COURSE CODE:	FWM 301
COURSE TITLE:	PRINCIPLES OF SILVICULTURE
NUMBER OF UNITS:	2 Units
COURSE DURATION:	Two hours per week

COURSE DETAILS:

Course Coordinator:	PROF. A.M. ADURADOLA
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Other Lecturers:	MR. A. O. OLADOYE

COURSE CONTENT:

Meaning of Silviculture, Importance of Silviculture in forestry practices. Analysis and study of problems of raising the tree crops. Climatic and Edaphic factors affecting tree growth. Tropical forest regeneration methods – Natural and artificial. Application for establishment and maintenance of forest for various purposes. Taungya and other silvicultural practices.

COURSE REQUIREMENTS:

This is a compulsory course for all students in the University. In view of this, students are expected to participate in all the activities and have minimum of 75% attendance to be able to write the final examination

READING LIST:

COURSE OUTLINE

1. INTRODUCTION

    - What is Silviculture
    - Silviculture in forest resources management
    - Silvicultural terminology

2. PRODUCTIVITY OF INDIVIDUAL WOODY PLANT

    - Determinants of dry production
    - Factors affecting plant growth (light, moisture, temperature, mineral nutrient supply, composition of atmosphere.
    - Physiological processes in tree growth.
    - Photosynthesis, Biosynthesis, Assimilation, Transpiration plant nutrients and metabolism.

3. STAND PRODUCTIVITY

    Stand classification (Origin, composition, structure)

    Factors affecting stand growth.

4. REGENERATION METHODS

    - Natural regeneration
    - Artificial regeneration
    - Enrichment planting
    - Taungya system

5. INTRODUCTORY NURSERY TECHNOLOGY

    - Seed technology (seed collection, storage and treatment

- Nursery operations (Permanent and temporary nursery mycouhiel inoculation and seed sowing)
- Nursery care

  (Shading watering, weeding pruning, soil management and seedling transportation).

SILVICULTURAL SYSTEMS AND TREE (FOREST) PRODUCTION

Silviculture derives from the word Silvis. Silvics is the study of the life history and general characteristics of forest trees and crops, with particular reference to environmental factors, as the boisic for the practice of Silviculture.

Silviculture has even variously defined as:

1. Dand Smith (1962) the art of producing and tending, a forest, the application of the knowledge of Silvics in the treatment of a forest, the theory and practice of controlling forest establishments, composition and growth.
2. It is also defined as the art and science of cultivating forest crops or that branch of forestry which deals with the establishment, development care and regeneration of stands.

The subject of Silvicultural practice consists of the various treatments of forest stands that may be applied to maintain and enhance their productivity. The duties of the forester with respect to Silviculture are to analyze the natural and economic factors of significance on each stand under his care and to derive and apply treatment most appropriate to the objective of management.

Silviculture occupies a position in forestry that is comparable or analogous to that of agronomy in agriculture. This is because it is concerned with the technical details of crop production. It is an applied science that rest ultimately upon this more fundamental natural and social sciences. In

Silviculture, information of forest crops and technical procedures are developed for the scientific tending and reproducing of these crops. In a broad sense we thus have both the principles and practice of Silviculture.

The principle provides the scientific basis, while the practice is the application of the scientific basis.

The principles of Silviculture are concerned with the interpretation of forest vegetation as influenced by the environments which consist of actors of the habitat such as climate, soil and biotic factors. It views the forest as a complex structure with different biological units. It provides knowledge with the law governing production, on the capacity of forest stand and basis for little management around at forest development.

The practice of Silviculture deals with methods used for achieving the objectives. Thus, it can be called applied Silvics. It deals with the relationship between cultural method of cutting a stand and natural regeneration which is expected to follow the cutting.

- Also deals with the reduction and tending of stand e.g. thinning and pruning operations.
- Also concerned with methods of improving bole and methods of clearing and improving the quantity of the stand.
- Applicability and advantages of various methods
- Comparison of various methods of collecting seed and other uses.

THE PLACE OF SILVICULTURE IN FOREST RESOURCES MGT.

Forest resources are increasingly constituting a significant element in the national economies of many tropical countries. Unlike the past, when forests were taken for granted because they were found almost everywhere, the awareness has increased of the direct and for reaching influences of forest, as available forest area is continually diminished while the demand for forest goods and services soars.

The use of forest resources can be classified under

1. Major use e.g. wood as industrial raw materials.
2. Intangible benefit such as recreation and watershed management.
3. Minor produce e.g. food (fruits) useful plants tannins, gums etc.

The use of plant materials as raw materials now stands next in importance to their uses as food directly or indirectly. Wood is still the world’s major structural material for building and other construction purposes. The Mahoganies of West African and the Meruntis of Malayan ran forest furnish the world with solid stocks and veneers for furniture. The mechanical/and chemical conversions of wood to pulp for the manufacture of paper and certain synthetic textiles consume enormous quantities of wood. Wood is aging treated to yield plastics, glues and special bonding agents. The distillation of wood yields a variety of valuable industrial chemicals such as methanol, acetic acids, turpentine, tanning materials and other products. In this age of energy shortages and oil politics the practice use and establishment of energy plantation or true plantation too harvest solar energy through bioconversion are being increasingly explored (Anom, 1970).

Besides supplying industrial raw materials, forest also have the added value of conservation for scenic purposes, stabilization of climate, maintenance of water supply and prevention of erosion. The dense, forest canopies form good protectors of soil against radiation and excessive diurnal temperature fluctuations. Vegetation generally serves as a good conserver of soil water by encouraging percolation and discouraging run-off. Its humus content also augments the water storage capacity of the soil for future use by booth plants and animals. Deforestation of upper parts of slopes often leads not only to increased evaporation of large quantities of water from the watershed but also alters the land use capabilities of the lower slopes trees also have an important function in breaking the forces of wind, thus preventing wind erosion. It has been shown by Haws (1959) that good wind-breaks induce relative calm up to twenty times the height of the trees on the leeward side and up to five times the height on the windward side such windbreaks help to increase the productivity of land by reducing the desiccating and abrasive of winds. Not only have these, forest provided food and habitat for wildlife. Wildlife management is almost impossible without some forms of forest management.

Modern forestry can then be defined as scientific management of forest resources for the continuous production of the important goods and services. However, unlike all other natural resources, forest resources are biologically renewable; they can grow and regrow after harvesting on the same site.

Hence to work effectively, forest resources management must be biologically as well as economically sound.

Siilviculture comes into forest resources management in the biological sector. Literally, it is understand to involve the formation of new or regeneration of old forests and caring for them until they are matured for the intended use. It is the science of how a forest crops can be produced naturally or artificially and cultured under the prevailing economic conditions to maturity for the projected use.

If the object of management is for cellulose production or as habitat or for recreational use, it is the duty of the Silviculturist to select those species and cultural techniques which will meet each objective. The Silviculturist is thus concerned not only with deciding what ought to be done but also the most economical way of achieving the various objectives. It must be noted that economic factors ultimately decide the silvicultural policy to be followed on any given area as the objective is usually to operate so as to maximize the value of benefits.

In recent times, the demand for land for other purposes and the general increase in cost of labour make intensive and efficient use of land available for forestry essential. It is apparent that only the most impressive evidence of prospective return may enable forestry areas of the tropics.

The importance of sound training in silviculture to enable the forest establish and nurture his forest in the most profitable ways, cannot be over-emphasized.

The silculturist needs a clear understanding of the factors that govern the growth of forest trees, both as individual and as stands, the interactions between the plants and their environments and the likely consequences of change in parts of the forest ecosystem.

PRODUCTIVITY OF INDIVIDUAL WOODY PLANT

The productivity of plant on a given site is measured by its biomass. Biomass is the amount of weight per unit area expressed in tons/acre or kg/hectare. It indicates the unit of efficiency between various sites. How long it takes the materials to be accumulated i.e. kg/ha/year or biomass per unit time gives the productivity.

DETERMINANTS OF DRY MATTER PRODUCTION

Dry matter maintain in woody plant is reflected in it growth. Growth is irreversible increase in size. This entails cell division of the somatic cell (the cambium either at the tip, stem or root).

Elongation of the cell

Differentiation of the cells cambium differentiate to provide phloem and xylem. Usually more xylem is produced than phloem.

Growth itself reflects an integrated physiological response to edaphic, climatic and biotic factors which by influencing the physiological processes. Contribute to the formation and expansion of the shoot. Because of this, it is extremely difficult to appraise the specific condition of under environmental factors to shoot growth. Among the most important environmental factors which affect plant growth are

1. Light
2. Water
3. Temperature
4. Mineral nutrient supply
5. Composition of atmosphere above and below the soil
6. Soil physical and chemical properties
7. Biotic factors e.g. insect
8. Other plants and animals
9. Cultural practices
10. Influence of genotype and age of the tree

Light

The main photosynthetic part of the plant is the shoot or leaves. In the case of forestry, this main point of conversion is in the shoot. The growth of plant shoot with respect to light is affected by

a. Degree of intensity
b. Photoperiod
c. Quality of light

PHYSIOLOGICAL PROCESSES IN TREE GROWTH

1. **Photosynthesis**: This is the greatest production process on earth crust the amount of CHO produced by it is seldom appreciated by foresters. It is generally accepted as the process by which CHO are manufactured from CO_2 and H_2O in chlorophylous plant tissues exposed to light energy is converted into chemical energy and stored in CHO from which it can be released in utilizable form for vital protoplasmic activities.

2. **Mechanism of processes**: The overall process of photosynthesis is an oxidation reduction reaction with CO_2 and H_2O, the photosynthetic sites being the chloroplasts. CO_2 in reduced and water oxidized essentially them in the transpresence of hydrogen from water to CO_2, leading to the formation of CHO. The energy required for these reactions is provided by sunlight. Chloroplasts also, visible light and use some of the energy to split water molecules into oxygen and hydrogen and to transfer the hydrogen to carbodioxide to form compound used an (CH_2O) units. Conventionally this can be summarized by the equation

$$6CO_2 + 6H2O \;\; \frac{\text{673 Kilo Calories gradient +energy}}{\text{Chlorophylous Cells}} \;\; C_6H_{12}+CO_2$$

The process is however not as simple as equation might imply like most physiological processes. This is a complex series of integrated reaction processes which appear to fall into at least three broad stages: Two photochemical is light reactions which provide the reduced pyrimidine nucleotide (NADPH) and ATP and One biochemical or dark reaction for the fixation and reduction, CO_2 using the reduced NADPH and ATP from the light reaction.

The photochemical stage involves the transporting light energy by chlorophyll and subsequent use in photolysis – a photocatalysed splitting of water molecules into hydrogen and oxygen.

$$2H_2O + 2A \xrightarrow[\text{Chlorophyll}]{\text{Light}} 2AH_2 + O_2$$

A profitable function of this reaction in the overall photosynthetic process is the provision of hydrogen atoms which are then stored in the chloroplasts by continuation with some hydrogen acceptor. This process is represented by the above reaction where A represents a hydrogen acceptor to which hydrogen is transferred from water by light energy absorbed by the chloroplasts. This phenomenon is known as "Hill reaction" after Hill (1937) who first demonstrated that illumination of a suspension of chloroplast in the presence of a suitable hydrogen acceptor resulted in the release of oxygen present evidence indications that the hydrogen acceptor is pyridine nucleotide which (NADP) on continuation with the hydrogen atom is transferred to the strong reductant, reduced pyridine nucleotide (NADPH2). Subsequent chemical transformations involving hydrogen utilize the hydrogen formed and storeed in this manner.

The second light reaction is the photosynthetic phosphorylation and the generation of Adenosine triphosphate (ATP) five Adenosine triphosphate (ATP) and inorganic phosphate. These photochemical reactions occur very rapidly (1 x 10^{-5}sec) and are independent of temperature but are influenced concentration CO_2.

The purely biochemical reaction stage (dark reaction) occurs more sparingly requiring about 0.04 second at 25^0C and is governed by 01 treatment is independent of carbodioxide concentration. In CHO synthesis the energy required to cause hydrogen to combine with CO_2 comes from light in a ATP and NADPH2.experiemnt have shown that where this products of photochemical reaction are available, the synthesis of carbohydrate can be carried out in the dark. Hence the reaction of CO_2 to form CHO is often referred to as dark reaction.

The dark reaction involves the continuation of CO_2 with a 5-carbon phosphorylated sugar called ribulose to form an unstable 6-carbon compound.

This breaks up into two molecules of a three-carbon energy rich sugar called phosphoglyceralaldehyde (PGAL) or triose phosphate. This is usually regarded as the first product of photosynthesis being the first substance formed after the ATP and NADPH2 from photochemical reactions have participated in the reduction of the carbodioxide

Most molecules of the triose phosphate are used in the formation of new ribulose with which more CO_2 can be processed. Some of them are used as a source metabolic energy by the all ion which it is synthesized and some are continued and re-arranged in glucose which is traditionally considered the end product of photosynthesis.

MAGNITUDE AND EFFICIENCY OF PHOTOSYNTHESIS

Approximately 3 x 10^{18} kcals of radiant energy are converted into chemical energy per year by terrestrial green plants through photosynthesis (Meyer *et al.*, 1960). In terms of weight, this is equivalent to producing 470 billion tones net of organic matter a year, using 690 billion tones of

CO_2 and 280 billion tones of air. Since green plants use about 80 billion tones of the food produced by this in kis, their true psstic production is about 550 billion tones (Greulech and Adams 1959).

It has been estimated that two-thirds of this amount is produced by forests.

The radiant energy used in this is only a small fraction of the total quantity of radiant energy impinging on the earth's surface estimated to be about 5 x 10^{20} kcals annually. Greulach and Adams (1959) recorded that leaves commonly absorb about 83% of the light that strikes them, reflect 12% and transmit about 5% and that of 83% absorbed only 4% is trapped by chlorophyll while most of the remainder is transferred into heat and re-radiated or lost otherwise. Since more than 99% of the incident radiant energy escapes capture by this they argued that plants could be considered as inefficient converters of solar to chemical energy.

With respect to forest stands, this apparent low efficiency can be traced to several factors like variations in spacing, age, time required to achieve maximum by growth and canopy closure, light intensity under which the trees are growth and availability of moisture and CO_2 among other factor for instance, photosynthetic efficiency is low in young stands in which canopies have not closed because of inefficiency in light interception. It is also low in or overcrowded stands of cause of poor light intensities for photosynthesis in shaded leaves. In such leaves and in senescent, the high ratio of RSS to PSS also results in low efficiency. These observations indicate that Photosynthetic efficiency in a tree stand increases with its age and reached a maximum value at the point of maximum leaf exposure (MLE).

When however, the photosynthetic efficiency is based on light energy absorbed by chlorophyll. Photosynthesis will be seen to be a very efficient proverb because about 90% of the absorbed light energy is converted to CHO. Percentage encourage maximum efficiency, the forest stand has to be handled at a point where the component trees expose maximum number of chloroplasts to solar radiation.

ENVIRONMENTAL FACTORS AFFECTING PHOTOSYNTHESIS

Several environmental factors influence the rate of PSS, among which are

1) CO_2 pressure susurrounding the Photosynthetic cells and CO_2 availability
2) Light intensity and light quality
3) Temperature
4) Water availability

   Beside these environmental factors, internal properties of the plant itself have some effect on rate of PSS, these are

5) Age of the plant
6) Chlorophyll content
7) Genotype and
8) Some less understood anatomical and chemical features of plant

AVAILABILITY OF CO_2

PSS occur only in the palisade layers (parenchyma cells) and also in the spongy mesophyll. The guard cells may also contain some chloroplasts in some species hence they do photosynthesize. Availability, CO_2 to photosynthetic differ depends in the rate of closure and opening, stomata and the condition of the atmosphere. The rate of closure and opening of stomata depends on light and also the movements of certain within the plant. This is counters balanced by the movement anions accompanied by movement of water, the stomata because turgid and hence opnes.

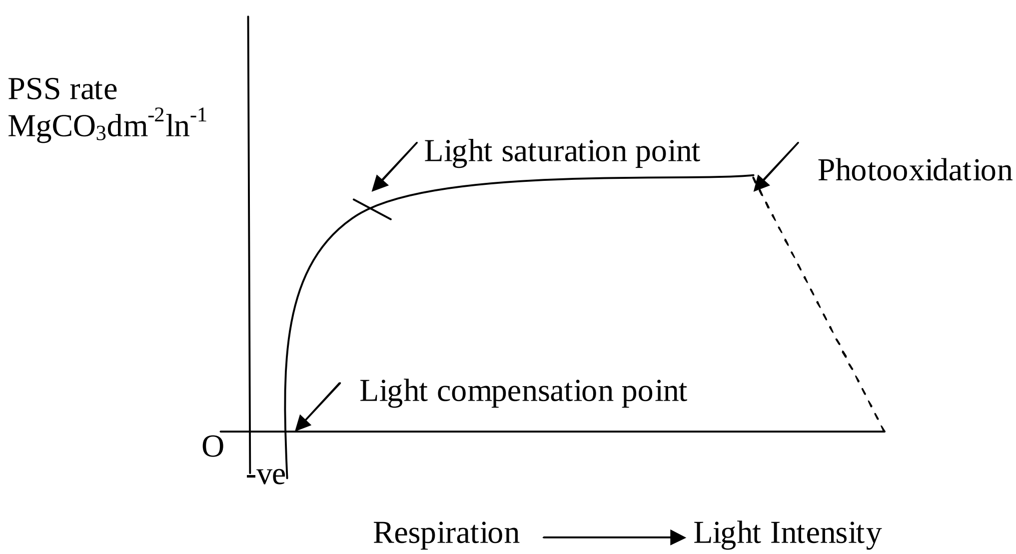
This is very effcienctat removing CO_2 from the atmosphere. Initially penetration of CO_2 into leaf is very rapid until it reaches the wet surface. The diffusion of CO_2 in water is about 1000 times slower than what it is in the atmosphere. Therefore rate of diffusion is reduced once it gets into the wet boundary layer. Even through the total distance between the cross section of leaf is very small, thus rate of diffusion from atmosphere to leaf seems to be the limiting factor in the supply of CO_2 from atmosphere into the photosynthetic site.

