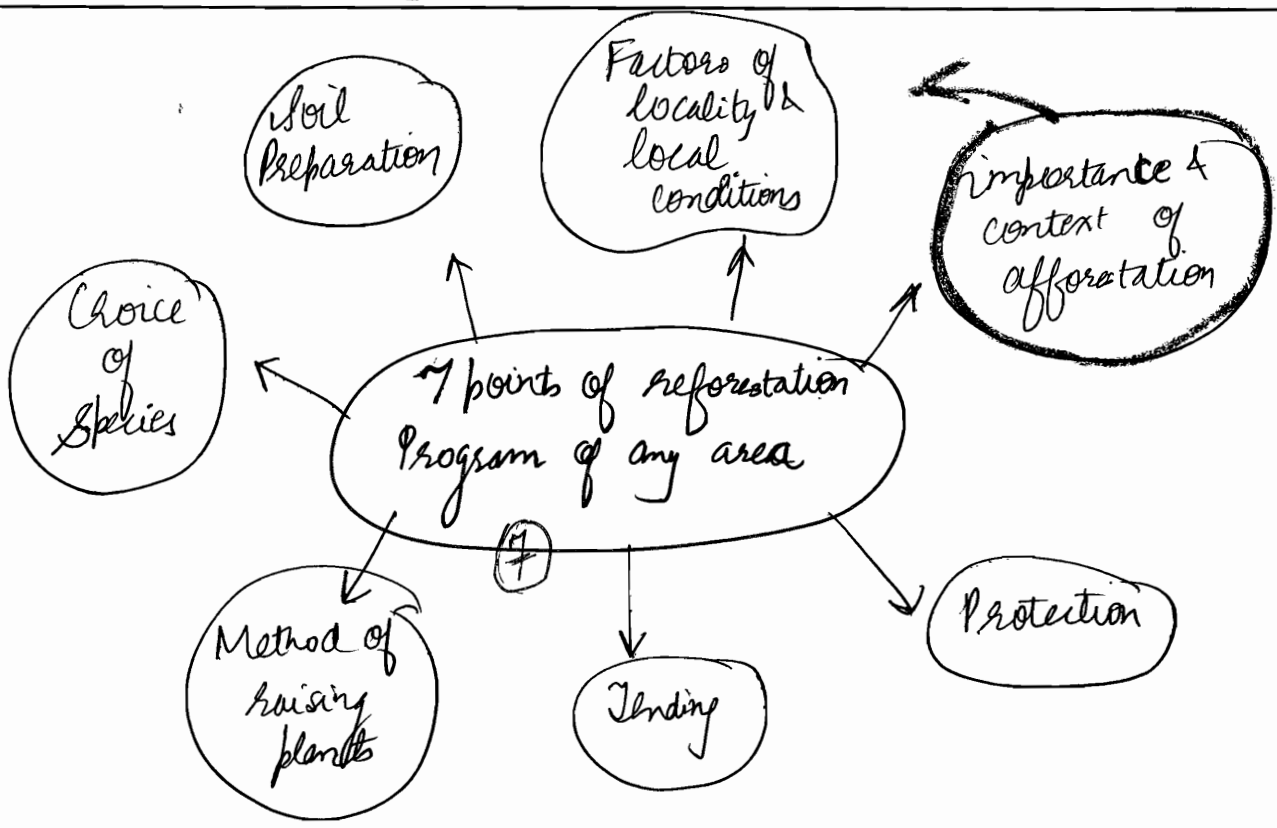
line planting
1 tree 1 sect.
$\Rightarrow N = \frac{x \times 10^4}{d \times e}$
x: hectare land


Method of Planting
3
Entire Planting
3
With naked roots
Most of the leaves are cut to reduce transpiration
plant taken out after shaking off the soil
pit should be of sufficient size s.t. there is no need to double the tap root
Collar : 10cm above ground s.t. when soil is pressed or subsides due to rain water, it does not go below ground level
With ball of earth
banana leaves or Munja grass wrapped around ball and tied well to ensure no damage while transportation
Remove covering while planting & ball should be so planted that plant is at centre & vertical
plants raised in containers
donas, moss tubes, basket, bottomless earthen pot : planted with container
plastic bag, earthern pot with bottom, metal tube : planted after removing container
Stump Planting
3
plant with single long tap root chosen
Preparation in nursery
very thick & very thin collar diameter plants are discarded
Upper shoot is removed & lateral roots are pruned to a total length of ≃ 30 cm. very sharp knife is used to prevent splitting
planted in holes made by round stick
technique of planting
test of good planting is that stump should not come out when pulled with ordinary force
advantage
5
Easy & cheap method
Easy transport w/o much damage
does not require soil preparation much
deep roots are developed
Grow fast → no loss in height due to cutting
Cuttings from either nursery grown plants or 1 or 2 year old plantation Cleaning
Planting Branch or Stem Cutting
longer cutting for drier areas
Preparation in nursery
Bark should not split while cutting
Small portion, having atleast 2 buds, outside soil & rest inside soil
Planting in Field
For willow & poplar, long (2-5m) stem cuttings, cut as obliquely as possible, are used for planting. Called SETTS

- In road side avenues, plants are watered during the first and second year to accelarate their growth so that they are beyond the reach of cattle as early as possible.
- 'Casuality Replacement' i.e. filling up of blanks is called Beating Up.

Afforestation





3 steps of desert area afforestation

Windbreak & Shelterbelts

- Taller trees in middle flanked by shorter trees on both sides
- Triangular cross section
- Shape & composition
- Only 1 or 2 rows
- typically 3 to 5 rows
- density & width
  - Partially perforated & penetrable shelterbelt has a larger zone of influence
- Orientation
  - at right angle to the prevailing wind
- height & spacing
  - Zone of influence 15 to 20 times the height
  - higher the trees, more the zone of influence on leeward side
  - 2nd shelter belt planted before the effect of 1st is over
- Choice of species
  - Prosopis Juliflora
  - Acacia Arabica
  - Munja Grass
  - non exacting, fast growing, wind firm, drought resistant, unpalatable to animals
- length
  - Length > 24 times the height
  - Eddies are produced at ends of shelterbelt
    - high velocities at end
    - therefore roads are usually not allowed to cross shelterbelts

Adv. of shelterbelts

- Protection to property
  - moving sand dunes destroy roads & rail line
- Red^{n} of wind velocity & erosion
- increase soil moisture
- Aesthetically pleasing
- increase in humidity
- Moderating Effect on Temp. of air & soil
- Supply of firewood, fodder ⇒ cowdung used as manure
- Increase in prod^{n} of agricultural & horticultural Crop

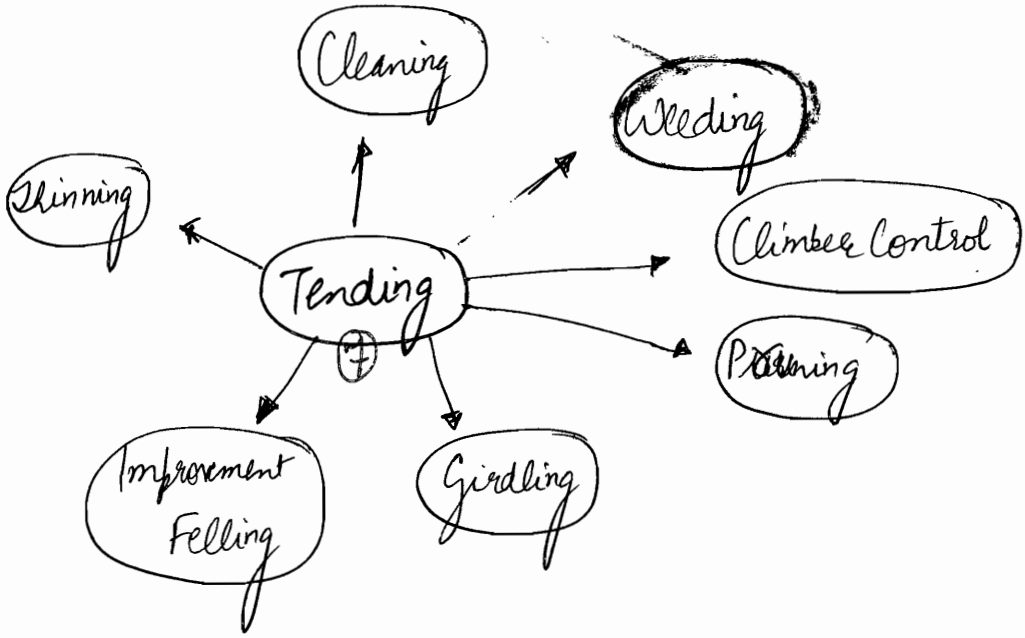
Sand Dune stabilization

- Species
  - Acacia Arabia
  - Prosopis Juliflora
  - Munja grass
- Sand is removed to a depth of 25 cm & dry plants are erected in the trench, plant touching plant
- mulching
- Closing the area against grazing & browsing via erecting a cattle proof fence

development of fuel & fodder blocks

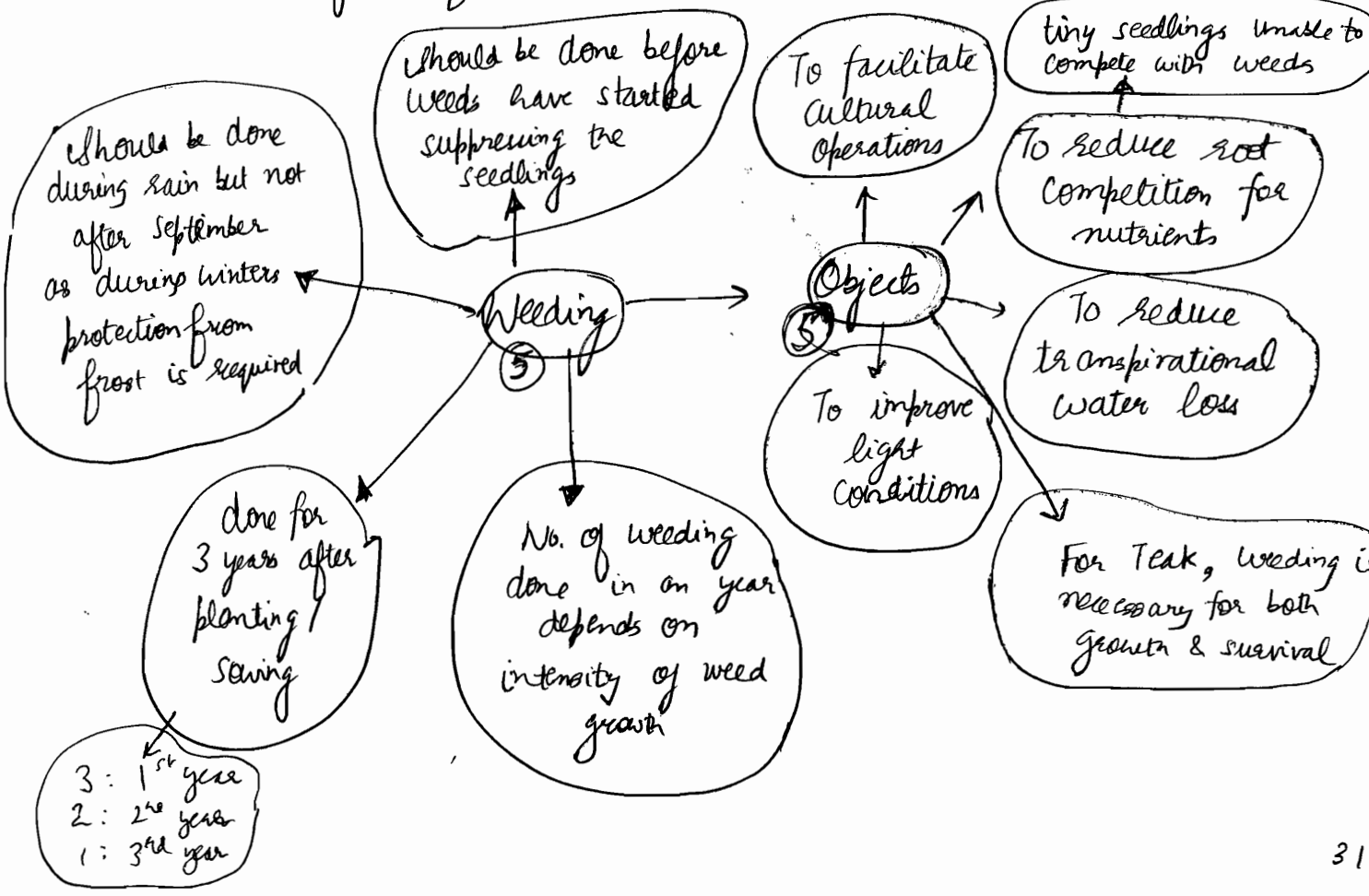

Farm Forestry
Objects
to release cowdung for use as manure
diverse ecosystem
Good soil & groundwater
Minor forest produce ⇒ cottage industry
Aesthetically important
leg fodder, fuel wood & small timber
Objections
hosts to pests
Animal damage
Shading Effect
Longer gestation period
Reduction in grazing ground
Allelopathy
prod" of chemicals by tree species that adversely inhibit Crops (Eucalyptus)
Reduction in Crop yield
Competition for roots
damage by birds
More labour is reqd.
Felling of trees cause damage to crops
Refer Geography notes
Environmental
soil
O2 rich atmosphere
biodiversity
microclimate improvement
Rehabilitation of degraded lands
ground water
Recycling of nutrients
Reduces pressure on forest
live hedge/ boundary demarcation
~~Benefits of farm forestry~~
Social
women in cottage industry
poor section upliftment
hedging against crop failure
increase of income in sustained manner
improvement of health & nutrition
migration reduction
Economic
Minor Products
firewood
Bark
tannin
dye
Chemical extraction
leaf
fodder
bidi wrapper
silk
Wood
increased output per unit area
- timber
- building material
- veneer
- boards/panels

Tending

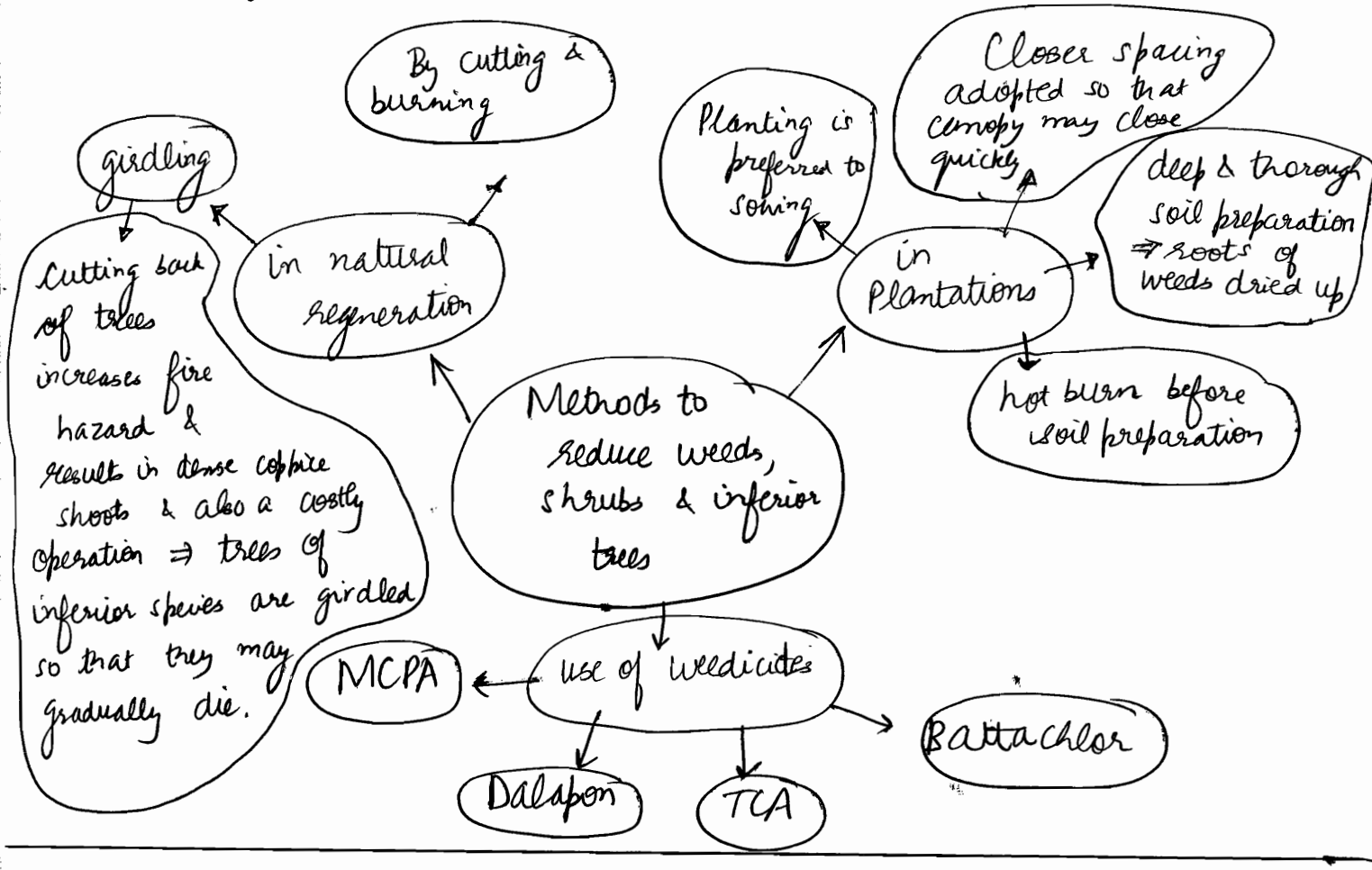


- Tending is defined as an operation carried out for the benefit of a forest crop at any stage of its life. It includes weeding, cleaning, ... & climber control. Ultimate aim is to produce high quality timber, thereby maximizing income.

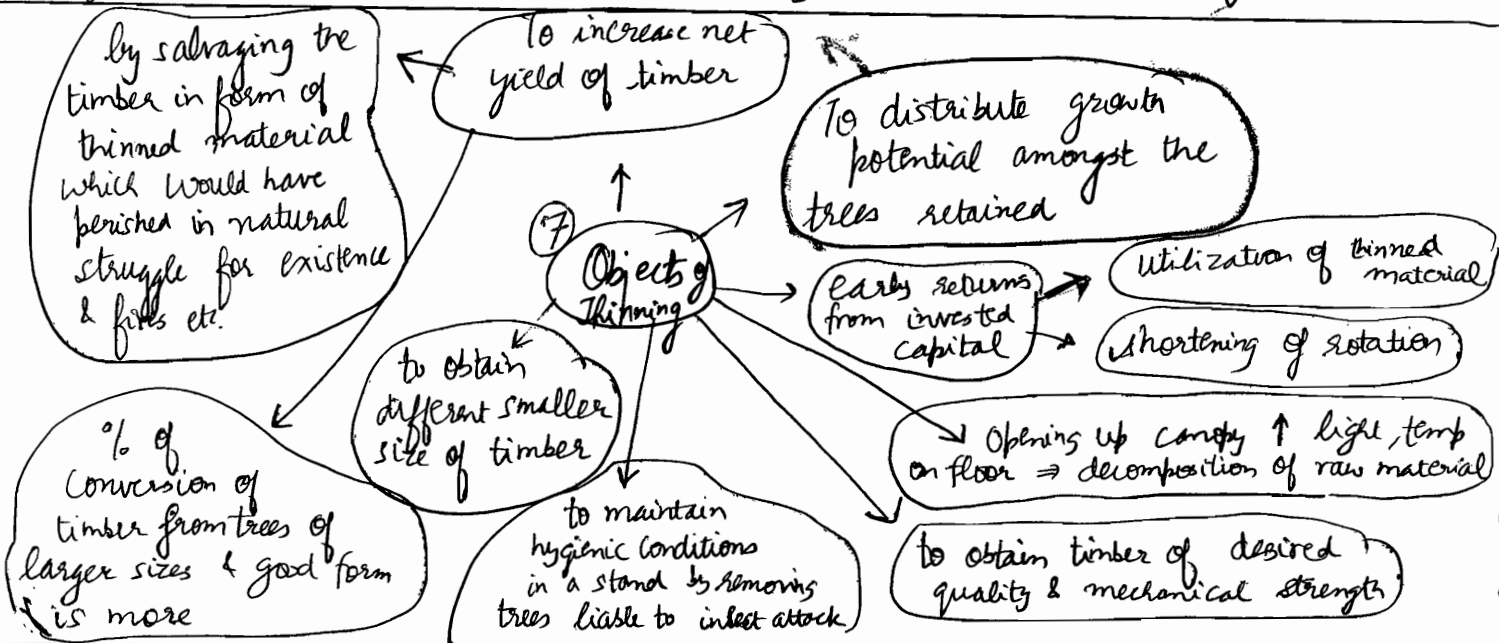
- Any unwanted plant that interferes with the growth of the individual of a favoured species is called weed.

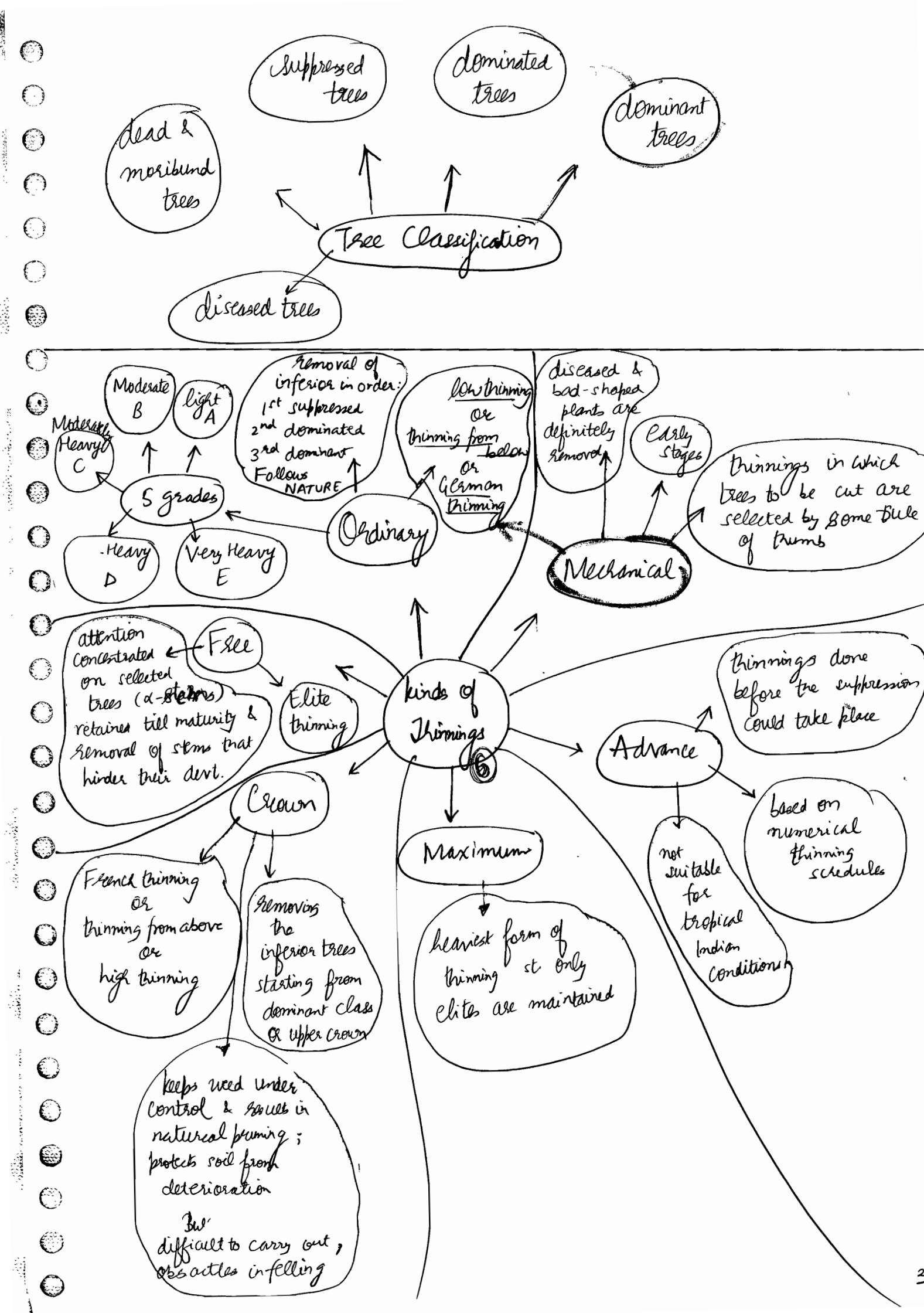


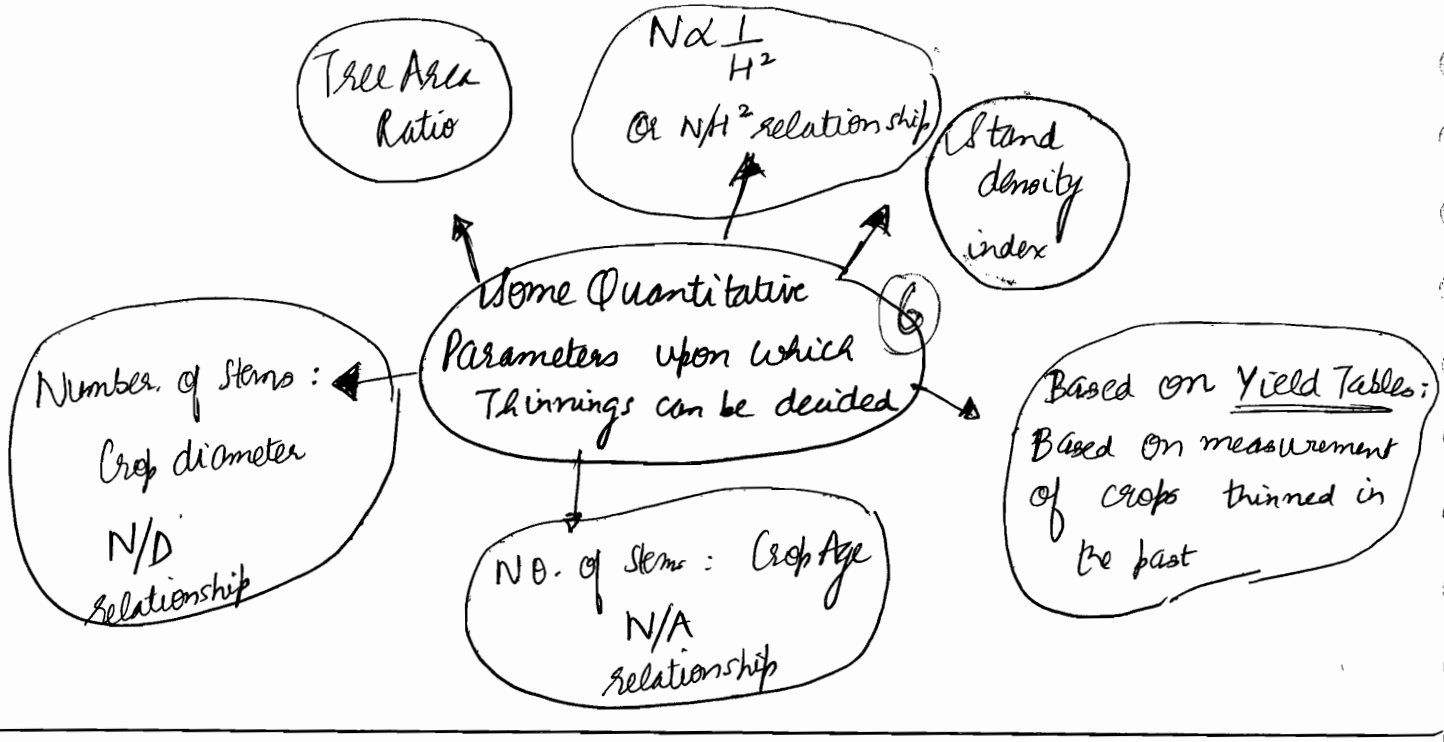
- Cleaning is defined as a tending operation done in a sapling crop, involving the removal of inferior growth, including individuals of favoured species, when they are interfering with the better grown individuals of the favoured species. It merges with thinnings as saplings grow into poles.



- Thinning refers to the fellings made in an immature stand for the purpose of improving the growth & form of trees that remain, without permanently breaking the canopy.




Suppressed trees
dominated trees
dominant trees
dead & moribund trees
Tree Classification
diseased trees
Removal of inferior in order:
1st suppressed
2nd dominated
3rd dominant
Follows NATURE
Low thinning
or
thinning from below
or
German thinning
diseased & bad-shaped plants are definitely removed
Early stages
Thinnings in which trees to be cut are selected by some Rule of thumb
Moderate B
light A
Moderately Heavy C
5 grades
Heavy D
Very Heavy E
Ordinary
Mechanical
attention concentrated on selected trees (α-stems) retained till maturity & removal of stems that hinder their devt.
Free
Elite thinning
kinds of Thinnings
Thinnings done before the suppression could take place
Advance
based on numerical thinning schedules
not suitable for tropical Indian conditions
Crown
French thinning
or
thinning from above
or
high thinning
Removing the inferior trees starting from dominant class or upper crown
Maximum
heaviest form of thinning st only elites are maintained
keeps weed under control & results in natural pruning; protects soil from deterioration
But
difficult to carry out, obstacles in felling



Selection Thinning Thinning carried out in irregular crops is called selection thinning. Its directed to maintain/ obtain selection composition in a crop, with all diameter classes adequately represented., therefore carried out in all the classes of canopy.

Improvement Felling Removal of less valuable trees in a crop in the interest of better growth of more valuable individuals.

Girdling Cutting through bark and outer living layer of wood in a continuous incision all round the bole of a tree. Aim is to kill inferior trees where their removal is either Uneconomical or adverse for nearby trees < mechanical damage / fire hazard

Pruning Removal of dead (dry pruning) or live branches (green pruning) from standing trees for the improvement of timber.

Bud Pruning Rubbing off the lateral buds to prevent the development of branches as a measure to obtain knot-free timber. Its a cheaper method.

- Rhizome → modified stem found underground (Bamboo, Ginger)
- Rhizobium → Root Nodule Bacteria involved in Symbiosis
- Rhizophora → Mangrove

- Soil
  - Endodynamorphic — Soils whose properties are influenced mainly by parent material
  - Ectodynamorphic — Soils whose properties are influenced mainly by factors other than parent material.

- Soil
  - Sedentary : in-situ formation from parent material
  - Secondary or Transported : soil derived from pre-existing soils via transportation and redeposition
    - Aeolian (wind) e.g. loess
    - Alluvial (water) e.g. Ganga Plain
    - Colluvial (mass wasting i.e. slow downward movement of soil, also called SOLIFLUCTION PROCESS)

- Soil structure is influenced by cementing material provided by colloidal matter in the form of minerals, oxides of iron & organic matter. Soil structure affects :
  - → moisture content → nutrient status → activity of microorganisms
  - → air content → soil erosion

- Chemical Properties of Soil

(1) Cation Exchange Capacity

Total capacity of soil to hold cations. (Ca^{++}, Mg^{++}, K^{+}, Na^{+})

Inorganic Colloidal matter : Clay
Organic Colloidal matter : Humus

more cation exchange capacity

In soils, which have high cation exchange capacity, high amount of fertilizers can be used & the nutrients will be absorbed. In coarse textured soil (less clay), if fertilizers are used, bases will be leached out unless organic matter is also added to improve the cation exchange capacity.

(2) pH of soil

acidic : H^+ excess
alkaline : OH^- excess

Mathematically, pH value = negative logarithms of H ion concentration

Optimum range of pH is required for plants to flourish.

- Humus is the dark and decomposed organic matter layer of the soil.

Factors influencing formation of humus :

- Nature & Composition of forest (Broad leaved)
- Climatic Factors (faster in hotter areas)
- Soil Organisms (bigger animals physical breaking of leaves, earthworms, bacteria)
- nature of soil (Poorly drained soil : high humus)
- lopping (reduces)

Importance of Humus

- Improvement of physical properties like structure, water holding capacity, ...
- Improvement of chemical properties like nutrients, cation exchange capacity, reduces pH value.

- Plant Succession refers to the gradual replacement of one plant community by another in the development of vegetation toward a climax

Climax is the culmination stage in plant succession for a given

environment. Vegetation is in equilibrium with environment & stays unchanged indefinitely. Here is a stage in the process of plant succession

Pioneer species refers to the earliest species in the process of plant succession. They usually invade a bare area such as newly exposed soil. The presence of pioneer species gradually promotes the establishment of a more exacting species.

Examples of succession | Primary succession

Coniferous (4)

Shrubs
↓
Blue Pine
↓
deodar
↓
spruce & fir

Estuarine (5)

mangrove scrub
↓
mangrove trees
↓
salt water HERITIERA
↓
swamp forest
↓
Evergreen Forest

हरी tie

Xerophytic (6)

lichen
↓
moss
↓
herbaceous weeds
↓
perennial grass
↓
shrubs (Zizyphus
↓
thorny forest (aca nilot

Retrogression or Regression refers to the reversal to some earlier stage of succession as a consequence of some adverse factors. Retrogression is the reason for secondary succession.

Theories of succession

Clement's Monoclimax Theory

- there is continuous change in vegetation due to interaction between plant community and habitat.
- succession is progressive and end product is climax.
- most dominant environment factor is climate ⇒ Climax is called Climatic clim

- due to different conditions of soil, biota there can be other climax like Preclimax, Postclimax, subclimax etc. But these variations ultimately progress into Climatic climax. (Monoclimax)

Poly Climax Theory

- depending on local variations, there can be more than 1 climax
- give examples
- more popular theory as it resembles the true conditions more closely.

Aubreville's Mosaic Theory

- Forest consists of a number of irregular small-units (like a mosaic : design made by fitting together different colours) with one of few dominants which develop on predictable yet different lines. — The positions of the sub units keep on changing and the mosaic is present at all times.
- Pattern of mosaic keeps on changing continually
- He criticized concept of a static & stable climax. According to him, there is dynamic equilibrium
  eg. Tropical Forests.

Theory of Vegetational Gradient of WHITTAKER

- NO absolute climatic climax for any area
- Climax = f (climate, soil, biotic factors) since these factors keep on changing climax keeps on changing
- Climax is, therefore, a partially stabilized state.
- Climax can be viewed as an average or the most probable population

⊙ Types of Forests from Guide : P- 20, 21, 22, 23

- **Seedling Establishment** refers to the development of a new crop to a stage where the young generation is considered safe from adverse influences like frost, drought or weeds & no longer needs special protection or tending operations other than cleaning, thinning & pruning.

- **Advance growth** refers to seedlings, saplings & poles of species of the overwood that have become estd. naturally in a forest before regeneration felling are started.

- **Seeding Felling** : Opening the canopy of a mature stand to provide conditions for securing regeneration from the seeds of the trees retained for the purpose.

Final Felling : Removal of the last shelter trees after regeneration has been accomplished under a shelterwood system.

Secondary Felling Regeneration felling carried out between the seeding felling & final felling under a shelterwood system in order to admit more light to the regenerated crop

Selection Felling refers to annual or periodic removal of exploitable trees, individually or in small groups, in an uneven aged forest in order to realize the yield & establish a new crop irregular in its constitution. Primary consideration is improvement of forest.

Selective Felling refers to removal of certain species of high value whose trees are above a certain size, without full regard to silvicultural requirement.

- **Regeneration Survey** (P-221) refers to the survey for the assessment of established & unestablished regeneration generally by sampling enumeration.
- It is done at the **time** of revision of working plan.
- The main **objectives** of regeneration survey are:

(1) To **compare** natural regeneration in any area at end of working plan with that in the beginning.

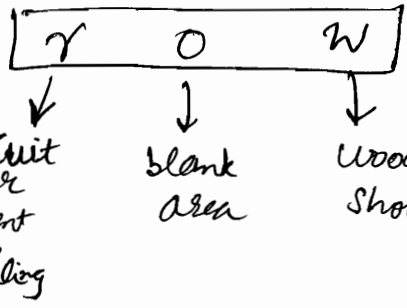
(2) To evaluate the **effects of operations** carried out during the working plan period.

(3) To prepare **stock map** of any area proposed to be regenerated & prescribe correct silvicultural treatment for various parts on basis of current status of regeneration.

- < give funde of sampling plots & intensity >
- **Colour Coding** used in presentation of survey on basis of status of regeneration

Green : Excellent
Yellow : Moderate
Red : Poor

- Besides **symbols** are used to classify areas



Improvement Felling refers to removal or destruction (girdling) of less valuable trees in a crop in the interest of better growth of the moree valuable individuals. Its usually applied to a mixed uneven-aged forest.

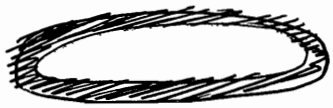
Girdling refers to cutting through bark & outer living layer of wood in a continuous incision all around the bole of a tree

Subsidiary Felling Operation done in a coupe following the main felling. It includes:

- removal, girdling of marked trees left unfelled
- cutting malformed & ill-developed advance growth
- remove stems damaged during main felling.

Q Where does the growth occur?

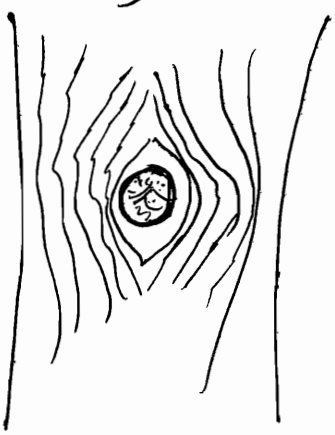
A Trees increase in diameter by the formation of new woody layer between the existing wood and the inner bark. The new woody layer, so formed, envelops the entire stem.



← new layer

Remember that dark pith & heartwood layers are dead.

Q What are those ring type structures on outer bark?



A

Knots : broken off branch portion.

- NFT's : Nitrogen Fixating Trees eg. leguminous Trees.
- FYM ; farmyard manure

Permaculture self maintained agricultural system modelled from natural ecosystems. It includes taking care of the Earth and return of surplus back to the system in the form of manure.

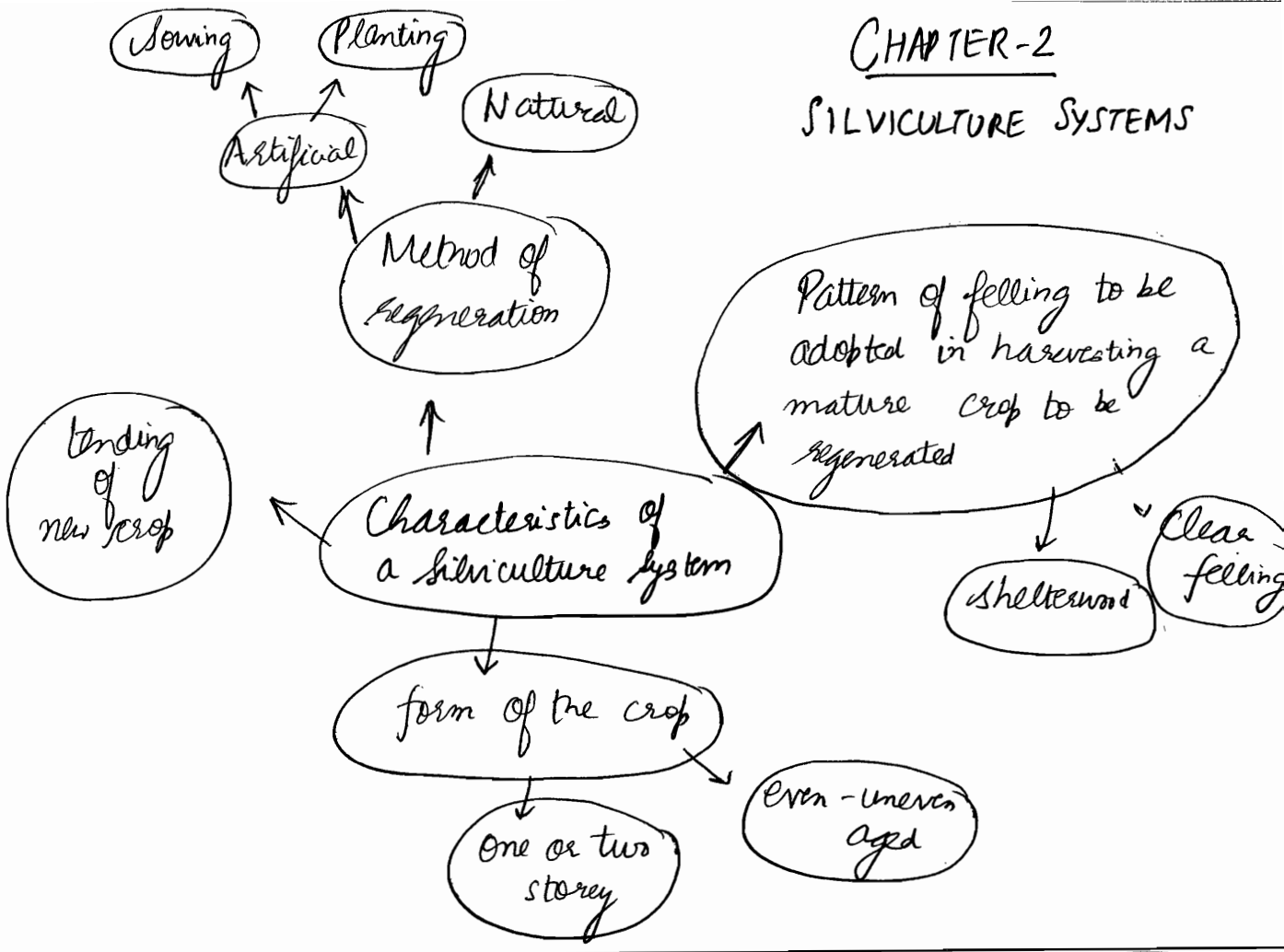
Polyculture Growing multiple crops in the same space, in imitation of the diversity of natural ecosystems, and avoiding monoculture.

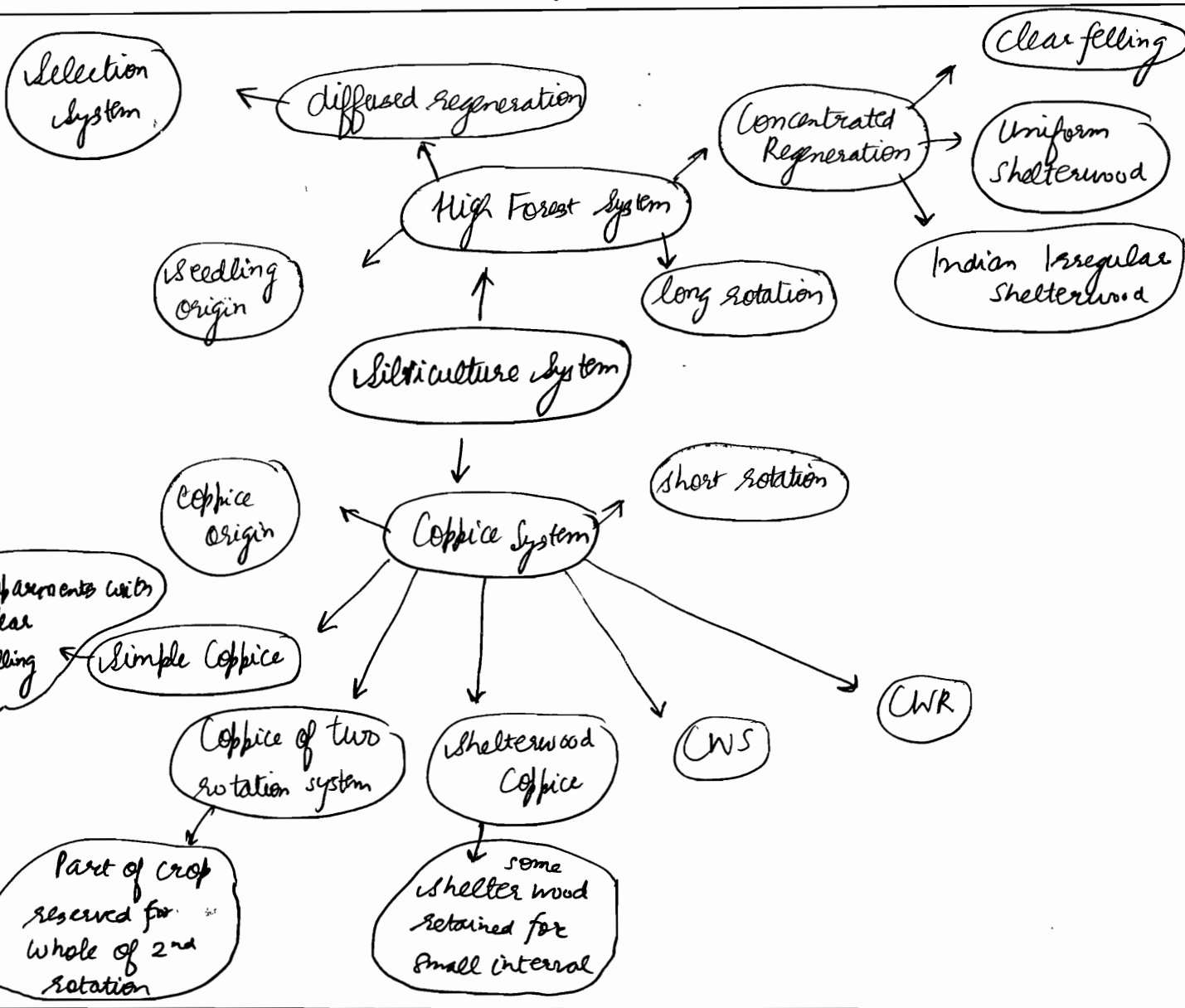
Carbohydrate Farming done in Brazil; farming of plants rich in sugar & starch in large quantities & from which ethyl alcohol is produced as a source of energy.

eg. Sugarcane, Jatropha

CHAPTER-2

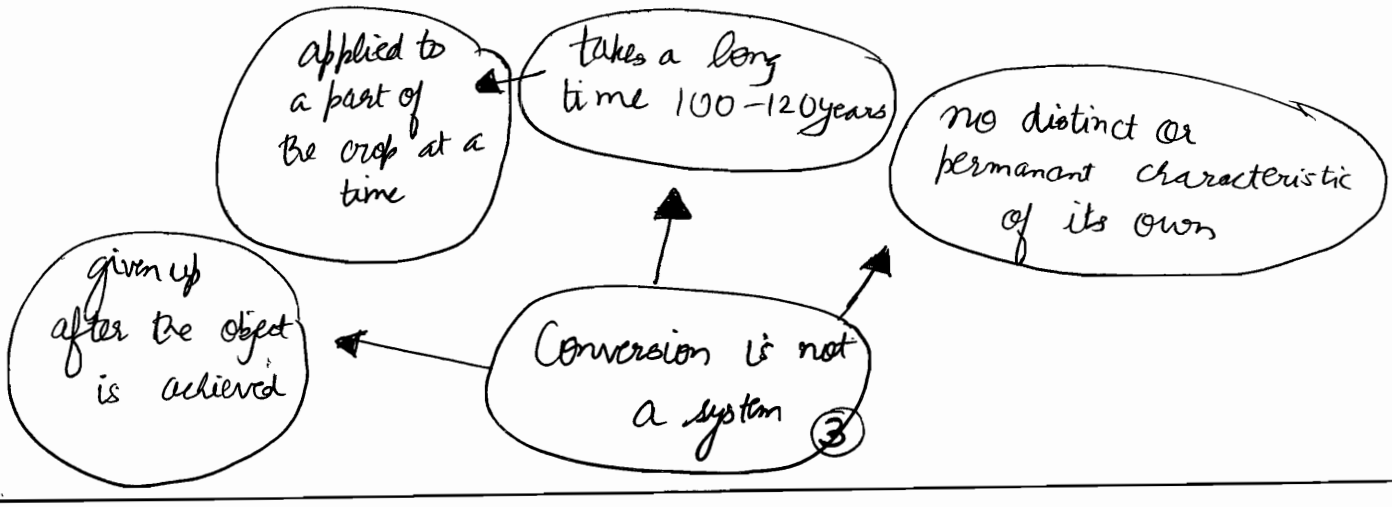
SILVICULTURE SYSTEMS

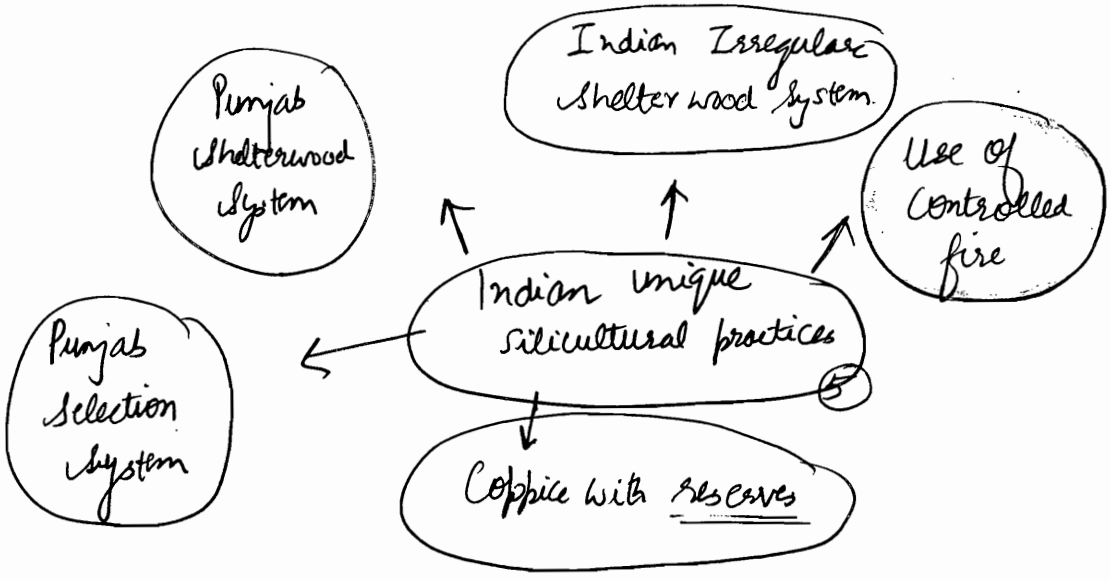


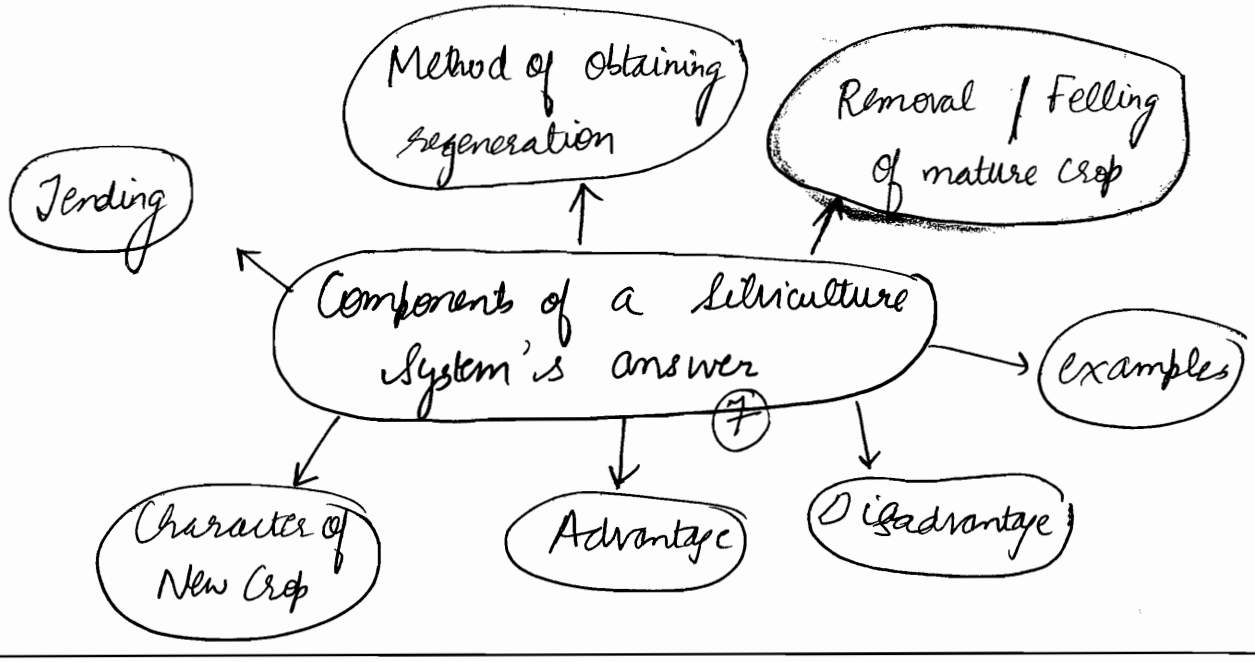


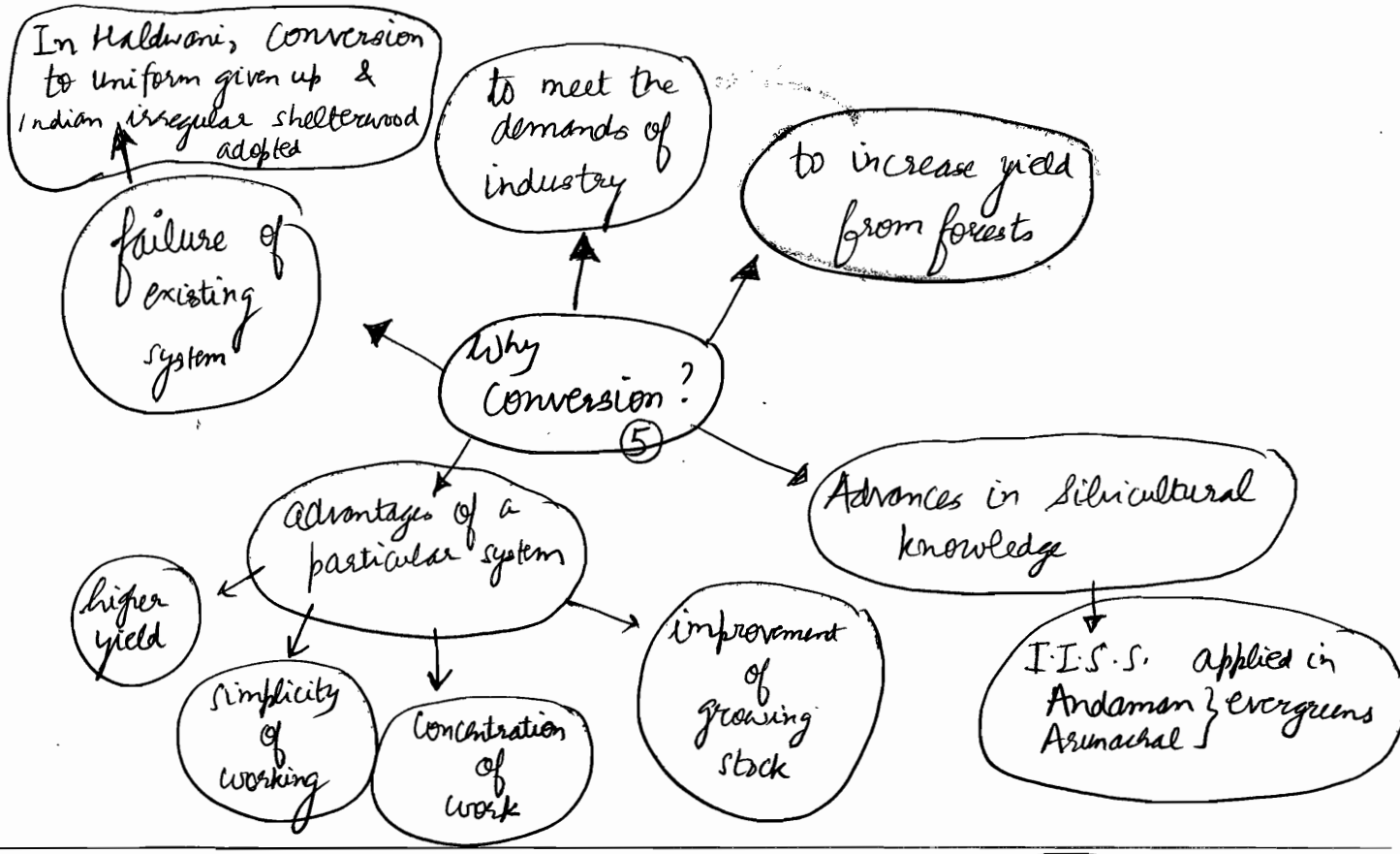
② Silviculture system may be defined as a [redacted] silviculture procedure worked out in accordance with accepted sets of silvicultural principles, by which crops are regenerated, tended & harvested. felled,