WIND

The leaf have a boundary layer which consist of vapour. This boundary layers prevents the movement of CO_2 into the leaf. With slight wind, the boundary can be destroyed,leaf become drier the rate of movement of CO_2 become faster enhancing higher rate of PSS.

LIGHT

It is the intensity and photoperiod that is important. In one of PSS, the quantity of light limit Psstic rate.



Below zero (0) no light is received, no PS: -ve PSS value.

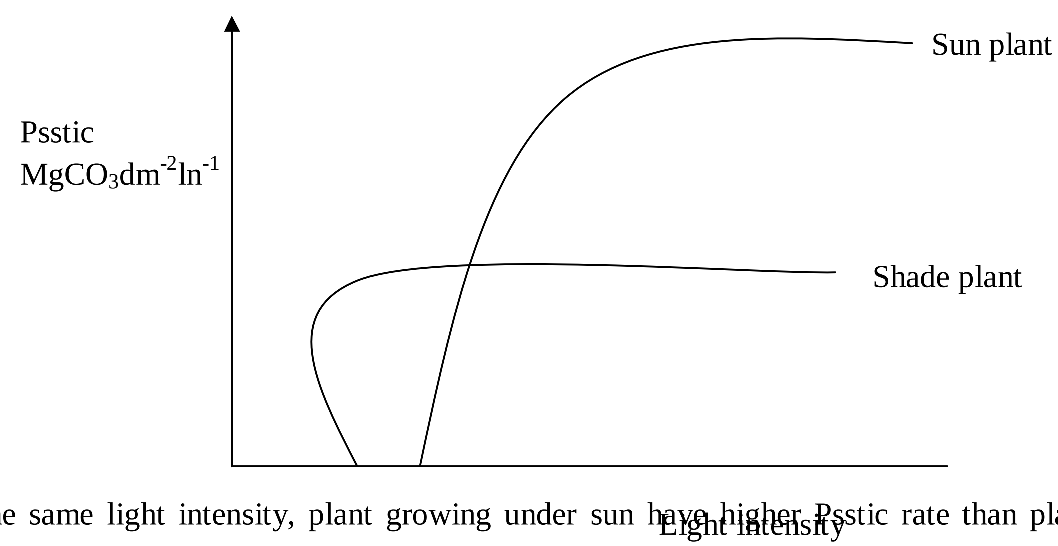
This point where CO_2 is given start is diminished by respiration above this point, the Pssic rate greater than rate of respiration, therefore we have positive Psstic values. The point where PSS = RSS is called the light compensation point.

They are plant living under such condition will not grow. If RSS is greater than the plant will eventually die.

With simultaneous above in light intensity, there is above in Psstiic rate. After this region, high in light intensity will not lead to high in Pstic rate. This point (a) is called light saturation point. If continue to high light intensity we shall have photooxidation in leave becomes destroyed due to excessive light intensity.

The compensation, light saturation and photooxidation points vary with species.

SHADE PLANT AND SUN PLANT



At the same light intensity, plant growing under sun have higher Psstic rate than plant under shade. Both may have same compensation point, but different saturation points.

If plant from sun is put under shade, it will experience downward in Psstic rate or suppress more than plants wed to shade based on this we classifying plants into

a) Sun plant: Have higher compensation point, have higher maximum Psstic rate, and saturated at 1/5 full sunlight.

b) Shade plants: Have lower compensation point, saturated at 1/10 of full sunlight. Sahdeplants are able to grow well under shade of taller trees.

MORPHOLOGICAL AND PHYSIOLOGICAL CHARACTERISTICS OFLEAVES

CHARACTERISTICS OF SHADE LEAVES

1) Low compensation point
2) A short range or a which light intensity stimulates PSS
3) Leave Psstiic rate at higher saturation point.
4) It posses more chlorophyll per unit weight than similar plant grading under sun.
5) Shade leaves are often thinner than those developed under sunlight, because sun stimulates the development of 2^{nd} layer of palisade parenchyma.

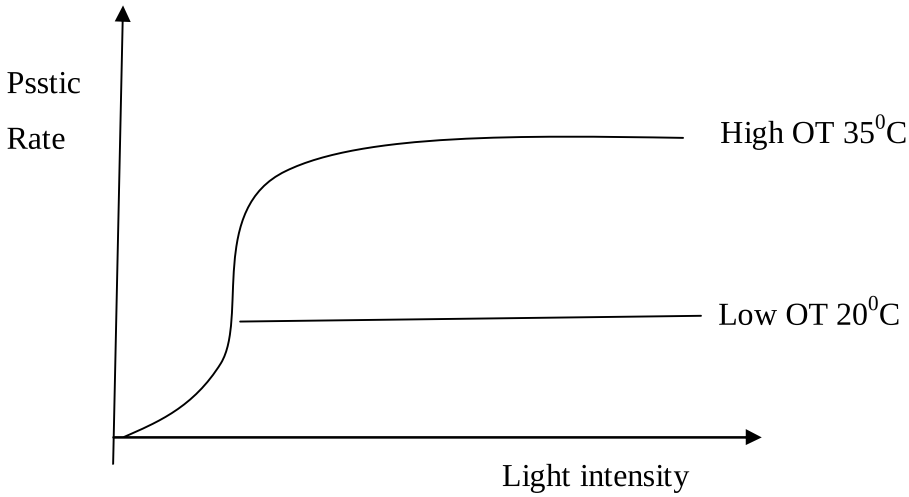
SUN LEAVE CHARACTERISTIC

1) High compensation point
2) Long range over which light intensity stimulates Psstic rate
3) Psstic rate at high saturation point
4) Less chlorophyll/want rot
5) Have the **development** of 2^{nd} layer palisade cells.

Shade plants are able to tolerate shade because of their low compensating point.

EFFECT OF TEMPERATURE ON PSSTIC RATE

Temperature range for plants growth is surprisingly very large on very hot days, leaf OT can reach 40^0C with Pss taking place, optimum range between 20-35^0C.



The influence of OT in Pss depends on both CO_2 availabilityboth light intensity. If these two are adequate, PSS willoccur faster at high OT than at lower OT.

This OThas little or no effect on photolysis. This is because energy required for photolysis is derived from light intensity.

All the reactions of the Calvin-Benzene cycle is OT dependent and in low rate of OT of nay of these reactors with between down the entire process.

The Q_{10} (respiratory efficiency/Quotient/rate) for processes like this in the laboratory varies from 2.0-3.0.

The rate of diffusion of CO_2 to reaction site will be high by higher OT. Q_{10} for diffusion of solute water very from 1.2 to 1.4. Q_{10} for entire PSS lie between 1.0 to 2.7. Apart from photolysis of water, other reactions of PSS we affected to a limit temperature.

WATER AVAILABILITY

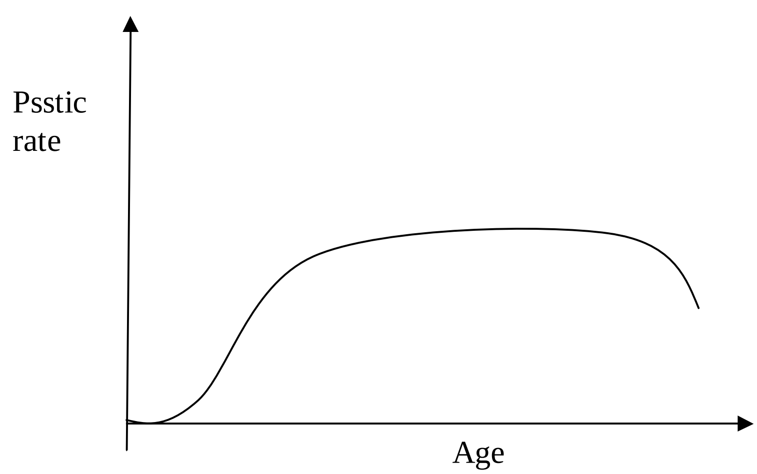
Through PSS require electron obtain from photolysis of water. This is not only reason why water is important. Water has 1^0 effects on PSS due to its action in closing and opening of the stomata. Under dry condition, stomata are closed down in diffusion of CO_2 downward in PSS.

LEAF AGE

As individual leaf on a plant grow and develops ability to photosynthesis increases with time and decreases later decreases when leaf become old – senescence – less chlorophyll be loss of functional chloroplast.

Chlorophyll content

Genetic constitution



CHLOROPHYLL CONTENT

Little correlation between amount of chlorophyll and PSS

Genetic Constitution: Some genotype and endogenous rhythmic affects PSStic rate

Endogenous rhythm: Some plant have diurnal variation in PSStic rate independent of the environment

RESPIRATION

Photosynthesis binds energy from solar radiation into complex organic compounds such as glucose and compounds synthesized from glucose by this potential energy can be utilized in metabolism by the tree the huge energy rich molecule must be broken down chemically and the energy released. The biochemical breakdown of photosynthesis is called respiration. In trees as in other living things, this process is characteristically combined with processes that incorporate a large portion of the released energy into ATP the "universal energy currency", which serves a readily available energy supply.

Respiration makes available the chemical energy stored in sugar and other foods and permits the use of this energy within the tree in a variety of useful ways.

Some of these are assimilation and other energy using process such as fat and protein synthesis mineral absorption and maintenance of protoplasma structure all require and make use of this released energy. An understanding of respiratory process is the necessary, for a god appreciation of various tree behaviours and silvicultural techniques. Root growth and seed germination are often hindered by soil condition which limit respiration, value remedial measures such as drainage and/or tillage are usually due to enhance respiration. Successful seed storage also partly depends on maintaining environmental conditions which control respiration of the seed.

Although some minimal level of respiration is essential for cell survival and to somewhat higher rate is needed for growth, the rate of respiration sometimes rises for above essential level and results in wasteful consumption of food which might otherwise be used in assimilation to product new tissues or accumulated in storage organs. Respiration can thus because competition of assimilation and accumulation of food, resulting in reduced growth and inadequate accumulation of reserves.

As respiration occurs in all living tissues continuously all the time and photosynthesis occurs early in the light and directly in the leaves, the rate of pss must be maintained at levels several times as rapid as the rate of respiration pss unit tissues of any net increase in dry weight is expected. Hence Polster (1950) has suggested that the productivity of a forest stand weight be increase more by treatments which reduce respiration than by treatments that increase Pss. Foresters can achieve this for example by pruning off lower branches which tend to respire more than they photosynthesize.

Mechanization of respiration

As in Pss the respiration breakdown of food does not occur as a single gross reaction but rather as a series of smaller step-wise reactions, each catalysed by an enzymes. The release of packets of energy is couple with photophorylation reaction that synthesis ATP from ADP and inorganic phosphates. These steps fall into two convenient groups, a preliminary group known as glycolyris in which the carbohydrate is oxidized to pyrunic acid and a second group concerned with subsequent oxidation of pyrunic acid. The first phase appears to take place in the same general way in many kinds of tissues either in preserve or absence of atmospheric oxygen. The second phase may follow a number of diverse patterns depending upon the kind of tissue and upon whether it occurs in the presence or absence of atmospheric oxygen. In the absence of oxygen and under certain other conditions, anaerobic oxidation of pyrunic acid usually occurs but the course of the reaction differs in different tissues and organisms. In trees, anaerobic respiration often occurs in roots in poorly gestation soils and in tissues where entrance of oxygen is restricted by impermeable structures such as fruit acid seed coats or land scale. In general the products of anaerobic respiration of pyrunic acid are incompletely oxidized compounds such as alcohols and organic acids and aldehydes. Consequently anaerobic respiration is generally considered undesirable because most of the energy released is not available for growth and because its products often are toxic to the tissues in which they are formed.

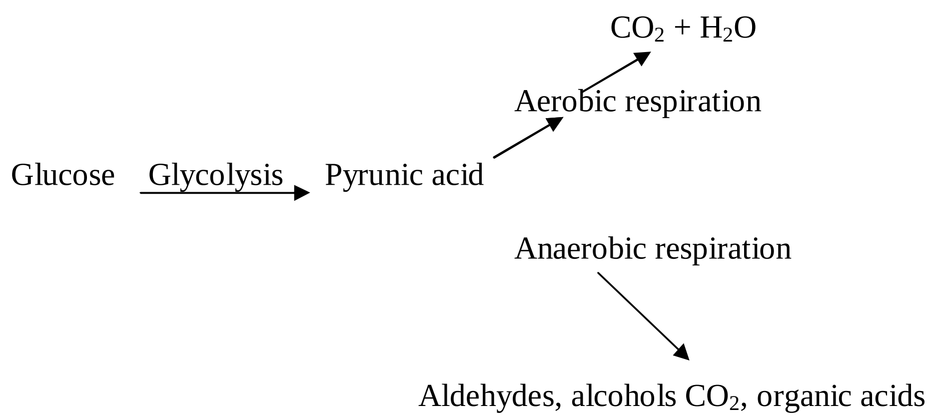
Under aerobic conditions or presence of oxygen, the oxidation of pyrunic acid usually occurs along entirely different pathways from those under anaerobic conditions and the end products are usually CO_2 and H_2O. the oxidation of pyrunic acid to CO_2 and H_2O is accomplished by a complex but cyclic series of reactions, known as the Krebs cycle. In this cycle, hydrogen atoms are split off in pairs by enzymes known as dehydrogenaces and we transferred through a series of hydrogen acceptors. These atoms finally combine with oxygen to form H_2O. much of the energy released is used to form high energy phosphate bonds which are coupled to ADP to form ATP. This aerobic phase of respiration appears to be restricted to the motochandria which contain all the enzymes essential to the complete oxidation of pyrunic acid by way of the Krebs cycle. The mitochandra are also the centres of synthesis of most of the ATP associated with respiration. Summary equations for the aerobic of sugar can be written as follows

$$C_6H_6O_6 + O_2 \xrightarrow{\text{Glycolyns}} CH_3COCOOH + 2H_2O + \text{Energy}$$

(Pyrunic acid)

$$CH_3COCOOH + 2.50_2 \xrightarrow[\text{cycle}]{\text{Krebs}} 3CO_2 + 2H_2O + \text{Energy}$$

The above discussions also show that the first stages of aerobic respiration of CHO COO the same acid the relationship can be shown as follows



Considering the cellular energtics, the number of ATP molecules generated per molecule of glucose oxidized is very significant since the energy released in the nature equations is mainly stored as high energy phosphate bonds. According to current views, 38 mols of energy-rich phosphate are formed in the aerobic oxidation of each molecule of glucose.

The energy liberated on hydrolysis of each energy-rich phosphate of ATP is about 12,000 claorie per mole. Thus, 456, 000 calories or about 65 percent, of the total energy in the glucose are transported to these high energy phosphate bonds where they are made available as a energy source for other chemical reactions. These phosphate bonds are thus the connecting link between the energy releasing reactions of respiration and the numerous energy consuming reactions which are integral steps in true metabolism. It follows that about 35 percent of the energy released when one molecule of glucose is completely oxidized is dissipated as heat.

RESPIRATION IN TREES

Being the only means through which energy in CHO manufactured by PSS can be constructively released, respiration I together with PSS ranked as the most important biochemical process known to man. RSS unlike PSS which occurs only in light tissue during both day and night, throughout the life of tree. Consequently a significant portion of the total amount of PSState produced is expected to be

The respiration demands however very greatly among species and tissues and also with time. Moller et al (1954) showed that the amount of respiration loss by trees varies with age. They reported that 40 percent of the total psstate was used by a 25 years old tree compared to 50 percent by an 85 years old tree of same species and attributed this difference to an increasing ration of respiring to photosynthetic tissues as the tree aged. Meristematic tissues on shoots, stems and elongating roots are also noted centres of intense respiration and large consumption of CO. young rapidly expanding leaves with relating high proportion of protoplasm in relation to cell wall materials respire mere rapidly per unit of dry weight than do old mature leaves with tick cell walls. Various specialized aerial roots and pneumatopharies are adapted for respiration and they consume considerable respiratory substrate. Food is depleted though Rss by vertical arial roots e.g. Aviumis spp and by lentils prop or still roots e.g in Rhizophere spp. Griley et al (1962) shared that Rs of arial prop roots of Rizophora maryle L. trees amount and to very considerable losses. The rates of loss in gram carton per square metre per day were for prop roots 2.03; sun leaves 3.04 and for shade leaves 0.48.