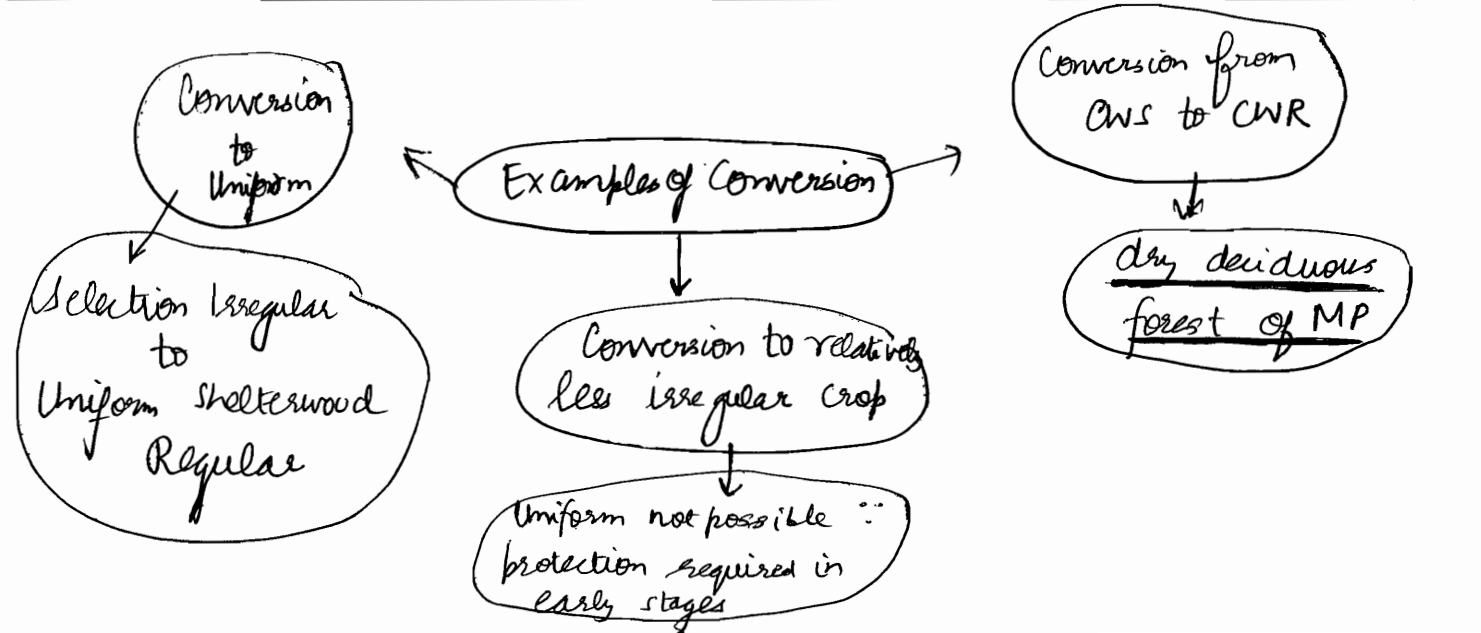
③ Conversion is a silviculture procedure designed to change the forest crops from one silviculture system to another. Changes can be in the mode of regeneration (coppice ⇌ high forest) or change in character of crop (regular ⇌ irregular)

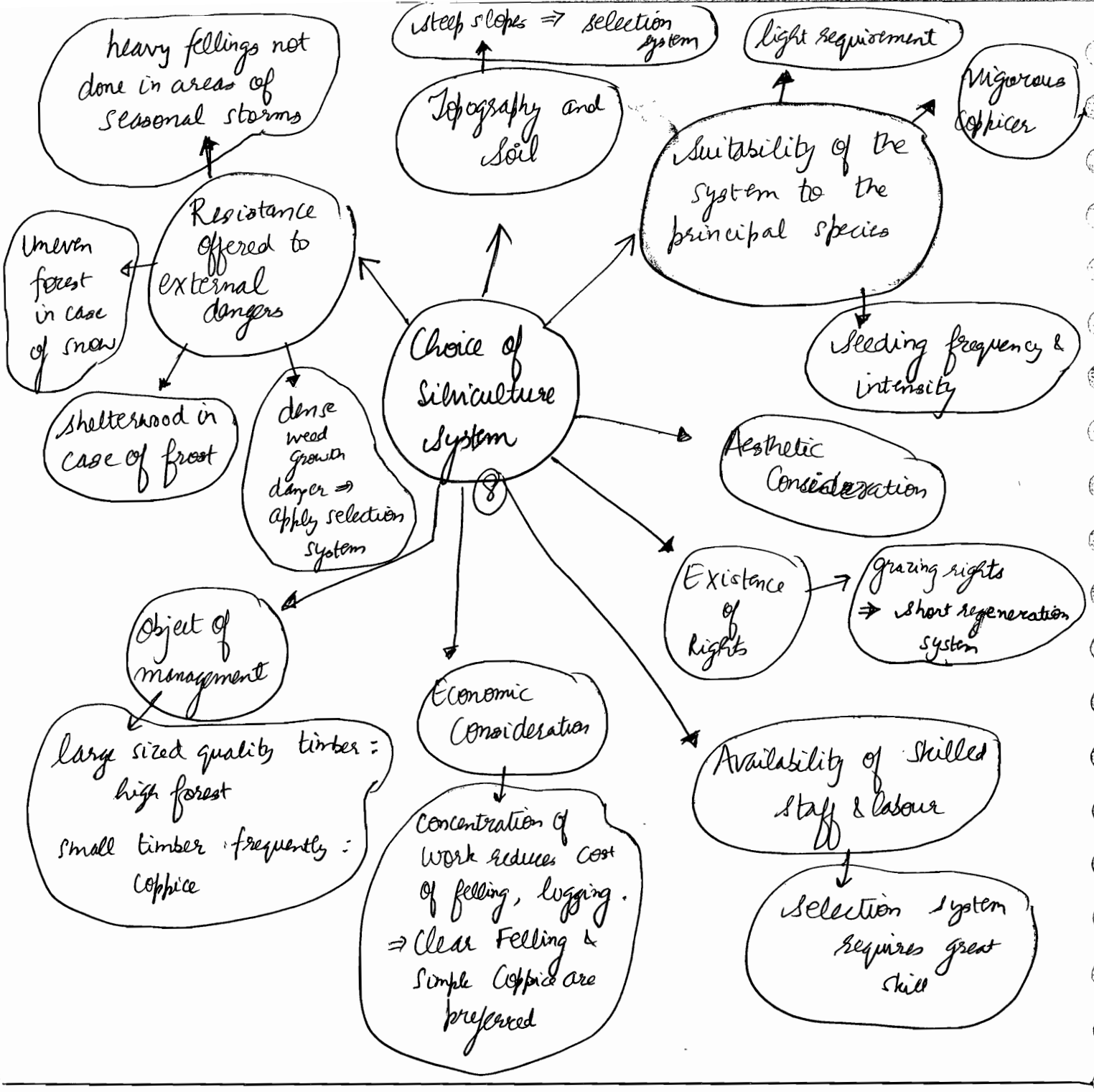





Method of obtaining regeneration
Removal / Felling of mature crop
Tending
Component of a Silviculture System's answer (7)
examples
Character of New Crop
Advantage
Disadvantage


In Haldwani, Conversion to Uniform given up & Indian irregular shelterwood adopted
failure of existing system
to meet the demands of industry
to increase yield from forests
Why Conversion? (5)
advantages of a particular system
higher yield
simplicity of working
Concentration of work
improvement of growing stock
Advances in Silvicultural knowledge
I.I.S.S. applied in Andaman, Arunachal } evergreens

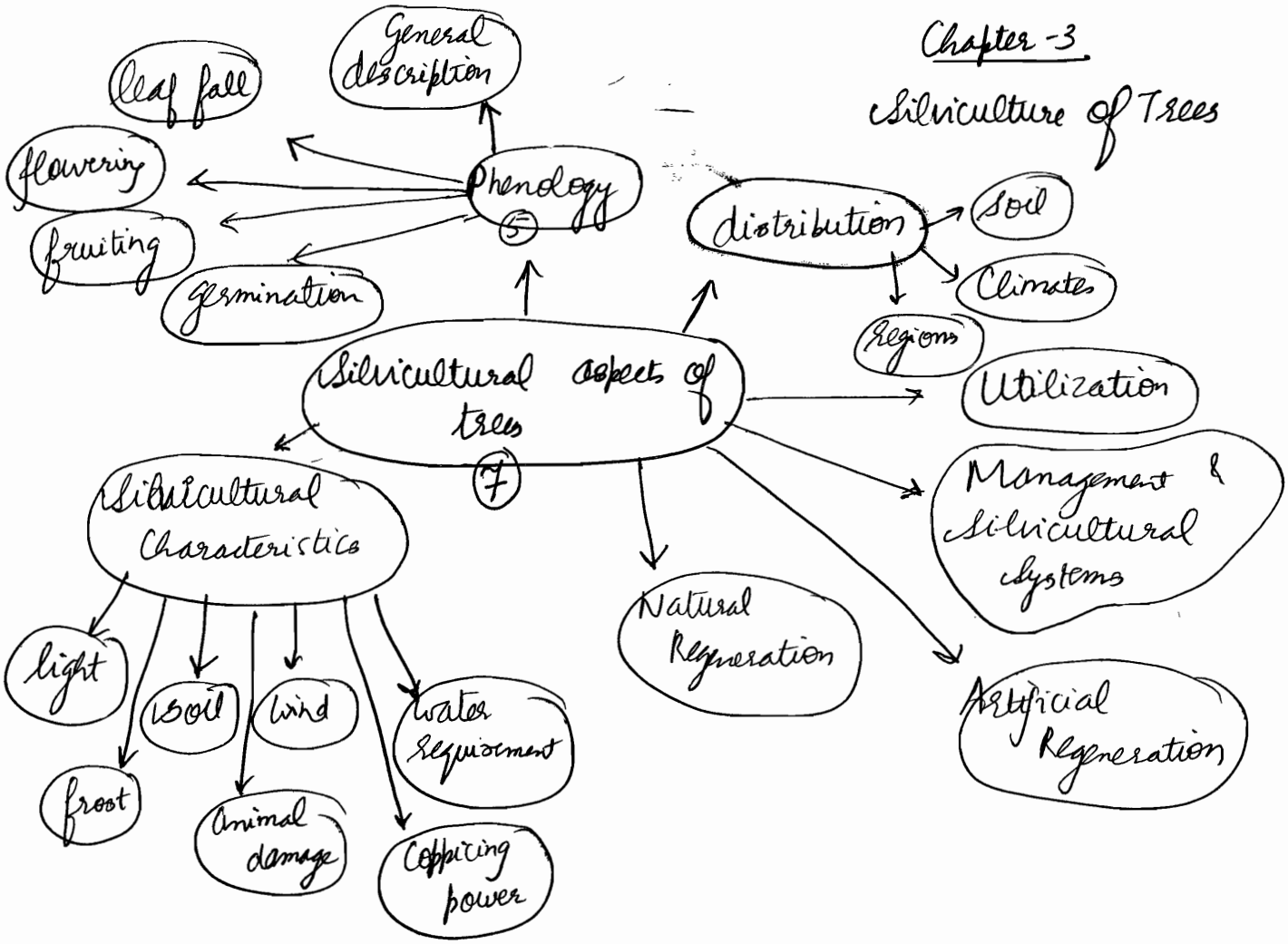

Conversion to Uniform
Examples of Conversion
Conversion from CWS to CWR
dry deciduous forest of MP
Selection Irregular to Uniform Shelterwood Regular
Conversion to relatively less irregular crop
Uniform not possible ∴ protection required in early stages



Dauerwald ⇔ Selection System

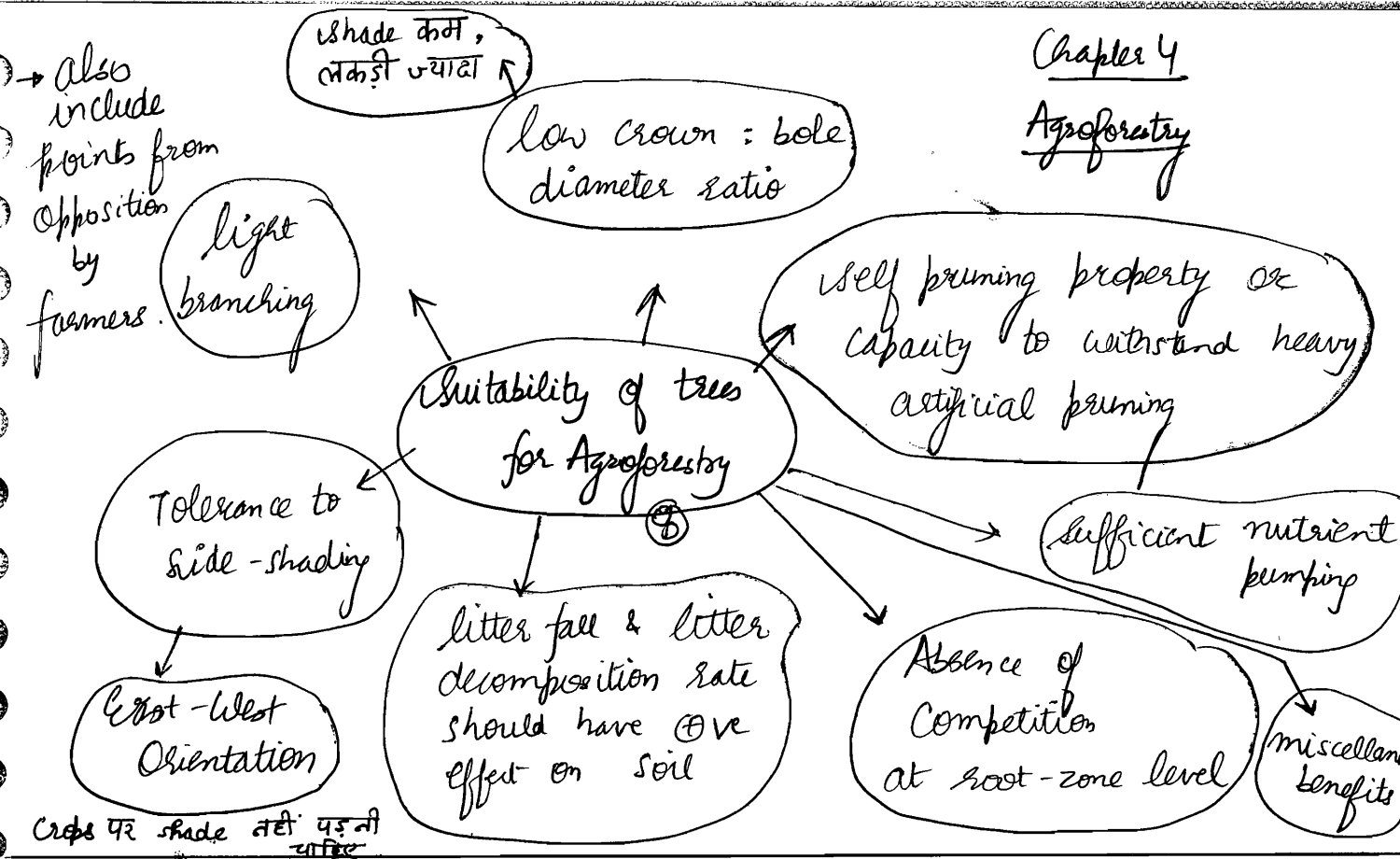
Chapter -3

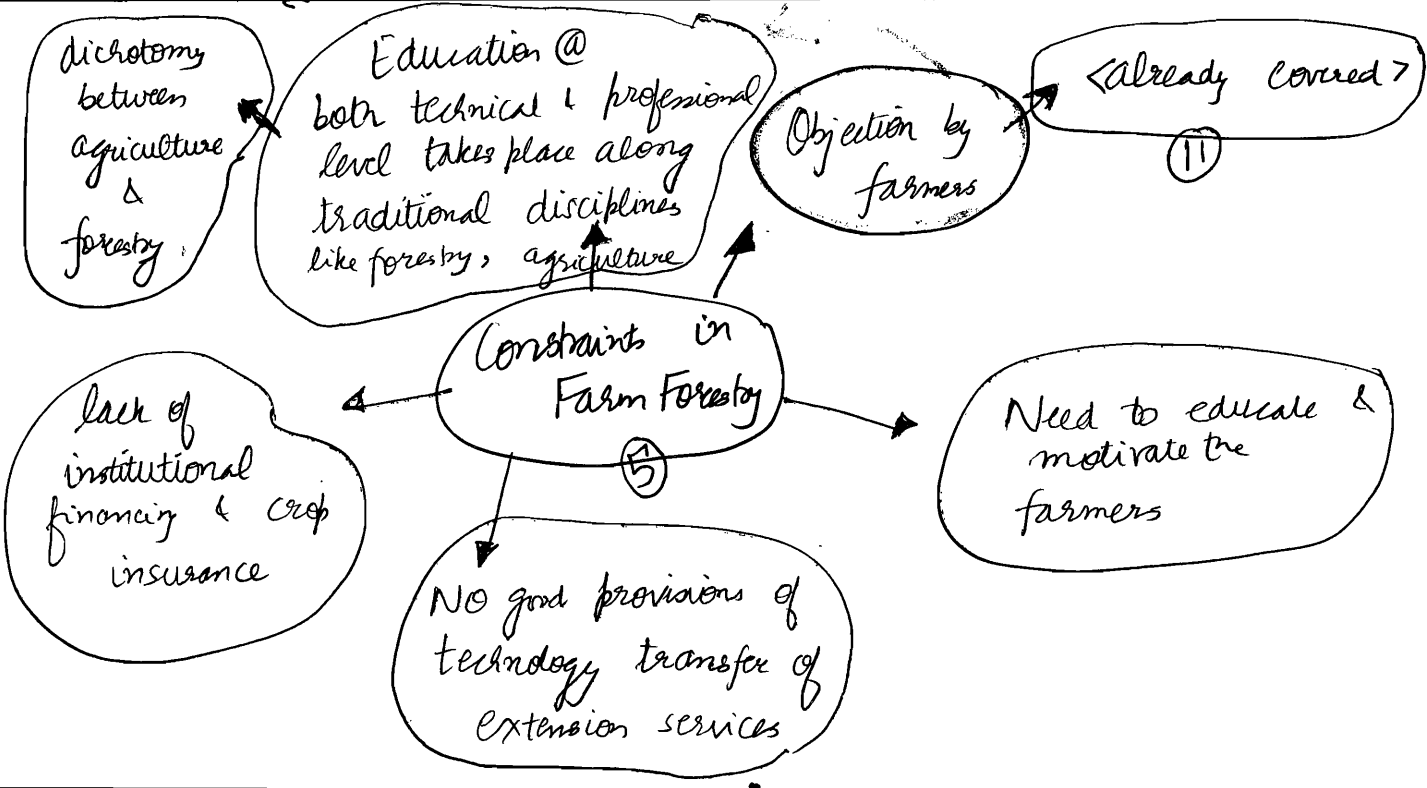
Silviculture of Trees



Chapter 4
Agroforestry

→ Also include points from opposition by farmers.





Promising MPT (Multi Purpose Trees)

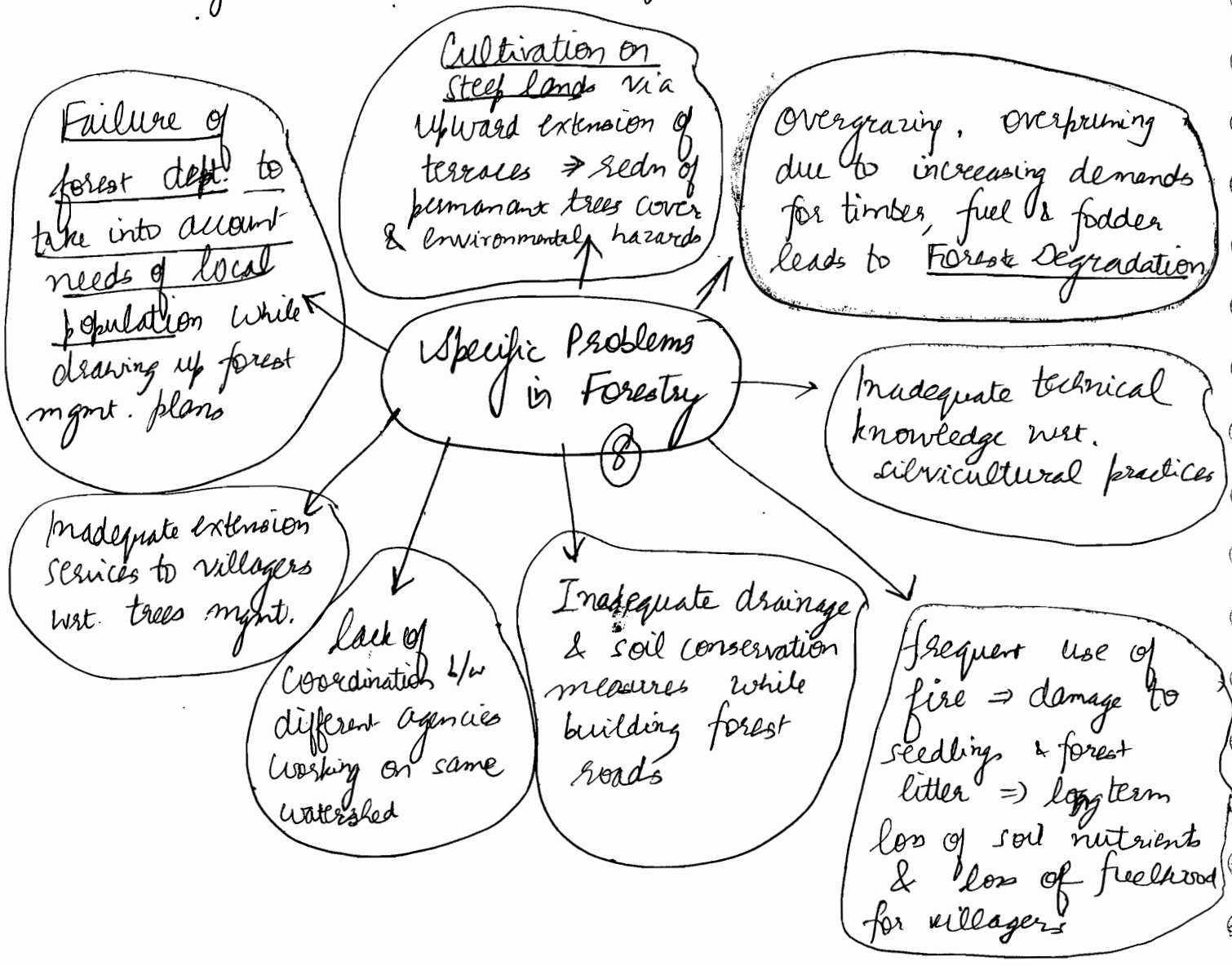
Capital:
- Azadirachta Indica
- Acacia Nilotica
- Prosopis Juliflora
- Populus (Poplar)
- Eucalyptus spp

Small:
- Emblica Officinalis
- Dalbergia Sissoo
- Casuarina Equisetifolia
- Mangifera Indica
- Zizyphus Mauritiana
- Bamboo spp.

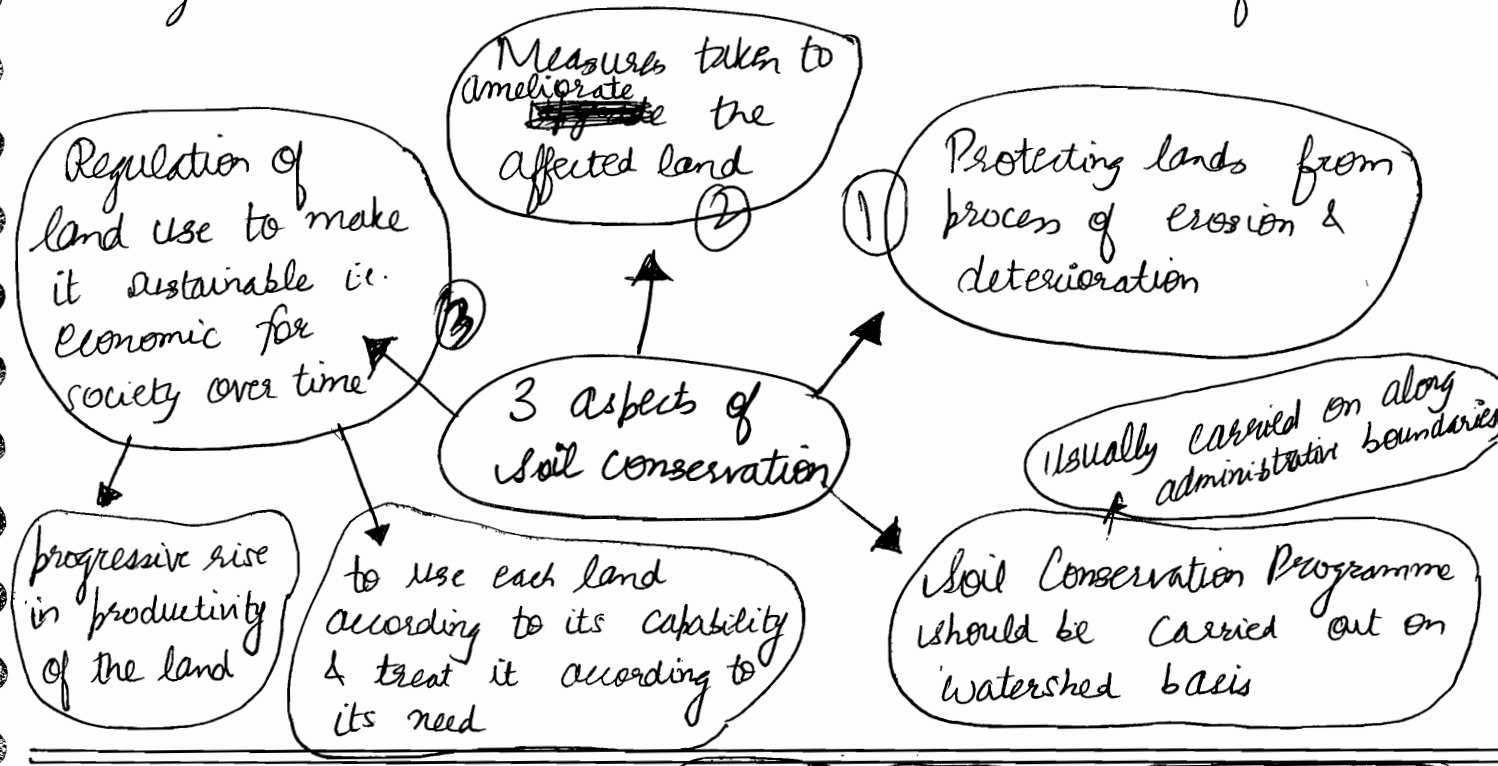
⊙ 3 problems of Jhum land : ⊙ Soil Erosion
⊙ Increased Run-Off
⊙ Loss in Nutrient Status

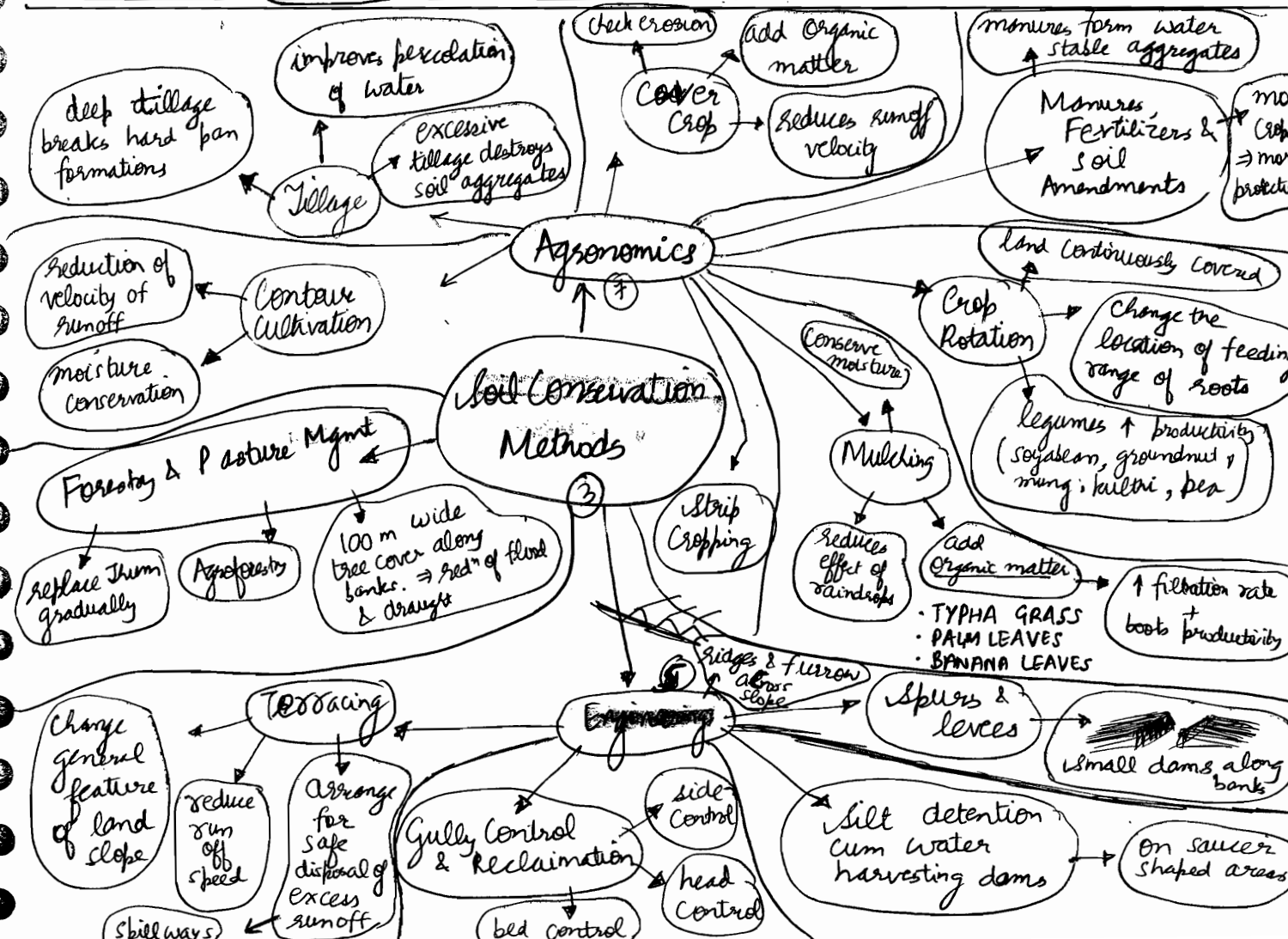
◉ Stabilization of watersheds is recommended to be achieved through massive afforestation programmes. Agroforestry systems mimic the major functions of forestry wrt. watershed afforestation. Thus, adoption of agroforestry practices is expected to provide the same benefits that are achieved through afforestation.

Aim of agroforestry is to optimise positive interactions between various biological components like trees, shrubs, crops & animals, and between these components & the physical environment so as to obtain a more sustainable & diversified production system from the land.



Soil is the topmost (1) layer of the Earth's surface which is composed of minerals and (2) organic matter and is capable of sustaining (3) plant life. Quantity, quality and frequency of economic output from any piece of land is dependent to a large extent on the nature & characteristics of the soil.





⊙ **Rhizome** : modified stem of a plant found underground, often sending out roots & shoots from its nodes. Ability to grow new shoots upwards. eg BAMBOO

Rhizobium : Soil Bacteria that fixes nitrogen by forming symbiotic nodule formations.

Plant —Photosynthesis made→ Organic compound

Rhizobium Bacteria Nodule

↑ Convert atm. N_2 to ammonia & provide nitrogenous compounds to plant eg. Glutamine Amino Acid.

Rhizobium

exchange pool / reservoir pool

① Restricted to legumes & a few others
→ Soyabean → mung
→ pea → kulth
→ groundnut

② Main nutrient is N

③ Increase the exchange reservoir by conversion of atm. unusable N to usable ammonia

④ —

Mycorrhiza

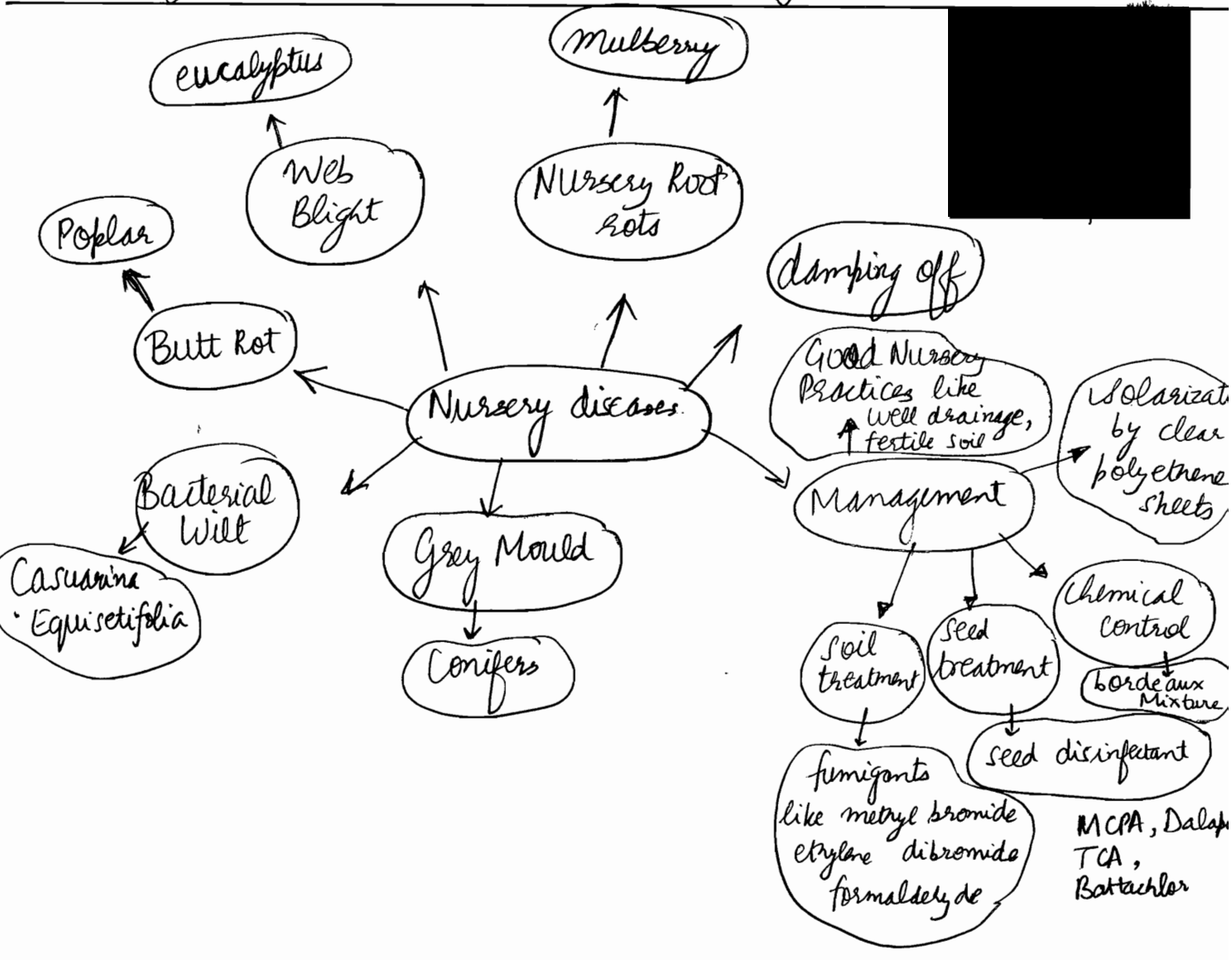
① Mycorrhizal Association of one type or other are universal in the roots of natural vegetation & most agricultural crops.

② Main nutrient is P

③ Does not provide access to previously unavailable reserves Absorption is increased.

P fertilizer expensive in tropics & tropical soil deficient in P
→ Slight increase in mycorrhizal efficiency is of great practical importance

- Apart from conserving soil & moisture, Contour plantation
  - increases soil depth
  - plant root system develops better as roots can penetrate softened bedrock (due to moisture)
  - worked contour serve as site for downhill rolling seeds to settle ⇒ this facilitates natural regeneration.
  - economic cost of investment is remunerated by greater plant survival, increased yield & shortened rotatio



[redacted]

⊛ Alley Cropping or Hedgerow intercropping is a good alternative to jhum cultivation. (jhumia are people who practice jhum cultivation)

Ecological Adaptation

CHAPTER - 5

MISCELLANEOUS - 1

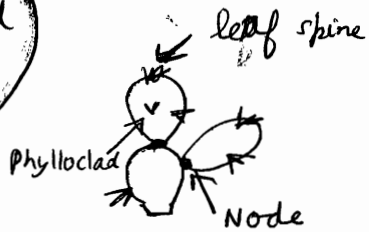
Conditions of habitat (4)
- Soil is physiologically dry
- deficient rainfall
- acute shortage of water
- high rate of transpiration
- extreme acidity

Examples: desert (hot & cold) steppes

Xerophytes

Major types (2)
- Phreatophytes (long roots)
- Succulents (eg. Cactus, Aloe) [fleshy structures]

Adaptations in Xerophytes (7)
- Reduction of respiration rate
- water storage
- leaves may transform into Phyllodes eg. Aloe
  - Reduction of transpiration
- true leaf modified into spines present all over phylloclade
  - reduced no. of stomata on leaves
  - stomata control mechanism
- stem become fleshy phylloclad performs functions of leaf



- Smaller cells & vacuoles to prevent dehydration
- Root system long & well developed
  - more fibres & root hair
  - Absorption of moisture during brief shower
- Root system may develop above the ground surface
- Epidermis is covered with layer of cuticle
  - red" of transpiration

Brackish water

Flowing fresh water

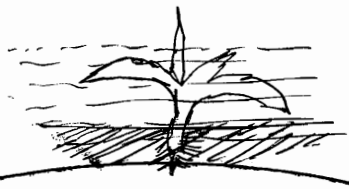
Coastal (saline) water

Conditions of Habitat (5)

Standing or static Fresh water

marshes & swamps

Hydrophytes



Waxy coating on leaves acting as check against wetting & clogging of stomata

Root system is reduced & less branched

leaves increase in length & become finely divided. Increases transpiration

external wall or epidermis contains chlorophyll

incoming light is weak

Adaptations in Hydrophytes (7)

perform function of roots

external wall or epidermis is thin

easily absorb gases & nutrients

Reproduction by vegetative propagation. as extreme wetness is obstacle for reproduction via sexual processes

Intercellular spaces are large & filled with air

storehouse for Oxygen

buoyancy

vital role in exchange of gases

---

high concentration of salt in water

hinders absorption of water by plants leading to water deficiency

physiologically dry soil

Conditions of habitat

high salinity in the soil

Halophytes

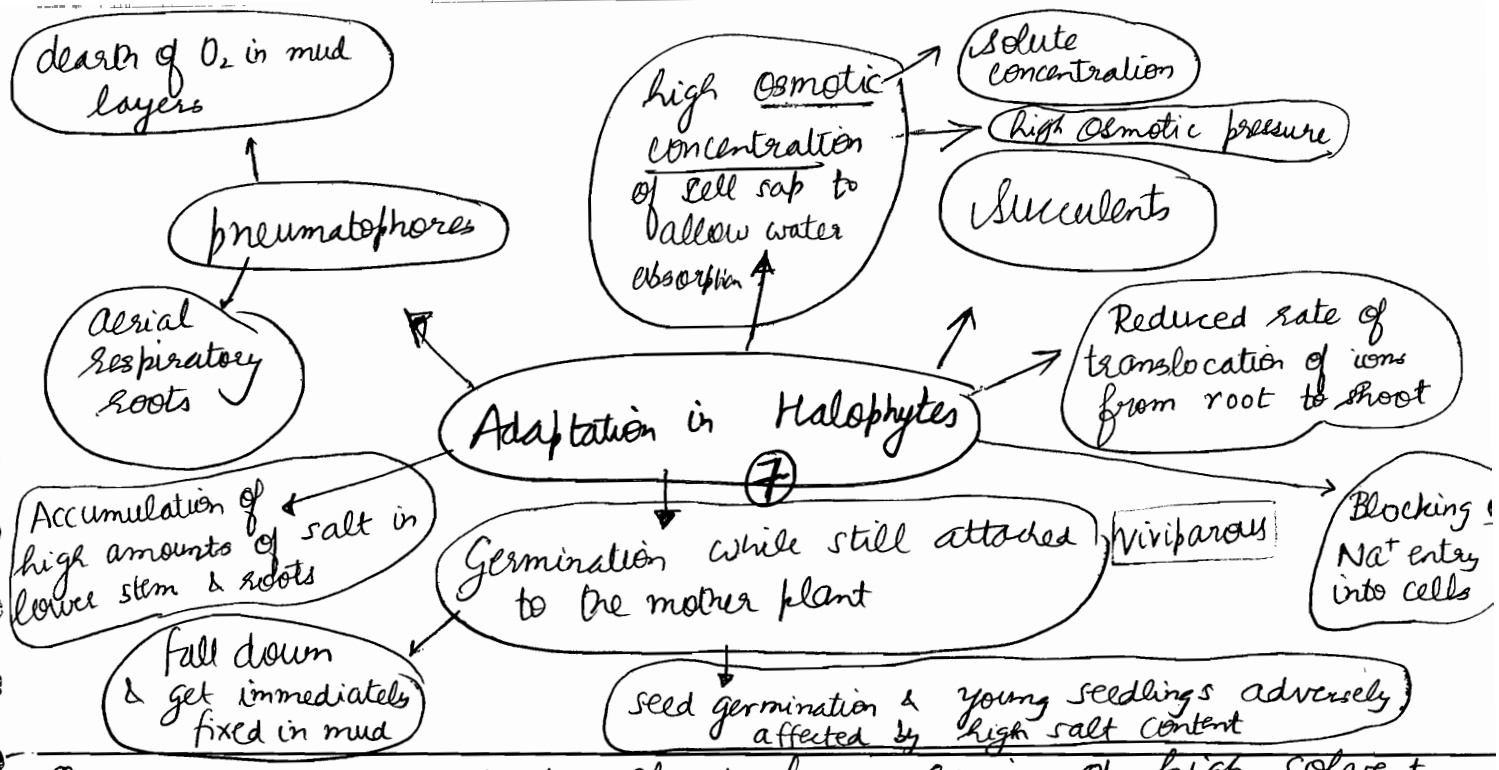
deltas, estuaries intertidal belts on sea coast saline soils in inland area dry & desert area

dry & desert salt halophytes

Types

mangroves

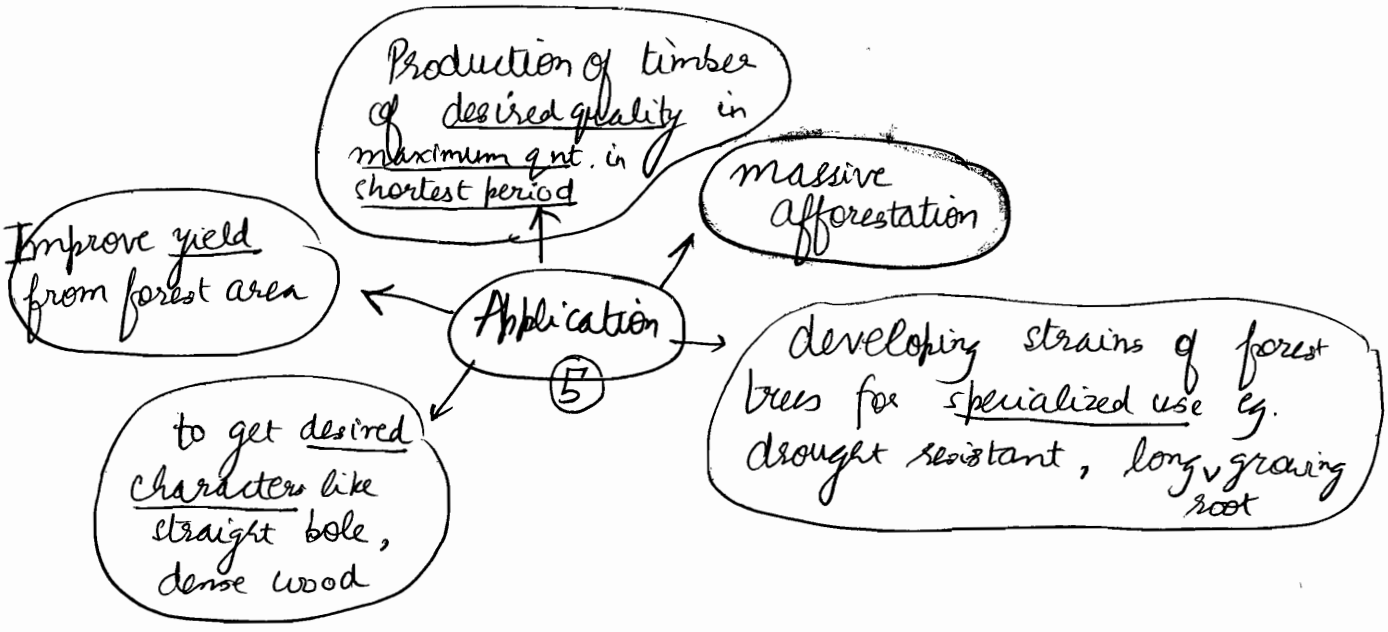
Remember Playa lakes

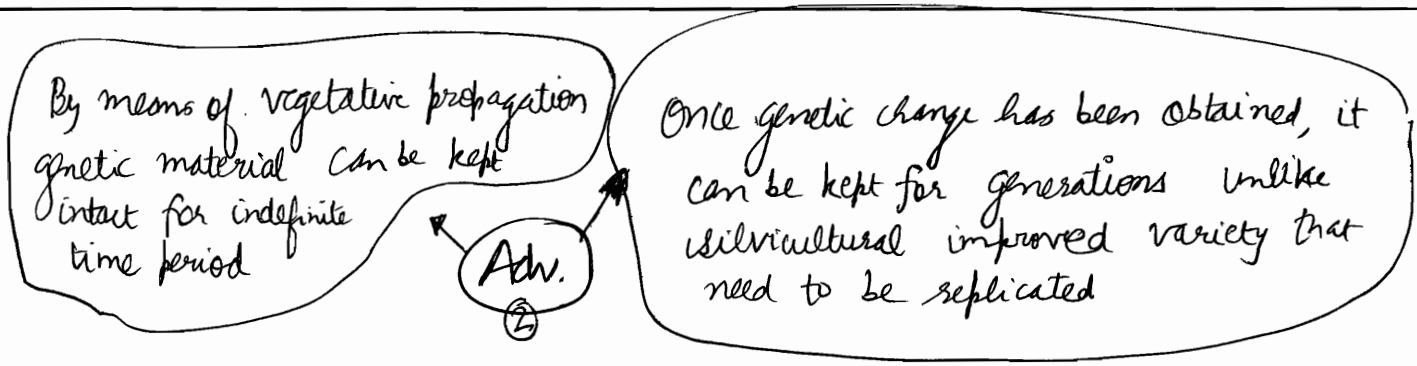


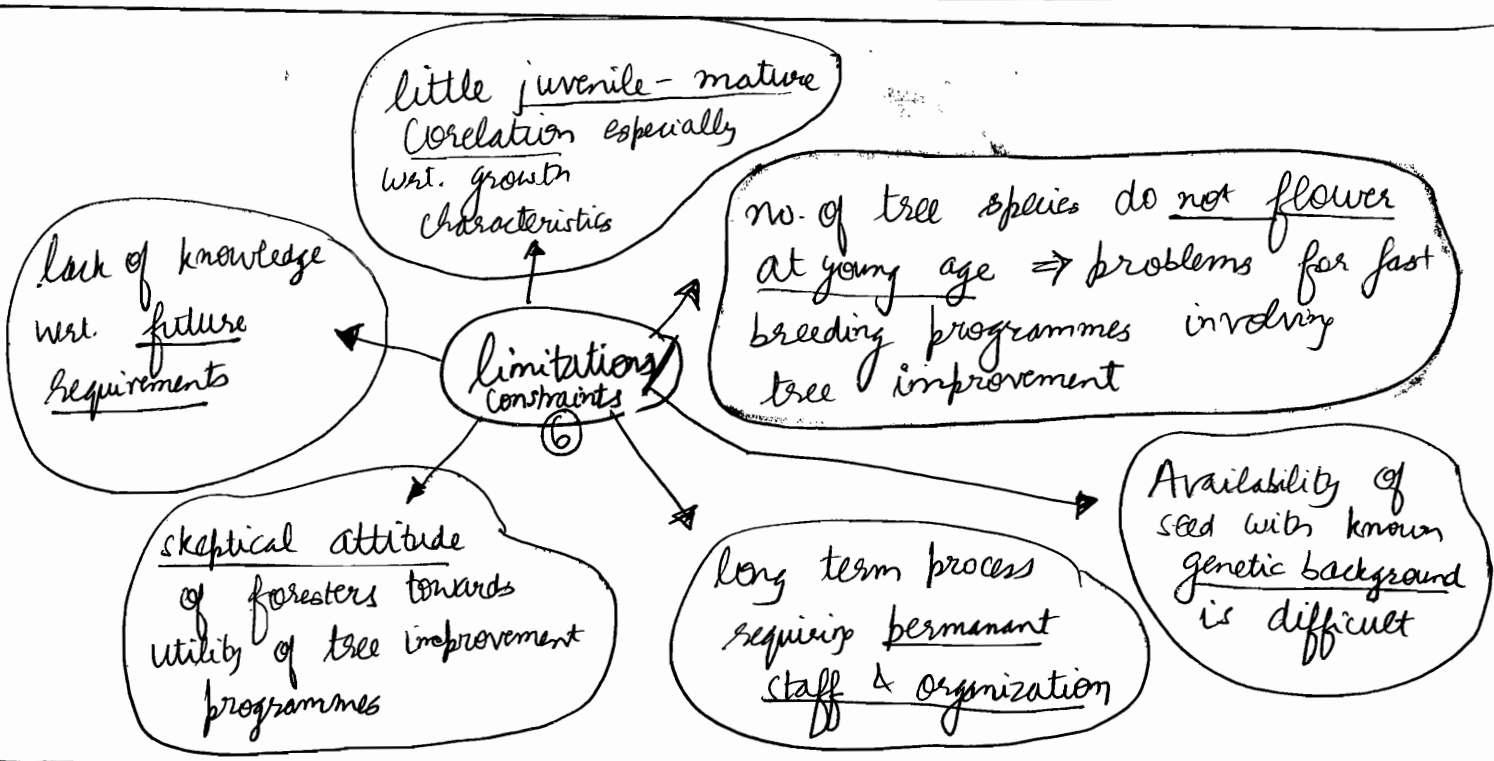
Osmosis is movement of solvent from region of high solvent concentration to low solvent concentration.

low osmotic concentration ⇒ low solute conc. ⇒ low osmotic pressure

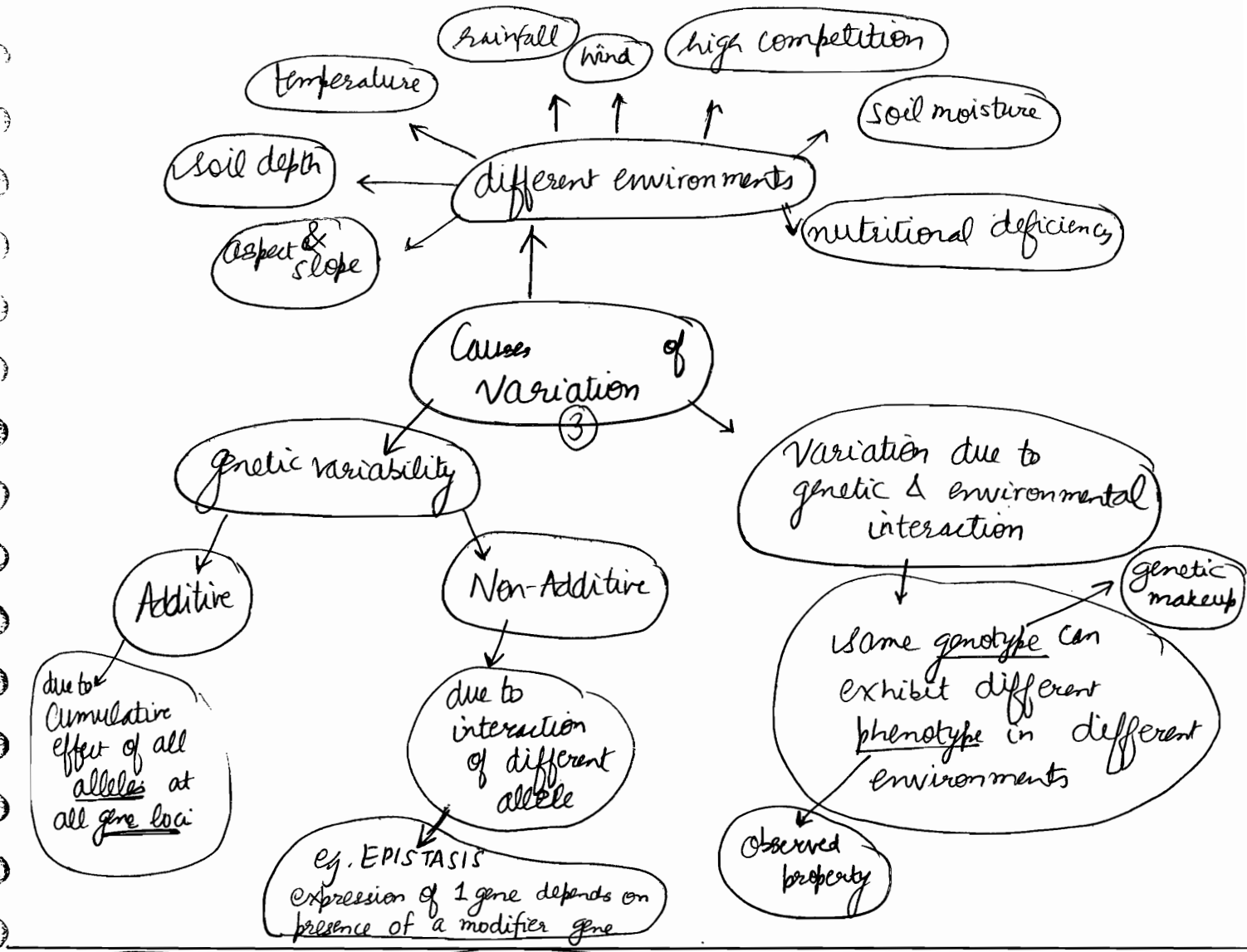
Tree Improvement

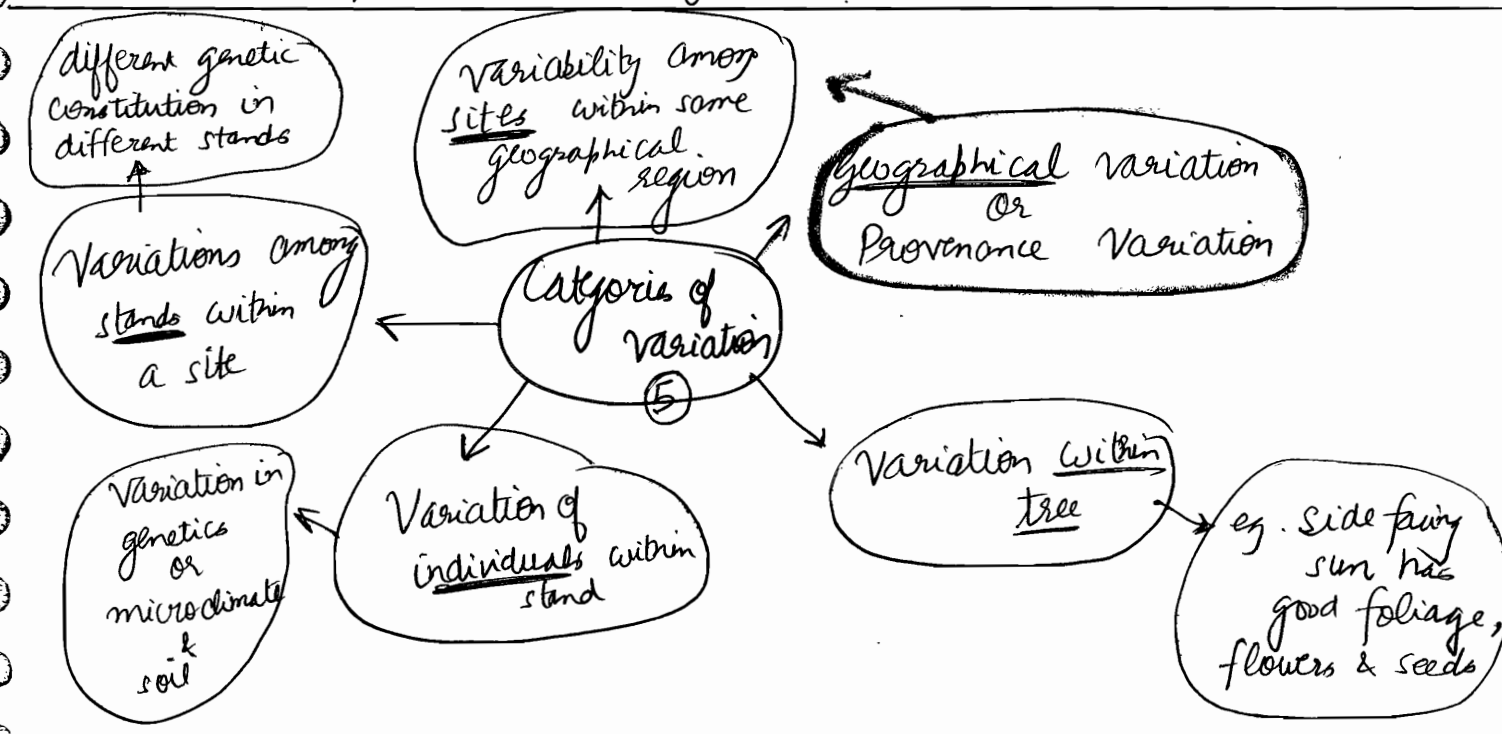


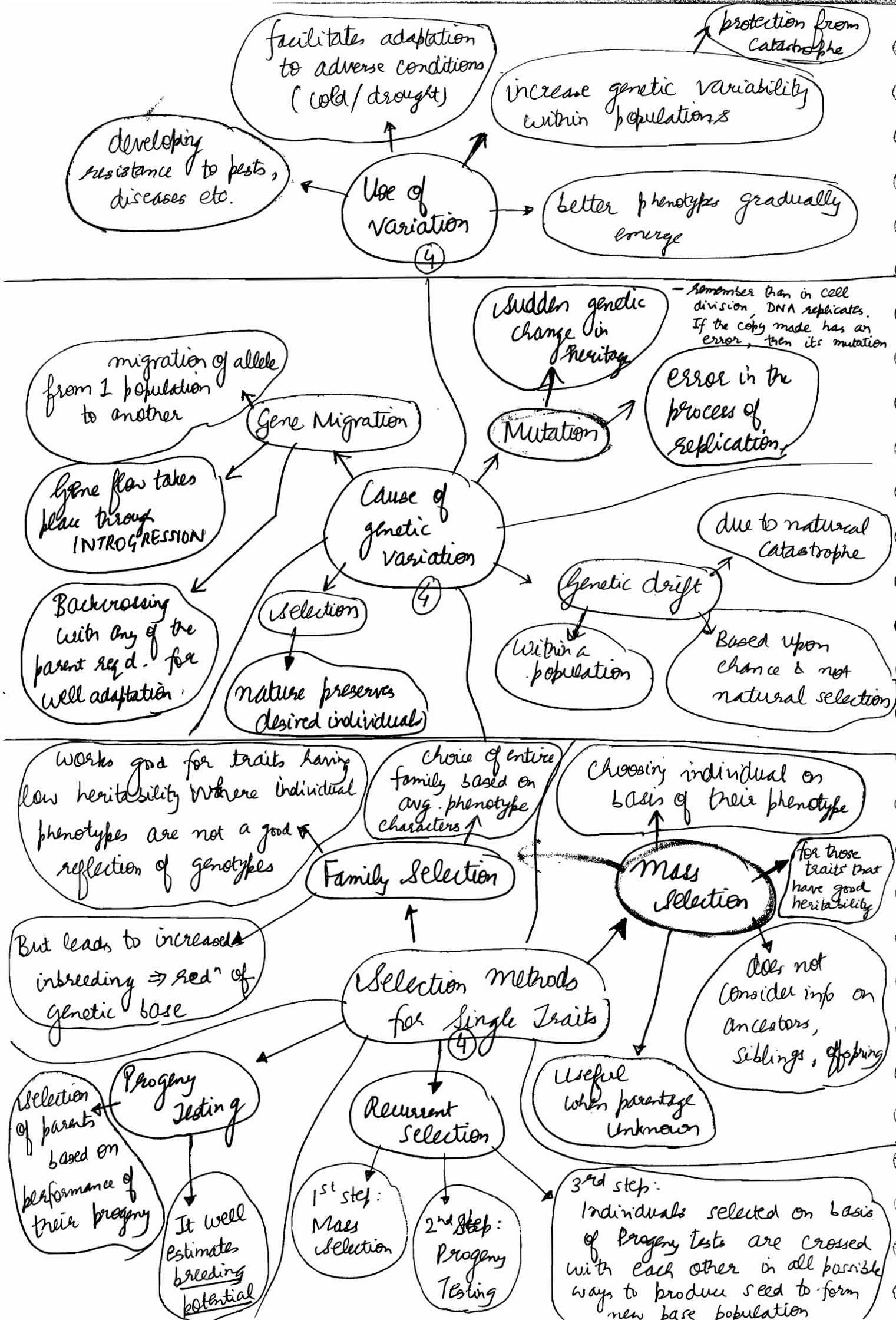




Variation refers to differences in the species and within in terms of both genetic & morphological aspects. Variance is the basic parameter upon which tree improvement stands.


rainfall
wind
high competition
temperature
soil moisture
soil depth
different environments
nutritional deficiency
aspect & slope
Causes of Variation
3
genetic variability
Additive
Non-Additive
due to cumulative effect of all alleles at all gene loci
due to interaction of different allele
eg. EPISTASIS
expression of 1 gene depends on presence of a modifier gene
Variation due to genetic & environmental interaction
genetic makeup
some genotype can exhibit different phenotype in different environments
observed property


different genetic constitution in different stands
Variability among sites within same geographical region
Geographical variation or Provenance Variation
Variations among stands within a site
Categories of variation
5
Variation in genetics or microclimate & soil
Variation of individuals within stand
Variation within tree
eg. side facing sun has good foliage, flowers & seeds


Use of variation (4)
facilitates adaptation to adverse conditions (cold/drought)
protection from catastrophe
increase genetic variability within populations
developing resistance to pests, diseases etc.
better phenotypes gradually emerge
Cause of genetic variation (4)
Gene Migration
migration of allele from 1 population to another
Gene flow takes place through INTROGRESSION
Backcrossing with any of the parent req'd. for well adaptation
Mutation
sudden genetic change in heritage
error in the process of replication
- remember than in cell division, DNA replicates. If the copy made has an error, then its mutation
Selection
nature preserves desired individuals
Genetic drift
due to natural catastrophe
within a population
Based upon chance & not natural selection
Selection Methods for Single Traits (4)
Family Selection
works good for traits having low heritability where individual phenotypes are not a good reflection of genotypes
Choice of entire family based on avg. phenotype characters
But leads to increased inbreeding ⇒ red^n of genetic base
Mass selection
Choosing individual on basis of their phenotype
for those traits that have good heritability
does not consider info on ancestors, siblings, offspring
Useful when parentage Unknown
Progeny Testing
Selection of parents based on performance of their progeny
It well estimates breeding potential
Recurrent selection
1st step: Mass selection
2nd step: Progeny Testing
3rd step: Individuals selected on basis of Progeny tests are crossed with each other in all possible ways to produce seed to form new base population

Selection Method for several traits (4)

Independent Culling
- Individuals that fall below are culled out
- minimum values for each trait of interest is set first

Tandem Selection
- Sequential selection of traits
- One character is looked into at a time
- then breed proceeded to get desired improvement
- move on to next trait
- But there is chance that improvements of 1st trait may be lost while proceeding to improve 2nd trait

Selection Index
- Combines information of all traits into a single index
- Each trait is assigned a weight
- Only those with higher index scores are selected
- Simultaneous selection Unlike sequentially (tandem)

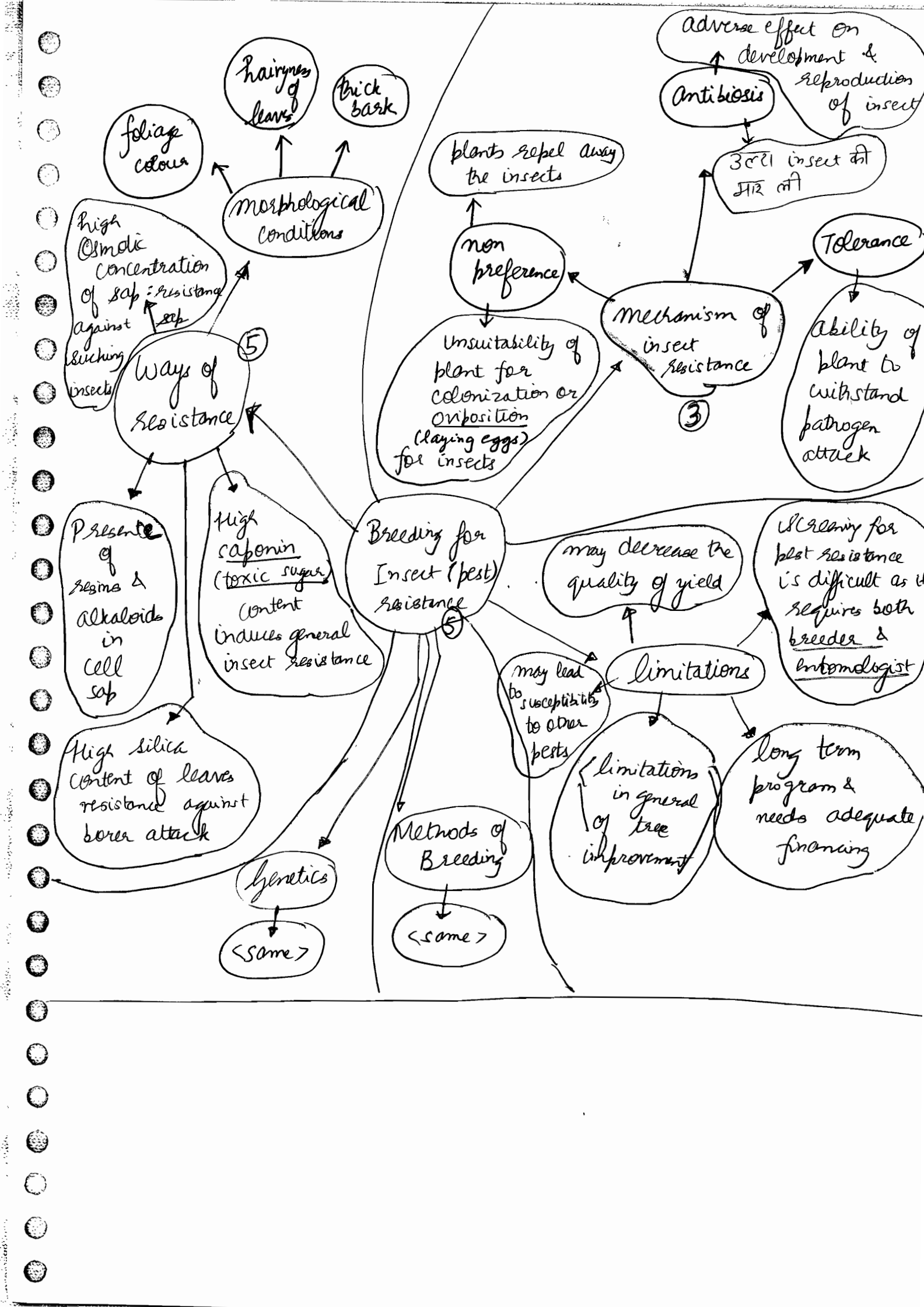
Recurrent Selection
- Simple Recurrent Selection
  - inter breeding of reselected specie
- Reciprocal Recurrent selection
  - pollen of A used to make ideal B females & pollen of B are used to make ideal A female

Tandem Selection

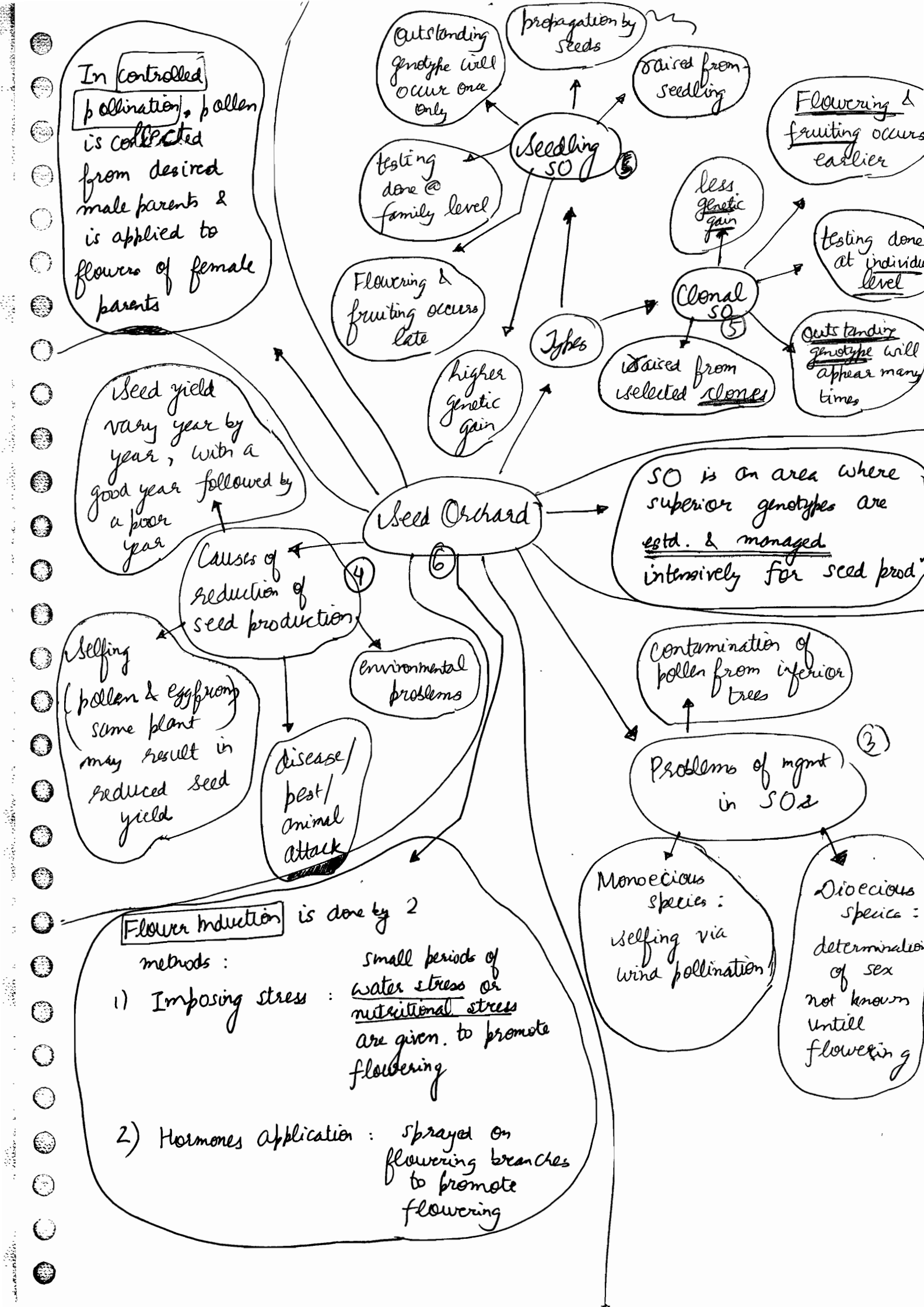
taller trees

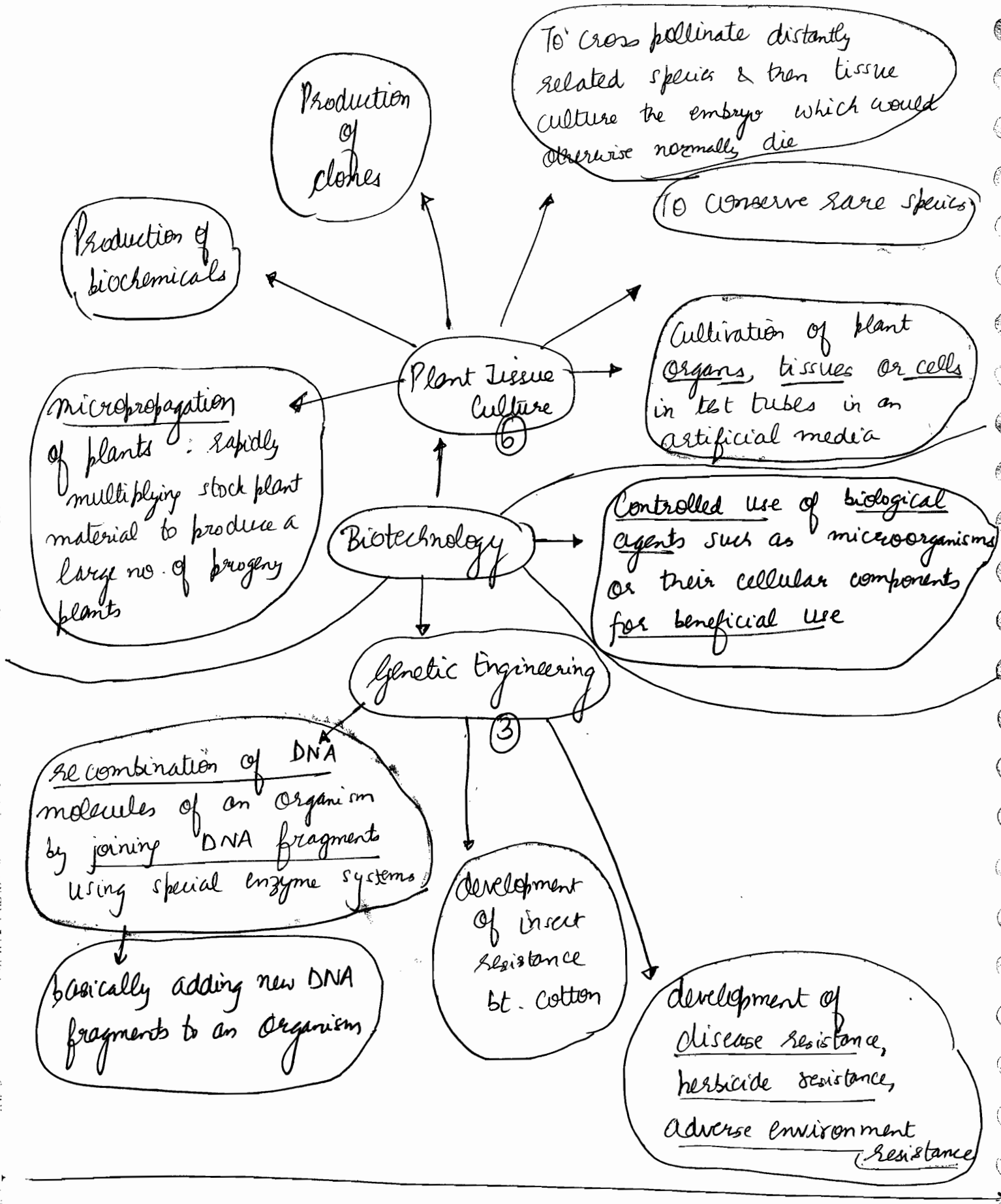
trees with black leaves but may become less tall


Breeding for disease resistance
5
types of disease resistance
2
vertical
specific to pathogen type
hypersensitive response
determined by oligogenes
horizontal
controlled by polygenes
mechanical response
Patrotype non-specific
general resistance against all harmful pathogens
disease development
4
Causal agent, say vector, contacts the host
Contact
Pathogen infects the plant, mainly through wounds
infection
establishment
pathogen derives nourishment from host
development
pathogen develops & causes injury
Mechanism of disease resistance
3
Mechanical
Arises due to Anatomical features
eg. closed flowering of wheat reduces infection chances
Nutritional
host does not fulfil nutritional requirement of pathogen
Pathogen not able to survive inside host
hypersensitive
immune response
After infection surrounding host cells dies & leads to death of pathogen itself
Methods
5
Selection
Choose the naturally occurring disease resistant plants
Introduction
Introduction of disease resistant species where they are not present before
Hybridization
mating resistant & host varieties
Genetic Engg.
recombinant DNA
Somoclonal variation
Cells are cultured in a medium & treated with pathogens. Disease free cells are screened from infected ones & used for devt. of disease resistant seedling
Genetics of disease resistance
oligogenic
particular gene
pathogen specific resistance
polygenic
offered by many genes for general protection
non specific
Cytoplasmic
genes present in cytoplasm offer resistance
Morphology is the study of form & structure of organisms
Morphology
Anatomy
form & structure of internal features
Eidonomy
form & structure of external features


Breeding for Insect (pest) resistance
5
Ways of Resistance
5
Morphological conditions
Hairyness of leaves
Thick bark
foliage colour
High Osmotic concentration of sap : resistance against sucking insects
sap
Presence of resins & alkaloids in cell sap
High saponin (toxic sugar) content induces general insect resistance
High silica content of leaves resistance against borer attack
Genetics
<same>
Methods of Breeding
<same>
Mechanism of insect resistance
3
non preference
plants repel away the insects
Unsuitability of plant for colonization or oviposition (laying eggs) for insects
Antibiosis
adverse effect on development & reproduction of insect
उस्ती insect की मार सी
Tolerance
Ability of plant to withstand pathogen attack
limitations
may decrease the quality of yield
may lead to susceptibility to other pests
limitations in general of tree improvement
long term program & needs adequate financing
Screening for pest resistance is difficult as it requires both breeder & entomologist

* Inbreeding: reproduction from mating of parents who are closely related genetically. It increases chances of offspring with recessive traits.


In controlled pollination, pollen is collected from desired male parents & is applied to flowers of female parents
Outstanding genotype will occur once only
propagation by seeds
raised from seedling
Seedling SO
testing done @ family level
Flowering & fruiting occurs late
Flowering & fruiting occurs earlier
less genetic gain
testing done at individual level
Clonal SO
Types
raised from selected clones
Outstanding genotype will appear many times
higher genetic gain
Seed yield vary year by year, with a good year followed by a poor year
Seed Orchard
SO is an area where superior genotypes are estd. & managed intensively for seed prod
Causes of reduction of seed production
Selfing (pollen & egg from same plant may result in reduced seed yield
environmental problems
disease/ pest/ animal attack
Contamination of pollen from inferior trees
Problems of mgmt in SOs
Monoecious species : selfing via wind pollination
Dioecious species : determination of sex not known until flowering
Flower induction is done by 2 methods :
1) Imposing stress : small periods of water stress or nutritional stress are given. to promote flowering
2) Hormones application : sprayed on flowering branches to promote flowering


To cross pollinate distantly related species & then tissue culture the embryo which would otherwise normally die
Production of clones
To conserve rare species
Production of biochemicals
Plant Tissue Culture
6
Cultivation of plant organs, tissues or cells in test tubes in an artificial media
Micropropagation of plants : rapidly multiplying stock plant material to produce a large no. of progeny plants
Biotechnology
Controlled use of biological agents such as microorganisms or their cellular components for beneficial use
Genetic Engineering
3
Recombination of DNA molecules of an organism by joining DNA fragments using special enzyme systems
basically adding new DNA fragments to an organism
Development of insect resistance bt. cotton
development of disease resistance, herbicide resistance, adverse environment resistance

Provenance trials

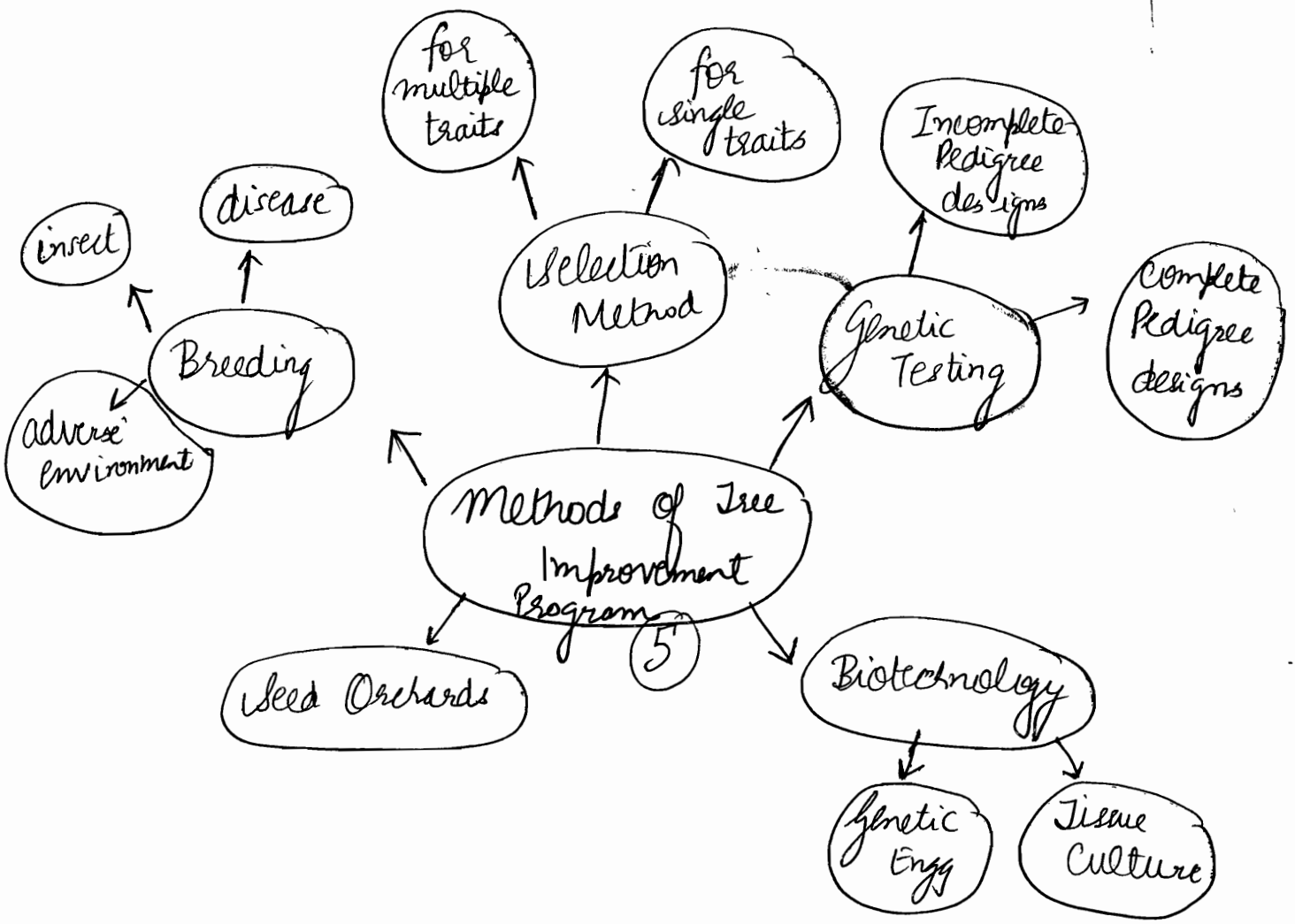
Provenance trials are special type of plantation experiments that help to understand how trees are adapted to different environmental conditions through genetic adaptation.

Provenance means "origin" and refers to a population of trees that come from a particular location.

To establish a provenance trial series, seeds are collected throughout an area of interest (district or state or country) Then seedlings are grown from all collection locations seeds in a systematic pattern.

Sources that grow best can be considered best adapted to the planting site conditions, and these are the sources that should be used for reforestation of areas that are similar to test environment.

- Expensive
- long term
- more the source, better the result of trials
- general limitations of tree improvement


Methods of Tree Improvement Program
5
Selection Method
for multiple traits
for single traits
Breeding
disease
insect
adverse environment
Genetic Testing
Incomplete Pedigree designs
Complete Pedigree designs
Seed Orchards
Biotechnology
Genetic Engg
Tissue Culture


Estimates general combining ability of any individual (GCA)
OPEN POLLINATED MATING
Seeds are collected from selected parent trees in natural stands
Each female parent is crossed with a mixture of pollen from a no. of selected male parents
POLY CROSS DESIGN
Incomplete Pedigree design
estimates only additive genetic variance & not non-additive genetic variance
3 difference
→Parent lose 2
→GCA, SCA
→ additive genetic variation
One parent is known for any progeny
Genetic Testing via Mating designs
Specially designed program for crossing of parent trees
estimates both additive & non-additive variance
1-1 crossing each parent is mated to only 1 other member of pollen
both parents are known to breeder
Complete Pedigree design
Single Pair Mating
Half dialled design
no reciprocal crosses
Full dialled design
each parent is crossed to all others in every combination
1st mating
Reciprocal mating
X:male Y:female
X:female Y:male
Estimate General Combining Ability (GCA) as well as Specific Combining Ability (SCA)

Genotype is the genetic make up of an organism, usually wrt. a specific character under consideration (i.e. specific allele make up of the individual)

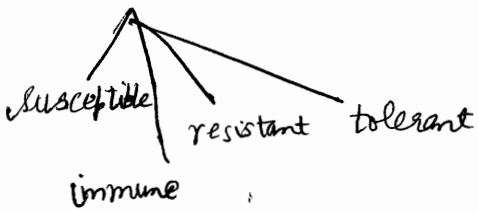
Phenotype is the organism's actual observed properties, usually wrt. a specific character under consideration

Locus is the position of the gene in the DNA.

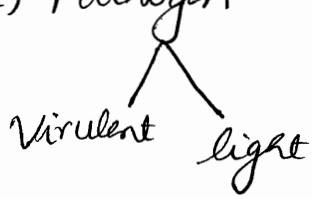
Recurrent selection : interbreeding of reselected plants.

Factors affecting disease development

1) Host



2) Pathogen



3) Environment
- Wet conditions or warm conditions increase pathogen growth.

Provenance selection is the best method for breeding for resistance to adverse environment.

The **width of PDZs** depends on mode of seed dispersal

Inbreeding is reproduction from mating of parents that are close related genetically.

It increases the chances of offsprings being affected by recessive traits i.e. decreased fitness.

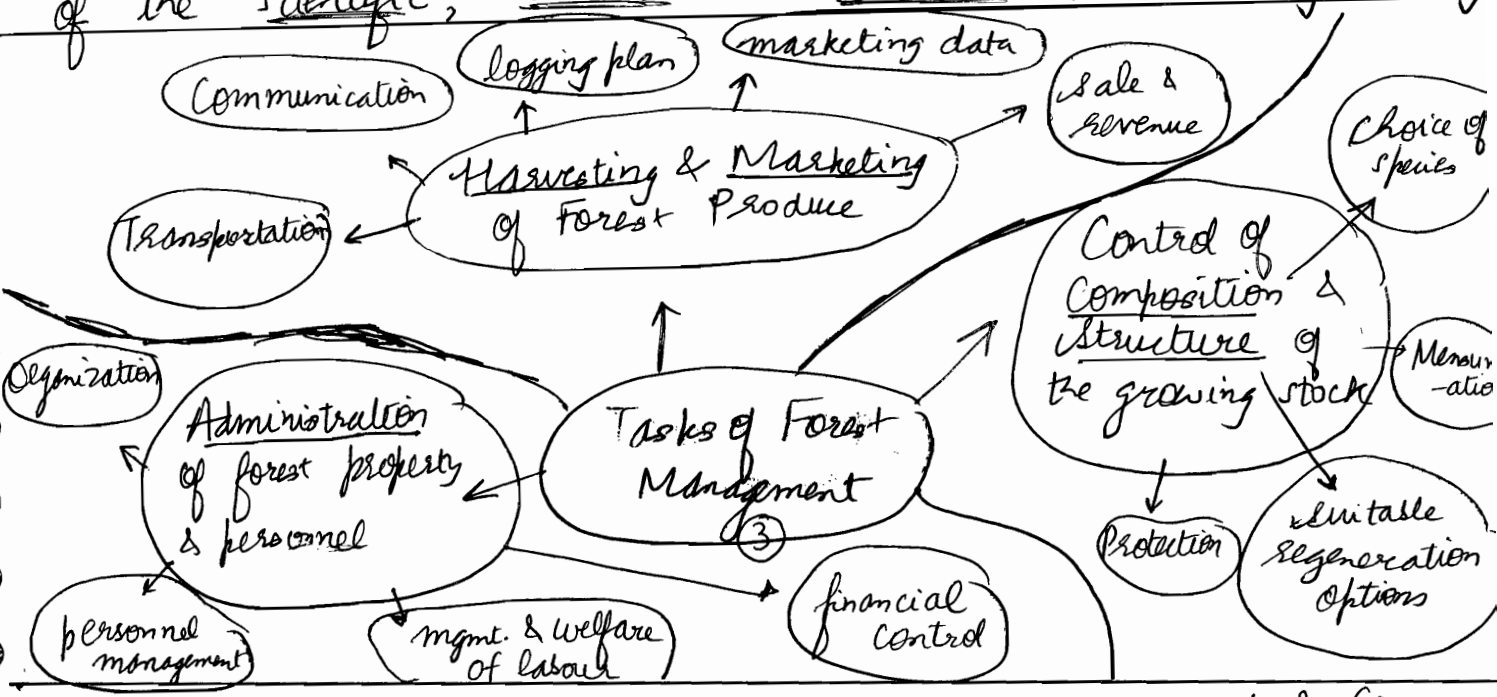
SOs are of 2 types < Production SOs (seedling or Clonal SO)
Breeding SOs (usually seedling SOs)

Silvicultural Operations of SOs : Weeding, Thinning, Fertilization (Fertilizers), Irrigation, Flower Induction.


PAPER

CHAPTER-6
FOREST MANAGEMENT

- **Forest Management** refers to the practical application of the scientific, technical & economic principles of forestry



- Major forest produce includes timber, small-wood & fire wood
- Minor forest produce includes all forest produce other than major forest produce, including fruit, leaves etc.
- By 42nd C.A., Forests & Wildlife was brought into Concurrent list.

⊙ Working Plans are the instruments of forest mgmt.

⊙ Working Circle is a forest area (forming a part or whole of a working plan area) organized with a particular object and under one silviculture system and one set of Working Plan Prescription.

⊙ Sustained Yield is the material that the forest can yield annually (or periodically) for perpetuity. It is the regular, continuous supply of the desired produce to the full capacity of the forest. It has two major aspects viz. Continuity of Yield & Continuity of Growth.

⊙ Growing stock is the sum (by volume) of all the trees growing in the forest.

Complete Series of Age Gradation

The simplest method of obtaining a sustained yield is to maintain a complete succession of equal areas of crops of all ages from one year old to the age of maturity (say n) and removing the n year old wood annually, and plant up the area again.

Such a series of trees or crops of all ages from seedling to the maturity age is known as Complete Series of Age Gradati

Progressive Yield

In a developing country like India, the demand for wood is progressively increasing. With economic development and rising living standards, demand is further expected to rise at a faster rate. Hence instead of sustained yield, progressive yield is the new paradigm.

Progressive Yield envisages raising the productivity of soil and of the crop, by silvicultural treatments, judicious tending, enrichment of crop composition by includi valuable forest species, and avoidance of loss of increment by effective protection.

Local labour is always fully employed

Contractors employed on felling, conversion and transport have an assured & steady income

Ensures steady income to state, facilitates budgeting & regulation of taxation

Arguments in favour of sustained Yield (6)

Wood-using industry has assured supply of raw material & local people sustained supplies of wood for their domestic use

Markets can be developed and their confidence gained with sustained supplies

---

Based on Conservative principles. Ignores the possibility of changes taking place in the use of forest products, due to change in technology & social value

Treats timber production as only a biological function and not a response to economic demand.

Ignores the relationship between forestry & other sections of national economy. Such a rigid & inflexible policy is not suitable for a dynamic & growing economy

Arguments against sustained Yield (7)

For sustained yield management, forest must conform to an ideal of normal forest. Maintaining such a forest, goes many-a-times against, financially sound decisions

Sustained Yield is an ideal. Wide fluctuations are quite common in yield

Regulated Annual Yields prevent an increase of felling & sales during time of high prices or vice versa

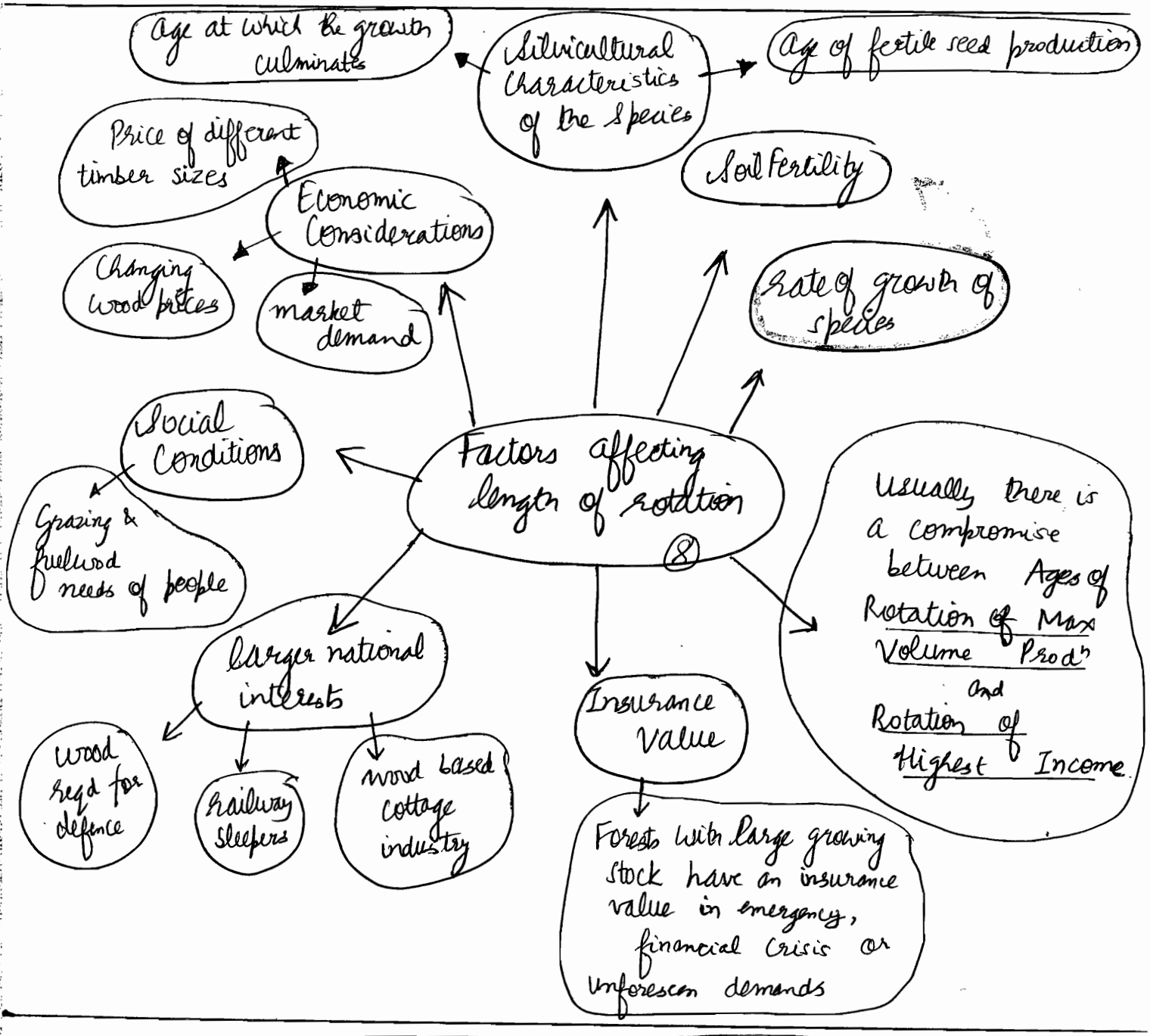
Does not foresee future trends of timber & forest product requirement

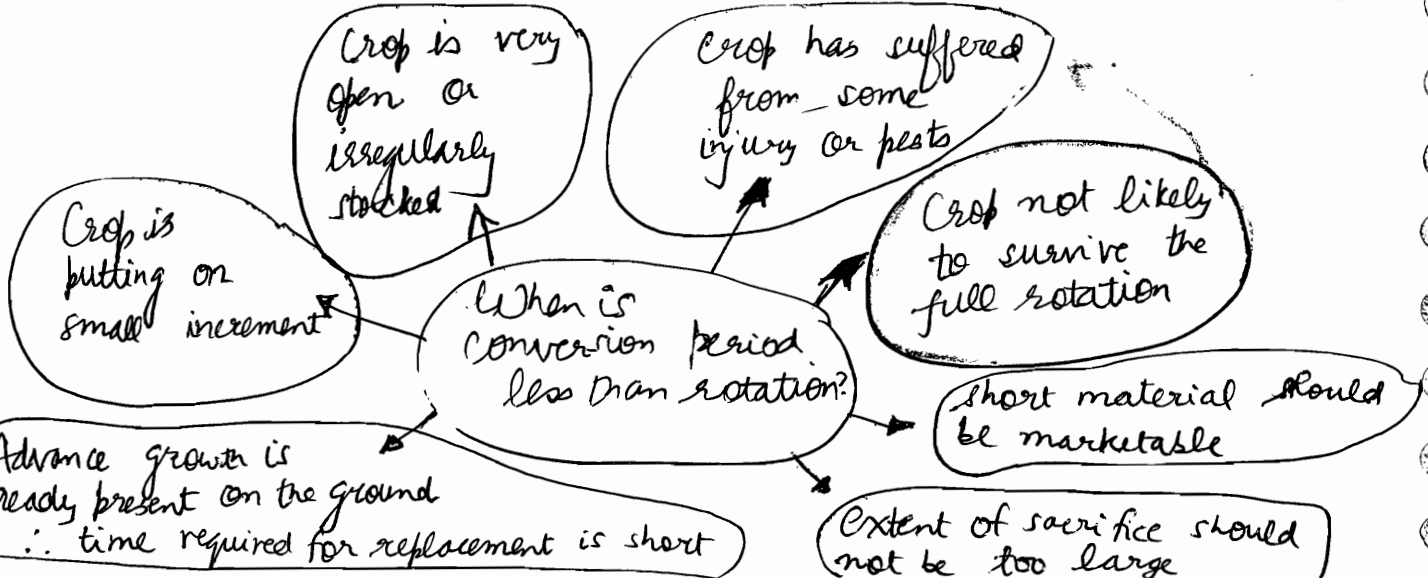
⊙ Rotation refers to the planned number of years between the formation (or regeneration) of a crop & its final felling.

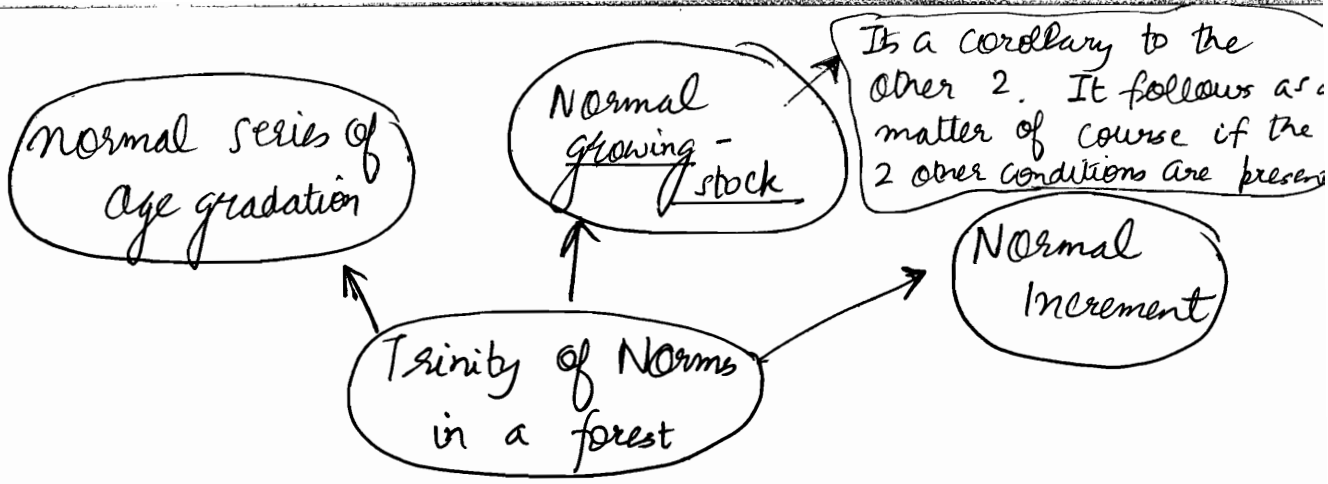
In the case of selection forest, avg. age at which a tree is considered mature ... for felling, is called rotation period.

⊙ The term rotation is correctly applicable only to even-aged trees, i.e. in regular stands. In irregular stands, exploitable size is the correct criteria instead of age.