Mycorrhizal roots also have very high respiration rates. Under high ATP of tropical forests, lossesof Psstste by Rss can be trearendens and greatly exceed those in trees of temperature zones. In the natural tropical rain/forests in the lowlands of jury consist for instance, respiration in roots, stems, branches and leaves consumed about 75% of the dry matter produced.

Relation of Pss and Rss to tree growth

This relation between Pss and Rss in best illustrate by their action in wood formation the primary goal of tree crop production. Wood consist largely of cellular which is made from glucose manufacture used by the process of Pss. All factors being variable, the amount of glucose available for wood formation will inverse sa rate of Pss increase. On the other hand, respiration which is the reverse of Pss, decomposes glucose, indicating that the amount of glucose available for wood formation.

Thus the difference between the ration of Pss and Rss will determine the amount of glucose available for wood formation. In other words the greater the rate of Pss in proportion to that of respiration, the greater will be the amount of CHO available for growth and development of a given tree. This statement expressed mathematically.

$P - R = G$

Where P = represents the rate of gross Pss

R = rate of Rss

G = the growth potential

Thus, the rate of Pss is high and the rate of Rss is also high or above normal, growth is likely to be low, whereas if the rate of Pss is high and the rate of Rss is low growth is likely to be high. In generals for satisfactory growth, the rate of Pss should be about ten times greater than the rate of Rss. In situation, pruning is closed stands or thinning to shape out the residual trees can be employed to bring and to keep this ratio at the desire point. Endently Pss and Rss form the foundation of situation or crop production.

Biosynthesis

Photosynthesis not used in respiration is utilized in the production of a variety of complex compounds through a series of to synthetic reactions. These chemical reaction essentially involves the conversion of relatively simple soluble foods into complex, insoluble constituent of all system under the catalysis of numerous kinds of enzymes. Same of the glucose is converted to a made range of structural and energy reserve carbohydrate and CHO derivatives which are important in the organization of new cells and tree growth. The disaccharide (sucrose) and polysaccharide (starch) form the two most important types of CHO easily utilized as food and energy reserves. In many plants they are form quickly and directly from the glucose produced in photosynthesis. Sucrose in formed by a contamination of glucose – 6- phosphate and glucopyranose – 6 – phosphate in the presence of a condensing enzymes and Uridine triphosphate. Starch is essentially a long chain condensation product which can be formed from glucose – 1 phosphate molecules by the action of the enzymes – starch phospherylase or other enzymes.

Starch forms the most important storage CHO in tree cells and it is especially important in trees that coppice as it is easily converted to soluble glucose for easy translocation to and from storage organs.the structural CHO formed some of the photosynthesis plug vital roles in plants in providing their cells with strength. Cellulose, the structural polysaccharide of the cell wall is a glucose. During the large amounts of cellulose are rapidly synthesized indicating that cellulose synthesis is a very important aspect of the chemistry of tree growth. The mechanization cellulose synthesis is not fully known, alghough information is fast acculative in cellulose synthesis andto involvement all wall formation (Bartes and Hussid, 1965; Ordin and Hall, 1968; flower et al 1968, Hassid 1967, Rampart, 1970).

Some of the photosynthesis is converted into oils, fats, waxes, stegols e.t.c. Fats are formed through the etherification of unsaturated fatty acids and glycerol all produced through the biochemical break down of carbohydrates waxes occur in the article differ from fats and oils in that glycerol is replaced by monohydric or dihydric alcohols in their synthesis fatty acids are also further condensed to produce a wax-like substance, suberin, also found in the epidemis of trees.

Source of the photosynthesis is used in the synthesis of protein a colloidal compound of high molecules weight and very complex chemical composition which forms the bulk of the living substance known as protoplasm. Its complexity within the understanding, all proteins however contain certain hydrogen, oxygen and nitrogen and source also contain phosphorus or sulphur. Essentially protein are synthesized by combining glucose molecules with certain compounds containing nitrogen and hydrogen to form amino-acid and their subsequent condensation to form complex proteins. The complex series of reactions involved appear to fall into three major steps: the reduction of nitrate-nitrogen to ammomium nitrogen, the reaction of sugars with the ammommium compound to form amino acids and the condensation of the animo acids to form protein.

NO_3^{-N} $\xrightarrow[\text{enzymes}]{\text{reduction}}$ NH_4^{-N} + (sugar) enzymes Amino acid $\xrightarrow{\text{condensation}}$ Protein

Assimilation: The dry matter which is incorporation into the structure of both protoplasm and cell walls during growth comes almost entirely from the net photosynthesis. The process whereby food are utilized in the building of protoplasm and cell walls by existing protoplasm is called assimilation.

Assimilation is an integral part of growth and there is concentrated in the meristematic region such as the cumtium and root and shoot tips. The simple sugars translocated to these regions are converted into cellulose, pestic compounds and lignin in new cell walls and the amino acids and amides into the protein framework of new protoplasm. In these processes small amounts of fats, minerals nutrients and growth promoting substance are also used in association with a variety of enzymes.

Translocation: The typical structural operation relating to translocation in yielding. This is removing the phylum and cumlium H_2O and nutrient transport initially would not be affected because their transportation is through the xylem. After sentence the root dies because movement of manufactured food from leaves is blocked. The phylum is made up of sieve tribe and carpanous cells is living nucleus through which transportation manufactured food takes places. Both companies cells and sieve fate original from the same cell. The phloem fabric in also used for support, while the phloem pregenchyyma are used for both storage and support. Analysis to the sieve fate shorts that the solute contains sucrose, starch, some amino acids, phosphate and nitrogen compounds.

Water uptake and loss in individual plant

It is generally known that liquid water moves from soil into root cells along a gradient of decreasing water potential (Spatyer 1967). However, the availability of soil water could either by static or dynamic (Blank et al 1974). The static availability of soil water to plant root is determined by the potential of soil water in the boundary layer surrounding the roots. The total potential of soil water may have other components such as the matrix potential, pressure potential due to external pressure grantational potential due to elevation and osmotic potential of sort solution. Matrix potential of soil expresses by its negation value a decrease of water potential composed with tree give water on the interface surfaces of the soil structure. Being the most important of all, the values of matrix potential are taken as values of total water potential of a soil as a tauter influencing plant growth.

The dynamic availability of water to plant roots or the quantitative features of the uptake is determined by the rate of water movement through the soil toward the absorbing roots and the absolute amount in the soil rhizosphere that immediately surrounding them. It is also determined by the rate of root growth and rate of renal of action absorption surface (Blank et al 1974).

As transpiration from a plant root in initially wet soil proceeds from day to day, if progressively reduces soil water content and soil water potentials. Since there must be a gradient of decreasing potential through the waters pathway from soil to atmosphere to provide the driving force for water flood, there is also a convinent machine in plant water potential and plant water contention and consequently an internal water design develops which involves in magnitude with time (Kiuoru 1969).

PLANT NUTRITION

Essentially of elements

Criteria for essentiality

1. Essential if is a situation medium, absence of the element leads to abnormal growth
2. Its essential if it forms an internal part of an essential metabolite. That is there must be a phonological process in the element partake.
3. if without it the plant cannot completion its high cycle.

Conventionally, status 16 essential elements are C,H, O, N, P, K Ca, S, Mg, Mn, Zn, Bo, Cu, Mo,Cl other are taken from the soil.

All these partake in one way or the other in the physiological process of the plant. Which abnormality either in usual observation or growth.

Factors responsible for condesirable uncertainty of deficiency symptoms

1. The symptom of deficiency of the same element may differ greater in Spp. Thus a wrong identification of deficiency may be made
2. Identical symptoms can be manifested for different deficiency e. g. N and S deficiency causes a general chlorosis. Chlorosis is also reserve in Fe deficiency.

3. In some cases there could be deficiency in plant and stunted growth without visual observation in colour.

4. Multiple deficiencies of elements add to complicate the symptoms e.g. P deficiency gives purplish colour, N-deficiency gives yellow colour. Thus difficulty arises in deficiency between the colour.

5. Ova abundance leading to toxicity. Some elements when present in soil could be toxic e. g. Gluclina in Aluminium rich soil gives some deficiency symptoms e.g. Phosphorus deficiency.

Some deficiency symptoms

Nitrogen: presenting aa, protoplasm and protein. Except drought condition, no other deficiency is as serious general chlorosis and etiolated habits. Pretended growth; the matured port more affected because of general movement of N from other to younger grading region. First manifested in the folder port.

Sulphur: deficiency symptom very sawn to that of N_2 plant chlorosis, spindl in appearance and poor growth why it resemble Nitrogen symptom is because it is present in certain protein used for growth.

Phosphorus: Present in protoplasm, nuclei acid and present in ATP and ADP. Most organic acid are in phosphorlated compounds

Symptoms

Dark green or bluish green foliage

- In pings the needles could be reddish, govern to purpose. In Pinnus radiate the needles could be reddish, in the some cases brown pigments stouts along the vein. Growth retarded in several deficiency plants is stunted.

Potassium: In many Spp K deficiency in observed

- Leaves because dark green or bluish green. In addition, we have characteristic spot development on the leaves
- Also we have marginal necrosis i.e. leaf spot start train leaf margin.
- In some cases leaf scotch i.e. leaves appears plants in the edges. Growth subnormal.

In several condition we have die baclcine cervical and dieing.

Calcium: Symptom of calcium deficiency appears earliest in the meristematic regions and young leaves. This is because it appears calcium requirement is his in soft tissue but there is lack of mobilization of Ca in the plant. Deficiency symptom shows first in the meristematic accas e.g. ferminal bonds, root tips and internal bonds. These growing require the severally damaged in same cases we have dealth and die back. Normally, Ca deficiency is in acidic soil (in acid soil low Ca low PH). Some of the symptom will be sometime to this of phosphorus.

Magnesium: Unlike calcium Mg is readily translocated train matured to young active part of the plant. Marginal chlorosis very common we have develop of varieties of color depending on spp. It starts within the leaf lamina spreading to the margin.

Generally the description of Mg deficiency is very difficult.

Fe (Iron): Fe is present in the soil in various oxidation younger forms. Usually Fe deficiency leads to chlorosis from younger leaves. At first, the vein remain given states it because chlorotic. In areas with much lime ($CaCO_3$) we have a lot of feggans contamination which is available to plant i.e. ion deficiency include by lima manganese symptom very E spp leaves shows intestinal chlorosis. In advanced stage we have nerotic spot. Severe cases leads to stunted growth.

Copper: (know the chemistry copper in soil): There is variation in symptom between spp leaves because chlorosis or deep green. There is rolling may leaves. In advanced stage we have rough bark and blisters dropping. In some cases gums exudates from broken parts of the steam called xanthema.

In addition young shoot die back.

Chlorine: It's deficiency in plant is not of economic importance. We have blue green shinning leaves when it's hot during the day, the leaves drop. It dungle in the wind and in it. They recover at night or spot can be observed. Under severe condition, plant from stunted.

Boron: Grinning tip are damaged and becomes covered leaves because distorted stem because cracked. Roots are mostly affected by bacteria infection.

Molybdenum: Vein are pole green in colour. Chlorosis gives a molting effect. Leaf margin appear sin light to Mg deficiency. There is rolling of leaf pore. Usually it resorts to stunted growth. In nursery soil, we have NH_4^{-N}. With constant use of fertilizer like in agricultural farm, we then have soil with more of NO_3^{-N}. The requirement molybdenum is smaller when we have NH_4^{-N} but greater when we have NO_3-N. This is because NH_4-N reacts with Aspartic and here readily mobilized, whereas NO_3-N has to undergo reduction of mobilization can occur. The 1st step is reduction than NO_3-N by nitrate reductate enzyme and this enzyme requires molybdenum is order to function.

Molybdenum is also required in the symbolic nitrogen fixation.

READ NITROGEN METABOLISM

WATER RELATION IN PLANTS

SOIL WATER ENERGY

The retention and movement of water in soil and involve energy transfer. water molecules are attracted to each other by design bonding. Hydrogen bonding accounts for the forces of adhesion, cohesion and surface that largely regulate the retention and movement of water in soils. Adhesion refers to the attractive forces between soil and water molecules. At the water-air interface, surface tension may be the only force retaining water in soils. It results from the greater attraction of water molecules for each other (cohesion) than for the air.

Water with high free energy tends to more toward a zone of lower free energy i.e. from wet soil to dry soil. The amount of movement, however, depends on the differences in the energy states (potential) between the two zones. Forces that affects are tree energy of soil solids for water by absorption and capillarity, called matrix force

(1) The attraction of ions and other solutes for water resulting in osmotic force and

(2) Attraction due to external pressure resulting on pressure potential. These three tend to reduce the free energy of the soil solution

(4) A fourth force is gravity acting in soil water, tending to more it from a higher elevation to a lower level.

The total potential of soil water there are the sum of matrix, osmotic, pressure and gravitational forces.

Gravitational potential is a positive force, but matrix, osmotic and pressure are negative because they reduce the tree energy level of water. The terms function and tension are used as positive expressions of the forces of the negative potentials that result from the attraction of soil for water. The energy required to remove water from soil pores or from the attraction of soil particles can be measured by applying fiction to a situated soil simple placed over s permeable membrane. It is expressed in fiscals (formerly in atmosphere or brains).

Soil water can be grouped into three functions on the basis of the force with which it is held in the soil. Gravitational water drains away under the force of gravity through the large soil pore spaces.

Capillary water is retained in the capillary pores and wound soil particles by force of cohesion and adhesion after gravitational water has moved anti hygroscopic water is retained very firmly as a thin flow around individual sort particles after capillary water has been removed. It is essentially non liquid and moves primarily in vapor farm and it is not available to higher plants.

STAND PRODUCTIVITY

A stand is a crop of trees forming a definite unit e.g. a structural unit.

Stand elite is a stand selected on account of its special quality.

Fully stocked stand: is a stand in which all growing space is effectively occupied by the forest crops, cut adequate ram is left for best development of tree crop i.e. little or no competition.

STAND FOR OR STRUCTURE

The arrangement of trees which are left standing and that new trees which appear at the cuttings determines the stand form.

This is best indicated by the profile of the tree grams. The most important criteria of stand form is age distribution. In general we have 3 types of stand structure.

1) Even-aged stand
2) Stand with two age classes
3) Uneven-aged stand

CHARACTERISTICS OF SHADE LEAVES

1) Low compensation point
2) A short range over which light intensity stimulated PSS
3) Lower Psstic rate at higher saturation point
4) Has more chlorophyll per a unit weight than sun plants
5) Shade leaves are thinner than sun plants

CHARACTERISTICS OF SHADE LEAVES

1) High compensation point long range over a light intensity stimulates Psstic rate
2) High Psstic rate at high saturation point
3) Less cholorophyll per unit weight
4) Development of 2^{nd} layer of palisade cells

STAND PRODUCTIVITY

In forestry practice, the batic unit of management is the stand which may be defined as an aggregate of trees or other growth, occupying a specific site and sufficiently uniform in age, enlargement, species composition and density. It is a silvicultural unit distinguishable within the forest and from other growth an adjoining area. (Hocker, 1973).

Growth of forest stands is of fundamental importance in forestry since it is by tending and reproducing individual stands that the forest is made to produce the required amount wood. Also by manipulating or stand, all the other distributes of the forest may be allotted far better or far worse. For instance, it is possible, through silvicultural operations carried out on the stands to alter the habit and the population of untolife change the quantity and quality of water in streams that transverse the forest and to alter the aesthetic appearance and the recreational values of the areas.

The forester is prematurity interested in the growth of the cuhole forest rather than in individual trees because lim chief concern is more with maximum volume and value per hectare rather than per tree. To attain this objective, he strive for the best continuation of members and sizes rather than for the most rapid growing individual of numbers and sizes rather than for the most rapid-growing individual tree which may be wasteful of space.

STAND CLASSIFICATION

To facilitate study and planning of silvicultura; operations, forest stands are usually classified according to their origin, composition, age and density.

ORIGIN

Forest may be regenerated from seed or gram sprants and suckers or from a continuation of them. Those that originates from seed are called high forests of forest of seed origin. Those reproduced vegetatively by bisprinats or suckers are called coppice stands. A forest composed of a mixture coppie and trees of seed origin is termed coprice with standards (Baker, 1950).

COMPOSITION

From economic viewpoint, the species composition of a forest is one of the most important features of its make up. Differences in this feature is probably the most readily recognized of all stands characteristics. Two general classes of stands are defined on this basis

1) Pure stands and
2) Mixed stands

A stand is considered pure if 50% or ore of it is composed of a single species. On the other hand, if the composition of a secure species exceeds 20% the stand is designated by mixed stand. A mixed stand is therefore one with two or more species, none which accounts for more than 50% of the total streams in the stand.

In nature, pure stand is an exception rather than the rule they are found where growth conditions are unfavourable for the growth. Pure stands can be and are usually artificially established. Artificially established mixed stand also do exist, for instance in Sapola, Nigeria where Hypsiphyla spp severely attack mahogany species, mixtures of *Nauclea chiderrichii* and mahogany species have even established and are thriving well.

In regenerating a forest, a decision has to be made between ranging the chosen species is pure or mixed stands. Such decisions are based on the comparison of the advantages and disadvantages of the two stands.

The main advantage of pure stand is probably

1) The simplicity of treatments, reproduction and harvesting.

2) Compared with mixed stands they are enrich and cheaper to plant and less difficultly to manage because they have even growth and uniform development cultural operations are less studies and require less skill.
3) Where suitable market for a species exist, pure stands make for maximum economic benefit.

The following disadvantages of pure crops are usually presented by protagonists of mixed stands.

1) Pure stands are less flexible in an inch of changing leve demand. For example, damage by weather, insects and fungal disease is sometime more injurious in pure crop: for instance *Phytolyma lata* does spread more in pure *Chiloptera excels* than in its mixture with other species.
2) It has been advance that sat deterioration may occur under pure crop of both artificial and hundreds. Mixtures are great favour for a variety of reasons. In considering then, it should be borne in mind that their advantages and diadvanatges are stand to be contrary to those of pure stands. The advantages mixed stands are that

1) They offer maximum protection from insects, diseases and in same instances, fire.
2) They are more flexible in case of changing level demands are the suitable for multiple use.
3) They are less exerting on the set since different species have different rooting depths and the field in different zones of the soil.
4) The differential rooting characteristics also help to minimize chances of wind-throw.

The main objection to mixed stands is however based on greater difficulty of management.

1) They are generally more difficult to establish, tend, harvest and evacuate to market.
2) The species have different physical characteristics and the need different management techniques.
3) Extraction of mixtures composed of only a few hectares each of the species is usually an economic and unattraction,

In other word, on how success is judged by economic returns, forest service and pure stands more desirable than mixed stands in their purest too justify their position in the economy. In the fiscal analysis have even, the choice between the two types of stands requires careful analysis of inert-dickers, soil operators and their tendency to deteriorate, as well as the prevailing economic demands for forestry ventures.

The local conditions and needs therefore play a substantial role in determining what to do.

STAND FORM OR STRUCTURE

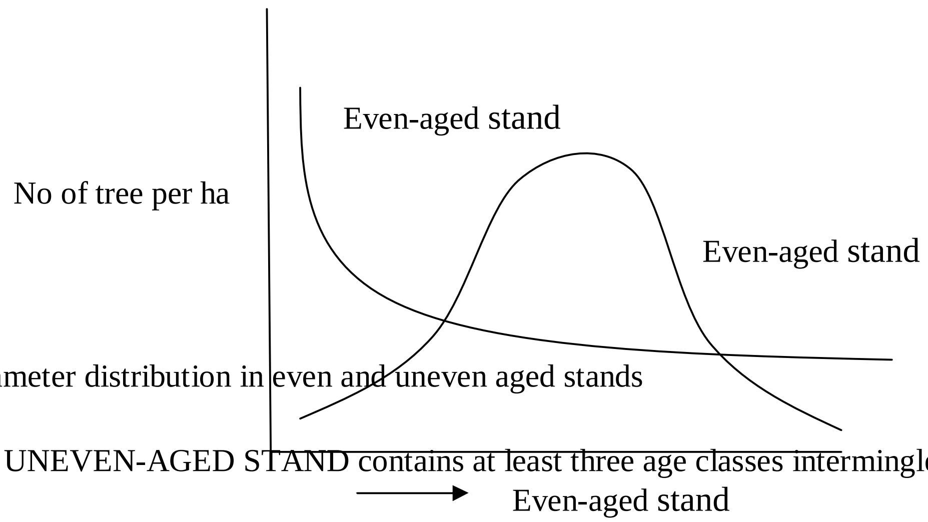
Forest stands may also be classified as the bases of their farm. The arrangement of trees, which are left standing and that of new tree which appear affected cuttings determines the stand form. This is best indicated by the profile of the tree grams. The most important criterion of stands form is age distribution. In general we have 3 types of stand structure.

1.Even-aged stands

2.Stand with two age classes

3.Uneven-aged stands

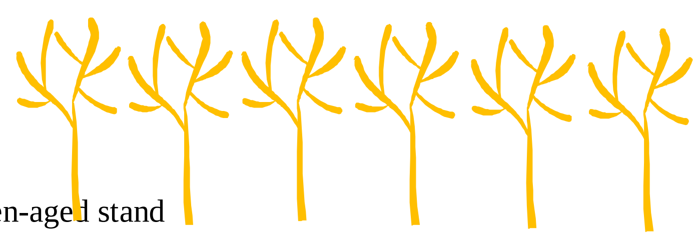
In an EVEN-AGED STAND all trees are the same age at least of the same age class, a stand is considered even-aged, if the difference in age between the oldest and youngest trees does not exceed 20% of the length of rotation. In practice even-aged stands are recognized from their even canopy and normal distribution diameters classes. In other words, the diameter of most trees in an even-aged stands cluster expands the mean.



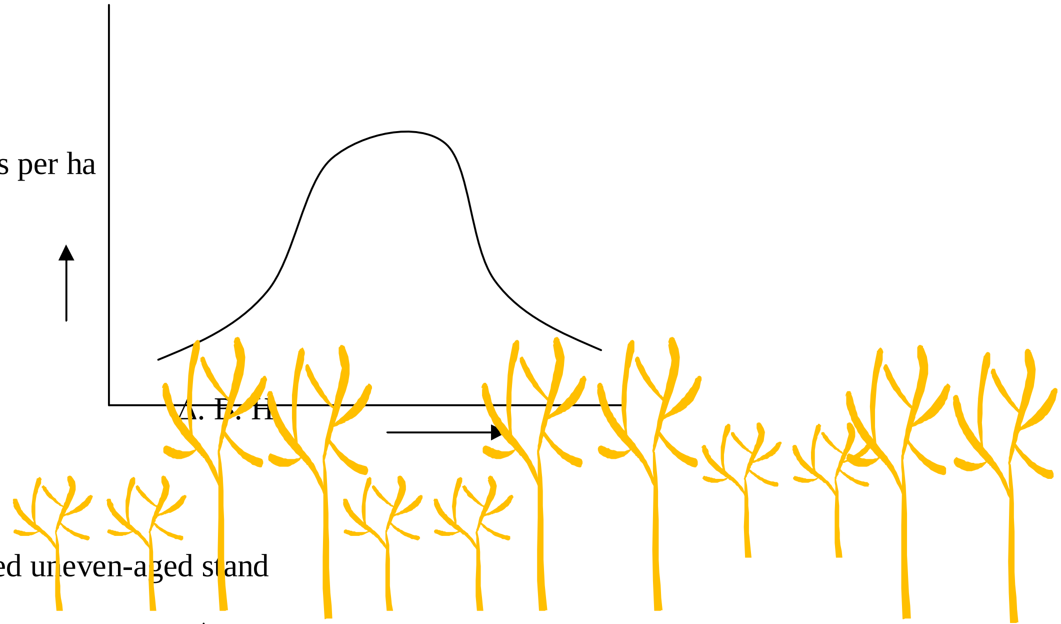
Diameter distribution in even and uneven aged stands

An UNEVEN-AGED STAND contains at least three age classes intermingled intimately on the same areas.

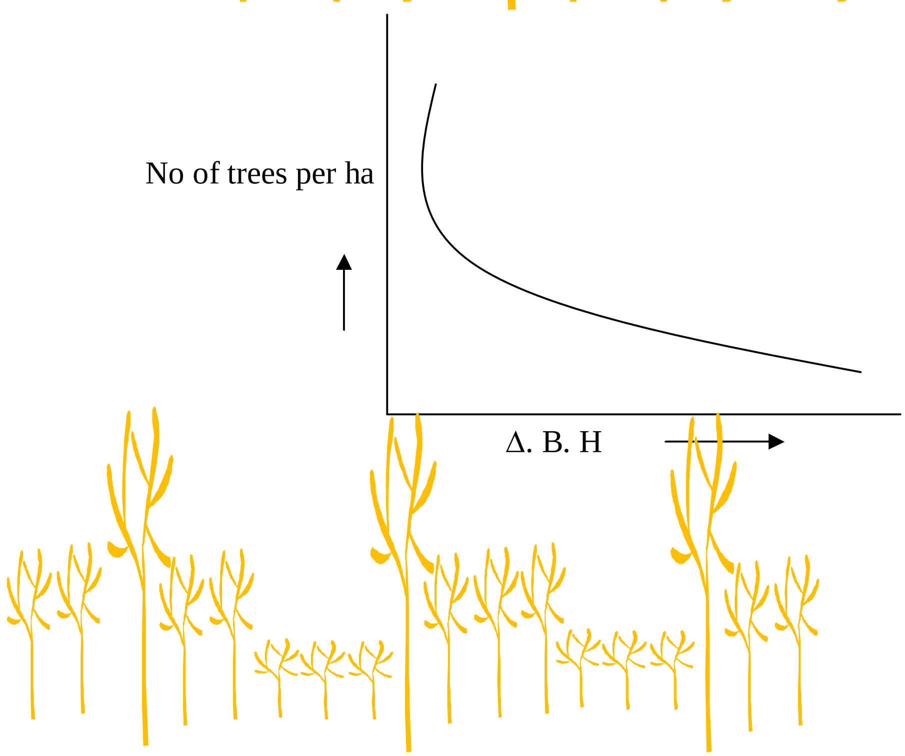
Trees of several age classes are present and individual trees within the stand are competing with others trees at different stages of dolpoint. Structurally uneven-aged stands present a broken or an uneven canopy in which the smallest trees are the young seedlings and samplings of newly regenerating species. The size class distribution is normally skewed to the right, indicating that the largest number of stems is in the smallest diameters class and that the number decreases regularly with increasing size.



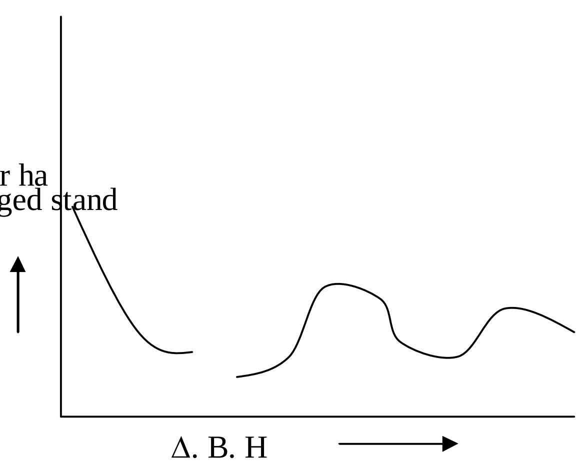
Even-aged stand



Balanced uneven-aged stand



Irregular uneven-aged stand



TYPICAL EXAMPLE OF 3 DIFFERENT TYPES OF AGE DISTRIBUTION

Distribution stand is made between balanced and irregular uneven-aged stands. A balanced uneven-aged stand consists of 3or more different age classes, each of which occupy an approximately equal; the age classes are also spaced at various form intervals all the way from newly established reproduction to trees rotation age. Such stands, once created, function as self-contained, sustained yield units.

Irregular uneven-aged stands do not contain all the age classes necessary to ensure that trees will arrive at relation age at short intervals indefinitely. Uneven aged virgin stands and stands which have been called over without plan are almost always irregular in age distribution.

The profile of a stand is a good criterion of age distribution because trees of the same age grow in height at roughly the same rate, provided site conditions are uniform, those that do not keep pace are suppressed and disappears. Therefore an even-aged stand tends to be almost san with in top. An uneven-aged stand is distinctly irregular in height; the greater the number of age classes, the more uneven the top of the canopy. This is not however trees of very old uneven-aged stands in many virgin forests. Growth in height becomes so slow in old trees that irregularities in height of uneven-aged stands gradually smoothens ant.

The climate growth of trees is more variable than their growth in height. The, the trees in uneven-aged stand are nowhere near as uniform in diameter as they are in height.

The decision to adopt a uniform or polycyclic system of regeneration which will result in even-aged or uneven-aged stands, is again based on careful consideration of the merits and demerits of each form.

Like pure stands, even aged stands tends to have same practical advantages, while uneven-aged stands like mixture, have same biological and environmental advantages.

The advantages of even-aged stand include:

i. A layer number of crop trees per hectare at any given stage of dolpant thin in uneven-aged stand.
ii. Longer, clearer and better almost cylindrical boles compared to the mere conicall and rough boles in uneven-aged stands. Consequently, quality of the product tends to be better than in uneven-aged stands.
iii. Shorter crowns concentrated for maximum efficiency at the top of the stems.
iv. Silvicultural treatments are easier to apply since the entire stand is involved.
v. Suitable mainly for light demanders

Clearance of even-aged stand at rotation age brings along some adverse effects to the site. These include

i. Loss of soil by erosion
ii. Loss of nutrients by run-off and volatilization
iii. Accelerated organic matter decomposition and
iv. Destruction of the normal soil organism that key the functioning of the ecosystem processes.

Those adverse effects of clear felling even-aged stands are avoided in uneven-aged forest management systems.

i. The site is rotated at all time as the entire stand is never totally removed
ii. The presence of trees of many sizes ensures that any physical damage to the stand may not result in complete lose as would be in even-aged stands with same size class.
iii. Uneven-aged stand management systems also favour the doplant of shade tolerant trees.

This makes continuous regeneration possible making it less important for the stand to depend on a seed crop maturing at a particular time for regeneration.

Even aged stand arrangement systems have, however been attraction to the tropical fosters for a long time.

The Malaysia unfair system and the tropical shortened system in West Africa are attempts at converting the natural uneven-aged forests into even-aged stands. Most tropical plantations are so full managed are even-aged stands. This attraction to evem-aged stands is based on their economic advantages.

They are easily managed, readily and completely sold and are easily and more economically harvested. Planting is closed and easy. Although foresters will continue to argue on the relative merits of the two systems, even-aged management will increasingly be more favoured because of its economic virtues in the inyount for and production in the tropics. Uneven-aged management will however still find use in protection forests as well as in the lesser accessible tropical forest formation system.

ENVIRONMENTAL FACTORS THAT AFFECT STAND GROWTH

Very numerous factors affects stand dolpont. These can be summarized under the following

1. Edaphic
2. Climatic
3. Topographic
4. Biotic

CLIMATIC

Basically, it is a measure of the atmosphere in providing moisture, heat, light and air to the plant.

MOISTURE

Availability to plant is usually in the form of rainfall. It is the most important environmental factor influencing plant growth. It shows the capacity of an environmental to support plant growth. However; rainfall is a crude means of indicating the capacity of an environment to supply water for tree growth. It is the quantity, distribution and reliability of rainfall which are significant only in as far as if contributes to moisture supply..

The implication of water in tropical true crop production are numerous plant gradually differ greatly in their water requirements; hence some are xerophytes while others are either mesophytes nor hydrophytes according to weather their needs are minimal, medium or maximal respectively. Furthermore the demand is not uniform. It is greatest at the period ofmaximum growth. These factors will influence the natural vegetation as well as the choice of exotic or indigenous species to be introduced into the locality. For example, trees with maximal water, reqiuremnts can only be grown in low rainfall areas if irrigation facilities are vaialble or can be provided.

In tropical savannas, rainfall determines the degree of survival of planted trees while throughout the tropics, rainfall pattern and dependability determine the commencement of tree planting. In low rainfall areas, weeds also help to deplete the available soil moisture. Under such condition, clean weeding of tree plantations is often adopted to conserve moisture.

Other sources of moisture to tropical forest tree crops are dew, fog and low clouds. In some areas dew usually forms during cloudiness nights and may persists to the following morning. The effectiveness of these sources depends on the vegetative cover and other local factors. In Tropical Africa for instance, abundant dew is formed on the large digitate leaves of *Musanga* *cecropoides* and this can be seen dripping down to the ground. Where leaves or leaflets are swell, the dew may be large but the water may not reach the ground.

However, its presence on the leaf surface during the first few hour of the day can reduce transportation and thus influence the water balance of the trees concerned. Fogs and low clouds tend to restrict their influence mainly to trees growing in mountains or along rivers and seashores.

SILVICULTURAL IMPLICATION OF TEMPERATURE (MINIMUM AND MAXIMUM ^{0}T)

The main difference in ^{0}T relations of tropical and temperature forests is the complete absence of value below freezing point which has profound biological effects on temperature vegetations. Both soil and our temperatures rarely all too critically dangers levels in the tropics. However, since a low prolongs the length of seed viability, artificially created low ^{0}Ts have been found itself in seed strength. If however ^{0}T are too low, frost will set in and cause death of plant. These planting and transplanting should be done at the minimum ^{0}T.

It should be noted that ^{0}T as such does not play a significant role in limiting the product forest, except where the minimum ^{0}T in so low as in frost which can change the integrity of the cell wall. Where we have a permanent icecarp on mountains, there is reduct in height and in no of trees that grow.