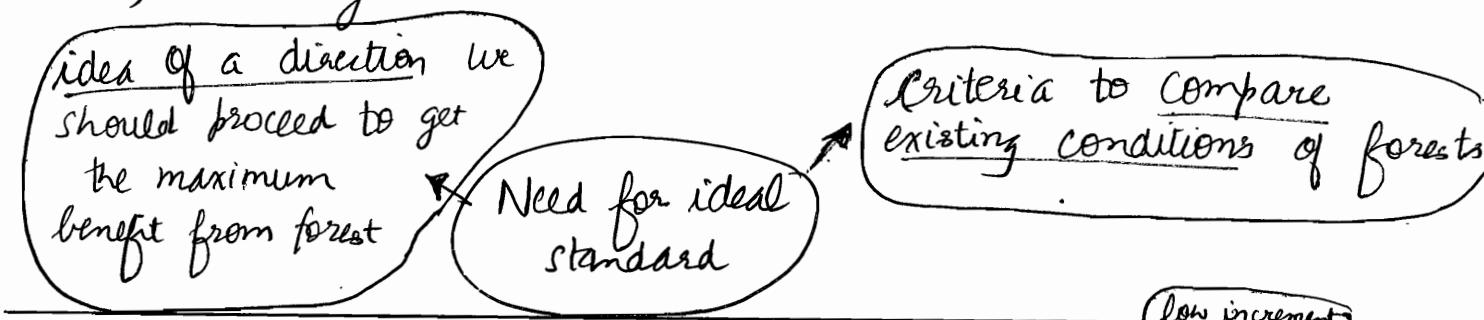
Soil Expectation Value (S_e) : the discounted present value of future returns from a property, minus the discounted present value of all future expenses necessary to earn these returns.

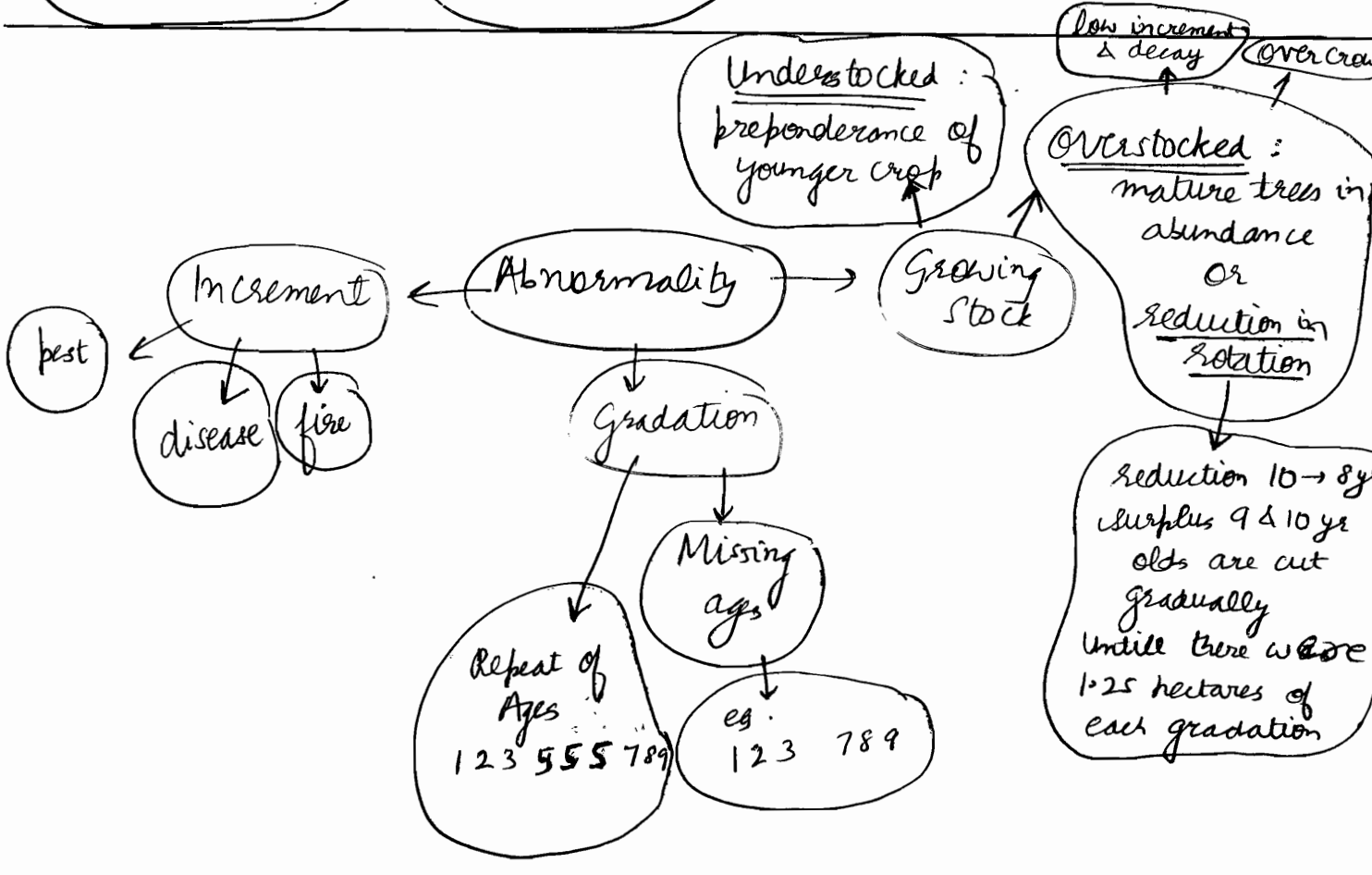






- **normal** does not mean usual/common in the context of forestry. It means an IDEAL condition.
- "as a matter of course" : naturally or automatically.
- Its not necessary that each gradation/class may be distinctly separated into separate crops.
  eg. all-aged selection Forest.





⊙ **Exploitable Size** : diameter / girth decided upon as the normal size for felling in order to fulfill the objects of management.

De Liocourt's Law (Balanced Forest)

In a fully stocked selection forest, number of trees in 1 diameter class to the next diameter class is in Geometric Progression

a, $\left(\frac{a}{q}\right)$, $\left(\frac{a}{q^2}\right)$, ...

a : number of trees in lowest diameter class

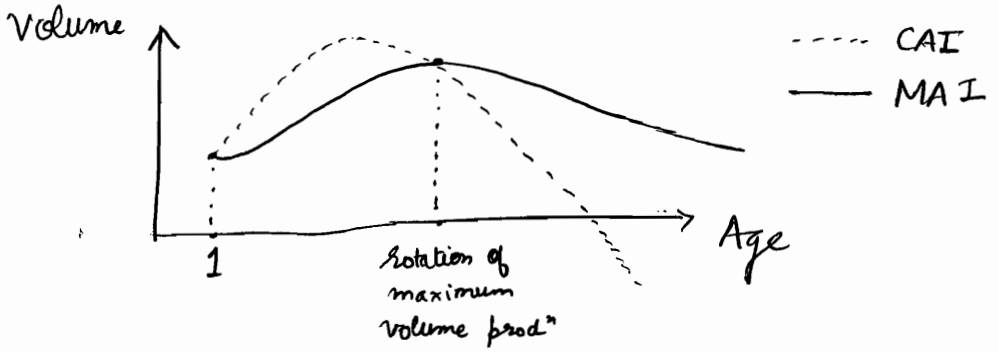
q : coefficient of reduction

- **Increment** is the increase in girth, diameter, basal area, height, volume of individual trees or crops during a given period.

  In forest management, increment refers usually to only volume increment & that too of crops rather than individual trees

- **Current Annual Increment** is the increase in growth that takes place in a particular year.

  Mean Annual Increment is the average annual increment upto a age i.e. total increment upto any specified age divided by that age.



- **Increment %** is the relation of the increment during a given period to a basic volume which may be taken as

  (i) mean of avg. volume for the period

  OR (ii) the volume at the beginning of the period

Pressler's Formula

$$\text{Increment Percent } (p) = \frac{\text{Increment}}{\text{Volume}} \times 100$$

- assumption : Current annual increment is equal for n years

$$= \frac{(V_f - V_i)}{n} \Big/ \frac{\left(\frac{V_f + V_i}{2}\right)}{n \text{ years}} \times 100$$

- Add intermediate felling volume to V_f.

$$= \left[\left(\frac{V_f - V_i}{V_f + V_i}\right) \times \left(\frac{200}{n}\right)\right]$$

→ In the year when MAI culminates, we have

$$MAI = CAI$$

$$\Rightarrow \frac{V_f + V_i}{2n} = \left(\frac{V_f - V_i}{n}\right)$$

$$\Rightarrow p = \left(\frac{V_f - V_i}{V_f + V_i}\right) \times \frac{200}{n} = \frac{n}{2n} \times \frac{200}{n} = \underline{\underline{\left(\frac{100}{n}\right)}}$$

Applicable when n is not too large.

Wschneider's Formula

Using Pressler's Borer, we can find out the no. of rings per cm.

let D (cm) be d.b.h. at present &

n be no. of ring in last cm

n years → 1 cm

⇒ 1 year → $\left(\frac{1}{n}\right)$ cm growth

⇒ $\left(\frac{2}{n}\right)$ cm growth in diameter

$$\Rightarrow D_{\text{last year}} = D - \left(\frac{2}{n}\right), \quad D_{\text{next year}} = D + \left(\frac{2}{n}\right)$$

$$p = \frac{\pi r_f^2 h f - \pi r_i^2 h f}{\pi r_i^2 h f}$$

$$= \frac{D^2 - \left(D - \frac{2}{n}\right)^2}{D^2} \times 100 \quad \text{or} \quad \frac{\left(D + \frac{2}{n}\right)^2 - D^2}{D^2} \times 100$$

1 year

Taking avg. we get

$$\boxed{p = \frac{400}{nD}}$$

Simple formula that can be used any time without knowledge of initial diameter.

Compound Interest Formula

$$D = d\left(1 + \frac{p}{100}\right)^n \Rightarrow \boxed{p = 100\left[\sqrt[n]{\frac{D}{d}} - 1\right]}$$

Some fast growing species include (>10 m^3/ha/annum

- Eucalyptus Hyb
- Casuarina Equisetifolia ✓
- Shorea Robusta ✓
- Tectona Grandis
- Populus spp.
- Tropical Pine
- Bamboo spp.

Determination of Increment

In Regular Forests: By Yield Table

Per Tree Method

$= \sum_i n_i C_i v_i$ (Total increment)

n: no. of trees in a dia class

v: volume per tree in a dia class

C: CAI per tree in a dia. class

Usually available for pure, even-aged, normally stocked & thinned to ordinary 'C' grade stands

By Increment %

Pressler

Schneider

Compound Interest

In Irregular Forests → Successive Enumeration

Andre's Formula

n_i: no. of trees in different diameter class

x: age corresponding to dia. over which enumeration is done (usually 20 cm)

$$Age_{mean} = \frac{n_1(p-x) + n_2(q-x) + \dots}{n_1 + n_2 + n_3}$$

p, q, r: true age of dia. classes

$$\Rightarrow MAI = \frac{\text{Growing Stock}}{Age_{mean}}$$

Biolley's Method

V_i, V_f

T : material removed during period (thinning)

R: recruitment (growing stock that has passed minimum enumeration limit : 20 cm)

n: Period between enumeration

$$MAI_{\text{during the period}} = \frac{(V_f - V_i) + (T - R)}{n}$$

$$= \left[\frac{(V_f + T) - (V_i + R)}{n}\right]$$

Use of statistical methods ← By Partial or Sample Enumeration

By Total or Complete Enumeration

Practiced only in valuable or small forests

Forest Measurement

Determination of Actual Growing Stock

Aerial Photography

In each age area, annual increment = i

GS after felling ($= I$) $= \frac{Ir}{2} - \frac{I}{2}$

Assume linear increase with time: A, B, C, D be volumes at age n, $2n$, $3n$, $4n$

GS $= n\left(A+B+C+\frac{D}{2}\right) \pm \frac{D}{2}$ before & after felling

GS $= \frac{Ir}{2}$

GS $= i + 2i + 3i + \dots ri$
$= \frac{r(r+1)}{2} i$
$= \frac{Ir}{2} + \frac{I}{2}$
(before felling)

from Final MAI

approx value

For F.S. $r \times i = I$
= total MAI of series
= Sum of All CAIs i.e. of all r age gradations

For each coupe, CAI = MAI $= i$

In clear felling system

from Yield Table

Read NGS

= Area under yield curve

GS $= n\left(A+B+C+\frac{D}{2}\right)$

Determination of Normal Growing Stock (NGS)

Yield curve

Shelterwood

Selection

Comparison

$GS_{MAI} > GS_{YT}$ in lower years while $GS_{MAI} < GS_{YT}$ in higher years

Felling's Constant C

$CI_r = \frac{GS}{SC}$

Volume m^3 per hectare

Age

(each on 1 hectare of land)

- An uneven-aged stand with maximum utilization of soil and air space should carry a larger volume of Growing stock per hectare as compared to an even aged crop on the same site.
- $\left(\begin{matrix}\text{Normal}\\ \text{Yield}\end{matrix}\right) = I \times R$ (in a rotation period)

  $= 2 * N\ GS$

  Therefore, the yield in a rotation period is twice the existing Growing stock. - the other half coming from increment put on by the G.S. during the rotation.

  Also half the increment is used in this way where other half goes to form the GS of next rotation.

- $\text{Utilization \%} = \left(\frac{\text{Yield}}{\text{Normal Growing Stock}}\right) \times 100\%$

  $= 200\%$ (for normal forest of complete age grad
- In order to have sustained yield, we should have equiproductive or reduced areas instead of equi-intensive areas.

  Density and Quality are two commonly used reducing factors.

Actual Area is modified to get a reduced Area equivalent to a fully stocked forest area with normal density 1.0.

< do examples on P-113, 114, 115 >

⊙ $\frac{\text{Reduced Area}}{\text{Actual Area}} = \frac{\text{MAI (Quality)}}{\text{MAI (Standard Quality)}} =$ Quality Reducing Factor

$\left(\frac{\text{density}}{\text{density of fully stocked stand}}\right)$ = Density Reducing Factor

→ Quality reducing factor, depending upon quality chosen, can be >1 or <1 or =1

while

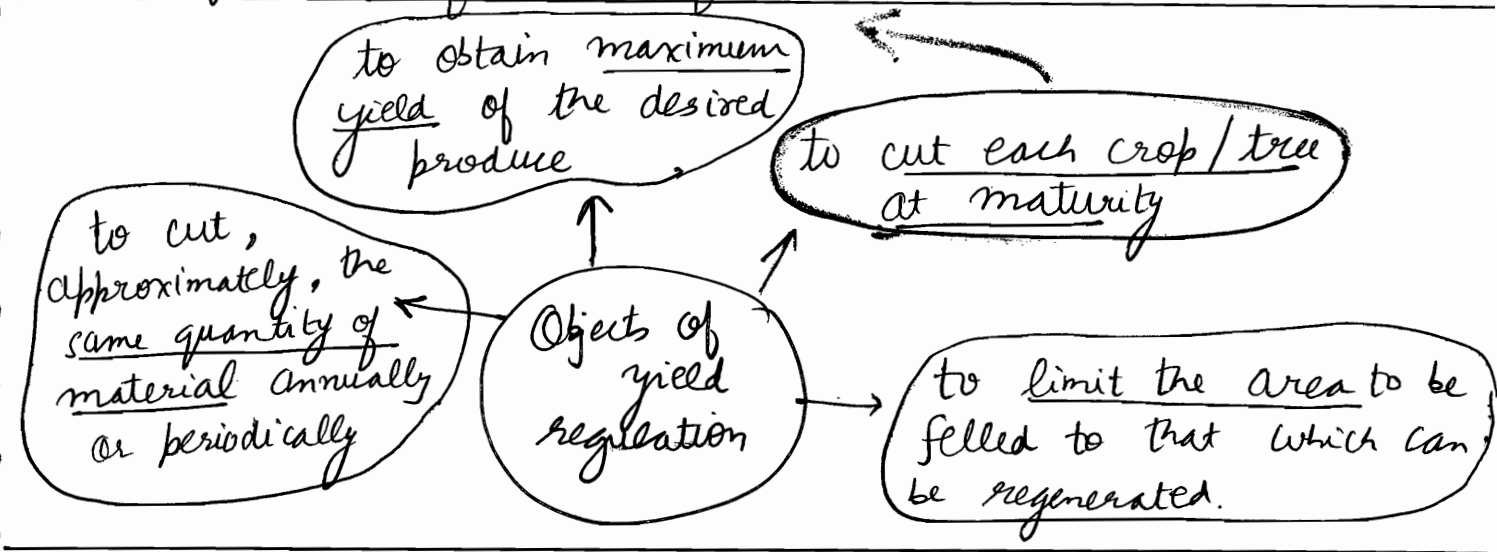
also density reducing factor ≠1/≤ 1 as we compare with normally stocked forest.

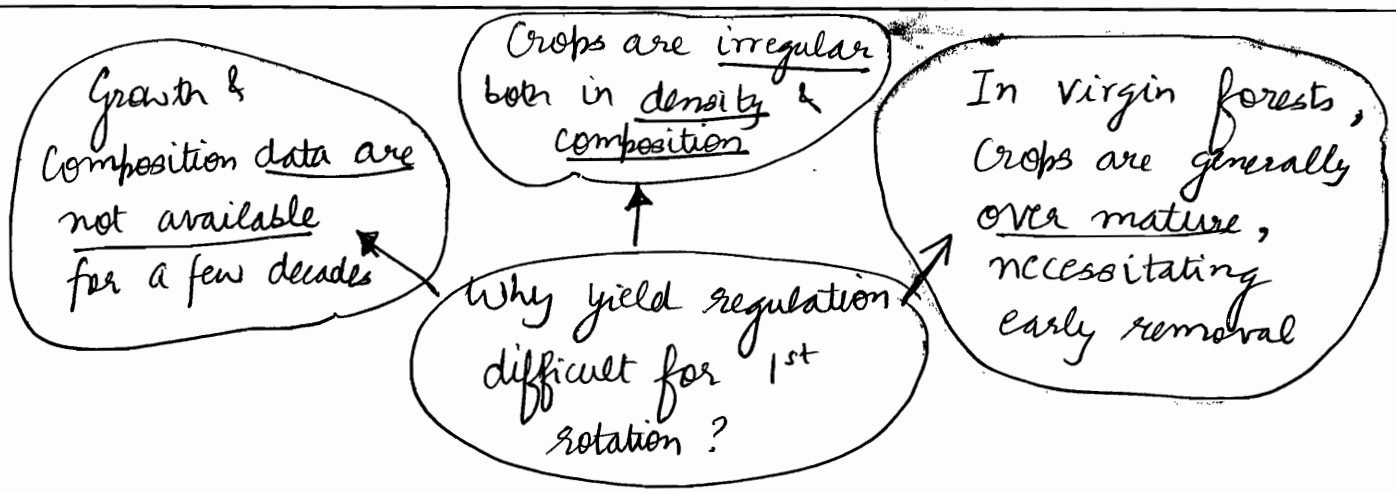
Yield Regulation

Yield Regulation refers to the determination of the yield in advance and the prescribed means to realize it!

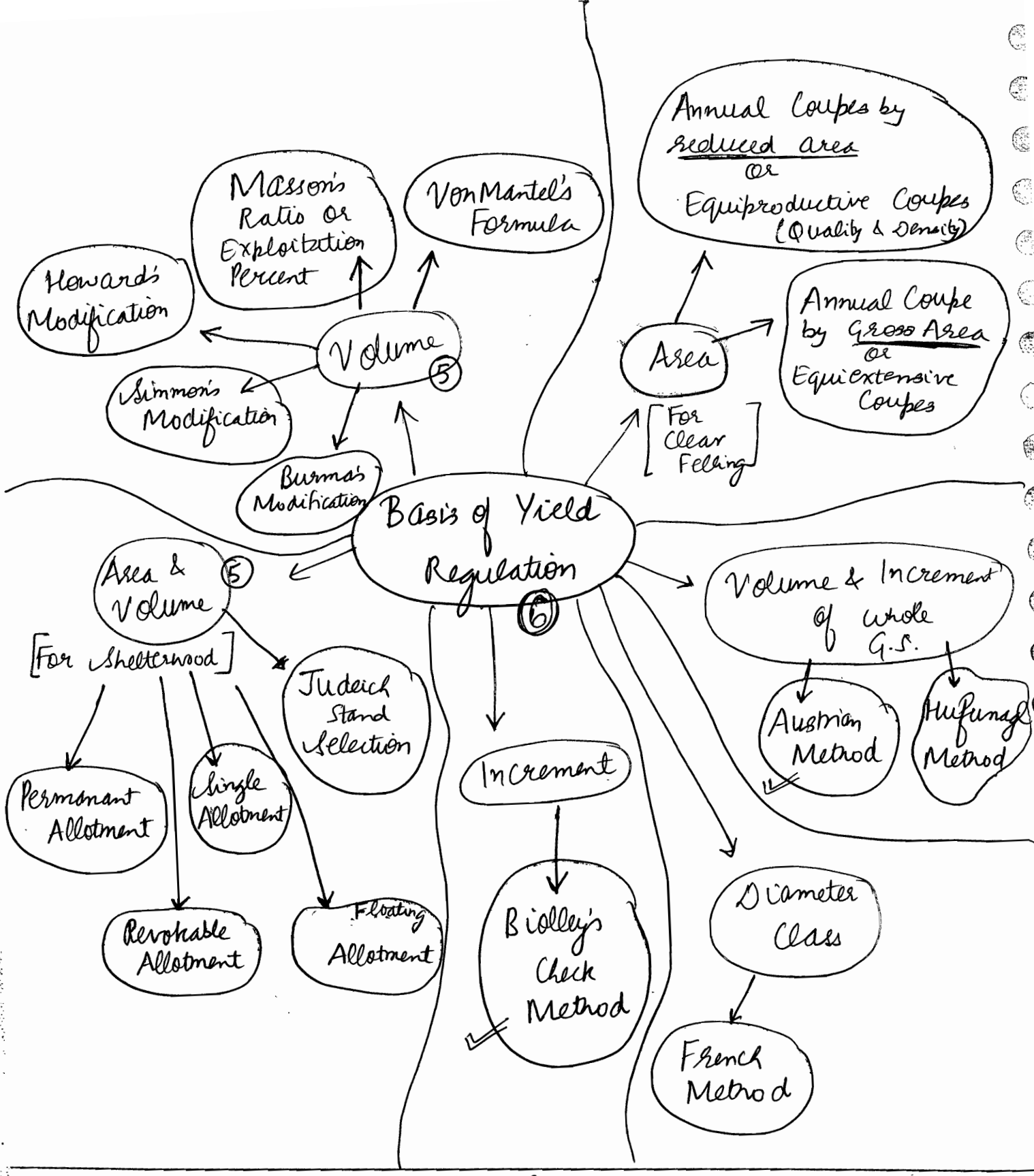
Therefore it involves two functions :

- Calculation/ determination of what the amount of yield should be
- prescribing the means of realizing it : how much, where & when to cut the calculated quantity from the forest.





- Yield is usually regulated for the period of the Working Plan as its neither possible nor desirable to fell exact quantity annually due to unforeseen contingencies.



Area Method

Adv : (1) Simplest Method in practice
(2) Establishment of age gradation is easier

Disadv : (1) It is very rigid in execution
(2) Felling does not consider crop condⁿ
(3) If rotation is changed, entire coupe needs to be redefined.
(4) Not possible to lay equiproductive coupes in forests.

Periodic Block Methods

In Periodic block method, Rotation is divided into a number of convenient periods. Area allotted to various periods are called Periodic Blocks (PBs). This method is less rigid. Final yield is obtained from matured periodic block over the period. Allotment of area to Periodic Blocks is done by 5 means.

Revokable Allotment

- Compartment damaged by pests, fire, insects
- Emphasis is given on PB I while rest of the PB's are allotted later based on crop condition
- Priorities to chose PB I for regeneration
- Compartments of mature crop with / without advance growth

Single Allotment

- Similar to revokable PB
- Unlike Revokable, here rest of the P.B.s are not allotted considering necessary revision later
- Area allotted to current regeneration block & compartments are allotted in this PB only
- Area & Period of this PB fixed

Permanent Allotment

- V_i : initial volume of P.B. I that needs to cut in time of P years
- i : Annual increment in PB I
- Number of P.B.s $= \left(\frac{R}{P}\right) = \left(\frac{\text{Rotation}}{\text{Regeneration Period}}\right)$
- Annual Yield $= V_i + \left(\frac{iP}{2}\right) / P$ (nice) $= \frac{V_i}{P} + \frac{i}{2}$
- Simple Method but Rigid in operation (Similar to Area Method)

Floating Periodic Blocks

- Similar to single allotment. But area & Period of the PB-I are not fixed in advance
- But $\frac{\text{Regeneration Period}}{\text{Rotation}} = \frac{\text{Floating PB}}{\text{Felling Series}}$ is valid
- Adv. Felling is done according to silvicultural characteristics of crops
- Disadv. Applicable only for normal forest

Judeich Stand Selection

- Short period of 10 years for yield regulation
- Treats every part of the forest according to its own financial merits
- Forest divided into a no. of compartments, each with suitable rotation & regeneration period
- difficult to execute but financially most profitable

GS or Volume Based Yield Regulation

Formula of Glorious Simplicity

Best applicable to regular even aged forests normal

Useful as Preliminary step in yield regulation

Adv

Easy to apply : requires GS & rotation only

Regulates yield according to GS eg overstocked will be heavily felled

Disadv.

does not take care of composition of G.S.

Enumeration of GS is not practicle always before yield calculation

Assumption of equal increment of all age gradations is wrong

Given only final yield & not intermediate yields obtained by thinning

Von Mantel Formula

We know $NGS = \frac{I \times R}{2}$

$\Rightarrow$ Normal Yield $= I = \frac{2\,NGS}{R}$

here, for Normal Forest $I = i \times R$

= Volume of oldest age-gradation

= total annual increment of FS

According to Von Mantel,

$\frac{\text{Yield}}{\text{G.S.}} = \frac{\text{Normal Yield}}{\text{Normal G.S.}}$

$\Rightarrow$ Yield $= \frac{2VGS}{R}$

Volume of GS measured upto $\frac{R}{3}$ years

$Y = \frac{9V}{4R}$

Burma's Modification

Masson's Formula

Put GS = 100

$\Rightarrow Y = \left(\frac{200}{R}\right) = \left(\frac{2}{R}\right)\%$

Called EXPLOITATION PERCENT OR MASSON'S RATIO

Assumed that girth is directly proportional to age of tree

Howard's Modification

Volume at wood at half rotation $= \frac{3}{4}$ G.S.

Volume

$R/2$

Enumeration till half rotation equivalent girth (not below that)

i.e. $x = (r/2)$

$\Rightarrow Y = \left(\frac{8V}{3R}\right)$

Gradations of Even aged stands make a normal forest which is overall uneven-aged

Simmon's Modification

$\frac{r}{n} = x$

$\frac{R}{n}$ $\quad R - \frac{R}{n}$

$\frac{V}{GS} = \frac{1}{2}\left(R - \frac{R}{n}\right)\left(I + \frac{I}{n}\right)$

$\frac{1}{2} R \times I$

$= \frac{(n^2-1)}{n^2}$

$\Rightarrow GS = \frac{V n^2}{n^2-1}$

$Y = \left(\frac{2RV}{R^2 - x^2}\right)$

V is volume of Fractional enumeration of GS down to some fixed dib-h which has equivalent age = x

$\Rightarrow Y = \frac{2Vn^2}{R(n^2-1)}$

Biolley's Check Method of Increment

$$\text{Increment} = \frac{(V_f + T) - (V_i + R)}{n}$$

In order to adjust for overstocked / understocked trees, we add another factor

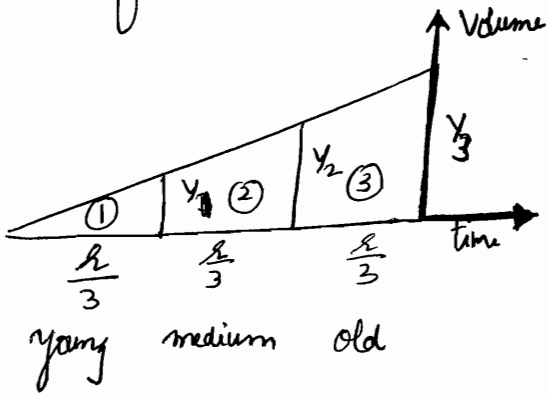
$$Y = \frac{(V_f + T) - (V_i + R)}{n} + \frac{(G_a - G_N)}{A}$$

$A \gg n$

G_a : actual G.S.
G_N : normal G.S.
A : Period of Adjustment (eg. 100 साल में धीरे धीरे overstock को adjust कर देंगे)

French Method : Diameter Basis

divides whole forest into 3 zones based on age (diameter classes)



$Y_3 : Y_2 : Y_1 = 3 : 2 : 1$

$\Rightarrow \boxed{V_1 : V_2 : V_3 = 1 : 3 : 5}$

Old Age class is removed in $\left(\frac{1}{3}\right)$rd of rotation

$$\Rightarrow \text{Yield in } \left(\frac{R}{3}\right) \text{ years} = V_0 + \frac{V_0 \times t_1 \times \frac{R}{3}}{2}$$

V_0 : volume of old age class
t_1 : increment per unit volume per annum

$$\Rightarrow \boxed{\text{Annual Yield} = \frac{V_0}{(R/3)} + \frac{V_0 t_1}{2}}$$

Austrian Method

Based on increment & G.S.

increment ↙ growing stock ↙

$$\text{Annual Yield} = Y = I + \left(\frac{V_a - V_n}{A}\right)$$

I : Increment in Normal Forest
V_a : Actual GS
V_n : Normal GS
A : Period of Adjustment

This method helps to produce normal forest from abnormal conditions.

CHAPTER - 7
WORKING PLAN

Forest Working Plan is a written schemes of mgmt. aiming at continuity of policy & action controlling the treatment of a forest.

The long term of working involved in forestry and the inevitable changes in personnel necessary for its mgmt., make it imperative that mgmt. plan is in the form of a written document to ensure continuity of policy.

(7) Characteristics of a Good Working Plan

- Based on thorough knowledge of the tract to be dealt with
- Be simple & brief so that subordinate staff can follow the ~~instructions~~ clearly (prescriptions)
- Aimed at achieving realistic & not idealistic objectives
- Provide itself as a work of reference upon whom future plans can be built upon
- Avoid limiting the discretion of executive staff to an irrational degree
- Should accomodate the possibility of accidents like fire, drought
- Recognize practical difficulties in transportation / marketing & limitations of technical asilities of staff

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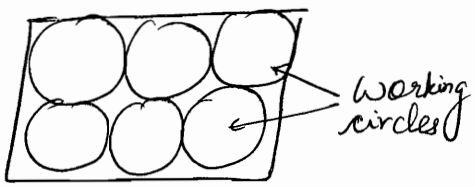
⊛ Forest division is the basic unit for working plan.



Administration units :

State

Forest Circle

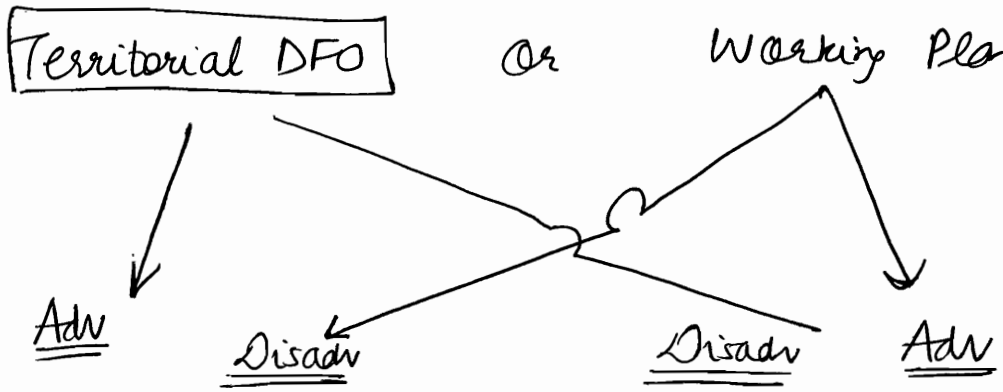
Forest Division

Forest division

Forest Range

Who chalks out Working Plan?

[Best approach is that the 2 officers work in cooperation]



① Territorial division has adequate staff for preparing a plan

② DFO and local staff has detailed knowledge of region

③ DFO correctly judges the performance of current WP

① WPO has enough time to go into every aspect of working plan formula while DFO is busy with regular, hectic schedule.

② Little chance of bias as WPO is new to the area Hence lesser errors in prescription.

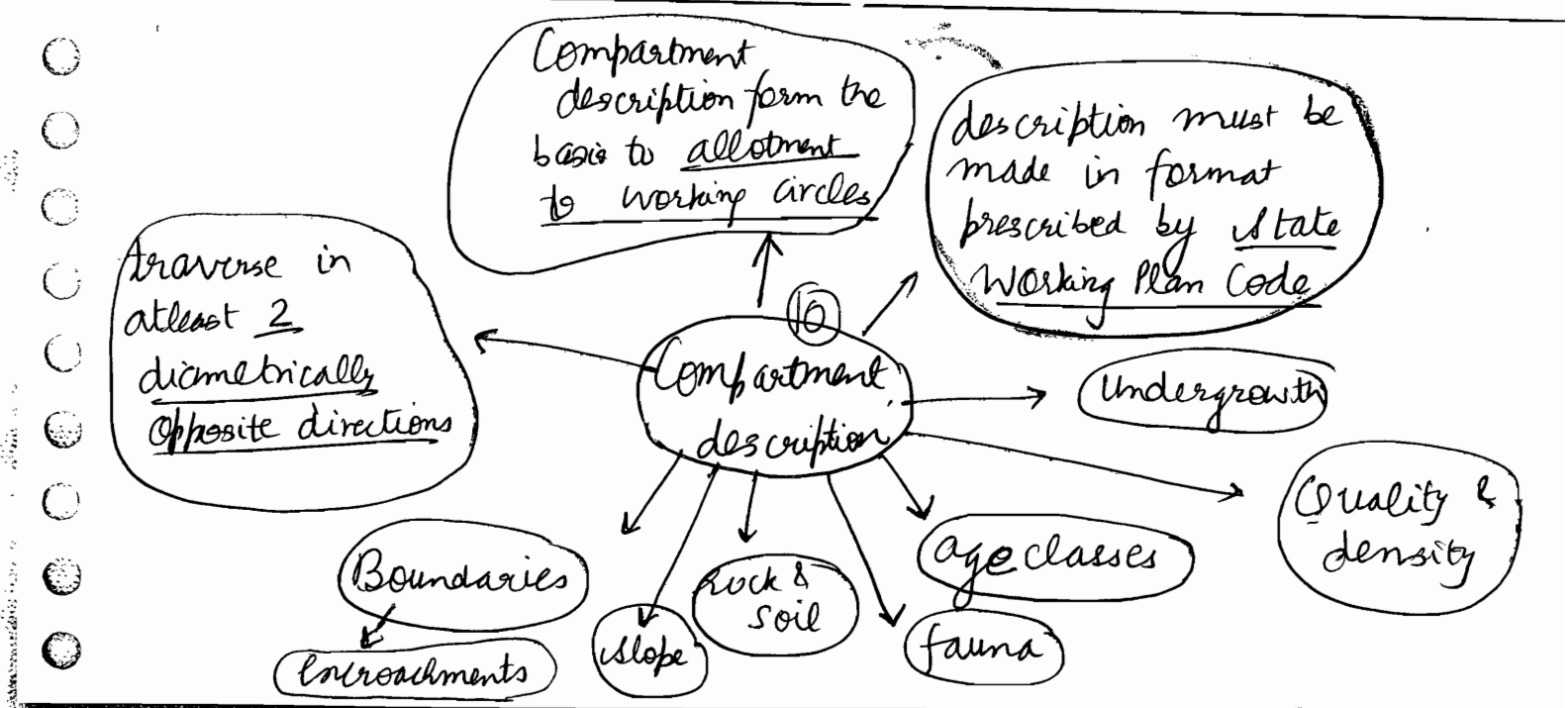
Factors affecting Period of Working Plan

- Process of making a W.P. requires time, labour & money which should not be expended too often ⇒ Unwise to make for very short time
- Usually around 10 - 15 years
- Poor seed years, drought, storms, fluctuations of market, size & species in demand etc. make it unwise to plan for long period
- Regeneration Period (≃ 20 years) & Rotation Period (≃ 80 years)
- Behaviour of nature eg. occurance of droughts, storms etc.
- Condition of G.S.
- Market Conditions
- Needs of the people

Take up the points from "mgmt topic Rotation Period"

(*) Besides, there are Annual Plans too.


Preparation of Working Plan
Field Work
done by WPO
Examination of territorial units
Working season
WPO should commence field work after rains
see demarcation of Blocks, Compartments & Sub Compar.
Compartment description
Stock Mapping
Collection of Statistical Data
keep in mind cost, time & accuracy
Forest Inventories
Use of Aerial Photography
② New sampling techniques like BITTERLICH METHOD OF POINT SAMPLING
③ Dendrometry i.e. measurement of trees w/o felling
④ satellite photography
2nd Preliminary Report
WPO makes it
1st Preliminary Report
made by Working Plan conservator
Part II : Future Mgmt. Prescriptions
What should be objects of mgmt.
Constitution of working circles
staff, labour
Part 1 : Summary of Facts
flora, fauna, produce
description of forest
Past mgmt.
Writing Up the Working Plan
WPO makes it
Regeneration Survey & Maps
Tree Enumerations
diameter class
species to be enumerated
given in 1st Preliminary report
Classification
fit/unfit
saleable/unsaleable


Compartment description
Compartment description form the basis to allotment to working circles
description must be made in format prescribed by State Working Plan Code
traverse in atleast 2 diametrically opposite directions
Undergrowth
Quality & density
age classes
fauna
rock & soil
slope
Boundaries
Encroachments

Stock Map is a (pictorial) graphic representation of the nature and composition of the forest. It gives a less detailed but more more easy to comprehend idea of the forest & can be prepared with much less trouble.

Following Stock Maps are usually prepared:

(1) Crop Composition

Pure Crop — More than 75% by one species
Main Crop — 50 – 75%
Mixed Crop — 25 – 50%
Miscellaneous Crop — < 25% by one species

(2) Land Use

Sal forest
Barren land
Mixed Forest
Cultivation Area

(3) Age Class distribution

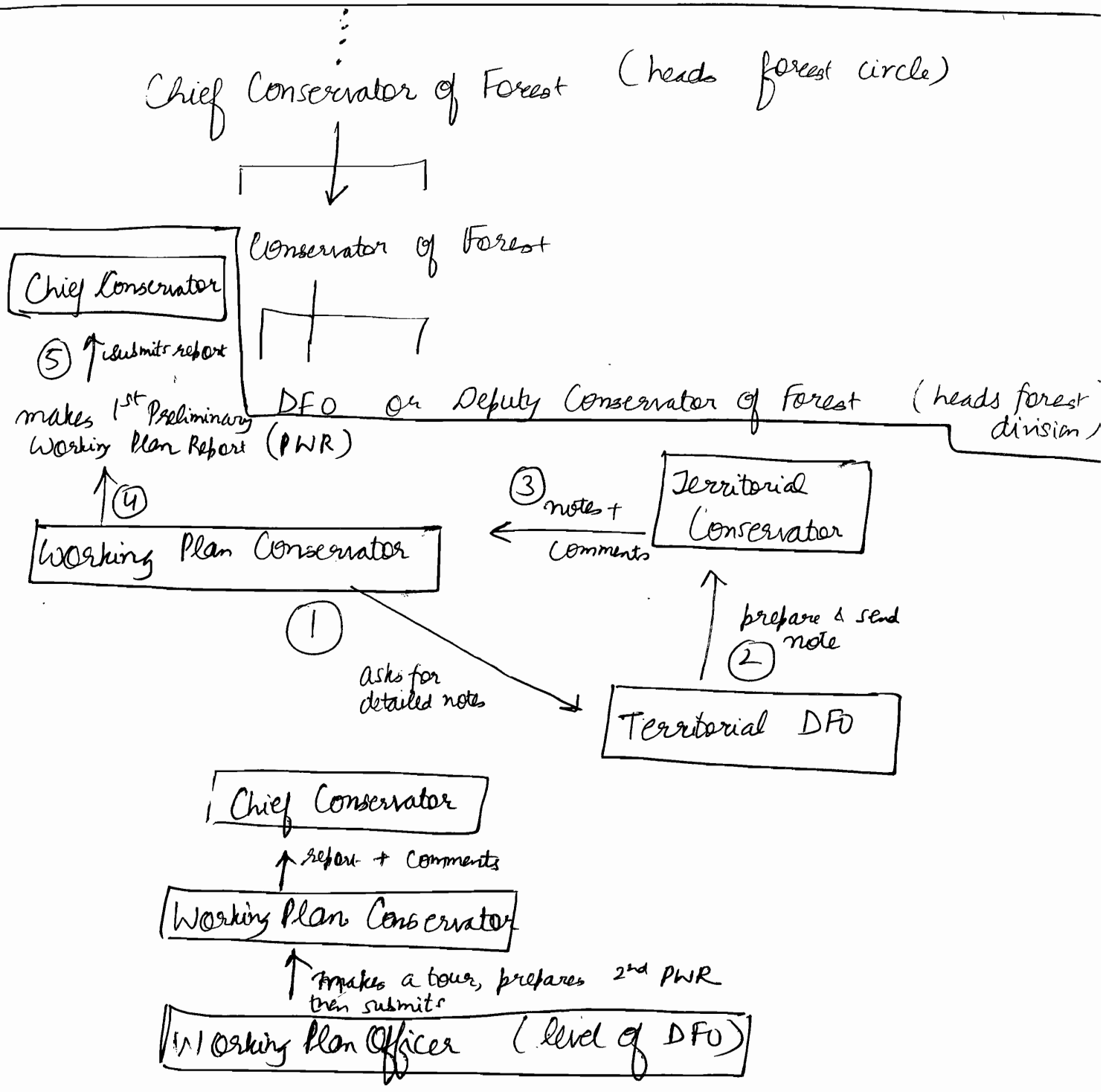
Seedling Crop
Pole Crop
Mature Forest
Over Mature Forest

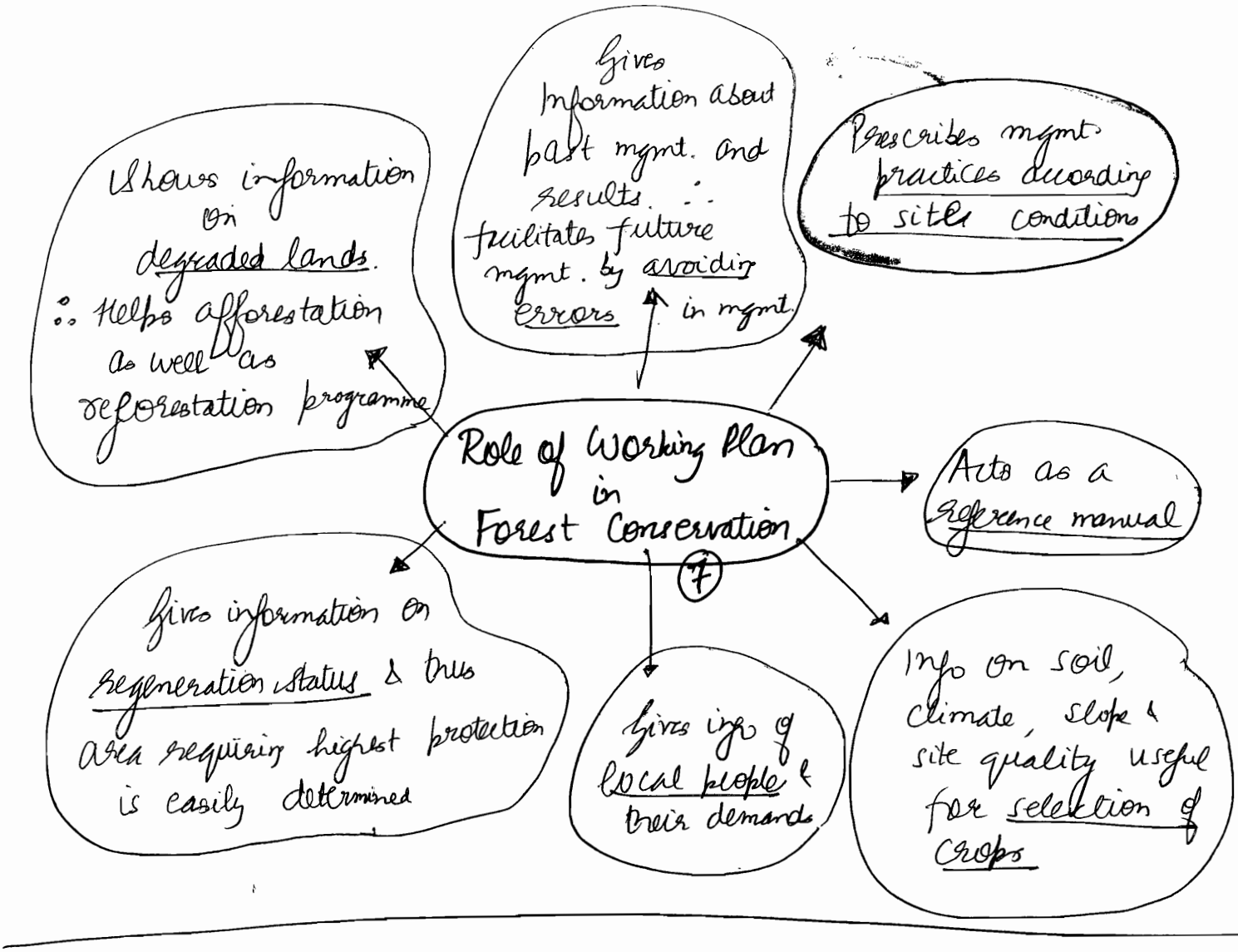
(4) Density

Closed Canopy	$\frac{1}{7}$ 0·6
Dense	0·4 – 0·6
Thin	0·2 – 0·4
Open	< 0·2
Sparse	

⊛ A working plan may be made –

1) Originally when no previous plan exists.
2) A little before expiry on the current working plan based on the performance of the current working plan.
3) In between the working plan due to heavy natural damage to entire division or many working circles in case of disasters.