The problem is more with the high ^{0}T encountered in the savannas. Exposure to relatively high ^{0}Ts often causes seed need growth and injury in trees. When ^{0}T rises above the maximum for growth a plant enters a quiescent state and with further heating, a lethal level which varies with species, methods of application, age of species and especially with the time of exposure. Direct heat injury is much more common in seedlings and young transports than in older trees and more on stems than leaves or root. The high level of leaf occurring at the soil surface often searches tender stems of tree seedlings

- A phenomenon known as stem girdle. Stem girdle causes death by killing the conductive and conical tissues or by injury that allows pathways to become established. The ^{0}T at which this injury begins for most tropical tree seedlings has not been fully established. However, to avoid this lethal ^{0}T, sliding is encourage in nurseries, and mulching is newly planted crops.
- Discrete known as sunscald arises from the heating of the back of branches and trunks of woody plants exposed to sun during the deciduous stage. Thin barked or fissured trees grown under forest conditions may also suffice sun search and sunscald from sudden exposure brought about by any sudden opening such as thinning.
- Besides the direct injuries effects of high ^{0}T, it is reckoned that when might ^{0}T is lower than day ^{0}T less CHO is used in respiration during the night, with the not result of increased growth (Kiamer, 1957). It has also been repeated that flowering and fruiting require higher and more fluctuating ^{0}Ts than seed germination. As a result, the natural range of a species towards cooler climate is at least in past liquefied by the ^{0}T at which it is just capable of refracting or providing viable fruits before vegetative growth is checked.
- Similarly ^{0}T determines the extent north or south of the equator to which a tropical species can be successfully introduced as an exotic.

LIGHT

The effect of light on tree growth depend on its quality of wavelength, its intensity or irradiance and on its diversion and photoperiod. ***The action spectrum*** – that range of wavelengths of light used in photosynthesis in which maximum growth occurs – is the full spectrum of visible light. Although in nature variation in wavelengths appears to be too small to be of any physiological importance (Krance and Kuglor, 1960).

Seed as well as some mature plants seems to be susceptible to the relative around redlight and infra-red waves.expperiemnt show that exposure to red light stimulates seed germination and height growth of dark gram seedlings. Exposure to infra-red light reverse the effect of previous exposure to red light. It also promotes the elongation of light gram seedlings while the greatest increase in dry weight occurs in the full spectrum of sunlight. Exposure of leaf blades is prevented by darkness, retarded in green light intermediate in blue and greatest in white light (Kramer and Kozlowski,1960).

LIGHT INTENSITY

It affects tree growth through its efforts on PSS, stomata opening and chlorophyll synthesis. It also affects height growth, leaf size and structure of both leaves and stems through its efforts on cell enlargement and differentiation.

Light intensity varies daily and seasonally and is also influenced by latitude, clouds, dust and fod as well as the nature of the preventing vegetation in the axis. A lot of data in fast accumulating on the effects of light intensity and its validation on tree growth. Wadsworth and Lawtorn (1968) reported that *Khaya grandifoliola* had a very low light requirement while *Pinns caubeceae* reqiuremore than full day light for optimal growth. Nuroboshi (1972) showed that in southern Nigeria at least 25% of full sunlight was necessary for satisfactory establishment and early growth of seedlings of *Nauclec diddarnchii*. He further showed that *Terminalia ivorensis* seedlings attained maximum day weight under 75% sunlight while *Tectona grandis* seedlings required full sunlight.

High light intensity can be an asset on hazard depending on species its stage of dolpoint and location.in most cases, it brings about thicker leaves with layer palisade cells, more stomata thicker cell walls and cuticle and flower and longer chloroplasts.

PHOTOOPERIODISM

The length daylight period, or photoperiod is another aspect of light factor which affect many aspects of growth and dolpont of plants, particularly in temperature regions where large seasons differences occur in the length of day. These varied responses of plants to the diameter of the daily period of light and darkness are designated by the team-photoperiodism. Plants which develop normally when photoperiod is less than a critical maximum are called short day plants while those that require dry length above a certain critical minimum are called long-day plants. A third category is the day natural plants that develop normally under the long and short.

However in nature, daylenght vary with latitude and season. In the tropics the natural variation in daylenght is small. At first if was presumed that this small variation in daylenght in the tropics would have little effect and that tropical plants would have conditions which are favourable for both vegetative and reproductive growth. This view has been refund by works of Njoku (1958) and Longman (1966) which showed profound effects of day length on the growth of tropical tree species and herbaceous plants. Day length has been shown by Longman (1966) to affect the rate of production and expansion of new leaves in *Triplochiton scleroxyhu*, *Termalia ivorensis*, *Terminalia superb* and *Chlorophora excels*. Day length also affected the growth in length of the main stem of these species.

Photoperiodic responses are the group in the tropical silviculture in the over of provenance or seed source selection and seedlings propagation. Photooperiodism also plays a large part in the natural distribution of photosensitive species. As a result it may source as a check upon the degree of north-south displacement possible in the choice and introduction of exotic tree species for plantation.

WIND

Wind behavior vary in a forest stand. 2 major effects of wind action can be identified.

First, their movement affect evapotranspiration. Turbulence wind destroys the boundary layer which dries up leading to a dessicating effect. This involves cohesive fares, more water in lost thins increasing evapotranspiration.

Sites exposed to constant strong wind experience characteristics dry condition. In areas subjected to dry harmattan wind, the dry season is dries than what rainfall figure will indicate dessicating wind also reduce relative humidity leading to conditions favourable for fire hazard.

Second effect is mechanical: This range from shewing and diverging of vegetation found in exposed area where wind blows constantly to some of the distractive effects of winds such as hurricane or tornado.

All these have profound effect on the physiogamy of the forest. That is they destroy the forest structure.

When we have permanent wind hroughout the year there is the dolpit of small trees with sclerophyllaus skin common in maintain thicekts.

Certain plants however on tolerate wind action against encroaching sahara e.g. *Arancaria excels, Casurina egunsetifolia, Azadirachta indica.* One of their basic reqiuremnts is deep tap root which provide anchorage and absorption of water from deep down the ground trees grown in such area have a lot of tension wood. Thus in shelter wood establishment, trees to be grown should be mainly for fuelwood and protection against desert encroachment. In less extreme cases, commercial timber may be produced, though true height and log length may be restricted.

HURRICANE

Hurricane are more spectacular in their result. in West Africa we have light squall-associated with thunderstorm. They may uproot trees, or blow down dead trees or cause damage to trees growing in the open. They create opening in the forest result in climber tangles. Because of the gap created in the forest they affect succession of the rainforest. In areas prior to harmattan, a typical structure dolp.

CYCLONE

Effect have defoliated and bark shedding caused by whipping off. The trees are forced to bend. Uprooting do occur eiher as a complete withdraw or the tree leaning against other standing trees.

The indirect effect are less spectacular, but serious e.g.

- Sunscold – leading to downward stem quality
- 20 insect and fungi attack from the breakages
- Dolpant of reach an wood in leaning wood.
- Dense climber growth from vine.

It appears that wind damage shows little correlation which soil depth. In a study carried art by Wadsworth and Englerth (1961) comparing the effects of wind action in a mixed and pure stand; they found out that:

1. In mixed stand – variation in damage were done to exposure of individual trees. Damage was also related to spp characteristics. The dominant were damaged than the subordination.
2. In pure even-aged stand – damage was less selective such stand if damaged were very severe, and suffice more than in mixed irregular stand.

Again thinning shortly before hurricane arises the severity of damage. Irrigation spp were however found to be more resistant than exotic spp.

EDAPHIC/SOIL FACTORS

The soil is important to tree growth in numerous ways. It provides trees with essential nutrients and is a stare hanse for water and oxygen, all of which are necessary for the physiological processes associated with tree growth. The soil also provides trace with space for root growth and the entire plant with mechanical support. The soil thus contributes to the growth in a very fundamental way.

Soil is however not unfair, not even in an area as small as an hectare. Like almost naturally formed bodies, soil exists in various forms or types. The type of soil dictates how best it can be managed to obtain the highest yield as well as the type of tree to grow and silvicultural management to adopt.

From stand point of tree growth a soil is recognized as productive only, if it has adequate water intake and water holding capacity, god aeration, adequate depth, and adequate supply of essential nutrients in available accounts. Soil management in silviculture mainly involves attempts to obtain the right combination of these conditions. The forest managers must be able to a appreciate tropical soils may vary considering in structure and in physical, chemical and abiotic properties, the distribution and rate of growth of forest stands are influenced mainly by those physical, chemical and biological characteristics of the soil which favour the availability of water, nutrients and air to the trees.

SOIL PHYSICAL PROPERTIES

The physical properties of a soil largely determine the ways in which it can be used. The size shape, arrangement and mineral composition of soils particles, depends as other sample physical properties such as the flow and storage of water, the movement of air, and ability, soil supply nutrients to plants. The physical of the soil is thus in many ways as important as its chemistry, partly + kansu physical properties are less easy to alter than chemical ones and partly because shortage, of air or water can cause rapid death of the tree. secondly, must chemical shortcomings can be made good simply by adding the necessary fertilizer while no amount of nutrient will make up for physical properties.

The effects of soil texture are frequently reflected in the composition and rate of growth of forest vegetation. Generally loam and day soils appear suitable for trees with high moisture and high nutrient requirements. Wilde (1958) recommends that soils for forest nurseries should have adequate content of soil colloids to ensure retention of a sterile supply of water and nutrient salts.

SOIL AGGREGATION

Soil aggregate can greatly modify the effect of texture as a factor affecting some important phenomenon related to the growth depending on the size, shape and management.

Soil structures largely determine the porosity and pore size distribution of soil; and the movement air and water within the soil. Aggregate soils, readily infiltrated by rain water, are well aerated and facilitated penetration of root systems. Soils of massive or puddle structure, on the other hand, hinder the growth of trees through being impermeable to rain water or being easily waterlogged and poorly aerated.

One major aspects of soil management in silviculture is ensuring maximum storage of rain water and the subsequent use of the available supply of soil, moisture. Tropical savannah, these factors may control the choice of species, time and rate of planting, site preparation and weeding methods as well as programme of irrigation and fertilizer application.

AIR IN THE SOIL

Air in the soil is also very important to tree life. The supply of oxygen available in the soil influences seed germination, while all the parts of the tree below ground, require oxygen for respiration. Soil reaction influences both the distribution and growth of forest vegetation. Soils with low oxygen content cannot be tolerated for a long period by tree which respire aerobically except they posses special adaptive devices such as stilt roots, breathing roots of pneumatophores.

SOIL DEPTH

Whatever the cause, shallowness of soil limits its utility restricting the supply of moisture, air, and utility by restricting the supply of moisture, air, and nutrients available to the forest stand and through reduction of stand stability. Generally, deep permeable soils through which tree roots can develop extensively provide much wide possibilities in tree crop production. If moisture is limited for instance, the deeper rooted plants may be able to find enough water to keep alive. This is usually the case with deep-rooted savannah trees which survive the dry season even through the associated grasses dieback.

CHEMICAL PROPERTIES OF SOIL

Apart from the physical features, chemical properties of soils must also be considered in determining the silvicultural potential of a soil and in adopting appropriate soil cultural management techniques. The soil chemical properties importance in tropical tree growth are the mineral content, soil reaction or degree of acidity or alkalinity (pH) and the cation exchange capacity of the soil.

All chemical factors can be influenced by the use of fertilizers or manure. However, silvicultural techniques can be employed to improve soil conditions. E.g. drastic opening of canopy is done with the aim of stimulating decay of organic matters of by to increased of and increased rate of decomposition. In some cases drainage schemes may improve the growth of non-mature spp which can do well in water logged condition.

TOPOGRAPHY

The effect of topography on stand productivity can be divided into 2

1. Effect on climate and
2. Effect on soil

EFFECT ON CLIMATE

Effect on climate is important with increase in altitude there is decrease in OT. There is widespread increase in precipitation which increases in altitude. The topography affect OT and disturb precipitation and can alter the climate of an area in close proximity.

It also affect solar radiation, especially of regions beyond the tropics. In the southern hemisphere, south facing sloping regions receive less energy pea nut area than those in the northern hemisphere.

The more shaded part of the slope tends to be cooler with decrease EVT, affecting spp and vegetation distribution.

EFFECT OF TOPOGRAPHY ON SOIL

Topography is an important independent factor of soil formation very in pH in production of soil catena [i.e. difference soil particles along a slope resulting in spp distribution. At base, we have tall trees which deep root.

The top support shallow rooters. On the higher side, the soil is constantly removed- leaving a skeletal soil. The soil deposited in the valley is more fertile which more nutrients and moisture- giving rise is to luxuriant vegetation. Based on this, difference plant formation can be observed along the soil catena. Constant soil erosion is expected along the slope, especially after heavy rainfall. In a steep topography, this would encourage soil erosion. In such process trees use improved while some are damaged lending to reaction wood due to bending.

BIOTIC FACTOR

Biotic factor i.e. all organism in this forest in the into – flora, - fauna – microorganism – man.

FAUNA

The main danger to forest stands are the disease causing insects, and arachnida. In many cases, the wildlife is important because they are dependent on the vegetation for shelter and food. sometimes we have *Tonoceau variegates* the must fundamental in the part played by these insects and ambrosia beetles with along with microorganism help in perpetuation of the nutrient cycle in the forest ecosystem. Some insects participate in the breakdown of organic matter e.g. earthworm help in the redistribution of organic matter in the soil.

Pollination and seed dispersal in the rainforest is dependent on assistance of animals. Wind pollination within the forest is unreliable, thus majority of forest seeds are either insect or bird pollinated.

FAUNA dispersing may be bats, rodents, insects, birds and wildlife. Some distributive effects of fauna to tree are

- Destruction of immature forest
- Attacks by insects on trees.
- Constant grazing by herbivore or damage by big animals elephant insect damage on leaves.

For example, it has been impossible to establish plantations of *Meliacea* because of damage by animals.

TOPOGRAPHY

This acts in combination with climate and soil on vegetation. The effect of topography is therefore secondary, hence we deal with topography in 2 broad contests.

TOPOGRAPHY AND CLIMATE

With increase in altitude, is widespread decrease in precipitation and temperature. Land configuration has bearing on rainfall pattern it directly aspects solar energy distribution especially beyond the tropics. In the southern hemisphere, it has been noticed that south facing slopes receive less energy per unit area than in the North facing slope. Shaded slopes are cooler, evapotraspiration reduced and this affects types of species in an area.

Topographical effect on wind also modifies the type of plant in an area.

TOPOGRAPHY AND SOIL

Soil isa function of parent material, topography, biotic, time and climatic factors. Topography is an independent factor of soil formation e.g. these are different soil types on various portions of the slope, each having different depth, horizon and nutrient status. Thus leads to differences in distribution of species along the slope. If soil creep occurs it makes the soil unable to support vegetation.

Diagram

TOPOGRAPHY AND SILVICULTURE

In the rainforest zone, e.g. South East Asia topography greatly influences the distribution of certain species.

Shorea curtisii tends to be isolated in some areas because of topography, there is not much that can be done to extend their area of occurrence.

Compartment division is independent on topography. In the even topography of southern Nigeria, you can superimpose rectangular compartments, but this is impracticable in fully regions of Asia for instance where irregular compartments are used.

Logging is easier in that topography and mechanization also favoured on that terrain.

BIOTIC FACTORS

These are organisms within and outside the forest but having significant effect on the ecosystem.

For ease of description, they can be grouped into micro and macro flora farm and man. All these harvesting interaction within the forest. Many fauna pose great danger to forest and forest establishments e.g. rodents, insects, fungi etc. they might not be conspicuous features but since they depend on forest resources for food, hey can easily affect stand development.

Termites, wood boring beetles and other micro-organisms consume the ground litter, and held in humus formation. The earthworms and other insect help to redistribute the soil nutrients. Pollination and seed dispersal especially in rain forest is assisted by the insects and smaller animals e.g. Ficus spp is pollinated by moth and mealy bugs. Because of the reduction in wind spread in the rainforest, dispersed is helped by animals.

Jones studied 123 spp in the rainforest 79 had edible fruits or seeds (69%).

46% of the 79 were in the dominant size classes. However, because of the widespread dispersal by animals, regeneration may often show little correlation with seed trees because a lot of these animals are mobile so carry trials to some other places to eat e.g. birds, bat, rodents and man.

Arboreal animals could destroy plants, physical attack on plants by big animals, constant browsing by herbivorous, rubbing of elephant tusks against trees can cause debarking etc. such destructions can pose silvicultural problems.

In many forest areas, elephants contribute to the formation of forest gaps which encourage growth of stranglers, climbers, fungal attack etc. in Kenya and other parts of East Africa, it has been alleged that animals like elephants are the main causes of causes of savanna vegetation.

Micro-organisms greatly affect plants in the nursery e.g. damping off. They are also of major importance in the breakdown of organic materials they also destroy logs.

Mycorrhizae association in leguminous plants also enhance N_2 fixation. In pines, the possession of mycorrhizae increases the absorption power of plants, while at the same time deriving its own symbiotic relationship.

MAN

Cultural operations by man affect forest and its establishment. Population pressure affects vegetations more plants are increasingly used and destroyed by man. Fire which is still used by man for hunting and other purposes has great repercussion on vegetation and other technological so also are his logging equipments.