Role of Working Plan in Forest Conservation
(7)
Shows information on degraded lands.
∴ Helps afforestation as well as reforestation programme
Gives information about past mgmt. and results. ∴ facilitates future mgmt. by avoiding errors in mgmt.
Prescribes mgmt. practices according to site conditions
Acts as a reference manual
Gives information on regeneration status & thus area requiring highest protection is easily determined
Gives info of local people & their demands
Info on soil, climate, slope & site quality useful for selection of crops

CHAPTER-8

FOREST MENSURATIO

★ inch (12) → feet (3) → yard (22) → chain (10) → furlong (8) → mile (1.6 km)

(30.48 cm)

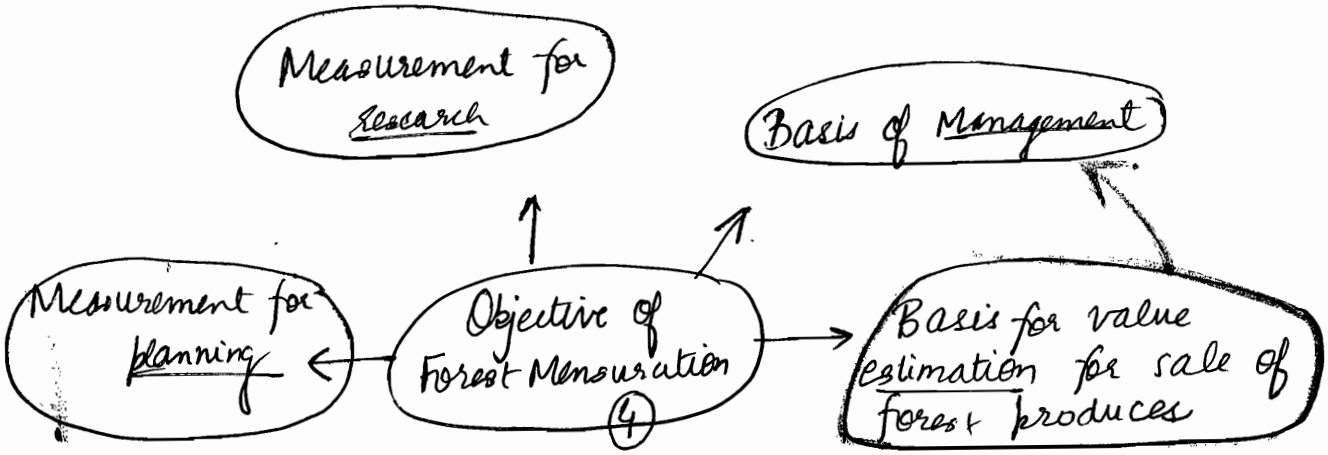
★ 10 square chain → 1 acre

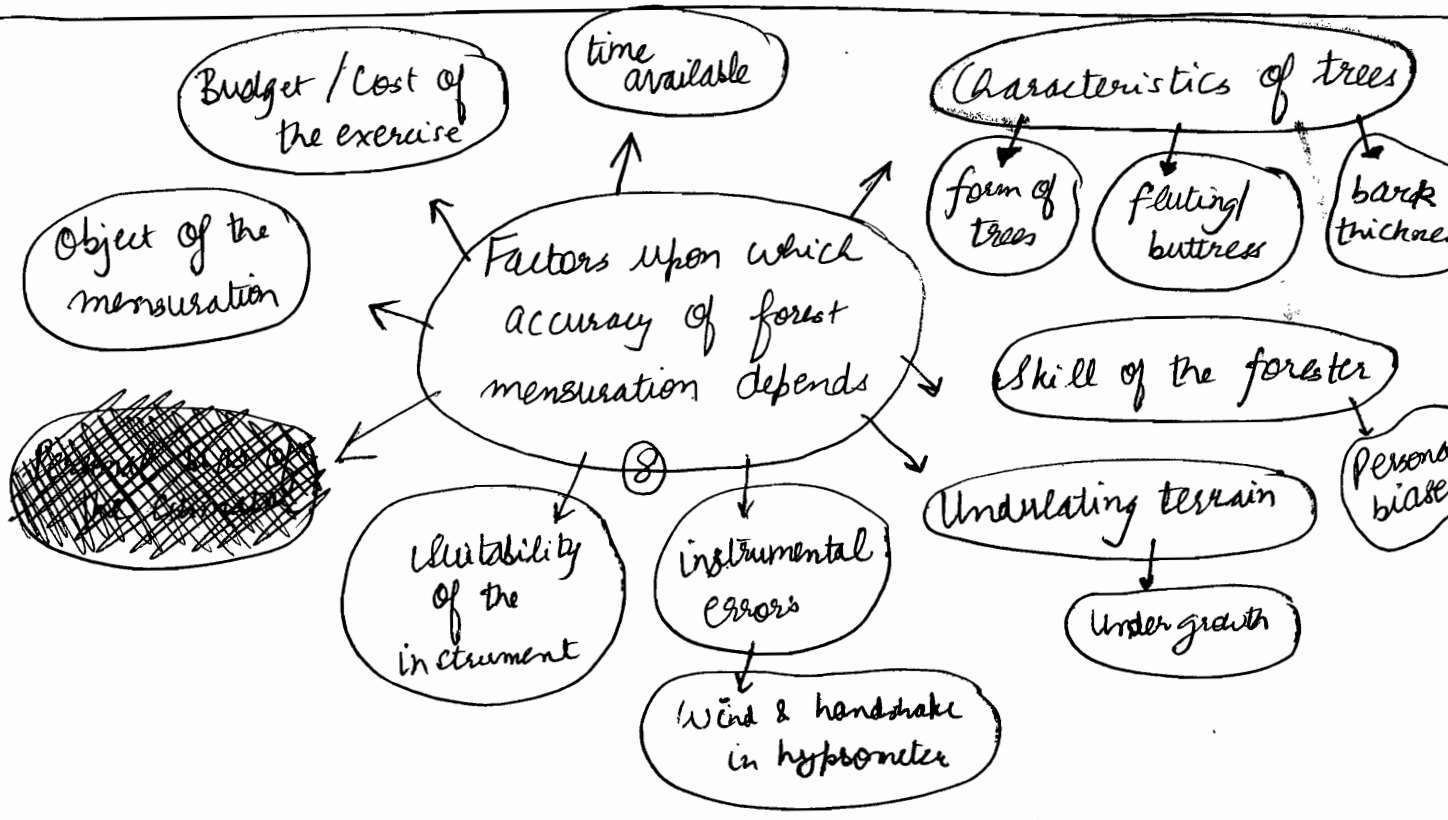
640 acre → 1 mile square

★ ounce (16) → pound (28) → quarter (4) → hundred weight (20) → ton (≈1016 kg)

(0.453 kg)

1 metric tonne = 1000





Diameter & girth

⊛ Measurement, usually, at Breast Height : 1·37m
(D·B·H) = 4 ft 6 inches
or
(G·B·H) = 4·5 ft

Reason for Breast Height (5)
- More useful that measurement at stump height ∵ stumps are never cut at a uniform height
- Convenient Height that avoid fatigue
- Uniform point of measurement that standardizes the data
- Abnormalities like root swell, buttress, etc. near base
- base usually covered with grasses, shrubs and thorns

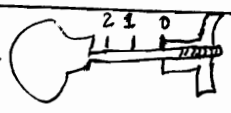
⊛ Unless specificied, by default, measurements are considered over bark ie. DBH (o.b.) and GBH (o.b)

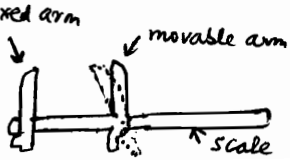
Area Measurement by 2 girth & their errors (or radius)

- ✓ $A - \Delta = \pi ab$
  - Area = $\pi \left(\frac{a+b}{2}\right)^2$ — Best Method, Minimum Error
  - error = $\frac{2}{32}k$
- Area = $\frac{g^2}{4\pi}$
  - error = $\frac{3}{32}k$
- ✓ $A - \Delta = \pi ab$
  - Area = $\pi \left(\frac{a^2+b^2}{2}\right)$ — Maximum Error
  - error = $\frac{4}{32}k$

Where $k = 4\pi (a-b)^2$
& ideal value of area $= \pi ab$

Instruments (4)
- Swedish Bark Gauge to measure bark thickness
- Tape (inch tape)
- Wooden Scale → Used to measure diameter of stumps or end of logs or sections or stump / stem analysis
- Calliper





Choice of instrument (3)

- accuracy required
- whether tree is standing or felled
- if felled, conditions in which logs are lying

Callipers

- Use
  - to make diameter of standing trees & logs
  - Girth = πd ⇒ Girth callipers are graduated to read the circumference
- Units
  - for sample plot or research purpose: cm and mm
  - for routine forest works: diameter classes painted in different colours
- disadv (4)
  - movable arm sticks when the scale is wet or dirty
  - taking 2 dia is cumbersome
  - difficult to locate major & minor axes
  - difficult to carry & handle
- adv (5)
  - diameter can be directly read
  - Point of arms touching the tree are always in sight ⇒ less error
  - Arms are firmly pressed against bole ⇒ crushing of loose bark hence accurate measurement
  - more accurate than tape
  - Errors are both positive & negative ⇒ usually neutralize to give more accurate result
- precaution (6)
  - movable arm must not be forced on the tree, causing damage to the arm
  - Reading should be taken before the caliper is removed
  - if more of elliptical than circular, then 2 diameters should be measured corresponding to major & minor axes of ellipse
    - Average dia. should be taken as the dia. ⇒ It involves minimum error in calculation of basal area
  - Caliper should be place at rt. angle to tree's axis
    - error = $D\sec\theta - D$
  - movable arm should be ⊥ to tree axis
    - $\Delta x = \frac{D}{2}\tan\theta$
  - scale arm should touch the tree stem
    - $\Delta x = L\tan\theta$

- accurate
- inconsistent

- Consistent
- less accurate

reinforced with metal wires to prevent expansion

ends are plated with some metal to prevent bearing off

to measure girth of trees & logs

provided with hook at the end to stick in the bark

Special features

Use

Some tapes are graduated to read diameter as $D = G/\pi$

different stretch due to different Tension affect measurement

frequently not applied in plane perpendicular to the tree

Observer does not see the full circumference of tree which may affect measurement accuracy

slower to use in area of dense shrub growth

rough bark exaggerates the diameter

Disadvantages (5)

Tape

should not be old to avoid expansion errors

Precautions (6)

if end is broken, then measurement taken from next cm.

must be flat against the tree & not twisted

tape must lie in plane ⊥ to axis of the tree

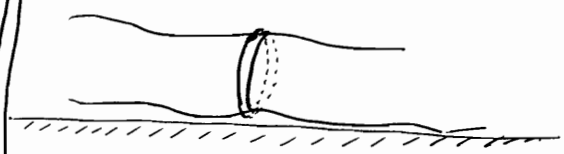
Care should be taken that no climber is included in the wrap of tape

should not be rolled when wet, dirty or twisted

Convenient to carry

Requires one measurement

in case of logs lying on ground tape is more convenient to use as



it difficult to take 2 dia measurements

Advantages (6)

Unlike callipers it does not give different readings for the same tree

measures "size" of the tree better than calliper as it touches the whole of tree

Errors are Always positive & systematic ⇒ adjustment is easier

Diameter classes

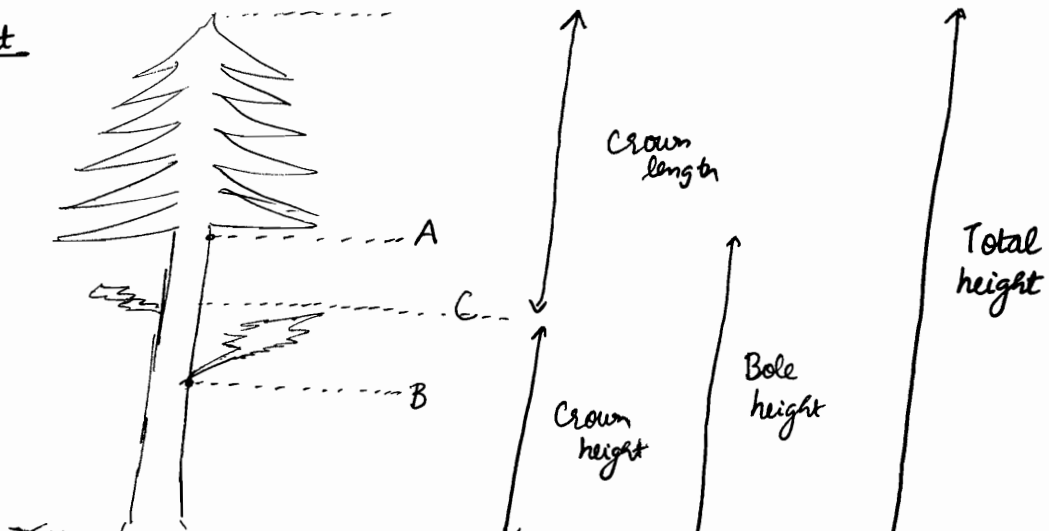
2 cm class interval : <30 cm d.b.h

5 cm class interval : 30-50 cm dbh

10 cm class interval : >50 cm dbh

⊙ **Standard colours** are used for different Class for use of illiterate workers.

Height



A : lowest green branches forming green crown all round (called Crown Point

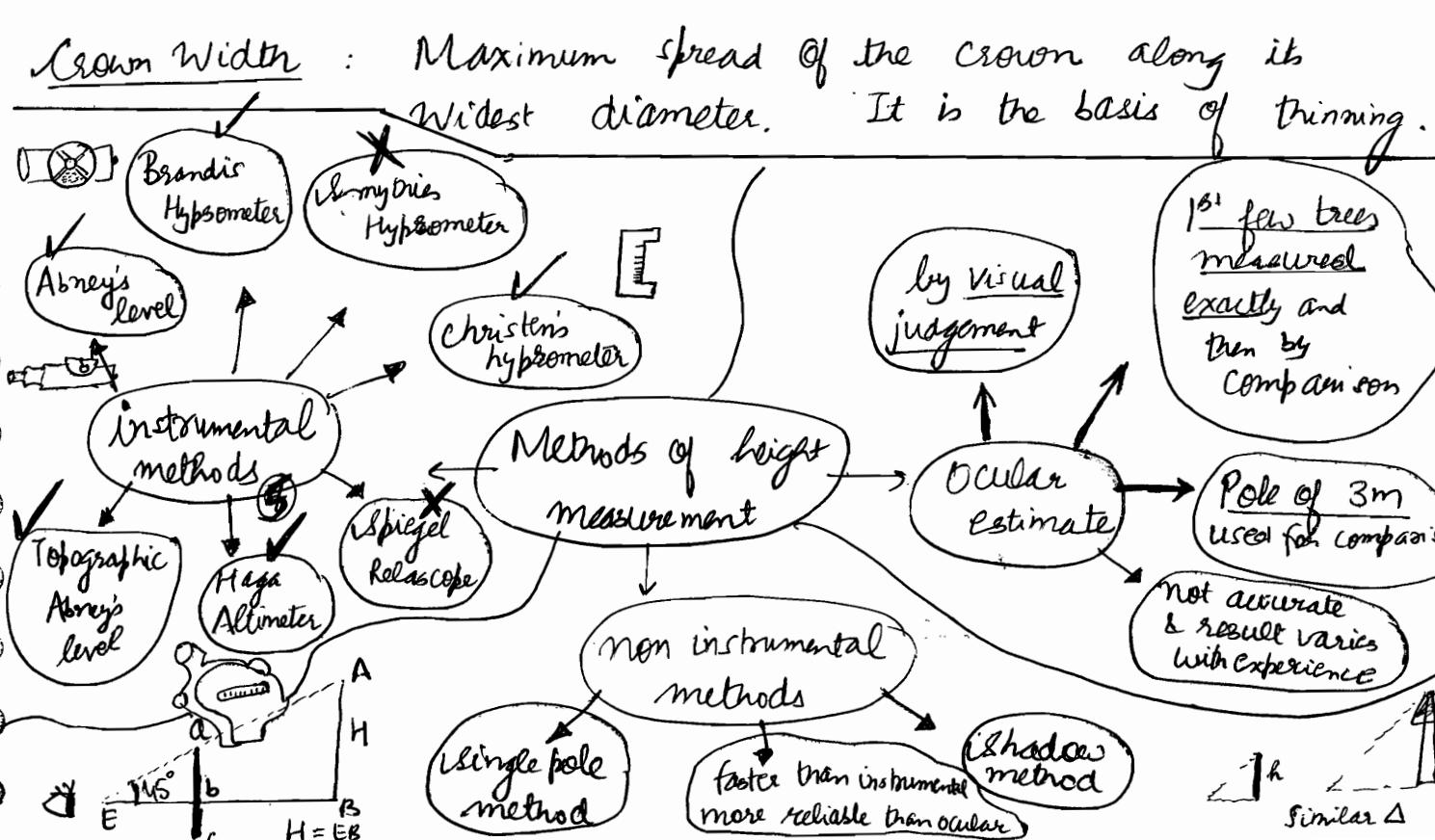
B : lowest green branch on bole

C : point half way between <A> and <B>

Commercial Bole height : height of the bole that is usually fit for utilization as timber

Standard Timber Bole Height : height from ground upto point where avg. diameter (over bark) is 20 cm

Crown Width : Maximum spread of the crown along its widest diameter. It is the basis of thinning.



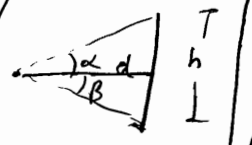
Principles of Height Measurement

Principle of similar triangles

- Shadow method
- Single pole method
- Christen Hypsometer
- Smy tries hypsometer

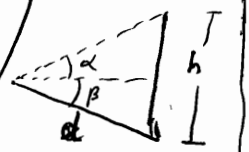
Trigonometric Principles

- Telescope
- Haga altimeter
- Abney's level
- Brandis hypsometer
- Tangent Method



$H = d \tan\alpha + d \tan\beta$

- Sine Method



$h = \frac{d \sin(\alpha+\beta)}{\cos\alpha}$

Christen's Hypsometer

description (4)

- Upper hole to suspend instrument lower hole to hang a weight
- A staff or known length used along
- graduations are wider apart at top & closer below
- 2 flages or projecting edges
- Staff is difficult to carry & placed

disadv. (5)

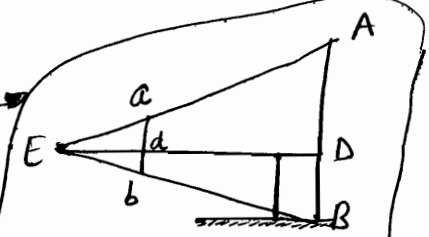
- fatigue by constantly holding out arm in reqd. position
- Not useful for large trees as close readings <30 m
- Shaking of arm & wind disturbance
- requires skill to hold top & bottom of tree within the hypsometer

adv (6)

- quicker to use
- distance between Observer & tree not reqd.
- height of tree can be read directly
- light & easy to transport

principle

- similarity of complete & lower triangles used

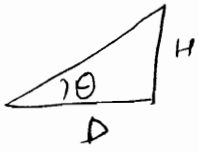


$AB = \frac{(BD * ab)}{bd}$

i.e. $AB \propto \left(\frac{1}{bd}\right)$

Hence graduations that way

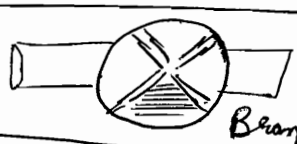
Haga Altimeter



$H = D \tan\theta$

$\frac{1}{H}\left(\frac{dH}{d\theta}\right) \times 100\% = \frac{D \sec^2\theta}{D \tan\theta} \times 100 = \left(\frac{200}{\sin 2\theta}\right)$

$\theta = 45°$ for minimum error

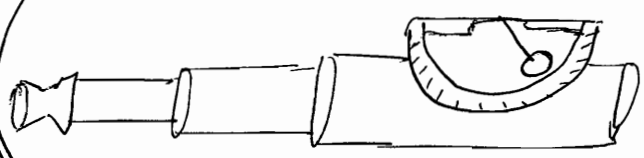


Brandis hypsometer

Abney's level

Description (4)

In Forestry, used for measuring tree heights, Contour surveying, alignment of roads

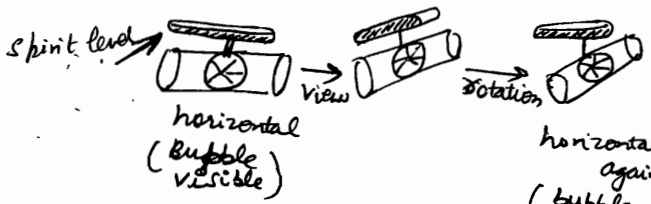


hollow tube with eyepiece on 1 side & short sighting tube on other end

Eyepiece has small horizontal wire and a mirror to see the spirit level's bubble

Spirit level fitted on the tube can be rotated by 1 wheel (big movement) & 1 screw (small movement)
Index Arm attached to spirit

As index arm is rotated (to make spirit level horizontal), index arm moves along graduated scale to read the angle of rotation



Advantage

- quick measurement for experienced forester
- accurate angle
- Small & light

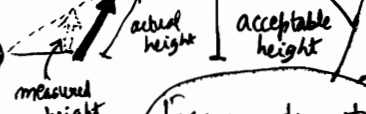
disadv.

- difficult to simultaneously view & move the wheel & screw
- prone to shaking of hand

Sources of Error in height measurement (5)

Error due to lean of trees

- Take measurement from a position st. lean is sideways & not towards or away from observer
- Measure the horizontal distance to the point vertically below the tip of the trees
- Take avg. of 2 heights: 1 leaning towards you & other leaning away



Instrumental Error

- Swinging of Christen hypsometer
- Brandis wheel swings so much with a rattling sound

Personal Error

- hand shaking in abneys level
- not getting tree correctly in b/w Christen hypsometer

Error due to measurement

- not possible to keep tape straight in bushes & shrubs

$H = D \tan\theta$

$\left(\frac{dH}{d\theta}\right) = D \sec^2\theta$

$\Rightarrow \%\ \text{error} = \frac{dH}{H} = \frac{200 d\theta}{\sin 2\theta}\ \%$

Error due to Observation

- lean of tree not properly observed
- difficult to see base of tree
- difficult to see top tip of broad leaved trees

POL

POMIL

α : horizontal to top top

β : horizontal to base of tree

θ : vertical to tree stem (absolute)

Measurement of height of leaning trees

lean away

$AB = EB \frac{\sin(\beta-\alpha)}{\cos(\alpha-\theta)}$

eye level above top & bottom

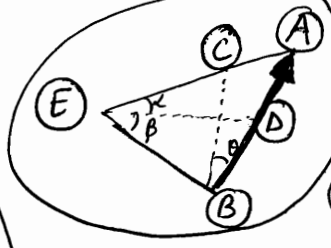
lean towards

$AB = EB \frac{\sin(\beta-\alpha)}{\cos(\alpha+\theta)}$

eye level between top & bottom

lean away

AB : tree
E : Eye
C : vertical
D : horizontal



$AB = EB \frac{\sin(\alpha+\beta)}{\cos(\alpha+\theta)}$

find $\angle BAE$ use sine theorem

Q5 ~~3rd~~ 4th sine rule

lean towards

$AB = EB \frac{\sin(\alpha+\beta)}{\cos(\alpha-\theta)}$

eye level below top & bottom

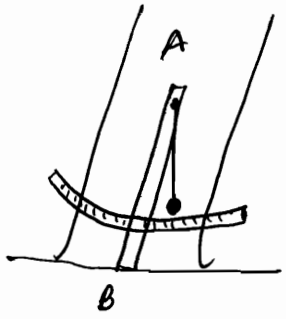
lean away

$AB = h = EB \frac{\sin(\alpha-\beta)}{\cos(\alpha+\theta)}$

lean towards

$AB = EB \frac{\sin(\alpha-\beta)}{\cos(\alpha-\theta)}$

⊙ **Plumb Bob** is used to measure lean of trees



Height Classes (Half of dia. classes)

⊙ 1 m class interval : < 15 m height

3 m class interval : 15 - 25 m height

5 m class interval : > 25 m height

Stem Form

- Metzger's Theory or Girder Theory
  1. → Tree stem ⇔ cantilever beam
  2. → Wind ⇔ Bending Force
  3. → Wind Pressure conveyed to lower parts in increasing measure.
  4. → To counter the danger of tree snapping at its base, growth material distributes to reinforce the base.
  5. → Isolated Tree ⇒ larger crown ⇒ high taper & high wind
  6. → Tree in dense Crops ⇒ cylindrical
  7. → Shear Stress $= \left(\frac{32\tau}{\pi d^3}\right)$ $\tau = F * l$

$\Rightarrow d^3 \propto l$

Hence cubic Parasoloid shape

X: Form Point
Wind Pressure estimated to act

Ⓐ Volume of cylinder = Basal Area * Height

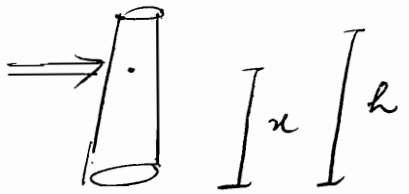
Form ratios

Form Factor ③
- Vol. of Tree / Vol. of cylinder
- by default Form Factor
- Artificial form factor
  - Volume of whole tree and basal area measured at breast height
- Absolute Form Factor
  - Basal Area measured at any convenient height & Volume of tree measured above that height
- Normal Form Factor
  - Volume of whole tree and Basal Area at height $\left(\frac{1}{n}\right)$ fraction of total height

Ⓑ Form Factor * Height of tree = Form Height

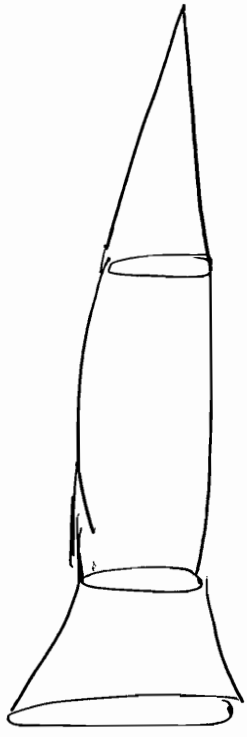
Form Quotient ②
- Mid-Diameter / D·B·H
  - Normal Form Quotient
- Absolute Form Quotient
  - For h = 2x
  - Normal Form Factor = 1 ⇒ discrepancy
  - Diameter at one-half of its height above the breast height / D·B·H.

⊙ Form point ratio = $\left(\frac{\text{Height of Form Point}}{\text{Total Height of Tree}}\right)$



$= \left(\frac{x}{h}\right)$

⊙ Sometimes trees is estimated as



Cone : $Y = kx$

Parabola : $Y^2 = kx$

Neiloid : $Y^3 = kx^3$

Volume

- Root volume important for : Santalum Album
  Acacia Catechu
- Bark volume important for : Acacia Arabica
  Wattles

Commercial Volume (Stump वाली)

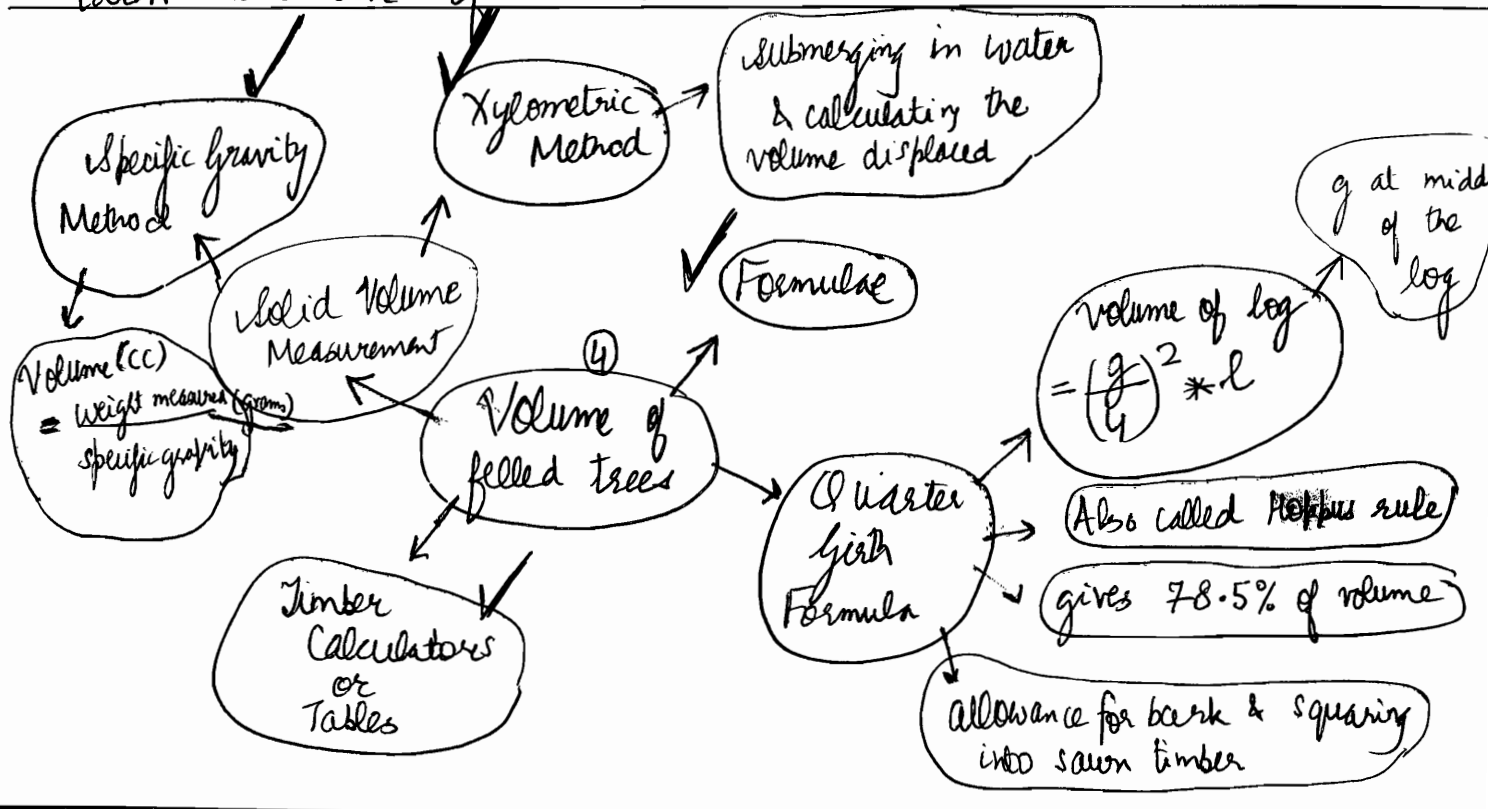
Volume of stem measured down to thin-end diameter upto which conversion is usually done. This volume excludes the volume of stump

Standard Stem Timber (Bark वाली)

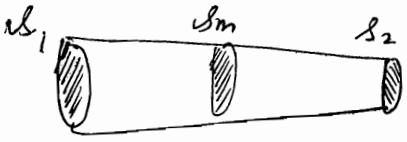
Volume of the stem wood timber in round from ground level down to 20cm diameter over bark, volume being taken exclusive of bark.

Standard Stem Small Wood

Volume of stem wood in round between 20cm diameter over bark & 5cm diameter over bark, volume being taken inclusive of bark.



⭐ Conversion Factor : Stacked Volume * Conversion Factor = (Solid Volume)



Cumbersome

Newton's or Prismoidal Formula → $\left(\frac{s_1 + 4s_m + s_2}{6} * l\right)$

most accurate formula

Quarter girth Formula

Formulae to calculate log volumes (4)

more accurate than Smalian's

Huber's Formula → $s_m * l$

Underestimates the volume

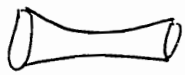
Overestimates the volume

Smalian's Formula → $\left(\frac{s_1 + s_2}{2}\right) * l$

Easier to measure ends with wooden scale

Easier to apply

Consider log as



A table showing for a given species, the avg. volume of trees for one or more given dimensions

Volume Table → dimensions include diameter, height, taper or their combination

Very subjective

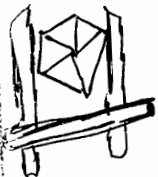
Ocular Estimate → Even same worker may estimate different volumes due to fatigue, hunger etc

Volume of Standing Trees (5)

w/o Climbing up height and finding diameter at various heights

Pentaprism calliper

Indirect Measurement → Relaskop, Optical dendrometers



ROP

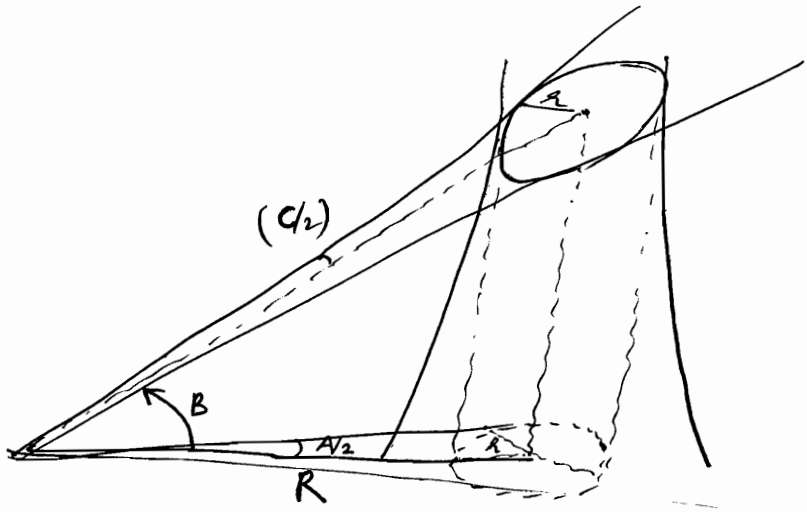
Direct Measurement → Similar to exact volume determination of felled trees; diameters at different height are measured by a man who climbs up the tree

Partly Ocular & Partly by Measurement → measuring diameter/height or both & estimating volume keeping taper in mind

Dendrometer

Optical instrument which is used to make diameter measurement at any point up the stem beyond the reach of forester.

A simple dendrometers measures 3 angles and from the distance from the tree, we can calculate diameter at any height



diameter = 2r

= 2R sin(A/2)

But we donot know

It can be shown that

$$\tan\left(\frac{A}{2}\right) = \frac{\tan\left(\frac{C}{2}\right)}{\cos B}$$

also $\sin\left(\frac{A}{2}\right) = \frac{\tan\left(\frac{C}{2}\right)}{\sqrt{\tan^2\left(\frac{C}{2}\right) + \cos^2 B}} \approx \frac{\tan\left(\frac{C}{2}\right)}{\cos B}$

$\Rightarrow$ diameter = $2R \frac{\tan(C/2)}{\sqrt{\tan^2(C/2) + \cos^2 B}} \approx 2R \tan(C/2) \sec B$

d.b.h : most imp. variable

Variables include diameter, height & form

3 variable table: most accurate but never used as its very difficult to prepare & use

Intended Application, Speed, Area extent, Accuracy,

Choice of Variables in volume table

1 variable tables: easy to prepare, easy to use but least accurate

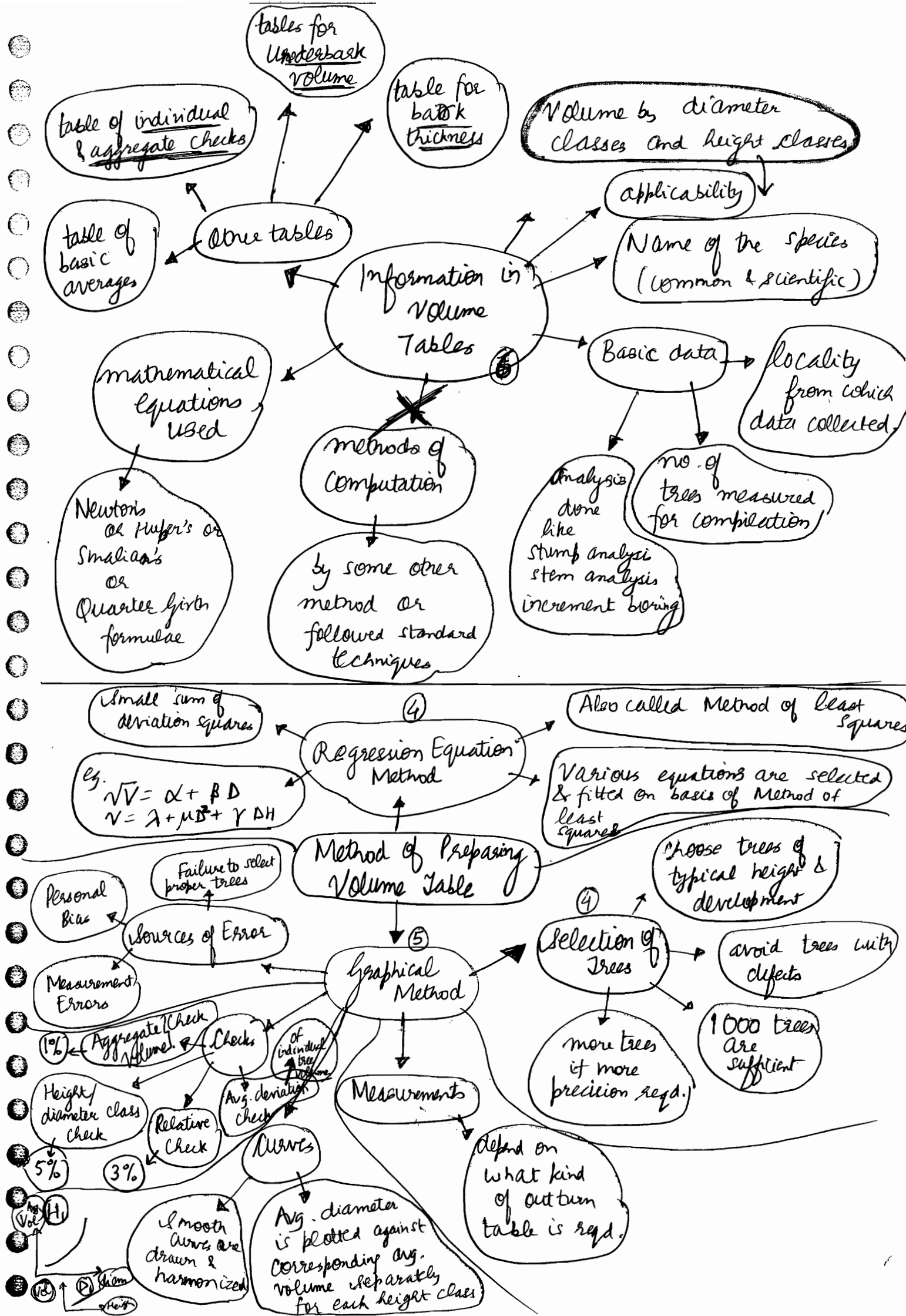
Only diameter sufficient for a small/restricted area eg. local volume table

At least 2 variables for a large diverse area

Saw Milling or Lumbering

log → lumber / timber / sawn wood

- Measuring timber to determine its volume or mass : Scaling of timber


Information in Volume Tables
Other tables
tables for Underbark volume
table for bark thickness
table of individual & aggregate checks
table of basic averages
Volume by diameter classes and height classes
applicability
Name of the species (common & scientific)
Basic data
locality from which data collected
no. of trees measured for compilation
Analysis done like stump analysis stem analysis increment boring
mathematical equations used
Newton's or Hufer's or Smalian's or Quarter girth formulae
methods of computation
by some other method or followed standard techniques
Method of Preparing Volume Table
Regression Equation Method
Also called Method of least Squares
Various equations are selected & fitted on basis of Method of least squares
eg. $\sqrt{V} = \alpha + \beta D$
$V = \lambda + \mu D^2 + \gamma D^2 H$
small sum of deviation squares
Graphical Method
Sources of Error
Personal Bias
Failure to select proper trees
Measurement Errors
Checks
Aggregate Check Volume
1%
Height/diameter class Check
5%
Relative Check
3%
Avg. deviation Check
of individual tree volume
Curves
Avg. diameter is plotted against corresponding avg. volume separately for each height class
smooth curves are drawn & harmonized
Measurements
depend on what kind of outturn table is req'd.
Selection of Trees
avoid trees with defects
1000 trees are sufficient
more trees if more precision req'd.
Choose trees of typical height & development

- **Aggregate Check** Actual volume of trees measured should be checked against the total volume read from final curve.
- **Height/Diameter Class Check** Aggregate Check applied to each diameter & height class.
- **Relative Check** When 2 or more tables are derived independently from same data, they should be checked against each other.
  eg: local volume table < derived from data / derived from general volume table

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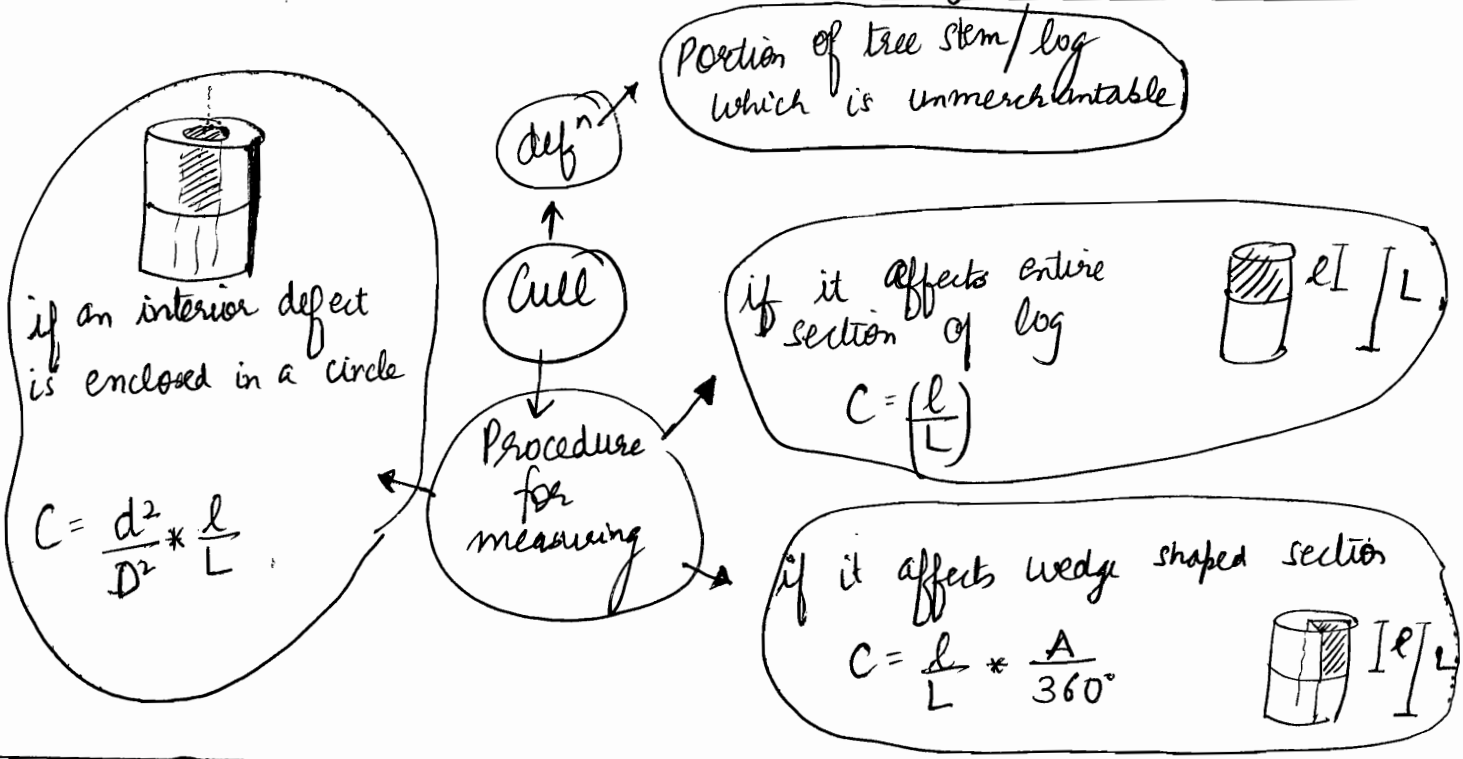
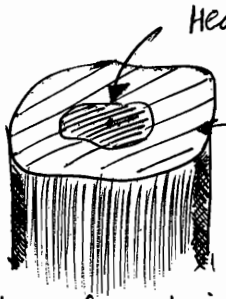
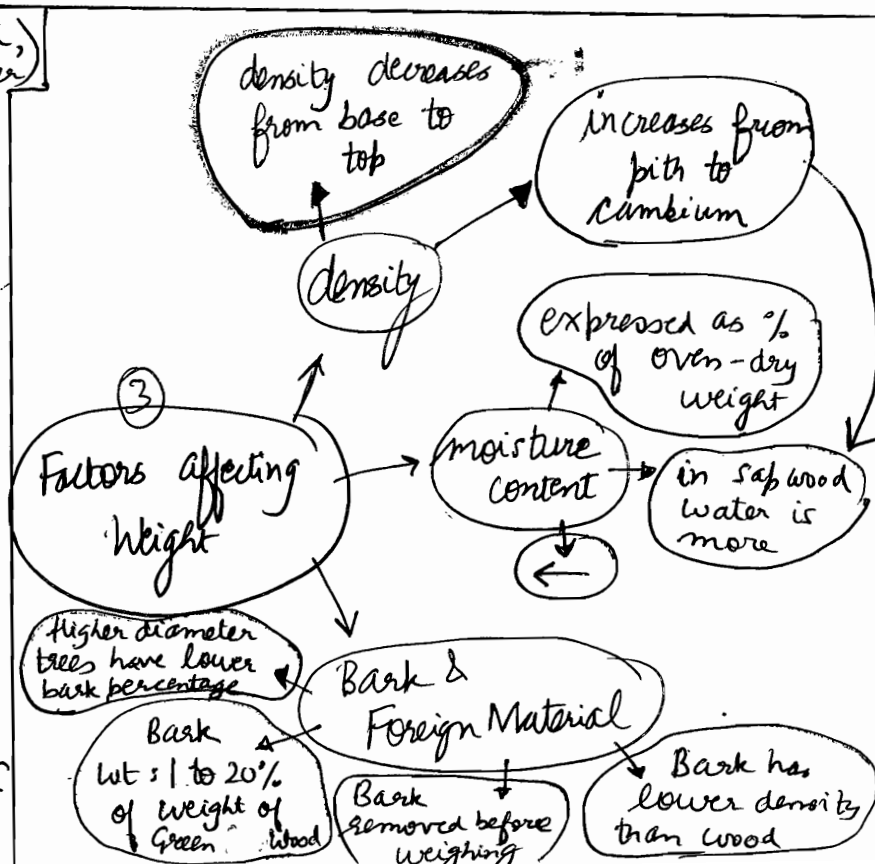


Weight



- Moisture content in a tree varies with locality, species, season of felling, length of time following the cutting of tree, age & physical condition of tree. This variability restricts use of weight as a measure of wood quantity.

Moisture occurs as free water in intercellular spaces & as absorbed water in the cells.



Biomass refers to the weight of the above ground vegetative matter produced per unit area. It includes wood, branches, bark, leaves, shrubs, herbs etc. growing above the ground.

Measurement of Biomass

- In fire wood estimation, usually measurements are done in earlier stages ∴ instead of dbh, diameter and girth are measured 50 cm above ground level
- Biomass Estimation using Regression Equation
  - $W = \alpha + \beta D^2 H$
- In case of multi-stemmed shrubs, girth of tallest shoot at 50 cm is measured & no. of shoots multiplied
- Biomass Estimation (Destructive Sampling)
  - Trees measured during dormant stage ie. winter
  - Trees grouped in diameter & girth classes
  - Good sample trees ~30 are selected
  - Measurement of girth at 50 cm, tree height
  - Tree is felled and separated into main stem, branch wood, leaves and each portion weighed separately
  - Sum of all weights is total biomass of tree

Age

- Count the rings on stump and add the estimated period the tree would have taken to grown up to stump height
  - Stump analysis
- Determination of Age of Felled Tree
  - But there are incidents of false rings
    - Rings that do not run right round the tree
  - In certain years of low growth or defoliator attack, ring formation may not take place
  - There might be closed-formed rings
    - difficult to count

p_1 : growth per unit diameter per year during 1st 2 periodic measurements

p_2 : " " " period between 2nd & 3rd periodic measurements

Age at start $= \left(\frac{1}{p_i \cdot s}\right)$; $s = \left(\frac{\log p_1 - \log p_2}{\log d_2 - \log d_1}\right)$

p_i : growth per unit diameter per year

Regression equation b/w Age & diameter, girth

Mathematical relationships

making 3 Periodic Measurements

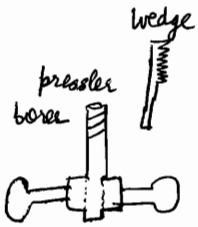
From existing records

takes few years for regeneration

there might beating-up operations

Determination of Age of Standing Trees (5)

- By number of annual shoots : Clear marks on bole
- Older trees have smooth & light coloured Bark
  - younger trees have rough cracked bark
- General appearance
  - Conical Crown in early age, then become circular
  - Older trees have less taper
- Pressler's Increment Borer



- small trees bored upto pith while bigger trees are bored for 5-10 rings
- advisable to seal the bore with sterilized wood to prevent subsequent damage to wood
- Wedge is inserted to cut out the bored wood piece
- Age is known either by
  1. 3 Periodic measurements
  2. Available diameter Age Curves

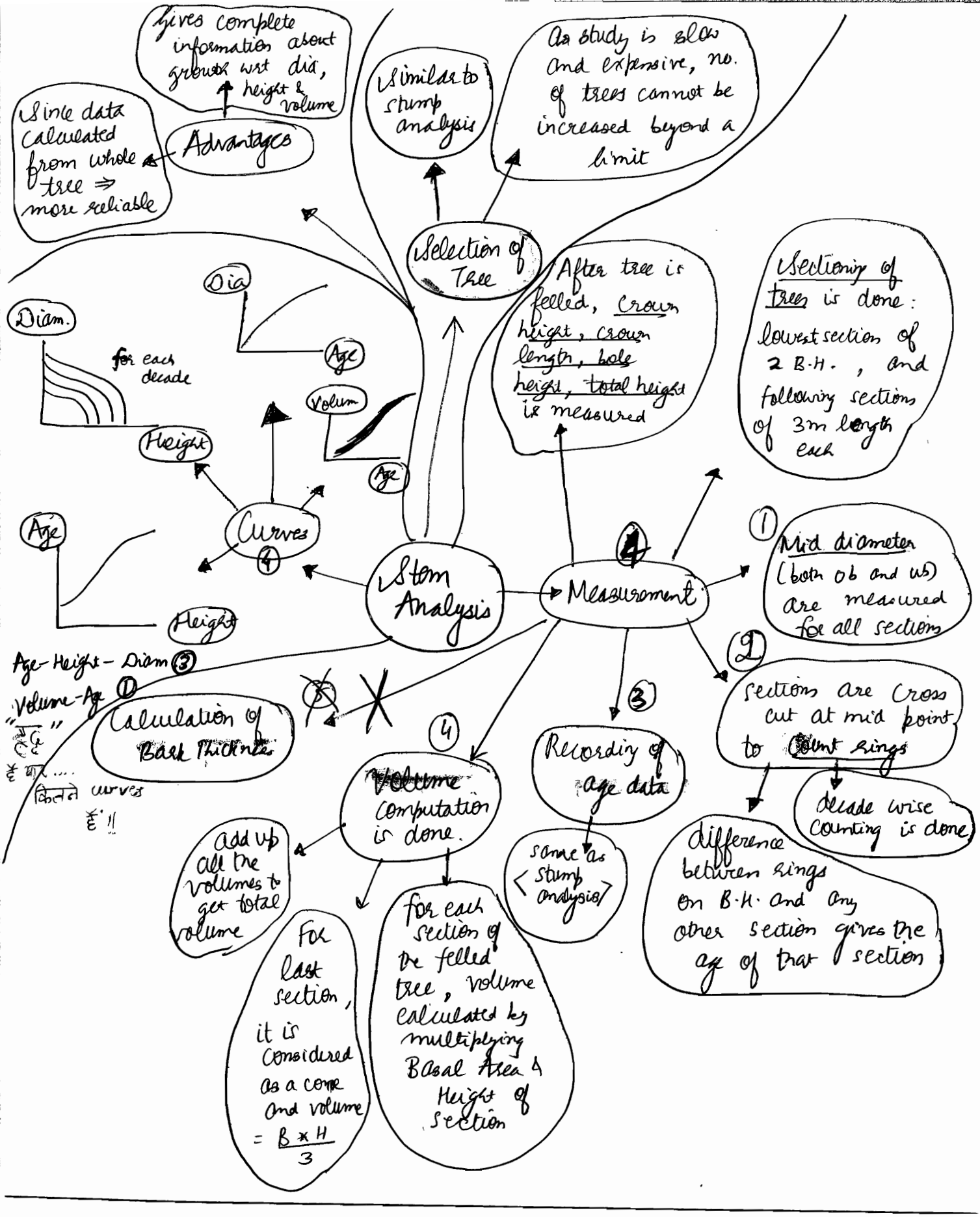
Growth

Determination of Growth of Trees with annual rings (3)

- Increment Boring
  - Obtaining rotation age
  - effect of adverse or favourable factors on diameter increment
  - Boring of stem with Pressler's Increment to determine age and diameter increment
- Stump Analysis
  - Analysis of stump cross section by measuring annual rings
  - aim is to estimate the age of the tree & its past rate of diameter & basal area growth
  - to know effect of ext. factors
  - Obtaining rotation age by analysis of age / diameter relationship
- Stem Analysis
  - Used to prepare local volume tables
  - aim is to estimate average rate of diameter, height and volume increment
  - Analysis of complete stem by measuring annual rings at diff. Cross sections

- linear growth due to original tissue or primary meristem, radial growth due to cambium or secondary meristem. (colour & variation)
- Seasonal variations in the growth are responsible for formation of tree rings. They are more prominent in temperate forests. Spring wood is lighter and more porous while summer wood is darker and denser. Thus a pattern of concentric rings appears across a cross section.

Few trees in tropical forest like Acacia Catechu and Tectona grandis show annual growth rings.



Q) Diameter of a sal tree in 1970 was 30 cm, in 1975 : 33 cm, in 1980 : 36 cm. Find age of tree in 1970.

A) Typical 3 periodic measurement example.

$$p_1 = \frac{3}{30*5} = 0.02 \quad ; \quad p_2 = \frac{3}{33\times5} = 0.018 \quad ; \quad S = \frac{\log p_1 - \log p_2}{\log d_2 - \log d_1} = 1.1$$

$$\therefore \text{Age} = \frac{1}{S\,p_1} = \frac{1}{1.1*0.02} \approx \boxed{45 \text{ years in } 1970}$$

Increment Boring

(1) Few trees of each diameter class are selected.

(2) For each tree, d.b.h are recorded (both ob & ub)
Tree is bored at 2 ends of diameter ⊥ to axis to core

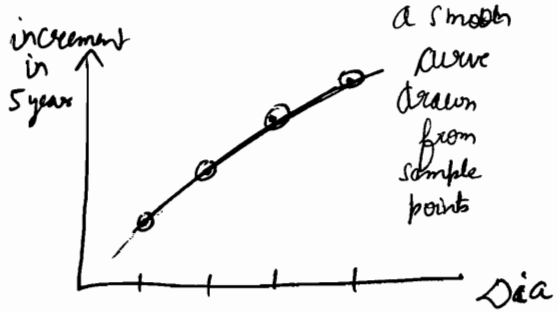
Length of outermost 5 rings of one end of each of the 2 diameters are recorded

(3) Diameter vs Increment Curve is drawn.

(4) From the smooth curve above,
we obtain initial diameter, increment, final diameter
(D_1) (i) ($D_2 = D_1 + 2i$)

then process repeated taking D_2 as initial diameter.

(5) Final diameters are plotted against equidistant point corresponding to age in years (5 rings ⇒ 5 years). Thus we get, from diameter - increment curve, an age - diameter curve.

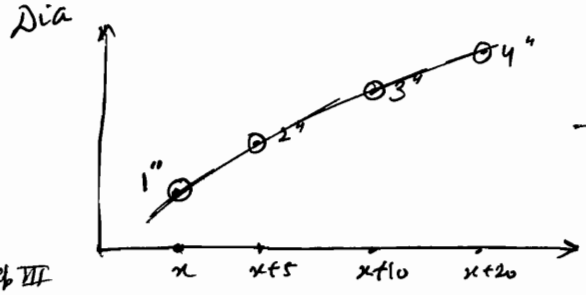


Step I

D_1	increment	D_{final} (D_1 + (2 * increment))
1	1'	1"
2 (=1")	2'	2"
3 (=2")	3'	3"
4 (=3")	4'	4"

■ random point is selected from previous curve. From D_1, D_{final} are calculated

Step II



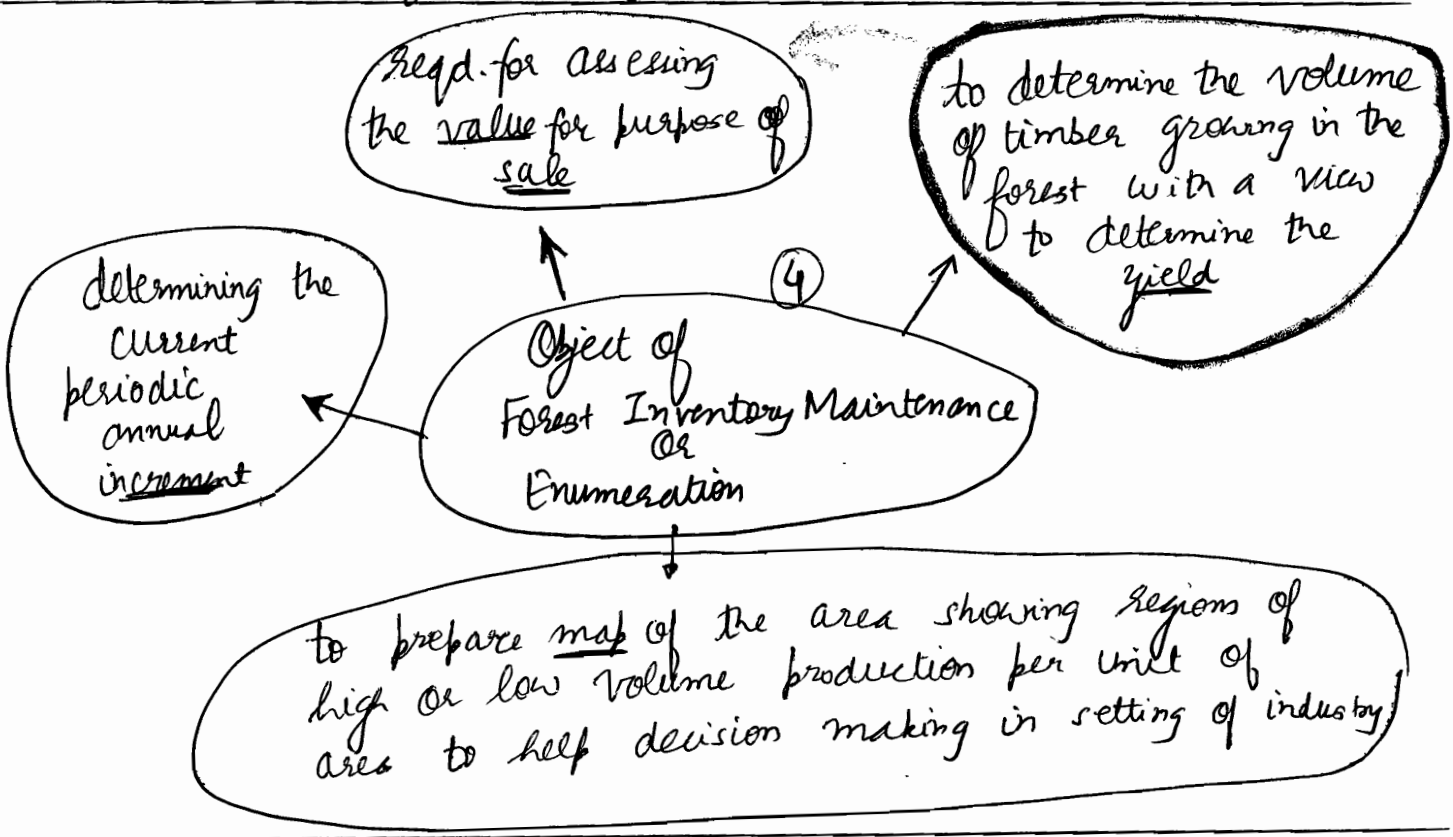
Step III

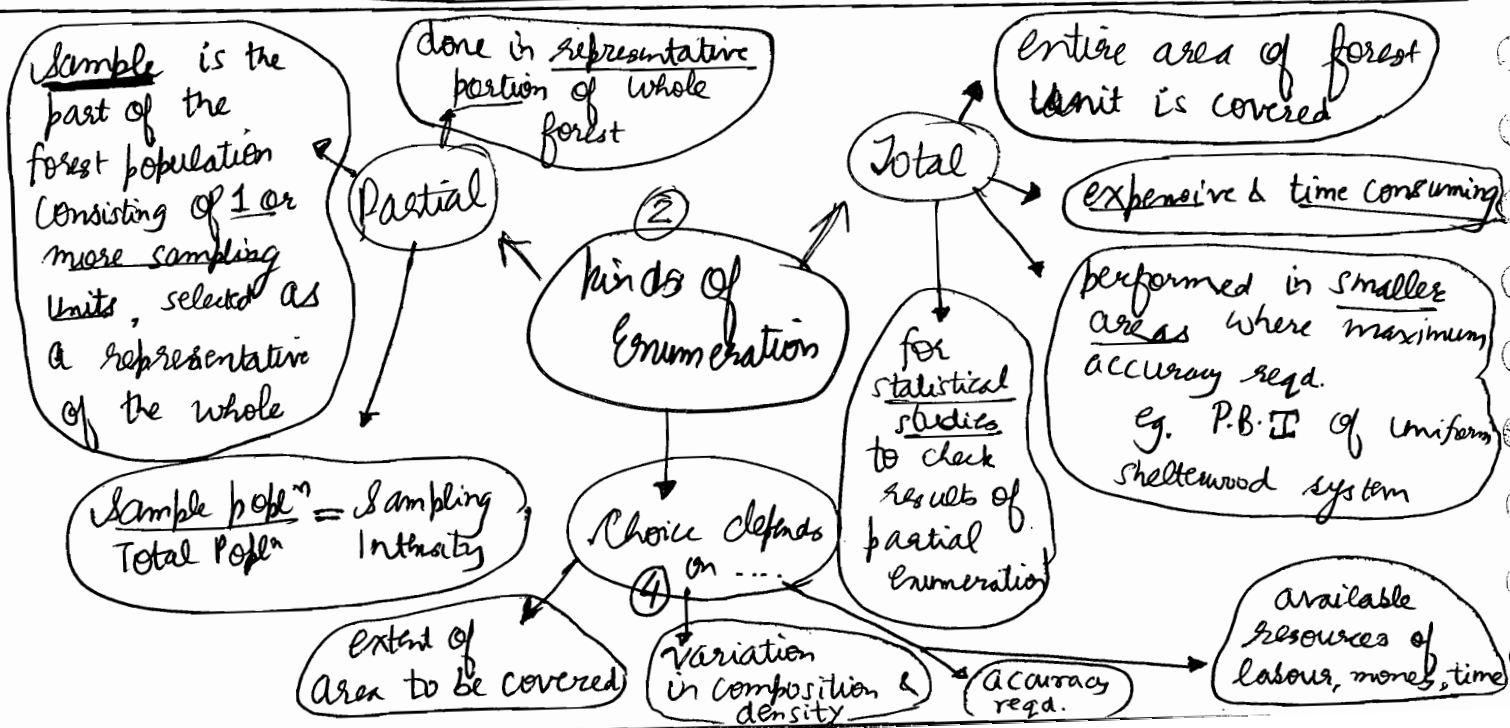
→ D_{final} are plotted against equidistant (separate by 5 units) points. Time Axis is corrected to shift by no. of years needed to reach lowest

Forest Inventory

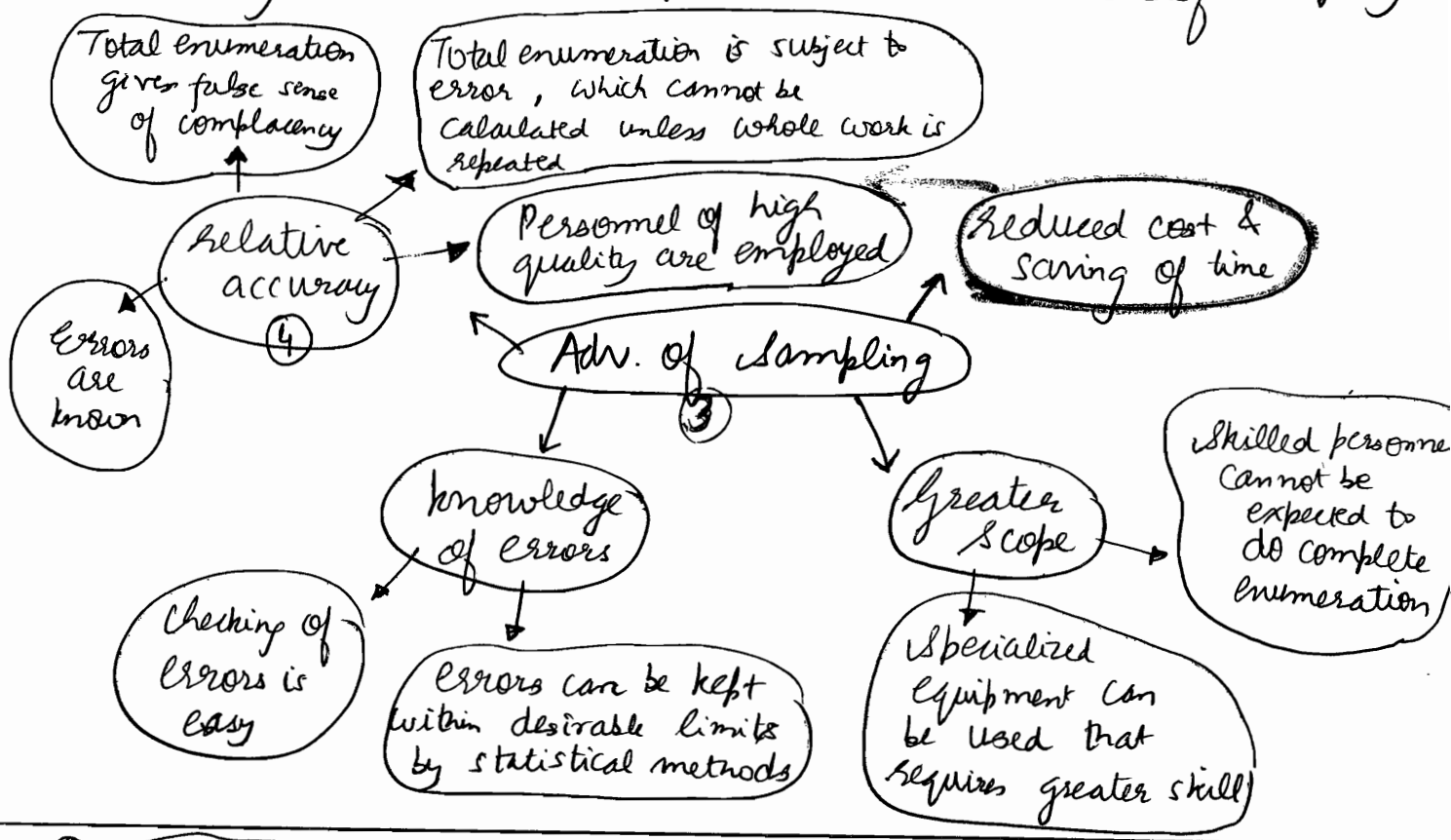
Forest inventory is the tabulated tree information arranged in hierarchial order. Its a quantitative description of quantity, quality, diameter distribution of forest trees and the characteristics of forest land.

"Forestry Inventory" is synonymous with the term **"Enumeration"** (counting of trees in a forest crop & their classification by species, size, condition etc.)





⊙ Sampling Units are subdivisions of the sample area. Record of each sampling unit is kept separately for working out statistical parameters like "error of sampling" et



Sampling Units composing a sample are selected s.t. all possible units of some size have equal chance of being chosen

Sampling Types or Designs

Samples are selected according to subjective judgment of the observer on the basis of certain rules/guidelines that indicate which sampling unit should be chosen

Random Sampling (6)

Non-Random Sampling

list sampling

randomly choose 5 numbers out of 30

Unrestricted or Simple

Sampling with varying prob.

Sequential

Selective

Stratified

Multiphase

eg. Point Sampling

Systematic

uniform dist'n simplicity

Multistage

Sampling Units are chosen with subjective judgment of observer

according to pre-determined pattern
eg. Tree every 30m

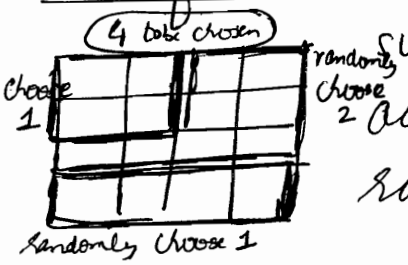
Choice of sampling design

same as those of <kind of enumeration>

(*) 5 to be chosen :

1	2	3	4	5	6
7	8	9	10	11	12
13	14	15	16	17	18
19	20	21	22	23	24
25	26	27	28	29	30

Stratified : Population is divided into homogenous sub-populations & then from each of them, according to their population size, simple random sampling is done.



Multiphase Sampling : Enumeration work is divided into multiple phases and for each phase same or different samples can be used.

eg. to determine no. of Bamboo culms in forest

→ $\phi 1$: to determine no. of clumps per hectare

→ $\phi 2$: to determine no. of culms per clump

List sampling : Another form of sampling with varying probability. eg: Hierarchial order (by size) of sampling units : taking cumulative size & then simple random sampling from cumulative list.

Compartment	Area (size)	Total
1	20	20
2	10	30
3	15	45
4	25	70
5	30	100

★ Choose 2 random numbers from 1 to 70 and we get (usually) 2 randomly selected compartments

Sequential Sampling : Aim is to achieve the average of total enumeration by convergence.

→ No. of observations in sample is not predetermined

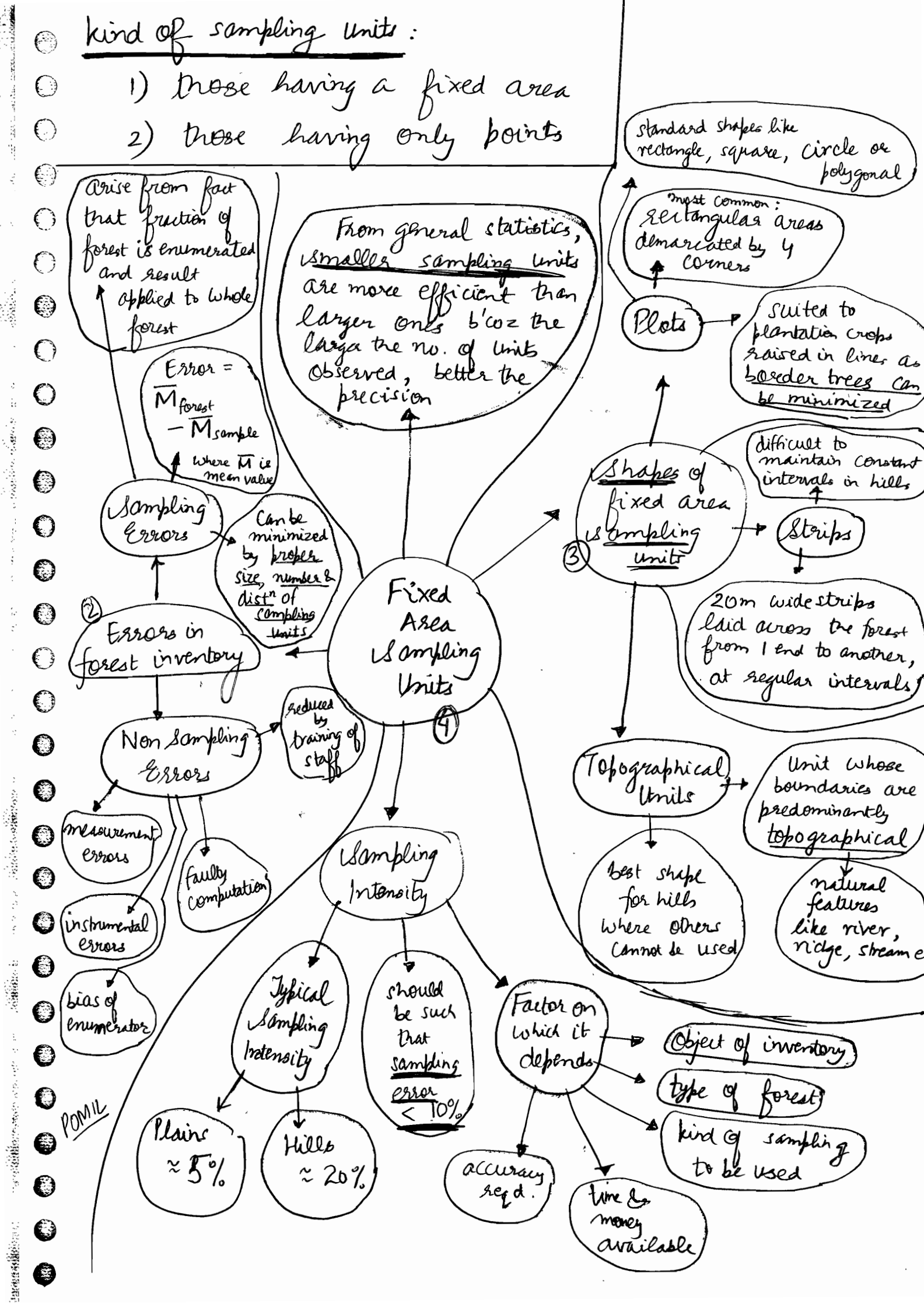
→ Sampling is stopped when the desired precision is reached. Confidence interval goes on decreasing at each stage of sampling.

→ Each sample, of course, contains the sampling units of previous sample.

desired Confidence interval

Kind of sampling units:

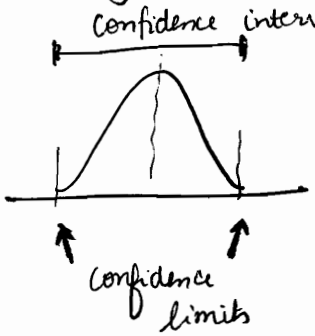
1) those having a fixed area
2) those having only points



Accuracy : size of the total error of the inventory and includes error due to bias.

Precision : refers only to sampling error and excludes error due to bias.

∴ An inventory can be precise without being accurate if error due to bias is present. An accurate inventory is always precise.



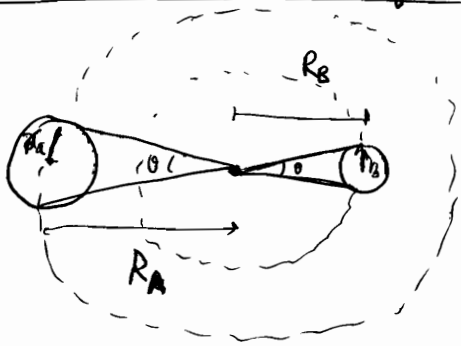
⊙ Estimates of the sample statistics lie in a range within which the true value is expected to lie at a given prob. The range is called confidence interval.

Principle of Point Sampling : "Counting from a random point, the no. of trees whose breast-height cross section exceeds a certain critical angle, when multiplied by a constant factor, gives an unbiased estimate of basal area per hectare".

The constant factor (F) is dependent only on size of the chosen critical angle.

$$\boxed{F = 2500\,k^2}$$

where $k = 2\sin\left(\frac{\theta}{2}\right)$



$$2\sin\left(\frac{\theta}{2}\right) = \frac{d_A}{R_A} = \frac{d_B}{d_B} = k \text{ (say)}$$

$$\boxed{1 \text{ hectare} = 10000\ m^2}$$

for $F = 1$, $\theta = 68.75' = 1.14°$

$$\Rightarrow \frac{\text{Basal area of tree}}{\text{Area of Plot}} = \frac{\pi d_A^2}{4\pi R_A^2}$$

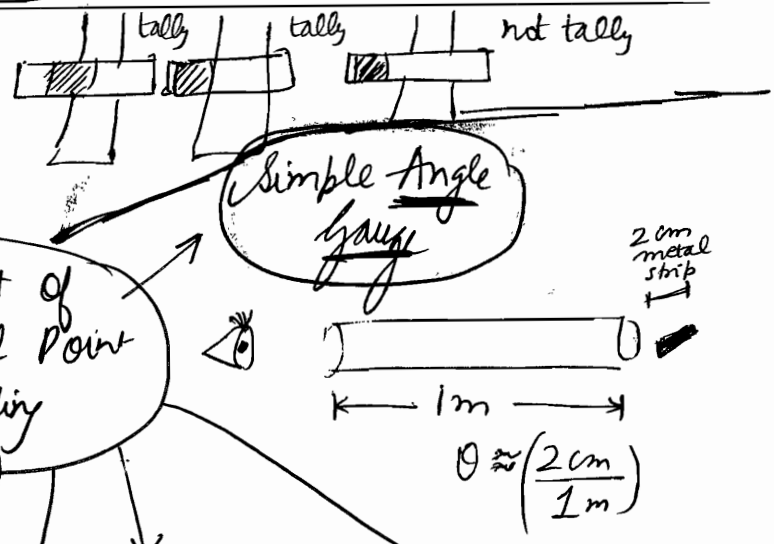
For 1 tree,
$\Rightarrow$ Basal Area per hectare $= 2500\,k^2 = F = \left(\frac{k^2}{4}\right)$
BASAL AREA FACTOR

Use of Horizontal Point Sampling (3)

- Stand Form Height calculated from subsample of trees
- Volume per hectare
- Basal Area * Stand Form Height
- Determination of Basal Area per Hectare
  - B.A. per hectare = Basal Area Factor (F) * No. of tally trees (n)
- No. of stems per hectare

Instrument of Horizontal Point sampling (4)

- Wedge Prism
  - Tree counted if image overlaps
  - need to kept perfectly vertical
  - Wedge shaped piece of glass: light rays bend according to critical angle
- Simple Angle gauge

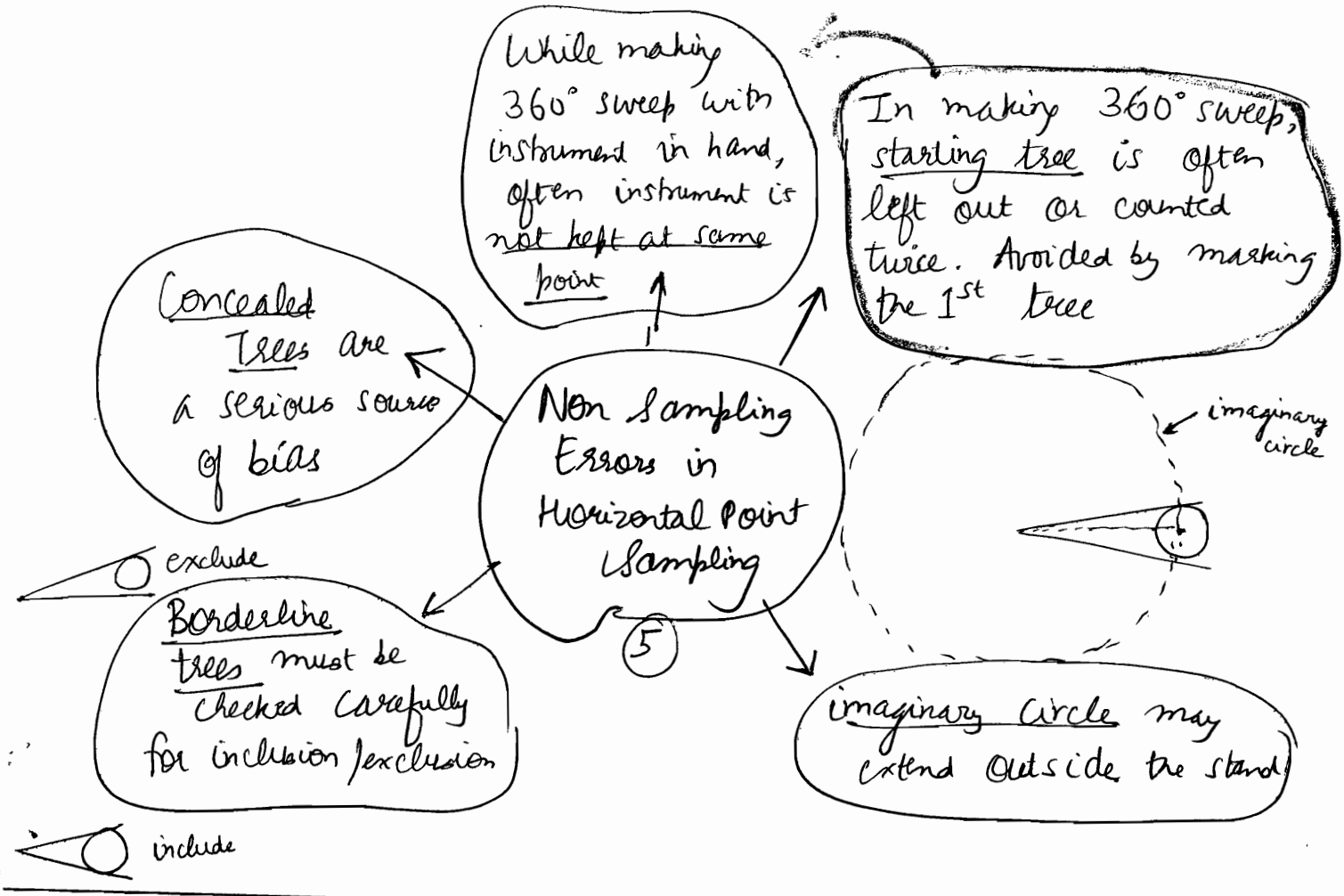


- Spiegel Relaskop
- Tele Relaskop

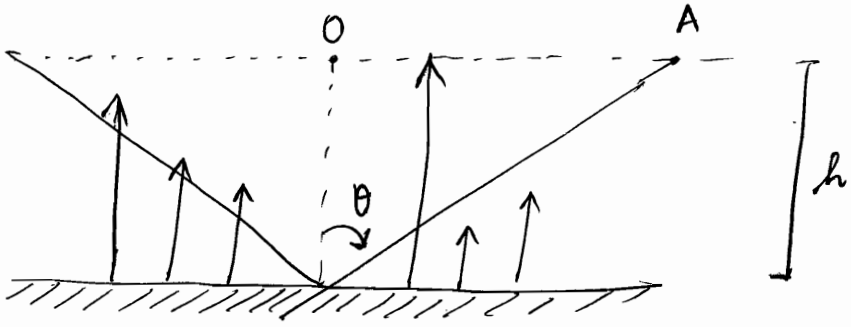
SWAT

Point Sampling vs Plot Sampling (5)

- Total Basal Area is measured by mere counting w/o diameter measurements
- Point sampling requires higher levels of skills of forester
- Sample trees are selected proportional to their area: thus big & valuable trees are selected preferentially
- Point sampling is difficult in dense areas. (tropical rainforest)
- Total Basal Area: more effectively estimated through point sampling
  No. of stems: more efficiently estimated through plot sampling



⊙ **Vertical Point Sampling** (to determine mean height of the stand) : All trees appearing taller than a critical angle are counted.



Corimeter Principle

h is the mean height of the stand

$OA = h \tan\theta$

Area of cone base $= \pi (OA)^2 = \frac{\pi h^2 \tan^2\theta}{10000}$ hectares
where avg. height = h

If no. of trees per hectare = N

$\Rightarrow$ No. of trees in this area of height avg = h : $\frac{N \pi h^2 \tan^2\theta}{10000}$

Tally $= n = \left(\frac{N \pi h^2 \tan^2\theta}{10000}\right)$

$\Rightarrow h = \sqrt{\frac{10000\, n}{N \pi \tan^2\theta}}$

Yield Table

Stand structure refers to distribution and representation of age and size classes of trees in a stand.

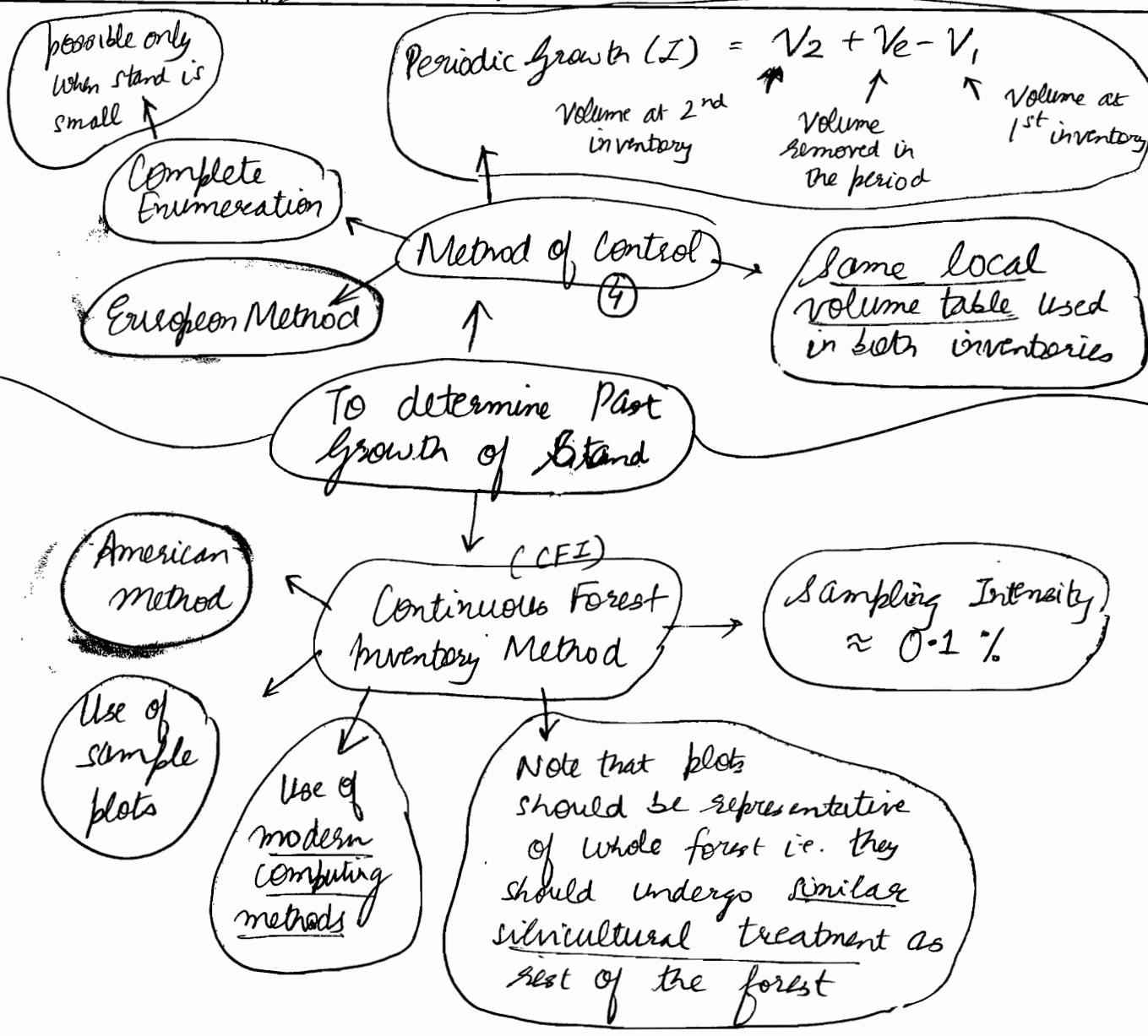
Broadly, of two types: Even aged
Uneven aged

Age class → yield table
Size class → stand table

Balanced Forest refers to a stand where the no. of stems by diameter class decrease in constant geometric progressio

eg. by De Liocourt's Quotient

$$\frac{N_1}{N_2} = \frac{N_2}{N_3} \cdot \frac{N_3}{N_4} = \ldots = q$$



Now in order to determine (predict) future growth, 2 factors are important :

① Stand density

② site quality

Stand density

Also called
- Crop density
- Density of stocking
- stocking

Stand density is a measure of relative completeness of tree stocking expressed as % of normal number of trees, basal area or volume.

Yardstick to measure normalcy is provided by yield table

But an understocked/overstocked forest does not grow in some proportion as normally stocked forest. ⇒ correction factor is modified based on one's experience

For species for which yield tables do not exist (or for uneven aged crop), density should be expressed as basal area per hectare

To estimate yield or future growth of a stand from a yield table, 1st estimate density of stand, then apply correction factor to the yield table figures of future growth. (Yield Tables are prepared for fully stocked stand)

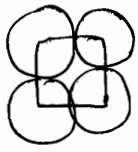
Closed : 1
dense : >0.6
thin : 0.4 - 0.6
open : 0.2 - 0.4
sparse : <0.2

~~Closed : 1.0~~
~~Dense : 0.75 to 1.0~~
~~Thin : 0.5 to 0.75~~
~~Open : < 0.5~~

Canopy Density

measure of relative completeness of canopy and expressed as decimal/fraction, taking closed canopy as unity

Square spacing



$\frac{\text{Crown Area}}{\text{Ground Area}} = \frac{\pi}{4}$

Equilateral Triangular spacing

$\frac{\text{Crown Area}}{\text{Ground Area}} = \frac{\pi}{2\sqrt{3}}$

Climate Veget. Productivity Index

C·V·P. index = $\frac{T_M}{T_m} \times \frac{P \times G}{12} \times \frac{E}{100}$

T_M : max Temp
T_m : min Temp

P : Precipitation
G : Growth Period

E : evapo-transpiration

Site Factors

does not take into account soil factor

Measure of relative productive capacity of a site. Its a complex of physical & biological factors of an area that determine what forest it may carry

Site Quality

Volume
Basal Area
Diameter
Height

Tree Characteristics

These reflect the productivity of the area

Vegetative Characteristics

Characteristic of vegetation could be used as basis to determine site quality

Plant Indicators

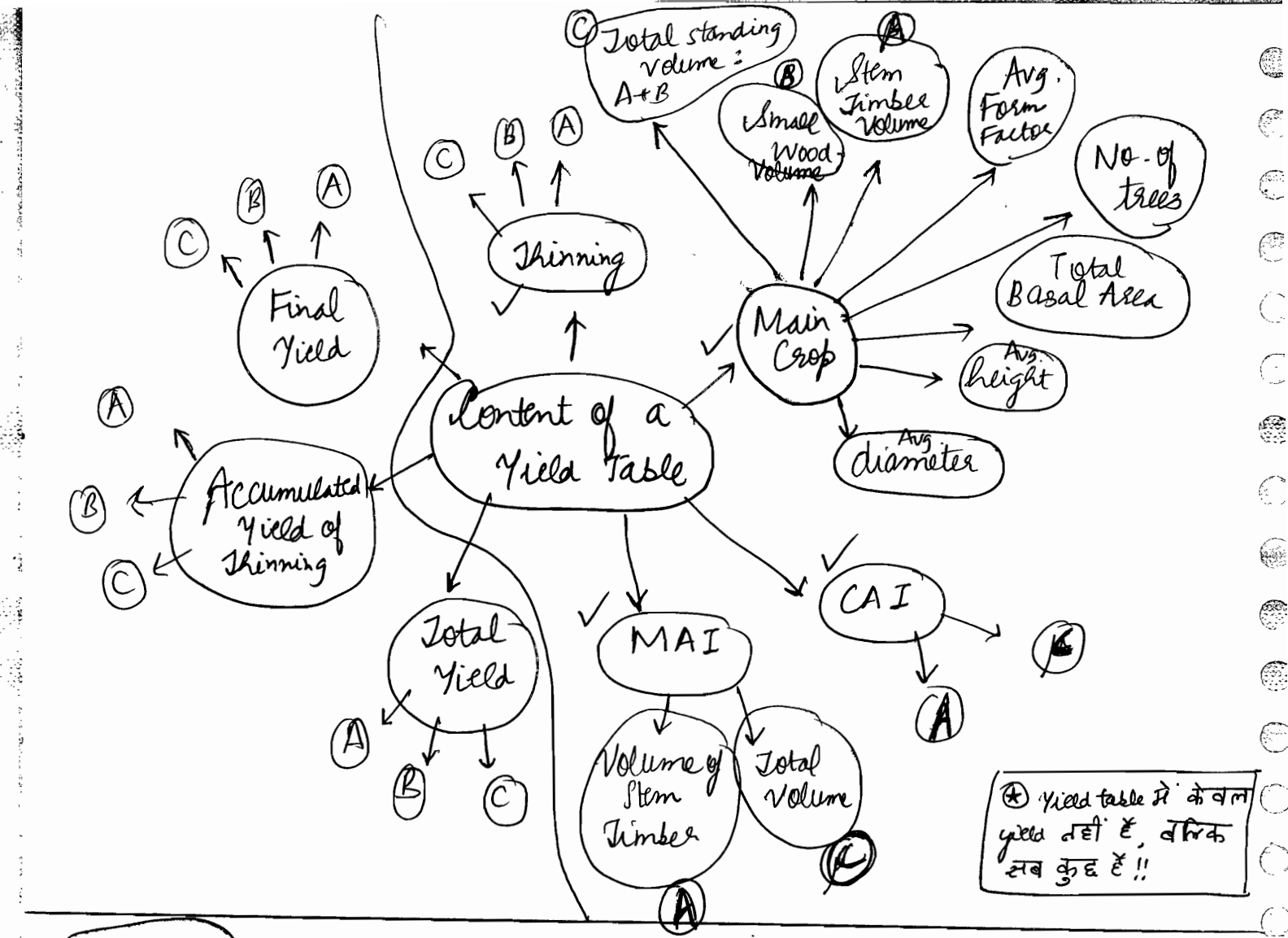
Based on theory that certain species of lower vegetation i.e. herbs and shrubs are clear indicators of the site quality & suitability of a site for a particular tree species

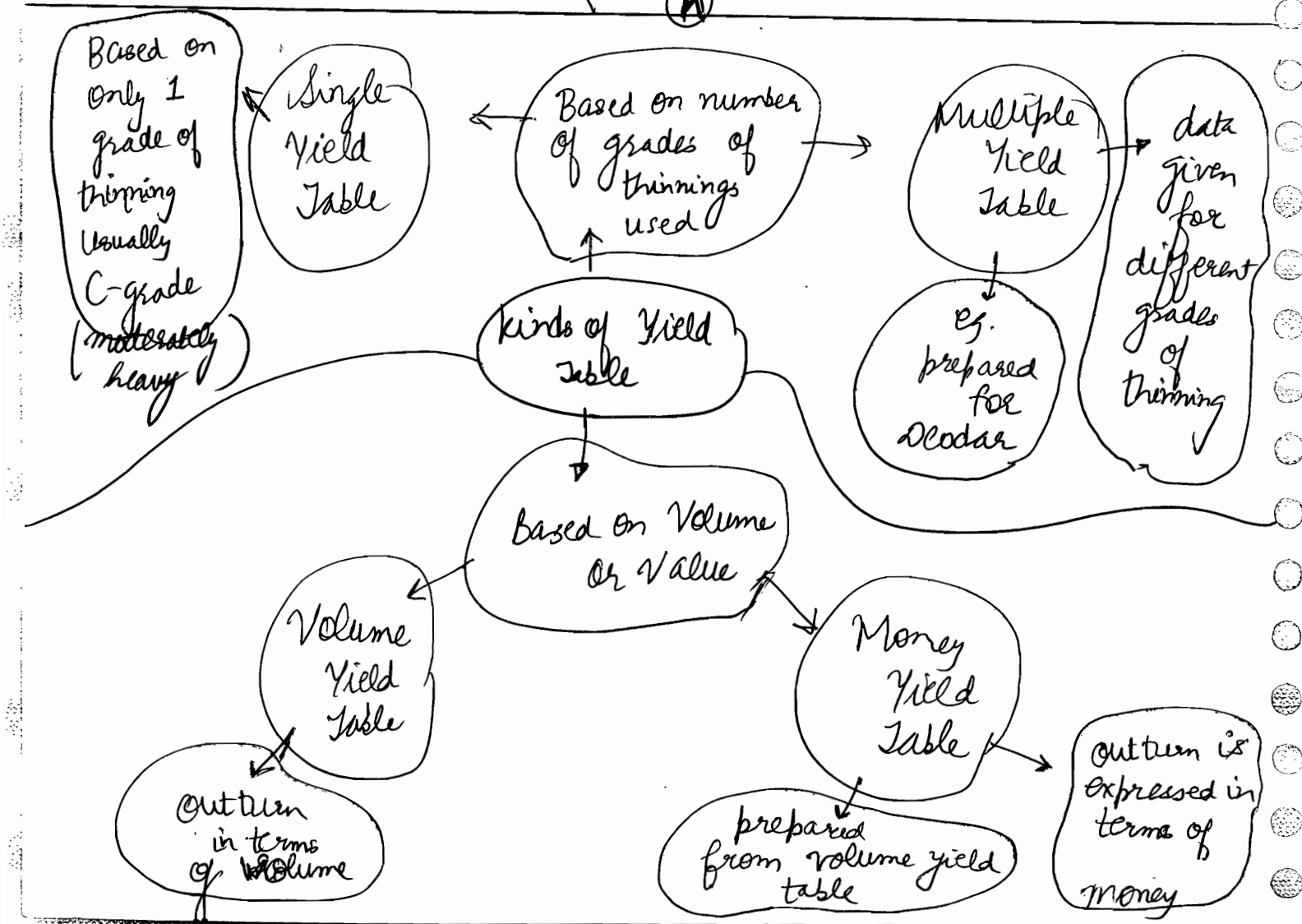
requires considerable ecological knowledge to deduce site quality from plant indicators

---

Yield Table is a tabular statement which summarizes per unit area, all the essential data related to development of a fully ① stocked and regularly ② thinned even-aged ③ crop at periodic intervals. It gives all the quantitative information regarding development of a crop.

In India, Yield Tables give information by site quality ① per unit area ② basis at interval of 5 or 10 years ③.


Content of a Yield Table
Final Yield
Thinning
Main Crop
Total standing volume = A+B
Stem Timber Volume
Small Wood Volume
Avg. Form Factor
No. of trees
Total Basal Area
Avg. height
Avg. diameter
Accumulated Yield of Thinning
Total Yield
MAI
CAI
Volume of Stem Timber
Total Volume
* Yield table में केवल yield नहीं है, बल्कि सब कुछ है !!


Kinds of Yield Table
Based on number of grades of thinnings used
Single Yield Table
Based on only 1 grade of thinning Usually C-grade (moderately heavy)
Multiple Yield Table
data given for different grades of thinning
eg. prepared for Deodar
Based on Volume or Value
Volume Yield Table
Outturn in terms of Volume
Money Yield Table
prepared from volume yield table
Outturn is expressed in terms of Money

Preparation of Yield Table

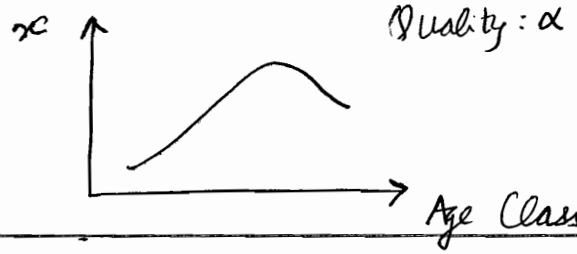
① Select the plots to be sampled

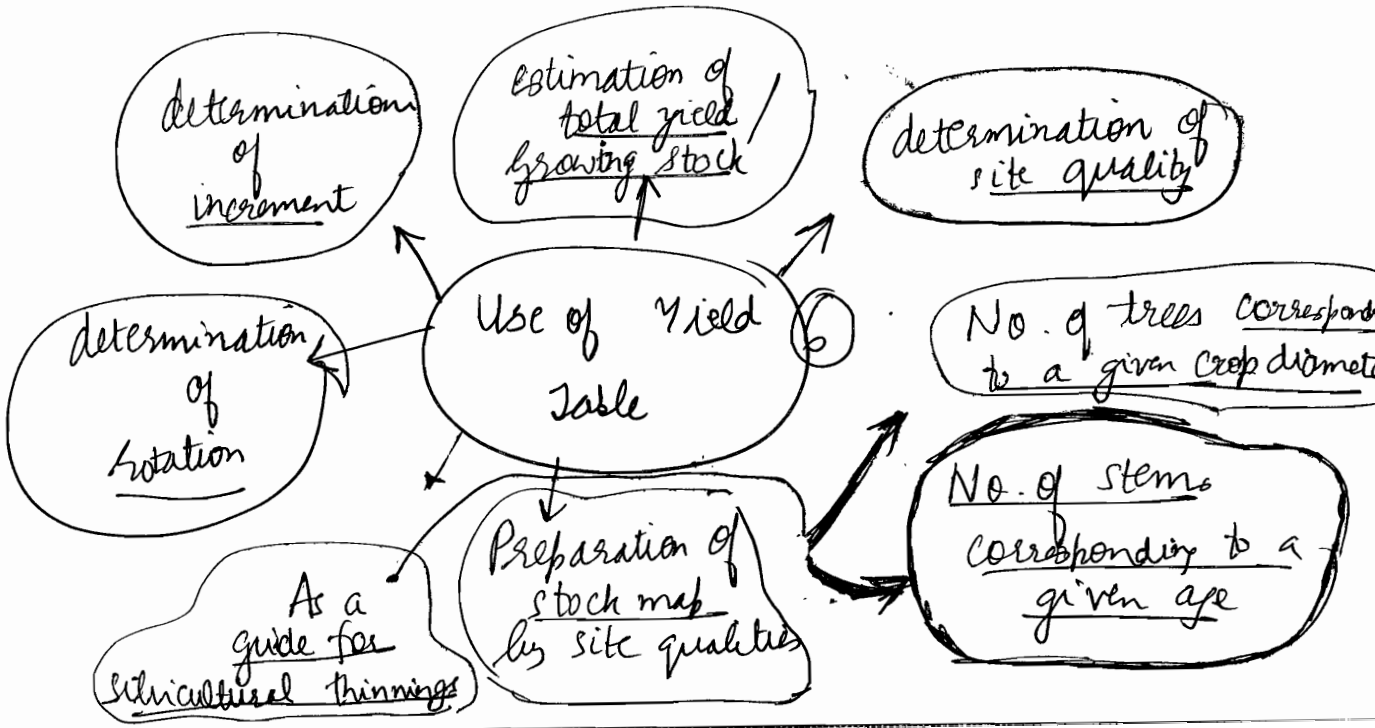
② By "vegetative" or "site factors" method, all plots are assigned in quality classes.

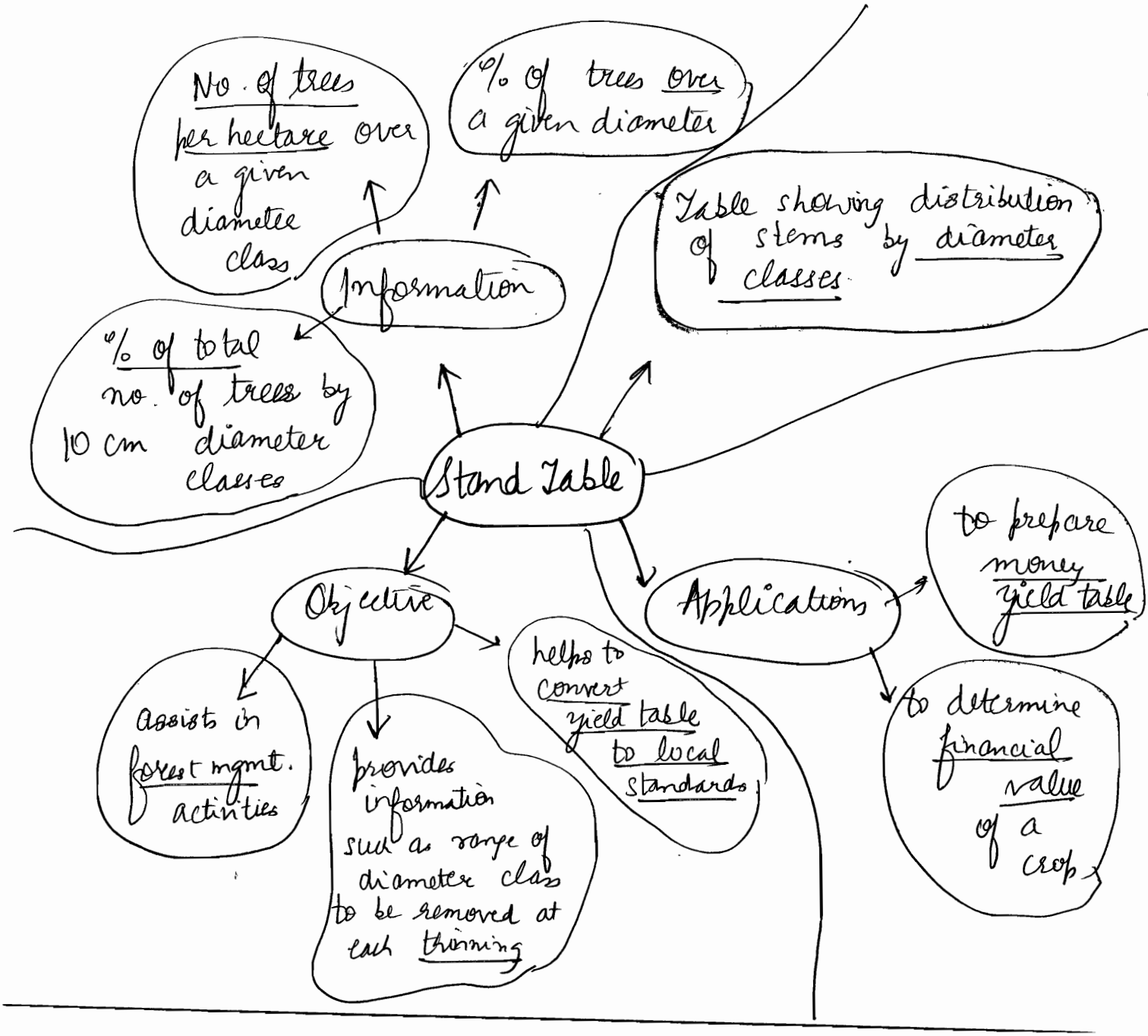
③ For each quality class, main crop data is grouped into classes by decade. Following averages (x) are computed:

- basal area per hectare
- no. of trees per hectare
- avg. crop diameter
- avg. crop height
- volume (A, B, C) per hectare
- " " form factor

④ For each quality, smooth curves are drawn.