The major type of cultivation practice in the tropics is shifting cultivation. An area is formed and after exhaustion it is left fro an another plot and allowed to revert to its original status. The time of revertion to original vegetation depends on soil fertility and population. In some cases, there is permanent destruction of forest done to intensive farming, leading to the existence of derived savanna or to forest.

FIRE

This is considered under the effect of man on the ecosystem. It is a principal influence on species traits and life history as well as ecosystem characteristics and processes – carbon, nutrient, water cycling productivity, succession and diversity.

The rain forest is very immuned to fire compared to the savanna because of high rainfall and humidity. However, in the dry season, there could be fire attack. Since an intense fire will kill most of the plant life above soil surface, the succeeding vegetation tends to be made up of light-seeded species that can move in from outside the burnt area, species with dominant seeds stimulated by heat. Many legumes fall in these categories and the abundance of these and other N_2-fitting plants is often increased by burnings. Also, in many parts of the world, recurrent tires favour the development of a shabby vegetation composed of sprouting species with characteristically tough foliage, low in nutritive value and slow to decompose.

Rainforest vegetation tends to move towards the savanna type, but if fire is again excluded, there will be re-establishment of a different succession back to the forest. The degree of re-establishment depends on many other factors like extent of soil degradation, severity of fire, availability of tree seeds in the area etc.

Apart from forest structure and composition, fire affects the boundary of the major forest types.

The effect of burning on soil organisms are highly variable depending on the intensity of the fire, depth below surface, time elapsed following burning, nature of soil and vegetation of the site. Changes in bacteria, fungi etc are more evident in the upper 2-5cm with a lot of decrease following intense fires.

Populations of earthworms, beetles, spiders, mites, centipedes and millipedes are mostly reduced by burning but increase thereafter. Earthworms tend to be more affected by post fire loss of soil moisture than by heat from burnin. Ants are loss affected than other animals because their characteristic features enable them survive in the lower soil layers. Fost fire decreases are not common on light burns, in soil below the surface 5-8cm, and at 6-12 months after burning. Fire effect is greater in forest than savanna due to greater accumulation of fuel, change from cool and moist forest floor to characteristic post fire conditions and greater fluctuation in temperature.

Micro-organism populations increase after fire, apparently due to sudden avaialability of mineral nutrients, increase in soil pH, and other soil chemical changes associated with burning.

FIRE IN SAVANNA

Fire stimulates renewed growth of grasses but damages woody plants Isoberlinia spp are very susceptible.

The Guinea savanna is burnt annually hence, severity of fire is important.

Savanna woodlands only occur in areas where annual fires are light with severe fires, vegetation degenerates into shrub savanna. There is an increase in grasses: tree ratio and ultimately grass savanna.

Early burning does not burn very well due to high moisture content, it may consume only about 25% of the herb stratum. Late burning could consume up to 90% of the herb stratum, hence it is very severe.

MICRO-CLIMATE

Micro-climate is the climate under a given vegetation. It varies from the upper layer, where conditions are similar to those in the open air to the ground level. On the height above the ground, and vertical and horizontal changes in external conditions. Since tree strata are not uniform in density, there are also variations from place to place at the same horizontal level.

To the silvicuturist, micro-climate represents a factor that is amenable to some degrees of control through the manipulation of the stand.

WIND

Air movement is slight within the forest even through strong wind might be blowing above the canopy. Infact, one of the most noticeable features of the lower layers of the forest is the extreme stillness of the air.

Richards (1957) made the following observation on wind velocity, within and outside the forest in southern Brazil.

150m outside forest	2.3m/sec
100m inside forest	0.5/sec

1000m inside forest – to small to determine.

However, the amount of wind speed in a sloppy forest is higher than that of flat terrain.

The effect of wind speed reduction is a reduction evapotranspiration in the under storey.

PRECIPITATION

This is effectively retarded by the forest depending on the number, shape and arrangement of the leaves and branches. Part of the rain intercepted by the leaves and crown is converted to stem flow, some of this sinks to the ground as infiltration. The proportion of the rain passing through tree crowns and stem flow varies with the character of the rainfall.

Thunder showers 26.7% % have been long continued fine rain 35.5% recorded in Brazil.

TEMPERATURE

This parameter shows marked difference at various levels of the forest. Temperature range is smallest in the under storey while the upper stratum has much wider range as there is a higher maximum value.

LIGHT

From the upper to lower stratum, light is perhaps the main parameter showing the greatest range of variation.

Compare for example the gloom of the undergrowth to the dazzling brightness in the tree-tops and gaps. However, some light pass between the leaves and others through gaps (sunfllecks). The remaining being reflected depending on the optical characteristics of the forest component.

Light falling on a forest will vary in intensity and spectral composition with the time of year, time of day and cloudiness of the sky. Measurement of light in forest is a bit difficult because of wind and cloudiness.

Experiments in Singapore and southern Nigeria exhibited the following:

Light form	Singapore	Nigeria
Sunflecks	50%	70%
Skylight	6%	8%
Transmitted	44%	25%
Light energy at floor	2%	3%

Logging and various silvicultural treatments lead to opening up to forest.

Forest poisoning, Malayan or tropical shelter wood system are all attempts of control over light.

HUMIDITY

A lot of differences occur between the various parts of the forest.

Temperature rise during the day lowers humidity and this is greatest in the crown. So, also do the mixing action of wind, convection that obtains through the day. Excessive wind causes dessicating effect. Range of humidity decreases from above downwards leading to a humidity gradient but at night, basically the same humidity exists throughout the whole stand.

Daily range of humidity is lower in the under storey than in the upper layers.

The silvicultural implication is that forest treatments e.g. cuttings and loggings bring about exposure and consequent death especially to young tender seedlings.

FOREST REGENERATION METHOD

Forest is the process by which a forest is reserved. Tropical forests are regenerated by new trees whenever light and other site factors are favourable under prevent stands.

Besides old age, catastrotophic events may lead to breaking up of old forest stand, and where soil has not been adversely affected, such disturbed areas are frequently taken over by new vegetation. Natural forest are regenerated mainly through this capacity to take advantage of natural disturbances. However such regeneration may not ensure that economically desirable trees are regenerated.

The characteristics' considered suitable in various parts of the tropics for ensuring the regeneration of mainly desirable species can be grouped into three:

1. Natural regeneration is obtained from seedlings originating either from natural seeding is from sprouts and other vegetative means.
2. Artificial regeneration obtained by total replacement of the old stand through planting young trees or applying seed, which is often termed direct saving.
3. Enrichment planting accomplished by planting trees I partially opened forests where the seedlings present are of unsatisfactory species, or if of desirable species are either insufficient in number or it not evenly distributed over the regenerated areas.

NATURAL REGENERATION

This is the only natural method and it is applicable in forests where there is an already existing adequate seedling population of desirable species all over the regeneration area. The method involves operations aimed at encouraging self-sown seeds to germinate and the resulting seedlings as well as all pre-existing young trees of the desirable species to develop through removal of their competitors.

The seeds may be derived from mother trees within the regeneration area. The regeneration of natural tropical forest by vegetative propagation is not extensively applied.

It is however governing importance in the regeneration of plantations especially those of gmelina, teak and the eucalypts.

CONDITION OF SUCCESS

Evidences have shown that natural regeneration method cannot be applied successfully to all tropical forest areas. While success has been recorded in areas with abundant and well distributed seedlings on the forest flaer, it has failed where these seedlings are lacking and difficult to induce.

To succeed, several workers have suggested that ecological conditions which guarantee seed availability, seed germination and establishment of satisfactorily density and distribution of regeneration before and after exploitation should be prevent. These are discussed as follows:

SEED PRODUCT AND DISTRIBUTION

The first pre-requisite is adequate seed supply over the regeneration area. Where seed is inadequate, these should be sufficient mother trees of the desired species capable of producing good seed bearers should be located, especially where the regeneration area was clear felled, so that wind or other seed dispersal agencies will ensure proper distribution of seed over the area. The problem in the tropics centres on the complex seed production cycles of most of the species. Some economically desirable species do not fruit yearly and those that do, heavily have good seed years at regular intervals in addition, both before and after seeds fal from the trees, they may be eaten by insects, birds and rodents – the same agents required for their proper distribution. These characteristics make it difficult to guarantee successful natural regeneration whn and where desired.

Infact, in practice it has only poured possible to increase the seedling stocking if silvicultural operations can be timed to coincide with abundant seed fall by desirable species.

GERMINATION AND SEEDLING ESTABLISHMENT

The next step in natural regeneration is successful germination. This largely depends on the inherent qualities of the seed such as seed dormancy, availability of adequate moisture and other physical conditions in the spot where the seed is deposited. Lack of rain at seed fall could cause failure in germination where viability is not impaired; delays in germination are dangerous since they lengthen both the period of exposure to insects, bird and rodents and the establishment period of the new crop.

Seedling establishment depends on seed bed conditions which vary from forest to forest depending on species composition and age.

Generally the most receptive seedbed is exposed mineral soil. In some forests, the slashes and litter accumulate to depths which interfere which regeneration. During net spells, seeds may germinate in the depth but the radicles seldom reach the mineral soil particularly if the seed is small. The problem is that how best to prepare the seedbed, so that seeds will he in direct contact with mineral soils.

Some of the methods include bulldozing the forest floor just before final felling and prescribed burning where feasible.

ARTIFICIAL REGENERATION

Artificial regeneration has been found useful where natural seedlings of the desired species are absent and difficult to obtain or where their performance in poor and unreliable. In Nigeria, the limited success so far achieved by natural regeneration methods has led to changes in emphasis from natural to artificial regeneration methods. This increasingly becoming the trend throughout the tropics the performance of natural regeneration has proved inadequate. The most urgent task facing tropical forests is to accelerate the conversion of unproductive natural high forest to something more productive. In these circumstance, natural regeneration methods will not sufficiently productive to meet the rising demand for all classes of wood products. Thus artificial regeneration is often resorted to whenever it is desired to replace the existing species with more productive ones.

Artificial regeneration in the tropics is accomplished by two main methods: planting and direct saving, with planting being more commonly used than direct saving. In almost every tropical country today, plantations of one species or another are a common sight. Species such as *Tectonal grandis, Gmelina arborea*, the encalphytus and tropical pinnes are the popularity to their capability to establish and grow well in plantations.

It appears that the conversion of tropical forests to plantations is destined to pre-occupy tropical forests for a considerable time to come.

ENRICHMENT PLANTING

This team is distinctly applied only to the technique of supplementing seedling regeneration in a naturally poor or degraded forest, by means of partial planting. It is therefore a forest establishment method involving both natural and artificial regeneration.

Enrichment planting is employed to increase the stocking of valuable species in areas where the regeneration of the required species is eiher scanty, partially successful or completely absent such situations arise where sampling prior to timber felling has shown a great deficiency in seedling regeneration of economic timber species or where both seddling regeneration and potential seed bearers are deficient for the extent that either timber felling is not worth delaying or no commercial exploitation is worthwhile.

Enrichment planting has also been found suitable where the species involved cannot be raised satisfactorily in plantations either because of risks of insect and other disease or become the species requires some amount of shade at least during its first year or two.

It has also been found useful where exploited or degraded high forest cannot be cleared for regeneration due to lack of taungya facilities and cost of labour. Under such conditions of poor natural regeneration and inadequate natural resources, enrichment planting may be the only way of covering the ground fast to keep pace with exploitation.

By retaining at least part of the canopy during regeneration, the enrichment planting method has ecologically, some of the conservative attributes of the natural forest. Where however, the forest has a protective value which the community cannot afford to lose during the period of conversion, particularly in areas, partial planting within existing canopy may be only method of improving the productivity of the forest.

Enrichment planting is caused out in two major ways:

1. Line planting and
2. Group planting

LINE PLANTING

Line planting can be defined as a method of establishing tree crops in lines spaced at intervals equal to slightly greater than the estimated final crop tree crown diameter. The forest are opened by writing parallel lines equidistant from each other and equivalent to the chosen planting escarpment. Suitable planting stock of proven species is then introduced at regular intervals along the lines. The general aim is to introduce vigorous stems of selected species so that their crowns are in god light condition. To achieve this, the line runs in an east-west direction to ensure that the plants get maximum light from the sun. Details of operates involved in line planting differ according to the silica requirements of the planted species.

GROUP PLANTING

In this method, the tree crop is established in groups. This is a more flexible into which can be applied to al types of forest.

INTRODUCTION TO FOREST NURSERY TECHNOLOGY

WHAT IS A FOREST NURSERY?

The nursery is the place where the young tree crops are raised under intensive management for later transplanting to the field. Although tree crops can be sown directly into the permanent field, experience has shown that raising seed lings in the nursery has a number of advantages. Some of the advantages are as follows:

Economy of Seed: fewer seeds are required for raising seedlings in the nursery than for sowing directly in the field. For instance Gmelina arboraea I. could be sown at stake; two seeds are planted per planting hole, the seedlings later being thinned to one. However when seedlings are planted in the nursery, only one seedling is planted per stand.

Seedlings receive more intensive care (protection from animals (rodents) diseases and pests, regular maintenance practices, watering/irrigation, manuring, application of artificial fertilizer) in the nursery.

Raising seedlings in the nursery affords the planter an opportunity for selecting well-grown, vigorous and disease-free seedlings.

The nursery provides the young plants a better medium of growth when still too tender, than when seeds were sown in the field.

However, raising seedlings in the nursery followed by transplanting to the field also has disadvantages. They concern mainly the high cost which nursery practices introduce into the total cost of tree crop production.

i. The cost of nursery equipment, tools and materials are additional to the normal costs of field planting.

ii. Nursery labour is specialized and therefore expensive.

iii. The high cost introduced into permanent tree crop by nursery practices flow over to field costs.

iv. It is more expensive to transplant seedlings than to plant seeds at stake.

Despite these disadvantages most tree crops are established in a nursery, particularly when either the varietals or genetic nature of the material can be guaranteed only for nursery grown/selected material, or when special techniques, for example, budding, grafting demand nursery techniques.

SEED AND VEGETATIVE PROPAGATION

Tropical forest planting stock is almost invariably grown in nurseries either from seed or in some cases from cuttings. This is particularly the case with seeds of many useful species which are unsuitable for direct sowing in the plantation on account of their small size, uncertain viability, dormancy, slow initial growth or because they are scarce and expensive to procure.

In the tropics, commercial nurseries are yet to become common and all planting stock must come from nurseries owned and run by the forest services. This approach gives the forest manager complete control over the species, the quantity and quality to raise and enable him to plan other 1 operations (e.g. site preparation).

SELECTION OF NURSERY SITE

In choosing a site for the establishment of a nursery, a number of important aspects must be taken into consideration. These can be broadly grouped into two:

i. Environmental factors and

ii. Procurable factors. Environmental Factors

a. **Nearness to Planting Site**: It is of great importance if nursery sites are located on or very close to the planting site.

b. **Water Supply:** nurseries should be located where a dependable, abundant and inexpensive supply of uncontaminated water is available.

c. **Land gradient:** Level pieces of land should be selected as nursery sites. This will reduce the costs of establishing and maintaining the nurseries.

d. **Soils**: Soils that most fully meet the requirements for growing a: diversity of species is uniformly deep with fine to coarse sandy loam texture underlain by some what stiffer but still permeable subsoil.

Such soils are better drained and easier to work and permit better seedlings root development than heavier soils. Extremely light and loose sandy soils with low organic matter content are susceptible to leaching and erosion under heavy rainfall or wind erosion in the savanna zones.

The acidity of the soil should be within a suitable range.

e. **Aspect;** (front that faces a particular direction) Nurseries should preferably not be exposed to winds

f. **Winds**: In the savanna region, protection against wind could also be very important. Very often the violent hot and dry winds in the dry season do cause a high rate of mortality among young seedlings in exposed nurseries. Under such conditions nurseries should preferably be sited in naturally sheltered areas.

PROCURABLE FACTORS

a. **Labour Supply**: Labour source is a factor that deserves serious consideration in locating a nursery. An adequate supply of labour and proper supervision especially when transplanting, weeding and lifting is essential.

It is of great advantage if nursery workers are g regular training and periodic orientation, seminars etc.

b. **Market**: The nearness of nursery sites to potential buyers is also of particular importance in commercial nurseries which raise seedlings for sale to planters.

c. **Supplies**: There are two categories of supplies to the nursery — capital equipment and tools, and consumable supplies such as closeness or nearness of sites to good roads, railway station, service centres.

d. **Services**: They are rendered by agricultural or forestry experts who are located in ministries of Agriculture, the Universities or the Research Institutes. Services of such experts as pathologists, entomologists, plant nutritionists can be obtained.

TYPES OF NURSERY

In the tropics particularly in West Africa two main types of nurseries are currently used. There are the temporary or shifting nurseries, and the permanent or central nurseries.

a. **Temporary or Shifting nurseries**

These are nurseries often used by peasant farmers (located near the permanent site) and used for a few years only, usually to grow planting stock for a limited area. Temporary nurseries are the most numerous type in the tropics. They are usually relatively small in size and are increased or decreased in size and number with demand for planting stock in the locality.

In Nigeria they are located invariably along streams or river banks, or on recently felled high forest areas, with abundance of organic matter in the soil.

Although crude, temporary nurseries have their attributes. Raising the stock on or near the planting sites eliminates the risks incidents on packing and reduces handling risks and cost of transportation to the minimum.

Permanent Nurseries or Standard or Central Nurseries

Permanent nurseries are usually large and more intensively managed. Standard nurseries are expensive but they usually produce better seedlings because growth conditions for plants are better controlled. There is no essential difference in the management and initial treatment of temporary and standard nurseries, except that the initial capital outlay is often greater in central nurseries. Important aspects of the standard nursery are as follows:

i. Windbreak The windbreak can provide materials and sticks for use in the nursery.

ii. Fence the fence is usually l-l.25m (use local material to reduce cost not barbed)

iii. Tools and materials shed: This is a walled Room provided with a doorway and windows. All tools, machinery and materials Used in the nursery are stored here.

iv. Chemical Store: A walled room, provided with a doorway and windows. It lies between the tool shed and the potting shed.

v. Potting Shed: A wire netting fenced area is created between the chemical store and the tool store. As the name implies, it is the area where seed boxes, baskets, polybags are filled, seed sown, seedlings potted before they are transferred to the plant house.

vi. Compost heaps Nursery plants grow very fast and demand much from the soil chemically and physically. Compost on the nursery site provides a reasonable quantity of refuse materials. This should be adjacent to the incinerator for operational reasons.

vii. Entrance This should be provided with a lockable iron gate and should be wide enough to take supply and evacuating vehicles.

viii. Rooting bins: These are propagators, constructed for rooting cutting. This method is used commonly with trees that rarely produce seeds. Artocarpus altilis (bread fruit).

In practice, the root which is to form Young lets is exposed and Wounded or cut across and left. This is normally done during the rainy season. New growth may be stimulated by use of growth substance (IAA) Indacetic acid.

INTRODUCTION TO FOREST NURSERY TECHNOLOGY

The nursery the place where the young tree crops are raised under intensive management for later transplanting to the fie1d. A1though can be sown-directly into the perm field, experience has shown that raising seedlings in nursery has a number of advantages. Some of the advantages are as follows:

i. Economy of Seed: fewer seeds are required for raising seedlings in the nursery than for sowing directly in the field. For instance Gmelina arboraea L. could be sown at stake; two seeds are planter per planting hole, the seedlings later being thinned to one. However when seedlings are planted in the nursery, only one seedling is planted per stand.

ii. Seedlings receive more .intensive (protection from animals (rodents) diseases and pests, regular m practice watering/irrigation, manuring application of artificial fertilizer) in the nursery.

iii. Raising seedlings in the nursery afford the p1anter an opportunity for selecting well-grown, vigorous and disease-free seedlings.

iv. The nursery provides the young plants a better medium of growth when still too tender, than when seeds were sown in the field.

However, raising seedlings in the nursery followed by transplanting to the also has disadvantages. They concern mainly the cost which nursery practices introduce cost of tree crop production.

i. The nursery equipment, tools and materials are additional to the normal costs of field planting.

ii. Nursery labour is specialized and therefore expensive.

iii. The high cost introduced into permanent tree crop by nursery practical flow over to field costs.

iv. It is more expensive to transplant seedlings than to plant seeds at stake.

Despite these disadvantages most tree crops are established in a nursery, particularly when either the varietals or genetic nature of the material can be guaranteed only for nursery growth/selected material, or when special techniques, for example, budding, grafting the demand nursery techniques.

Seed and vegetative propagation

Tropical forest planting stock is almost invariably grown from seed or in some cases from cutting. This is articular1y the case with seeds of 1 u species are u for direct sowing ‘in the p1ántãtion on account of their small size, uncertain viability ‘ initial growth or because they are scarce expensive to procure.

In the commercial nurseries are yet to become common and all planting stock must come from nurseries owned and by the services. This approach gives the forest control over the species, the

SOME COMMON SILVICULTURAL TERMS

Advance growth - Young trees which have established themselves in openings in the forest, or under forest, or under forest cover, before regeneration work is commenced.

Afforest, to -To establish a forest on an area from which forest vegetation has always or long been absent.

Aspect - The, direction towards which a slope faces.

Bark scorch - .See under 'Sunscald'

Basal. Area -The area of the cross section of a stem, usually of a tree at breast height.

Base Exchange - The process whereby a soil absorbs certain cations (positively charged ions) from the soil solution arid. gives up other cations in equivalent quantities; the colloidal fraction of the soil is primarily concerned.

Beat up - To restock blanks in a regeneratede area with fresh sowing or plantings (also "fill").

Biome - A living community formed by all the organisms occurring together in a given habitat.

Biotic factor - The, influence of living organisms, as opposed. to climatic and. edaphic factors. Usually restricted to, the influence of animas (including man).

Blank	-	A. gap in a plantation or forest where for, any reason, few or no trees are growing.
Bole	-	Trunk: the main stem of a tree
Bole, clear	-	The part of a bole that is free of branches.
Branch wood	-	The woody portions of a tree exclusive of the bole or roots.
Breast height	-	4’ 6’’ from the level of the ground at it highest point.
Broadcast sowing		-The Scattering of seed more or less evenly over an area, either one on which a crop, is to be raised. or a nursery bed, as opposed to ‘“patch” or sowing.
Broadleaved tree		-A tree belonging to the botanical group Dicotyledons, as opposed to Monocotyledons and. Conifers.
Bud, to		-To graft, using as the scion a small portion. of the stem ‘bearing a single bud..
Burning, controlled	-	Any deliberate use of fire whereby burrning is restricted to ‘a’ predetermined area and intensity.
Burning early	-	Controlled burning early in the dry season before leaves and. undergrowth are completely dry, or before the leaves are shed, as an insurance a later fire damage.

Burning, late	-	Controlled or uncontrolled burning late in the dry season, after loaf-fall where the trees are deciduous.
Burr	-	A term applied both to a large excrescence on a tree trunk or major branch and. to the enlarged rootstock found in certain trees. The grain is highly contorted and presents a characteristic type of figure.
Bush fallow	-	Secondary woody growth developing between periods of cultivation.
Butt	-	the bottom of a tree or log.
Buttress		-An outgrowth from 'the butt connecting it with then roots, especially common in tropical rainforest species; an exaggerated form of root swelling.
Canopy	-	The cover of branches anti foliage formed by tree crowns.
Canopy, closed	-	A Canopy in which the individual tree crowns are in general contact with one another
Canopy density	-	The completeness of tree canopy, of ton expressed as a decimal, taking closed canopy as unity
Catch crop		-A crop grown temporarily on land that will eventually carry a crop of different species, in order

to maintain the productivity or prevent the erosion of the land prior establishment of the main crop.

Catchments area -The total area draining into a given waterway lake or reservoir.

Cleaning -An operation, usually in a young sapling crop, consisting of cutting back weeds, climbers, creepers, and/or young trees of inferior species and Coppice growth, when interfering with the main crop species.

Clearing - An open space in the forest.

Climber - A plant that climbs up trees or other supports by twining round them or holding on to them by tendrils, hooks, or other attachments.

Cline - A pattern of genetical variation in which the differences of a character or characters are graded in a definite direction in space.

Clone - A group of individual derived from a common parent by asexual reproduction.

Co-dominant - A tree with a portion of its crown in the upper canopy, but below the crown level of the dominants

Collar, (root)	-	The transition zone between stem and. root, sometimes recognizable in seedlings by a slight swelling.
Compartment	-	A territorial unit o a forest, permanently defined for purpose of a administration, description, and record.
Compost	-	A mixture of vegetable materials which has been allowed to rot, often with the addition of animal and/or mineral products; used as a soil improver.
Conifer	-	A tree belonging to the order Coniferales of the botanical group Cymnospermae, bearing cones need-shaped or scale like leaves, usually evergreen.
Coppice	-	A crop coppice shoot.
Coppice, to	-	To fell trees with a view to their producing coppice shoots; to produce coppice shoots.
Coppice Shoot	-	A shoot arising from an adventitious bud at the base of a tree that has been cut near the ground. Also called ‘stool shoot’
Coppice, system	-	Crop removed by clear felling; regeneration by coppice shoots, resulting in an even-aged crop.
Coppice with standards	-	Crop consisting partly of vegetative shoots, partly of trees that are generally of seedling origin; selected stems are retained at each felling to form

uneven-aged overwood worked by selection on a rotation that is some multiple of the cop rotation.

Cord, standard	-	A stack of round or cleft wood containing 128 stacked cubic feet and usually measuring 4ft. X 8ft. X 4ft.
Coupe	-	A felling area, usually one of an annual successon
Counterfire, to	-	Intentional burning towards an advancing forest fire so as to effect their mutual extinction.
Cover, crown	-	The horizontal projection the ground of a tree crown.
Cover, ground.	-	The carpet of herbaceous plants and low shrubs which covers the soil,
Creeper	-	A plant which crows m horizontally on or near the ground. putting out roots at intervals.
Crop, cover	-	A subsidiary crop of low plants introduced in a plantation to afford cover, between or below the main crop, also any crop used to protect land erosion.
Crop (forest)	-	The trees, bamboos, etc., growing on a given area.
Crop, final	-	that portion of the stand that it is intention to retain to the end of the rotation.
Crop, main	-	The stand left after thinning.

Crop, nurse	-	A crop of trees or shrubs grown to foster the growth of another and. more important tree crop in its youth.
Crop, tree	-	Any tree destined, to form of the final crop; more universally any tree forming or destined to form a part o the forest crop.
Gross, to	-	Fertilization of the female gametes of one individual by the male gametes of another whether in natures or artificially.
Crown	-	The upper branchy part of a tree above the bole.
Crown class	-	Any class into which the trees forming a stand or crop are divided on the basis of the type of crown and its position with reference to the general canopy and to the crowns of surrounding trees.
Cull, to	-	To reject inferior plants from nursery stock.
Cultivation, shifting	-	A method of cyclical cultivation, chiefly in the tropics, where cultivator cut some or all of the tree crop, burn it, and raise field for one or more years before moving on to another site and repeating the process.
Damping off	-	The killing o young seedlings by certain fungi that cause decay of the stems or roots.

Deciduous	-	Term applied to trees which are normally leafless for some time during the year.
Deforest, to	-	To remove the tree crop from a piece of land without the intention of reforesting.
Dibble, to	-	To show seeds, or plant seed1ings, in holes made with a planting ‘peg.
Dieback	-	The progressive dying, usually backwards from the tip, of any portions of a plant.
Dominant	-	A tree forming part of the dominant tree class.
Dominated	-	Applied to a tree that has its crown somewhat below the level reached by its dominant neighbours, forming part of the dominated tree class.
Drill	-	A line impressed on a seedbed for receiving seed. Any implement used for making such impressed lines.
Drill	-	Tending towards racial deterioration, in particular towards a loss of vigour and productiveness.
Ecology	-	The study of plants and animals in relation to their environment.
Edaphic	-	Pertaining to the soil (in ecology).

Emergent - A tree, or a species of tree, whose crown projects at maturity above the level of the highest complete canopy of the natural forest.

Environment - All of the factors of a site, biotic or otherwise.

Epicormic branch shoot - A branch originating from a d or adventitious bud arising on the trunk or an older branch

Erosion, gully - Rapid water erosion producing gulleys.

Erosion, sheet - Erosion, of a fairly uniform layer of material

from the land; surface; often scarcely.

perceptible, especially when caused by wind.

Escape - A plant originally cultivated, now found wild.

Establishment - Development of a new crop, natural or assisted to a stage where the young regeneration, natural or artificial, is considered safe from normal adverse influence such as frost, drought or weeds, and no longer needs special protection or tending operations other than cleaning, thinning and. pruning.

Establishment period - The period between the initiation of natural regeneration or the formation of a plantation and its being considered established.

Even-aged	-	Applied to a stand in which the trees are of nearly the same age.
Evergreen	-	Applied to three which are never entirely without green foliage
Exacting	-	Making high demands as regards soil and other factors.
Exotic	-	Not native to the area in question.
Filer	-	A tree of species of inferior value retained in thinning or cleaning in the absence of any more valuable stem.
Firebreak	-	An existing barrier, natural or otherwise, or one prepared before a fire occurs, from which all or most of the inflammable materials have been removed, designed to stop light surface fires and to a line from which to work and counter fire if necessary; also to facilitate the movement of men and equipment and fire fighting.
Forest	-	(a) plant community predominantly of trees, usually with a closed canopy. (b)An area set aside for the production of timber and other forest produce or maintained under woody vegetation for certain indirect benefits which it provides, e.g. climatic.

Forest, communal - A forest and owned and generally managed by a community such as a village, town , tribal authority or Native Administration, the Embers of which share in the produce or proceeds.

Forest, irregular - A forest composed of trees of markedly different ages.

Forest, mixed - A forest composed of trees of two or more species intermingle in the same canopy.

Forest, protective - An area, wholly or partially covered, with woody growth managed. primarily to regulate stream flow, prevent, erosion, hold shifting sand, or exert any other benefic influence.

Forest, communal - A forest managed primarily for its produce.

Forest, pure - A forest composed almost entirely of trees of one species.

Forest, regular - Forest composed of even-aged trees.

Forest floor - A general term for the surface of the ground.

Forest influences - All effects upon health, climate, soil and water supply resulting from the presence of forests.

Forest outlier - An area of forest separated form the main occurrence of its type, its presence been due usually to some local variation in ecological conditions.

		An isolated area of high forest surrounded by savanna; almost always associated with a stream and increased soil moisture.
Forest type	-	A category of tree cover defined by any convenient features of its composition or condition; usually the recognized types are defined by assortment and proportions of merchantable species present.
Forestry	-	Application of all relevant arts, and. sciences to the management of forest areas, including the establishment of new forests and utilization of their products, for their sustained maintenance and optimum use for human welfare. (C. F. agriculture which covers whole theory and practice rising and. harvesting field crops; and horticulture everything concerning gardens).
Forestry, multiple-use	-	The simultaneous use of a forest area for two or more purposes, often in some measure conflicting e.g. the production of wood with forest grazing and wild-life conservation.
Form	-	The rate of taper of a log or stem.
Formation	-	Includes all the operations contributing to the creation of a new crop up to the point where it is considered, established.

Gall	-	Localized swelling on a plant caused by a plant or animal organism.
Germination	-	The development of a normal seedling from a seed.
Germinative precent	-	A general term for the percentage, by number, of seeds in a given sample that actually germinate.
Germiative capacity	-	The percentage, by number, of seeds in a given sample that actually germinate, irrespective of time.
Girdle, to	-	To cut through or otherwise destroy the bark and outer living layers of wood in a ring round the bole.
Girdle, frill, to	-	To make a series of downward cuts through the bark and outer tissues all round the bole of a tree, usually for purpose of poison.
Girth, breast height	-	The girth of a stem measured over bark at 4ft. 6 ins.
Girth exploitable	-	The minimum girth at breast height at which trees are consideral suitable for conversion. The girth down to which all portions of a bole or tree must be exploited as timber or fuel under a permit or licence.
Girth quarter	-	The girth of a tree or log divided by four. A measure commonly used in countries where volumes are reckoned in hoppus feet.

Girth class	-	One of the intervals into which the range of girth of trees or logs is divided for c1assification or use; also the trees or 1ogs felling into such an interval.
Groud flora (layer)	-	The lowest storey or stratum of a many layered plant community, consisting of herbs, grasses, low shrubs, Bryophytes and seedlings of trees, lianes, creepers and climbers.
Growing stock	-	The sum (by number of volume) of all the trees growing in the forest or a specified part of it.
Hell in, to	-	To store young plants prior to planting by placing them in a trench and covering the roots or rooting portions with soil.
Hardening off	-	Preparing seedlings in a nursery for planting out by gradually reducing watering, shade, etc.
Humidity, absolute	-	The amount of water vapour per unit volume of space.
Humidity, relative	-	The ratio, generally expressed as a percentage, of the amount of water vapour present in the air to the amount required for the saturation at the same temperature.

Humus	-	The more or less decomposed or decomposing organic matter (leave, twigs, etc.) of the soil which may form a separate layer or be intimately mixed with the mineral particles.
Interplant	-	To set young trees among existing forest growth, planted or natural.
Intolerant species	-	See under light demander
Layer, to	-	To reproduce, either naturally or artificially, by layers
Layer	-	An undetached branch, lying on or partially buried in the soil, which strikes rot and is capable of independent growth after separation from the mother plant.
Leader	-	The terminal shoot of a tree or plant.
Lift, to	-	To loosen and remove a plant from the ground as in transplanting
Light demander	-	A species that requires abundant light for its best development
Litter	-	The uppermost layer of organic debris (deed. vegetable matter) on a forest floor freshly fallen or only slightly decomposed, and consisting chief of leaves but also including bark fragments twigs, etc.