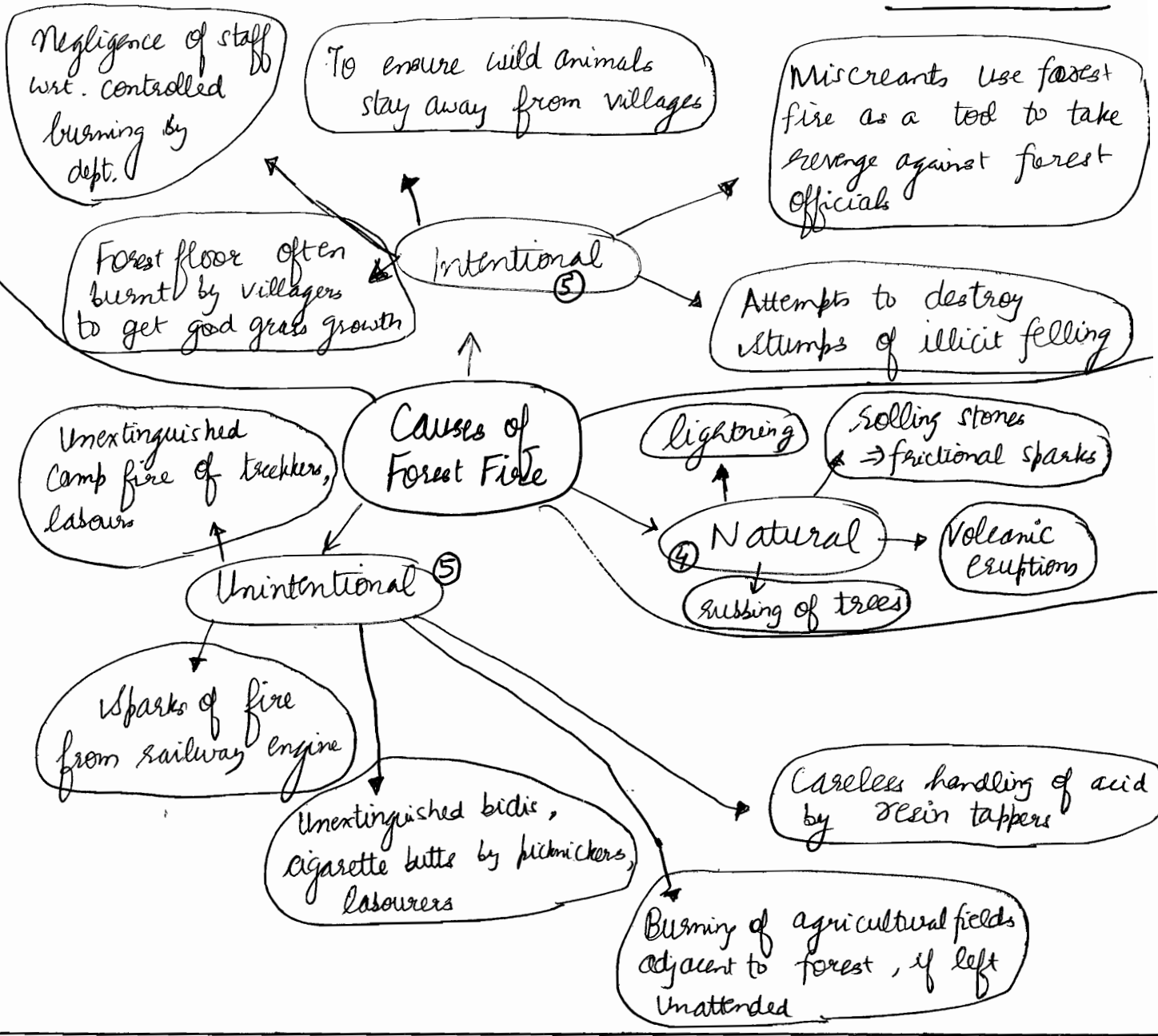

Stand Table
Information
No. of trees per hectare over a given diameter class
% of trees over a given diameter
Table showing distribution of stems by diameter classes
% of total no. of trees by 10 cm diameter classes
Objective
Assists in forest mgmt. activities
provides information such as range of diameter class to be removed at each thinning
helps to convert yield table to local standards
Applications
to prepare money yield table
to determine financial value of a crop

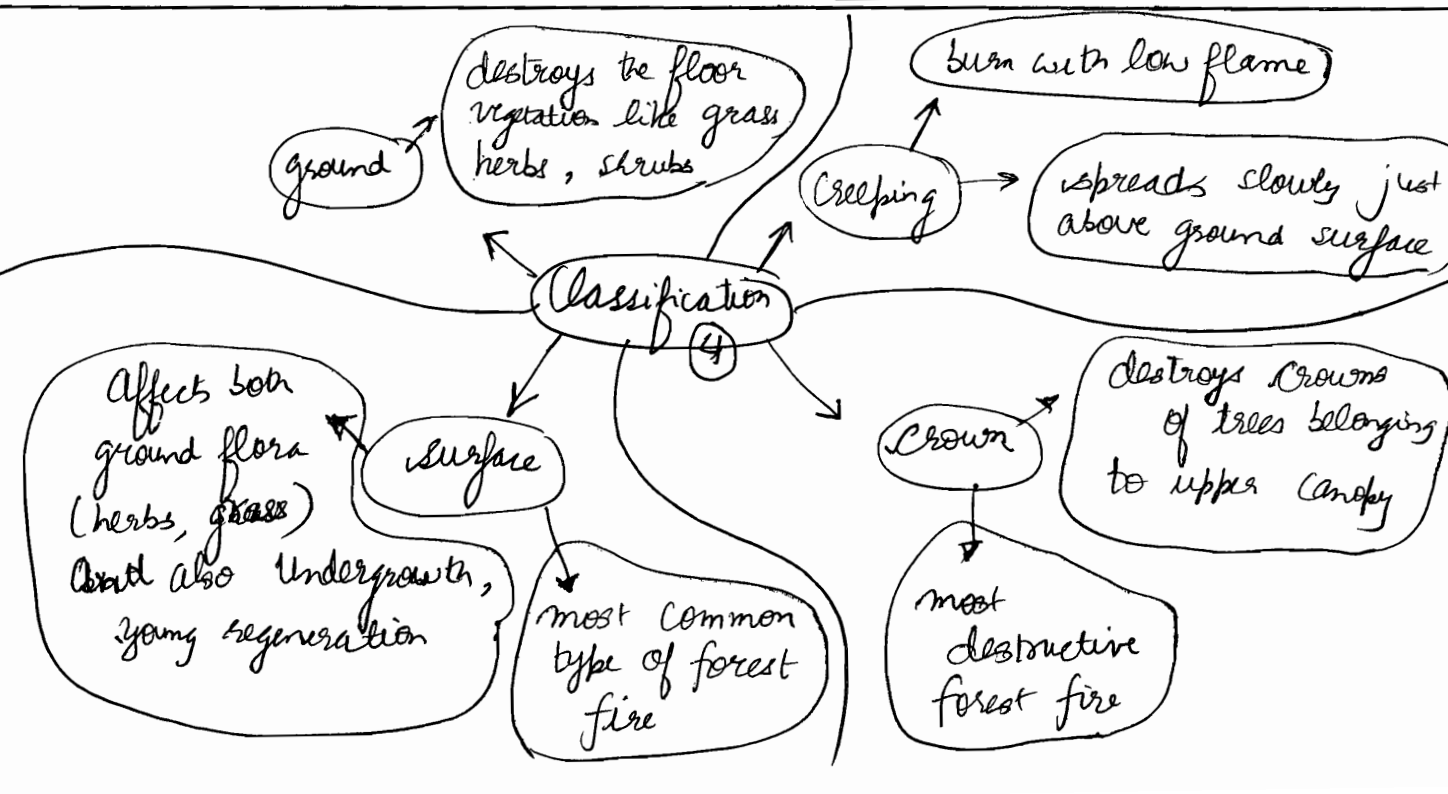
- Point Sampling is also called –
  - Bitterlich
  - Variable Plot
  - Prob. Proportional to Size (pps)
  - ~~Prob. Proportional to Prediction (PPP) : 3P Sampling~~

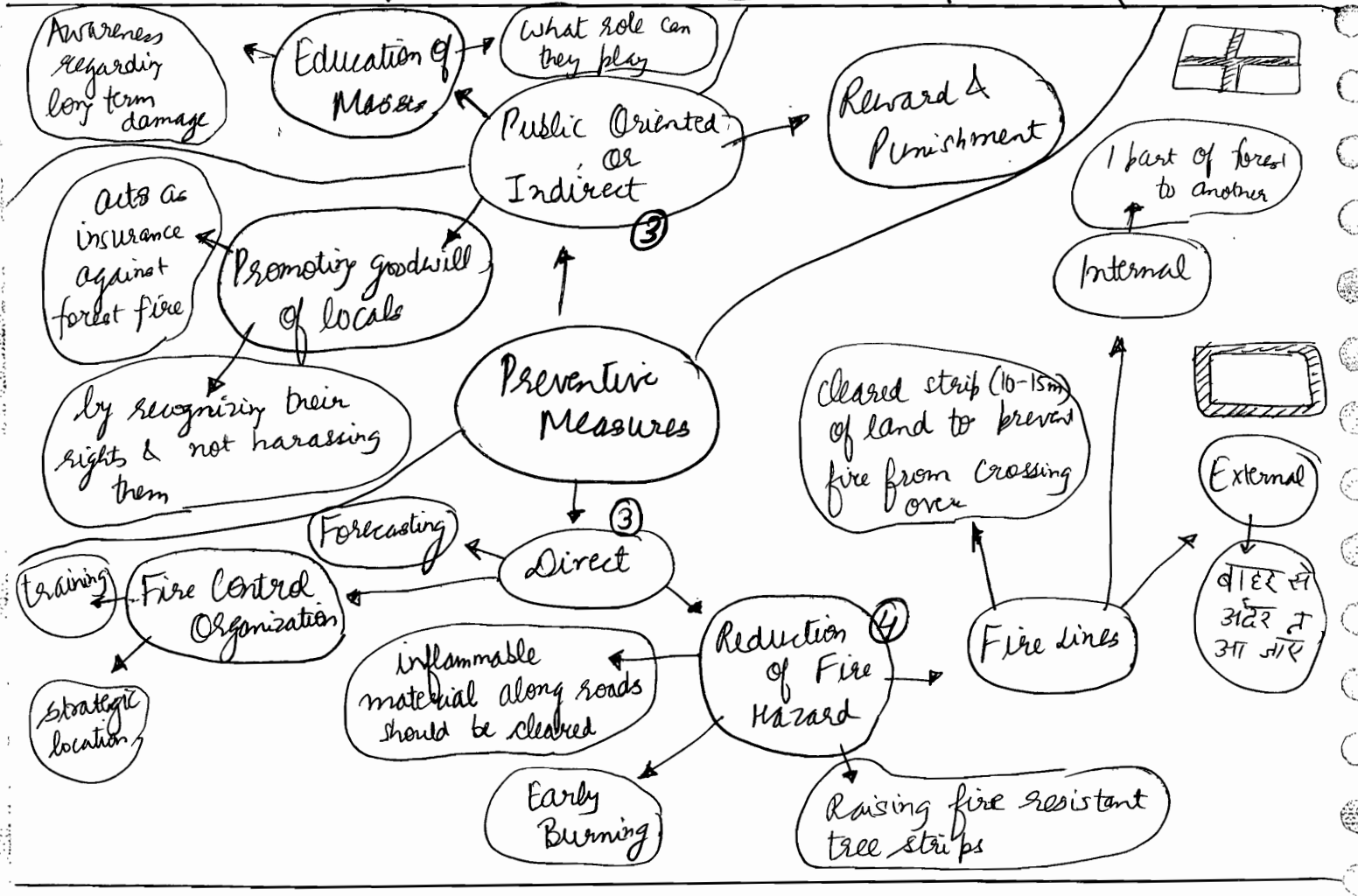
Forest Fires

Chapter - 9

MISCELLANEOUS - 2

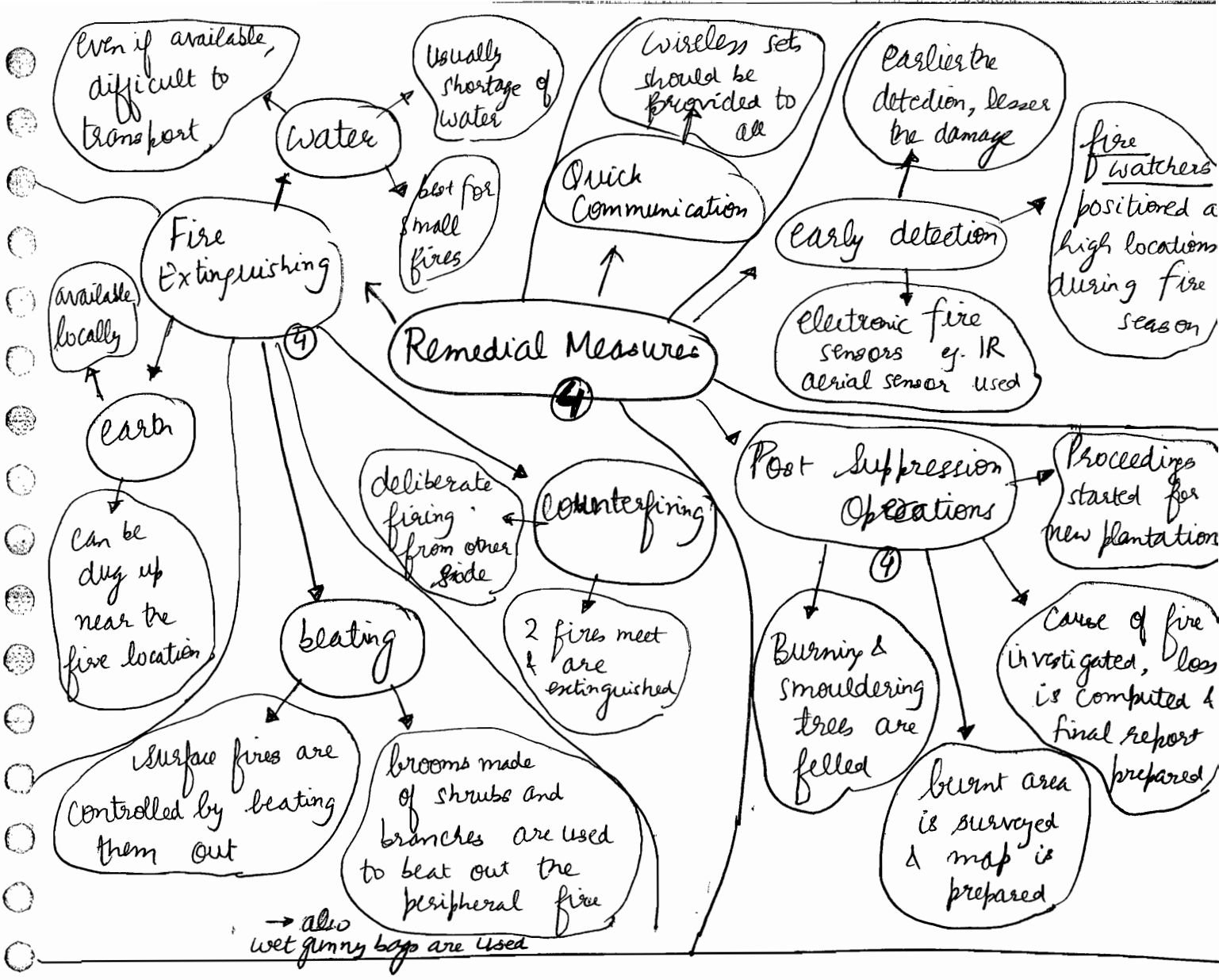






⊛ adverse : hostile : inimical : unfavourable : untoward.

⊛ Cork is fire resistant. It a subset of bark tissue. Mainly used to prepare wine stoppers. Bark stripped every 10 years to get cork from some trees.


Remedial Measures
4
Fire Extinguishing
4
water
Even if available, difficult to transport
Usually shortage of water
best for small fires
earth
available locally
Can be dug up near the fire location
beating
Surface fires are controlled by beating them out
brooms made of shrubs and branches are used to beat out the peripheral fire
also wet gunny bags are used
counterfiring
deliberate firing from other side
2 fires meet & are extinguished
Quick Communication
Wireless sets should be provided to all
early detection
Earlier the detection, lesser the damage
Electronic fire sensors eg. IR aerial sensor used
fire watchers positioned at high locations during fire season
Post Suppression Operations
4
Burning & smouldering trees are felled
burnt area is surveyed & map is prepared
Cause of fire investigated, loss is computed & final report prepared
Proceedings started for new plantations

Injuries by plants and Animals

Parasites
- Cuscuta
- mistletoe
- Loranthus

* Grazers feed on grass, herbs on forest floor; Browsers feed on twigs, shoots, leaves of shrubs, wood climbers

- deodar, Acrocarpus : Bark
- sal : regeneration

Logging

Felling

- Trees should not fall at a place where its difficult to carry out their conversion
- Felling should ensure least damage to themselves & surrounding forest
- Trees should be felled as near the ground level as possible for maximum extraction of sound timber
- No felling should be carried out in a strong wind
- Whenever a tree is about to fall, a timely warning should be given to all persons working in the vicinity
- Ropes & Cables should be used esp. in case of leaning trees
- falling tree should not be allowed to lodge upon other. If a tree gets entangled, it should be freed immediately with help of cables

Conversion

Conversion is the process of preparation of timber of commercial sizes in the form of
- timber in round or as logs
- roughly converted timber
- sawn timber such as beams, sleepers, scantlings etc.

Form of conversion depends on... (5)
- availability of skilled labour
- demand of market
- availability of conversion facilities like tools, saw mills
- nature of terrain & transport
- damage likely to be caused to forest

★ Conversion सीधा full conversion .... हो सकता है, जंगल के अंदर only 1st Part of conversion हो, या फिर पूरा ही block का हो

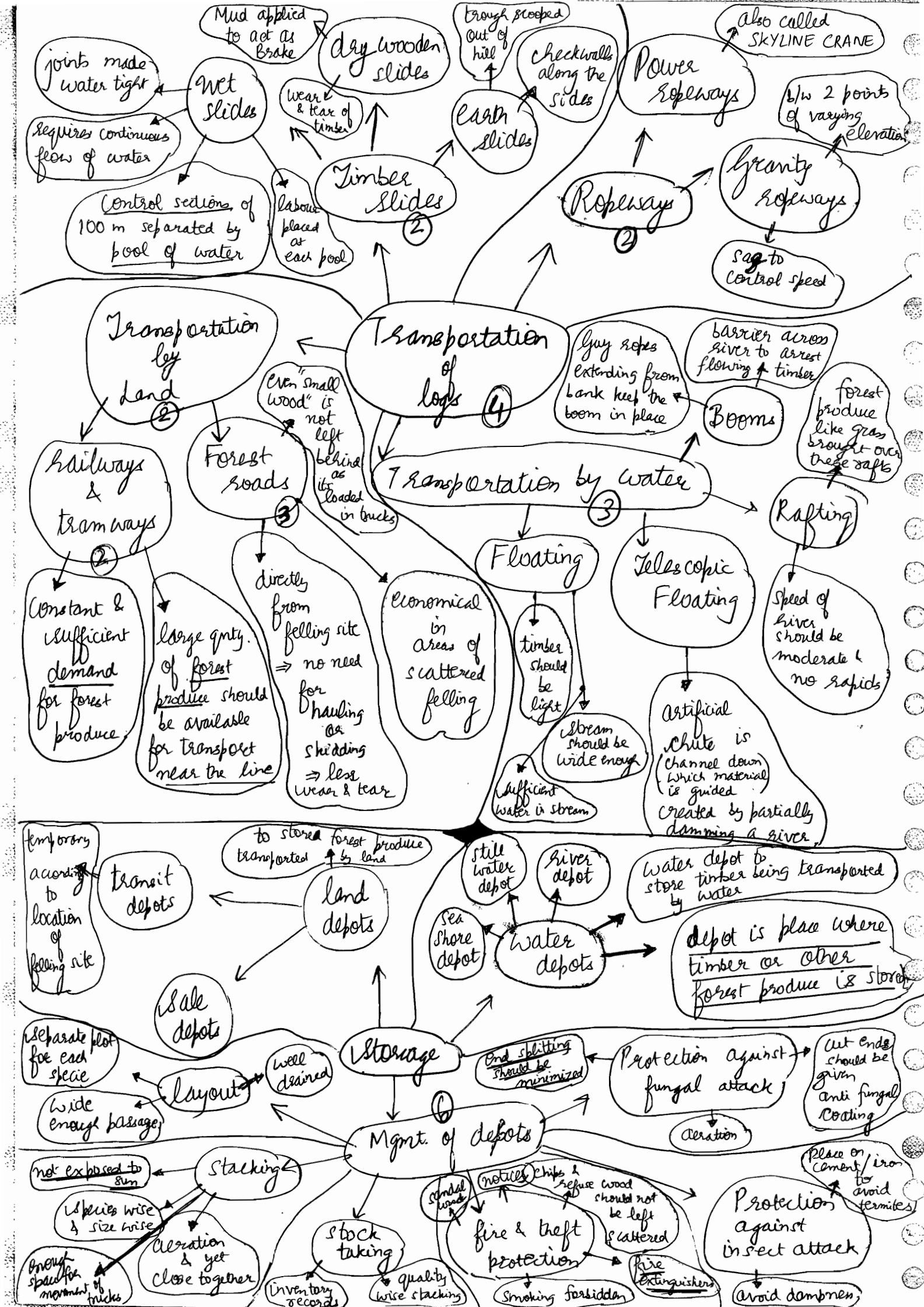
Components of Conversion

Limbing: trimming off the branches from felled trees

Bucking: Cross Cutting of main stem into logs

Sawing: production of commercial form of wood in saw mills (machine saw) or Hand saw (in forest itself)
- Squares
- Beams
- Scantlings
- Poles
- Sleepers
- Planks

lbs (pounds)


Transportation of logs 4
Transportation by land 2
Railways & tramways 2
Constant & sufficient demand for forest produce
large qnty. of forest produce should be available for transport near the line
Forest roads 3
directly from felling site ⇒ no need for hauling or skidding ⇒ less wear & tear
"even small wood" is not left behind as it's loaded in trucks
economical in areas of scattered felling
Transportation by water 3
Floating
timber should be light
stream should be wide enough
sufficient water in stream
Telescopic Floating
artificial chute is channel down which material is guided
created by partially damming a river
Rafting
speed of river should be moderate & no rapids
forest produce like grass brought over these rafts
Booms
Guy ropes extending from bank keep the boom in place
barrier across river to arrest flowing timber
Ropeways 2
Power Ropeways
also called SKYLINE CRANE
Gravity ropeways
b/w 2 points of varying elevation
sag to control speed
Timber Slides 2
Control sections of 100 m separated by pool of water
labour placed at each pool
Wet slides
joints made water tight
requires continuous flow of water
Dry wooden slides
Mud applied to act as Brake
wear & tear of timber
Earth slides
trough scooped out of hill
checkwalls along the sides
Storage 6
Mgmt. of depots
Layout
separate plot for each specie
well drained
wide enough passage
Stacking
not exposed to sun
species wise & size wise
enough space for movement of trucks
aeration & yet close together
stock taking
inventory records
quality wise stacking
fire & theft protection
sandal wood
notices
chips & refuse wood should not be left scattered
Fire extinguishers
Smoking forbidden
Protection against insect attack
Place on cement/iron to avoid termites
avoid dampness
Protection against fungal attack
aeration
cut ends should be given anti fungal coating
End splitting should be minimized
Water depots
still water depot
River depot
Sea shore depot
depot is place where timber or other forest produce is stored
Water depot to store timber being transported by water
Land depots
to store forest produce transported by land
transit depots
temporary according to location of felling site
Sale depots

Consideration for transit depots

- Stacking should be done by species & size. Facilitate checking & accounting
- timber should not be stacked under the sun as it may crack. Upper surface should be covered with grass
- Enough space should be allowed in between rows of stacks for free movement of trucks
- Notices prohibiting smoking, kindling of fire should be there
- Records should be made of inventory for accounting purpose

4 new points

Consideration for sale depot

- For valuable species like sandalwood, measures should taken regarding security of premise
- location should be close to main line of transport
- timber should be well aerated in stacks
- <Considerations of transit depot>
- well drained site as dampness causes deterioration of timber
- sold material should be dispatched asap
  - reduce risk
  - space for new inventory

Sawmill (5)

- Plant with different types of machines for sawing logs into planks, scantlings, boards, beams etc
- Selection of machines for Permanent sawmill (5)
  - maximum daily output
  - low operational cost
  - accuracy in producing timber of reqd. dimensions
  - ease of use
  - efficient use of wood with less wastage
- Type of saws (3)
  - Reciprocating type
    - Cut in 1 or both strokes
    - Hand saw
    - Saw is a cutting tool with toothed edge
  - Revolving type
    - Chain saw
  - Travelling type
    - Band saw
- Method of Sawing (2)
  - Plane Sawing
    - || to growth rings
  - Quarter Sawing
    - ⊥ to growth rings
- Selection of machine for Portable sawmill (5)
  - minimum time should be spent on site preparation
  - Machines that can be easily dismantled & transported are preferred
  - machine should use portable generator sets
  - set up in forest where it is difficult to transport wood & its economical to convert wood in forest itself
  - But there should be good foundation for high speed machines

Machines used in wood workshops (5)

- Various grades of fineness
- Sand papering machines
- thicknessing machines
- Surfacing machines
- General Purpose circular saws
  - cutting
  - ripping
  - levelling
- Boring machines
- a plant comprising various small machines & tools for finishing of the wood product

Defect in timber (6)

- hole
  - Caused by insects, birds or mechanical injuries
- knot
  - Cut off portion of branch leaves a mark
- decay or rot
  - brown or light grey patch on timber
- inbark patches
  - patches of bark full enclosed inside the bark
- flute
  - longitudinal depressions on surface of converted material
- Spiral grain
  - Spiralling along length of the log
  - measured in terms of acute angle they make with the axis of the log
  - Usually 45° spiral

System of extraction & disposal (3) (1)

- Working by pvt. parties
  - malpractices
- Working by govt. agency
  - inefficient
- Working by govt. & pvt. parties
  - transportation, conversion, by pvt.
  - felling & sale by govt.

Sale of timber

- Method of sale (2)
  - By auction
  - By negotiation
  - By fixed tariff
  - By tender
- System of sale (3)
  - Lump sum sale
    - fixed sum paid for forest produce
    - 3 instalments: 0, 1/2, 1
  - Payment on outturn
    - Sale of entire coupe or area
    - Sale of marked standing trees
    - Sale by license & permits of certain produce (eg. grass)

Forest Industry

- Major forest based industries
  - Plywood, Hard board
  - Newprint
  - Paper & Pulp
  - Tanning, Resin, Lac
  - Saw milling
  - Sports goods bat, sticks, racket
  - Furniture & Cabinet
  - Pencil
  - Match making

(3) Shortcoming of saw milling industry

- Kerf is the wastage caused due to "width of saw cut". Due to lack of modern thin-kerf machines, there is a lot of wastage

- Lack of integrated saw milling. In integrated saw mills, waste of one process / operation is used as input for other ⇒ possible to use > 90% of wood

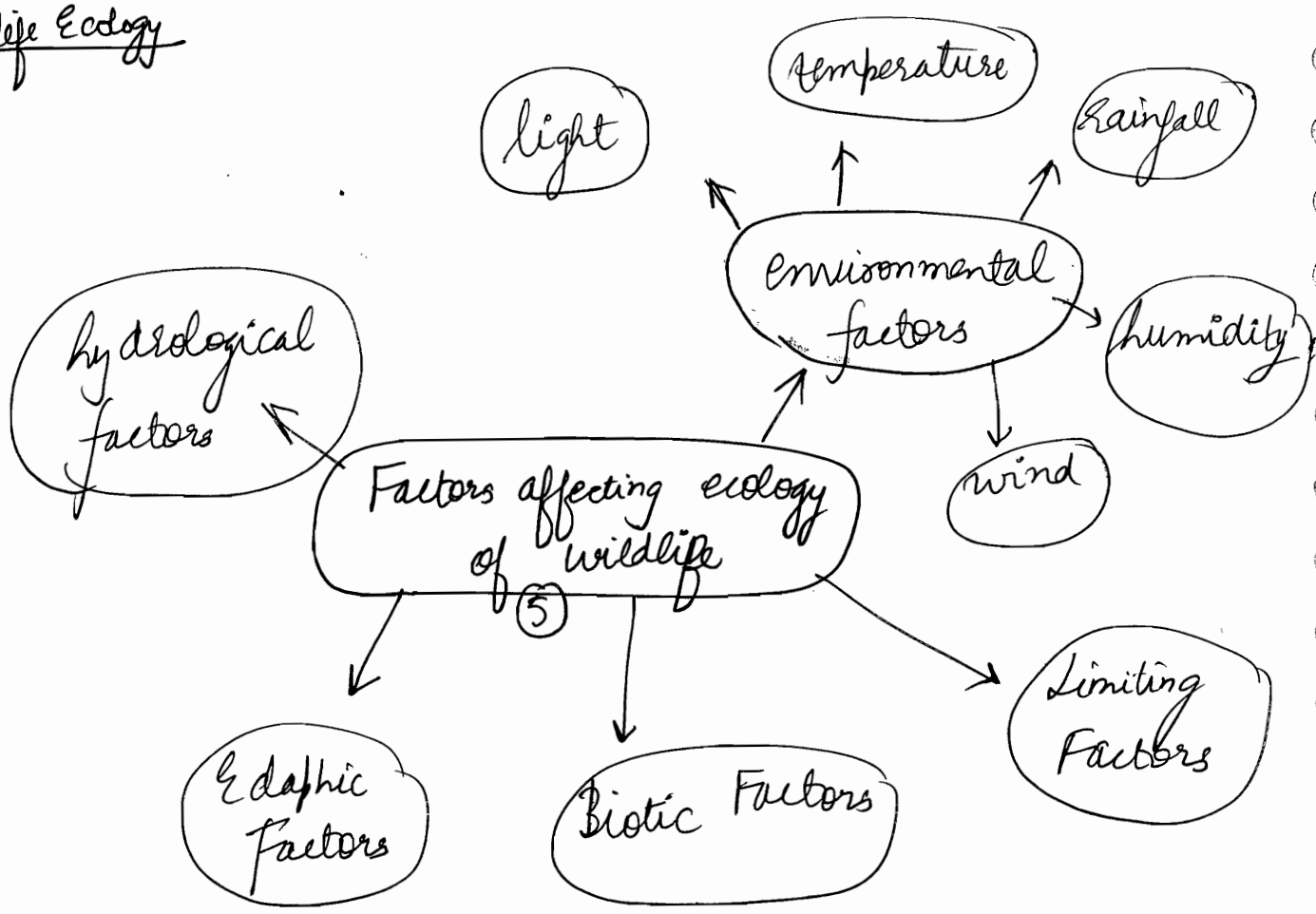
(4) dry sawing

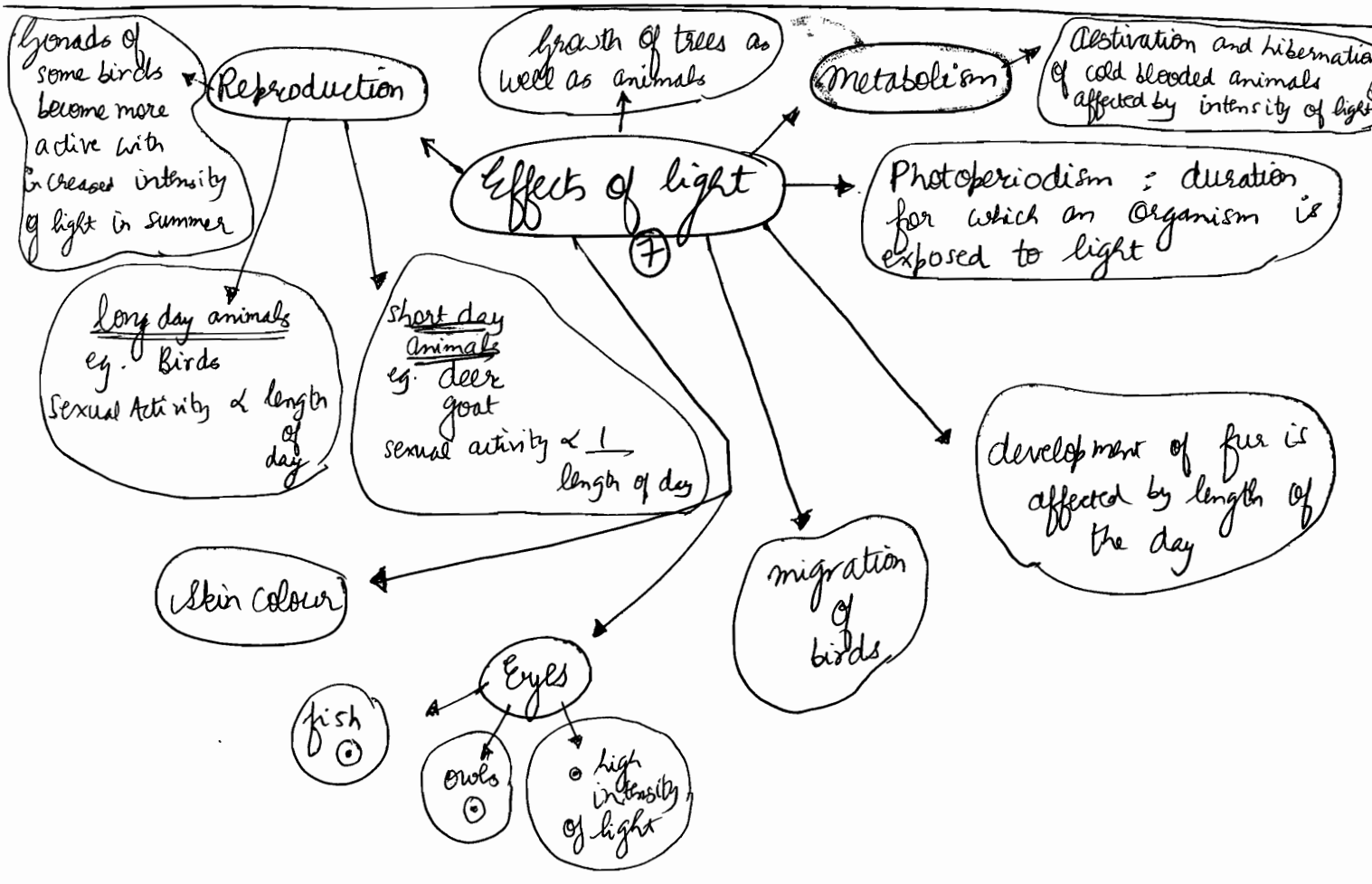
- When dry sawing of logs kept in sun, 40% of timber is spoilt by cracks
- danger of fire breaking out
- Wood is not easy to cut in case of dry sawing
- excessive wear & tear of tools

Grading of Timber

- Based on Sizes
- Structural Strength
- Based on Quality
- Based on Species
- Based on Appearance & Odour
- Based on defects

Wildlife Ecology






Effect of temperature on Animals
8
Adaptations like
- hair, fur
- fat & thick skin
- sweating to keep cool
Aestivation by cold blooded animals during Summer
Hibernation by Cold blooded animals during winter
6
Self imposed dormancy
metabolic activity at lowest ebb
Heart Beat reduced
Animals, during this time live under rocks, in burrows
Reserves of fat & glycogen provide energy for survival
eg. FROGS AMPHIBIANS
Thermal migration to areas of Optimal temperature conditions
Metabolic Activities brought about by enzymes influenced by temp.
↑ activity upto a limit then drop in activity
Gloger's rule
Color of Mammals & birds of warm regions is darker
Bergmann's Rule
Species of colder regions are larger in size
⇒ larger animals has lower surface area per unit weight ⇒ lower radiation heat loss eg Polar Bear
Allen's Rule
Animals of cold areas have a more compact structure
i.e. tail, ear, neck
eg. short ears reduce the exposure to blizzards
eg. Arctic Fox vs desert fox
(Gloger : radial)
Gloger ⇒ Colour
Bergman ⇒ large
Allen ⇒ anatomy
Effect of hydrological factors : adaptations
9
migration in search of water
Feathers in birds, scales in reptiles help to reduce water loss
lower animals such as earthworm have the ability to absorb water through their skins
Birds excrete solid urea as they need more water to fly
ability to maintain water reserves in body
no. of water sources determine Carrying capacity of the land
modification of kidney function to conserve water
nocturnal animals avoid heat of the day
Underground burrows help avoid dessication due to day's heat

Fate of vegetative matter on soil top layer (7)

- disintegrated organic matter is also acted upon by different fungi & bacteria
- Organic matter loses its form & structure
- Undecomposed matter consists of sugar, starch, proteins, cellulose, lignin, resin etc. Soil organisms use starch, sugar, carbohydrates for their energy needs
- Crickets, termites, earthworms use organic matter as food & disintegrate it
- Lignin & waxes do not undergo much change
- Carbon is oxidized & CO_2 is released
- Bacterial Activity stops after fresh organic matter is used up

Law of minimum

- A minimum supply of food, water & shelter requirements are req'd. for survival
- Eg small ↑ in CO_2: good for plant
  large ↑ in CO_2: toxic

Limiting Factors

- availability of a "requirement", below or above a certain limit may also limit the abundance / growth of the species
- distribution of any species is species is adversely affected if an environmental factors exceed maximum tolerable limit or reduce below minimum tolerable limit
- Something like a limiting reagent

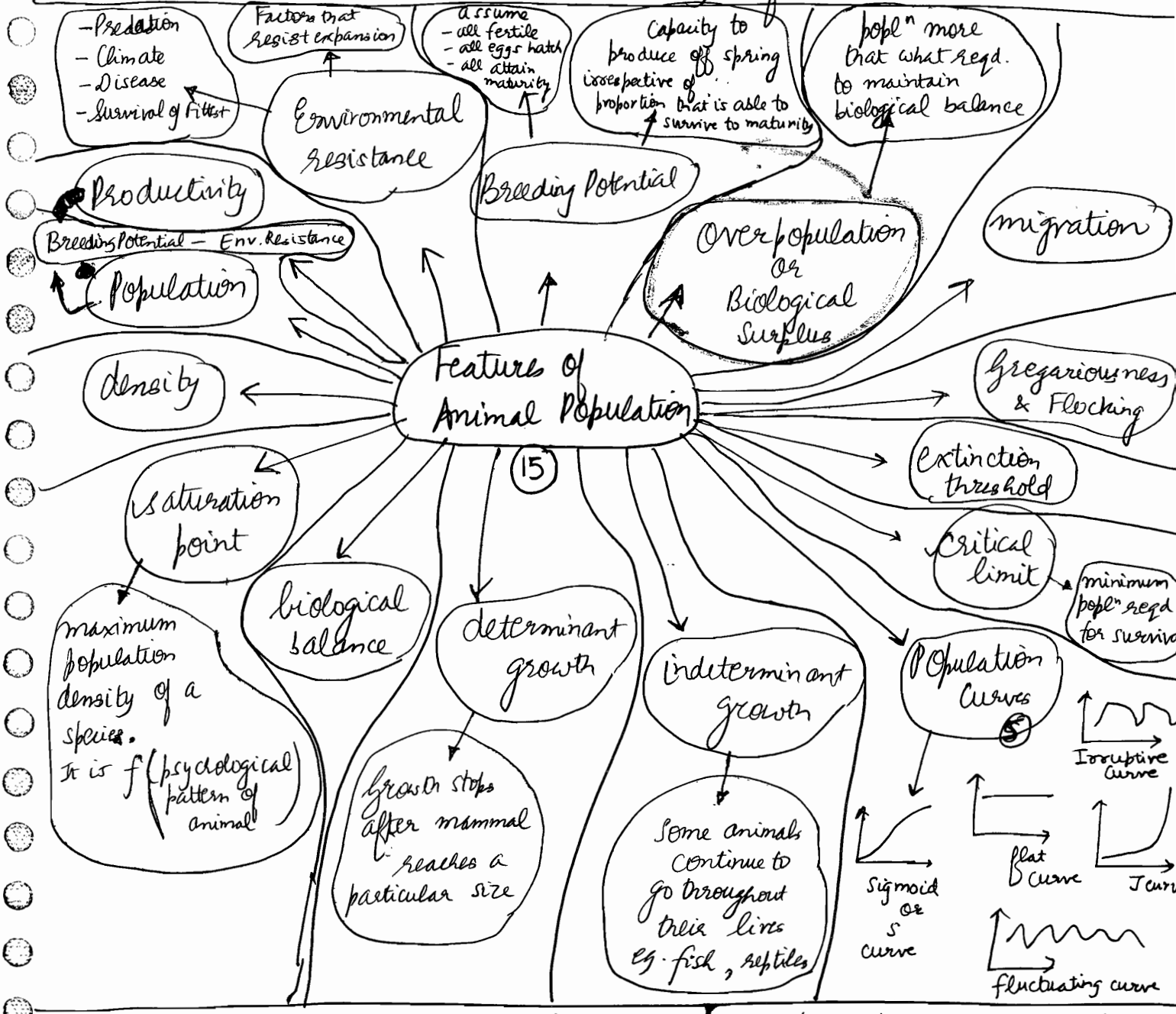
Law of tolerance

- All environmental factors have a tolerance level in relation to a particular species
- There is a critical minimum level & critical maximum level

Upper limit of tolerance
zone of physiological stress
Optimum range
Zone of physiological stress
lower limit of tolerance

Wildlife Biology

"The greater the complexity of biological community, the greater its stability and ^ (in order to promote ecological resistance to invaders and to prevent damaging explosions in native population, the best course is to conserve the variety of nature.



- Critical popl^n depends on
  - area of reserve
  - availability of food
  - predation, competition, poaching
  - psychological requirement (sense of security)

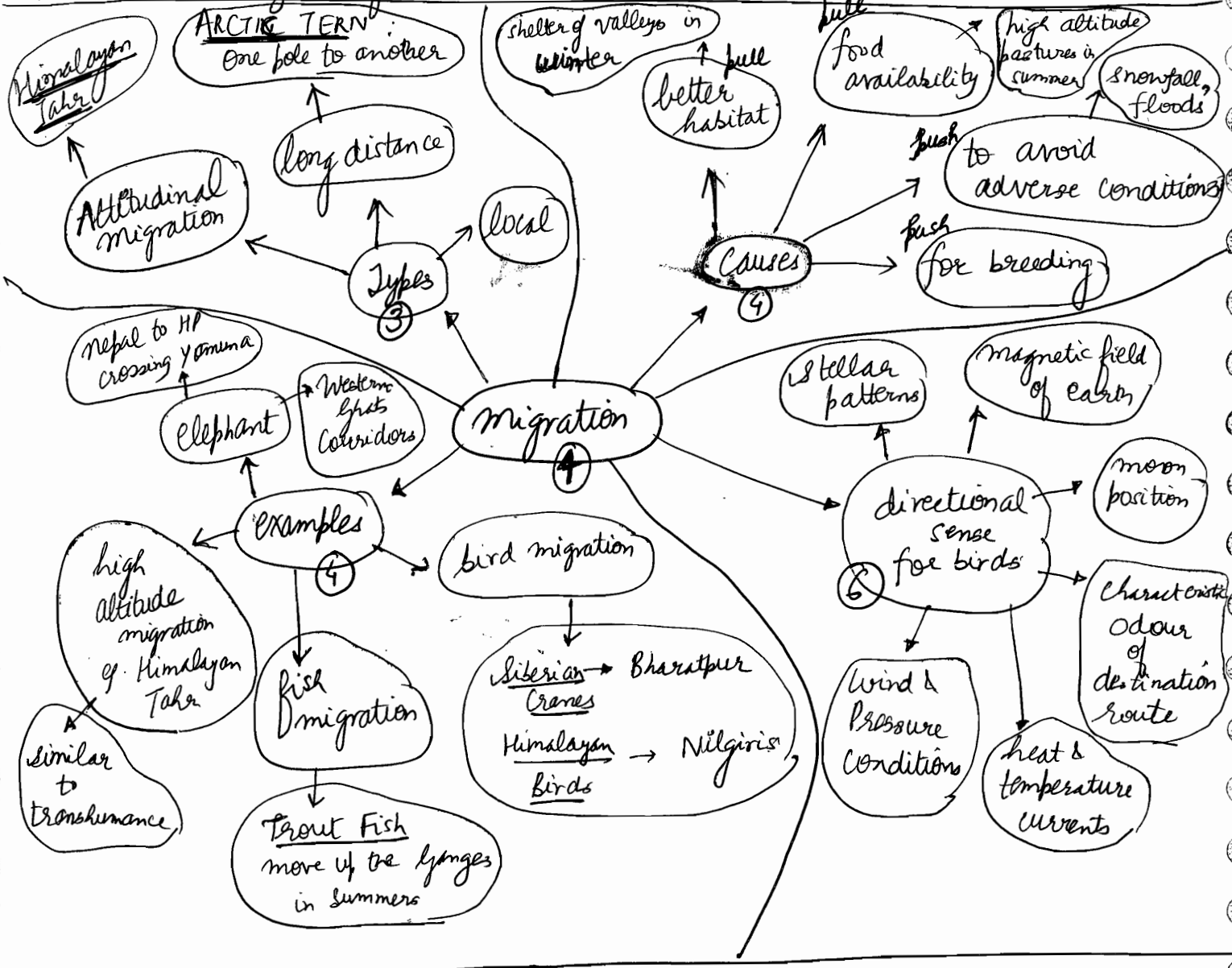
- Productivity pertains to actual reproduction of a particular species.
  Following factors affect productivity:
  - breeding potential
  - environmental resistance
- Population = Productivity + Original Popl^n.
  Population = Breeding Potential − Environmental Resistance
  (includes Original ones)

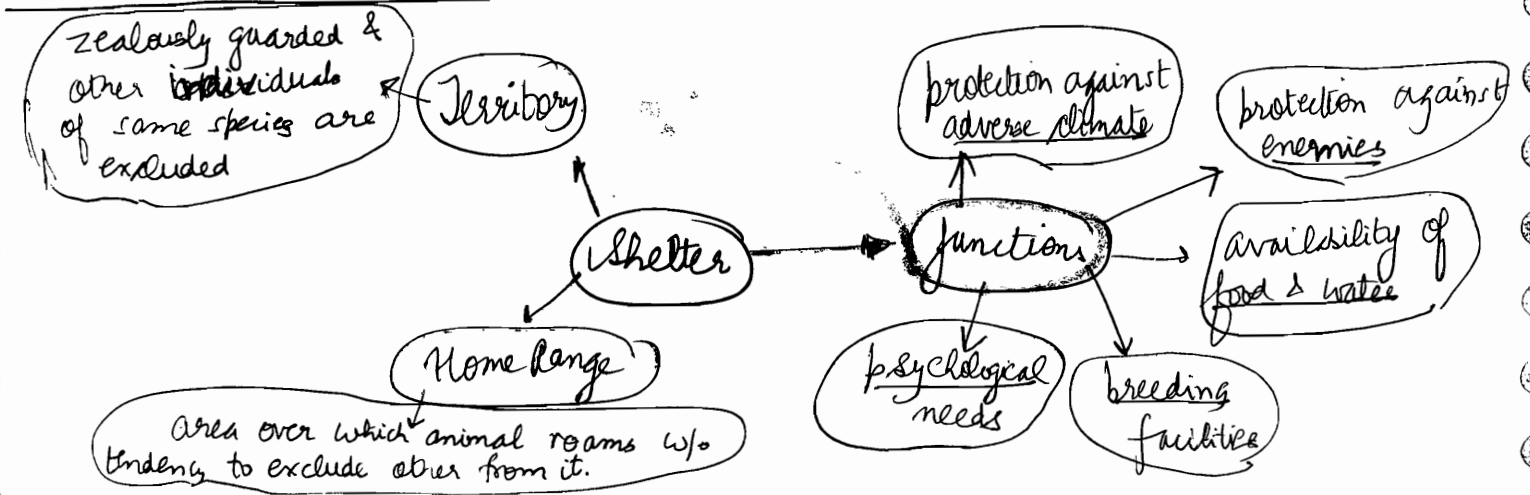
Gregariousness & Flocking

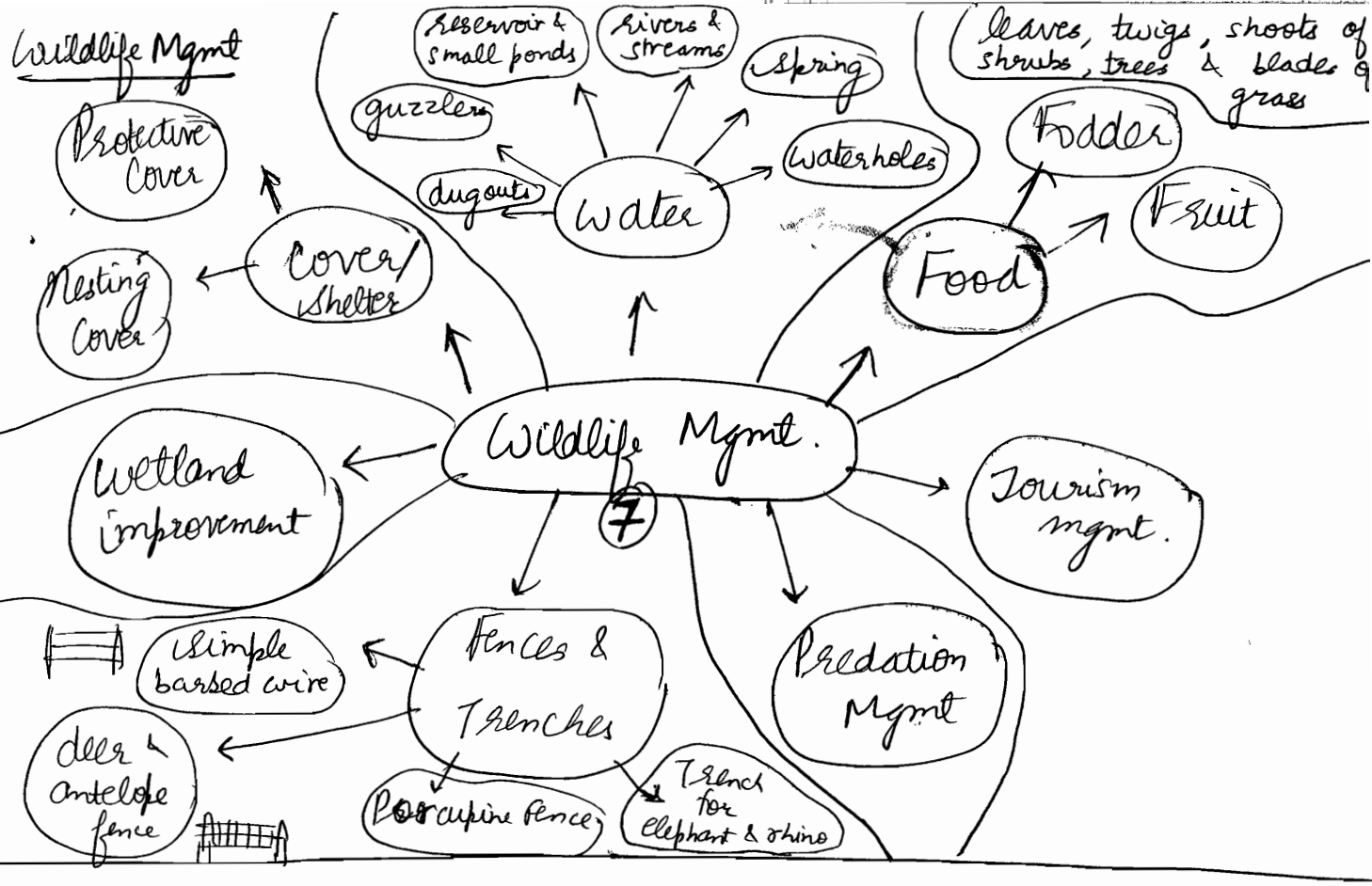
- Tendency of animals to stay together & live in groups.
  eg. deer, antelope, monkeys, elephants, birds, lions
- On on other hand, leopards & tigers are loners.
  Also predatory birds like eagles.

Pecking Order

System of social dominance in species showing flocking, based upon relative strength of individuals.