Lop and top	-	The branches and. top cut from ea tree, generally one felled or fallen.
Lower storey	-	See under storey
Main or middle storey	-	The highest almost complete canopy of the forest
Maturity	-	The stage at which a tree is capable of reproducing itself by seed and has attained its full height.
Measure Hoppus	-	The cubic contents of round timber assessed by the method of multiplying the square of the quarter girth in inches by the length in feet and dividing the result by 144 to get the volume in hoppus feet. A log measuring 78.5 hoppus feet contains 100 cubic feet true measure.
Mor	-	A type of humus 1ayer which is practical1y unmixed with the mineral oil and usually shows a well-defined line of demarcation from it. Usually more or less matted and compacted, with very high acidity poor nutrient supplies, very restricted fauna, and absence of earthworms. Often also called Raw Humus.
Mulch	-	Organic material such at cut grass, foliage, etc., used as a soil covering, chiefly to conserve moisture and check weed growth,

Mull	-	A type humus layer wity a loose crumb structure mingled below with the mineral soil and associated with relatively low acidity, high nutrient supplies and rich soil fauna.
Mycorrhiza	-	The phenomenon of the probable symbiotic, or at least non-parasitic, association between the root or rhizome of a green plant and a fungus.
Nursery	-	An area where young trees are raised for eventual planting.
Recruitment	-	Those tree which have entered a particular category during a specified period – especially seedlings which have recently appeared in a regeneration area or stems which have grown into a particular diameter or girth class.
Regenerate, to	-	To renew a forest crop by natural or means.
Regeneration area	-	The area laid down, normally in a working plan or scheme to be regenerated in a specified time.
Regeneration, artificial	-	The renewal of a forest crop by self-sown planting, or other artificial methods.
Regeneration, natural	-	The renewal of a forest crop by self-sown seed, or by coppice or toot-suckers.

Regrowth - The new crop obtained. as a result of natural or artificial regeneration means.

Release - The freeing of and. other vegetation from growth overtopping or immediately surrounding them.

Relict - A community or species wi4oh through the operation of a compensatory or protective feature, has survived some ignorant change that has altered the general vegetation of the surrounding territory.

Rhizome - A stem of root like appearance lying on or under the ground., which roots and sends up shoots.

Root, stilt - An adventitious root which emerges from the butt of a true, above ground level, so that that tree appears as if supported on flying buttresses; e.g. mangrove of the genus Rhizophora.

Root sucker - A shoot rising, from the root of a woody plant.

Rotation - The planned number of years between the formation of regeneration of a crop and its final felling.

Rotation, silvicultural - The rotation through which a species retains satisfactorily vigour of growth and reproduction on a given site.

Sample plot	-	A plot chosen as representative of a larger area of forest, either for enumeration or for study of growth or for determining the effect of thinning or of treatment, etc.
Sapling	-	A young tree in vigorous height growth up to the time when the lower branches begins to fall. Usually within the height range of 3 to 10 feet.
Saturation deficit	-	The difference between actual and maximum vapour pressure at the same temperature.
Savanna woodland	-	Tropical or sub-tropical forest, usually with a single layer of trees, a more or less closed canopy, and undergrowth mainly of grass.
Savannah, open	-	Tropical or sub-tropical vegetation in which there are isolated trees, or groups of tree and climber thickets, in a general matrix of grass.
Savanna	-	Tropical or sub-tropical g containing scattered trees or shrubs.
Saw, pruning	-	A saw, generally with a shorts curved blade, designed to cut branches on the pull stroke, and with a short long handle.
Scarify	-	To break up a forest floor an topsoil preparatory to natural regeneration or direct sowing.

To wear down by abrasion or by acid treatment an outer, more or less impervious seed coat, in order to assist or hasten germination.

Scion - Any unrooted portion of a plant used for grafting or budding on to a rooted stock.

Scorch - Injury to bark, flowers, foliage or fruit by excessive sun, by hot, salt-laden, fume-laden or unduly strong winds, or unbalanced nutrition. On leaves the injury is chiefly at the margins.

Scrambler - A plant which, owing to 1ack ok of rigiidity in its stem, and. absence of special climbing organs, uses other vegetation as its support.

Seed bearer - A tree used for, or capable of providing a supply of seed, especially one reserved, for this purpose during regeneration felling.

Seed drill - A device for sowing seed in lines.

Seed orchard - A plantation raised or treated expressly for the production of seed, usually for superior race

Seedbed - A prepared are in which seed is sown

Seeding	-	The act on the part of a plant of producing seed. The regeneration of a forest from seed, usually by natural means, as in seeding felling.
Seed year	-	A year in which a species bears an adequate amount of seed.
Seedling	-	(a) A tree grown from generally used for a young tree before it reaches the sapling stage (up to 3 feet high). (b) A young tree in the nursery which has not been transplanted.
Self, to	-	Fertilization of the female gametes by the amle gametes of the same individual, whether in nature artificially.
Shade—bearer	-	A seed capable of persisting and developing.
Shelterbelt	-	A belt of trees/ shrubs maintained for the purpose of shelter from wind, sun etc.
Nursery bed	-	A prepared area in a nursery where seed is sown, or into which transplants or cuttings are put.
Nursery stock	-	Generally, whatever is grown in a nursery for planting out; also plants supplied from a nursery.
Overmature	-	The condition of a tree or crop which has passed. (a) the best exploitable age or size, or (b) the age

after which it may be expected to become more and more unsound.

Overstocked	-	A condition of over crowing in tree crops, leading to retarded growth.
Over wood	-	The upper storey of a two-storyed high forest or of any crop in which two distinct crown layers occur, either temporarily or permanently; e.g. seed bearers over regeneration, standards over coppice or a crop of trees over baboos.
Period, conversion	-	The period during which the change from one silvicultural system is effected.
Period, preparatory	-	The period proceeding a change of si1vicu1tural system, during which special operations are undertaken to prepare for conversion.
		A period during which the conditions of canopy and soil are being modified with a few to rendering them suitable for natural regeneration felling are begun.
Photoperiodism	-	Response in the ontogeny of an organism to the relative duration of day and night.
pH value	-	The negative logarithm of the reciprocal of H ion concentration in a solution; a pH of 7 indicates

neutrality, higher values indicate alkalinity and lower values acidity.

Pioneer - A species that invades a bare area such as a newly-exposed soil or rock surface.

Any new arrival in the early serial development of plant communities, usually with particular reference to certain species whose presence appears to promote the establishment of more exacting species.

Plantation - A forest crop raised artificially, either by sowing or planting.

Plantation, taungya - A plantation in which the forest crop is raised

in combination with temporary cultivation of field crops.

Planting, ball - Planting young, trees with their roots undisturbed in a ball or earth,

Planting, group - Planting trees, etc., in groups. Often used for a method of improving natural forest or scrub by planting groups of valuable species at wide intervals.

Planting, improvement - Planting of valuable tree species at relatively wide intervals in degraded or naturally poor forest or scrub, with a view to improving the value of the crop, and not with a view to establishing a regular plantation.

Planting, line - A method of improving natural forest or scrub by sowing or plant1 trees along widely spaced lines or on strips opened up through it.

Planting, pit - A careful method of planting in loosened soil replaced in a dug pit.

Planting, tube - Planting out young trees in open tubes of various materials, in which they have been raised from seed, or into which they have been transferred from the seed bed.

Planting out - Transferring nursery stock to the forest.

Pneumatophore - A knee-shaped or spike-like projection of the roots of swamp trees enabling submerge roots to obtain oxygen.

Pole - (a) A young tree from the time when the lower branches begin to die up to the time when height-growth begins to slow down. Usually within the range of 10 ft. tall and 1 foot in girth at breast height.

(b) A young tree of suitable size for te1egraph or building poles, but too small to provide sawn timber.

Pollard - A tree that has been cut in order to obtain a head of shoots, usually above the height to which browsing animals can reach.

Pre-germination - The procedure of germinating seed, usually until the radicle just emerges, before sowing in the forest or nursery.

Pre-treatment - Various treatments applied to seed prior to sowing to increase the rapid or completeness of germination.

Elimination of inferior and worthless components of a forest crop in advance of exploitation, to provide conditions suitable for the establishment of natural seedlings of desired species.

Prick out, to - To transplant small seedlings individually into nursery beds or boxes.

Provenance - The geographical source or place of origin from which a given lot of seed or plants was collected; the material from such a source of origin.

Prune, to	-	To rewove live or dead branches from standing trees for the improvement of the tree or its timber.
Pruning, root	-	The pruning of roots, particularly for the purpose of encouraging the development of a compact, fibrous root system
Puddle, to,	-	To dip, the roots of young plants in thin mud to their moisture.
Range natural	-	The geographical and altitudinal limits within which an organism occurs naturally.
Shrub	-	A woody perennial plant of low stature (usually less than 20 feet), and frequently branching from the base.
Shrub layer	-	The layer of shrubs and sapling in forest.
Silvics	-	The study of the life history and genera characteristics of forest trees and crops, with particular reference to environmental factors, as the basis for the practice of silviculture.
Silviculture	-	The art science of cultivating forest crops; or that branch of forestry which deals with the establishment, development, care and regeneration of stands.

		(a) Foundations or the scientific basis called. silvics in U.S.A., or forest eco1ogy and silvicultural characteristics in British circles.
		(b) Practice or the application of the scientific basis.
Site	-	The complex of physical and biological factors for an area which determine what forest or other vegetation it may carry. Sites are classified either qualitatively by the climate, soil and vegetation into “sites type” or quantitatively by potential wood production into “site classes”.
Site class	-	
Size, exploitable	-	The diameter or girth decided upon as the normal size for felling in order to fulfill the objects of management
Soil, alkaline	-	A soil that is alkaline in reaction (more than pH 7.0)
Soil, alluvial	-	A secondary soil derived essentially from fllodplain material, immature and without horizons, other than

		strata caused by deposition of material at different times.
Soil, colluvial	-	A secondary, immature soil derived from soil material of older origin, deposited by local erosion on the lower slopes of gentle hills.
Soil, degraded	-	A soil that has been subjected to stronger leaching than the type of soils of the area, and hence lower in fertility.
Soil, elluvial	-	A soil or soil horizon from which materials, soluble or insoluble, have been leached or washed out by percolating water.
Soil illuvial	-	A soil or soil horizon into which materials, soluble or insoluble, have been leached or washed and deposited.
Soil, mature	-	A soil which has reached the full development to be expected under existing weathering end biological processes.
Soil, sedentary	-	A soil formed from the parent material in situ.
Soil, top	-	A specified depth of soil from the external surface.
Soil augur	-	A tool for taking a sample of soil down to some depth from the surface.

Soil pit	-	A pit with one or more vertical faces in order to examine the exposed. soil profile.
Soil profile	-	The appearance of a soil in vertical section with particular reference to the sequence of layers that may be differentiated.
Soil structure	-	The arrangement of the individual soil particle into aggregates of definite size and shape.
Soil texture	-	A property dependent upon the variously sized mineral particles present in the soil mass; used for differentiating soil types within a soil series. Clays, silts, loams, sands and gravels.
Sowing, broadcast	-	The scattering of seed more or less evenly over a whole area, either one on which a crop is to be raised directly or a nursery bed.
Sowing, direct	-	Sowing seed directly on to the area where the crop is to be raised, as opposed to sowing in a nursery.
Spacing	-	The distance between the trees put out in a plantation, or standing in a crop.
Stagheaded	-	The condition of a tree with dead upper branches projecting above the green portion of the crown.
Stake, to	-	To support plants with stakes against loosening by wind, etc.

Start	-	A crop of trees forming a definite unit, e. g. silvicultural
stand elite	-	A stand selected seed collection on account of its specially good quality.
Stand, fully-stocked	-	A stand in which all growing space is deemed to be effectively occupied by the forest crop, but adequate room is left fro the best development of the crop trees.
Standard	-	A tree selected to remain standing over a younger, or new, crop for some special purpose.
Stem	-	The principal axis of a plant from which buds and shoots are developed. In trees, stem, bole and trunk are all synonymous.
Stock	-	A rooted plant on which a scion is grafted.
Stool	-	The lowest part of the tree above ground; a living stump expected to produce coppice.
Storey	-	A horizontal layer or stratum, appearing as two or more canopies.
Strangulation	-	Constriction of the bole of living trees by metal bands or other means, with the object of stimulating flowering and seed production.

Stratification	-	The operation of storing seeds in, and often in alternate layers with, a moist medium such as sand or peat, in order to maintain viability or overcome dormancy.
Strike, to	-	To take or cause to take root (applied to cuttings).
Stripling	-	A sapling grown in a nursery, and. stripped of its leaves (and branches) before planting out.
Stump	-	The base of a tree and its roots left in the ground after felling.
Stumped Plant	-	A plant from the nursery in which root and shoot have been cut back -to a considerable extent. Also called “root and shoot cutting”.
Stump, to	-	To cut back t root and. shoot of a plant before planting.
Sunscald	-	Localized injury to bark and cambium often resulting in wounds and caused by exposure of a stem to intense sunlight and high temperature.
Suppressed	-	Applied to a plant or tree dominated and restricted by its neighbours, which has practically ceased to grow.
System, clear-felling	-	Old crop cleared over a considerable area at one time; usually regenerated artificially, sometimes

with the assistance of an agricultural crop, but natural regeneration sometimes possible.

System, conversion	-	A method of silvicultural procedure designed to change forest crops-from one system or one (set of) species to another, e.g. coppice to high forest, selection forest to uniform, etc.
System, coppice	-	See under coppice
System, group	-	Opening of the canopy distributed over whole regeneration area and executed to form fairly regular distributed gaps, which are enlarged by subsequent fellings as the groups of regeneration develop. Regeneration mainly natural and new crop more or less uniform.
System, shelterwood	-	Old crop removed. in two or more successive fel1ings, called regeneration felling, the first of which is the seeding felling and. the last the final feeling.
System, Silvivultural	-	A method of silvicultural procedure worked out in accordance with accepted principles, by which forest crops are tended, harvested, and regenerated.
System, tropical shelterwood	-	Opening of the canopy distributed fairly evenly by rather gradual throughout regeneration area, and executed by climber cutting and the thinning or

		removal of the middle natural, and new crop more or less uniform.
System, uniform	-	Opening of the canopy distributed fairly evenly and quickly throughout regeneration area, and regeneration mainly natural with fairly short regeneration interval resulting in a more or less even-aged and uniform new crop.
Top root	-	The primary stout root descending more or less vertically from the centre of the tree
Taungya	-	Shifting cultivation; a taungya plantation is one in which the forest crop is raised in combination with temporary cultivation of field crops.
Tending	-	Any operation carried out for the benefit of a crop, at any stage of its life., but essentially covers operations on the crop itself and on competing vegetation and not regeneration fellings nor ground operations such as oil working, drainage, controlled burning.
Thicket	-	A crop composed of saplings
Thinning	-	A felling made in an immature stand for the purpose of improving the- growth and form of the trees that remain, without permanently breaking the canopy.

Thinning, crown	-	Thinning on the basis of the density of the crowns of the more dominant trees.
Thinning, low	-	Thinning air the basis of reducing the basal area of the stand by removing in general the poorer and lower canopy trees.
Tolerant species	-	See under shade bearer,
Transplant	-	A seedling after it has been lined out in nursery (also as verb).
Tree	-	(a) A large woody perennial plant having a single well-defined stem (bole or trunk) and a more or less definite crown. (b) The stake of growth beyond the pole stage, when the rate of height growth slows down and crown expansion becomes marked.
Tree, elite	-	A tree specially selected fro seed collection or for vegetative propagation on account of some specially good quality it may posses
Tree, mother	-	A tree which is capable of producing seed., especially, in natural regeneration operations.
Tree, nurse	-	A tree grown or retained to protect or foster the growth of other trees during this youth.

Tree, weed	-	A tree of a species having little or not economic or silvicultural value.
Tree, wolf	-	A vigorous, usually badly-shaped. tree, larger than its neighbours, and. threatening to spoil better-shaped trees in the vicinity.
Undergrowth	-	The lowest layer of vegetation above he forest floor.
Under-plant, to	-	To plant or sow under an existing stand.
Understory	-	The lower storey of a forest crop
Uneven-aged	-	Ranging considerably in age, usually by more than 20 years, and in size.
Upper storey Viability	-	See also emergent
Viability	-	The potential capacity of a seed to geminate
Weed, to	-	To clean; to remove or cut back any growth interfering with the growth of the crop at the seedling stage.
Whip	-	A tall over-slender tree in the upper canopy which whips the crowns of its neighbours, and will not become a desirable crop tree.
Wilding	-	A natural seedling used in forest planting.
Windbreak	-	A shelterbelt or other obstacle maintained against the wind.

Windfall - A tree or trees thrown by the wind

Wind-firm - Able to withstand strong winds without being thrown or broker.

Witches broom - An abnormal bushy growth of parts of the branch system on trees or shrubs, markedly different from that of the normal plant and characterized by the shortening of the internodes and excessive proliferation; generally pathogenic in origin.

Wolf - See "Tree, Wolf"

Wrench - To break the finer roots of nursery plants, with out removing them from the soil, by heaving the soil with a fork or similar implement, or by partly lifting the plant and reforming.

The definitions are largely taken from "British Commonwealth Forest Terminology",

Part I, published by the Expiro Forestry Association. 1953.