⊙ Protective Cover (escape, winter or refuge cover)
- Hedgerows
- Brush Piles
- Natural & Artificial Roosts
  - Artificial
  - Natural

⊙ Nesting Cover
- Ground Nesting Cover
- Den & Nesting Trees (trees with nests are not felled)
- Nest Boxes
  - wood duck nest box
  - squirrel
  - birds

(should be
- light weight
- durable
- large enuff
- climate resistant
- economical & simple to build)

nest: constructed space by birds, where they sit, rest, sleep, lay eggs & take shelter

roost: temporary place for birds either to rest or escape a predator


Wetland Improvement
Potholes
excavation with bulldozers, draglines, or manually
these are open water basins less than 1 hectare area
Blasting for hard country rock
Shallow marshes
dredging
ditching
Artificial Flooding
Seasonally Inundated Basins
Adequate provision to retain rainwater
dikes are formed to control water level
levees are seeded for raising a permanent vegetative cover
spillways are used to provide drainage
Predator management
tendency in hoofed animals & rodents to over populate if no control
⇒ problems of starvation, disease, scarcity of food
live on surplus of prey species ⇒ no negative effect on latter's popⁿ
Occupy the apex position in the ecological triangle
importance of Predators
not necessarily destructive for humans : barn owl is helpful
Eg. Tiger Reserve
high scientific value
source of recreation in wild
keep the popⁿ of unwanted prey species in check


Wildlife Viewing areas
landforms
Area of Interest
Viewpoints
waterhole
rivers lakes
Points of Interest
Tourism Resource Inventory
saltlicks
temples
waterfall
Walking / trekking / cycling
Picnic & camping
Viewing wildlife on foot, camel, elephant, jeep etc.
Some limited activities allowed in Buffer / Tourist zone
Tourism zone Mgmt
Core & Buffer zones
Tourism Mgmt.
5
Visitor Carrying capacity
Signs & maps
Bunker type
Ground level type
elevated type
Hides & Machans
Social Carrying capacity
Facility Carrying capacity
Physical Carrying Capacity
level to which visitors can tolerate presence of other visitors
Accomodation, amenities
level of recreational use after which visitors cause irreparable damage to wild
Scale & distances
public amenities
position of visitor
Maps show
boundaries
Areas / points of interest
points of entry / exit
Roads / parking
Signs
Orientation
conveying instruction for helping visitor
directional
showing way to a place
interpretative
to convey conservation message
Frames Per second

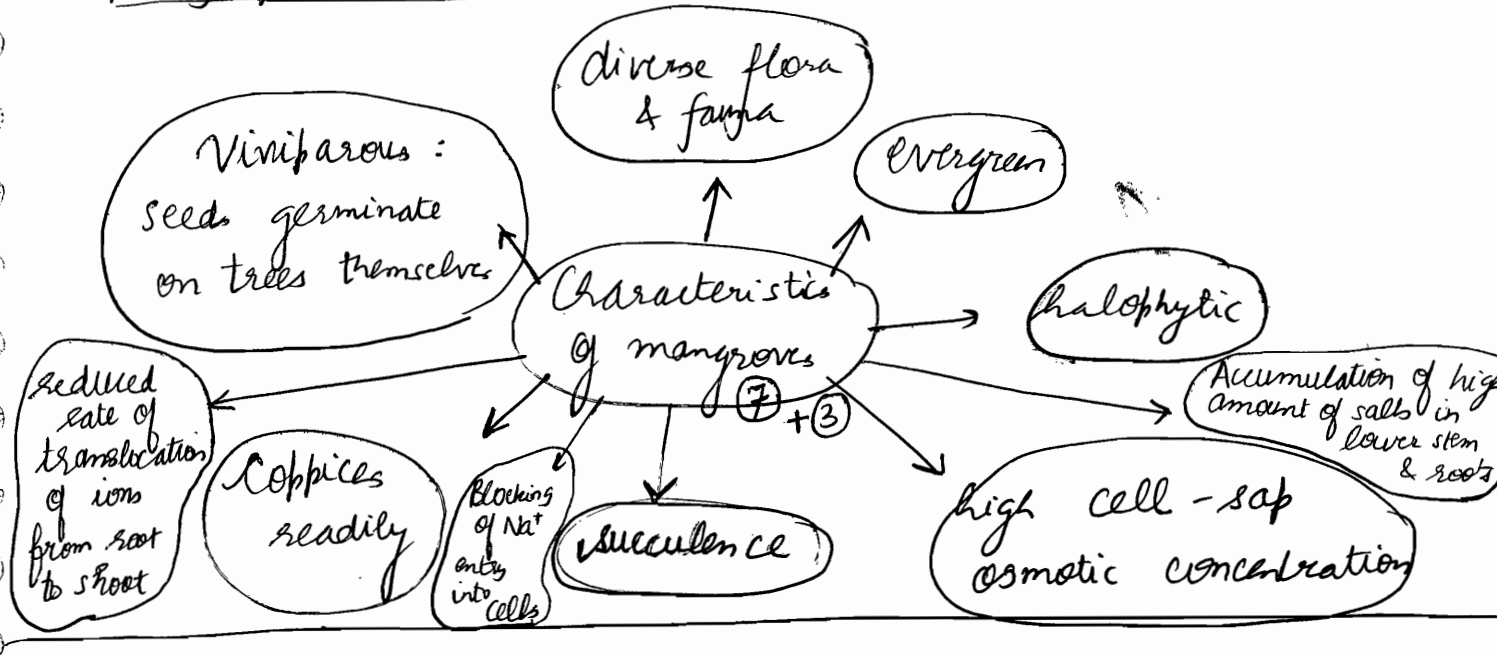
- Eurythermal animals: Capacity to tolerate a wide range (elongated) of temp
  Stenothermal animals: Can tolerate only a narrow range of temperature. (short range)

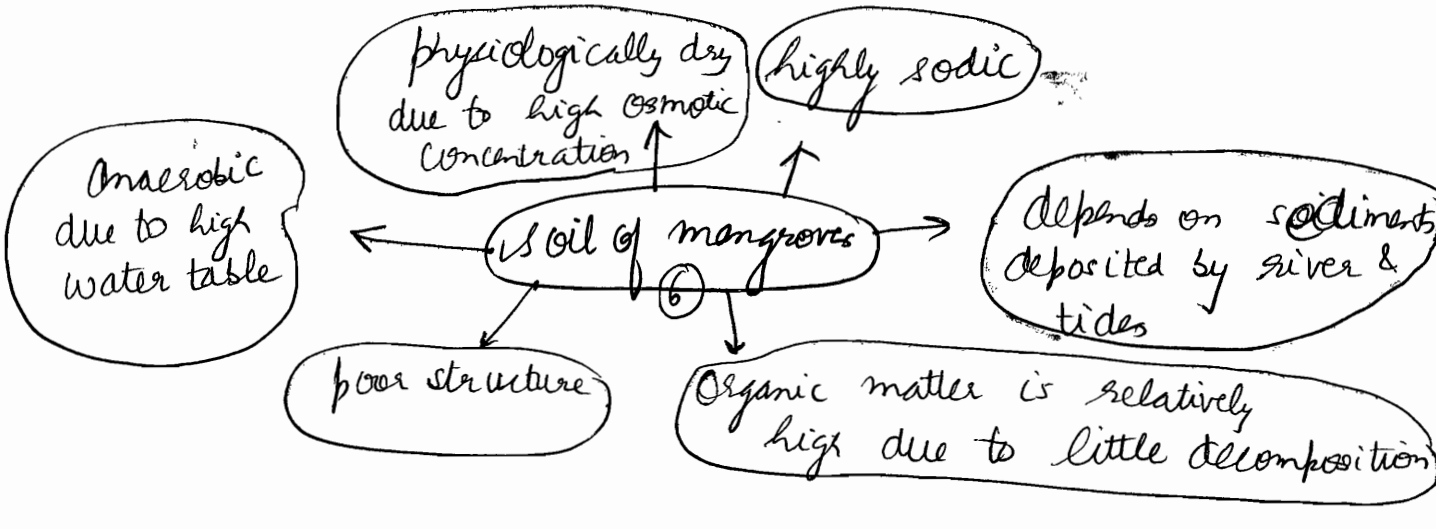
- Wings : Flight
  Feathers : Body insulation, control of flight, camouflage

Mangroves

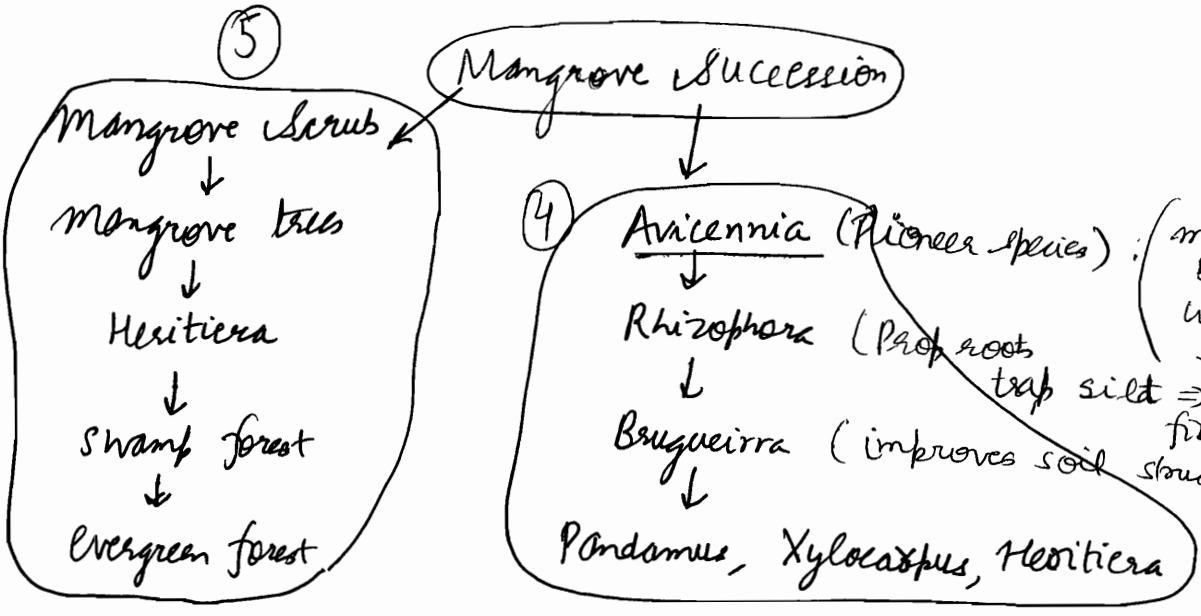
(1)

Mangroves are halophytic trees & bushes growing below the (2) high water level of spring tides. They have remarkable capacity for salt water tolerance (3)





(5)



Avicennia

Proximal

Rhizophora

towards sea water, subject to tidal waves ⇒ stilt roots, prop roots

zonation

middle

Bruguiera

Core zone of mangroves

distal

Xylocarpus

Heritiera

Pandanus

towards land, lower salinity, lower duration of tidal submersion

Management of mangroves (4)

Felling straps are oriented 45° to tidal waves ⇓ facilitate dispersal of seeds & protection from tidal erosion

Harvesting

disease & pest control

Insecticides & pesticides are washed away

stem borer

termite

leaf eating caterpillar

Crab eat succulent roots

Artificial regeneration

Small seeds plants (easily washed away) require saplings from nursery

Avicennia

Aerial seeding

Afforestation (6)

Area selection

local's consideration

extensively degraded that needs immediate attention

Specie selection

Plant Succesion & Zonation ↑ fundc

Site preparation

Slash should be burned & Collected

Weed eradication

Protection

Pest Control

Cattle Fence

Algae damage due to waterlogging

Beating Up

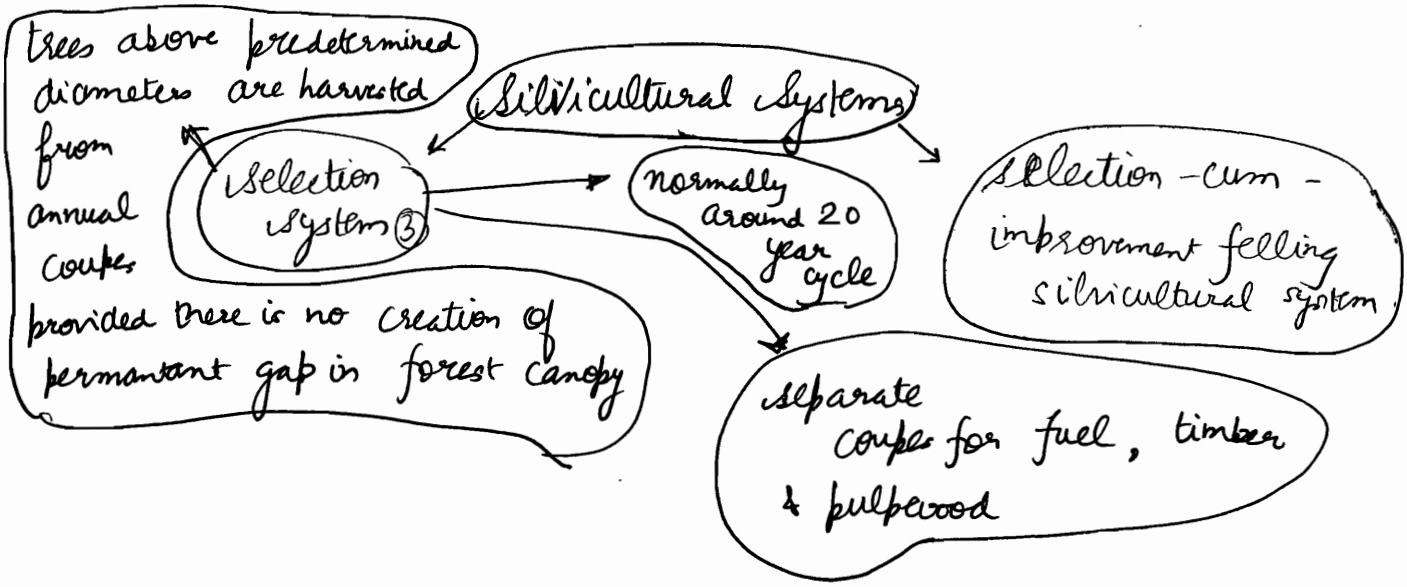
Casualty replacement

Fish Bone Technique Plantation

Plantation at 45° degree to wave action

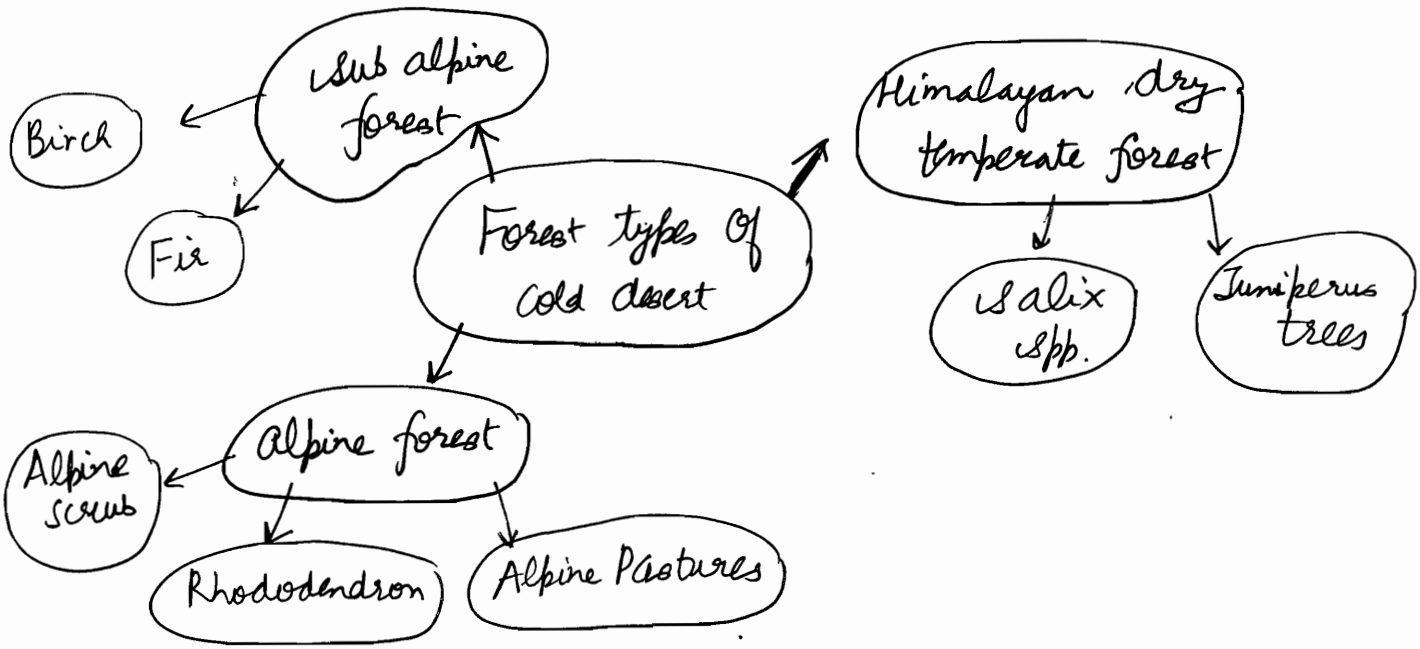
Herringbone formation

do not draw direction of sea

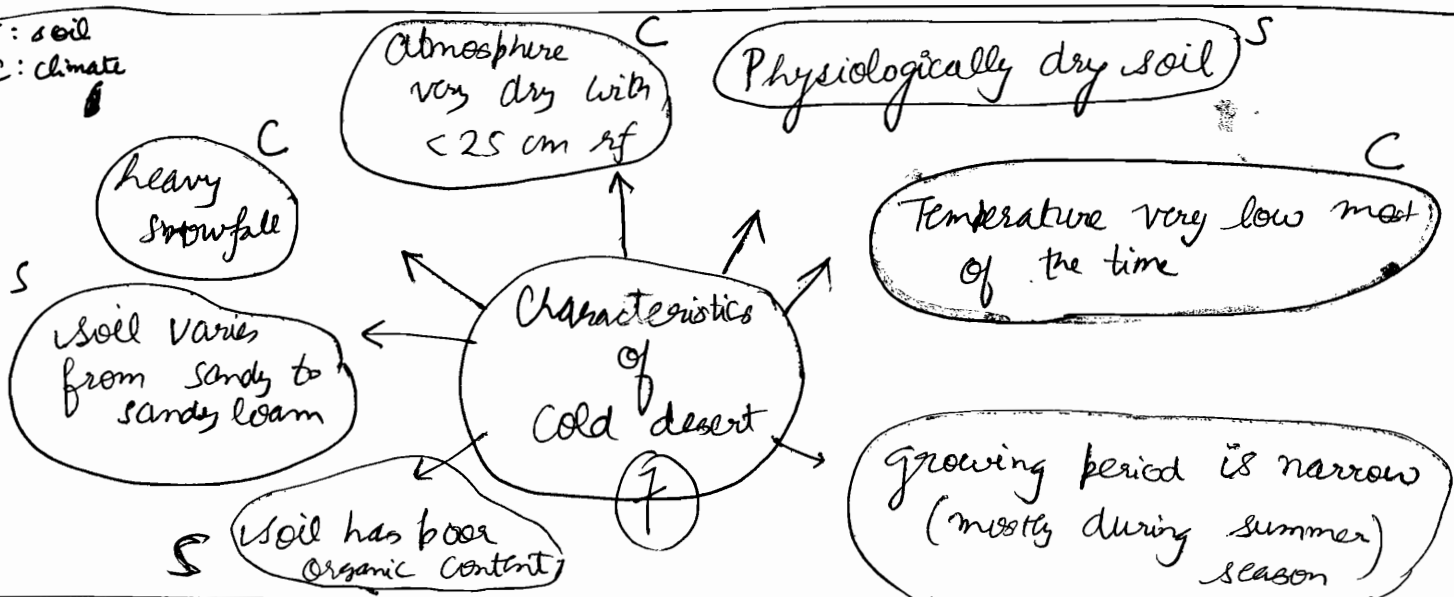


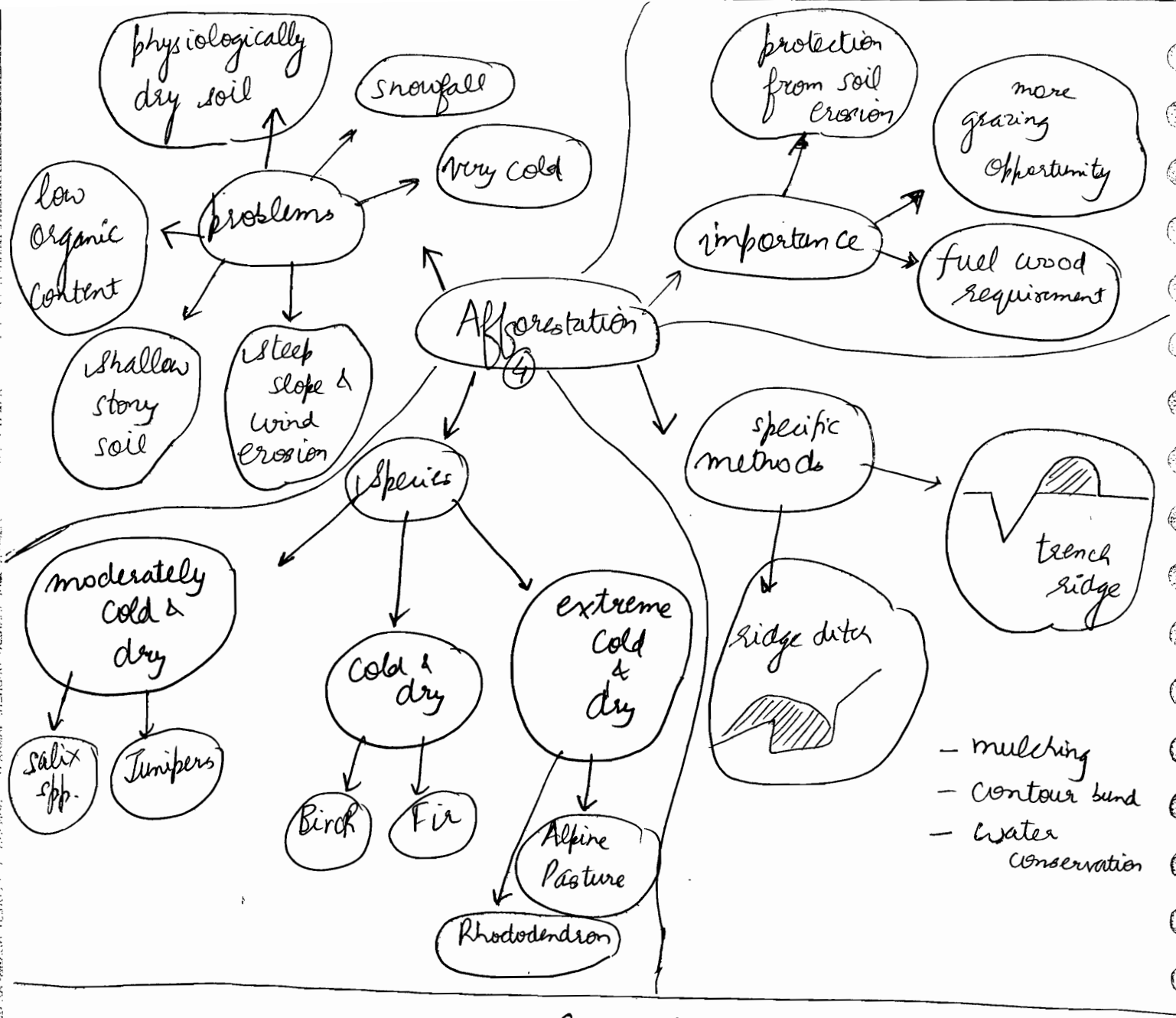
Cold desert

Cold desert is an area which experiences extreme cold weather and denuded terrain. Also referred to as temperate desert. Occur in India @ Ladakh, Leh, kargil, Spiti valley



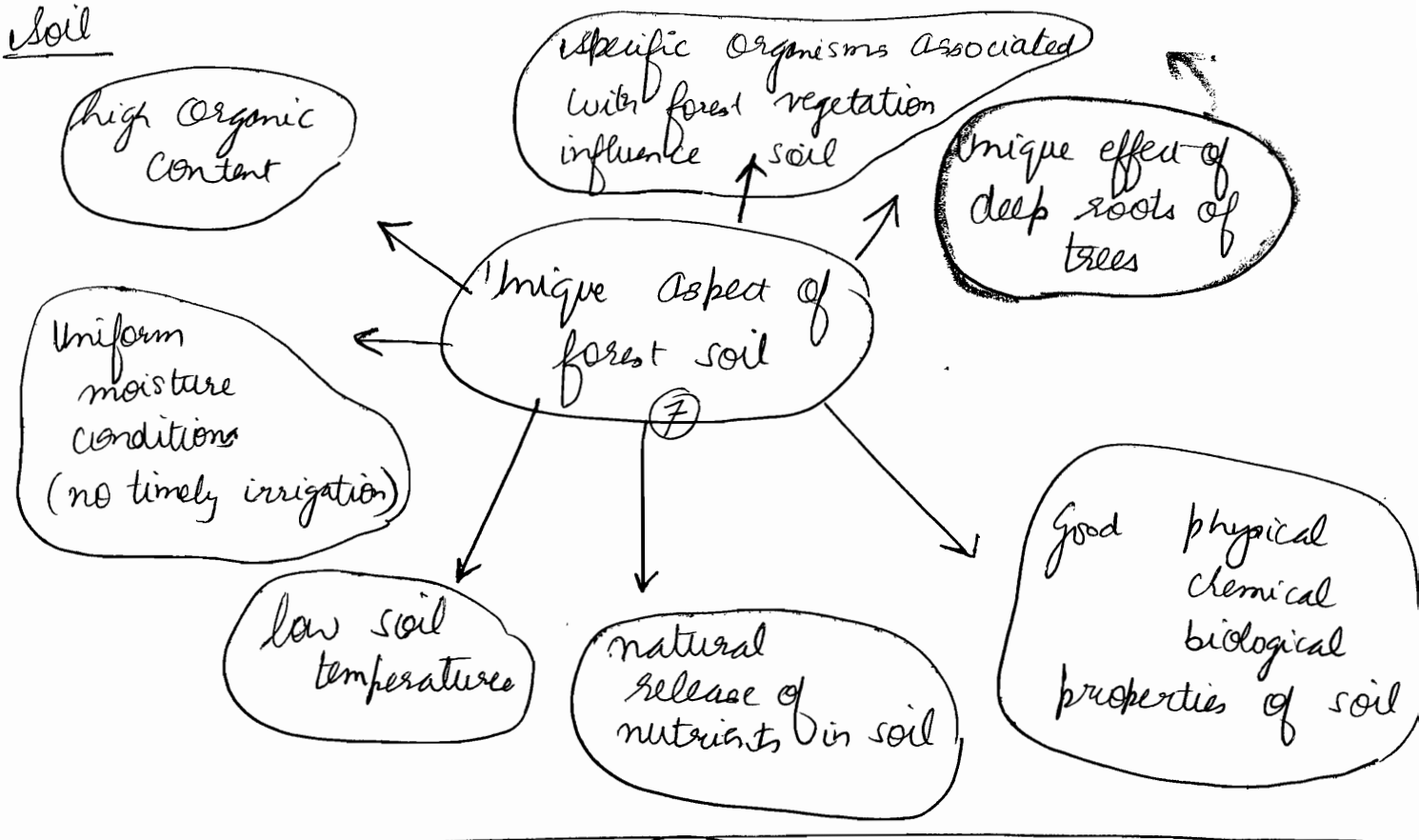
3S : soil
3C : climate

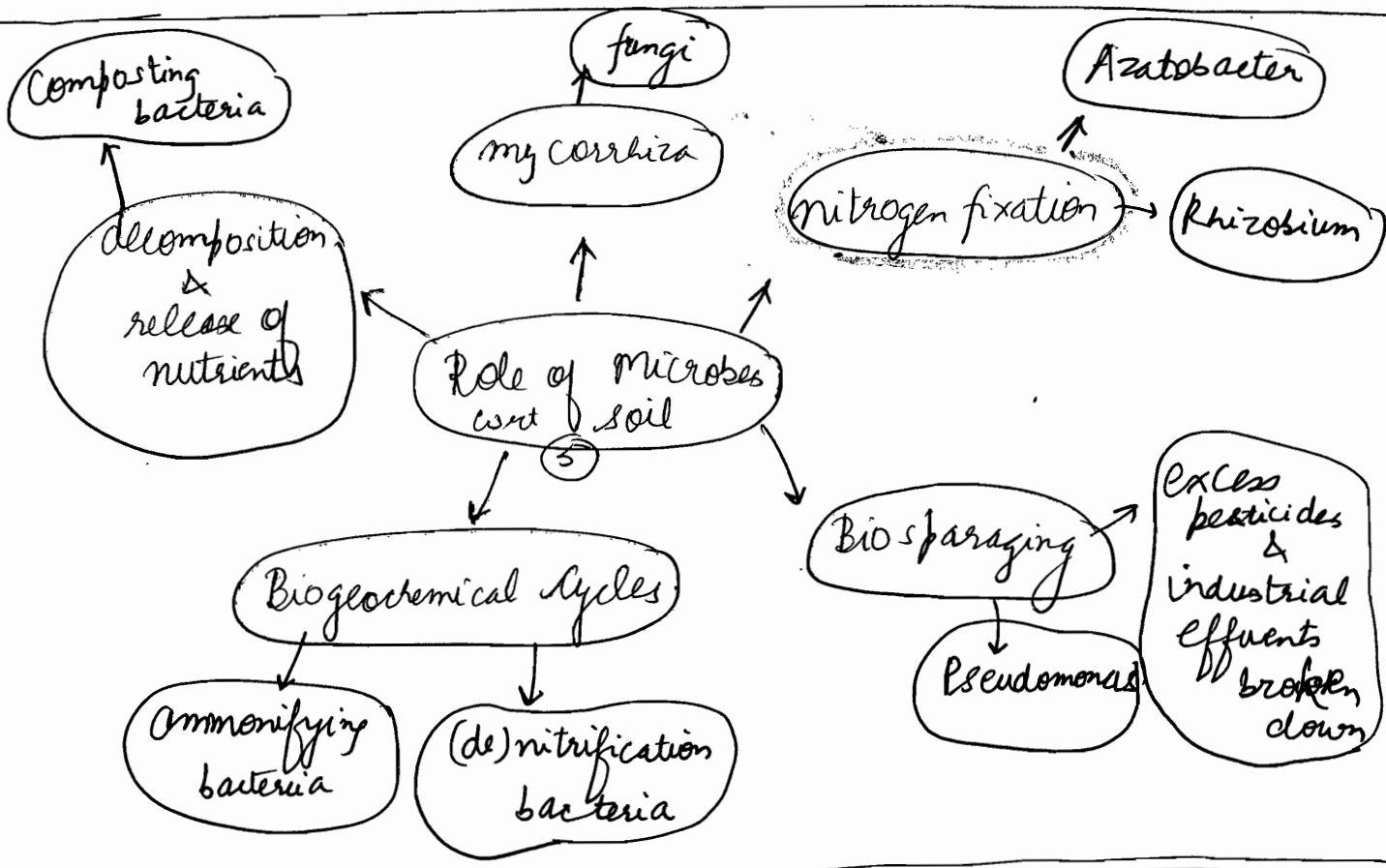


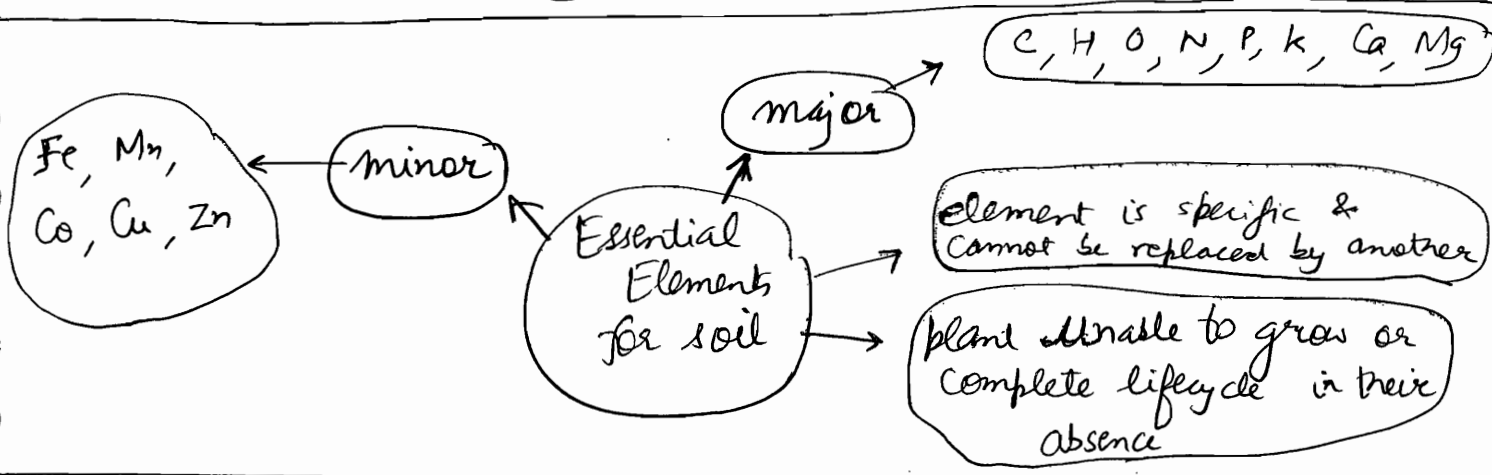


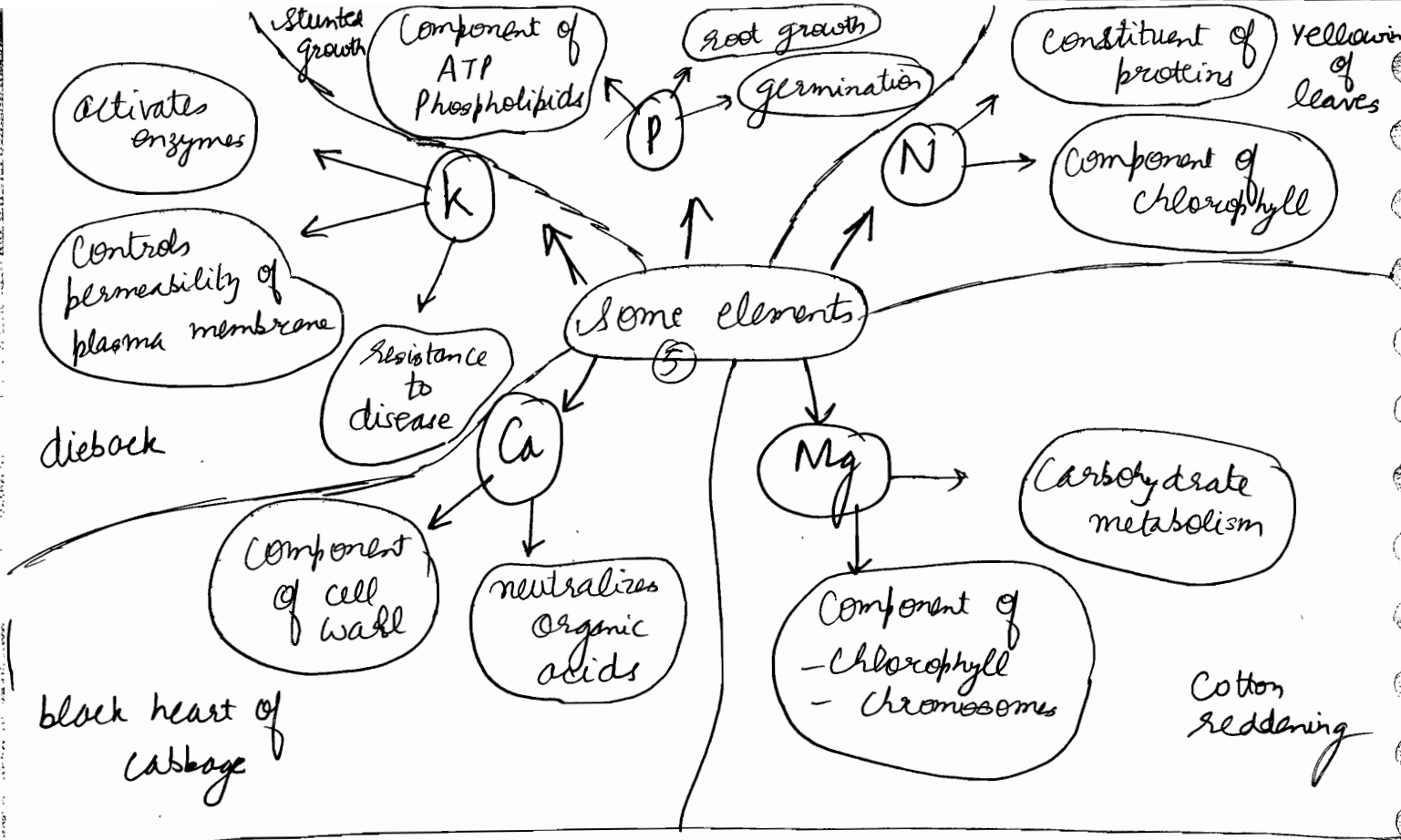
★ Mangroves belong to Group 4B of Champion & Seth Forest Classification.

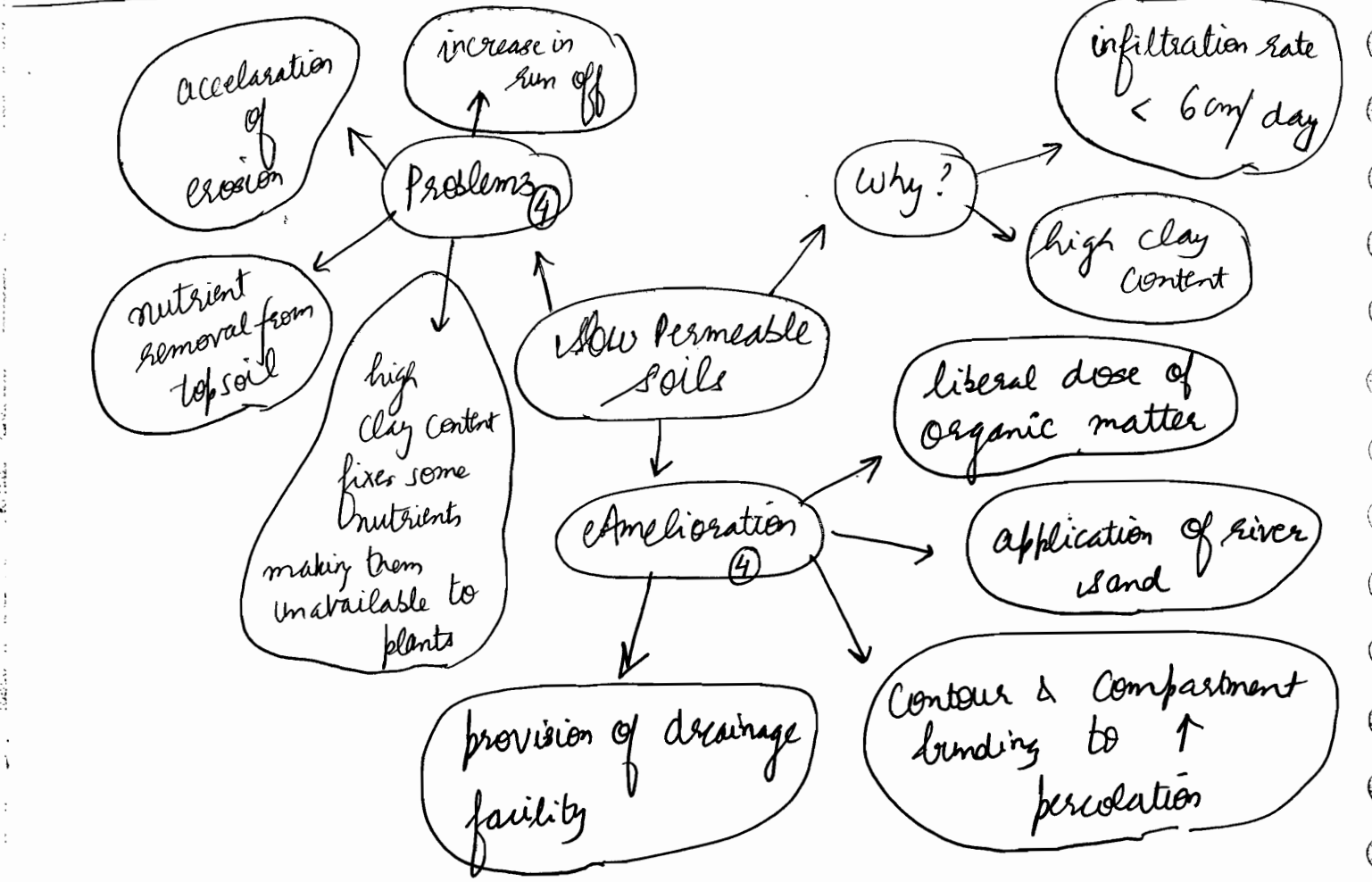
Soil


Unique aspect of forest soil
7
high organic content
specific organisms associated with forest vegetation influence soil
unique effect of deep roots of trees
Uniform moisture conditions (no timely irrigation)
low soil temperatures
natural release of nutrients in soil
Good physical chemical biological properties of soil

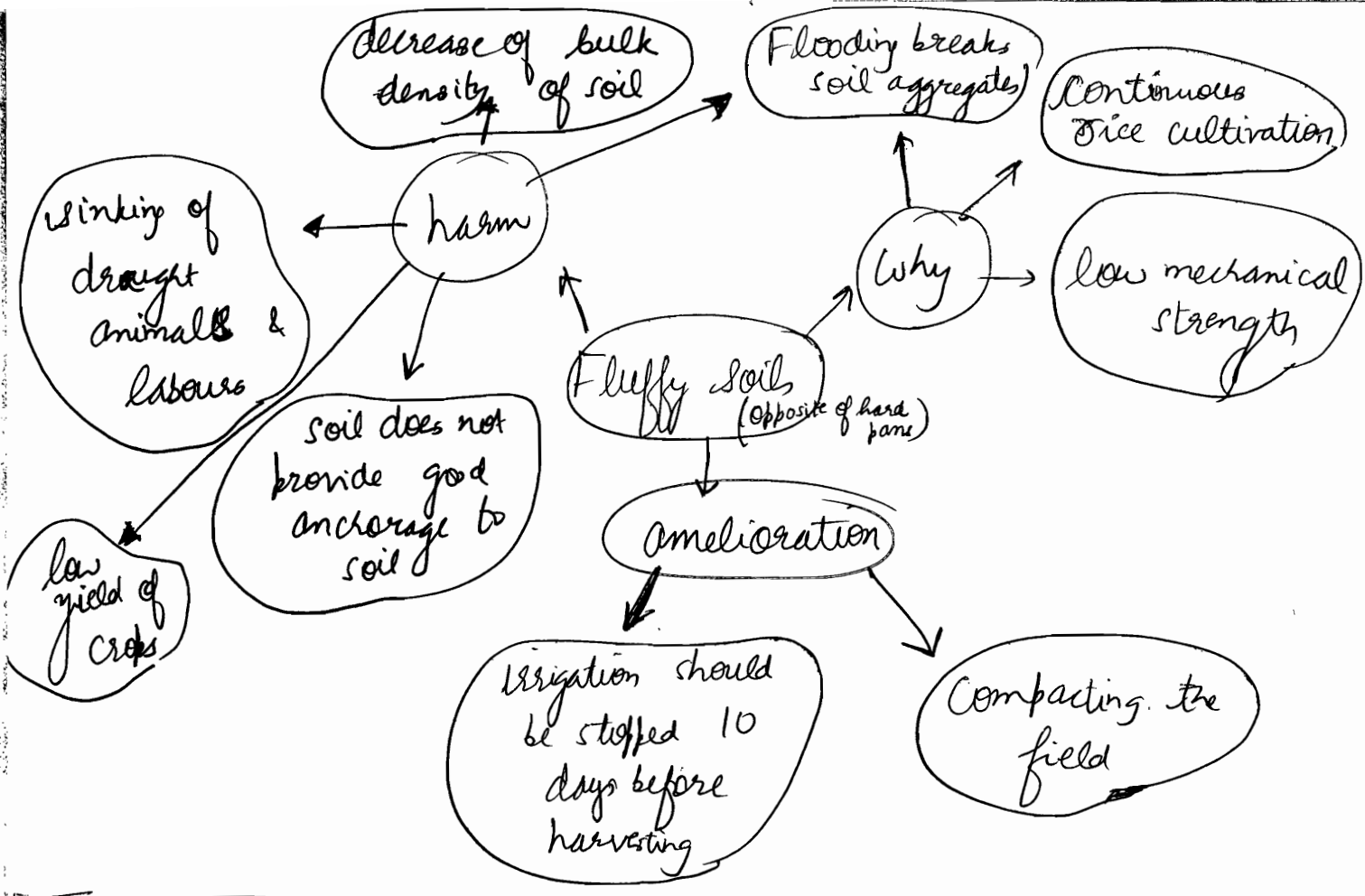

Role of Microbes in soil
5
decomposition & release of nutrients
Composting bacteria
mycorrhiza
fungi
nitrogen fixation
Azatobacter
Rhizobium
Biogeochemical Cycles
ammonifying bacteria
(de)nitrification bacteria
Biosparaging
Pseudomonas
excess pesticides & industrial effluents broken down


Essential Elements for soil
major
C, H, O, N, P, K, Ca, Mg
minor
Fe, Mn, Co, Cu, Zn
element is specific & cannot be replaced by another
plant unable to grow or complete lifecycle in their absence


Some elements
5
K
Activates enzymes
Controls permeability of plasma membrane
P
Component of ATP Phospholipids
Stunted growth
root growth
germination
N
Constituent of proteins
Yellowing of leaves
Component of Chlorophyll
Ca
Resistance to disease
Component of cell wall
neutralizes organic acids
Mg
Carbohydrate metabolism
Component of - Chlorophyll - Chromosomes
die back
black heart of cabbage
Cotton reddening


Problems
4
acceleration of erosion
increase in run off
nutrient removal from topsoil
high clay content fixes some nutrients making them unavailable to plants
Slow Permeable Soils
Why?
infiltration rate < 6 cm/day
high clay content
Amelioration
4
liberal dose of organic matter
application of river sand
provision of drainage facility
Contour & Compartment bunding to ↑ percolation


Excessively Permeable soil
Problems
Soil unable to retain nutrients
leaching of applied fertilizers
devoid of finer particles & organic matter
those having more than 70% sand
Why?
Amelioration
4
Compacting the field with
- 400 kg stone roller
- empty coal-tar drum filled with 400 kg sand
8 to 16 times
Reduces non-capillary pores
polythene sheets can be spread below soil surface
fine dose of organic matter
Application of clay soil
Hardpans
problems
3
prevents root proliferation
increase of bulk density
limits nutrient uptake only from topsoil
decrease of percolation
Why
Clay or Fe/Al oxides or Calcium carbonate
Continuous crop growth with heavy implements
Amelioration
3
deep ploughing of soil
Application of Organics
Cultivation of deep & hard rooted crop to encourage natural breaking of hard pan : Mango, Ber



Waterlogged soils :- depth of water table < 2m

marshy land :- permanently / periodically inundated by water

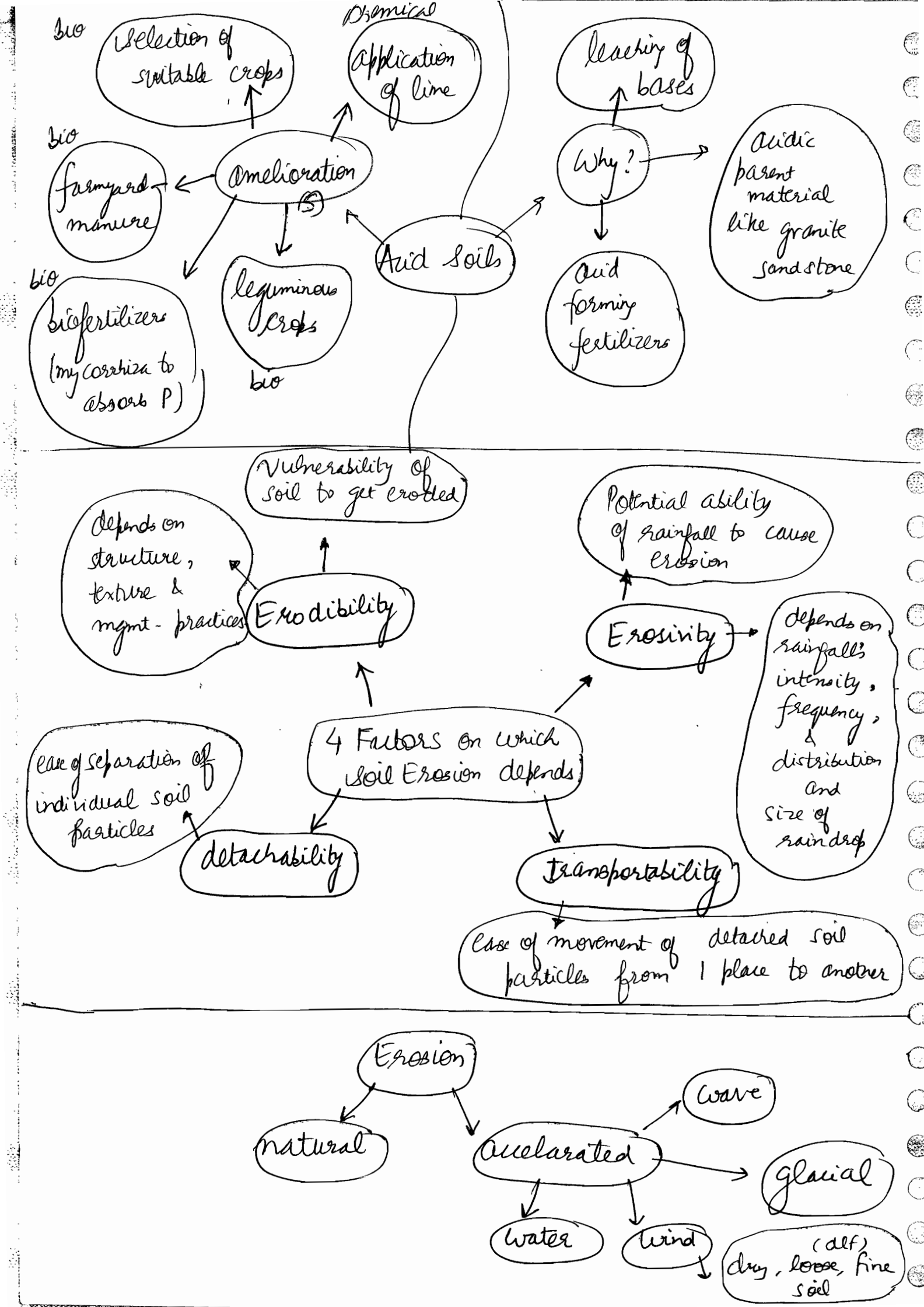
- An area is said to be waterlogged when the water table rises to an extent that soil pores in root zone of a crop become saturated, resulting in
  - restriction of normal circulation of air
  - decline in the level of O_2
  - increase in level of CO_2

- Causes of waterlogging
  - excess irrigation
  - excess rainfall
  - improper drainage

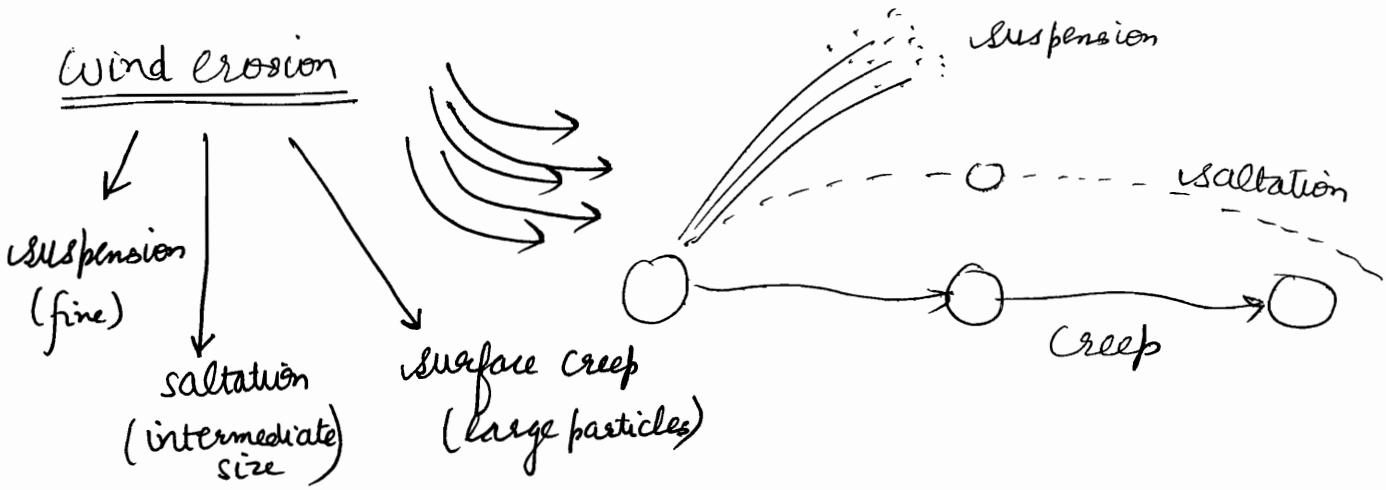
- deteriorates soil structure.

- Alleviation of waterlogging / write for soil with low percolati
  - provision of drainage
  - appropriate land use : wet crops like rice, bamboo
  - utilization of land for aquaculture

→ alleviate :- to provide relief from pain
→ ameliorate :- to make better, improve


Bio
Selection of suitable crops
Chemical
Application of lime
Bio
farmyard manure
Amelioration
Bio
biofertilizers (mycorrhiza to absorb P)
leguminous crops
Bio
Acid Soils
leaching of bases
Why?
Acidic parent material like granite sandstone
Acid forming fertilizers
Vulnerability of soil to get eroded
Depends on structure, texture & mgmt - practices
Erodibility
Potential ability of rainfall to cause erosion
Erosivity
Depends on rainfall's intensity, frequency, & distribution and size of raindrop
4 Factors on which soil Erosion depends
ease of separation of individual soil particles
detachability
transportability
Ease of movement of detached soil particles from 1 place to another
Erosion
natural
Accelarated
wave
glacial
water
wind
dry, loose, fine soil
(alf)

Wind erosion

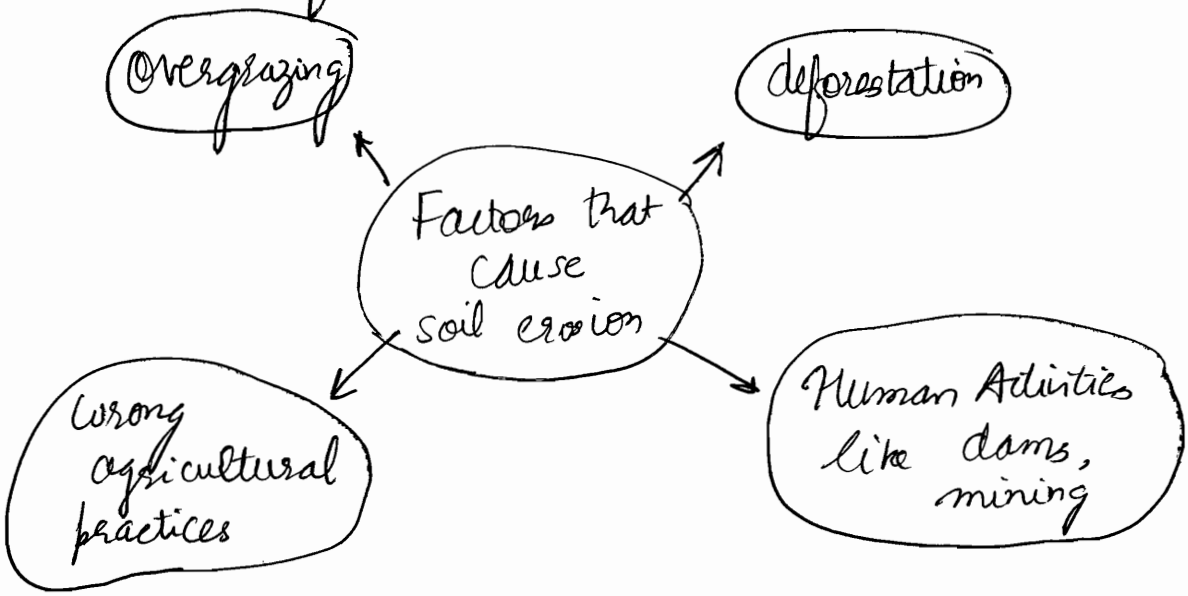


- Arenaceous — rich in sandy soil
- Argillaceous — " " clayey soil
- Calcareous — " " $CaCO_3$
- Carbonaceous — " " Carbon

→ Soil fertility is the capacity of the soil to supply nutrients to crops in the form that can be utilized by plants.

→ Soil Productivity is the ability of the soil to produce a particular crop under a specific management system.

→ Soil erosion refers to detachment and transportation of soil material from one place to another, through the action of wind, water, ice, waves etc.



Harms due to erosion

- deposition of sands on productive fields
- loss of fertile top layer
- loss of soil layer that took 1000s of years to form
- siltation of lakes & rivers ⇒ channel capacity ↓ ⇒ overflow ⇒ floods
- reduced percolation ⇓ ground water table ↓ ⇒ droughts
- increased run off

Water erosion

- rill
- sheet
- splash
- ravine
- gully
  - gullies can be V shaped or U shaped
  - Active (further erode) or Inactive (stable)

Soil loss equation : R × K × LS × C × P

- R → erodivity
- K → erodability
- LS → slope length
- C → cover of vegetation
- P → Practices like terracing, bunding, contour farming

राधा कृष्ण (गए) Lok Sabha
Communist Party (की ticket पे)

Agrostological measures : Use of grass
eg. Munja

Forests role in soil conservation

- Obstruction to run off ⇒ reduces run off rate
- intercept rain drops
- reduce velocity of ↑ wind
- more percolation, less run off
- Organic matter ⇒ better soil structure
- deep roots

(★) In short, reduces erodability, detachability & transportability